GEOLOGICAL SURVEY OF MISSOURI

RAPHAEL PUMPELLY, DIRECTOR

PRELIMINARY REPORT

ON THE

IRON ORES AND COAL FIELDS

FROM THE

FIELD WORK OF 1872

With 190 *Illustrations in the Text and an Atlas*

PRINTED BY AUTHORITY OF THE LEGISLATURE OF MISSOURI

UNDER THE DIRECTION OF THE

BUREAU OF GEOLOGY AND MINES.

NEW YORK
JULIUS BIEN
1873.

TABLE OF ERRATA.

I., p. 40, 41, for Mr. Otto Worth, read Mr. Otto Wuth.

I., p. 122, for Big Bogg Mountain, read Big Bogy Mountain.

I., p. 125, 154, 157, 160, 165, 167, 174, 183, for Chapter V., read Chapter VI.

I., p. 179, for Chapter IV., read Chapter VI.

I., p. 160, for Chapter IV., read Chapter V.

OFFICE OF THE GEOLOGICAL SURVEY,
ST. LOUIS, April, 1873.

To the President and Members of the Bureau of Geology and Mines.

GENTLEMEN :—I have the honor to transmit to you herewith reports of the work of the Geological Survey during the season of 1872. Entering upon the duties of Chief Geologist in the Spring of that year, the larger portion of my time had necessarily to be devoted to the organization of field and office corps, to the preparation of the plans of the survey and its administrative work. But little opportunity was left me, during the brief tenure of my office, to engage in scientific investigations, and the ill-health which compelled me to tender to you my resignation, has also prevented me from making those final observations in the field, requisite to a report on the general Geology, and more especially on the Iron Deposits, of the Porphyry region of the State.

I have, therefore, been obliged to limit my remarks on that District to a somewhat fragmentary discussion of the questions involved, leaving untouched many important points for want of a few connecting facts.

I have the honor to be, Gentlemen,
Your obedient servant,

RAPHAEL PUMPELLY,
Director Geological Survey.

GEOLOGICAL SURVEY

OF

MISSOURI.

IN 1849, a Memorial was presented to the 15th General Assembly, signed by Falkland H. Martin, Sol. D. Caruthers, Saml. T. Glover, W. G. Minor and De Witt C. Ballou, setting forth the advantages to be derived from a geological survey of the State, and urging liberal appropriations therefor. In their Memorial they stated in detail, what should be required in connection with such a survey, making it incumbent to show, by descriptions and maps, all the various features of surface-configuration ; to investigate the causes affecting health ; the agricultural capacity of the various soils ; to describe the water-courses and water-powers ; to analyze the waters of the springs and to give full descriptions of the rock-formations and analyses of minerals.

But it was not until the session of 1852–53 that a "Geological Survey" was really inaugurated.

On April 12, 1853, Prof. G. C. Swallow was appointed "State Geologist," and began work in May.

The First Annual Report of Progress (4 pages) and the Second Annual Report (in two parts, respectively 207 pages and 239 pages) were published together in one volume in 1854.

The Third Annual Report of Progress (6 pages) was printed in 1857 ; the Fourth (14 pages) in 1859 ; and the Fifth (19 pages) in 1861.

The Second Annual Report contains a preliminary discussion of the general geology of the State ; reports on five counties—St. Louis, Franklin, Moniteau, Cooper and Marion ; and a report on the then more important mineral resources. The other annual reports are statements of progress.

During the period which intervened between the publication of the Second Report and the stopping of the Survey in 1861, a large portion of the State had been visited by members of the corps, and full reports were written on the following counties: Cape Girardeau, Perry, St. Genevieve, Jefferson, Crawford, Phelps, Pulaski, Laclede, Wright, Ozark (including Douglas), Clark, Morgan, Miller, Saline, Chariton, Macon, Randolph, Shelby, Osage and Maries.

The gentlemen connected with the Survey under Prof. Swallow, from its beginning to the suspension in 1861, were, Dr. A. Litton, 1853–1861; Dr. J. G. Norwood, 1858–1861; F. B. Meek, 1855; Dr. B. F. Shumard, 1853–1858; G. C. Broadhead, 1857–1861; Henry Engelman, 1857; Edwin Harrison, 1858; Dr. John Locke, 1860; C. G. Wheeler, 1860; P. C. Swallow, 1857–1861; F. Hawn, 1854; W. Hough, 1857; R. B. Price, draftsman, 1853–1858; H. A. Ulffers, draftsman, 1854 and 1860.

After the Survey had been discontinued, the Legislature authorized L. D. Morse and G. C. Swallow to publish all the results of the work of the previous seven years; but the project was abandoned on account of the expense.

In 1870 the Legislature passed an act organizing a Mining Bureau, to be composed of the Governor and nine members, one from each congressional district. Upon this Board was conferred the power of appointing the geologist. Under that law Albert D. Hager was appointed State Geologist, and held the position until the end of August, 1871. Mr. Hager published one Report of Progress.

The law was amended March 18, 1871, and the Board made to consist of four members besides the Governor. Dr. Norwood remained temporarily in charge of Survey from September 1, 1871, until my appointment in November, 1871. Under Dr. Norwood, G. C. Broadhead was appointed assistant, and C. M. Litton subassistant.

I was appointed State Geologist on the 25th November, 1871. The law concerning the Survey at that time was as follows:—

AN ACT to provide for a "Bureau of Geology and Mines," to complete the Geological Survey of the State of Missouri.

Be it enacted by the General Assembly of the State of Missouri, as follows:—

SECTION 1. There is hereby created and established a Bureau of Geology and Mines for the State of Missouri, which shall be under the direction and in charge of a board of managers, which shall consist of the Governor, who shall be president of the board, and four citizens from the State at large, who shall be appointed by the Governor, shall hold their office for the term of two years, and until their successors are appointed and qualified.

SEC. 2. As soon as the board of managers is organized, as provided in the preceding section, the present State Geologist may appoint, subject to the approval of the board of managers, one assistant paleontologist and geologist and one assistant chemist, to assist him in the discharge of his duties; and said State Geologist may employ such subordinates and laborers as may be deemed necessary by the board; *provided*, the whole expenditure of the board shall not exceed the sum hereinafter appropriated.

SEC. 3. It shall be the duty of the State Geologist and his assistants, under the instructions and directions of the board of managers, to carry on and complete the geological survey of the State already begun, with a view to determine the order, succession, arrangement, relation, position, dip or inclination and comparative magnitude of the several strata or geological formations within this State, and to discover and examine all beds or deposits of ore, coal, marls, and such other mineral substances and mineral waters as may be useful or valuable, make full and complete examinations, assays and analyses of such rocks, clays, marls, ores, and other substances as may indicate useful results, and to perform such other duties as may be necessary to make a full and complete geological and mineralogical survey of the State.

SEC. 4. It shall be the duty of the State Geologist to make, or cause to be made, a detailed report of each county, as soon as the survey thereof shall be completed; each county report shall be accompanied by an accurate map and section of the county, on which shall be represented, by colors and other appropriate means, the various areas occupied by the prairie, timber, and bottom lands, and by the different geological formations in the State, and to mark thereon the localities of the respective beds or deposits of the various mineral substances discovered; and on the completion of the survey of the State he shall make a complete report of the geology and mineralogy of each county, comprising a full account of the discoveries made; and each of such reports shall be delivered to the board of managers as soon as completed.

SEC. 5. It shall be the duty of the State Geologist to collect, in triplicate, all rocks, ores, coals, fossils, and such other mineral substances discovered as may be necessary to form a complete cabinet collection of the geology and mineralogy of the State.

SEC. 6. It shall be the duty of the board of managers to report to the General Assembly, on the first week of each session, the progress and condition of the survey, a detailed account of all moneys spent, and all such reports of the State Geologist and his assistants as have been completed, together with all such information as may be deemed necessary and useful.

SEC. 7. It shall be the duty of said board to collect and take possession of all materials accumulated by the previous surveys, whether reports, maps, sections, collections, instruments or other property belonging to the State; and all persons now in possession of the same shall deliver them up to the order of the president of the board of managers.

SEC. 8. It shall be the duty of the board to determine, as far as may be, what work has been done by each one employed in previous surveys, the character of the work done by each, the condition of such work, how much of the State has been actually surveyed, and how much of said work may be made available in completing the survey of the State, and embody the same in their first report to the General Assembly.

SEC. 9. The board may make such by-laws and regulations for the government and control of its own meetings, and the labors of the State Geologist and his assistants, as may be deemed necessary; it may appoint officers and committees to audit and allow accounts and look after particular departments of the work, and discharge such other duties as may be necessary to carry on the objects of this bureau.

SEC. 10. As a full compensation for the members of the board of managers, they shall be allowed their necessary expenses while attending to the duties assigned them by this act. The board shall fix the salaries of the State Geologist, not to exceed three thousand dollars, and his assistants, which shall not exceed two thousand dollars per annum of actual service, and of all others employed in the work of the survey.

SEC. 11. All accounts for salaries and expenses shall be made under oath, and certified by the board and filed with the Auditor of the State, and the pay of the State Geologist and his assistants shall be made out of the appropriation made for civil officers of the State.

SEC. 12. The sum of five thousand dollars is hereby annually appropriated out of any money in the treasury not otherwise appropriated, to defray the incidental expenses of the bureau created by this act, and the geological survey, and no more than this amount shall be thus expended in any one year.

SEC. 13. The board of managers shall have the general management of the survey, and have full power to remove the State Geologist or any of his assistants and appoint their successors when deemed necessary for the good of the work entrusted to them.

SEC. 14. It shall be the duty of the board to cause the geological collections made previous to the year 1870, to be distributed in accordance with the laws under which those collections were made, except the one collected for the State Capitol, which shall be given to the School of Mines and Metallurgy; and all subsequent collections made in triplicate shall be given, one suit to the State University, one to the State School of Mines and Metallurgy, and one to the city of St. Louis, which shall be deposited by the authorities of that city in some institution for the advancement of science or general education.

SEC. 15. The president of the board shall, from time to time, certify to the State Auditor the sums of money required to pay the salaries of the State Geologist and his assistants, and for the incidental expenses of the bureau; and on receiving such certificates, the Auditor of State shall draw his warrant on the Treasurer of the State for the requisite amounts in favor of the parties and persons entitled to receive the same, and shall charge the several sums so paid to the account of the proper appropriation.

SEC. 16. The entire expenses of carrying out the provisions of this act shall not exceed, in any year, the sum of ten thousand ($10,000) dollars.

SEC. 17. The State Geologist and his assistant, before entering upon the discharge of their duties, shall each take an oath before some officer of this State qualified to administer oaths, that they will honestly, faithfully, and fairly perform all the duties required of them by this act, to the best of their ability, and that they will not permit any person to have access to any of their books or papers, or communicate their contents to any person or persons, and that they will not disclose or make public any mine or valuable deposit, other than in their official reports (except to the owner or owners of the land surveyed), and that they will abstain from all speculations in their own behalf, or in the behalf of others, during the progress of such survey and in relation thereto.

SEC. 18. An act entitled an act to establish a Mining, Metallurgical, and Geological Bureau for the State of Missouri, and to provide for its support and management, and to authorize a geological survey, approved March 24, 1870, and all other acts and parts of acts inconsistent with this act, are hereby repealed.

SEC. 19. This act shall take effect and be in force from and after its passage.

Approved March 18, 1871.

At the end of March, 1872, this act was amended in the following manner :—

AN ACT to amend Secs. 2, 11, and 12 of an act entitled An Act to provide for a Bureau of Geology and Mines, to complete the Geological Survey of the State of Missouri, and to repeal Sec. 16 of said Act.

SECTION 1. Sec. 2 of said act is hereby amended so as to read as follows : Sec. 2.—The board of managers are authorized to appoint one State Geologist, and, upon the nomination by the State Geologist (which nomination shall be made within sixty days after his appointment), one assistant palæontologist and geologist, one analytic chemist and one assistant chemist : and said geologist may employ such additional subordinates and laborers as may be deemed necessary by the board.

SEC. 2. Sec. 11 is hereby amended so as to read as follows : Sec. 11. All accounts for salaries and expenses shall be made under oath, and certified by the board and filed with the Auditor of State.

SEC. 3. Sec. 12 is hereby amended so as to read as follows : Sec 12. The sum of 20,000 dollars is hereby appropriated annually out of any money in the treasury not otherwise appropriated, to pay the salaries and incidental expenses of the bureau created by this act, and of the Geological Survey ; and the expenditure in connection with the same shall not in any event exceed the appropriation herein designated and set apart for that purpose.

SEC. 4. Sec. 16 is hereby repealed.

SEC. 5. This act shall take effect and be in force from and after its passage.

The organization of the Survey was as follows:—

Board of Managers.

Governor B. GRATZ BROWN, *ex-officio President*, 1872.
Governor SILAS WOODSON, *ex-officio President*, 1873.

MR. EDWIN HARRISON,	MR. FORREST SHEPHERD,
PROF. SYLVESTER WATERHOUSE,	GEN. J. H. HAMMOND.

The two last-named gentlemen resigned during the summer, and their places were filled by

HON. A. W. MEYERS, HON. L. A. BROWN.

Mr. A. A. BLAIR was appointed as Secretary of the Board.

State Geologist,

RAPHAEL PUMPELLY.

Assistants,

MR. G. C. BROADHEAD,	DR. ADOLF SCHMIDT.
MR. REGIS CHAUVENET, *Chemist.*	MR. W. E. GUY,
PROF. W. B. POTTER,	MR. C. J. NORWOOD,
MR. J. R. GAGE,	MR. ALEXANDER LEONHARD.

At different times during the year the following gentlemen were employed: J. Pumpelly, in charge of the triangulation in Iron County; P. N. Moore, in magnetic observations; F. Tunica, topographer; C. Gayler and B. Vitzthum v. Eckstadt, draftsmen. W. Bartlett, T. J. Caldwell, T. A. Minor, A. J. Püls, A. Hoeber, M. F. Healy.

Considering the fact, that Missouri presents both considerable diversity in regard to its rock-formations, and a wide range of extensively developed mineral resources, it appeared desirable to organize the new Survey in such a manner, that, while the general and stratigraphical geology of the State should be studied by competent geologists, the study of the distribution and manner of occurrence of the various important mineral resources should be entrusted to two or three departments, in charge, respectively, of men whose previous experience should prove them to be specially adapted to this difficult work.

Conformably with this plan, the survey of the general and stratigraphical geology was divided into five departments, viz. :—

Survey of the North-west.
" South-west.
" North-east.
" South-east.
" Porphyry region of the South-east.

That portion of the survey relating to Economic Geology was divided into three departments, viz.:—

Department of Iron-Ores and Iron-Metallurgy.
" Ores other than Iron.
" Fuels and Construction Materials other than Iron and Wood.

During the past year Mr. Broadhead, assisted by Mr. Norwood, has studied the general geology of the north-west.

In the north-east, Prof. Potter, assisted by Mr. Leonhard, surveyed Lincoln County.

In the porphyry region of the south-east, I began work in May, assisted by Mr. Gage and Mr. Guy.

In July, the Pilot Knob Iron Company requested the Geological Survey to make, at the expense of the company, an examination and a topographical map of their lands, which occupy a large part of four townships. As these townships contain the key to the geology of the porphyry district, the offer of the company was accepted. At the end of the season, a considerable portion of the district had been surveyed, and a map of Pilot Knob and vicinity (Plate I. of the Atlas), embracing about twenty-four square miles, had been drawn.

In the department of Economic Geology, Dr. Schmidt was engaged in studying the distribution and mode of occurrence of the iron-ores, and the condition and experience of the iron-metallurgy of the State. Dr. Schmidt was appointed to this important position because of his extensive experience, obtained first as director of iron-works in Europe, and afterward when in charge, during several years, of the scientific department of an extensive Bessemer steel establishment.

In the department of Economic Geology, important work has also been accomplished in the analyses of coals by Mr. Chauvenet, and of iron-ores by Mr. A. A. Blair, and by Dr. Wendel, of Troy.

During 1873, in the department of Economic Geology, especial attention will be given to the study of the distribution and modes of occurrence of lead, zinc, nickel and other ores, while the study of the iron-ore deposits will be extended beyond the fields of last season's work.

It is intended to begin a systematic study of the building materials of the State, as soon as a sufficiently large amount of material shall have accumulated to justify the employment of a specially qualified assistant, and the establishment of a laboratory for the experimental tests. In this connection, the report of Prof. Smith (Appendix A), on the methods and results of the extended series of tests made by the St. Louis Bridge Company, will be of interest.

It was considered desirable to publish the results of the work of the Survey of 1872, and the hitherto unpublished results of the former Surveys, in separate volumes. After hearing an able speech by General Rozier favoring the bill, the Legislature passed an act appropriating $3,000 for printing the reports of B. F. Shumard, F. B. Meek, and G. C. Broadhead, made to Prof. Swallow previous to 1861, and $9,000 for printing the report on work done in 1872. The printing of the first-mentioned work was undertaken by Messrs. Regan & Carter, State Printers, at Jefferson City; but it was found that the large number of maps and illustrations in the text accompanying the report of 1872, rendered it impossible to have the work done for $9,000 by any western house. A contract was finally made with Mr. Julius Bien, of New York, whose extensive facilities for the use of photo-lithographic and photo-relief processes enabled him to undertake the work. In justice to Mr. Bien, it should be added that he has exceeded the requirements of the specifications in several of the most costly items.

R. P.

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BY

ADOLF SCHMIDT, PH.D.

CHAPTER I.

NOTES ON THE GEOLOGY OF PILOT KNOB AND ITS VICINITY.

BY RAPHAEL PUMPELLY.

THE region represented on the topographical map of Pilot Knob and its vicinity (Pl. I., Atlas) consists of a group of four masses of porphyry, separated from each other by valleys of the lowest Silurian Limestone known in Iron County. The porphyry forms the entire substructure of the region.* It had been eroded into hills and valleys before the deposition of the limestones.

By reference to the map it will be seen that the limestone does not often rise above the 200-foot contour-line. But in places, as in the north-west extension of Cedar Hill, we find a heavy deposit of clay, with chert and mammellated quartz ("mineral blossom") and sandstone lying over the limestone and rising to the 350-foot line. This level (350 feet above the datum of the map) is about the normal height for these clay and chert terraces through this portion of the country; but they have generally, within the area of this map, been removed by erosion, except where they remain in place as terraces and patches on the slopes of the hills.

The porphyries are older than the Silurian, and belong to the Archæan (Azoic) formation, of which they may be the youngest member in Missouri. They are the near equivalents in point of age of the great iron-bearing rocks of Lake Superior, New Jersey, and Sweden. They are stratified on an immense scale, but owing

* No granitic rocks occur within the area of the map; but a few miles to the eastward there is an extensive development of granite, apparently chiefly chloritic and syenitic, in Madison County. The few observations, bearing on the question of relative age, made by both Dr. Norwood and myself, should seem to indicate that the granitic rocks are older than the porphyries. In the north-western part of Madison County several granite hills are capped with porphyry.

The red granites may be an exception to this, supposed, rule.

The fact that the granites contain numerous dykes of hornblendic rocks, while none are known to occur in the porphyries, may go toward proving the greater age of the granite.

to the rarity of interstratified beds of other rocks, the unravelling of the internal structure of the district is a difficult problem.

On Pilot Knob the strike of the formation is S. 50° E. from the true meridian, and throughout the southern half of the map the strike may be generally assumed to vary between S. 40° E. and S. 60° E., and the dip of the strata to be to the south-west.

While all the porphyries of Iron County probably contain a greater or less percentage of free silica, this is not always visible to the naked eye, nor do all the varieties exhibit the feldspars in distinct crystals.

While it would be difficult to make an absolute classification covering all the transitional forms, we can recognize (within the area of Map, Pl. I.) three very distinct varieties characterized by external features.

a. **Porphyry with few or no Crystals.**—Gray, pink, flesh-color, and brown are common colors in this variety; the rock is compact, very hard, striking fire abundantly with the steel, and breaking with a conchoidal fracture. It frequently contains grains of smoky or limpid quartz, and sometimes very isolated minute crystals of either pink or white feldspar, the latter generally striated and apparently oligoclase; the rock is frequently banded in very thin layers, and may be very massive or have a columnar or tabular structure. It weathers through pink to a dirty yellow or white.

b. **Porphyry containing Crystals of Feldspar without Grains of Quartz.**—The usual colors are light and dark brown and purple, more rarely black, gray, and pink; the matrix is very compact and tough, breaks with a conchoidal fracture, strikes fire with the steel, and is often banded. Its distinguishing characteristics are the absence of quartz in grains, and the abundance of crystals, one-sixth to one-fourth inch long, of white or pink feldspar, which is generally triclinic. Although quartz is not present in the form of grains, it sometimes predominates in the alternate layers of the banded varieties.

c. **Porphyry abounding in Grains of Quartz and Crystals of Feldspar.**—The matrix of this variety varies in color from purplish gray to dark purple or black, and the feldspar crystals are usually white and triclinic.

Feldspar and quartz appear to be the only primary constituents in any of the porphyries of this region. But there are several accessory minerals which occur frequently, and are evidently secondary products. The most common among these is epidote, and a soft, greenish substance resembling steatite, apparently an alteration product of the epidote. A chlorite-like mineral occurs frequently in the first stages of weathering, both impregnated in the matrix and traversing the feldspar-crystals. Magnetite and specular iron-ore occur in minute impregnations, sometimes imparting a decided polarity to the fragments of the rock. Fluorite, of a beautiful amethystine color, is found, not unfrequently, in small cavities and seams.

The Silurian rocks of the district are probably the Third Magnesian Limestone of Swallow, with, in places, remains of the Second Sandstone capping it.

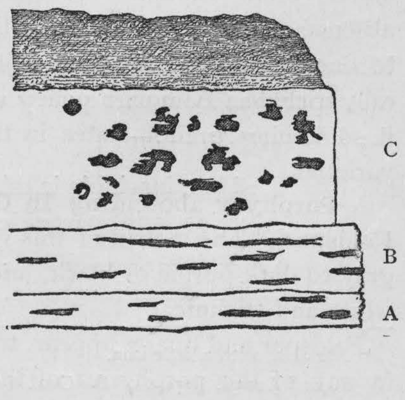
At the contact of this series with the porphyries there are very generally beds of calcareous sandstone and conglomerate.

These limestones are dolomites, in which the process of dolomization has in many places run its course to completion.

The beds are generally from a few inches to six or eight feet thick. The thinner beds contain 10 per cent. to 20 per cent. of impurity, in the form of clay, and sometimes of chlorite, which gives a greenish tinge, often mistaken for a copper mineral. These thinner beds are also often pyritiferous. The more compact beds often contain layers of chert, but aside from this the insoluble impurities, in the form of clay and free silica, seem to range considerably below 10 per cent.

These heavier layers have generally a buff tinge, and contain numerous small cavities lined with beautiful crystals of dolomite. Sometimes crystals of calcite and of copper pyrites and iron pyrites occur in these cavities.

Fig. 1.



The annexed section, and the corresponding analyses by Mr. Chauvenet, refer to the lower beds of the dolomite at Mr. Mace's quarry, Sec. 8, T. 33, R. 4, E.

	A	B	C
Silicious matter..........	5.11	3.85	2.06
Iron, as peroxide........	*4.67	1.07	none
Carb. Lime.............	47.50	52.50	54.32
Carb. Magnesia.........	42.19	42.56	43.82
	99.47	99.98	100.20

In order to compare these limestones with true dolomite, we compare the per cent. of carbonate of lime in each with that of the carbonate of magnesia, the atomic ratio being 54.35 : 45.65. The following figures show the amount of carbonate of magnesia required in each to make it equivalent to the carbonate of lime :—

A	B	C
39.89	44.09	45.62

Bed "A," therefore, contains more magnesia than the dolomite ratio calls for ; the others somewhat less.

On the same property a pyritiferous limestone, from a thin bed somewhat shaly and colored green by the presence of chlorite, was examined by prospecting shafts, some years since, by persons looking for nickel-ore. This rock was analyzed by Mr. Chauvenet, with the following result :—

Silicious matter........................	17.88
Iron, as peroxide........................	3.75
Carb. Lime	43.52
Carb. Magnesia	34.25

The annexed section (Fig. 2) is taken at the quarry near Iron Mountain, from which the furnaces derive their flux.

A specimen from this quarry was analyzed by Dr. Litton, with the following result :—†

Residue, insoluble in dilute hydrochloric acid	6.97
Alumina, with peroxide of Iron...........	1.11
Carbonate of Lime......................	50.38
Carbonate of Magnesia..................	41.74

* Alumina, with a little iron.

† Second Annual Report of the Geol. Surv. of Missouri, Part II. p. 78. 1855.

Fig. 2.

8. Stiff, dark, brown, foliaceous clay.

7. Highly-weathered dolomite.

6. Brown and gray dolomite, with very irregular cavities, lined with crystals of dolomite.

5. Very compact, hard, and fine-grained dolomite.

4. Similar to No. 6, with crystals of calcite porphyritically enclosed.

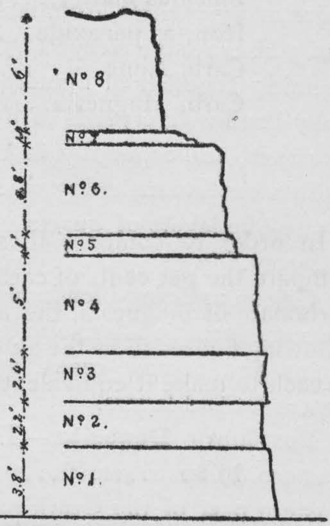
Greenish marly seam.

3. Similar to No. 5.

Greenish marly seam.

2. Similar to No. 4.

1. Massive, gray, and purple-gray, medium grain, with sporadic cavities.



MAGNESIAN LIMESTONE QUARRY N. W. OF IRON MOUNTAIN.

An average sample of the rock from this quarry was taken at the Iron Mountain furnace, and analyzed by Dr. Wendel, of Troy, N. Y., for Dr. Schmidt's Report on the Iron Metallurgy of the State,* with the following result :—

Silica	5.30
Lime	27 48
Magnesia	18.37
Phosphorus	0.003
Sulphur	0.09

An average sample, taken in the same manner and for the same purpose, from the quarry at Pilot Knob, was analyzed by Dr. Wendel, with the following result :—

Silica	3.93
Lime	29.40
Magnesia	19.27
Phosphorus	0.02
Sulphur	0.16

* To be published in the next volume.

The magnesian limestone, in some of the more massive beds, contains many cavities, from less than an inch to several feet in diameter. These have very ragged outlines, as though formed by the running together of numerous smaller cavities. They are generally lined with crystals of dolomite, but in many places, in certain horizons, and especially in the upper beds, the walls are covered with a continuous lining of crystalline quartz resting on concentric agate-like layers of quartz. This geode quartz is called "mineral blossom."

Galena and zinc-blende also occur very extensively in this rock, in some localities disseminated through it, in others occupying gash-veins and narrow caves, and in others again forming extensive interstratified layers.

Residuary Deposits.—The Archæan (Azoic) rocks of southeastern Missouri are the exposed portions of the skeleton of the eastern part of the Ozark range. They appear as knobs 1,400 to 1,800 feet above the sea, and rising 300 to 700 or more feet above the valleys at their bases. They form an archipelago of islands in the Lower Silurian strata which surround them as a whole, and separate them from each other.

These rocks, consisting, as has been already remarked, chiefly of granites and felsitic porphyries, reach their most extensive surface-development in the region forming the northern part of Madison, Iron, and Reynolds, and the southern part of St. Francis and Washington Counties.

The rocks overlying them belong to the oldest known members of the Silurian, and they may be the deep-sea equivalents of the Potsdam sandstone, or even older.

As has been already stated, they are true dolomites, frequently underlaid by gritstone beds, and often covered by heavy masses (50 to 120 feet thick) of clay and chert in loose aggregations.

This region of porphyries, as well as the Ozark range, generally, through southern Missouri, has apparently been above the level of the sea from a very early period to the present time. The higher portion of the elevation does not seem to have been submerged since before the Upper Silurian period ; while broad areas on the flanks of the range have apparently been dry land since the Carboniferous. The absence of the finer and coarser detrital material due to glacial action, as well as of all evidence of the direct mechanical action of ice, prove that the region in question remained undisturbed by the various surface-modifying agencies of the Glacial period. The rocks of the Ozarks, thus exposed to the undisturbed action of atmospheric agencies, present to us in their present condition one of the most instructive records of geological history—one that is full of important facts.

Both the Archæan crystalline rocks and the Silurian strata have undergone immense changes in volume, and in other respects, under this long-continued influence. The gradual removal of the soluble constituents has left important residuary deposits of such substances as were insoluble, especially in the Silurian strata—as clay, flint, crystallized quartz, sulphuret of iron, galena, etc. The more conspicuous instances of this kind among the pre-Silurian rocks are residuary occurrences of iron-ore.

The constituents of the granitic and porphyry rocks offered a far greater resistance to the action of this process of removal than the limestone strata. Still, the amount of disintegration and of full decomposition has been very great in these older formations, although it would not be easy to say what proportion of the change has taken place since the deposition of the Lower Silurian limestones. The porphyries and granites had undergone an enormous amount of erosion before the limestones were formed; an amount at least several times as great as that they have suffered since that remote time.

In the porphyries as well as in the granitic rocks of the region we find the destructive action developed in two marked directions, respectively the resultants of influences due to local external causes, and to the structure, texture, and mineral composition of the rocks. These directions are—

(*a*) The forming of polygonal blocks on the surface, and the gradual disintegration and decomposition of these in place and on the talus. This is the case with most of the porphyry exposures.

A layer of 3 to 4 feet of this detritus covers the residuary clay-deposit of the Silurian limestone on the west flank of Pilot Knob; it lies on a slope of 11°.

On the ridge of red granite at Ex-Governor Brown's quarry, the polygonal blocks are of great size, and their surface-disintegration in place has left picturesque, rounded masses hundreds of tons in weight.

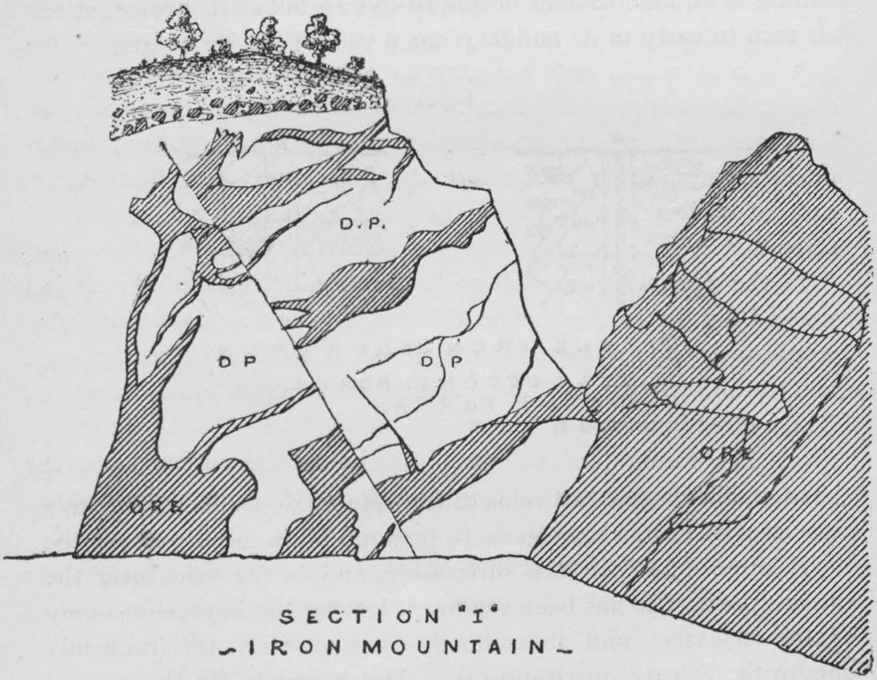
(*b*) Disintegration and decomposition in mass. This, among the porphyries, is best illustrated in Iron Mountain, where the entire porphyry-hill is changed to a clay.

It is well shown, also, in Madison County, among the gray and green (chloritic) granites, where, over considerable areas, complete disintegration has taken place to a depth of certainly more than 50 feet, and possibly several times that depth.

The formation of residuary deposits of iron-ore, having their origin in the gradual removal of very resisting crystalline rocks, is one of the local results of this weathering away and decomposition of the rock, and is well illustrated in the "surface-ore" at Iron Mountain.

This hill, which rises about 250 feet above its base, is wholly covered by a mantle of ore-detritus, associated with some clay. The only knowledge we possess of its internal structure is gathered from

Fig. 3.



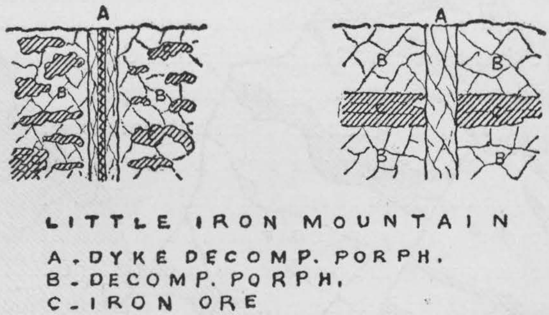
the mining excavations at and near the summit and on the spur called Little Iron Mountain. The appearances in these indicate deposits of the most irregular form, and which should seem, from the results of magnetic observations, to lie in zones extending north-northeast.

In all the excavations the porphyry is decomposed, generally to a clay.

At the summit an immense mass of solid ore is exposed, while the decomposed porphyry adjoining this is traversed in all directions by veins of all sizes and of the most irregular shapes, forming a reticulated network of ore and rock. The foregoing figure (Fig. 3), from a sketch by Mr. Guy, represents the exposed face of one of the great excavations. The shaded portion on the right is a part of the great ore-mass, about 50 feet high. D P is the decomposed porphyry. One of the numerous "faults" is also shown in the sketch.

Similar irregular veins and masses of ore exist in Little Iron Mountain. A remarkable dyke is exposed here, which traverses a vein of ore, and has all the appearance of resulting from the decomposition of an independent porphyry-dyke ; but in its prolongation it is seen to carry in its middle plane a vein of comby quartz.

Fig. 4.



The smaller seams and veins of Iron Mountain frequently contain crystals of apatite, which seems to be a more rare occurrence in the larger ore-bodies. In the surface-ore, and in the veins near the surface, the apatite has been removed, leaving the impressions only of the crystals ; and these honey-comb cavities are frequently lined with delicate quartz-prisms. This accounts for the greater freedom of the surface-ore from phosphorus, as is shown in the comparative analyses.

That the ore-seams existed before the decomposition of the enclosing rock, is shown by the existence of similar occurrences of ore, on a smaller scale, in many of the hills of unaltered porphyry.

The surface of Iron Mountain, when discovered, was covered with a layer from four to twenty, or more, feet thick, of bowlders of pure ore, associated with ore-pebbles and ore-sand, and but little clay. The ore-detritus represents all the varieties of structure, texture, and mineral associates peculiar to the different forms of ore-masses, veins, and seams of the mountain.

As the volume of the ore-veins represents but a small percentage of the volume of the hill, the amount of the decomposed porphyry that has been wholly removed to cause such an accumulation of ore, from broken-up veins, must have been proportionately great. But the present mantle of ore-detritus represents only a portion of the concentration caused by the removal of porphyry, for the excavations at the base of the hill show heavy stratified deposits of detrital ore, having exactly the same origin, and which was washed down the slope and concentrated by the waves of the Silurian ocean.

While the present ore-mantle represents a concentrating process which has been in operation since the deposition of the Lower Silurian limestone, the bedded ore-detritus shows that the process was active before that time, and inferentially that the porphyry was even then wholly decomposed to a considerable depth.

The instance of Iron Mountain is an extreme case, where the decomposition of the porphyry in mass facilitated the separation of the ore from the rock and the mechanical removal of the latter.

There are very many points where sand and bowlders of the finest iron-ore occur on the surface, to a considerable extent. In most instances of this kind these fragments were originally isolated impregnations, segregations, or the filling of small gashes in the rock, and are the residue of a large amount of disintegrated porphyry.

In the Silurian limestone of this region, as of the Ozark range generally, the formation of residuary deposits has attained an extensive development. The long-continued wastage of strata, consisting of dolomite containing a considerable amount of insoluble substances in the form of clay, both diffused and in shaly layers, and of silica in chert-layers and nodules and quartz-geodes, has left its record in heavy masses of residuary material which cap many of the dolomite hills, and, in the porphyry region, form terraces upon the flanks of the knobs of older rocks.

On the west flank of Pilot Knob a shaft was sunk, to a depth of about 70 feet, wholly in a residuary mass of clay containing fragments of chert, geodes of quartz, and masses of brown hematite pseudomorphous after pyrites.

On the tops of many of the flat dolomite hills there are immense quantities of mammellated crystalline quartz which originally formed the lining of the intricate geode cavities of the dolomite, and which is known as "mineral blossom," from its very general association with lead and zinc ores. There are numerous deposits of iron-ores on the flanks of the Ozarks, which owe their origin to this process of residuary concentration, and which are very uncertain as regards extent. In many places these beds of loose quartz-geodes are associated with extensive accumulations of limonite, which is, at least to a large extent, pseudomorphous after pyrite. Again, over areas of hundreds, or even thousands, of square miles, this "mineral blossom" has workable accumulations of galena and carbonate of lead for its associates in the residuary clay deposits.*

Pilot Knob.—Pilot Knob is a conical hill, nearly circular, with a north and south diameter, at the base, of about one mile. Its top is 662 feet above the datum of the map; 1,112 feet above the St. Louis directrix; 1,521 feet above tide.

On its eastern side it is connected with another group of porphyry-hills, by a neck a little more than 200 feet higher than the western base.

The rock skeleton of Pilot Knob is composed chiefly of more or less massively-bedded porphyries, porphyry conglomerates, and beds of hard, specular iron-ore.

All these strata are somewhat tilted up; their strike is N. 50° W.; S. 50° E. from the true meridian, and their inclination is S. W. by S. In the eastern cut, near the summit, the inclination or dip is 21°. In the lower or westernmost cut it is 14.

By levelling between the points along the line of the greatest dip, I find the mean inclination of the ore-bed to be 13°, and shall assume this for the whole hill.

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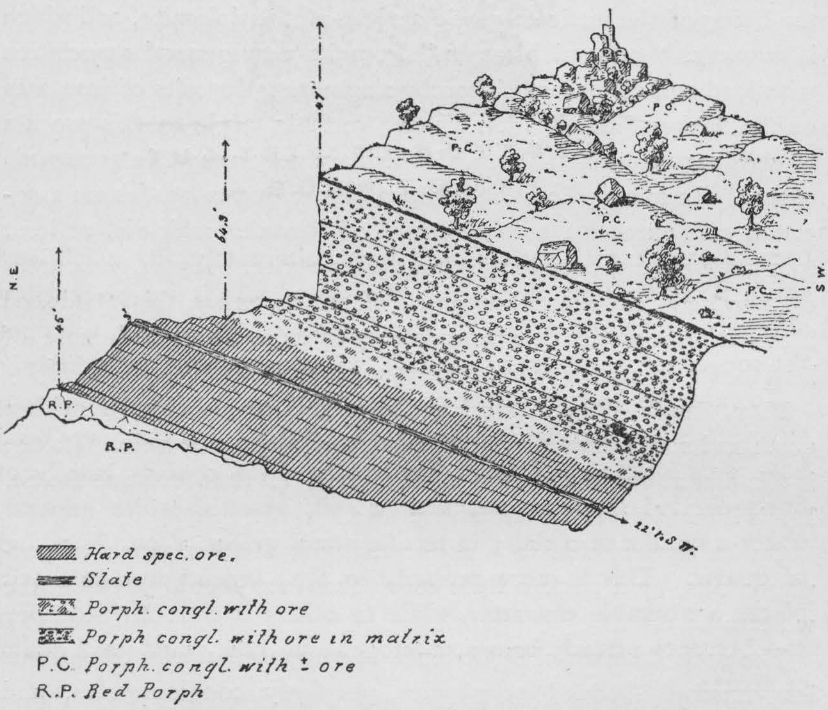
* Prof. Whitney was, I believe, the first to call attention to the occurrence of residuary deposits of clay, in explaining the origin of the red clays of the upper Mississippi lead-region.

The top of the Knob consists of stratified porphyry conglomerate, with an actual thickness of 140 feet (150 feet in a vertical line).

This rock is made up of small and large, more or less angular, pebbles of porphyry cemented together by iron-ore, and containing also frequent layers and bodies of ore.

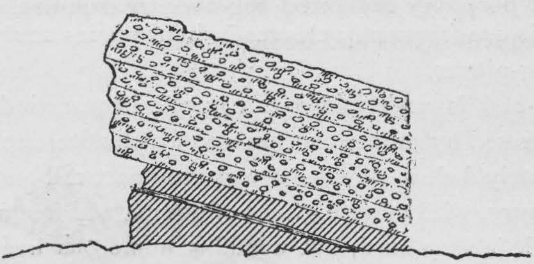
Fig. 5.



SECTION IN THE "GREAT CUT"
PILOT KNOB
1872

The upper portion of the series—a purple conglomerate more or less mottled with gray—has the pebbles and matrix nearly equally divided. The pebbles are rarely more than one inch in diameter, and are of brown porphyry and gray quartz, with others of a yellowish-gray substance, easily scratched, and apparently an altered porphyry. The matrix is generally a very fine-grained iron-ore, containing small grains of limpid quartz. Although the only visible crystalline forms of the iron-ore are those of specular ore, this conglomerate matrix possesses decided polarity. A compass held close to the rock, and moved gently a few inches in any direction

Fig. 6.



SECTION OF WEST CUT
PILOT-KNOB

parallel to the rock-surface, will have, alternately, its north and south poles strongly attracted. But the needle is not perceptibly affected at a height of four or five feet above the surface, nor does the conglomerate series, as *a whole*, affect the needle appreciably.

Toward the bottom of the conglomerate series the conglomerate structure is less marked in the eastern openings, and the lower beds have only isolated pebbles. The matrix here consists mainly of finely-divided specular ore, with a soft, greenish-white mineral, either a steatite or a clay; in this lie small grains of porphyry and of quartz. This is more properly an ore; indeed, it assumes in places a workable character, while in others it contains little ore, and becomes a nearly brown, homogeneous rock, with small grains of quartz.

Below this lies the ore-bed, with a vertical thickness of 46 feet. It is divided into two beds by a slate-seam 10 inches to 3 feet thick. This seam, which is very persistent, lies in the great cut 31 feet above the foot-wall of the lower ore-bed.

The upper ore-bed is more variable in thickness, having in the slate-seam a regular foot-wall, but having no very well defined hanging-wall, the ore often rising into the overlying rock.

The upper ore-bed is so distinctly stratified as to be a well-characterized flag-ore, and is considerably leaner than the lower bed. The slate-seam which divides the two ore-beds is variable in character, having in places the appearance of a clay-slate, in others of talcose-slate. while it not unfrequently has all the characteristics of a porphyry.

The great ore-bed which lies below the slate-seam is a very compact, dense, and hard ore, very finely stratified in layers from 1 line to ½ inch thick. In places the alternate layers are somewhat silicious. This ore frequently cleaves in joint planes at right angles to the bedding-planes.

The ore-bed is underlaid by a purple-brown, indurated, clay schist, traversed by numerous threads of a steatite-like mineral.

Immediately below this lies a very compact red and brown jaspery porphyry, with minute grains of quartz, and free from feldspar-crystals. It is very hard, but contains numerous irregular-shaped patches one-eighth inch to several inches in diameter, of a soft, greenish and brownish mineral resembling steatite, which is possibly an alteration-product of the porphyry.

Below this, on the eastern slope, is a compact red jaspery porphyry, with a decided tendency to spherulitic structure. The spherules are from the size of a pin-head to that of a pea; they are of the same color as the matrix, and usually contain a small nucleus of a soft, greenish-white mineral—probably steatite. The same substance that forms the nuclei, coats also the surfaces of the spherules, and is distributed very generally through the rock in such a manner as to give it a brecciated appearance. The matrix contains very isolated minute grains of limpid quartz.

Further down the eastern declivity are outcrops of a compact, pinkish-gray porphyry, rarely containing visible grains of quartz. It contains an iron-ore, both minutely disseminated and also more concentrated in dark, irregular streaks. This rock has a tendency to tabular cleavage, and weathers through pink to yellowish white.

Underlying this we find, on the neck which connects the Knob with the hills to the eastward, a pinkish-brown porphyry with conchoidal fracture, containing grains of limpid quartz and scattered small crystals of feldspar.

A few hundred feet further east, and forming the next lower rock, is a very hard, flesh-colored porphyry, slightly mottled through the presence of irregular spots containing steatite and minute grains of iron-ore. The rock contains small grains of quartz and crystals of feldspar, which are more or less riddled with holes containing a chlorite.

The next lower rock is that which forms the western declivity of the hill next east of the Knob. It is a pinkish-gray, slightly-banded porphyry, containing innumerable small cavities filled with a chlorite, and has a well-marked columnar structure.

The inclination of the strata forming Pilot Knob being nearly the same as that of the surface of the western slope, we should expect to find the same series and thickness by boring at any point on the west slope. But there have been disturbances, which probably render this impossible, on the lower half of the western declivity.

Below the 400-foot contour-line, the rock-surface has a steeper slope than that of the hill. A shaft sunk at about the 325-foot contour, after going through about 3 feet of loose rubble of ore and porphyry, was sunk through nearly 64 feet of clay without striking rock; whereas, if there had been no disturbance, the shaft should have been wholly in the conglomerate beds which overlie the ore, and the present bottom of the shaft should be very nearly in the hanging-wall of the upper ore-bed. The absence of these rocks is due to the erosion which the south-west flank of the hill had suffered before the deposition of the Silurian rocks.

There are evidences of another disturbance. This is a zone of fracture visible in both the great cut and in the lower cut. Its course is about S. 30° W., and it is marked by a breccia of broken-up and re-cemented fragments of ore and porphyry. It does not appear to have "faulted" the ore-beds.

From the foregoing data, taken in connection with the form of Pilot Knob as determined by the topographical survey, we can delineate on the map the shape of the remaining portion of the ore-bed, assuming, of course, that the dip and strike remain the same, respectively, as in the upper part of the hill, and that the ore-beds are also persistent, and neither replaced by other rock material nor thrown out of position by faults.

As the western limit is probably buried beneath 75 to 90 feet of clay and chert, its delineation is only roughly given.

The south-western and northern limits are probably near the truth.

The area thus indicated is about 200,000 superficial yards as a maximum for the extent of the ore-bed.

The indication of the limit on the map may be of service in determining the best points to attack the ore-bed on the west or southern flank.

The two best points for exploration are :—

1. On the north-west, where the ravine intersects the limit-line, about 200 feet north of the incline and near the 375-feet contour.

2. On the limit east and south-east from Station 6, on the survey-line running south from the summit, there is (west of Station 6) an old opening in the conglomerate series that belongs above the ore. No line of levels was run to it ; therefore, in placing its position at 20–40 feet above the ore-bed, I am making an estimate only.

The great thickness of the clay-deposit on the south-west flank would render it undesirable to attempt to approach the ore from this direction, before proving the bed near the two points above indicated.

The shaft that was started for exploration, about 500 feet south-east of the western turn-table, has its collar a little more than 60 feet above where the ore-bed should be.

Before leaving Pilot Knob, I will remark that the clay-deposit on the west flank may have a technical value. It consists of a very pure white variety and a rusty variety. The two kinds could probably be separated. Their composition, as shown by the accompanying analyses made by Mr. Chauvenet, should give, especially to the white, a very decided value as material for the fabrication of chinaware :—

ANALYSIS OF CLAYS.

	I. *Opalescent White Clay.*	II. *Brown Clay.*
Silica	63.50	57.22
Alumina	24.55	22.89
Peroxide of Iron	none	7.81
Lime	1.60	1.10
Magnesia	0.48	0.46
Water of composition	7.30	7.95
Hygroscopic Water	2.20	2.90
	99.63	100.33

Cedar Hill.—The rocks forming the south-western flank of Cedar Hill are the north-western extension of the conglomerates and ore-beds of Pilot Knob.

At the time of my visit to this point, the working had not progressed far enough to indicate with certainty whether the ore after being taken out corresponds to the ore-bodies distributed irregularly in the conglomerate on Pilot Knob, or to the great ore-bed proper.

It is quite possible that the real equivalent of the Pilot Knob ore-beds has not yet been reached on Cedar Hill.

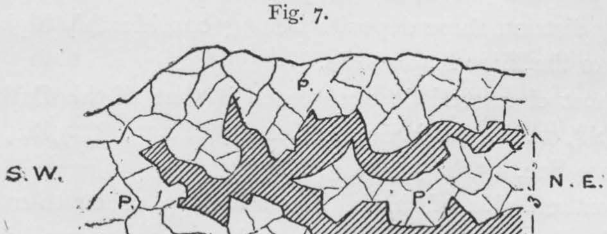
I collected a thoroughly average sample of the stock-pile at the mine, which was analyzed by Mr. Blair, with the following result:—

Insoluble silicious matter......	5.62	per cent.
Peroxide of Iron............	93.54	"
Sulphur.....................	none	
Phosphoric Acid.............	0.090	"
Equal to—		
Metallic Iron................	64.47	"
Phosphorus	0.039	"
Sulphur.....................	none	

The ore opened in the cuts on Cedar Hill, at the time of my visit, is very hard, dense, and heavy, and very uniform in character. It breaks in prisms, with sharp edges, owing to a well-marked columnar structure. The ore contains minute grains of limpid quartz. It has all the appearance of a porphyry in which the matrix has been wholly replaced by iron-ore; and the irregularity of its mode of association with the porphyry heightens the resemblance.

The annexed cut, taken in one of the openings, will show what irregular forms the deposit assumes:—

Fig. 7.



SECTION OF "CUT"
ON CEDAR HILL

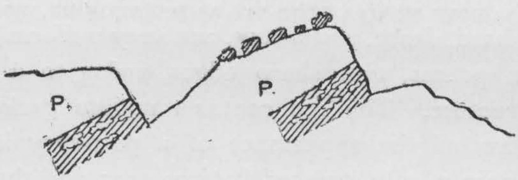
The shaded portions are ore. P is the mottled, altered porphyry associated with the ore.

In the N. W. $\frac{1}{4}$ of the S. E. $\frac{1}{4}$ of Sec. 28, east of Pilot Knob, there is another zone of iron-bearing beds. At one point, shown to me by Mr. Crane, there are beds of jaspery slate, containing more or less specular ore. The indications are such as would make it desirable to have some exploration done.

We found at another point (half-way between Station 4 on line 12 and Station 7, line 14), a bed or beds of ore, which deserve some work in the way of "proving."

It is a rich granular ore, somewhat resembling that of Shepherd Mountain. The outcrop is not sufficiently exposed to enable one to give an opinion as to the extent of the deposit. All that can be seen without digging are what seem to be two beds, one and one-half to two feet thick, of rich ore, more or less mixed with somewhat decomposed porphyry.

Fig. 8.



The deposits of manganese-ore and of manganiferous iron-ore form a very interesting feature of the porphyry region, and promise to be of considerable economic importance.

So far as I can judge, in our present limited knowledge of the porphyry district, these deposits belong considerably higher in the series than the Pilot Knob beds.

The most characteristic occurrence is that of the Cuthbertson-Buford hill, which, beginning in Sec. 19, T. 33, R. 4, E., runs W. N. W. into Sec. 13, T. 33, R. 3, E.

The northern side of this hill, near the top, seems to consist of a very dark, almost black porphyry, with numerous small crystals of white feldspar and grains of quartz.

The southern declivity, the rocks of which overlie those of the northern side, consists of a much-altered bedded rock of fine grain, which has in places the appearance of an indurated sandstone, in others that of an altered porphyry. It contains numerous broad and flat cavities partially filled with a red, ochreous substance. Fresher fragments exhibit a brown, fine-grained rock, consisting largely of minute grains of quartz cemented together by a quartz or porphyry matrix.

There are no natural exposures of the rock in place, but on the Cuthbertson tract the surface is bestrewed with large and small fragments of manganese-ore, and, in places, of specular iron-ore. A cut in the Cuthbertson tract exposes a bedded deposit consisting of exceedingly ragged tabular masses of manganese-ore, separated by a red, ochreous clay.

The following are analyses of this ore and of the specular ore, by Mr. Chauvenet:—

Manganese Ore.

Insoluble silicious matter	0.44
Peroxide of Iron	3.30
Manganese as protoxide	68.02

The manganese exists in the ore as sesquioxide, with a probable admixture of binoxide.

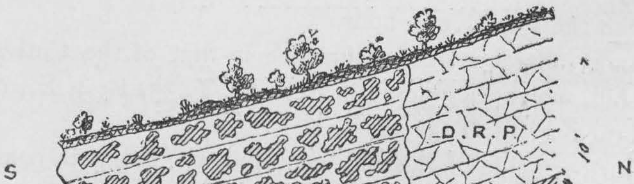
Metallic manganese	52.47

Specular Ore.

Insoluble	2.45
Peroxide of Iron	97.85
Manganese	trace

It lies upon the bedded rock described last above.

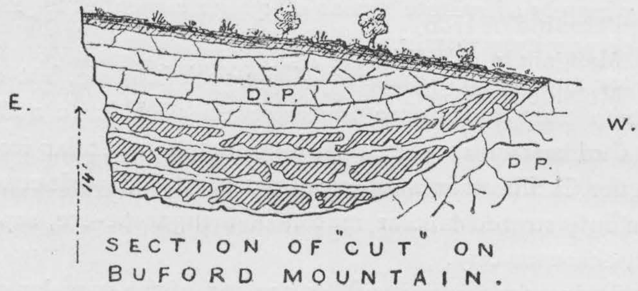
Fig. 9.



MANGANESE DEPOSIT ON CUTHBERTSON'S HILL
SECTION 19 T. 33. R. 4 E.

Further west, at the Buford bank, a larger cut gives a better exposure.

Fig. 10.



Here we find a bedded deposit of the same nature as that on Cuthbertson's tract, with the difference that this one is a manganiferous iron-ore of a very superior quality. The cut exposes a stratified deposit of a ragged black iron-ore, overlaid by beds of pink, altered porphyry.

The whole thickness of the ore-bed was not visible, but I estimate it at nearly 14 feet in the cut, though it thins out at the outcrop on the hill-side.

A sample consisting of a large number of chippings was taken by myself as a close average of the ore. This was analyzed by Mr. Chauvenet, with the following result:—

Insoluble	8.54	per cent.
Peroxide of Iron	68.30	"
Manganese as protoxide	15.84	"
Sulphur	0.017	"
Phosphoric Acid	0.102	"
Equal to—		
Metallic Iron	47.81	"
Metallic Manganese	12.32	"
Sulphur	0.017	"
Phosphorus	0.044	"

This is a remarkably fine ore for the manufacture of *Spiegeleisen*.

Of the extent of the deposit nothing can be known until more work is done.

Near this point there is a very irregular deposit, apparently a pocket, of ore nearly free from manganese, as appears in the annexed analysis by Mr. Chauvenet:—

Insoluble	13.42
Peroxide of Iron	85.76
Manganese as protoxide	trace
Metallic Iron	60.03

Near Cuthbertson's, but apparently belonging, geologically, a little higher, is the manganese deposit on Mr. Marble's land. It forms an interstratified layer, 3–5 inches thick, in a decomposed porphyry.

A specimen of this was analyzed by Mr. Chauvenet, with the following result:—

Insoluble	10.35
Peroxide of Iron	14.22
Manganese as protoxide	51.06
Lime	2.75
Magnesia	0.43
Water	3.89

Mr. Marble also sank a pit in his wood-lot, near the last-named locality, and after passing the soil, found about 3 feet of the ore in ragged masses, and below these a reddish, manganiferous, soft hematite (I.), associated with another variety (II.) containing less manganese. In samples of these Mr. Chauvenet made the following determinations:—

	I.	II.
Insoluble	17.66	35.96
Peroxide of Iron	49.34	58.70
Manganese as protoxide	21.18	3.77
Metallic Iron	34.53	
Metallic Manganese	16.44	

This is a soft, maganiferous hematite of excellent quality.

At all of the points mentioned on this hill the strike of the beds is N. 65°—80° E., and the dip, more or less gentle, toward the south.

Overlying these manganiferous beds we find a metamorphic limestone. This remarkable occurrence, which was first brought to my notice by Mr. Gage, is well exposed on Mr. Huff's land; it is a more or less thinly-stratified rock, with essentially two characteristic constituents. In one extreme we have a pink to greenish-pink, crystalline limestone, containing irregular layers, one-sixtieth of an inch to several inches thick, of a dark-brown, fine-grained material, which strikes fire readily, and shows under the glass a large percentage of quartz in minute grains, cemented by a quartz or porphyry matrix.

While the limestone bands effervesce strongly with acid, the dark bands are not acted upon except where they contain very thin layers of the limestone. The limestone is, in places, tinged green, probably from the presence of a chlorite.*

In the other extreme, the main body of the rock consists of the silicious material just described, containing very subordinate layers of the carbonate. In places, this laminated structure is highly contorted; the carbonate layers are often broken up, and the fragments distributed very irregularly in the brown silicious rock.

On the weathered surface the removal of the limestone gives rise to the same flat cavities, filled with ochrey earth, that we found in the rock accompanying the manganese-ores on Cuthbertson's tract.

On the south-west 1/4 of Sec. 20, T. 33, R. 4, E., and over a considerable portion of the valley between this point and Huff's, there is a very compact, dark-brown, almost black porphyry, containing small crystals of white feldspar and grains of quartz, with some disseminated magnetite. In places the feldspar and quartz are abundantly crystallized, but more generally they are hardly visible except under the glass. The surface weathers dirty yellow, and then displays a distinctly-banded structure, which is rarely apparent on fresh surfaces. This is probably either the equivalent of the banded rock at Huff's, or it is younger.

Another interesting instance of the occurrence of manganese-ore in porphyry was examined by assistant P. N. Moore, on Section 16, T. 33, R. 2, E., in Reynolds County.

It occurs in one of the members of a series of bedded porphyry rocks, which may be here briefly described.

1st. A flesh-colored porphyry with a very compact matrix,

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* For an analysis of this limestone, see p. 26.

abounding in grains of smoky quartz and crystals of feldspar, is overlaid by

2d. A black porphyry with very hard matrix, abounding in grains of smoky quartz and crystals of a triclinic feldspar. In this occurs the black oxide of manganese ; it is in narrow, comby strings, which are in places isolated, in others united to form a reticulated network throughout the mass ; in this form the rock resembles a conglomerate, the ore representing the cement. In other instances the manganese has wholly replaced the matrix, the crystals of feldspar and grains of quartz alone remaining intact. Finally, in portions of the rock the replacement has been complete ; here no traces of the porphyry, either crystals or matrix, remain, while a more or less porous, semicrystalline mass of the manganese-ore takes their place.

A specimen representing an intermediate variety of this series was analyzed by Mr. Chauvenet. It is very compact and hard, striking fire with the steel. The matrix is jet black, with metallic lustre, and has the same texture and fracture as the parent porphyry, and, like this, contains grains of quartz and crystals of feldspar—in this instance not striated. The whole appearance of the specimen is identical with that of the adjacent porphyry, except as regards the color and lustre of the matrix.

Insoluble	45.55
Peroxide of Iron	5.48
Manganese det. as protoxide	37.04
Lime	2.73
Magnesia	0.81

The analysis of the insoluble portion gave—

Silica	74.98
Alumina	14.69
Iron	none
Lime and Magnesia	traces
Potash	9.64
Soda	0.67
	99.98

The insoluble portion is very clearly a typical felsitic porphyry with orthoclase for its feldspar. It is evident that the manganese and the other soluble constituents take the place of more than half of the porphyry in this specimen. That the resemblance of the ore to the porphyry is not merely accidental, is shown by other instances of a similar nature.

On the land of Mr. Ackhurst (Sec. 19, T. 33, R. 4, E.) is a dark porphyry containing grains of quartz and abundant crystals of white feldspar; the matrix is frequently, in places, a compact manganese-ore.

It would seem that we have, in these occurrences, instances of replacement; but it is difficult to imagine a direct substitution of manganese oxides for the decomposition products of a porphyry, and all the more so, in this case, from the fact that the analysis shows the remaining porphyry, which is intimately associated with the ore, to have its normal constitution.

In this connection the metamorphic limestone at Huff's (near the manganiferous ores on Cuthbertson's, Marble's, and Ackhurst's land) may be of additional interest. As was mentioned before, this is nearly wholly changed into a porphyry or jasper rock, it having here a schistoid structure, in which the alternate laminæ are an impure, compact carbonate of lime, having, according to Mr. Chauvenet's analysis, the following constitution:—

Insoluble	35.81
Peroxide of Iron	5.35
Lime	31.62
Magnesia	1.10
Carbonic Acid	25.83
	99.71

Here is a member of the porphyry series which was originally, unquestionably, a limestone, but in which the original physical and chemical characteristics have almost wholly disappeared. It should not seem impossible that the manganiferous rocks which have been described may have had a similar origin, and that the manganese and iron oxides owe their present existence to a former replacement of the lime-carbonate by iron and manganese salts. The porphyry, which now surrounds these ores, may be due to a previous contemporaneous or subsequent replacement of the lime-carbonate by silica and silicates.

But there is so strong a resemblance between the mode of occurrence of these ores and that of certain of the iron-ores—that of Cedar Hill, for instance—that any hypothesis explaining the one must probably satisfy the requirements of the other.

3d. Geologically above this manganiferous bed lies a porphyry conglomerate or breccia, consisting of pebbles of a red, compact porphyry, containing grains of quartz and crystals of feldspar, cemented by porphyry of a similar character. This rock resembles very strongly the Calumet conglomerate on Lake Superior. Overlying this is

4th. A bright, red, compact jasper, apparently an altered sandstone which passes upward into

5th. A dark-brown, compact, banded porphyry, abounding in minute crystals of feldspar and equally small grains of quartz. This rock contains here and there layers of very small pebbles, parallel to the bands. Still higher this rock becomes darker colored, while some of the bands become green, from the presence of epidote. Higher in the series occurs a mottled-red and greenish-white rock. The red portions are easily scratched, and the white are still softer, having about the hardness of limestone. Grains of quartz occur indifferently through the red and white spots, while crystals of triclinic feldspar are frequent in the red spots and rare in the white. At first sight, the rock has the appearance of a variegated marble.

The greenish-white substance was analyzed by Mr. Chauvenet, with the following result:—

Silica	65.61
Alumina	20.52
Protoxide of Iron	1.99
Lime	1.97
Magnesia	2.37
Potash (trace of Soda)	7.93
	100.39

This rock is clearly an altered porphyry, and the white portion represents the more advanced change. It is interesting as an instance in which the change appears to have been accompanied by a removal of silica and of iron, while the alkaline constituents were apparently not affected.

Next above this comes

6th. A porphyry with brown matrix, containing crystals of triclinic feldspar, with few or no grains of quartz, but with numerous 1/8 to 3/4 inch spherical, crescent-shaped and irregular cavities filled with quartz, often showing free crystallization in the centre.

REPORT OF MR. REGIS CHAUVENET.

PROF. RAPHAEL PUMPELLY,

Director Missouri Geological Survey:

DEAR SIR:—I herewith submit the results of such of this year's chemical work as is fit for tabulation, together with a brief description of the methods of analysis used, and a short discussion of some of the more important coals, in regard to their prominent chemical and physical characteristics.

Respectfully yours,

REGIS CHAUVENET,

Chemist of the Geological Survey.

ST. LOUIS, *April* 23, 1873.

CHAPTER II.

ANALYSES OF FUELS, IRON-ORES, AND PIG-IRONS.

BY REGIS CHAUVENET AND A. A. BLAIR.

THE analyses of coals given in these tables are what are commonly known as "proximate" analyses. The four constituents, viz., Water, Volatile Matter, Fixed Carbon, and Ash, can be subdivided into all the elementary bodies contained in the coal, but in most instances no more elaborate analysis was undertaken. We may class these four into combustible and incombustible material. Water and ash coming under the latter head, their sum will represent the percentage of weight of the coal unavailable for heating purposes.

The method followed in these examinations was one which has received the approval of the best experimenters. A weighed quantity of the coal, reduced to powder, was placed in a platinum crucible, and kept at a constant temperature of 110° C. until it ceased to lose weight. An hour was always sufficient time for this operation. The loss indicated *water*. The crucible being now closed, though not tightly, it was heated in a Bunsen gas-burner until the flame of the escaping gas was no longer seen. The full heat of a gas blast-lamp was then directed upon it for three minutes. After cooling, the loss of weight gave the *volatile matter*. In estimating ash, a fresh portion of coal was sometimes taken, but more frequently the coke left from the last operation was ignited in the same crucible, with free access of air. The loss of weight by this ignition gave *fixed carbon*, and by deducting the weight of the empty crucible from the last weight, the amount of *ash* was obtained. The color of the ash was noted, as a rough indication of its composition: the white is usually calcite; reddish-browns are due to iron; slate and chocolate indiçate shale.

A few coals were analyzed by the combustion furnace (organic analysis) for total carbon and hydrogen, as well as nitrogen in a few instances. In the table giving the results, the last column is headed "Deficiency." The sum of the total carbon, hydrogen in the volatile matter, water, and ash, will always fall short of 100 per cent. by a figure varying greatly in different coals. This is called the "deficiency," since it cannot be all ascribed to oxygen, though probably oxygen and sulphur (and nitrogen in those cases where it is not given) would fully supply the "deficiency." The low deficiency of the coals used at the St. Louis Gas-works is worthy of notice. The only Missouri coals besides these which seem to promise well are, unfortunately, found in very small seams. Westlake's coal, in Pettis County, has been used for gas at Sedalia. As coking gas-coals, this coal, Linn's (Chariton County), George's (Cass County), and possibly Munn's (Henry County), promise tolerably well. But no coal in the whole number of those examined is equal to that now in use at the St. Louis Gas-works.

In using the combustion furnace, bi-chromate of lead was substituted for oxide of copper, and with good results. The few nitrogen determinations were made by mixing the sample with soda-lime in the tube, and collection of the ammonia in hydrochloric acid, which was then treated in the usual manner, the result always being calculated from the metallic platinum obtained from the double chloride of platinum and ammonium.

Sulphur was not determined in many coals. In fact, in order to get a correct idea of the amount of sulphur, especially when it is in the form of pyrites, large samples are necessary, representing various parts of the bed, and these should be broken up and thoroughly mixed. Such elaborate sampling was not possible in the case of these coals. After a few determinations of sulphur, the system was followed of examining, for sulphur, only those coals in which no pyrites, or very trivial quantities, were visible to the naked eye. The impression being very common that sulphur in coal exists only in the form of iron pyrites ($Fe\,S_2$), several experiments were made with a view to testing the accuracy of this idea. A table will be found illustrating these experiments, and the single example of the "Baker" coal will show the fallacy of the belief. Mr. John W. Meier, of St. Louis, who has made trials of various coals, states that there are other coals similar to the "Baker" in containing sulphur and no iron. The question is one of some interest for coke-manufacturers. While a large proportion of the pyrites in coal-slack can be removed by washing, it is not probable that sulphur not united with iron could be thus eliminated.

The method adopted for the determination of sulphur was as follows: One gramme of the coal, well mixed and finely powdered, was mixed with twelve grammes of carbonate of soda, and from four to six of nitre. (With bituminous coal, four is enough.) The mixture is made in a capacious platinum crucible, and heated in the flame of a Bunsen burner until in a state of tranquil and complete fusion. After cooling, the mass is dissolved in water, the solution acidulated with muriatic acid, and evaporated to perfect dryness, to render any silica insoluble, re-dissolved in very dilute muriatic acid, filtered, and the filtrate treated with chloride of barium, and allowed to stand for twenty-four hours. It may here be stated that the very best brands of "C. P." carbonate of soda contain sulphur in some form; hence it is absolutely necessary to make a separate test of that re-agent, and the simplest way is probably to repeat the operation, without the coal, and subtract the result from that first obtained.

This method is also the best for sulphur in coke, a determination which is frequently of importance. The only difference is, that six or seven parts of nitre should be used instead of four, as with bituminous coals.

Specific Gravity was determined by the bottle. The sample was always left in contact with the water for not less than twelve hours, before weighing, in order to thoroughly expel the air.

In glancing at the general results obtained, a few coals seem to call for special notice. The Pacific Coal Company's mines, near Knob Noster, Johnson County, are extensive, at least as compared with most of the developments in that region, and the coal, of which large and well-averaged samples were obtained, is remarkably free from sulphur, being in this respect superior to most Illinois coals. This coal is much used on the Mo. P. R. R., and although its ash never falls below eight per cent. and sometimes exceeds ten, it is probable that the trouble this would cause in burning it in locomotives, is more than counterbalanced by its freedom from sulphur, and the consequent saving in boiler-repairs. Over this coal is a curious shale, decomposing rapidly upon exposure to the air, and consequently never left in the workings. It is very bituminous, is used to run the hoisting-engine, etc. at the mine, and when thrown in heaps, heats and finally takes fire spontaneously. It is of small value as a fuel.

Near Warrensburgh are some excellent coals, but in thin seams, and not worked upon any extensive scale. As a class, these coals show a very low ash. South of the town, and some miles from any other opening, is Grove's coal, which, from the character of its "top," its somewhat greater thickness, and its analysis, seems to belong to a different seam from the other Warrensburgh coals, but when visited was just opened, and but little could be determined about it.

Linn's Coal (Chariton County) is quite remarkable for its low percentage of ash (1.64), being the best coal examined in this respect. Equally curious are some of the Ray County coals in their high per cent. of water, one sample from Hayson's (Swanwick) mine giving 12.55 per cent.

No true "cannel" coal was examined. Many bituminous shales are known as such in their respective neighborhoods, but their ash (25 to 40) is too high, and their use must remain very limited.

Several analyses of ores, clays, and limestones are appended to these tables. Though these are given in the text, under their proper heads, it may be convenient, for some purposes, to have all the analytical results brought together. While the tables here given do not include all the chemical work done during the past year, it is believed that no result of interest or importance has been omitted.

RAY COUNTY.

Name of Coal.	Water.	Volatile.	Fixed Carbon.	Ash.	Color of Ash.
Smith's	10.05	38.55	45.40	6.00	White.
Howell's	8.05	41.85	45.80	4.30	Do.
Oberhultz	11.02	32.48	46.30	10.20	Gray.
Hughes	8.15	37.60	46.35	7.90	Light brown.
Godfrey	7.20	30.30	37.30	25.20	Brown.
Camden Mines	10.33	37.73	42.04	9.90	Gray.
Swanwick Hayson's, top	10.00	37.85	48.30	3.85	Light brown.
Do. middle	12.55	37.05	46.65	5.75	White.
Do. bottom	11.20	38.50	46.70	3.60	Nearly white.
Coke made from Camden coal	3.25	4.88	83.37	8.50	*

PETTIS COUNTY.

Newport's	3.95	33.10	46.26	16.69	Red.
Westlake's	4.47	39.19	51.73	4.61	Gray.

* This coke was from "Collins's" coal.

SAINT LOUIS COUNTY.

Name of Coal.	Water.	Volatile.	Fixed Carbon.	Ash.	Color of Ash.
Parker & Russell	9.17	38.49	43.19	9.15	Light gray.
Do.	9.55	38.28	42.99	9.18	Do.

HENRY COUNTY.

Jordan, top	3.47	42.18	45.85	8.50	Purple gray.
Do. bottom	5.14	37.91	46.82	10.13	Do.
Owens, near Clinton	8.30	36.95	48.65	6.10	White, faint purple.
Do. middle	7.14	38.66	48.35	5.85	Nearly white.
Williamson	7.76	44.77	43.32	4.15	Dark purple.
Munn's	7.50	37.30	50.75	4.45	Red.
H. Neff	5.89	38.01	39.97	16.13	Light chocolate.
Ogan's	8.48	33.96	43.16	14.40	Chocolate.
Britt's, top	2.89	28.55	50.71	17.85	Reddish.
Do. middle	3.88	43.67	43.42	9.03	Light gray.
Osage Coal Co	5.65	36.95	41.87	15.53	Do.
Do. bottom	4.86	41.74	37.24	16.16	Light chocolate.

LA FAYETTE COUNTY.

Franke's	5.55	42.95	44.08	7.42	Light brown.
Payne's, top	8.85	37.25	44.80	9.10	Cream.
Do. middle	7.02	37.67	39.66	15.65	Very light brown.
Do. bottom	7.75	34.05	40.03	18.17	Light chocolate.
Ennis & Cundiff, top	6.95	42.61	43.42	7.02	Do.
Do. near bottom	7.03	40.72	47.11	5.14	Chocolate.
*Lexington Coal Co., top	5.79	36.03	47.31	10.87	Light brown.
* Do. middle	8.15	34.71	47.29	9.85	Do.
* Do. near bottom	6.36	36.28	47.80	9.56	Yellow brown.
* Do. bottom	6.25	35.03	50.04	8.68	Very light brown.
*Tilden Davis	8.21	37.56	46.84	7.39	Nearly white.
*Graham's	6.53	35.19	47.46	10.85	Very light brown.

JOHNSON COUNTY.

Mrs. Wingfield's	7.31	41.88	46.36	4.45	Pale red-brown.
Sylvester Orr's	5.87	40.06	43.45	10.62	Dark gray.
Bruce's	5.31	43.65	43.12	7.92	Pale gray.
Tapscott's	3.30	36.85	33.05	26.80	Light slate.
B. Owsley	7.40	43.07	38.37	11.16	Pinkish gray.
†Pacific mines	4.28	40.30	47.22	8.20	Nearly white.
† Do.	4.29	40.24	47.27	8.20	Do.
† Do.	4.85	39.85	45.30	10.00	White.
† Do.	4.60	42.50	44.55	8.35	Do.
‡Zimmermann's	6.77	45.10	44.01	4.12	Very pale slate.
‡ Do. bottom	7.09	42.14	47.15	3.62	Pale brown.
‡Zoll's, top	5.39	45.89	45.56	4.16	Pale gray.
‡ Do. bottom	6.32	45.38	44.98	3.32	Do.
‡Grove's	7.80	34.90	51.20	6.10	Reddish slate.
‡Gillum's	7.29	42.27	46.95	3.49	Slate.
‡Goudy's	5.60	44.95	44.45	5.00	Pale brown.
§Mineral charcoal	1.59	15.63	71.28	11.50	Reddish slate.

LINCOLN COUNTY.

Link's, top	8.17	32.58	46.50	12.75	Light gray.
Do. next top	7.85	32.75	46.25	12.65	Do.
Do. middle	8.40	35.22	46.33	10.05	Do.
Do. below middle	8.25	34.55	47.50	9.70	Do.
Do. bottom	7.90	33.90	49.00	9.20	Light brown.

* From the Lexington coal-bed.
† Near Knob Noster.
‡ Warrensburgh coals.
§ From Zoll's bank, Warrensburgh.

NAME OF COAL.	Water.	Volatile.	Fixed Carbon.	Ash.	COLOR OF ASH.
Baker's	8.50	39.50	46.45	5.55	White.
Meadows's, top	6.30	39.20	44.30	10.20	Light brown.
Do. bottom	6.75	36.80	42.00	14.45	Do.
Upson's	1.15	41.25	49.60	8.00	Very pale brown.
Hine's	6.75	36.40	45.75	11.10	Light red-brown.
CARROLL COUNTY.					
Jas. Goodson's	2.97	36.36	47.83	12.84	Light brown.
Jos. Meddlin's	2.07	29.94	47.03	20.96	Dark brown, white specks.
"Little Compton"	4.37	44.58	47.21	3.84	Reddish brown.
SALINE COUNTY.					
L. Bohn	6.02	40.33	42.09	11.56	Pink.
Haynie [Miami]	2.58	31.22	35.18	31.02	Deep red.
"Cannel" *	3.53	48.30	42.39	5.78	White, with brown specks.
PITTSBURGH (PA.). (ST. LOUIS GAS-WORKS.)					
Average sample	1.31	36.61	54.17	7.91	Faint gray.
BIG MUDDY COAL (ILL.).					
Sample No. 1	5.86	33.08	57.48	3.58	
Do. 2	5.88	32.81	57.66	3.65	
CHARITON COUNTY.					
Linn's	5.82	38.01	54.53	1.64	Salmon.
ANDREW COUNTY.					
Niagara Creek	8.94	34.75	45.38	10.93	Red brown.
LIVINGSTON COUNTY.					
Graham's	5.38	42.27	44.98	7.37	Pale brown.
NODAWAY COUNTY.					
J. C. Smith's	3.53	42.72	40.71	13.04	Very light brown.
CASS COUNTY.					
George's	7.80	33.20	55.75	3.25	Rich brown.
MACON COUNTY.					
"Bevier"	12.05	40.75	43.50	3.70	Pinkish gray.
CALLAWAY COUNTY.					
Fulton Coal Co	7.43	38.90	45.85	7.82	Pink.
Nesbitt's	5.00	33.95	40.73	20.32	Dark purple slate.
NEBRASKA (STATE), NEAR NEMAHA.					
Omaha Coal Mining Co	4.93	38.17	49.44	7.46	Red brown.

SULPHUR AND IRON—COALS.

NAME OF COAL.	IRON.	SULPHUR.	Sulphur required by iron to form Fe Sz.	Specific Gravity.
Smith's, Ray Co	0.84	2.41	0.96	1.249
Godfrey's, Ray Co	2.83	4.179	3.23	1.293
Newport's, Pettis Co	3.99	4.406	4.56	1.347
Zoll's, Johnson Co	1.05	2.916	1.20	1.243
Pacific Mines, Johnson Co	0.49	0.759	0.56	1.350
Link, Lincoln Co	0.70	2.036	0.80	1.255

* Locality not known. Used at St. Louis Gas-works.

Name of Coal.	Iron.	Sulphur.	Sulphur required by iron to form Fe S_2.	Specific Gravity.
Hines, Lincoln Co.	5.21	2.230	5.95	....
Meadows, Lincoln Co.	4.44	4.910	5.07	....
Baker, Lincoln Co.	none	2.632	none	1.165
Pittsburgh (St. Louis Gas-works)	0.56	0.770	0.64	....
Howells, Ray Co.	...	2.702	....	1.257
Oberhultz, Ray Co.	...	4.609	....	1.277
Hughes, Ray Co.	...	4.170	....	1.328
Mrs. Wingfield's, Johnson Co.	...	4.504	....	1.252
Westlake's, Pettis Co.	...	2.670	....	1.319

Specific Gravity of a few Coals.

Name.	Sp. Gr.	Name.	Sp. Gr.
Smith's, Ray Co.	1.249	Zimmermann's, Johnson Co.	1.225
Howell's, Ray Co.	1.257	Mrs. Wingfield's, Johnson Co.	1.252
Oberhultz, Ray Co.	1.277	Sylv. Orr's, Johnson Co.	1.377
Hughes, Ray Co.	1.328	Bruce's, Johnson Co.	1.271
Godfrey, Ray Co.	1.293	Tapscott's, Johnson Co.	1.529
Newport, Pettis Co.	1.347	Pacific Mines, Johnson Co.	1.350
Westlake, Pettis Co.	1.319	George's, Cass Co.	1.261
Groves, Johnson Co.	1.312	Link, Lincoln Co.	1.255
Goudy's, Johnson Co.	1.228	Baker, Lincoln Co	1.165
Zoll's, Johnson Co.	1.243	Mineral charcoal	1.803

Ultimate Analyses of Coal.

Name of Coal.	Fixed Carbon.	Combined Carbon.	Total Carbon.	Hydrogen in Water.	Hydrogen in Volatile matter.	Total Hydrogen.	Nitrogen.	Water.	Ash.	Deficiency.
Pacific Mines, Johnson Co.	47.22	23.11	70.33	0.47	4.66	5.13	1.45	4.28	8.20	11.08
Mrs. Wingfield's, "	46.38	25.98	72.34	0.81	4.81	5.62		7.31	4.45	11.09
Tapscott's shale, known as "cannel"	33.05	24.96	58.01	0.37	4.99	5.36		3.30	26.80	6.90
Zoll's, Johnson Co., (Warrensburgh)	45.56	28.72	74.28	0.60	5.47	6.07		5.39	4.16	10.70
Zimmermann's, Johnson Co.	44.01	30.75	74.76	0.75	5.58	6.33		6.77	4.12	8.77
Gillem's, Johnson Co.	46.95	29.56	76.51	0.81	4.80	5.61	1.56	7.29	3.49	6.35
Grove's, "	51.20	17.32	68.52	0.86	4.81	5.67	1.72	7.80	6.10	11.05
George's, Cass Co.	55.75	10.50	66.25	0.86	4.35	5.21		7.80	3.25	18.35
Westlake's, Pettis Co.	51.73	17.50	69.23	0.50	4.99	5.49	1.51	4.47	4.61	15.19
Pittsburgh, used at St. Louis Gas-works	54.17	23.45	77.62	0.14	5.31	5.45	1.84	1.31	7.91	6.01
Saline Co. "Cannel," used at St. Louis Gas-works	42.39	35.27	77.66	0.39	6.00	6.39		3.53	5.78	7.03

Hydraulic Limestone, Lincoln County, over Meadows's Coal.

Silica	21.35
Peroxide of iron	1.79
Lime	42.16
Magnesia	0.66
Carbonic acid	34.14
	100.10

CLAYS FROM LINCOLN COUNTY.

	Under Coal in Baker's Shaft.	Morris's Shaft.	Colbert's.
Silica	34.40	72.35	65.35
Alumina	*18.62	18.11	23.25
Lime	15.27	1.09	0.52
Magnesia	6.25	1.48	1.27
Hygroscopic water		1.46	2.14
Water of composition	†23.09	3.05	4.83

LINCOLN COUNTY IRON-ORES.—PARTIAL ANALYSES.

	Morris's Shaft. 1.	Morris's Shaft. 2.	Morris's Shaft. 3.	Morris's Shaft. 4.	Humphrey's.	Murphy's.
Insoluble silicious	....	26.98	15.42	7.74	11.66	4.10
Peroxide of iron	4.72	63.12	79.64	84.30	86.56	95.32
(Metallic iron)	3.30	44.18	55.75	59.01	60.59	66.72

A BOWLDER OF RED HEMATITE FROM T. 49, R. 1, E.

Section 12, *Lincoln County, gave*—

Insoluble silicious	7.55
Peroxide of iron	91.95
(Metallic iron)	64.36
Sulphur	0.017
Phosphoric acid	0.023
(Phosphorus)	0.010

CLAYS FROM PILOT KNOB.

	Brown.	White.
Hygroscopic water	2.90	2.20
Water of composition	7.95	7.30
Silica	57.22	63.50
Alumina	22.89	24.55
Peroxide of iron	7.81	none
Lime	1.10	1.60
Magnesia	0.46	0.48
	100.33	99.63

LIMESTONE OF ST. JOSEPH BRIDGE.

Silica	4.25
Peroxide of iron	1.00
Lime	30.55
Magnesia	19.09
Carbonic acid	44.61
	99.50

Per cent. of magnesia less than in dolomite.

LIMESTONES.—IRON COUNTY.

	A	B	C	Pyritiferous.
Insoluble silicious	5.11	3.85	2.06	17.88
Peroxide of iron	‡4.67	1.07	none	3.75
Carbonate of lime	47.50	52.50	54.32	43.52
Carbonate of magnesia	42.19	42.56	43.82	34.25

If the percentage of carbonate of lime in these analyses is assumed as one equivalent, and the corresponding amount of carbonate of magnesia calculated according to the formulæ for dolomite, CaO, CO_2, MgO, CO_2, we have—

	A	B	C	Pyritiferous.
MgO, CO_2	39.89	44.09	45.62	36.55

* With some peroxide of iron.

† Total loss by strong ignition, including a little carbonic acid.

‡ Iron and alumina.

by which it appears that A has more magnesia (in proportion to its lime) than dolomite—the others less.

METAMORPHIC LIMESTONE. (Sec. 19, T. 33, R. 4, E.)

Insoluble silicious	35.81
Peroxide of iron	5.35
Lime	31.62
Magnesia	1.10
Carbonic acid	25.83
	99.71

MANGANIFEROUS IRON-ORES.

	Buford Mountain.	Buford Mt. Upper cut.	Δ 239 Marble's.	Δ 240 Marble's.	Marble's Field.
Insoluble silicious matter	8.54	13.42	17.66	35.96	10.35
Peroxide of iron	68.30	85.76	49.34	58.70	14.22
Manganese (reduced to protoxide)	15.84	trace	21.18	3.77	51.06
Lime	....	....	....	....	2.75
Magnesia	....	....	....	....	0.43
Sulphur	0.017	....	....	....	Water 3.89
Phosphoric acid	0.102	....	....	....	
Metallic iron	47.81	60.03	34.54	41.09	9.95
Metallic manganese	12.22	....	16.34	2.91	39.38

	Cuthbertson's Manganese-ore.	Cuthbertson's Iron-ore.
Insoluble silicious	0.44	2.45
Peroxide of iron	3.30	97.85
Protoxide of manganese	68.02	trace of Mn.
Metallic manganese	52.47	

"SHUT-IN" ORES.

	Δ 27.	Δ 29.	Δ 29.
Insoluble silicious matter	1.75	2.10	....
Peroxide of iron	93.90	98.50	....
Sulphur	....	0.078	....
Phosphoric acid	....	0.057	0.062

ANALYTICAL LABORATORY OF CHAUVENET & BLAIR,
218 *Pine St., Saint Louis, April* 21, 1873.

PROF. R. PUMPELLY,

Director Missouri Geological Survey :

DEAR SIR :—At your suggestion I hereby submit, in a tabulated form, for convenience of reference, the analyses of iron-ores and pig-irons made by me for the survey, from samples taken by Dr. Adolf Schmidt. These analyses were made for the immediate use of Dr. Schmidt, and are incorporated in his exhaustive report. There are also a number of analyses made for private parties and published by their permission. In determining the amounts of sulphur and phosphorus in the ores and pig-irons, 5 grammes of the material was always used; consequently "a trace" of sulphur or phosphorus means a trace in 5 grammes.

It had been my intention to devote some space to the chemical action of some of the iron-ores in the blast-furnace, and the nature of this action especially in relation to silicon in the resulting pig-metal; but the impossibility of getting perfectly reliable data in many cases, and the objections of iron-masters, in others, to make public the results of their experiments, oblige me to defer it to some future time.

Yours, very respectfully,

ANDREW A. BLAIR.

IRON MOUNTAIN ORES.

	2a.	*2a.*	*2b.*	*2b.*	27.	127.	31.	5.	128.
Insol. silicious matter	4.71%	....	6.76%	....	....	....	....	1.88%	....
Peroxide of iron	91.45	....	86.75	....	96.78%	....	95.15%	95.04	....
Protoxide of iron	2.34	....	5 72	....	....	....	....	2.57	....
Alumina	0.93	....	....	....	....	....	....	0.75	....
Lime	0.45	....	....	....	....	....	....	0.15	....
Magnesia	0.19	....	....	....	....	....	....	0.12	....
Manganese	none	....	....	....	....	....	....	none	....
Sulphur	none	none	none	none	0.016	0.008	0.003	0.005	0.012
Phosphoric acid	0.252	0.248	0.081	0.073	0 119	0.112	0.125	0.071	0.067
	100.322							100.586	
Insol. silicious matter.									
Silica	3.99%	....	....	....	3.28%	....	4.54%	1.57%	....
Alumina	0.47	....	....	....	....	....	....	0.04	....
Lime	0.06	....	....	....	....	....	....	0.02	....
Magnesia	0.03	....	....	....	....	....	....	0.017	....
	4.55							1.65	
Metallic iron	65.78	....	65.17	....	67.75%	....	66.60%	68.63	....
Phosphorus	0.110	0.108	0.035	0.030	0.052	0.049	0.057	0.031	0.029

2a, *2b*.—Specular ore from enclosed conglomerate mass in the backbone-vein, cut A, on south side of Iron Mountain.

2a deflects the compass-needle; *2b* does not, yet *2b* is more magnetic and contains more magnetic oxide than *2a*.

These two samples being practically the same, the great difference in the amounts of phosphoric acid seemed unreasonable. The analyses were therefore repeated, and the results were practically as before.

27.—Specular ore from backbone-vein, cut II, north side of mountain.

127.—Average sample of quarry-ore taken by Maj. Brooks.

31.—Average sample of surface-ore from western slope.

5.—Average sample of surface-ore from south-east slope.

128.—Average sample of surface-ore taken by Maj. Brooks.

All the samples, except 127 and 128, were taken by Dr. Schmidt.

NOTE.—The samples Nos. 127 and 128 were collected by Maj. T. B. Brooks with great care, and represent thousands of chippings, in 127 from the quarry-ore, and in 128 from the loose surface-ore. After being thoroughly powdered, portions were sent by Maj. Brooks to three chemists, viz.: Prof. Allen, of Yale College, Mr. Otto Wuth, of Pittsburgh, and Mr. A. A. Blair, of St. Louis. As the determination of phosphorus and sulphur in perfectly average samples of this great ore-deposit, is a subject of considerable technical interest, the results obtained are here given:—

No. 127—*Quarry-Ore.*

	WUTH.	ALLEN. Double determination.		BLAIR.
Phosphorus	0.016	0.043	0.042	0.049
Sulphur	....	....	....	0.008

No. 128—*Surface-Ore.*

Phosphorus	0.016	0.025	0.026	0.029
Sulphur	....	....	....	0.012

[R. P.]

PILOT KNOB ORES.

	47.	45.	45 (Rep.).	36.	16.
Insoluble silicious matter	14.75%	5.57%	......	......	......
Peroxide of iron	84.33	90.87	......	67.38%	62.88%
Protoxide of iron	0.15	1.67	......	......	......
Alumina	0.75	0.53	......	......	......
Lime	0.21	1.76	......	......	......
Magnesia	0.14	0.13	......	......	......
Manganese	none	none	......	......	......
Sulphur	traces	0.078	......	0.006	0.079
Phosphoric acid	0.035	0.069	0.063	0.092	0.101
	100.365	100.677	......	......	......
Insoluble silicious matter.					
Silica	13.27	5.18	......	......	......
Alumina and trace of oxide of iron	1.44	0.36	......	......	......
Metallic iron	59.15	64.91	......	47.16	44.01
Phosphorus	0.015	0.031	0.027	0.041	0.044

	50.	46.	48.	40.
Peroxide of iron	87.18%	83.28%	77.02%	52.18%
Metallic iron	61.03	58.29	53.91	36.52

47. Soft ore from central cut (B). 45. Hard ore from central cut (B). 36. Ore from lower strata eastern cut (C). 16. Average sample from upper strata eastern cut. 50. Specular ore from western cut (A). 46. Hard ore from central cut (B). 48. Ore in conglomerate central cut. 40. Average sample of better ore on refuse-heaps. All taken by Dr. Schmidt.

SHEPHERD MOUNTAIN, ETC.

	20.	21.	23.	68.	C.H.	L.M.
Insoluble silicious matter	5.15%	6.76%	......	......	5.62%	15.33%
Peroxide of iron	94.84	88.56	96.70%	79.39%	93.54	84.60
Protoxide of iron	1.80	2.97	......	14.22	.....	.....
Alumina	....	1.55	......	......	.....	0.32
Lime	...	0.35	......	......	.....	0.38
Magnesia	....	0.04	......	......	.....	0.15
Manganese	....	none	......	......	.....	none
Copper	....	minute trace	......	none	.....	......
Sulphur	none	none	none	none	none	0.021
Phosphoric acid	0.025	0.039	0.032	0.038	0.090	0.065
	....	100.269	......	......	......	100.866
Insol. silicious matter.						
Silica	4.05%	5.98%	......	......	......	14.45%
Peroxide of iron	.....	0.07	......	......	......	none
Alumina	.....	0.46	......	......	......	0.51
Lime	.....	0.12	......	......	......	0.06
Magnesia	.....	0.05	......	......	......	0.04
	....	6.68	......	......	......	15.06
Metallic iron	66.52	64.31	67.69	66.63	65.47	59.22
Phosphorus	0.011	0.017	0.014	0.017	0.039	0.027

20. Average sample upper part of central vein (B).
21. " lower " " "
23. Soft ore from " " " "
68. Ore from eastern vein.

The above all taken by Dr. Schmidt.

C. H. Sample of Cedar Hill ore taken by Prof. Pumpelly, and representing average of vein.

L.M. Sample of Lewis Mountain ore taken by Prof. Wm. B. Potter, and analyzed for Pilot Knob Company, by whose permission it is published.

SPECULAR AND RED HEMATITE ORES.

	1.	2.	3.	4.	5.	6.
Insoluble silicious matter..	11.19%	9.30%	.....	.....	....	0.87%
Peroxide of iron..........	85.95	76.45	27.40	87.92	97.23	98.96
Protoxide of iron.........	0.77	.....	4.11	.....	.....	......
Alumina................	0.97	.....	.....	.....	.....	......
Lime...................	0.12	.....	36.01	.....	.....	......
Magnesia...............	0.07	.....	.....	.....	.....	......
Manganese.............	none	.....	.....	.....	.....	......
Carbonic acid...........	0.48	.....	29.51	.....	.....	......
Water..................	0.46	13.65	2.45	0.03	0.47	......
Sulphur................	0.126	0.052	0.044	none	none	trace
Phosphoric acid.........	0.116	0.478	0.098	0.089	0.092	0.062
	100.252	......	......	......	......	......
Insoluble silicious matter.						
Silica..................	9.78%	6.78%	0.27%	11.32%	2.06%	......
Alumina................	1.33	.....	.....	......	.....	......
Lime...................	none	.....	.....	......	.....	......
Magnesia...............	0.12	.....	.....	.....	.....	......
	11.23	.....	.....	......	.....	......
Metallic iron............	60.76	53.51	22.38	61.54	68.08	69.27
Phosphorus.............	0.051	0.208	0.043	0.039	0.040	0.027

1. Purple paint-ore from Meramec mine. 2. Ochrey ore from do. 3. Red ore and yellow rock, with spathic ore, from do. 4. Hard, silicious specular ore from do. 5. Average sample best specular ore from do.

1, 2, 3, 4, and 5, taken by Dr. Schmidt.

6. Blue specular ore from Orchard bank, Salem District, Dent County, analyzed for Mr. O. A. Zane, and published by permission. Now worked by Salem Iron Company.

SPECULAR AND RED HEMATITE ORES.

	7a.	*7b.*	8.	9.	10.	11.
Silica..................	0.69%	0.68%	8.39%	......	......	......
Peroxide of iron.........	97.94	97.08	88.37	83.51%	90.03%	78.38%
Protoxide of iron.........	trace	0.31	......	......	......	......
Alumina................	1.17	1.50	.....	......	......	......
Lime...................	.....	.....	......	......	......	......
Hygroscopic water.......	0.02	0.08 }	3.09			
Combined water.........	0.19	0.23 }		......	......	......
Carbonic acid...........	none	0.21	......	......	......	......
Sulphur................	none	none	trace	......	......	......
Phosphoric acid.........	0.068	0.079	0.207	0.079	0.083	0.205
Insoluble silicious matter..	.....	.....	.....	17.05	5.73	14.13
Metallic iron............	68.56	68.19	61.86	58.45	63.02	54.86
Phosphorus.............	0.029	0.034	0.091	0.034	0.036	0.089

7a, *7b*. Piece of ore from Iron Ridge, partly blue specular and partly red paint-ore; *7a*, blue specular, *7b*, soft, red paint-ore. These samples were taken for a comparison of the two kinds of ore, and is particularly interesting on that account. 8. Average sample from Iron Ridge mine.

The above taken by Dr. Schmidt.

9. Blue specular ore from Beaver Branch. 10. Partly decomposed ore from same. 11. Soft paint-ore from same. These Beaver Branch ores were analyzed for Missouri Furnace Company, and are published by permission.

BROWN HEMATITE ORES.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Insol. silic. matter..	.. .	.....	.....	.....	.....	8.66%	7.17%	7.42%	8.35%
Peroxide of iron....	84.02%	77.42%	82.02%	.....	84.10%	81.96	78.73	79.82	79.53
Water............	10.98	12.49	12.80	.....	11.60	.....	.....	.....	.....
Sulphur...........	0.171	0.147	0.015	0.084	none	none	0.009	trace	none
Phosphoric acid....	0.861	0.076	0.091	0.084	0.077	.....	.....	.....	.....
Manganese.........	.....	none	.....	.....	.....	.....	.....	.....	.....
Silica.............	3.08	8.05	5.13	.....	3.59	.....	.....	.....	.....
Metallic iron......	58.81	54.19	57.41	.....	58.87	57.37	55.11	55.87	55.67
Phosphorus.......	0.376	0.034	0.041	0.037	0.034	0.058	0.081	0.061	0.071

	10.	11.	12.	13.	14.	15.	16.
Insol. silic. matter..	4.88%	3.60%	6.97%	4.34%	9.41%	39.22%	7.08%
Peroxide of iron....	82.27	85.09	80.98	78.38	80.35	49.12	75.42
Water............	.....	.....	.....	.....	.....	8.87	.....
Sulphur..........	trace	trace	none	none	trace	0.001	0.035
Phosphoric acid....	.....	.....	.....	2.891	0.249	0.206	0.859
Metallic iron.......	57.59	59.55	56.68	54.86	56.24	34.38	52.79
Phosphorus........	0.074	0.028	0.123	1.262	0.109	0.089	0.375

1. Brown and red hematite from Marmaduke bank. 2. Limonite from Sheldon bank. 3. Do. from White bank. 4. Do. (pipe-ore) from Elm Hollow bank. 5. Do. do. from Indian Creek bank. All on the Osage River.

6, 7, 8, 9, 10, 11. From Camden Co. Analyzed for Mr. H. S. Reed, and published by permission.

12. From Perry Co. Analyzed for Mr. Reed, and published by permission.

13. From Perry Co., opposite Grand Tower. Analyzed for Big Muddy Iron Company, and published by permission of Mr. Jas. E. Mills, Vice-President.

14. From Indian Ford, Bollinger Co. Analyzed for Mr. Wm. B. Spear, and published by permission.

15. From near Irondale, and used in the furnaces there and at Iron Mountain. Analyzed for Messrs. E. Harrison & Company, and published by permission.

16. Analyzed for Wm. E. Romer, Esq., of Grand Tower, and published by permission.

1, 2, 3, 4, and 5 samples were taken by Dr. Schmidt.

PIG-IRONS.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Sulphur..........	0.024%	0.017%	0.005%	trace	none	trace	0.016%	0.026%	....
Phosphorus.......	0.133	0.062	0.116	0.165%	0.098%	0.116%	0.136	0.196	....
Combined carbon ..	....	....	....	....	....	....	....	....	....
Graphitic carbon...	3.293	....	....	....	....	....	....	....	....
Silicon...........	3.230	2.624	1.329	0.942	1.389	1.354	0.630	1.347	4.850

	10.	11.	12.	13.	14.	15.	16.	17.	18.
Sulphur..........	....	none	0.045%	0.006%	0.103%	0.134%	0.141%	0.061%	none
Phosphorus.......	....	0.168%	0.147	0.153	0.097	0.141	0.107	0.141	0.116%
Combined carbon ..	....	0.810	.... } 4.220		....	0.625	0.850	....	....
Graphitic carbon...	....	3.000	.... }		....	2.775	2.500	....	....
Silicon...........	1.517	3.840	3.325	3.425	5.898	3.443	2.847	2.234	2.770

1. Made in the fall of 1872, at Vulcan Iron Works, from Iron Mt. ore alone; ½ Big Muddy coal, ½ Connelsville coke. 2. Made at Pilot Knob Iron Co.'s furnace, from ⅔ Pilot Knob and ⅓ Shepherd Mt. ores, charcoal and hot blast. 3. Made at Scotia Iron Works, from Scotia ores, charcoal, and hot blast. 4. Made at Meramec, from Meramec ores,

$\frac{1}{2}$ half hard and $\frac{1}{2}$ soft, charcoal and cold blast. 5. Made at Iron Mountain, from Iron Mt. ores, with 8% of limonite. 6. Irondale, hot blast. 7. Irondale, cold blast; both charcoal, and same ores as 5. 8. Made at Moselle, from Iron Ridge and St. James ores, with 8% Moselle limonite, charcoal and hot blast. 9. Made at Pilot Knob Iron Co.'s Works, from all Pilot Knob ore, charcoal and hot blast. 10. Made at same, $\frac{2}{3}$ Shepherd Mt. and $\frac{1}{3}$ Pilot Knob, charcoal and hot blast. 11, 12, and 13. Made at Big Muddy Iron Co.'s furnace, at Grand Tower. 11 and 13 from $\frac{1}{2}$ Pilot Knob ore, $\frac{1}{2}$ Iron Ridge and St. James red hematites, using $\frac{2}{5}$ Connelsville coke, $\frac{3}{5}$ Big Muddy coal. 12. Same, except that the Illinois Patent Coke Co.'s coke was substituted (using a larger proportion) for the Connelsville coke.

These analyses were made for Big Muddy Iron Co. and published by permission of James E. Mills, Esq., Vice-President.

14, 15, 16, 17, and 18. Made at South St. Louis Iron Co.'s furnaces. Analyzed for them, and published by permission of Mr. H. S. Reed, President. 14. Glazed pig, made from all Pilot Knob ore. 15 and 16. No. 1 and 2 Foundry, from all Iron Mt. ore, made in summer of 1872. 17. Made from Iron Mt. with some Iron Ridge soft, red hematite. 18. Made from all Iron Mt. ore, spring of 1873. All with Connelsville coke and Big Muddy coal.

1, 2, 3, 4, 5, 6, 7, and 8 were samples taken by Dr. Schmidt or sent to him for the use of the survey.

CHAPTER III.

THE IRON-ORES OF MISSOURI.

BY ADOLF SCHMIDT, PH.D.

A. *General Distribution.*

MISSOURI is one of the richest States in iron-ores on the North American continent. These ores are, however, very unequally distributed over the State.

Very little iron-ore is found in the whole northern part of the State north of the fiftieth township-line, and in a range of counties on the western border. These districts are covered by the coal-measures, which, although containing clay-ores and carbonates of iron, do not contain them in such quantities and in such positions as to make them workable. According to Mr. G. C. Broadhead's statements, these ores in the coal-measures of Missouri occur either as single nodules, or as thin beds, varying from one to twenty inches in thickness, imbedded in the carboniferous clays and slates. They lie, generally, deep below the surface, from 20 to 60 feet, and not close enough to the coal-beds to be mined conjointly with the latter. These ores are, besides, not very rich in themselves.

The only point where the region of workable iron-ore reaches, north of the Missouri River, is in Callaway County, where red, earthy hematite occurs as a stratum in the ferruginous sandstone of the subcarboniferous system.

South of the Missouri River there are, between this river and the fortieth township-line, valuable deposits, mostly of limonite, in Franklin, Osage, Morgan, and Benton Counties. This kind of ore also occurs nearly over the whole central and southern part of the State. In the southern part the counties of Stoddard, Bollinger, Wayne, Ozark, Douglas, Christian, and Greene, contain considerable deposits of it.

But by far the richest portion of the State in iron-ores is that between the 30th and 40th township-lines. Within this zone, iron-ores abound in the greater part of the counties situated between the Mississippi in the east and the Upper Osage River in the west. *Limonite* banks are scattered over the whole of this vast region, being, however, somewhat concentrated in three districts. The most eastern of these is composed of Bollinger, Wayne, and the southern part of Madison Counties; the second but smaller concentration is in the south-eastern part of Franklin County; while the third and most important one of this ore is found on the Middle Osage River, between Warsaw and Tuscumbia, in Benton, Morgan, Camden, and Miller Counties. This latter district extends also to the Upper Osage, above Warsaw, into St. Clair and Henry Counties. But while the limonites are deposited on the Second and Third Magnesian Limestones in the rest of the State, they here lie on the subcarboniferous limestone. The Upper Osage district also contains good deposits of subcarboniferous *red hematites*, occurring here in the same way as in Callaway County.

The *specular ores* are much more concentrated in certain parts of the State than either the limonites or the carboniferous hematites, and also occur in much larger masses. There are two important specular-ore districts, different by their geographical positions, different entirely by the mode of occurrence and the geological position of their ores, but quite similar, on the other hand, in the mineralogical character and the chemical composition of these ores. The one of these districts is the Iron Mountain district in the east, extending only over a small area, in southern St. François and northern Iron Counties, but containing two enormous deposits, besides numerous smaller ones. The ore is here in veins, beds, and other less regular forms in the porphyry. The second specular-ore district lies more toward the centre of the State, yet mainly in its eastern half. Its principal deposits, as far as known at present, are concentrated in three counties, Crawford, Phelps, and Dent. The occurrence of the specular ores, however, extends somewhat into the surrounding counties of Washington, Franklin, Maries, Miller, Camden, Pulaski, and Shannon. The specular ore in this central ore-region is always more or less distinctly connected with the Lower Silurian Sandstones, especially with the so-called Second Sandstone. Many of these deposits are disturbed and broken, and altered in regard to their position and contents.

From all that has been said, we may infer that, according to our present knowledge, there are three principal and important iron-regions in Missouri, namely :—

1. The eastern region, composed of the south-eastern limonite district and the Iron Mountain specular-ore district. This region has its natural outlet, at present, over the Iron Mountain Railroad.

2. The central region, containing principally specular ores, and having its commercial outlet over the St. Louis, Salem & Little Rock and the Atlantic & Pacific Railroads.

3. The western or Osage region, with its limonites and red hematites. This region will have to establish an iron industry of its own, because it is too remote from the present ore-markets. Its present connection with these markets is down the Osage River to Osage City, and from there either over the Missouri Pacific Railroad or down the Missouri River. A railroad from Jefferson City, through Cole, Moniteau, Morgan, Benton, Henry, St. Clair, Bates, and Vernon Counties to Fort Scott, which would touch the Upper Osage districts, is partly in construction, partly under consideration.

These three principal regions, combined, form a broad ore-belt, running across the State from the Mississippi to the Osage, in a direction about parallel to the course of the Missouri River, from south-east to north-west, between the thirtieth and fortieth township-lines. The specular ores occupy the middle portion of this belt, the limonites both ends of it. The latter are, besides, spread over the whole southern half of the State, while the subcarboniferous hematites occur only along the southern border of the North Missouri coal-field, having thus an independent distribution, and being principally represented in Callaway, St. Clair, and Henry Counties.

To make this distribution of ores more apparent and clear, I have added to this report the accompanying "Preliminary Map, showing the Distribution of Iron Ores in Missouri." Atlas, Plate IV.

This map contains about 280 deposits. Its title indicates that it does not pretend to be complete. It represents only a first effort toward a more complete map, and contains the results of information obtained during the summer of 1872. Such a map can, in fact, hardly ever be entirely complete, because new ore-banks are continually being discovered and opened.

Neither does this map pretend to show the exact relative character and size of the single ore-banks. It is only intended to show, in a generally correct and clear manner, the general distribution of the ores. For this purpose it was necessary, however, to mark every single deposit that has come to my knowledge, and to indicate those deposits which, *according to their present appearance*, seem to be more extensive than others, by larger sizes. This led to the adoption of five sizes, with a respective estimate of yield of smeltable ore.

Below 20,000 tons,	for size,	1.
20,000 to 100,000,	"	2.
100,000 to 500,000,	"	3.
500,000 to 2,000,000,	"	4.
Above 2,000,000,	"	5.

To distinguish the different kinds of ores, I use three colors, thus :—

Red, for red hematite.
Blue, for specular ore.
Brown, for limonite.

As regards the character of the deposits, those which, like veins and beds, are generally supposed to be more or less continuous, are marked by squares. All the other deposits, which are supposed to be either decidedly limited or very irregular, are marked in a circular form.

Another distinction made on the map is that between undisturbed, disturbed, and drifted deposits. This distinction was unavoidable, on account of the very frequent occurrence of disturbed deposits, especially in the central ore-region.

In the following chapters of this report the ores and deposits will be described under the following geographical arrangement :—

Eastern Ore-Region.

ORE-DISTRICT ALONG THE MISSISSIPPI RIVER.
IRON MOUNTAIN DISTRICT.
SOUTH-EASTERN LIMONITE DISTRICT.
FRANKLIN COUNTY DISTRICT.
SCOTIA DISTRICT.

Central Ore-Region.

STEELVILLE DISTRICT.
ORE-DISTRICT ON THE UPPER MERAMEC AND ITS TRIBUTARIES.

Salem District.
Iron Ridge District.
St. James District.
Rolla District.
Middle Gasconade District.
Lower Gasconade District.
Callaway County District.

Western Ore-Region.
Lower Osage District.
Middle Osage District.
Upper Osage District.

South-western Ore-Region.
White River District.
Ozark County District.

CHAPTER IV.

THE IRON-ORES OF MISSOURI.

BY ADOLF SCHMIDT, PH.D.

B. *Description of Ores.—General Description.*

It may be inferred, from the contents of the preceding chapter, that there are principally two species of iron-ores in Missouri, hematite and limonite. These can be easily distinguished from each other by their exterior appearance, the hematite being either grayish black, with a slight bluish or reddish tint, or red in various shades; while the limonite is always brown or yellow. But the best and least deceptive distinction is made by the streak of these ores—that is, by the mark they produce when rubbed against a rough, white porcelain-plate. The streak is invariably red with the hematite, and yellowish brown to yellow with limonite. If the ores are not too hard, the color of the streak can also be discovered, though less plainly, by scratching the ores with a knife. The hematite occurs in two very different and distinct varieties, the specular ore and the red hematite.

Specular Ore is bluish-black to steel-gray, with a more or less metallic lustre, and a more or less crystalline structure. Its mineralogical hardness is about 6, which is also about the hardness of hardened cutlery-steel. Thus an ordinary pocket-knife will not scratch the hardest specular ores; but it will scratch the softer kinds, though not without some effort, there being no great difference in their respective hardness. The streak of pure specular ore is cherry-red to dark-red, with a purple tint. Its magnetic qualities vary considerably in the same kinds of ore and in the same localities. Most specular ores are, however, slightly magnetic.

This description refers to specular ore in its pure and natural condition, being then composed chemically of nearly pure peroxide of iron, containing about 70 per cent. of metallic iron. But this ore is sometimes found mixed with foreign substances, as quartz, sand, flint, porphyry, clay, pyrites, apatite, etc., which generally change somewhat its qualities and diminish its value. Specular ore also frequently undergoes physical and chemical changes by a gradual alteration under the influence of air, water, or mineral solutions. These alterations, which will be spoken of more fully hereafter, sometimes change the character of the ore completely. We find the specular ore to pass, under certain conditions, into compact red hematite, and into soft red hematite, by other influences into limonite, by others into carbonates. These various ores, as far as they are merely the products of such gradual alterations, will be described together with the specular ores from which they are derived. It is a very remarkable fact, that all the Missouri specular ores, with but a few exceptions, have pretty nearly the same mineralogical and chemical character, whether they occur in the porphyry or in the Silurian sandstone.

Red Hematite, when not produced by transformation of specular ore, but occurring as an original mineral in the subcarboniferous strata of Missouri, has a dark-red color, either with a yellowish or more frequently with a bluish tint. The fracture is uneven and dull in the earthy, somewhat conchoidal with a slight lustre in the compact, varieties. The structure is never crystalline, but either earthy and more or less porous, or compact and fine grained, or coarse grained to oölitic. The hardness is less than that of most specular ores. It varies from 5 to 6, but rarely reaches the latter figure. The streak is cherry-red to yellowish red. This ore is unmagnetic.

Red hematite, when exposed to atmospheric influence, seems to become more porous, and is altered gradually into brown and yellow limonite. These subcarboniferous hematites consist of a somewhat clayish peroxide of iron, and contain from 50 to 60 per cent. of metallic iron.

Limonite, also known as "brown hematite," has a dark, grayish-brown color. Nearly all the limonite occurring in Missouri is dull, and sometimes earthy in the fracture, amorphous. It occurs partly in porous masses, the irregular pores and cavities being filled with yellow ochre, partly in botryoidal and stalactitic forms. The hardness of compact limonite is about 6, and pretty uniform. The streak is yellowish brown. Limonite is unmagnetic. It is chemically composed of peroxide of iron, and water in varying quantity, and contains from 45 up to 60 per cent. of metallic iron.

It is sometimes clayish, and in several localities mixed with broken chert. It is invariably accompanied by soft, yellow ochre, distributed in small cavities throughout its mass, but also occurring in larger accumulations occasionally.

Limonite does not seem to undergo any material changes by exposure.

SPECIAL DESCRIPTION OF MISSOURI IRON-ORES.

a. SPECULAR ORES.

1. *Specular Ores in Porphyry.*

Iron Mountain Ore.—The iron-ore of the Iron Mountain corresponds in its mineralogical qualities to the general characterization of Missouri specular ore as given above, and may be considered as a type. It is very uniform in its character in the various parts of the vein. Also the surface-ore has the same appearance and qualities, with the only exception that it is in the great average a little softer, its hardness being generally slightly below 6, while that of the vein-ore is slightly above 6. The color of both is steel-gray, with a slight tint of blue. Their streak is dark red to purple. Both have an uneven fracture, a nearly metallic lustre on fresh-broken faces, a subcrystalline to massy structure. The structure is occasionally inclined to become lamellar. In this case the ore is brittle, and breaks in long flat splinters with very thin and sharp edges. The surface of fracture of such pieces is very bright, and shows indications of a coarse crystallization, the single indistinct crystals being flattened and drawn in length in the direction of the long axis of the splinter. Many of these splinters are strongly magnetic, some less so. The former show a distinct polarity. The magnetic axis, however, never coincides with or ever lays parallel to any one of the three main axes of the splinter, but it is always in an inclined position to all of them. Marks of distinct crystallization are very rare in the Iron Mountain ore. Wherever distinct crystals occur in holes or fissures, they are mostly small and micaceous. These small micaceous crystals are sometimes also distributed throughout the mass of the softer ore, filling the very finest pores. This is more frequently the case in the surface- than in the vein-ore.

All Iron Mountain ore is magnetic. I have not been able to discover a single piece entirely free from magnetism. Some of it, besides the special variety above mentioned, is strongly magnetic with distinct polarity, the north pole of a compass-needle being attracted by one side and repulsed by the other side of the same piece, producing very strong declinations. The greater part of the Iron Mountain ore acts, however, but slightly on the needle, but shows, nevertheless, frequently distinct polarity. Some of it does not seem to act at all on an ordinary compass-needle. But when reduced to a fine powder, some parts of it are invariably attracted by a magnet of ordinary power, while other parts, although equally fine, are not attracted. This remark, which is correct even for the impure ores from the small veins of but one to two inches' thickness, as they occur in the so-called "bluff," proves the universal distribution of magnetism in the Iron Mountain ore, and besides indicates that this magnetism is a quality inherent in certain small particles only, while others are free from it. This is one step, unfortunately but a small one, toward the explanation of the inequality existing between the magnetic strength of one piece of ore and that of another. This inequality exists to such an extent that sometimes a piece of ore, whose largest dimension does not exceed one inch, is found to be in part strongly magnetic, in part very weak, as may be seen when the piece is broken and the single fragments tested. This inequality seems to be independent of the location, and shows itself in the same manner and degree in the large vein, in the smaller veins, and in the surface-ore. Pieces inclined toward a crystalline structure are more generally strongly magnetic than others, also those containing secretions of micaceous crystals. Small differences in the chemical composition do not seem to influence the magnetism. The latter seems especially not to be dependent on small variations in the amount of protoxide the ore contains.

We see from the following analyses that the sample No. 3, although strongly magnetic, contains only 2.34 per cent. of protoxide, while the sample No. 4, which is very little magnetic, contains 5.72 per cent. of it. The magnetism of these samples was tested by approaching the single pieces to the north pole of a compass-needle.

Afterward, however, some of them were reduced to a powder, and were tested by approaching a magnet to the powder. Tested in this way, the powder of No. 4 seemed to be attracted more lively and more copiously than that of No. 3. A repetition of these tests showed the same results.

These facts would invite to a closer investigation of these matters. The axis of polarity in single pieces of Iron Mountain ore is never either parallel nor rectangular to the cleavage or to the surface of fracture, and runs very frequently from one point near the edge to another point near the centre of the piece on the opposite side. No ore with active magnetism, constituting a natural magnet, and attracting iron-filings, was found on the Iron Mountain.

The following analyses, made by Mr. A. A. Blair, of St. Louis, will show the chemical composition of the Iron Mountain ores :—

	Vein-Ore.				Surface-Ore.		
	1.	2.	3.	4.	5.	6.	7.
Insol. silicious matter.	.....	.....	4.71	6.76	.....	1.88	.....
Peroxide of iron	.....	96.78	91.45	86.75	.....	95.04	95.15
Protoxide of iron	.....	.....	2.34	5.72	.....	2.57	.....
Alumina	.....	.....	0.93	.....	.....	0.75	.....
Lime	.....	.....	0.45	.....	.....	0.15	.....
Magnesia	.....	.....	0.19	.....	.....	0.12	.....
Manganese	.....	.....	0.00	.....	.....	0.00	.....
Sulphur	0.008	0.016	0.00	0.00	0.012	0.005	0.003
Phosphoric acid	0.112	0.119	0.252	0.081	0.067	0.071	0.125
	.....	.....	100.322	.....	.....	100.586	.....
Metallic iron	.....	67.75	65.78	65.16	.....	68.53	66.60
Phosphorus	0.049	0.052	0.110	0.035	0.029	0.031	0.057
			Insoluble Silicious Matter.				
Silica	.....	3.28	3.99	6.16	.....	1.57	4.54
Alumina	.....	.....	0.47	.....	.....	0.04	.....
Lime	0.149	.....	0.06	.....	0.13	0.02	.....
Magnesia	.....	.....	0.03	.....	.....	0.017	.....
Specific gravity	.....	.....	5.149	4.934	.....	4.835	4.929

1. Average sample of the vein or quarry ore from all parts of the mountain, sampled by Major T. B. Brooks, of Marquette, in May, 1872.

2. Average sample of ore from the eastern part of the principal vein (cut D).

3 and 4. Average sample of ore from the western part of the principal vein (cut A).

3. Decidedly magnetic pieces.

4. Pieces not acting on a compass-needle.

5. Average sample of the surface-ore from all parts of the mountain, sampled by Major T. B. Brooks, of Marquette, in May, 1872.

6. Average sample of surface-ore from the south slope of the mountain.

7. Average sample of surface-ore from the north-west slope.

The metallic iron in samples 1 and 5 was determined by Dr. Otto Wuth, of Pittsburgh, as follows:—

1. Vein-ore .... 66.049 per cent.
5. Surface-ore .... 67.416 per cent.

From the above analyses we may conclude that the Iron Mountain ore is very rich and very uniform, in general; that the surface-ore is a little richer in metallic iron, and less phosphoric than the vein-ore; that both are nearly free from sulphur; and that the percentage of phosphorus is variable, though never running very high. A comparison made between the analyses 3 and 4 on the one hand, and 2 on the other hand, might indicate that the vein-ore grows richer toward the west. The number of analyses is, however, too small to warrant the correctness of such a conclusion.

It will be noticed that the specific gravity, as given above, agrees well with the results of the analyses.

The Iron Mountain ore is in the whole very pure and nearly free from mechanical admixtures of foreign matter. A few minerals, however, occur in it occasionally, namely, porphyry, apatite, and quartz.

Admixtures of porphyry never occur in such a manner as to injure the ore, the enclosures having so large a size that the porphyry is easily separated from the ore. This is therefore more of geological than of mineralogical interest.

Fine clay, probably of porphyric origin, is sometimes intimately mixed with the ore in the smaller veins in the "bluff." The thicker veins are entirely free from it. Apatite must have been very frequent formerly in those parts of the veins which are in immediate contact with, or at least in pretty close vicinity of, the porphyry-walls, to judge from the numerous large and small holes of crystalline shape to be found in the ore in such places. These holes occur generally in larger or smaller groups, in some parts of the principal vein, as well as in the "bluff" veins and in the surface-ore. The crystals which originally filled these holes were hexagonal prisms of varying sizes, from the smallest up to a length of 3 inches and a diameter of 1 inch. They generally start at the wall of the vein, or at the wall of some fissure existing in the vein, and reach into the ore, sometimes perpendicular to the wall, but more frequently at some angle to it, and often nearly parallel to each other. The prisms are distinct and sharp near the wall, where they start from, but the more they reach into the ore the smaller is their diameter and the less distinct and sharp their edges. Many run out into a sharp point and look almost like sharply-pointed pyramids, or, when rounded off, as they frequently are, like needles or lances. Some, however, show indications of the basis of the prism, also at that end of the crystal which lies free in the ore.

All these crystallic holes are very likely impressions of crystals of apatite formerly present in the ore, and some of them, though fortunately but few, are yet filled with nearly fresh apatite. The empty holes are generally clad out with a very thin layer of a fine ferruginous clay.

The third mineral found in the Iron Mountain ore is quartz. It occurs but rarely, and nearly always near the walls of the veins, especially in disturbed places, or near large enclosures of broken porphyries in the interior of the principal vein. This quartz is there evidently the result of a process of infiltration, which has taken place long after the formation of the ore. It fills small fissures or irregular cavities, or the crystallic cavities above described, which were left after the removal of the apatite. It is always more or less distinctly crystalline, and sometimes forms drusy aggregations of crystals, slightly covered with yellow hydrated peroxide of iron (yellow ochre).

Pilot Knob Ore.—The Pilot Knob ore differs somewhat in its qualities from most of the other specular ores in the State. Its color is steel-gray to pearl-gray, with a very marked tint of sky-blue. Its lustre is so faint that it can scarcely be called submetallic. Its structure is crystalline to granular, with a very fine grain barely to be seen with the naked eye. Its fracture is either even or sub-conchoidal. It shows a plain stratification, and splits parallel to it into plates ¾ to 2 inches in thickness. These plates break in parallelopipeds with sharp edges and with surfaces that are sometimes at right angles, but more frequently inclined to each other. The faces parallel to the stratification are generally even, or nearly so; the others are either subconchoidal or irregular, with sharp edges and corners. The general flight of two faces situated opposite each other is always more or less parallel. The hardness of the Pilot Knob ores is very variable, and the faces parallel to the stratification are always perceptibly harder than those lying in other directions. The former are mostly near 6½, the latter near 6. There are, however, a few places in the Pilot Knob mine where the ore is considerably softer, about 5½. The hard ore passes gradually into the soft. All Pilot Knob ores are very brittle. Their streak is uniformly dark red. Also the poorer ores show this streak.

None of the Pilot Knob ores from the main body of the deposit, neither below nor above the slate-seam, disturb an ordinary compass-needle, with the exception of the uppermost layers of poor ore, in the eastern cut, immediately below the conglomerate which forms the summit of the mountain. Also, most of the fine ore which is mixed with this conglomerate has polaric magnetism. The greater part of it acts on the needle very strongly. This conglomerate has indications of stratification, and the magnetic axes run either at a right angle or parallel to it. The ore found in loose pieces in the conglomeratic detritus covering the western slope of the mountain is also polaric-magnetic, some of it strongly so. Magnetic pieces of thinly-stratified, poor ore are also found loose in the creek north-east of the mountain. All ores on the Pilot Knob, those in the deposit as well as those in the conglomerates, are slightly attracted by a magnet, when they are ground fine, and those which, as above mentioned, act strongly on the needle, are not attracted by the magnet with any greater power or in any larger quantity than those which do not seem to act on the needle at all.

The chemical composition of the Pilot Knob ores from different parts of the mine is very different, as may be seen from the following analyses, made by Mr. Andrew A. Blair, of St. Louis :—

	Ores in the main Ore-bed below the Slate-seam.					Ores above the Slate-seam.		
	1.	2.	3.	4.	5.	6.	7.	8.
Insoluble silicious matter	.....	.....	14.75	5.57	.....	.....	.....	.....
Peroxide of iron	87.18	83.28	84.33	90.87	67.38	77.02	62.88	52.18
Protoxide of iron	.....	.....	0.15	1.67	.....	.....	.....	.....
Alumina	.....	.....	0.75	0.53	.....	.....	.....	.....
Lime	.....	.....	0.21	1.76	.....	.....	.....	.....
Magnesia	.....	.....	0.14	0.13	.....	.....	.....	.....
Manganese	.....	.....	0.00	0.00	.....	.....	.....	.....
Sulphur	.....	.....	trace	0.078	0.006	.....	0.079	.....
Phosphoric acid	.....	.....	0.035	0.069	0.092	.....	0.101	.....
	.....	.....	100.365	100.677	.....	.....	.....	.....
Metallic iron	61.03	58.29	59.15	64.91	47.16	53.91	44.01	36.52
Phosphorus	.....	.....	0.015	0.031	0.041	.....	0.044	.....
			Insoluble Silicious Matter.					
Silica	.....	.....	13.27	5.18	30.10	.....	28.16	.....
Alumina (with a trace of peroxide of iron)	.....	.....	1.44	0.36	.....	.....	.....	.....

1. Average sample of ore from the main ore-bed below the slate-seam, in the western cut (A).

2. Hard ore from the central portion of the main ore-bed, below the slate-seam, west of the soft ore (analysis 3), in the central cut (B).

3. Soft ore from the central portion of the main ore-bed, below the slate-seam, in the central cut (B).

4. Hard ore from the central portion of the main ore-bed, below the slate-seam, east of the soft ore (analysis 3), in the central cut (B).

5. Average sample of ore from the main ore-bed, below the slate-seam, in the eastern cut (C).

6. Ore in conglomerate, 5 feet above the slate-seam, in the central cut (B).

7. Average sample of ore from the strata above the slate-seam, in the eastern cut (C).

8. Average sample of the better ore on the refuse-heaps of the eastern cut (C). This ore is not smelted, nor shipped, but thrown away with the rock-refuse.

We may conclude from these analyses that there is a great difference between the richness of the ore in the main bed below the slate-seam, and that of the ore above the slate-seam, the former showing, in the lower and central parts of the deposit, an average of about 60 per cent. of metallic iron, while the latter contains only

53 per cent., or, as this latter ore is very variable in itself, we may say from 45 to 55 per cent. The ore from the upper part of the deposit, from the eastern cut (C), is decidedly poorer than that from the central and western cuts. It contains only 47 per cent. below the slate-seam, and 44 per cent. above it, and the uppermost and poorest layers stand as low as 36, and some would analyze considerably lower than this. The ores from the last-mentioned uppermost layers, in the eastern cut, are thrown away now. But a considerable part of them could undoubtedly be smelted with profit in the Pilot Knob furnace. They could not be shipped, being too poor to pay for both the transport and the smelting. But they would give a fair profit, when smelted in place, especially when mixed with some of the richer ores or with limonites, or, better, with both. As the metallurgical and commercial value of ores increases very rapidly with their richness, I have no doubt that a great gain would result for the Pilot Knob Company, in money and in reputation, if the 60 per cent. ores from the lower and central part of the main bed would be kept and sold separate. These could be shipped to Indiana, Ohio, and Pittsburgh, and command high prices, while the 50 per cent. ores could be used in Missouri and Illinois, mixed with other Missouri specular ores and limonites, and while the 35 to 40 per cent. ores would be smelted at Pilot Knob.

We see from the above analyses that the Pilot Knob ores contain very little sulphur and phosphorus. Their principal impurity is silica.

This silica is either chemically combined, or, more likely, intimately mixed with the ore in microscopic particles or grains. Mr. Blair's analyses show it to vary from 5 to 13 per cent. in the richer ores, and to be as high as 30 per cent. and over in the poorer ores.

The upper part of the ore above the slate-seam is often intimately mixed with porphyry. The main bed is entirely free from it. Besides these two kinds of admixtures, a few minerals occur occasionally in very small quantity in fissures, as the micaceous oxide of iron and a yellowish-white, lamellar, crystalline, translucent heavy-spar. These two minerals occur rarely, but generally together and mixed with each other, in fissures, in the eastern portion of the central cut (B), below the slate-seam. A mineral resembling the last described, probably also heavy-spar, sometimes forms a thin film, composed of many crystalline lamellæ of a vitreous lustre, over the even faces of separation of the ore, especially over those which have a nearly vertical position in the bed. This film is, in some instances, very pure and transparent; in others it is more grainy, of a reddish color, opaque, and up to one-eighth inch thick. In the latter case it is not pure, but seems to be mixed with loose and extremely small grains or crystals of quartz. Mr. Chauvenet found the specific gravity of the sample No. 3, which is soft ore from the central part of the main bed, = 4.386, and that of sample No. 4, which is hard ore from the same place, = 5.019. These results agree with the results of the chemical analyses, which show much more silica and less iron in the soft ore than in the hard.

Shepherd Mountain Ore.—The ore from Shepherd Mountain, in its mineralogical qualities and chemical composition, resembles a little more a magnetite than any other ore in Missouri. It is, however, in the main a specular ore, very similar to that of the Iron Mountain, as above described. Its color and streak are slightly darker than those of the latter. Its hardness is considerably less, being about 5½ in the average. Its lustre is less bright. It has no stronger tendency toward a crystalline structure. The crystalline faces, though equally indistinct, are rather smaller. Splendent lamellæ of micaceous crystals, disseminated through the mass, as they occur rarely in the Iron Mountain ore, are quite general in the Shepherd Mountain ore, and the ores from these two localities may generally be distinguished exteriorly from each other by this characteristic, as well as by the marked difference in their lustre. The Shepherd Mountain ore is also much tougher and less brittle, and breaks with less sharp corners and edges.

In some places in the depth of the northern vein (A), the ore gets nearly black in color, finely granular, and fully black in the streak, thus approaching a true magnetite. A very soft, black ore occurs in irregular masses of limited extent in the upper part of the central vein (B). These masses show a more distinct crystallization, and sometimes aggregates of lamellar crystals of specular hematite in the forms of the rhombohedric system. The glittering, small crystals of micaceous ore are very numerous in some parts of these soft masses, while other parts are quite dull. The ore in the small southern outcrop (C) has a distinct, coarsely crystalline structure, with a pretty bright metallic lustre.

When inspected through a magnifying glass, the Shepherd Mountain ore appears to be composed, on the one hand, of crystalline parts, with a color and a lustre very similar to that of the Iron Mountain ore ; on the other hand, of a dull, dark-red, ground mass surrounding the crystalline parts. Sometimes the one prevails, sometimes the other. I found a specimen in which these two distinct kinds of ore form alternate, undulating layers about one-eightieth of an inch in thickness, giving the piece a striated appearance.

The magnetic qualities of the Shepherd Mountain ore are much more pronounced than those of either the Iron Mountain or the Pilot Knob ores. Here again we have to distinguish two different modes of action of magnetism, which seem to be independent of each other in certain respects and within certain limits ; first, the magnetic influence of the ore on a compass-needle, and second, the attractive influence of a magnet on small particles of ore. The influence on the needle is much less dependent on the chemical composition and on the structure of the ore than on its position in the vein. The specimen No. 1, amongst the following analyses, contains 1.8 per cent. of protoxide, and is much more magnetic than the No. 2, which contains 2.97 per cent. There is no decided and regular difference between the magnetic strength of hard and soft, of dull and bright, of fine-grained and coarse-grained ore ; but all the ore in the upper part of the vein, from the outcrop to a depth of 30 or 40 feet, acts strongly on the needle, while the action of the ore from the lower part is much weaker, though very different in different places. Besides being stronger magnetic, the upper ore is also decidedly polaric, the axis of polarity being nearly parallel to the cleavage. Regarding the lower ore in Shepherd Mountain, it is a remarkable fact that, although acting on the needle invariably, it is, with rare exceptions, entirely unpolaric, while the Iron Mountain and Pilot Knob ores, although mostly weaker, are nearly always polaric. A piece of this lower Shepherd Mountain ore repels the north pole of a magnetic needle, and attracts its south pole, and, when the piece is turned over, instead of acting in a reversed manner, it allows the needle to return to its natural position, and does not produce any deflection whatever. In the northern vein (A) the strongly magnetic and polaric ore is more frequent, and reaches deeper than in the central vein (B). There also occurs some ore (analysis No. 4) which contains a large amount of protoxide, and has most of the mineralogical characteristics of a true magnetite, especially a deep-black streak.

All Shepherd Mountain ore is strongly attracted by a magnet of ordinary power, when either pulverized or ground coarsely. No decided difference can be discovered in this respect between the ore which strongly disturbs the needle and that which affects it but little. Neither can a difference be discovered in this respect between the polaric and the unpolaric ore. When a polaric piece is broken or ground, the single fragments are polaric. From a strongly polaric piece, I broke off some particles from the north pole and also some from the south pole. Each of these particles had itself two poles, when tried by approaching it to a compass-needle, and all these particles were attracted by both poles of a magnet. The position of each single particle, when attracted by the north pole, was however reversed, when compared to the position of the same particle when attracted by the south pole.

When the ore is finely pulverized, only a part of the powder is attracted, while the rest seems to be unmagnetic. This fact shows that the magnetism is inherent in certain very small particles only, while others are free from it, and explains the difference between the two modes of magnetic action. A piece of ore containing comparatively but few though strongly magnetic particles, may not disturb the needle ; nevertheless, when the ore is pulverized, a magnet will exert a lively attraction on the magnetic part of the powder.

Bowlders of ore are sometimes found on the Shepherd Mountain which are strong natural magnets, possessing active magnetism, and attracting iron-filings. A piece of iron, when rubbed against such a natural magnet, becomes itself a magnet.

The chemical composition of the Shepherd Mountain ore may be seen from the following analyses made by Mr. Andrew A. Blair, of St. Louis :—

	1.	2.	3.	4.
Insoluble silicious matter	5.15	6.76	.....	.....
Peroxide of iron	94.84	88.56	96.70	79.39
Protoxide of iron	1.80	2.97	.....	14.22
Alumina	....	1.55	.....	.....
Lime	....	0.35	.....	.....
Magnesia	....	0.04	.....	.....
Manganese	....	0.00	.....	.....
Copper	....	trace in 5 grms.	.....	0.00
Sulphur	0.00	0.00	0.00	0.00
Phosphoric acid	0.025	0.039	0.032	0.038
	.....	100.269	.....	.....

	1.	2.	3.	4.
Metallic iron	66.52	64.31	67.69	66.63
Phosphorus	0.011	0.017	0.014	0.017
		Insoluble Silicious Matter.		
Silica	4.05	5.98	....	....
Peroxide of iron	....	0.07	....	....
Alumina	....	0.46	....	....
Lime	....	0.12	....	....
Magnesia	....	0.05	....	....
Specific gravity	....	4.714	....	....

1. Average sample of ore from the upper part of the central vein (B); magnetic; streak dark red.

2. Average sample of ore from the lower part of the central vein (B), about 80 feet below the outcrop; slightly magnetic; streak dark red.

3. Soft, friable ore from the lower part of the central vein (B); slightly magnetic; streak dark red.

4. Hard, black ore from the northern vein (A); strongly magnetic; streak black.

These analyses show that the Shepherd Mountain ore is very uniform in its chemical composition, very rich in iron, and almost entirely free from sulphur and phosphorus. It is very nearly as rich as the Iron Mountain ore, and much purer than either this or the Pilot Knob ore.

It is, besides, nearly free from mechanical admixtures, small specks or thin seams of a soft, white clay, probably decomposed porphyry, being the only foreign matter generally found in it. The northern vein (A) contains, in a few places near its outcrop, some crystalline iron pyrites. This mineral, however, occurs very rarely, and does not injure the general quality of the ore in the northern vein, as the above analysis, No. 4, shows. The Shepherd Mountain ore is perhaps the best iron-ore in Missouri.

Specular Ores from the smaller Deposits in Iron County.—These ores are very variable, approaching partly the Pilot Knob ore, partly the Iron Mountain ore, in their general character. Micaceous ore is of very frequent occurrence in most of these smaller deposits. On Buford Hill, 2½ miles west of Iron Mountain, micaceous oxide is found almost exclusively. It occurs in considerable irregular accumulations, mixed with quartz. The crystalline lamellæ have a black color, a bright lustre, and variable sizes, up to one-fourth inch diameter. The ore is strongly magnetic, with distinct polarity.

The ore from Cedar Hill, north-west of Pilot Knob, resembles the

Pilot Knob ore externally. It has a grayish color, with but little lustre, and is very dense, hard, and brittle. The streak is red. This ore is distinguished by the absence of all magnetism. It does not affect the needle, and is not attracted by a magnet, after being crushed or pulverized. It is sometimes mixed with specks and seams of brown porphyry. Most of it is pure and very rich in iron.

Mr. Blair found in an average sample, taken by Prof. Pumpelly from all parts of the mine—

Insoluble matter	5.62
Peroxide of Iron	93.54
Sulphur	0.00
Phosphoric Acid	0.090
Metallic Iron	65.47
Phosphorus	0.039

The ores found imbedded in stratified porphyry in some localities, one-half mile east of Pilot Knob, are more like the Iron Mountain ore, having a darker color, a brighter lustre, and a less degree of brittleness than the Pilot Knob ores. They are mostly softer than 6. All the specimens I found there have a pretty strong magnetic polarity.

The ore from Lewis Mountain, near Arcadia, is very variable in its mineralogical qualities. Most of it looks like the Cedar Hill ore, and is unmagnetic. Other parts are softer and tougher. Wherever crystallization appears, the ore is micaceous and magnetic. The following analysis, made by Mr. A. A. Blair, of St. Louis, shows this ore to be about equal in quality to the better ores of Pilot Knob. This analysis was kindly furnished to me by Hon. Thomas Allen :—

Insoluble silicious matter	15.33%	
Peroxide of Iron (including a small amount of protoxide)	84.60	= Metallic Iron..59.22%
Alumina	0.32	
Lime	0.38	
Magnesia	0.15	
Manganese	0.00	
Sulphur	0.021	
Phosphoric Acid	0.065	= Phosphorus..0.027
(Excess due to the presence of protoxide.)	100.866	

INSOLUBLE SILICIOUS MATTER.

Silica	14.45
Alumina	0.51
Lime	0.06
Magnesia	0.04

What has been said of the Lewis Mountain ore may also be applied to that of Hogan Mountain. Masses of soft, coarsely crystalline, semi-micaceous, slightly magnetic ore, are, however, more frequent in the latter than in the former.

The Buford Mountain ore is dull, dark-colored, soft, in part earthy. It is partly massy, with indications of stratification, partly in irregular botryoidal forms, and frequently mixed with specks and seams of decomposed porphyry, of white and red clay, of hydrated peroxide of iron, and of black peroxide of manganese. The streak is therefore very variable, being red where the iron-ore prevails, and black where the manganese-ore prevails. The ore has a strong polar magnetism. An average sample, taken by Professor R. Pumpelly from all parts of the lower or main cut, was analyzed by Mr. Regis Chauvenet, of St. Louis, and gave the following result:—

Insoluble matter	8.54	per cent.
Peroxide of Iron	68.30	"
Peroxide of Manganese	19.46	"
Sulphur	0.011	"
Phosphoric Acid	0.102	"

As this ore is rich in both iron and manganese, and as the oxides of both these metals are, to all appearance, intimately mixed, this ore is likely to prove a very valuable material for the manufacture of Spiegeleisen, now so extensively used in the Bessemer process.

Ores with little iron and much manganese were found by Prof. Pumpelly on Mr. Cuthbertson's land in that vicinity, and analyzed by Mr. Chauvenet, showing—

Insoluble matter	0.44	per cent.
Peroxide of Iron	3.30	"
Peroxide of Manganese	83.56	"

The above descriptions will suffice to characterize the specular ores occurring in the porphyries of the eastern iron-region of Missouri.

2. Specular Ores in Sandstone.—I have mentioned above, that the specular ores occurring in the Silurian sandstones in the central ore-region, have nearly the same mineralogical and chemical properties as the specular ores just described. They differ, however, considerably in one respect. I have alluded to the alterations which specular ores often undergo, passing either into soft, red hematite, or into limonite, or into carbonates. These alterations have not been spoken of in the special description of the specular ores in the porphyry, because they never take place there. We may find these specular ores, which have originated in the porphyry, in their original position as veins, beds, etc., in the solid porphyry; we may find them in veins, in the clayish "bluff" of Iron Mountain, or broken up into large and small fragments, imbedded in loose detritus in the same locality, or in outcrops, or as surface-ore being exposed to the atmosphere during an incalculable length of time. In no case can we find these ores to have undergone any material changes in their chemical or mineralogical character. On the other hand, those specular ores which have originated in the sandstone are invariably altered when broken up, or when exposed to external chemical influences. These alterations will be more fully spoken of in the following special description of the ores in which they occur, especially in that of the Scotia Iron Ridge and St. James ores. I will however say here, that they take place in three distinctly different directions, depending in each case on the character of the external influence which causes them.

First. When certain specular ores are directly exposed to the influences of the atmosphere, or when they are in such a position that both air and water may have access to them alternately, the ores become gradually changed into brown and yellow limonites.

Second. When these same specular ores are broken up in larger or smaller blocks, and covered with sandy detritus, so that water or mineral solutions have access to them, while the atmospheric air is more or less completely excluded, the ores become gradually changed into a soft, red hematite, which is in many instances greasy to the touch.

Third. When these same specular ores are broken up and in a state of gradual transformation into soft, red ores, or else when they are already transformed into soft, red ores, certain mineral solutions containing carbonic acid seem to dissolve the iron under certain circumstances, and to depose it again as carbonate in fissures and cavities, either in the ore itself, thus changing the latter gradually into spathic ore, or in the adjacent rocks.

The last-mentioned transformation occurs but rarely, and on a small scale; the first is more frequent, though not generally very extensive; but the second is quite common, and has produced thorough-going changes in several important deposits, while no broken-up or disturbed deposit is entirely free from it.

The fact that these transformations do not occur in the specular ores which have originated in the porphyry, leads us to consider more closely the dissimilarity, however small it may be, between these ores and those originally imbedded in the sandstone. In doing so, we find that the latter are in the average somewhat softer, their hardness varying from 5½ to 6. They are also a little less silicious, less compact, and more porous. The small, irregular cavities and cracks which are occasionally found in the former are quite universal and more equally distributed in the latter. When sufficiently large, these cavities are also clad with numerous small crystals of peroxide of iron, but they are less frequently filled with quartz or other minerals. Regarding their form, these cavities look somewhat different in the two different kinds of specular ores. While those in the porphyry-ores seem to be produced in part by the removal of minerals formerly enclosed in them, in part by a local crystallization of the mass of the ore, and by the expansion or contraction effected by crystallization, the cavities in the sandstone-ores have more the appearance as if they were produced by a very slow and uniform contraction of the ore, which may have taken place during its consolidation, perhaps by a gradual abstraction of the fluid from which the ore was precipitated.

I have the impression that the above slight differences between the two kinds of specular ores of Missouri are sufficient to account for the great difference in their capability of being altered by exterior influences. The associated rocks or soils may, however, contribute toward effecting this difference. The porphyry-ores, when broken up or exposed, are generally associated with less penetrable, clayish materials, the sandstone-ores with sandy and cherty detritus, which presents an easier passage to water or solutions.

If the existence of numerous small cavities in the mass of the sandstone-ores is not one of the principal causes of the alterations of these ores, the fact that these alterations nearly always start in such cavities certainly proves that their existence greatly facilitates and promotes transformation of any kind.

Franklin County Specular Ores.—There are a few occurrences of specular ore in Franklin County, in the neighborhood of Stanton and in the north-west corner of Washington County. The greater part of these ores is not very pure, as far as can be observed from the present condition of the ore-banks. The hard ores are either silicious in themselves or intimately mixed with sand, so much so in one locality as to constitute rather an impregnated sandstone than a real iron-ore. They have a dark, bluish-gray color, a light-red streak, and are slightly magnetic. The soft, red ores, as produced by the alteration of the specular, have a light-red color and streak, are somewhat greasy, and mixed with very fine, clayish substances. They are, however, sufficiently rich for being smelted.

Scotia Ores.—The specular ore of the two Scotia banks, on the Meramec River, in Crawford County, occurs in various forms and in nearly all stages of transformation. The hard, unaltered ore is in bowlders imbedded in the soft, red ore.

The hard ore is steel-gray, with a submetallic, and on fresh-broken surfaces frequently metallic, lustre. It has a finely-crystalline structure, an even to subconchoidal fracture. Its hardness is 5½ to 6. It is slightly polaric-magnetic. It is pretty uniform in its appearance and structure, but contains those numerous and pretty equally distributed little cavities of which I have spoken above. The Scotia ore is, however, distinguished from all the other known specular ores in the State by the frequent occurrence of larger drusy cavities, which contain botryoidal and reticulated forms of ore, and are covered all over with small, highly-splendent crystals of peroxide of iron, which often have an irised tarnish, and play in all colors, presenting a beautiful appearance.

Smaller and larger, well-formed and transparent quartz-crystals, up to one quarter-inch diameter, often of a fine yellow color and of a bright, vitreous lustre, are likewise met with in these irregular cavities, which sometimes reach a length of several inches. Occasionally such cavities are filled by amorphous or subcrystalline, wax-yellow jasper, enclosing thin seams of white quartz and fine specks of crystalline ore.

The soft, red hematite which forms the greater mass of the ore in the Scotia No. 1, as far as it is at present disclosed, is not a very uniform material. It breaks with very irregular surface, almost like a conglomerate, and is full of irregular streaks, running in the deposit more or less vertical, of similar though somewhat differently colored and composed materials. Some of these are red, crystalline, and glittering, and often silky or greasy, others yellowish brown and earthy. The main body of this ore seems to be an irregular but intimate mixture of these same two materials, which separately form the streaks just described. The hardness of the mass is only 2 to 3. Its streak is red to brownish red. It is not magnetic.

Soft, yellow iron-ochre occurs also in big seams through the ore-deposit, and some large pockets of it reach into it from the surface. This ochre is generally very porous, mixed with broken chert or with red loam, and permeated irregularly by very thin seams of subcrystalline quartz.

The bowlders of hard specular ore are generally surrounded by a layer of red ore, which has not fully the same degree of softness as the rest of the soft ore. Yet the transition from the hard to the soft ore is here more abrupt than in the Iron Ridge and Meramec deposits, and pieces showing this transition very plainly are comparatively rare. Nevertheless, all appearances indicate that the red ore has been gradually formed by an alteration of the specular ore, while the ochre seems to be a later product.

The deposit called Scotia No. 2 is distinguished by the occurrence of long and fine stalactites, all of which are, in the greater part of their mass, transformed into red ore. Some of those, however, which are over an inch thick have preserved a specular kernel, though softened to about 4 in the mineralogical scale of hardness.

The following two analyses, made by Dr. August Wendel, of the Bessemer Steel Works, Troy, N. Y., will show the composition of the Scotia ores, and also the chemical difference between the hard and the soft ore :—

	1. Hard Specular.	2. Soft Ore.
Metallic Iron	69.37	63.15
Silica	0.59	1.52

Alumina	0.11	0.76
Magnesia	traces	traces
Phosphorus	0.016	0.105
Sulphur	0.058	0.095
Water	0.20	7.95

1. Average sample of the hardest speculur ore from the eastern cut (a) of the Scotia No. 1. Looks very pure. Amorphous to sub-crystalline. Hardness, 5½ to 6½. Slightly magnetic.

2. Average sample of soft, red hematite from Scotia No. 1., partly red and greasy, partly earthy and slightly greasy, partly yellow ochre, with numerous small specks of specular ore and fine seams of quartz.

By calculating the peroxide of iron from the above percentages of metallic iron, we find for No. 1, 99.1 per cent.; No. 2, 90.21 per cent.

These analyses show that the hard Scotia specular ore is nearly pure peroxide of iron and nearly free from impurities, while the mixed soft, red, and ochrey ores contain some quartz, some probably hydrated silicate of alumina, a considerable amount of water, nearly twice as much sulphur and six times as much phosphorus as the hard ore. Nevertheless, these soft ores are quite rich in metallic iron.

The chemical changes which have taken place in the specular ore, by its transformation into soft, red ore, consist principally in the introduction of four substances, namely: of hydrated silicate of alumina, which substance very likely produces the greasiness of some of the soft ore; of water in considerable quantity; of phosphoric acid, and of sulphur. The three last-named substances are probably in combination with the iron. Quartz has besides been infiltrated into seams in the ochre. From the loose and porous structure of these soft ores, it must be supposed that some oxide of iron has been removed, and was partly replaced by hydrous silicates and phosphates. I shall come back to this subject in speaking of the Iron Ridge and St. James ores, of which similar comparative analyses have been made.

The high amount of water in analysis 2 is undoubtedly due to the presence of a considerable quantity of yellow ochre in the sample analyzed.

Specular Ores in the Steelville District.—The Steelville ores resemble the Scotia ores very closely, and do not need a special description. Some of the banks of this district seem to be almost entirely composed of hard, specular ore, as the Cherry Valley banks, which, although not yet opened, present that appearance. The ores of some other banks are more or less broken up and altered into soft, red ore, which is here also conglomeratic in its fracture, but less streaky, and more even in its color and general character than the Scotia ore. Distinct crystallization is rarely seen. Stalactitic forms of specular ore, exteriorly converted into red ore, occur at the Cherry Valley banks. Quartz is not often found in these ores. Transformation of surface-ore into brown and yellow limonite is here very frequent, and can be well observed at the Cherry Valley and Ferguson banks. Smaller pieces are often entirely changed. Large bowlders retain a kernel of specular ore with mostly straight and sometimes almost sharp limits, which limits become irregular in such places only, where the small cavities and pores in the specular ore happen to be more numerous. The limonite is much more porous than the specular ore, and a removal of iron has evidently taken place during the transformation. The crystalline particles seem to resist this transformation better than the amorphous or subcrystalline ground-mass; for the limonite contains numerous specks of small, crystalline, specular ore. But the uppermost layer of bowlders is generally free from them, which shows that also these crystals finally become altered. The porousness of the limonite increases toward the surface, and the color gets more yellow, owing to very fine seams of ochre. Close to the specular kernel, the limonite is mostly dark brown, sometimes reddish brown. The cavities in the specular ore near its limit are clad with a brown or reddish-brown, earthy film. With the formation of this film the change evidently begins. This film seems to get gradually thicker and more brown. The small cavities seem to widen and often to run into each other, thus forming larger cavities and spongy masses. The limonite partly remains brown, partly is altered into yellow ochre, permeating the brown ore irregularly in extremely fine seams.

The specular ore close to the limit of the limonite is apparently as hard as ever, and no gradual softening of the ore seems to precede this kind of alteration.

I will add here two analyses of pure specular ores from the Steelville district :—

	Steelville. No. 1.	Cherry Valley. No. 1.
Silica	1.84	1.73
Peroxide of Iron	97.49	....
Alumina	0.07	....
Lime	0.34	....
Magnesia	0.12	....
Phosphoric Acid	0.14	....
Sulphur	0.00	0.16
Metallic Iron	68.24	67.69
Phosphorus	0.061	9.039

The sample from the Steelville No. 1 bank was analyzed by Dr. Otto Wuth, of Pittsburgh, for the "Iron Mining Company of Missouri," and the result published in the prospectus of this company. The second analysis was made by Dr. A. Wendel, of the Bessemer Steel Works, Troy, N. Y., from an average sample taken by myself at the Cherry Valley bank. Most of the latter sample was a pure, crystalline, specular ore. All of it was magnetic, a few pieces strongly so.

These ores are, according to these analyses, very rich in iron, and sufficiently pure for any purpose. In comparing these analyses with those of the Iron Mountain, Scotia, and other ores from deposits which are opened and mined, it must be borne in mind that the former were made with samples picked up on or near the surface, where they may occasionally have taken up some phosphoric acid from the ashes of the grass and brushes, which are purposely burnt off every year in many districts of central Missouri, or some sulphur from the reducing action of decaying plants on solutions of sulphates.

Specular Ores on the Upper Meramec River and its Tributaries.—None of the specular ore-banks in this district are as yet opened to any extent, and my last remark will therefore also apply to them. To judge from the appearance of the surface-ore, some of these banks, as the Winkler, Lamb, Benton Creek, Fitzwater, and Hutchins Creek banks, are likely to contain specular ore almost exclusively, although on all of them superficial transformations into limonite are developed more or less. Others, as the Grover, Arnold, and Smith banks, seem to contain much red ore besides the specular. Both kinds of ore have here about the same mineralogical character as those in the Steelville district.

Pronounced magnetic properties are however, here, more frequently met with. Some of the specular ores from Benton Creek, Fitzwater, Hutchins Creek, and Smith banks are strongly polaric, especially those which are crystalline, or which contain numerous small crystals. Amorphous ores, as they sometimes occur, rarely possess magnetism in an observable degree. Also stalactitic specimens are generally unmagnetic. Some black sandstone, strongly impregnated with iron, but giving a light-red streak, from the Benton Creek bank, has distinct polarity.

Fine stalactitic forms, "pipe-ores," occur on the Smith bank No. 1. Some of these show on their upper side, which was exposed to the atmosphere, a beginning of a change into limonite, while a thin layer on the under side, which was imbedded in loam and sand, is changed into soft, red ore.

Many of these "pipe-ores" consist of clusters of thin, hollow stalactites, regular pipes, one-eighth to one-quarter of an inch in diameter, with comparatively wide holes and thin walls. They are covered on their inside walls with crystals of peroxide of iron, and on the outside with a thin film of dark-yellow limonite. The structure of these thin stalactites, whether hollow or massive, is generally crystalline and granular, rarely radiated. But they are sometimes surrounded concentrically by larger stalactites, in whose hollow interior they lie like a casting in the mould. These larger surrounding stalactites have always a radiated structure. They never close tight to the kernels which they surround. There is always a cylindrical space between the inner wall of the large and the outside wall of the small stalactite. This space is either empty, in which case both walls are covered with small crystals of oxide of iron, or it is filled with soft, red ore, perhaps produced by the alteration of such crystals.

This cylindrical space is sometimes very narrow and nearly filled up with splendent crystals. Thus the fracture of the stalactite shows sometimes a small, round, crystalline surface in the centre, surrounded first by a thin, annular layer of more loose and much more splendent crystals, and outside of this by a thick layer of less bright ore with a radiated structure. These formations sometimes repeat themselves. A specimen I found on the Cherry Valley bank, where they are, however, less frequent, has five layers of radiated ore, alternating with thin layers of either splendent crystals or soft, red ore. The whole stalactite, thus composed, is divided in two halves by a thin crack, running across all the layers and through the thin central kernel, and being filled with the same splendent crystals which form some of the annular layers. The whole stalactite is exteriorly converted into soft, red ore, and lies loose in a conformable cavity in a piece of specular ore, the wall of which cavity is also covered with a layer of red ore.

Stalactites split lengthways, by a thin crack, partly filled with fine crystals of oxide, have also been found at the Scotia No. 2 bank, of which I have spoken before.

I add two analyses of ores from the upper Meramec district:—

	1.	2.
Silica	0.98	17.97
Peroxide of Iron	98.62	....
Alumina	0.05	....
Lime	0.19	....
Magnesia	0.08	....
Phosphoric Acid	0.076	....
Sulphur	0.00	0.21
Metallic Iron	69.03	56.01
Phosphorus	0.033	0.098

Analysis 1 was made by Dr. Otto Wuth, of Pittsburgh, for the "Iron Mining Company of Missouri," and published in their prospectus. The specimen was taken from one of the Smith banks, and was evidently a very clean piece of specular ore.

Analysis 2 was made by Dr. A. Wendel, of Troy, N. Y., from an average sample of the various kinds of rich and poor surface-ore, taken by myself at the Benton Creek bank. This sample consisted only of one half-inch good specular ore. The other half was mostly a dull, black, uncrystalline, very hard, brittle, and silicious ore, mixed with some hard, grainy, and sandy ore of a black color and of a weak, resinous lustre. The object of this analysis was principally to see whether these silicious materials, which sometimes occur, especially at the outskirts of specular ore-banks, are worth smelting, as I supposed they were from their color and weight. The result of the analysis shows that these materials are yet quite rich in iron, though less pure in regard to phosphorus and sulphur. Clean specular ore, from this and all other localities in this district, would undoubtedly analyze as favorably as the above specimen 1.

Specular Ores in the Salem District.—Most of the ores of this district seem to be unaltered specular, corresponding in their properties to the general characteristics of this ore. The small, irregular cavities are very distinct and numerous in them, having sometimes the form of short cracks, wider in the middle and thinning out toward both ends.

Alterations into soft, red ore can be observed on the Arnold, Jamison, Pomeroy, and Taylor banks, and very fine alterations into limonite on the Simmons Mountain, and on the Arnold, Taylor, and Pomeroy banks, in the latter two on a pretty large scale.

Fine specimens of specular ore with a mossy and reticulated structure are sometimes found on Simmons Mountain.

The following observations I made in this district will throw some light on the paragenesis of the various materials connected with the specular-ore deposits in sandstone :—

I found on the Arnold bank botryoidal and mammillary forms of specular ore, clinging directly to a slightly ferruginous but otherwise unaltered sandstone, composed of coarse, loose grains with hardly any cement. The grains are slightly red, apparently from a thin film of red ore deposited on their surfaces. The specular ore is superficially converted partly into red ore, partly into brown limonite.

A specimen from the Taylor bank shows wax-yellow jasper of the same description as that observed at the Scotia bank, filling irregular and reticulated cavities in the ore. Other cavities in the same specimen are filled with transparent quartz. A specimen from the Jamison bank represents a conglomerate of irregular grains of ore, each of which is either partly or wholly surrounded by a variable layer of fine-grained, yellow sandstone adhering to it. They are cemented together by a coarse crystalline, transparent or white quartz.

Infiltrations of transparent quartz in the massive specular ore are frequent on the Jamison bank and on the Simmons Mountain. This infiltration seems to be accompanied or followed by a recrystallization of the ore, or by an alteration of enclosed particles of specular ore into loose aggregates of splendent ore-crystals.

The limonite on the Simmons Mountain is, as most metamorphic limonite, full of pores and of large holes. These holes frequently contain infiltrations of crystalline quartz. Splendent ore-crystals, of a flat, rhombohedric form, are found lying on the quartz. Such ore-crystals are also seen there, lying on films of limonite which cover specular ore. Some of those rhombohedric crystals are themselves again exteriorly, or thoroughly, changed into brown limonite.

The porous limonite on the Pomeroy bank contains yellow ochre in its seams and cavities.

When these observations are held, together with others mentioned previously, and with the following—that the Scotia ores contain seams of wax-yellow jasper in specular ore, seams and specks of crystalline, transparent quartz and of splendent ore-crystals in the yellow jasper, seams of crystalline quartz in yellow ochre, and rhombohedric ore-crystals lying on drusy, crystalline quartz—we come to the conclusion that the order in which these various minerals have come into existence, beginning with the oldest, is as follows :—

1. Sandstone, white or yellow.
2. Sandstone, colored by, or impregnated with, oxides of iron.
3. Massy specular ore.
4. Yellow jasper, perhaps simultaneous with the latter.
5. Soft, red, and greasy ore.
6. Brown limonite.
7. Yellow ochre.
8. Transparent, crystalline quartz.
9. Rhombohedric, splendent ore-crystals.
10. Red and brown incrustations of these crystals.

The specular ores of the Salem district are decidedly more magnetic than any I have mentioned, with the only exception of those from Shepherd Mountain. As the ores in the Upper Meramec district are more magnetic than those in the Steelville district, it is evident that there is a gradual increase of magnetism in the ores, from north to south, from the northern boundary of Crawford County toward the central part of Dent County. Here, however, as in the Iron Mountain and Shepherd Mountain, the magnetism seems to have its seat principally near the surface of the ground. Specimens taken from the south-eastern ore-shaft on Simmons Mountain, about twenty feet below the surface, are nearly unmagnetic, while the ore near the surface in the same locality is distinctly polaric, some of it so strong that pieces two or three inches thick act on the needle from a distance of one to two feet. Pieces from the surface, which are, in the greatest part of their mass, converted into limonite, and contain only irregular and rough seams of specular ore, cropping the limonite in various directions, show nevertheless distinct polarity. Wholly converted pieces are unmagnetic. Magnetic but unpolaric pieces are comparatively rare, and generally attract the south pole and repulse the north pole of a compass-needle. Also stalactitic specimens possess polarity, the polar axis being parallel to the position of the stalactites. The specular ores from the Pomeroy, Taylor, Orchard, Jamison banks, and the "pipe-ore" from the Wiggins bank, have mostly a very strong polarity. Quartz-infiltrations seem to diminish the magnetism.

In the Salem district, as everywhere else in Missouri, unaltered specular ores contain very little sulphur and phosphorus, besides being very rich in metallic iron. The following analyses are proofs of this very important fact :—

	1. Arnold Bank.	2. Simmons Mountain.	3. Jamison Bank.	4. Wiggins Bank.	5. Huzzah Bank.
Silica..............	4.12	1.41	0.94	0.87	2.64
Peroxide of Iron....	95.24	98.14	98.62	98.96	97.26
Alumina...........	0.11	0.06	0.06	.....	.....
Lime..............	0.33	0.24	0.23	.....	.....
Magnesia	0.15	0.11	0.08	.....	.....
Sulphur............	0.00	0.00	0.00	trace	trace
Phosphoric Acid....	0.052	0.038	0.07	.....	.....
Metallic Iron.......	66.66	68.69	69.03	69.27	68.08
Phosphorus.........	0.023	0.016	0.031	0.027	0.03

All these analyses were evidently made with clean specular specimens. Protoxide of iron was not determined, although undoubtedly present in determinable quantity, to judge from the mineralogical properties of these ores, and from the fact that it is invariably found in such ores when sought. Analyses 1, 2, 3, and 5 were made by Dr. Otto Wuth, of Pittsburgh; analysis 4 by Messrs. Chauvenet and Blair, of St. Louis. The three first analyses were made for the "Iron Mining Company of Missouri," and published in its prospectus; the last two for Mr. O. A. Zane, of St. Louis, who kindly put them at my disposal.

Iron Ridge Ores.—Unaltered specular ores from Iron Ridge are similar to the Scotia and Steelville ores in their general mineralogical character. They are rather more porous, and contain frequently enclosures of crystalline, transparent quartz. They are less magnetic than the Steelville ores, and as Iron Ridge is situated north of Steelville, they present a further proof that the magnetism of the ores in the central ore-region decreases toward the north and increases toward the south. Pieces of over three inches' diameter do not deflect a compass-needle. Fine ore-powder is, however, somewhat attracted by a magnet, especially the crystalline and glittering particles. The red ore is unmagnetic. By far the greater part of the ore from the Iron Ridge No. 1 is softened, and altered into a red and frequently clayish hematite. The transition from the specular to the red ore can be observed in the bowlders which are imbedded in the soft mass of ore, which principally constitutes the deposit. When these bowlders, which are sometimes two or several feet in diameter, are broken, the interior is seen to consist of a somewhat porous but pretty hard specular ore, of bluish-gray color, and composed of a subcrystalline matrix with little lustre, and of numerous very small and splendent crystals. Toward the outside of the bowlder the matrix gets softer, more porous, and disappears by degrees, leaving finally a spongy agglomeration of glittering black crystals. This black, crystalline zone in the section of a bowlder is from one-eighth to one-half inch thick. It is surrounded by and passes into a similar crystalline and glittering zone of red color, one-half to one and a half inches thick, which itself gets gradually less bright, then more and more greasy, then mixed with specks and flakes of white clay, and finally turns into a soft, clayish, dull and pale, red hematite, of which a considerable part of the deposit is composed.

The gradual disappearance of the matrix, and the appearance of the clay, are in many bowlders very plain and unmistakable. These two changes are, however, not simultaneous. The white clay is never seen in the black crystalline, and rarely in the red crystalline, zone.

The following analyses, made by Mr. Andrew A. Blair, of St. Louis, will show the chemical changes accompanying this interesting transformation:—

	1.	2.	3.
Silica	0.69	0.68	8.39
Peroxide of Iron	97.94	97.08	88.37
Protoxide of Iron	trace	0.31	....
Alumina	1.17	1.50	....
Hygroscopic Water	0.02	0.08	....
Combined Water	0.19	0.23	3.09
Carbonic Acid	0.00	0.21	....
Sulphur	0.00	0.00	traces
Phosphoric Acid	0.068	0.079	0.207
Metallic Iron	....	....	61.86
Phosphorus	....	....	0.091

The samples 1 and 2 are taken both from the same bowlder, which had a diameter of over 3 feet.

Sample 1 is specular ore, pure, porous, very little softened, from the centre of the bowlder.

Sample 2 is from the outside of the bowlder, more than a foot from the central part, where sample 1 was taken, and consists of soft, crystalline, glittering, and somewhat greasy red ore.

Sample 3 is an average sample, taken from all parts of the mine, and containing some specular but mostly soft ores of all varieties.

We see from the first analysis that the unaltered specular ore from Iron Ridge is free from sulphur, and has but little phosphorus, and is very rich in iron.

The second analysis shows an increase in protoxide of iron, alumina, water, and phosphorus, and a small amount of carbonic acid. The latter is probably combined with the protoxide of iron, being just about as much as is necessary to make carbonate of iron. This would indicate that carbonic acid might have something to do with this transformation, perhaps by dissolving and removing the matrix. As the alumina has increased, while the silica has not increased, we must suppose that either some alumina was added and combined with some of the silica already present, or that some silica was removed and replaced by water, so as to form a hydrated silicate of alumina, which, I think, produces the greasy appearance and touch. Some of the alumina may be or may have been in combination with phosphoric acid.

The analysis 3 proves that the soft and fully transformed ore is not nearly as pure as that in the bowlders—a conclusion which we had already drawn from the comparative analyses made with the Scotia ores.

Specular Ores in the St. James District.—The ores in the St. James district are, when fresh and unaltered, very similar to the unaltered Scotia and Iron Ridge ores. They are, perhaps, a little less porous and a little more magnetic. They occur in very variable conditions and alterations.

The Meramec bank is especially interesting in this respect. There we find very pure and clean ore, generally somewhat softened; we find very hard and silicious ore, containing in its cavities transparent, crystalline quartz and yellow jasper; we find soft, red hematite in all stages of transformation; we find greasy paint-ores in various colors, from light red to dark purple; we find brown and yellow ochres, and porous, soft limonites, with seams of a very fine and uniform reddish-brown clay; we find the spathic iron-ore in specks and seams in red ore and in a peculiar, very dense, yellow, ferruginous limestone; we finally find ferruginous chert-conglomerates and sandstones, impregnated with iron-ore, or intimately mixed with brick-red and yellow ochres. As the Meramec bank was found to contain so many varieties of ore, it seemed to present a fine opportunity for comparative analyses. As, however, time and means would not allow to have a large series of analyses made, five of the most characteristic specimens were selected for this purpose. They were analyzed by Mr. Andrew A. Blair, of St. Louis, with the results given in the following table, under 1, 2, 3, 4, 5.

The two analyses 6 and 7 are taken from a pamphlet, entitled "Contribution to a Knowledge of the Iron-Ores of Missouri," published in 1872 by Prof. Charles P. Williams, Director of the School of Mines of Missouri. They refer to other ores from this district.

MERAMEC BANK.

	1.	2.	3.	4.	5.	6.	7.
Insoluble silicious matter	....	....	11.19	9.30	....	.....	.....
Peroxide of iron	97.23	87.92	85.95	76.45	27.40	84.463	49.245
Protoxide of iron	....	....	0.77	....	4.11	0.783	1.203
Alumina	....	....	0.97	....	....	7.278	none
Lime	....	....	0.12	....	36.01	trace	0.374
Magnesia	....	....	0.07	....	....	0.114	0.000
Carbonic acid	....	....	0.48	....	29.51	trace	0.530
Water, combined	0.47	0.03	0.46	13.65	2.45	trace	0.087
Sulphur	0.00	0.00	0.126	0.052	0.044	0.050	0.022
Phosphoric acid	0.092	0.089	0.116	0.478	0.098	0.153	0.109
Manganous oxide	....	....	0.00	....	....	0.360	0.213
	....	....	100.252	....	....	.....	.....
Metallic iron	68.06	61.54	60.76	53.51	22.38	59.733	35.397
Phosphorus	0.040	0.039	0.051	0.208	0.043	0.066	0.047

Insoluble Silicious Matter.

	1.	2.	3.	4.	5.	6.	7.
Silica	2.06	11.32	9.78	6.78	0.27	6.686	46.330
Alumina	....	....	1.33	....	....	.....	.....
Lime	....	....	0.00	....	....	.....	.....
Magnesia	....	....	0.12	....	....	.....	.....
			11.23				

1. Is an average sample of the best ore found in the Meramec mine. It is a somewhat softened and slightly altered specular ore.

2. Is a hard and silicious specular ore from bowlders in the central and upper part of the Meramec bank.

3. Is a soft, greasy paint-ore of purple color, from pockets in the Meramec bank.

4. Soft and ochrey, porous limonite, brown and yellow, with some thin seams of very fine, brown clay from the outside of some of the bowlders in the Meramec bank.

5. Pretty dense but soft, red ore, and hard, yellow limestone, mixed, both containing crystalline, spathic ore in numerous specks and seams, from the lower part of the Meramec bank.

6. Is an ore from T. 38, R. 6, Sec. 33, probably the "Santee and Clark's bank." Prof. Williams describes the specimen thus:—

"Mammillary and concretionary, with concentric layers, the central one being the blue-specular variety, the second of the brownish-red hematite, and the outer one a thin coating of brown hematite, probably limonite."

7. Is from T. 38, R. 6, Sec. 29, probably the "James bank." Prof. Williams describes the specimen as "finely granular, compact, brownish-red ore."

The analysis 1 shows that the clean specular ore, although in this case slightly decomposed or altered, is very rich in iron, free from sulphur, and does not contain much phosphorus.

Analysis 2 shows that the harder and more silicious ore, when it has the natural color and brightness of a true specular ore, does not contain any more sulphur and phosphorus than the ore which is not silicious.

A complete analysis has been made of sample 3, principally for the purpose of finding out whether the supposition, made above, that the greasiness is produced by a small admixture of very fine and perhaps hydrated silicates of alumina, holds good, or what else may cause it. The result of the analysis does not suggest any other cause, but seems to support the above supposition. As in the 2d of the Iron Ridge analyses, we also meet here with a small amount of carbonic acid, and with a corresponding amount of protoxide of iron, so as to suggest the probability of the presence of carbonate of iron, and to lead us to the belief that carbonic acid is one of the agencies which effect, or at least prepare, the transformation of specular into red ore. Another interesting feature in this analysis is, that the percentage of phosphorus is increased but little, when compared to analyses 1 and 2, and that the increase is about in the same proportion as that from No. 1 to No. 2 of the Iron Ridge analyses. It seems therefore probable that the paint-ore is nothing else but the crystalline and glittering red ore (similar to the Iron Ridge sample 2), in a crushed and compressed condition. The comparatively large amount of sulphur in analysis 3 is also remarkable, and explains the purple color, which is undoubtedly produced by sulphides of alumina, lime, magnesia, and perhaps of alkalies in minute quantities. Analysis 4 gives the practically important result that the yellow ochre contains a very large amount of phosphorus, much larger than any of the other hard or soft ores.

Analysis 5 proves that the peculiar hard, yellow rock in which the spathic iron-ore frequently occurs, is a very dense carbonate of lime, probably mixed with some silicate and phosphate of lime, and with some peroxide of iron. This rock, as well as its enclosures, would deserve a repeated chemical examination, separate from that of the red ore, with which it was mixed in sample 5.

Analyses 6 and 7 are interesting, because, considering the mineralogical description of the specimens, they fully agree with and confirm the results of all the analyses of ores given in this report, and lead to the same conclusions and views regarding those ores.

Specular Ores in the Rolla District.—The Rolla ores are nearly all more or less altered, or at least softened, though many not so much as to lose entirely their specular appearance. Most of them consist of specular and of soft red particles intimately mixed. They do not attract the needle perceptibly, but are attracted by a magnet partially, when powdered fine. Their porosity is very unequal in different parts of a piece or bowlder. Some parts are dense, while others contain irregular cavities up to an inch in length and one-quarter of an inch in width, clad with crystals, or, more frequently, with a film of red ore. Such ores are those from the banks on Big Beaver Creek. They pass into red ores, softening at first, and then changing their color into dark red, and finally getting earthy and lighter red. The ores in the immediate vicinity of Rolla are mostly thus transformed, and besides frequently mixed with spathic iron-ore in specks and seams. This spathic ore sometimes occurs in larger masses, and is then accompanied by white or light-gray clay, enclosing well-formed crystals of iron pyrites, either single or in bunches.

The following analyses were taken from Prof. Charles P. Williams's "Contribution to a Knowledge of the Iron-Ores of Missouri":—

	1.	2.	3.	4.	5.
Ferric Oxide (Peroxide of Iron)........	89.684	97.572	45.968	77.905	83.275
Ferrous Oxide (Protoxide of Iron).....	0.684	0.400	18.988	2.251	1.206
Manganous Oxide......	0.252	0.265	......	0.000	0.715
Alumina..............	0.199	0.802	......	......	traces
Lime.................	2.097	0.568	0.289	......	traces
Magnesia.............	trace	0.166	trace	......	traces
Silicic Acid (Silica).....	2.951	1.144	1.159	......	3.099
Carbonic Acid.........	......	trace	......	......	.....
Phosphoric Acid.......	0.249	0.035	0.281	0.033	0.315
Sulphur..............	trace	0.009	trace	0.094	0.000
Combined Water.......	.....	trace	......	......	.....
		100.981			
Metallic Iron	63.306	68.611	46.944	56.283	59.220
Phosphorus...........	0.109	0.015	0.122	0.014	0.137

The empty spaces in the above table, as well as in all the preceding ones, indicate in each case that the respective substance was not determined. The various specimens are described by Prof. Williams as follows :—

1. From T. 36, R. 7, Sec. 26 (perhaps the Hyer bank). "Blue specular mixed with brownish-red hematite, and containing some limonite and spathic iron."

2. From T. 37, R. 8, Sec. 33 (perhaps the Beaver Creek bank). "Blue specular ore, finely granular and compact; powder gives particles attracted by the magnet."

3. From T. 37, R. 8, Sec. 20 (perhaps the Buckland bank). "Mixed spathic iron and limonite, with some blue specular ore; powder slightly magnetic."

4. From T. 37, R. 8, Sec. 21 (perhaps the Kelly bank, No. 2). No description of this sample is given. It was probably a silicious specular ore.

5. From T. 37, R. 8, Sec. 15 (perhaps Taylor's Rolla bank). "Brownish-red hematite, somewhat cellular, slightly magnetic."

In comparing these descriptions with the above analyses, we see that the samples 1, 3, 5, which enclosed some red hematite, limonite, and spathic ore, contain much more phosphorus than the pure specular ores 2 and 4.

Analyses 1 and 2 show that the specular ores from the Rolla district are as rich in iron as any in central Missouri, and analysis 2 shows that, in an unaltered state, they are nearly free from injurious ingredients. As the same observations have been made regarding the ores of all the other districts, we may infer that these observations are generally true, and generally applicable to all specular ores that have originated in the Silurian sandstones of Missouri.

Gasconade and Miller County District.—The specular ores on the Gasconade River, and in Miller and Camden Counties, are similar to those above described. Some ores near Linn Creek are almost entirely unmagnetic. The specular ores found south of Tuscumbia seem to be very pure, to judge from the following analysis made by Messrs. Chauvenet and Blair, of St. Louis, of a sample from the west bank. This analysis was kindly furnished to me by Mr. M. S. Cartter, of St. Louis :—

Insoluble	11.077
Peroxide of Iron	88.52
Sulphur	trace
Phosphorus	trace
Metallic Iron	61.96

b. RED HEMATITES.

A general description of the red hematite found in the carboniferous formation of Missouri has been given in the introduction to the third chapter of the present report. According to that description there are three varieties of this ore, namely: one, dull-red, soft, earthy, and frequently coarsely porous to spongy, and uneven in the fracture; another, dark, bluish gray, sometimes with a slight submetallic lustre, hard, dense, and compact, with very fine grain, and with a subconchoidal fracture; a third, coarse grained to oölitic, the grains being of the compact ore, and surrounded and cemented by the earthy ore. The earthy variety is the most common. The other two varieties have only been observed in Callaway County. The earthy ore sometimes encloses spathic iron-ore. When exposed to atmospheric influences it is altered into limonite.

Callaway County Hematites.—The red hematites in the subcarboniferous strata of Callaway County occur in the most variable forms. The "Old Digging" and "Murphy's Hill," five miles south-east of New Bloomfield, contain some handsome, coarsely oölitic ore, besides the earthy hematite.

The ores from the vicinity of New Bloomfield are mostly compact and heavy, some bluish gray, others dark red. They frequently show a thin stratification. They are also found in concretionary forms, and seem occasionally to pass into the earthy hematite. They sometimes enclose spirifera and other fossils. Some of the ore on the Henderson bank has an earthy or a finely oölitic structure.

The ore on the Knight bank, near Fulton, is in part dense and concretionary, in part earthy. The latter has a light-red color and streak, and is especially distinguished by the admixture of a large amount of spathic iron-ore in specks and seams. Concretions of this ore are hard, and sometimes reach the mineralogical hardness 6. Spongy hematites are rarely found in Callaway County.

The following analyses were made by Mr. F. Emmerton, of the Joliet Iron and Steel Works, and were put at my disposal through the kindness of Mr. A. B. Meeker, of Chicago :—

	New Bloomfield Ores.		Knight Bank.
	1. Compact Variety.	2. Earthy Variety.	3.
Metallic Iron	63.87	61.17	53.00
Silica	5.80	8.63	....
Phosphoric Acid	0.10	0.165	1.87
Sulphur	0.017	0.018	....

The specimen 3 was of the red, earthy kind, mixed with spathic iron, as above mentioned. This ore is probably altered, and has taken up a considerable percentage of phosphorus, besides the carbonates. The analyses 1 and 2 show that the dense as well as the earthy varieties of these ores, when unaltered and free from carbonates, do not contain a large amount of injurious ingredients, and are very rich in iron.

Hematites in St. Clair and Henry Counties.—The red hematites in the north-eastern corner of St. Clair County, and those in the southern and eastern portions of Henry County, seem to belong exclusively to the soft, earthy, and spongy variety, and are very frequently and extensively altered into soft, spongy, brown or yellow limonites, as far as can be judged from the present appearance of the banks, none of which are as yet opened. The following analysis was made by Mr. A. A. Blair, of St. Louis, from a mixed sample of soft, spongy, partly red but mostly brown hematite, from the Marmaduke bank :—

Peroxide of Iron	84.02
Silica	3.08
Phosphoric Acid	0.861
Sulphur	0.171
Water	10.98
Metallic Iron	58.81
Phosphorus	0.376

This ore has a high percentage of metallic iron, but is not very pure in regard to sulphur and phosphorus. As the specimen had to be taken from the surface, where the ore had been in contact with the soil and its vegetation for a long period, and as it was almost entirely altered into limonite, it may be expected that the ore to be found in the hematite banks of this district, when opened, will contain a much smaller quantity of these substances, and will probably also prove richer yet in iron.

c. LIMONITES.

I have given a general description of the Missouri limonites in the introduction to the present chapter (III.), to which description I must here refer. From that it would seem that two different varieties could be distinguished, the porous and the stalactitic. This is, however, not really the case. Indeed, if we inspect those limonites, which apparently consist of one coherent though porous mass, more closely and more carefully through a magnifying glass, we find them almost invariably composed of single, but densely-packed, round, stalactitic columns, and we find also that the pores, which are seen by the naked eye, are generally interstices left between such stalactites, or between less regular mammillary or botryoidal forms. These pores are distinguished from those found in the specular ores of central Missouri, by sharper and smoother outlines, curved toward the inside of the cavity, thus forming very sharp angles, which point, not in two opposite directions only, but always in several directions. We may therefore say, in general, that all the Missouri limonites, with the exception of some of those produced by transformation of specular ores, are of stalactitic structure and origin.

The appearance of the pores and cavities does not, however, present a perfectly reliable means by which the original limonites might be distinguished, in all instances, from those produced by the alteration of specular ores, for two reasons: first, because the specular ores occur themselves not unfrequently in stalactitic forms, similar to those of the original limonites; second, because both kinds of limonites, and especially those produced by alteration, often lose their original structure entirely, through the influence of atmospheric agencies, both kinds becoming thereby either irregularly streaky or more or less spongy.

Ores in the South-eastern Limonite District.—Several limonite deposits, situated along the Mississippi River, have been favorably reported on by Dr. B. F. Shumard, in his geological reports on St. Genevieve, Perry, and Cape Girardeau Counties, which reports will be found in the second volume of the present (third) Annual Report of the Geological Survey of Missouri.

I have inspected but one locality in this district, namely, the Collins bank in Perry County. The limonite which occurs there is very dense, hard, and apparently silicious, and is frequently mixed with fine chert-breccia. It is also found as an impregnation of sandstone. The ores in the vicinity of Irondale, Washington County, are in part hard and botryoidal or reniform, in part soft and ochrey. They sometimes contain splendent quartz in seams.

The richest part of the south-eastern limonite district is in the southern portion of Iron, Madison, and Bollinger Counties, and in Wayne County. Most of the limonites, which are found abundantly in these counties, are hard, compact, and massive, yet showing distinctly their stalactitic origin in the structure. The Cornwall limonites are softer and more ochrey than the others, but pretty free from foreign mechanical admixtures.

The ores found east of Marquand and Marble Hill are hard, and in many places very pure, while in others they seem to be more silicious, and enclose fragments of white chert, and then resemble somewhat the above-described limonites of Perry County.

The following analyses will show the chemical composition of the south-eastern limonites :—

	1.	2.	3.
Peroxide of Iron	72.58	81.40	80.98
Silica	5.84	3.01	1.98
Sulphur	0.17	0.07	0.00
Water	14.96	11.78	....
Metallic Iron	50.81	56.98	56.68
Phosphorus	0.34	0.15	0.123

The two first analyses were made by Dr. August Wendel, of the Bessemer Steel Works, Troy, N. Y., the third by Messrs. Chauvenet & Blair, of St. Louis. I owe the latter to the kindness of Mr. H. S. Reed, of St. Louis.

Sample 1 was an average sample taken at the Ford bank, near Cornwall, and consisted of one-third hard limonite, and two-thirds soft limonite, mixed with some ochre.

Sample 2 was a hard, dense ore of stalactitic structure, from the Francis bank, 6 miles south of Marble Hill.

Sample 3 was a hard limonite, from the vicinity of Marble Hill.

We see that these ores, although less rich and less pure than the specular and red ores, are, however, good and valuable. We also see that the hard limonites are purer than the soft, ochrey ones.

Franklin County Limonites.—The Moselle limonites, and the brown ores south of Stanton, have mostly a dark color, and are partly hard and dense, partly soft and not unlike a fine sponge. A few banks in the vicinity of the Moselle Iron Works are distinguished by the reniform structure of their ores. These are commonly called "kidney-ores." The single kidneys are sometimes several inches in diameter, and have walls, half an inch thick, of very hard, dark-brown limonite, passing, toward the outside, into an ochrey clay. The hollow space inside these kidneys frequently contains rounded pieces of a very fine, hardened clay of white or yellowish color.

Admixtures of chert are not often seen in this district. But in some localities heavy-spar is mixed with the ore. Also pseudomorphs after pyrites occur, some of which contain undecomposed masses of this mineral in the centre.

The following analysis was made by Dr. August Wendel, of Troy, from a specimen of hard, dark-brown limonite, containing fine, irregular pores, evenly distributed, from the Bowlen bank, south-east of Moselle:—

Peroxide of Iron	81.38
Silica	2.88
Sulphur	0.13
Water	11.70
Metallic Iron	56.97
Phosphorus	0.12

This analysis has a great resemblance with that of the Francis bank ore, as given above.

A good specimen from the Blanton limonite bank, 10 miles south of Stanton, was analyzed by Mr. A. A. Blair, and contained—

Peroxide of Iron	84.16
or Metallic Iron	58.91

Limonites in the Central Ore-region.—A look on the ore-bank map which accompanies this report will show that the central ore-region contains a number of limonite deposits, besides its numerous deposits of specular ore. These limonites resemble those of Franklin County very closely. Some such ores in the Steelville district are very clean and uniform, while some on the tributaries of the Upper Meramec are occasionally mixed with white chert. Heavy-spar has not been found with the limonites of this region. Also pyrites occurs rarely.

Limonites on the Osage River.—The western ore-region of Missouri, on the Osage River, contains almost exclusively limonites. Those on the Lower and Middle Osage River, near Tuscumbia, Linn Creek, Boulinger Creek, and Warsaw, are mostly fine, pure ores of medium hardness and of a very favorable degree of porosity. Their structure is very distinctly stalactitic, and true stalactites are frequently met with on some banks in considerable quantities ; as, for instance, on the Indian Creek, on the Elm Hollow, and on some banks near Tuscumbia. These stalactites are generally round in section, long and thin. Their diameter varies from $\frac{1}{16}$ to $\frac{1}{2}$ inch. They are always massive, and are formed of a dense and hard, grayish-brown ore. They do not show a crystalline structure in their fracture; but the surface is almost invariably covered with small pseudomorphous crystals after pyrites or after marcasites. In some instances these crystals are larger, up to $\frac{1}{4}$ inch in diameter, and constitute the main portion of the stalactitic individuals, which then appear externally to be altogether composed of aggregated crystals. The single stalactites are themselves aggregated either in bunches or in wavy sheets. The inside of bunches sometimes consists of sulphide of iron ; in most cases, however, they are entirely changed into limonite.

That ore, which forms large coherent bodies, and which is much more common than the true stalactites, is also of stalactitic origin, to judge from the shape and distribution of its pores and cavities, and was undoubtedly deposited in caves, from solutions which have been infiltrated from above.

The Osage ores are mostly free from foreign matter. In a few localities only, chert is found mixed with the ore. The walls of the small cavities are generally covered with a layer of brown and yellow ochre. Larger masses of ochre have not been discovered.

While the ores on the Lower and Middle Osage, which I have just described, occur on the Silurian limestones, the limonites on the Upper Osage, above Warsaw, are found on the subcarboniferous limestones, and are also somewhat different mineralogically. They have a very dark, sometimes nearly black, color. The stalactitic structure is less common and less distinct than many of the other limonites occurring on limestones in Missouri. On the other hand, botryoidal and mammillary forms, consisting of numerous thin and parallel layers of dark-brown ore, are very frequent. The single layers peel off from each other easily, and are sometimes naturally separated from each other by fine, empty fissures with rough surfaces. The massy ore, which is more common, is often spongy in the fracture, and is mixed irregularly with small botryoidal masses and seams of a soft but splendent limonite, of nearly black color and of vitreo-metallic lustre.

The chemical composition of the Osage limonites will be seen from the following analyses, made by Mr. Andrew A. Blair, of St. Louis. The first analysis was kindly furnished to me by Mr. M. S. Cartter, of St. Louis :—

	Lower Osage.	Middle Osage.			Upper Osage.
	1.	2.	3.	4.	5.
Peroxide of Iron....	67.07	82.02	84.10	.....	77.42
Manganese........	.....	.....	.....	.....	0.00
Silica...........	.....	5.13	3.59	.....	8.05
Phosphoric Acid....	.....	0.091	0.077	0.084	0.076
Sulphur...........	.....	0.015	0.00	0.084	0.147
Water............	.....	12.80	11.60	.....	12.49
Insoluble matter....	14.27	....	.....	.....	....
Metallic Iron.......	46.95	57.41	58.87	.....	54.19
Phosphorus........	.....	0.041	0.034	0.037	0.034

1. Soft, earthy limonite, from the Laclede bank, near Tuscumbia.

2. Hard limonite, with a stalactitic structure, the pores filled with yellow ochre ; from the White bank, near Boulinger Creek.

3. Loose pipe-ore, broken stalactites, from the Indian Creek bank, near Warsaw.

4. Stalactitic aggregate of pseudomorphous crystals of limonite after marcasite, from the Elm Hollow bank, near Warsaw.

5. Average sample of ore from the Sheldon bank, on Bear Creek; in part a moderately hard, brown limonite, containing some yellow ochre in its pores; in part a very dark, nearly black, mammillary limonite; in part a spongy limonite, with dark-brown, submetallic seams.

All these ores are rich in iron, and contain but little sulphur, while the percentage of phosphorus is so low that they can, in this respect, almost be compared with the specular ores. These limonites on the Osage River are indeed remarkable for their chemical purity. It is also apparent, from the above analyses, that there is no difference in this respect between the stalactites and the massy ore.

Analysis 4 was made for the purpose of investigating whether pseudomorphs after sulphides do not contain a considerable amount of sulphur. The result shows that such pseudomorphs may be as pure as the rest of the ore.

As a part of sample 5 looked nearly black, it was supposed that it might contain some oxide of manganese. The analysis, however, showed that this is not the case.

CHAPTER V.

IRON-ORES OF MISSOURI.

BY ADOLPH SCHMIDT, PH.D.

C. *Modes of Occurrence and Descriptions of Deposits.*

WE have seen in the preceding chapters, II. and III., that two principal mineralogical species of iron-ores are represented in Missouri - the hematite and the limonite—and that the hematite occurs in two very different and distinct varieties, the specular ore and the red hematite.

We have, moreover, seen in section A that the specular ore occurs either in porphyry or in sandstone; that the red hematite forms strata in the carboniferous system; and that the limonite is generally deposited on limestone. This gives us four classes of original ore-deposits. I have mentioned, in the same connection, that the deposits of specular ore in sandstone are very frequently found to be disturbed and broken, and altered in regard to their position. Some of them, according to their present appearance, seem to be broken up entirely, and their parts and fragments seem to be drifted some distance, and to be deposited a second time, either irregularly or in alternate layers, with the sandy and cherty detritus produced by the destruction of sandstones and limestones. Such is the present appearance of many specular-ore banks, as well as that of some deposits of red hematite and of limonite.

Very few deposits of this character, however, have been opened, and none of them are as yet sufficiently opened and worked to allow a clear insight into their structure and formation. It is not impossible, in some instances perhaps probable, that the working of such deposits will lead to the discovery of original deposits in the interior of the same hills on which the former appear, and that these will prove to be only outliers of such original deposits in their vicinity, and not to be beds of far-drifted ore. Their present appearances, however, do not generally indicate this, and we have to judge them by what we can see, to avoid losing ourselves in bold suppositions and speculations. Therefore, as long as the internal structure of these deposits is not better known, we must place them in a separate class, as "drifted deposits."

Thus, for the purpose of a systematic description of the modes of occurrence of iron-ores in Missouri, we are led to assume the existence of the following eight kinds of deposits :—

a. Deposits of specular ore in porphyry.
b. Deposits of specular ore in sandstone.
c. Disturbed deposits of specular ore.
d. Drifted deposits of specular ore.
e. Strata of red hematite.
f. Disturbed or drifted deposits of red hematite.
g. Deposits of limonite on limestone.
h. Disturbed or drifted deposits of limonite.

a. DEPOSITS OF SPECULAR ORE IN PORPHYRY.

The deposits of specular ore in the porphyries of eastern Missouri, especially in St. François and Iron Counties, occur in the most varied sizes and shapes. There are very large deposits side by side with those scarcely workable. There are regular veins, as in Shepherd Mountain and Iron Mountain ; there are regular beds, as in Pilot Knob and in some localities east of it ; there are irregular deposits, some of which somewhat approach veins by their shape, as on Lewis Mountain ; while others have proved to be isolated pockets, as on Hogan Mountain.

The principal and most common kind of porphyry of which the greater portion of the hills in the vicinity of the ore deposits, and in general most of the porphyry-hills in that whole region, are composed, is chocolate-brown to brownish-black in color, and contains numerous small feldspar-crystals, pretty evenly distributed in the matrix. These feldspar-crystals are generally not over one-eighth inch long and about one-half as wide. Some of them are colorless and transparent, others red and opaque, the latter being mostly thicker, without being longer than the former. The red crystals have the appearance of orthoclase, the transparent ones that of oligoclase.

These two kinds of feldspar-crystals occur sometimes separate, sometimes together. I will call this porphyry the brown or normal porphyry. It is very hard and brittle. It breaks in thin and flat splinters with very sharp edges and with a subconchoidal fracture. It breaks very suddenly under the hammer, and the splinters fly off with great rapidity and vehemence.

This porphyry sometimes contains quartz either in light-gray grains or in transparent crystals, colorless or slightly yellow. Also specks of a green mineral, perhaps chlorite, and iron and copper pyrites occur in it. Large masses of a brown feldspathic rock of a dirty-brown color, containing no crystals, and being tougher and softer than the surrounding rock, are frequently met with in this normal porphyry. So are also smaller streaks and masses of red porphyry. The latter are of very variable and irregular shapes, and seem to be produced by accidental infiltrations which changed the color of the rock.

The brown or normal porphyry occurs in some localities flaked and banded, with black, brown, and red, parallel, undulating, thin stripes ; the crystals cutting through the stripes in the matrix. But this porphyry is always massive, never stratified. By gradual decomposition the transparent feldspar turns opaque and white, the red feldspar light brown and yellow. When the whole mass of the porphyry is gradually decomposed by the dissolving action of the atmosphere, or of acid waters on its alkalies, it turns at first pale brown, then light red, then light yellow, and finally white. It gets at the same time more and more soft and friable, and is finally changed into a white or gray or light-yellow, loose, clayish mass, in which sometimes the original feldspar-crystals can be indistinctly recognized, the transparent ones as very white spots, the red ones as yellow spots of a darker shade than the surrounding clay.

Another kind of porphyry, which is less frequent than the former, but occurs in immense bodies, so that large portions of certain hills are composed of it, is the "red porphyry." This porphyry has a light flesh-red color, and contains generally no feldspar-crystals. In very rare instances, however, small, red crystals of a darker shade than the matrix are found in it, either single or irregularly distributed. This porphyry, when entirely intact, is nearly as hard and brittle as the normal porphyry, and breaks then with a subconchoidal fracture. It is, however, rarely found thus—probably owing to its being much more liable to be decomposed than the normal porphyry. As mostly found, it is much softer, rather tough in breaking, and presents, when broken, an even to irregular fracture.

The red porphyry is very frequently inclined to assume a stratified appearance, and in several localities forms regular strata, apparently extending, in uniform thicknesses, over considerable areas. The thickness of the single layers varies from one-quarter of an inch to several inches. These stratified porphyries seem to contain sometimes transparent feldspar-crystals, though very rarely. But they are principally distinguished by the more frequent, though irregular, occurrence of quartz in grains and specks.

The red porphyry passes by gradual decomposition and under removal of the alkalies, at first into a peculiar, light-yellow, soft rock, somewhat resembling an uncrystalline limestone, and finally into a more or less white, loose, clayish mass. Such a clayish mass is the so-called "bluff" on the Iron Mountain. The red porphyry, at its lines of contact with the brown porphyry, either mixes with the latter irregularly, or passes into it gradually by taking up feldspar-crystals and by assuming a darker color. Both porphyries must therefore be considered to be of a similar and simultaneous geological origin.

The red porphyry seems, however, to be in a certain relation, though not a very plain one, to the ore-deposits, and to be in a closer connection with them than the normal porphyry. The latter contains very seldom veins or seams or specks of ore, while all such are very common in the red porphyry. Large masses of red porphyry occur in close proximity to the ore-deposits on Iron Mountain, Pilot Knob, Shepherd Mountain, and Cedar Hill. Certain enclosures in the Iron Mountain veins, the distinct stratification of the ore-bed on Pilot Knob, and other facts to be mentioned hereafter, indicate that both these hills were originally composed of red porphyry.

It might be supposed from this that red porphyry owes its existence to a mere change of color produced by the same influences which caused the deposition of the ore. This is, however, not so ; for the red porphyry, besides being somewhat different lithologically, occurs very frequently without ore, and veins and seams of ore do occur sometimes in the brown porphyry without producing in the latter a decided and uniform change of color. We also see from this that the existence of ore-deposits, although evidently favoring the vicinity of the red porphyry, is by no means dependent upon its immediate proximity.

The question, how iron-ore deposits like those which are found in such variable shapes in these porphyries may have been formed, is one which is treated in a general way in all manuals of geology, and more specially in numerous other geological publications. I will, however, say a few words on this subject, with special reference to these East-Missouri deposits.

It seems to me, in the first place, that these deposits of specular ore, being all of a very similar mineralogical character, being all associated with the same kind of rock, and all situated within a small area of territory, must have been produced by one and the same kind of geological action, although the chemical action may have been different in different localities. Regarding this geological action, we may consider whether the specular ores can have been brought into their present places and shapes by injection in a melted condition, or by distillation in a gaseous state, or by segregation from the adjacent rocks, or by infiltration of chalybeate waters and springs and precipitation from the same.

1. The descriptions of the various deposits which I shall give hereafter will show the impossibility of supposing that the ores were injected in a melted condition. There is no sign of the action of very high heat on the associated rocks. All the enclosures found in the veins and beds of ore are of such a character that they would combine and smelt in a very short time, when in contact with such large masses of melted ore. The ore is found in very thin fissures, of such an extent that a force capable of filling them with melted ore would certainly have opened the fissures, and would have produced thicker veins. Smelted and chilled ore has a very different appearance from that existing in these deposits.

2. A distillation could rather be thought possible. But distillations of iron-salts occur only in volcanoes, and are then mixed with other distilled matters, and never form large deposits. Here, on the contrary, the deposits are very extensive, the ore very pure, and neither lavas nor any other volcanic rocks are found in the ore-region, nor does the configuration of the ground indicate the former presence of any kind of volcanic action.

3. These specular-ore deposits cannot be derived from segregation, by waters penetrating the adjacent porphyries, dissolving iron

out of their mass, and depositing it in the fissures; for, such an action would have altered these porphyries uniformly along the veins and beds, which is not found to be the case. Such segregation could, besides, hardly have produced such immense deposits as on Iron Mountain and Pilot Knob, and would certainly have caused a less uniform structure and frequently stalactitic forms.

4. The specular-ore deposits of eastern Missouri, therefore, must all have been formed by infiltration and precipitation from chalybeate or iron-bearing waters, similar to those which occur still in all parts of the world in the form of chalybeate springs, and are now forming ore-deposits in numerous localities.

All rocks of which the earth is composed are more or less penetrable by water; all are more or less broken or permeated by wide or narrow cracks and fissures; nearly all of them contain iron, some in very small, others in larger quantities. The iron can be dissolved and extracted from these rocks by certain solutions at certain temperatures. From the bottom of the sea, of the lakes, of the rivers, from the surface of the ground all over, waters continually filtrate into the rocks below. These waters all contain more or less carbonic acid and other substances which they take up from the atmospheric air and from the soil. As they descend they dissolve various other matters under various circumstances, from the rocks through which they flow. They follow the easiest and widest channels. They grow warm, and sometimes hot, partly by the natural warmth of the rocks, partly through the heat produced by chemical reactions. The higher temperature and the higher pressure increase their capacity for dissolving mineral matters, with which they become charged as much as the existing circumstances allow. They may contain chlorides, sulphates, silicates, carbonates; they may contain silica, alumina, alkalies, lime; they may contain zinc, lead, iron, etc.

When these solutions have reached a sufficiently high temperature, and happen to find sufficiently easy channels upward, they will rise through such channels, driven by the pressure of the colder and therefore heavier solutions which follow them, and frequently assisted by the development of gases through chemical reactions. In this course upward they will again follow the preëxisting natural channels, wide fissures, small cracks, irregular holes and pockets. When they reach porous or loose strata, they will penetrate and impregnate them. When they come in contact with strata of materials which they are apt to decompose chemically at the existing temperature, they will alter, transform, metamorphose them. When these materials are such as to precipitate oxides of metals from the solution, these oxides will be precipitated and ore-deposits will be formed. The same effect may result when solutions of different chemical composition meet. The same effect must result when such metallic solutions approach the surface, where their pressure and temperature, and therefore their dissolving capacity, is diminished or altered.

As the circulation of waters and watery solutions just described, although locally variable, has existed during the whole geological history of our globe, as it exists still, it is evident that the largest fissures and cavities, when kept filled with however dilute yet continuously renewed metallic solutions for hundreds and thousands of years, under otherwise favorable conditions, will finally become filled with deposits of ores.

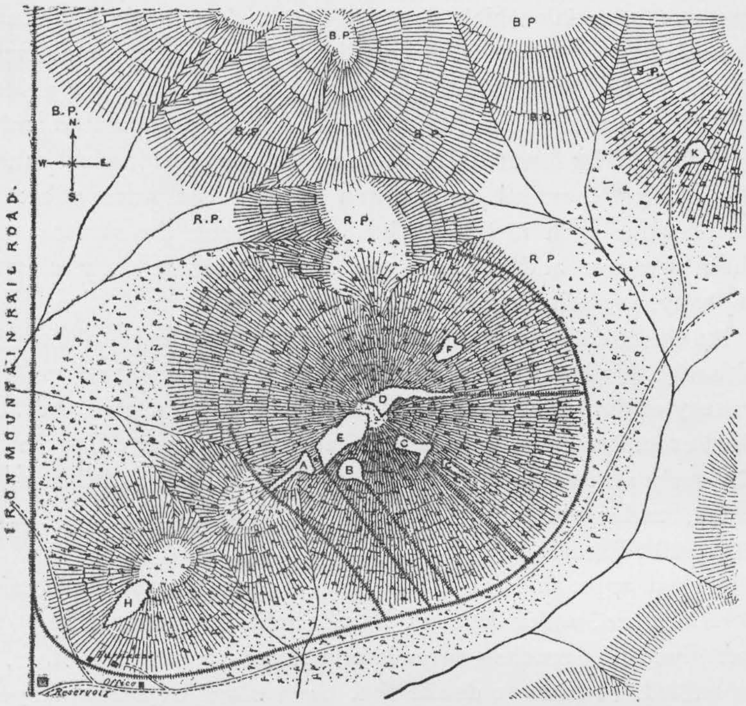
It also appears evident from the above, that the same mineral solutions can, under different local conditions, produce very different kinds of deposits—veins in one place, pockets in another, beds in a third. I have no doubt that the various deposits of specular ore in porphyry, which I will now proceed to describe, were formed in this wise.

Iron Mountain.—T. 35, R. 4, E., Sec. 31, north-east quarter, St. François County. The Iron Mountain is undoubtedly the largest ore-deposit in Missouri.

For the size and exterior description of the Iron Mountain hill, I may refer to page 75 of Prof. G. C. Swallow's Second Annual Report, where Dr. A. Litton mentions and describes it in a very lucid manner. This report was published in 1855, at which time the main part of the hill had not been opened, and no accurate knowledge could then be had of its internal geological structure. The openings which have been made meanwhile enable me to give a more detailed account of it.

The accompanying topographical sketch, Fig. 11, of the Iron Mountain and its surroundings, shows the surface-geology, the distribution of the porphyries, the extent of the surface-ore, and the position of the cuts or openings made by mining operations. The surrounding hills are composed mainly of the normal brown

Fig. 11.



SKETCH OF THE IRON MOUNTAIN

REFERENCES:

LEVELS ABOVE ZERO-LINE		
A – 155'	E – 200'	B.P. – BROWN PORPHYRY
B – 175'	F – 130'	R.P. – RED "
C – 180'+120'	H – 60'	B.C. – BLUE CONGLOMERATE
D – 145'	K – 80'	SURFACE ORE
		LIMITS OF CUTS

Scale. 1200 ft to the inch

porphyry. A zone of red porphyry, frequently mixed with ore in larger and smaller seams and specks, runs along the north side of the Iron Mountain, across the ridge which connects the latter with the hill north of it. This zone of red porphyry thus separates the ore-deposit from the brown porphyry on the north side. The red porphyry in places becomes paler and takes a reddish-gray color. In the eastern portion of the zone the porphyry is half decomposed, forming a soft, yellow rock, which in one place, near its contact with the blue porphyry, is in distinct layers or strata from one to several inches thick, and has sometimes been taken for a limestone.

The red porphyry in the western portion of the zone seems to pass into the normal porphyry, in some places gradually, while in others it mixes irregularly with the latter, constituting a rock of a conglomeratic appearance and of a dull-brown or bluish color, with irregular flesh-red enclosures. This is the case in the place marked B C on the sketch.

The whole surface of the Iron Mountain itself is covered with surface-ore, which also extends over the south-western knob, called the Little Iron Mountain, and reaches into the valley south and west, and across the valley north-west of the mountain, and over a part of the slope of the opposite hill. This surface-ore, which, according to the preceding chapter of this report, is of the same character and composition as the vein-ore, occurs in more or less rounded bowlders and pieces, of very variable sizes, from a diameter of several feet down to a pretty fine sand, all irregularly mixed with each other, as well as with a fine, clayish or sandy detritus of a yellow or red color, and with single bowlders of half-decomposed porphyry. Pieces of a coarse-grained sandstone are sometimes found with it on the south-west slope. The surface-ore generally lies directly under a few inches of soil, and varies from one to five feet in thickness, which is, however, considerably exceeded in some places, especially on the south side, below cuts B and C, where it attains a thickness of 40 feet and over.

The main body of the hill, as far as opened, consists of a loose clayish mass, undoubtedly decomposed porphyry, known amongst the miners under the name of "bluff." This "bluff" and its origin have been described above. It is in the north-western half of the mountain, to the west of the principal ore-vein, of a very uniform and purely clayish character, while on the south-eastern half it has a more conglomeratic character. In this latter half, especially in the northern part of it, the "bluff" contains masses, which, from their partly preserved darker tint and from the numerous decomposed feldspar-crystals they contain, must be considered as being altered *normal* porphyry, while the north-western bluff seems to be exclusively altered *red* porphyry. A large mass of entirely fresh and unaltered, thickly stratified, red porphyry has been struck by the lower cut C, made on the east side through the "bluff." (See Fig. 6.) This mass, which is uncovered to a height of about 30 feet, contains numerous fine ore-seams, and evidently is not in its original position, as the stratification dips about 40° toward the east. Large disturbed masses of unaltered brown porphyry have been struck in cut D, on the north-east side. (See Fig. 17.)

The whole immense clayish mass of decomposed porphyry or "bluff," forming certainly the upper part if not the whole of the Iron Mountain, is cut in two pretty nearly equal halves by an enormous vein of specular ore, from 40 to 60 feet thick, striking N. 53° E., which direction may be observed on the sketch by drawing a line through the cuts A E D F. Whether the main portion of this vein is in a vertical or somewhat inclined position cannot now be ascertained. It seems to be rather irregular in thickness and shape, to be split up in two branches for a part of its length, and to enclose large bodies of broken ore mixed with porphyry. This large and principal vein is called the "backbone" of the Iron Mountain.

The "bluff" contains, however, besides the backbone-vein, numerous other veins of various and very irregular thicknesses, from less than one half-inch up to 6, and in places, 10 feet. These smaller veins cross the bluff in various directions, not subject to any definite rule. The limits between each of these veins and the "bluff" are very sharp, and there is nowhere a gradual transition from the ore into the "bluff."

A line drawn through the cuts A E D F along the backbone, when prolonged in both directions, will pretty nearly touch the cut H on the Little Iron Mountain in the south-west, and the cut K on the hill across the valley in the north-east. As both these cuts have struck large bodies of ore, it seems probable that the principal vein extends over the whole distance from H across the hill to K, which is not much less than a mile.

The Iron Mountain ores have been described in the preceding chapter of my report.

To make the mode of occurrence of the specular ore in the Iron Mountain more plain, I will illustrate the above general description by a few sections taken in the different mining-cuts, adding explanations as far as required or desirable. The position of these cuts, as well as their elevation above the zero-line of the topographical survey, are given on the sketch, Fig. 11.

The cut H, near the blast-furnaces on the Little Iron Mountain, is not worked now; but much ore has been taken out of it and more seems to be left, especially in depth. This place is, however, at least near the surface, greatly disturbed, and the formation is to a great extent composed of displaced materials. The following two sketches present some interesting features :—

Fig. 12.

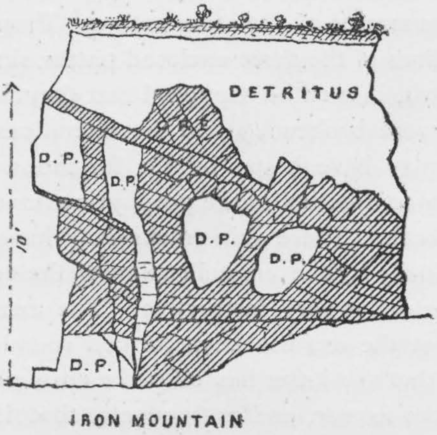
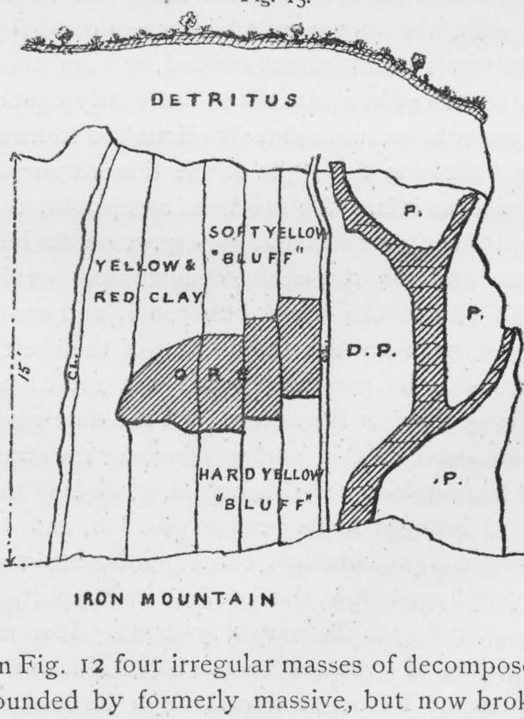


Fig. 13.

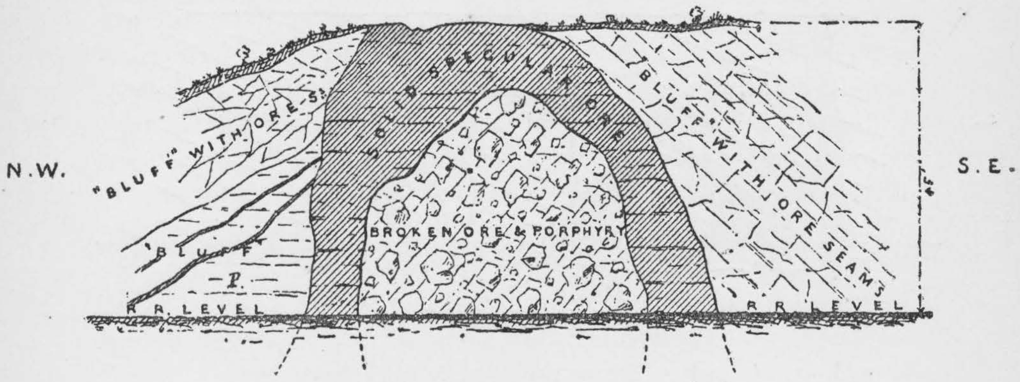


We see in Fig. 12 four irregular masses of decomposed porphyry, (D P) surrounded by formerly massive, but now broken, specular ore. Such enclosed masses of rock are, however, rarely entirely surrounded on all sides by ore, although it looks so in the present section. In digging or blasting, perhaps only a few feet further, an entirely different section would present itself, and the apparently floating masses would be found to be in connection with, or supported by, other masses of the same nature. From the parallelism of the contour-lines of the three enclosed pieces, situated on the left side in the sketch, it must be supposed that they formed originally one mass, but were broken up and the interstices filled with ore. The breaking may have begun by the formation of thin cracks, produced by the contraction of the porphyric mass during its drying or cooling, or both. These thin cracks may have been widened, afterward, gradually by the crystallization of the ore. The jointed structure of the ore is very instructive. The arrangement of the joints shows that the ore has been formed round the preëxisting porphyry, and that the latter has offered a strong resistance to the contraction of the former, and consequently that the porphyry was still hard and fresh when the ore contracted, and that its decomposition took place afterward. Wherever there was an equal resistance on both sides, the ore separated in nearly parallel plates. In the lower part, where no resistance existed, the ore contracted and separated into blocks of irregular shape but nearly equal size.

Fig. 13 represents an undoubtedly disturbed formation. That portion of it which is to the right of the thin clay-seam (Cl) may have been formed as it is. We see here an upright, ramified ore-vein, having on the right side solid porphyry, on the left side, between the vein and the clay-seam, decomposed porphyry. The mass to the left of this clay-seam, between it and another thicker clay-seam, to be seen on the utmost left of the sketch, was evidently not formed in its present position, but must have slid into this position long after its formation. At the time when the thick mass of ore enclosed in this part was formed, the stratification in the porphyry was undoubtedly horizontal, while it is now vertical. When afterward brought in its present position, and when, owing to the gradual decomposition and consequent contraction and softening of the porphyry below, the ore lost its support, it broke off in plates corresponding to the porphyry-strata. It is not unlikely that its natural jointed structure has predisposed it to that effect.

Fig. 14 represents a cross-section through the backbone-vein in

Fig. 14.



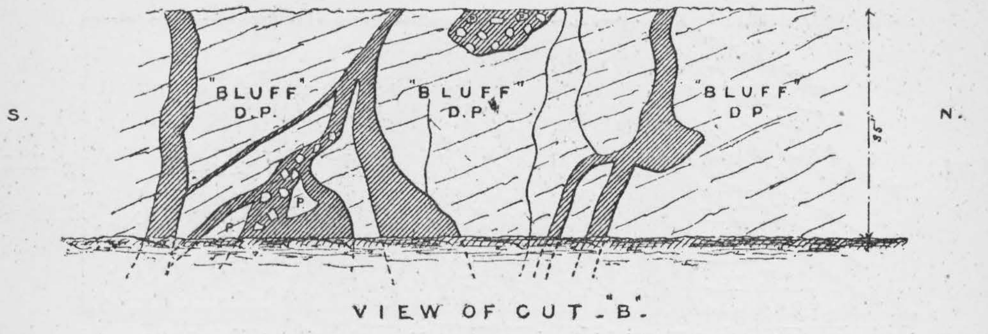
SECTION OF CUT "A".

cut A, the working-level of which is about 60 feet below the summit of the Iron Mountain. The vein is here divided in two branches, from 12 to 18 feet thick each. These branches join above, enclosing a mass of broken ore and porphyry, mixed with quartz and apatite. This mass seems to be the product of destruction of numerous smaller ore-veins in porphyry, formerly existing in this same place or close by. The porphyry may have been broken up by the crystallization of the ore in its seams, and the ore by contraction and by the decomposition of the porphyry. All the pieces of ore have sharp edges and corners. All the porphyry is more or less decomposed.

P is slightly decomposed, but yet pretty hard, porphyry, passing into the loose, clayish "bluff" above it. The "bluff" on the south-east side of the vein is all a loose, soft clay of a yellow color. The surface of the big vein is wavy and very smooth. The small ore-veins which cross the "bluff" in all directions vary from one-fourth to 3 inches in thickness, a few near P are up to 12 inches thick. The "bluff" does not contain any ore outside of these veins.

Fig. 15 gives a section of a characteristic part of cut B. This section shows in what a varied and often peculiar manner the smaller ore-veins cross the mass of the "bluff," enclosing larger and smaller pieces and blocks of decomposed porphyry, frequently changed into soft clay. Most of these veins strike about east-west in this place. The ore has the same mineralogical character as that of the backbone-vein. It contains perhaps a little more

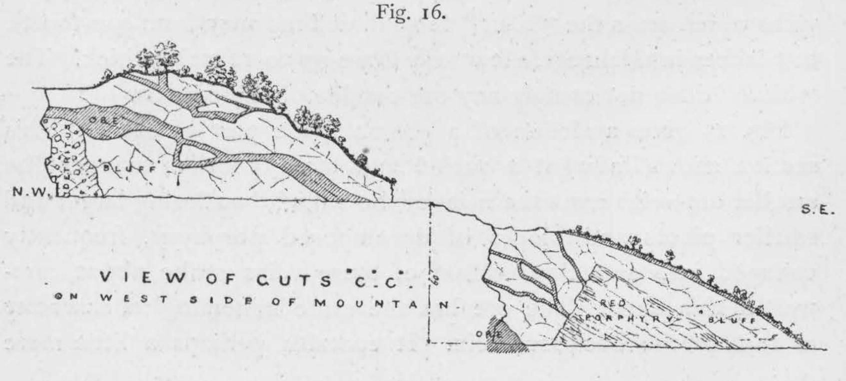
Fig. 15.



quartz and more apatite, or crystalloid holes formerly filled by apatite. These holes are generally sitting on the walls of the veins. The ore resembles the surface-ore closely. The smaller the veins are, the more impurities they contain in proportion to the quantity of ore. The "bluff" is here very plainly a decomposed porphyry, sometimes imperfectly decomposed, in which case it is composed of a bluish-gray or bluish-brown matrix, enclosing white, decomposed feldspar-crystals. It seems from this appearance that a large part if not the whole of the "bluff" in this cut is derived from the normal porphyry.

Fig. 16 represents a section through both the cuts C C, which lie about in one vertical plane, on the south-western slope of the Iron Mountain. The upper cut is about 60 feet, the lower one 120 feet, below the summit. The upper cut shows another characteristic section of veins running through the "bluff." What is marked as "detritus" is composed of blocks and pieces of colored clays

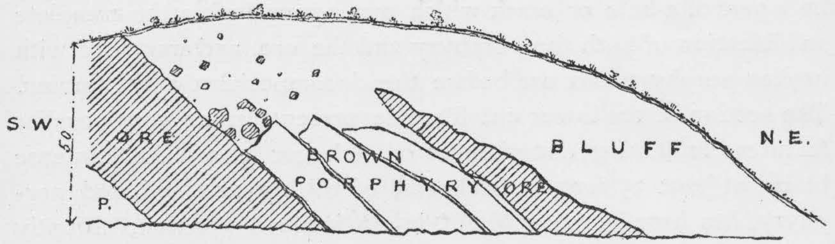
Fig. 16.



(decomposed porphyries), mixed with ore in pieces, the latter also somewhat softened by partial decomposition. Irregular holes and cracks in this mass are filled with yellow and red loam. This must be a part of a hole or crack which was opened after the complete solidification of both the porphyry and the ore, and was filled with broken porphyry and ore before the decomposition of the former. The section of the lower cut likewise presents some very peculiar features, indicating disturbances on a larger scale. An immense block, at least 35 feet in thickness, of thickly-stratified, red porphyry, lies here in the "bluff" in an inclined position, abruptly cutting off the ore-veins. This flesh-red porphyry is hard, and entirely fresh in its fracture and color, and encloses numerous ore-seams, one-quarter to 3 inches thick. This block was evidently exposed to the influence of the solution that deposited the ore, but not exposed to those influences which produced the decomposition of the rest of the porphyry. To explain this satisfactorily, we must suppose that this decomposition was not effected by atmospheric influence exclusively, but that it was effected partly, or at least prepared and begun, by acid solutions, and that this block would have occupied an isolated or elevated position, while this, perhaps, preparatory action took place, and that it could not then be reached by the solutions. Afterward this block may have fallen over on the slope of the hill, sunk into the "bluff" gradually, cutting off the ore-veins, and may finally have been covered by a layer of bluff-clay washed down from the hill. The somewhat irregular character of the "bluff" overlying it seems to support this theory; otherwise the strange position of this block could only be explained by assuming that it was raised from below after the decomposition of the overlying porphyry.

However this may be, the presence of this intact, red porphyry with ore-seams, proves that the geological action by which the veins were filled was not the same as that which decomposed the porphyry, but that the latter took place much later than the former. For it might be supposed that the decomposition of the porphyry and the deposition of the ore had been effected, if not by the same solution, at least by a simultaneous chemical action. Another fact, however, besides the above, speaks against these suppositions. We find on Iron Mountain no instance of a total or partial replacement of porphyry by iron-ore, which replacement would have been the unavoidable consequence of such a simultaneous chemical action, as I propose to show in my description of the Pilot Knob deposit.

Fig. 17.



VIEW OF CUT "D"

In Fig. 17, which represents a section of cut D on the north-east slope of Iron Mountain, we find the brown or normal porphyry in a disturbed position, similar to that of the red porphyry in Fig. 16. We also see a cross-section of the north-east part of the back-bone-vein, which is here in one solid mass, about 30 feet thick, and inclined toward the north under an angle of about 50 degrees.

P is a part of an immense solid mass of hard and intact normal porphyry, underlying the backbone-vein and being in close contact with it. This porphyry frequently contains specks and thin seams of green chlorite (?). Thin seams of ore also occur, though very rarely. The porphyry overlying the vein, in three flat pieces of a rather variable thickness from 3 to 10 feet, is very nearly of the same description. These three flats of porphyry, however, are not in close contact either with the backbone-vein, or with each other, or with the flat mass of ore that overlies them. All these masses lie loose over each other, being in contact at certain points only, while separated by clay-seams or empty spaces at other points. The "bluff" contains here no continuous ore-veins, but only single pieces of ore in such positions and so distributed as indicated in the above illustration.

This locality, as well as the whole north-eastern portion of the Iron Mountain, has evidently been subjected to great disturbances long after the formation of the ore and after the decomposition of the porphyry. The fact that the backbone-vein has not, so far, been struck by the cut F, which is situated on the line of its strike, and the presence of the above-mentioned conglomerates a little farther east, support this view, besides the appearance of cut D.

In the neighborhood of cut K, on the hill north-east of Iron Mountain, we find both the red and the normal porphyries. According to Dr. Litton's description (see Second Geol. Report, 1855) of a well bored near the furnaces, porphyries and large masses of ore exist there to a depth of more than 150 feet, overlaid by some magnesian limestone and sandstone. This shows that the porphyries are pre-Silurian, which fact is verified by numerous observations made in other localities.

When we look over all that has been said about the Iron Mountain, the geological history of this deposit naturally presents itself as follows :—

The whole Iron Mountain was composed originally of porphyries, which also filled the valley east and south of it.

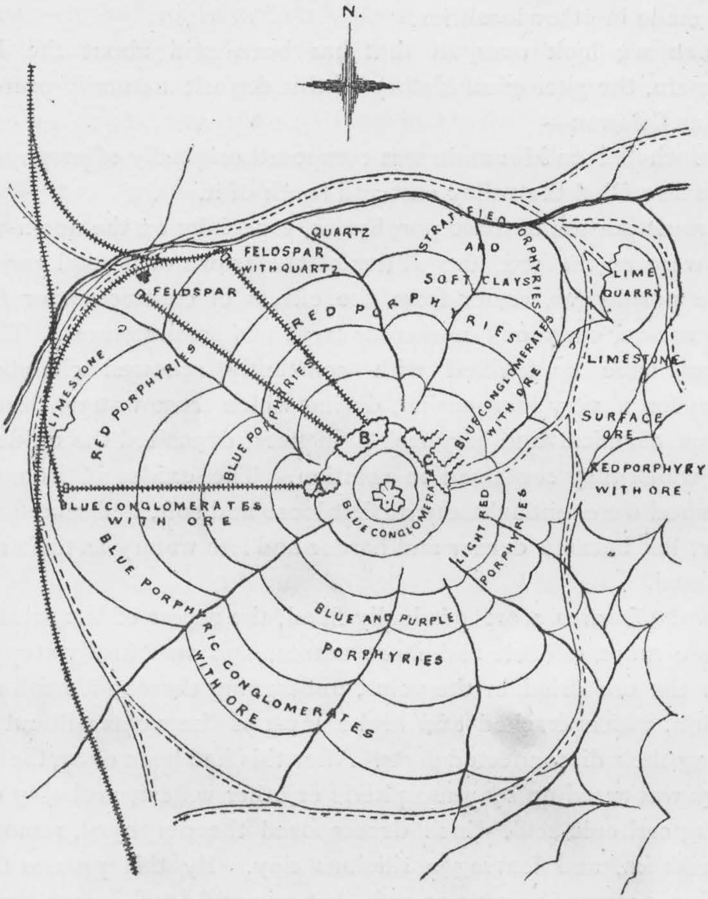
A great portion of these porphyries, especially on the north-west side, were of the red, the others of the brown or normal variety. These porphyries, either from the effects of contraction or from other causes, contained numerous large and small fissures. These fissures were kept filled with constantly renewed chalybeate waters for a very long period, during which these waters, through various chemical and physical influences, deposited the oxides of iron, which they contained in solution. The oxides of iron thus deposited were undoubtedly at first loose and soft, and mixed with water, but became denser and harder and less watery as their mass increased.

As the fissures were gradually filled, the access of the solutions became more difficult and more scarce, and was finally stopped. Then the ore dried in the veins, undergoing thereby a small contraction, which cracked and broke most of the veins without displacing their disconnected parts. After this had been done, the porphyry was acted on by atmospheric or other waters, probably containing carbonic acid, which decomposed the porphyry, removing the alkalies, and leaving a silicious clay. By this process these porphyric masses became so soft that rain and flood waters washed them off readily, the consequence of which was that, simultaneous with the erosion of the valleys, the cracked and disjointed ore-veins lost their support, and fell to the ground in single bowlders and pieces, thus forming the beds of surface-ore which now cover the slopes of the hill, and which fill a part of the now-eroded valleys.

Pilot Knob.—T. 34, R. 4, E., Sec. 29, Iron County.—For the dimensions and the external appearance of Pilot Knob, I refer to Dr. A. Litton's description, given on page 79 of the "Second Annual Report of the Geological Survey of Missouri."

I give hereby, in Fig. 18, a topographical plan, showing the surface-geology of the Pilot Knob :—

Fig. 18.



SURFACE GEOLOGY OF PILOT KNOB

Although the surface-geology does not always give perfectly reliable indications regarding the interior geological structure of a mountain, it generally allows us to draw certain valuable conclusions. The ore on Pilot Knob is not in veins, but forms a regular bed in the porphyry. The top of the Pilot Knob, according to our sketch, is composed of "blue conglomerates." These consist of a dark, bluish-gray, porphyric matrix, enclosing large and small, but mostly sharp-edged, pieces of a light-gray, or reddish-gray to reddish-brown, porphyry. No distinct feldspar-crystals are visible in it. But the blue matrix contains numerous small, almost microscopic, crystals of iron-ore, more or less equally distributed through its mass. These conglomerates are all strongly magnetic with polarity. They have frequently a distinct though wavy stratification.

They form large groups of rocks on the summit, and compose the upper part of the mountain itself, directly overlying the ore-bed, into which they pass by degrees, becoming more and more impregnated with ore and mixing with ore irregularly above the bed. They also lose their conglomeratic character in this direction, and a few feet above the ore-bed constitute a uniform bluish-gray porphyry, strongly impregnated with ore, and containing thin layers of a fine conglomerate.

Their maximum thickness, measured to the top of the rocks, may be estimated at an average of about 100 feet; that of the ore-bed at about 40 feet. Immediately below the ore-bed we find the same uniform bluish-gray porphyry, which directly overlies it, also mixed with small ore-crystals, although in a less number. These "blue porphyries" are likewise found on the surface for some distance down the slope of the hill, as is indicated on the above sketch. All of them contain a little ore in very minute, isolated crystals, not often visible to the naked eye.

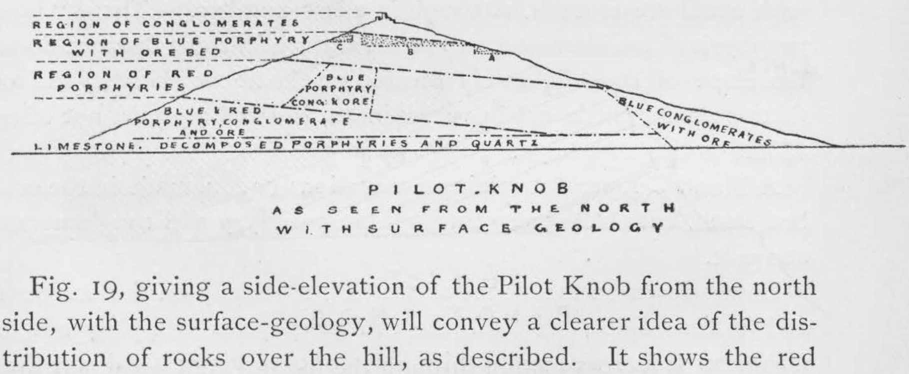
A B and C represent mining excavations or cuts made in the ore-bed itself, but cutting also through the porphyry and conglomerate above it.

Lower down on the slopes of the hill, especially on the northern and eastern sides, we find the red porphyries cropping out in masses of such a size and position as to leave very little doubt that a large portion if not the whole of the middle and lower parts of the hill must be composed of them. They are mostly hard and unaltered, and correspond in their appearance to the general description given above, containing but rarely admixtures of feldspar-crystals or of quartz.

Such is the distribution of the rocks on Pilot Knob. We notice, however, two streaks of "blue conglomerates with ore," running down the hill, one on the north-east and one on the west side. These conglomerates, with specks and impregnations of crystalline ore, are similar to those found on the summit. They are all broken up, in pieces and bowlders, partly decomposed, and are evidently washed down from above. This seems to have taken place on quite a large scale on the west and south-west sides, where these broken and either partly or entirely decomposed masses are spread in considerable thickness over a large area, and reach down to the foot of the hill. The ascent of the Pilot Knob is much less steep there than on the northern and eastern slopes. These loose masses are to a great extent altered into white or yellow clay. Several shafts have been sunk into them to a depth of near 70 feet without reaching the solid rock. We find another, though smaller accumulation of broken and decomposed materials along the foot of the hill on the north side. There we find also feldspathic rock, feldspar mixed with quartz, quartz without admixture, and pieces of stratified porphyry.

In a few places at the foot of the north-eastern and north-western slopes we find deposits of magnesian limestone, apparently overlying the porphyry.

Fig. 19.



PILOT. KNOB
AS SEEN FROM THE NORTH
WITH SURFACE GEOLOGY

Fig. 19, giving a side-elevation of the Pilot Knob from the north side, with the surface-geology, will convey a clearer idea of the distribution of rocks over the hill, as described. It shows the red porphyries spreading over the lower two-thirds of the hill, but partly covered by decomposed materials and by loose, broken porphyries and conglomerates. Higher up it shows the region of the blue porphyries, with the mining-cuts A B and C, which indicate the position of the ore-bed. It finally shows the conglomerates on the summit.

It must be remarked that this sketch does not represent a section, but a view of the hill. It is, however, probable that it would represent a pretty correct section through the Pilot Knob from east to west, if we would mark the whole mass below the "region of blue porphyry" as "red porphyry," leaving off the mention of the various detrital materials, which probably only cover the surface to a certain depth.

The ore-bed, and the stratified conglomerates above it, dip toward the south-west from 13 to 22 degrees, according to Professor Pumpelly, who also found the strike to be S. 50° E.

I will add here some sections through the ore-bed, as they appear in the three mining-cuts A B and C on Pilot Knob, to illustrate more fully the mode of occurrence of the ore in this deposit. The ore itself has been described in section B of this report.

Fig. 20.

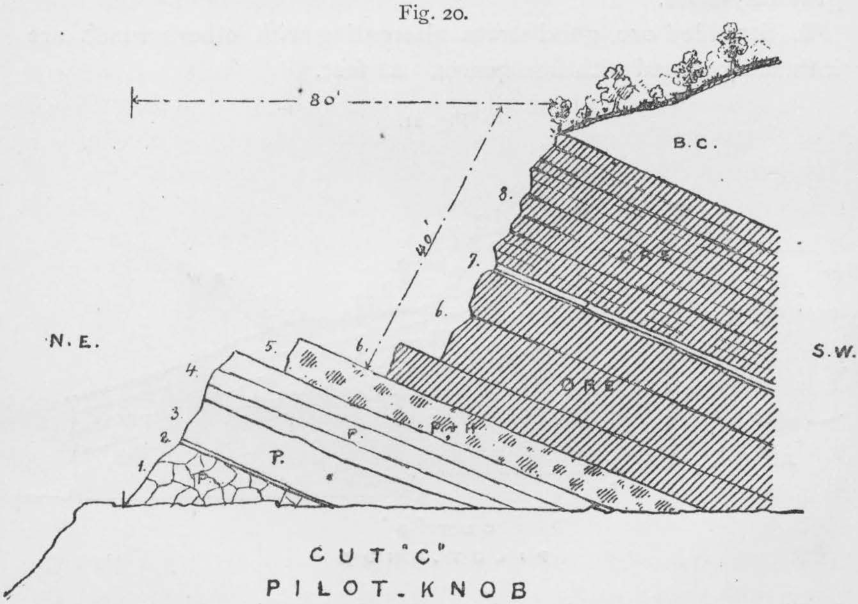


Fig. 20 is a cross-section through the highest and most eastern cut C made in the upper outcrop of the ore-bed. This section shows the following consecutive strata :—

1. Broken-up porphyric mass, without stratification, containing numerous irregular fissures. Its color is bluish gray. It encloses flakes of green serpentine, and small masses of white clay and of half-decomposed red porphyry. The thickness, as far as uncovered, is 15 feet.

2. Seam of hard, blue porphyry. 3 inches thick.

3. Compact porphyric mass, partly bluish gray, partly reddish brown, containing some serpentine in fissures. 10 feet. Between 3 and 4 is a large empty fissure, parallel to the strata, evidently produced by a sliding motion of layer 4 over layer 3.

4. Bluish-gray porphyry, distinctly stratified. Strata parallel to those of the ore. 8 feet.

5. Dark-blue, nearly black porphyry, mixed with ore irregularly. 4 feet.

6. Good-looking though silicious specular ore. 16 feet.

7. Is composed of three parts, namely, a 1-foot stratum of hard, red porphyry without ore, a 1–2 feet stratum of ore, interstratified with red porphyry in very thin layers, and a 1-inch seam of light-gray clay-slate.

8. Stratified ore, good strata alternating with others which are intimately mixed with fine quartz. 22 feet.

Fig. 21.

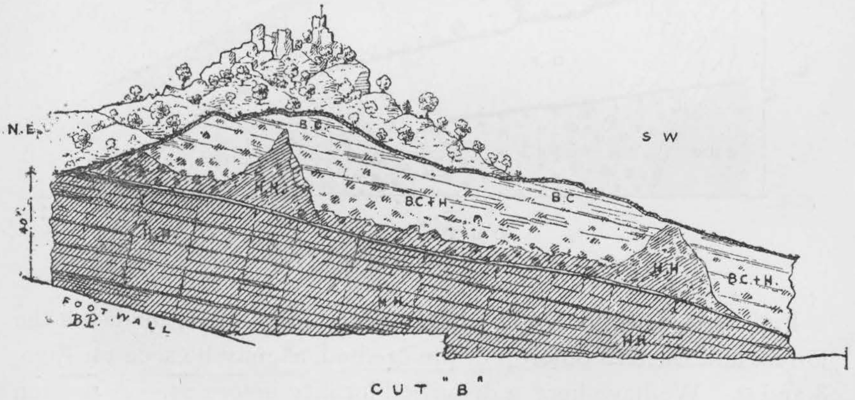
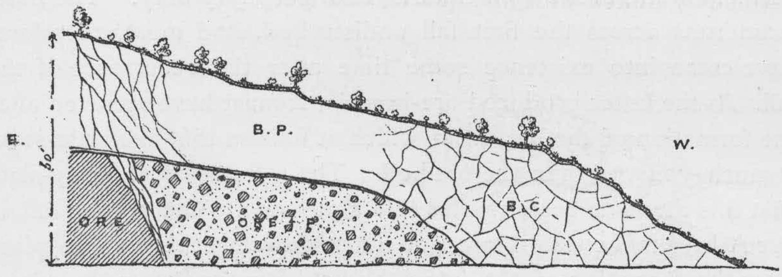


Fig. 21 represents the main cut B, which is about 420 feet above the valley west of the knob, and 160 feet below the highest point. This figure shows the foot-wall, consisting of a slightly ferriferous, blue porphyry; the main ore-bed (H H) nearly 40 feet thick, consisting of somewhat silicious specular ore, stratified more or less distinctly; a seam of light-gray clay-slate, varying from 6 to 18 inches in thickness, and containing no particles of ore whatever; another irregular layer of ore (H H) above the seam, mixing gradually with and passing into the blue conglomerate (B C).

The ore in the central part of the cut below the slate-seam is considerably softer than that either east or west of it. Analyses of these various ores have been given in section B.

If the slate-seam in cut B, Fig. 11, is the same as that in cut C, Fig. 10, as it appears to be, the thickness of the ore below the seam diminishes considerably toward the south-east, while the thickness of the ore above the seam increases in the same proportion, leaving the total thickness of the ore the same. The absence of ore in the slate-seam makes it probable that this seam is of later origin than the ore, being, perhaps, produced by a slide of the upper part of the bed over the lower part, whereby, through the irregularities of the surfaces, an empty fissure was left in places, similar to the empty fissure between layers 3 and 4 in Fig. 10, and was gradually filled up with a fine clay washed into it by surface-waters.

Fig. 22.



CUT "A"
PILOT-KNOB

Fig. 22 is a section exposed by the mining-cut A, made on the lowest and western outcrop of the ore-bed, as may be seen on Figs. 8 and 9. We have here a disturbed locality before us. A portion of the ore-bed may have been underwashed here, broken off, and fallen down on the slope of the hill, the débris being then either carried away by floods or buried under the porphyric detritus. We see, therefore, in this cut an abrupt end of the ore-bed below the slate-seam. Above the ore and the seam, and close to the ore below the seam, is a nearly vertical streak of broken porphyric masses with some ore, permeated nearly vertically by numerous fissures mostly filled with red, yellow, and white clay or loam, washed into them from above. The porphyric parts are to a great extent converted into green steatite. Many pieces are thus altered on the outside, while the inside is yet tolerably fresh porphyry. The broken ore is poor and silicious, similar to the less pure ore above the slate-seam in cut B. This whole irregular and mixed mass was evidently produced by a fall, and subjected, during a long period, to the influence of surface-waters. Adjoining it, below the seam, we find a breccia of ore, imbedded in more or less fine porphyric detritus, above the seam a mass of blue, ferriferous porphyry (B P), which is solid where the slate-seam is in its natural position, but broken up into a blue conglomerate (B C) where the slate-seam makes a sudden turn downward, indicating another break-down, produced by an underwashing of the stratum of blue porphyry.

The cut A, according to this description, presents two disturbances or falls, which have occurred at different times. The one affected the ore-bed and all the overlying strata; the second, of smaller extent, broke up a thick layer of porphyry only. The slate-seam runs across the first fall undisturbed, and must, therefore, have come into existence some time after the occurrence of the fall. As the latter produced ore-breccia, it must have occurred after the formation of the ore, from which it follows that the slate-seam is much younger than the ore-bed. The softness of the clay-slate that fills the seam corroborates this statement. The second fall in cut A breaks the slate-seam, and must therefore have taken place after the formation of the latter, and a long time after the occurrence of the first fall, and after the formation of the ore-bed.

As to the extent of the Pilot Knob deposit, we find, by throwing a look on the map, Fig. 8, that as far as opened at present, by the three cuts, A, B, and C, it seems to cover a triangular area, measuring 1,000 feet along the base, from east to west, and 600 feet in the height of the triangle. But the fact that the ore-bed dips in the south-western direction, at nearly the same angle as the surface of the ground, leaves the possibility of its extension over a considerable distance in that direction.

In regard to the geological and chemical action which may have created the ore-deposit on Pilot Knob, we must recall the introductory remarks on the formation of the specular-ore deposits of this region in general. Referring to this deposit specially, I fully agree with Professor Pumpelly, who, by more detailed and more thorough investigations, has come exactly to the same conclusion, namely, that it has been formed by a gradual replacement of stratified porphyry by ore, effected by solutions similar to those which deposited the ore in the Iron Mountain and in the other places.

The stratification of the ore-bed, and of the impregnated and half-metamorphosed porphyries overlying it, is very plain and regular.

Stratified porphyries are found at the foot of the north-eastern slope of the knob, and very extensively in a large district east of it; but C, Fig. 20, shows a layer of red porphyry interstratified with ore.

The general appearance of the ore-bed, especially as shown in cut B, Fig. 21, as well as the appearance of numerous single specimens, and the partly impure and silicious character of the ore, naturally suggest the idea of an impregnation and gradual replacement of porphyry by ore, besides other circumstances mentioned in my introductory remarks.

Furthermore, such a replacement is not only possible, but it must be expected, at least partially, under certain circumstances.

When a solution of sulphate or chloride of iron, containing also carbonic acid, remains during a long time in contact with porphyry, the carbonic acid will decompose the porphyry, combining with its alkalies and dissolving them. The alkaline carbonates will almost simultaneously precipitate oxides of iron from the solution, and these oxides will fill the pores produced in the porphyry by the removal of the alkali. The silica is thereby set free, and will perhaps also to a small extent be dissolved, but the greater part of it will remain mixed with the ore, and make the latter silicious. The removal of the silicate of alumina contained in the porphyry is more difficult to explain. It has been shown, however, by Bischof, in his *Lehrb. d. chem. und phys. Geol.*, ed. 1863, vol. i. p. 86, that silicates of alumina can be decomposed by bicarbonate of iron in solution, and removed in the form of a soluble bisilicate of alumina and iron.

Considering, in our present case, that the solutions producing the transformation did not act perhaps on silicate of alumina previously existing as a free substance, but that they may be supposed to have acted on silicate of alumina which was undergoing at the same time its separation from the alkalies, and therefore, *quasi in* *statu nascendi*, various other modes of decomposition or solution may be thought of.

This is not, however, the place to discuss such questions. My only purpose in touching them was to show the possibility of a chemical action, by which the formation of the Pilot Knob deposit by replacement may have, and undoubtedly has, taken place.

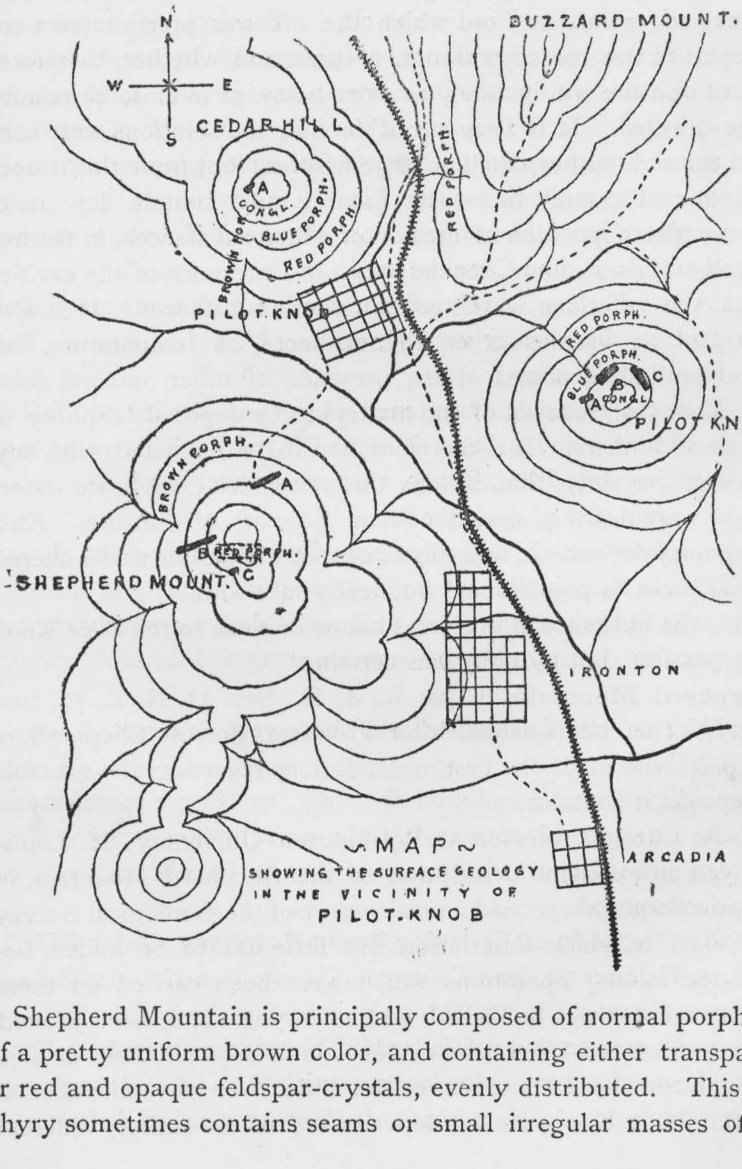
Another question regarding the formation of this deposit, is, whether the solutions from which the ore was precipitated were conveyed to this locality through fissures, and whether, therefore, veins of iron-ore will be likely to exist below or in close proximity to the ore-bed. It is very probable that the solutions were conveyed through either small or large fissures; but from this it does not follow necessarily that these fissures must contain deposits of ore; for the deposition of ores or of other substances, in fissures or cavities, is not alone dependent on the presence of the cavities and of the solutions which contain these substances. It is also dependent on various other circumstances, as temperature, unlimited or limited access of air, presence of other mineral solutions, facility of renewal of the matters to be deposed, rapidity of motion, and others. It is therefore not to be expected, with any degree of certainty, that cavities through which chalybeate waters flow, or were flowing, should contain deposits of iron-ore. Also a temporary deposition, and subsequent re-dissolution under altered circumstances, is possible and frequently met with.

Thus, the existence of ore-veins below or close to the Pilot Knob bed is possible, but by no means certain.

Shepherd Mountain, T. 34, R. 4, E., Sec. 31, N. E. ¼, Iron County.—This hill is named after Professor Forrest Shepherd, of St. Louis, who made the first investigations regarding the valuable ore-deposits it contains.

Dr. A. Litton, Professor at Washington University, St. Louis, has given an excellent description of the Shepherd Mountain, in Professor Swallow's second annual report of the Geological Survey of Missouri, to which description but little has to be added, because the mining operations which have been carried on there since that report was published, seventeen years ago, have proved the correctness of Dr. Litton's views, in nearly all their details. Although Shepherd Mountain is but little over one mile distant from the Pilot Knob, its ore-deposits are of an entirely different character, being unquestionably veins, which, if they do not cut through the hill in its whole width, certainly extend over considerable distances. I give, in Fig. 23, a small map showing the relative position of the Pilot Knob, Shepherd Mountain, and Cedar Hill, also indicating the surface-geology of that district.

Fig. 23.



Shepherd Mountain is principally composed of normal porphyry, of a pretty uniform brown color, and containing either transparent or red and opaque feldspar-crystals, evenly distributed. This porphyry sometimes contains seams or small irregular masses of red porphyry, which look as if produced by changes caused by infiltrations of some kind. The brown porphyry is in places beautifully banded, but never stratified. Some of it, on the upper part of the hill, is magnetic with distinct polarity, and is then found to be intimately mixed with single, microscopic particles of ore, absolutely invisible to the naked eye. The porphyry close to the ore-veins is considerably decomposed, quite soft, and mixed with large masses and veins of red and white clay. These clayish masses are sometimes impregnated with ore, or permeated by small veins of ore, which veins also penetrate more or less into the solid and intact porphyry. On the summit of the hill, south-east of cut B, we find a zone of red porphyry, about 50 feet wide, running across the hill from east to west, as indicated in Fig. 13.

Three places have been opened on Shepherd Mountain, marked respectively A, B, and C on the map.

Cut A has disclosed a vein of specular ore, with some magnetite, 10 to 20 feet wide, nearly vertical, striking N. 62° E. (true). This cut is about 500 feet long.

Cut B on the west side has opened a length of about 1,000 feet of a quite similar vein, striking N. 68° E. (true). This vein, however, contains very little, if any, true magnetite, but is almost exclusively composed of specular ore.

The southern cut, C, is hardly opened enough to see its character. It looks thus far like a vein striking pretty nearly in the same direction as the other two veins, and containing a coarsely crystalline, specular ore, crossed by numerous thin seams of red porphyry.

It will be noticed that the strike of these veins is directed toward the Pilot Knob.

These deposits have undoubtedly originated in the same manner as those on Iron Mountain; but the surrounding porphyry has been very little altered, while most of that on Iron Mountain is entirely decomposed.

Smaller Deposits of Specular Ore in Porphyry, Cedar Hill, T. 34, R. 4, E., Sec. 30, Iron County.—The position of Cedar Hill can be seen on the map, Fig. 13. This map shows that the surface-geology, on the south-eastern slope of Cedar Hill, is very similar to that of Pilot Knob, the red porphyry at the foot passing into bluish and conglomeratic porphyries toward the summit. In the place marked A, however, where a mine has been opened in summer, 1872, the porphyry is red again. This red porphyry, however, takes a bluish color in the proximity of the ore, and the walls of the ore-deposits are in some places composed of a blue, porphyric conglomerate, similar to that on Pilot Knob. This seems to indicate that the blue color, and perhaps also the conglomeratic to spherulitic structure, might be due to infiltrations of the same ferriferous solutions which deposited the ore.

The Cedar Hill is not sufficiently opened to allow a judgment regarding its ore-deposits. In September, 1872, about two acres of ground were freed from the soil, and showed two parallel, vein-like segregations, 1 to 4 feet in width, and about 100 feet in length, cropping out on the surface. Their strike was about 60–70° north-west. A shaft 10 feet deep was sunk on one of them, but showed it to be of an irregular section, so as to leave some uncertainty regarding its continuation in depth. These small segregations, surrounded by hard and solid porphyry, are not always workable in themselves, but they may be offshoots of some larger deposit, to the discovery of which they might lead.

Occurrences of specular ore were observed in some other localities in that vicinity, namely, in T. 34, R. 4, E., Sec. 18-19, 17-20, and T. 34, R. 4, E., Sec. 19, S. W. ¼ S. W. ¼.

One and one-half miles east of Pilot Knob, in T. 34, R. 4, E., Sec. 28, N. ½, coarsely crystalline specular ore is found in seams through a red, banded, and stratified rock, of the appearance and fracture of jasper, overlying a series of stratified porphyries. The succession of strata which presents itself there, with a south-western dip, is from south-west to north-east, as follows :—

Slates of red, banded porphyry.

Stratified quartz-porphyry.

Slates of red porphyry.

Green porphyry.

Banded jasper.

Jasper, with specular ore.

Buford Hill, T. 35, R. 3, E., Sec. 26, two miles west of Iron Mountain, in Iron County, is a pretty high and steep hill, consisting principally of brown porphyry, occasionally mixed with a brown, jasper-like, feldspathic rock, and with light-red porphyry in some places. These three kinds of rocks seem to be mixed there irregularly. Some micaceous iron-ore, mixed with quartz, is found in a depression between the hill itself and a low spur on its north-eastern side. Red porphyry occurs at a short distance south of it. The quartzeous ore is spread in large and small pieces over the ground, and extends along the slope of the hill over a distance of more than one hundred feet, in a line striking north-east to south-west. A little lower down on the same slope a streak of greenstone may be observed, running about parallel to the direction of the ore. This greenstone, which occurs in loose fragments, is fine grained, of a dark-green color, with white specks. It has the appearance of a diorite. It contains numerous black, microscopic crystals, of a metallic lustre, probably peroxide of iron.

The same kind of ore, accompanied by the same kind of greenstone, is said to exist in some places on the west side of the hill. Nowhere, however, are plain indications of the presence of larger masses of ore.

Buford Mountain, N. E. ¼ Sec. 24, T. 33, R. 3, E., Iron County, contains a bed of manganiferous specular ore in decomposed porphyry, apparently of a not inconsiderable extent.

Big Bogg Mountain, S. E. ¼ Sec. 13, T. 33, R. 3, E., the Russell No. 1 bank, E. ½ Sec. 3, T. 33, R. 3, E., and the Shut-in bank, N. ½ Sec. 2, T. 33, R. 4, E., all in Iron County, are also deposits of specular ore in porphyry, and have been mentioned and described by Dr. A. Litton in the second geological report.

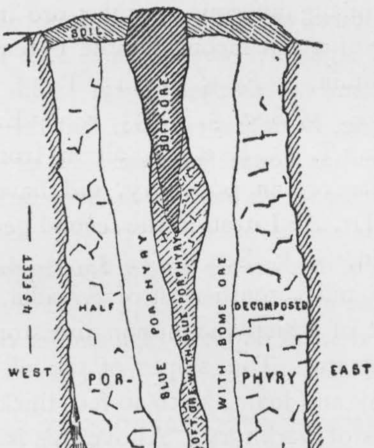
Lewis Mountain, S. ½ Sec. 6, T. 33, R. 4, E., Iron County, one and one-half miles south-west of Arcadia, is a small porphyry-hill, at the foot of which magnesian limestone is deposited in nearly horizontal strata. The slopes of the hill are covered with red and yellow clay and loam, 30 to 40 feet thick, mixed with half-decomposed pieces of porphyry. Above this is 2 to 4 feet of soil, mixed with rounded pieces of hard, specular ore, some pure, some mixed irregularly with brown porphyry in such a way as to indicate a gradual replacement of porphyry by ore. Indeed, in some specimens the brown porphyry, containing feldspar-crystals and brown quartz-grains, passes imperceptibly into specular ore, whereby the feldspar-crystals disappear, while the brown grains of quartz are preserved, and lie in exactly the same manner in the ore as in the porphyry.

An irregular vein, varying from 1 to 5 feet in thickness, strikes across the hill about N. 75° W. This vein contains in some places specular ore, while in other places, where the vein is thinner, it is filled with red loam. This fact seems to show that the vein, which was originally of a more limited extent, has been opened more and extended by the crystallization of the ore, or by freezing water, and that the cracks thereby produced were afterward filled with loam washed into them from above. Some red, blue, and conglomeratic porphyries occur near the ore, and also small accumulations of micaceous ore-crystals, accompanied by quartz.

Cuthbertson bank, north-west quarter Sec. 19, T. 33, R. 4, E., and Ackhurst bank, south-west quarter Sec. 18, T. 33, R. 4, E., are deposits of manganiferous specular ores and magnetites and manganese-ores.

Hogan Mountain, south-east quarter Sec. 14, T. 33, R. 3, E.,

Fig. 24.



CUT ON HOGAN MOUNTAIN.

Iron County, contains irregular pockets of mostly soft, coarsely crystalline or micaceous, specular ore, in a peculiar, light-red, granular quartz-porphyry, which in the immediate vicinity of the ore is decomposed, and assumes a blue color when mixed with the ore.

Fig. 24 represents a section of such a pocket as opened by a cut. The massive, red porphyry on both sides of the cut is of the above description, and is covered by a dry soil, containing many pieces of broken porphyry. On both sides of the pocket we find the red porphyry half decomposed to a thickness of several feet. We further find, in immediate contact with the ore, a blue porphyry, mixed with some ore. The pocket itself is filled in its lower part with a blue porphyry conglomerate, strongly impregnated and mixed with ore, and in its upper part with pure, soft, crystalline, specular ore. This pocket, getting smaller below, runs out into a fissure, which splits in several branches, enclosing a large fragment of half-decomposed red porphyry, and a mass (C) of a gray conglomerate, mixed with pieces of a jasper-like porphyry and with quartz. The fissures are filled with a soft, loose, chloritic clay, undoubtedly a product of the decomposition of adjacent porphyries. R P is a dark, reddish-brown, very hard and massive porphyry.

It seems probable, from this section, that the solution which has deposited the ore has come from the side, or from above, out of fissures in porphyries which have since been destroyed and washed away, and that the cracks below the pocket were opened either by the crystallization of the ore or by the freezing of water, and afterward filled with fine clay.

There are several small deposits of a similar character on Hogan Mountain.

b. DEPOSITS OF SPECULAR ORE IN SANDSTONE.

The valuable and, in part, extensive deposits of specular ore in sandstone, the ores of which have been described in Chapter III. of the present report, occur in the eastern part of central Missouri, south of the Missouri River, especially in Crawford, Phelps, and Dent Counties, and constitute, together with the two following categories *c.* and *d.* of ore-banks, that iron-ore region in the State which in Chapter II. I have called the "Central Region." It has been mentioned there that many of these deposits have undergone great disturbances in their position. I shall describe under the present head, *b.*, only such deposits of specular ore in sandstone as are either entirely undisturbed, or which have been broken in place by being underwashed, or by a contraction of underlying strata or of their own mass, without subsequent removal of any great portion of their mass. Those deposits which were broken and separated into two or several parts, the single parts being shifted or moved to a greater or less distance, I shall describe under the two following heads, *c.* and *d.*

All these deposits belong to the Lower Silurian formation, and more especially to those strata which have been designated and described by Prof. G. C. Swallow, in the Second Annual Report of the Geological Survey of Missouri, page 125, as "Second Sandstone." Wherever I have been able to trace distinctly the geological position of these specular-ore banks, I have found them to be associated with this second sandstone, which has its place above the third and below the second "Magnesian Limestone." As the second sandstone is represented more or less extensively in the whole central part of southern Missouri, a great portion of which has been very little investigated as yet, we may hope that numerous other deposits will yet be discovered in the State, besides those to be described hereafter, and besides all those to be mentioned in our ore-bank list in Chapter V.

These deposits of specular ore have generally a lenticular shape, with either circular or elliptic outlines. They are frequently found in an inclined position, in which case they usually dip with the slope of the hill. Sometimes the ore is cut off abruptly at the outskirts, by nearly vertical walls, consisting of nearly vertical layers of clay, chert, and sandstone. In this case, these deposits appear like large, round, somewhat lenticular pockets in the sandstone, clad with layers of clay and chert, and filled with specular ore, which is often more or less altered into soft, red hematite. The thickness of these deposits is in the average about one-fifth to one-sixth of their average diameter. The ore is directly surrounded and underlaid by formerly continuous, but now broken and disconnected, strata of green or gray chert or flint, sometimes mixed with a fine, silicious, white clay, or with red loam. Below these chert-layers we find alternating strata of chert, sandstone, and of chert-breccia cemented by sandstone, sometimes continuous, but mostly broken. Below these are the regular strata of the second sandstone, running parallel with the above, and forming a circular or elliptic depression, in which the deposit lies. At the outskirts of this depression, where the sandstone strata suddenly change their nearly horizontal position, to curve downward and to run beneath the ore-deposit, the upper strata are frequently broken off, and form an annular outcrop round the deposit.

All these various rocks surrounding and underlying the specular-ore deposits, have in some cases their original and natural color and appearance, while in other cases they are ferruginous, or colored and impregnated by iron-ore, whereby the sandstone turns brown or black, and glittering with numerous fine ore-crystals throughout its mass, while the chert is colored green or red, and the clay or loam is transformed into a reddish-brown, sometimes pretty hard, ferruginous clay-rock.

In the Meramec bank we find regular layers of clay, chert, and sandstone, not only under but also above the ore-deposit. In most other places the ore is either covered with loose detritus, broken chert, and soil, or else it lies bare, in which latter case the specular ore is often changed into limonite near the surface.

The above description gives us the following two series of successive layers of rocks lying above, in, and under the specular-ore deposits in sandstone :—

1.	*Sandy and Cherty Soil.*	
2.	Sandstone with solid chert-layers. Same, impregnated with iron-ore. Sandstone, loam, and chert, broken and mixed. Solid chert. Broken chert and clay.	Cherty detritus and Limonite.
3.	*Soft Red Hematite.*	
4.	*Hard Specular Ore.*	
5.	White clay or red loam.	Ferruginous clay-rock.
6.	Clay and broken chert.	Ferruginous chert-breccia.
7.	Broken sandstone and chert with layers of solid chert.	Sandstone, colored or impregnated by iron-ore.
8.	*Second, Lower Silurian, Sandstone.*	

Not all these strata are equally and invariably represented in all the deposits.

All the beds of rock thus associated with the ore-deposits seem to be in the same relative position in which they have originated, but to be in part broken, in part half-destroyed and altered.

It seems that these specular-ore deposits were originally formed in a lenticular shape, and imbedded in or on a sandstone containing layers of chert, and that they were afterward partially or wholly underwashed, some of the softer sandstone being thus removed, while the harder cherty parts and layers remained. In consequence of this action, a slight shifting of the whole mass of ore may have taken place, which somewhat crushed and mixed some of the underlying materials, and brought the deposit in a more or less inclined position. In some instances large caves, which are so common in all limestones, and which are undoubtedly formed by the dissolving action of acid waters, may have existed in the Third Magnesian Limestone, below the ore-deposits, and may have caused either a gradual or a sudden sinking, without which the origin of the pockets with almost vertical walls, in which such deposits are sometimes found, cannot easily be explained. The original lenticular masses of ore may have been formed either by deposition from chalybeate waters in depressions on the surface of the sandstone, and afterward covered by other strata, and condensed and altered by pressure and higher temperature, or else they may have come into existence by a gradual replacement of lenticular limestone-deposits formed in the above-described manner in the sandstone. While the first supposition appears as the more simple and as the more natural and intelligible one, the second one is supported by the two following facts :—

Irregular rounded masses of a very dense and hard orange-yellow, subcrystalline limestone, interspersed with pretty large gray crystals of carbonate of iron, are sometimes met with in the midst of the ore, and passing into the latter.

Mr. G. C. Broadhead found, in the lower coal-measures of Henry County, a stratum of limestone from 3 to 6 inches thick, which is partly converted into red hematite, containing no carbonic acid. This transformation has taken place from both the upper and the lower surfaces of the stratum, and has reached a thickness of three-quarters to one inch, from either surface, while the interior consists yet of the unaltered gray limestone.

Another fact, however, which speaks in a certain measure against the second of the above two suppositions, is this, that lenticular deposits of limestone have nowhere been observed in the Silurian sandstone of Missouri. I will not attempt to decide whether any such deposits have existed and have all been metamorphosed into ore-deposits, or whether the supposition is incorrect.

These undisturbed or slightly-disturbed deposits may be recognized by the following external characteristics :—

1. They mostly occupy a high topographical position, lying on summits of hills or of ridges if undisturbed, or on the upper part of slopes close to the summits if somewhat disturbed.

2. They have a circular or elliptical outline, inside of which the ground is covered all over with surface-ore of various sizes, partly specular, partly limonite, more or less rounded and smoothed, especially on the upper side, from being exposed to rain and storm. The larger the size of these pieces and bowlders on the surface, the more confidently a good deposit may be expected.

3. They are surrounded by annular outcrops of solid or broken red clay-rock, chert-breccia, black or brown impregnated sandstone, and finally of yellow or white sandstone. These annular sandstone outcrops are frequently very conspicuous.

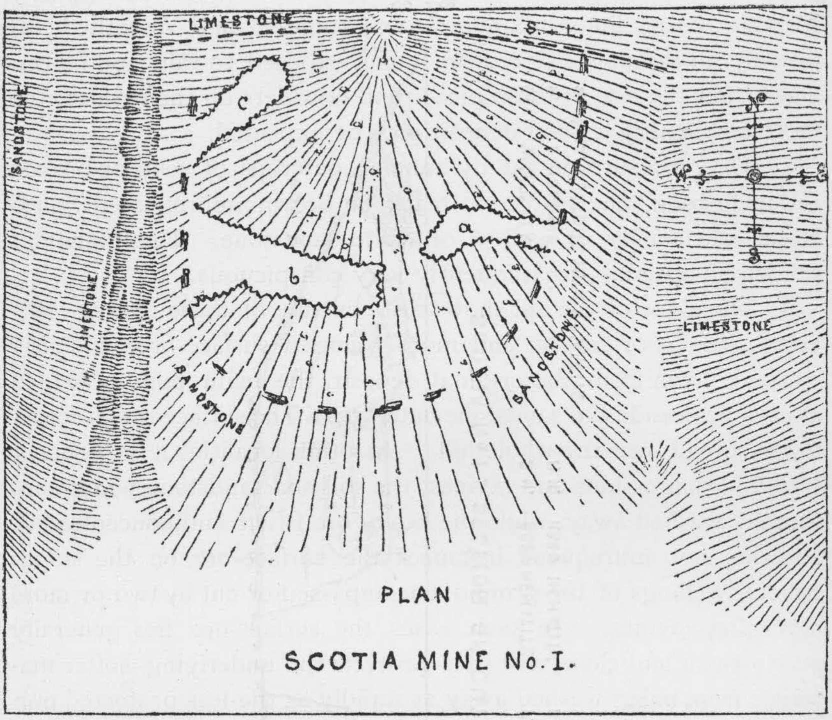
4. The slope of the hill shows also, outside of these annular outcrops, streaks of smaller and more rounded surface-ore, evidently washed down from the original deposit, the main body of which always lies inside the sandstone outcrops. The surface-ore is sometimes spread over the whole hill. In other localities it is concentrated in depressions and ravines, the soil and sandstone being continually washed away, while the heavy ore is left and concentrated. In other not unfrequent instances the surface-ore on the slopes covers swellings of the ground, encompassed or cut by two or more diverging ravines. In such cases the surface-ore lies generally pretty thick and close, and thus protects the underlying softer materials from being washed away as rapidly as the less protected portions of the same slope. It is obvious that these swellings have been produced by such an unequal protection of the ground. When opened by shafts, these swellings are then found to consist of loose, sandy detritus, with little or no ore, overlying the solid sandstone. The extent of the surface-ore, however thick and close it may lie, when outside of the annular outcrops of sandstone, is therefore no proof of a corresponding extent of the deposit.

I will now proceed with the special description of a number of ore-banks belonging to this category of undisturbed or slightly-disturbed deposits of specular ore in sandstone.

Scotia No. 1, Sec. 1, E. ½ S. E. ¼, T. 38, R. 3, W., Crawford County.

This deposit lies in a low sandstone-hill, which forms a spur on the southern end of a higher limestone-hill, and is separated by two narrow valleys from the surrounding high hills, composed of Third Magnesian Limestone at the base, and of Second Sandstone in the upper part.

Fig. 25.

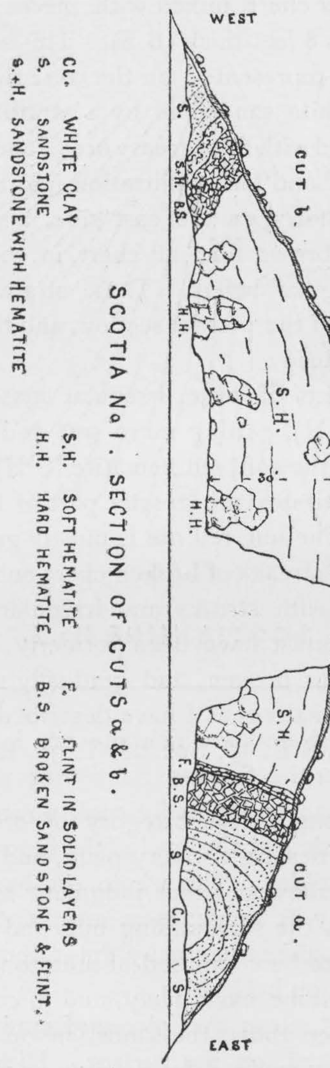


The Second Sandstone on which the ore is bedded occupies a much lower level than the Second Sandstone which caps the surrounding hills. It has undoubtedly sunk down gradually into its present location, which is at the level of the limestone, by which it is surrounded on three sides. The whole ore-bank sank down with the sandstone, and by its weight may have kept the latter in place, and protected it against destruction by the waters which effected the erosion of the valleys on both sides.

S and L, on Fig. 25, mean that pieces of sandstone and limestone are found there, mixed, on the surface. Distinct outcrops and openings of both these kinds of rocks are found on the other two hills, east and west of the ore-hill.

The broken line across the ore-hill shows the probable limit of the ore. The annular outcrop of sandstone round the ore is also indicated. The surface-ore extends over an area about 180 feet wide and over 200 feet long. *a*, *b*, *c*, are cuts made for the purpose of mining the ore.

Fig. 26.



The foregoing, Fig. 26, represents a section through the cuts *a* and *b*, showing the interior structure of the upper part of the ore-deposit.

We see here nearly corresponding strata on both sides of the ore, all dipping toward and apparently under the ore. There is the Second Sandstone (S), yellowish-white, dipping about 40° on the west side, and considerably more on the east side. Next to this sandstone is, on the east side, a stratum of breccia of green, red, and yellow chert, mixed with pieces of sandstone, and cemented by red loam 8 feet thick (B S). This same stratum, with the same thickness, is represented on the west side; but it is there separated from the white sandstone by a stratum, 5 feet thick, of Sandstone impregnated with fine, greasy ore (S and H), probably produced by an accidental and local infiltration into the regular Second sandstone. Then follows, on the east side, a stratum (F), 2 feet thick, of green and brown flint or chert, in solid and nearly unbroken but very irregular layers. These strata will undoubtedly meet below the level of the present section, and thus form a pocket, in which the ore is placed.

The ore itself consists of large, irregular masses of hard, blue, specular hematite (H H), getting more soft and light-colored outside, and passing into the soft, red hematite (S H), which surrounds them, and which constitutes the greater part of the bank, as far as opened at present. The soft, red ore is mostly greasy to the touch. It contains sometimes streaks of broken chert and of clay, and is in its upper part mixed with streaks and irregular masses of yellow ochre. All this ore must have been formerly one solid mass of specular ore, which was broken, and gradually softened, and subjected to such transformations as I have described in section B.

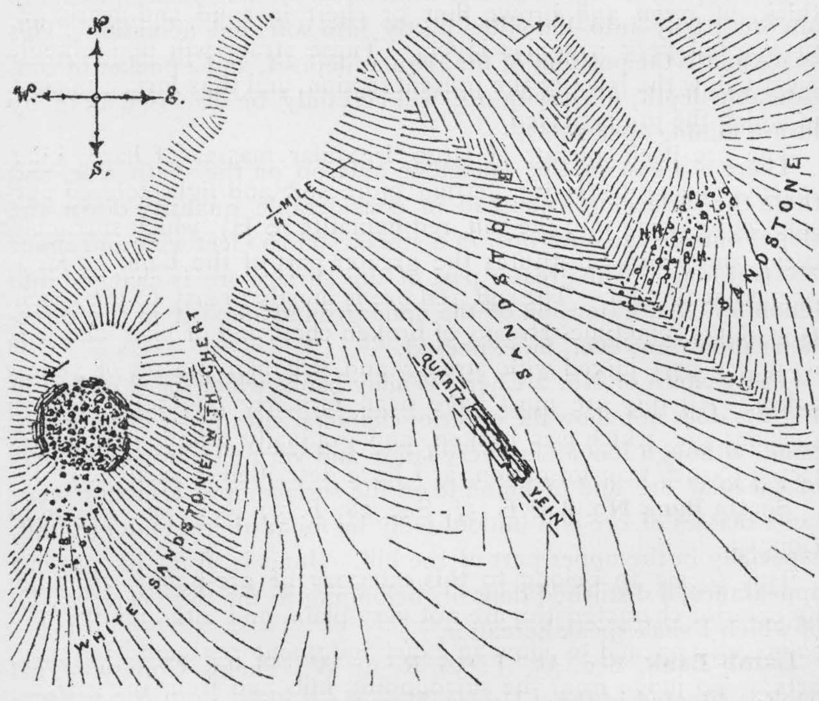
Scotia Bank No. 2, S.E. ¼, Sec. 28, T. 39, R. 2, W., Crawford County.

This seems to belong to this category of ore-banks, although its exterior characteristics are not very plain, and although it is not sufficiently opened to allow an exact judgment regarding its character. To judge from the surrounding hills and from the surface-rocks, the hill seems to be composed of limestone capped by sandstone, or else of sandstone exclusively, and to contain a considerable mass of ore, situated above the sandstone on the summit of the hill. The ore is thickly covered by detritus on the north-east side, while it is but a few feet below the surface on the south-west side, near the summit. Its presence there has been proved both by a shaft and by a ditch, which are from 80 to 90 feet apart.

At the foot of the hill, which is about 150 feet below the summit, a tunnel was made, and struck immediately under the soil, the soft, red ore enclosing pieces and bowlders of specular ore, and numerous broken stalactites of specular, partly converted into red, ore. This ore, several feet thick, dips with the slope, and is underlaid conformably by a layer of green chert, 2 feet thick, which itself lies on a mass of broken chert and sandstone, mixed with clay and loam. All these materials that were struck by the tunnel are undoubtedly detached parts of the main ore-bank on the summit.

Cherry Valley, No. 1, E. ½ S. W. ¼, Sec. 4, T. 37, R. 3, W., Crawford County, 6 miles east of Steelville.

Fig. 27.



H. H. SPECULAR ORE B. H. BROWN HEMATITE

CHERRY VALLEY BANK.

Fig. 27 gives a topographical sketch of the two Cherry Valley banks, neither of which is as yet opened. Nevertheless, the western or No. 1 bank will readily be recognized as a very distinct and characteristic example of a nearly undisturbed deposit of specular ore in sandstone. The lower part of the hills in that region is composed of Third Magnesian Limestone, the upper part of Second Sandstone. On the summit we observe an annular outcrop, several feet thick, of white and yellow Second Sandstone, having in part the appearance of a vitreous quartzite, and dipping toward the centre, but so steep that the strata are in most places nearly in a vertical position. Inside of this outcrop of light-colored sandstone, and placed conformably to it, is an annular outcrop of a sandstone colored or impregnated by oxides of iron.

The circular space inside of these outcrops, 150 feet in diameter, is entirely covered with ore, the numerous large bowlders consisting principally of specular ore, while most of the smaller pieces are altered partly into limonite, partly into soft, red hematite. This space marks the position of the regular deposit, and a pocket of considerable depth, filled with ore, will certainly be disclosed here by future mining operations.

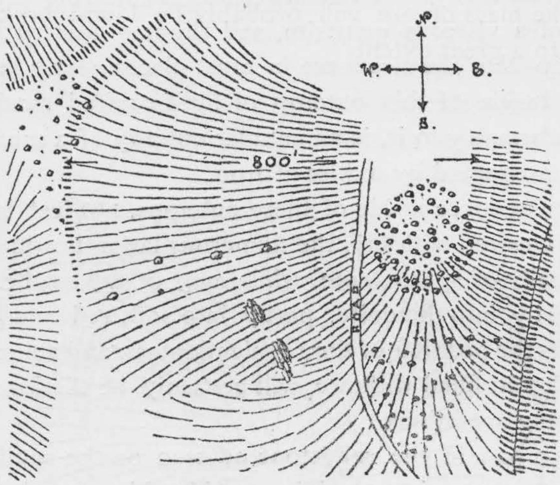
There is a gap in the sandstone outcrop on the south side, and there the surface-ore is spread in considerable quantity down the slope, outside the outcrops, in a streak 50 to 60 feet wide and about 200 feet long. The greater part of this surface-ore is changed into limonite. An extension of the underground deposit in this direction cannot, however, be expected.

The eastern or No. 2 Cherry-Valley bank, which is sketched in Fig 27, does not show the exterior characteristics of an undisturbed bank, although it contains very large and very numerous bowlders of specular ore and of limonite on the surface, and although very large masses of ore will undoubtedly be found there underground, especially in the upper part of the hill. But it is, from its present appearance, a disturbed deposit, belonging to the third category C, of which I shall speak hereafter.

Lamb Bank, Sec. 35, T. 36, R. 6, W., Phelps County.—This bank is situated in the "Upper Meramec" district, on the dividing ridge between the Benton Creek Valley and the Norman Hollow, at the head of the western branch of Benton Creek.

The main part of the bank is situated close to the highest point, and is nearly round, 150 to 200 feet in diameter. No distinct annular outcrops are perceptible, however, and the limit of the body of massive ore can therefore not be determined with great accuracy. But an annular streak of ferruginous clay-rock and of chert-breccia can be traced nearly all round the bank, from the loose pieces lying on the surface.

Fig. 28.



SURFACE ORE

LAMP BANK.

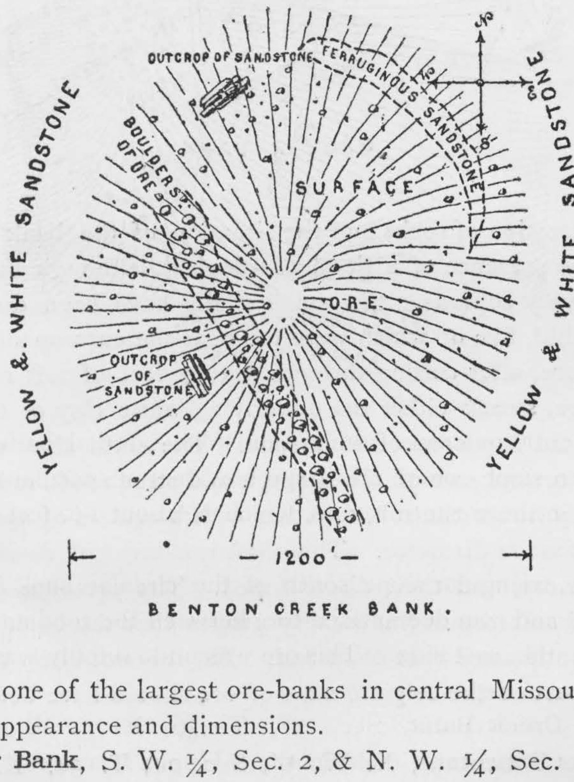
A horizontal outcrop of white sandstone is found half-way down the western slope, where also large bowlders of specular ore occur, as well as in the western ravine, which is about 130 feet below the bank.

The low, triangular slope south of the circular bank is covered with small and rounded surface-ore, between the road and the little ravine on the east side. This ore was undoubtedly washed down from the main deposit.

Benton Creek Bank, Sec. 32, T. 36, R. 5, W., Crawford County.—On Benton Creek, in the "Upper Meramec" district.

The sketch (Fig. 29) shows a large hill, 150 to 200 feet high, covered with surface-ore, which is partly specular, partly limonite, partly strongly-impregnated sandstone. The surface-geology indicates yellow and white sandstone on the lower half of the hill, cropping out in several places on the slopes and dipping in each case toward the centre of the hill. On the north-west side we find a ferruginous or impregnated sandstone on the surface, extending in a curved streak round the hill. All this points toward the existence of a large ore-deposit inside these sandstones. A peculiar feature of this bank is a straight zone of very large bowlders of specular ore running across the hill from north-west to south-east. This bank is somewhat disturbed, but it has preserved its circular character. The mass of ore will probably be found broken, but not scattered to a great extent.

Fig. 29.



BENTON CREEK BANK.

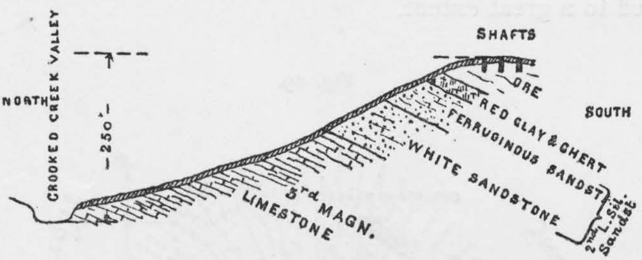
This is one of the largest ore-banks in central Missouri, judging from its appearance and dimensions.

Grover Bank, S. W. ¼, Sec. 2, & N. W. ¼, Sec. 11, T. 35, R. 4, W., Crawford County.—This ore-bank is situated in the "Upper Meramec" district, on the top of a high ridge, with pretty steep slopes, cut by numerous ravines, which descend gradually through lower ranges of hills into the broad valley of Crooked Creek.

The ore does not lie thick, either on the slopes or on the hill. It is more concentrated in the ravines. Fig. 30 presents an elevation, showing the various rocks met with in going from the Crooked

Creek valley up to the bank, namely, the Third Magnesian Limestone, the Second Sandstone, which becomes ferruginous near the bank, above this a thin streak of red clay with chert, and finally the ore on the summit.

Fig. 30.



GROVER BANK

This succession of rocks and the situation of the bank seems to warrant the presence of a good ore-deposit, although the surface-ore is not very copious. Six small shafts have been dug on the top of the hill, five of which were too near the outcrop of the ore, and therefore, after cutting through 5 to 7 feet of soft red and of specular ore, struck either the underlying white clay or the chert-breccia or the impregnated sandstone. The sixth shaft was made nearer the central part of the summit, and struck soft, red hematite immediately below the soil, together with bowlders of specular ore up to one foot in diameter. This shaft was brought down six feet only in the ore, and then discontinued. The presence of a large amount of soft ore in this locality proves that the bank has been broken up and somewhat disturbed. But it is not likely that a considerable part of the original mass of ore should have been washed away.

Simmons Mountain, N. W. ¼, Sec. 24, T. 34, R. 6, W., Dent County, ½ mile south-west of Salem.—This is one of the largest, if not the largest deposit of specular ore in the central ore-region. It received its name from its original owner, Mr. C. C. Simmons, of St. Louis.

Fig. 32 is a view of the Simmons Mountain, which is a nearly isolated hill about ninety feet high, above the plateau south of Salem, on which it is situated, and covering over thirty acres of ground.

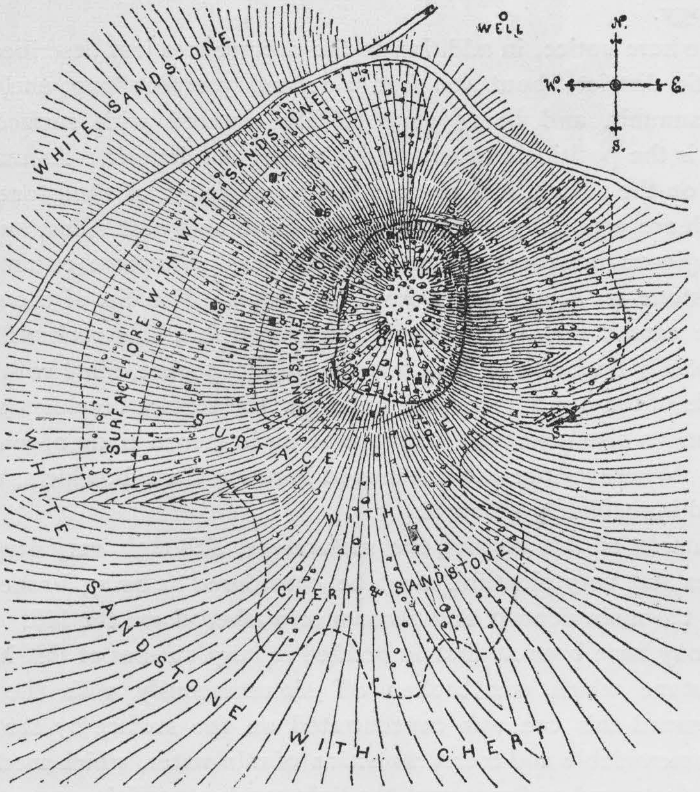
J. Bien, lith.

SIMMONS MOUNTAIN.

Before being opened.

FIG. 31.

Fig. 32.



SIMMONS MOUNTAIN.

—— LIMIT OF SOLID ORE COVERING A DISTRICT 500' LONG & 400' WIDE.

— — — LIMIT OF OTHER ROCKS. S. OUTCROP OF SANDSTONE.

The main body of the hill seems to be composed of Second Sandstone, which is found in pieces on the surface, and has been uncovered by a digging at the foot of the north-western slope, close to the road. The sandstone on the surface is mixed with pieces of chert on the southern and south-western sides, near the base. Higher up it is mixed with specular surface-ore, which extends over a very large district, increasing in frequency and size toward the summit.

Some of the surface-ore on the slopes is altered into a fine and pure limonite (brown hematite), but most of it is specular. The latter occurs in bowlders, several feet in diameter. The following topographical sketch will give a better idea of the surface-geology.

We here notice, in addition to the occurrences just described, an elliptic district, about 400 feet wide and 500 feet long, enclosing the summit, and being very thickly covered with surface-ore. This is the position and extent of the original deposit. As may be seen on the sketch, it is surrounded by outcrops of sandstone (S), which are especially distinct on the north and west sides, and are ferruginous in several places. On the east side some outcrops of sandstone are found lower down the slope. The dip of the sandstone cannot now be distinctly recognized, but this rock will undoubtedly be found to form a large elliptic pocket, filled with ore. Inside of the upper sandstone outcrops, the surface-bowlders are of enormous size, evidently outcrops of an immense body of massive ore. Wherever the soil is removed between these bowlders, ore is found immediately below it.

Outside of this district, the surface-ore, although very large in places and very plentiful, must be considered as being broken off from the main deposit and thrown or washed down the hill. This ore may have been at first imbedded in large masses of detritus of sandstone which was broken off simultaneously with the ore. Afterward this ore was concentrated on the surface by the slow but unavoidable and merciless action of rain-water, which mechanically destroyed and removed the light sandy materials surrounding and underlying the ore, while the ore itself, being too heavy to be carried off by such action, remained in place. This outside surface-ore is therefore not indicative of the existence of large bodies of ore below it.

These views have been fully verified by a number of shafts which have lately been sunk on the Simmons Mountain, and which on our sketch are marked by the numbers 1 to 9. The shafts 5, 6, 7, 8, and 9, which are outside the elliptic district, disclosed 15 to 25 feet of loose, sandy detritus, and finally struck the solid sandstone. Shafts 5 and 6, which are the nearest to the deposit, met with more clayish materials, and streaks and masses of white clay and chert, which are so frequently found in close proximity to such deposits. The shafts 1, 2, 3, and 4, although sunk quite near the limits of the deposit, but inside of them, went through 25 to 30 feet of solid, pure, specular ore, without reaching the foot-walls. I was lately informed that, since my last visit, one of these shafts has struck the clay at a depth of a little less than 30 feet. This is not at all astonishing, on account of the proximity of the shafts to the limits of the pocket. The fact that none of these shafts has reached the clay at a less depth, proves that the walls of the pocket are nearly vertical, and points to a great thickness of the ore in the central portion of the deposit. At the foot of the Simmons Mountain, and north of it, a well has been sunk, which is marked in Fig. 32. This well is over 60 feet deep. It passed through—

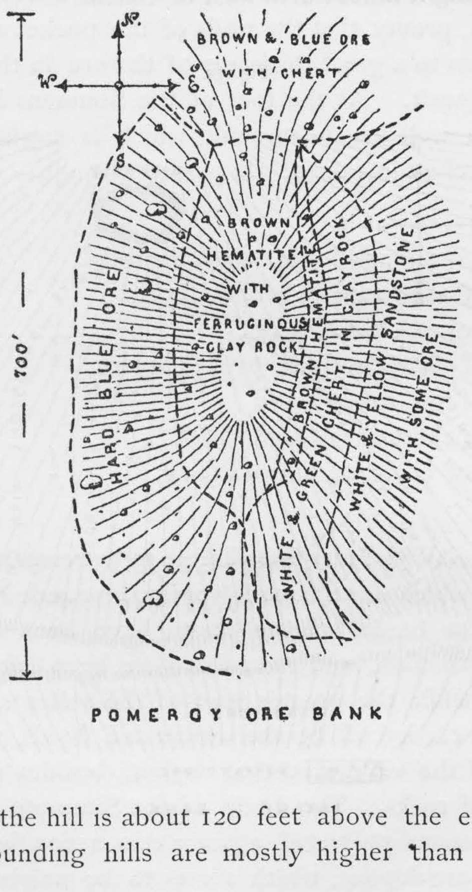
8—10 feet of soil and loose, sandy material.
6—7 feet of sandstone in broken layers.
15—18 feet of red, sandy loam.
6 feet of chert, in thick, broken layers.
6—8 feet of red, sandy loam.
3—4 feet of chert, in broken layers.
14 feet of chert, mixed with clay.

All the materials just mentioned seem to be remnants of destroyed sandstones which must have formerly surrounded the Simmons Mountain. The harder cherty strata have been evidently less subject to destruction, and have therefore been left in place and concentrated, while the greater part of the softer sandstone was destroyed and carried off by the waters and floods, which effected the erosion of the valleys in that region, besides washing away whole strata of rocks. The body of the Simmons Mountain was in a great measure protected against this action by the size and weight of its ore-deposit, which seems to be nearly undisturbed, resembling in this respect the Cherry Valley No. 1 and the Lamb banks above described.

Pomeroy Bank, Sec. 10, T. 34, R. 6 W., Dent County, three miles north-west of Salem.

This quite extensive ore-bank was evidently underwashed on the west side, and broken and turned or moved in that direction, as can be easily perceived from the study of the surface-geology on our sketch. The mass of the ore does not seem, however, to be much scattered, nor to have been removed to any considerable extent; so that we may rank this bank with the disturbed deposits (*b*).

Fig. 33.



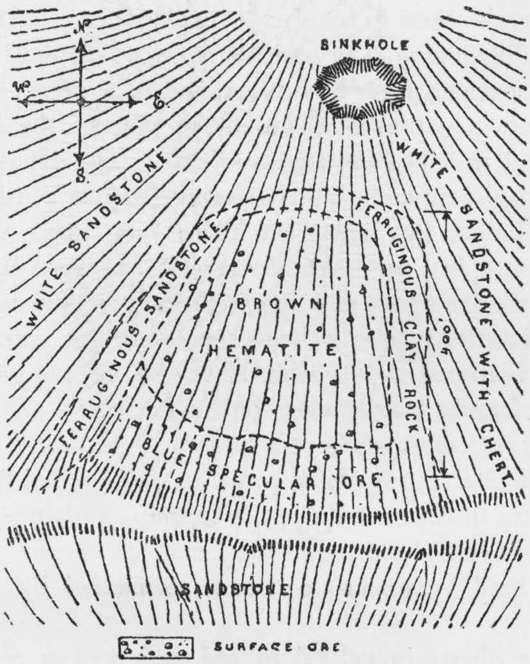
POMEROY ORE BANK

The top of the hill is about 120 feet above the eastern valley; but the surrounding hills are mostly higher than the Pomeroy hill.

In throwing a look on Fig. 33, we find that the principal mass of the surface-ore, although in large quantities and sizes, is here not situated on the summit, but on the western slope, where indeed, besides the cherty soil, hardly anything else but ore is seen on the surface. The summit is occupied by ferruginous clay-rock and pieces of ore altered into limonite. On the eastern slope we have a zone of the well-known breccia of white and green chert, cemented by clay-rock, and lower down the ordinary, white or yellow, Second Sandstone. No regular outcrops are to be seen; but the succession of rocks from the east to the west, shows that a considerable mass of ore must exist in the western and central parts of the hill.

Taylor Bank, S. W. ¼ of S. W. ¼, Sec. 12, T. 34, R. 7, W., Dent County, eight miles north-west of Salem.

Fig. 34.



TAYLOR BANK.

On this topographical and geological sketch of the Taylor bank we meet with circumstances very similar to those just described. We find about the same succession of rocks, and the whole ore-bank situated on the slope, the specular ore occupying the foot of the hill. The surface-ore extends over an area about 400 feet square. The main body of the ore will probably be found in the upper part of the semicircular space, which is surrounded by a zone of ferruginous rocks. This bank has been undoubtedly underwashed on the south side, and disturbed in its position. North of the bank, near the summit of the hill, is one of the round sink-holes which so frequently occur on hills composed of Second Sandstone and Third Limestone. They are, perhaps, caused by the existence of large cavities in the limestone, which have caused a sinking of the overlying sandstone. This sink-hole does not at present seem to be in any connection with the ore-deposit.

Iron Ridge No. 1, N. E. ¼, Sec. 29, T. 39, R. 5, W., Crawford County.—I give here a plan and section of the Iron Ridge mine. The ore-deposit seems to be of a lenticular shape, but curved horizontally, while dipping at an angle of about 40 degrees toward the east. The specular ore is all broken, and to a great extent altered into soft, red hematite, in which the remains of the specular ore are imbedded as half-converted bowlders. The deposit is entirely surrounded by loose materials, and has undergone considerable disturbances; but at the time when these took place the ore-bank must have been in a solid and intact state, because its limits are sharp and well marked, and the main body of the ore, although broken up interiorly, has not been separated into several smaller bodies, nor scattered about, as far as can be seen at present. The succession of rocks may be observed as follows:—

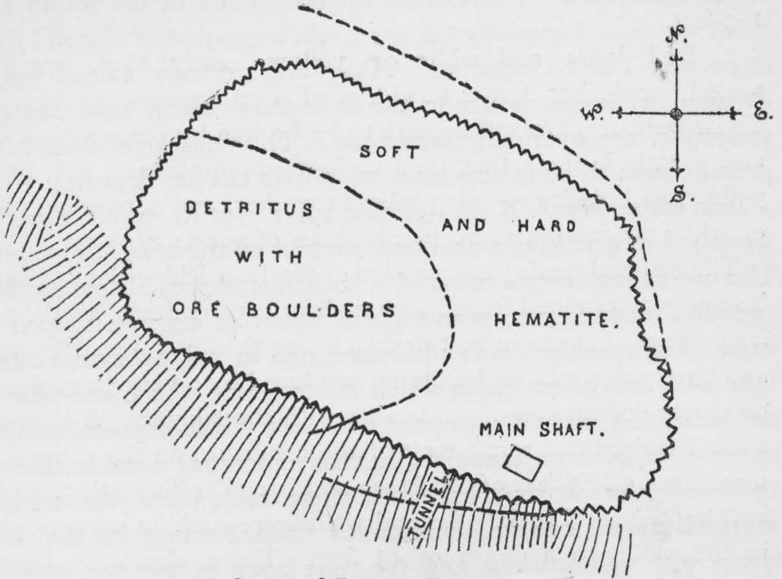
1. Cherty and sandy soil. 1–3 feet.

2. Clayish and sandy detritus, white, yellow, and light red, enclosing pieces of chert and chert-breccia in sandstone, and sometimes masses of soft sandstone. 40 feet.

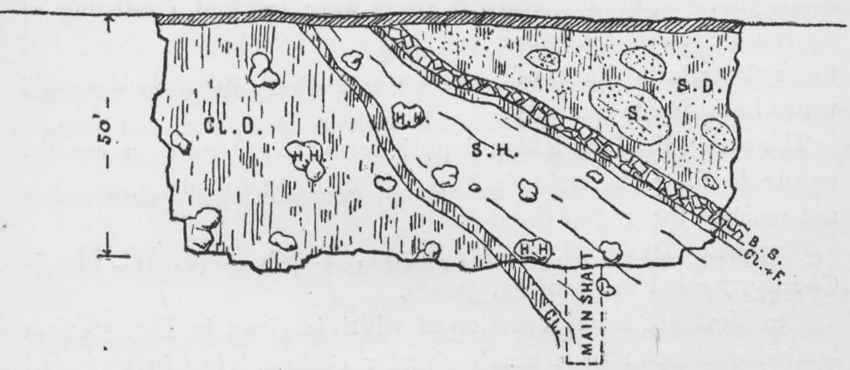
3. Very hard breccia of sandstone, cemented by quartz. 2–4 feet.

4. Broken chert, imbedded in red and yellow clay or loam. 1–3 feet.

5. Soft, red ore, partly greasy, enclosing bowlders of hard specular ore, exteriorly converted into red ore to a greater or less extent. These bowlders form about one-third of the whole mass, and grow larger with the depth, being apparently 5 to 8 feet in diameter at the bottom of the main shaft. The average thickness of the deposit, as far as now opened, is about 25 feet.



PLAN OF MINE.



SECTION OF DEPOSIT BEFORE BEING WORKED

CL.D.	CLAYISH DETRITUS	S.H.	SOFT HEMATITE
CL.	YELLOW PLASTIC CLAY	H.H.	HARD HEMATITE
CL.+F.	CHERT IN RED & YELLOW CLAY	B.S.	BROKEN SANDSTONE
S.D.	SANDY DETRITUS	S.	SANDSTONE
~~	LIMIT OF CUT	———	LIMIT OF ORE

IRON RIDGE ORE BANK & MINE.

6. Yellow, plastic clay, sometimes with pieces of specular ore. 1–3 feet.

7. Red loam and white or yellow, sandy clay, irregularly mixed, enclosing large bowlders of decomposed specular ore. These bowlders are soft enough to be broken by picks and sledges, and present in their fracture a variegated appearance, red, brown, yellow, and black ore being mixed together, and containing specks of white clay and in some places seams of quartz.

The original geological position of the Iron Ridge deposit cannot be safely determined from its immediate surroundings, all the regular geological strata in that district being thickly covered by sandy and cherty detritus, undoubtedly produced by a very extensive and complete destruction of sandstones with chert-layers. A bore-hole, a few hundred feet south-west of the ore-bank, on the same ridge, went through 65 feet of this loose and irregular formation, without striking the solid rock. Several wells were sunk in various places in the valley to a depth of 45 feet. There, also, drifted masses were found to a depth of 12 to 15 feet, consisting of broken chert, of rounded pieces of sandstone, and of sand. Below this more solid, yet not quite undisturbed, rocks were reached, consisting of alternate strata of sandstone and more or less broken chert. Of these strata, a thickness of 30 feet was pierced, without obtaining water in desirable quantity.

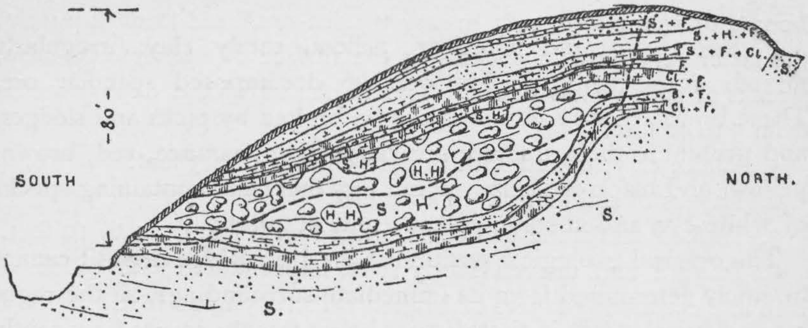
The ore in the Iron Ridge deposit seems to extend to a considerable depth. The main shaft is now over 50 feet deep, and has not reached the end of the deposit.

Meramec Bank, N. W. 1/4, Sec. 1, T. 37, R. 6, W., Phelps County, 7 miles south of St. James.

The Meramec bank, a section of which is given in Fig. 36, is a lenticular deposit of a nearly circular outline, lying in clay and chert beds, in the Second Lower Silurian sandstone. Its inclined position, as well as the broken condition of the ore, indicate former disturbances, probably caused by a partial destruction and removal of the underlying sandstone, especially on the south side, where a deep ravine or narrow valley has been eroded, perhaps by the same waters that may have underwashed the ore-deposit.

In this valley, through which a road leads down to the Meramec Iron Works, outcrops and bluffs of the Second Sandstone are exposed. The dip of the sandstone is very irregular, mostly, however, 10 to

Fig. 36.



SECTION OF MERAMEC MINE

S.	SECOND SANDSTONE	CL.+F.	CLAY WITH CHERT
S.+F.	SANDSTONE WITH FLINT	F.	SOLID FLINT
S.+F.+CL.	SANDSTONE WITH FLINT & LOAM	S.H.	SOFT HEMATITE
S.+H.+F.	SANDSTONE WITH ORE & CHERT	H.H.	HARD HEMATITE

——— LIMIT OF CUT

20 degrees to the north-west, about in the direction of the ore-bank. Lower down, in the vicinity of the iron-works, the Third Magnesian Limestone is exposed with a dip of 10 to 15 degrees north-north-west. A large spring, discharging about 10,000 cubic feet of water per minute, of a temperature of 58° F., uniform all the year round, comes out of this limestone, proving that it must contain enormous cavities and spacious subterranean channels. The limestone is thickly bedded and contains numerous chert concretions. The upper strata are more irregular, and enclose layers and masses of sandstone. The Second Sandstone in the vicinity of the ore-bank occurs on the north and west sides in distinct outcrops dipping toward the ore. This sandstone is often thinly bedded, and shows sometimes a wavy striation on the surface of the layers, similar to that which is frequently produced on loose river-sand by the waves of a shallow water.

The succession of strata in a section through the ore-deposit, as represented by Fig. 36, seems to be the following :—

1. Second Lower Silurian sandstone.
2. Broken chert, imbedded in red, sandy clay. 12 feet.
3. Chert-breccia in sandstone. 4 feet.
4. Soft, red hematite with many bowlders of specular ore, more or less altered on the outside ; also, in places, irregular, large

masses of hard, yellow limestone, with seams and specks of carbonate of iron ; also, soft, greasy "paint-ore," red to dark purple, the latter very pure in pockets on the surface of the deposit ; also, streaks of soft, yellow ochre. The thickness of the deposit varies from 5 to 40 feet.

5. White clay, mixed with broken chert. 0 to 5 feet.

6. Layers of solid chert. 1 to 2 feet.

7. Broken sandstone and chert, mixed with loam. 1 to 10 feet.

8. Impure and uneven sandy rock, impregnated with oxides of iron and containing layers of broken chert. 5 to 20 feet.

9. Alternate layers of sandstone and of massive chert. 5 to 20 feet.

10. Dry, sandy soil, containing small, rounded particles of specular ore. ½ to 2 feet.

All the strata above the ore are very irregular in their position and thickness. Most of them can, however, be traced across the whole mining-cut. That portion of the section, Fig. 36, which is below the limit (— — —) of the cut, is imaginary, and has been added merely to give a clearer picture. The ore might, perhaps, in the central part of the deposit, extend deeper into the sandstone than is indicated in that section.

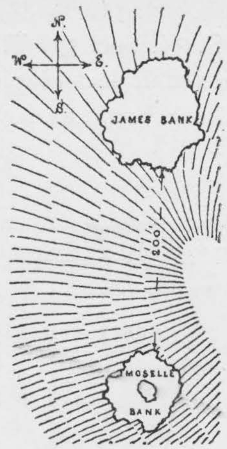
James Bank and Moselle No. 9, S. ½ of S. E. ¼, Sec. 29, T. 38, R. 6, W., Phelps County, 2 miles south of St. James.—These two banks are situated close together, on a low ridge, on the plateau of St. James, between the Dry Fork and the Bourbeuse Rivers.

The formation in that district is Third Magnesian Limestone, capped by Second Sandstone. This may be observed along the Dry Fork River, south of St. James. The two ore-deposits mentioned are in the sandstone. The sketch on next page, Fig. 37, shows their relative position.

Both these banks are nearly worked out ; the best and richest ores are all taken out, and the walls and the bottoms of the deposits are laid bare. These places, therefore, offer a good opportunity for the geologist to study the character of these pocket-like deposits in the sandstone.

The ore formerly contained in these pockets was mostly soft, red, and in part greasy hematite, enclosing large bowlders of specular ore. The ore filled a nearly circular depression in the sandstone,

Fig. 37.



with pretty steep walls. The ore was 10 to 15 feet higher in the centre than at the circumference. The James bank had about 35 feet average height, and a diameter of over 200 feet, and furnished about 30,000 tons of ore.

The Moselle bank was 20 feet thick in the average, and 150 feet in diameter, and may have contained 12 to 15,000 tons of ore, some of which is yet in place.

The James bank lies at the edge of the northern slope of the hill, and dips slightly north. The Moselle bank lies at the edge of the western slope, and dips west. These last observations, made on two banks so similar in every respect, and in so close proximity to each other, go far to prove that the dip of such deposits follows the slope of the hill, and that both were produced by the same cause, namely, by erosion.

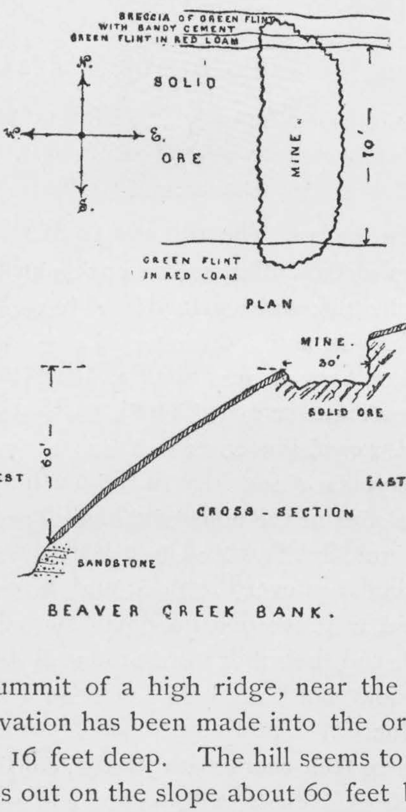
The walls of these two, now empty, banks, consist of a mixture of green and white broken chert, with yellow and red clay, partly soft, partly indurated.

The face of the walls is rather uneven, the ore reaching in places into the chert in irregular masses. The limits between the chert and the ore are, however, well marked. The bottom consists of a white or gray broken chert, mixed with white clay.

A shaft has been sunk into this mass, in the centre of the James bank, 22 feet deep, without reaching the solid rock. In the lower part of this shaft, the clay turned dark gray, green and black, and was mixed with iron pyrites, in small concretions or as a fine crystalline grit.

Beaver Creek Bank, S. ½, Sec. 33, T. 37, R. 8, W., Phelps County, 5 miles south-west of Rolla.—I give here a plan and an elevation of the Beaver Creek bank, as far as it was opened and known in summer 1872.

Fig. 38.



BEAVER CREEK BANK.

It lies on the summit of a high ridge, near the head of Beaver Creek. An excavation has been made into the ore, 70 feet long, 30 feet wide, and 16 feet deep. The hill seems to consist of sandstone, which crops out on the slope about 60 feet below the mine, as seen in the above elevation.

The ore seems to be pretty solid, and in its greater part specular, but slightly altered or softened. The above plan shows that the mass of ore extends about 70 feet from north to south, being cut off on both sides by nearly vertical layers of green chert imbedded in red loam. Next to this a layer of chert-breccia may be observed on the northern wall. The extent of the deposit in other directions cannot as yet be estimated, because the ground surrounding the bank is covered by soil, without any plain surface-indications of either rocks or ore.

Other deposits, which probably belong in this category, are the Craig bank, in the "Upper Meramec" district; the Wiggins and the Ziegler banks, in the Salem district; and the Mont Rouge, Mocassin Bend, and Hancock banks, in the specular-ore district, on the Middle Gasconade River, and in Miller County. The exact location, with a few particulars, of these banks is given in the general ore-bank list, section D.

c. DISTURBED DEPOSITS OF SPECULAR ORE.

The specular-ore deposits, of which I intend to speak under this head, were originally such as described under *b*. They were, however, not only broken by contraction, or by underwashing, or by more violent geological actions, but they were also divided into two or more large portions, which portions were separated from each other by the removal of one, or of more than one, or of all of them, from their original position. We may, accordingly, distinguish two kinds of such "disturbed deposits," namely :—

1. Masses of specular ore which have been removed from their original position and deposited elsewhere, in a more or less irregular manner, and

2. Remaining portions of original deposits, from which other portions have been separated and removed.

Such disturbances must have taken place in some instances slowly and gradually, in other instances with more rapidity and violence, which difference of action must have exercised a marked influence on the condition in which the various deposits are found at present. The more rapid and violent this action was, or the greater the distance over which a certain mass of ore has been shifted, the more will the present ore-bank be broken up, and the less of those more solid rocks with which it was originally associated will adhere to it, as chert, sandstone, breccia, and the more directly will it be imbedded in loose detrital materials.

Some of the deposits, which I shall describe or mention in this category, are not yet sufficiently opened to give a final decision regarding their character. They may prove to be broken-off parts of larger deposits situated in close proximity, and may lead to the discovery of the latter.

FRANKLIN COUNTY ORE-DISTRICT.

Thurmond Bank, N. ½ N. W. ¼, Sec. 19, T. 41, R. 1, W., Franklin County.—This bank is situated 2 miles north of Stanton, in a rather rough country, with steep, high hills, separated by narrow valleys and ravines. The soil is mixed with, and in places covered, by broken white chert. No outcrops of regular geological strata are perceptible, nor any surface-rocks, which might give a clue to determine the formation. The Thurmond bank is as yet but imperfectly opened. The surface-indications consist of a number of large pieces of limonite, and of some small, sharp fragments of a very hard and silicious specular ore. They are scattered over a surface about 50 feet wide and 200 feet long, over a slight swelling of the ground extending down the slope of a moderately steep hill.

A shaft was sunk here a number of years ago, in a vain attempt to find copper-ores. It is said that this shaft, which is yet open to a considerable depth, passed through 37 feet of red iron-ore. Some heaps of soft, red, somewhat clayish hematite, mixed with pieces of soft "paint-ore," are seen at the mouth of the shaft. All appearances indicate that this is a greatly disturbed and dislocated deposit.

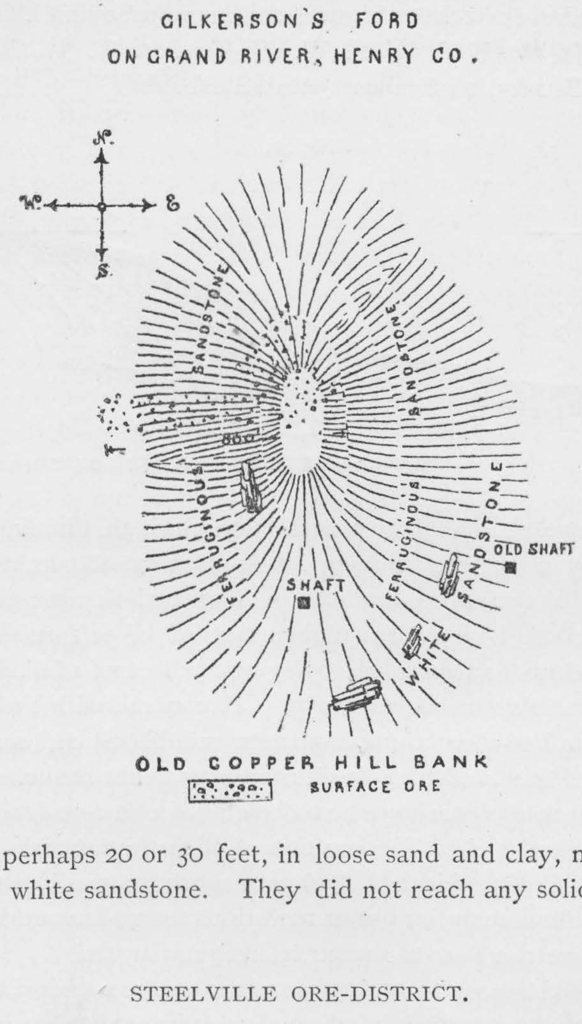
Old Copper Hill, E. ½ N. E. ¼, Sec. 23, T. 40, R. 2, W., Crawford County.

This bank is not opened. It has externally a great resemblance to an undisturbed bank, as which it would have to be considered if the surface-ore was larger, less rounded, and more concentrated on the summit of the hill. As it is, the bank has more the appearance of being the remainder of a disturbed deposit, large parts of which would have been removed. A circumstance which is very strange, and which also points to a disturbance, is, that fragments of white sandstone, in part sharp-edged, are found together with the surface-ore on the summit, while the upper part of the hill generally seems to consist of a dark-colored and ferruginous sandstone.

The hill is pretty steep, and nearly isolated. The surface-ore is specular, in some places pure, in others mixed with sand, and passing into a strongly-impregnated sandstone. The pieces are all rounded, none over head-size, most under fist-size.

The two shafts, indicated on the annexed sketch, were sunk to a

Fig. 39.



depth of perhaps 20 or 30 feet, in loose sand and clay, mixed with pieces of white sandstone. They did not reach any solid strata of rock.

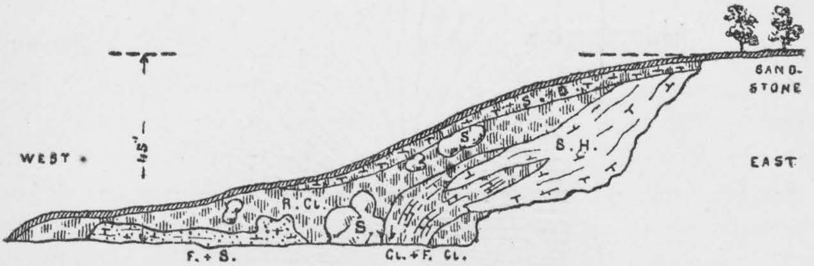
STEELVILLE ORE-DISTRICT.

Cherry Valley No. 2, W. ½ S. E. ¼, Sec. 4, T. 37, R. 3, W., Crawford County.

This bank is represented in Fig. 27, and has been mentioned and characterized in connection with the description of the Cherry Valley No. 1 bank, from which it is only ¼ mile distant. It consists of a streak of large and copious, specular and brown surface-ore, about 20 feet wide and say 200 feet long, extending down the south-western slope of a hill into a ravine, and a short distance up the opposite slope. This bank has the appearance of a disturbed though undoubtedly very valuable deposit. Ore is found in less quantity in several other places on the surrounding hills.

Steelville No. 1, E. ½ S. W. ¼, Sec. 5, T. 37, R. 4, W., Crawford County, 2 miles west of Steelville.

Fig. 40.



STEELVILLE ORE BANK. SECTION.

The above sketch gives a section through this bank, which is opened by a large mining-cut. As Fig. 40 shows, this bank represents a typical example of a disturbed deposit of the first kind. We see here an irregular mass (S H) of soft, red hematite, with bowlders of specular ore lying at the foot of a hill, imbedded in loose materials, as white clay (Cl), clay mixed with broken chert (Cl + F), broken chert and sandstone mixed (F + S), red, sandy loam (R Cl), and fine sandstone-detritus with some broken chert (S D). The red loam encloses large bowlders (S) of a fine-grained, yellow, very hard sand-rock. The position of all these materials, including the ore, makes it evident that they must have slid down the hill, some simultaneously, others at various times, and must have been thrown there one over the other, in irregular layers.

Some of the loose materials round the ore are undoubtedly products of the destruction of cherty sandstone-strata, in which the deposit originally lay. It will be noticed that the excavation made by the miners has nearly reached the solid sandstone which seems to compose the hill and which is likely to cut off the ore. There are, however, indications of specular and red ores in other places, which make it probable that other loose masses of ore have been thrown down at the foot of this hill and buried under the detritus.

ORE-DISTRICT ON THE UPPER MERAMEC RIVER AND ITS TRIBUTARIES.

Winkler Bank, S. ½, Sec. 14, T. 36, R. 6, W., Phelps County. —This bank is situated on the plateau between West Benton Creek and Norman Hollow, and spreads over three flat hills, lying in a north-south line, somewhat curved toward the east.

The south-eastern slope of the most northern of the three hills is covered with good and large surface-ore, mixed with some broken chert. The central hill shows scarcely any ore on the surface, but frequently pieces of sandstone. The southern hill is very wide and flat, and bears on its western slope a very extensive streak of surface-ore, about 1,200 feet long and 100 to 400 feet wide. Most of this ore is rounded off, and not very large, and looks as if it had been drifted. A number of pieces, however, reach and exceed head-size. The ore at the south end is very hard and silicious, that at the north end is purer and softer.

This bank is untouched, and its exterior appearance does not convey an exact idea of its character. It is not unlikely that the ore on the northern hill forms a separate deposit from that on the southern hill, and that the latter deposit has been more disturbed and broken, and the ore scattered over a larger surface. From all appearances the Winkler bank seems to contain considerable quantities of specular ore.

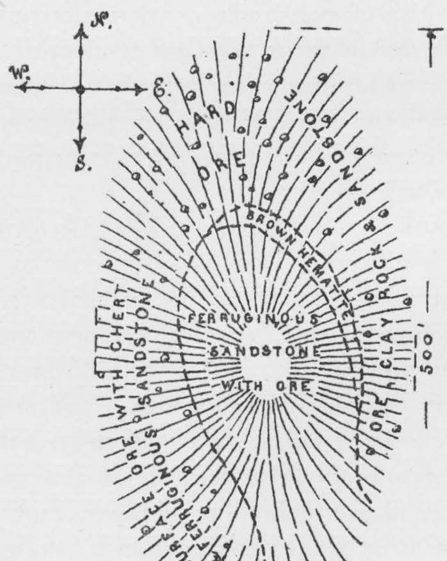
Arnold Bank, S. E. ¼, Sec. 4, T. 35, R. 5, W., Dent County. —This bank is not yet thoroughly opened. But it presents a very similar appearance to that of the Steelville No. 1, and is undoubtedly a deposit which was formerly imbedded in sandstone, and fell or slid down to the foot of the hill simultaneously with the erosion of the ravine, near which it lies. The hill itself is sandstone, which has been struck by a shaft sunk 12 feet deep near the summit of the hill, about 50 feet above the ravine. The ore is principally spread over a swelling of the ground, reaching from the ravine about 40 feet up the slope, in a width of 40 to 50 feet. On this ground large bowlders and smaller pieces of surface-ore, mostly rounded, are found, together with pieces of white, yellow, and red sandstone, containing thin seams of specular ore. Also pieces of broken chert, and of an impregnated or ferruginous sandstone, are quite frequent. Numerous bowlders of ore are deposed in the ravine. The hill on the other side of the ravine is likewise sandstone. A ditch made at the foot of the hill on which the ore is found struck red clay, mixed with paint-ore and with bowlders of specular ore. A second shaft, sunk 12 feet deep into the slope, on a place about 40 feet above the ravine, passed through red, sandy clay, mixed with pieces of ferruginous and of white sandstone, and with bowlders of specular ore. The whole slope is evidently thickly covered with sandy detritus, enclosing irregular and unevenly distributed masses of broken ore.

Other banks of this district, which are likely to belong in this category, are the N. G. Clark No. 2, C. C. Cook, Arthur, and St. L., S. and L. R. R. banks. Their location, etc., is given in the ore-bank list, in Chapter V.

SALEM ORE-DISTRICT.

Orchard Bank, E. ½ S. E. ¼ S. E. ¼, Sec. 13, T. 34, R. 6, W., Dent County, close to Salem.

Fig. 41.



ORCHARD BANK.

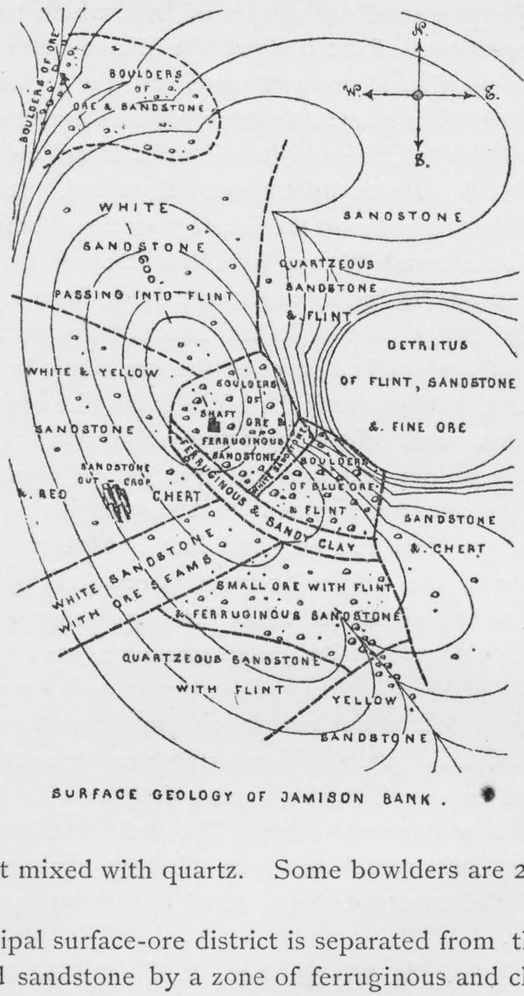
This bank is remarkable for the large development of sandstone, colored and impregnated by oxides of iron, which seems to compose the greater part of the body of the hill, as well as for the unusual relative position of ore and sandstone, the former occupying here an annular space round the latter. These facts, together with the flatness of the hill, the height of which is only about 30 feet, prove that this deposit has been greatly disturbed. It seems likely that the ore lay originally on the impregnated sandstone, and that both occupied a much higher level than they do now. A large part of the ore was broken into pieces varying from a pea to head-size. Another large part of it has undoubtedly been carried off. How much of the original mass of the ore is left in the hill, can only be ascertained by practical work. It may be observed in this locality, as in several others, that the white sandstone gradually passes into the yellow and into the ferruginous sandstone. The argillaceous or calcareous cement that surrounds the single sand-grains is changed into red clay and into reddish-brown iron-ore. In other places, the original cement is replaced by amorphous quartz, so that the sandstone takes the appearance of a quartzite, which itself in places loses its grainy structure, passing into a solid flint or chert.

It also seems that under certain circumstances the sand-grains, when enclosed in a quartzous or ferruginous cement, have been dissolved and removed, leaving a mere skeleton of a former sandstone, with a cellular structure. The cells and irregular holes of such masses have sometimes been filled up again, either partly or wholly, by a transparent quartz of a dark appearance, or by yellow jasper.

Jamison Bank, S. W. ¼, Sec. 1, T. 33, R. 6, W., Dent County, 3 miles south of Salem, on the vast plateau dividing the waters of the Meramec from those of the Current River.

This bank occupies the highest point on a rather flat, semicircular hill, which lies round a nearly circular depression (sink-hole ?), apparently filled with fine detritus of chert, sandstone, and specular ore. The surface-geology, as given in Fig. 42, is very irregular, but nevertheless seems to be grouped in a general way round that part of the summit and eastern slope over which the largest and most copious surface-ore is spread. The ore is specular, in part

Fig. 42.



SURFACE GEOLOGY OF JAMISON BANK.

pure, in part mixed with quartz. Some bowlders are 2 to 3 feet in diameter.

The principal surface-ore district is separated from the ordinary light-colored sandstone by a zone of ferruginous and clayish materials.

Another smaller district, with rounded surface-ore, is seen about 600 feet to the north-west, another in a small ravine to the south. Both are probably drifted outliers of the main deposit, which lay originally at a higher level, above the present top of the hill, perhaps a little north of it.

I view this bank in a similar light as the Orchard bank, and consider it as containing the remnants, perhaps pretty large, yet incalculable, of a former lenticular deposit in sandstone, which has been broken, and partly destroyed and removed.

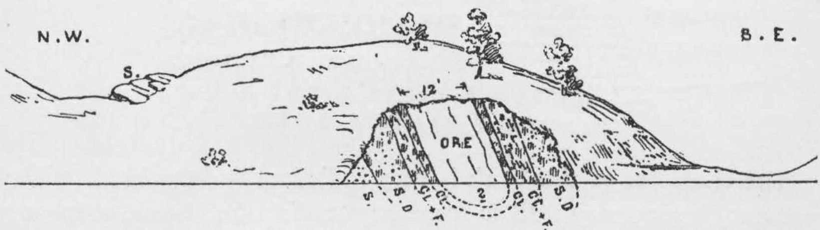
The shaft marked on Fig. 42 was 10 feet deep, end September, 1872, and had not struck any solid rock, but stood in a red, sandy loam, with bowlders of sandstone and of specular ore.

Other banks in the Salem district, and in Shannon County, which may be supposed to belong in the category of more or less disturbed deposits, are the Barksdale, Merriam, Shannon, and Current River banks. The locations, etc., are given in Chapter V.

ST. JAMES ORE-DISTRICT.

Thornton Bank, N. E. ¼ Sec. 33, T. 38, R. 6, W., Phelps County.—The situation and appearance of this bank may be seen from Fig. 43.

Fig. 43.



S. WHITE SANDSTONE CL.+F RED CLAY WITH WHITE CHERT
S.D. YELLOW & RED SANDY CLAY CL. WHITE CLAY

THORNTON BANK.

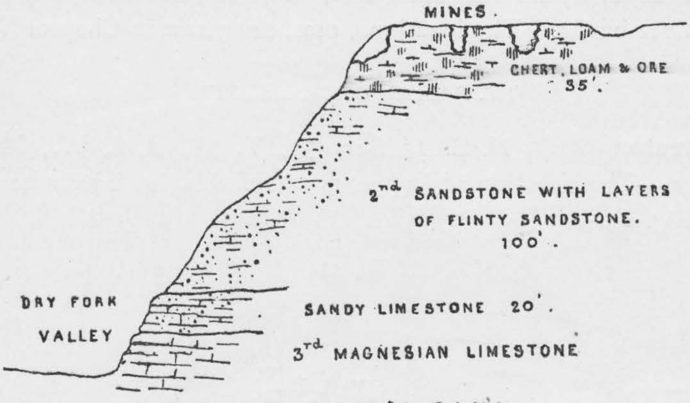
The ore is soft red, with small pieces of hard specular. No large bowlders have as yet been found in it. The character and position of the ore is such that it must be considered as a bed-like or a lenticular deposit, which has been brought into its present vertical position by some exterior disturbance, and then broken and decomposed. The deposit can so far be traced over a small space only, and is perhaps a removed portion of some larger bank. The ore seems to be associated with the rocks in which it originally lay, or at least with their detritus. As the succession of these rocks is the same on both sides, the supposition suggests itself that the corresponding strata might come together below the ore, and thus constitute a pocket, which is crushed sidewise, in the direction from S.E. to N.W. The hill is Second Sandstone.

Santee and Clark's Bank, S. W. ¼, Sec. 33, T. 38, R. 6, W. Phelps County.—This bank lies on a high bluff of Third Magnesian

Limestone and Second Sandstone, on the east side of Dry Fork River.

Several small openings have disclosed irregular masses of red and brown ore, imbedded in layers of chert and loam.

Fig. 44.



SANTEE & CLARK'S BANK

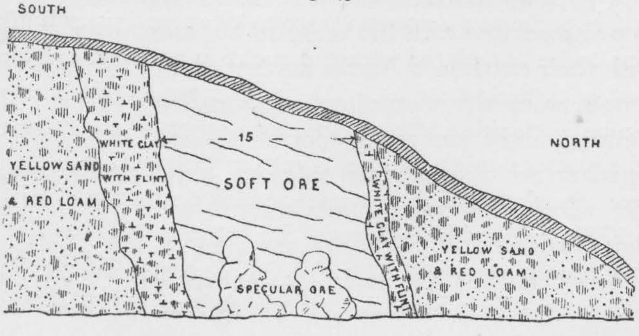
The character of this bank is very indistinct and doubtful. The present digging may lead to some larger, disturbed bank, or it may disclose a drifted deposit. The materials which surround the ore are evidently of a detritic nature, and not now in the place where they were formed.

Another deposit which might belong here is the South Mountain (see Chapter V.).

ROLLA ORE-DISTRICT.

Kelly Bank No. 1, E. ½, Sec. 18, T. 36, R. 8, W., Phelps County.

Fig. 45.

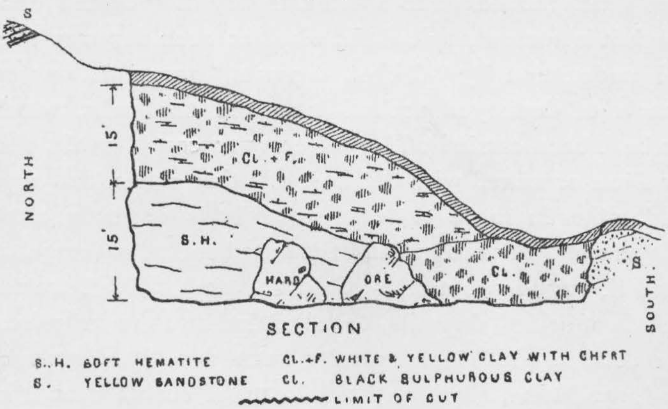


KELLY BANK. No. 1.

This bank is situated near the summit of a hill composed of Second Sandstone in its lower part, while no solid rock can be seen higher up. The bank itself has a decided resemblance to the Thornton bank, above described, but it seems to be more extensive, and contains larger masses of hard, specular ore. It differs, besides, by the detritic character of the associated rocks. There is next to the ore, on each side, a thick layer (1–3 feet) of white clay mixed with broken chert, and outside of this a mass of yellow sand and red loam, irregularly mixed, and free from chert. When opened further, this deposit may be found to be a large fragment of a disrupted-layer deposit, or else an original ore-pocket, which has been pressed and crushed sidewise. The layers of clay and chert are evidently in their original position relative to the ore, but they are broken and mixed. It is doubtful whether this statement could also be extended to the surrounding mass of sand and loam.

Buckland Bank, S. ½, Sec. 20, T. 37, R. 8, W., Phelps County.—This bank lies at the foot of a sandstone hill, in the crossing of two ravines.

Fig. 46.



I give here a section of the mining-cut made in it, which presents a very plain instance of a disturbed specular-ore bank. This deposit seems to be actually overturned; the ore, which in regular deposits lies above the clay and chert (Cl and F), is here covered by the detritus of these materials. On the south side of the cut we find a mass of black, tenacious clay (Cl) mixed with fragments of a half-triturated, dark-gray clay-slate, and with pieces of pyrites, and impregnated with sulphate of iron. I have mentioned a somewhat similar sulphurous mass as having been found in the James bank, near St. James, below the ore and below the chert and clay beds that underlie it. It is therefore probable that also in the Buckland bank this mass lay below the clay and chert and ore formerly, but that the ore-deposit was underwashed with the erosion of the ravines in which it is situated, and broken and overturned.

The proximity of the regular sandstone on all sides, as marked on the sketch, shows that this deposit cannot extend horizontally much over the limits of the present cut; but it may extend somewhat in the depth.

Another bank in this district, which I shall mention in Chapter V. as Moselle No. 10 bank, seems also to belong in this category of disturbed deposits.

d. DRIFTED DEPOSITS OF SPECULAR ORE.

In the general introduction to this Chapter (IV.), I have given the reasons which induce me to add a category of "drifted deposits," although it is somewhat doubtful whether such deposits really exist. I understand by "drifted deposits," accumulations of loose fragments of destroyed or half-destroyed ore-banks, which fragments have been carried off by water over considerable distances, either alone or mixed with detritus of other rocks, and again deposited, either in more or less regular beds or strata, alternating with layers of other broken and triturated rocks, or irregularly distributed through large masses of such detritus. We have therefore two kinds of drifted deposits, the stratified and the irregular.

The detritus which accompanies such deposits always consists of sand, sandstone, chert, and red loam, of such a character as to leave no doubt that the original deposits were in the Silurian sandstone.

Specular-ore banks, having the exterior habitus of drifted deposits, are very numerous in the central ore-district of Missouri. I intend to describe a few of them in the following lines, but as none of them is sufficiently opened as yet to allow a clear insight into its interior composition, I must leave to future mining operations to decide whether any, and how many, of these banks, really are what they externally look to be, namely, "drifted deposits," or whether, on the contrary, the bowlders and pieces of ore visible at present are only outliers of either intact or disturbed deposits, which now lie hidden in the ground.

FRANKLIN COUNTY ORE-DISTRICT.

Blanton Specular Bank, N. ½ S. E. ¼, Sec. 29, T. 40, R. 1, W., Washington County.—Some rounded surface-ore, mostly small, is found on three flat spurs of a low ridge. Strata of solid sandstone crop out at the foot of these spurs, dipping slightly south-west. The spurs point about north.

A hole, dug 15 feet deep on the top of the most eastern spur, passed through drifted, sandy detritus, with little ore, and then struck a layer of chert.

This bank consists, according to these observations, of a low sandstone-hill, thickly covered with detritus, through which single pieces of specular ore are unequally distributed. The presence of larger and workable masses of ore is not impossible, but is nowhere plainly indicated. The ore itself is of good quality.

Primrose Hill, S. W. ¼ N.W. ¼, Sec. 32, T. 40, R. 1, W., Washington County.—This bank is, as far as opened at present, of a similar character as the Blanton specular bank. But the prospects are here better. The surface-ore, mostly small and rounded, occurs on the inner side of a high horseshoe-shaped ridge, enclosing a deep ravine. The spurs ending the curved ridge point north-east. Pieces of a hard sandstone with quartz-cement, and of ordinary soft sandstone, are also found on the surface.

The ridge was investigated by three shafts, one on the northern slope of the western spur, the two others on the inner slope of the central and highest portion of the horseshoe. Neither of these shafts has reached the solid rock as yet. The two upper shafts are forty feet deep, in fine, sandy detritus, mixed with streaks and irregular masses of soft, red hematite, and of broken stalactites of half-decomposed specular ore, sometimes cemented by soft sandstone.

It is not unlikely that workable masses of ore will yet be met with in this vicinity.

STEELVILLE ORE-DISTRICT.

The Scotia district contains one bank that may belong here, namely, the Bleeding Hill. The Steelville district contains the N. G. Clark No. 1, the Knox, the Sea and Marsh, and the Ferguson banks, all in Crawford County. The last-named bank is the most worked, and therefore the most interesting of them.

Ferguson Bank, Sec. 21, T. 37, R. 4, W., Crawford County.

Fig. 47.

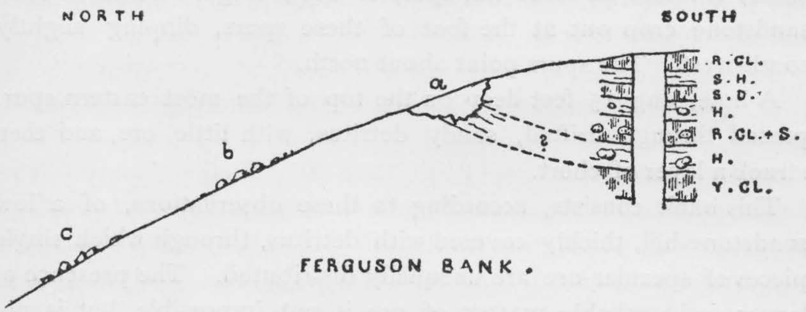


Fig. 47 gives an elevation of this bank, as it now appears. A flat northern hill-slope shows, in several places marked *a*, *b*, *c*, horizontal zones of larger and smaller specular ore on the surface. These zones are in some places very distinct, in others less so. They are from four to eight feet wide, measured down the slope. They seem to run across the slope, and to terminate on either side, in a ravine. The ravine on the western side is the deepest, and contains irregular accumulations of rounded ore. A shaft sunk, near the highest point of the slope, to a depth of twenty-two feet, passed through

6 feet of soil and red loam,
2 feet of soft, red hematite,
2 feet of red and yellow sandy clay,
2 feet of soft, red hematite, with pieces of specular ore,
2 feet of red clay, with pieces of sandstone and some chert,
8 feet of large bowlders of specular ore, imbedded in soft, red hematite,

below which a layer of light-yellow, clayish ochre was struck. All these materials seemed to be in layers of irregular thickness, generally dipping into the hill.

An opening made at the point marked *a*, has cut through a 6-feet layer of white sand and clay with bowlders of white sandstone dipping along the slope. Below this, layers of red clay with small ore were struck, dipping into the hill; below these, and dipping in the same direction, a 16-inch layer of broken chert with sandy clay, and 2 inches of fat, white clay; finally, large bowlders of specular ore, softened, and altered into red ore on the outside.

The above description would indicate that a considerable portion of this hill might be composed of alternate layers of broken ore and of detritus of rocks.

ORE-DISTRICT ON THE UPPER MERAMEC.

Smith Banks, Sec. 26, T. 36, R. 6, W., Phelps County.—The three Smith banks are situated on three very flat slopes or swellings of the ground, all pointing south, and lying about on an east-west line, within a distance of one half-mile. The two western banks, No. 1 and No. 2, are very near together, and have a very similar appearance. In both of them good specular ore, in very numerous, rounded pieces, is spread over a flat, triangular slope, encompassed by two small converging ravines, or water-runs, which unite at the lowest and southern end of the bank. The upper, wider, and most northern part of the slope, which forms the base of the triangle, passes into a plateau.

This triangular space, over which the ore extends, is about 250 feet wide at the base and 300 feet long in the western or No. 1 Smith bank; and it is 250 feet wide at the base and 600 feet long in the central or No. 2 Smith bank. The ore of the latter rarely exceeds fist-size, while that of the former is generally somewhat larger, and sometimes reaches head-size. Pieces of broken chert and sandstone are found with the ore. The No. 1 bank extends 12 to 20 feet over its western ravine and up the opposite slope, where the ore, however, has a somewhat different character, being mostly stalactitic, or "pipe-ore."

Three holes were dug, 8 to 10 feet deep, on various points of the Smith bank No. 1. They passed through loose masses of broken white sandstone, sand, broken chert, white clay, and red loam, all mixed irregularly, and containing in places some soft, red hematite and some rounded specular ore, the latter principally concentrated in the soil or near the surface. I have explained the process by which such a concentration is effected, in my description of the Simmons Mountain, in division *b* of this chapter.

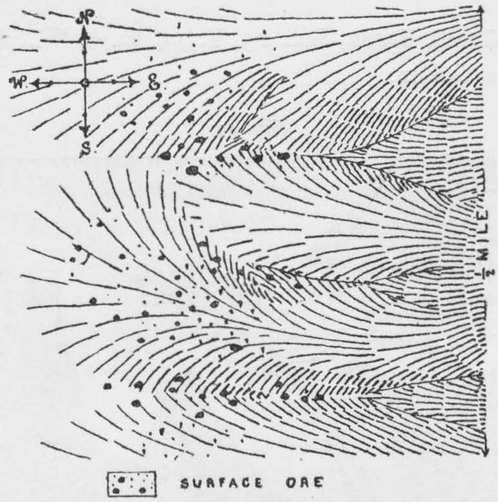
There is no doubt that the now visible portions of the two western Smith banks have the character of irregular, drifted deposits. They may contain, occasionally, larger and workable accumulations of ore; but no one can tell whether or where they exist.

The Smith bank No. 3 has a different appearance. On the upper part of a flat slope a circular depression of sandstone is perceptible, having a diameter of about 50 feet, and being marked by annular outcrops. Inside of these outcrops is a small accumulation of specular ore, in rounded pieces, from nut- to head-size. This description would indicate the presence of an undisturbed deposit of the category *b*; but the scarcity of the surface-ore, the small size of most of it, the light color of the surrounding sandstone, the absence of ferruginous materials, the very slight dip of the sandstone-outcrops, and the small diameter of the circular space they enclose, all this together makes me believe that this bank was formed by a slight depression of the sandstone, in which depression some drifted ore has found a resting-place.

Fitzwater Bank, Secs. 33 and 34, T. 35, R. 4, W., Dent County.—This bank occupies a pretty high position, being about four hundred feet above the Fitzwater Creek. It lies on the western slope of a ridge, which is composed of Third Magnesian Limestone, capped by Second Sandstone. The ore seems to overlie the latter. A sandy soil, mixed with fine chert, and with pieces and larger masses of chert, either porous or dense, covers the surface of the hills.

The ore-bank is as yet untouched. Fig. 48 is a topographical sketch of this locality, showing the manner of distribution of the surface-ore over one large central spur, and over the adjacent slopes of two spurs, north and south of the central one. The best indications extend about fifteen hundred feet north and south, and about eight hundred feet east and west. Most of the ore is below the size of the fist, and rounded off at the corners and edges. In some places, however, it reaches and exceeds the size of the head. This is especially the case in the ravines, where the most considerable accumulations are found. Pieces of yellow sandstone, and

Fig. 48.



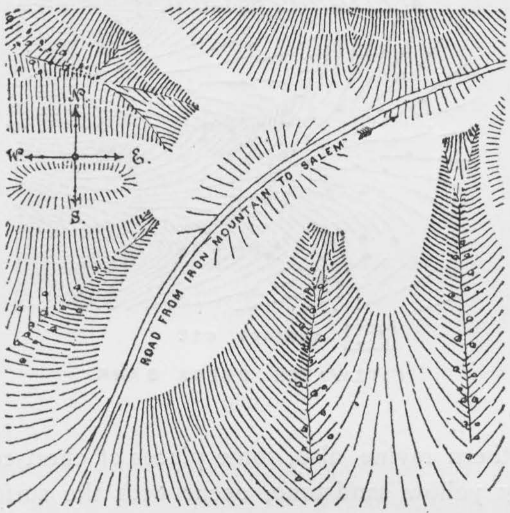
near the northern ravine, also, some pieces of chert-conglomerate, cemented by yellow sandstone, occur with the surface-ore. No ferruginous rocks have been observed. The ore seems to be most abundant at a certain level along the slopes, which level is about eight feet below the highest point on the two northern spurs, which are flat and low. The southern spur, a part of which only is visible on the sketch, is considerably higher, and the level of the most abundant surface-ore is there much farther below the highest point. These observations indicate that there might exist a thick and extensive layer of drifted ore, running nearly horizontally through all three spurs, and covered by a mixed detritus of sandstone, chert, and ore. It is, however, obvious that such a conclusion cannot be drawn with any degree of certainty. The character of this bank is not indicated with sufficient clearness, by its external appearance, to make a reliable judgment possible.

Other banks in this district, which may be supposed to be drifted deposits, are the Santee, the Anderson, the Blackwell, the Reuben Smith, and the Carson banks, the location, etc., of which will be given in Chapter V.

SALEM ORE-DISTRICT.

Hutchins Creek Bank, Sec. 15, T. 34, R. 4, W., Dent County, 9 miles east of Salem.

Fig. 49.



HUTCHINS CREEK BANK.

The topographical sketch, Fig. 49, shows that this bank has much resemblance to the Fitzwater bank, and that its character is even less pronounced than that of the latter. Good specular ore, from nut-size to one foot diameter, mostly rounded, is found in four ravines on the west and south sides of a high ridge. Quite scarce and only very small ore is seen on the spurs between the ravines. The ore in the ravines does not reach a higher level than about 30 feet below the top of the ridge. The hills are covered with soil and chert. Large and small pieces of white sandstone are met with on the lower part of the slopes. I could not find any ferruginous rocks. The district represented in Fig. 40, and containing the four ravines in which the ore is principally concentrated, measures over one-quarter of a mile in each direction.

Practical opening and working only can decide whether the ore in the ravines has come from a coherent deposit existing in the ridge, or whether it is derived from a drifted deposit, and has been concentrated in the ravines by the gradual erosion of the latter.

Other deposits in this district are the Huzzah, the Pittsburgh, the Norris, the Hayes, and the Orchard & Young banks. For locations, etc., see Chapter V.

IRON RIDGE DISTRICT.

Iron Ridge No. 2, Sec. 33, T. 39, R. 5, W., Crawford County.—A pretty extensive tract of slightly undulating ground, ½ mile north of Iron Ridge Station, on the Atl. and Pac. R. R., contains in many places indications of specular ore, and occasionally shows large bowlders of good surface-ore. A number of ditches were made to investigate this tract, and disclosed irregular accumulations, mostly of small extent, of rounded ore with red clay, of white clay with pieces of chert, and of impregnated sandstone. This locality has decidedly the appearance of an irregular, drifted deposit.

Other banks, supposed to be of a drifted nature, are, in this district, J. P. Card & Co.'s, Senator Buckland's, the Dorey, the Isabella, and N. G. Clark & Co.'s banks; in the St. James district the Thompson, the A. C. L. No. 1, the Railroad Nos. 1, 2, 3, the Lenox, the Hall, and the Seaton banks. See the ore-bank list, Chapter V.

ROLLA DISTRICT.

Kelly Bank No. 2, N. E. ¼, Sec. 21, T. 37, R. 8, W., Phelps County.—Two openings have been made, one on the summit and another on the eastern slope of a hill apparently composed of sandstone covered by cherty soil.

The lower opening shows a double succession of layers of clay, of broken chert, and of broken, ferruginous sandstone, dipping 45° south-east, and below this an irregular mass of soft hematite, red and brown, containing thin veins and small pockets filled with crystalline carbonates of iron. These carbonates are also found as cement of broken chert. On the north side of the cut is a large mass of a loose, gray rock, probably triturated calcareous sandstone. This rock contains single crystals of iron pyrites, and also veins of carbonate of iron. The latter is evidently formed after these masses were brought into their present irregular position.

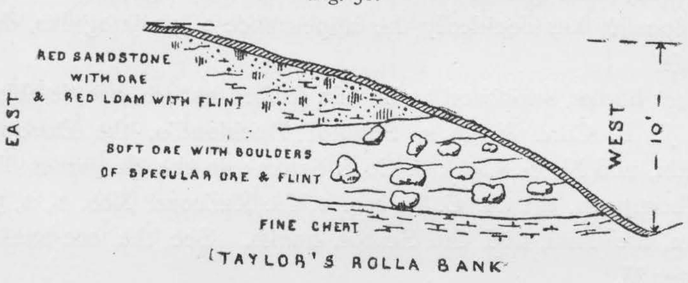
The upper opening shows a bed of bowlders of limonite, some

1--2 feet in diameter, imbedded in red loam, without any chert. This limonite is in its general appearance more like that found in limestone, and unlike the limonite formed by alteration of specular ore.

The Kelly No. 2 bank is evidently a locality which has undergone several strong disturbances at various epochs. The materials met with in the lower cut especially may have been broken up, drifted, deposited, and after that once more disturbed and broken.

Taylor's Rolla Bank, S. W. ¼, Sec. 15, T. 37, R. 8, W., Phelps County.—This bank is situated a short distance from the Kelly bank No. 2. It is less irregular in its formation, and has more distinctly the character of a drifted deposit, as may be seen from the section, Fig. 50.

Fig. 50.



The bottom of the cut consists of a bed of finely-broken chert. Above this is a layer, 3 feet thick, of soft, red hematite, in part clayish, and full of seams, specks, and irregular masses of spathic iron-ore (carbonate of iron), and enclosing bowlders and pieces of specular ore and of chert. Above this are 5 feet of alternate layers of red, somewhat ferruginous sandstone, and of red loam with broken chert. A cherty soil covers the slope.

Other perhaps drifted deposits are, in this district, the Hyer, the Cold Spring, the Coleman, the Piney Creek, the Baird, the Hudgeons, the Camp Creek, and the Railroad No. 4 banks; in the Gasconade district, the Frost, the A. C. L. No. 2, the Railroad No. 5, the Morgan, and the James pipe-ore banks; on the lower Osage River, the Wimar Creek, the Belans Creek, and the Linn Creek banks.

e. STRATA OF RED HEMATITE.

The red hematites of the carboniferous formation, which hematites I have mentioned in Chapter I. and described in Chapter II., do not occur as deposits with definite limits, lying as independent and foreign developments between or across the regular stratified or unstratified geological rocks; but, unlike all other deposits of iron-ore in Missouri, they form and compose in themselves regular geological strata.

These strata of red hematite, although always in the carboniferous system, do not seem, however, to occupy the same geological horizon in all the localities where they are found. While occurring in the so-called Ferruginous Sandstone of the subcarboniferous formation in Callaway and Cooper Counties, and on the Upper Osage River (in St. Clair and in the south-eastern corner of Henry County), the strata discovered near Calhoun, in Henry County, lies, according to Mr. G. C. Broadhead's investigations, in the Lower Coal-measures.

The development of red hematite in the Ferruginous Sandstone seems frequently to extend over large areas. The sandstone in such districts becomes more and more impregnated with iron, contains more and more nodules and layers of pure ore, and finally entire strata of sandstone, varying in thickness from a few inches to three and more feet, are replaced by the ore.

None of the deposits of this kind are as yet sufficiently opened and worked to allow the geologist to decide whether this ore was formed directly after and on the surface of the underlying sandstone, or whether it was infiltrated afterward, gradually removing and replacing either beds of limestone in the sandstone, or beds of the sandstone itself, which happened to be more soluble than other layers, or more liable to be attacked and altered by the chalybeate solution, at the temperature then existing.

CALLAWAY COUNTY DISTRICT.

Old Digging, Sec. 22, T. 45, R. 10, W., Callaway County.

Fig. 51 is a sketch of this locality. The lower part of the hills seems to be composed of subcarboniferous limestone, the upper of ferruginous sandstone. Large and small fragments of chert are found all over the surface of the ground. The ore has been discovered in two places, near the top of the hill, on both sides of the ravine. On the western hill a hole was dug a number of years ago, and it is said that many tons of ore were taken out of it and were worked in a charcoal-hearth in the valley.

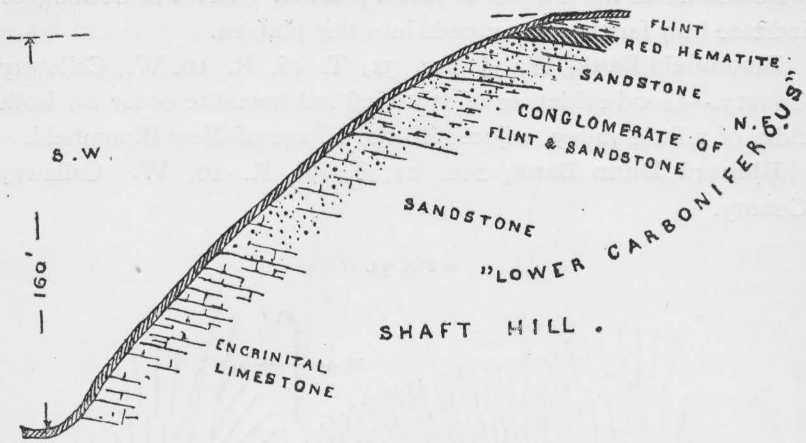
Fig. 51.

On the east side of the ravine, and rather close to it, an outcrop is perceptible, consisting of a 5-inch stratum of solid, pure, red hematite. The place is not opened, and the total thickness of the ore cannot be seen.

As the ore in both these outcrops, east and west of the ravine, seems to be in place, it is probable that a stratum of ore extends from the one to the other, and perhaps through the whole hill.

Shaft Hill, N. W. 1/4, Sec. 4, T. 45, R. 10, W., Callaway County. —This hill, of which I give a geological section in Fig. 52, is one of the most hopeful localities, and one whose structure is most clearly seen, in this ore-district. It is now being opened and worked. The annexed section was made from the indications perceptible on the surface. The strata seems to dip slightly north-east. The limestones, sandstones, and conglomerates are exposed in

Fig. 52.



several places, forming high bluffs. The ore and the strata overlying it are not exposed, and have to be judged from the pieces found on the surface. Fragments of ore are found at a certain level all round the hill. A stratum of ore undoubtedly runs through the hill, and its thickness may, from the surface-indications, be estimated as varying from one to three feet. In some places, however, it seems to reach a thickness of five feet. The hill is nearly round, and has, at the level of the ore-bed, a diameter of about 800 feet.

The ore occurs sometimes in nodules or lenticular concretions, composed of several concentric layers, and apparently imbedded in loose sand; sometimes in thin layers, alternating with layers of loose sand; sometimes as thick, massive strata.

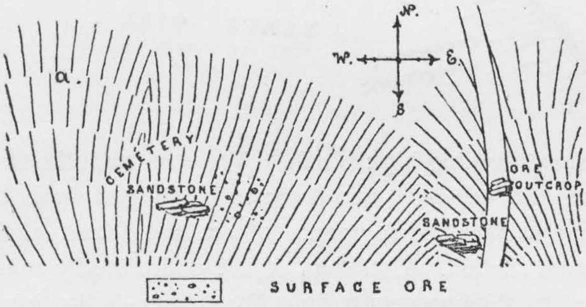
A shaft was dug, ten years ago, on the eastern slope of the hill, near a deep ravine, at a level considerably below that of the regular ore-bed. The shaft went eight feet deep through sand and broken ore and chert. Larger masses of ore have lately been discovered there. This part of the Shaft Hill deposit has probably been displaced, and is only the remainder of a portion of the regular ore-stratum which was underwashed and partly destroyed by the erosion of the ravine.

Raph Dunn Bank, S. E. ¼ Sec. 32, T. 46, R. 10, W., Callaway County.—This bank is situated close to the Shaft Hill bank, and separated from the latter by a deep ravine. The ore-deposit must have been originally a continuation of that on Shaft Hill, to judge from the similarity of their position. Outcrops of the ore can be observed on the east side of the hill, near the top. Toward the west and north the hill passes into a plateau. There is nothing to indicate how far the ore extends into this plateau.

Bloomfield Bank, W. ½ Sec. 32, T. 46, R. 10, W., Callaway County.—Good evidences of stratified red hematite occur on both sides of a little valley, adjacent to the village of New Bloomfield.

Richard Dunn Bank, Sec. 21, T. 46, R. 10, W. Callaway County.

Fig. 53.



RICHARD DUNN BANK

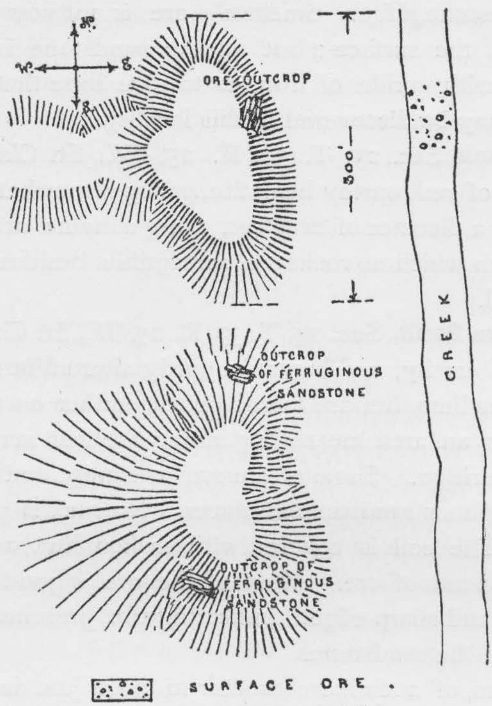
Strata of red hematite are perceptible three miles north of New Bloomfield, on the road to Fulton. The ore crops out in the road for a distance of about twelve feet down the slope. Sandstone is seen both above and below the ore. One-quarter of a mile west, on the same slope and level, stratified ore has been found immediately below the soil, in digging graves in a cemetery. A connection between those two points cannot be traced at present.

Knight Bank, Sec. 2, T. 46, R. 10, W., Callaway County.

A fine outcrop of dense and fine-grained hematite is seen on the eastern slope of the northern low hill, as represented in the sketch, Fig. 54. The ore is over two feet thick, and dips north about twenty degrees. It can be seen only in two places, about twenty feet apart. But the ore seems to be in place, and may therefore be expected to run through the hill. Due east of this hill, small and large pieces and plates of ore are found loose in the bed of the Middle Auxvasse Creek, as indicated on the sketch.

The southern low hill in Fig. 54 shows, at both its northern and southern slopes, outcrops of a ferruginous sandstone, overlaid by

Fig. 54.



KNIGHT S BANK.

thin seams of red ore. These indications are, however, not sufficient to warrant the presence of workable ore in this southern hill.

UPPER OSAGE DISTRICT.

Brown Bank, Sec. 23, T. 40, R. 24, W., Henry County.—The Brown bank is situated on the dividing ridge between Osage and Grand Rivers. This ridge consists of subcarboniferous rocks. Red, earthy hematite, partly changed into brown and yellow limonite, is found on the surface over a very large area, associated with ferruginous sandstone. The bank is not opened, and the thickness and extent cannot be estimated with any degree of certainty from the present appearances.

Gover Bank, Sec. 16, T. 39, R. 24, St. Clair County.—Large and small fragments of ferruginous sandstone, frequently very rich in iron, together with some brown and red hematite, are spread over a zone several hundred feet wide, and about one-fourth mile long, across a limestone ridge. Smeltable ore is not now seen in large quantities on the surface ; but all the sandstone is so strongly impregnated with oxide of iron, as to give hope that a larger deposit of ore may be discovered in this locality.

Collins Bank, Sec. 23, T. 39, R. 25, W., St. Clair County.—An outcrop of red, earthy hematite, partly somewhat argillaceous, extends over a distance of 200 feet, along a ravine at the foot of a steep slope, on which no rocks are perceptible besides broken chert above the soil.

Marmaduke Bank, Sec. 23, T. 39, R. 25, W., St. Clair County.—Fragments of earthy, red hematite, partly altered into a yellowish-brown, porous limonite, are found on the surface on the summit of a ridge, over an area measuring about 600 feet across, and 400 feet along the ridge. Some of the ore is sandy, and passes into a regular ferruginous sandstone in places. No rock is perceptible on the ridge. The soil is covered with broken flint, which is mixed with the fragments of ore. Most of the ore is good and the fragments large and sharp-edged, indicating the presence of a stratified deposit in the sandstone.

Other banks, of a similar character to those just described, seem to be, the Black Fork and the Lamine banks, both in Cooper County, and the Parkes bank, near Calhoun, in Henry County. The ore of the last-named bank is in the coal-measures, as mentioned above. For the location, etc. of these banks, see Chapter V.

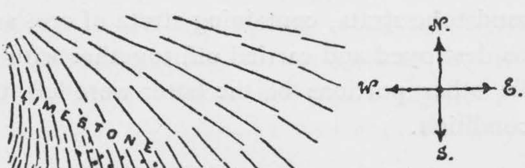
f. DISTURBED OR DRIFTED DEPOSITS OF RED HEMATITE.

I will describe under this head a few either drifted, or at least greatly disturbed, deposits of originally stratified red hematite. Although having at present the appearance of such half-destroyed deposits, they may lead to the discovery of coherent banks when they are more closely investigated.

Murphy's Hill, Sec. 15, T. 45, R. 10, W., Callaway County.—This locality is situated a short distance east of the "Old Digging" bank, which has been above described. No ore is here to be seen in place, but large, somewhat rounded pieces and plates of red ore are found in two ravines, and were evidently washed down from the hill. The hill itself seems to be principally composed of sandstone. Large masses of limestone are, however, projecting from the lower part of the slopes, apparently between the sandstone.

Henderson Bank, Sec. 12, T. 45, R. 11, W., Callaway County.

Fig. 55.



HENDERSON BANK

The sketch, Fig. 55, shows the occurrences of ore to be observed at the Henderson bank, namely, loose and rounded surface-ore in several places on the two hills, west of the road; loose surface-ore along the road, on the northern slope of the eastern hill; a small and indistinct outcrop of stratified ore at the foot of this hill, near the ravine; and finally, loose surface-ore in the ravine.

The two western hills are composed of encrinital limestone, which is laid bare in several places, and seems to reach the summits, and to be covered only by soil. This soil is thick and copious on the plateau on the northern hill, and is there used for agricultural purposes. Loose ore is sometimes thrown up by the plough on this plateau. The hills are about 40 feet high above the creek. The hill east of the road is thickly covered with a fine sandy soil and by vegetation, and does not show any evidences of rocks. The ore-outcrop at the foot of this hill dips slightly north-west. The ore is a dark-red, fine-grained hematite in thin layers, and is associated with layers of chert. The exposure extends, however, over a few feet only, and is therefore too small to allow a reliable judgment regarding its character.

All appearances at the Henderson bank seem to indicate that the encrinital limestone which composes the hills was formerly covered by sandstone-strata, containing strata of ore, and that this sandstone was destroyed and carried off, together with portions of the ore, while other portions of the latter were left, though in a dilapidated condition.

g. DEPOSITS OF LIMONITE ON LIMESTONE.

The distribution of the limonites over the State has been described in Chapter II. All undisturbed limonite deposits are found on limestone. The deposits along the Mississippi lie partly on the Upper Silurian shales and limestones, partly on the Second Magnesian Limestone, according to Shumard's reports. All the other deposits of limonite in the eastern ore-region, as well as those in Franklin County and in the central region, seem to lie on the Third Magnesian Limestone, as far as their position could be ascertained. The same geological position is occupied by the limonites on the Lower Osage and some of those on the Middle Osage, while those in the western parts of Camden and Morgan Counties, and those in Benton County, are on the Second Magnesian, and those on the Upper Osage on the lower carboniferous limestones.

The ore occurs neither in veins, nor in beds, nor as strata, nor in lenticular or other pockets of well-defined limits and regular shape. It is deposited in irregular cracks, pockets, and cavities, either on or near the surface of the various limestones. These cavities have sometimes very large dimensions, in depth as well as width, as will be seen from the following descriptions. In other instances they are quite small; but wherever they exist, they are not single, but a larger number of them is generally found together on a comparatively small space. They are also mostly near the present surface of the ground, and not covered by rock-deposits. The underlying limestone, especially the Third Magnesian, is often sandy, sometimes so much so as to be readily taken for a calcareous sandstone. The rock is more sandy and more loose where it is in immediate contact with the deposit, showing that it has been exposed to dissolving agencies.

The ore is occasionally mixed with broken chert. In some localities, where the banks are sufficiently opened to make observations possible on this point, the ore in the upper part of the deposits is considerably harder and denser and richer than in the lower part, where it is more inclined to be light, porous, ochrey, and clayish.

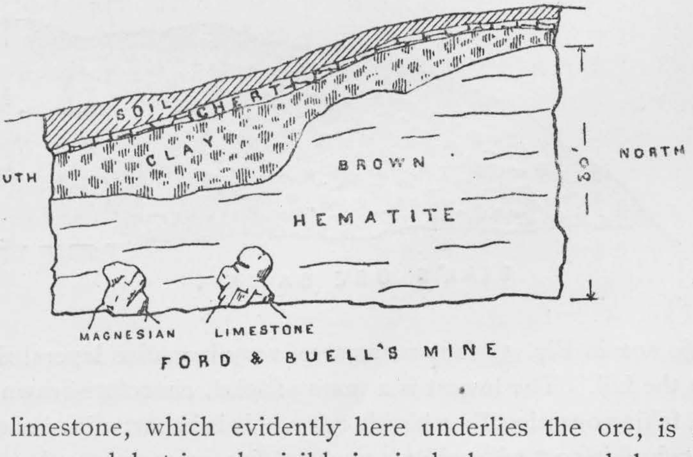
This fact, and the invariably stalactitic structure of the ore, are proofs that the solutions from which the ore was deposited have been infiltrated from above. The chemical influence of the carbonate of lime has undoubtedly contributed, in no small extent, to precipitate and deposit the iron in the form of hydrated oxide.

SOUTH-EASTERN LIMONITE-DISTRICT.

The limonite deposits along the Mississippi River are described in Dr. B. T. Shumard's reports on St. Genevieve, Perry, and Cape Girardeau Counties.

Ford Bank, T. 33, R. 7, E., one-half mile from Cornwall Station, on the eastern branch of the Iron Mountain Railroad, in Madison County.—This bank is opened and mined, and is one of the largest and most coherent limonite deposits. The ore-indications on the surface extend about 1,500 feet along a low, flat hill, to a width of about 500 feet. The bank is mined in two different cuts: Fig. 56 represents a section through one of them.

Fig. 56.



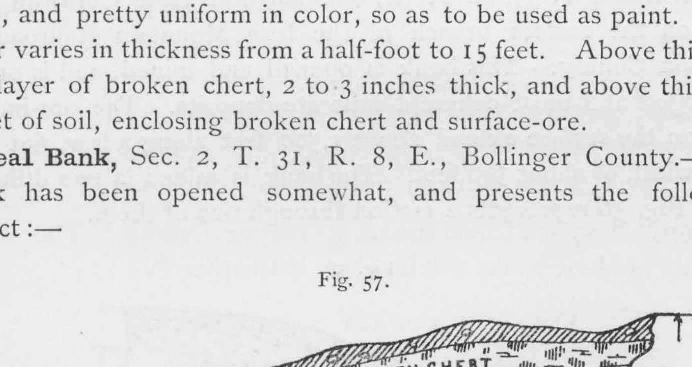
The limestone, which evidently here underlies the ore, is not much uncovered, but is only visible in single, large, rounded masses of irregular shape. This limestone is so sandy and loose on its surface that it has there the appearance of a soft, calcareous sandstone.

The ore lies immediately above it. It is a limonite, which in this deposit is softer and less distinctly stalactitic than in most other limonite banks. It consists of irregularly-mixed masses of yellow and reddish-brown, porous ores, and of somewhat harder, dark-brown, but generally porous limonite, frequently in botryoidal and mammillary forms. The softer ore passes occasionally into a pure yellow ochre. The best, purest, and hardest ore is in the upper part of the deposit ; the softer and ochrey ore is found more in the lower part. But all the ores are mingled irregularly, without any perceptible law or rule, and without any sign of stratification. They are in some places clayish, and contain seams of brown and red clay. The thickness of the ore is very variable and irregular. It is in places only 10 feet and less, and reaches in other places 30 feet.

Above the ore is an irregular layer of reddish-brown clay, fine, pure, and pretty uniform in color, so as to be used as paint. This layer varies in thickness from a half-foot to 15 feet. Above this clay is a layer of broken chert, 2 to 3 inches thick, and above this 1 to 5 feet of soil, enclosing broken chert and surface-ore.

Deal Bank, Sec. 2, T. 31, R. 8, E., Bollinger County.—This bank has been opened somewhat, and presents the following aspect :—

Fig. 57.



DEAL'S ORE BANK.

We see in Fig. 57 four successive, very irregular layers, sloping with the hill. The lowest is a mass of solid, chocolate-brown limonite, taking occasionally a bluish color. It is in part mixed with yellow ochre, in part with white or yellow, fine or coarse, broken chert.

The layer above the ore is red clay, with broken veins of ore which enclose broken chert.

Above this is a yellow, sandy clay, mixed with fine chert, and interstratified with layers of this chert.

Above this is a cherty soil, with bowlders of good, hard, and dense limonite.

It may be hoped that the ore in this deposit will turn purer toward the bottom. This can be ascertained only by actual prosecution of the work, because none of the numerous localities where limonite occurs, mixed with chert in this manner, have as yet been fully opened, so as to give a basis for general conclusions in this respect. It seems, however, not unlikely that the chert has come into the ore from above, through the same apertures in which the solutions came, and that the chert has been retained in the upper ore, and that the lower portion of it, therefore, will contain less of it.

Irondale Banks.—Several limonite banks exist in the vicinity of Irondale, in Washington County. The ore is there deposited in numerous small, irregular pockets on the surface of the Third Magnesian Limestone. Larger coherent masses are rarely found.

Other undisturbed limonite banks in the eastern ore-district are the Russell No. 2, McLaughlin, Singer, Dinger, Lindsey, and Love banks in Iron County, the Jessie Lutz and Francis banks in Bollinger County, the Buffum bank in Reynolds County, and the Clarkson, Silvy, and Crane banks in Wayne County. The location, etc. of these banks will be given in Chapter IV.

FRANKLIN COUNTY ORE-DISTRICT.

Moselle Banks.—The various limonite banks in the vicinity of Moselle Furnace seem to have the same general character as the above-mentioned Irondale banks. Some of them, however, contain larger masses of ore, as, for instance, the

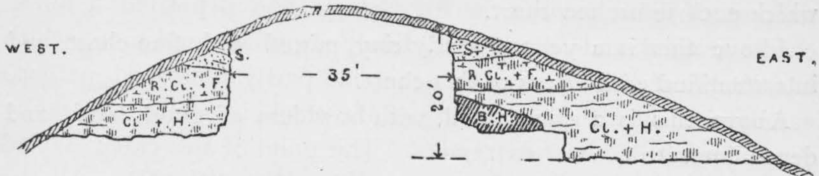
Bowlen Bank, N. W. 1/4 Sec. 5, T. 41, R. 2, E., Franklin County.

We have here the following succession of rocks, beginning with the lowest:—

1. Solid and uniform mass of pure, hard, chocolate-brown limonite, porous, with small, equally distributed pores (B H).

2. Clayish limonite, with irregular masses of yellow ochre, soft and friable, and easily crushed into a fine, dry, yellow dust (Cl + H).

Fig. 58.



3. Red loam, with green and gray broken chert (R Cl + F).

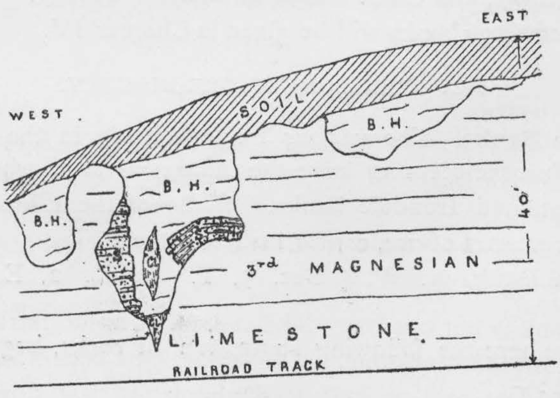
4. Sandstone, colored and impregnated with oxides of iron, in disturbed and broken layers (S).

5. Dry soil, with some chert.

As no limestone has as yet been struck, the ore will certainly extend to a greater depth, and may prove to form a considerable coherent deposit.

Iron Hill, Sec. 17, T. 42, R. 1, E., Franklin County.—The Iron Hill deposit seems to consist of numerous smaller cracks and cavities on the surface of the Third Magnesian Limestone, which cavities are in part or wholly filled with brown limonite and with yellow ochre. Some of these cavities have been cut through by the railroad-line, three miles west of Moselle Station. The following illustration, Fig. 59, gives a section of one of these :—

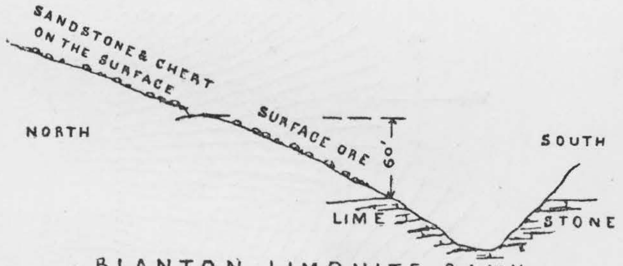
Fig. 59.



The Third Magnesian Limestone is here thickly stratified and very sandy, especially in the lower layers, and near the irregular depressions and cavities. The latter all start from the surface and reach more or less deep into the body of the limestone. In the deepest of these cavities, in Fig. 59, we find deposited a loose, coarse-grained and ferruginous, thinly-stratified sandstone, which has afterward been broken up again and partly destroyed, perhaps simultaneously with the opening of the crack in which the cavity terminates at its lower extremity. The point of this crack is filled with white clay and with broken, white chert (Cl+F). All the rest of the cavity is nearly filled with limonite (B H), in irregular, botryoidal, and stalactitic forms, mixed with yellow ochre and some chert. The lower part is mostly ochre; the higher portions are harder, and form one coherent, porous mass of limonite, in places mixed with heavy-spar. The thickest and least porous forms of the limonite enclose sometimes a core of pyrites. An oblong space, now filled with an indurated red clay (Cl), exists in the centre of the lower part of the cavity, and seems to indicate that the ore has been formed gradually from the walls of the cavity toward the centre, as well as from the top toward the bottom. There can be no doubt that the infiltration has taken place from above.

Blanton Limonite Bank, S. ½ S. W. ¼ Sec. 29, T. 40, R. 1, W., Washington County, on the southern slope of the Blanton Hills.

Fig. 60.



BLANTON LIMONITE BANK

This bank is not opened. The ore seems to lie on the limestone and beneath the sandstone. The surface-ore occurs in pieces and large bowlders, and can be traced about 150 feet down the slope and 60 feet along the slope.

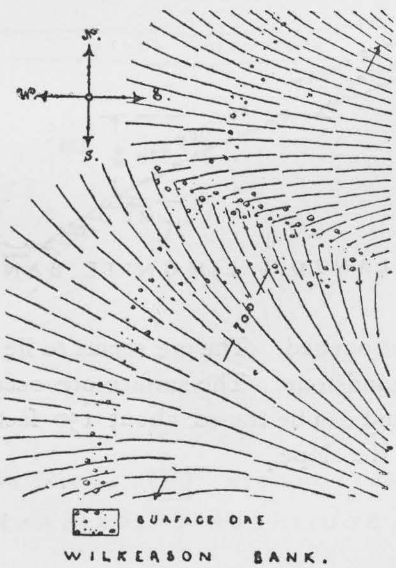
CENTRAL ORE-REGION.

Steelville No. 2 Bank, E. ½ S. W. ¼, Sec. 5, T. 37, R. 4, W., Crawford County.—This is a limonite bank, situated but a few hundred feet north of the Steelville No. 1 bank of specular and red ore.

This limonite bank presents a very fine show of large surface-ore on the eastern slope of a sandstone hill, near its foot. A brown, impregnated sandstone is found above the ore on the same slope, passing into a white sandstone, which forms the summit. It is not now to be seen what rock underlies the ore, because the latter descends to the foot of the hill and into the valley. The surface, over which the ore is spread, is about 400 feet long and 30 to 40 feet wide. A narrow belt of breccia of gray and green chert, cemented by an indurated clay, encircles the ore above, and separates it from the sandstone. Some soft, red ore has been found close to the bank north of it. These facts would indicate that this might be a transformed specular-ore deposit; but the absence of all specular ore and the mineralogical character of the limonite make it more probable that it will prove to be an original limonite deposit on the Third Magnesian Limestone.

Wilkerson Bank, Sec. 34, T. 36, R. 4, W., Crawford County.

Fig. 61.



WILKERSON BANK.

As Fig. 61 shows, this bank exhibits a considerable quantity of surface-ore, in bowlders from one-half to two feet in diameter, lying in a curved line along the north-western slope of two hills, 15 to 20 feet below the summit, and being also concentrated in the ravine which separates the two hills. No distinct outcrop of rock can be seen. Pieces of chert are mixed with the surface-ore, and occasionally some sandstone on the southern, and single pieces of limestone on the northern, hill.

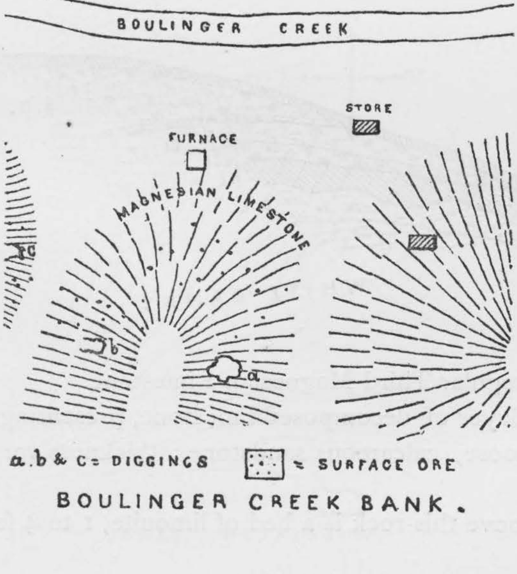
Other banks of limonite on limestone exist on Crooked Creek, and in several localities along the Gasconade River, also in numerous places in the southern part of the State. Many of these banks will be found in the list in Chapter V. of this report.

ORE-REGION ON THE OSAGE RIVER.

The most important limonite region in Missouri is on the Osage River. The banks on the Lower Osage, in Miller County, seem to be mostly disturbed, and do not therefore belong in our category *g*; but very numerous banks of this character exist on the Middle and Upper Osage Rivers, some of which I will now describe.

Furnace Bank, on Boulinger Creek, Sec. 4, T. 39, R. 18, W., Camden County.

Fig. 62.

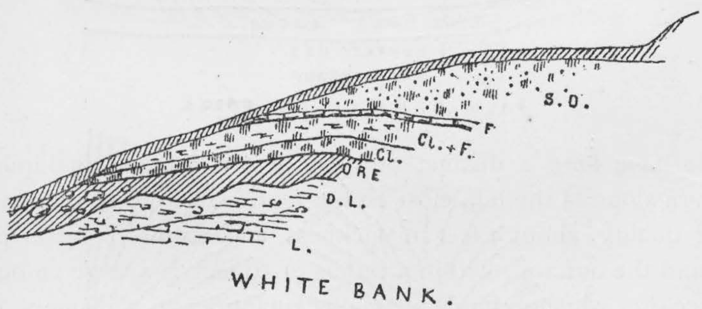


BOULINGER CREEK BANK.

Fig. 62 is a topographical sketch, on a very small scale, showing the extent of the surface-ore, the three openings, *a*, *b*, *c*, made into the deposit by the miner, and the position of the blast-furnace, which has been erected near the foot of the main hill, to smelt the ore. The distance between *a* and *c* is about one-quarter of a mile. The openings *a* and *b*, out of which a considerable quantity of good limonite has been taken already, have shown that the ore lies on the irregular surface of the Third Magnesian Limestone, which composes the main body of the hill. This limestone is very sandy near the ore, and has there the appearance of a loose, calcareous sandstone. The ore seems to form in some places a layer of irregular thickness on the limestone, and, besides, to fill all the pockets and cavities on the latter. One such cavity, which has been struck in the opening *a*, has been mined to a depth of 12 feet in the solid and pure ore without reaching the bottom.

White Bank, S. E. ¼ Sec. 7, T. 39, R. 18, W., Camden County. —The White bank, which has been opened by a tunnel and a shaft, has a great resemblance in its general character to the Furnace bank. The layer of ore on the limestone continues here pretty steadily some distance into the hill ; but larger cavities filled with ore have not been met with, so far. The following section, Fig. 63, will give an idea of the position of the ore as seen at present :—

Fig. 63.



L is the regular Third Magnesian Limestone.

D L is a layer of decomposed limestone, presenting the appearance of a loose, calcareous sandstone ; thickness varies from 2 to 30 inches.

Ore. Above this rock is a bed of limonite, 1 to 4 feet thick, soft and earthy, enclosing irregular masses of hard, solid ore of more or less stalactitic structure.

Cl. Dark-red to brown, strongly ferruginous clay or loam, ½ to 2 feet.

Cl+F. White and green clay in thin and irregular layers, with sand and chert, 1 to 3 feet.

F. Layer of white chert, 1 to 3 inches.

S. D. Layers of yellow sand and variegated clays and loams, with more or less broken strata of sandstone.

Palm Bank, on Dry Creek, N. W. ¼ Sec. 12, T. 40, R. 19, W., Morgan County.

Fig. 64.

PALM BANK ON DRY CREEK

We have here a distinct outcrop of ore in the ravine upon the western slope of the hill, close to the foot. The ore is a limonite of good quality, about 4 feet in thickness, and seems to be in place. Around the outcrop, within a radius of 30 feet, is a large amount of surface-ore, which extends in smaller quantities to a distance of 50 or 60 feet up the slope. The soil on the hill is mixed with chert. No other rocks are visible.

Wigwam Bank, Sec. 10, T. 40, R. 19, W., Morgan County.—The ore is a limonite, which is very largely mixed with chert, so much so as to form a breccia in some cases. There are, however, portions of it which are pure. It is found on the western slope of a cherty hill, the lower part of which seems to consist of a sandy, magnesian limestone. The ore extends about 1,000 feet along the slope and 60 feet vertically. Some sandstone is found on the surface of the upper part of the hill, a short distance from the ore and apparently above it.

Cout's Bank, on Flat Rock Branch, Sec. 14, T. 40, R. 19, W., Morgan County.—The ore lies on the east slope of a hill in a zone about 30 feet wide, extending 150 feet down the hill-side. It is a limonite, massive, but frequently mixed with fine, broken chert. A large amount of broken chert is seen on the surface, but there is no rock exposed.

Walker Bank, Sec. 36, T. 41, R. 20, W., Benton County, is situated at the top of a high, cherty hill, over which single pieces of ore are widely scattered. The outcrop of ore is circular, about 20 feet in diameter, and consists of large bowlders, some of which are several feet in diameter. The ore is a limonite of good quality.

Gun Bank, Sec. 33, T. 40, R. 20, W., Benton County.—Here a large amount of surface-ore is scattered for a distance of 50 feet vertically and 500 feet along the northern slope of a low, flat hill. Two test-pits have been sunk and numerous drill-holes, all of which struck the ore at a depth from 4 to 6 feet below the surface.

The ore is a good-quality limonite, and the bank is one of the most promising in this region.

Richwoods Bank, Secs. 3 and 4, T. 39, R. 22, W., Benton County.—Here the ore lies upon the western slope, in a belt about 30 feet wide, and extending some 200 feet up the hill.

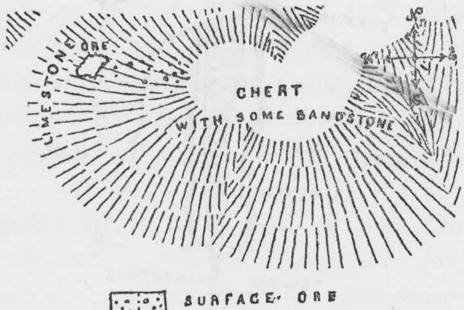
Above the ore is a yellow sandstone. The rock below is covered by soil, but at the foot of the same hill, a few hundred yards distant, is an outcrop of limestone, probably the Third Magnesian.

Indian Creek Bank, Sec. 26, T. 42, R. 21, W., Benton County.—The hill on which the ore is found is about 100 feet high. At the base, and extending probably 20 feet vertically, is a horizontal limestone, probably the Third Magnesian.

Above this, on the western slope, the surface is covered with chert and pieces of limonite-ore. At one place is a large bowlder of many tons' weight. It is partly formed of fine pipe-ore broken, and the pieces cemented again by ore. Other pipe-ore is mixed with the soil near by. Some surface-ore, though scarce, is found higher up on the southern slope, and on the top of the hill.

Sandstone probably forms the top of the hill above the limestone; the ore will be found, not forming a coherent deposit, but only larger or smaller accumulations in the cavities on the limestone.

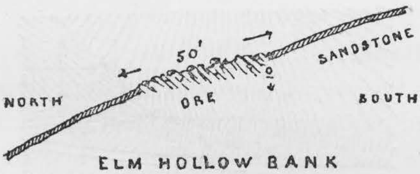
Fig. 65.



INDIAN CREEK BANK

Elm Hollow Bank, Sec. 36, T. 41, R. 22, W., Benton County. —The ore at this place lies upon the northern slope of a hill, over a surface perhaps 50 by 100 feet. It consists of numerous pieces, varying in size, not rounded. Chert is scattered over the whole

Fig. 66.



ELM HOLLOW BANK

hill, and near the top, above the ore, occur pieces of sandstone. There is a probability of this being a coherent deposit. In some of the larger pieces of the ore a core of pyrites was found.

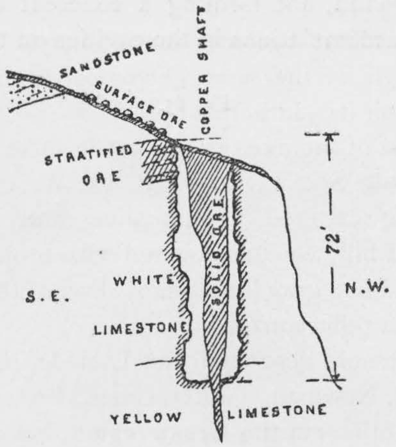
Copper Bank, Sec. 27, T. 39, R. 24, W., St. Clair County.

This bank is upon the north-west slope of a hill into which a shaft has been sunk to a depth of 72 feet, in search of copper.

The shaft is in a whitish limestone, probably the encrinital, and follows a crevice which is filled with a soft, earthy limonite. The course of this crevice is north-east and south-west.

At the mouth of the shaft, stratified ore appears several feet thick, and above this is an outcrop of ferruginous sandstone.

Fig. 67.



COPPER BANK

Sheldon Bank, Sec. 8, T. 38, R. 24, W., St. Clair County.— This hill seems to consist of a coarse-grained, semicrystalline, gray limestone, filled with encrinites, which crop out over the slope to a height of 80 feet. Higher up pieces of ferruginous sandstone are

Fig. 68.

SHELDON'S BANK

found scattered. The principal part of the ore is in bowlders, from one to three feet diameter, lying in the midst of large limestone outcrops. It is also found in smaller pieces higher up in the region of the sandstone. On the lower part of the slope the ore is solid limonite, somewhat argillaceous and ochrey, and inclined to stalactitic forms.

Higher up the hill it becomes more sandy. The hill north of this is 150 feet high, of the same geological formation, and shows some surface-ore on its southern slope.

This bank is one of the most promising in this region.

Greenwell Bank, Sec. 15, T. 39, R. 25, W., St. Clair County. —The ore occurs scattered 70 feet along and 40 feet down the slope of a low, flat hill, which is covered with broken flint and large bowlders of crystalline, gray limestone. Part of the ore is hard and solid, and part is argillaceous.

Besides these already described, the Laclede, the Big and Little Manqua, the Carl, Newman, Turkey Creek, Brown, Gover, Collins banks, and many others in this Osage region, belong to this class of ore-deposits.

h. DISTURBED OR DRIFTED DEPOSITS OF LIMONITE.

Some of the limonite deposits seem to have been disturbed from their position, others partly destroyed, broken up, and re-deposited. We find, therefore, some apparently on the sandstone, others as drifted ore imbedded in the soil, subsoil, or in other destroyed and drifted materials. Few of these deposits are, however, as yet sufficiently opened to allow a reliable judgment regarding their character.

Matthews Mountain, Sec. 3, T. 32, R. 6, E., Madison County. —The prevalent rock here is limestone, with cherty soil, but porphyry-hills are abundant. The porphyry is brown or reddish brown, with crystals of a transparent feldspar. Matthews Mountain is a high, steep hill, seemingly composed of this porphyry, although the rock-mass is covered with a thick layer of porphyritic detritus, with large, sharp-cornered pieces of porphyry. These are mixed with pieces and large, rounded bowlders of dense limonite. Near by, some test-pits have been sunk to a depth of 5 to 10 feet, in which large bowlders of ore were found mixed with the detritus, but the solid rock was not reached.

As no deposits of limonite are known to occur in porphyry, it has probably in this case been drifted into the detritus, from some limestone which has been eroded or washed away.

Poblick's Bank, Secs. 23 and 24, T. 32, R. 8, E., Bollinger County.—The ore is a hard limonite, occurring imbedded with white flint and pieces of sandstone in the soil and subsoil on the southern slope of a high and steep hill. No limestone is seen in this vicinity. The geology of this locality is the same as at the Gilman, Turkey Hill, and Murdoch banks, hereafter to be described. The surface seems to consist of irregular, unconformable, and indistinctly stratified red and yellow clays, mixed with sand and chert, and with pieces of sandstone originating from destroyed strata. This formation, which has evidently a secondary character, and looks as if deposited by greatly agitated waters, probably rests upon the top of the magnesian limestone, which can be seen directly, in a few localities, only in some of the deepest ravines. The soil covering this formation is itself clayish, but mixed with fine and coarse chert as well as with large pieces of flint, and often with pieces of limonite. This surface-ore seems in some places to have no connection with coherent deposits, while in others it has led to the discovery of more substantial deposits of irregular shape.

Gilman Bank, N. W. ¼ Sec. 1, T. 31, R. 8, E., Bollinger County.—At this place the soil is covered by, and encloses, a large quantity of white chert, mixed with fragments of a white sandstone. The Third Magnesian Limestone is seen cropping out in the bed of Crooked Creek, a half-mile from the ore-bank.

The mass of ore is of lenticular shape, and lies imbedded in yellow clay, mixed with fine, white chert. The ore is broken and fractured into pieces and blocks, which have, however, sharp corners and edges, and are so disposed as to indicate that they must have been at one time parts of the same coherent deposit, and have been broken apart by irregular shrinkage, or by movements of the surrounding masses.

Beds and layers of solid flint, which occur in the ore and clay, are also broken and fractured in a similar manner.

Turkey Hill, N. W. ¼ Sec. 32, T. 31, R. 10, E., Bollinger County.—The ore here is found at the foot of a steep hill near the bottom of a ravine. It consists of bowlders, large and small, of a generally pure, dark-colored limonite, which are imbedded and irregularly distributed in a yellow, marly clay, containing much white chert and flint.

A tunnel has been run about 20 feet into the hill, through clay containing ore-bowlders, without reaching the solid rock.

Murdoch Bank, Sec. 16, T. 30, R. 9, E., Bollinger County.—The ore of this bank is found scattered thinly over a surface of 2 to 3 acres on the top of a flat hill, and extending somewhat down the western slope. Near the top, the ore is impure, being mixed with a breccia of flint, the ore serving as the cement. On the slope it grows purer, but scarcer. There has been considerable prospecting done here, by scattered diggings and a shaft, but without disclosing anything but clay and chert.

Other banks, probably belonging to this class, in the eastern ore-region, are the Collins, Leeds Hill, Creder, Orth & Livering, Baker, and Lutz.

FRANKLIN COUNTY ORE-DISTRICT.

Stanton Hill Bank, S. W. ¼ of N. E. ¼, Sec. 36, T. 41, R. 2, W., Franklin County, is a circular depression of about 50 feet diameter, in a dark-colored sandstone which crops out all round, and toward the centre grows very ferruginous, where it has almost the appearance of crystalline, specular ore. The only pure ore found is a limonite. The lines of the strata in the sandstone are very much distorted, and its whole appearance indicates a disturbance from its original position.

OSAGE RIVER ORE-REGION.

In the Osage River ore-region there are very few deposits of class *h*, but of these the Carpenter and Grissom banks are the most important.

Carpenter Bank, Sec. 12, T. 46, R. 21, W., Benton County.

Fig. 69.

L. Sandy limestone.

C L. Ferruginous, reddish-brown loam.

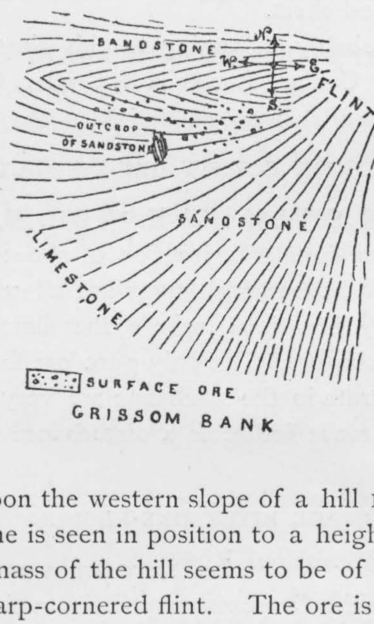
C L+F. Clayish sand, with one distinct half-inch layer of fine, white chert.

The ore covers the surface for but a small area, of perhaps 20 feet diameter, but is found scattered in less quantity in various other places on the same flat hill.

There is no ore in the strata of the cut; it is only found in the soil covering the strata, having been drifted there; but it may possibly be only an outlier of some deposit higher up the hill.

Grissom Bank, on Turkey Creek, Sec. 28, T. 46, R. 21, W., Benton County.

Fig. 70.



The ore lies upon the western slope of a hill 150 feet high. At the foot, limestone is seen in position to a height of about 16 feet. Above this the mass of the hill seems to be of sandstone, covered with pieces of sharp-cornered flint. The ore is in large pieces of irregular shape, very porous, partly of stalactitic fracture. Some of it is sulphurous. A singular feature of this bank is the appearance of the ore in large quantity and exclusively above the sandstone outcrops. From this feature some disturbance was inferred. The Sample and Tuscumbia banks are the only others of class *h* in this region having come to my knowledge.

CHAPTER VI.

THE IRON-ORES OF MISSOURI.

BY ADOLF SCHMIDT, PH. D.

D. *List of Deposits of Iron-ore in Missouri.—Explanation of the Signs used in the List of Deposits of Iron-ore in Missouri.*

THE following list contains all the deposits of iron-ore in Missouri which have come to my knowledge. As this list has been made principally for commercial and industrial purposes, the deposits were arranged according to their position along the various routes of transport, railroads or navigable rivers, over which the ores would have to be carried to their respective markets, or to those places where they may be used directly in the manufacture of iron.

They were arranged as follows :—

Deposits along the	Mississippi River	Nos.	1 to 6
" "	Iron Mountain R. R.	"	7 to 56
" "	Atlantic & Pacific R. R. east of Cuba	"	57 to 76
" "	St. Louis, Salem & Little Rock R. R.	"	77 to 125
" "	Atlantic & Pacific R. R. west of Cuba	"	126 to 181
" "	Missouri Pacific R. R.	"	182 to 198
" "	Osage River	"	199 to 273
"	in other parts of the State	"	274 to 278

The following columns are used in the list :—

Column 1. Consecutive Numbers.

Column 2. Name of deposits, or "banks." These names are taken either from the present or former owners, or from the lessees, or from people who live in the neighborhood, or from creeks, towns, or counties, or from other objects or circumstances having some connection with these ore-banks.

Column 3. Location of deposits, giving the township, range, and section. These were mostly obtained from the owners or lessees of the banks to which they refer.

Column 4. Counties in which the banks are situated.

Column 5. Names of the owners or lessees, or both.

Column 6. Probable character of deposit. The signs used in this column refer to the division of iron-ore banks, as given and explained under I. C. of the present report, in brief thus :—

a. Deposits of specular ore in porphyry.
b. Deposits of specular ore in sandstone.
c. Disturbed deposits of specular ore.
d. Drifted deposits of specular ore.
e. Strata of red hematite.
f. Disturbed or drifted deposits of red hematite.
g. Deposits of limonite on limestone.
h. Disturbed or drifted deposits of limonite.

Ore-banks which were not visited by members of the Survey have no sign in the 6th column.

Column 7. Probable size of deposit. As mentioned under I. A. of the present report, I have divided the various ore-banks in five sizes, according to the *number of tons of workable ore* they are supposed to contain, from their appearance and condition in summer, 1872. These sizes are :—

1.	Estimated at less than		20,000	tons.
2.	"	20,000 to	100,000	"
3.	"	100,000 to	500,000	"
4.	"	500,000 to	2,000,000	"
5.	"	more than	2,000,000	"

Column 8. Character of the ore. This column is required, because the 6th column cannot be filled for all the banks, and because many banks, though having, for instance, the general character of specular-ore deposits, contain also red hematites or limonites, produced in the course of time by altering influences.

Column 9. Distances from the nearest railroads or navigable rivers. I have considered this column indispensable, because the immediate industrial importance of the various banks depends in a great measure on their accessibility, and on their distances from the routes of transport. This column is less important for some deposits which are directly connected with iron-works.

EASTERN ORE-REGION OF MISSOURI.—ORE-DISTRICT ALONG THE MISSISSIPPI RIVER.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
1	Saline Creek bank..	T. 37, R. 7, E., Sec. 12.....	St. Genevieve.....	Kaufman estate.....	....	....	Limonite..	Mississippi, 12 m..	Shumard.
2	Kaufman's bank ..	T. 37, R. 8, E., Sec. 11.....	St. Genevieve.....	Kaufman's estate.....	....	....	Limonite..	Mississippi, 7 m ..	Shumard.
3	Wittenberg bank...	T. 34, R. 14, E., Sec. 19....	Perry...........	....	....	....	Limonite..	Mississippi, ½ m..	Shumard.
4	Collins' bank......	T. 34, R. 13, E., Sec. 36....	Perry...........	Molke & Hogan....	h.	1	Limonite..	Mississippi, 2 m..	Shumard.
5	Birmingham bank...	T. 33, R. 14, E., Sec. 6, S. ½.	Perry...........	St. Louis & Birmingham Mining Co...	....	....	Limonite..	Mississippi, 1½ m..	Shumard.
6	Williams's bank....	T. 31, R. 13, E., Sec. 10, N. W. ¼..................	Cape Girardeau...	Williams	....	....	Limonite..	Mississippi, 9 m..	Shumard.

IRON MOUNTAIN ORE-DISTRICT.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
7	Iron Mountain.....	T. 35, R. 4, E., Sec. 31, N. E. ¼....................	St. François.....	Iron Mountain Co..	a.	5	Specular...	I. M. R. R., o m.	....
8	Pilot Knob........	T. 34, R. 4, E., Sec. 29, N. W. ¼....................	Iron............	Pilot Knob Co.....	a.	4	Quartzous specular..	I. M. R. R., o m.	....
9	Shepherd Mountain.	T. 34, R. 4, E., Sec. 31, N. E. ¼....................	Iron............	Pilot Knob Co.....	a.	3	Specular & magnetic.	I. M. R. R., 2 m.	....
10	Cedar Hill.........	T. 34, R. 4, E., Sec. 30.....	Iron............	Pilot Knob Co.....	a.	2	Quartzous specular..	I. M. R. R., 1 m.	....
11	....	T. 34, R. 4, E., Sec. 28.....	Iron............	Pilot Knob Co.....	a.	1	Indications of quartzous hematites.....	I. M. R. R., 2 m.	....
12	....	T. 34, R. 4, E., Sec. 18, 17, 19, 20..................	Iron............	Pilot Knob Co.....	a.	1		I. M. R. R., 1 m.	....
13	....	T. 34, R. 4, E., Sec. 19, S. W. ¼....................	Iron............	Pilot Knob Co.....	a.	1		I. M. R. R., 1 m.	....
14	Buford Hill........	T. 35, R. 3, E., Sec. 26.....	Iron............	Iron Mountain Co..	a.	1	Indic. of micaceous & spec. ores.	I. M. R. R., 2 m.	....

15	Buford Mountain....	T. 33, R. 3, E., Sec. 24, N. E. ¼....................	Iron............	Pilot Knob Co.......	....	....	Specular...	I. M. R. R., 1 m.	....
16	Big Bogg Mountains.	T. 33, R. 3, E., Sec. 13, S. E. ¼....................	Iron............	....	....	....	....	I. M. R. R., ½ m.	2d Mo. Geo. Rep't, Pt. II. p. 83.
17	Russell bank.......	T. 33, R. 3, E., Sec. 3, E. ½..	Iron............	Giles Russell, of Ironton...........	....	....	Specular...	I. M. R. R., 3 m.	2d Mo. Geo. Rep't, Pt. II. p. 84.
18	Leeds Hill.........	T. 33, R. 4, E., Sec. 16 & 17.	Iron............	Allen, Leeds & Hogan	....	....	Limonite ..	I. M. R. R., 2 m.	....
19	Shut-in bank.......	T. 33, R. 4, E., Sec. 2, N. ½.	Iron............	Pilot Knob Co.......	....	....	Magnetic & specular..	I. M. R. R., 3 m.	....
20	Lewis Mountain.....	T. 33, R. 4, E., Sec. 6, S. ½.	Iron............	Allen, Leeds & Hogan	a.	1	Specular...	I. M. R. R., 2 m.	....
21	Cuthbertson bank ..	T. 33, R. 4, E., Sec. 19, N. W. ¼....................	Iron............	Cuthbertson.........	....	....	Manganiferous specular ...	I. M. R. R., 1 m.	....
22	....	T. 33, R. 4, E., Sec. 19 & 20.	Iron............	....	....	....	Limonite...	I. M. R. R., 1½ m.	....
23	Ackhurst bank......	T. 33, R. 4, E., Sec. 18, S. W. ¼....................	Iron............	Ackhurst............	....	....	Manganiferous specular ..	I. M. R. R., ½ m.	....
24	Hogan Mountain....	T. 33, R. 3, E., Sec. 14, S.E. ¼	Iron............	Hogan, of Arcadia..	a.	1	Specular ..	I. M. R. R., ½ m.	....
25	Russell No. 2 bank..	T. 32, R. 4, E., Sec. 17.....	Iron............	Giles Russell, of Ironton...........	....	....	....	I. M. R. R., 4 m.	....
26	McLaughlin bank...	T. 31, R. 3, E............	Iron............	McLaughlin, of St. Louis...........	g.	1	Limonite ..	I. M. R. R., 2 m.	....
27	Singer bank........	T. 30, R. 3, E., Sec. 2, S. ½.	Iron............	Singer, Nimick & Co., of Pittsburgh.	....	....	Limonite ..	I. M. R. R., 2 m.	....
28	Dinger bank.......	T. 30, R. 3, E., Sec. 2, N. ½ N. W. ¼..................	Iron............	Judge Dinger, of Ironton	....	....	Limonite ..	I. M. R. R., 2 m.	....
29	Lindsey bank......	T. 30, R. 4, E., Sec. 15, N. ½ S. W. ¼.................	Iron............	Lindsey, of Ironton..	....	....	Limonite ..	I. M. R. R., 3 m.	....
30	Clarkson bank......	T. 28, R. 4, E., Sec. 19.....	Wayne.........	Lindsey & Clarkson..	....	....	Limonite ..	I. M. R. R., 2 m.	....
31	Buffum bank.......	T. 28, R. 2, E. { Secs. 23, S. E. ¼, and 24, S. W. ¼.	Reynolds........	Lindsey & Buffum...	....	....	Limonite ..	I. M. R. R., 6 m.	....

Iron Mountain Ore-District.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
32	Gilvy bank	T. 28, R. 3, E., Sec. 26, S.E. ¼	Wayne	Gilvy, of Mill Springs	....	....	Limonite pipe-ore	I. M. R. R., 1 m.	....
33	Crane bank	T. 28, R. 3, E., Sec. 36, N. ½ S. E. ¼, & E. ½ S. W. ¼	Wayne	G. W. Crane, of Pilot Knob	..	....	Limonite	I. M. R. R., ½ m.	....
34	Love bank	T. 35, R. 1, W., Sec. 33	Iron	....	....	....	Limonite	I. M. R. R., 25 m.	....
35	Prentiss bank	T. 39, R. 4, E., Sec. 4, N. E. ¼	Jefferson	Prentiss	g.	1	Limonite	I. M. R. R., 2 m.	....
36	Irondale bank	T. 36, R. 3, E., Sec. 15	Washington	Harrison & Co.	g.	1	Limonite	I. M. R. R., ½ m.	....
37	Scott bank	T. 36, R. 3, E., Sec. 16	Washington	Harrison & Co.	g.	1	Limonite	I. M. R. R., 1½ m.	....
38	Eaton bank	T. 36, R. 3, E., Sec. 9	Washington	Harrison & Co.	g.	1	Limonite	I. M. R. R., 1½ m.	....
39	Kirkpatrick bank	T. 36, R. 3, E., Sec. 17	Washington	Harrison & Co.	g.	1	Limonite	I. M. R. R., 2½ m.	....

South-Eastern Limonite-District.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
40	Mathews Mountain	T. 32, R. 6, E., Sec. 3	Madison	Dundas & others	....	1	Limonite	I. M. R. R., 9 m.	....
41	Ford's bank	T. 33, R. 7, E.	Madison	Ford & Buell	g.	2	Limonite	I. M. R. R., ½ m.	....
42	Poblick's bank	T. 32, R. 8, E., Sec. 23 & 24	Bollinger	Gilman of Fredrickstown	h.	1	Limonite	I. M. R. R., 2 m.	....
43	Gilman bank	T. 31, R. 8, E., Sec. 1, N. W. ¼	Bollinger	Gilman of Fredrickstown	h.	1	Limonite	I. M. R. R., ½ m.	....
44	Deal's bank	T. 31, R. 8, E., Sec. 2	Bollinger	Col. Deal, Charleston, Mo.	g.	1	Limonite	I. M. R. R., ½ m.	....
45	Turkey Hill	T. 31, R. 10, E., Sec. 32, N. W. ¼	Bollinger	Brown, of St. Louis County	h.	1	Limonite	I. M. R. R., 2½ m.	....
46	Murdock bank	T. 30, R. 9, E., Sec. 16	Bollinger	Lincy Murdock, of Marble Hill	h.	1	Limonite	I. M. R. R., 2 m.	....

47	Jessie Leetz bank...	T. 30, R. 9, E., Sec. 11.....	Bollinger........	Jessie Leetz........	g.	1	Limonite..	I. M. R. R., 3 m.	....
48	Francis bank.......	T. 30, R. 9, E., Sec. 25.....	Bollinger........	R. O. Thomson and others, of St. Louis	g.	2	Limonite..	I. M. R. R., 6 m.	....
49	H. Creder bank....	T. 30, R. 9, E., Sec. 1......	Bollinger........	H. Creder.........	....	....	Limonite..	I. M. R. R., 2½ m.	....
50	Orth & Livering bank	T. 30, R. 9, E., Sec. 12 & 13.	Bollinger........	Orth & Livering....	....	....	Limonite..	I. M. R. R., 2 m.	....
51	Peter Baker bank..	T. 30, R. 10, E., Sec. 6, N. E. ¼..................	Bollinger........	Peter Baker........	....	....	Limonite..	I. M. R. R., 1½ m.	....
52	Philip Baker bank..	T. 31, R. 10, E., Sec. 32, N. E. ¼..................	Bollinger........	Philip Baker.......	....	....	Limonite..	I. M. R. R., 1½ m.	....
53	Peter Eaker bank..	T. 30, R. 10, E., Sec. 16, N. W. ¼..................	Bollinger........	Peter Eaker........	....	....	Limonite..	I. M. R. R., 2 m.	....
54	John Leetz bank....	T. 30, R. 10, E., Sec. 7, S. E. ¼..................	Bollinger........	John Leetz.........	....	....	Limonite..	I. M. R. R., 1½ m.	....
55	G. Shell bank......	T. 30, R. 10, E., Sec. 17, N. W. ¼..................	Bollinger........	G. Shell...........	....	....	Limonite..	I. M. R. R., 2 m.	....
56	Spion bank........	T. 27, R. 8, E., Sec. 26.....	Stoddard........	James M. Spion, of Fredrickstown...	....	....	....	I. M. R. R., 16 m.	....

FRANKLIN COUNTY ORE-DISTRICT.

57	Moselle, No. 1.....	T. 42, R. 1, E., Sec. 14.....	Franklin	Moselle Iron Works, J. H. Brown & Co. of Grungstown, O.	g.	1	Limonite..	A.& P. R.R., 1 m.	....
58	Moselle, No. 2.....	T. 42, R. 1, E., Sec. 20, S. W. ¼..................	Franklin	J. H. Brown & Co..	g.	1	Limonite..	A.& P. R.R., ½ m.	....
59	Moselle, No. 3.....	T. 42, R. 2, E., Sec. 8......	Franklin	J. H. Brown & Co..	g.	1	Limonite..	A.& P. R.R., 2 m.	....
60	Moselle, No. 4.....	T. 42, R. 2, E., Sec. 30.....	Franklin	J. H. Brown & Co..	g.	1	Limonite..	A.& P. R.R., 5 m.	....
61	Moselle, No. 5.....	T. 42, R. 2, E., Sec. 30.....	Franklin	J. H. Brown & Co..	g.	1	Limonite..	A.& P. R.R., 5 m.	....
62	Moselle, No. 6.....	T. 42, R. 2, E., Sec. 31.....	Franklin	J. H. Brown & Co..	g.	1	Limonite..	A.& P. R.R., 5 m.	....
63	Moselle, No. 7.....	T. 42, R. 2, E., Sec. 31.....	Franklin	J. H. Brown & Co..	g.	1	Limonite.	A.& P. R.R., 5 m.	....
64	Moselle, No. 8.....	T. 42, R. 2, E., Sec. 33.....	Franklin	J. H. Brown & Co..	g.	1	Limonite..	A.& P. R.R., 6 m.	....
65	Bowlen ban k......	T. 41, R. 2, E., Sec. 5, N. W. ¼	Franklin	J. H. Brown & Co..	g.	2	Limonite..	A.& P. R.R., 6 m.	....
66	Iron Hill..........	T. 42, R. 1, E., Sec. 17.....	Franklin	....	g.	1	Limonite.	A.& P. R.R., 0 m.	....
67	Thurmond bank....	T. 41, R. 1, W., Sec. 19, N. ½ lot 2, N. W. ¼..........	Franklin	B. Thurmond, of Staunton.........	c.	1	Red & spec. hematites	A.& P. R.R., ½ m.	....
68	Staunton Hill......	T. 41, R. 2, W., Sec. 36, S. W. ¼ S. E. ¼...........	Franklin	"Iron Hill" Co....	h.	1	Limonite..	A.& P. R.R., 2 m.	... .

Franklin County Ore-District.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
69	Clark & Co. bank...	T. 40, R. 1, W., Sec. 1.....	Franklin	Clark & others, of Sullivan.........	h.	1	Limonite..	A.& P. R.R., 1 m.	....
70	Old Copper Hill....	T. 40, R. 2, W., Sec. 23, E. $\frac{1}{2}$ N. E. $\frac{1}{4}$...............	Crawford........	Hamilton Iron Co..	c.	2	Specul'r ore	A.&P. R.R., $3\frac{1}{2}$ m.	....
71	Blanton Specular b'k.	T. 40, R. 1, W., Sec. 29, N. $\frac{1}{2}$ S. E. $\frac{1}{4}$...............	Washington......	Hamilton Iron Co..	d.	1	Specul'r ore	A.& P. R.R., 7 m.	....
72	Blanton Limonite b'k	T. 40, R. 1, W., Sec. 29, S. $\frac{1}{2}$ S. W. $\frac{1}{4}$.................	Washington	Hamilton Iron Co..	g.	2	Limonite..	A.& P. R.R., 7 m.	....
73	Primrose Hill......	T. 40, R. 1, W., Sec. 32, S. W. $\frac{1}{4}$ N. W. $\frac{1}{4}$..........	Washington......	Hamilton Iron Co..	d.	1	Hematites.	A.&P. R.R., 10 m.	....

Scotia Ore-District.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
74	Scotia, No. 1......	T. 38, R. 3, W., Sec. 1, E. $\frac{1}{2}$ S. E. $\frac{1}{4}$.................	Crawford........	Scotia Iron Co.....	b.	3	Spec. & red hematites	A.& P. R.R., 8 m.	....
75	Bleeding Hill.......	T. 38, R. 2, W., Sec. 4, S. W. $\frac{1}{4}$....................	Crawford........	....	...	....	Specul'r ore	A.& P. R.R., 9 m.	Shumard.
76	Scotia, No. 2......	T. 39, R. 2, W., Sec. 28, S. E. $\frac{1}{4}$....................	Crawford........	Scotia Iron Co.....	b.	2	Spec. & red hematites	A.& P. R.R., 9 m.	....

Central Ore-Region of Missouri.—Steelville District.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
77	N. G. Clark, No. 1.	T. 38, R. 4, W., Sec. 26, E. $\frac{1}{2}$ N. E. $\frac{1}{4}$..............	Crawford........	N. G. Clark.........	...	....	....	S. L., S. & L. R. R. R., $1\frac{1}{2}$ m...	....

78	Knox bank........	T. 38, R. 3, W., Sec. 26, E. ½ S. E. ¼................	Crawford........	Samuel Knox..........	......	......	....	S. L., S. & L. R. R. R., 8 m....	....
79	Cherry Valley, No. 1	T. 37, R. 3, W., Sec. 4, E. ½ S. W. ¼................	Crawford........	Thos. James' estate, Card, Lewis & Co., Lessees..........	b.	3	Specul'r ore	S. L., S. & L. R. R. R., 6 m....	....
80	Cherry Valley, No. 2	T. 37, R. 3, W., Sec. 4, W. ½ S. E. ¼....	Crawford........	Thos. James' estate, Card, Lewis & Co., Lessees..........	c.	2	Spec. ore & Limonite	S. L., S. & L. R. R. R., 6 m....	....
81	Steelville, No. 1....	T. 37, R. 4, W., Sec. 5, E. ½ S. W. ¼................	Crawford........	Missouri Iron Co., (Crawford, Scott & others)........	c.	1	Specular & red hematites..	S. L., S. & L. R. R. R., 0 m....	....
82	Steelville, No. 2....	T. 37, R. 4, W., Sec. 5, N. E. ¼...................	Crawford........	Missouri Iron Co., (Crawford, Scott & others).......	g.	2	Limonite..	S. L., S. & L. R. R. R., 0 m....	....
83	Lea and Marsh bank.	T. 37, R. 4, W., Sec. 5, S. ½ S. E. ¼................	Crawford........	Lea & Marsh..........	......	....	Red & specular hematites..	S. L., S. & L. R. R. R., ½ m....	....
84	Ferguson bank.....	T. 37, R. 4, W., Sec. 21, N. ½ S. E. ¼, & S. E. ¼ S. W. ¼..	Crawford........	Grover & Crawford.	d.	1	Specular & red hematites....	S. L., S. & L. R. R. R., ½ m....	....

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
85	Santee bank	T. 37, R. 6, W., Sec. 36	Phelps	Santee & Wagner, of Rolla	...	...	...	S. L., S. & L. R. R. R., 6 m	...
86	Winkler bank	T. 36, R. 6, W., Sec. 14, S. $\frac{1}{2}$.	Phelps	D. Carson, A. & W. James	c.	2	Specul'r ore	S. L., S. & L. R. R. R., 7 m	...
87	Smith bank, No. 1	T. 36, R. 6, W., Sec. 26, S. W. $\frac{1}{4}$ S. W. $\frac{1}{4}$	Phelps	Missouri Iron Co.	d.	1	Specul'r ore	S. L., S. & L. R. R. R., 4 m	...
88	Smith bank, No. 2	T. 36, R. 6, W., Sec. 26, S. E. $\frac{1}{4}$	Phelps	Missouri Iron Co.	d.	1	Specul'r ore	S. L., S. & L. R. R. R., $3\frac{1}{2}$ m	...
89	Smith bank, No. 3	T. 36, R. 6, W., Sec. 26, S. E. $\frac{1}{4}$	Phelps	Missouri Iron Co.	d.	1	Specul'r ore	S. L., S. & L. R. R. R., $3\frac{1}{2}$ m	...
90	Lamb bank	T. 36, R. 6, W., Sec. 35, N. E. $\frac{1}{4}$	Phelps	D. Carson, A. & W. James	b.	3	Specul'r ore	S. L., S. & L. R. R. R., 3 m	...
91	Benton Creek	T. 36, R. 5, W., Sec. 32, W. $\frac{1}{2}$ S. E. $\frac{1}{4}$, & E. $\frac{1}{2}$ S. W. $\frac{1}{4}$	Crawford	Thos. James's estate, Card, Lewis & Co., Lessees	b.	4	Specul'r ore	S. L., S. & L. R. R. R., 2 m	...
92	N. G. Clark, No. 2	T. 36, R. 5, W., Sec. 34, W. $\frac{1}{2}$ N. W. $\frac{1}{4}$	Crawford	N. G. Clark	...	...	...	S. L., S. & L. R. R. R., $\frac{1}{2}$ m	...

93	C. C. Cook bank...	T. 36, R. 5, W., Sec. 34, S. E. $\frac{1}{4}$ N. W. $\frac{1}{4}$..........	Crawford.......	C. C. Cook..........	...	...	....	S. L., S. & L. R. R. R., $\frac{1}{2}$ m....	....
94	Craig bank.........	T. 36, R. 5, W., Sec. 24, S. E. $\frac{1}{4}$ N. W. $\frac{1}{4}$..........	Crawford.......	W. James & Twitchell..........	...	...	Specul'r ore	S. L., S. & L. R. R. R., $\frac{1}{2}$ m....	....
95	Arthur bank.......	T. 36, R. 4, W., Sec. 18, S. E. $\frac{1}{4}$................	Crawford.......	Revold Bros., St. Louis..........	...	...	Specul'r ore	S. L., S. & L. R. R. R., 2 m....	....
96	S. L., S. & L. R. bank	T. 36, R. 5, W., Sec. 24, N. E. $\frac{1}{4}$ S. E. $\frac{1}{4}$, & S. W. $\frac{1}{4}$ N. E. $\frac{1}{4}$................	Crawford.......	St. Louis, Salem & Little Rock R. R. Co..........	...	...	....	S. L., S. & L. R. R. R., $\frac{3}{4}$ m....	....
97	Wilkerson bank....	T. 36, R. 4, W., Sec. 34, W. $\frac{1}{2}$ N. E. $\frac{1}{4}$, & S. E. $\frac{1}{4}$ N. W. $\frac{1}{4}$................	Crawford.......	Wilkerson, on Crooked Creek........	g.	2	Limonite..	S. L., S. & L. R. R. R., 5 m....	....
98	Key bank.........	T. 36, R. 4, W., Sec. 27, W. $\frac{1}{2}$ S. E. $\frac{1}{4}$, & S. W. $\frac{1}{4}$ N. E. $\frac{1}{4}$................	Crawford.......	Judge Wm. Key....	...	...	Limonite..	S. L., S. & L. R. R. R., 5 m....	....
99	Anderson bank.....	T. 36, R. 4, W., Sec. 26, N. W. $\frac{1}{4}$ S. E. $\frac{1}{4}$...........	Crawford.......	Clark, Wallace & Anderson..........	...	...	....	S. L., S. & L. R. R. R., 6 m....	....
100	Dry Creek bank....	T. 36, R. 3, W., Sec. 15....	Crawford.......	....	...	...	Limonite..	S. L., S. & L. R. R. R., 12 m...	Shumard.
101	—— bank.........	T. 36, R. 3, W., Sec. 36, N. $\frac{1}{2}$.	Crawford.......	....	...	...	Limonite..	S. L., S. & L. R. R. R., 14 m...	Shumard.
102	Grover bank.......	T. 35, R. 4, W., { Sec. 11, N. W. $\frac{1}{4}$... Sec. 2, S. W. $\frac{1}{4}$...	Crawford.......	Grover & Raney....	b.	2	Specul'r ore	S. L., S. & L. R. R. R., 6 m....	....

ORE-DISTRICT ON THE UPPER MERAMEC AND ITS TRIBUTARIES.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
103	Arnold bank.......	T. 35, R. 5, W., Sec. 4, S. E. ¼....................	Dent...........	Missouri Iron Co...	c.	1	Specul'r ore	S. L., S. & L. R. R. R., 1½ m...	....
104	Blackwell bank.....	T. 35, R. 6, W., { Sec. 12, S. ½ S. W. ¼.. Sec. 13, N. ½ N. W. ¼..	Dent...........	Graff, Bennett & Co., of Pittsburgh....	....	....	Specul'r ore	S. L., S. & L. R. R. R., 2 m....	....
105	—— bank.........	T. 35, R. 5, W., Sec. 32, S. W. ¼....................	Dent...........	....	....	....	Specul'r ore	S. L., S. & L. R. R. R., 1 m....	Shumard.
106	Fitzwater bank.....	T. 35, R. 4, W., Sec. 33 & 34.	Dent...........	William James, of St. James........	d.	2	Specul'r ore	S. L., S. & L. R. R. R., 8 m....	....
107	Reuben Smith bank.	T. 35, R. 3, W., Sec. 13, E. ½ S. E. ¼...............	Crawford........	David Carson, of Maramec Iron Works	....	....	Specul'r ore	S. L., S. & L. R. R. R., 18 m...	....
108	Carson banks.......	T. 35, R. 3, W., Sec. 14 & 16.	Crawford........	David Carson......	....	....	....	S. L., S. & L. R. R. R., 16 m...	....

SALEM DISTRICT.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
109	Huzzah bank.......	T. 34, R. 3, W., Sec. 9, S.E. ¼ N. W. ¼, & N. E. ¼ S. W. ¼.	Dent...........	Graff, Bennett & Co. of Pittsburgh....	....	....	Specul'r ore	S. L., S. & L. R. R. R., 18 m...	....
110	Hutchins Creek bank	T. 34, R. 4, W., Sec. 15....	Dent...........	Wm. James, of St. James..........	d.	2	Specul'r ore	S. L., S. & L. R. R. R., 11 m...	....

111	Pittsburgh bank....	T. 34, R. 5, W., Sec. 13....	Dent...........	Isabelle Furnace Co. of Pittsburgh.....	.....	.....	....	S. L., S. & L. R. R. R., 6 m....	....
112	Norris bank........	T. 34, R. 5, W., Sec. 12....	Dent............	Card & Lewis, of St. Louis	.....	.....	....	S. L., S. & L. R. R. R., 6 m....	....
113	Hayes bank........	T. 34, R. 5, W., Sec. 20, S. E. ¼ N. E. ¼...........	Dent...........	Card & Lewis......	.....	.....	....	S. L., S. & L. R. R. R., 2½ m....	....
114	Orchard bank	T. 34, R. 6, W., Sec. 13, E. ½ S. E. ¼ S. E. ¼........	Dent...........	Card & Lewis......	c.	2	Specul'r ore	S. L., S. & L. R. R. R., ½ m....	....
115	Simmons Mountain .	T. 34, R. 6, W., Sec. 24, N. W. ¼..................	Dent...........	C. C. Simmons, of St. Louis, & Missouri Iron Co....	b.	4	Specul'r ore	S. L., S. & L. R. R. R., o m....	....
116	Orchard & Young b'k	T. 34, R. 6, W., Sec. 27, N. ½	Dent...........	Graff, Bennett & Co. of Pittsburgh.....	d.	1	Specul'r ore	S. L., S. & L. R. R. R., 3 m....	....
117	Pomeroy bank......	T. 34, R. 6, W., Sec. 10....	Dent...........	Wm. James, of St. James	b.	3	Spec. ore & limonite.	S. L., S. & L. R. R. R., 3 m....	....
118	Taylor bank	T. 34, R. 7, W., Sec. 12, S. W. ¼ S. W. ¼..........	Dent...........	Taylor & Clark.....	b.	3	Spec. ore & limonite.	S. L., S. & L. R. R. R., 8 m....	....
119	Wiggins bank......	T. 33, R. 7, W., Sec. 9, N. E. ¼ N. E. ¼...........	Dent...........	Zane, of St. Louis..	.....	.....	Specul'r ore	S. L., S. & L. R. R. R., 9 m....	....
120	Jamison bank	T. 33, R. 6, W., Sec. 1, S. W. ¼	Dent...........	Missouri Iron Co...	c.	2	Specul'r ore	S. L., S. & L. R. R. R., 3 m....	....
121	Ziegler bank........	T. 33, R. 5, W., Sec. 2.....	Dent...........	Mrs. Ziegler	.....	.....	Specul'r ore	S. L., S. & L. R. R. R., 8 m....	....
122	Barksdale bank.....	T. 33, R. 4, W., Sec. 26, E. ½	Dent...........	Cable & Co. of Ohio.	.....	.....	....	S. L., S. & L. R. R. R., 15 m...	....
123	Merriam bank, on Pigeon Creek	T. 32, R. 7, W., Sec. 28, S. ½	Dent...........	Widow Merriam, of Cleveland, Ohio..	.....	.....	Specul'r ore	S. L., S. & L. R. R. R., 20 m...	....

Salem District.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
124	Shannon bank......	T. 31, R. 6, W., Sec. 13....	Shannon	W. James, of St. James	....	....	....	S. L., S. & L. R. R. R., 24 m...	....
125	Current River bank.	T. 31, R. 6, W., Sec. 16....	Shannon	W. James, of St. James	....	....	Specul'r ore	S. L., S. & L. R. R. R., 24 m...	....

Iron Ridge District.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
126	J. P. Card & Co.'s bank...........	T. 38, R. 5, W., Sec. 13, S. W. ¼...................	Crawford........	J. P. Card & Co....	....	....	....	A.& P. R.R., 2 m.	....
127	Senator Buckland's bank...........	T. 38, R. 5, W., Sec. 12, N. E. ¼ N. E. ¼............	Crawford........	Senator Buckland...	....	....	....	A.& P. R.R., 1 m.	....
128	Iron Ridge, No. 1..	T. 39, R. 5, W., Sec. 29, N. E. ¼...................	Crawford........	Iron Ridge Co.....	b.	3	Spec. & red hematites	Iron Ridge branch road, 0 m.....	....
129	Dorey bank.......	T. 39, R. 5, W., Sec. 29....	Crawford........	W. A. Dorey, of Iron Ridge...........	d.	1	Specul'r ore	Iron Ridge branch road, ½ m......	....
130	Iron Ridge, No. 2..	T. 39, R. 5, W., Sec. 33....	Crawford........	Iron Ridge Co.....	d.	1	Specul'r ore	A.& P. R.R., 1 m.	....
131	Isabella bank.......	T. 39, R. 5, Sec. 34, S. ½ S. W. ¼...................	Crawford........	Isabella Furnace Co., of Pittsburgh....	....	....	Specul'r ore	A.& P. R.R., 1 m.	....
132	—— bank.........	T. 39, R. 8, Sec. 11, N. ½...	Phelps	....	....	....	Red & spec. hematites	A.& P. R.R., 12 m.	....

133	N. G. Clark & Co.'s bank...........	T. 38, R. 5, W., Sec. 25, S. ½ S. E. ¼...............	Crawford........	N. G. Clark & Co..	....	....	....	A. & P. R.R., 5 m.	....

St. James's District.

134	Meramec bank.....	T. 37, R. 6, W., Sec. 1, N. W. ¼....................	Phelps..........	Thos. James's estate.	b.	3	Spec. & red hematites	A.& P. R.R., 7 m.	....
135	Thompson bank....	T. 37, R. 6, W., Sec. 17, N. ½.	Phelps..........	Th. James & E.Dunn	....	....	....	A.& P. R.R., 5 m.	... .
136	Dry Fork bank.....	T. 37, R. 7, W., Sec. 13....	Phelps..........	....	....	....	Limonite..	A.& P. R.R., 4 m.	Shumard.
137	Thornton bank.....	T. 38, R. 6, W., Sec. 33, N. E. ¼....................	Phelps..........	Lett, of St. James..	c.	1	Spec. & red hematites	A.& P. R.R., 3 m.	....
138	Santee & Clark's b'k	T. 38, R. 6, W., Sec. 33, S. W. ¼....................	Phelps..........	A. James & Dunn..	c.	1	Brown & red hematites	A.& P. R.R., 3 m.	....
139	South Mountain....	T. 38, R. 6, W., Sec. 23....	Phelps..........	Th. James & Co....	....	....	Spec. & red hematites	A.&P.R.R., 2½ m.	
140	Moselle, No. 9......	T. 38, R. 6, W., Sec. 29, S. ½ S. E. ¼...............	Phelps..........	J. H. Brown & Co., of Youngstown, O.	b.	1	Spec. & red hematites	A.& P. R.R., 3 m.	These two banks are only 200 feet apart; James bank lies due north of Moselle No. 9.
141	James bank........	T. 38, R. 6, W., Sec. 29, S. ½ S. E. ¼...............	Phelps..........	Thos. James's estate.	b.	2	Spec. & red hematites	A.& P. R.R., 3 m.	
142	A. C. L., No. 1 b'k.	T. 37, R. 7, W., Sec. 1, W. ½.	Phelps..........	Agricultural College.	....	....	....	A.& P. R.R., 2 m.	
143	Railroad b'k, No. 1.	T. 37, R. 6, W., Sec. 6.....	Phelps..........	A. & P. Railroad Co.	....	....	....	A.& P. R.R., 2 m.	
144	Railroad b'k, No. 2.	T. 37, R. 6, W., Sec. 8.....	Phelps..........	A. & P. Railroad Co.	....	....	....	A.& P. R.R., 4 m.	
145	Railroad b'k, No. 3.	T. 37, R. 6, W., Sec. 32....	Phelps..........	A. & P. Railroad Co.	....	....	....	A.& P. R.R., 8 m.	....
146	Lenox bank........	T. 37, R. 7, W., Sec. 36, N. W. ¼....................	Phelps..........	Lenox...............	....	....	....	A.& P. R.R., 6 m.	....
147	Hall bank.........	T. 36, R. 6, W., Sec. 5, N. W. ¼.......	Phelps..........	Hall................	....	....	....	A.& P. R.R., 8 m.	....
148	Seaton bank.......	T. 36, R. 6, W., Sec. 30, N. ½	Phelps..........	Seaton..............	....	....	....	A.&P.R.R., 12 m.	....

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
149	Hyer bank	T. 36, R. 7, W., Sec. 26, W. ½	Phelps	Dr. Hyer				A.&P. R.R., 12 m.	
150	Cold Spring bank	T. 36, R. 7, W., Sec. 29, S. ½	Phelps	W. James				A.&P. R.R., 12 m.	
151	Coleman bank	T. 36, R. 8, W., Sec. 34, N. ½	Phelps	Coleman				A.&P. R.R., 10 m.	
152	Moselle, No. 10	T. 36, R. 8, W., Sec. 20, N. E. ¼	Phelps	J. H. Brown & Co. of Youngstown, Ohio			Spec. & red hematites	A.& P. R.R., 7 m.	
153	Kelly bank No. 1	T. 36, R. 8, W., Sec. 18, E. ½	Phelps	Major Kelly, of Rolla	c.	1	Spec. & red hematites	A.& P. R.R., 6 m.	
154	Piney Creek bank	T. 36, R. 9, W., Sec. 23, N. ½	Phelps	W. James, of St. James				A.& P. R.R., 6 m.	
155	Baird bank	T. 37, R. 9, W., Sec. 35, E. ½	Phelps	Baird				A.& P. R.R., 2 m.	
156	Hudgeons bank	T. 37, R. 9, W., Sec. 36, N. ½	Phelps	Hudgeons				A.&P. R.R., 1½ m.	
157	Beaver Creek bank	T. 37, R. 8, W., Sec. 33, S. ½	Phelps	Thomas Jones' estate	b.	2	Specul'r ore	A.& P. R.R., 4 m.	
158	Mont Rouge	T. 35, R. 8, W., Sec. 35	Dent	Thomas James & Co.			Specul'r ore	A.&P. R.R., 18 m.	
159	Buckland bank	T. 37, R. 8, W., Sec. 20, S. ½	Phelps	Senator Buckland, of St. Louis; W. James, Lessee	c.	1	Spec. & red hematites	A.& P. R.R., ¼ m.	
160	Kelly bank, No. 2	T. 37, R. 8, W., Sec. 21, N. E. ¼	Phelps	Major Kelly, of Rolla	d.	1	Red & br'wn hemat. & carb'nates	A.& P. R.R., 2 m.	
161	Taylor's Rolla bank	T. 37, R. 8, W., Sec. 15, S. W. ¼	Phelps	Taylor, of St. Louis.	d.	1	Red & spec. hematites	A.&P. R.R., 1½ m.	
162	Camp Creek bank	T. 38, R. 8, W., Sec. 32, N. ½	Phelps	Love				A.& P. R.R., 3 m.	
163	Railroad bank, No. 4	T. 38, R. 8, W., Sec. 12, E. ½	Phelps	A. & P. R. R. Co.				A.& P. R.R., 6 m.	

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Ore-District on the Middle Gasconade River.

164	Frost bank	T. 37, R. 10, W., Sec. 13, E. ½	Phelps	Frost, Santee & Co. of Rolla				A. & P. R. R., ½ m.	
165	A. C. L. bank, No. 2	T. 37, R. 10, W., Sec. 23	Phelps	Agricultural College.				A. & P. R. R., 2 m.	
166	Railroad bank, No. 5	T. 37, R. 10, W., Sec. 26	Phelps	A. & P. R. R. Co.				A. & P. R. R., 2 m.	
167	Bee Creek bank	T. 37, R. 10, W., Sec. 29	Pulaski				Limonite	A. & P. R. R., 4 m.	Shumard.
168	Morgan bank	T. 35, R. 10, W., Sec. 10, N. E. ¼	Phelps	Morgan				A. & P. R. R., 11 m.	
169	Waynesville bank	T. 36, R. 11, W., Sec. 30, N. E. ¼	Pulaski		g.	1	Limonite	A. & P. R. R., 10 m.	Shumard.
170	Mocassin Bend	T. 37, R. 12, W., Sec. 31	Pulaski	W. James, of St. James			Specul'r ore	A. & P. R. R., 3 m.	
171	James Pipe bank	T. 37, R. 12, W., Sec. 21	Pulaski	W. James, of St. James				A. & P. R. R., 1½ m.	
172	Hancock bank	T. 38, R. 12, W., Sec. 14	Miller	W. James & Co.	b.	2	Specul'r ore	A. & P. R. R., 3 m.	
173	—— bank	T. 39, R. 11, W., Sec. 5	Maries				Specular & red ore	A. & P. R. R., 12 m.	Broadhead.
174	Bear Creek bank	T. 36, R. 14, W., Sec. 25	Laclede				Limonite	A. & P. R. R., 2 m.	Shumard.

White River District.

175	St. Mark bank	T. 30, R. 19, W., Sec. 18	Webster	Atl. & Pac. R. R. Co.			Limonite	A. & P. R. R., 3 m.	Broadhead.
176	—— bank	T. 29, R. 24, W., Sec. 24 & 25	Green				Limonite	A. & P. R. R., 6 m.	Broadhead.
177	Wilson Creek bank.	T. 27, R. 23., W., Sec. 7, S. W. ¼	Christian				Limonite	A. & P. R. R., 2 m.	Swallow.
178	—— bank	T. 27, R. 23, W., Sec. 19, W. ¼	Christian				Limonite	A. & P. R. R., 3 m.	Swallow.
179	—— bank	T. 27, R. 24, W., Sec. 14 & 15	Christian				Limonite	A. & P. R. R., 2 m.	Swallow.
180	Smart bank	T. 27, R. 24, W., Sec. 24, E. ½	Christian	Atl. & Pac. R. R. Co.			Limonite	A. & P. R. R., 3 m.	Swallow.
181	Railroad bank No. 6.	T. 25, R. 25, W., Sec. 2, N. W. ¼	Barry	Atl. & Pac. R. R. Co.			Limonite	A. & P. R. R., 6 m.	Swallow.

Ore-District on the Lower Gasconade River.

182	—— bank	T. 44, R. 7, W., Sec. 31	Osage				Limonite	Mo. Pa. R. R. 10 m.	Broadhead.
183	—— bank	T. 44, R. 7, W., Sec. 32	Osage				Limonite	Mo. Pa. R. R. 11 m.	Broadhead.
184	—— bank	T. 44, R. 7, W., Sec. 33	Osage				Limonite	Mo. Pa. R. R. 12 m.	Broadhead.

Ore-District on the Lower Gasconade River.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
185	—— bank........	T. 44, R. 7, W., Sec. 34....	Osage..........	....	....	....	Limonite..	Mo. Pa. R. R. 12 m.	Broadhead.
186	Jacket bank........	T. 43, R. 8, W., Sec. 34....	Osage..........	....	....	....	Limonite..	Mo. Pa. R. R. 16 m.	Broadhead.

Callaway County District.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
187	Palmer bank.......	T. 45, R. 10, W., Sec. 22...	Callaway........	John Palmer.......	g.	1	Limonite..	Louisiana & Missouri R. R. R., 4m.	....
188	Old Digging.......	T. 45, R. 10, W., Sec. 22...	Callaway........	....	e.	2	Red hematite.....	L. & M. R. R. R., 4 m....	....
189	Murphy's Hill......	T. 45, R. 10, W., Sec. 15...	Callaway........	....	f.	1	Red hematite.....	L. & M. R. R. R., 4 m.........	....
190	Henderson bank....	T. 45, R. 11, W., Sec. 12...	Callaway........	A. B. Meeker, of Chicago.........	f.	1	Red hematite.....	L. & M. R. R. R., 2 m.........	....
191	Shaft Hill.........	T. 45, R. 10, W., Sec. 4, N. W. ¼...................	Callaway........	A. B. Meeker......	e.	2	Red hematite.....	L. & M. R. R. R., 1½ m.........	....
192	Raph Dunn bank...	T. 46, R. 10, W., Sec. 32, S. E. ¼...................	Callaway........	A. B. Meeker......	e.	2	Red hematite.....	L. & M. R. R. R., 1½ m.........	....
193	Bloomfield bank....	T. 46, R. 10, W., Sec. 32, W. ½...................	Callaway........	....	e.	1	Red hematite.....	L. & M. R. R. R., ¾ m.........	....
194	Richard Dunn bank.	T. 46, R. 10, W., Sec. 21...	Callaway........	A. B. Meeker......	e.	1	Red hematite.....	L. & M. R. R. R., 2½ m.........	....
195	Knight bank......	T. 46, R. 10, W., Sec. 2....	Callaway........	A. B. Meeker......	e.	1	Red hematite.....	L. & M. R. R. R., 2½ m.........	....

196	Black Fork bank...	T. 48, R. 19, W., Sec. 3....	Cooper........	....	e.	1	Red hematite.....	Missouri river, 5 m.........; Boonville R. R., 11 m.......	Swallow.
197	Lamine bank.......	T. 48, R. 19, W., Sec. 33...	Cooper........	....	e.	1	Red hematite.....	Missouri river, 7 m.........; Boonville R. R., 13 m.......	Swallow.
198	Parkes bank.......	T. 43, R. 25, W., Sec. 25...	Henry..........	Cyrus Newkirk, of Sedalia...........	....	....	Red hematite.....	Missouri, Kansas & Texas R. R., $1\frac{1}{2}$ m.	....

OSAGE, OR WESTERN ORE-REGION OF MISSOURI.—ORE-DISTRICT ON THE LOWER OSAGE RIVER.

199	....	T. 42, R. 11, W., Sec. 20, N. W. $\frac{1}{4}$...............	Osage..........	....	....	....	Limonite..	Osage river, $\frac{1}{4}$ m..	Broadhead.
200	West bank.........	T. 41, R. 12, W., Sec. 34, S. E. $\frac{1}{4}$..................	Miller..........	Cartter, Lambert & Whiteside, of Osage City...........	....	....	Limonite (& spec.) ores	Osage river, 4 m..	....
201	Wimar Creek bank.	T. 39, R. 12, W., Sec. 4....	Miller..........	Dr. Smith & others, of New York.........	....	....	Specul'r ore	Osage river, 9 m..	....
202	Belan's Creek bank.	T. 39, R. 12, W., Sec. 15...	Miller..........	....	....	....	Specul'r ore	Osage river, 12 m.	Meek.
203	....	T. 39, R. 13, W., Sec. 5, N. $\frac{1}{2}$	Miller..........	Cartter, Lambert & Whiteside.........	....	....	Limonite (& spec.) ores	Osage river, 8 m..	....
204	Laclede bank......	T. 40, R. 13, W. Sec. 23, S. $\frac{1}{2}$	Miller..........	Cartter, Lambert & Whiteside.........	....	....	Limonite..	Osage river, 4 m..	....
205	....	T. 40, R. 13, W., Sec. 22...	Miller..........	Cartter, Lambert & Whiteside.........	....	....	Limonite (& spec.) ores	Osage river, 4 m..	....
206	Sample bank.......	T. 40, R. 13, W., Sec. 15, S. W. $\frac{1}{4}$...............	Miller..........	Cartter, Lambert & Whiteside.........	....	....	Limonite (& spec.) ores	Osage river, $2\frac{1}{2}$ m.	....
207	Tuscumbia bank....	T. 40, R. 14, W., Sec. 11...	Miller..........	Cartter, Lambert & Whiteside.........	....	....	Limonite (& spec.) ores	Osage river, 2 m..	....

ORE-DISTRICT ON THE LOWER OSAGE RIVER.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
208	—— bank	T. 40, R. 15, W., Sec. 35	Miller				Limonite	Osage river, 2 m	
209		T. 41, R. 17, W., Sec. 27, S. W. ¼	Morgan				Limonite	Osage river, 7 m	
210	Linn Creek bank	T. 38, R. 16, W., Sec. 30, N. E. ¼ N. E. ¼	Camden	Osage Iron Works Co. (Condee, Campbell & Co.)			Specul'r ore	Osage river, 6 m	

ORE-DISTRICT ON THE MIDDLE OSAGE RIVER.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
211	Big Niangua b'ks.	T. 38, R. 17, W., Sec. 26	Camden	Osage Iron Works Co. (Condee & Campbell			Limonite	Osage river, 6 m	
212		T. 38, R. 17, W., Sec. 32	Camden				Limonite	Osage river, 8 m	
213		T. 38, R. 17, W., Sec. 33	Camden				Limonite	Osage river, 7 m	
214		T. 38, R. 17, W., Sec. 29	Camden				Limonite	Osage river, 7 m	
215	Little Niangua banks	T. 38, R. 18, W., Sec. 13	Camden	Osage Iron Wks. Co.			Limonite	Osage river, 7 m	
216		T. 38, R. 18, W., Sec. 14	Camden				Limonite	Osage river, 8 m	
217		T. 38, R. 18, W., Sec. 11	Camden				Limonite	Osage river, 7 m	
218	Carl bank	T. 39, R. 17, W., Sec. 7	Camden	Osage Iron Wks. Co.			Limonite	Osage river, ¼ m	
219	Furnace bank	T. 39, R. 18, W., Sec. 4	Camden	Osage Iron Wks. Co.	g.	1	Limonite	Osage river, 2½ m	
220	Boulinger Cr. b'ks.	T. 39, R. 18, W., Sec. 5	Camden				Limonite	Osage river, 3 m	
221		T. 39, R. 18, W., Sec. 8	Camden				Limonite	Osage river, 3½ m	
222		T. 39, R. 18, W., Sec. 9	Camden				Limonite	Osage river, 3 m	
223	White banks	T. 39, R. 18, W., Sec. 7, S. E. ¼	Camden		g.	1	Limonite	Osage river, 6 m	
224	Palm bank	T. 40, R. 19, W	Morgan		g.	1	Limonite	Osage riv. 3–4 m	
225	Wigwam bank	T. 40, R. 19, W., Sec. 10	Morgan		g.	1	Limonite	Osage river, ½ m	
226	Couts bank	T. 40, R. 19, W., Sec. 14	Morgan		g.	1	Limonite	Osage river, ½ m	
227	Newman bank	T. 40, R. 19, W., Sec. 21, S. E. ¼	Camden	Osage Iron Wks. Co.			Limonite	Osage river, 2 m	

228	Walker bank......	T. 41, R. 20, W., Sec. (36)?	Benton........		g.	1	Limonite..	Osage river, 2 m..	....
229		T. 41, R. 20, W., Sec. 25...	Benton........		....	....	Limonite..	Osage river, 3 m..	....
230	Buffalo Creek b'ks.	T. 41, R. 20, W., Sec. 26...	Benton........	R. H. Melton, of	....	....	Limonite..	Osage river, 3 m..	....
231		T. 40, R. 20, W., Sec. 25...	Benton........	Warsaw.........	....	....	Limonite..	Osage river, 2 m..	....
232		T. 40, R. 20, W., Sec. 26...	Benton........		....	....	Limonite..	Osage river, 2 m..	....
233	Gun bank	T. 40, R. 20, W., Sec. 33 ..	Benton........		g.	2	Limonite..	Osage river, 3 m..	....
234		T. 39, R. 20, W., Sec. 5....	Benton........		....	....	Limonite..	Osage river, 5 m..	....
235		T. 39, R. 20, W., Sec. 19...	Benton........		....	....	Limonite..	Osage river, 10 m.	....
236	Big Deer Creek	T. 39, R. 20, W., Sec. 30...	Benton........	R. H. Melton......	....	....	Limonite..	Osage river, 11 m.	....
237	banks.........	T. 39, R. 21, W., Sec. 24...	Benton........		....	....	Limonite..	Osage river, 12 m.	....
238		T. 40, R. 21, W., Sec. 35, E. ½	Benton........		....	....	Limonite..	Osage river, 5 m..	....
239		T. 40, R. 20, W., Sec. 17...	Benton........		....	....	Limonite..	Osage river, 1 m..	....
240		T. 39, R. 21, W., Sec. 5, N. ½	Benton........		....	....	Limonite..	Osage river, 6 m..	....
241		T. 39, R. 21, W., Sec. 5, S. ½	Benton........		....	....	Limonite..	Osage river, 8 m..	....
242	Turkey Creek b'ks	T. 39, R. 21, W., Sec. 4....	Benton........		....	....	Limonite..	Osage river, 6 m..	....
243		T. 40, R. 21, W., Sec. 34...	Benton........	R. H. Melton......	....	....	Limonite..	Osage river, 5 m..	....
244		T. 40, R. 21, W., Sec. 35, W. ½	Benton........		....	....	Limonite..	Osage river, 5 m..	....
245	Grissom bank	T. 40, R. 21, W., Sec. 28...	Benton........		h.	2	Limonite..	Osage river, 5 m..	....
246	Carpenter bank.....	T. 40, R. 21, W., Sec. 12...	Benton........		h.	1	Limonite..	Osage river, ½ m..	....
247	Richwoods bank....	T. 39, R. 22, W., Sec. 3 & 4.	Benton........		g.	1	Limonite..	Osage river, 4 m..	....
248		T. 40, R. 22, W., Sec. 36...	Benton........		....	....	Limonite..	Osage river, 4 m..	....
249		T. 40, R. 22, W., Sec. 27...	Benton........		....	....	Limonite..	Osage river, 2 m..	....
250		T. 40, R. 22, W., Sec. 26...	Benton........	R. H. Melton......	....	....	Limonite..	Osage river, 2 m..	....
251		T. 40, R. 22, W., Sec. 24...	Benton........		....	....	Limonite..	Osage river, 2 m..	....
252		T. 40, R. 22, W., Sec. 12...	Benton........		....	....	Limonite..	Osage river, 1 m..	....
253		T. 40, R. 22, W., Sec. 14...	Benton........		....	....	Limonite..	Osage river, 1 m..	....
254		T. 40, R. 22, W., Sec. 15...	Benton........		....	....	Limonite..	Osage river, ½ m..	....
255	Kreissel bank......	T. 42, R. 21, W., Sec. 25...	Benton..........	Louis Kreissel......	....	....	Limonite..	Osage river, 10 m.	....
256	Indian Creek bank..	T. 42, R. 21, W., Sec. 26...	Benton..........	R. H. Melton......	g.	1	Limonite..	Osage river, 8 m..	....
257	Butcher bank......	T. 42, R. 21, W., Sec. 27...	Benton..........	Henry Butcher.....	....	....	Limonite..	Osage river, 8 m..	....
258	....	T. 41, R. 21, W., Sec. 36...	Benton........				Limonite..	Osage river, 2 m..	....
259	....	T. 41, R. 21, W., Sec. 35...	Benton........				Limonite..	Osage river, 2 m..	....
260	....	T. 41, R. 21, W., Sec. 33...	Benton........				Limonite..	Osage river, 1 m..	....
261	....	T. 41, R. 21, W., Sec. 32...	Benton........	R. H. Melton......	....	....	Limonite..	Osage river, 1 m..	....
262	....	T. 41, R. 21, W., Sec. 31...	Benton.				Limonite..	Osage river, 1 m..	....
263	Elm Hollow bank..	T. 41, R. 22, W., Sec. 36...	Benton........		g.	1	Limonite..	Osage river, 1 m..	....
264	Teabo bank........	T. 41, R. 23, W., Sec. 22...	Benton........		g.	1	Limonite..	Osage river, 4 m..	....

Ore-District on the Upper Osage River.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
265	Brown bank........	T. 40, R. 24, W., Sec. 23...	Henry..........	R. H. Melton......	e.	2	Red & bro'n hematites	Osage river, 2 m..	....
266	Gover bank........	T. 39, R. 24, W., Sec. 16...	St. Clair........	R. H. Melton......	e.	1	Red hematite.....	Osage river, 2 m..	....
267	....	T. 39, R. 24, W., Sec. 29...	St. Clair........	R. H. Melton......	....	....	Limonite..	Osage river, 1 m..	....
268	Bradshaw bank.....	T. 39, R. 24, W., Sec. 28...	St. Clair........	R. H. Melton......	....	....	Limonite..	Osage river, 1½ m.	....
269	Copper bank.......	T. 39, R. 24, W., Sec. 27...	St. Clair........	R. H. Melton......	g.	1	Limonite..	Osage river, 2 m..	....
270	Sheldon bank......	T. 38, R. 24, W., Sec. 8....	St. Clair........	R. H. Melton......	g.	2	Limonite..	Osage river, 1 m..	....
271	Greenwell bank.....	T. 39, R. 25, W., Sec. 15...	St. Clair........	Greenwell..........	g.	1	Limonite..	Osage river, 2 m..	....
272	Collins bank........	T. 39, R. 25, W., Sec. 23...	St. Clair........	....	....	....	Red & bro'n hematites	Osage river, 1½ m.	....
273	Marmaduke bank...	T. 39, R. 25, W., Sec. 23...	St. Clair........	....	e.	2	Red hematite.....	Osage river, 1 m..	....

Ozark County District.

No.	Name.	Location.	County.	Owners or Lessees.	Probable character of Deposit.	Probable size of Deposit.	Character of Ore.	Distance from the nearest railroad or navigable river.	By whom reported.
274	....	T. 22, R. 12, W., Sec. 36...	Ozark..........	....	....	....	Limonite	60 to 90 miles from I. M. R. R., and about same distance from St. L., S. & L. R. R. R.	Shumard.
275	Lantz bank........	T. 22, R. 15, W., Sec. 34...	Ozark..........	....	....	....	Limonite		Shumard.
276	....	T. 23, R. 12, W., Sec. 29...	Ozark..........	....	....	....	Limonite		Shumard.
277	....	T. 23, R. 12, W., Sec. 23...	Ozark..........	....	....	....	Limonite		Shumard.
278	Saw-mill bank......	T. 26, R. 11, W.	Douglas........	....	....	....	Limonite		Shumard.

PART II

GEOLOGY

OF

NORTHWESTERN MISSOURI

BY

G. C. BROADHEAD

AND OF

LINCOLN COUNTY

BY

W. B. POTTER.

PROF. R. PUMPELLY,

Director of the Geological Survey of Missouri:

DEAR SIR:—In presenting the Reports of my work during the past year, I would mention the many obligations due to Mr. C. J. Norwood for his valuable assistance in the field during the whole season.

I am also indebted to many citizens of the State for information in regard to localities, collecting specimens, etc.; especially to Dr. A. J. Bell and L. T. Collier, of Chillicothe; H. H. Beeson, of Ray County; Wm. Zook, of Forest City, Mr.—— Lewis, Chief Engineer K. C., St. Joseph & C. B. R. R., St. Joseph; E. P. West, of Kansas City; and Dr. John Britts, of Clinton, Henry County. To the St. Louis, K. C. & N. R. W., I am under obligations for *free* transportation of specimens.

Respectfully,

G. C. BROADHEAD,

Assistant Geologist.

ST. LOUIS, MO., *March*, 1873.

CHAPTER I.

AREA AND TOPOGRAPHICAL FEATURES OF THE COAL-FIELD.

THE coal-measures of Missouri comprise an area of about 22,995 square miles, including 160 square miles in St. Louis County, 8 in St. Charles, and a few outliers in Lincoln and Warren; the remainder in North-West and Western Missouri.

This includes 8,406 square miles of upper or barren measures, about 2,000 miles of exposed middle, and 12,420 of exposed lower measures.

Boundary.—The boundary between the upper and middle coal-measures I have elsewhere defined. It will be found delineated on the map. The boundary between the middle and lower coal is not well defined, but is limited by a thick-bedded, coarse, micaceous sandstone, sometimes of not great extent, at other times of great thickness. We suppose it to enter the State in the west part of Bates County and to pass thence via Butler to Chilhomee in Johnson County; thence, northwardly 4 miles west of Warrensburgh to 4 miles east of Aullville, Lafayette County; thence, irregularly meandering through Lafayette County, crossing the Missouri river, passing to ten miles east of Carrollton, Carroll County; thence, to the south-east corner of Livingston County, from which point it bears north-east to the centre of Linn County, and thence, northward. The southern and eastern boundary of the lower coal-measures is as follows: (through Barton, Bates, Vernon, and St. Clair, the boundary has not yet been well defined); entering the State in Barton, it passes north-east through the eastern part of Vernon; it enters St. Clair about one-half way up, on its western line, thence, meanders eastward to a point a few miles north of Osceola; thence, northward to within eight miles of Clinton, Henry County; thence, north-east to the east line of Henry County; thence, northwardly, with occasional variations of sandstones, as much as eight miles east to Brownsville, Saline County; thence, north-eastward to Marshall, and thence, to Miami. On the north side of the river it passes eastward, from a point opposite Arrow Rock, to the east line of Howard County; thence, in a meandering course via Columbia, Boone County, New Bloomfield and Fulton, Callaway County, to the north-east corner of Callaway; thence, north-eastwardly to a point three miles west of the north-east corner of Montgomery County; thence, north-west to near the mouth of Lick Creek, Ralls County; thence, south-west to Mexico, Audrain County. From thence, to the north-west corner of Monroe County; thence, irregularly trending northward, to the north-west corner of Knox County; thence, to a point on the north line of Lewis County, about twelve miles west of the Mississippi river; thence, northwardly to the Desmoines river, on the north line of the State of Missouri.

East of this, are small outliers in Montgomery, Warren, Lincoln, and St. Louis Counties, and perhaps others in south-west Missouri.

Thickness.—The aggregate thickness of the upper coal-measures is 1,317 feet, including only about 4 feet of coal, of which there are two seams of one foot in thickness: the others are very thin seams or mere streaks. The middle coal-measures include a total thickness of about 324 feet, in which are embraced about 7 feet of coal, including two workable seams of 21 and 24 inches; one other of 1 ft. that is worked under favorable circumstances, and six seams too thin to work. The lower measures include from 250 to 300 feet, embracing about five workable seams of coal, varying in thickness from 1½ ft. to 4½ ft., and thin seams varying from 6 to 11 inches, and several minor seams and streaks: in all, 13 ft. 6 in. of coal. We therefore have in Missouri nearly 1,900 ft. of coal-measures with a total aggregate of 24 ft. 6 in. of coal. The thinner seams of coal are not often mined, except in localities remote from railroad transportation. The coal from thicker seams (those from 1½ to 2 and 4 ft.) is generally sold at ten cents per bush. at the mines.

The thin seam, 10 to 14 inches on Nodaway river, is sold at over 20 cents per bush. at the mines. The reason of this is the difficulty of mining (there being so much superfluous material to be removed) and the remoteness of other coals.

Miners seem to prefer to work a bed of 2 ft. to 2½ ft. in thickness, to even one of greater thickness. We would consider all beds over 18 in. thick as workable coals. The estimated area, where such may be reached within two hundred feet from the surface, is about 7,000 square miles.

THE FOLLOWING IS A CONDENSED VERTICAL SECTION OF THE COAL-MEASURES:

No.	LOCALITY.
1—339 feet, including 230 feet above the connected section.	
2—12 in. coal.	Holt, W. part of Nodaway and Northwardly; also White Cloud, Kansas.
3—392 feet	
4—12 in. coal	Andrew, Buchanan, De Kalb, Gentry, and Platte.
5—207 feet	
6—10 in. coal	Platte County.
7—379 feet to base of upper coal-measures	
8—3 in. coal at top of middle coal-measures	Pleasant Hill, Missouri City, and Princeton, Mercer County.
9—164 feet	
10—1 foot coal	Cass, Johnson, Lafayette, and Livingston, also Grundy,
11—70 feet	
12—2 feet (Lexington coal)	Lafayette, Johnson and Ray.
13—36 feet	
14—7 in. coal	Lafayette and Ray.
15—14 feet	
16—21 in. coal	Lafayette, Johnson, Carroll, and Livingston.
17—50 to 90 feet	
18—1½ ft. (Warrensburgh coal)	Johnson, Henry, Chariton.
19—52 feet	
20—7 in. coal	Johnson.
21—18 feet	
22—1 foot 8 in. coal	Johnson.
23—18 feet	
24—8 in. coal	Johnson.
25—4 feet	
26—2 feet coal	Henry.
27—48 feet	
28—2½ feet to 4 feet 5 in. coal.	Randolph, Boone, Callaway, Johnson, Henry, Vernon, Bates, Adair, Sullivan, Putnam, Audrain, and Macon.
29—11 feet	Macon.
30—11 in. coal	Macon, Henry and Johnson.
31—about 13 feet	
32—2 feet coal. 10 inches of clay near base.	Ralls, Audrain, St. Louis, St. Charles and Montgomery, Henry and Johnson.

TOPOGRAPHY OF THE COAL-MEASURES.

The general surface of a country is governed by the constituents of the underlying rock formations. Where they consist mostly of limestones which approach near the surface, we find a rugged tract of country. Where sandstones prevail, the slopes are more gentle. When clays or shales exist, we have flat land. Alternations of these will present combinations of the foregoing. The coal-measures include varieties of all these, and generally alternately arranged. The thickest entire limestone group is 30 ft., with shales above and below; so of course, our area of broken land is limited. The thickest groups of limestone occur in the lower part of the upper coal-measures. Along the line of their outcrops, may be occasionally seen rugged and steep hillsides, which characteristics may be observed from Cass County on the south, through Jackson, Platte, Clay, Ray, Caldwell, Daviess, Gentry, Worth, and Harrison. Higher in the series, are thick shale formations, as seen at Weston and St. Joseph. The country northward is flat and rolling, as we find through Gentry and Worth, Platte, Buchanan, and De Kalb. Above these, are alternations of thick and thin strata of limestone, with sandstones, shales, and clays, and the resultant is the undulating and rolling portion of North-West Missouri, lying near and extending west from Platte river. The bluffs of the Missouri, in the region of the upper coal-measures, attain an elevation of from 250 to 330 feet above the bottom-land; and the elevation of the highest ridges inland is but little if any more. The summits of the highest ridges in Nodaway County, above One Hundred and Two river and Platte river, are but little over 200 feet, and none of the adjacent bluffs exceed 50 feet in height; the same may be also said of Nodaway river, except near where it joins the Missouri bluffs, where they measure 250 feet. On N. Grand river, the immediate bluffs measure from 30 to 120 feet, within the upper coal district. As we descend, the hills recede. Near the base of the upper coal series, it is often 200 to 250 feet from the valleys to the top of remote ridges. Lower down in the middle coal series we have a great thickness of sandstones and shales, with long and very gentle slopes, and the bluffs near streams from 25 to 50 feet high, rising to 100 feet at a half-mile to a mile distant.

We also observe another characteristic near the junction of the upper and middle measures. The upper sandstones, one hundred or more feet in thickness, have been mostly denuded, leaving isolated mounds of sandstone, capped by lower limestones of the upper coal-measures. They are generally 80 to 100 feet above the general surface of the lower plains. This enables us to trace out the boundary between the upper and middle coal series very readily.

The mounds near Harrisonville, Cass County, reach to the top of the middle coal series, as also Centre Knob, and knobs north in Johnson County, and Wagon Knob, in Lafayette County, and are generally capped with limestones, which occupy the base of the upper coal series.

In Lafayette County we have a remarkable ridge coming in from the south-west and extending northwardly, just west of the line between Ranges 27 and 28, including a width of about one mile. Grady's Knob, although separated from the main ridge, occupies the northern terminus of it; it is generally capped with limestone, No. 78, of the upper coal-measures, but sometimes the limestone has been broken up and worn away, leaving exposed the underlying sandstone. The denudation on the east side is apparently not so much as on the west, but on the west the erosion has been very great, extending to a depth of at least one hundred feet, with a width of over twelve miles. This wide tract includes the beautiful Greenton valley, Texas prairie, and Sniabar valleys. The various branches of the Sniabar have also cut their channels through this valley to a depth of from 40 to 100 feet. Along the Missouri river, in the vicinity of the middle series, the bluffs do not attain the height found in the upper series. They vary in height from 100 to 165 feet. In the lower part of the middle coal-measures we again observe the phenomena of mounds capped with limestone, the base of the mound extending into the lower measures. We find here evidences of a great denudation, for the mounds are frequently over a hundred feet in height, sloping with a long and gentle descent, blending into the wide-stretching intervening plains. This is the case along the west line of Missouri, from Fort Scott to Cass County; others occur along the border of Bates and Vernon, and occasionally in Henry. A range of mounds passes N. E. from near Clinton to the N. E. part of Henry County, and from thence at intervals northwardly in the east part of Johnson County. The lower coal-measures being mainly composed of sandstones and shales, with but few limestone beds, we find the country correspondingly flat; the bluffs along the streams, are not often over fifty feet in height, and blend into the higher land by gentle slopes.

The southern portion of Missouri, including the Ozark ridge, and most of the State south of the Missouri and Osage rivers, excepting the two western tiers of counties, is elevated from one thousand to fourteen hundred feet above the sea, and includes only Lower Silurian rocks flanked by Lower Carboniferous.

On the west flank near the State line the country is not often over eight hundred feet above the sea. On the west and north flank of this high land the coal-measures commence. On the south side of the Missouri river we find the middle and lower coal not over eight hundred or nine hundred feet above the sea.

In North Missouri the same formations are about eight hundred to one thousand feet above the sea. The elevation of the eastern and southern outcrop of the upper coal-measures, near the base, is eight hundred and seventy-five to nine hundred and ninety feet.

Towards the north-west part of the State the upper measures are more elevated, and may reach from one thousand to eleven hundred feet above the sea.

CHAPTER II.

LOWER COAL-MEASURES.—BY G. C. BROADHEAD.

HENRY COUNTY COAL.

THE middle coal measures may be found only in north-west portion of Henry County. The lower coals crop out near Windsor, Calhoun, Clinton and south-west. Besides the coal-beds, the rocks consist mostly of sandstones, generally soft with some, shale and clay beds, with rarely limestone, and some beds of iron carbonates, red hematites and clay-iron ore. In the region of the lower coal-measures mounds are occasionally seen, rising by long and gentle slopes to an elevation of fifty to one hundred feet above the height of surrounding country, showing that denudation has been very great since the coal-measures were deposited. These mounds are capped with middle coal-measures, with lower coal at the base.

The line of my recent observations in the county extended from the north-east corner of the county to Clinton, with various observations north and south of my route. In this district the bluffs along the streams seem to be in no place of greater height than forty or fifty feet, and the general surface of the country rises sixty to seventy feet above the valleys. The vertical outcrops being limited, the exact correlation is difficult; still, although I failed in obtaining a connected vertical section of all the beds, I think I have them placed in about the regular order of succession.

The lowest may include certain sections taken by Mr. C. J. Norwood, near Fort Lyon, Benton County, and southward, near Tebo Creek, and along that stream as high up as the forks two miles south of Calhoun, of which the following is an abstract:—

Henry County.

In Section 15, T 43—R 24, observed outcrop of 3 to 4 feet "Ferruginous sandstone."

Benton County.

On Barker's Creek, in south-west quarter, Section 36, T. 43, R. 23, on Mr. D. I. Williams's land, noticed the following :—

No. 1—3 feet bluff and local drift.

2—1 foot 2 in. brown and black sandy, thinly laminated shales.

3—1 foot 3 in. bituminous and thinly laminated sandy shales, with concretions of carb. of iron.

4—5 inches coal.

5—2 feet black, laminated sandy shales, containing *Cordaites*.

In north-west quarter, Section 6, T. 42, R. 23, **D. I. Williams's Land.**

No. 1—3 feet shaly, soft sandstone.

2—1 foot black, laminated, sandy and bituminous shales.

3—6 " coal.

Oak and hickory is the principal timber here ; country rolling.

At Fort Lyon, in Section 6, T. 42, R. 23, I obtained the following :—

Section No. 50.

No. 1—Long slope.

2—8 feet light red sandstone, hard and in one bed, specked and streaked with white.

3—½ foot clay.

4—3 inches carbonaceous matter.

5—2 feet clay, containing *Stigmaria ficoides*.

6—12 feet Arenaceous shales ; some black and brown, others ash-colored.

7—3 feet slope.

8—Outcrop of ferruginous sandstone—about 6 inches.

9—3 feet bed of lower carboniferous chert—containing fossils *Glauconome*—(*sp.*) and an internal spire of a small brachiopod (*Spirifer ?*).

10—5 feet slope to Creek.

Henry County.

"On Section 26, T. 42, R. 24—observed outcrop of ferruginous sandstone. This sandstone is seen very often along the road leading from Fort Lyon to Leesville. It disappears from view about one mile from Leesville."

"In the north-west part of the north-east quarter, Section 11, T. 41, R. 24, the following section is seen, on a gully in the prairie, **north-west of Leesville.**

Section 51.

No. 1—8 feet slope, covered with chert, containing *Spirifer Forbesi? Crinoid* stems, *Bryozoans* (2 *sp.*) *Capulus? Amplexus, Phillipsia.* Archimedes chert, evidently from the Warsaw and Keokuk groups.

2—5 feet gray and white, very coarse-grained limestone—Encrinital limestone of Swallow, Burlington limestone of Hall; it abounds in *Crinoid* stems, and contains *euomphalus latus.* Upper part mostly thin layers—lower part more compact."

"In north-west quarter, Section 13, T. 43, R. 24, on **Elm Creek,** observed a bed of compact drab chert; weathers brown: contains a cast of a *Productus,* in size and appearance resembling *Prod. mesialis* of Hall, *Retzia Verneuiliana, Amplexus, Spr. Keokuk, Bryozoa,* and what appears to be a cast of *Spr. pseudo-lineatus.*"

"This chert as seen by the fossils is evidently from the Warsaw and Keokuk limestones."

"**On Tebo Creek,** in north-east quarter, Section 2, T. 41, R. 24, the following is seen:

No. 1—Slope.

2—8 feet Encrinital limestone, gray and coarse-grained. Irregularly bedded, contains *Zaphrentis, Crinoid* stems, and *Prod. Flemingii* var. *Pr. Burlingtonensis.*"

"Following the creek one-quarter of a mile farther up, as far as the north-west part of the north-west quarter of Sec. 2, T. 41, R. 24, the limestone is seen, exposed at intervals on the north bank, cedar, willow, oak, elm, and sycamore trees growing all along the bank. Here the following section was obtained.

Sec. 52.

No. 1—35 feet slope—lower part covered with chert and ferruginous sandstone: chert containing small *Spirifer, Chonetes, Bryozoa,* and *Crinoideæ.* On the upper part are tumbled pieces of ferruginous sandstone.

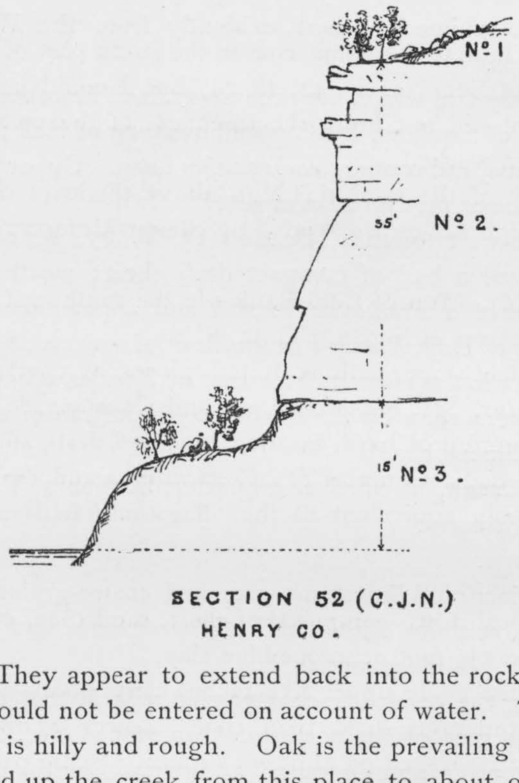
2—35 feet Encrinital limestone—color gray: lower part very coarse-grained and somewhat friable; upper part finer grained.

3—15 feet slope to water."

See sketch, fig. 1.

"One-eighth of a mile farther up: Encrinital limestone is exposed on the bank of creek, from Sec. 52 to this place, and beyond. At this place it is exposed on the south bank, and in it are two caves; two or three hundred yards farther up stream, two more

Fig. 1.



SECTION 52 (C.J.N.)
HENRY CO.

are seen. They appear to extend back into the rock quite a distance, but could not be entered on account of water. The country around here is hilly and rough. Oak is the prevailing timber."

"Followed up the creek from this place to about one-half of a mile above the mouth of Barker's creek. Here the encrinital limestone is exposed on the south bank, about twenty feet thick; it is rough and irregularly bedded.

"At a ford on Tebo creek, in the north-west quarter, Sec. 4, T. 41, R. 24, this limestone is again seen, cropping out at the water's edge."

"In the west part of Sec. 17, T. 42, R. 24, on a road leading north to Calhoun, noticed 20 feet buff soft sandstone, containing concretions of iron ore: on the top a few inches of ore. The lower part presents a banded appearance. It is thick bedded and is greatly washed, so as to form a shallow cave.

"**On James's Fork,** at ford on road leading to Calhoun, in south-west part of the south-east quarter of Sec. 7, T. 42, R. 24, this sandstone is exposed, and is also seen some distance beyond."

"From the foregoing it is evident that the encrinital limestone first seen on the Tebo in north-east quarter of Sec. 2, T. 41, R. 24, is exposed at intervals from that place nearly as far up as James's Fork."

"There is said to be some coal in the south part of the north-east quarter of Sec. 34, T. 42, R. 24, but I could not find any. The informant did not know the thickness of the vein, and says it has not been worked.

"This part of the section is high above the level of Tebo Cr. Most of the high ridges are capped by chert with ferruginous sandstone over-lying it."

"**Sec. at Mr. Munn's Coal-Bank**—in the south-east part of the south-west quarter of Sec. 17, T. 42, R. 24.

No. 1—17 feet slope, with scattered pieces of chert, containing *Prod. muricatus*, *Spr. plano-convexus* and *Ch. mesoloba*.

2—2 feet outcrop of hard, mottled blue and drab, silicious limestone, in thin beds. Contains *Pr. Prattenianus* and *Crinoid* stems. This is probably equivalent to the 'flagstone' beds of Brownsville.

3—20 feet slope.

4—5 feet local drift—composed of chert, sandstone, etc.

5—1 foot to 1½ foot ochreous blue clay.

6—28 inches coal: upper five inches very poor—some places more like bituminous shale than coal. Lower 23 inches good. Has a rusty appearance on exposed surface. Some parts brilliant.

7—Sandstone—micaceous.

"The coal lies in what was formerly the bed of a wide branch, but which has long ago run dry. This coal is very likely the lowest of the coal-measures." The following is a proximate analysis by Mr. R. Chauvenet.

Water	7.50
Volatile	37.30
Fixed carbon	50.75
Ash	4.45

—color of ash, red (ox. iron); cokes tolerably.

The above sections of Mr. Norwood indicate loose masses of lower carboniferous chert reposing on the encrinital limestone. The chert indicates a mingling of forms, pertaining to the St. Louis, Warsaw and Keokuk limestones. For we observe *Chonetes* (resembling *Ch. Shumardana*), *Pr. mesialis* and *Spr. pseudlineatus*, *Bryozoans*, *Capulus*, and *Amplexus* resembling those of the Keokuk group, and *Retzia Verneuiliana* of the Warsaw group. In Dr. John Britts' collection at Clinton, I saw a fine specimen of *Melonites* and also of *Lithostrotion* obtained from cherty beds on Grand river, twelve miles from Clinton. These are characteristic fossils of the St. Louis limestone.

The gray limestone which is found underlying the chert undoubtedly belongs to the encrinital or Burlington group. The chert in No. 1, and the silicious bed No. 2, at Munn's coal-bank, cannot be distinguished, either in color or texture, from the flagstone beds of Brownsville, Saline county, which occur at that place near the base of the coal-measures.

OTHER BEDS NEAR THE BASE OF THE COAL-MEASURES.

The coal at C. B. JORDAN'S mine on Grand river in Sec. 25, T. 41, R. 26, is probably the same bed as Munn's. It occurs thus:—

1st—15 feet blue calcareous slate (flagstone), weathering drab, occurs in uniform layers of generally about two inches in thickness —is jointed, with generally perpendicular faces, and forms good roof for the coal.

2—32 inches coal.

3—9 feet blue shales with iron ore concretions; upper one foot blue clay in thin laminæ, resting on two feet of blue fire-clay, then sandy clay. Mr. Jordan has run in several drifts, about 100 feet into the hill, and employs several miners. The coal is black and shiny. About 4 inches below the top is a one-inch slate seam. The middle layer of coal also contains some iron pyrites.

Proximate analysis by Mr. Chauvenet of Jordan's coal (top of bed):—

Water	3.47
Volatile	42.18
Fixed carbon	45.85
Ash	8.50

—color of ash, purple gray.

Jordan's coal bottom of seam:—

Water	5.14
Volatile	37.91
Fixed carbon	46.82
Ash	10.13

—Color of ash, purple gray.

The overlying silicious slates would probably furnish good material for indoor pavements, and would also do very well for ordinary sidewalks.

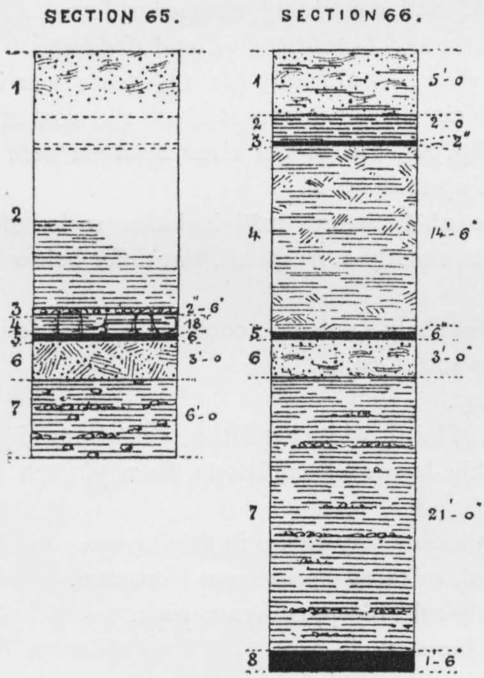
At Gilkenson's Frod on Grand river, about three quarters of a mile west of Jordan's, in about the centre of Sec. 26, T. 41, R. 26, we find exposed a section of rocks which are probably just above the section at Jordan's. They appear just above the ford, in the following order:—

Section 65.

No. 1—Sandstone.

2—Shale.

Figs. 2 and 3.



3—2 to 6 inches iron-stone, equivalent to Section 64, No. 9, and probably also to Section 63, No. 3.

4—18 inches calcareo-bituminous bed, shaly, and passing into a ferruginous limestone; contains *Lophophyllum proliferum*, *Chætetes—Ch. mesoloba*, *Spr. cameratus*, *Prod. muricatus*, *Pr. castatus*, *Athyris subtilita* and an undescribed cephalopod (Cyrtoceras ?).

5—6 in bituminous coal.

6—3 feet blue and brown sandy clay passing into sandstone.

7—6 feet blue shales with concretions of carbonate of iron.

About 150 yards up stream this section is somewhat modified thus:—

Section 66.

No. 1—5 feet buff shaly sandstone.

2—2 feet blue shales.

3—2 in. coal.

4—14½ feet shales and fire-clay.

5—6 in coal=65—5.

6—3 feet sandstone abounding in stigmaria.

7—21 feet shales abounding in lenticular beds of iron carbonate, weathering red and containing numerous ferns, also, *Lepidodendron*, *Lycopodites* and *Lepidastrobus*, and *Cordaites*.

8—Coal in river: could only see 1½ feet; was informed that it was 3 feet thick; if so it corresponds to the coal at Jordan's. If there is no dip, the fall in the river between here and Jordan's would bring it up to his coal.

The Section at Jackson's mill includes rocks of last section. The upper beds exactly correspond, but differ below thus:—

Sec. 64.

No. 2—4 feet shaly sandstone containing a few ferns.

3—10 inches rotten coal.

4—2 feet clay.

5—1½ feet of hard, white sandstone containing *Sigillariæ*.

6—3 feet thin layers of sandstone, from ½ inch to 1½ inches thick.

7—16 feet 3 inches clay shales in thin layers.

8—6 in. hard, calcareo-pyritiferous ironstone.

9—9 in. shaly calcareo-pyritiferous rock.

10—17 in. blue clay.

11—18 in. bituminous shales.

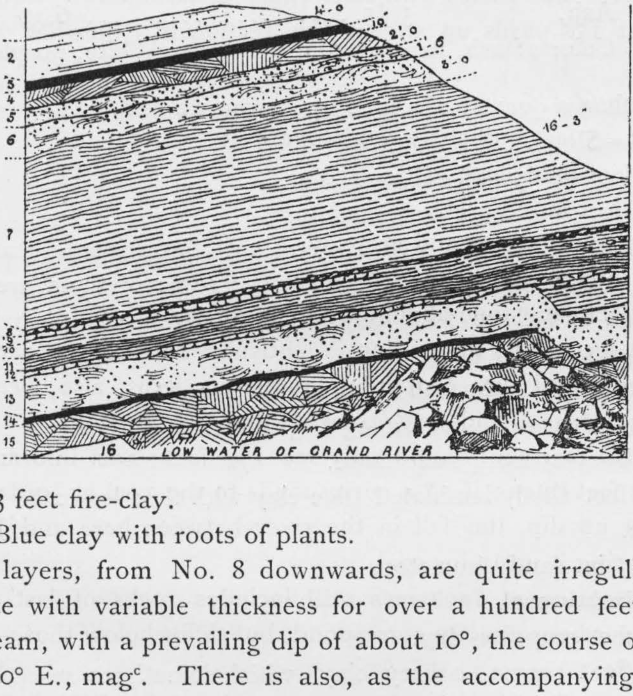
12—5 in. calcareous shale.

13—3 to 4 feet of hard sandstone, containing *Caulerpites marginatus* and remains of mineral charcoal.

14—6 to 12 in. coal; covered in some places with a crust of pyrites.

Fig. 4.

SECTION 64
JACKSON'S MILL ON GRAND RIVER,
HENRY CO



15—3 feet fire-clay.

16—Blue clay with roots of plants.

The layers, from No. 8 downwards, are quite irregular, and undulate with variable thickness for over a hundred feet down the stream, with a prevailing dip of about 10°, the course of which is N. 40° E., mag^c. There is also, as the accompanying sketch will show, a dip or fault of about two feet at the north-east end of the outcropping.

The coal-beds of Mrs. Tyler and of Benj. Owens on and near the creek, 2½ miles south-east of Clinton, may be the same as the Jordan bank. Their position with the horizon would so indicate.

The coal from Mrs. Tyler's is extensively used at Clinton. It is reached by a shaft. Arriving at the mine at dark, I did not have an opportunity of making correct examinations. The overlying light blue shale abounds in numerous very pretty ferns and an occasional *Lepidodendron*, with a few leaves of *Cordaites*.

Benj. Owens works an open bank in the edge of the creek, from which is obtained a black brilliant coal; bed 21 inches thick, with very little sulphur: the upper three inches is crumbly: has black shale just above with four or five feet of ochry clay shales above it. Proximate analyses by Mr. Chauvenet, of

	OWENS.	OWENS (MIDDLE).
Water,	8.30	7.14
Volatile,	38.66	36.95
Fixed carbon,	48.35	48.65
Ash,	5.85	6.10
Color of ash,	nearly white.	White, purple tinge.

Less than a quarter of a mile up stream we find,

No. 1—Slope.

2—4 feet sandy and ochrey shale.

3—10 in. drab crumbling sandstone.

4—4 feet blue shales, with large round concretions of carbonate of iron, which shell off in curved flags: some of them are over a foot thick and three feet long. These shales are probably the equivalent of No. 7 of Sec. 66.

About a mile and a half up stream is Sec. 61.

No. 1—Sandstone containing *Stigmaria.*

2—About 25 feet gentle slope.

3—8 feet thinly laminated blue clay with thin lenticular beds of iron ore.

4—1½ in. sandy iron-stone.

5—2 inches coal.

6—2 feet gray fire-clay.

7—1 foot brown, ochrey clay, which sometimes resembles the last.

8—1 foot blue clay.

9—Thin coal-streaks.

10—6 in. hard gray sandstone.

11—2 feet sandy clay with roots of *Stigmaria.*

There is a thin coal-seam still higher up, which is exposed on the prairie three-quarters of a mile west, as appears from the following notes:—

No. 1—2 feet sandstone.

2—Streak of rotten coal.

3—2 feet irregular bed of massive friable sandstone.

4—8 feet drab shales.

5—3 feet blue shales in thin laminæ.

6—3 inches coal=Sec. 61, No. 5.

7—4 feet blue clay—the upper 1 foot brown streaked.

Sec. 63, on bluff just west of Clinton, includes portions of the last three sections. We find,

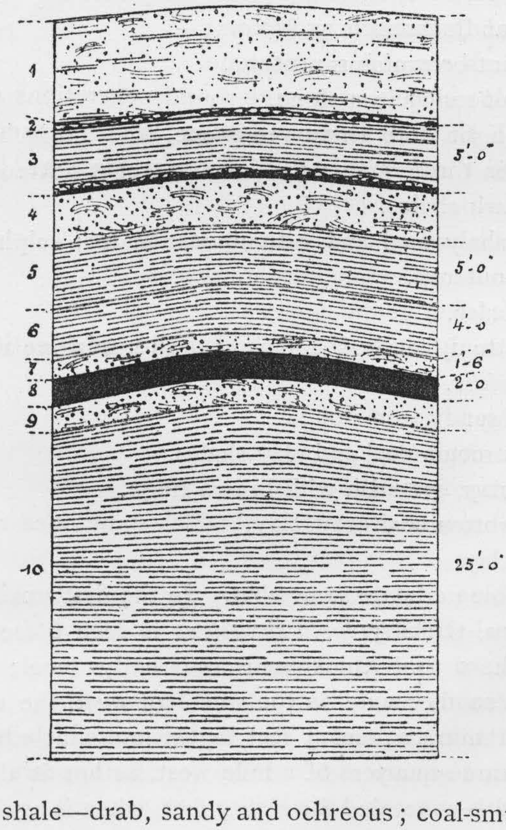
No. 1—Chocolate-colored sandstone with some shale beds.

2—Outcrop of iron-stone concretions.

Fig. 5.

SECTION 63.

AT CLINTON, HENRY CO.



3—5 feet shale—drab, sandy and ochreous; coal-smut at bottom. A little above the base is 5½ inches of red calcareous iron-stone, abounding in fossils, including *Pr. muricatus*, *Hemipronites crassus*, *Ch. mesoloba*, *Ch. Verneuiliana*, *Spr. plano-convexus*, *Discina* (small sp.). This stratum is of even thickness, and jointed by planes perpendicular to the deposit; has evidently been a limestone, now changed to an iron ore. I regard it as equivalent to the layer of ferruginous iron-stone seen in the railroad cut at Calhoun.

4—Outcrop of sandstone.

5—5 feet shale to outcrop of crumbling sandstone with *Sigillaria*.

6—4 feet shales—dark blue below.

7—1½ feet sandstone.

8—2 feet outcrop of coal-smut.

9—Hard shelly sandstone with *Stigmaria*, Dip 10°, N. 10° E. mag.[c].

10—25 feet shales to branch; rather slaty below.

The Section at Calhoun is as follows:—

No. 1—6 feet brownish sandstone.

2—1 foot red sandy iron-stone.

3—27 feet light drab shaly sandstone, with a 6-inch stratum at top, abounds in *Caulerpites;* the lower 3 feet is ochreous.

4—1 foot dark shales.

5—1 foot shaly coal and bituminous shales; sulphur efflorescence on the outcrop.

6—3 feet shales.

7—4 inches to 2 feet buff and light drab sandstone abounding in *Stigmaria ficoides*.

8—1 foot clay.

9—6 inches rotten coal and clay shales.

10—3 feet clay, greenish with brown tinge.

11—1 foot rotten coal.

12—2 feet clay.

The beds here undulate somewhat. In the first small cut west of railroad bridge, the *Stigmaria sandstone* is seen 6 feet above the railroad track, 1 foot thick and apparently level; crossing a valley about 400 feet wide to the next cut west, the sandstone is 4 feet above the track, and 3 feet in thickness, at which place it furnishes a good quarry rock. Fifty feet farther it dips beneath the track, and is concealed for eighty feet, when it again rises and in a short distance is four feet above the track, and apparently level for 600 feet. A short valley here intervenes, beyond which we find the upper numbers of our section, as quoted above.

Sec. 59.

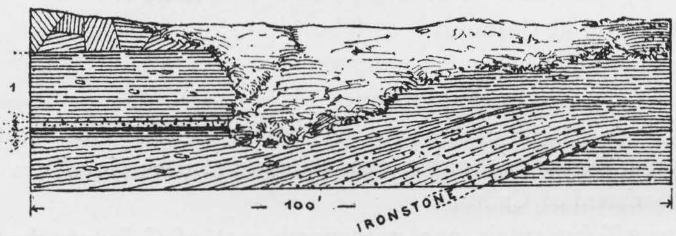
No. 1—Ochre shales with hollow iron-stone concretions.

2—6 inches ferrruginous limestone; weathers with a red crust and contains *Brachiopoda*, including *Pr. muricatus, Pr. Pratteni-anus, Chonetes Verneuiliana.* The interior of the rock is a drab ash; next is a 1/2-inch red band, then 1/2 to 3/4 inch composed of red and brown alternations and brown exterior.

This may probably be equivalent to the ferruginous fossil stratum at Clinton.

Fig. 6.

SECTION 59.
AT CALHOUN, HENRY CO.



3—1 foot sandy shales.

4—5 inches rotten coal and slate.

5—1 foot blue and ochrey shales. Drab sandy shales occur about 15 feet beneath, resting on sandy iron-stone. The latter is 6 inches thick at its lower extremity, where it dips beneath rail-road grade, thinning out at fifteen feet, and covered unconform-ably by sandy shales. (See sketch.)

There is a white efflorescence on the shales below the iron bed, and a similar deposit, on the overlying shales.

The accompanying sketch shows the position of the bed and its dip.

At Laban Parks, 1 1/2 mile north of Calhoun, the upper series of the Calhoun rocks contains a good red hematite in considerable quantities.

A vertical section of rocks here would exhibit—

No. 1—Soil.

2—Deposit of porous red hematite: about 3 feet. Good iron ore.

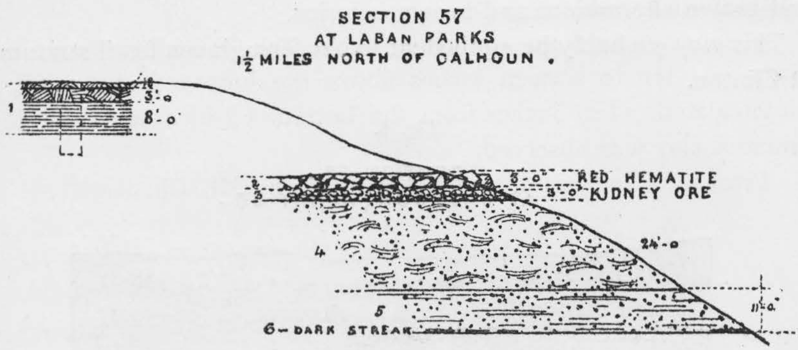
3—3 feet brown ochre concretions.

4—24 feet sandstone — upper portion drab and buff — ripple marked ; brown toward bottom.

5—11 feet bluish drab and shaly sandstone.

6—Dark streak of apparently rotten coal=No. 5 of Calhoun section.

Fig. 7.



Similar iron ore is said to occur at several other localities in the neighborhood of Calhoun.

Across Tebo creek, one mile north-east of Calhoun, the upper sandstone beds are quite ferruginous, both brown or red. Two and a half miles east of Calhoun, at Henry Neff's mines, we find the following :—

No. 1—6 feet brown sandstone, abounding in concretions of brown hematite.

2—5 feet shales.

3—2 feet coal.

One hundred and fifty feet west, we find

No. 1—Sandstone.

2—1 foot dark shales, with seams of rotten coal, sometimes thickening to 6 inches.

3—1½ foot to 3 feet sandy shales with *Stigmaria*, and streaks of coal.

4—14 inches lead blue clay.

5—2 feet coal.

The quality of the coal at these openings seems poor ; later drifts have been pushed into the hill, at about a quarter of a mile east, disclosing a better quality. The seam here is 3 feet thick, described as follows :—

No. 1—6 inches at top with shining black bands, other dull streaks, and a few concretionary bands of pyrites.

2—4 inches just beneath the above, like it, but has charcoal partings.

3—6 inches or more, at the middle of bed. Is shiny, with carbonaceous partings and brown rust on the joints; said to be a good blacksmith's coal.

4—Specimens from 16 inches above the bottom resemble the last. At ten to sixteen inches above the bottom iron pyrites is intercalated. Ten inches from the bottom a 2-inch seam of bituminous clay was observed.

Proximate analysis of top coal at Neff's by Mr. Chauvenet:—

Water	5.89
Volatile	38.01
Fixed carbon	39.97
Ash	16.13

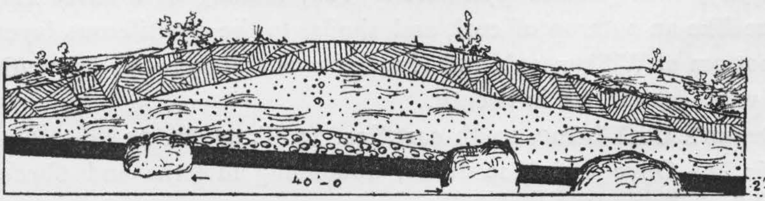
Color of ash, chocolate.

At a bluff three hundred feet east of the last, the coal is capped by ten inches of sandstone, and dips west.

At the east end the sandstone reposes directly on the coal. In the middle exposure of the bluff, the coal is capped by a lenticular bed of ferruginous conglomerate, forty feet long, one and a half foot thick in the middle and tapering to a point each way. (See sketch, Sec. No. 54.)

Fig. 8.

SECTION 54.
HENRY CO.



The coal rests on soft gray sandstone, containing *Stigmaria ficoides*, a few feet of which was exposed.

On the road from Calhoun to Windsor are many exposures of soft brown sandstone.

At Thos. Dillon's, in Sec. 21, T. 43, R. 24, we have

Section 48.

No. 1—25 to 30 feet mostly soft, light brown sandstone; a few beds are hard enough to form a tolerably good building material—occasional remains of large forms of *Sigillariæ* and *Calamites* are found.

2—Smut from coal.

3—6 feet shaly slope.

4—2 feet yellow sandstone at bottom.

5—22 inches outcrop of coal: upper half rotten, lower part firm.

6—14 feet sandy shales.

7—Sandstone in creek with *Lepidodendron*, *Sigillariæ*, *Cordaites*, &c.

The equivalence of the coal of this section with that at Neff's is apparent.

Further up the creek which passes this place, in Sec. 17, T. 43, R. 24, on land of H. C. Mullins, is a thin coal-seam, which probably occupies a higher geological position.

Our section here is about this:—

No. 1—6 feet soft sandstone.

2—6 feet clay, and outcrop of shelly limestone.

3—30 feet slope.

4—1 foot coarse conglomerate.

5—6 feet thinly laminated shales, with about ten bands of carbonate of iron, varying from 3/4 to 1 1/2 inch in thickness.

6—8 to 10 inches coal; said to be thicker elsewhere.

7—7 feet clay, with occasional brown and nodular layers of soft sandstone.

8—1 1/2 inch jointed pyritiferous bed, looking at a short distance like an outcrop of coal, and similar to the pyritiferous layer at bottom of Williamson's and Hughes' coal. The rocks dip south 60° west—about one in twenty.

Organ's Coal Mine, south-east Sec. 34, T. 44, R. 24.

No. 1—Olive and blue shales, abounding in ferns and *Cordaites*, &c.

2—3 inches coal.

3—10 inches blue clay in thin laminæ.

4—23 inches coal, with band of iron pyrites near the bottom, in even layers of one inch, and another a little thicker.

A proximate analysis of the bottom by Mr. Chauvenet, gives:—

Water	8.48
Volatile	33.96
Fixed carbon	43.16
Ash	14.40

Color of ash, chocolate.

Several shafts have been sunk and a good deal of mining done on **B. Williamson's** land, near western part of south-east of south-west of Sec. 35, and eastern part of south-west, south-west Sec. 35, T. 44, R. 24. The section here is :—

No. 1—Limestone in loose masses.

2—15 feet slope ; outcrop of sandstone at lower part ; somewhat ferruginous.

3—10 inches coal.

4—1 foot clay in thin laminæ.

5—2½ to 3 feet coal : good quality.

6—6 inches pyritiferous rock.

7—6 inches coal.

A proximate analysis by Mr. Chauvenet gives :—

Water	7.76
Volatile	44.77
Fixed carbon	43.32
Ash	4.15

Color of ash, dark purple ; cokes tolerably well.

From loose débris lying near the mouth of the pit, on the opposite side of the stream, I obtained a number of fossils from calcareo-ferruginous rocks, quarried, very likely, from above the coal, and including, *Naticopsis Altonensis*, *Spr. cameratus*, *Prod. muricatus*, *Spr. plano-convexus*, *Spr. Kentuckensis*, *Spr. lineatus*, *Nucula ventricosa*, *Pleurotomaria sphærulata*, *Loxonema*, *Orthoceras cribrosum*, *Edmondia*, *Chonetes mesoloba*, *Athyris subtilita*. Associated with the above were fragments of septaria, intersected with minute calcite veins which are sometimes replaced by zinc blende. There is a dip here of 10° to 15° west, as shown by the presence of sandstone in the creek, two hundred yards below. Coal is mined in the creek, two miles south of Windsor, on the land of Mr. Hunton. On the land of B. Hughes, at East County line, two miles south of Windsor, we find a shaft sunk 15 feet to coal, 34 inches thick, including a 2-inch pyritous band, cutting off 2 or 3 inches of coal at the bottom. The coal is quite iridescent.

On a small branch, one-eighth of a mile north, we find shaly sandstone, dipping west about one in five. The latter fact would tend to show that the coal of Hunton, one-half a mile south-west, and at a much lower horizon, is equivalent to that at Hughes'.

The several coal outcrops south and west, as well as others north, would indicate the existence of coal at Windsor, but borings do not. Near Windsor depot, borings have been made 137 feet deep, passing through 80 feet of shaly sandstone, with only a few thin coal-seams in the first seventy feet, then sandstone to the bottom, at which depth hard sandstone was reached, into which they bored eleven feet. The latter is probably lower carboniferous. This boring would either indicate that our coal-beds, above described in this vicinity, had thinned out, or (and the dip may warrant the conclusion) that the geological position of Williamson's coal is higher. From the evidence we have, it seems probable that the Windsor sandstone dips beneath Williamson's coal. The sandstone must also extend to the base of the coal-measures, and furthermore belongs to a division of the lower coal series, as evidenced by remains of ferns and other plants embraced in the outcroppings in the railroad cut. It is generally a soft brown, micaceous, and often shaly sandstone ; often quite ferruginous, and generally too soft for building purposes. Three miles south of Windsor it forms a perpendicular bluff of very irregular, thick, but soft strata, reposing on five inches of coal. At this place it is cross-laminated.

In Section 25, T. 44, R. 24, at the edge of Johnson County, we have,

No. 1—20 feet sandstone.

2—Outcrop of septaria—color blue black. The outer crust of one inch, with no perceptible joint. The interior traversed by joints supplied with brown and white calcite. Between the inner and outer portions is a beautifully shaded brown band. At one place I observed a dark, blue black, heavy concretionary limestone, which I refer to the same horizon as the septaria. It is very fine-grained, with occasional lines and specks of white and brown calcite, which are probably the remains of fossils ; observed *Pr. muricatus* and *Spr. cameratus*.

3—Coal-smut.

4—8 feet slope.

3—Greenish gray sandstone.

Three-quarters of mile west, I observed,

No. 1—Shales containing a few red ochre concretions.

2—1½ feet outcrop of coal.

3—8 feet clay and shales.

4—8 inches coal.

5—4 feet clay.

Along the lower slope at this place are many tumbled masses of septaria, and black concretionary limestone, abounding in fossils, supposed to have originated from above the coal. Among the fossils I observed *Pleurotomaria sphærulata*, *Discina Missouriensis*, *Cardium* (?), *Lexingtonensis*, *Rynchonella Osagensis*, *Pr. muricatus*. Coal is mined in several places in Sections 20, 29, and 22, T. 42, R. 26. On Dr. G. W. Britt's land, in north-east quarter of the south-east quarter of Section 29, it is 27 inches thick; at Munson's in north-west quarter of the north-west quarter of 22, it is 30 inches, and at other openings, from 25 to 30 inches thick.

The mining at these several localities is along small tributaries of Field's Creek, and is all near the surface: the coal is generally reached at from six to eight feet. It is easily mined, and water does not often interfere with mining operations. A general section is thus:—

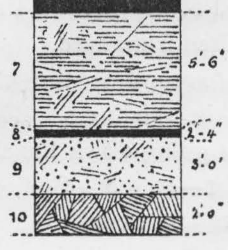
Section 62.

No. 1—2 inches flagstone, of arenaceous limestone, in very even inch layers:—color dark ash-gray; rings under the hammer.

Fig. 9.

SECTION 62

DR G.M. BRITTS . HENRY CO.



2—1 foot to 2 feet shales.

3—16 inches to 2 feet limestone; deep ash blue; jointed in rhomboidal blocks; rings under the hammer; its weathered surface shows minute remains of fossils in relief.

4—2½ feet calcareous shales, *Spr. cameratus* and *Pr. muricatus*.

5—1½ foot bituminous shale, containing grayish, globular concretions, and sometimes embracing lenticular beds of dark limestone, which abounds in fossils, including, *Solenomya radiata*, *Nucula ventricosa*, *Ch. mesolaba*, *Ch. Verneuiliana*, *Prod. muri-*

catus, Pr. Nebrascensis, Nautilus ferratus, N. Spirifer lineatus, Hemipronites crassus, Spirifer cameratus, Pleurotomaria sphærulata, Orthoceras cribrosum, Edmondia glabra? Loxonema cerithiformis, Polyphemopsis peracuta, P. inornata.

6—27 to 30 inches coal.

7—5 to 6 feet clay and shales.

8—2 to 4 inches coal.

9—3 feet sandy clay passing into a sandstone, containing *Stigmaria.*

10—2 feet clay.

The lower part of this Section is, I think, equivalent to the upper part of the upper extension of Section 61, previously mentioned.

A proximate analysis of G. M. Britts's coal by Mr. Chauvenet gives :—

	TOP.	MIDDLE.
Water	2.89	3.88
Volatile	28.55	43.67
Fixed carbon	50.71	43.42
Ash	17.85	9.03
Color of ash—reddish with white specks.		Light gray.

The coal in the Osage Coal Co.'s shaft on the railroad two and a half miles south-west of Calhoun, I regard as equivalent to Britts's coal.

The following is from observations made at the **Osage Coal Co.'s mines by C. J. Norwood,** November 7th, 1872 :—

"These mines are located on the M. K. and T. Railroad, two and a half miles south-west of Calhoun. The coal here is reached by means of a shaft, sunk to the depth of sixty feet. There are two veins; the first, in descending order, is from 18 to 20 inches thick and about forty feet below the surface; this vein is not worked at the present time, but I am told that formerly some coal was taken from here.

The second is the one worked at present, and averages 28 inches in thickness. The following is a section of what could be seen in going down the shaft :

No. 1—40 feet—Soil, clay, etc.

2—1 ½ foot coal.

3—11 feet—cribbing.

4—1½ feet hard, fine-grained, dove-colored silicious (?) limestone; breaks with a conchoidal fracture in one compact bed; remains of *Athyris* (?) was the one fossil seen.

5—1½ foot dark pyritiferous shales, containing *Spr. Cameratus*, *Athyris subtilita*, *Spr. plano-convexus*, etc.

6—8 in. bituminous shale. This shale furnishes a good roof for the coal.

7—24 to 32 inches coal.

8—1 foot clay. Nos. 5 to 8 are seen in the mine.

In some places several thin seams of iron pyrites occur in the coal: at one place I noticed as many as five, and from three to four inches apart. At five inches from the bottom of the coal, a streak of pyritiferous shale occurs. It also contains considerable carbonate of lime. In the overlying shales pyritiferous concretions, of different sizes and shapes, are found—some globular, others lenticular, and others again appear to have been at one time *two*, but which have coalesced so as to form one. The prevailing shape is globular. When broken open, iron pyrites is displayed at the centre. They sometimes contain fossils; in one specimen we find a *Pleurotomaria* as the nucleus. Some are quite large and heavy, and sometimes break down the shales overhead; then they are removed and the limestone (No. 4) is left as the roof. In some places there are slips, or, as the miners say, "horsebacks;" that is, the coal is crushed down or interrupted by the overlying shales, thus:—

Fig. 10.

"HORSEBACK" IN OSAGE COAL MINES.

These "horsebacks" do not extend very far, but are great drawbacks to the miner. At these interrupted places the coal is generally very slaty and hard to mine. There are two entries at the bottom of the shaft, running north-west and south-east, one on each side of the shaft, as seen by the accompanying diagram.

"In the south-east entry there are eight rooms, and in the north-west twelve. The south-east entry is about 80 yards in length. The mine is damp and badly ventilated.

"The coal, when cleaned of the pyrites (which is attempted), is good.

A proximate analysis of Mr. Chauvenet gives:—

Water	5.65
Volatile	36.95
Fixed carbon	41.87
Ash	15.33

Color of ash, light gray.

Section 46—taken at Mr. B. Williamson's—includes rocks belonging to the middle coal-measures, as follows:—

No. 1—33 feet slope, from the top of the mound; about the middle are tumbled masses of drab limestone, containing *Fusulina cylindrica*, with numerous broken forms of *Chætetes milleporaceus*.

2—Outcrop of bluish drab limestone: slate said to underlie it, and at six or seven feet below the limestone is 16 inches of coal.

3—24 feet slope.

4—1½ feet outcrop; lower part limestone; the upper 6 inches a coarse, soft, brown ochre, abounding in fossils, mostly univalves; contains *Pr. Prattenianus*, *Chonetes mesoloba*, *Aviculopecten*, *Pleunotomaria sphærulata*, *Loxonema*.

5—3 feet olive drab shales.

6—10 feet slope.

7—4 feet outcrop of bluish drab shelly limestone; upper portion brown specked, and rings under the hammer.

Below this it is probably not over fifty feet to the coal, corresponding to the working vein of Williamson's.

Mr. Chauvenet observes concerning the analyses of Henry County coals, that there is no good coking coal in the county; that Britts's top will coke, but has 26 per cent. ash; that Munn's is the best coal on the list, Williamson's about as good,—also Owen's.

From Windsor to Brownsville.—On John R. Gray's land, in Johnson County, Sec. 1, T. 44, R. 24, coal has been taken out at several places, a quarter of a mile west of Mr. G.'s house, along a branch; also farther down same branch, on land of Mr. Owsley. The section of rocks is as follows:

Sec. 45.

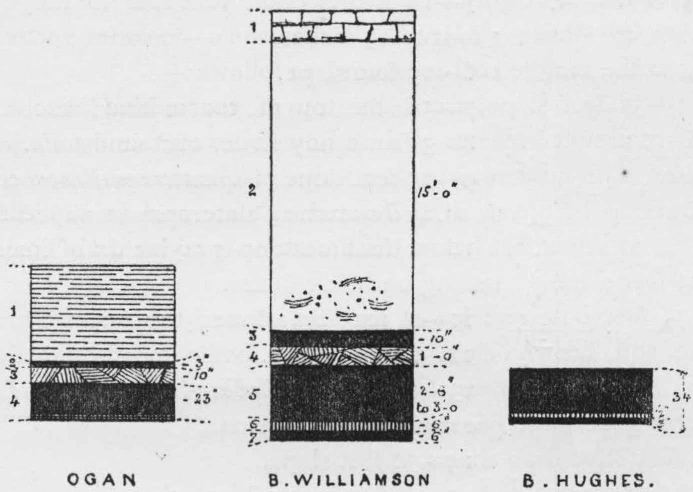
No. 2—2½ feet blue-black shales, containing a few *Brachiopods*, *Chonetes*, etc.

3—4 inches bituminous shales, containing a few fossils: *Discina Missouriensis*, etc.

4—2 feet bituminous limestone, abounds in *Brachiopoda*, viz., *Pr. semireticulatus*, *Pr. muricatus*, *Pr. costatus*, *Athyris subtilita*, *Spr. cameratus*, *Chonetes mesoloba*, *Discina*, and *Pleurotomaria sphærulata*.

Fig. 11.

SECTIONS NEAR WINDSOR, HENRY CO.



5—10 inches coal.

6—4 feet fire-clay ; upper part blue ; the upper 1½ feet olive streaked with brown ; then 1 foot green and sandy clay, with efflorescence on the surface ; the lower part is brown.

Mr. Gray sunk a well at his house on the hill, forty feet deep, reaching sandstone at fifteen feet, and coal on the bottom. A long, gentle slope, extending a half a mile east, reaches a branch, along which are exposed outcrops of lower carboniferous chert, mingled with white clay, and overlaid by sandstone resting unconformably on it.

The house of Mr. Gray is 66 feet above this sandstone outcrop, and the coal only being 40 feet below the level of the ground at the house, we would naturally suppose this to be the lowest coal in the neighborhood.

At Pettis County line on Muddy Creek, we observed some lower carboniferous chert.

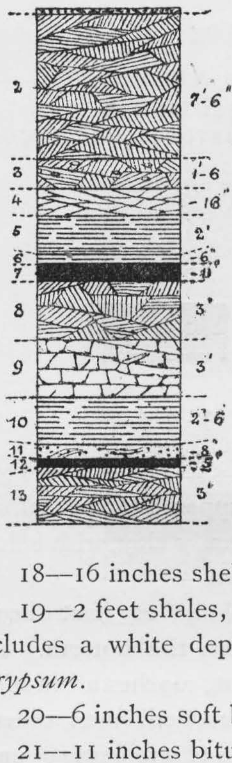
From the top of a high mound at Elijah Cook's, in Sec. 14, T. 47, R. 24, I made Sec. 44, along the slopes, to the valley northward, as follows :

No. 1—12 feet slope, from the hilltop to outcrop of shelly limestone.

2—38 feet slope.

3—19 inches ash-blue fine-grained limestone in even beds, jointed, and weathering brown.

Fig. 12.
SECTION 44.
JOHNSON CO.



4—2 feet bituminous shale.

5—14 inches coal; vein said to range from 1 foot to 15 inches.

6—19 feet slope.

7—5 inches tough, coarse blue limestone.

8—3 feet sandy shales and sandstone.

9—25 feet slope; appearances of iron concretions, and occasional outcrops of sandy shales.

10—1 foot outcrop grayish drab limestone, resting on black shales.

11—A few feet of sandy shales.

12—20 feet slope.

13—10 feet, including a few feet of hard greenish-gray sandstone.

14—30 feet slope.

15—A few inches black clay.

16—7½ feet light-blue clay.

17—1½ feet brown ochrey clay, full of small *selenite* crystals.

18—16 inches shelly red limestone; contains *Pr. muricatus*.

19—2 feet shales, upper part dark olive: the middle 6 inches includes a white deposit; the lower part is brown, abounding in *gypsum*.

20—6 inches soft black shales.

21—11 inches bituminous coal.

22—3 feet fire-clay.

23—3 feet rough ferruginous bed, with gypsum in the crevices.

24—2½ feet clay shales.

25—8 inches thin-bedded sandstone.

26—5 inches coal.

27—3 feet fire-clay.

Total, 175 feet from the bottom of No. 1. The upper half of the section is undoubtedly middle coal-measures, the lower part including lower coal-measure rocks. About two miles north are the coal-mines, generally known as the *Dunksburgh Mines;* they lie about 2½ miles south-west of Dunksburgh, and include quite a number of openings. The coal-bed which is worked lies quite low in the lower measures, near the base. The only one worked much, when I was in the neighborhood, was that of John W. Porter, leased by George W. Wilson; they have a shaft sunk 20 feet to the coal, from the bottom of which entries are extended. A section (Sec. 42) shows:

No. 1—4 feet clay.

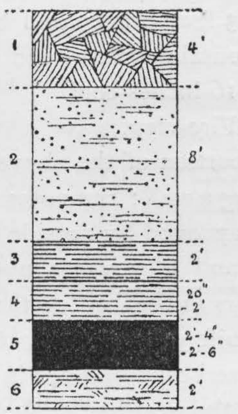
2—8 feet shaly sandstone.

3—2 feet soft blue shale.

Fig. 13.

SECTION 42

J. W. PORTER, JOHNSON CO.



4—20 inches to 2 feet hard black slate.

5—2 feet 4 inches to 2 feet 6 inches coal.

6—2 feet soft rotten coal.

No. 4 resembles some varieties of coal, and measured 16 inches at the bottom of the shaft, with a 2-inch band of hard, calcareo-pyritiferous shale at the top. Plates of carbonate of lime occur between the joints of the coal, and a few large masses of iron pyrites are occasionally found.

The top coal is said to ignite more readily and burn quicker, but does not possess as great heating power as the bottom. At the foot of the hill to the north I observed outcrops of shaly sandstone. Following down the branch toward Blackwater, we find outcrops of thick-bedded, fine-grained, light buff and brown sandstone. Three-quarters of a mile north-east from Porter's mine Mr. John Parks has extended into the hill quite a number of horizontal drifts, but all were in a tumbled, unused condition when I made my examinations. I here made Sec. 41.

No. 1—Slope with fragments of limestone.

2—1 foot drab and blue shale.

3—6 inches deep blue, shelly bituminous limestone; contains *Chonetes Verneuiliana* and *Spr. cameratus.*

4—20 inches blue and bituminous shale.

5—16 inches bituminous coal.

At the north part of the workings I observed eight feet of sandstone, occupying a lower horizon than the coal, and dipping south 10°. Two hundred yards south I observed a sandstone on the hill-top. I regard this coal equivalent to the bed at Porter's; it is probably also equivalent to J. R. Gray's.

ROCKS NEAR BROWNSVILLE, IN PETTIS COUNTY.

At Dr. Ryland Tuck's, in the east part of Sec. 21, T. 48, R. 23.

Section 40.

No. 1—12 feet clay.

2—44 feet sandstone.

3—7 feet silico-calcareous flagstone and shales, similar to the rock over the coal at Jordan's, on Grand river, Henry County.

4—3 feet ochrey and bituminous shale, with some iron pyrites, and containing ferns and *Cordaites*.

5—16 inches coal.

6—Fire-clay.

A portion of the above section includes rocks passed through in sinking a well; the notes were furnished me by Dr. Tuck, and afterwards proved by outside measurements of mine. About two hundred and fifty yards north-west, a coarse, bluish-gray limestone appears in the bed of the branch, which is undoubtedly of lower carboniferous age. Rocks similar to No. 3 of above section were observed cropping out in the road at Dunksburgh.

On the west half of the south-west quarter of Section 15, T. 48, R. 23, on W. T. Collin's land, two shafts have been sunk fifty to sixty feet, passing through sandstone and calcareo-silicious flagstone to coal, said to vary from 18 inches to 3 feet in thickness. Lower carboniferous chert and limestone occur in the valley below, and but little lower than the horizon of the coal.

The thickness of sandstone in this vicinity is probably about fifty feet, and it affords a very excellent building material. Collin's quarries are about three-quarters of a mile east of the above-named shafts. I have elsewhere noticed them in accounts of building-stones. The coal-bank of Louis Böhm, in Saline County, four miles west of Brownsville, is probably the equivalent of those last named. It is overlaid by 7 feet of variegated shale, separating it from sandstone. One foot of black clay rests immediately on the coal. The upper one foot of the seam is crumbly and shaly; the lower 16 inches is good coal.

An analysis of the top coal by Mr. Chauvenet gives :—

Water	6.02
Volatile	40.33
Fixed carbon	42.09
Ash	11.56

Color of ash, pink.

The beds connecting the lower coal-measures with the "chert beds" and Encrinital limestone were identified at several places near Brownsville, as follows :—

Sec. 38, one and a half miles east.

No. 1—11 feet slope, with tumbled masses of brown sandstone. Lower coal-measures.

2—25 feet brown and light-colored sandy clay.

3—8 feet brown and ochrey shales.

4—3 feet white clay.

5—2 feet concretionary hematite.

6—6 inches brown and red sandstone.

7—8 inches chert and purple clay.

Encrinital limestone appears a short distance down the branch.

At the flagstone quarry, half a mile east of Brownsville, Sec. 39.

No. 1—7 feet slope from hill-top.

2—10 feet outcrop of brown and chocolate-colored sandstone ; the same as seen at Collin's quarry, and No. 2. of Sec. 40.

3—10 feet slope.

4—A few inches band of black clay.

5—2 feet drab shales.

6—4 feet blue, and sometimes mottled blue and drab, calcareo-silicious and slightly bituminous flagstone ; occurs in layers, varying from one inch to a foot. This equals No. 3 of Sec. 40, and is also represented by the calcareous slate overlying the coal of Jordan's on Grand river, Henry County.

This rock is very much used in the construction of sidewalks at Brownsville, for which it is very suitable, being in even layers and quite strong. Fossils seem to be rare ; I observed obscure remains of ferns.

7—50 feet slope.

8—14 feet of gray Encrinital limestone in branch.

Pyrites occurs in No. 6, and near the outside is generally replaced by oxide of iron. I do not imagine the pyrites to be so abundant as to mar the usefulness of this for ordinary purposes. Outcrops of this rock are seen at several places in ravines near the line of Saline and Lafayette Counties.

Around and in Brownsville are occasional outcrops of white chert, intermingled with potter's clay, lying below the coal-measures and above the Encrinital limestone; I could not obtain the proper thickness, but suppose it to be about twenty feet; at the bottom is about one foot of red and yellow ochre. Below the bridge on Blackwater we find about twenty feet slope, strewn with tumbled masses and fragments of lower carboniferous chert, resting on forty-one feet of Encrinital limestone.

The section is as follows:—

Section 37.

No. 1—20 feet cherty slope.

2—12 feet gray, coarse-grained limestone: upper part shelly, middle firm and of a faint flesh tint; lower part shelly, abounding in crinoid stems and containing in the lower part shelly limestone with a little chert in lenticular forms.

3—5½ feet limestone and chert.

4—13 feet coarse, gray suture-jointed limestone; resembles No. 2.

5—1½ feet soft, fine-grained saccharoidal limestone.

6—11½ feet light-gray or whitish limestone. The upper part abounds in *Chonetes Shumardana*, *Orthis Mitchellini*. The lower beds are firmer, and may afford a good building material: they are of coarse texture and contain *Spr. striatus*. Sweet springs issue from the beds. Most of the beds would make good lime.

Our Section at Miami, Saline County, includes Lower carboniferous rocks as follows:

No. 1=88 feet slope—clays of "Bluff" formation.

2—A few feet shale.

3—10 to 14 inches, hard, light-gray sandstone, abounding in *Stigmaria ficoides*.

4—4 feet 8 inches sandy shale; a brown ochreous layer in the upper part; lower 1 foot dark, shading to black.

5—18 inches coal; rather inferior.

An analysis by Mr. Chauvenet gives:—

Water	2.58
Volatile	31.52

Fixed carbon	35.18
Ash	31.02

Color of ash, deep red.

6—5 feet slope.

7—4 feet fire-clay.—Base of coal-measures.

8—21 feet red, brown, white and olive clay: contains some chert, *Archimedipora*, other *Bryozoans* and a small *Spirifer*.

9—5 feet cherty mass, from above.

10—17½ feet light gray limestone; contains *Spr. striatus*, *Orthis Mitchellini*, a *crinoid* (*Actinocrinus?*) and many stems. A short distance off, and over No. 3 I observed black carbonaceous matter indicating the presence of coal. The coal No. 5 has a 2-inch clay seam intercalated about the middle.

Bates and Vernon Coal-Fields.

Near the line of Bates and Vernon are numerous outcrops of coal, varying from 2 to 3 feet. It can be mined with but little trouble; the only drawback to its present success is want of proper transportation. It crops out along valleys, about 50 feet below the general elevation of the country, or about 150 feet below the top of the highest mounds. A bed crops out near the base of Brushy mound which may probably be a lower bed. A section here of the rocks near the water is as follows:—

No. 1—Sandstone.

2—2 feet 3 inches coal.

3—4 inches shales and coal.

4—5 feet fire-clay.

5—9 feet shales with large sandy, ferruginous nodules and lenticular beds of carbonate of iron, occurring in 2-inch layers.

6—6 feet blue shale to ordinary water in the Marmaton river. On the Marmaton, six miles above, a one-foot bed of coal crops out beneath, containing beds of carbonate of iron.

These coal-fields have not yet been carefully examined, and the notes above written are the results of imperfect observations, made when otherwise engaged, several years ago, but I feel justified in placing this coal among the lower coal-measures.

Lafayette County.

In going from the east line of Lafayette County to Lexington, we pass in succession from the lower to the middle coal-measures.

At **Henry Franke's mine,** one and a half miles east of Concordia, I obtained the following section—No. 36.

No. 1—24 feet earthy slope.

2—2 feet sandstone.

3—14 inches pyritiferous limestone.

4—5½ feet slate enclosing pyritiferous concretions.

5—3 inches slaty cannel (?) coal.

6—21 inches bituminous coal.

7—2 inches slate and coal.

8—2½ feet fire-clay.

9—Clay and sandstone.

No. 5 is hard, has a dull appearance, splintery fracture, and appears like semi-bituminous coal and slate, or cannel coal. A few inches of the top coal has joints lined with iron pyrites, with an occasional similar horizontal seam. Calcite plates are sometimes introduced and the pyrites is seen blending with them. The coal has charcoal partings. The middle coal is pure black and brilliant, and almost free from iron pyrites. Below the middle it resembles the top, and includes much iron pyrites. The bottom coal is rather dull looking. There is a probability that the coal of Franke, and Graham's, which is close by, may be the equivalent of Section 62—No. 6. A half-mile north of Concordia, a coal-seam of 10 inches appears in a ravine, associated thus :—

No. 1—Sandstone.

2—Ochrey and clay shales.

3—2 to 3 feet ash-blue calcareous shales. Lower part abounding in *Prod. muricatus.*

4—10 inches coal.

5—Fire-clay.

This seam and that of Franke's I am uncertain whether to place in middle or lower coal series, but their position is probably near top of lower coal-measures.

A proximate analysis of Franke's coal by Mr. Chauvenet gives :

Water	5.35
Volatile	42.95
Fixed carbon	44.08
Ash	7.42

Color of ash, light brown.

UPPER SANDSTONE OF THE LOWER COAL-MEASURES.

A coarse, generally thick-bedded, brown or buff sandstone, filled with small particles of mica, is found occupying the top of the lower coal series. I have observed it 80 feet thick near Butler, Bates County, in coarse, thick beds. It is probably identical with the sandstone of Sugar Creek, Cass County, although my observations have not been such as to identify it. At Warrensburgh it is nearly a hundred feet thick, and north of the town, for several miles, forms the admirable building-stone now so extensively used. In the quarries here, it can be obtained of any desirable thickness. It is next seen near Aullville, Lafayette County, on Gen. J. O. Shelby's land. Several quarries are here opened, showing single beds of three feet in thickness of tolerably good building rock. Some of the layers are rather soft; the others are somewhat indurated. The next place where it was observed was on the McCausland farm, two miles north of Higginsville.

This farm includes parts of Sections 25 and 36, T. 50, R. 26, and Secs. 30 and 31, R. 25. On it are occasional outcrops of bituminous sandstone. A good deal of labor and money has been expended, and borings to the depth of 800 feet were made for oil, but none reached in quantities. The rock is mostly soft, thick-bedded, but some is shaly; it appears blue and gray on the weathered surface, but a fracture discloses a black color and a strong smell of mineral tar. It crops out fifteen to twenty feet thick near the old works. It was also observed presenting a similar character a half of a mile south-west. The following notes I copy from Prof. Swallow's report, published in the *Missouri Republican*. First, his section:

No. 1—"Buff and brown marls and clay	5 to 50 feet.
2—Blue and brown sandy shales	10 to 50 feet.
3—Bluish gray and brown sandstone	20 to 50 feet.
4—Blue and brown sandy shales	5 to 50 feet.

No. 3 is the oil-stone."

"Wherever this rock occurs on the McCausland farm it indicates the presence of petroleum ; it is usually so saturated that it plainly shows on a fresh fracture, and will freely burn in the fire. The sandstone shows evidence of important disturbance since its first deposition. It is traversed by vertical fractures, open at the top and running nearly east and west, and the beds usually dip 10° to 15° from this fracture. The fractures are filled with blue, plastic impure clay."

"The petroleum is found as solid asphaltum, breaking with shiny fracture, as a dark viscid fluid, like tar, and as thin amber-colored oil." My time was too limited to ascertain the extent and thickness of the sandstone. I regard it as of the same age as the Berlin sandstone and that above the mouth of the Tabbo, which would go to prove that there is a northerly dip of about fifty feet in nine miles. The smell of petroleum was very strong on a fresh fracture, and the water in pools in the branch, tasted quite unpleasant. In its northern extension, this Lower coal-measure sandstone crops out at various points, low in the bluffs on the Missouri river, from the Saline County line to the bluffs above the mouth of the Tabbo. Fifteen feet of sandstone crops out two miles below Edwards' mill, from the edge of the water. Mr. Edwards, in sinking a well on the river bottom, pierced an eight-inch coal-seam at eighteen feet depth, and struck sandstone passing into it forty feet.

The following is the **Section at Berlin, made by C. J. Norwood** :—

Section 22.

No. 1—100 feet slope ∠30°.

2—14 inches ashy blue argillo-pyritiferous limestone in one bed : on the top a thin shelly layer contains fossils, viz.:—*Bellerophon* (2 sp.) large and small, *Chonetes*, *Crinoid* stems, *Bellerophon Montfortiana*, small *univalves*, etc. Equivalent to No. 32 of the Lexington section.

3—2 feet bituminous shales.

4—4 feet dark shales.

5—2 feet yellowish and bluish drab limestone ; top greenish gray ; abounds in *Ch. mesaloba*, and contains a large *Productus*, also several *sp.* of *Allorisma*.

6—30 feet slope.

7—25 feet sandstone, generally soft; some parts indurated; mostly drab, some parts with brown specks; plants and *Calamites*.

8—5 feet sandstone conglomerate; contains iron concretions and silicified wood, etc.

9—14 feet green sandy shales and shaly sandstone.

10—1 foot shaly blue limestone, fossils, etc.

11—6 inches dark, sandy limestone, in thin shaly layers; contains *Pr. muricatus*.

12—3 feet slope to the water of the Missouri.

The rocks dip 8° N. E. Number 34 of Lexington section should occur in No. 4.

The sandstone bluffs here form bold mural escarpments. One mile above the mouth of the Tabbo this sandstone rises about 60 feet, extending from the river upwards. The section at the bridge on the Tabbo includes a series of rocks which are probably below the sandstone, viz.:—

No. 1—Bluff.

2—4 feet blue, thinly laminated shales, with blue calcareous concretions.

3—1 foot black slate, with thin coal laminæ.

4—16 inches blue and gray clay.

5—2 inches bituminous coal.

6—18 feet thinly laminated blue clay shales bearing a 2-inch band of iron-stone midway, and also small crystals of selenite.

7—Deep ash blue shaly limestone, containing *P. muricatus*.

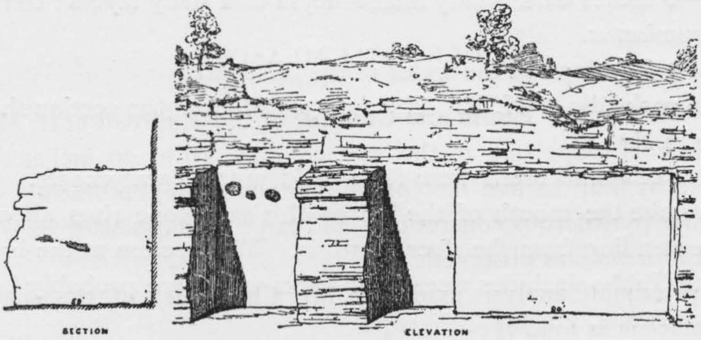
8—14 feet clay shales, to the water in the creek.

The Berlin sandstone, that of the McCausland farm, and at Warrensburgh, may all be considered of the same age, but only on the McCausland farm was it observed to contain petroleum. North of the Missouri river it is again seen, a few miles above Miami Station; the more western and probably the upper beds are shaly, with indurated sandstone concretions of various sizes. At the "White rock" quarries there is exposed 60 to 70 feet of light gray sandstone, 60 feet of which is without a horizontal seam. The rock is coarse, gritty, valuable for grindstones, and extensively used as a building rock, being shipped to many remote places. It contains numerous remains of fine plants, more especially the hard concretionary portions, including *Calamites*, *ferns*, *Cordaites*, *fruits*, etc.

At Miami station this rock is replaced by a coarse brown sandstone, also affording good material for building. Outcrops are occasionally seen nearly to De Witt.

We next observe it on Grand river bluffs, below Compton's ferry, as a coarse brown sandstone, containing numerous hollow concretions of brown hematite. This is also probably the sandstone

Fig. 14.



WHITE ROCK QUARRY, CARROLL CO.

found on the water's edge on the Grand Chariton, in Adair County. If the coal-measures are to be divided into middle and lower, this would probably be the dividing bed.

CHAPTER III.

MIDDLE COAL-MEASURES.

On the land of **Ennis and Cundiff**, at the Railroad near Mulky Creek, coal crops out at the surface from 16 to 20 inches thick, capped by four to five feet of bituminous shale, embracing small globular pyritiferous concretions, and large ferruginous masses. A small *Discina* was observed.

A proximate analysis made by Mr. Chauvenet of the coals at this place is as follows :—

	NEAR TOP.	NEAR MIDDLE.
Water	6.95	7.03
Volatile	42.61	40.72
Fixed carbon	43.42	47.11
Ash	7.02	5.14
Color of ash	light chocolate with white specks.	Chocolate.

A shaft sunk on a little higher ground, revealed, as Mr. Ennis informed me :—

No. 1—2½ feet dark shale.

2—8 feet clay.

3—7 feet "soapstone ;" (clay).

4—8 inches hard, tough band.

5—2 feet limestone, fine-grained, bluish drab, weathers brown. The only fossil observed was a small *Allorisma*.

6—8 inches hard band like No. 4, but harder.

7—5½ feet hard black slate, full of globular concretions, and a few large bituminous concretions.

8—21 inches coal.

9—9 feet thinly laminated ochrey clay shales.

10—20 feet slope.

11—6 feet ferruginous and sandy limestone.

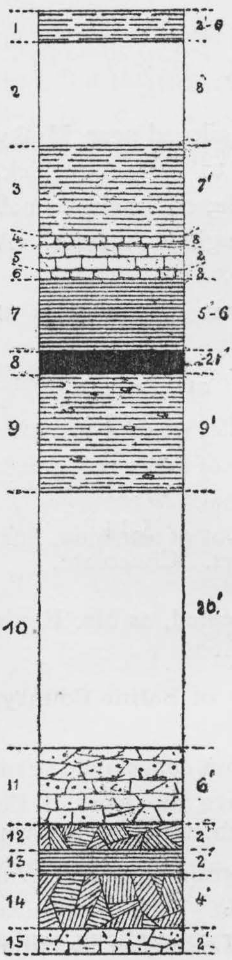
12—2 feet blue clay.

13—2 feet hard bituminous slate.

14—4 feet fire-clay.

15—2 feet rough, nodular, gray, sandy limestone.

Fig. 15.
MULKY CREEK
LAFAYETTE CO.



These rocks apparently dip down stream, to the northward. A quarter of a mile north I obtained fossils from the overlying bituminous shales; including *Nucula ventricosa*, *Pleurotomaria carbonaria*, *Lophophyllum proliferum*, *Orthis carbonaria*, and from calcareo-bituminous concretions, *Orthoceras cribrosum* and *Pr. splendens*. In the railroad cut one mile north-west, the Lexington coal crops out 50 feet above the Mulky Creek coal, by the measurements of the railroad engineers. The Section here is :—

No. 1—Clay.

2—3 feet limestone in irregular beds.

3—2½ feet bituminous shales.

4—5 inches sandy and ochrey shales.

5—4 inches impure coal.

6—12 inches good coal, *Lexington* bed.

7—6 inches black clay with remains of plants and minute selenite crystals.

8—5 inches blue fossiliferous clay, with *P. castatus*, and *Athyris subtilita*.

9—3 feet blue clay.

10—6 feet 10 inches thick-bedded, rough, gray limestone; in the upper part it abounds in *Fusulina cylindrica;* also contains *Pleurotomaria*, *Athyris*, and *Crinoid* stems, and minute dolomite crystals. This limestone is probably hydraulic.

Aullville is situated on a gently sloping terrace, about twenty-five feet above the valley of Davis Creek, and between fifty and seventy-five feet below the top of the higher ridge to the south. Its topographical horizon must therefore be over fifty feet below the Lexington coal, and probably below the Mulky coal, unless the latter should have a strong dip westward, in which case it ought to be soon reached, by shafts. The Lexington coal is mined in the ridge two and a half miles east. On the land of Charles Payne it is 18 to 20 inches thick, with overlying rocks, thus :—

No. 1—4 feet limestone.

2—2 feet slate.

3—1½ feet pyritiferous and bituminous bed with many fossils, mostly *Chonetes mesoloba*.

4—4 inches black clay.

5—18 inches bituminous coal.

6—fire-clay.

Proximate analysis of Payne's coal by Mr. Chauvenet :—

	TOP.	MIDDLE.	BOTTOM.
Water	8.85	7.02	7.75
Volatile	37.25	37.67	34.05
Fixed carbon	44.80	39.66	40.03
Ash	9.10	15.65	18.17
Color of ash.	Cream.	Very lt. brown.	Lt. chocolate.

At Osborn's quarry, one mile north of Aullville, we find 16 inches of coarse, bluish-gray limestone : one even bed of this I recognized to be twenty-seven feet below the Lexington coal.

Fourteen feet below it is an outcrop of one foot of ash-blue, fine-grained limestone, weathering light brown.

MISSOURI RIVER SECTIONS.

Three Miles below Waverly, in the edge of **Saline County,** Mr. C. J. Norwood made Sec. 24 :—

"No. 1—55 feet slope, ∠ 30°. The Lexington coal should occur here about 4 feet above No. 2, or 126 feet above the level of the bottoms.

2—3 feet rough, irregularly bedded, coarse-grained, gray ferruginous limestone—some parts blue : two layers. This is equivalent to the 'Fusulina limestone' in the Lexington Section. = Sec. 18, No. 28.

3—29 feet slope. At the lower part are outcrops of olive clay shales.

4—15 inches ashy blue pyritiferous limestone, holding *Chonetes mesoloba*, *Crinoid* stems, &c. = Sec. 23, No. 9.

5—2 feet bituminous shales.

6—15 feet slope, with tumbled masses of yellowish-drab limestone; top greenish gray; equivalent to Sec. 22, No. 5.

7—72 feet slope to the bottom.

The 7-inch vein of coal seen at Lexington should occur in No. 6."

Just above Waverly the following section appears on a small branch:—

No. 1—Long steep slope; bluff formation.

2—24 feet bluish sandy shales in thin layers.

3—14 feet—upper two feet covered with débris, containing bituminous shale and coal; probably a coal-bed is concealed. At the lower part is a dark fire-clay, ferruginous near the base.

4—3½ feet bituminous shales, containing spheroidal concretions, and an occasional thin band of limestone; observed *Ch. mesoloba*, *Spr. plano-convexus*, &c.

5—3 feet drab fire-clay.

At the water's edge, on the river, are several thin layers of greenish sandstone.

Abstract of C. J. Norwood's Notes.

On the bluff near Waverly, Mr. Norwood observed 14 inches of bituminous shale, 26 feet above the river.

One mile above he observed 2 feet of limestone at 88 feet above the river: color gray or bluish-drab, and containing *Crinoid* stems, *Spr. plano-convexus*, *Spr. cameratus*, &c. Marked Sec. 25, No. 2.

About forty-five feet above the river, and lying below, were masses of tumbled, concretionary, black bituminous limestone, containing *Discina*, *Gonatites*, *Pr. muricatus*, and abounding in *Cardiamorpha Missouriensis*.

These fossils would indicate the presence of the Mulky coal.

"A quarter of a mile above, fifteen feet of sandy shales crop out, seven feet above water in the river. Sec. 26, No. 2, two and a half miles above Waverly, includes two feet of limestone cropping out 65 feet above the river, resembling that of Sec. 25, No. 2, and containing *Spr. cameratus*, *Spr. plano-convexus* and *Ch. mesoloba*, *Athyris subtilita* and *Pr. castatus*. Below it and within fifteen feet are black concretions abounding in *Cardiamorpha*, &c. We must therefore consider that the limestone No. 2 is the equivalent of that over the Mulky coal.

The following section (No. 27) was seen one-quarter of a mile above Sec. 26.

"No. 1—93 feet slope.

2—20 feet shaly sandstone and sandy shales.

3—18 feet hard, laminated, argillaceous shales.

4—9 inches coal.

5—2 feet fire clay, containing *Stigmaria ficoides:* the lower 6 inches very hard and pyritiferous.

6—10 feet slope to river."

One-half or three-quarters of a mile further, Mr. Norwood found Sec. 28 exposed thus :—

"No. 1—Slope.

2—2 feet dove-colored, hard, pyritiferous limestone: contains *Bellerophon*, *Crinoid* stems, *Athyris subtilita*, *Spr. plano-convexus*, *Fusulina cylindrica* and small *univalves*. This is probably equivalent to the bed twenty-seven feet below the Lexington coal, and numbered 32 of the section made there.

3—6 inches black streak.

4—15 feet shales.

5—20 feet slope to river."

"Fifteen feet of sandstone crops out at the edge of the water in the river, two miles below Edwards' mill. Mr. Edwards in sinking a well, on the river bottoms, pierced an eight-inch coal-seam at 18 feet depth, and passed forty feet into sandstone."

"The following section is exposed one-quarter of a mile above Edwards' mill.

Sec. 29.

No. 1—"55 feet long slope. The Lexington coal should occur here, seventy-three feet above the level of the river bottoms.

2—15 inches rough, gray limestone. Some parts yellowish drab; equivalent to Section 24, No. 2.

3—25 feet slope.

4—5 feet hard shales.

5—16 inches ashy blue, pyritiferous limestone, shelly on top. *Fusulina cylindrica*, etc.: equivalent to Section 22, No. 2.

6—18 inches bituminous shale.

7—5 feet slope: place for the seven-inch vein of Lexington.

8—6 inches blue limestone: three layers.

9—5 feet blue clay.

4

10—2 feet light yellowish drab limestone: one bed contains *Ch. mesoloba*.

11—1 foot calcareous shales (passing into a limestone), containing concretions.

12—22 feet slope to bottoms."

One mile above Edwards' mill, I observed at one hundred feet elevation the limestone corresponding to the first limestone occurring two feet over the Lexington coal. At 65 feet above the bottom are several feet of bituminous shale, containing near the upper part a dull, but deep blue, shaly, fucoidal limestone. A brown limestone crops out ten to fifteen feet above the limestone above named.

The best exposures of rocks, embracing the Lexington coal, are seen at LEXINGTON.

The following is a general section by C. J. Norwood, made up and condensed from a number of sections made at that place.

General Section.

No. 1—40 feet bluff.

2—2 feet sandstone: hard.

3—22 feet shales: arenaceous.

4—3 inches shales: bituminous.

5—2 inches coal: bituminous.

6—7 feet shales: arenaceous: upper four feet hard and laminated.

7—6 feet sandstone: shaly: buff-colored.

8—16 inches shales: dark blue: some part calcareous and hard.

9—3 inches limestone: blue: concretionary.

10—7½ feet shales: argillaceous: blue, streaked with red.

11—6 inches coal.

12—3 inches shales: dark.

13—6 inches fire-clay.

14—3 feet shales: arenaceous.

15—4 feet limestone: irregularly bedded: gray and drab; sometimes quite nodular: generally coarse-grained. Abounds in *Chætetes milleporaceus*, contains *Fusulina cylindrica* and *Athyris subtilita*.

16—6 feet shales: drab, green and dark.

17—4 feet sandstone: hard, brown and gray, in one thick bed.

18—27 inches shales: argillaceous, olive and red.

19—6 inches clay; black and blue, with three streaks of coal: this coal sometimes thickens to 6 inches, and again is entirely absent.

20—8 feet shales: argillaceous and arenaceous: buff and olive, also red.

21—3½ feet limestone: drab: shelly on top: thick-bedded: good for building: contains *Chætetes milleporaceus*, *Archæocidaris* spines, *Fusulina cylindrica* and *Athyris subtilita*.

22—3½ feet limestone: shaly and rough: abounds in *Meekelea striato-castata* and *Ch. Smithii* (?). *Athyris subtilita*, *Hemipronites crassus*, *Pr. castatus*, *Pr. Prattenianus*, a *Fish-tooth*, *Bryozoa*, *Archæocidaris* and *Crinoid* stems are also found.

23—3 feet shales and thin beds of limestone abounding in *Ch. Smithii* (?) and containing *Spr. cameratus*, *Pr. costatus*, *Hemipronites crassus* and *Athyris subtilita*.

24—3½ feet shales: dark blue and drab, with nodules of limestone: abound in *Chonetes*.

25—5 feet limestone: dull blue and yellowish drab: contains *Pr. costatus*, *Spr. plano-convexus*, *Chonetes*, *Athyris subtilita*, *Aviculopecten carboniferus*, *Bellerophon*, *Fusulina cylindrica*, and a long spine of *Archæocidaris*.

26—14 inches shales: bituminous.

27—5 inches slaty coal.

28—21 inches good coal: the working vein.

29—4½ feet fire-clay and shales.

30—4 feet limestone: gray and blue: thick-bedded: good for building purposes. Contains large *Nautilus*, a small *Bellerophon*, *Pr. costatus*, *Ch. mesoloba*, *Athyris subtilita*, *Archæocidaris* stems, and abounds in a small *Fusulina*, on account of which the rock presents a very pretty appearance when fractured. It is easily recognized by this peculiarity.

31—21 feet shales: argillaceous: blue, drab, red and yellow.

32—15 inches limestone: pyritiferous: color blue: hard: one bed: shelly on top; contains small univalves on the surface.

33—28 inches shales: bituminous: contains *Discina Missouriensis*.

34—4 feet dark calcareo-pyritiferous shales: abounding in *Pr. costatus* and containing *Hemipronites crassus*, *Pr. Rogersii*, *Athyris subtilita*, etc. Sometimes there occurs a concretionary bed of black bituminous limestone, containing fossils.

35—7 inches coal.

36—4 feet drab shales and nodules of limestone.

37—16 inches rough concretionary limestone: pyritiferous.

38—2 feet dark olive shales and limestone nodules.

39—2 feet greenish gray limestone: upper part abounds in *Ch. mesoloba*, and contains *Pr. costatus*, *Hemipronites crassus*, *Athyris subtilita*, *Fusulina cylindrica*. (Lowest rock seen at Lexington.)

40—8 inches tough, very hard band.

41—5½ feet hard black slate full of globular concretions, and a few large bituminous limestone concretions.

42—21 inches coal—The "Mulky Seam."

43—9 feet thinly laminated ochrey shales.

44—20 feet:—rocks not exposed.

45—6 inches ferruginous and sandy limestone.

46—2 feet blue clay.

47—2 feet hard bituminous slate.

48—4 feet fire-clay.

49—2 feet rough nodular, gray sandy limestone.

"Numbers forty to forty-nine, inclusive, are not exposed at Lexington, but were seen on Mulky Creek, east of Aullville."

"The following are the most important sections made at Lexington:—

"Sec. 15 made on **Graham's Branch**, commences at the bridge, crosses it on the Lexington and Independence road, and follows up the branch as far as Graham's coal mine. Distance one-quarter of a mile."

"No. 1—80 feet long slope.

2—4 feet hard brown sandstone.

3—10 feet slope.

4—3 feet fine-grained drab limestone: irregularly bedded: weathers brown: contains *Athyris*, *Chonetes*, *Fusulina*, large *Crinoid* stems, etc.

5—5 feet shales and thin beds of bluish drab limestone and nodules, abounding in *Pr. castatus*: containing *Chonetes*, *Hemipronites crassus*, *Crinoid* stems and *Archæocidaris* spine and plate.

6—5 feet slope and shales.

7—5 feet dull blue and yellowish drab, irregularly bedded limestone. Contains *Bellerophon*, *Chonetes*, *Aviculopecten carboniferus*, *Athyris*, *Spr. plano-convexus*, etc.

8—14 inches bituminous shale.

9—22 inches coal—" Lexington Coal." *

10—3 feet slope.

11—3 to 4 feet hard, pyritiferous, blue and gray limestone : thick bedded. Abounds in a small *Fusulina :* contains a large *Nautilus*, small *Bellerophon*, *Athyris*, *Pr. costatus*, *Chonetes mesoloba*, *Archæocidaris* spine, &c.

12—21 feet blue, drab, red, and yellow shales : argillaceous.

13—15 inches hard blue pyritiferous limestone in one bed : shelly on top, and containing small univalves on the surface.

14—28 inches bituminous shales containing *Discina Missouriensis.*

15—3 feet dark calcareo-pyritiferous shales, containing *Pr. Rogersii*, *Athyris*, *Hemipronites crassus*, and abounds in *Pr. costatus :* sometimes there is interstratified a bed of concretionary, black bituminous limestone.

16—7 inches coal.

17—4 feet drab shales and nodules of limestone.

18—14 to 20 inches hard, rough, irregularly bedded, somewhat concretionary pyritiferous limestone.

19—2 feet dark olive shales, with limestone nodules.

20—2 feet greenish gray argillaceous limestone, in the bed of the branch. The upper part abounds in *Ch. mesoloba*, and contains *Pr. costatus*, *Hemipronites crassus*, *Athyris*, etc.

" **Just West of the Ferry Landing** the following, Sec. No. 18, is exposed :—

No. 1—52 feet bluff.

2—15 feet bituminous shale.

3—3 inches bituminous shale.

4—1 to 2 inches streak of coal-smut.

5—7 feet sandy shales ; upper four feet blue and hard.

6—6 feet shaly buff sandstone.

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* A proximate analysis of Graham's Coal, made by Mr. Chauvenet, gives :—

(MIDDLE)

Water	6.53
Volatile	35.19
Fixed carbon	47.46
Ash	10.82
Color of ash.	Very light brown.

7—16 inches dark shales; some parts hard and calcareous.

8—3 inches concretionary limestone; blue; weathers brown.

9—7½ feet blue clay, streaked with red.

10—6½ inches coal.

11—3 inches dark shales.

12—6 inches fire-clay.

13—4 feet slope.

14—5 feet irregularly bedded drab limestone; abounds in *Chætetes* and *Fusulina*.

15—5 feet drab and dark shales.

16—3 feet hard brown sandstone; one thick bed; also gray or drab.

17—8 feet buff and olive shales.

18—4 feet 10 inches drab limestone; thick-bedded; shelly on top; good for building; *Chætetes milleporaceus*, *Fusulina*, *Athyris*, etc. Equivalent to Sec. 15, No. 4.

19—4 feet drab and dark blue shales, with thin beds and nodules of limestone. Contains *Chonetes*.

20—4 feet dull blue, irregularly bedded limestone.

21—3 inches shales with pyritiferous concretions.

22—8 inches bituminous shales.

23—1½ inches of coal.

24—4 inches pyritiferous shales—very hard.

25—21 inches coal—working vein. Dips 8° to S., 50° E.

26—14 inches clay.

27—3 feet slope.

28—3 feet thick-bedded gray limestone.

29—38 feet slope to the level of the Missouri river."

Opposite the Hemp Warehouse, above the Ferry landing, Sec. 30 is seen:

No. 1—bluff.

2—50 feet shales; sandy: 2 feet hard sandstone at six feet from top.

3—5 feet drab limestone; top nodular; contains *Fusulina*, *Chonetes* and *Spr. cameratus*.

4—16 feet shales (and sandstone ?)

5—6 inches coal.

6—8 feet shales.

7—3 feet drab limestone; thick-bedded with *Chætetes*.

8—9 feet limestone and shales.
9—7 feet limestone.
10—8 inches shales.
11—2 inches coal.
12—3 inches slaty coal.
13—22 inches coal.
14—2 feet fire-clay.

If we examine the grouped sections we will find that the coal undulates at various elevations in the Lexington bluff, varying from twenty-seven to forty-six feet above the river. Its general thickness is from *twenty-one* to *twenty-three* inches.

At Tilden Davis's Mine it is 20 inches thick, capped by $1\frac{1}{2}$ feet bituminous shales separating it from the limestone, and underlaid by 1 foot 8 in. fire-clay. Just west of the ferry landing it is *twenty-one* inches, with 14 inches of clay underlying it. Here it dips 8° to S., 50° E.

An analysis of Mr. Davis's coal by Mr. Chauvenet gives :—

Water	8.21
Volatile	37.56
Fixed carbon	46.84
Ash	7.39
Color of Ash	nearly white.

A four-inch pyritiferous band rests on it with one and a half inches of coal, and still above on this there rests 1 foot of bituminous shales.

At **R. G. Tucker's** the coal is also divided, as at the last abovementioned place, by 3 inches of slaty coal.

The upper coal 2 inches, and the lower 22 inches.

Eight inches of slate lies between the coal and the roof, which is limestone. On the land of General Graham, on the branch at the upper end of Lexington, the coal is from 19 to 22 inches thick, with 14 inches of slate above, separating it from the limestone. Numerous driftings have been made in the hill at various times, and a great quantity of coal taken out. The quality will compare favorably with most of the Missouri coals.

Two miles from Lexington, on the Sedalia road, the same coal-seam has been worked at many places on lands of **R. C. Vaughn** and of ——— **Eckles,** now leased by the "**Lexington Coal Com-**

pany," for twenty-five years. This company employs twenty-five miners and furnishes the railroad with coal.

They have fourteen main entries—nine in the Vaughn tract and five on the Eckle tract—extending from fifty to seventy-five feet. The coal varies from 19 to 20 inches, separated near the top by a slaty seam, thus :—

No. 1—Limestone.

2—Slate, 1 foot.

3—Calcareo-bituminous bed, 0 to 2 inches.

4—Coal, 1 to 2 inches.

5—Clay, sometimes replaced by slate 1 to 6 inches.

6—Coal, 19 to 22 inches.

7—Fire-clay.

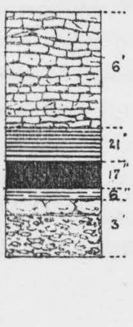
An analysis of this coal, made by Mr. Chauvenet, gives :—

	Top.	No. 3.	No. 4.	Bottom.
Water	5.79	8.15	6.36	6.25
Volatile	36.03	34.71	36.28	35.03
Fixed carbon	47.31	47.29	47.80	50.04
Ash	10.87	9.85	9.56	8.68
Color of Ash.	Lt. brown.	Lt. brown.	Yellow brown.	Very light brown.

The "LEXINGTON COAL CO." also have control of the now abandoned "GOODIN BANKS," extending along the bottoms, about three miles above Lexington. Formerly a great deal of mining was done about two miles above Lexington, but the works are now all abandoned.

This coal seems to thin in a south-westerly direction. On the Little Sniabar, six miles a little west of south, our section shows—

Fig. 16.
SECTION
ON LITTLE SNIABAR.
6 MS. S. OF LEXINGTON



No. 1—6 ft. limestone, irregularly bedded.

2—21 inches bituminous shale.

3—17 inches coal.

4—6 inches shale.

5—3 feet fusulina limestone.

At Holman's, several miles south of Greenton, we find—

No. 1—4 feet 9 inches limestone ; contains *Chætetes milleporaceus.*

2—1½ feet olive and bituminous shales.

3—1 foot coal, upper part impure; lower part good.

Our sections show a seam at 36 feet below the Lexington coal, varying from 4 to 8 inches in thickness. It is not used. The general section at Lexington shows its position with regard to other beds. Eight miles south-east of Lexington it appears thus:—

Section 32.

No. 1—8½ inches blue shaly limestone. *Athyris, Hemipronites crassus, Chonetes mesoloba, Rhombopora lepidodendroides.*

2—5 inches olive shales.

3—2 feet 1 inch bituminous shales.

4—14 inches dark blue calcareous shale.

5—3 inches coal.

6—2½ feet fire clay.

7—2 feet rough nodular limestone: contains *Athyris subtilita, Pr. Prattenianus, Pr. costatus.*

At Wellington the rocks appear thus:—

Sec. 14 (C. J. Norwood).

No. 1—75 feet rocks concealed.

2—3 feet greenish sandy shales.

3—5 feet drab shaly sandstone.

4—10 feet 4 inches slope.

5—3 feet irregularly bedded, light drab, tolerably fine-grained limestone; weathers brown, contains small *Chonetes, Athyris, Fusulina cylindrica* and large *Crinoid* stems. No. 21 of Lexington Section.

6—3 feet shales and concretionary limestone; abounds in *Chonetes Smithii* (?) contain *Athyris, Hemipronites crassus, Spr. cameratus, Archæocidaris* and *Crinoid* stems and *Lophophyllum proliferum*, also *Crinoid plates.*

7—1½ feet mottled green and blue clay.

8—2 feet light blue clay.

9—2 feet dark argillaceous shales.

10—7 feet yellowish drab and blue, irregularly bedded limestone in several layers; the upper part mostly blue and argillaceous. Contains *Spr. plano-convexus, Athyris Chonetes, Edmondia, Euomphalus rugosus, Bellerophon, Trilobite* (*Phillipsia?*) This rock is equivalent to Number 25 of the Lexington section.

11—4 feet slope; place for Lexington coal.

12—17 inches irregularly bedded blue and drab ferruginous limestone: full of specks of calcite; nodular on top, lower part compact; *Athyris*, *Crinoid* stems, *Fusulina* and *Lophophyllum proliferum*, are the fossils seen. Some portions are light drab or gray.—To river.

At Napoleon we have

Sec. 12 (**C. J. Norwood**).

No. 1—67½ feet slope.

2—10 feet reddish clay.

3—5 feet olive, somewhat calcareous shales.

4—2 feet yellowish drab, irregularly bedded limestone; contains remains of *Producti* and of a small *Bellerophon.* Top rock at sawmill below Lexington.

5—2 feet buff, calcareous shales, abounding in *Ch. mesoloba*, and containing a larger *Chonetes* (*Ch. Smithii?*) *Athyris*, *Spr. cameratus*, *Hemipronites crassus* and *Crinoid* stems.

6—26 inches irregularly bedded, drab limestone; contains *Fusulina cylindrica*, *Athyris*, *Spr. plano-convexus*, *&c.*

7—6 inches green and yellow shales, containing *Spr. plano-convexus* and *Hemipronites crassus.*

8—9 feet slope.

9—6 inches somewhat concretionary, dove-colored limestone; some parts bluish gray.

10—2 feet outcrop sandstone.

11—14 feet slope, on which are tumbled masses of gray limestone.

12—3 feet irregularly bedded, slightly bluish drab limestone; somewhat shelly. Weathers brown. Some parts blue; traversed by seams of calcite. On the surface are *Fusulina cylindrica*, *Athyris*, *Spr. plano-convexus*, *Pr. costatus*, *Archæocidaris* spines, *Chætetes milleporaceus*, *&c.* Equivalent to No. 21 of Lexington section.

13—2 feet slope.

14—Outcrop of light drab or gray, nodular limestone, containing *Spr. cameratus*, *Pr. costatus*, *&c.*; abounds in *Chonetes.* To river.

"It appears from the foregoing that the Lexington coal would be reached at Napoleon, by sinking a shaft to the depth of twenty feet below No. 14, of the foregoing section."

One-half of a mile above Napoleon.

Section 11 (**C. J. Norwood**) is exposed.

No. 1—Slope.

2—2 feet red clay.

3—1 foot green clay.

4—1½ feet outcrop of bluish drab limestone; weathers brown.

5—2 feet slope.

6—1½ feet drab limestone with yellow streaks running through it; weathers buff. Equivalent to No. 15, of Lexington Section.

7—6 feet slope and shales—dark and light green.

8—5 feet outcrop soft drab sandstone; upper 3 feet thin layers.

9—18 feet slope.

10—Outcrop somewhat shelly, bluish drab limestone; contains *Fusulina*, &c. Equivalent to No. 21 of Lexington Section. To river.

Carroll County.

In the eastern part of the county we have previously noted sandstone referable to the lower coal-measures. At the upper end of the "White rock" quarry it reposes on 2 feet of coal. One mile up the bluffs is the coal mine of James Meddlin, also, probably in lower coal-measures. Its locality is in the south-east quarter of the south-west quarter of Section 6—T. 52, R. 21, and occurs thus:—

No. 1—Shaly slope; dark and yellow variegated.

2—18 to 19 inches coal; contains some pyrites in the upper part.

An analysis by Mr. Chauvenet gives:—

Water	2.07
Volatile	29.94
Fixed Carbon	47.03
Ash	20.96

Color of ash, dark brown, with white specks.

3—3 feet clay, with limestone and pyritiferous concretions and septaria.

4—12 to 14 inches coal.

5—31 feet to bottoms.

One mile further along the bluffs, we find the last section continued upwards, as follows:—

No. 1—5 feet white clay.

2—7 feet soft, buff brown sandstone.

3—37 feet shales, with occasional ochrey layers.

4—7 feet shales, with concretions of carbonate of iron, and ochre near top, and a 6-inch bed of carbonate of iron and septaria near bottom. The fossils from the upper stratum are a large *Discina*, a *Lingula*, *Pleurotomania* and *Bellerophon*.

5—15 feet shales.

6—5 inches ash blue, hard concretionary limestone.

7—20 inches bituminous shales.

8—Outcrop of rotten coal.

9—3 feet ochreous and olive shales.

A mile and a quarter west, 30 feet of sandstone replaces Nos. 3 and 4 of last section, and so continues for two miles further.

Other exposures along the bluffs west of this should be referred to the **Middle Coal Measures.**

Section 161 at **Hardwick's Mill.**

No. 1—63 feet from hill-top.

2—23 inches gray limestone. (No. 30 of Lexington Section.)

3—20 feet—The upper five feet includes nodular masses of limestone.

4—12 feet sandy shales.

5—1 foot even-bedded, bluish-gray limestone, contains *Lophophyllum proliferum*, *Fusulina cylindrica*, etc. (No. 32 of Lexington Section.)

6—1 foot blue shales.

7—Bituminous shales.

8—75 feet to water in the Wakenda.

One-half a mile west, the lower portion is better exposed, thus :

Section 162.

No. 2—8 inches limestone, even layer, dark ash blue, equivalent to No. 5 of last section (No. 32 of Lexington Section), or No. 41 of General Section.

3—1 foot olive clay shales.

4—2 feet bituminous shales with small round concretions.

5—10 feet clay ; blue above, and yellow or buff below.

6—4 feet limestone, in one thick bed ; drab and brown ; upper part weathers brown ; it may be hydraulic ; no fossils observed. This is probably equivalent to the limestone overlying the coal on Mulky Creek, Lafayette Co., and the limestone lowest seen below Lexington. (No. 39 of Lexington Section.)

7—8 feet hard, dark slaty rock, calcareous and silicious. The upper half is in dark olive drab layers, forming flagstones, one-half to one inch thick; below is black and bituminous coal of variable

8. thickness; as thick as one foot—(No. 42 of Lexington Section) No. 31 of General Section.

9—4 feet fire-clay.

10—Sandstone.

On Jas. Goodson's land in the south-east quarter of Section 36, T. 59, R. 23, the coal is 12 to 14 inches thick, and the connection of rocks seen was this:

No. 1—3 feet limestone.

2—3 feet dark shales with small round concretions.

3—2 feet black bituminous shales; a portion calcareous and containing fossils.

4—12 to 14 inches coal.

An analysis by Mr. Chauvenet gives:

Water	2.97
Volatile	36.36
Fixed carbon	47.83
Ash	12.84

Color of ash—light brown.

A quarter of a mile south from the last, on the branch, the coal is 18 to 19 inches thick.

The same coal is worked on the land of C. W. Lane in the south-west quarter of the south-east quarter of Section 36, T. 53, R. 23. This and other pits were filled with débris. There has not been much outlay in mining expenses at any of them. The overlying bituminous shales occasionally contain large, black, bituminous limestone concretions abounding in many very nice fossils, mostly *Cardiamorpha Missouriensis*, *Cardinium? Lexingtonensis* (*Sw*), 2 *sp. of Goniatites*, a *Nautilus*, *Pleuratomaria sphærulata*, *Nucula Ventricosa*, *Goniatites Hathawayensis? McCh. Goniatites politus*, *Goniatites planorbiformis*, *Orthoceras cribrosum*, *Nautilus decoratus? Discina* ——, *Discina Missouriensis*, *Pr. Prattenianus*, *Aclis Swalloviana? Hemipronites crassus*, and *fish spine*, allied to *Leptacanthus*.

On the Missouri bluffs, three or four miles below Carrollton, two feet of limestone (No. 39 of Lexington Section) crops out fifty-two feet above the bottoms. Investigations in the lower slope at this place might disclose the coal seen near Hardwick's Mill.

Some of the beds of rock of the last sections occasionally crop out in the bluffs above Carrollton, and for eight miles further, but no coal was seen. Four miles above Carrollton, limestone equivalent to No. 39 of Lexington Section crops out fifteen feet above the bottoms.

The Stanley coal-mine, 1½ miles north-west of Carrollton, was examined by Mr. C. J. Norwood, who obtained this Section.

No. 1—20 feet of sandy shales—hard.

2—2 inches streak of coal.

3—28 inches sandy shale with *Stigmaria ficoides.* Crystals of sulphuret of iron seen in lower part.

4—18 inches good coal. Dips 25° S., 20° E. and inwards. Mine dry.

This coal must be below the coal at Hardwick's Mill and vicinity. If so, and the position of recognized limestones tends to prove it, the rocks have slightly risen from Hardwick's Mill to Carrollton. Westwardly they gradually descend. About six miles west of Carrollton, I observed an outcrop of 22 inches of limestone, which I refer to No. 32 of the Lexington Section, cropping out on a gentle slope, about thirty feet above the Missouri bottoms.

The rock has a dove shade, weathering to a chocolate-brown, and containing *Fusulina, Athyris, Spr. lineatus* and large *Crinoid* stems. The joints are covered with minute calcite incrustations. This rock resembles that of Wörsten's quarry in Livingston Co.

Near this, and probably on a lower horizon, observed a *fucoid,* supposed to be *Caulerpites marginatus.*

At Rocky Ford, on the Wakenda River, about half a mile before it enters the Missouri bottoms, I observed eight feet of ochrey and blue shales, resting on an even-bedded, ash-blue limestone, at top shaly, and containing *Fusulina, Crinoid* stems and *Spr. cameratus.* I refer it to No. 32 of the Lexington Section. This limestone, I suppose, was also struck in the shaft of Fred'k Strauss, on the edge of the river bluffs, in N. E. quarter of the N. W. quarter of Section 12, T. 52, R. 25, at 17 feet below the surface. Mr. Strauss informed me that it rested on one foot of black slate, with four to ten inches of coal below. These rocks were not seen any further west. One and a half miles west, sandstone again appears about twenty-five feet above the bottoms, and nine feet thick, the upper five feet in thin ochrey layers. Lower part one thick bed ; at one place hard and concretionary ; otherwise it might afford a good building stone. At the county line of Ray County we find, at twenty-five feet above the bottoms, 7 ft. of limestone and sandstone conglomerate. The upper 2 feet, limestone : the lower 5 feet, a thick bed of very hard, brown sandstone and conglomerate of round silicious pebbles. Eight feet above the conglomerate is five feet of gray shelly limestone, containing *Fusulina cylindrica, Chætetes milleporaceus, Athyris subtilita ;* this may be No. 39 of Lexington Section.

Ray County Coal.

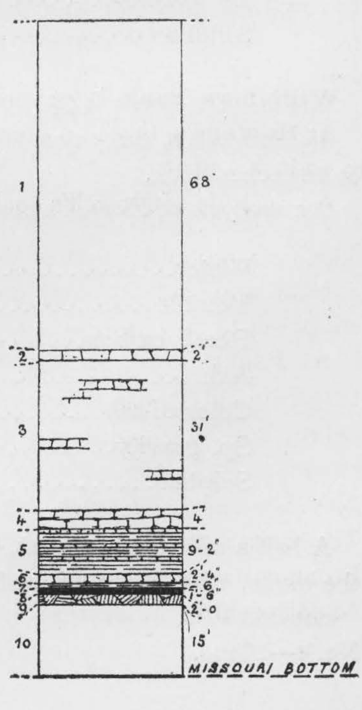
The Lexington coal-bed is occasionally opened at points along the Missouri bluffs, from the east county line to Camden.

Above Camden, the formations dip strongly west, and the Lexington coal is no longer seen, but is replaced in the bluffs by higher rocks. Around Richmond, on the waters of Crooked river, the coal is worked at many places. The mines near the east county line are worked by horizontal driftings—more than half of them only during the winter season : and during last summer only two or three men were constantly engaged. The **Section at Oberholtz,** from the hill-top down, was as follows :—

Fig 17.

SECTION 173

AT OBERHOLZ, RAY CO.



Section 173.

No. 1—68 feet slope.

2—2 feet equivalent to No. 15 of Lexington Section : color light drab.

3—31 feet slope.

4—4 feet brown limestone, abounds in *Chætetes milleporaceus.*

5—9 feet 2 inches alternations of thin beds of limestone and buff shales, abounding in fossils, including *Chonetes mesoloba, Chonetes* ——, *Athyris subtilita, Pr. costatus, Pr. semireticulatus, Pr. Prattenianus, Hemipronites Crassus* and *Spr. cameratus.*

6—2 feet 4 inches hard blue limestone in irregular layers: contains *Athyris subtilita.*

7—6 inches shale.

8—1½ feet coal (Lexington seam) said to increase to 20 inches.

9—2 feet clay.

10—15 feet gentle slope to Missouri bottoms.

An analysis of Oberholz coal, by Mr. Chauvenet, gives :—

Water	11.02
Volatile	32.48
Fixed Carbon	46.30
Ash	10.20
Color of ash	gray
Sp. gravity	1.277
Sulphur	4.609

Williams's Bank is 75 yards further west.

At Howells's, three-quarters of a mile further west, the coal is 16 to 22 inches thick.

An analysis of Howell's coal by Mr. Chauvenet gives :—

Water	8.05
Volatile	41.85
Fixed carbon	45.80
Ash	4.30
Color of ash	white
Sp. gravity	1.257
Sulphur	2.702

A half a mile further west, the above rocks are found lower in the bluffs, with the upper beds exposed, thus :—

Section 174.

No. 1—Slope.

2—15 feet drab sandy shales.

3—5 feet mostly smooth red shales, a part sometimes green.

4—6 inches nodular limestone ; fossils.

5—3 feet green shales.

6—Limestone equivalent to No. 15 of Lexington Section.

7—25 feet to Missouri bottoms.

One mile west of this, the limestone equivalent to Sec. 173, No. 4 (21 of Lexington Section) was observed ten feet above the bottoms, indicating the position of the Lexington coal just 2 feet below the line of their surface.

At Smith's Mill, three miles north-east of Richmond, the Lexington coal is reached in a shaft of forty feet depth. Its place is near the level of water in Crooked river, at **Searcy's and Harberson's.**

Analysis of Smith's coal :—

Water	10.05
Volatile	38.55
Fixed Carbon	45.40
Ash	6.00
Color of ash	white
Sp. gravity	1.249
Sulphur	2.41

Limestone No. 25, which forms the roof of the coal, is seen at many places on Crooked river, north-east of Richmond and along the stream to two miles north-west of Richmond. The following (Sec. 176), illustrating the rocks above the coal, was observed two miles north of Richmond, on Crooked river.

No. 1—3 feet limestone, containing *Fusulina*, *Producti*, *Crinoid* stems and *Chatetes milleporaceus*.

2—7 feet of limestone and shales, divided thus :—

a—4 inches shales. In upper part *Hemipronites* and *Chonetes* abound.

b—4 inches limestone.

c—2 inches shales.

d—4 inches limestone.

e—9 inches shales and nodules of limestone.

f—1½ feet shales.

g—8 inches shales and lenticular forms of limestone.

h—3 feet blue shales; in upper part are found *Spr. cameratus*, *P. punctatus* and *Athyris*.

3—4 feet blue limestone; upper 9 inches shaly.

4—6 inches black shales.

5—Coal.

J. S. Hughes' Coal Mines are located one mile south of Richmond, on S. W. qr. of Sec. 31, T. 52, R. 27, on line of St. Louis and St. Joseph R. R. Their shaft is 95 feet deep from the surface. From the bottom, entries extend east and west for over 500 feet, the coal varying from 22 to 28 inches in thickness, including the top 5 or 6 inches of good coal, then 1 to 2½ inches dark clay resting on good coal. The overlying bituminous shale is generally 2 to 4 inches thick; only at one place on the river was it observed 1 foot thick. It contains calcareous matter, with some fossil remains. The underlying clay is 1 foot to 18 inches thick, thus giving a clear space between the cap rock and bed rock of 4 feet 3 inches to 4 feet 6 inches, or enough room for small mules to work. Mr. Hughes informed me that there are only about three barrels of water per week.

The following is a section of his shaft, which is located on the S. W. quarter of Sec. 31, T. 52 R. 27 W.

No. 1—Soil	2	feet.	
2—Clay	12	"	
3—Soft sandstone	4	"	
4—Blue soapstone	9	"	
5—Red shale	16	"	
6—Flint (?) and limestone	5	"	
7—Soapstone and slate	2	"	6 in.
8—White sandstone	6	"	
9—Lime and sandstone	5	"	
10—Soapstone	8	"	
11—Slate	2	"	
12—Fire-clay	2	"	
13—Flint rock (is limestone)	5	"	6 in.
14—Shale	3	"	
15—Slate	4	"	
16—Limestone, dark gray	5	"	
17—Slate	0	"	3 in.

No. 18—Coal (generally 2 feet)	2 feet	3 in.
19—Fire-clay (6 to 8 inches)	1 foot	6 in.
Total depth	95 feet	

An analysis of the coal of Hughes & Co., by Mr. Chauvenet, gives :—

Water	8.15
Volatile	37.60
Fixed carbon	46.35
Ash	7.90
Color of ash	light brown
Sp. gravity	1.328
Sulphur	4.17

He employs thirty men.

At the Lawson (formerly King's) mines, on the Railroad, two and a half miles south of Richmond, owned by C. O. Godfrey & Co., fifteen to twenty men are kept at work, and the coal is taken out from drifts run in horizontally for several hundred feet. The coal is 2 feet thick, with a 2-inch clay seam five inches from the top. The overlying bituminous shale is about four inches thick, and the under-clay one foot, making quite a limited space between the roof and floor.

An analysis of the coal, by Mr. Chauvenet, gives :—

Water	72.11
Volatile	30.30
Fixed carbon	37.30
Ash	25.20
Color of ash	brown.
Sp. gravity	1.293
Sulphur	4.179

Camden Mines.

An analysis of Camden coal, by Mr. Chauvenet, gives :—

Water	10.33
Volatile	37.73
Fixed carbon	42.44
Ash	9.90
Color of ash.	gray.

The "NORTH MISSOURI" mines, owned by C. O. Godfrey & Co., on St. L., K. C., and N. R. W., at the lower end of Camden, employ sixteen miners. The shaft is sixty feet deep, and the platform sixteen feet above the railroad track. From the bottom, entries are extended in various directions: 280 yards north, 500 north-west, 190 west, and 100 east. At present (August, 1872), two to three railway car-loads are raised per day, each car containing about 250 bushels of coal. Water somewhat interferes with mining operations. Each day about 100 to 150 bbls. have to be raised out. The manner of elevating the water is very simple. At the bottom of the shaft is a sump, of the capacity of several hundred gallons, into which the seeping water is conveyed by slight ditches alongside of the tramway. Boxes of the capacity of several barrels, with valves in their bottoms, are let down into the sump; they immediately fill, and are raised and lowered in the same manner as the coal; as fast as one is elevated the other is lowered. The gin is worked by horse-power. For much of the information concerning these mines, I am indebted to Mr. Henry Booth, foreman.

The coal, 19 to 21 inches thick, is black, brilliant, with a little clay, 3 inches from the top, and a few knife-edges of iron pyrites in the upper part. The lower one inch is shaly, with 3 inches black under-clay resting on fire-clay. The coal is jointed, with calcite plates in the joints. In the bed of the ditch below the railroad, opposite the shaft, are thin beds of limestone, equivalent to No. 23 of Lexington section, some of them forming very pretty slabs covered with fossils, viz., *Hemipronites crassus*, *Chonetes*, *Producti*, etc. A few feet above it, is limestone, corresponding to No. 21 of Lexington section; the top of the latter being twenty-one feet below the mouth of the shaft, indicating the position of the coal to be quite low.

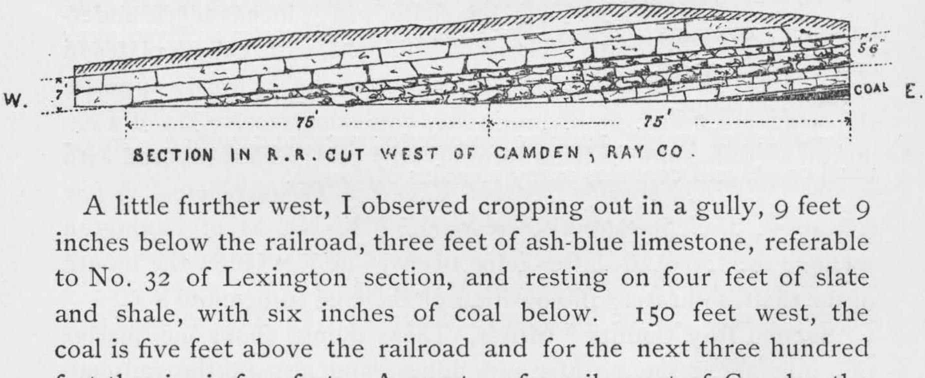
"Second Ray County" Mines. These mines, about one-quarter of a mile above the N. Missouri mines, and also on the railroad, are owned by Thos. Collins, and, when examined, worked six men. Mr. Collins informed me that he worked forty-five men in the winter of 1871 and 1872. The shaft is fifty feet deep. From the top of the shaft to the railroad track is 20 feet. The driftings extend far into the hill. Intersecting them is a passage for ventilation, which terminates at an air-shaft near the main shaft, and seems to give thorough ventilation. Coal measured at various places in these mines was, 18, 22, 23 and 24 inches, average about 23.

From 1 to 1½ feet of bituminous shales on top and 1 to 2 feet of fire-clay beneath; an average of about four and a half feet between bed-rock and cap-rock. The height of main entry is four feet near its mouth, and further in, three feet. Cap-rock seven to eight feet thick. A very fair coke was made from Collins' coal, of which the following is the analysis by Mr. Chauvenet:—

Water	3.25
Volatile	4.85
Fixed carbon	83.37
Ash	8.50

The shafts at Camden are sunk from a terrace on the hill-side. A quarter of a mile above Collins' mines, the Lexington coal is seen near the grade of the railroad, having risen thirty feet from Collins' shaft. This may explain the fact of more water being in the "North Missouri" mines than in the "Second Ray County" mines, the water passing between the eastward dipping strata, from the "Second Ray County" to the "North Missouri" mines.

Fig. 18.



A little further west, I observed cropping out in a gully, 9 feet 9 inches below the railroad, three feet of ash-blue limestone, referable to No. 32 of Lexington section, and resting on four feet of slate and shale, with six inches of coal below. 150 feet west, the coal is five feet above the railroad and for the next three hundred feet the rise is four feet. A quarter of a mile west of Camden the rocks dip about one in twelve. (See Fig. 18.)

Eight hundred and twenty feet further, a shaft sunk forty feet struck limestone No. 21 of the Lexington Section, indicating a dip of fifty-eight feet in eight hundred and twenty feet, or 1 to 14.

SWANWICK SHAFT.

The shaft of Thomas Huyson is 86 feet deep to top of coal, of which he furnished me the following:

46 feet.
No. 1—Surface.
2—Shaly sandstone, red, blue and gray.
3—16 feet of red shales.

40 feet.
4—6 feet being layers of sandstone separated by soft blue clay.
5—22 feet blue slate.
6—$4\frac{1}{2}$ feet rock (reported flint).
7—3 feet blue clay.
8—4 to 5 feet impure limestone.
9—20 inches to 2 feet coal.
10—6 to 18 inches under-clay.
11—6 to 8 feet hard limestone.

From one to two barrels of water have to be removed every morning. The slate over the coal is almost entirely wanting here; the limestone generally resting directly on the coal, but the under-clay correspondingly thickens—a fortunate provision in nature—as otherwise there would not be room enough to mine. The section from hill-top here is the following:—

No. 1—5 feet slope.

2—4 feet limestone, weathering brown and ringing under the hammer; contains *Athyris*, *Spr. cameratus*, *Chætetes milleporaceus* and *Crinoid* stems.

3—8 feet slope.

4—2 feet of rough, nodular limestone; weathers with a ferruginous crust, and contains many remains of fossils.

5—124 feet sloping gently to top of shaft.

Around the hill, and associated with limestone (probably the same as No. 4), I found amber-colored crystals of heavy spar, also a little iron ore. In the limestone I observed *Spr. Kentuckensis* and *Spr. lineatus*.

Section 178 is seen one mile north-west of Richmond.

No. 1—3 feet bluish-drab, rough-looking limestone, weathering drab.

2—8 feet slope.

3—Tumbled masses of fine-grained, dove-colored limestone.

4—100 feet. Less than forty feet below the top, abounds soft brown sandstone. At fifty feet are tumbled masses of gray limestone.

5—Red shales.

6—About 45 feet to the Lexington coal.

The upper members of the Section can be compared with the Swanwick Section.

An analysis of the Swanwick coal by Mr. Chauvenet gives :—

	TOP.	MIDDLE.	BOTTOM.
Water	10.00	12.55	11.20
Volatile	37.85	37.05	38.50
Fixed carbon	48.30	46.65	46.70
Ash	3.85	5.75	3.60
Color of ash	Light brown.	White.	Nearly white.

The Swanwick coal is remarkable for a large percentage of water : it does not coke well.

GRAND RIVER—CHARITON AND CARROLL COUNTIES.

The rocks along this river and its vicinity, in these counties, may be referred to the lower coal-measures. Outcrops are unfrequent.

Bowman's Quarry.—This consists of about four and a half feet of very hard, coarse sandstone, cropping out about twenty-eight feet above the railroad. This rock was used for bridge masonry on the St. L. K. C. and N. R. W. It is in tolerably even layers, but is difficult to quarry. Twenty-eight feet, mostly shales, extend below it, to the railroad. Four feet above the railroad track is a one-foot concretionary bed of carbonate of iron. There is a thin bed of coarse, reddish, calcareous sandstone above the ore bed, and dark clay beneath.

Kirkham's Coal.—The Kirkham bed is one and a half miles above Brunswick, on the line of the St. Louis, Chillicothe, and Omaha Railroad ; it was formerly worked, but recently nothing has been done there.

Prof. Swallow, in his report to North Missouri Railroad (1866), mentions the existence of two seams of coal, nineteen and a half feet apart, each 1½ feet thick.

I presume he obtained his section from the shaft, now filled up. All that I could see was :—

No. 1—Upper slope.

2—2 feet blue and ochreous shales.

3—16 to 18 inches coal.

4—1½ feet fire-clay, with *Stigmaria ficoides*.

5—6 feet shaly sandstone.

6—2 feet sandy shales.

7—15 inches hard calcareous sandstone.

Same as quarry rock at Bowman's.

8—1½ feet light green and red argillaceous shales.

9—1½ feet shaly sandstone to railroad.

Wm. Tyler's Coal.—In the edge of the ravine in S. ½, S. W. ¼, Section 33 T., 54 R., 20 W., there is said to be 18 inches coal; concealed from view when the locality was examined by us. Five feet above is 1½ feet outcrop of buff and blue limestone, possibly hydraulic, and containing mostly *Spr. cameratus*. The coal is probably equivalent to the Kirkham coal.

Section 157 at Linn's, three-quarters of a mile north of Tyler's.

No. 1—Shaly and sandy slope.

2—3 feet shales.

3—3½ inches mottled bluish limestone. Hydraulic?

4—6 inches olive clay.

5—1½ feet bituminous shales.

6—4 feet blue clay shales.

7—18 to 19 inches coal.

8—Fire-clay.

An analysis of the top of this coal, made by Mr. Chauvenet, gives:—

Water	5.82
Volatile	38.01
Fixed carbon	54.53
Ash	1.64
Color of ash	Salmon brown.

The series above given is well exposed here.

T. S. Anderson's, on Section 20, T. 54, R. 20. The coal was not exposed. The débris thrown out indicates a capping of bituminous shales, and bituminous limestone, containing *P. muricatus*, *Lophophyllum*, and a few striated plants. Mr. Turner, in Sec. 28, T. 54, R. 20, informed me, that in sinking a well from the hill-top at his house, coal was reached at fifty feet. The formations passed through were—

No. 1—8 feet sandy clay.

2—10 feet joint clay.

3—Sand to bottom.

Two hundred yards west of Turner's, in a branch, I observed a bed of limestone, and a short distance from it clay and bituminous shales are seen, dipping 5° to the south-west.

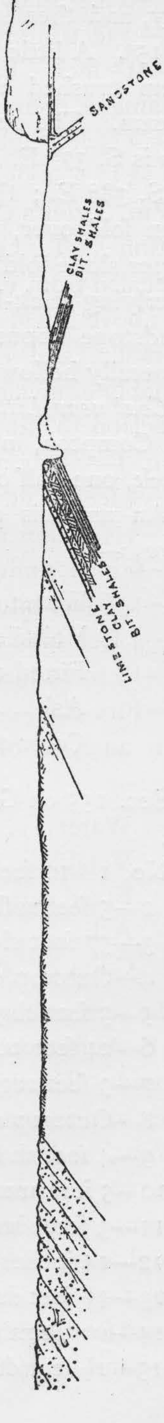
Mr. Turner informed me that wells have been dug on the ridges, 90 feet deep, striking sandstone at from eight to sixteen feet. This would make the sandstone over eighty feet thick. The geological position of Linn's and Anderson's coals must be below this sandstone, and the sandstone equivalent to that of Miami Station, and Berlin. Its denudation must have been very unequal, and very great at some places.

Sec. 156 (Fig. 19). *On Grand River, about two miles below the mouth of the Hurricane.* The rocks here show marks of great disturbance, for about 1,600 feet along the stream. At the lower exposure we find mostly thin layers of indurated green sandstone, containing ferns, dipping 37°, course S. 21° W. Mag. The distance across the outcrop is about one hundred steps.

Outcrops are then not much exposed up stream for five hundred feet; we then find a few feet of sandstone dipping at an angle, varying but little from that first observed, with line of strike bearing S. 44° E. Further up stream is an outcrop of four feet of nodular and shaly limestone, containing *Pr. semireticulatus, Pr. muricatus, Chonetes, Spr. plano-convexus, Spr. cameratus, Lophophyllum.* This is underlaid by two feet clay, which rests on an outcrop of three feet bituminous shales. The dip of latter is 24° to S. 30° W., Mag.

Right here a ravine ten feet in width has cut through and has probably washed away the coal which was not seen; but fire-clay is found just beyond, reposing on nodular limestone, which is underlaid again by fire-clay, the latter resting on the anticlinal axis. Bituminous shale rests on the

Fig. 19.



SECTION ON GRAND RIVER. CARROLL CO MO.

clay, and then shaly sandstone, dipping N. 50° E. and at an angle of 15°. A little more than two hundred feet up-stream the rocks seem crushed up, or folded, and then extend horizontally up-stream. The outcrop is seen 12 feet thick; next to the river the dip is S. 37° E. ∠53°. Half-way across this on the top the strike is S. 38° E.; these rocks are then vertical for a short distance, then fold over, dipping at ∠49°, N. 21° W. The layers on the upper slope fold over and extend horizontally up-stream under the overlying thick-bedded brown sandstone. The lower part of this sandstone abounds in concretions of brown hematite, which are generally hollow.

Coal near Little Compton. A pretty good coal is dug out at Little Compton, in Sec. 17, T. 55, R. 21, and at several places on a creek, one-half of a mile north, in the south part of Sec. 8.

An analysis of the Little Compton coal, by Mr. Chauvenet, gives :—

Water	4.37
Volatile	44.58
Fixed carbon	47.21
Ash	3.84
Color of ash	reddish brown.

Sec. 155 on Grand river, in north-west part of Sec. 16, T. 55, R. 21.

No. 1—10 feet slope.
2—5 feet soft buff sandstone.
3—57 foot slope.
4—Outcrop of bituminous shales.
5—5 feet clay shales.
6—24 feet buff micaceous sandstone, brown specked.
7—3 feet argillaceous shales.
8—Outcrop of hard light dove-colored cherty limestone.
9—4 feet shales.
10—3 feet arenaceous limestone; greenish tinge, weathers brown.
11—3 feet shales.
12—14 inches limestone.
13—4½ feet dark blue shales.
14—10 feet shales.
15—1½ feet dark blue shales.

16—1 foot shales and ironstone. Upper 2 inches solid, weathering red,—below shaly.

17—20 inches dark shales.

18—5 feet—upper ½ foot whitish, below dark blue.

19—4 feet shales and sandy concretions.

20—4 inches iron-stone.

The rocks of this section very closely resemble those of some of the lower coal groups, on Clear Fork, Johnson County, also on Grand river, Henry County, and on Marmaton, Vernon County. The coal of Little Compton and on Toe String creek may be concealed in the lower part of No. 3. The bituminous shales No. 4 may have slid down from above, for the outcrop was insufficient to place them exactly in No. 4. Upon a second examination of rocks and fossils collected on Grand river, from near the lines of Carroll and Livingston, they present types of those overlying the coal at Warrensburgh, Johnson County. I am therefore disposed to consider this as of the same age. At Edmondson's ferry on Grand river, at the line between Carroll and Livingston, the rocks dip southeast from 11° to 19°, and include in the outcrops, for three hundred feet along the stream, most of the corresponding beds of coal seen in the Section at Leaton's, viz. :—

No. 1—Sandstone.

2—Coal.

3—Clay and shales.

4—Limestone.

5—Shales.

6—Limestone abounding in fossils : *Spr. cameratus*, *Ch. mesoloba*, *Pr. muricatus*, *Spr. plano-convexus*, *Athyris*, *Crinoid* stems.

7—Shales.

8—Limestone.

9—Bituminous shales.

10—Clay.

11—Coal.

I give the rocks in the order of their succession, from the top down: the correct thickness could not be obtained. Compare this with the section at Leaton's, and the parallelism will be apparent.

CONNECTING BEDS OF THE UPPER AND MIDDLE COAL-MEASURES.

Sections of C. J. Norwood in Jackson County. The top rock (No. 98) at Kansas City, is also the highest at Independence. It is a light gray or flesh color, abounding in streaks and specks of calc-spar. Section No. 4 of Mr. Norwood, at Independence Landing, includes 25 feet 10 inches of outcrops of the above limestone at 63 feet from the hill-top.

One hundred and fourteen feet below this limestone, No. 78 crops out 20 feet thick, its base ninety feet above the Missouri river. At Blue Mills Landing, No. 78 is 112 feet above the Missouri river. The section here is as follows :—

" Section 5—At and two hundred yards below **Blue Mills** Landing.

No. 1—31 feet slope.

2—16½ feet " Bethany Falls " limestone (No. 78).

3—3 feet slope.

4—19 inches bituminous shales (77^a).

5—6 inches ash blue, hard, compact limestone, calcite specks disseminated.

6—6 inches blue clay, thin band of yellow at top (76^b).

7—5 inches to 7 inches concretionary blue limestone ; contains *Pr. punctatus* and *Spr. cameratus*. Equivalent to 76^a.

8—28 inches clay shales.

9—2 feet slope.

10—1½ feet outcrop of gray limestone (No. 74).

11—3 feet drab limestone ; three layers, splintery (No. 74).

12—9 feet 8 inches slope.

13—14 feet sandy shales.

14—72 feet slope to river."

" In the branch, one hundred yards above ' Donohoe's ford,' on the Little Blue, one mile and a half from its mouth, and about three hundred yards up the branch, Section 8 is seen.

No. 1—Slope.

2—8 feet blue clay shales.

3—1 foot hard blue calcareous shales.

4—2 inches coal.

No. 5—6 inches fire-clay.

6—3 feet slope.

7—10 feet sandy shales and shaly sandstone, with indurated sandstone concretions."

"In the branch are tumbled masses of 'Bethany Falls' limestone. Their place could not be ascertained: but think it is about fifty or sixty feet up.

It is believed in this part of the county that lead is to be found in this branch. There is a tradition that old settlers got their lead here, and moulded bullets of it. No one at present knows the exact place from where the lead was taken.

"**At Sibley Landing** the following, Section 9, is seen:

No. 1—77½ feet long slope and bluff, from level of road leading south, to Independence and Lexington road.

2—6 feet olive, argillaceous shales, with bands of purple clay.

3—3 feet 4 inches mottled, red, purple, buff and white clay.

4—9 feet sandy shales and shaly sandstone. Lower 7 feet shaly sandstone.

5—20 feet slope.

6—27 to 32 inches irregularly bedded, coarse-grained drab limestone; some parts yellowish drab; rough on top; weathers buff and brown. Contains *Chætetes milleporaceus*, *Crinoid* stems, *Bellerophon Montfortiana*, *Fusulina cylindrica*, *Pr. splendens*, *Athyris subtilita*, *Spr. plano-convexus*, *Spr. lineatus*. *Traversed by Calcite veins*. (No. 15 of Lexington section.)

7—2½ feet shales, divided as follows:

a—6 inches buff and green calcareous shales with limestone concretions, containing *Pr. splendens*, *Hemipronites crassus*, *Chonetes* ——, *Spr. plano-convexus*, etc.

b—2 feet green shales, with red and purple shales. Upper four inches containing *Spr. plano-convexus*, etc. In the lower part is a two-inch bed of concretionary arenaceous limestone, color green and drab, containing fossils. Abounds in *Spr. plano-convexus*.

8—3 feet very nodular, silicious limestone, mostly gray, some parts a bluish drab. Irregularly bedded. No fossils seen.

9—8 inches green argillaceous shales to water.

No. 6 of this section, on comparison of the various grouped sections, is found to be 48 feet above the Lexington coal.

"In a branch on **Col. A. G. Steele's place,** one-half of a mile west of Sibley, in S. W. ¼ Sec. 34, T. 51, R. 30 W., noticed an outcrop of one foot of bituminous shale.

Col. Steele informed me that coal 11 inches thick has been taken out eleven feet below this shale. The coal may possibly be No. 11 of Lexington Section.

A quarter of a mile farther down appear tumbled masses of limestone equivalent to Sec. 9, No. 6; in the branch three feet of brown sandstone is exposed, probably equivalent to No. 17 of Lexington Section.

"On Mr. Hudpith's land, about one and three-quarters of a mile west of Sibley, on the river bottoms, is a fine bed of quaternary sand, used very extensively for plastering, which is sometimes hauled as far as twenty-five miles.

"The following is the boring of Embree's and Proctor's well, at their mill at Sibley landing, as furnished me by Mr. Embree.

No. 1—10 feet clay.

2—15 feet shales.

3—2 feet limestone (No. 6 of Sec. 9).

4—13 feet rock.

5—15 feet shales.

6—Coal; does not know thickness (No. 19? of Lexington Sec.).

7—Rock.

"On **Messrs. J. L. and J. S. Walker's** land, in Sec. 5, T. 50, R. 30, and also on **Mr. Joseph Willis's,** in Sec. 32, T. 51, R. 30, I noticed in a branch, from 2 to 4 feet of red drift sand, with bands of black sand from 1 to 3 inches thick traversing it. Also saw many granite and quartzite boulders, with a few small boulders of carb. of iron, all belonging to the drift period.

"*Sec.* 7—Two and a half miles east of Sibley, on the Missouri river, includes part of the rocks of the Sibley Section, as follows:—

No. 1—46 feet slope.

2—5 feet red and brownish-red sandstone; thin layers. Some parts traversed by white streaks.

3—5 feet olive, slightly sandy, argillaceous shales, banded with red.

4—7 inches somewhat concretionary gray limestone. *Crinoid* stems and *Spr. lineatus*.

5—15 inches red shales. No. 62?

6—8 feet dark-blue argillaceous shales and slope.

7—2 feet slope.

8—2½ feet irregularly-bedded drab limestone, in three layers, with shaly partings. Upper layer thickest; lower one foot has a greenish tinge; weathers brown. Contains *Athyris*, *Fusulina*, *Spr. plano-convexus*, etc. Equivalent to No. 6 of Sec. 9.

9—7 inches green shales, containing *Spr. plano-convexus* and *Athyris subtilita.*

10—4 feet slope. At the top dark-blue shales appear.

11—1½ feet very rough, coarse-grained, mostly gray limestone, containing *Crinoid* stems. No. 8 of Sec. 9.

12—7 feet slope to river.

Springs under No. 8. The rocks here dip 11° N. 20° E.

"The following section occurs three-quarters of a mile ABOVE COGGSWELL'S LANDING.

No. 1—Slope.

2—32 inches irregularly bedded, hard drab limestone, containing *Athyris subtilita*, *Fusulina cylindrica*, etc. Equivalent to No. 8 of Sec. 7.

3—7 inches green shales, containing *Spr. plano-convexus.*

4—3 feet slope.

5—16 inches rough gray limestone. No. 11 of Sec. 7.

6—8 feet slope to river.

The rocks here make a dip of 5° N., 15° E.

"**On Mr. Levis's** land, near mouth of branch running into Fire prairie, near Mr. John Hambright's house, Sec. 21? T. 50, R. 29 W.; the following is seen:—

Section 13.

No. 1—57 feet slope.

2—2 feet outcrop rough gray limestone—silicious. *Tuteumergle* on top. No. 5 of Sec. 10.

3—8 feet drab and buff sandstone; irregularly bedded; lower 6 feet, thin layers and shaly.

4—5 feet slope—lower part mostly clay.

5—10 to 12 inches coal; crumbling on top.

6—1 foot dark pyritiferous clay, to water.

The coal is probably No. 19 of the Lexington Section."

"**On Mrs. Martha J. Calston's** land, one-quarter of a mile east of Little Blue, N. E. ¼ of the S. E. ¼ of Sec. 25, T. 51, R. 31, we find 20 feet of Bethany Falls limestone (Nos. 78 to 80) sixty feet above the bottoms of Little Blue."

"One mile S. E. of Sibley ten feet of No. 78 appears, 227 feet above the Missouri river, or 218 feet above the limestone No. 6 of Sec. 9 at Sibley.

"*Section* 10 is seen one mile west of Napoleon.

No. 1—10 feet Bethany Falls limestone—*on a knob.*

2—186 feet long steep slope—thickly timbered.

3—3 inches red argillaceous shales.

4—3 inches green argillaceous shales.

5—3 feet 9 inches rough, gray silicious limestone with 6 inches of *Tuteumergle* on top.

6—7 feet soft drab sandstone.

7—10 feet slope to river, springs under No. 5.

Lafayette County.

Section 19.

"This is seen three miles south of Wellington, from the top of Grady's Knob, to bridge crossing branch running into the south fork of Sniabar, on the Wellington and Greenton road.

No. 78 {
No. 1—2½ feet light drab, irregularly bedded limestone; top shelly; contains *Fusulina* and *Crinoid* stems on top.
2—2 feet bluish drab, tolerably coarse-grained, somewhat ferruginous limestone; weathers brown, calcite seams and speck disseminated. *Athyris* and *Crinoid* stems.

3—163 feet long steep slopes. (This constitutes the knob.)

4—Outcrop of soft brown sandstone.

5—15 feet slope.

6—8 inches of gray, coarse-grained, silicious limestone; abounds in *Crinoid* stems. Spring underneath.

7—2 feet sandy shales.

8—72 feet long, undulating slope.

9—3½ feet drab limestone; upper part a bluish tinge, lower part light drab; contains *Athyris subtilita*, *Pr. costatus*, *Crinoid* stems, and *Chætetes milleporaceus.* Equivalent to No. 21 of Lexington Section.

10—5 feet slope.

11—5 feet shales and nodules of limestone, abounding in *Chonetes* and containing *Pr. costatus*, &c.

No. 12—2 feet clay.

13—3 feet dark shales. These pass into thin layers of dull blue, argillaceous limestone, abounding in *Pr. costatus*, and containing *Athyris*, *Chonetes* and a large *Productus*.

14—2 feet irregularly bedded, dull blue, argillo-pyritiferous limestone, containing *Crinoid* stems, *Pr. costatus*, *Hemipronites crassus* and *Spr. cameratus*. Equivalent to No. 25 of Lexington Section."

A section taken on Lexington and Greenton road, six miles south of Lexington, was as follows :—

No. 1—20 feet slope from hill-top.

2—16 feet.—The upper part includes a few feet of limestone No. 78, the lower part slope and shales.

3—9 feet.—Upper 2 feet brown, sandy-textured limestone, then irregularly bedded and nodular. Lower 2 feet in flag-like strata. Gray, crinoidal and ferruginous. The upper part is traversed by fissures in which are stalactitic forms of very pretty amber-colored arragonite. This limestone corresponds to No. 74 of General Section and is very near the base of the upper coal-measures.

4—5 feet gray and olive shales.

5—1 foot red shales, apparently a good quality for paints.

6—127 feet slope,—all middle coal-measures.

7—7 feet outcrops of shale and limestone.

8—1½ feet limestone, No. 25 of Lexington Section.

9—7 feet slope.

10—21 feet brown crumbling limestone, No. 30 of Lexington Section.

11—20 feet shales ; upper four feet, white and ochrey. Middle four or five feet, red.

12—14 inches even bed of blue bituminous limestone, No. 32 of Lexington Section.

13—1 foot blue shales.

14—2 feet bituminous shale, containing many small round concretions.

15—1 foot 9 inches dark olive calcareous shales, containing *Pr. semireticulatus*, *Chonetes*, and *Spr. lineatus*.

16—1 foot of coal in the branch, equivalent to No. 35 of Lexington Section.

From measurements made by Mr. C. J. Norwood and myself, between the Bethany Falls limestone (No. 78 of Gen. Sec.) and well-recognized rocks over the Lexington coal, we arrive at the following results, as vertical distances, between No. 78 and the Lexington coal.

The result of my examinations along the line of the Pacific Railroad in Johnson County, in 1871, was 260 feet.

Mr. C. J. Norwood's measurements at Sibley, in Jackson County, 271 feet.

Mr. Norwood's measurements one mile west of Napoleon, Lafayette County, 250 feet.

Mr. Norwood's measurements on Grady's Knob, Lafayette County, 276 feet.

Two of his measurements are above, and one below my first measurement. We may therefore consider that 260 feet is about the correct distance, and shall in future accept it.

The base of the upper-coal measures being 25 feet below the base of the Bethany Falls limestone (No. 78) gives 235 feet as the position of the Lexington coal below the top of the Middle series.

The following is a GENERAL SECTION OF THE MIDDLE COAL-MEASURES.

No.	Thickness. Ft.	In.
72—Arenaceous limestone and calcareous sandstone		
71—Blue and bituminous shales	1	6
70—Coal. (2 to 4 inches)		4
69—Sandstone and shales	123	
68—Limestone, containing *Chætetes milleporaceus*	2	
67—Marly shales	7	
66—Purple shales	10	
65—Sandstone or shales	22	
64[a]—Bituminous shales		3
64—Coal	1	
63—Shales	7	
62—Shaly sandstone	6	
61—Dark shales and thin concretionary bed of limestone	1	7
60—Blue shales streaked with red	7	6
59—Coal		6
58—Dark shales		3
57—Fire-clay		6
56—Sandy shales	3	
55—Irregularly bedded limestone: abounds in *Chætetes milleporaceus* and *Fusulina cylindrica*	4	
54—Drab, green and dark shales	6	
53—Hard, brown and gray sandstone	4	

No.		THICKNESS. Ft.	In.
52	Shales, olive and red	2	3
51	Clay, blue and black, with three streaks of coal. Sometimes a 6-inch seam of coal, and at others thins out		6
50	Shales, argillaceous and arenaceous; buff, olive and red	8	
49	Drab limestone	7	
48	Shales and thin beds of limestone, quite fossiliferous; abounding in *Chonetes*	6	6
47	Limestone, dull blue, irregularly bedded	5	
46	Bituminous shales	1	2
45	Coal. Lexington seam	2	2
44	Fire-clay	4	6
43	Limestone: color gray, abound in *Fusulina*	4	
42	Blue, drab, red and yellow clay	21	
41	Limestone; generally an even layer; somewhat bituminous and pyritiferous	1	3
40	Bituminous shales	2	4
39	Shales, dark, calcareo-pyritiferous	4	
38	Coal		7
37	Drab shales and limestone nodules	4	
36	Limestone—rough, concretionary, pyritiferous	1	4
35	Olive shales and limestone nodules	2	
34	Greenish-gray limestone; upper part abounds in *Chonetes mesoloba*	2	
33	Hard tough band		8
32	Hard black slate full of globular concretions, and occasional large concretions of bituminous limestone, abounding in many fine fossils, including *Cardiamorpha Missouriensis*, *Goniatites* (3 *sp.*), *Nautilus* and *Discina*	5	6
31	Coal. Mulky seam	1	9
30	Clay shales; thinly laminated	9	
29	Space; rocks not exposed	20	
28	Ferruginous and sandy limestone		6
27	Blue clay	2	
26	Bituminous slate; hard	2	
25	Fire-clay	4	
24	Rough, nodular, gray sandy limestone	2	
23	Micaceous sandstone, of Lower coal-measures	90	

GROUPED SECTIONS.—The accompanying maps of Grouped Sections will show at a glance the beds of coal to be met with in certain districts. Where a Section appears near the upper part of the sheet, we may reasonably conclude that other beds, appearing in remote localities, and occupying a lower position on the sheet, may be reached by sinking shafts to the proper depth.

SANDERS WELL.

On Mr. John Frederick Overman's land, in N. E. ¼ of N. E. ¼ of Sec. 34, T. 52, R. 29, Ray County, borings for "oil" have been extended to a depth of 802 feet below the surface. The exposed section of rocks there is :

No. 1—5 feet shelly gray limestone, No. 78 of General Section.

2—98 feet long slope.

3—15 feet thin layers of bituminous sandstone, of coarse texture : occasional drops of coal-tar are seen between the layers, and in some places the rock is coated with it. The borings were prosecuted under the supervision of Mr. H. H. Beeson, and the well is known by the name of the Sanders well. Mr. Beeson had the kindness to give me a copy of his section of borings, and further assisted me in procuring a suit of specimens taken out. The total depth of the well is 802 feet, with the following section :—*

No.	DEPTH from top of well. Ft.
1—5 feet black bituminous sandstone, showing oil on surface and thoroughly impregnated with it	9
2—40 feet loose adhering light greenish limestone, rough fracture	49
3—30 feet dark ash sandy clay	79
4—28 feet dark gray coarse bituminous sandstone	107
5—5 feet good bituminous coal	110
6—6 feet drab limestone	116
7—16 feet greenish drab clay shales	132
8—2 feet coarse dark gray limestone	134
9—8 feet variegated greenish shales, with dark carbonaceous markings of plant remains, and also bituminous shales with thin calcareous seams, containing a fish-tooth—*Petrodus ?*	142
10—4 feet ash blue clay, highly calcareous	146
11—6 feet gray limestone, fine-grained	152
12—25 feet light gray, coarse sandstone	177
13—6 feet indurated green clay	183
14—22 feet indurated, fine-grained, light green, micaceous sandstone	205
15—12 feet light dove-colored smooth clay	217
16—4 feet coal ; good bituminous	221
17—6 feet bluish gray, shaly micaceous sandstone	226
18—18 feet smooth blue clay shales	244
19—9 feet black, calcareo-bituminous shale : coal and pyrites also reported	253
20—10 feet nodular, green and gray pyritiferous limestone	263
21—3 feet. Specimens seem to be a mingling of coal, iron pyrites, zinc blende and carbonate of lime	266
22—15 feet smooth clay with thin seams of carbonate of lime	281
23—5 feet clay, coal, iron pyrites and zinc blende	286
24—9 feet drab and green banded, soft micaceous sandstone	295

* The measurements and totals are as given by Mr. H. H. Beeson.

No.		DEPTH from top of well. Ft.
25—	10 feet rough dark specked coarse pea-green sandstone	305
26—	4 feet chocolate-colored hard clay shales	309
27—	4 feet blackish blue shaly sandstone and dark chocolate-colored sandstone with leaves of *Stigmaria*	313
28—	46 feet light gray, blue, and olive shaly micaceous sandstone	359
29—	4 feet dark gray coarse sand. A mixture of light and dark grains	363
30—	12 feet dove-colored clay	375
31—	10 feet mostly fine and pure silicious sand: grains both round and angular, and generally of pure silex; the other darker material not very abundant but so generally diffused as to give the whole a drab color	385
32—	7 feet fine, nearly black sand, composed of grains of clear quartz and silicious fragments of various colors and some of other material, including bituminous shale	392
33—	23 feet blue shale, a portion slightly calcareous	415
34—	55 feet mostly fine, clear grains of sharp and round sand, with but little extraneous material	470
35—	12 feet coarse white sand, grains mostly round; a few dark coarser particles are diffused	482
36—	10 feet soft, dove-colored sandy clay	492
37—	15 feet exceedingly fine-grained sand; many particles are transparent but the general appearance is drab	507
38—	12 feet very coarse, sharp sand of all colors, white, brown and dark, the general appearance being a brown or reddish gray	519
39—	12 feet dark drab, coarse sand, composed of angular, drab and dark grains with very few clear ones	531
40—	14 feet dull or dirty drab clay and sand, mostly fine	545
41—	16 feet very fine-grained compact dove-colored limestone, contains a very little iron pyrites	561
42—	118 feet coarse dark gray crystalline pure limestone, contains a little white chert and a few fragments of fossils—Spirifer and Actinocrinus	679
43—	52 feet light brownish gray sand, composed of clear, white, brown and yellow grains of chert and quartz and some calcareous matter	731
44—	10 feet mostly white chert, with a little calcareous matter	741
45—	30 feet drab fine sand, contains chert and clear quartz grains, round and angular	771
46—	8 feet brown sand of various colored pebbles with brown matter between	779
47—	14 feet similar to last, but of a light color	793
48—	9 feet similar to last. In bottom	802

The specimen obtained from No. 3 is undoubtedly limestone, but I think if exposed the strata might present alternations of limestones and other rocks. For I find in the coal-measures no solid limestone bed as much as forty feet thick. There may also be a slight error in No. 5. Its position is near the geological horizon of the coal at Halden and at Graham's Mill, Livingston County, which is its northern development, and where it is of variable thickness. But I have not seen it over 1½ feet thick. It might possibly swell up after the manner of a coal-pocket. But it is possible that the thickness given may include both bituminous shales and coal. Gas was reported to have issued from the depth of 480 feet, and water with 15 per cent. of salt at from 500 to 600 feet.

The hole was reamed out 8 inches wide to a depth of 359 feet, below which the bore was 4¾ inches in diameter. The appearances do not indicate that there has been any oil-flow from the lower depths. The "oil rock" corresponds to No. 69 of General Section. I have not seen it containing petroleum at any other localities, but have been told that it has been found near Blue Mills, Jackson County. The tar springs occasionally found in the south-west part of Cass County, probably flow from the same sandstone. The outcrops of this sandstone on Grand river, between Utica and Gallatin, do not expose any petroleum. Numerous petroleum springs are reported by Prof. Swallow* to exist in Miami County, Kansas, and they also probably flow from the same sandstone.

It thus seems to bear the greater quantity of oil in its southern extension. This sandstone must not be confounded with that of the McCausland farm, in Lafayette County, the latter occupying a position in the lower coal-measures.

Another oil well was bored in the northern part of Ray County, but thus far there are no profitable results from any of them, nor have I, at any place in Missouri, seen indications to warrant a great expenditure of money in such enterprises.

SECTION OF THE BORING AT KANSAS CITY.

MADE WITH A DIAMOND DRILL.

No.	THICKNESS of Strata. Ft.	In.	DEPTH from surface. Ft.	In.
1—Drift at top to bed rock	37			
2—Fine-grained bluish limestone. (No. 78)	21		58	
3—Light blue clay	1		59	
4—Dark-colored clay	4		63	
5—Gray limestone. (No. 74)	13		76	
6—Dove-colored clay shales	100		176	
7—Bituminous sandy clay. Bitumen rose to surface	4		180	

* Vide Geology of Kansas, p. 86.

No.	THICKNESS of Strata. Ft.	In.	DEPTH from surface. Ft.	In.
8—Clay	84		264	
9—Bituminous limestone:—brown	4		268	
10—Soapstone	5		273	
11—Limestone. Increase of water and rock oil	18		291	
12—Arenaceous clay. (Soft drab sandstone)	4		295	
13—Light buff limestone	23		318	
14—Dove-colored soapstone or clay	24		342	
15—Arenaceous clay (dove-colored)	23		365	
16—Dark clay and shelly coal: fossils	5		370	
17—Dark blue micaceous clay	25		395	
18—Very dark blue fine-grained sandstone	37		432	
19—Dark shales. Salt water here	1		433	
20—Coal		4	433	4
21—Fire-clay	10		443	4
22—Clay and limestone (Marlite)	5	8	449	
23—Dark slate and coal: fossils—fragments of plants. Salt water flowing	1	6	450	6
24—Coal, dense and bright		6	451	
25—Clay and limestone	16		467	
26—Coarse gray sandstone. Strong brine	12		479	
27—Gray and fine sandstone	10	6	489	6
28—Blue clay	3	6	493	
29—Clay or soapstone	7		500	
30—Dark dove fine-grained sandy clay	119		619	
31—Black shale	3		622	
32—Coal	1		623	
33—Clay with sand	50		673	
34—Thin laminated dark clay and shales	6		679	
35—Black bituminous shales	3		682	
36—Coal	1	8	683	8
37—Clay and mud	16	4	700	
38—Mud	34	10	734	10
39—Dark mottled crystalline sandstone	10	2	745	
40—Vitreous crystalline limestone	13		758	

CHAPTER IV.

UPPER COAL-MEASURES.

GENERAL VERTICAL SECTION OF UPPER COAL-MEASURE ROCKS BELOW THE ATCHISON COUNTY GROUP.

No.	Thickness.	Total Thickness.	Description and List of Fossils.	Locality where found, etc.
224	4 ft.	1087′	Shelly, porous, ferruginous limestone.	City Bluffs.
223	36 ft.	1083′ 6″	Shales; Septaria occur near the upper part.	Nodaway Co.
222			Septaria 6 in. to 1 ft. *Prod. Pratteniauus.*	do.
221	48 ft.	1047′ 6″	Shales.	
220	2 ft.	989′ 6″	Spathic limestone, a 4-inch bed of carbonate of iron and lime at lower part. Fossils, *Bellerophon, Kansasensis, Murchisonia, Nucula Beyrichii, Fusulina cylindrica* and *Crinoid* stems.	Quitman and vicinity. Forest City and vicinity. White Cloud, Kansas.
219	2 ft. 6 in.	987′ 6″	Sandy shales.	Same locality.
218	1 ft. 6 in.	985′	16 in. to 2 feet pyritiferous limestone, abounds in many beautiful fossils, including *Eutolium, Aviculatum, Schizodus curtus, Pinna peracuta, Pseudomonotis radialis, Allorisma subcumata, Allorisma (Sedgwickia) granosus, Aviculopecten, Edmondia, Lima retifera, Hemipronites crassus, Syntrilasma hemiplicata, Retzia punctalifera, Terebratula bovidens, Productus Pratteniauus, Chonetes, P. Nebrascensis Aviculopinna Americana, Solenopsis? Goniatites, Naticopsis Altonensis, Macrocheilus. Euomphalus rugosus, Nautilus occidentalis, Macrocheilus primogenius, Bellerophon marconianus, Pleurotomaria* like *P. carbonarius, Polyphemopsis inornata, P. peracuta. Bellerophon percarinatus* large *Bellerophon. Fusulina cylindrica, Orthoceras, Fistulafora nodulifera.*	Same locality as last. Quitman. Forest City. Florida Co. Nodaway Co.
217			Sandstone not always present.	Forest City.
216	4 ft. 8 in.	983′ 6″	Blue and bituminous shales. At Allen's in Nodaway County, black	do.

No.	Thickness.	Total Thickness.	Description and list of Fossils.	Locality where found.
			concretionary limestone occurs in the shales, containing many fossils. The blue shales are also fossiliferous. Fossils are *Sp.* (*Martinia*) *plano-convexus*, *Rhynchonella Osagensis*, *Athyris subtilita*, *Bellerophon carbonarius* and *Goniatites*.	Quitman. Allen's on Nodaway River.
215	10 in.	978' 10"	4 to 16 inches coal, generally divided into different seams by 2 to 4 inches blue clay.	Forest City. Florida Co. Sand Co.
214	17 ft.	978'	Sandstone and shales, *Ferns* and *Stigmaria*.	Quitman. White Cloud.
213	4 ft.	961'	Clay shales with *Aviculopecten Coxanus*.	N. part of Nodaway Co.
212	4 ft.	957'	Deep blue compact limestone, abounds in *Lingula* ; other Fossils, *Aviculopinna Americana*, *Pinna peracuta*, *Ctenacanthus?* *Pleurophorus?* *Productus Nebrascensis*, *Prothyris elegans*, *Edmondia Nebrascensis*, *Lima retifera*, *Discina*, *Synocladia biserialis*, *Ferns*, and specks of coal on epidermis of plant remains.	Quitman. Quitman. Florida Co. Rolling branch in Holt and Nodaway.
211	6 in.	953'	Ash blue limestone, corals, crinoideæ and Bryozoa, *Athyris subtilita*, *Productus Prattenianus*, *Prod. Nebrascensis*, *Edmondia Nebrascensis?* *Macrocheilus*, *Orthoceras cribrosum*, *Syncladia biserialis*, *Rhombopora lepidodendroides*.	Braddy's Mill in Iowa. Smith's Mill Nodaway Co.
210	4 ft.	952' 6"	Brown shale, with nodular limestone layer. Fossils, *Fusulina cylindrica* and *Athyris subtilita* very abundant, also has *Chonetes*, *Terebratula bovidens*, *Spirifer Cameratus*, *P. splendens*, *Prod. Prattenianus*, *P. costatus*, *P. symmetricus*, *P. Nebrascensis*, *Prod. semireticulatus var. Calhounianus*, *Hemipronites crassus*, *Retzia punctalifera*, *Solenomya*, *Macrodon—Allorisma*, *Bryozoa*. *Scaphiocrinus hemisphericus*, *Rhombopora lepidodendroides*, *Chætetes*, *Fistulapora nodulifera*, *Lophophyllun proliferum*.	Same locality as last, also Forest City. Oregon.
209	10 in.	948' 6"	Dark ash blue limestone. abounds mostly in *Hemipronites crassus*, its interior generally replaced by crystallized carbonate of lime, often in form of dog-tooth spar. Other Fossils, *P. Nebrascensis*, *P. Prattinianus*, *Prod. splendens*. *Spirifer cameratus*, *Sp. Kentuckensis*, *Retzia punctulifera*, *Chonetes granulifera*, *Athyris subtilita*, *Pinna peracuta*, *Aviculopinna Americana*, *Myalina Swallovi*,	Braddy's Mills, Smith's Mill, Forest City, near Bridgewater.

No.	Thickness.	Total Thickness.	Description and List of Fossils.	Locality where found.
			My. subquadrata, *Phillipsia*, *Bellerophon*, *Rhombopora lepidodendroides*, *Crinoid* spines and stems.	
208	1 ft.	947′ 8″	Calcareous shales.	Same loc. as last.
207	1 ft. 6 in.	946′ 8″	Blue and bituminous shales.	do.
206	1 ft. 4 in.	945′ 2″	Blue limestone, resembles No. 209. Fossils are *Hemipronites crassus*, *Productus Nebrascensis*, *P. Pratteniamus*, *Ath. subtilita*, *Pleurotomaria*, *turbiniformis*. Interior of fossils often contain calcite crystals.	Same as last and near Oregon and at Iowa point.
205	2 ft. 6 in.	943′ 10″	Drab shales, in thick laminæ.	do.
204	1 ft. 4 in.	941′ 4″	Dark green shales.	do.
203	8 in.	940′	Nodular green shales.	do.
202	1 ft. 4 in.	939′ 4″	Yellow shales.	do.
201	10 in.	938′	Coarse ash blue or gray suboolitic limestone, weathers rough, contains *Athyris subtilita* and *Prod. Nebrascensis*.	Bridgewater, Smith's Mill, and Kunkell's Mill.
200	2 ft. 6 in.	937′ 2″	Light green passing into blue shales; has limestone concretions.	Same locality as last.
199	2 ft. 6 in.	934′ 8″	Ash blue, rough, shelly limestone, weathers brown. Fossils are *Archæocidaris megastylus*, *Bryozoans*, *Myalina subquadrata*, *Allorisma*, *Aviculopecten*, *Athyris subtilita*, *Sp. cameratus*. *Retzia punctulifera*, *Hemipronites crassus*, *Productus Nebrascensis*, *Chonetes Smithii*, *Nautilus occidentalis*, *Goniatites*, *Fusulina* abounds.	Forest City, Smith's Mill. Bridgewater, Kunkell's Mill.
198	2 ft.	932′ 2″	Blue shales.	
197	2 ft.	930′ 2″	Ash blue or buff limestone, weathers brown. Fossils, *Rhombopora lepidodendroides*, *Fistulapora nodulifera*, *Fusulina cylindrica*, *Archæocidaris*, *Zeacrinus mucrospirus ?* stems of *Crinoids*. *Prod. punctatus*, *Sp. cameratus*, *Pinna peracuta*.	Smith's Mill. Bridgewater, Forest City, Kunkell's Mill.
196	3 ft.	928′ 2″	Brown shales, *Archæocidaris*, crinoid stems, *Spirifer cameratus*, *Athyris subtilita*.	Bridgewater, Smith's Mill, Forest City.
195	4 ft.	925′ 2″	Sandy shales and sandstone.	Same loc. as last.
194	1 ft.	921′ 2″	Bituminous shales. Sometimes a thin coal seam.	do.
193	3 ft.	920′ 2″	Sandy, micaceous shales.	do.
192	1 ft. 9 in.	917′ 2″	Grayish blue limestone.	Kunkell's Mill, Forest City.
191	5 in.	915′ 5″	Shales.	do.
190	6 in.	915′	Grayish blue limestone, abounds in Univalves, including following fossils: *Aclis Swalloviana*, *Pleurotomaria*, *Polyphemopsis peracuta*, *Naticopsis Altonensis*, *Naticopsis ventrica*, *Macrocheilus ventricosa*, *Chonetes*, *Schizodus Wheelerii*, *Athyris subtilita*, *Chætetes*, *Nu-*	Kunkell's Mill, near Oregon, in Holt Co.

No.	Thickness.	Total Thickness.	Description and List of Fossils.	Locality where found.
			culana bellistriata, *Bellerophon Kansasensis*, *Aviculopecten occidentalis*.	
189	3 ft. 6 in.	914′ 6″	Blue shales.	do.
188	10 in.	911′	4 to 10 inches dull blue limestone, sometimes has a bed of cone-in-cone structure on upper surfaces. Fossils are *Allorisma subcuneata*, *Pinna peracuta*, *Edmondia*, *Myalina subquadrata*, *Athyris subtilita*, *Spirifer cameratus*, *Chonetes*, *Spiriferina Kentuckensis*, *Productus Nebrascensis*, *Hemipronites crassus*, *P. Prattenianus*, *Murchisonia*, *Bellerophon Marconianis*, *B. ellipticus Rhombopora lepidodendroides*, *Crinoid stems*, *Platycrinus ? spines of Archæocidaris megastylus*, *Bryozoa*, and *Fistulapora nodulifera*.	
187	3 ft.	910′ 2″	3 to 4 ft. Fusulina shales. Other fossils are *Archæocidaris*, *Crinoideæ*, *Spirifer cameratus*, *Athyris subtilita*, *Terebratula bovidens*, *Hemipronites crassus*, *Polypora*.	Holt Co., between Forbes and Forest City.
186	15 ft.	907′ 2″	Ash-gray limestones. Fossils, *Spiriferina Kentuckensis*, *Terebratula bovidens*, *Productus splendens*, *P. Nebrascensis*, *Chonetes*, *Athyris subtilita*, *Hemipronites crassus*, *Spirifer lineatus*, *Allorisma*, *Eutolium aviculatum*, *Bellerophon crassus*, *Bell. Kansasensis*, *Nautilus*, *Naticopsis Altonensis*, *Chætetes*, *Fusulina cylindrica*, *Syntrilasma hemiplicata*, *Lophophyllum proliferum*, *Sp. cameratus*.	Same as last. Mo. Nodaway Riv. Nicholson. Ohio Mills. Iowa point. Bridgewater.
185	5 ft.	892′ 2″	Blue and bituminous shales.	Same as last.
184	2 ft.	887′ 2″	Even layer fine-grained limestone. Would polish well.	
183	7 ft.	885′ 2″	Shales.	do.
182	5 ft.	878′ 2″	Buff limestone.	Ohio Mills.
181	2 ft.	873′ 2″	Sandstone.	Forbes and N. W.
180	2 ft.	871′ 2″	Slope. No rocks seen.	to Forest City.
179			Limestone.	On Brockman's
178	11 ft.	869′ 2″	Slope. No rocks seen.	Branch, Holt Co.
177	2 ft.	858′ 2″	Drab limestone, with *Fusulina*.	do.
176	8 in.	856′ 2″	Bluish ash limestone.	do.
175	4 in.	855′ 6″	Shales.	do.
174	1 ft. 6 in.	855′ 2″	Drab limestone.	do.
173	18 ft.	853′ 8″	Slope. No rocks seen.	do.
172			Bituminous shales outcrop.	do.
171	5 ft.	835′ 8″	Pale-green shaly limestone, with *Fusulina*.	Near mouth of Nodaway River.
170	44 ft.	830′ 8″	Slope. No rocks seen.	
169	2 ft.	786′ 8″	Dark ash shelly limestone, *Fusulina* abounds.	Near Savannah.
168	3 ft.	784′ 8″	Dark olive shales.	
167	3 ft.	781′ 8″	Light-drab limestone, has calcite	Near Savannah.

No.	Thickness.	Total Thickness.	Description and List of Fossils.	Locality where found.
			specks, upper part nodular, lower layer even. Fossils, *Syringapora multattenuata*, *Fistulapora nodulifera*, *Nautilus occidentalis*, *Spirifer* (*Martinia*) *lineatus*, *Spiriferina Kentuckensis*, *Terebratula bovidens*.	
166	3 ft.	778′ 8″	Shelly and nodular limestone. Abounds in *Fusulina cylindrica*. Other fossils are, *Syringapora Multattenuata*, *Bryozoa*, large crinoid stems, *Chenomya Minehaha*, *Chenomya Leavensworthensis*, *Myalina subquadrata*, *Athyris subtilita*, *Hemipronites crassus*, *Spirifer cameratus*, *Sp. lineatus*, *Prod. costatus*, *and* a fish-tooth.	do.
165	3 ft.	775′ 8″	Dark shales.	do.
164	1 ft.	772′ 8″	Bituminous shales.	do.
163	4 in.	771′ 8″	Fusulina shales.	do.
162	10 in.	771′ 4″	Fusulina limestones.	do.
161	9 ft.	770′ 6″	Yellow shales and limestone nodules.	do.
160	4 ft. 6 in.	761′ 6″	Light-brown limestone, rough fracture. Has dark-brown streaks and white specks, full of fossil remains.	do. and on Island Branch in Gentry Co.
159	5 ft.	757′	Clay shales.	Highest rock in Platte and Buchanan Co.
158	1½ in.	752′	Coal near Savannah.	Savannah.
157	9 ft.	751′ 10″	Shaly sandstone.	do.
156	3 in.	742′ 10″	Coal.	do.
155	8 ft. 6 in.	742′ 7″	Sandy shales.	do.
154	2 ft.	734′ 1″	Fusulina limestone.	do.
153	9 ft.	732′ 1″	Shales.	do.
152	9 ft.	723′ 1″	3 to 14 ft. strong, tough silicious and oolitic limestone, even layers, sometimes cross-laminated. Fossils, *Pinna peracuta*, *Myalina Swallovi*, *Monoptira*, *Lingula*, *Aviculopecten occidentalis*, *Schizodus*, *Macrodon tenuictriata*.	do. and at mouth of Nodaway. Amazonia. Block's Mills.
151	2 ft.	714′ 1″	Shales.	
150	27 ft.	712 1″	27 to 35 feet irregularly bedded, grayish drab limestone with occasional chest layers. Fossils are *Fusulina cylindrica* (most abundant), *Athyris subtilita*, *Spirifer cameratus*, *Sp. lineatus*, *Rhynconella Osagensis*, *Orthis carbonaria*, *Syntriolasma hemiplicata*, *Retzia punctulifera Spiriferina Kentuckensis*, *Chonetes Smithii*, *Productus splendens*, *Prod. Prattenianus*, *P. Nebrascensis*, *P. costatus*, *P. punctatus*, *Myalina Swallovi*, *Edmondia reflexa*, *Solenomya*, *Hemipronites crassus*, *Monoptera gibbosa*, *Allorisma granosus*, *Allorisma* ——, *Bellerophon* ——, *Goniatites*, *Macrochei-*	Island W. in Gentry Co. N. of Savannah. Amazonia. Mo. of Nodaway R. St. Joseph. Block's Mills. Iatan. Niagara Creek. Andrewes.

No.	Thickness.	Total Thickness.	Description and List of Fossils.	Locality where found.
			lus ventricosus, *Fistulapora nodulifera*, *Rhombopora lepidodendroides*, *Pleurotomaria*, small *Phillipsia and* a *fucoid.*	
149	3 ft.	685 1	Shales.	
148	2 ft.	682′ 1″	Blue and bituminous shales.	
147	2 ft. 4 in.	680 1″	Limestone.	Mo. Nodaway.
146	4 ft.	677′ 9″	Shales.	
145	8 ft.	673′ 9″	Slope, no rocks seen.	
144	5 ft.	665′ 9″	Whitish shales.	
143	7 ft.	660′ 9″	Buff limestone. Fossils, *Chenomya Minehaha*, *Allorisma subcuneata*, *Hemipronites crassus*, *Productus splendens*, *Prod. costatus*, *P. semi-reticulatus*, *Spirifer cameratus*, *Sp. plano-convexus*, *Crinoid* stems, *Lophophyllum proliferum.*	St. Joseph. Amazonia. Iatan.
142			Local bed of sandstone observed at St. Joseph.	
141	3 in.	653′ 9″	Black streak, traces of coal.	Amazonia.
140	5 ft. 10 in.	653′ 6″	Dark clay.	do.
139	4 ft.	647′ 8″	Red shales—makes good dark red paint, found at various places in bluffs from Iatan to Amazonia.	Amazonia, St. Joseph, Block's Mills, Island branch, and E. of Savannah.
138	4 ft.	643′ 8″	Green shales.	
137	7 ft.	639′ 8	Ferruginous limestone, conglomerato.	St. Joseph.
136	42 ft.	632′ 8	Shales, at Amazonia.	Amazonia, E. of Savannah.
135	4 ft.	590′ 8″	Sandstone.	Niagara Cr. Andrew Co., 12 miles below St. Joseph, Blocks' Mills, Iatan, Sugar Cr., Buchanan Co.
134	24 in.	586′ 8″	Shales and coal-seams, includes 11½ inches of coal separated into several thin layers by black shales.	
133	11 ft.	584′ 8″	Shaly slope.	
132	1 ft.	573′ 8″	Sandy, ferruginous, shaly limestone. Fossils, *Bellerophon percarinatus*, *Bell. carbonarius*, *Bell. Kansasensis*, *Hemipronites crassus*, *Myalina subquadrata*, *Astartella vera.*	St. Joseph, above and below.
131	22 ft.	572′ 8″	Mostly shales.	do.
130	6 ft.	550′ 8″	Red and green shales.	St. Joseph and below.
129	4 ft.	544′ 8″	Green shales, with bands of yellow ochre.	do.
128	4 ft.	540′ 8″	Limestone, *Athyris subtilita*, *Spirifer cameratus*, *Orthis carbonaria*, *Allorisma subcuneata*, *Pinna peracuta*, *Fusulina cylindrica*, *Hemipronites crassus.*	St. Joseph and 3 miles above.
127	56 ft.	536′ 8″	Shales.	Below Iatan and above Weston.
126	2 ft. 6 in.	480′ 8	Numerous fossils, *Astartella vera*, *Nuculana bellistriata*, *Leda Oweni*,	Weston, and 3 miles N.

No.	Thickness.	Total Thickness.	Description and List of Fossils.	Locality where found.
			Nucula ventricosa, *Myalina subquadrata*, *Schizodus*, *Pinna peracuta*, *Monoptera*, *Bellerophon Kansasensis*, *Bell. carbonarius*, *Bell. percarinatus*. *Orthoceras cribrosum*, *Lophophyllum proliferum*, *Pleurotomaria*, *Nautilus occidentalis*, *Prod. Nebrascensis*.	
125	21 ft.	478' 2"	Shales.	Weston.
124	8 in.	457' 2"	Drab, rough sandstone.	do.
123	10 in.	456' 6"	Black shales, sometimes thin coal and remains of cicadeous plants.	Do. and Watson in Daviess Co.
122	6 ft.	455' 8"	Shales.	do.
121	18 ft.	449' 8"	Limestone—12 to 18 feet, *Spirifuria Kentuckensis*, *Athyris subtilita*, *Pleurotomaria*, *Hemipronites*.	Same localities as last.
120	37 ft.	431' 8"	Shales.	Weston.
119	15 ft.	394' 8"	Sandstone Calamites, etc.	Waldron.
118	10 in.	379' 8"	Coal—shaly.	3 miles above Waldron.
117	4 ft.	378' 10"	Shales.	
116	15 ft.	374' 10"	Sandstone.	As last.
115	3 ft.	359' 10"	Sandy limestone, Fossils *Myalina subquadrata*, *Aviculopecten carbonarius*, *Chonetes granulifera*, *Hemipronites crassus*, *Meekella striato-costata*, *Athyris subtilita*, *Productus Prattenianus*, small *Crinoid* stems, and *Lophophyllum proliferum*.	Weston.
114	10 in.	356' 10"	Shales.	do.
113	3 ft. 6 in.	356'	Buff limestone.	Weston and Waldron.
112	13 ft. 6 in.	352' 6"	Limestone ; gray contains *Bryozoa* *Meekella striato-costata*, *Spirifer cameratus*, *Productus*, *Prattenianus*, *P. Nebrascensis*, *P. punctatus*, *Fusulina cylindrica*.	Same localities as last.
111	5 ft. 6 in.	339'	Shales, the middle 8 inches bituminous, light and dark blue variegated, —*fucoids*.	Weston.
110	4 ft.	333' 6"	Blue limestone, many small univalves, *Loxonema*, *Pleurotomaria*, *Athyris*, *Hemipronites*, *Orthis carbonaria*, *Syntriclasma*, *Chonetes*, *Macrodon*, *Rhombopora* and *Synocladia biserialis*.	Platte Co., below Weston, Waldron, and at Saul, Missouri.
109	19 ft.	329' 6"	Shales, contains a band of bituminous shales.	
108	18 ft.	310' 6"	Irregularly bedded blue and gray limestone, with buff shaly partings. Plattsburgh Group. Fossils numerous, especially *Bryozoans*. Also in gray bed at top, *Naticopsis Pricei*, *Bellerophon carbonarius*, *Murchisonia* ——, *Macrodon*, *Orthoceras cribrosum*, *Myalina Swallovi*, *Nuculana bellistriata*, and a thin layer of cone-in-cone. Below we find many *Bryozoans*, large *Macrocheilus* (*inhabilis*), *Bellero-*	Farley. Union Mills. Waldron. Parkville, near Liberty, Plattsburgh.

No.	Thickness.	Total Thickness.	Description and List of Fossils.	Locality where found.
			phon, *Polyphemopsis* ——, *Pleurotomaria turbiniformis*. *Ath. subtilita* (large var.), *Prod. splendens*, *P. Nebrascensis*, *P. costatus*, *P. symmetricus*, *Prod. Americanus*, *Prod. punctatus*, *P. Prattenianus*, *Myalina Subquadrata*, *My. Swallovi*, *Spirifer cameratus*, *Pinna peracuta*, *Edmondia Unioniformis*, *Aviculopecten providencis*, *Retzia punctulifera*, *Astartella vera*, *Eutolium aviculatum Monoptera*, *Nautilus occidentalis*, *Orthoceras cribrosum*, *Crinoid* stems, *Synocladia biserialis*, *Petalodus destructor* and another fish-tooth, spine of *Archæocidaris*, *Fistulapora nodulifera*, *glabella* of *Phillipsia major*.	
107	1 ft.	292′ 6″	*Calcareous* sandstone contains *Eutolium aviculatum*, *Myalina Kansasensis*, *My. subquadrata*, *Aviculopecten occidentalis*, *Athyris subtilita*.	Same locality as last.
106	5 ft.	291′ 6″	Sandy shales.	
105	2 ft.	286′ 6″	Conglomerate.	
104	14 ft.	284′ 6″	Shaly sandstone.	
103	21 ft.	270′ 6″	Soft buff sandstone and shales.	
102	1 ft.	249′ 6″	Ferruginous conglomerate, hard calcareous, *Myalina subquadrata*, *Phillipsia major*.	
101	3 ft.	248′ 6″	Shales.	
100	3 ft.	245′ 6″	Hard ferruginous limestone, 3 to 10 ft. Contains large fossils, *Productus Nebrascensis*, *P. Americanus*, *Myalina subquadrata*.	Parkville. Waldron. Liberty.
99	31 ft.	242′ 6″	Sandy shales.	
98	30 ft.	211′ 6″	Irregularly bedded gray and buff thin bedded limestone. Fossils are, *Productus splendens*, *P. costatus*, *P. Rogersis*, *Terebratula bovidens*, *Athyris subtilita*, *Meekella striatocostata*, *Syntriclasma hemiplicata*, *Myalina Swallovi*, and *Bryozoans*.	Top Rock, at Kansas City, Parkville, Waldron, Independence.
97	25 ft.	181′ 6″	Blue clay shales, has ochre concretions, *P. Prattenianus*.	Kansas City and Parkville.
96	5	156′ 6″	Bluish-gray limestone, contains large fossils, *P. costatus*, *P. Americanus*, *P. punctatus*, *Prod. symmetricus*, *Prod. splendens*, *P. Nebrascensis*, *Sp. cameratus*, *Hemipronites*, *Myalina ? Swallovi*, *Athyris*, *Polyphemopsis*, *Chætetes*, head of *Phillipsia*, *pygidium* of *Phillipsia major*, *Naticopsis*, *Nautilus ferratus*, *Fistulapora nodulifera*, *Rhombopora lepidodendroides*, *Synocladia biserialis*, *Polypora submarginata*, *Fenestella Shumardana*.	Same locality as above. Liberty, De Kalb Co. Daviess Co. Gentry Co. Independence.

No.	Thickness.	Total Thickness.	Description and List of Fossils.	Locality where found.
95	2 ft. 9 in.	151′ 6″	Blue and bituminous shales.	
94				
93	13 in.	148′ 9″	Shales. *Pleurotomaria*, *Polyphemopsis*, etc.	
92	1 ft. 1 in.	147′ 8″	Even bed of coralline limestone.	
91	5 ft.	146′ 7″	Blue shales. Fossils in upper 6 in. *Athyris*, *Rhombopora*, *Sp. Kentuckensis*.	
90	9 ft.	141′ 7″	Drab limestone *Campophyllum torquiam*, *Lophophyllum proliferum*, *Fistulapora nodulifera*, *Productus splendens*, *Meekella Sp. cameratus*, *Sp. Kentuckensis*, *Athyris*.	Parkville. Kansas City and bluffs opposite.
89	5 ft.	132′ 7″	Blue and olive shales.	Kansas City.
88	2 ft.	127′ 7″	Nodular and buff shales.	
87 *b*	3 ft.	125′ 7″	Irregularly bedded bluish drab limestone.	do.
87 *a*	18 ft.	122′ 7″	Fossils, *Eutolium aviculatum*, *Macrodan tenuistriata Bryozoa*, *Aviculopecten*, *Avic. providencis*, *Sp. Kentuckensis Retzia punctulifera*, *Terebratula bovidens*, *Aviculopecten occidentalis*, *Edmondia reflexa*, *Pleurotomaria turbiniformis*, *Bellerophon crassus*, *Synocladia biserialis*. The rock is beautifully oolitic.	Kansas City and Clay Co. opposite, below Parkville.
86	15 ft.	104′ 7″	Shales.	Kansas City.
85*d*	14 in.	89′ 7″	Blue limestone, Fossils are *Allorisma regularis*, *Archæocidaris*, *Crinoid* stems, *Chonetes*. *P. splendens*.	N. Mo., Junc. Clay Co.
85*c*	2½ ft.	88′ 5″	Blue clay shales.	Same locality.
85*b*	4 in.	85′ 11″	Rotten coal—*cordaites*.	Same locality.
85*a*	8ft. 8 in.	85′ 7″	Very dark blue silicious limestone, with lenticular forms and concretionary beds of black chert. Fossils numerous, especially in upper part, including *Lingula* — *Bellerophon percarinatus*, *B. Montfortiana*, *Platyostoma*, *Peoriensis*, *Naticopsis Pricei*, *Archæocidaris*, *Aviculopecten occidentalis*, *Avic. carbonarius*, *Pinna peracuta*, *Aviculopinna Americana*, *Myalina Kansasensis*, *My. subquadrata*, *My. Swallovi*, *Schizodus Wheelerii*, *Edmondia Nebrascensis*, *Allorisma*, *Pleurophorus*, *Pseudomonotis*, *Athyris*, *Hemipronites crassus*, *Prod. Nebrascensis*, *P. symmetricus*, *Solenomya*, *Euomphalus rugosus*, *Bryozoa*, *Phillipsia major*.	Same locality as last, also, Independence, L. Blue, Pleasant Hill, Liberty, and in Daviess and Harrison.
84	9 ft. 4 in.	76′ 11″	Fine-grained dove and drab colored limestone, calcite specks throughout.	Randolph, Mo. City.
			In 2 beds, *Athyris* and *Orthoceras*.	Kansas City.
	5 in.	67′ 7″	Shales.	Pleasant Hill.
83	3 ft. 8 in.	67′ 2″	Irregularly bedded drab and blue limestone, some chert concretions,	Same locality as the last, and also

No.	Thickness.		Total Thickness.		Description and List of Fossils.	Locality where found.
					and has buff shaly partings. Fossils, *Productus Nebrascensis*, *P. punctatus*, *P. costatus*, *P. splendens*, *Athyris subtilita*, *Spirifer cameratus*, *Sp. Kentuckensis*, *large Nautilus*, *Myalina Kansasensis*, *Lophophyllum*, *Orthoceras*, *Archæocidaris*, *Fusulina*, *Syringopora*, large *Crinoid* stems, *and Bryozoa.*	Greenwood and half way to Lee's Summit. Gallatin, in Daviess Co., Groomer's Mill, in Daviess Co., Amos's in Jackson Co.
83		5 in.	61′	6″	Blue shales.	
82		14 in.	61′	1″	Concretionary ash blue limestone. Large *Rhynchonella*, *Prod. splendens*, *Athyris*, *Myalina Swallovi.*	N. Mo. Junction. Kansas City, P. Hill and Amos.
81*c*		11 in.	60′		Blue shales.	
81*b*	1 ft.	7 in.	59′		Bituminous shales, contains *Hymenophillites adnascens.*	
81*a*	2 ft.		57′	5″	Clay shales.	
80	4 ft.		55′	5″	Nodular and shelly fine-grained limestone.	
79	1 ft.		51′	5″	Oölitic limestone, near Pleasant Hill is 4 feet, and Kirtly's quarry, Livingston Co., is 8 feet.	
78	20 ft.	8 in.	50′	5″	"Bethany Falls" limestone dun and gray. *Athyris*, *Hemipronites*, *P. costatus*, *Prod. Nebrascensis*, *P. splendens*, *P. punctatus*, *Edmondia*, *Allorisma regularis*, *Meekella*, *Archæocidaris*, *Crinoid* stems, *Lophophyllum*, *Syringopora multattenuata*, *Scaphiocrinus hemisphericus.*	Kansas City, Owens' landing, Liberty landing, Greenwood, Pleasant Hill, Lonejack, Chapel Hill, Harrisonville, Greenton, Gallatin, Bethany, Pattonsburgh.
77*b*	2 ft.	2 in.	29′	9″	Blue clay shales.	
77*a*	1 ft.	4 in.	27′	7″	Bituminous shales.	
76*c*	1 ft.	2 in.	26′	3″	14 to 18 inches dull blue limestone, contains *Lophophyllum* and *Sp. cameratus.*	
76*b*		7 in.	25′		Blue clay shales.	
76*a*		6 in.	24′	6″	Concretionary limestone, *Meekella*, *Hemipronites*, *Spirifer cameratus*, *Athyris subtilita*, *P. Prattenianus*, *Chonetes*, *Rhombopora*, *Bryozoa*, *Allorisma subcuneata.*	
75	2 ft.		24′		Blue clay shales.	
74	6 ft.		22′		Gray and ferruginous limestone, *Athyris subtilita*, *Lophophyllum proliferum*, *Crinoids*, *Rhombopora*, is somewhat oölitic.	
73	14 ft.		16′		Clay shales—sometimes replaced by a porous sandstone.	
72	2 ft.		2′		Calcareous sandstone and sandy limestone, abounding in fossils, *Myalina subquadrata*, *Pinna peracuta*, *Aviculopecten providencis*, *Bellerophon* (large), *Pleurotomaria* (2 or 3 Sp.), *Loxonema*, *Naticopsis*, *Phillipsia*, *Euomphalus rugosus*, *Straparollus umbilicatus*, *Orthoceras cribrosum*, *Nautilus*, *Schizodus.*	Only found south of Mo. River, Pleasant Hill, and Harrisonville.

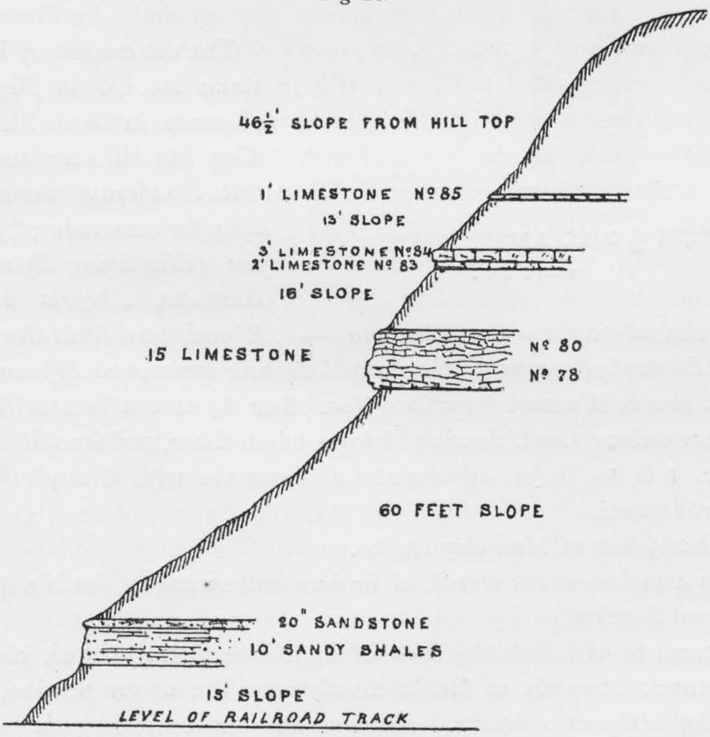
AREA AND THICKNESS.

The upper or barren coal-measures of Missouri include a vertical thickness of 1,087 feet, from No. 72 of our General Section of upper coal-measures, to No. 224 inclusive. To this we may add 180 feet of Atchison County rocks, with probably about 50 feet of rock not seen in Missouri, but which should be placed above No. 224, and at a lower geological position than our Atchison County rocks, thus making a total of 1,317 feet of upper coal-measures, extending to the highest rock in Atchison County, and embracing an area of 8,406 square miles, including the rocks in the counties of Atchison, Holt, Nodaway, Andrew, Buchanan, Clinton, Dekalb, Gentry, Worth, Harrison, Daviess, Platte, Clay and most of Cass, Jackson and Caldwell, with limited areas in Johnson, Lafayette, Ray, Livingston, Grundy and Mercer. The south and east boundary of the upper coal-measures is about as follows: Entering the State near the south-west part of Cass County, passing eastwardly, near Harrisonville, thence, north-east across the mounds between Big Creek and Camp branch, thence, north-east to the middle of T. 46, R. 29, thence, north to Chapel Hill in Lafayette County, thence, via Oak Grove and Pink Hill, Jackson County, to Blue Mills or Owen's landing on the Missouri river. Crossing the river the line passes down to the vicinity of Albany, Ray County, thence, it trends off to the north part of Ray County and the line of Caldwell and Livingston Counties, thence, northwardly along the ridges on the west side of the east fork of Grand river, to the line of Grundy and Mercer Counties, and thence, northwardly to the Iowa State line. Around and without this line are occasional outliers of upper coal-measure rocks, for instance, Centre Knob at Kingsville, Johnson County, and the knobs to the North; the long ridge East and North of Greenton, Lafayette County, Grady's Knob, near Wellington, and hills east of Grand river, Mercer County. Within this border where the streams have made deep erosions, the sandstones Nos. 65 to 69 of the middle coal series, are often exposed for some distance up stream, as for instance on Big Creek, Cass County, nearly to the Jackson County line, on Little Blue, Jackson County, as far up as the middle of T. 48, and on Shoal Creek, Caldwell County, nearly to Kingston; and up the west fork of Grand river, above Gallatin.

In this great thickness of upper coal-measures, only about 8 thin seams of coal are found, amounting in the aggregate to about four feet, including one of 10 inches, another of about a foot; two are of 3 inches in thickness, and the others mere streaks of one to two inches thick.

Descriptive Sections along the Missouri River.—In ascending the Missouri river, the lower strata of the upper coal-measures are first seen a half-mile above Albany, Ray County. At this place, No. 78 crops out 12 feet in thickness at 130 feet above the bottoms. Two miles further west, 16 feet of this limestone is seen at an elevation of 112 feet above the bottoms, with sandy shale reaching within 33 feet of the limestone. Four feet above the base of the hill is one foot of dark olive brown calcareo-arenaceous shale containing remains of fossils, including *Spirifer* (*Martinia*) *plano-convexus*, *Lophophyllum proliferum* and *Crinoid* stems. Ten miles west, at the east end of Missouri City, the bluffs appear thus :—

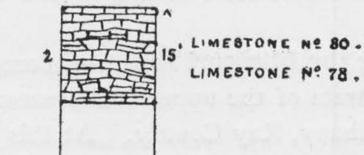
Fig. 20.



EAST END OF MISSOURI CITY
CLAY CO.

The limestone (84) in the foregoing Section is fine-grained buff and drab, containing many small calcite specks. Dendritic markings and occasional crystals of calc-spar appear on the joints. One half mile above MISSOURI CITY the bluffs appear as shown in Fig. 21.

Fig. 21.



SECTION ½ MILE ABOVE MISSOURI CITY CLAY CO.

At LIBERTY LANDING limestone No. 78 crops out, 14 feet above the railroad; at the tunnel it forms the roof. Our Section here is thus:—

TUNNEL ST. L. K. C. & N. R. R.

The concretionary limestone No. 76 in Fig. 22 abounds in fossils, including *Meekella striato-costata*, *Hemipronites crassus*, *Spirifer cameratus*, *Spirifer (Martinia) lineatus*, *Chonetes*, *Athyris subtilita*, *Aviculopecten* ——, *Allorisma* ——, *Rhombopora lepidodendroides*, *Lophophyllum proliferum*, small *Crinoid* stems, and *Bryozoa*.

At North Missouri Junction, Nos. 78 to 85 of our General Section are well exposed. Section 189 was taken there, and is as follows:

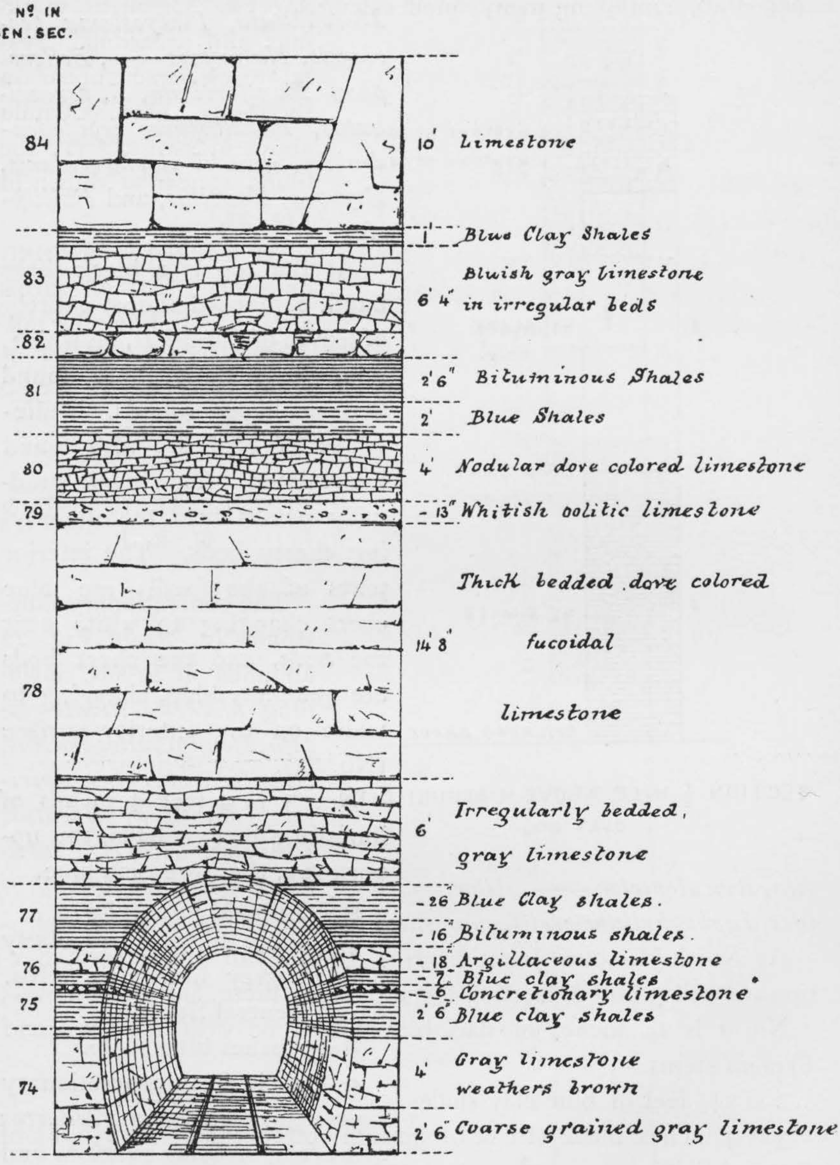
No. 1 is 14 inches of dark-blue limestone with *Chonetes* and *Crinoid* stems.

2 is 2½ feet of blue clay shales.

3 is 4 inches black streak of impure rotten coal. (In No. 85 of General Section.)

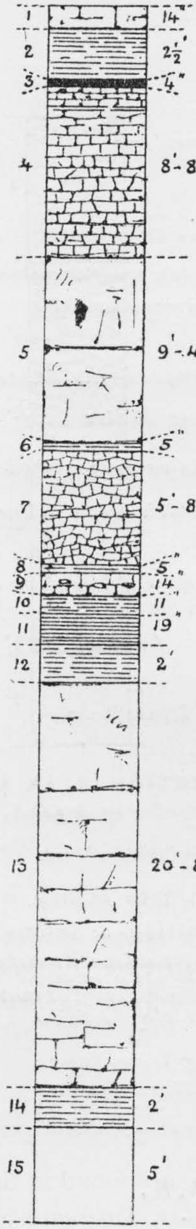
4 consists of 8 feet 8 inches of dark blue, nearly black cherty limestone; abounds in fossils mostly near the upper portion, including *Athyris subtilita*, *Hemipronites crassus*, *Lingula* ——, *Productus Nebrascensis*, *P. symmetricus*, *Myalina Kansasensis*,

Fig. 22.



SECTION ON ST. L. K. C. & N. R. R.
ABOVE LIBERTY LANDING, CLAY CO.

Fig. 23.



SECTION 189 AT N. MO. JUNCTION CLAY CO.

M. subquadrata, *Pseudomonotis*, *Murchisonia*, *Platyostoma peoriensis*, *Naticopsis* ——, *Bellerophon Montfortiana*, *B. percarinatus*, *Rhombopora lepidodendroides*, arms of *Archæocidaris*, *Bryozoa*, *Nautilus*, and *Phillipsia*.

At the top is a black shaly band, composed almost entirely of leaves of *Cordaites*, on which, upon examination, are found very small gasteropods. Knife-edges of coal are also found intercalated. This band gradually passes into the underlying cherty beds. The interior parts of the fossils are blue chert changing to white near the *testa*, and the chert beds are generally blue, changing to white on the exterior surface (No. 85).

No. 5 is 9 feet 4 inches of limestone in two beds, the upper gray, the lower ash blue.

6 is 5 inches blue shale.

7 is 5 feet 8 inches irregularly bedded gray limestone. No. 83 of General Section.

8—5 inches blue shale.

9—14 inches concretionary limestone, containing *Productus splendens*, *Athyris subtilita* and *Myalina Swallovia*.

No. 10 is 11 inches blue shale.

11—19 inches bituminous shales.

12—2 feet clay shales.

13—20 feet 8 inches of limestone, including Nos. 78, 79 and 80.

14 is 2 feet blue shales,—and

15 is 5 feet slope to grade of railroad.

At Randolph the top of No. 80 is level with the grade of the railroad. A half-mile further we have the Section annexed:

No. 1—3 feet dark blue cherty limestone, contains large and fine specimens of *Bellerophon percarinatus* (No 85).

2 is 3 feet dark blue concretionary limestone.

3—2 inches chert.

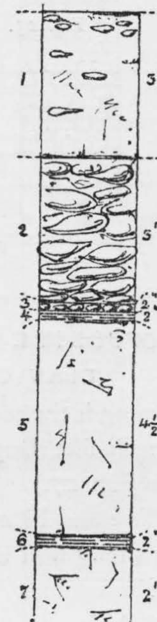
4—2 inches shales.

5—Four and one half feet fine-grained limestone, admits of a fine polish (No. 84).

6—2 inches green shale.

7—2 feet gray limestone, abounds in *Productus costatus*, *Prod. punctatus* and *P. Nebrascensis*. (No. 83 of General Section.)

Fig. 24.



SECTION NEAR RANDOLPH CLAY CO.

Section 189 at North Missouri Junction.

Half a mile further we have the following:—See Fig. 26.

No. 1—83 feet slope.

2—6 feet of fine-grained limestone in 3 to 8 inch beds, freely working, and separated by buff shaly partings; abounds in *Campophyllum torquium*, *Lophophyllum proliferum*, *Fistulapora nodulifera*, *Productus splendens*, *P. costatus*, *Athyris subtilita*, *Spirifer Kentuckensis*.

No. 3—47 feet slope.

4—8 feet deep blue cherty limestone. (See Fig. 25.)

5—21 feet to bottoms.

In No. 4 of last Sec. (85 of Gen. Sec.), are found at this place in the upper portion, *Bellerophon percarinatus*, *Naticopsis* and *Murchisonia*. The lower beds contain *Myalina subquadrata*, *Schizodus*, *Pinna peracuta*, *Solenomya*, *Aviculopecten occidentalis*, *Hemipronites crassus*, *Fish-tooth* and *Orthoceras cribrosum*.

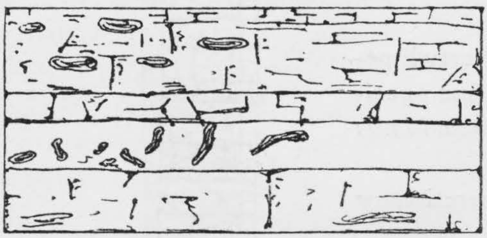
A little further along the bluffs, we find :—

No. 1—Shaly limestone.

2—4 feet shales.

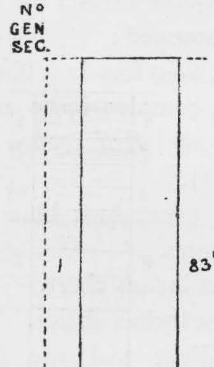
3—6 feet limestone, containing concretions of black chert (85).

Fig. 25.



N° 85 OPPOSITE HARLEM
CLAY CO.

Fig. 26.



SECTION OPPOSITE HARLEM
CLAY CO.

The following is the section, one mile east of the Pacific Depot, at Kansas City. (See Fig. 27.)

No. 1—Blue and bituminous shales.

2—2 feet shelly buff limestone.

3—1 foot limestone.

4—1 foot shale.

5—4½ feet shaly slope.

6—7 feet Oölitic limestone (No. 87).

7—21 feet slope.

8—4 feet blue cherty limestone, fossiliferous at top, shaly below.

9—1 foot banded deep-blue silicious limestone.

10—3 to 5 inches deep black-blue chert.

11—14 inches compact deep-blue silicious limestone.

12—8 inches shelly limestone.

13—21 inches deep-blue limestone with dark chert concretions.

14—3 feet concretionary, deep-blue, limestone with blue chert concretions.

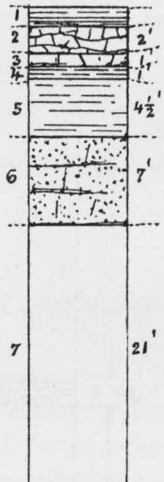
15—3½ feet shaly slope.

16—6½ feet gray limestone (No. 84).

17—16 feet to Missouri bottoms.

The following section, Fig. 28, taken 800 feet east of the Union depot, Kansas City, represents the correlation of strata from No. 82 to 85 inclusive.

Fig. 27.



SECTION AT KANSAS CITY
1 MILE EAST OF PACIFIC DEPOT

Fig. 28.

SECTION AT KANSAS CITY
800' EAST OF UNION DEPOT

No. 1—7 feet limestone and chert. The upper portion dark blue-black shelly limestone, abounding in fossils, including *Bellerophon percarinatus*, *Platyostoma Peoriensis*, *Euomphalus rugosus ?* (*large Sp.*) *Myalina Kansasensis*, *Myalina Swallovi*, *Schizodus Wheelerii*, *Pleurophorus ? Allorisma*, *Aviculopecten occidentalis*, *Aviculopinna Americana*, *Pinna peracuta*, arms of *Archæocidaris* and *Bryozoa*. The middle bed abounds in deep blue chert concretions of irregular shape, incased in a matrix of dark-blue silicious limestone (No. 85).

2—is 2½ feet of concretionary limestone and shales.

3—2 feet dark olive bluish shales (No. 85).

4—11 inches shelly limestone.

5—39 inches fine-grained limestone (No. 84).

7—33 inches limestone, contains some chert. *Productus costatus* abounds (No. 83).

8—10 inches shale.

9—Limestone—lower beds concealed.

Opposite Fort Scott depot, a quarter of a mile above, the strata are thus :—Fig. 29.

1—Bluff formation on hill-top.

2—30 feet limestone (No. 98 of Gen. Sec.), generally in thin, irregular layers of gray, bluish-gray and flesh-colored limestone, which are often traversed by veins of calcite ; contains occasional fossils, such as *Productus punctatus*, *P. Nebrascensis*, *P. splendens*, *Bryozoa* and *Meekella*.

No. 3—is 25 feet of blue and olive-colored clay shales.

4—5 feet limestone, abounding in mostly large *Producti*, *P. costatus*, *P. punctatus*, *P. Americanus*, *P. Prattenianus*, *Sp. cameratus*, and *Hemipronites crassus*.

5—2 feet 9 inches blue and bituminous shales, elongated concretions in the upper part.

6—13 inches shales abounding in small *Pleurotomaria*, *Polyphemopsis*, &c.

7—13 inches even bed of blue limestone variegated with irregular dark windings.

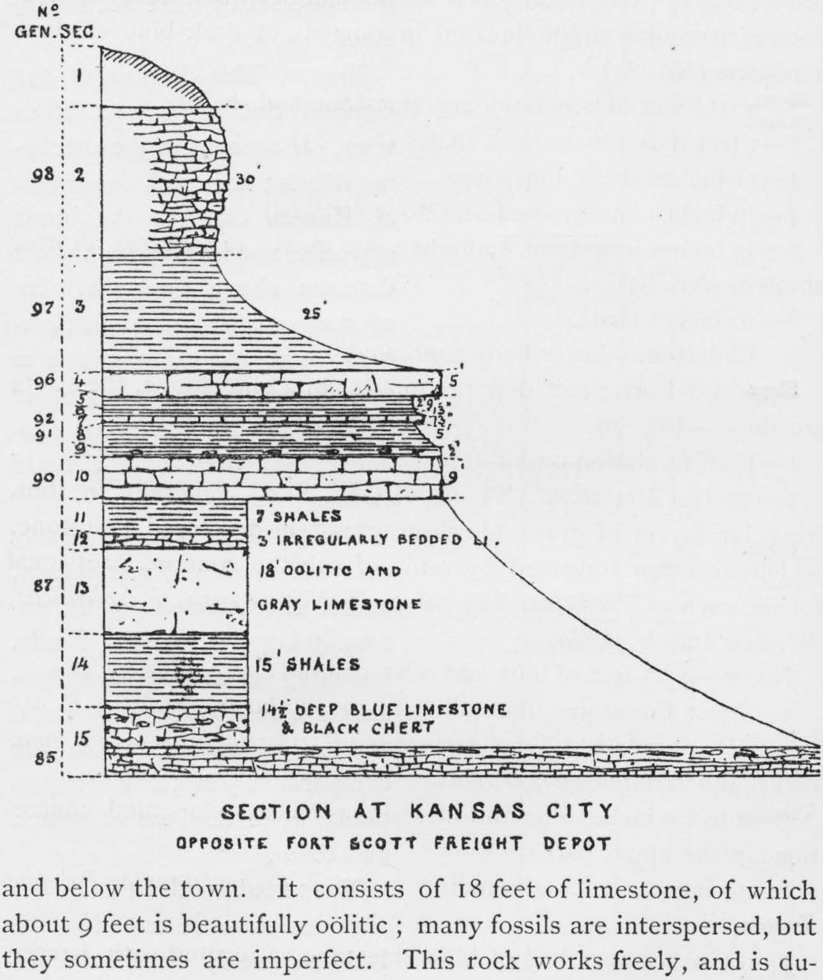
8—5 feet blue shales. In upper part abounds in *Athyris*, *Rhombopora* and *Spirifer Kentuckensis*.

9—2 feet shales and limestone nodules.

10—9 feet greenish-gray even-bedded limestone ; contains *Campophyllum torquium*, *Prod. splendens* and *Athyris subtilita*.

Sec. I. Kansas City, opposite Fort Scott Freight Depot. Part of No. 11, and Nos. 12, 13, 14 and part of 15 are concealed here, but crop out a few hundred feet east. No. 87 is better developed at Kansas City, especially on the hillside near the Union Depot

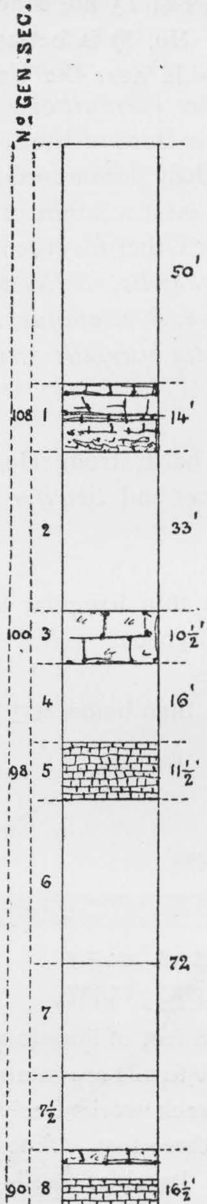
Fig. 29.]



SECTION AT KANSAS CITY
OPPOSITE FORT SCOTT FREIGHT DEPOT

and below the town. It consists of 18 feet of limestone, of which about 9 feet is beautifully oölitic ; many fossils are interspersed, but they sometimes are imperfect. This rock works freely, and is durable. It occurs in layers of two and three feet. A few fossils are beautifully crystallized in the interior. Its chief fossils are, *Aviculopecten occidentalis*, *Avic. providencis*, *Eutolium aviculatum*, *Macrodon tenuistriata*, *Edmondia reflexa*, *Hemipronites crassus*, *Pleurotomaria turbiniformis*, *Retzia punctulifera*, *Athyris subtilita*, *Terebratula bovidens*, *Sp. Kentuckensis*, and *Synocladia biserialis*.

Fig. 30.



SECTION AT PARKVILLE
PLATTE CO.

A quarry of this oölitic limestone was observed about halfway from Kansas City to Parkville. At and near Parkville its associated strata appear, but the oölitic beds were not recognized.

No. 90. This division of our General Section is not often seen, on account of the overlying débris; it is well developed at Kansas City, in the bluffs opposite, and is last seen a short distance above Parkville. Its most characteristic fossil is *Campophyllum torquium*, which is scarcely recognized in any other strata; it also contains *Productus splendens* and *Crinoid* stems.

No. 96. This is found nearly everywhere where No. 90 is seen, and is characterized by the unusually large size of its fossils, including several species of *Productus* with *Spirifer cameratus* and *Hemipronites*, which are comparatively larger in this particular rock than we elsewhere find them.

No. 100 abounds in large fossils, similar to those of No. 96. It is an evenly stratified limestone, strong and durable. Between Parkville and Waldron it suddenly thickens up and is suboölitic.

The Parkville Sections appear thus:—Fig. 30.

1—14 feet gray limestone at top, abounding in univalves, then a few feet of brittle brown limestone; then a few feet of gray limestone, abounding in fossils, including *Productus Nebrascensis*, *P. splendens*, *Pr. costatus*, *Prod. Prattenianus* var. *Americanus*, *Athyris subtilita*, *Chonetes Verneuiliana*, *Edmondia Hawni*, *Crinoid* spines and stems. One-third of the distance from the bottom is a 4-inch chert bed, with shaly decomposing limestone below. At the bottom is generally an even stratum of 10 inches, which is useful for building purposes. Other fossils contained are *Petalodus destructor*, *Macrocheilus inhabilis*, *Bellerophon*, *Naticopsis*, *Murchisonia*, *Orthoceras cribrosum*, *P. punctatus*, *Prod. Symmetricus*, *Pinna peracuta* and *Synocladia biserialis*. (108 of Gen. Sec.)

2—is 33 feet slope.

3—10½ feet of coarse, brownish-gray, hard, strong, close-textured limestone, containing *Prod. Americanus* and *Spirifer cameratus*. (100 of Gen. Sec.)

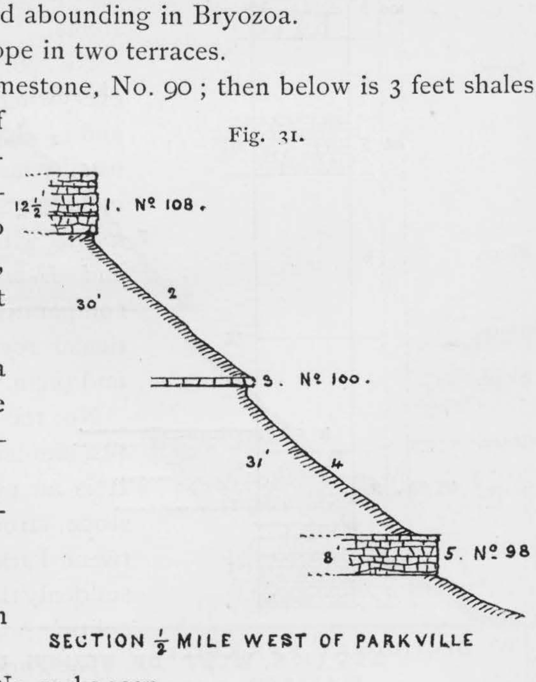
4—16 feet slope.

5—11½ feet of limestone, No. 98, in thin irregular layers, with buff shaly partings, and abounding in Bryozoa.

6 and 7 is 72 feet slope in two terraces.

8—includes 3 feet limestone, No. 90; then below is 3 feet shales, resting on 10½ feet of drab silicious limestone, in even fine-grained layers of 2 to 6 inches in thickness, and occasional chert layers.

Fig. 31.



SECTION ½ MILE WEST OF PARKVILLE

West of Parkville a half-mile, we have the following section:—(Fig. 31.)

1—12½ feet limestone (No. 108).

2—30 feet slope.

3—outcrop of brown limestone (No. 100).

4—31 feet slope. No rocks seen.

5—is 8 feet of limestone in thin and irregular layers (No. 98).

The limestone (No. 88) in the above Section is the top rock seen at Kansas City and Independence, and which disappears beneath the horizon just below Waldron. Wherever seen it is a gray limestone in thin irregular layers, separated by thin buff shale bands.

Section West of Brush Creek, Platte County. (See Fig. 32.)

35 feet slope from hill-top.

No. 2—11 feet limestone. No. 108. Upper part, ash gray; middle, brown, soft; lower part like the upper.

3—1 foot coarse, rough calcareous sandstone, contains *Myalina Kansasensis* and *Aviculopecten occidentalis*.

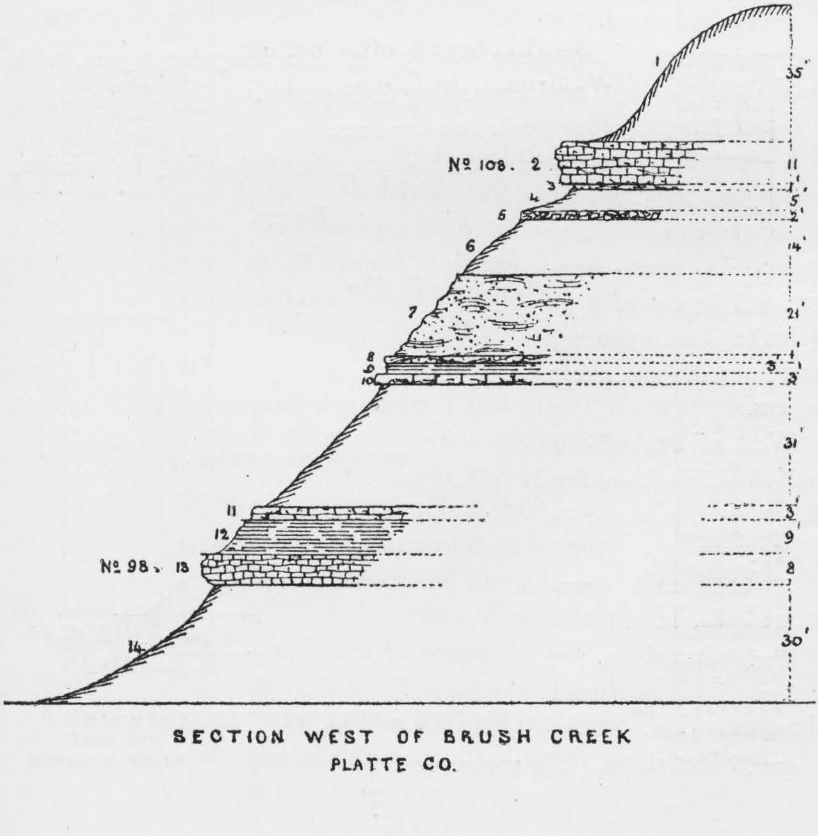
4—5 feet slope.

5—2 feet fossiliferous calcareous conglomerate.

6—14 feet slope ∠45°.

7—21 feet soft buff sandstone.

Fig. 32.

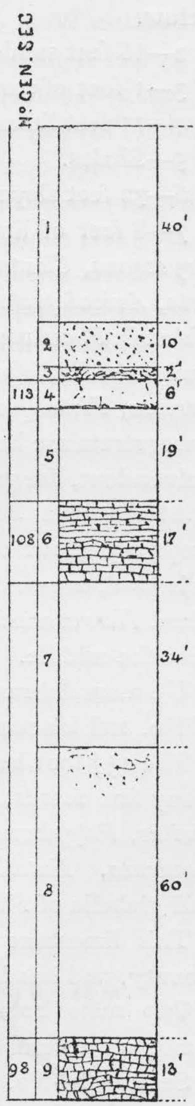


SECTION WEST OF BRUSH CREEK
PLATTE CO.

8—1 foot hard dark, gray, rippple-marked sandstone.
9—3 feet shales.
10—3 feet limestone.
11—31 feet slope.
12—9 feet shales.
13—8 feet limestone (No. 98 of Gen. Sec.).
14—30 feet to bottoms, 4 feet below railroad.

Three-quarters of a mile above the last section, No. 100 crops out in one thick bed of 8 feet at 27 feet above the railroad; it is a little ferruginous, quite hard and oölitic. In one place it is cross-laminated for a foot and a half near the base, the laminæ resting at an angle with the horizontal surface, of about 30°; at another place is an intercalation of a few feet abounding in fossils, principally *Productus Nebrascensis*, *Prod. Prattenianus*, *Bryozoa* and a *Goniatite*.

Fig. 33.



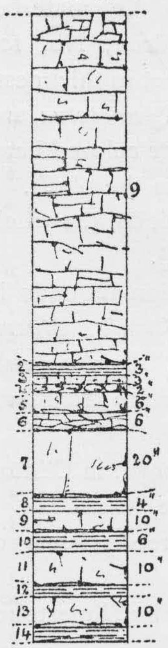
SECTION 5
ONE MILE
BELOW WALDROW

Section 5, one mile below Waldron, is as follows:—Fig. 33.

1—40 feet slope.
2—10 feet sandstone.
3—2 feet hard sandstone.
4—6 feet buff limestone, in one thick bed, is weather cracked (No. 113).
5—19 feet slope.
6—17 feet Plattsburgh limestone (No. 108).
7—34 feet slope.
8—60 feet slope, some sandstone near upper part.
9—13 feet limestone, corresponds to No. 98.

The structure of the Plattsburgh limestone (No. 6 of above Section) is given in Fig. 34.

Fig. 34.



PLATTSBURGH
LIMESTONE
PLATTE CO.

A little further the sandy

band at base of No. 108, was observed 2 feet in thickness, very hard and firm, and abounding in small univalves and a few *Acephala*, including *Solenomya*, *Aviculopecten occidentalis*, &c.

At Waldron we have:

1—52 feet slope, about 35° near hill-top, becoming steeper below.

2—16 feet sandstone.

3—1 foot of conglomerate.

4—11 feet limestone, containing *Fusulinæ*.

5—Shales.

6—32 feet slope.

7—8 feet of limestone (No. 108) abounding in fossils, including *Bryozoans*, *Chætetes?* *Athyris*, *Myalina subquadrata*, *Pinna peracuta*, *Aviculopecten occidentalis*, *Edmondia unioniformis*, *Avic. providencis*, *P. costatus*, *Prod. punctatus*, *P. Prattenianus*, *Spirifer Kentuckensis*, *P. Nebrascensis*, *Meekella striato-costata*, *Macrodon tenuistriata*, *Fistulipora nodulifera* and spines of *Archæocidaris*. The lower strata are heavy, and brownish gray; the brown seams are pulverulent, the gray crystalline, and afford a good building material.

At Samuel Morrow's, two miles above Waldron, No. 100 crops out about 10 feet above the railroad, and 8 feet in thickness. It is hard, coarse deep grayish brown, contains *Prod. punctatus*, and *Prod. Nebrascensis*; the fossils are in a narrow lighter colored band near the middle. Nos. 108 and 112 appear higher in the bluffs.

Up a small branch, a quarter of a mile from the bluffs, the whole of No. 108 is seen to be 18 feet in thickness (Fig. 35).

The 1½ foot bed near the lower part of this Section abounds in many fine fossils, including *Pleurotomaria turbiniformis*; *Macrocheilus*, *Polyphemopsis*, *Monoptera*, *Pinna peracuta*, *Myalina subquadrata*, *Eutolium aviculatum*, *Allorisma*, *Myalina Swallovi*, and glabella of *Phillipsia major*.

This limestone is well developed near Plattsburgh, in Clinton County, and has been called "Plattsburgh limestone."

One mile below Platte River Ferry and three-quarters of a mile up a small branch observed as follows:—

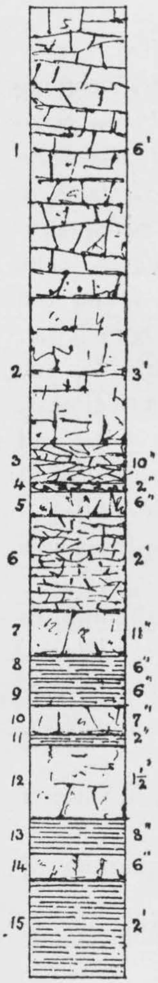
Section 8—No. 2 is 8 feet of roughly bedded shelly buff limestone. (No. 112 of Gen. Sec.)

3—5 feet slope.

4—3 feet limestone in two beds, the upper, 2 feet thick, the lower, 1 foot thick; color blue, weathering brown. Abounds in univalves. Its chief fossils are, *Athyris subtilita*, *Hemipronites crassus*, *Orthis carbonaria*, *Macrodon*, *Chonetes*, *Meekella striato-costata*, *Syntrilasma hemiplicata*, *Spirifer* (*Martinia*) *lineatus*, *Myalina subquadrata*, a small *Pleurotomaria*, *Loxonema*, *Synocladia biserialis* and other *Bryozoans* (No. 110).

No. 5—4 feet shales (No. 109).

Fig. 35.



No. 1.—6 feet limestone, broken in strata, brown near top.

2—3 feet coarse tough brownish ash-gray limestone.

3—10 inches shelly ash-blue limestone.
4—2 inches chert bed.
5—6 inches bluish ash-gray limestone.

6—2 feet shaly decomposing limestone.

7—11 inches bluish gray limestone.
8—6 inches mottled blue and olive clay shales.
9—6 inches brown calcareous shales.
10—7 inches limestone.
11—2 inches brown clay.

12—1½ feet limestone; abounds in fossils.

13—8 inches clay shales.
14—6 inches limestone.

15—2 feet shales.

SECTION 7
PLATTE CO.

Up an eastern fork of the branch on which last Section was made we observed

1—15 feet thinly stratified buff sandstone.

2—10 inches shaly coal, containing *Cordaites.*

3—4 feet fire-clay and shales.

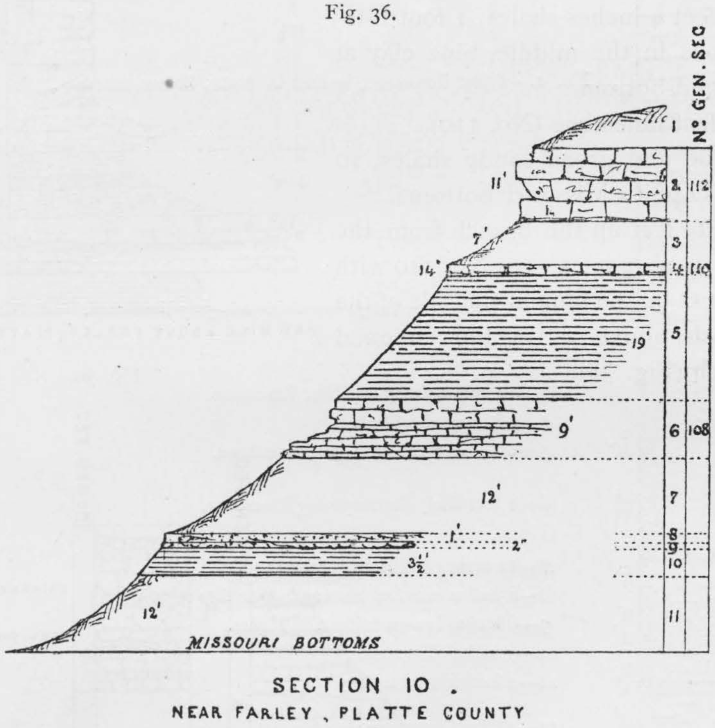
4—15 feet sandstone.

5—13½ feet shelly limestone (112 of Gen. Sec.)

6—3 feet 3 inches shales, with 8 inches of bituminous shale near the middle.

7—4 feet limestone (110 of Gen. Sec.)

Fig. 36.



SECTION 10.
NEAR FARLEY, PLATTE COUNTY

Section 10. (See Fig. 36.)

No. 1—Slope.

2—11 feet limestone (112).

3—7 feet shaly slope.

4—14 inches limestone (110).

5—19 feet shales.

6—9 feet limestone (No. 108). Contains *Retzia*, *Productus Prattenianus*, *Productus symmetricus* and *Edmondia*.

7—12 feet slope.

8—1 foot brown sandstone.

9—2 inches sandstone conglomerate.

10—3½ feet shales.

11—12 feet slope to Mo. bottoms.

One mile further, No. 108, is at level of river bottoms, and three-quarters of a mile further is the following Section:—(See Fig. 37.)

12½ feet limestone (No. 112).

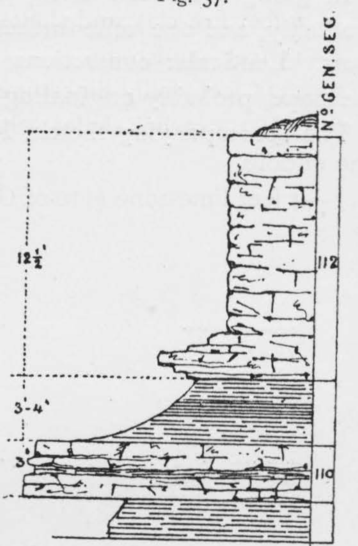
3 feet 4 inches shales, 1 foot bituminous in the middle, blue clay at top and bottom.

3 feet limestone (No. 110).

Blue and green sandy shales, 10 feet slope to Missouri bottoms.

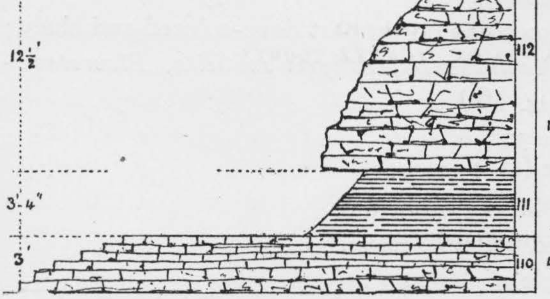
Fifty feet up the branch from the last, water passes over No. 110 with No. 112 on the bluff at the side of the branch above as in the annexed sketch (Fig. 38).

Fig. 37.



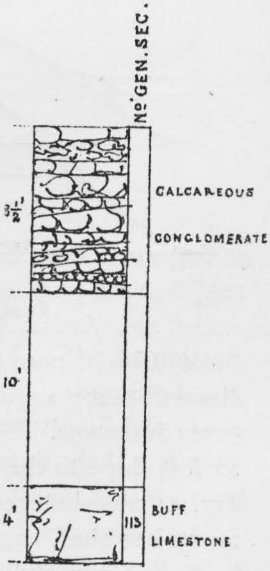
ONE MILE ABOVE FARLEY, PLATTE CO

Fig. 38.



ONE MILE ABOVE FARLEY
PLATTE CO.

Fig. 39.



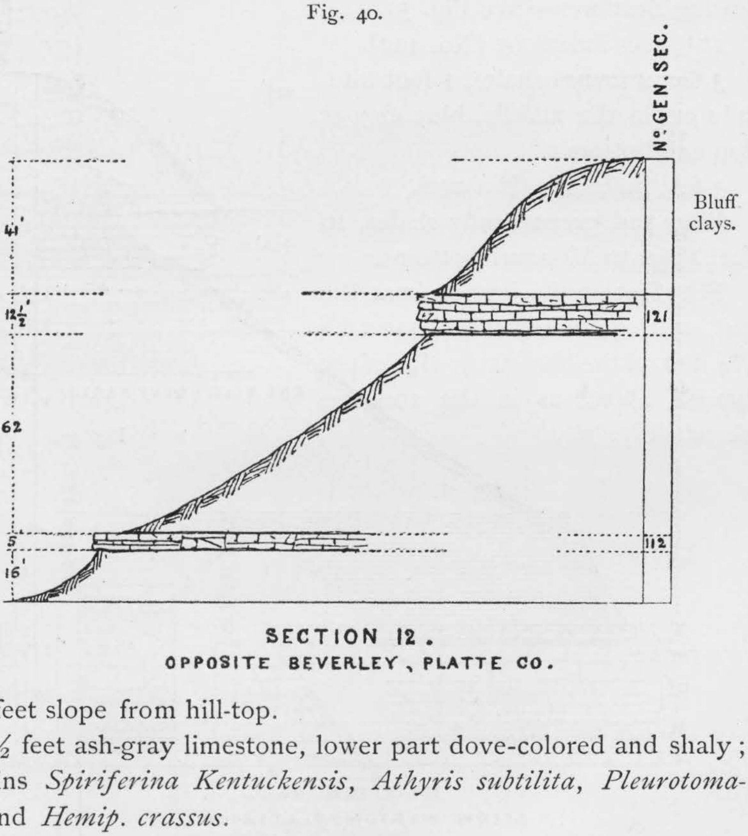
SECTION
1½ MILES ABOVE
FARLEY, PLATTE CO.

Half a mile further is a similar waterfall, and a quarter of a mile beyond our rocks appear to have changed somewhat and are as shown in Fig. 39.

In going westward along the bluffs we find these beds rising gradually, and one mile further, No. 112 is 19 feet above the bottoms. Lenticular concretions of iron carbonate are found along the slope, probably originating from the shale beds just above.

The accompanying sketch, Fig. 40, was taken opposite *Beverly*.

Fig. 40.



SECTION 12.
OPPOSITE BEVERLEY, PLATTE CO.

41 feet slope from hill-top.

12½ feet ash-gray limestone, lower part dove-colored and shaly; contains *Spiriferina Kentuckensis*, *Athyris subtilita*, *Pleurotomaria*, and *Hemip. crassus*.

Slope 62 feet; angle 30°.

5 feet limestone.

16 feet slope to the Missouri bottoms.

Fig. 41 was sketched below Weston.

1—25 feet bluff, angle of slope 40°.

2—15 feet perpendicular escarpment of No. 121.

3—50 feet slope, angle 35°.

4—23 feet dark drab shales.

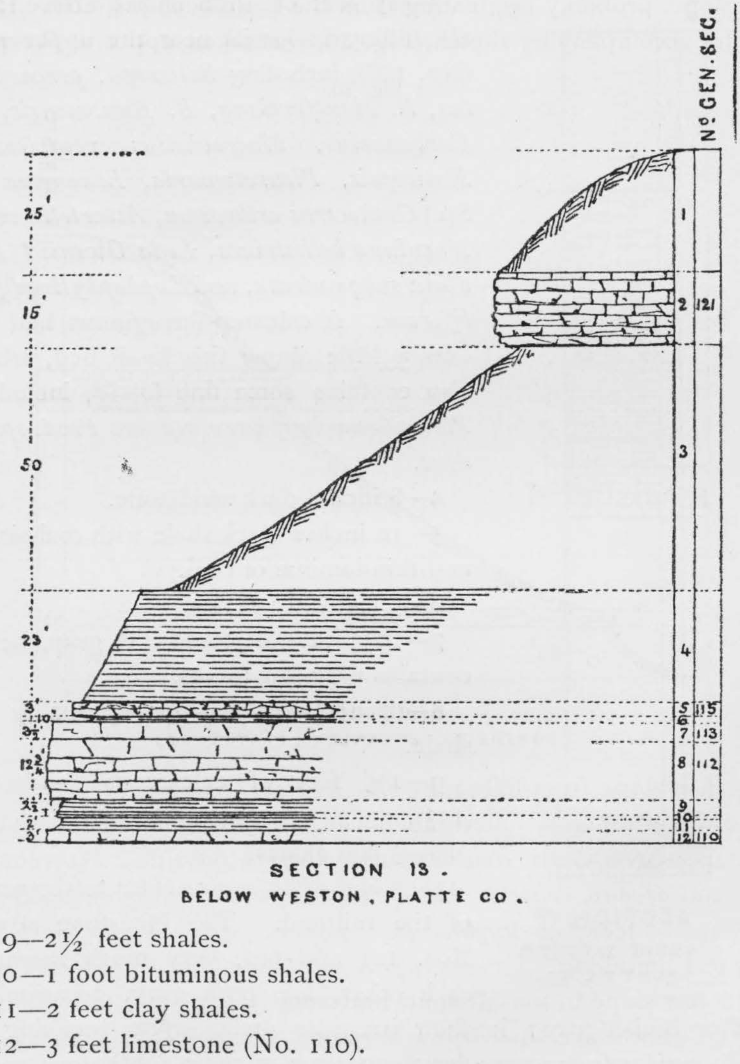
5—3 feet arenaceous calcareous bed with fossils (115).

6—10 inches shales.

7—3½ feet buff limestone (113).

8—12¾ feet limestone (No. 112).

Fig. 41.



SECTION 13.
BELOW WESTON, PLATTE CO.

9—2½ feet shales.

10—1 foot bituminous shales.

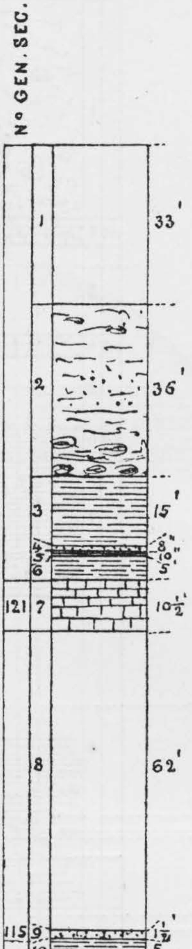
11—2 feet clay shales.

12—3 feet limestone (No. 110).

No. 5 (115 of Gen. Sec.) contains *Myalina subquadrata*, *Hemipronites crassus*, *Chonetes Verneuiliana*, *Productus Prattenianus Bryozoa*, *Crinoid* stems and a dark winding *fucoid*.

No. 112 is bluish gray, containing *Fusulina cylindrica*, *Archæocidaris*, *Prod. splendens*, *Spiriferina Kentuckensis*.

Fig. 42.



SECTION 17
ABOVE WESTON
PLATTE CO.

The section just above Weston is as follows:—Fig. 42.

1—33 feet marly clays of bluff or loess.

2—36 feet drift.

3—15 feet of drab shales (No. 125), abounding in fossils near the upper part (No. 126), including *Belleroph. percarinatus*, *B. Montfortiana*, *B. Kansasensis*, *B. Carbonarius*, *Macrocheilus ventricosus*, *Naticopsis*, *Pleurotomaria*, *Loxonema* (2 Sp.) *Orthoceras cribrosum*, *Astartella vera*, *Nuculana bellistriata*, *Leda Owenii ? Myalina subquadrata*, and *Lophophyllum proliferum*. A calcareo-ferruginous bed occurs a little above this fossil bed, which also contains some fine fossils, including *Pleurotomaria sphærulata* and *Prod. splendens*.

4—8 inches dark sandstone.

5—10 inches black shale with coal plants and thin laminæ of coal.

6—5 feet drab shales.

7—10½ feet limestone (121), gray, shelly, contains very few fossils.

8—62 feet shaly slope—probably all shale.

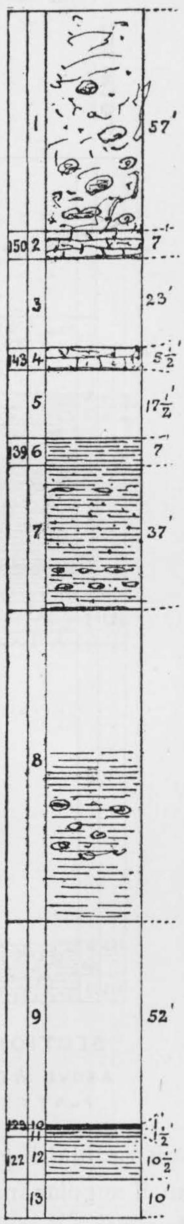
9—1½ feet of calcareous sandstone (115).

10—5 feet shales.

11—5 feet of limestone (112) to the grade of the railroad. The limestone strata, Nos. 121 and 112, very much resemble each other, are both gray, occasionally buff or bluish-gray; in their irregular shelly layers breaking in small angular fragments; by comparison of their contiguous rocks they can be easily distinguished. In Sections 12, 13 and 17, both strata are exposed.

The following (Sec. 19), Fig. 43, is appearance of Section 3 miles above Weston :—

Fig. 43.



SECTION 19
PLATTE CO.

1—57 feet drift, containing boulders of granite, quartzite, greenstone, limestone of coal-measures, &c.

2—7 feet limestone (150), color ash gray, with some chert in upper part : contains *Fusulina cylindrica*, *Syntrilasma hemiplicata* and *Prod. splendens.*

3—23 feet slope.

4—5½ feet ferruginous limestone (143).

5—17½ feet shaly slope.

6—7 feet red shales (No. 139).

7—37 feet of sandy shales ; contains some ochrey concretions.

8—Coal concealed near the top, and below is 83 feet of slope—35° to 45° ; occasional flags of sandstone and shales are seen, together with some Septaria. The lower 40 feet is shale.

9—52 feet to terrace, 35° slope.

10—1 foot shaly coal-smut (123).

11—1½ feet black and blue laminated shales.

12—10½ feet shales (122).

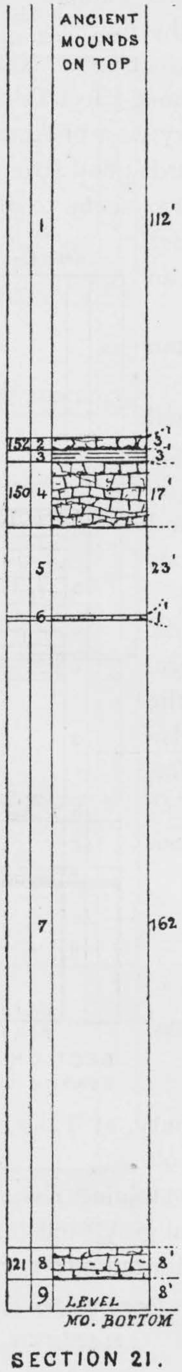
13—10 feet slope to railroad. Limestone (121) is probably concealed here.

The limestone No. 121 appears to be nearly horizontal and at same elevation for 1½ miles above Weston. A half-mile above Bear Creek it is 67½ feet above the bottoms ; at Sec. 19 not over 10 feet above ; a quarter of a mile further it is 20 feet above ; at Jatan only the upper half is exposed and 1½ miles above it dips beneath the horizon.

One and a half miles above Jatan we measured the bluffs and found them 335 feet high, with the following Sec. No. 21, Fig. 44. No. 2 here consists of 3 feet even-bedded lime-

Fig. 44.

NO. GEN. SEC.



SECTION 21.
PLATTE CO.

stone, gray and silicious containing *Fusulina* and *Myalina* (152).

No. 3 is three feet of shales.

No. 4—17 feet of ash gray, irregularly bedded limestone, containing *Chonetes granulifera, Productus Nebrascensis, Pinna peracuta, Allorisma* ——, *Bellerophon Montfortianus, Fusulina cylindrica.* This limestone also contains concretions of blue chert (No. 150).

No. 6 is one foot of limestone.

No. 8—8 feet of limestone (No. 121).

No. 9—8 feet to Missouri bottoms.

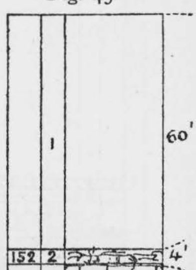
No. 4 of this Sec. (No. 150 of Gen. Sec.) was first observed 3 miles above Weston, and again high in the bluffs above Jatan and northwardly and westwardly; it is extensively quarried in the hills north of St. Joseph, is the highest rock seen at Amazonia, is well developed just above and on the railroad west of the mouth of Nodaway river and dips beneath the Missouri one mile above. It crops out in the hills of One Hundred and Two river and its branches near Savannah, on Niagara Creek, Andrew County, and Island Branch in Gentry County. The layers are not often over 6 inches thick—but some near the lower part are 2 feet in thickness. They are nearly always separated by partings of buff shales. It is easily recognized both from its fossils, irregular thickness of beds and persistent concretionary chert layers. Some portions are said to make good hydraulic cement.

No. 152 lies just above the last, separated by only a few feet of shales, and occurs in very even layers; the color is dark bluish gray, weathering drab. It abounds in *Fusu-*

lina cylindrica, and generally has a one to two inch deposit of carbonate of iron and lime resting on the upper surface. Below Block's Mill a similar layer occurs beneath the limestone. This limestone is found at most places where No. 150 occurs. Near the Platte and Buchanan county line it is only about 3 feet thick; at Lander's quarry it is 8 to 9 feet, and at a quarry west of Amazonia 14 feet. It is often cross laminated. It affords good strong and durable rock for building. *Lamella branchiata* seem to be the most abundant class of fossils found. The species observed were 2 of *Myalina*, a *Monoptera* and an *Aviculopecten*.

Near County line of Platte and Buchanan we have in Sec. 22 the following :—Fig. 45.

Fig. 45.



SECTION 22
PLATTE CO.

No. 2 is 4 feet slope, on which are tumbled masses of limestone corresponding to No. 152, containing *Myalina Swallovi*, *Aviculopecten occidentalis*, *Hemipronites crassus*, *Bellerophon* and *Fusulina cylindrica*. The limestone is sometimes oölitic.

No. 3 is 35 feet of limestone in irregular beds, separated by buff shaly partings, and with occasionally blue chert in lenticular forms. On the top it abounds in *Fusulina cylindrica*, and also contains *Bellerophon*, *Chætetes?* *Athyris subtilita*, *Productus Prattenianus*, *Prod. Nebrascensis*, *P. costatus*, *Syntrilasma hemiplicata* and *Allorisma regularis*.

No. 4 is 5 feet blue and bituminous shales.

5—36 feet slope.

6—Fragments of brown conglomerate.

8—3 feet clay shales,—olive-colored.

9—8 inches bituminous coal.

10—1 foot clay.

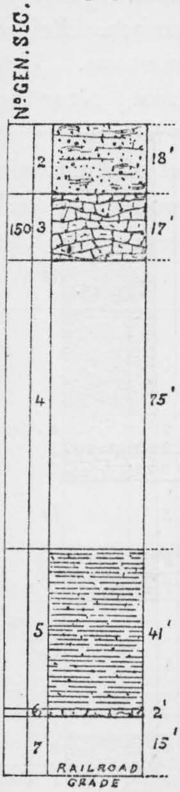
Near the south-east corner of Buchanan County, at Tank, opposite Sugar Creek Lake, we made Sec. 26, Fig. 46.

On No. 1 are fragments of buff limestone containing *Fusulina*.

2—Is 18 feet of thinly stratified hard buff and gray sandstone.

3—Is 17 feet of rough irregularly bedded limestone; has some black chert (No. 150).

Fig. 46.



SECTION 26.
BUCHANAN CO.

4—75 feet slope, with red shales about five feet from bottom.

5—41 feet sandy shales.

6—2 feet dark-colored, evenly bedded ferruginous limestone, rough fracture, weathers red, upper and lower bed 9 inches thick, with a shale band beneath the upper layer (128).

7—15 feet slope to railroad.

Near the upper end of Sugar Creek Lake we made Sec. 27.

No. 1—Top slope.

2—18½ feet of limestone (No. 150).

3—77 feet shaly slope.

4—Outcrop of coal.

5—40 feet to railroad.

In the Missouri bluffs, 2 miles above Rushville, No. 150 is 122 feet above the railroad. It presents here about the same characteristics as at other places, occurring in irregular layers of buff, brown and gray limestone, from 4 to 6 inches thick, separated by buff shaly partings.

From the north line of Platte County to the county line of Andrew there are but few exposures of rock low in the hills, but Nos. 143 and 150, and occasionally 152, are seen a hundred feet or more above the base.

No. 128 was only positively recognized near St. Joseph. The following Section was taken 2½ miles below St. Joseph :—(Sec. 31, Fig. 47.)

No. 1—72 feet bluff.

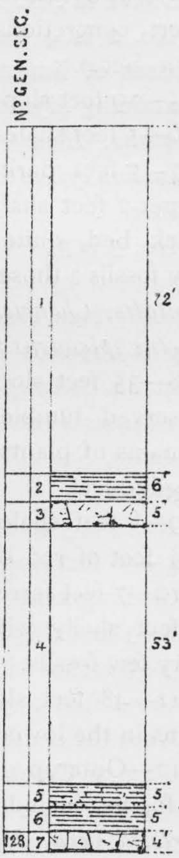
2—6 feet sandy shales.

3—5 feet ferruginous limestone.

4—53 feet slope.

5—5 feet shales.

Fig. 47.



SECTION 31
BUCHANAN CO.

6—5 feet red and green shales.

7—4 feet even-bedded bluish gray limestone, containing *Spirifer cameratus* and *Athyris subtilita* (No. 128).

The section at King's hill, Fig: 48, below St. Joseph, is :—

No. 1—72 feet, marly clays of bluff.

2—8 feet sand.

3—2 feet white calcareous concretionary bed.

4—7 feet limestone irregularly bedded, abounds in *Fusulina*, also contains *Retzia punctulifera*, *Orthis carbonarius*, *Crinoid* stems, blue chert concretions and calcite specks (150 of Gen. Sec.).

5—19 feet slope.

6—5 feet shales.

7—7 feet dark brown limestone (No. 143), upper 2 feet shaly, light drab ; next below is a thick bed, quite ferruginous. Contains very few fossils ; those seen were *Aviculopecten occidentalis*, *Chonetes*, *Hemipronites crassus*, *Productus splendens* and *Fusulina cylindrica.*

8—35 feet slope. On the lower part were observed tumbled masses of sandstone with remains of plants probably *Lepidostrobus* and a flaglike leaf.

9—8 feet shales ; lower, 2 feet green, with 1½ feet of red overlying.

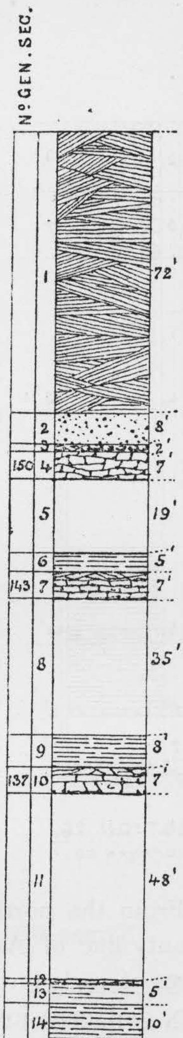
10—7 feet ferruginous limestone (137), upper 2 feet shelly with crust of iron oxide. Has very few fossils.

11—48 feet slope ; some ironstone concretions in the lower shales.

12—Outcrop of shaly limestone abounding in fossils, including *Nuculina bellistriata*, *Astartella vera*, *Myalina subquadrata*, *Hemipronites crassus*, *Bellerophon Kansasensis*, *&c.*

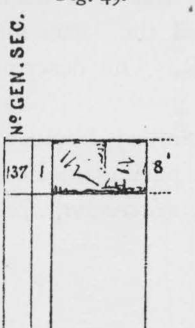
13—5 feet shaly slope.

Fig. 48.



SECTION 34.
BELOW ST. JOSEPH.

Fig. 49.



SECTION 36.
BUCHANAN CO.

14—10 feet red and green clay shales; 4 to 4½ feet red shales at the top; at the bottom are 4 feet of green ochrey shales; occasional thin bands of yellow ochre concretions and streaks of yellow ochre occur in shales.

15—4 feet limestone (No. 128).

16—80 feet shales; has streaks of yellow ochre; lower part sandy.

One and a half miles above St. Joseph, No. 137 projects from the bluffs 10 feet in thickness, in one bed, at 92 feet above the railroad, which winds along the base of the bluffs. At this place it is gray, slightly ferruginous, and breaks into small angular fragments.

Three Miles above St. Joseph.

SECTION 36. (See Fig. 49.)

No. 1—8 feet thick bed of limestone (No. 137).

2—70 feet slope.

3—Outcrop of shelly limestone abounding in fossils (132).

4—18 feet shaly slope.

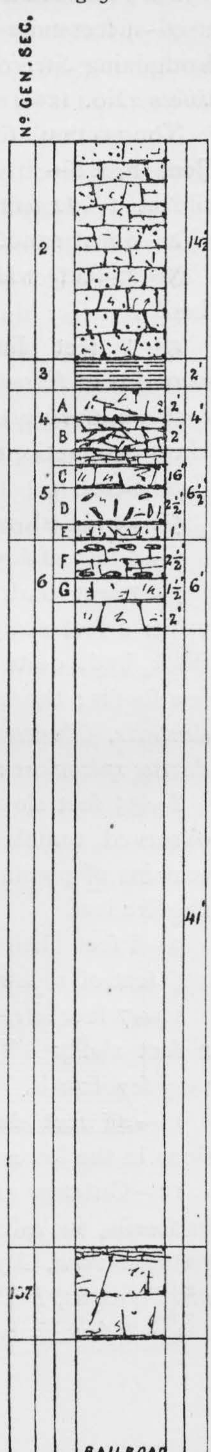
5—2 feet shales.

6—3 feet 4 inches jointed limestone (No. 128).

At Zimmerman's Quarry, 1½ miles west of Amazonia (See Fig. 50), Nos. 150 and

Fig. 50.

SECTION AT ZIMMERMAN'S QUARRY, ANDREW CO



152 are both well exposed. Certain layers of the first have been used successfully in making hydraulic cement, and the latter for bridge masonry on the K. C. St. Jo. & C. B. R. R. Our descriptive section is—1st top slope overlying,

No. 2—14½ feet of oölitic limestone with splintery fracture. Beds rest directly on each other without any shale partings. Fossils are, *Schizodus*, *Monoptera*, *Myalina Swallovi*, *Macrodon*, *Spirifer cameratus*, *Lingula* and *Fusulina*.

No. 3—2 feet shales.

4A is 2 feet blue and brown limestone.

4B—2 feet blue and brown shelly; abounds in *Productus Nebrascensis*.

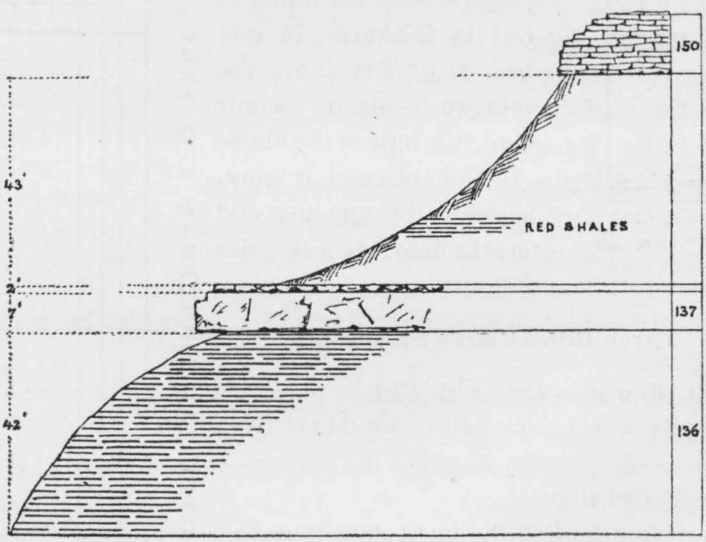
38—5 upper 3 inches blue, below 2 inches shaly limestone.

5C—16 inches brown and blue limestone.

5D—2½ feet limestone; abounds in Fusulina.

5E—1 foot brown with *Fusulina*.

Fig. 51.



SECTION 37 AT AMAZONIA
ANDREW CO.

Limestone, No. 150.
43 feet slope.
2 feet nodular limestone.
7 feet gray limestone, 137.
42 feet shales, No. 136.

6F—2½ feet alternations brown and blue chert, concretions near middle; contains *Fusulina*, *Chætetes*, and *coral*.

6G—1½ feet mostly brown, with coral, *Fusulina*, &c.

Fossils in No. 4 are generally replaced by clear crystals of carbonate of lime, var. "dogtooth" Spar. Its fossils include *Crinoid* in scalenohedra stems, *Prod. Prattenianus*, *Sp. cameratus*, *Hemipronites*, *Athyris*, *Fistulipora*, *Chonetes*.

No. 5 includes numerous specimens of *Rhombopora*, *Fistulipora*, *Bryozoa*, *Monoptera*, *Productus Prattenianus*, *P. Nebrascensis*, *Spirifer Kentuckensis*, *Allorisma* ——, *Sp. cameratus*, *P.*

The limestones are generally blue and the fossils white, giving a pleasing contrast. We collected some fine specimens showing *Fusulina cylindrica* standing in relief on a dark surface.

No. 137 is last seen here.

A little East of Nodaway River is Sec. 47.

No. 1 is ancient mounds on top.

3—11 feet gray limestone in thin irregular beds, contains *Athyris* and a coral (No. 186).

4—130 feet slope.

5—2 feet brown limestone.

7—2 feet ash-blue shelly limestone.

9—12 feet limestone, No. 150.

10—3 feet shales, chocolate-colored, sandy.

11—2 feet dark-brown and black shales.

12—2 feet limestone in four thin and irregular beds.

13—4 feet blue shales to water in Nodaway river.

One Mile West of Nodaway River No. 150 sinks beneath the Missouri.

Sec. 49 was taken at the latter place and is as follows:—(See Fig. 52.)

No. 1—Slope of 25 feet from the hill-top—no rocks seen. Mound on top.

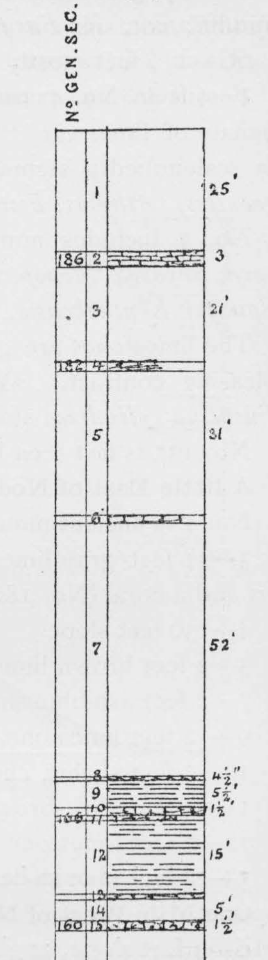
2—3 feet irregularly bedded buff and gray mottled limestone (186).

3—21 feet slope—outcrop of soft buff limestone, with brown ochrey concretionary spots and streaks (182).

5—Is 31 feet slope, outcrop of buff and drab limestone at the lower part.

7—52 feet slope.

Fig. 52.



SECTION 49
HOLT CO.

8—4½ inches of nodular decomposing soft drab limestone; contains *Athyris subtilita* (large var.) and *Bellerophon.*

9—5½ feet shales.

10—1½ feet of drab limestone abounding in *Fusulina.*

11—Outcrop of brown decomposing limestone (166).

12—15 feet shaly slope.

13—Outcrop of brown shaly limestone.

14—5 feet slope.

15—1½ feet of dark olive-colored limestone, somewhat brown tinged (160).

16—23 feet slope.

17—6 inches shaly dark bluish ash limestone.

18—1 foot greenish drab limestone, with dark calc-spar lines.

19—5½ feet shales (153).

20—3 feet coarse, tough, hard, dark ash-gray limestone (152).

21—2 feet to railroad grade, and 150 feet west base. No. 20 is at grade.

22—12 feet shaly slope.

23—9 feet limestone (No. 152) to water in the Missouri river.

Three-quarters of a mile west, No. 17 of above Sec. (154 of Gen. Sec.) is near the railroad grade and rises and falls above and below the grade for about a mile, when it is last seen. Nearing Forbes, No. 160 (15 of Sec. 49) appears at 15 feet above the railroad.

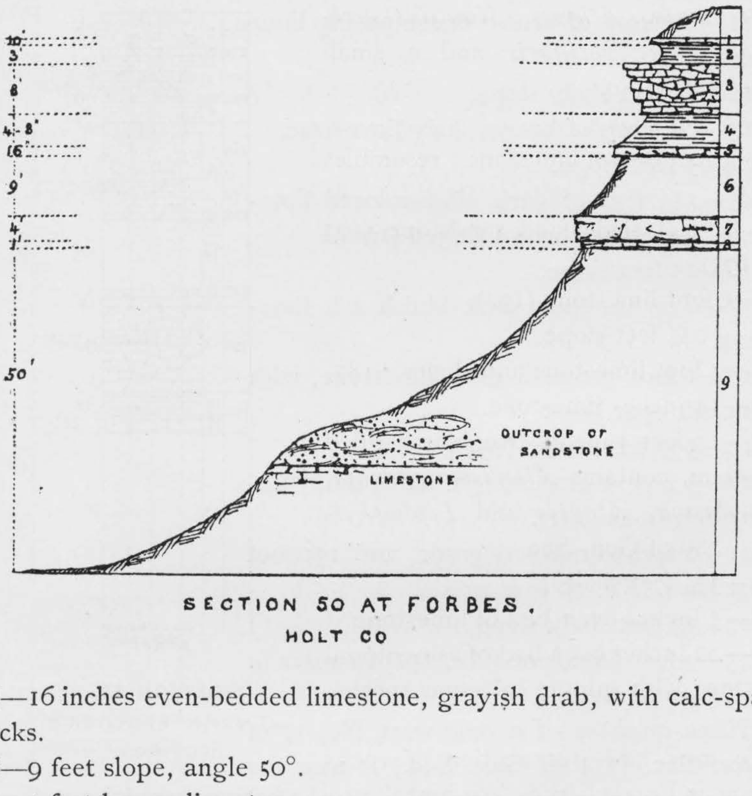
Sec. 50 (See Fig. 53)—No. 1—10 inches ash-blue limestone, upper part weathers brown; contains *Allorisma* and *Productus Prattenianus.*

2—3 feet yellow shales, full of *Fusulina.*

3—8 feet irregularly bedded ash-gray and buff limestone, with buff shaly partings. Contains *Fusulina*, *Lophophyllum*, *Athyris*, *Syntrilasma*, *Retzia punctilifera*, *Spirifer cameratus*, *Sp. Kentuckensis*, *Fistulipora*.

4—4 feet 8 inches shaly slope, angle 45°.

Fig. 53.



SECTION 50 AT FORBES.
HOLT CO

5—16 inches even-bedded limestone, grayish drab, with calc-spar specks.

6—9 feet slope, angle 50°.

7—4 feet brown limestone.

8—1 foot soft brown limestone.

9—50 feet slope.

Rocks of the last section are occasionally seen to within one mile of Forest City, where they give place to a higher group.

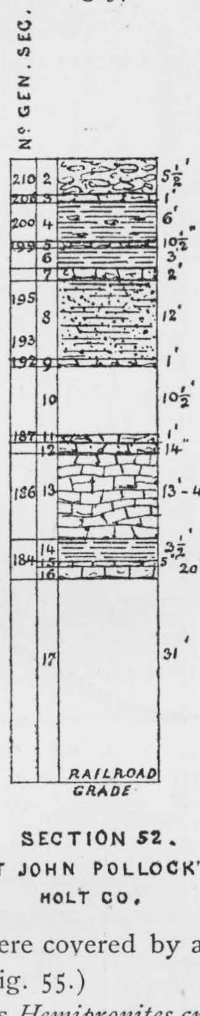
Sec. 52, at John Pollock's, 4 miles below Forest City, appears thus:—(See Fig. 54.)

No. 1—Bluff formation.

2—5½ feet nodular limestone, contains *Chonetes* and *Athyris subtilita* (No. 210).

3—1 foot dark ash-blue limestone; abounds in *Hemipronites* *crassus*, *Athyris subtilita*, *Productus Nebrascensis* and *Myalina subquadrata* (206).

Fig. 54.



SECTION 52.
AT JOHN POLLOCK'S
HOLT CO.

4—6 feet green shales, with limestone nodules (200).

5—10½ inches brown limestone; contains *Productus Nebrascensis*, *Prod. Prattenianus*, *Athyris*, *Nautilus occidentalis*, *Archæocidaris* and a small *Allorisma*. (199).

6—3 feet shales.

7—2 feet brown limestone; resembles No. 5.

8—12 feet shales and sandstone (193 and 195).

9—1 foot limestone (192).

10—10½ feet slope.

11—1 foot limestone and shales. 187.

12—14 inches limestone.

13—13 feet 4 inches irregular-bedded limestone, contains *Allorisma granosa*, *Syntrilasma*, *Athyris* and *Lophophyllum*. 186 of Gen. Sec.

14—3½ feet shales.

15—5 inches even bed of limestone.

16—20 inches even bed of ash-colored limestone with minute calc-spar specks. 184.

We now add our section of rocks seen near Forest City. We find the rocks here covered by a deep bluff deposit, below which are seen—(See Fig. 55.)

220—1 foot brown shaly limestone, contains *Hemipronites crassus*, *Prod. Prattenianus* and *Fusulina cylindrica*. Beneath is 4 inches grayish-blue layer of carb. of lime and iron.

219—4 feet shales.

218—Eighteen inches of ash-blue silicious and pyritiferous limestone, abounding in many fine fossils, including *Entolium aviculatum*, *Syntrilasma hemiplicata*, *Platyostoma*, *Nautilus*, *Terebratula bovidens*, *Allorisma*, etc. Below this is 0 to 4 feet shales, then

217—10 to 16 inches sandstone.

216—0 to 30 inches bituminous shales ; then 2 inches sandy clay, resting on

215—4 inches coal.

214—2 feet light-blue clay shales.

214—2 feet sandy shales.

25 feet shaly slope.

Shales at bottom.

210—3 inches shaly and nodular limestone.

210—1½ feet brown shales and concretionary nodules of limestone, abounding in fossils, including mostly *Fusulina cylindrica* and *Athyris subtilita*, also contains *Retzia punctilifera*, *Spirifer cameratus*, *Prod. Nebrascensis*, *Prod. Semireticulatus*, var. *Calhounianus*, *Hemipronites* and *Crinoid* stems.

210—10 inches rough concretionary limestone.

210—10 inches shales.

209—10 inches even bed of blue limestone.

207—2 feet blue shales.

206—13 inches blue limestone, abounds in *Hemipronites crassus*, *P. Nebrascensis*. In the interior of the fossils are often calcite crystals, sometimes of dog-tooth variety.

205—10 feet shales.

199—1½ feet ash-blue limestone, weathers brown.

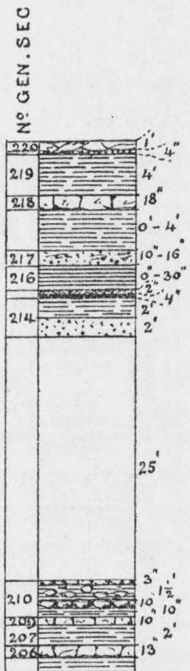
2 feet 10 inches yellow shales, gray streaks.

197—1½ feet of brown limestone.

196—7 feet yellow shales; bands of bituminous shales at the lower part.

193—2½ feet of sandstone.

Fig. 55.



GENERAL SECTION
FOREST CITY
HOLT CO.

192—1 foot 9 inches of grayish-blue limestone.

191—5 inches shales.

190—6½ inches gray limestone, abounds in many fine univalves.

189—3½ feet blue shales.

4 inches even layer of deep-blue limestone.

8 feet blue shales. At the base of this, and resting on No. 186, is a calcareous stratum, abounding in *Archæocidaris*, *Rhombopora*, etc. Limestone No. 186 is near the base of the hill, but is generally concealed.

We have thus far steadily witnessed the appearance of different strata high in the bluffs, and have seen them gradually become lower in ascending the Missouri valley, until we have left behind and beneath us many hundred feet of upper coal-measure rocks. At the west line of Andrew County, just east of Nodaway River, No. 186 is 205 feet above the Missouri bottoms. One and a half miles west it is 170 feet above. At Forbes, 3 miles west of the latter, it is only 70 feet; 4 miles further, and north-west, at Jno. Pollack's, it is 36 feet above; 3 miles further, a little west of north of the latter, and near Forest City, it disappears beneath the horizon.

Our Forest City Section will include all the different strata found at and near that place. Of course the different strata are not all exposed at any one place, but they occur in such a manner that the principal beds are easily recognized, and the subordinate layers can be connected by vertical measurements in different localities.

The upper "spathic limestone" (No. 220) was seen at but few places; it was observed one and a half miles above Forest City, and also below the town, occurring as the highest well-marked rock. The bed of carbonate of iron externally resembles an ordinary limestone, but its weight and lustre show it to be heavily charged with carbonate of iron.

No. 218 was observed one mile below and one and a half miles above Forest City, and at intermediate points. It forms the root wherever coal (215) is worked. It is from 16 to 24 inches in thickness, is dove-blue, weathers with a bright brown ferruginous crust, often 2 inches thick, and is sometimes perpendicularly jointed. It is very hard, with splintery fracture and pyritiferous. It abounds in rare and beautiful fossils, including *Edmondia*, *Entolium aviculatum*, *Macrodon*, *Lima retifera*, *Schizodus curtus*, *Allorisma granosus*, *Allorisma subcuneata*, *Solenopsis?* *Polyphemopsis inornata*, *P.*

peracuta, Platyostoma? Macrocheilus, Bellerophon Marcouianus? Naticopsis Altonensis, Terebratula bovidens, Aviculopinna Americana, Syntrilasma hemiplicata, Nautilus occidentalis; also contains *Productus Pratteniauus* and *Hemipronites crassus.*

No. 212 was not observed in the Missouri bluffs, but we reasonably suppose it to exist there in its proper geological position. It is well developed in the north-east part of Holt County and in the western part of Nodaway. Its principal fossils are, *Lingula, Pinna peracuta,* and *Aviculopinna Americana.*

About 30 feet below No. 218 are the shales and nodular limestone beds of No. 210, about 4 to 5 feet in thickness, abounding in different species of fossils, including immense numbers of *Fusulina cylindrica,* often weathered out and strewn over the surface, resembling scattered wheat-grains. *Athyris subtilita* is also very abundant. Its other fossils include *Hemipronites crassus, Productus Nebrascensis, Productus symmetricus, Prod. splendens, Prod. semireticulatus,* var. *Prod. Calhounianus, Spirifer cameratus, Terebratula bovidens, Retzia punctulifera, Rhombopora lepidodendroides, Lophophyllum proliferum, Fistulipora nodulifera, Scaphiocrinus hemisphericus, Zeacrinus mucrospinus,* and *Bryozoa.*

The blue limestone, No. 209, at the base of the last-named beds, is also easily recognized, containing but a few fossils, but well-marked ones, principally a large var. of *Hemipronites crassus* and *Prŏd. Nebrascensis.* The interior of these fossils is generally clear, crystallized calcite.

The following Section (See Fig. 56) at Iowa Point, Kansas, nearly opposite Forest City, includes most of the beds seen at the latter place, but presents slight variation in thickness and general appearance.

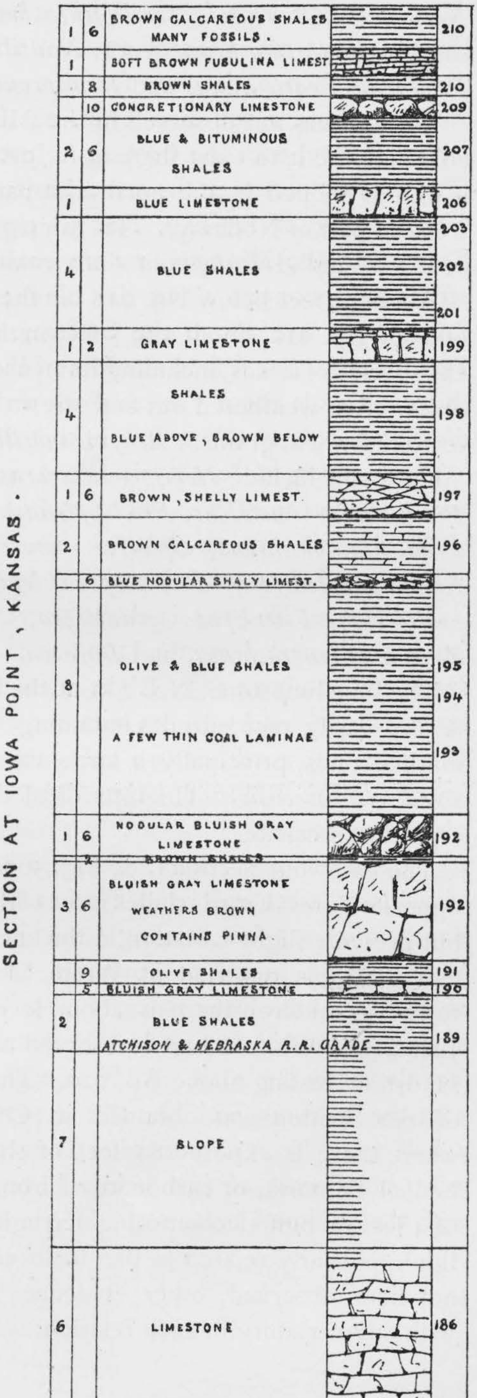
No. 218 is quarried at White Cloud, Kansas, just below the town; its outcrop there is about level with the Missouri bottoms. Just above White Cloud I observed a thickness of 61 feet of shaly sandstone resting above No. 220. The further upward connection of our Section was obtained at City Bluffs, Nodaway County, where there is exposed 84 feet of shales, containing an occasional bed of Septaria, or carbonate of iron. Above these is an outcrop of 4 feet of buff decomposing ferruginous limestone. This last, I think, is nearly related to the Rulo coal-bed ; but as the coal was not here observed, other evidences are too indefinite to place it with any certainty in such relation.

From near Forest City, for 20 miles northward along the Missouri bluffs, no outcrops of the rock are seen, and the connection of the Forest City with the Atchison County rocks is broken. The next exposures are found at McGuilliam's Mill, near the north line of Holt County. The upper beds in Atchison County were all correctly connected. An examination of some nearly related strata west of the Missouri river failed to supply the broken link in the chain, but there is probably 40 or 50 feet between the lower and upper rocks. Under a separate head I shall endeavor to trace the relation of the Nebraska beds with those of Missouri. The upward extension of this Section will be found in my Report on Atchison County.

Dip of Rocks.

Along the Missouri bluffs, within the limits of the Upper Coal-Measures, I have observed no remarkable dip nor disturbance of strata, but the dip is regularly north of west.

Fig. 56.



Nos. 78 and 80 of our General Section, as stated in first part of this report, are seen in the bluffs a half-mile west of Albany, Ray County, at an elevation of 130 feet above the bottoms. Tracing these beds thence, they are found regularly lower and lower in the bluffs until we reach Randolph, 24 miles west, where the upper surface is level with the bottoms. Just across the river, in Kansas City, No. 80 occupies the same horizontal position, and at an elevation above of 127 feet, No. 98 projects in bold escarpments. Recrossing the Missouri, we are enabled to trace No. 98 by its occasional outcrops along the bluffs; its top bed west of Brush Creek is 38 feet above the bottoms, and 90 feet below No. 108. Two miles further it is at the foot of the hill, and No. 108 is 94 feet above. This is about 5 miles north and 16 miles west of Randolph, showing a descent of 127 feet in that distance.

The last-named locality is about a mile below Waldron. We here find the top of No. 113 at 25 feet above No. 108. Along the bluffs, six miles north-west of this, No. 108 is at the edge of the bottoms, and shows a descent of 94 feet in six miles.

At Weston, No. 113 is about 5 feet above the bottoms, and we find a north-west descent of 109 feet in 16 miles. At this point No. 121 is 76 feet above 113. Eight miles north-west, or one mile above Jatan, it is on level with the bottoms, and No. 150 is 186 feet above. Ten miles due north, or two miles above Rushville, No. 150 is 122 feet above the Railroad, being depressed in that distance 44 feet, which may probably be about the natural descent of the Missouri Valley. From this point to St. Joseph, a distance of 13 miles, the trend of bluffs is north-east, and 2 miles below we find No. 150 at an elevation of 175 feet, having risen 43 feet in that distance. The bluffs from St. Joseph to Amazonia, 10 miles, bear a very little west of north. At the latter place, No. 150 is 94 feet above the Railroad, having descended 81 feet in that distance. One mile west it is 54 feet above the Railroad. At Nodaway River, 6 miles west, it is level with the bottoms, and No. 186 is 197 feet above. One mile and a half west, No. 186 preserves about the same elevation, and ten miles north-west, or just below Forest City, it is about on a level with the Missouri bottoms.

CONDENSED VERTICAL SECTION OF MISSOURI COAL MEASURES.

G. C. BRDADHEAD.

Series	Nº	Space Feet	Space In.	Description	Locality	Total from Top Feet	Total from Top In.	Total from Base Feet	Total from Base In.
Upper Coal Series								1887	—
	1	339	—	Space					
	2	—	12	Coal	Holt Co. West Part of Nodaway Co.	339	—	1548	—
	3	392	—	Space		340	—	1547	—
	4	—	12	Coal	De Kalb, Andrew, Buchanan & Platte Cos.	732	—	1155	—
	5	207	—	Space		733	—	1154	—
	6	—	10	Coal	Platte Co.	946	—	941	—
	7	379	—	Space		946	10	940	2
Middle Coal Series	8	—	3	Coal	Pleasant Hill, Missouri City & Princeton	1319	10	567	2
	9	164	—	Space		1320	1	566	11
	10	—	12	Coal	Cass, Johnson, Lafayette and Livingston Cos.	1484	1	402	11
	11	70	—	Space		1485	1	401	11
	12	2	—	Lexington Coal	Lafayette, Johnson & Ray Cos	1555	1	331	11
	13	36	—	Space		1557	1	329	11
	14	—	7	Coal	Lafayette & Ray	1593	1	293	11
	15	14	—	Space		1593	8	295	4
	16	—	21	Coal	Lafayette, Johnson, Carroll & Livingston Cos.	1607	8	279	4
Lower Coal Series	17	90	—	Space		1609	5	277	7
	18	—	18	Warrensburgh Coal	Johnson, Henry & Chariton Cos.	1699	5	187	7
	19	52	—	Space		1700	11	186	1
	20	—	7	Coal	Johnson Co.	1752	11	134	1
	21	18	—	Space		1753	6	133	6
	22	—	20	Coal	Johnson Co.	1771	6	115	6
	23	18	—	Space		1773	—	114	—
	24	—	8	Coal	Johnson Co.	1791	—	96	—
	25	4	—	Space		1791	8	95	4
	26	2	—	Coal	Johnson, Henry, Macon Cos.	1795	8	91	4
	27	48	—	Space		1797	8	89	4
	28	4	5	Coal	Johnson, Henry, Bates, Vernon, Chariton, Randolph, Boon, Callaway, Adair, Sullivan, Putnam & Macon	1845	8	41	4
	29	11	—	Space		1850	1	36	11
	30	—	11	Coal	Johnson, Henry & Macon Cos.	1861	1	25	11
	31	13	—	Space		1862	—	25	—
	32	2	—	Coal	Henry, Johnson, Pettis & Saline Cos.	1875	—	12	—
	33	10	—	Space		1877	—	10	—
						1887	—		

CHAPTER V.

ECONOMIC GEOLOGY OF THE COAL-MEASURES.

CATALOGUE OF COAL-BANKS EXAMINED BY G. C. BROADHEAD DURING THE YEAR 1872.

IN HENRY COUNTY.—LOWER COAL-MEASURES.

	Thickness.		Locality.	Owner and Remarks.
	Feet.	Inches.		
1	2	8	Sec. 25, T. 41, R. 26, near base of coal-measure.	C. W. Jordan.
2		6	Gilkerson Ford, on Grand River.	Near base of coal-measures.
3	1	6+	Gilkerson Ford, on Grand River, said to be 3 feet.	
		2	Gilkerson Ford.	
3		10	Jackson's Mill.	
		1	do.	
4	1	9	2 miles S. E. of Clinton.	Benj. Owens.
5	2	6	N. E. Sec. 29, T. 42, R. 26.	—— Hancock.
6		4	N. E. N. W. Sec. 29, T. 42, R. 26.	
7	2	6	S. W. S. E. Sec. 20, T. 42, R. 26.	Williams & Odle, 27 to 30 inches coal.
8	2	3	N. E. N. E. Sec. 29, T. 42, R. 29.	Geo. M. Britts.
9	2	6	N. W. N. W. Sec. 32, T. 42, R. 29.	Judge Munson.
10	2		Clinton.	Rotten coal.
11	1	6	2½ miles S. W. of Calhoun.	Osage Coal Co.
	2	4	do. do.	do. do.
C. J. N.	2	4	S. W. ¼ Sec. 17, T. 42, R. 24.	Munn's.
13	3		2½ miles E. of Calhoun.	Henry Neff.
	2	6	Same loc. as last.	And same coal.
14	1	10	Sec. 22, T. 43, R. 24.	T. Dillon's.
15		8½	S. E. N. E. Sec. 17, T. 43, R. 24.	H. C. Mullin's.
16		10	S. W. S. W. Sec. 35, and S. E. S. W. Sec. 35, T. 44, R. 24.	Benj. Williamson's.
	3		do. do. do. do.	do. 2½ to 3 ft.
		6	do. do. do. do. These 3 veins are almost touching, one above the other.	do.
17		3	S. E. Sec. 34, T. 44, R. 24.	Ogans.
	2		do. do.	do.
18	3		3 miles west of Windsor.	P. H. Shelton's.
19	2	8	2 miles S. of Windsor, at edge of Benton Co.	B. Hughes.
C. J. N.		6	N. W. ¼ Sec. 6, T. 42, R. 23, Benton Co.	D. J. Williams.
21	1	4	Sec. 1, T. 44, R. 24.	Jno. R. Gray.
	1	4	do. do.	B. Owsley's.
22	1	2	Sec. 14, T. 47, R. 24.	Elijah Cook.
		11	do. do.	

Thickness.			Locality.	Owner and Remarks.
	Feet.	Inches.		
23	2	6	2 miles S. W. of Dunksburgh Johnson Co.	Jno. W. Porter's.
24	2		1½ miles S. W. do. do.	Jno. Parks.
25	1	4	Sec. 21, T. 48, R. 23, Pettis Co.	Dr. R. Tuck.
26	1	6	N. W. S. W. ¼ Sec. 15, T. 48, R. 23, Pettis Co.	T. Collins.
27	1	4	4 miles W. of Brownsville, in Saline Co., 10 inches rotten coal above.	Louis Bohn.
28	2		½ mile north of Concordia, Lafayette Co.	Henry Franke.
29	1	9	Mulky nines, 2½ miles E. of Aullville, Lafayette Co.	Ennis Cundiff.
30	1		Railroad Cut, 1½ miles S. E. of Aullville, Lafayette Co.	
31	1	6	2½ miles N. E. of Aullville, Lafayette Co.	Chas. Payne's.
32	1	7	2 miles S. E. of Lexington, Lafayette Co.	R. C. Vaughan, 19 to 22 in. Lex. Coal Co.
33	2		In Lexington, Lafayette Co.	R. G. Tucker.
C. J. N.	1	10	do. do.	Gen. Graham.
C. J. N.	1	11	E. of Stone Bridge, Lexington, Lafayette Co.	
C. J. N.	1	8	Lexington, Lafayette Co.	Tilton Davis.
C. J. N.	1	9	West of Ferry Landing, Lexington, Lafayette Co.	
C. J. N.	Lexington coal. 1	4	4 miles below Berlin, Lafayette Co.	Wollemans.
38	1		15 miles S. W. of Lexington, Lafayette Co.	Holmans.
39	1	5	Little Sniabar, 6 miles south of Lexington, Lafayette Co.	
	1		do. do. do. do.	
40		5	2 miles E. of Judge Wood's, Lafayette Co.	These beds are 34 feet 7 inches below Lexington coal.
		5	Lexington, Lafayette Co.	
41		8	2 miles below Lexington, Lafayette Co.	
C. J. N.		7	Lexington, Lafayette Co.	
C. J. N.		9	3 miles above Waverley, Lafayette Co.	
C. J. N.		6½	At Lexington, Lafayette Co.	40 ft. above Lex. coal.
C. J. N.	1	6	10 miles N. of K. Noster, Johnson Co.	Alexander Dreer.
44	not	known.	At Sibley, Jackson Co.	In well.
45		2	On branch near Donohoe's Ford, on Little Blue, Jackson Co.	
46	not	seen.	Napoleon, Jackson Co.	Said to be 8 to 10 in.
47	1		Levissie's, near Hambright's, Jackson Co., T. 50, R. 29.	Wm. Levissie.
G. C. B.	1	6	Near E. line of Ray Co., on Mo. Bluffs.	Oberhultz.
	1	6	do. do. do. do.	Williams.
49	1	6	1 mile west of same, Ray Co.	Howell's.
50	1	8	2 miles E. of Richmond, Ray Co.	Smith's Mill.
	1	8	do. do. do.	Sear cup.
51	2		S. W. Sec. 31, T. 52, R. 27.	J. S. Hughes & Co., 22 to 28 in.
52	2		2 miles N. of R. and L. Junction, Ray Co.	C. O. Godfrey. Lexington coal.
53	2		Swanwick, Ray Co.	Thos. Hayson, 20 in. to 2 ft. coal.
54	1	11	2d Ray Co. Mines, Camden, Ray Co.	T. Collins, 18 to 24 inches.
	1	9	N. Mo. Mines, do. do.	C. O. Godfrey & Co., 19 to 22 in.
55	1	7	S. E. S. W. Sec. 6, T. 52, R. 21, Carroll Co.	James Meddlin.

Thickness.			Locality.	Owner and Remarks.
	Feet.	Inches.		
55	1	2	Are 2 seams separated by 3 feet of clay, Carroll Co.	James Meddlin.
56	2		White Rock, Carroll Co.	A. J. Kendrick.
57	1	4	2 miles west of White Rock, Carroll Co.	—— Little.
58	1		Near Hardwick's Mill, Carroll Co.	Irregular thickness.
59	1	2	4 miles E. of Carrollton, Carroll Co.	Jas. Goodron.
C. J. N.	1	6	1½ miles N. W. of Carrollton, Carroll Co.	Stanley.
G. C. B.	1	6	Miami, Saline Co.	L. W. Heeney.
62	1	6	Kirkham-bank, Chariton Co.	Cunningham.
63	1	6	8½ S. W. ¼ Sec. 33, T. 54, R. 20 W., Chariton Co.	Wm. Tyler's.
64	1	7	2½ miles N. W. of Brunswick, Chariton Co.	Linn's.
65	2		Little Compton, Carroll Co.	
66	1	8	N. E. corner of do.	On Grand River.
67	1	6	S. W. and N. W. ¼ Sec. 20, T. 56, R. 21.	Wm. Leaton's.
68	1	2	N. W. ¼ Sec. 26, T. 56, R. 22, Livingston Co.	Ch. Wurster's.
69	1	4	At Bedford, Livingston Co.	2 veins of coal.
70		3	Sec. 19, T. 56, Range 23, Livingston Co., 2 feet coal said to be in shaft.	Anton Good.
71	2		W. ½ N. E. ¼ Sec. 11, T. 58, R. 24, Livingston Co.	Abel Cox.
72	1	3	N. W. Sec. 31, T. 58, R. 22, at Collier's Mill, Livingston Co.	Mr. Collier.
	1	8	E. ½ S. E. ¼ Sec. 30, T. 58, R. 2, Livingston Co.	L. Collier.
C. J. N.	1	4	4 miles S. of Chillicothe, on Grand River, Livingston Co.	
74		10½	Graham's Mill, on Grand River, Livingston Co.	
75		3	N. of Mooresville 2 miles, Livingston Co.	Clark's.
76		10	N. E. of Mooresville 2 miles, Livingston Co.	Murray bank.
77		6	Trenton, Grundy Co.	
78		6	1½ miles S. of Princeton, Mercer Co.	
		3	do. do. do.	
79		6	5 miles do. do	At Bricky Bend.
80		3	1 mile west of Winston, Daviess Co.	
81		2	Near Bridgewater, Nodaway Co.	Jno. Lund.
82	1		12 to 16 inches N. W. of S. W. ¼ Sec. 9, T. 64, R. 37, Nodaway Co.	Jas. C. Smith.
83		11	1 mile below mouth of Sand Cr., Nodaway Co.	Burdick.
84	1		Sand Creek, Nodaway Co.	
85	1	2	Quitman, do.	
86		10	On Florida Cr., do.	Martin's.
87		4	Near Forest City, Holt Co.	
88		5	S. W. ¼ Sec. 16, T. 59, R. 36, W. Andrew Co.	Wm. Barr.
89		1½	2 miles N. E. of Savannah, Andrew Co.	
90		10	On Niagara Creek, Andrew Co.	
91		7	12 miles S. of St. Joseph, Buchanan Co.	Hinman's.

Thickness.			Locality.	Owner and Remarks.
	Feet.	Inches.		
92	1	1	Near Hall's Station, Buchanan Co.	
93		7	S. fork Sugar Creek, S. line of Buchanan Co.	
94		8	Block's Mill, Platte Co.	
95		8	2 miles below Block's Mill, Platte Co.	Rees.
96		9	Mo. Bluffs, 3 miles above Weston.	
97		10	Near Saml. Morrow's, Platte Co.	

Total......................................97 localities.

NOTE.—Localities with initials C. J. N. affixed were examined by Mr. C. J. Norwood, all others by G. C. Broadhead.

DESCRIPTIVE LIST OF BUILDING ROCKS, LIME AND HYDRAULIC LIMESTONES AND FIRE-CLAYS.

Building Rock.—Rocks suitable for most building purposes can be obtained in any of the counties of Missouri, although in some districts it has to be transported for many miles. In Atchison County they are only found *in situ* at a few places on the Missouri bluffs and a few miles off on Rock Creek, and near the east county line. In the interior the "lost rock" of the Drift period is used for the common purposes of walling wells and building foundations for houses. In Holt County also, above Forest City, rock is scarce.

BUILDING STONE OF THE UPPER COAL-MEASURES.

The following description will include such building stone as can be considered strong, durable and handsome. I would first mention the limestones. Among the coal-measure rocks it is only among the upper series that we can look for a good, strong and desirable limestone. The limestones near the horizon of a coal-bed cannot always be recommended; they are generally of an ash-blue color, and often contain iron pyrites, and the first freezing weather cracks them. The gray limestones break irregularly; the blue limestones are generally jointed by cracks perpendicular to their planes of deposit, and when exposed, as is often the case in the bed of a stream, they present the appearance of a floor paved with rhomboidal blocks. Some of the limestones, if quarried in the spring and left exposed throughout the summer, evaporate their moisture, and ensuing frosts do not seriously injure them ; whereas, if the same rock were quarried in fall or winter, it would soon crack in many directions and become worthless. Many of the limestones of the coal-measures contain iron pyrites ; such rocks near their exposed faces generally lose their sulphur, and a thick brown crust is formed on the outside, which sometimes envelops the rock in concentric bands, often several inches thick, which easily scale off.

Descriptive List.

No. 209 occurs in the bluff at **John Pollock's**, Holt County, at an elevation of 97 feet above the Missouri bottoms. One mile below Forest City it is 75 feet above, and at the lower limits of the town it is 40 feet above. At these localities it is one foot thick and affords a beautiful and strong rock.

The contained fossils generally have a lining of crystallized calcite. If polished it would look well. It is 5 and 6 inches thick near Bridgewater, Nodaway County, and at Braddy's Mill, on Nodaway River, in Iowa, and 10 inches thick near the south-west part of Nodaway County.

No. 207 is found from 2 to 2½ feet below No. 209, and is almost exactly like it in color, texture and fossil remains, but is generally of greater thickness and firmer.

Near Forest City and at Kunkell's it is 16 inches thick ; 10 inches at Smith's Mill, in Nodaway County ; 13 inches at Braddy's, and 5 and 9 inches near Bridgewater.

No. 192.—At Kunkell's Mill is an outcrop of 21 inches of bluish-gray limestone ; this bed was also occasionally observed a little below Forest City, at about 30 feet elevation above the bottoms, and generally free from weather-cracks. From present developments, I would suppose it to be a very good material for strong masonry.

No. 184 crops out at John Pollock's, 4 miles below Forest City, in two beds ; the upper, 5 inches, and the lower, 20 inches thick. It also crops out at Forbes's, 16 inches thick, and at Ohio Mills 2 feet in thickness. But wherever found it is an even-bedded, fine-grained, bluish-drab limestone, with occasional specks of calc-spar disseminated, and would admit of a fine polish.

The next limestone deserving of attention as a building stone is

No. 152. This is evenly stratified, with no shale partings, sometimes oölitic and sometimes cross-laminated, generally of a brownish-gray color ; a freshly quarried slab exhibits a blue fracture. Its greatest observed thickness was 14 feet, in the railroad quarry one mile west of Amazonia. Many quarries of it have been opened on the creek 2½ miles north-east of Savannah. It occurs here in neat strong flags of 2 to 6 inches thick, and also in thicker beds, suitable for large dimension stone.

From these quarries quantities of the rock were formerly hauled to St. Joseph, and used in the buildings of that city. Three or four feet thickness was also observed near Block's Mills, in Buchanan and Platte Counties, high up in the bluffs.

No. 143, seven feet, and No. 128, four feet thick—both appearing in bluffs below St. Joseph. They are useful for strong, rough masonry.

No. 143, a few miles above St. Joseph, is 10 feet in thickness, chiefly in one bed.

No. 100, occurring in bluffs between Parkville and Platte River, is generally of even surface and thickness, strong and heavy. Between Parkville and Waldron it is oölitic.

The lower beds of No. 108 have been much used at Parkville for building. They are 6 and 9 inches, and therefore of very good thickness for ordinary building ; the layers are quite uniform.

No. 92 affords a good, substantial and rather good-looking building rock, but it is only in one layer, of about 13 inches. It is dark-blue, variegated with irregular wavy ramifications of a different shade, probably of coralline origin. It has been quarried in bluffs at Kansas City, and used in many buildings. It may also be found at Parkville.

No. 90 affords a good material for building purposes ; it is a grayish-drab, tolerably fine-grained limestone, with occasional specks of calc-spar, and occurs in a tolerably even strata, and works as freely as most limestones. It is especially well marked by a fossil (*Campophyllum Torquium*), which is quite abundant, and presents its true type in this rock, but is almost entirely unknown anywhere else. It is quarried opposite the Union Depot, Kansas City, and may be found near the same horizon around Kansas City, cropping out in the bluffs opposite, and occasionally as far up as Parkville.

But it is in No. 87 that we find the best and easiest working limestone of the upper coal-measures; it is whitish or light-gray, sometimes, near the line of deposit, of a bluish shade and beautifully oölitic, some *oölites* as large as $\frac{1}{16}$ inch, but generally smaller; from 40 to 50, averaging generally about 40 to a lineal inch, or 160 to 200 per square inch. A good quarry has been opened along the side of the road above the Union Depot at Kansas City. It appears there 18 feet in thickness. Other good quarries are worked a mile below Kansas City, where it can be quarried in blocks 2 and 3 feet thick. A good quarry is opened in the bluffs just opposite Kansas City, and also 2 or 3 miles above; for large dimension stone I consider it very valuable.

No. 84, at its greatest development, is 9 feet 4 inches thick, generally in two beds, which make it very suitable for large dimension stone; it is very fine-grained; the lower 3 or 4 feet as one bed of dove-blue fine-grained limestone, with many pellucid specks of calc-spar disseminated, admitting of a fine polish, is found at Kansas City, at Randolph and Missouri City, Clay County, and in the railroad cut at Pleasant Hill, Cass County.

No. 79 is a whitish and sometimes ferruginous gray silicious limestone, in thick beds easy to work, and probably withstands the effects of the weather better than any other coal-measure limestone; it is contained between Nos. 78 and 80, almost blending with them, and at Kansas City cannot be altogether separated. At North Missouri Junction it is only one foot thick. At Greenwood, Jackson County, there is about 6 feet of it in thick beds, mostly oölitic, of a gray and bluish-gray color. At several places near Pleasant Hill, Cass County, there are quarries of it. It is there about 4 feet thick, of a whitish or bluish-gray and sometimes brownish-gray color, and is known by the local name of Cotton rock. At Kirtly's quarry, near Mooresville, Livingstone County, there is exposed 8½ feet of whitish oölitic limestone, in layers of relatively 32 inches, 16 inches and 17 inches. A great deal has been used from this quarry, chiefly by the Hannibal & St. Joseph Railroad Company. Other quarries of this oölitic limestone are seen near Princeton, in Mercer County, and near the east line of Caldwell County.

No. 74.—This limestone has been extensively used for masonry on the Pacific Railroad, and the Lexington, Lake, and Gulf Railroad; in Cass and Jackson Counties, it occurs in two beds, one of 8 to 12 inches, the other of 12 to 16 inches thick, of very even surface, jointed, fracture showing deep ash-blue, color variegated with darker windings; it would be handsome polished. Good quarries are near Lone Jack and south-west for four miles, and three and four miles north-east and east of Pleasant Hill.

About east of Bridgewater and at the bridge on the Platte River are two very even layers of 4 and 6 inches of strong, tough sandy limestone, a first-rate rock for paving; its geological position is near the base of No. 150.

SANDSTONES.

In the northern part of Atchison County, near McDonald's, and a few miles below, are outcrops of hard, blue, and drab calcareous sandstone, generally splitting in thin but very even flags. This is the only really good building material that can be found for many miles.

Sandstone No. 195, near Forest City, is a soft grayish drab, very easily worked, and seems to last very well in-doors, but appears to poor advantage in the quarry. Sandstone of similar age, but very different in appearance, has been quarried on One Hundred and Two River, below Bridgewater, and used for masonry on the railroad; it occurs here in thick, rough beds, rather difficult to quarry; is a hard, coarse brown or buff soft micaceous sandstone, with sometimes minute calcite lines. A portion is a hard blue, with plant remains.

At Mrs. Martin's, in the south-west quarter of Section 25, Township 65, Range 34, is a hard blue sandstone, which is said to make good grindstones. Two feet of outcrop appears near the edge of the water in Honey creek.

A few miles south-west of Cameron is an outcrop of 3 feet of ripple-marked sandstone, which is also said to make good grindstones.

SANDSTONE OF MIDDLE AND LOWER COAL SERIES.

On the bluffs of the east fork of Grand river, at Gillaspy's Mill, Livingston County, there is exposed 86 feet of buff and gray sandstone, including Nos. 65 and 69, of which 25 feet forms excellent building material, mostly in thick layers.

In Lafayette County, near the mouth of "Terrebonne," or Tabbo, are thick beds of coarse buff and brown sandstone, generally soft;

but I have no doubt that excavations here would develop layers of good building rock.

On Gen'l J. O. Shelby's land, near Aullville, are several sandstone quarries. Ledges three feet in thickness were observed; the indications are tolerably good. This is of the same geological age as the rock at mouth of Terrebonne.

On W. T. Collins's land, one mile south of Brownsville, Saline County, there is an excellent sandstone quarry, with probably at least 25 feet of good quarry rock, and the total thickness of sandstone is about 50 feet. Some of the beds are four feet thick and present a good working face. The rock is a chocolate-brown firm sandstone, and lies near the base of the coal-measures. This sandstone is occasionally seen along the bluffs of Blackwater, for 5 or 6 miles south-west; it has sometimes a whitish shade. It is also quarried at and near Clinton, Henry County. The quarry west of Clinton appears thus :—

No. 1—4 feet drab sandstone, in layers of 2 to 6 inches.

No. 2—A layer of 2 feet.

No. 3—One of 2½ feet.

No. 4—6 feet of irregular layers of various thickness of sandstone.

The Clinton rock is ripple-marked, and uniformly of a drab color, with sometimes green partings.

At Mrs. Suttle's quarry, east of Clinton, the quarry rock is 5½ feet thick, in 3 layers of 2 feet 9 inches, 2 feet, and 6 inches. The rock is more brown than the Clinton rock ; in other respects it is similar.

On Sugar creek, in Cass County, a buff-brown sandstone in good thick beds has been quarried and used in the abutments of railroad bridges over Grand river ; it is easy to work and quite substantial ; it is probably of the same age as that of Berlin, Lafayette County, and of Warrensburg. On Sugar creek it abounds in *Sigillariæ*.

The sandstone quarries that have been worked most extensively are those of Miami and Warrensburg.

Thick-bedded sandstone appears in the bluffs one mile above De Witt, and from thence to one and a half miles above Miami Station. It is generally buff or brown, except near the western terminus at "White rock," where it is whitish with a faint blue shade. The quarry rock above ground is 60 feet thick, mostly in a single bed, with no sub-lines of stratification. Dark seams appear at one place, and a few indurated concretionary forms of blue sandstone are sometimes interpolated; otherwise the rock is easy to work and good in all respects. It is gritty, and would make good grindstones. Large quantities have been quarried and shipped on the railroad during the past few years. The hard concretionary forms generally contain many fossil plants, chiefly *calamites* and allied genera. Just along the bluffs west the sandstone is replaced by sandy shales abounding in many hard concretionary forms of sandstone.

The Warrensburg sandstone was spoken of in my report of last year (see Chap. VI.); since that time the force of quarrymen and facilities for getting out the rock have been increased. I consider it one of the best quarries of Western Missouri.

At Brownsville there is quarried a tough, silicious rock in very even flags, colored blue and drab variegated, and much used for street-paving. It can be found east of the town in thin and thick layers. I observed it 4 miles west and 2 to 4 miles south-west; it also has its equivalent in similar thin layers of flagstone lying over the coal at Jordan's, 5 miles south of Clinton, Henry County.

Although of a different geological age, this flagstone closely resembles that before noted from Nodaway County, and the flagstone of Osage City, Kansas. Near Jackson's Mill and Gilkerson's Ford, in Henry County, we find 1½ feet of whitish hard sandstone, firm and gritty enough for whetstones or hard grindstones. A similar bed, and probably of the same geological age, crops out in the bluffs of Miami, Saline County; at both places it contains remains of *Stigmaria*.

Limestones of the Middle Coal-measures.—On Judge W. T. Wood's land, 6 miles south of Lexington, we find the following rocks:—

No. 1—2 feet light-blue limestone with shaly partings.

No. 2—21 inches drab limestone with *Chætetes Milleporaceus*.

No. 3—5 inches compact limestone.

No. 4—23 inches compact dull drab limestone with a faint green tinge.

The above is the thickness of the respective layers; it affords a pretty good building material, and some of it is no doubt susceptible of a good polish, and may also be hydraulic; its geological position is 15 to 20 feet above the Lexington coal.

At Charles Würster's, a few miles south of Bedford, Livingston

County, is a quarry of dark-blue limestone in two layers of 9 and 11 inches respectively, and very even surface, it is jointed, contains *Fusulina* and *Archæocidaris* and is probably equivalent to No. 55 of the General Section, and admits of a fine polish. The abutments of the bridge across Grand River, at Bedford, are constructed of it.

Hydraulic Limestones and others suitable for common Lime. —No. 112—A tolerably good rock for ordinary lime. Locality, at Weston, and below as far as Parkville. Color, buff-gray.

No. 150—Occasionally in the bluffs a few miles above Weston, at Block's Mill, and in the bluffs above to St. Joseph ; at Amazonia good cement has been made from it ; near St. Joseph it has been much used for lime. It is also found on Niagara Creek, One Hundred and Two River, Andrew County, and at Island Branch, Gentry County. General color, ash-blue.

No. 110—Blue limestone, may be a good lime-rock, and a portion probably hydraulic. Locality, at Weston, and near Morrow's, in Platte County.

No. 160—At Caldwell's quarry, one mile south of Savannah ; this rock appears as if it might be hydraulic. It is 4½ feet thick at this place. Color, a dull drab.

167—May be hydraulic. Locality where found was in Black Cut, 1 mile south of Savannah, 2½ miles north-east, and on the Missouri bluffs one mile above the mouth of Nodaway River. Color, drab.

Nos. 206 and 209 may be good lime-rocks, and may sometimes possess hydraulic properties. Locality, near Forest City, on Nodaway River, Nodaway County, and near Bridgewater. Color, dark ash-blue.

199—Would do for lime. Locality, near Forest City ; fine-grained. Color, drab.

190—May be hydraulic. Locality, obtained at Kunkell's, Holt County. Color, dark ash-blue.

184—May be hydraulic. Locality, below Forest City and at Ohio Mills. Color, bluish-drab.

218—May be hydraulic. Locality, near Forest City and in Nodaway County, at Quitman, on Florida Creek, Sand County ; the lowest rock at King's Mill, Atchison County, occurring also near Vangrudy's. Color, ash-blue.

201—Is probably hydraulic ; it occurs near Forest City, at Smith's

Mill, on Nodaway River and vicinity, and near Bridgewater; it is best seen on Dog Creek, near Bridgewater. Bluish-drab.

197—At the same localities as the last. It is probably hydraulic. Bluish-drab.

Drab limestone from Graham's Mill, Livingston County. It may be hydraulic. Section 134-9.

Blue limestone from Collier's quarry, Livingston County. It may be hydraulic. Section 147-3.

Good limestone for lime occurs at Isaac Miller's, 1 ½ miles north-west of Gentryville. Buff-gray.

The following limestones of Daviess County may be good for lime or hydraulic cement:—

Section 120-17—At Gallatin. Deep-blue, compact.

Section 120-19—Like the last. Same locality.

108-5—Similar to the last; from Pattonsburgh.

108-1—Dark-blue limestone. Same locality as the last.

109-6—Ash-gray limestone. On Grand River, near the west line of Daviess County.

104-1—Ash-colored *fusulina* limestone on Big Creek, below Pattonsburgh.

120-15—Deep ash-colored limestone. Gallatin.

123-5—Ash-blue argillaceous limestone. On South Big Creek, near Harmon's.

115-3—On Railroad, 2 miles south of Jameson. Ash-blue limestone.

120-20—Gray limestone. At Gallatin.

102—Nos. 1, 2 and 3. Will make lime. No. 3 is said to be good for that purpose. Locality—on a west branch of Sampson Creek, north-west from Pattonsburgh, also in the vicinity of Grand River, near the line of Gentry and Daviess Counties. Color, buff-gray.

110-2—Fine-grained, bright-brown, compact limestone; may do for lime. Gentry County, on the hill-tops, on the south side of Grand River, near the east county line.

No. 98—Good for lime; at Kansas City, Parkville and Independence.

No. 90—At Kansas City and Parkville; may be hydraulic.

Section 152-8—On Grand River, Livingston County, near William Leaton's. May be hydraulic. Hydraulic (?) limestone on William Tyler's land, near Brunswick, Chariton County.

162-6—Near Hardwick's Mill, Carroll County. Bluish-drab; probably hydraulic.

161-2—At Hardwick's Mill; resembles the last named.

Section 169—Deep-blue limestone; may be hydraulic. On Sherwood's land, west of Carrollton, Carroll County.

Section 175-4—Ash-blue limestone; may be hydraulic; 2 miles north-east of Richmond; similar rock at most of the coal-banks near Richmond and Camden; limestone under the coal at Lexington, color ash-gray; rough; may be hydraulic. Section 15-11.

Section 28-2—4 miles above Waverley, Lafayette County, fine-grained, bluish drab limestone, probably hydraulic.

Section 34-3—Dark ash-blue, shading to drab, probably hydraulic. Osborn's, near Aullville, Lafayette County.

At Mulky coal-mines, Lafayette County, ash-blue limestone, probably hydraulic. The limestone over the coal, on the land of Dr. G. M. Britts and vicinity in Henry County, is probably hydraulic, and also a fair building rock; specimens are marked 62-3. This limestone also overlies the coal 2½ miles west of Calhoun on the railroad.

12-12—Heavy, hard ash-blue, may be hydraulic; Napoleon, Lafayette County. A rough nodular drab limestone from near Knobnoster, Johnson County; may be hydraulic.

The above list includes many different strata, from near the top almost to the base of the coal-measures. Some of them will make pretty good common lime, others will make hydraulic lime or hydraulic cement. The proper experiments will prove what they may be suitable for.

Mahan defines limes as follows: "Common or air-lime will air-slake, or slake by having water poured over it, and will only harden in the air. Hydraulic lime slakes thoroughly like common lime when deprived of its carbonic acid, and does not harden promptly under water. Hydraulic cement does not slake, and usually quickly hardens under water. Fat limes give a paste which is unctuous to the sight and touch; meagre limes yield a thin paste. Common limes are fat—hydraulic limes are meagre; but all meagre limes are not hydraulic.

"The limestones which yield hydraulic limes and cements are either argillaceous or magnesian, or argillo-magnesian. The hydraulic energy differs according to the proportion of lime and clay in their composition. It is necessary that a certain proportion of clay should enter into the composition of the limestone. These rocks are generally some shade of drab, or of gray, or of dark grayish-blue; compact texture, fracture even or conchoidal, with a clayey or earthy smell and taste."

Polishing rock.—At Groomer's Mill, in Daviess County, I collected a specimen of a light, somewhat porous, buff, silicious rock, rather soft. A similar stone was collected between Cass and Jackson Counties, 3 miles west of Greenwood; also at one mile north of Greenwood and at a few miles north-west. It seems to occur in strata several inches thick, and closely resembles the polishing stone of Newton County, but is somewhat colored brown with iron-rust, whereas the Newton County rock is a cream-color. Its geological position is in No. 85.

Other rocks observed lying just below the coal-measures.—At Miami and Brownsville, Saline County, are beds of gray limestone of coarse texture, which will sometimes admit of a good polish, and are excellent rocks for making lime. They belong, geologically, to the Encrinital limestone group.

Clays suitable for Fire-brick.—These clays are often met with in the coal-measures, and generally, although not always, may be found just beneath the coal-beds. At Allen's coal-bank, in Nodaway County, are 10 to 15 feet of clay, which has been made into excellent brick for common building purposes. It is a smooth, laminated, snuff-drab clay.

At Quitman, 2½ feet smooth, light-drab clay.

No. 205 is 4 feet of olive-blue and dove-colored, a little rough, with a very little sand in it; it is found near Forest City, Oregon, Smith's Mill and Bridgewater.

Section 78–3—At Vangundy's, Atchison County; hard, fine grained, olive-colored clay.

99–6—Isaac Miller's, Gentry County; 4 feet of very smooth olive clay.

No. 97—At Kansas City, thin laminæ of dark-blue clay.

174–3—Ray County, 5 feet part red, part green.

174–5—3 feet green clay. Near east county line, Ray County.

157–8—Chariton County, 2 feet bluish-gray fire-clay; seems quite pure. Under Linn's coal.

Section 155–18—5 feet blue and whitish clay, 1½ miles north-east of Little Compton, Carroll County.

The clay under the Lexington coal seems generally a pure gray, of variable thickness, 6 inches to 3 feet.

DESCRIPTIVE LIST OF PAINT-BEDS, CLAYS, ORES, &c.

OBSERVED IN COAL-MEASURES OF WESTERN MISSOURI, DURING THE YEAR 1872.

IRON ORES.

Iron pyrites occurs in numerous localities in every county ; most of the coal contains it in the joints, and it is also found in the shales adjacent, and most of the ash-blue limestone contains large quantities ; such limestones, although often appearing very well when first quarried, will crack under the first winter's cold. A thick brown crust is also generally formed on the exposed surfaces.

Brown and red hematite.—In N. ½ of N. E. ¼ of N. E. ¼ Section 25, T. 43, R. 25, on the land of Laban Parks, one and a half miles north of Calhoun, Henry County, are seen numerous boulders or masses of a porous red oxide of iron strewn over the surface. A pit dug there revealed 3 feet of red clay below the soil, containing numerous masses of iron ore. Beneath the iron ore are large quantities of brown ochre. This deposit covers an area of over 5 acres. On the hillside north of the railroad at Calhoun is an outcrop of one foot of a horizontal band of red sandy iron ore ; streak, red.

In the railroad cut at Calhoun is an outcrop of limestone, whose interior shows a bluish ash-color, but which weathers with a thick red crust of oxide of iron. A similar outcrop, 5½ inches thick, was observed on the roadside a quarter of a mile west of Clinton. Two and a half miles east of Calhoun we find from 1½ to 2 feet bed of iron oxide concretions, and brown sandstone overlying a 3-foot coal-bed.

In Johnson County, near and at Knobnoster, are numerous iron oxide concretions in sandstone ; also at Warrensburgh, as developed in the railroad excavations at these places.

Similar concretionary forms occur in the sandstone on Grand River, Carroll County, below the mouth of Hurricane Creek, and are quite numerous in sandstone south of Nevada, Vernon County. But at neither of these places have I found the ore sufficiently abundant for working.

Soft ochre concretions, generally yellow or brown, often occur in the shales of the coal-measures, and sometimes in considerable quantities. They probably will only be useful for making ochre paints.

SPATHIC ORES.

Under this head are found occasional lenticular bands of *Iron ore* (*carbonate*) and *Septaria*. The latter is generally found in beds of bituminous shales, and is often pyritiferous. Its color is dark-blue or black, with a network of calcareous veins ramifying both from near the centre and around the centre.

On the Marmaton, five miles north of Nevada and near the foot of Brushy Mound, Vernon County, I observed several good bands of carbonate of iron, very near to thick coal-beds. The bands are about 4 inches thick. At Gilkerson's Ford, on Grand River, five miles south of Clinton, Henry County, the shales contain tolerably thick concretions of carbonate of iron, generally enclosing plant remains, *Ferns*, *cordaites*, *&c.* Thick coal-beds also occur at this place. The iron ore weathers red, is ash-colored within, streak gray or brownish-gray.

At Jackson's Mill, Henry County, a 6 inch bed of carbonate and sulphuret of iron rests on a 9-inch pyritiferous rock. On the creek, three miles east of Clinton, Henry County, are lenticular and concretionary masses of carbonate of iron, in some places a foot thick, and in concretionary forms 1 to 3 feet long.

Thin layers of carbonate of iron occur in the shales near Windsor, but in insufficient quantities to work.

In Carroll County, three miles above White Rock, are 7 feet of shales, with concretionary beds of iron ore, which, near the upper part, are ochrey, with carbonates; the lower 6 inches has some *septaria* concretions. The carbonate is bluish to snuff-colored, with gray or chocolate-colored streak. Some of the ochre is soft-brown, banded. Fossils occur, including *Discina*, *Lingula* and *Productus Prattenianus*.

On Grand River, near Little Compton, Carroll County, several layers of carbonate of iron are exposed in the bluffs, thus :—

Section 155.—No. 1—Shales, with sandstones and limestones above them.

13—4½ feet dark-blue shales with yellow streaks.

14—10 feet shales.

15—1 foot 6 inches very dark-blue shales.

16—1 foot layers of iron-stone with shaly partings.

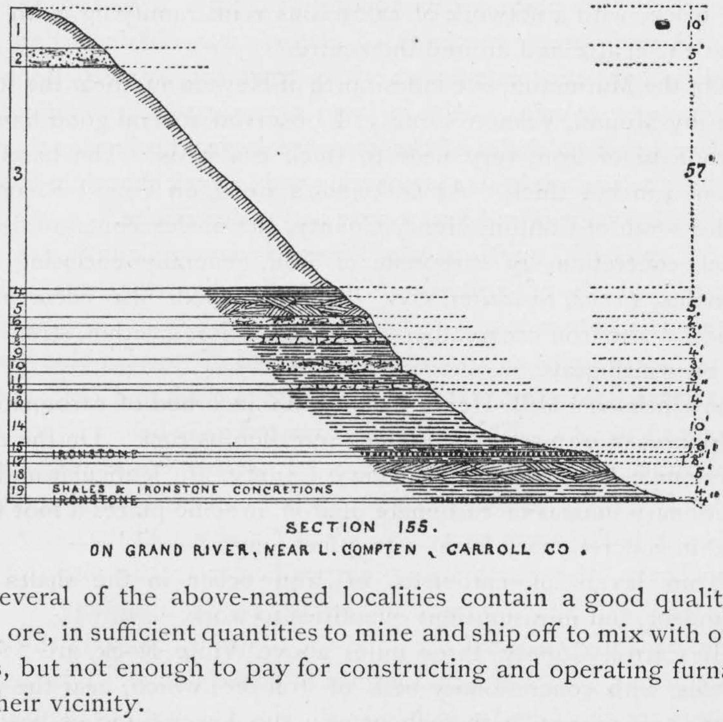
17—20 inches dark shales.

18—5 feet white and blue clay.

19—4 feet shales and sandy iron-stone.

20—4 inches brown, weathering to dark-brown, carbonate of iron ore: streak, chocolate-brown, to the water in Grand River.

FIG. 57.



SECTION 155.
ON GRAND RIVER, NEAR L. COMPTEN, CARROLL CO.

Several of the above-named localities contain a good quality of iron ore, in sufficient quantities to mine and ship off to mix with other ores, but not enough to pay for constructing and operating furnaces in their vicinity.

One and a quarter miles south of Princeton, Mercer County, is a 4-inch bed of carbonate of iron; fracture, dark grayish-blue; streak gray; outer crust brown, with streak chocolate-brown; occurs in lenticular forms in the shales of 73 of General Section.

This may prove a band of some value. Near Winston (one mile west), observed a 2 to 4-inch band of carbonate of iron, color blue, weathering to dirty drab with gray streak. Its position is just over coal No. 123 of General Section.

The shale-beds at Weston, 4 miles below and 3 miles above, contain many concretions of carbonate of iron, including many of *septaria.* Specimens collected four miles below are bluish-brown within, weathering brown; streak, chocolate-brown. At Weston are bright-brown concretionary beds with brown streak, mostly from No. 125, but some from a higher position. Three miles above Weston are found many loose fragments and concretions of carbonate of iron, which seem to occur in considerable quantity, but were so covered with shaly débris that it was impossible to arrive at any correct conclusion as to whether there was enough to search after. The ore at this place seems to originate from Nos. 125, 127 and 136. A very pretty specimen of *septaria* was obtained here; its streak is light chocolate-brown; it is traversed by deep flesh-colored heavy-spar veins. Above Jatan *septaria* 2 inches in diameter weather out from shales of the same geological horizon as those at Weston; color dark-brown weathering red; streak chocolate-brown; ramified by veins of red heavy-spar and white calcite.

At City Bluffs, on Nodaway River, Nodaway County, are concretionary beds of *septaria* 7 inches in diameter, ramified by numerous calcite veins.

No. 220 contains an apparently good bed of grayish-blue spathic iron, streak light-gray. It is about 4 inches thick and occurs at the lower part of 220. This is found from one mile below Forest City to about a mile and a half above. It is also found at Quitman, Nodaway County, and at other places in that vicinity, and at Allen's coal-bank in the north part of Nodaway County. At the latter place it is fibrous, the fibres being perpendicular to the plane of the limestone bed, 2 inches thick and resting on the limestone.

Similar fibrous mineral occurs at the top of No. 188, in thickness 2 to 4 inches, sometimes in the form of cone-in-cone. Fibrous carbonates are also found associated with No. 152, both at the top and bottom.

The report on the Coal-measures near the Pacific Railroad, written last winter, contains an account of the carbonate of iron beds on Clear Fork and Walnut Creek, and the ochre beds at and near Knobnoster; all valuable deposits.

Extensive deposits of brown hematite were observed at several places near Brownville, in Saline County, occupying the horizon of the chert-beds at the top of the lower carboniferous rocks.

Paint Stuffs—Red Ochre Clays.—At C. McGuilliam's Mill, Holt County, is a 2-feet bed of rough-feeling red clay which colors brick-red.

At Amazonia, and better developed one mile north on the Savannah road, is 4 feet of smooth, deep brick-red clay. Its geological position is No. 139 of the Gen. Sec. It is seen on the Rochester road, three miles east of Savannah; below St. Joseph one mile, and also at 12 miles, near Block's Mills, and three miles above Weston, and 5 feet thick on Island Branch, Gentry County, I consider it valuable as a paint clay.

No. 130 also contains a red ochre; it is found one mile below St. Joseph. These beds are doubtless continuous for many miles, and may be found at most intermediate points between their distant outcrops.

On South Big Creek, Daviess County, five miles west of Gallatin, there is exposed 2½ feet of thinly laminated, smooth red clay. At Trenton, Grundy County, we find one foot of bright, deep-red clay.

Probably of similar geological age to the last, is that at Collier's Mill and vicinity. At the mill, in 6½ feet of shaly slope, is exposed an outcrop of red clay; stains a deep red. In the same neighborhood, on W. ½, of the S. W. quarter, Section 29, T. 58, R. 22, is a paler red shale.

Another seam of red clay is also sometimes found below No. 96, which is said to make an excellent "fire-proof paint." It occurs near Hickman's Mills, in Jackson County, also at Independence Landing, east of Liberty, and near Parkville.

Six miles south of Lexington, on the Greenton road, is 1 foot outcrop of deep-red clay shale. The same bed was observed at Missouri City, Clay County, in the bluff above the town and in the road at Hunt's Mill, Jackson County, where it is 2 feet thick. It would form a good material for dark-red paint. Its geological position is about 5 feet below No. 74 of the General Section.

About 50 feet above the Lexington coal we find, in Lafayette and Ray Counties, about 5 or 6 feet of light-red shales streaked with green. This was observed at Lexington, at several places near Richmond, and on the Missouri bluffs, near the east county line of Ray County. Its geological position is about No. 60 of the Middle and Lower Coal Section.

Another purplish-red band occurs in No. 66. At Strasburgh, Cass County, it is intercalated with 10 feet of olive shales. It was also seen on Blackwater, in the west part of Johnson County.

The same bed of red clay shales was also observed one mile south-east of Oak Grove, near the line of Jackson and Lafayette Counties. This bed is sometimes too sandy for a paint, but when found as a pure clay would make a good dark-red paint. About 15 feet below the Lexington coal-bed we also find, at Lexington and on the Little Sniabar, about 5 feet of light-red shales, which may sometimes answer the purpose of a light-red ochre.

In the above list are included ten different red-ochre beds as observed at 26 different localities, making an aggregate thickness of from 30 to 35 feet. I have not tested them with oil, but find that most of them will, when mixed with water, stain a dark, pretty red; a color very suitable for painting station-houses, cars and barns. None of the above-named beds have as yet been practically used, yet we see that we have inexhaustible supplies.

Yellow Ochres.

In my Report on the country adjacent to the Pacific Railroad will be found a notice of the ochre beds of Knobnoster and vicinity, which are by far the most important yellow ochres in Western Missouri; other localities are the following:—

At Rockport, Atchison County, we find 15 inches of blue and olive shales, mostly banded olive and yellow, with but few laminæ of blue.

Near Milton, Atchison County, I observed 1½ feet of bright yellow ochre; in the bed it has more of an olive tinge, but stains bright yellow; it is overlaid by a 10-inch band of soft yellow limestone and is underlaid by 4 inches to one foot of red shales. In Platte County, a quarter of a mile above Farley, I observed 4 to 8 inches of a rough yellow ochre just beneath No. 108.

A mile west of Winston, Daviess County, No. 121 is found to contain a one-foot intercalated bed of rough, brownish yellow ochre, which is probably calcareous.

On the banks of Big Creek, below Pattonsburgh, Daviess County, we find 3 feet of bright yellow ochre mixed with nodules of limestone; its geological position is just below No. 78 of the General Section.

On Luther Collier's land, near Collier's Mill, Livingston County, a shaft for coal exposes the following:—

No. 1—10 feet clay.

2—10 feet thinly laminated blue and buff clay shales with bands of yellow ochre.

3—4 inches yellow ochre; shade bright.

At William Leaton's, on Grand River, near the south line of Livingston County, is 6 inches brown ochre, full of selenite crystals; shade bright yellow.

At Herriman's, 4 miles south of Chillicothe, is a deep olive-yellow ochre, shading to amber-colored clay.

In Carroll County, a quarter of a mile west of Hardwick's Mill, is an outcrop of shales, mostly blue wi h yellow ochre bands, yellow predominating near the lower part. The yellow is smooth, soft, and of a bright shade.

At Rocky Ford, on Waconda River, near the west line of Carroll County, are 4 feet of mostly yellow ochre shales interlaminated with blue; shade a bright yellow.

In Kansas City is found 2 to 3 feet of yellow ochrey clay just overlying No. 87. It is probably calcareous, but shades to a bright yellow.

In the railroad cut, 1½ miles east of Aullville, Lafayette County, the Lexington coal is overlaid by 5 inches of bright yellow sandy ochre. On the creek 3 miles east of Clinton, Henry County, I observed one foot of clay with yellow ochre.

At Brownsville, Saline County, we find on the horizon of the chert-beds which occupy the upper part of the lower carboniferous rocks at this place, patches of deep brick-red and smooth, bright yellow ochre. These beds seem to be exposed at most places where openings have been made in the ravines. We may estimate the beds as at least one foot in thickness.

ZINC.

Sulphuret of zinc was often observed contained in the interior of concretions of Septaria. Beautiful examples of this were obtained in a carbonaceous rock on Sugar Creek, Buchanan County, near Platte County line. At Hughes' mines, near Richmond, in Ray County, sulphuret of zinc occurs in the limestone overlying the coal. Minute crystals were observed associated with carbonate of lime in the interior of a fossil near Forest City.

On Dog Creek, Nodaway County, it was found in calcite veins in limestone No. 196; in concretions of carbonate of iron, at Gilker son Ford, on Grand River, Henry County; in similar concretions a

Williamson's coal-mines near Windsor, Henry County. Small crystals were seen in limestone No. 80 at Amo's, Jackson County.

Beautiful crystals of *Aragonite* were obtained on the Greenton road, six miles south of Lexington, attached to limestone No. 74.

Gypsum.—Crystals of selenite were found in a 2-feet clay bed on Grand River, Trenton, Grundy County, also in a similar position on Grand River in the north-east part of Carroll County; and near Mr. Elijah Cook's, Johnson County, they were found diffused throughout 5 feet of shales.

CHAPTER VI.

GEOLOGICAL REPORT ON THE COUNTRY ADJACENT TO THE PACIFIC RAILROAD, FROM SEDALIA TO KANSAS CITY.

PREFATORY REMARKS.

THE following report is the result of examinations made mostly in October and November, 1871, with a view to obtain a horizontal section of the rocks, between the places above named, connecting the lower carboniferous, and the lower and upper coal-measures. The observations were confined mostly to within from 4 to 10 miles of the railroad. That part included between Pleasant Hill and Kansas City is mainly compiled from personal observations made at various times within the past few years.

Pettis County, west of Sedalia.—The lowest observed rock I refer to the age of the 1st Magnesian limestone.* The next more recent has been known as the Cooper marble, and I shall so distinguish it in this report. Still above, we have a part of the group known in Prof. Hall's and Prof. Swallow's Reports of Western Geology as the "Chemung;" in the Illinois reports of Worthen and Meek, and the Iowa reports of White and St. John, as the "Kinderhook Group." This is only represented near Sedalia by the Chouteau limestone of Prof. Swallow. Above this we find a part of the lower, and then of the upper carboniferous.

In the north-west corner of Section 12, T. 45, R. 23, is exposed five feet of buff and drab 1st Magnesian limestone containing chert. Above this and resting on it is five feet of close-grained drab magnesian limestone, part of it dark bluish gray with particles of calcite; this rock I suppose to be the equivalent of the Cooper marble.

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* Missouri Geol. Surv. Second Annual Rep.

Lying in the creek and in near proximity to the lower limestone-beds, and on the same horizon, is a mass of coarse sandstone, whose proper geological horizon I could not determine with certainty, but I presume that it has been deposited in a valley of erosion subsequent to the above-named limestones. Chert occurs on the hills above. North of this, on Big Muddy, are found rocks of more recent formation,—showing a dip northward. Lower down-stream the Chouteau limestone is found, and two and a half miles south-east of Dresden it is found near the hill-top, with older rocks below. At this place the

1st Magnesian Limestone

rises 34 feet above the water, and is well marked. Its general color is buff, and it contains some whitish and gray chert and a few red bands. I collected a (local) specimen, of a beautiful pink color, coarsely crystalline, with some pearly crystals which seem to be dolomite.

Resting on the Magnesian limestone at this place we find the

Cooper Marble.

Of this there is nine to fourteen feet of a compact drab limestone, clouded with slightly darker shades, and containing specks of calcite. At one place it is a very uniform drab, with many minute specks of calcite disseminated. No fossils were observed by which to identify its correct geological age. The rock below it undoubtedly belongs to the 1st Magnesian limestone, and it is capped by 14 feet of Chouteau limestone. The hill is 97 feet high.

The rocks here seem to occupy a low anticlinal axis. For two miles up-stream the Chouteau limestone is at the water-edge, and four miles down-stream 3 feet of Cooper marble is seen at the base of the hill. At the latter place it is a fine-grained drab limestone, traversed by minute veins and specks of magnesian carbonate of lime, and admits of a fine polish.

Chouteau Limestone.

On the bluffs of the Muddy, in centre of Sec. 19, T. 46, R. 21, we have :—

No. 1—15 feet slope from hill-top.

2—15 feet cherty slope.

3—52 feet of dull drab compact limestone, with concretions of chert and compact quartz, with a bed of bluish-drab subcrystalline limestone near the upper part, in which occur a few fossils.

4—32 feet of dove and drab-colored limestone, with some veins and concretions of calcite.

5—3 feet Cooper marble.

In the above descriptive section we have 84 feet of undoubted Chouteau limestone, with 15 feet of cherty slope above, which latter may probably be also referred to this group; this would make 99 feet of Chouteau limestone, which is probably its greatest thickness in this vicinity. In No. 3, *Bryozoa* (probably *Gorgonia*) abounds throughout its upper beds. Other fossils obtained were *Spirifer Marionensis*, *Chonetes ornata*, two small species of spiny *Producti*, *Spirifer lineatus*, a *Terebratula*, *Pernopecten* (*Entolium*), *Shumardana*, and a small *Orthis*. In the lower beds are *fucoidal* remains.

These strata prevail for two miles north of Sedalia. On exposure they become of a drab color. Some of the chert is beautifully variegated white and dove-colored, and is traversed by minute calcite veins. *Bryozoans* are diffused throughout.

Rhynchonella Cooperensis and *Spirifer Marionensis* are occasionally found. I also obtained a small univalve, which may probably be a *Murchisonia*.

Chert, limestone and buff shales are sometimes interstratified.

Quarries of thick-bedded, compact bluish-drab limestone are opened at several places on the Sedalia and Georgetown road. At one of these I observed several vertical cracks or joints. One exhibited a vertical length of 15 feet, the adjacent rock closely appressed, yet there was a well-marked weathered band a foot in width on each side of the crack.

North of Georgetown, at the railroad bridge on the Muddy, the Chouteau beds appear in the creek, and for about 25 feet up the bluffs, of a compact, dark, uneven drab color, containing concretionary and other forms of calcite sparingly diffused. Following up the Little Muddy for several miles, we find from 3 to 15 feet of the upper Chouteau beds exposed along the bluffs, mostly free from chert, and in thick, even strata, with but few fossils, only remains of *Bryozoans*, and rarely *Spirifer Marionensis*, with an occasional calcite concretion.

Within two miles of Dresden this group disappears beneath the Burlington beds.

South of Dresden the Chouteau limestone is found in the ravines and on the bluffs of the Muddy. I here obtained a fossil which I am inclined to refer to *Poteriocriuus Meekianus* of Shumard. Two and a half miles south-west of Dresden I obtained from the top beds a *Euomphalus*, a *Zaphrentis* and a *Chemnitzia* (?).

BURLINGTON LIMESTONE.

This is the next group seen in the ascending order.

The lower strata, formed of a coarse, buff, brown and gray, close-grained limestone, appear on a branch 2½ miles south-west of Dresden ; the lower 2 feet, a whitish-gray, close-grained limestone, reposes directly on the Chouteau limestone. In the brown beds we obtained *Euomphalus latus*, *Spirifer* ——, *Orthis Mitchellini* and remains of *Crinoideæ*.

On the Little Muddy, 2 miles north-east of Dresden, we have, 1st, 20 feet of gray limestone, the upper part white, middle brown, somewhat shelly, with many *Crinoid* stems, the lower part fine-grained and suture-jointed. *Zaphrentis ?* is found near the middle and *Spirifer* —— in the lower part. Below this there is 20 feet slope to the creek, in which I observed the Chouteau limestone. One mile further down the stream the Section is thus :—

1—10 feet cherty slope.

2—29 feet mostly coarse gray, shelly, crinoidal limestone.

3—9 feet thick beds of gray limestone, inclining to buff.

4—8 feet Chouteau limestone.

The railroad excavations near Georgetown show, 1st, soil ; 2d, chert ; mostly irregularly arranged ; much of it tumbled in with red clay.

3—8 feet yellowish shaly sandstone, with chert concretions.

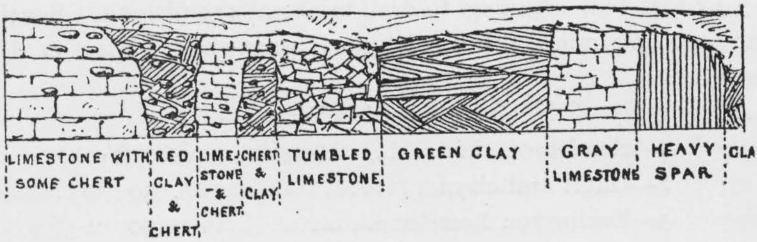
4—4 feet gray limestone, with many *Crinoid* stems, and interstratified with red clay.

5—3 feet rough concretionary chert-bed, with buff shaly partings ; is interstratified with brown limestone which contains chert concretions.

6—Coarse crystalline bluish-gray limestone, with *Zaphrentis centralis*, *Orthis Swallovi*, *Or. Mitchellini*, *Or. Mitchellini*, var. *Burlingtonensis*, *Spirifer Grimesii*, &c.

In the railroad cut on the north side of the Muddy similar beds appear, abounding in *Crinoideæ*. The strata here are much broken, as appears from the following sketch :—

Fig. 58.



SECTION IN R. R. CUT 1 MILE N. OF GEORGETOWN PETTIS CO.

Gray limestone with crinoidal remains is found in the creek north of Dresden. I also obtained here *Productus Flemingii*, var. *Burlingtonensis*. The Burlington beds in this vicinity are not over 50 feet in thickness.

CHERT-BEDS.

Above the Burlington beds, just described, are found loose deposits of chert, nowhere seen in regular strata *in place*, but in large tumbled masses, evidently very close to their place of deposit. In the creek north of Dresden were obtained the following fossils, viz. : *Hemipronites umbraculum*, *Chonetes Shumardana*, *Spirifer* (like *Sp. Leidyi*), *Spirifer* (near *Forbesii*), the pygidium of a *Phillipsia*, 2 species of *Capulus* and *Archimedes*.

These chert-beds may be 20 feet thick. Above them is found 15 to 20 feet of clay, mostly olive or white, sometimes slightly red tinged. There was no guide by which I could determine the proper geological horizon of these clay beds. They are evidently near the top of the lower carboniferous rocks. Masses of chert were sometimes seen lying above, but these are evidently the result of local-drift agency. The value of the clay is economically important, for it is very much used in making pottery. Important beds of these clays occur on and near Little Muddy, north of Dresden, and two and a half miles south-west of Dresden.

SANDSTONE.

In the railroad cut west of Muddy we have :—

1—15 feet soil and clays.

2—6 feet cherty beds.

3—4 feet buff inclining to drab micaceous sandstone. South of Lamonte two miles, this sandstone is seen about 20 feet in thickness.

A summary of the above would indicate :—

1—Sandstone	20 feet.
2—Chert and clays	30 "
3—Burlington limestone	50 "
4—Chouteau do	99 "
5—Cooper marble	14 "
6—First magnesian limestone	34 "

Total—247 feet of rocks below the

COAL-MEASURES.

In my examinations in Pettis County sufficient data were not obtained to construct a complete section. More extended observations to the north-west might disclose the proper connecting links.

A short distance on the south side of the Pacific Railroad, about one and a half miles west of Sedalia, a patch of coal was noted occupying a shallow depression in the Chouteau limestone. Its proper thickness could not be obtained. Some work has formerly been done here, but at present the pit is filled up.

In the S. W. ¼ of the S. W. ¼ Sec. 10, T. 45, R. 22, there is a similar coal deposit on the land of Harrison Haley. The pits were full of water and no coal could be seen, but from the present appearances the deposit seems rather irregular, thinning out eastwardly down the branch and thickening to the west. Chouteau limestone appears in the branch just below the eastern outcrop ; and 175 feet west it is 20 feet below the surface, and the coal (according to Mr. Haley) is 20 feet thick. The coal is of a dull black color, and has, intercalated, a good deal of iron pyrites. A species of calamite was obtained from the coal.

In the adjoining forty-acre tract north, being the N. W. ¼ of the S. W. ¼ Sec. 10, T. 45, R. 22, on the land of G. W. Ewers, are beds of coal-measure rocks in which a shaft was being sunk, of which the following Section was obtained from the workmen. I would state that it was partly verified by the specimens collected :—

1—6 feet clay and local drift.

2—3 feet dark laminated clay.

3—4 feet soft, light gray sandstone.

4—6 feet dark sandy shale.

5—2 feet sandy pyritiferous beds.

6—2½ feet black slate.

7—6 inches black slate, containing impressions and remains of plants, including *Cordaites*, *Ferns*, *Lepidostrobus?* and crystals of iron pyrites.

8—4 feet soft gray sandy bed, passing from a shale to a sandy conglomerate.

9—1 foot 3 inches pyritiferous bed.

10—Bituminous coal.

This shaft is located on a hillside at the edge of a ravine sloping 15° to 20° S. E. Seventy-five feet S. E. a pit was sunk 16 feet to coal, and 50 feet further east the coal is 4 feet below the surface. The workmen informed me that they drilled 8 feet into the coal without passing through it. Chert is found strewn on the hilltop above. It may be that this bed connects with Haley's, but it is on much higher ground. The area of extent could only be determined by borings. It may yet be found at other places in this vicinity.

The above, although true coal-beds, are not connected with the main regular fields. We come next to speak of these.

At Monroe Thompson's in S. E. ¼ of the N. E. ¼ Sec. 8, T. 46, R. 22, there is about two feet of bituminous coal covered with dark semi-bituminous shales, which are sometimes variegated and often pyritiferous. The coal also contains some iron pyrites and has a blue and buff underclay. Brown shales appear above the overlying dark shales. A quarter of a mile west we find 10 feet of drab and yellow ochrey shales, some of which are slightly purple-tinged; beneath, are a few feet of shaly sandstone with thin coal laminæ.*

Coal is found in the creek at Whitfield's, 4 miles north of Lamonte, overlaid by dark blue clay shales containing *Stigmaria ficoides*. A half mile west we have—

* Eastward, a half mile down the creek, is an outcrop of sandstone, which is probably lower carboniferous. Thompson's coal must therefore be about the lower part of the coal series.

1—Sandstone with lower slope of 10 feet.

2—Dark shales.

3—Bituminous shales.

4—4 inches yellow ochrey shales.

5—10 inches semi-bituminous shale.

South, one mile up the creek, at A. B. Gardner's, we observed—

1—5 feet of fine-grained ferruginous sandstone, some of it red-stained.

2—2 feet dove-colored fire-clay.

3—1 foot coal, containing a portion of a peculiar-looking undescribed plant, the surface of which is covered with iron pyrites.

A half-mile further south, at Gardner's well, I obtained from a gray sandstone, portions of large-sized trunks of trees ; one fragment 4½ inches in diameter, with the appearance of a central axis or pith about ¼ of an inch in diameter surrounded by a ½ inch band. Another similar but smaller specimen shows an elliptic cross-section 1⅜ × ⅝ inch, having also a small central axis with exterior bands—surface black. It is with doubt that I refer these plants to the genus *Caulopteris.* Other specimens were here obtained, consisting of *Cordaites*, carbonaceous remains and fragments of coal sparingly diffused through the sandstone.

At Wood Ray's, two miles west, is—

1—6 feet light-brown sandstone with remains of *Sigillaria*, *Calamites* and *Cordaites.*

2—5½ feet thinly laminated clay shales with dark, dull-blue, irregular shaped pyritiferous nodules.

3—6 inches bituminous shales with many remains of *Solenomya radiata* and *Lingula.*

4—Bituminous coal.

A half-mile north-east *Cordaites* and ferns are quite abundant in clay shales. Coal lies just below.

At Sol. Sandridge's, 3 miles N. W. of Lamonte—

1—Sandy shaly slope.

2—1 foot of bituminous coal.

3—Thin laminæ of bituminous shale with remains of plants.

4—4 feet light-gray fire-clay, slightly sandy.

5—3 feet dark ash-blue sandy shales.

6—2 feet dark-blue fire clay—thin laminæ with remains of plants.

A quarter of a mile east a 3 foot bed of coal is said to have been found, in digging a well. In the adjacent ravine are found tumbled masses of bluish drab limestone and septaria.

The most important coal mines observed in the county were those of **Newport** and **Westlake,** near the Pacific Railroad, about half-way from Dresden to Lamonte. The two shafts are on different tracts, about 100 yards apart, and represent the same bed.

The Newport shaft is about 35 feet deep, and sunk on the hillside. The foot of the hill is about 20 feet below the top of the shaft. The coal is 2′ 3″ to 2′ 6″ in thickness. The Westlake shaft is not so deep, being sunk on lower ground. I had not an opportunity of going into these shafts, but the Westlake coal was reported to be thicker than the Newport. The specimens of coal seemed of good quality—hard, black, and brilliant, jointed, with calcite plates between the joints, and carbonaceous matter occasionally between the laminæ ; it contains some iron pyrites. Overlying the coal is a thin stratum of bituminous shale, from which I obtained a fragment of a plant, with round scars on the surface arranged in a regular quadrilateral form, about six-eighths of an inch from centre to centre. A section of rocks here would appear about thus :—

1—16 feet of sandstone and shales.

2—15 to 20 feet mostly argillaceous shales.

3—Bituminous coal.

The following is an analysis of these coals by Mr. Chauvenet :—

	Newport.	Westlake.
Water	3.95	4.47
Volatile	33.10	39.19
F. Carbon	46.26	51.73
Ash	16.69	4.61
Color of ash	Red	Gray
Sulphur	4.406	2.67
Sp. gr	1.347	1.319
Total Carbon		69.27
Total Hydrogen		1st trial 5.49
		2d trial 5.52
Nitrogen		1.50
		Cokes well, and is a good gas coal.

A 3 feet bed of coal (probably the same as the Newport stratum) was reported to have been passed through in digging wells at several places near Lamonte, viz.: 2 miles south, and 2 and 3 miles west and north-west. Sandstone was reached at 15 feet depth, in the well at Lamonte; it is also found at 1 and 2 miles north-west, which would indicate its thickness to be as much as 35 feet, and probably even 50 feet. This is undoubtedly the same sandstone which was observed at A. B. Gardner's.

West of Pettis County.

In the construction of the following Section, difficulties were encountered in connecting the various beds. I had made about 30 sections, extending six miles north and ten miles south of Knob Noster, before I could connect No. 8 with No. 30. Below No. 4 I am not altogether certain of having reached the base of the series; I have only 22 feet. There may be from 10 to 20 feet more, mostly clay or shales. Again, the connection of 24 with 40 was found at only one place, No. 40 cropping out in the bluff on one side of a stream, and No. 24 across on the other side; but I think I obtained about the proper distance between. Above No. 40 we find, at Warrensburgh, a great thickness of sandstone, with no apparent intervening beds, whereas on the Blackwater, near Hammond's Ford, there is a calcareous bed about the middle, resting on a thin bed of coal, and in place of sandstone mostly shales. On the Post Oak, near McClellan's, we find sandy shales above No. 40, and extending up to No. 43, and of much less thickness than is reported to be in the Warrensburg well.

The shale-beds between the limestones, included from No. 50 to No. 59, are of variable thickness. From No. 64 to No. 71 was obtained from elevations along the Pacific Railroad, near Strasburgh. Above No. 71 there was no trouble in making the connections, nor was there any in recognizing the various beds.

The following is the General Section, numbering from the base upward, including the lowest rock on Clear Fork and the highest at Kansas City:—

No.	Ft.	In.	Total Ft.	Total In.	Description.	Locality.
98	30		731	6	Limestone, gray or bluish drab, mottled.	Kansas City and Independence.
97	26		701	6	Shales.	do. do.
96	6		675	6	Limestone, large *Productus*.	do. do.
95	1	6	669	6	Olive clay shales.	Kansas City.
94	2		668		Dark blue shales.	do.
93	1	4	666		Bluish drab.	do.
92		10	664	8	Dull blue argillaceous limestone.	do.
91	6		663	10	Buff and olive shales.	do.
90	6		657	10	Limestone, with *Campophyllum*.	do.
89	3		651	10	Blue and olive shales.	do.
88	2		648	10	Nodular and buff shales.	do.
87	20		646	10	Limestone, upper ½ oölitic.	Kansas City and Liberty.
86	20		626	10	Shales.	
85	16		606	10	Deep blue limestone, blue chert and shales.	Kansas City, Independence, Liberty; Pleasant Hill, the top rock.
84	4		590	10	2 to 4 feet marble bed.	Kansas City and Pleasant Hill.
83	10		586	10	Irregularly bedded limestone.	Kansas City, Pleasant Hill, Greenwood.
82	1	6	576	4	Blue and brown limestone.	Pleasant Hill.
81	7		574	10	Blue and bituminous shales.	Pleasant Hill and Greenwood.
80	2		567	10	Fine-grained drab limestone.	Pleasant Hill.
79	4		565	10	Oölitic limestone.	Pleasant Hill and Greenwood.
78	12		561	10	Shelly gray limestone. (No. 166, or Bethany Falls limestone, of my Mo. River Sec.)	Pleasant Hill, Greenwood, Kansas City, Lone Jack, Chapel Hill, Greenton, Pink Hill, Owens' Landing, Randolph, and at Gallatin, Davis County, and Bethany, Harrison Co., etc.
77	6		549	10	Shales.	
76	1	6	543	10	Argillaceous limestone, fucoidal.	Pleasant Hill and Green wood.
75	4		542	4	Shales.	
74	4		538	4	Gray crinoidal limestone.	Pleasant Hill and E. Linn, Cass Co.
73			534	4		Pleasant Hill and Amos, Jackson Co.
72	14		532	10	Clay shales, or porous sandstone.	E. of Pleasant Hill.
71	1		518	10	Sandy limestone.	Pleasant Hill.
70	1	6	517	10	Calcareous sandstone; 3 inches coal just below.	Harrisonville, Pleasant Hill, Mo. City, Amos.
69	35		516	4	Sandy shales.	
68					A few inches of coal.	Near P. R. R., Cass and Johnson Co. line.
67	15		481	4	Clay shales.	
66	4		469	4	Buff sandstone.	Top of hill E. and W. of Lucas.
65	45		465	4	45 to 55 feet sandstone and shales.	Homes quarry and West.
64	2		420	4	Limestone, with charlites.	Lucas, Big Creek, and Bl. Water.
63	7		418	4	Marly shales and limestone nodules.	do. do.
62	10		411	4	Olive and purple shales.	do. do.

No.	Ft.	In.	Total. Ft.	Total. In.	Description.	Locality.
61	22		401	4	Sandy shales and shaly sandstone.	Lucas and Holden, and Blackwater, 6 miles N. of Holden.
60						
59	1		379	4	Holden coal.	Holden, Georges, Brush Cr., and Blackwater.
58	6		378	4	Shales.	
57	2		372	4	Meekella limestone.	Holden.
56	9		370	4	Shales.	
55	6		361	4	Limestone. *Archæocidaris*, *Fusulina*, and *Chætetes*.	Pin Oak, Lexington, and Carbon Hill.
54	14		355	4	Sandstone.	
53	7		341	4	Shales and clay.	
52	9		334	4	4 to 9 feet limestone.	Lexington, Sniabar, Blackwater.
51	14		325	4	Shales and thin beds of limestone.	
50	5		311	4	4 to 8 feet limestone.	Lexington, Sniabar, Blackwater, and McClellan's.
49	1		306	4	Yellow calcareous shale.	Brush Creek and Blackwater.
48	1		305	4	Blue fossiliferous shales.	
47	3		304	4	Allorisma limestone.	Brush Creek.
46	7	2	301	4	Bituminous shales.	
45		5	294	2	5 to 18 inches hard slaty coal.	McClellan's and Tapscott's.
44	1	6	294	7	$1\frac{1}{2}$ to $2\frac{1}{2}$ feet coal—Lexington.	McClellan's & Blackwater.
43	3		293	1	Soft black shale.	
42	9		290	1	60 to 90? feet sandy shales and sandstone, with coal in middle.	
41	1		200	1	Nodular limestone.	
40	4		199	1	Limestone.	Near Warrensburgh.
39		10	195	1	Dark clay shales.	
38	2		194	3	Bituminous shales.	
37	2	6	192	3	Blue shales.	
36	2	3	189	9	Light blue clay shales.	
35	1	6	187	6	Warrensburgh coal.	do.
34	2		186		Fire clay.	
33	50		184		Sandy shales.	Knob Noster and Carbon Hill.
32		7	134		Shaly coal.	
31	13		133	5	Sandy and clay shales.	
30	3		120	5	Fossiliferous shales and clay ironstone.	Near Knob Noster and 6 miles north on Walnut Creek, and six miles S. W.
29		6	117	5	Bituminous limestone.	
28	1		116	11	0 to 2 feet bituminous shales.	
27	1	8	115	11	1 foot to 20 inches coal.	Knob Noster, Langston's, Cox's, etc.
26	4		114	3	Fire clay.	
25	9		110	3	3 to 9 feet shales.	
24	3		101	3	Rough limestone.	do. do. do.
23	1.	8	98	3	Dark shales.	
22		3	96	7	Bituminous shales.	
21		8	96	4	Coal.	Knob Noster.
20	2	6	95	8	Fire clay.	
19	2		93	2	Dark shales—*Stigmaria*.	
18	1	6	91	2	15 to 26 inches coal.	Higgins, Ramey, K. N.
17	3		89	8	Shales.	
16	1		86	8	Hard black slate.	Clear Fork, 6 miles S. W. of K. N.
15	4		85	8	Ochrey and sandy shales, 3 to 4 feet.	Clear Fork, K. N., ochre bed.
14	6		81	8	Sandstone.	Clear Fork, K. N., quarries.

No.	Ft.	In.	Total. Ft.	Total. In.	Description.	Locality.
13		10	75	8	Dark shales, with thin coal seams.	
12	4		74	10	Sandy shales, with ochrey concretions.	Clear Fork, 5 miles S. W. of Knob Noster.
11	1		70	10	Ironstone.	
10	24		69	10	Sandy shales and sandstone.	Knob Noster.
9	4	6	45	10	Thinly laminated clay shales, with plants.	Knob Noster, and at Minersville.
8	4	5	41	4	Bituminous coal.	Clear Fork and Minersville.
7	5		36	11	Shales and fire clay.	
6	6		31	11	White sandstone.	Dr. Rodgers' quarry, Clear Fork.
5		11	25	11	Coal.	do. do. do.
4	3		25		Fire clay.	
3	10		22		Shales, with thin seams of coal.	Munroe Thompson, in Pettis County.
2	2		12		Coal.	do. do. do.
1	10		10		Clay.	

In describing the sections I have resolved them into their various groups, throwing together those more nearly related and peculiar to a certain district of country; for example, The Clear Fork Group, including about 84 feet, from No. 1 to 10; it is found on Clear Fork and Walnut Creek, and includes from two to three workable beds of coal and three thinner seams.

2—The Knob Noster Group, from 16 to 33, including 97 feet, in which are four coal-beds, two of which are workable. This is best developed around Knob Noster.

3—The Warrensburgh Group, of 75 to 100 feet, from No. 33 to No. 43, includes one good workable coal-bed and another thin one, and thick sandstone beds.

4—Lexington Group includes from 43 to 55, equal to 70 feet, with one good coal-bed and several limestone beds, with *Chætetes milleporaceus* and *Fusulina cylindrica* in nearly every limestone. It is found at McClelland's, Brush Creek, Black Water, Lexington, Sniabar, near Austin, Cass County, and south-westward.

5—The Holden Group, from No. 55 to 64, includes 59 feet, cropping out near Holden; also on Black Water, and Big Creek, Cass County, between the P. R. Road and M. K. and T. R. R. It includes a one-foot bed of good coal.

6—The Mound Group, from No. 64 to No. 77, comprises 133 feet of mostly sandstone and shales, with three thin seams of coal;

it is found in the mounds of Johnson and Cass, and lies at the top of the middle coal-measures.

7—Upper coal-measures ; no coal has yet been found ; 170 feet.

Clear Fork Group.—The following section was taken partly on Walter L. Long's land, in N. W. ¼ of the S. W. ¼ Sec. 18, T. 45, R. 24, and partly on Dr. Rodgers's land, a quarter of a mile north.

Sec. 11.

No. 1—34 feet slope from the hill-top.

2—4 feet sandstone.

3—26 feet mostly shales, chocolate-colored and light blue.

4—4 feet clay shales, with occasional thin laminæ of coal and some pyritous concretions, with zinc blende occupying the centre. Remains of *Cordaites* are abundant in the lower part, a few ferns and a *Lepidodendron*, perhaps *L. diplotegioides*.

5—3 feet bituminous coal (No. 8 of Gen. Sec.). The upper 6 inches is shaly ; the rest of the seam contains good coal, but has a good deal of iron pyrites.

6—5 feet clay and shales.

7—6 feet fine-grained, light-drab sandstone, in very even strata ; said to make good grindstones.

8—8 to 11 inches coal ; has sulphur incrustations on the surface.

9—3 feet fire-clay.

A general section at Minersville, on the Pacific Railroad, is about as follows :—

No. 1—8 feet sandstone.

2—14 feet shales.

3—1 foot 3 inches coal.

4—1 foot light-yellow clay, with remains of roots of *Stigmaria ;* a good ochre.

5—3 feet red and yellow clay.

6—2 feet sandy shales.

7—0 feet 6 inches shaly sandstone.

8—2 feet blue shales.

9—0 feet 8 inches ironstone.

10—28 feet mostly blue shales.

11—0 feet 4 inches thin shaly laminæ, with knife-edges of coal.

12—4 feet dove-colored brown-streaked fire-clay.

13—2 feet blue shales.

14—0 feet 6 inches brown ochrey shales.

15—Bituminous coal 53 to 60 inches. The upper portion of No. 15 is 23 inches thick in the Pacific mines, and generally about the same thickness in Cockrell's mines, thickening at one place to 30 inches. It is interstratified with slaty laminæ, and becomes covered with thread-like crystals of iron sulphate, crumbling to white powder on exposure. This stratum was also, in many places in the mines, especially in closed-up passages, covered with dense woolly masses of similar crystals of a pale greenish tinge. Just at the top is an occasional three-quarter-inch band of brittle black coal, bright and shiny like jet. In General Cockrell's mines I obtained a fine specimen of *Lepidodendron*, *Sigillariæ*, and a few other plants very nearly related.

The *lower* 30 *inches of the coal-bed* is of good quality, black, somewhat shiny, and jointed, with occasional calcite plates between the joints; between the laminæ there is often carbonaceous matter.

Four analyses, made by Mr. Chauvenet, of coals from the Pacific mines, give the following results:—

Water	4.28	4.29	4.85	4.60
Volatile	40.30	40.24	39.85	42.50
F. Carbon	47.22	47.27	45.30	44.55
Ash	8.20	8.20	10.00	8.35
Color of Ash	nearly white.	nearly white.	white.	white.
Sp. grav	1.350	....	....	....
Sulphur	0.759	....	....	....
Total Carbon	7.033	....	....	....
Hydrogen	5.13	....	....	....
Nitrogen	1.449	....	....	....

In the overlying shales (9 of Gen. Sec. 13 of the section at the mines) I obtained ferns (*Neuropteris ?*), a *calamite*, and a stem of a tree-fern; and *Aviculopecten rectalateraria* (Cox) was quite abundant. In the overlying sandstone (No. 10 of Gen. Coal-Meas. Sec.), about 18 to 20 feet above coal No. 8, are numerous remains of *Stigmaria ficoides*, the roots traversing the sandstone in every direction, some fine specimens of which were obtained on the bluffs of the Clear Fork, near Minersville, also near the railroad, west of Knob Noster.

On the Clear Fork, at the railroad bridge, we have, No. 1—1 foot of beautiful, bright yellow ochre.

2—1 foot light-drab fire-clay.

3—6 inches sandy pyritiferous bed; contains crystals of iron pyrites.

4—Close-grained greenish buff limestone, only found at this locality; supposed to be a local bed, occupying a position near the base of the coal series.

On the branch near the railroad I observed the following section, about a half-mile west of Knob Noster:—

No. 1—40 feet slope; some sandstone.

2—6 feet dark-blue shales.

3—0 feet 8 inches coal.

4—5 feet ochrey bed, with streaks of yellow and blue clay.

5—3 feet of dark-blue clay.

From 2 to 5 of this section inclusive may be referred to the upper part of No. 10 of General Section.

On a branch of Clear Fork, in Sec. 17, T. 45, R. 24, we have as follows:—

Sec. 13.

No. 1—Outcrops of hard sandstone.

2—Bituminous shale.

3—Clay, shale.

4—15 feet sandstone on slope; 1 foot of blue shale at bottom.

5—3 inches coal.

6—3 feet soft crumbling sandstone.

7—7 feet dull light-blue shales.

8—5 inches coal.

9—4 feet thinly-laminated ochrey shales, equal to No. 4 of the last described section.

10—5 feet blue clay shales.

11—Bituminous coal; thickness not seen.

No. 10 of the above section is a dark lead blue, a little sandy, and contains some iron pyrites, with fossils, viz., *Lingula* and *Cordaites*.

On Copperas Creek, within a mile of its mouth, the following sections were obtained. I place them alongside, so as to be readily compared. They were taken 200 yards apart, except the first, which was about a quarter-mile distant from the second.

23 c.	23 b.	23 a.	Sec. 23.
2 feet light-blue fire-clay.			
2 feet brown shales.		Coal seam appears.	
6 feet blue and green sandy shales.		7 feet shales.	Shales.
16 inches coal.	Coal outcrop.	1 foot coal.	1 foot coal.
Blue fire-clay.	18 feet shales.	12 feet shales — blue below.	{ 4 feet ochrey clay. 3 feet blue shales.
	2 feet coal.	4 to 8 inches coal.	1 foot coal.
	Blue fire-clay.	Blue fire-clay, with remains of *Sigillaria*.	6 inches dark clay.
			3 feet ochrey clay.
			7 feet drab and ash sandy shales.

In the above sections (13 and 23) there are three coal-beds, one of which attains workable thickness. The parallelism of sections 13 and 23 is apparent, and their geological position is in No. 10 of Gen. Sec.

On Clear Fork, in Sec. 25, T. 47, R. 25, I obtained several sections whose geological position is probably a little above those just described, to wit :—

Sec. 18.	Sec. 19.
	10 inches ironstone.
	10 inches blue and dark shales.
	2½ feet ochrey shales.
4 feet sandstone.	2 feet sandstone.
6 inches blue shale.	9 inches blue shale.
3 inches coal, sulphate efflorescence.	8 inches coal.
6 inches blue shale, yellow streaked; leaves of *Stigmaria*.	2 feet fire-clay.
4 feet blue shales, with a 4-inch bed of ironstone near the middle.	

A half-mile north we have—

No. 1—Outcrop of thin-bedded ochrey shales.

2—Outcrop of coal.

3—4 feet blue shales.

4—2 feet drab sandy shales.

5—11 feet drab sandstone.

6—4 feet shales, blue at lower part, with thin crystals of selenite.

Boyce's coal-bank on Clear Fork, one mile south, occupies a position nearly related to the last-named sections, but I hesitate to name its exact position in the General Section.

Sec. at Boyce's.

No. 1—8 feet sandstone and shales.

2—32 inches coal, the upper 7 inches shaly.

3—3 feet ochrey shales, red and yellow.

4—11 feet dark shaly sandstone and shales, quite pyritiferous in the lower part.

The Maxwell (formerly McQuarry) bank, one mile south, we find to be the equivalent of Boyce's coal, near the edge of the water in Clear Fork, 35 inches thick of apparently a good quality of hard bituminous coal, much of it coated with a yellow efflorescence. Overlying it is 15 feet of mostly thin and even-bedded sandstone, with some black partings and sulphuret incrustations on the face of the lower part.

The following is a section of the rocks on Walnut Creek, near the Pacific Railroad crossing, the lower 10 feet including rocks equivalent to part of No. 10 of General Section.

No. 1—Limestone in the railroad cut, west of the creek; No. 24 of the Gen. Sec.

2—6 inches shale.

3—4 inches shaly coal.

4—10 inches blue shales.

5—8-inch bed of ochre, brownish yellow, hard and soft.

6—5 feet blue shales.

7, 8, and 9—Include 25 feet long gentle slope of 300 yards.

10—Light-blue clay shales.

11—6 feet dark-blue shales in thin layers, becoming bituminous below; contains remains of a few *Lingulæ*, and some narrow-leaved grass-like plants; resembles shales at W. Ray's, in Pettis County.

12—8 inches bituminous coal.

13—7 feet fire-clay and shales; the lower 2 or 3 feet is sandy and ferruginous, with concretions and lenticular beds of carbonate of iron with numerous fern leaves; some of the concretions contain zinc blende. Towards the lower part are reddish-gray thin beds of sandy ironstone.

14—2 inches thin laminæ of light-blue clay shales.

15—2 inches bituminous coal.

16—2 feet shales, containing remains of ferns, calamites, and a few other stems of plants, some of them composed almost entirely of iron pyrites, sometimes including a small nucleus of zinc blende.

Similar flagstones to those found at this section occur two miles down-stream, containing many beautiful remains of fern leaves, etc.

The following section was obtained on Clear Fork, five miles south-west of Knob Noster. It includes most of the above-described rocks, with some beds higher in the series.

Sec. 28.

No. 1—25 feet slope, with outcrops of sandy shales and shaly sandstone.

2—6 inches hard, bluish, bituminous limestone.

3—1 foot bituminous coal.

4—4 feet fire-clay.

5—5 feet shales.

6—3 feet irregularly-bedded limestone: No. 24 of Gen. Sec. contains *Prod. costatus*.

7—8½ feet shaly slope, two beds of coal concealed, the upper of 8 inches and the lower of 1½ feet (same as Higgins's coal); *Stigmaria* leaves in lower shales.

8—3 feet fire-clay and shales, upper part sandy.

9—1 foot hard bituminous slate; contains *Hymenophyllites adnascens?* and probably another *Sp.* (the section a half-mile up stream has a peculiar branching fucoid).

10—4 feet ochrey and sandy shales and clay.

11—6 feet sandstone.

12—10 inches dark shale.

13—4 feet sandy shales and ironstone concretions.

14—1 foot ironstone; contains a little zinc blende.

15—1 foot dark olive shales.

16—1 foot brown ironstone.

17—10 feet shaly slope; black shales near the lower part.

18—9 feet 8 inches sandstone, some of it shaly.

19—5 feet sandy shales.

20—4½ feet blue shales, with *Cordaites*.

21—Bituminous coal in creek—No. 8 of Gen. Sec.

The Clear Fork group, we perceive, includes about six distinct beds of coal, three of which are workable, and relatively 11 inches, 4½ feet, and 2 feet to 2½ feet thick, and three thin seams of 4 inches, 5 inches, and 3 inches, one of them sometimes thickening to a foot.

Knob Noster Group.—This includes from No. 16 to No. 33, and embraces about 97 feet. From No. 16 to 30 inclusive we find above, in Sec. 28[a]. From the top of Knob Noster to the lower grounds west of the town, I obtained the following section :—

No. 1—Sandstone on the top of the Knob.

2—5 feet débris on the slope ; some nodular lumps of limestone.

3—Limestone, with some chert on the top ; contains *Chætetes milleporaceus* and *Fusulina cylindrica.*

4—123 feet; a bed of sandstone appears about 50 feet below the top, and also near the lower part, with concretions of iron oxide.

5—3 feet shales, containing *Chonetes Flemingii*, etc.

6–6 inches shaly bituminous limestone, containing *Spirifer cameratus, Chonetes Flemingii, Productus muricatus, Prod. costatus, Athyris subtilita, Nucula ventricosa, Chonetes mesoloba* [this = No. 29 of Gen. Sec.].

7—1 foot of bituminous coal.

8—3 feet fire-clay and shales.

9—3 feet irregular-bedded limestone ; contains *Sp. cameratus, Sp. lineatus, Prod. costatus,* and *Prod. semireticulatus.*

10—20 inches dark-olive clay shales, with a few whitish concretions.

11—5 inches bituminous shale.

12–8 inches bituminous coal.

13—4½ feet shales and fire-clay.

14—15 inches bituminous coal (at Higgins's it is 2½ feet, at Elliott's 2 feet, and at Falconer's 2½ feet).

15--3 to 4½ feet ochre bed ; remains of *Stigmaria.*

16–8 feet ferruginous sandstone and shales—quarry rock (No. 14 of Gen. Sec.).

17—5 feet olive and green sandy shales.

18—4 feet red and purple clay.

19—6 feet blue drab and olive shales.

20—10 feet outcrop of sandstone, abounding in leaves of *Stigmaria.*

A section obtained one mile south-east of Knob Noster includes from 6 to 13 of the above section, as follows :—

Section 7.

No. 1—Shaly limestone, containing *Chonetes Flemingii, Ch. Verneuiliana, Prod. costatus, Spirifer cameratus, Prod. muricatus.*

2—20 inches coal.

3—4 feet shales.

4 2 feet grayish, ash-blue limestone; contains *Prod. costatus, Spirifer lineatus, Phillipsia,* and *Athyris subtilita* (var. *Maconensis Sw.*).

5—20 inches dark-olive clay shales.

6—3 inches bituminous shales.

7—8 inches bituminous coal.

8—2½ feet dove-colored fire-clay, yellow streaked.

9—2 feet dark indigo-blue and drab clay shales.

10—15 inches bituminous coal (No. 18 of Gen. Sec.).

11—3 feet dove-colored fire-clay.

12—Sandy shales.

A section similar to the last described was obtained on Walnut Creek, one mile south of the Pacific Railroad, as follows:—

Section 16.

No. 1—Outcrops of hard sandstone.

2—2 feet sandy shales.

3—3 feet clay shales, abounding in *Chonetes Flemingii,* containing also *Productus Prattenianus, P. muricatus, Orthoceras cribrosum, Athyris subtilita.*

4—6 inches dark-blue shaly limestone (29 of Gen. Sec.); contains *Spirifer cameratus, Sp. Kentuckensis, Chonetes Flemingii, Productus costatus, Prod. semireticulatus, Prod. Prattenianus, Prod. muricatus, Athyris subtilita, Orthoceras cribrosum, Naticopsis Altonensis.*

5—1 foot of bituminous coal.

6—34 inches shales.

7—3 feet irregular and rough-bedded limestone; fracture shows ash-blue; weathers drab; contains *Lophophyllum proliferum* and *Spirifer lineatus.*

8—7 inches shale, upper part brown, black-streaked below.

9—3 inches bituminous coal.

10—Fire-clay.

On Bennett J. Langston's land in S. W. ¼ of the S. W. ¼, Sec. 22, T. 47, R. 24, we find:—

Section 5.

No. 1— Dark snuff and drab colored shales, with flattened spheroidal concretions of limestone and ironstone.

2—2½ feet bituminous shales.

3—1 foot deep-blue pyritiferous limestone, shelly and fossiliferous [= No. 29 of Gen. Sec.].

4—22 inches good coal.

5—8 inches shaly coal.

6—5 feet fire-clay.

No. 2 contains black pyritiferous concretions of various shapes, abounding in some very fine fossils, including *Productus muricatus*, *Rhynchonella Osagensis*, *Spirifer cameratus*, *Spirifer Kentuckensis*, *Chonetes mesoloba*, *Ch. Verneuiliana*, *Discina Missouriensis*, *Hemipronites crassus*, *Aviculopecten pellucidus*, *Cardium? Lexingtonensis*, *Nucula ventricosa*, *Solenomya radiata*, *Pleurotomaria carbonaria*, *Pleurotomaria spherulata*, *Macrocheilus* like *primogenius*, *Naticopsis* ——, *Orthoceras cribrosum*, *Goniatite? Caulopteris?* and a small *Athyris* in shale, *Aviculopecten Providencis?* and contains zinc-blende.

No. 3 contains *Productus semireticulatus*, *Spirifer cameratus*, *Prod. muricatus* and *Prod. Prattenianus*.

At Cox's coal-bank, on a branch of Walnut Creek, about the half-mile corner of Sections 28 and 29, T. 47, R. 24, we have as follows :—

Section 17.

No. 1—Clay and soil above.

2—3 feet mostly bituminous shales; the upper 2 inches is somewhat calcareous; contains *Prod. muricatus*, *Spir. cameratus* and *Athyris subtilita*.

3—1½ feet calcareo-bituminous shale, containing *Nautilus* ——, *Aviculopecten* ——, and *Chonetes mesoloba*.

4—2 feet to 2½ feet of bituminous coal; has a local dip northward of 1½ feet in 50 feet.

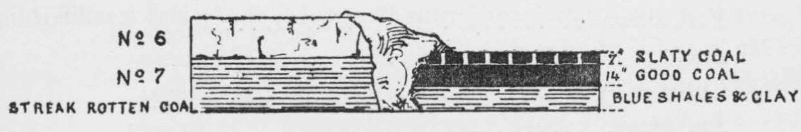
5—2½ feet blue clay.

6—2 feet rough-bedded limestone, slightly pyritiferous; contains *Prod. punctatus*, *Prod. costatus*, *Spirifer cameratus*, *Sp. opimus?* large *Crinoid* stems, *Spirifer Kentuckensis* and *Prod. semireticulatus* [= No. 24 of Gen. Sec.].

7—3 feet blue shales, with small crystals of selenite.

One hundred yards up-stream the section appears thus :—

Fig. 59.



The same beds are seen at Hines, near the east county line, west of Pilot Knob, at which place we have the following section :—

No. 1—50 feet from top of hills, some sandstone in upper part.

2—20 feet outcrop of sandstone at top, with limestone on lower slope, resembling No. 24 of Gen. Sec.

4—4 feet clay shales.

5—2 feet nodular calcareous bed, containing *Prod. costatus, Prod. muricatus, Sp. cameratus, Athyris subtilita, Chonetes Verneuiliana.*

6—Bituminous coal, 1 foot or more.

On Lash's land, in Sec. 30, T. 47, R. 24, is an outcrop of coal in a branch leading off west; overlying it we find shales somewhat ochrey and containing round concretions of dark-blue limestone, with fossils, including *Prod. muricatus, Pleurotomaria spherulata, Pl. depressa? Athyris subtilita,* a small *Goniatite,* and a small *Acephala,* which may be a *Pleurophorus.* These beds probably occupy the horizon of Langston's and Cox's coal.

Between two and three miles south is the well-known "Ramey" bank. It is now owned by Sylvester Orr, and leased by Roberts and Sickles. The coal is equivalent to the "Higgins" coal, corresponding to No. 18, Gen. Sec. It is a hard, black, bituminous variety, sometimes with streaks of more brilliant black; has sometimes mineral charcoal between the laminæ and calcite plates between the joints. Between some of the horizontal laminæ are remains of *Cordaites,* and probably portions of a larger plant which often contain iron pyrites throughout. The coal is 24 to 28 inches thick.

An analysis of the coal by Mr. Chauvenet gives the following :—

Water	5.87
Volatile	40.06
F. Carbon	43.45
Ash	10.62
Color of Ash	dark gray
Sp. grav.	1.377

The overlying shales are 10 feet thick, the upper portion blue clay, the lower dark bituminous, containing fossils, viz. : *Discina Missouriensis* (*Sw.*), *Aviculopecten rectilateraria* (*Cox*), *Lingula carbonaria, Sh.*, and a very pretty specimen of *Palæoniscus*, which may be *P. gracilis* of Newberry.

At Mr. James Mudd's coal-bank, just west of the south-east corner of Sec. 8, T. 46, R. 24, a shaft is sunk 20 feet, passing mostly through clay shales. The coal (No. 27 of Gen. Sec.) is of good quality, 21 to 24 inches thick, with occasional bands of pyrites, and in the vertical joints are plates of calcite. Upon unpacking, I find the coal covered with minute crystals of iron sulphate. Between the coal-laminæ were observed obscure markings of a lycopodiaceous plant with minute longitudinal scars. Overlying the coal is 3 feet of dark-blue pyritiferous shaly limestone, abounding in fossils, including *Productus muricatus, Prod. semireticulatus, Nucula ventricosa, Spirifer cameratus, Sp. Kentuckensis, Sp. planoconvexus, Chonetes mesoloba, Ch. Verneuiliana, Ch. Flemingii, Hemipronites crassus, Athyris subtilita, Rhynchonella Osagensis, Retzia punctulifera, Pleurotomaria speciosa ?* (*M. & W.*), *Pl. Grayvillensis, Bellerophon percarinatus, B. carbonarius, B. Montfortianus, Discina Missouriensis, Orthoceras cribrosum, Spirifer lineatus, Crinoid* stems and cone-in-cone structure.

Six miles south-west of Knob Noster, on the head of a branch running westwardly, we have :—

No. 1—55 feet of sandy shales [equivalent to No. 33 of Gen. Sec].

2—7 inches coal.

3—1 foot of fine clay and shales, with remains of calamites and sigillariæ.

A quarter of a mile down-stream we have, on a horizon just below the above-named—

Section 9.

No. 1—13 feet mostly shales, with an outcrop of shaly coal, and a lenticular bed of ironstone near the lower part.

2—16 inches black calcareous shales, with *Prod. muricatus, Productus Prattenianus, Prod. costatus, Prod. semireticulatus, Chonetes mesoloba, Ch. Flemingii, Athyris subtilita, Spirifer Kentuckensis, Sp. cameratus, Orthoceras cribrosum, Bellerophon percarinatus,* and *Crinoid* stems.

3—2 inches black shales with *Spirifer (Martinia) planoconvexus* and *Athyris subtilita.*

4—6 inches soft, bituminous shale.

5—16 inches coal [= No. 27 of Gen. Sec.].

One hundred yards further down-stream :—

Section 10.

No. 1—Smut and particles of rotten coal.

2—5 feet blue, yellow and brown shales, and fire-clay.

3—4 inches calcareous shales.

4—6 inches rotten coal.

5—5 feet variegated shales.

6—4 inches snuff-colored shales, with gypsum.

7—2 feet alternations of blue and yellow clay.

8—2 inches coal.

9—6 inches yellow, brown and blue clay.

10—13 inches bituminous coal.

11—Fire-clay.

In this vicinity fragments of limestone were observed on the hill-tops, closely resembling the limestone over the Warrensburgh coal.

On Copperas Branch, about Sec. 32, T. 45, R. 24, a number of fossils were obtained from deep-blue concretionary limestone, including *Cardiamorpha Missouriensis, Cardium? Lexingtonensis, Nucula ventricosa, Spiriferina Kentuckensis, Sp. (Martinia) planoconvexus, Sp. (Martinia) lineatus, Productus muricatus, Bellerophon* ——, *Pleurotomaria depressa, Nautilus planivolvis?* and *Prod. costatus.* This group of fossils is similar to that noted above as being found at Lash's.

At Neal's coal-bank, in Sec. 11, T. 45, R. 25, are similar fossils in an evenly-bedded deep blue limestone, with deep-blue bituminous shales overlying the coal, from which bed I collected *Cardiamorpha Missouriensis*, *Cardium ? Lexingtonensis*, *Rhynchonella Osagensis*, *Athyris subtilita*, *Prod. muricatus*, *Goniatites Hathawayanus* (McC.). Impressions of plants occur in the coal, which may be referred to *Stigmarioides ?*

Reavis's and Tarhorst's coal-banks, up creek one-quarter and a half mile west, occupy the same stratigraphical position as Neal's, and can be referred to No. 18 of General Section.

Warrensburgh Group.—In lot No. 4, of the north-west quarter of Sec. 5, T. 44, R. 24, we find near the hill-top occasional outcrops of ash-colored limestone, often abounding in *Productus muricatus*, showing a red nacre, and sometimes containing minute particles of zinc-blende; from its fossils, and its position in the hills, I am disposed to refer it to No. 40 of General Section. If this conclusion be correct, the coal at Mrs. Wingfield's, in Lot 3 of north-west quarter of Sec. 5, T. 44, R. 24, must be equivalent to the Warrensburgh coal. The seam at Mrs. Wingfield's is 22 inches thick; is a hard, black, brilliant coal; contains very little iron pyrites; has impressions of plants with round scars placed a little less than an inch from centre to centre. The coal is overlaid by a brown ochrey shale, containing *Lepidodendron*. The underclay is blue, with *Stigmaria ficoides*.

An analysis of Mrs. Wingfield's coal by Mr. Chauvenet gives the following results :—

Water	7.31
Volatile	41.88
F. Carbon	46.36
Ash	4.45
Color of Ash	pale brown
Sp. grav	1.252
Sulphur	4.304
Total Carbon	72.34
Hydrogen	5.62

Near the 212 mile-post on the Pacific Railroad, and just west of Carbon Hill, I obtained the following :—

Section 30.

No. 1—4 feet nodules of limestone and fossils, many good specimens weathered out, including *Prod. muricatus*, *Athyris subtilita*, *Lophophyllum proliferum* and *Spirifer cameratus*, *Rhynchonella Osagensis*, *Spirifer (Martinia) planoconvexus*.

2—1½ feet of earthy-looking, mottled, ashy gray and blue limestone, containing *Prod. muricatus*, *Sp. cameratus* and *Chonetes mesoloba* and *Crinoid* stems.

3—3½ feet blue and bituminous shales, abounding in fossils, especially in a pyritiferous layer, including *Bellerophon Carbonaria*, *B. Kansasensis*, *B. Montfortiana*, *B. percarinatus*, *Pleurotomaria subconstricta*, *Loxonema cerithiformis*, *Discina Missouriensis*, *Orthoceras cribrosum*, *Nautilus* ——, *Chonetes Flemingii*, *Ch. mesoloba*, *Ch. Verneuiliana*, *Hemipronites crassus*, *Spirifer cameratus*, *Nucula ventricosa*, *Sp. Kentuckensis*, *Athyris subtilita*, *Goniatites Hathawayanus?* *Lyonsia? pretensa*, *Athyris Missouriensis* (*Sw.*), *Prod. muricatus*, *Aviculopecten pellucidus*, *Aviculopecten Coxanus*, *Solenomya* ——, *Astartella concentrica*, *Nuculana bellistriata*, *Myalina* ——, *Cordaites*, *Macrodon carbonaria*.

4—22 inches coal, with plant impressions.

5—8 feet shaly slope.

6—2 feet nodular limestone; contains *Productus punctatus* and *Spirifer lineatus*.

7—10 feet dark-gray micaceous sandy shales.

At the railroad, about the horizon of No. 3, we find dark-blue concretionary limestone beds abounding in *Cardiamorpha Missouriensis*, *Spirifer lineatus*, *Prod. muricatus*, *Rhynchonella Osagensis*, *Aviculopecten rectilateraria*; also contains the stem of a plant.

At Rudy's, which is probably in the south part of Sec. 11, T. 45, R. 25, we have—

Section 25.

No. 1—15 feet slope from hill-top.

2—Outcrop of shelly brown limestone.

3—15 feet slope; a good many fossils were found weathered out, including *Athyris subtilita*, *Chonetes mesoloba*, *Productus muricatus*, *Cyathaxonia prolifera*, *Allorisma regularis* and *Petrodus occidentalis*.

4—5 feet slope.

5—18 inches bluish-drab, compact limestone; weathers brown; contains *Prod. semireticulatus*, *Chonetes Verneuiliana* and *Spirifer lineatus* and *Athyris*.

6—2 feet bituminous shales; contains *Petrodus occidentalis*, *Discina Missouriensis*.

7—Concealed coal.

8—25 feet sandy slope; some hard sandstone. The fossils in No. 3 are of similar type to those in No. 40, therefore I have placed this section in the Warrensburgh group, although from the surrounding topography I was inclined at first to give it a higher position in the series.

The Warrensburgh Coal (No. 35 of Gen. Sec.) is mined at many places around Warrensburgh. From many sections taken I select a few, as follows:—

At Gowdy's, east of the town one mile, we have—

No. 1—27 feet slope and clay.

2—3 feet nodular limestone and shales.

3—4 feet limestone.

4—4 feet shales.

5—2 feet bituminous shales.

6—3 feet clay shales.

7—22 inches coal.

An analysis of Gowdy's coal by Mr. Chauvenet gives the following:—

Water	5.60
Volatile	44.95
F. Carbon	44.45
Ash	5.00
Color of Ash	pale-brown
Sp. grav	1.228

The last section was taken near the head of Pott's Branch. Along this branch the coal is mined at many places, and always by horizontal drifts. It is generally from 18 to 22 inches thick and often beautifully irridescent. The underclay contains *Stigmaria ficoides*. Plants are sometimes found in the coal, occurring as pyritous plates.

In Zimmerman's coal, two and a half miles east of Warrensburgh, are thin pyritous plates of plants, somewhat rugose, with minute pits a quarter-inch apart, about one and one-third times as long as broad, and arranged in a lozenge form.

At Rock & Co. mines on Railroad, 2 miles west of Warrensburgh, we have—

Section 29.

No. 1—Shales.

2—2 feet of limestone, upper layer of 7 inches, separated by 5 inches of shale from a lower layer of 10 inches; contains *Prod. muricatus.*

3—10 inches olive shale.

4—2 feet bituminous shale.

5—2½ feet blue shales, with dull-blue calcareo-pyritiferous concretions; contains *Prod. muricatus.*

6—27 inches light-blue clay shales.

7—18 inches bituminous coal.

From concretions in the overlying shales I obtained *Cardiamorphia Missouriensis.*

At several places in this neighborhood *Prod. muricatus* is found very abundant on the slope below the limestone. One fish-tooth was also found.

On Pott's Branch, a half-mile below Gowdy's, I obtained the following:—

Sec. 32.

No. 1—6 feet outcrops of limestone, containing *Productus muricatus.* [= No. 40, Gen. Sec.]

2—Slope.

3—16 to 18 inches coal.

4—2 feet fine clay.

5—Slope; at 45 feet below No. 1 we find 1 foot of coal with 3 feet of fine clay beneath, and just up the branch about 60 feet, I observed 2 feet of rough-looking limestone, containing *Productus semireticulatus* [= No. 24 of Gen. Sec.]. The coal in the branch I refer to No. 21 of Gen. Sec.

Above the limestone, No. 40 of Gen. Sec., there is a great thickness of sandstone; a well dug near the normal-school building, at Warrensburgh, is reported to have passed through 95 feet of it. This may include the upper clays and local drift of 10 or 15 feet; but its greatest thickness is certainly a little over 80 feet.

The upper beds are mostly either in thin layers or shaly; the sandstone is generally composed of coarse, round, and sometimes clear, silicious grains, cemented by ferruginous matter, forming either a brownish-gray or reddish-brown sandstone. Ironstone concretions often occur, sometimes forming cavities of several inches in diameter, the sides composed of hard oxide of iron, sometimes banded red, dark and brown.

The lower division includes from 40 to 60 feet of coarse gray or drab sandstone, and occupies the top and sides of the bluffs on the Blackwater north of Warrensburgh.

At Sheppard's quarry, 1 mile north of the town, the rock is a coarse gray or drab, thick-bedded micaceous sandstone.

At Davis's quarry, north of Sheppard's, the rock is a bluish-gray micaceous sandstone; the upper bed is over 18 feet thick, with no apparent seam except on the north side, where there appears several knife-edges of coal passing horizontally and upward, the thickest not over a half-inch in thickness.

West of the last, on Gen. Cocknell's land, near the Blackwater, we have about 50 feet of thick beds of light-drab micaceous sandstone, with some appearance of conglomerate at the base, and at one place beneath the sandstone I observed an outcrop of gray limestone, containing *Lophophyllum proliferum*, and abounding in *Spirifer lineatus*.

At Moore's quarry, on the Blackwater, two miles north-west of Cocknell's, we have 25 to 30 feet outcrop of a similar sandstone, coarser than Cocknell's, and somewhat buff-stained. It appears in one bed of over 20 feet in thickness.

At Warrensburgh I obtained only one specimen of the *Equisetaceæ*.

In Davis's quarry are minute black fragments of plants. No other fossils were observed.

No. 6 of the following section, taken on the Post Oak, in north-east quarter, Sec. 9, T. 45, R. 26, I refer to the horizon of the Warrensburgh sandstone.

Section 31.

No. 1—15 feet slope from hill-top.

2—3 feet ash-gray limestone; abounds in *Chætetes milleporaceus* and *Fusulina cylindrica*.

3—21 feet slope.

4—3 feet brown limestone, abounding in *Spirifer lineatus* [= No. 50 of Gen. Sec.].

5—7 feet slope, outcrops bituminous shales and coal.

6—60 feet dark-drab, sandy shales.

7—1 foot bluish-drab, nodular limestone.

8—3 feet shaly slope.

9—10 inches limestone; weathers brown; fracture shows ash-blue ; contains *Prod. muricatus*, *Prod. Prattenianus*, *Sp. cameratus*, *Sp. planoconvexus* [= No. 40 of Gen. Sec.].

10—3 feet dark, ash-colored shales ; contains *Prod. muricatus*, *Spirifer* (*Martinia*) *planoconvexus* and *Pleurotomaria*.

11—4 inches limestone.

12—Bituminous shales.

Lexington Group.—The following is section at Judge Adams's, about south-west quarter, Sec. 11, T. 45, R. 25 :—

Sec. 24.

No. 1— 3 feet bluish-drab limestone ; contains *Chætetes millepo-raceus*.

2—27 feet slope.

3—4 feet irregularly bedded grayish-drab limestone.

4—14 feet slope.

5—22 inches ; even bed of bluish-drab limestone ; weathers brown.

6—Bituminous shale ; coal said to be under it.

At Mr. McClellan's coal-bank, in the north-east quarter, Sec. 9, T. 45, R. 26 :—

Section 31*a*.

No. 1—56 inches limestone ; weathers light-brown ; upper 2½ feet even bed ; below, irregular and somewhat concretionary ; contains a small *Crinoid*, *Fusulina cylindrica*, *Spirifer* (*Martinia*) *lineatus*, *Lophophyllum proliferum*, and *Discina Missouriensis*.

2—8 inches of bituminous shales, somewhat jointed at lower part ; contains some small calcareo-pyritiferous concretions. *Aviculopecten rectilateraria* in lower part.

3—5 inches slaty cannel-coal, abounding in fossils ; is jointed ; has subconchoidal fracture and dull appearance ; fossils appear between the laminæ, and are generally converted to iron pyrites, and include *Orthoceras cribrosum*, *Bellerophon carbonarius*, a small species of *Pleurotomaria*, which may be *P. Grayvillensis?* a *Murchisonia ?* a *Crinoid* (*Poteriocrinus ?*), *Lophophyllum proliferum*, *Lingula carbonaria*, *Aviculopecten rectilateraria*, *Productus muricatus*, *Solenomya soleniformis ?* *Edmondia unioniformis*, *Cordaites* and *Neuropteris* (small sp.).

6—Bituminous coal, of good quality ; has calcite plates between joints ; 18 inches.

7—Soft, dark shale, with remains of *Cordaites*.

The following section was made on the east side of Brush Creek, commencing in the railroad cut and extending to Brush Creek, three-quarters of a mile north :—

Section 35.

No. 1—13 feet earth and clay ; soil 2 feet.

2—2 feet light-drab, tolerably fine-grained limestone ; abounds in *Spirifer lineatus*, supposed to be the equivalent of No. 64.

3—10 feet buff, shaly sandstone ; a few fucoids in upper part ; also contains *Caulerpites marginatus*.

4—23 feet slope.

5—Outcrop of limestone, containing small *Crinoid* stems, *Bryozoa*, large *Fusulina cylindrica*, and abounds in *Chætetes milleporaceus ;* upper part weathers brown [= No. 55 of Gen. Sec.].

6, 7, and 8—includes 32 feet ; on the upper 21 appear outcrops of sandstone, thin blue shelly limestone, and slope below.

9—Limestone, with remains of *Crinoid* stems.

10—8 feet slope.

11—4 feet limestone.

Section 34 is made up of the lower beds of Section 35 and other outcrops on the west side of the creek, and appears thus :—

Section 34.

No. 1—6 feet earthy slope ; hill-top.

2—Sandstone, with peculiar ripple-like markings, arranged regularly on either side of a narrow flat surface—may be fossil [= No. 61 of Gen. Sec.].

3—42 feet slope.

4—Limestone, with *Chætetes* and *Fusulina* [= No. 55].

5—Slope, about 40 feet.

6—8 feet limestone, weathers brown ; contains *Athyris subtilita*, *Spirifer lineatus*, *Zaphrentis*, *Fusulina cylindrica*, *Productus Prattenianus*, *Prod. costatus*, *Prod. splendens.*

7—1 foot yellowish calcareous shales ; abounds in *Spirifer* (*Martinia*) *planoconvexus*, *Athyris subtilita*, *Sp. cameratus*, *Spirifer Kentuckensis*, *Chonetes mesoloba*, *Ch. Verneuiliana.*

8—1 foot black shales.

9—6 inches argillaceous limestone ; ash, drab-color ; contains *Sp. planoconvexus*, *Allorisma regularis.*

10—2 feet light-green clay shales.

11—6 inches limestone, like No. 9.

12—3 feet bituminous shales; a calcareous stratum in the lower part, containing *Athyris subtilita.*

In the south-east quarter of Sec. 21, T. 46, R. 27, on Graham's land, is an outcrop of coal which is sometimes worked; overlying it I observed a 5-inch cannel-coal stratum similar to that seen at McClellan's, and also fossiliferous. The position of this coal is a little below No. 12 of Sec. 34.

At Murray's Ford, on the Blackwater, in Sec. 16, T. 46, R. 27, our section includes both the overlying limestone and the coal, and is as follows:—

Section 36.

No. 1—10 feet slope.

2—8 feet of outcrops of rough limestone; contains *Chætetes milleporaceus, Fusulina cylindrica, Prod. costatus, Spirifer lineatus, Athyris subtilita.*

3—11 feet of olive-colored shales; some calcareous nodules in the lower part; contains also *Prod. muricatus, Prod. æquicostatus, Chonetes mesoloba*, and *Athyris subtilita, P. splendens?*

4—30 inches limestone; contains *Spirifer lineatus, Meekella striato-costata, Sp. cameratus, Productus costatus*, and *Prod. splendens.*

5—1½ feet shaly beds; abounds in *Spirifer* (*Martinia*), *planoconvexus.*

6—6 feet bituminous shales.

7—14 inches outcrop bituminous coal.

8—4½ feet to the creek.

A half-mile above Murray's Ford we have—

Sec. 36*a*.

No. 1—3 feet limestone in even strata; weathers brown.

2—8 feet bituminous shale; in the lower part there is an occasional black calcareo-ferruginous bed, often as much as 2 feet thick, and traversed by numerous calcareous reticulations; fossils are *Cardiamorpha Missouriensis* and a small *Goniatites.*

3—5 inches hard black slate; contains *Productus muricatus, Chonetes mesoloba, Prod. Prattenianus, Sp. cameratus, Solenomya soleniformis, Lingula* ——, *Discina Missouriensis*, and a small crushed specimen of *Pleurotomaria.* Between the layers are occasional thin pyritous plates, with calcite between the joints.

4—About 25 feet of slope.

5—Calcareous sandstone in branch, with *Caulerpites marginatus*, *Prod. punctatus*, *Prod. costatus* and *Hemipronites crassus*.

On Mr. Brown's land, about Sec. 17, T. 46, R. 27, the coal is about 19 inches thick, traversed by a few pyritous veins; otherwise the quality seems good. The overlying black shale contains *Bellerophon carbonarius*, *Chonetes mesoloba*, *Prod. muricatus*, and a few *Crinoid* stems.

At Hammond's Ford, three-quarters of a mile south-west:—

Sec. 37.

No. 1—37 feet slope from hill-top.

2—2 or more feet limestone, like 36, No. 4.

3—37 feet slope.

4—2 feet shelly calcareous sandstone; contains *Productus punctatus*, *Sp. cameratus*, and *Prod. costatus*.

5—6 inches coal.

6—24 feet shaly slope.

From 12 to 15 miles west of Warrensburgh, on and near the old main road from Warrensburgh to Pleasant Hill, our section includes—

No. 1—12 feet slope, with buff sandstone in lower part.

2—3 feet dark, ash-blue limestone; contains some chert; the upper portion is brown, with a metallic ring; contains *Fusulina cylindrica*, *Chætetes milleporaceus* and *Zaphrentis*; total thickness not seen here, but from observations elsewhere I make it about 9 feet.

3—11 feet slope.

4—Outcrop of limestone; contains *Athyris subtilita*, *Sp. lineatus*, and a *Fusulina* somewhat smaller than that found in No. 2.

5—33 feet slope.

6—4 feet even-bedded limestone [= No. 50, Gen. Sec.].

7—3½ feet dark, ash-clay shales.

8—2 feet bituminous shales, with black calcareous concretions, containing *Chonetes mesoloba*, *Discina Missouriensis*, and *Cardiamorpha Missouriensis*.

9—Lower slope covered with débris from above; 16 inches coal concealed.

On Moses Tapscott's land, on the bluffs on south side of the Blackwater, in T. 46, near line between Ranges 27 and 28, the section appears as follows:—

No. 1—Outcrop of whitish limestone, containing a little chert.

2—40 feet slope.

2½—3 feet limestone, with *Spirifer lineatus.*

3—8 feet bituminous shale.

4—18 inches cannel-coal [= No. 45 of Gen. Sec.].

5—6 inches bituminous coal.

6—1 foot calcareo-pyritiferous bed.

7—6 inches bituminous coal.

From No. 3 I obtained a *Nautilus* and a *Productus muricatus* (with very long spines). No. 4 corresponds to the upper slaty coal of McClellan's, and is used at the steam-mill 2 miles east of Holden, for which purpose it is said to answer well. Some calcite plates occur in the joints. From this stratum I obtained *Aviculopecten rectilateraria*, *Lingula* ——, and a fragment of a large *Lamellibranchiate*, probably a *Myalina*. Some of the fossils are pyritous, and occasional pyritous plates are intercalated.

An analysis of Tapscott's coal by Mr. Chauvenet gives the following:—

Water	3.30
Volatile	36.85
F. Carbon	33.05
Ash	26.80
Color of Ash	light-slate
Sp. grav	1.529
Total Carbon	58.01
Hydrogen	5.036

At Ray's coal-bank, a quarter of a mile west, the bituminous coal is 16 inches thick, with 8 feet of bituminous shale and 16 inches of limestone above it. In the overlying bituminous shale I observed a good many fossils, including *Solenomya soleniformis* (Cox), *Chonetes mesoloba*, *Ch. Verneuiliana*, *Prod. muricatus*, *Prod. Wabashensis*, *Spirifer cameratus*, *Sp. Kentuckensis*, *Orthoceras cribrosum*, *Bellerophon carbonarius*, *Lexonema cerithiformis*, *Pleurotomaria Grayvillensis*, a *Nautilus*, a *Lingula*, and a very small *Macrocheilus*.

Near East Pin Oak, 2 miles east of Holden, No. 55 forms a bench 4 feet high, extending for a short distance along the stream. It is there mostly of a grayish or drab ash-color, and contains *Athyris subtilita*, *Sp. lineatus*, *Prod. costatus*, *Archæocidaris megastylus*, *Fusulina cylindrica* and *Chætetes milleporaceus* abounds. One specimen shows it surrounding a *Zaphrentis*. Across the creek, near the railroad, the upper part is more brown. From it I obtained similar fossils to those last named, together with *Loxonema rugosa*, *Spirifer* (*Martinia*) *planoconvexus*, *Prod. costatus*, and *Chonetes*. From the same rock I obtained in the creek, west of Holden, the Pygidium and Glabella of a small *Phillipsia*.

On the east side of Sally's Fork of the Pin Oak, 1½ miles north of Holden, we have—

Sec. 38.

No. 1—2 feet of nodular limestone, with *Productus costatus*, *Meekella striato-costata* and *Hemipronites crassus*.

2—9 feet slope.

3—4½ feet light-drab limestone, fine grained ; contains *Fusulina cylindrica*, *Archæocidaris*, and *Chætetes milleporaceus*, the latter appearing in fringe-like borders on the face of the rock ; in some specimens the coarser tubes appear in small clusters projecting about a quarter of an inch beyond the finer [=No. 55 of Gen. Sec.].

4—Is 14 feet of sandstone (= No. 54 of Gen. Sec.).

5—Outcrop of brown limestone.

6—17 feet slope to the water in the creek.

A half-mile further down the creek—

Section 39.

No. 1—Slope.

2—4½ feet limestone, ferruginous on top, like No. 3 of Sec. 38.

3—19 feet slope.

4—9 feet, irregularly bedded, contains some chert, also *Fusulina cylindrica* and *Productus costatus* (= No. 52 of Gen. Sec.).

At the junction of East and West Pin Oak we find No. 4 of Sec. 39 cropping out 36 feet above No. 50 of Gen. Sec.

The following section was made two years ago on the Missouri bluffs, just below Lexington :—

No. 1—Bluff formation.

2—Shales.

3—4 feet rough-bedded, drab limestone ; abounds in *Chætetes milleporaceus ;* also contains some large *Crinoid* stems, *Fusulina cylindrica*, *Athyris subtilita*, *Spirifer lineatus*. At top we have a brown bed, containing *Nuculana bellistriata*, *Bellerophon Montfortianus*, *Pleurotomaria* and *Myalina*.

4—5 feet drab shales with limestone nodules.

5—5 feet hard brown sandstone.

6—2 feet shales and fine clay—light olive, with red splotches.

7—5 inches black and olive shales.

8—5 feet blue clay.

9—4 feet fine-grained limestone, top brown.

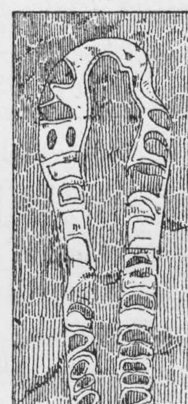
10—3 feet thin beds of rough limestone and shales.

11—4 feet blue shales and masses of blue nodular limestone; abounds in *Chonetes Flemingii*, *Archæocidaris* and *Prod. costatus.*

12—4 feet irregularly-bedded, dark-blue limestone; on Little Sniabar it is 8 feet thick, and contains *Retzia punctulifera*, *Athyris subtilita*, *Sp. Kentuckensis*, *Sp. cameratus*, *Sp. lineatus*, *Productus semireticulatus*, *Prod.*——, *Macrocheilus*, *Naticopsis*, *Bellerophon*, *Pleurotomaria*, arms of *Crinoids* and *archæocidaris*.

Fig. 60.

A



B

FOSSIL FROM LIMESTONE Nº 47 LAFAYETTE CO.

On the Little Sniabar and at Lexington I obtained specimens of a very peculiar fossil, which I have never found anywhere else, nor have I ever seen a description of a similar one. It consists of a central axis or siphuncle, around which are arranged a succession of rather irregular septa, divided into numerous nearly uniform-sized segments, which sometimes give the fossil the general appearance of a small ear of corn. In some specimens these segments or grains are of limestone, separated by thin chalcedonic walls. In some, the central axis is of dark limestone, in others it is worn out. The annexed figures are of two distinct specimens, one a transverse the other a longitudinal section, marked A and B respectively. From the latter we perceive the septa have a general curvature in one direction. None of the specimens are exactly straight, nor do they all curve regularly. Some curve suddenly back, others apparently anastomose. I will not undertake to say to what class or genus it may belong.

13—Bituminous shale, 6 inches; on Little Sniabar, 2 feet.

14—Coal, generally 22 inches.

15—3 feet shales and fire-clay. The upper 3 inches on Little Sniabar is bituminous, then 1 foot fine clay.

16—3 feet hard, close-grained limestone in one bed. On Little Sniabar it is 4 feet thick, and rests on 3 feet of clay; abounds in *Fusulina* and a large *Bellerophon*, and at one place I observed very pretty *Bryozoa*.

17—20 feet blue-red and drab shales.

18—3 feet bituminous shales.

19—0 feet to 8 inches coal.

20—4 feet shales and nodules of limestones.

21—1½ feet irregularly-bedded, pyritiferous limestone.

22—2 feet shales.

23—2 feet even-bedded limestone, from which I obtained a large *Nautilus*.

Two miles below Lexington I observed a rough, brown limestone abounding in *Allorisma regularis;* I suppose it to be the same as No. 23 of the above section.

Holden Group.—The following is a section taken just west of Holden:—

No. 1—20 feet of mostly clay shales in thin layers, some ochreous; contains lenticular ochreous concretions; some are quite fossiliferous and abound in ferns, mostly *Neuropteris*, also *Sphenophyllum* and *Annularia*, with stalks of some other plant, whose centre is sometimes composed of zinc-blende and iron pyrites, the latter sometimes changed to sulphate of iron; some stems also three-quarters of an inch in diameter, with a thin exterior calcite ring.

2—1 foot of bituminous coal (= No. 59).

3—4 feet shales.

4—2 feet light-drab limestone; contains *Meekella striato-costata*, *Prod. costatus* (= No. 57).

5—8 feet shaly slope; 3 feet limestone, covered.

6—16 inches limestone, somewhat nodular and shaly; contains many fossils, including *Chonetes mesoloba*, *Sp. cameratus*, *Prod. costatus*, *Hemipronites crassa*, *Chonetes Flemingii*, *Prod. splendens*, *Athyris subtilita*, *Meekella*, *Prod. Prattenianus*, *Lophophyllum proliferum* and *Bryozoa*.

7—1½ feet shales.

8—19 feet sandstone.

9—8 feet cherty, irregularly-bedded limestone.

On the Blackwater, at the crossing of the Holden and Chapel Hill road, I observed—

No. 1—2 feet light-drab and tolerably fine-grained limestone; in some placers there are appearances of large fucoids (= No. 64).

2—20 feet of dark-olive, sandy and clay shales; contains some curious cylindrical sandstone, with concretionary forms; the annexed figures are cross-sections of two—natural size.

In south-west quarter, Sec. 16, T. 46, R. 28, we have—

Sec. 40.

No. 1—4 feet limestone (= No. 64 of Gen. Sec.).

2—30 feet shales.

3—1 foot coal (= No. 59).

4—6 feet shales.

5—Outcrop of drab limestone.

6—8 feet slope.

7—4 feet limestone, containing *Archæocidaris;* corresponds to No. 55 of Gen. Sec.

At one place in this vicinity I observed an outcrop of brown limestone 16 feet below No. 1, and up the branch 200 yards I observed bituminous shales, which I am inclined to place a little above No. 1.

One and a half miles west, No. 1 forms the bed of the Blackwater, and contains *Fusulina* and *Chætetes*.

Howe's quarry is about a mile further west. The rock there is a soft, brown sandstone in thick beds, and occupies a higher geological position than the rocks we have been speaking of.

Cass County.

The following section, at the forks of Big Creek, near Strasburgh:—

No. 1—2 feet drab limestone, somewhat rough, nodular, and shelly; contains *Chætetes milleporaceus* and *Fusulina cylindrica*.

2—6 feet marlite-shales and calcareous nodules.

3—10 feet of olive and purple shales.

4—4 feet earthy sandstone and sandy shales.

5—10 feet mostly argillaceous shales, blue and olive, with a bed of ironstone and many small, hard, sandstone concretions, also purple shaly bands; contains ferns similar to those found at Holden.

6—8 feet shaly sandstone, to the water in the creek.

7—1 foot coal in creek (= No. 59).

A mile and a half south-west, at Rocky Ford on Big Creek, No. 1 of last section appears in the creek, and contains *Athyris subtilita*, *Lophophyllum proliferum*, *Spirifer* (*Martinia*) *planoconvexus*, *Hemipronites crassus*, *Productus Wabashensis* and small *Crinoid* stems.

At Wm. George's, near one-half mile, corner of Sec. 31 and 32, T. 45, R. 29, we have—

No. 1—15 feet soil and clay.

2—8 feet yellow clay shales.

3—2 feet limestone, containing *Chætetes milleporaceus* and *Fusulina cylindrica* and *Syringapora multattenuata*.

4—Shales brown—exact thickness not seen—from 10 to 20 feet.

5—1 foot hard, black, brilliant coal.

6—Blue clay.

Mound Group.—This includes about 130 feet. A section west of Strasburgh, extending from top of Mound to creek, is about as follows :—

No. 1—5 feet irregularly-bedded, light-drab limestone, on hill-top (= No. 78 of Gen. Sec.).

2—About 20 feet slope.

3—1 foot even-bedded, jointed limestone, with brown crust ; corresponds to lower parts of No. 74.

4—50 feet slope, mostly shales.

5—4 feet of buff sandstone.

6—45 feet slope ; ochrey shales appear in the ravines.

7—Limestone at creek (= No. 64 of Gen. Sec.).

No. 5 of above section affords an excellent building-rock ; it is quarried at Carey's, also at Haynes's, near the railroad, a mile east of the creek. In the ravines in Haynes's field a few inches of shaly coal appear about 15 feet below the top of No. 6 of the above section, and on Falls Branch, one mile south-east in Johnson County, it occurs thus :—

1—4 feet chocolate-colored and ochrey shales.

2—Smut from coal.

3—6 feet shales.

4—6 inches dark ash-blue calcareous ironstone.

5—8 feet dark-olive shales.

On the State road, a mile north-east, near the old Longacre place, there is an outcrop, which is probably referable to No. 4 of the above section, of a calcareo-ferruginous bed abounding in fossils, including *Lophophyllum proliferum*, *Spirifer planoconvexus*, *Astartella vera*, *Pleurotomaria sphærulata* and *Macrocheilus*.

At Elijah Davis's, in Sec. 18, T. 45, R. 29, bituminous shale crops out in the ravine, and is also reached in a well on the adjacent hill. Data furnished by Mr. Davis is as follows :—

1—7 feet soil and clay.

2—15 feet yellow clay shale.

3—1 foot black slate.

4—2 feet blue shale.

5—Bituminous shale. Mr. Davis says he drilled through it 15 feet to limestone, passing through a strong stream of water. The bituminous shale contains some pretty impressions of *Hymenophyllites adnascens?*

In the hill north of Harrisonville, Nos. 70 and 71 crop out and contain a large *Schizodus*, *Pinna peracuta* and *Myalina subquadrata*. High up in the mounds south-east the same beds appear, generally abounding in large-sized fossils, including *Myalina Subquadrata*, *Pinna peracuta*, *Aviculopecten Providencis* and a large *Bellerophon*. These beds also appear at several places at Pleasant Hill, containing quite a variety of fossils, including the above named—*Schizodus* (2 sp.), *Loxonema rugosa*, *Macrocheilus*, *Orthoceras*, *Pleurophorus? Phillipsia* and *Pleurotomaria* (1 or 2 sp.).

UPPER COAL-MEASURES.

The Upper Coal-Measures make their first appearance in the western part of Johnson County, capping the high mounds, and, as such, extend northwardly, via Chapel Hill, and on still north by Greenton, occupying the summit of the main ridge between the south fork of Sniabar and Little Sniabar.

The top of Centre Knob is 95 feet above the grade of the Pacific Railroad, north-east, with 5 feet of Upper Coal-measure limestone on top (= No. 78 of Gen. Sec. or No. 166 of my Mo. Riv. Sec.). The general trend of these mounds, including the extreme southern limit of the Upper Coal-measures, is from Centre Knob westward, passing across the middle of Cass County. Nothing further than thin seams of coal have been observed among these rocks. The most complete section was obtained at Pleasant Hill, as follows :—

No. 1—4 feet clay shales.

2—0 feet 4 inches decomposing bed, brownish, ochrey; contains *Myalina Kansasensis*, *Pinna peracuta*, *Bryozoa*, *Athyris subtilita*, var. *Hawni*, *Spirifer cameratus*, *Sp. Kentuckensis*, *Productus Prattenianus*, and *Productus Rogersi* (= upper part of No. 85 of Gen. Sec. or 158 of Mo. Riv. Sec. of 1861).

3—4 feet dark-drab clay shales.

4—2 feet buff decomposing limestone, with disseminated particles of calcite and fragments of *Crinoid* stems.

5—3 feet blue silicious limestone; weathers drab; fracture conchoidal; abounds in a beautiful univalve resembling in general appearance an elongated *Pleurotomaria*, but having a roundish aperture with obscure lines of growth, and about 8 angular whorls—may be a *Murchisonia*. The same fossil is also occasionally found in No. 4; contains also a small univalve, which may be a *Soleniscus*, and a *Pleurophorus?*

6—2 feet drab, fine-grained, silicious limestone, with numerous specks of calc-spar disseminated; when not too cherty, admits of a fine polish; contains an *Orthoceras* (*aculeatum?* Sw.), *Nautilus* and *Pleurotomaria*.

7—8 feet rough and irregularly-bedded grayish-drab limestone, with many specks of calcite; has buff shaly partings; contains brown and white calcite, and rose-colored heavy-spar—a peculiar fucoid, cylindrical, about an inch in diameter, the periphery of silicious cherty material sometimes studded within with minute quartz crystals; some with a calcite band between the inner and outer part. Abounds in *Productus splendens*, contains also *Prod. Rogersi*, *Productus costatus*, *Productus punctatus*, *Spirifer cameratus*, *Myalina subquadrata*, *Allorisma regularis*, *Lophophyllum proliferum*, *Bellerophon crassus*, *Sp. lineatus*, *Athyris subtilita*, *Phillipsia*, *Eumicrotis sinuata* (M. & W.) *Archæocidaris biangulata* and *Bryozoa*. *Productus costatus* has very long spines.

8—1½ feet brown and buff calcareous shales.

9—4 feet blue shaly limestone, turns brown on exposure; contains a large undescribed *Rhynchonella*.

10—1 foot bituminous shales.

11—3 feet blue and bituminous shales, with *Cordaites*, and an occasional knife-edge of coal.

12—3 feet blue and buff clay.

13—2 feet fine-grained light-drab limestone.

14—4 feet oölitic and subcrystalline limestone ; the oölitic bed is sometimes ferruginous.

15—10 feet shelly, gray limestone (= 78 of Gen. Sec. and No. 166 of Mo. River Sec.) ; abounds principally in *Productus splendens*, *Productus costatus*, *Spirifer cameratus*, and more rarely in *Rhynchonella Osagensis*, *Retzia punctulifera*, *Athyris subtilita*, *Spirifer lineatus*, *Prod. punctatus* and *Prod. Pratteniamus*.

16—6 feet blue and bituminous shales. No. 77 of Gen. Sec.

17—1½ feet limestone and shales, fossiliferous ; includes *Spirifer planoconvexus*, *Polyphemopsis inornata*, *Bellerophon carbonarius*, *Meekella striato-costata*, *Macrocheilus ventricosus*, a small *Chonetes*, small *Crinoid* stems, *Bryozoa*, *Rhombopora lepidodendroides*, *Hemipronites crassus*, *Productus Prattenianus*, and small branching fucoids.

18—4 feet shales.

19—4 feet gray limestone, sometimes quite ferruginous ; contains numerous small *Crinoid* stems, *Athyris subtilita*, *Lophophyllum proliferum*, *Productus Rogersi*, *Hemipronites crassus*, remains of *Crinoideæ*, probably *Zeacrinus*, *Spirifer cameratus*, and several small univalves ; at one locality a thin, shaly, gray bed contains *Monoptera gibbosa ?*

20—14 feet shales = No. 72 of Gen. Sec.

21—2 feet calcareous sandstone, or sandy limestone, color outside dark brownish gray ; fracture within sometimes blue ; tough ; abounds in fossils, including *Euomphalus rugosus*, *Goniatites globulosus*, *Myalina Swallovi*, *M. subquadrata*, *Eumicrotis* (small sp.), *Schizodus* (small sp.), *Lyonsia pretense ? Bellerophon* (large sp.) abounds. Also contains *Pleurotomaria turbiniformis*, *P. tabulata*, *Pl. tumida*, *Naticopsis Pricei*, *Loxonema rugosa*, *Soleniscus typicus*, *Orthoceras cribrosum*, *Macrocheilus*, *Nautilus*, *Phillipsia*, *Turritella*.

22—40 feet sandstone and sandy shales ; soft, brown sandstone in the upper part, then bluish shales with carbonaceous partings. In some places we find near the top a bed containing a large-sized *Discina* and *Aviculopecten occidentalis*. The following is the section, furnished me by Rev. Mr. Lymington, of Pleasant Hill, of rocks passed through in digging his well :

No. 1—1½ feet soil and subsoil.

2—9 feet brown clay, with remains of decomposing ferruginous limestone.

3—1½ feet calcareo-argillaceous shales, light drab color, contains *Rhynchonella* and *Athyris subtilita.*

4—1½ to 2 feet even-bedded limestone, dull light blue; weathers brown.

5—3 inches bituminous shale; some fossils.

6—2½ to 3 inches good bituminous coal.

7—1 or more feet dark-blue clay shale.

The position of the coal is just below No. 72 of Gen. Sec.

No. 21 of Pleasant Hill section corresponds to 70 and 71 of Gen. Sec.

The following is a section at Amos's, in Jackson County, the upper beds well developed in the cut of the Lexington and Lake & Gulf Railroad.

No. 1—15 feet of mostly gray limestone, in some places very ferruginous; contains some handsome calcite crystals of various forms and colors; amber-colored, white and transparent—"nailhead and dogtooth-spar," in mammillary and drusy forms, some of the crystals long, slender and acicular: fossils are *Lophophyllum proliferum, Productus costatus, Prod. splendens, Prod. punctatus, Pr. Prattenianus, Prod. æquicostatus, Spirifer cameratus, Sp. lineatus, Sp. Kentuckensis, Myalina subquadrata, Athyris subtilita, Productus Rogersi, Allorisma regularis* and arms of *Archæocidaris.*

A fine specimen of the *Nautilus* was obtained from this quarry, of the following dimensions: across the disc, 12 inches; thickness between dorsal and ventral margin, 4 inches; length of last septum, 6 inches; thickness of the other septa, $\frac{6}{10}$ of an inch on the dorsum, and $\frac{3}{10}$ on the ventral surface; septa concave, concavity a little less than the greatest thickness of the septa. The dorsum is nearly flat, very slightly raised in the middle; sides are somewhat flattened, and somewhat angularly rounded toward dorsal margin.

2—1 foot deep-blue, argillaceous limestone; contains *Hemipronites crassus, Productus costatus* and *Rhynchonella* (1 inch diameter). No. 82 of Gen. Sec.

3—2 feet bituminous shales.

4—5 feet shaly slope.

5—15 feet rough, shelly limestone. No. 78 of Gen. Sec.

6—10 feet mostly sandstone, the upper beds with holes and winding cavities; contains a large *Productus*.

7—10 feet shales.

8—2 feet even-bedded, blue limestone, much used for building purposes on railroad.

9—2 feet bituminous shales.

10—20 feet shales. Near the lower part is a thin calcareous bed, abounding in fossils, including *Myalina Swallovi*, *Nuculana bellistriata*, and an elongated univalve.

The following is a section on the railroad one half-mile north of Greenwood:—

No. 1—8 feet gray, irregularly-bedded limestone; contains *Productus Rogersi*, *Prod. costatus*, *Prod. splendens*, *Athyris subtilita*, *Prod. punctatus* and *Bryozoa*.

2—9 feet slope, bituminous, shaly, and hid.

3—6 feet gray limestone, lower part oölitic.

4—13 feet brittle drab limestone, No. 78.

5—1½ feet bituminous shales.

6—3 feet clay shales.

7—1 foot ferruginous limestone, with *Hemipronites crassus* and *Syringapora*.

8—1 foot calcareous and ferruginous shales; abounds in *Spirifer Kentuckensis*, *Sp. planoconvexus*, *Sp. cameratus*, and *Chonetes Flemingii*.

9—Brown, ferruginous, decomposing limestone, in bed of creek.

At the mouth of Elm Grove Branch we find No. 78 of Gen. Sec. In the bed of the creek, and a short distance below, No. 81 sticks out of the bank, abounding in *Hemipronites crassus*. Nos. 84 and 85 crop out higher up in the bluffs. Along the Pacific Railroad, 2 miles north of Lee's Summit, No. 85 is seen skirting along the hillsides.

On the bluffs of Cedar Creek, 3 miles north of Lee's Summit, we have—

No. 1—Outcrop of brown, decomposing limestone.

2—15 feet slope; at the lower part are outcrops of deep-blue limestones, blue chert, and some brown, decomposing limestone.

3—25 feet slope; rocks concealed.

4—15 feet limestone, No. 78 of Gen. Sec. (=166 of Mo. Riv. Sec.)

5—2 feet clay shales.

6—1 foot bituminous shales.

7—6 inches blue limestone, argillaceous (= No. 76).

8—1 foot nodular limestone and shales (= No. 76).

9—8 inches limestone.

10—2½ feet blue shales.

11—4 feet ferruginous limestone.

Little Blue Valley, near the Pacific railroad, cuts into the series about 40 feet below No. 70. In following the railroad to Independence we gradually rise in the series to the top of our section. No. 98 crops out at several places around Independence. It is a gray and tolerably pure limestone, containing many specks and wavy bands of calcite, and but few fossils. On the Spring Branch, east of Independence, we find the various beds in descending order to No. 69. At the railroad depot, at Independence, No. 96 crops out, containing a large variety of *Prod. costatus*. Descending Rock Creek Valley, we find No. 78 a little above the base of Missouri bluffs. At Kansas City, below the Union depot, we have—

No. 1—6 feet brown and gray limestone, with large fossils, especially *Prod. costatus*, No. 96 of Gen. Sec. or old No. 146 Mo. Riv. Sec.

2—1½ feet olive shales.

3—2 feet dark-blue shales.

4—16 inches bluish-drab shales.

5—10 inches dull-blue argillaceous limestone.

6—6 feet buff and olive shales.

7—6 feet limestone.

8—3 feet shales, bluer near top, dark below.

9—2 feet buff, nodular shales.

10—20 feet of gray limestone, more than half of the upper part oölitic, and containing numerous remains of fossils, small *Rhynchonella*, *Pleurotomaria* like *P. turbiniformis*, *Retzia punctulifera*, *Loxonema*, *Spirifer Kentuckensis*, *Macrodon carbonaria*, *Aviculopecten* (large sp.), *Bellerophon*, *Nautilus*. Most of the fossils have lost their markings. The upper part of this stratum is generally cross-laminated.

11—20 feet mostly shales.

12—14 feet deep-blue limestone, masses and lenticular concretions of dark-blue chert in the upper part, shaly and concretionary beds below. No. 85 of Gen. Sec.

13—2 feet shales.

14—4 feet fine-grained, brittle limestone, with numerous calcite specks.

15—10 feet irregularly-bedded limestone, with brown shaly partings; some chert.

16—1½ feet deep-blue, argillaceous limestone.

17—4 feet blue and bituminous shales.

18—18 feet gray, shelly limestone, No. 78 of Gen. Sec. and old No. 166 of Mo. Riv. Sec.

At Kansas City Bridge, No. 78 lies below the Pacific Railroad track, and rises gradually west. A quarter of a mile west it is above the railroad track, having risen 18 feet in that distance. No. 98 stands out from the bluff in bold, rounded projections. Fossils do not abound. I observed *Prod. costatus* (large var.), *Prod. Rogersi*, *Prod. punctatus*, and *Bryozoa*. Just below, a nearly flat terrace extends out for nearly 50 feet.

Where the bluffs approach Turkey Creek, we have—

No. 1—23 feet of gray limestone (= No. 98 of Gen. Sec.), quite shelly.

2—26 feet slope.

3—6 feet limestone, with large *Productus* (= No. 96).

4—69 feet slope, débris from above.

5—10 inches chert, color dark-blue, and decomposing buff, with many fossils, including *Platyostoma Peoriensis*, McCh., *Loxonema cerithiformis*, and a larger univalve, resembling a *Murchisonia*, is very abundant.

6—4 feet coarse, dark, brownish, gray limestone, containing *Solenomya*, *Bellerophon crassus* and *Nautilus ferratus*.

7—9 feet slope.

8—4 feet shaly limestone beds, containing *Aviculopecten occidentalis*.

9—Outcrop of limestone. No. 83.

10—14 feet slope.

11—18 feet limestone. No. 78 of Gen. Sec.

No. 78, lying near the base of the Upper Coal-measures, is easily recognized wherever found. From its peculiar form of weathering, it is often recognized even at a distance. I first observed it in 1860, at Bethany, in Harrison County, occupying the bed of Big Creek. In subsequent notes I called it the Bethany Falls limestone, and it was so named in my section read before St. Louis Academy of Science in May, 1862, and is numbered 162 of that section. I observed it near Gallatin, in Daviess County, in the western part of Livingston, in Caldwell and in Clay Counties on the Missouri bluffs. No. 85 contains beds of deep-blue limestone and deep-blue chert; is found in Harrison, Daviess and Clay Counties.

No. 77 is generally shales, but appears as a thick-bedded sandstone in ridge west of Crawford's Fork, Cass County.

ECONOMIC GEOLOGY—MATERIALS FOR BUILDING.

Some of the limestone-beds at Kansas City afford a good material for building, especially No. 87. Its upper part is light-gray, beautifully oölitic, and very durable. The dark-brown, coarse limestone occurring near the upper part of No. 85 is strong and durable; it is quarried in bluffs near Turkey Creek. No 79 is handsome, durable, works free, and furnishes a good material for a fire-rock; it is sometimes wanting; it is quarried at Greenwood, Pleasant Hill and vicinity. It is sometimes beautifully oölitic. No. 84 is light-drab or dove-colored, containing minute particles of calcite; admits of a fine polish, but is sometimes cherty and hard to dress, and is therefore objectionable as a marble. It is found at Kansas City, near Greenwood, and in Parker's quarry, Pleasant Hill. Some of the lower beds of No. 78 are in even layers, and are useful for building. No. 74 is good, strong and durable, and thick-bedded; it is quarried at various places around Pleasant Hill. Sometimes the upper portion is wanting, and the lower appears as a very even-bedded, dark-blue limestone, variegated with dark windings throughout; is vertically jointed, forming rhomboidal masses. It has been extensively used in railroad bridges and culverts. The principal quarries are at William Hodges's, in Sec. 9, T. 45, R. 30; numerous quarries north of Pacific Railroad, in Secs. 15, 9, 10, 22 and 23, T. 46, R. 30, Cass County, and in Jackson County, at Amos's, Lone Jack, and at Chapel Hill, in Lafayette County. Nos. 70 and 71, from quarries 2 miles east of Harrisonville, have been extensively used in the construction of bridges and culverts on the M. K. & T. R. R. The beds in these quarries are 2 feet in thickness. Most of the sandstone used in the railroad bridge over Crawford's and Percival's fork of Big Creek, was obtained from Carey's quarry on the railroad, 2 miles west, and Haynes's, 1 mile east. There is about 4 feet thickness of it in beds of 1 to 2 feet, works free, and is quite durable. Some of the stone used at the last-named bridges, and most of it for 6 miles east, was brought from Howe's (now Hobbs's) quarry, on the Blackwater, 5 miles north of Kingsville. It occurs in thick beds, but is of inferior quality. I refer it to No. 65 of General Section.

No. 55 is quarried at many places near Holden. It is durable, and suitable for all ordinary purposes, but is rather hard and irregularly bedded.

The Warrensburgh sandstone is a superior article, and is very extensively used. It is of various shades of brown, gray, drab and blue, and generally contains scales of mica disseminated throughout. In Warrensburgh it is a deep-brown ; at Sheppard's, coarse gray or drab ; at Davis's, bluish-gray ; at Cocknell's, coarse light-drab ; at Moore's, a little coarser and buff-stained. At Moore's, 4 miles north-west of Warrensburgh, it crops out 20 feet thick from the water's edge without a seam. At Cocknell's the beds are apparently as thick. At Davis's the quarry-pit is worked down 18 feet, with no seam on three sides, and only thin coal-seam on the fourth side. From this quarry the rock is shipped to Kansas City and other places. The window-sills and caps of the Agricultural College, at Columbia, are from Davis's quarry. The pillars of the Court-House, at Lexington, are from a sandstone quarry on the north side of the Blackwater, and have been in use over twenty years.

Quarry of Dr. Rodgers, on north-west, Sec. 17, T. 45, R. 24. The rock is a whitish or light-colored drab, very fine grained, of firm texture and even strata, and very durable ; said to make good grindstones.

The sandstone of the Knob Noster quarries is micaceous, soft, easy to work, and of various shades of red, buff and brown. Sandstone belonging near the top of the lower carboniferous occurs in thick beds 2 miles south of Lamonte.

The lower part of the Burlington and the upper Chouteau beds are generally easy to work, are of uniform thickness, and afford an excellent material for building. Good quarries are near Georgetown and on the Little Muddy north-east of Dresden. Near Sedalia the Chouteau beds too often contain chert concretions.

The marble beds on the Big Muddy, west of Sedalia, have been described in the first part of this report. I would only add that the rock is easy to work and admits of a fine polish.

Lime.—The Burlington limestone beds are the best for lime ; the rock is quite abundant near Georgetown. Some of the upper coal-measure limestones make good lime, but not very white. Nos. 78 and 98 make good lime.

Sand.—The best sand for plastering is procured from the Kansas River. The Missouri River sand is also extensively used, but contains many impurities and is too fine. At Warrensburgh the sand from decomposing sandstone is used, but there is a difficulty in crushing it fine enough. Sand from crushed sandstone is used sometimes at Pleasant Hill, but it lacks sharpness. The Missouri and Kansas River sands are shipped by rail to many places.

Potters' Clay.—Extensive deposits of good quality of potters' clay are exposed at several places near Dresden and at Lamonte. The brown stoneware that I have seen made from it is very good. Beds of *fire-clay* from 2 to 4 feet in thickness underlie most of the coal-beds in the eastern and central parts of Johnson and the western part of Pettis Counties. None of these clay-beds have yet been put to any practical use, but they are undoubtedly valuable ; some of them are quite sandy.

Clay ironstone, or carbonate of iron, is often met with in the lower shale beds. In the concretions in the shale over the coal, 2 miles west of Warrensburgh, I obtained what seems to be "spathic iron."

Carbonate of iron and lime occurs in lenticular and reniform beds, sometimes of even thickness for some distance, on Clear Fork, six miles north of Knob Noster. Sec. 18, No. 5, contains a 4-inch bed reticulated by numerous cross-veins of calcite. Sec. 18 and 19 are near together, and include a 10-inch bed of ironstone with 5 to 7 feet below, separating it from sandy shales containing similar thin ore-beds. Similar iron-beds, occupying the same geological horizon, crop out on Clear Fork, 5 miles south-west of Knob Noster, as shown in the following :—

Sec. 27.

No. 7—1 foot black slate (= No. 16 of Gen. Sec.).

8—3 feet shales.

9—6 feet sandstone.

10—4 feet sandy shales, with some beds of carbonate of iron.

11—1 foot ironstone (carbonate iron).

12—1 foot clay shales.

13—1 foot ironstone.

The foregoing section, we perceive, includes a total thickness of over 2 feet of a comparatively good iron-ore within a few feet of vertical thickness. In Sec. 28—11 the equivalents of above ore-beds are included. These beds certainly underlie the whole country as far as the east county line of Johnson, and westward may be found at greater depths.

The shale-beds of No. 61, at Holden, contain many flattened ironstone concretions, some solid in the centre, with no appearance of fossils, but the greater number when broken display to view many plant-remains, including *Neuropteris*, *Sphenophyllum*, and *Annularia*, with some fragments of plant-stems.

Nos. 65 and 69 contain flattened concretions of ironstone—kidney ore.

The sandstone at Warrensburgh and at Knob Noster contains many hollow iron concretions.

Ochre.—On Richard Harris's land, south side of Knob Noster, there is an outcrop of yellow ochre 4½ feet thick, of every shade from light to dark-yellow, some even slightly red-tinged. It is mostly soft, but some is hard and compact; it contains a few obscure remains of plants. In one opening it appears 4½ feet thick; one hundred and fifty feet off it is thus:—

No. 1—2 feet shale, red and yellow, in thin laminæ.

2—16 inches bituminous coal.

3—10 inches brown and yellow ochre.

4—1 foot light-brown ochre.

5—1 foot dove and yellow fire-clay.

This ochre-bed appears in the railroad cut, but not so well developed; also at Mr. Carpenter's, 1½ miles north-east, and on the adjoining land of Higginbotham's we have 4 feet of dark-brown, shaly, good iron ochre, with many remains of roots of *Stigmaria*. It appears again in the railroad cut at Minersville, cropping out beneath a 15-inch coal-bed, with one foot of light-yellow clay containing *Stigmaria* roots at top, succeeded by 3 feet of variegated clay, red and yellow. At this place the amount of iron contained is small. This ochre-bed was originally a simple bed of fire-clay, but into which much oxide of iron has introduced itself. In some places it is a light-yellow, sandy fire-clay. In others we find it hard, firm, good iron-ore. It underlies the country around Knob Noster, at least for two miles north and several miles south.

At Boyce's coal-bank, 5 miles north-west of Knob Noster, we have 32 inches of coal resting on 3 feet of ochrey shales, color red and yellow.

On Franklin Craig's land, on Copperas Creek, we have red clay with yellow clay.

These ochre-beds, we perceive, occupy the place of the coal underclays, and we find them of every grade, passing from a pure fire-clay and a clay slightly tinged with iron to a bed of good iron-ore.

The shale-beds of No. 65 often abound in ochre concretions, and many are found on Falls Branch, Johnson County, and in Sec. 25 and 36, T. 46, R. 30, Cass County.

At Pleasant Hill we find No. 69 containing ochre concretions.

Iron oxide is quite abundant, sometimes in attractive crystallized forms, in the railroad cut on the L. L. and G. R. R., at Amos's, in Jackson County, occurring in No. 83 of Gen. Sec.

Iron pyrites is found in both the shales and coal in the west part of Pettis County. Some quite handsome forms occur at Munroe Thompson's ; it is also quite abundant at Haley's and Ewer's coal-bank. On Walnut Creek, at the railroad crossing, are found many stems of plants composed entirely of iron pyrites.

Fossils contained in shales are in many places entirely composed of iron pyrites, sometimes forming handsome specimens. I might mention those obtained from Langston's, six miles north of Knob Noster, Fairchild's at Carbon Hill, and in the cannel-coal stratum at Mrs. McClellan's, at Tapscott's, and at Wray's.

Zinc-blende often forms a small nucleus in ironstone concretions, and in this position was found on Walnut Creek, near the Pacific Railroad crossing, in the shales over the coal at Long's, and in the concretions at Holden. It is sometimes found in the centre of a plant-stem. A small quantity of zinc-blende was found in limestone No. 83, at Amos's, in Jackson County.

Gypsum.—The shales in the lower coal-measures sometimes afford many selenite crystals. The shales below No. 24 in the railroad cut, both east and west of Walnut Creek, contains quantities of them ; also the shales over Tarhorst's coal ; near the middle of Sec. 28 and

No. 7 of Sec. 17, Cox's coal-bank. They are quite abundant in the blue shales on Clear Fork, six miles north-west of Knob Noster, and No. 4 of Sec. 10, six miles south-west of Knob Noster.

Calcite.—Beautiful forms of calc-spar were obtained from No. 83, Parker's quarry, at Pleasant Hill, and Amos's, in Jackson County. Among them were found white, transparent, pink, and amber-colored; in form rhombohedrous, dogtooth spar, nailhead spar, acicular and mammillary forms.

Heavy-Spar.—An irregular vein occurs in the lower Burlington beds on the Lexington & Sedalia Railroad, north of the Muddy; it seems to be about 10 feet wide. A handsome flesh-colored variety occurs at Parker's quarry, Pleasant Hill, and at Amos's quarry, Jackson County.

Springs.—A correct knowledge of the geology of a district will often enable us to tell with near approximation at what depth to expect to find water. In digging wells at Pleasant Hill, water is always found in No. 77, and all the springs of that vicinity issue from either 73 or 77. Wells have been dug nearly a hundred feet deep, commencing in No. 69, and only obtained weak supplies of water. On the Missouri bluffs, in Jackson County, are many cool, pleasant-tasting springs of water issuing from No. 77. The large spring at Independence issues from No. 97. In the middle and lower coal-measures springs are rare. At Mr. Carpenter's, one and a half miles north-east of Knob Noster, there is a well of very clear and exceedingly pleasant-tasting water, supposed to contain alum.

Three miles north-west of Warrensburgh is a large mineral spring on low, marshy ground. The water seems to contain sulphuretted hydrogen, and is slightly tinged with iron.

Coal.—In my General Section, above described, we have 19 feet 9 inches of coal, distributed as follows:—

Near the base No. 2 is........................2 feet.
At about 25 feet up in the series No. 5 is.........11 inches.
At 41 feet No. 8 is.............................4 feet 8 inches.
From 41 to 65, three thin beds of 3 in., 5 in., and 1 ft. = 1 foot 8 inches.
At 91 feet No. 18 appears........................1 foot 6 inches.
At 96 feet No. 21 is..............................8 inches.
At 116 feet No. 27 is.............................1 foot 8 inches.
At 133 feet No. 32 is.............................7 inches.

At 186 feet No. 35 is............................1 foot 6 inches.
At 293 feet No. 44 is............................2 feet.
About 240 feet No. 42 has.......................6 inches.
At 379 feet No. 59 is............................1 foot.
About 480 feet No. 68 has.......................5 inches.
At 534 feet No. 73 has..........................3 inches.

The coal-beds, we perceive, are thicker and more crowded toward the base of the series, becoming few and far apart as we ascend, and also very thin.

The lowest coal, No. 2, may be found in Pettis County. No. 5 occurs on Clear Fork, 11 inches thick; I also think it is the equivalent of the coal at A. B. Gardner's, Pettis County. No. 8 is mined at Long's, Gabby's and other places in the same vicinity on and near Clear Fork. The most extensive mining is done at Minersville on the Pacific Railroad. The mines on the south side of the railroad belong to the Pacific Mining Company, those on the north to General F. Cocknell. The coal from these mines is all sold to the Pacific Railroad Company, and is used at their machine-shops and on their engines. The upper 1½ to 2 feet, being quite shaly, is only used by the miners, or else thrown into a refuse-heap and burned up. The lower 30 to 36 inches only is sold. The Pacific mines at their eastern shaft work about 20 men. The main shaft is 42 feet deep. From the foot of the shaft the main drift or entry extends south 600 to 700 feet; there are 2 cross-drifts and 2 abandoned ones. The coal is hauled by mules on trucks to the foot of the shaft, and from thence is raised to the surface by steam-power. This company's other mine, one-quarter of a mile west, employs a smaller force. A steam-engine is also employed.

On the north side of the railroad are General Cocknell's mines. Thirteen men are now employed,—they have worked 20. The shaft is 45 feet deep. From the bottom an entry extends 150 yards east and another 125 north-east, with several cross-driftings.

The mines of Higgins, east of Walnut Creek, are in No. 18. A great many entries have been made into the hill and much coal taken out.

The bank of Roberts and Sickles, on the land of Sylvester Orr, is referred to the same horizon as that of Higgins. The coal is 24 to 28 inches thick. The entrance is on a hillside, and passes in a little over 50 feet.

James Mudd's coal-bank in south-east, Sec. 8, T. 46, R. 24, is 21 to 24 inches thick, and is reached by a shaft 20 feet deep, from the bottom of which entries extend off at right angles. This coal may be referred to No. 21 of the General Section. These coals are mainly sold in the neighborhood.

Besides the above, there are evidences of a great deal of mining having been done formerly around Knob Noster,—many mines being now abandoned.

Tarhorst's, Neal's and Reavis's, on a west branch of Clear Fork, six miles south-west of Knob Noster, are all worked at present. The coal is of very good quality and is used at Warrensburgh.

Mrs. Wingfield's coal is much esteemed by blacksmiths; it is hauled by them 10 miles to Warrensburgh, and is preferred to any of the different coals which are nearer.

No. 35 is mined west of Carbon Hill, at Fairchild's, and at many places around Warrensburgh, principally on Pott's Branch, and generally by horizontal driftings. This coal is remarkably irridescent.

A good deal of mining has been formerly done at different periods of time on the Pin Oak and north and east on the Blackwater, but at present but few of the mines are worked.

The Holden coal, No. 59, is, when seen, of very excellent quality, but is not worked much now, being only one foot thick; it has been worked at Holden and westward on the waters of the Blackwater, and is occasionally mined at Strasburgh, near the Pacific Railroad, and at William George's, near the M. K. & T. R. R., in Cass County. It is a first-rate coal, remarkably free from ash. The Clear Fork and Warrensburgh coals both contain occasional handsome specimens of mineral charcoal, called by the miners "Mother of Coal." This is useful to polish tinware.

The following is a table of analyses, by Mr. Chauvenet, of the different mines of the Warrensburgh coal:—

	B. Owsley (middle).	Bruce.	Zimmerman.		Zoll.		Gilleurs	Mineral charcoal.
				(bottom).	(bottom)			
Water	7.40	5.31	6.77	7.09	6.32	5.39	7.29	1.59
Volatile	43.07	43.65	45.10	42.14	45.38	45.89	42.27	15.63
F. Carbon	38.37	43.12	44.01	47.15	44.98	45.56	46.95	71.28
Ash	11.16	7.92	4.12	3.62	3.32	4.16	3.49	11.50
Color of Ash	pink, gray	pale gray	pale slate	very pale brown	pale gray	pale gray	slate	reddish slate
Sp. grav.		1.271	1.225			1.243		1.803
Sulphur						2.916		
Total carbon			74.76			74.28	76.51	
Hydrogen			6.33			6.07	5.61	
Nitrogen							1.555	

An analysis of coal at William George's, Cass County, by Mr. Chauvenet, gives the following result:—

Water	7.80
Volatile	33.20
F. Carbon	55.75
Ash	3.25
Color of Ash	rich brown
Sp. gravity	1.261
Total Carbon	66.25
Hydrogen	5.21

Superficial Deposits.—The Missouri bluffs on the south side form the southern boundary of the drift. A few bowlders of granite, greenstone, and quartzite have been found at Kansas City, near Lexington, and Berlin—the largest about 9 inches in diameter. I refer them to altered drift, for they evidently have been transported with gravel and sand, partly ferruginous, to which beds the name "altered drift" is sometimes applied. The only place where I have observed these beds of sand and gravel in the interior was near Big Salt Spring, in Saline County, 15 miles from the Missouri River, where they are exposed on the side of a low hill.

Bluffs.—At Kansas City and vicinity we find a deep deposit of finely-comminuted sand and marly clay; colors brown, drab, and yellow. Stalactitic forms of sandy iron-ore occur in the sandy beds, and in the marly beds are found rough, spherical, calcareous concretions, somewhat nodular, in shape very much like an artichoke. Two species of shells are sometimes found, which may be referred to the genera *Succinea* and *Helicina*.

The soil based on these clays is generally very rich, and the woodlands furnish a luxuriant growth of linden, elm, oak, hickory, hackberry, sugar-tree, black walnut, cherry, pawpaw, mulberry and coffee-tree.

These peculiar beds seem to be mostly confined to the vicinity of the Missouri River. The railroad cuts, south and east, show a more stiff, harder clay, variegated brown, drab and yellowish. I have part of the leg-bone of a mammal dug out of a well at Pleasant Hill, at a depth of 28 feet.

The general thickness of these clays on the hill-tops is not often over 10 feet, but is sometimes 16 to 20.

In digging excavations of foundations for bridges, we find in the beds of streams a succession of logs, blue clay, leaves, gravel, and decomposed *Unionidæ*.

From these shell-beds I obtained the tooth of an ox (species extinct) at a depth of 12 feet below the surface.

To Mr. Chas. M. Litton, of St. Louis, I am indebted for much valuable assistance in the field.

PROF. RAPHAEL PUMPELLY,

Director Geological Survey of Missouri:

SIR:—In compliance with your request I have prepared and herewith transmit a full report on the geology of Lincoln County.

To Mr. Alexander Leonhard, who was associated with me in the work of the past season, I am indebted for valuable services rendered in the field and in the preparation of maps, etc., accompanying this report.

Your obedient servant,

WILLIAM B. POTTER,

Assistant.

CHAPTER VII.

GEOLOGY OF LINCOLN COUNTY.

GENERAL GEOLOGY.

BY W. B. POTTER.

SURFACE FEATURES.

LINCOLN COUNTY is bounded on the north by Pike County, on the east by the Mississippi River, on the south by St. Charles and Warren, and on the west by Warren, Montgomery, and Pike Counties, and contains nearly eighteen townships, or an area of about six hundred square miles.

Topographically, the county is divided into two parts by a main ridge, which enters on the north in Sec. 3 and 4 of T. 51, R. 1, W., and passes on in a general south-south-easterly direction.

The drainage-waters on the east side flow directly into the Mississippi through Bryant's Creek and King's Lake, Sandy, Hurricane, McLean's and Bob's Creeks; while the western part is drained by North and West Forks, which join near the centre of the county, forming Cuivre River, and this, flowing around the southern end of the main ridge, is joined by Big Creek or Eagle Fork, and passes on into the Mississippi in a general easterly direction.

The county, thus divided, exhibits quite different topographical features. In the eastern part the work of aqueous erosion has been very great. The streams and branches have worked out a system of deep and ramifying valleys, leaving hills and ridges, in some cases with rounded and easy slopes, but often with perpendicular sides, as remnants of what were once continuous beds. The different degrees of hardness of the various rock-strata appear in the manner in which they have withstood this erosive action. The range of high knobs in the north-eastern part of the county have gentle slopes at the base, where they are made up of the easily decomposed shales and slates of the Hudson group, and grow steeper as these beds give place in ascending to the firmer limestone of the Hamilton, while the summits are protected by the still denser Chouteau limestone. The sandstones and limestones of the lower magnesian series, too, being less firm and dense, are found to be more deeply eroded than the durable limestone of Trenton age. The coal-measures which are represented in the high ridges in this part of the county have been protected there from erosion by the very hard and compact hydraulic limestone which caps the ridges; the shales and coal of the coal-measures being so soft and easily acted upon, that they must have been swept away gradually but for this protection.

The ridges vary considerably in height, in some cases rising over a hundred feet above the adjacent valleys. Near the middle of the county the general direction is parallel with that of the main dividing ridge, or nearly north-west to south-east; but farther east the general trend is east and west, while the range of knobs, from four to five hundred feet high, is about north and south.

The slopes of the ridges are generally quite steep, and covered with a thin soil yielding a growth of small timber, mostly post-oak, with some white, black, and red oak. In some cases the soil is deep and well adapted for growing tobacco and grain, and that nearer the bluffs yields fine crops of wheat.

The western half of the county is mostly high prairie-land, cut through in many places by the North-west and Eagle Forks of Cuivre River and their tributaries, affording a fair distribution of timbered land. The timber consists mostly of white, black, red, and burr oak, hickory, black walnut, maple, and in the bottoms sycamore. The uplands are for the most part gently-undulating prairies, with occasionally deeper hollows, from which small streams take their rise. The soil varies in thickness from one to two and a half feet, and is mainly dark-colored mould, with a mixture of sand and clay.

The principal stream of the county is Cuivre River, which, with its branches, drains the whole western half. The North Fork enters the county about the middle of T. 51, R. 2, W., and flows in a general south-easterly direction, receiving the waters of Sulphur Fork, Mill and Fort Spring Creeks, besides many minor branches, and joins the West Fork in the upper part of T. 49, R. 1, W. All the large streams and branches enter North Fork from the north and east; this being due to the broad and gentle slopes there offering a more extended surface of drainage, while the land on the south and west is higher and more abrupt, through which the waters, collected over a more limited area, and hence in small streams, have cut deep and narrow channels.

West Fork enters the county in the southern part of T. 50, R. 3, W., and flows in a westerly direction, generally through a deep and narrow valley, but with occasional wide-spreading bottoms. Its principal branches are Camp and Turkey Creeks on the south and Lead Creek on the north. From the junction of these Forks, Cuivre River flows south-easterly along a broad valley, from one-half to one and a half miles wide, the bottoms being rich and well wooded, and shut in by bold escarpments of rock. Sugar Creek from the east, and Crooked Creek from the west, enter the Cuivre before it reaches the southern limit of the county, where it is joined by Big Creek or Eagle Fork. From this point it flows in an irregular easterly course into the Mississippi, near the middle of T. 48, R. 3, E. During certain seasons of the year the river is navigable for small steamboats as far as Moscow, a distance of nearly twenty-five miles.

The north-eastern portion is watered by Bryant's Creek, which flows with a north-east and easterly course through a broad valley, with high and somewhat abrupt ridges on the south side, the high land on the north sloping gradually for a mile or more toward the stream. Broad bottoms occur at many places, with a heavy growth of timber. After reaching the bottoms of the Mississippi, this stream turns south and flows a number of miles along the river, forming, with the addition of other streams, a broad and shallow body of water, called King's Lake. The other principal streams of the eastern part of the county are Lost, Hurricane, Sandy, and McLean's Creeks, which take their rise in the range of knobs already mentioned, and flow through deep and narrow valleys into the Mississippi bottom, emptying into King's Lake. Bob's Creek, farther south, rises near the head-waters of Bryant's Creek, and, receiving the drainage-waters of the western slopes of the range of knobs, passes around the southern extremity of the latter, and, with Brushy Fork, enters the Mississippi a short distance north of Cuivre.

The Mississippi bottom varies in breadth from one and a half to three miles, and consists mostly of prairie-land, a narrow fringe of timber occurring only along the banks of the streams and the foot of the rock-bluffs.

One of the marked features of the surface in many parts of the county is the occurrence of small conical depressions, known as sink-holes. They are found always in the high land and near the edge of a ravine or valley, and sometimes in great numbers, as in Sec. 10, T. 49, R. 2, E., where fourteen occur in a row within a few hundred feet. These have originated from the surface-water making its way through the crevices and joints of the limestone, enlarging them by wearing away the edges of the limestone until they became large cavities, through which the overlying soil is carried, causing it to cave in, and forming the funnel-like depression. Springs often obtain their supplies of water from these sink-holes, and large streams disappear in them, and after flowing a distance underground reappear in the valleys below.

Most of the caves, of which there are many of large size in the county, have been formed in this way, aided in some cases by the waters of the streams flowing past.

In Sec. 15, T. 51, R. 2, W., on Anderson's Fork, a large and well-formed natural bridge has been worked out of the limestone bluff through similar agencies. The limestone belongs to the Receptaculite, or upper, beds of the Trenton formation, and forms a perpendicular wall of sixty feet on the west side of the stream. About fifty feet from the edge of the bluff there is a large sink-hole, from the bottom of which a passage from four to ten feet wide and eight to twenty-five high leads back to the outside wall of the bluff at the edge of the stream, forming a complete bridge overhead.

STRATIGRAPHICAL GEOLOGY.

The following is the order of succession and thickness of the various geological formations appearing at the surface within the limits of Lincoln County :—

Quaternary System.	Alluvium, Bottom Prairie, Bluff or Loess, Drift (bowlders),	75 ft.
	Lower Coal-Measures,	35 "

Carboniferous System.	Subcarboniferous.	Ferruginous Sandstone,	20 ft.
		St. Louis Limestone,	90 "
		Archimedes "	80 "
		Encrinital "	180 "
Devonian System.		Chouteau Limestone,	50 "
		Vermicular Sandstone and Shale,	50 "
		Hamilton Group,	30 "
		Onondaga Limestone,	6 "
		Hudson Group,	65 "
		Trenton "	230 "
		Birdseye and Black River,	30 "
Lower Silurian System.	Lower Magnesian Series.	1st Magnesian Limestone,	50 "
		Saccharoidal Sandstone,	65 "
		2d Magnesian Limestone,	35 "

The Lower Silurian occupies about one-third of the entire county area in the northern and north-eastern parts.

The Devonian appears in a narrow stripe along the southern margin of the Silurian, and as isolated areas in the high knobs of the north-eastern townships.

The Carboniferous occupies the remainder—nearly two-thirds of the county—and is almost entirely of the Subcarboniferous division, the Coal-Measures covering only a very limited area in the high ridges of the south-east.

The occurrence of so wide a range of geological formations within the limits of this county is due to an uplift of the Lower Silurian on the north and east.

The overlying formations were afterward very extensively removed by surface erosion, leaving, thus, the lower strata exposed to view. In the high knobs and hills of the north-eastern part the remnants of these overlying formations are still to be seen in the Onondaga, Hamilton and Chouteau beds, occurring there as geological islands in the Silurian area.

The main axis of this uplift seems to have been in a general direction of W. 30° N., and near the southern border of the present Silurian area. By reference to the section along the Mississippi bluffs, it will be seen that between McLean's and Sandy Creeks a strong anticlinal arch intersects the bluffs, the lowest formation that appears being the Second Magnesian limestone, with the Saccharoidal sandstone overlying it conformably. On the south side a fault has taken place, and the Vermicular group rests against these with the Chouteau and Encrinital limestones beyond, while toward the north the strata dip gradually and at a decreasing angle as far as Little Bill's Branch, where another smaller fault has taken place and later beds appear. This anticlinal arch and the great fault can be traced through the county to its north-western border, and it is along this line that the Devonian formations for the most part appear.

The amount of uplift of this Silurian area must have been about four hundred feet, judging from the thickness of the overlying formations as exposed in other parts of the county. The upturned strata of the St. Louis limestone, near the line of fault, show that the period of disturbance must have been later than the Subcarboniferous; and though there is no evidence in Lincoln County to prove how much later it was, still, across the Mississippi, in Pike County, Illinois, the undisturbed strata of the Coal-Measures appear resting uncomformably upon the tilted beds of the Subcarboniferous limestone, proving the disturbance to have been anterior to the Coal epoch.

In the north-eastern part of the county, at Little Bill's Branch, there occurs another fault, as already mentioned, on the south side of which the Receptaculite limestone of the Upper Trenton is in place, and in the north the Chouteau limestone and Vermicular shales. This small area of Devonian formations seems to be the remnant of a much larger area extending toward the east, but now cut away by the waters which excavated the great Mississippi Valley. It was probably also a part of the Devonian beds, which, previous to the uplift, covered the entire region, but which, with the exception of a few high knobs, have since been swept away. Owing to the faulting of the strata along the branch, this area was not elevated to any great extent, and the beds, remaining more nearly horizontal, offered greater resistance to the action of surface erosion, and are thus left as we now find them.

In other parts of the county the strata show evidence of a slight movement. Along Bryant's Creek, from the Mississippi bluffs for a distance of several miles toward the west, the strata rise at an angle of from 3° to 8°, being greater toward the east. The Hudson group gradually gives way to the Trenton, and in the north-eastern part of T. 51, R. 1, W., the Lower Magnesian series appears at the surface. From thence the dip is very gentle toward the west. Also in the southern half of the county, where the Subcarboniferous prevails, the same general structure may be seen. East of Cuivre River the dip is very perceptible toward the north-east, giving in succession outcrops of formations from the Coal-Measures to the Encrinital limestone. Beyond the river the dip is very slight toward the west.

We have thus two great and nearly parallel anticlinal arches in the northern and southern parts of the county, and seemingly independent of the line of fault which separates them.

SECOND MAGNESIAN LIMESTONE.

This is the oldest geological formation represented in Lincoln County. It occurs in the Mississippi bluffs, south of Sandy Creek, forming the lowest beds of an anticlinal arch for a distance of over a mile. On the south it first appears rising at an angle of 15° from the line of fault, where the Vermicular sandstone and shales rest against it. Rising at a gradually diminishing angle, the crown of the arch is reached within a quarter of a mile to the north, and here the formation is about thirty-five feet thick, and consists of—

No. 4—Dull yellowish white or gray earthy magnesian limestone, in beds from one to ten inches thick and destitute of fossils, with thin sandy beds interstratified. 18 feet.

No. 3—Light-brown, dense, and rather silicious limestone, with crystals of calcite and dolomite in cavities. 5 feet, passing into

No. 2—Coarse yellowish crystalline limestone, in beds six to twelve inches thick, with calcite in thin veins and cavities. 6 feet.

No. 1—Covered slope to the foot of the bluffs. 6 feet.

For a distance of nearly half a mile these beds are quite horizontal, appearing at intervals from the covered slopes. Beyond, they begin to descend, and, in the north-east $\frac{1}{4}$ of Sec. 2, T. 49, R. 2, E., within a quarter of a mile of Sandy Creek, disappear beneath the Saccharoidal sandstone.

On the south side of Sandy Creek, in Sec. 35, T. 50, R. 2, E., there is an exposure of fifteen feet of a thin-bedded, earthy, magnesian limestone, dipping at an angle of 8° to the north-west, which, from its position, is undoubtedly the 2d Magnesian. The layers are, in places, much disturbed, showing an irregular wave-structure; but the general dip prevails, carrying the formation under in a short distance.

This exposure of the 2d Magnesian is due to a bend in the creek toward the south, which has cut into the anticlinal arch beyond the general line of the valley, and reached the lower beds near the axis.

No organic remains were found in any part of this formation, but its well-marked lithological character, and its relation to the overlying Saccharoidal sandstone, leave no doubt as to its true position in the geological scale.

THE SACCHAROIDAL SANDSTONE.

This formation, as developed in this county, consists of a white or reddish-brown and generally coarse granular sandstone, in thick beds, often showing no signs of stratification, or in thin, regularly stratified layers. The pure white variety is composed of grains of quartz, imperfectly cemented together and crumbling readily on exposure, while the dark-colored beds are of firmer texture and more durable, the oxide of iron with which it is colored furnishing additional cementing power.

The most noted points where this sandstone is developed are in the Mississippi bluffs from the north side of Sandy Creek, for a distance of three miles south, and west along the creek and its branches for about the same distance. On the Mississippi it forms the top of the anticlinal arch already alluded to. The total thickness here is about sixty-five feet, the upper part in thinner layers irregularly stratified, and the lower in heavy-jointed beds, from which blocks of great size have fallen to the foot of the bluffs, or lie scattered along the intervening slope. On the weathered surface this rock is of a dark, reddish-brown color, and in the interior of a lighter brown or yellow—all more or less stained with oxide of iron. It forms the main part of the bluff as far south as the line of fault, where it appears cropping out in the top of the hills, over the 2d magnesian limestone; and in the higher hills, near

Sandy Creek, it is overlaid by the 1st Magnesian; but the slopes of the bluffs are so well covered with detritus that it is not possible to obtain a good section at any point. The dip to the north and west carries the sandstone gradually down to the Mississippi bottom. It forms the greater part of the bluffs on both sides of Sandy Creek bottom, with an exposure, on the north side, of nearly thirty-five feet, and a general dip of 7° to N. 20° W., which causes it to disappear about a quarter of a mile to the north. It consists of thin-bedded, well-stratified, fine-grained sandstone of a dull yellowish-gray color, with beds of coarser sandstone, and in thicker layers interstratified.

West of the Mississippi bluffs the sandstone appears in the hills and ridges along lower Sandy Creek and its branches, cropping out at intervals only in the north bank, but forming bold perpendicular bluffs on the south side, where it consists of massive beds irregularly jointed, but exhibiting no signs of stratification.

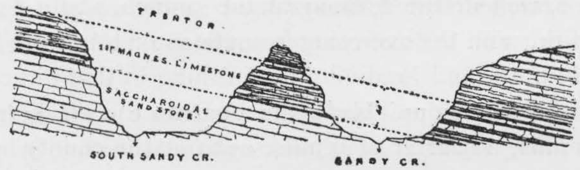
With a dip of nearly 10° to N. 18° W., it descends gradually along the bluff to the bed of the creek, a crumbling mass, undermined in many places by the running water, forming "sand-caves," which show the light yellow and sometimes pure white sand of the freshly-fractured surface. Along the whole length of the creek and its main branches, South, Middle and North Sandy, the dip in the strata is west of north 10° to 25°, and at an angle of 5° to 15°, diminishing toward the west. This dip carries the Saccharoidal sandstone beneath the surface on the North Branch, about a quarter of a mile north-west of Robertson's Mill, while across the intervening ridge, on Middle Sandy, thirty-six feet of it are exposed in the bluffs.

The accompanying section, taken nearly north and south across Middle and North Sandy, in Secs. 28 and 33 of T. 50, R. 2, E., will show the position of the strata at this region.

Fig. 61.

On the Middle, near its junction with the South Sandy, the Saccharoidal forms the main part of the bluff, being nearly forty feet in thickness, and is overlaid by twenty-five feet of the 1st Magnesian limestone. It dips gently up-stream, and disappears about a mile further on, from which point, across the intervening ridge to the South Sandy, a thickness of forty feet is exposed in the bluffs on the south side, as will be seen in the accompanying sketch, section taken across all three branches from near the middle of Sec. 32 to south of Sec. 20, T. 50, R. 2, E.

Fig. 62.



The South Sandy flows nearer the axis of the anticlinal, so that the angle of the dip is much less, and the sandstone appears in the bluffs along nearly its entire length, giving place to the 1st Magnesian limestone near the section-line between 31 and 32.

In the north-western part of the county there are two other localities in which the Saccharoidal sandstone occurs. One of these is in Townships 50 and 51, R. 1, W., on the main branches of Mill Creek, where it forms perpendicular bluffs of pure white, crumbling sand-rock, tinged on the surface with light yellow, red, and dark brown. In south-east of Sec. 33, T. 51, R. 1, W., near the township line, the line of upheaval crosses the south branch in the direction of N. 50° W. The Trenton dipping, at an angle of 20° to S. 60° W., appears in the bed of the creek, and further on the 1st Magnesian rises at an angle of about 15°, which diminishes gradually up the branch, and, beyond, the Saccharoidal sandstone, rising very gently, forms the lower part of the bluffs for a mile and a quarter, and then disappears in the high hills near the head of the stream. Its greatest observed thickness was thirty feet, occurring in heavy beds indistinctly stratified.

On the main branch of Mill Creek this formation also appears rising from the south-west, near the middle of Sec. 33, T. 51, R. 1, W., and, forming the base of the bluffs for about a mile, passes under the 1st Magnesian limestone, near the old Auburn Church. The thickness of the formation on this branch is about twenty-five feet.

A section affords the following :—

No. 3—Trenton limestone in the high hills.............25 feet.
2—First Magnesian limestone.........................48 feet.
1—Saccharoidal sandstone...........................25 feet.

The greater part of No. 3 is in heavy beds, but the upper ten feet are in thin layers and of fine grit.

On the Sandy Branch of Anderson's Fork, near the section-line, between 3 and 4 of the same township, a small area of Saccharoidal sandstone occurs in the bottom of the branch, about 8 feet thick. The dip of this and the overlying formations on the south is 5° to 7° nearly due south, and gradually diminishing in that direction. On the north the sandstone disappears beneath the 1st Magnesian in the higher hills, a quarter of a mile south of the county line. The sandstone is of a fine, gritty character, of a yellowish gray color, and in thin layers from two to six inches thick.

In the north-east ¼ of Sec. 5, on a branch of Gwin's Creek, running north-east into Pike County, there is exposed six feet or more of a thin-bedded, yellow sandstone, similar to that occurring on the Sandy Branch of Anderson's Fork. The beds dip very slightly toward the north, and are overlaid by about thirty-five feet of the 1st Magnesian.

No fossils were found in any of the beds of this formation.

THE FIRST MAGNESIAN LIMESTONE.

This limestone appears in the county in the same general localities as the members of the Lower Magnesian series already described, having been forced to the surface through the overlying beds of the Trenton group, and exposed more fully by the streams which have cut deep channels into them.

The main beds of the formation are composed of a dull-gray or yellowish crystalline magnesian limestone in thick layers ; silicious in places, and with cavities containing calcite and dolomite, while other beds are of a light-yellow color, in thin, regular layers with interstratified blue and drab shales, oölitic and sandy layers. The formation appears in the top of the high hills and north of Sandy Creek overlying the Saccharoidal sandstone, about twenty feet of thin-bedded, yellow, earthy and part sandy layers capping the high bluffs on the Mississippi.

The dip to the north and west which prevails in the strata along the Sandy and its branches, as shown in previous sections, carries the 1st Magnesian lower in the bluffs and exposes it more fully farther up the creek.

In the dividing ridge between the North and Middle Sandy, at Myers's Farm, the full section of about fifty feet is exposed between the Saccharoidal sandstone and the Black River beds, as follows :—

No. 8—Covered top.

7—Thin-bedded, bluish-gray, dense, brittle limestone, filled with vermicular cavities.

6—Yellowish-gray subcrystalline magnesian limestone, in beds from two to ten inches thick, with disseminated crystals of calcite.

5—Light-yellow crystalline limestone.

4—Dull-brown, earthy limestone.

3—Light-yellow arenaceous limestone in thin layers.

2—Bluish-gray limestone, in thin beds, with interstratified blue and drab shales, oölitic and sandy layers.

1—Saccharoidal sandstone to the bed of the creek.

On the North Sandy the 1st Magnesian descends rapidly to the bed of the stream, and disappears in Sec. 20.

On the Middle Sandy thirty-eight feet are exposed in the bluffs overlaid by the Black River beds, in the north-east corner of Sec. 32, T. 50, R. 1, E., as appears in the following section :—

No. 5—Light-gray and drab, thin-bedded, compact limestone, with vermicular markings.

4—Dark, yellowish-gray, earthy magnesian limestone, with disseminated masses of calcite.

3—Light-yellow, fine crystalline magnesian limestone.

2—Dark-brown, earthy limestone.

1—Light-yellow, sandy, thin-bedded limestone.

These beds finally disappear in the creek bottom, near the crossing of the section-line between 29 and 30.

On the South Sandy it forms the highest part of the main ridge, and with a gradual dip descends to the bluffs in the middle of Sec. 32, and from there west to the head of the stream cropping out in the side-hills, passing under the lower Trenton, in the centre of Sec. 31.

On the South and Middle Branches of Mill Creek the 1st Magnesian makes its appearance, rising from the bed of the streams at an angle of about 10° to the north-east. It forms the top of the dividing ridge, and skirts along the high bluffs, disappearing finally in the hills at the heads of the streams.

A section taken at Ellis's Farm, near the head of the South Branch, gives the following :—

No. 9—Covered top of hill.

8—Light-drab, compact, thin-bedded limestone, weathered into holes and winding passages, with *Orthoceratites* resembling *Ormoceras tenuifilum*.

7—Thin-bedded, drab, dense limestone, interstratified with light-blue shaly limestone and fine limestone conglomerate of light-drab color.

6—Light-buff, crystalline, magnesian limestone, with crystals of calcite scattered through the mass, and the layers from one to fifteen inches thick.

5—Dark-brown, fine-grained magnesian limestone.

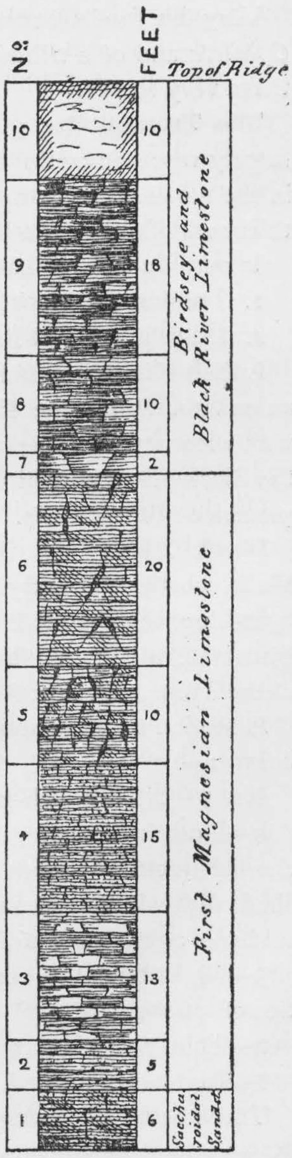
4—Light-yellow, sandy magnesian limestone.

3—Bluish-gray, compact, thin-bedded limestone with thin partings of drab-colored, soft shales, and interstratified oölitic and sandy layers.

2—Thin, irregularly stratified sandy and limestone conglomerate layers, passing into

1—Thin-bedded, well-defined Saccharoidal sandstone, to the bed of the south branch of Mill Creek.

Fig. 63.



In the bed of the Sandy Branch of Anderson's Fork, as already mentioned, the 1st Magnesian limestone crops out in the east middle of Sec. 9. Rising gently toward the north-east, it forms the top of the bluffs overlying the Saccharoidal sandstone, with an exposure of forty feet, and still further north is lost in the high hills about the head of the branch.

On the small branch of Gwin's Creek, in Sec. 5, it may be seen overlying the Saccharoidal which occupies the bed of the stream, but owing to the surface-covering no accurate measurements could be made.

Very few fossils occur in any part of this formation, a species of *Ophileta* and of a trilobite like *Bathyurus* being the only ones, and these very scarce.

The Trenton Group.—This important series of limestones is very largely represented in Lincoln County, covering an extended area in the northern and north-eastern townships, and exhibiting a total thickness of about two hundred and thirty feet.

It may be divided into—

1. Trenton limestone.
2. Black River and Birdseye limestone.

Lithologically it is not easy to separate the two members, nor by an examination of the fossils can the dividing line be determined with accuracy, but the occurrence of a few forms characteristic of the Black River and Birdseye limestones in other regions marks the presence of these beds.

Black River and Birdseye Limestone.—In the Mississippi bluffs, north of Sandy Creek, there occur a series of drab and light-blue, thin-bedded, compact beds overlying the 1st Magnesian limestone, which may be referred, in part at least, to this division of the Trenton group.

A section taken in south-east ¼ of Sec. 26, T. 50, R. 2, E., is as below :—

No. 5—Light bluish-gray, fine crystalline limestone.

4—Drab and dark-gray, compact, brittle limestone, with conchoidal fracture in beds one to ten inches thick, many of which are filled with winding passages and irregular cavities on the weathered surface : a few species of *Orthoceratites*.

3—Light-blue, less compact limestone, with small veins and cavities of calcite.

2—Thin, shaly layers of drab-colored limestone.

1—Light buff-colored, fine crystalline magnesian limestone.

These beds dip toward the north in the bluff and pass out of sight within half a mile, and give place to the overlying Trenton limestone.

On Sandy Creek the same formation was observed at several points, with some differences in lithological characters. In the tops of the hills north of Robertson's Mill, a thin-bedded, compact, brownish limestone with vermicular cavities crops out at intervals a short distance above the 1st Magnesian limestone, but the junction could not be seen. Following up the North Branch of the Sandy as far as Myers's Farm, these brown and drab beds form the main part of the bluff, overlying the light buff-colored beds of 1st Magnesian and dipping to the north-west. At the top of the intervening ridge, between the North and Middle Sandy, about five feet of the same appears, as will be seen in the cross-section taken there and already given.

At Cheeley's Farm the following section occurs :—

No. 10—Covered top of hill.

9—Dark-gray, subcrystallined limestone, with veins and scattered crystals of calcite.

8—Nearly white, compact limestone in thin layers.

7—Brown and drab, thin-bedded, very dense limestone.

6—Bluish-gray limestone, filled with vermicular cavities and thin bedded.

5—Light-brown, oölitic and brecciated limestone.

4—Dull, yellow, crystalline magnesian limestone, with crystals of calcite scattered through it ; beds from two to eight inches thick.

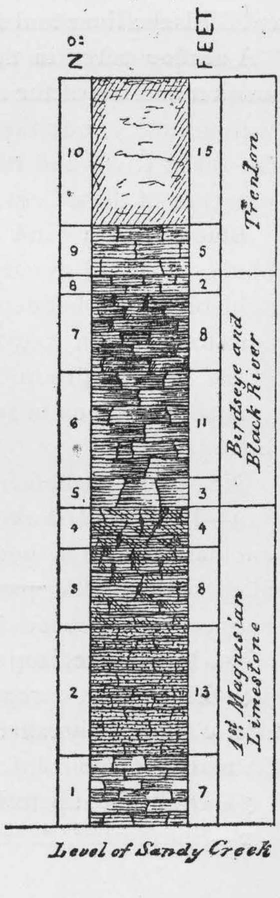
3—Light-yellow, crystalline magnesian limestone, in thick beds.

2—Brown, earthy magnesian limestone.

1—Yellow, arenaceous, shaly limestone.

Bed of Sandy Creek.

Fig. 64.



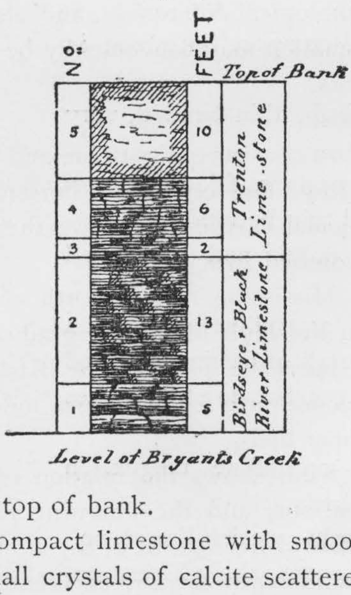
The dip of these beds is in the same general direction as that of the underlying Lower Magnesian series, namely, N. 10° to 35° W., but the angle is noticeably less, in the former not exceeding 5° to 7°, and diminishing toward the west.

On the North Branch this formation gives place to the Trenton limestones in the south part of Sec. 20, T. 50, R. 2, E.; on the Main Sandy it disappears near the east line of Sec. 30, while on South Branch it continues to the head of the stream and is lost in the high hills.

In T. 51, R. 1, E., on Bryant's Creek, thin drab, brown and bluish gray, compact limestones, similar to those seen on Sandy, crop out in the lower part of the ridges and bluffs for a distance of three or four miles. A gradual rise in the strata may be traced along Bryant's Creek toward the west from the Mississippi bluffs, and near the middle of the township above named the Black River and Birdseye limestones appear.

A section taken in the south-east quarter of Sec. 16 shows the position and character of these beds.

Fig. 65.



No. 5—Covered top of bank.

4—Light-gray, compact limestone with smooth conchoidal fracture, containing small crystals of calcite scattered sparsely through the mass.

3—Drab, fine crystalline.

2—Bluish-gray, dense, thin-bedded, with vermicular cavities.

No. 1—Brown, very dense and brittle limestone, in beds from one to six inches, and perforated in every direction.

Nos. 1 and 2 contain *Orthoceratites* in abundance, but no *Brachiopods.*

Further west, in the next township, these beds of the Black River, etc., are lost in the high dividing ridge which separates the waters of Bryant's and Mill Creeks. But on the western slope, near the head of the latter, they appear again beneath the well-marked Trenton and in places resting upon the 1st Magnesian Limestone, as may be seen in the section at Ellis's Farm, already given.

Along the upper part of the Sandy Branch of Anderson's Fork they crop out, exhibiting the same lithological characters as in the localities mentioned above, and dipping slightly to the south-west.

Of the fossils occurring in this formation the *Orthoceratites* alone appear; of these, *Ormoceras tenuifilum* are the most common. *Gonioceras anceps* also occurs.

The Trenton Limestone.—This formation is very largely developed in Lincoln, having a total thickness of two hundred and thirty feet, and covering a large area in the northern part of the county. From the marked lithological differences, and also in the character of the fossils, the formation may conveniently be divided into

Upper Trenton beds.

Lower Trenton beds.

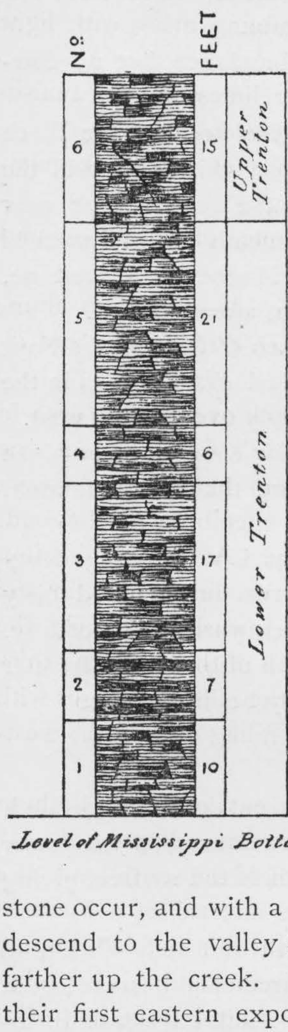
The Lower Trenton consists of light-blue and drab, thin-bedded, compact, buff and gray, fine crystalline limestones, in the lower part filled with vermicular cavities on the weathered surface, giving it a peculiar honey-combed structure.

It occurs in the Mississippi bluffs, north of Sandy Creek, at first cropping out in the high hills, and, gradually descending in the face of the bluff, takes the place of the Black River and Birdseye beds, and passes on north for five or six miles before it disappears beneath the upper beds.

Fig. 65, already given, shows the relation of these beds with the underlying formations, and the following section, taken near Hurricane Creek, in Sec. 14, T. 50, R. 2, E., shows the character of the beds at their junction with the Upper Trenton.

No. 6—Coarse crystalline, light-gray and yellowish-white limestone, with *Strophomena alternata*, *Leptæna deltoidea*, *Leptæna sericea*, and other fossils.

Fig. 66.



Level of Mississippi Bottom

No. 5—Thin-bedded, fine-grained, reddish-brown limestone, with a large number of well-preserved fossils, the most common being *Leptæna deltoidea*, *Orthis tricenaria*, *Orthis* like *O. subæquata* and a *Murchisonia*.

4—Thin-bedded, light-gray crystalline—fossiliferous.

3—Compact drab, with crystals of calcite in veins and cavities, weathering to light yellow, and in beds from four to eighteen inches thick.

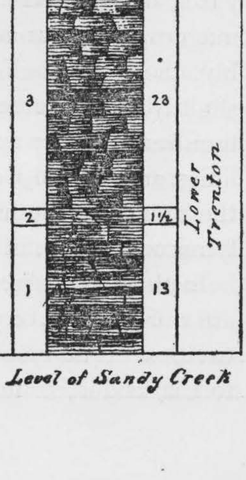
2—Light-gray and white, thick-bedded magnesian limestone, with ferruginous stains on weathered surface.

1—Light-blue, fine crystalline, somewhat shelly limestone, full of irregular cavities—seen at various intervals in the slope at foot of the bluffs.

High up in the hills on the north side of Sandy the lower beds of light-blue, honey-combed limestone occur, and with a slight westerly dip descend to the valley a mile and a half farther up the creek. On the south side their first eastern exposure is a mile or more west of Robertson's Mill. In Sec. 30, T. 50, R. 2, E., the whole Lower Trenton forms the high perpendicular bluffs on both sides of Main Sandy, and beyond, near the township line, is overlaid by the coarse fossiliferous beds of Upper Trenton.

The annexed section, Fig. 67, taken at Miller's Farm, shows the relation of the two members of the Trenton:—

Fig. 67.



Level of Sandy Creek

No. 5—Coarse crystalline, light-gray and white limestone, of uneven texture, weathering into a rough, crumbling mass, with light ferruginous stains—very fossiliferous.

4—Finer crystalline, thin-bedded, shelly limestone, of bluish-gray color, with an immense number of *Strophomena*.

3—Brown, compact limestone, with veins of calcite—regular-bedded, with thin, argillaceous, shaly partings.

2—Very hard, compact, silicious limestone, of light-blue and drab colors, weathering to a dull yellow.

1—Thin-bedded, light-gray, with many fossils—the most abundant being *Leptæna deltoidea*, *Orthis* like *O. testudinaria* and *O. tricenaria*.

The Lower Trenton forms the surface-rock over a large area in T. 51, R. 1, E. It first appears on Bryant's Creek, about one mile south-west of Diggs's Mill, rising from beneath the coarse and shelly, fossiliferous beds of the upper member, and beyond, forms the main bluffs of the Creek Valley. A previous section shows the appearance of the Black River limestones in the bed of the stream near the middle of the township, carrying the Lower Trenton higher up in the hills. South of the creek the thin-bedded drab and gray beds crop out along the hills and ridges with the loose, shelly, honey-combed layers, extending on into the western part of T. 50, R. 1, E.

On Cunningham's Branch of Bob's Creek, east of Snowhill, these lower beds appear in the bed of the stream, dipping S. 45° W. at an angle of 23°, and in the low bluff of the south bank at a less angle. Higher up the branch, over an interval of a hundred yards of covered bottom, a light yellowish, thin-bedded, impure magnesian limestone forms the bed of the stream, and this is probably the 1st Magnesian Limestone. This latter formation dips slightly to the north-east, and is soon lost. After an interval of one hundred and fifty yards the thin-bedded fossiliferous drab and gray limestones of the Lower Trenton again appear, and by following up the branch to the hills on the north-east, may be traced to the overlying coarse crystalline beds of the Upper Trenton.

In the high ridges at the head of Fort Spring Branch the beds are thin, shelly, of a light bluish gray color, and full of vermicular cavities. The material used for the "Rock Road," from Auburn to Clarksville, is mostly obtained from these beds.

At Fort Spring, a half-mile south of Auburn, the following section was taken :—

No. 4—At the top of the bluff a grayish-blue, close-grained, crystalline limestone, weathering into holes and irregular passages, in layers ten inches to two feet thick. 11 feet.

3—Same in thin layers. 2 feet.

2—Fine white crystalline limestone. 7 feet.

1—Compact, very hard, chocolate brown, thin-bedded limestone, with flat nodules of red chert, and containing *Leptæna deltoidea* and several species of *Murchisonia* in large numbers ; also a species of *Subulites* like *S. elongata.* 6 feet.

In T. 51, R. 1, W., the Lower Trenton occupies the high ridge land, with the Black River limestone in the valleys below. About the head of Mill Creek its characteristic beds appear and extend west to Sandy and Anderson's Forks, forming bold, perpendicular bluffs. The next township on the west has the Upper Trenton more fully developed, the Lower occurring only in the north-east sections.

At the junction of Sandy and Anderson the following section was taken :—

No. 4—Compact, light-gray, crystalline limestone, in thick beds. 16 feet.

3—White, coarse, crystalline limestone, with crystals of calcite in cavities and ferruginous stains on weathered surface. 7 feet.

2—Light bluish-gray, close-grained limestone, with cells and cavities on weathered surface. 15 feet.

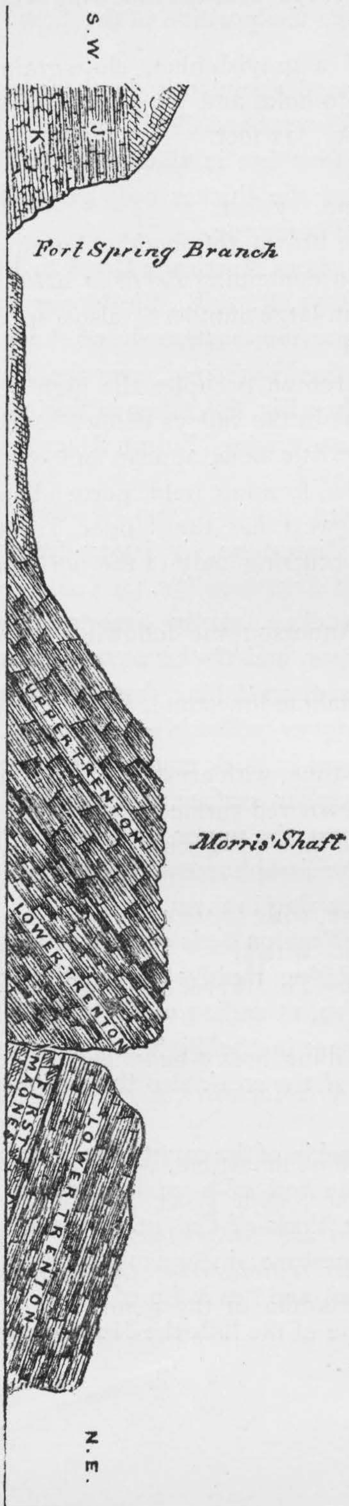
1—Drab, brittle, compact limestone, with *Leptæna*, *Murchisonia*, and *Subulites* to the bed of the Fork. 4 feet.

The Upper Trenton Limestone.—This division of the Trenton formation consists of—

No. 2—Light-blue and white, crystalline, heavy-bedded limestone, passing into shelly beds below, with *Receptaculites*, *Leptæna sericea*, and *Orthis testudinaria.* 56 feet.

1—Gray and white, coarse, crystalline limestone, which crumbles easily where exposed to the weather, with great abundance of fossils, of which the most common are *Strophomena alternata*, *Leptæna deltoidea*, *L. sericea*, *Orthis testudinaria*, *O. tricenaria*, several species of *Murchisonia*, a trilobite of the genus *Illænus ;* also *Chætetes Lycoperdon.* 25 feet.

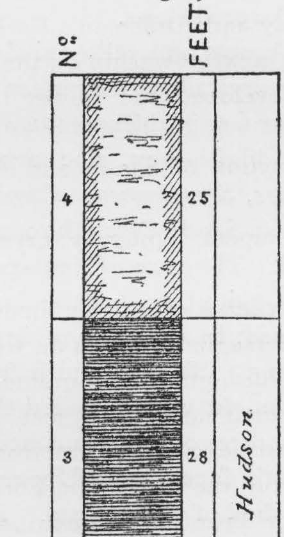
Fig. 68.



No. 2 seems to be the equivalent of the Galena limestone of Iowa, containing many of the same species of fossils, and especially of *Receptaculites*. Some specimens of lead have been found in this limestone in Lincoln County, though insignificant in quantity. (See next Chapter.)

In Sec. 10, T. 50, R. 1, W., this limestone is well exposed near the line of fault which traverses the county. At this point Fort Spring

Fig. 69.



Branch has cut through the upturned strata nearly at right angles to the strike, showing in the bluff the position of the beds. A section of this is given in Fig. 68.

A species of *Receptaculites* is found abundantly in these upper beds, together with *Strophomena alternata* and *Orthis testudinaria*. These layers are from six inches to four feet in thickness, the thinner being of a light-gray color, and the thicker beds generally a white, closely crystalline, magnesian limestone.

In the eastern part of the county, from Hurricane Creek to Little Bill's Branch, near the middle of T. 51, R. 2, E., the Upper Trenton is the surface formation. A previous section shows the position of these beds in the bluffs of the Mississippi, over the Lower Trenton, and the following section (see Fig. 69), taken in Sec. 24, T. 50, R. 1, E., shows the relation to the overlying Hudson River shales.

No. 4—Covered slope.

3—Light-brown and yellow shales.

2—White crystalline magnesian limestone, in layers from six inches to four feet in thickness, with *Receptaculites*.

1—Light bluish-gray, fine crystalline, shelly limestone, with *Receptaculites*, *Strophomena alternata*, and *Orthis testudinaria*.

Lower down Sandy Creek the coarse, crystalline, fossiliferous beds are exposed. They are of light-gray or yellowish-white color, the upper layers quite thin, but the lower in thick masses, weathering, where exposed, to a rough and irregular surface, more or less soft and crumbling. To distinguish from the upper or Receptaculite beds, these might well be called the Strophomena beds, from the immense numbers of this genus occurring in them.

On Bryant's Creek, these Upper Trenton beds appear at Diggs's Mill in the bed of the stream. Rising rapidly toward the west, they form the surface-rock in Secs. 12, 13 and 14 of T. 51, R. 1, E., and sweeping off to the south appear in the high ridges between New Hope and the creek. North of the creek also they appear in the higher hills.

In the extreme north-western township of the county the same beds may be seen cropping out along the bed of a small branch which flows south-east into the Sulphur Fork of Cuivre. It is a light-gray, subcrystalline magnesian limestone, in layers varying from three inches to two feet in thickness, and has a dip of about 10° to the south-west. Higher up the slope of the hills the Hudson group appears in several places where the covering had been washed away, and in the tops of the hills the Chouteau limestone is exposed.

The Hudson River Group.—As occurring in Lincoln County, this formation consists of—

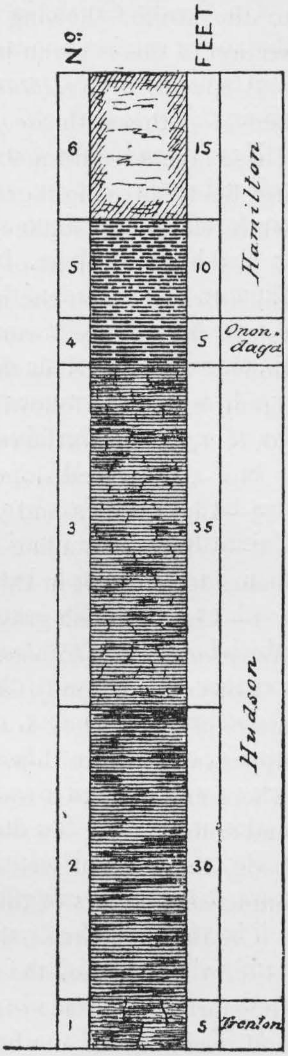
1st. Impure, magnesian limestone, of a dull blue, drab or buff color, generally in layers from three to six inches thick, and with a number of fossils, of which we recognized fragments of *Isotelus gigas*, a species of *Dalmania*, of *Rhynchonella*, *Strophomena alternata* and *Leptæna sericea*.

2d. Blue and olive-colored argillo-calcareous shales, which, on exposure, weather to a light-buff color, affording no fossils.

These beds are found overlying the Upper Trenton, in the high knobs in the north-east part of the county, and in the ridges and hills south of Gwin's Creek, along the Pike County line, also in many places along the line of uplift, cropping out from beneath the Devonian formations.

A section (Fig. 70) taken on the north side of the Knob, south of New Hope, shows the position and character of the formation.

Fig. 70.



No. 6—Covered slope.

5—Dark-brown and drab, argillaceous limestone in thin beds, with partings of soft shales containing a few specimens of *Atrypa reticularis*.

4—Fine, hard, white oölitic limestone, weathering to brown or red color, containing *Zaphrentis cornicula* in abundance.

3—Argillaceous limestone in thin layers, of a dull, bluish-drab color, containing *Dalmania*, *Leptæna sericea*, *Strophomena alternata*, and a *Modiolopsis*.

2—Light-olive colored argillo-calcareous shales, weathering light-buff color.

No. 1—Light-blue subcrystalline limestone, with Trenton fossils.

On Sandy Creek, in Sec. 21, T. 50, R. 1, E., Nos. 2 and 3 of the above section appear in the high hills overlying the Receptaculite beds of the Upper Trenton—No. 2 twenty-five and No. 3 about thirty feet thick.

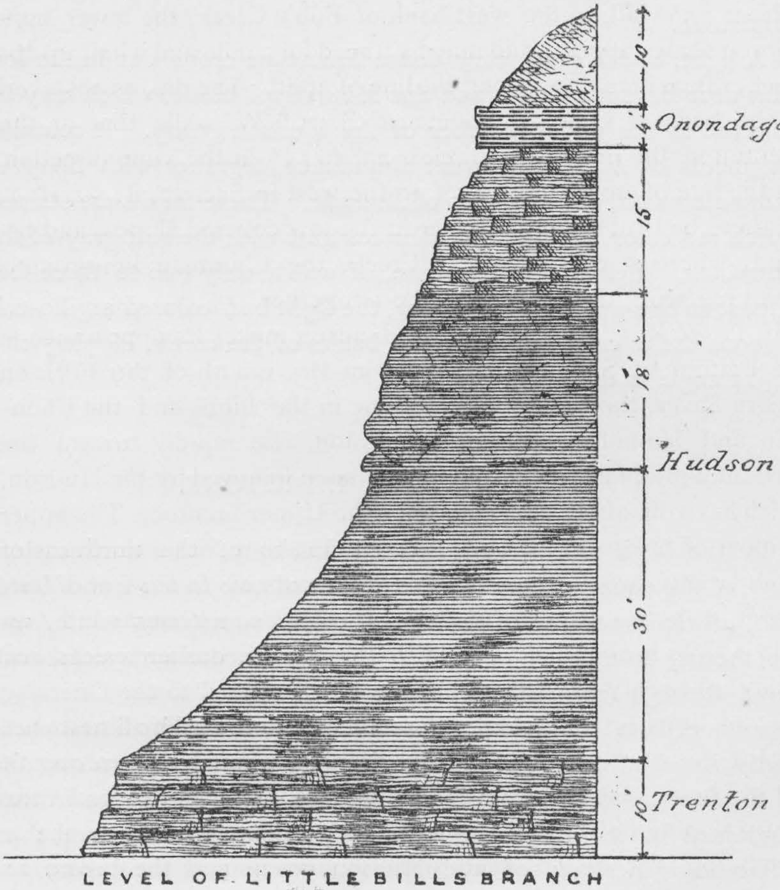
Near Snowhill, in the west bank of Bob's Creek, the lower buff-colored shales appear, and may be traced for a mile and a half up the creek, which here flows along the line of uplift. The dip, as observed in the beds of shale, is about 10° S. 70° W. while that of the Trenton in the bed of the creek is 23° to 25° in the same direction. As the line of uplift sweeps off to the west in Sec. 22, T. 50, R. 1, E., these beds of shale disappear in the low covered slopes, and beyond, where it crosses Sugar Creek, the Chouteau limestone is found replacing the Hudson group altogether.

In T. 51, R. 2, W., Sec. 21, the Hudson makes its appearance in the bottom of Sulphur Fork. From the mouth of the Fork on Cuivre River, the Encrinital limestone in the bluffs and the Chouteau and Hamilton beds, in succession, rise rapidly toward the north at a gradually increasing angle, soon followed by the Hudson, which has a dip of 15°, and rests upon the Upper Trenton. The upper member of the group, the argillaceous limestone, has a thickness of about twenty-two feet, and affords fragments of *Isotelus* and *Dalmania*, a species of *Avicula* with *Strophomena alternata* and *Leptæna sericea* in abundance. The yellow argillaceous and calcareous shales are twenty-five feet in thickness.

From Sulphur Fork these beds are found in the small branches toward the east, cropping out at intervals where the covering of soil has been washed away. West of the fork it is also seen in the gently sloping hills, as far as the middle of Sec. 7, and beyond this no outcrop of it was observed to the western limit of the county.

In T. 51, R. 2, E., a few of the higher hills and knobs contain the Hudson group, presenting some slight lithological differences. At Gay's Hill, a small isolated knob in Sec. 19, there occurs near the top, and beneath the well-marked Onondaga limestone, a light, buff-colored, earthy magnesian limestone, in beds from six inches to two feet in thickness. No fossils could be obtained from this limestone, but in the underlying light-drab, thin-bedded limestone, the usual Hudson fossils occur. From its stratigraphical position it would appear to be the upper part of the Hudson, the equivalent of the light-blue and drab, argillaceous limestone in other localities. The accompanying section (Fig. 71) at this point shows the relation of the various strata:—

Fig. 71.



No. 6—Covered top of hill.

5—White and gray, oölitic limestone, weathering to reddish brown, with *Zaphrentis cornicula*, *Atrypa reticularis*, *Strophomena rugosa*, and a species of *Pentamerus*.

4—Light buff-colored, earthy, magnesian limestone, in beds six inches to two feet in thickness; no fossils.

3—Light-drab, compact, thin-bedded, argillaceous limestone, with characteristic Hudson fossils, as given before.

No. 2—Brown and yellow argillo-calcareous shales, of a bluish-gray and olive color, where not exposed to weather.

1—Receptaculite beds of the Upper Trenton.

No. 4 occurs in the hills to the south of Gay's Hill.

No. 5 is represented in some places by a fine, white, fossiliferous sandstone.

A light, bluish gray, very dense limestone crops out in the low hills near Bryant's Creek and the Mississippi bluffs, which may be referred to the upper member of the Hudson group. It contains fragments of *Isotelus* in great abundance, together with *Strophomena alternata*, and a species of *Avicula*. These fossils are stained a rich red color, giving a peculiar contrast with the soft gray of the limestone. Below this limestone, of which only two to three feet appear in the well-covered slopes, the light buff-colored argillo-calcareous shales crop out along the banks of the creek, dipping at a slight angle to the north-east.

THE ONONDAGA LIMESTONE.

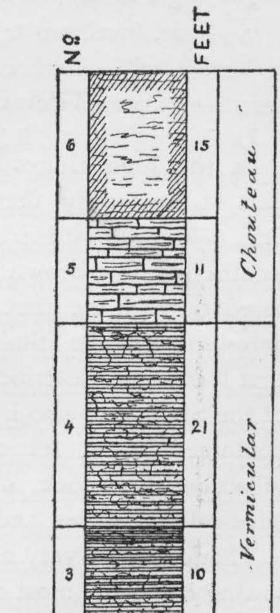
In the high ridges and isolated knobs of the north-eastern part of the county, there is an exposure of two to six feet of hard, fine, oölitic limestone of light-gray color, sometimes white, and weathering to a brown or reddish shade, with darker specks scattered through the mass. This has been referred to the Onondaga limestone, from its lithological resemblance to the oölitic limestone of that formation, described as occurring in the north-eastern counties of the State, and also from the marked character of the fossil forms contained in it. Its stratigraphical position is between the argillaceous limestone of the Hudson group and the brown and olive-colored shales and shaly limestone of the Hamilton.

The fossils are very abundant, and beautifully preserved, the following being the most characteristic genera and species : *Zaphrentis cornicula*, *Cyathophyllum rugosum*, *Atrypa reticularis*, *Strophomena rugosa*, *Chonetes hemispherica*, and a *Pentamerus*.

At Guy's Hill, part of this oölitic limestone is replaced by a fine-grained sandstone containing *Atrypa reticularis*, a species of *Spirifer* and a *Pentamerus*, and the coral *Cyathophyllum rugosum* in great abundance. This sandstone seems to be somewhat calcareous, weathering and crumbling readily, and exhibiting stains of oxide of iron. The hill above named was the only point where this change in the character of the formation was observed. The greatest thickness of the limestone is six feet, exposed in the knob south of New Hope, and overlying the Hudson group. It thins out toward the south and east, in the knobs at Gallows Gap, a thickness of two feet only appearing, but presenting the same characters as described above. Further south it does not appear in the hills and ridges, they not being high enough to take in the Devonian.

The Hamilton Group.—This group is represented in Lincoln County, at many points along the line of uplift which traverses the county, in the high knobs of the north-east, and at the base of the Mississippi bluffs, near Bryant's Creek. At the latter point there occur a series of bluish-green and black shales and slates, which, from the presence of some characteristic fossils, would seem to belong to the upper part of the Hamilton group. As, for instance, the *Lingula spatulata*, which, according to Prof. Hall, is limited to the Genesee slate, appears in immense numbers in this black slate. The latter appears at intervals in the base of the bluffs from five to eight feet in thickness, and overlaid by olive-green argillaceous shales ; and still higher up come the sandy and argillaceous shales referred with hesitation to the Vermicular group. The slopes are so much covered by detritus that no good section can be obtained here. On a small branch, however, which flows into Bryant's Creek from the south, the following section (Fig. 72) was taken :—

Fig. 72.



No. 6—Covered slope.

5—Buff-colored, argillo-magnesian limestone.

4—Thin-bedded, irregularly stratified, sandy and argillaceous shaly limestone with oölitic beds interstratified.

3—Greenish-blue and brown shales.

No. 2—Black slate, with *Lingula spatulata*.

1—Bluish-gray, argillaceous, shaly limestone, containing a few specimens of *Atrypa reticularis* and a species of *Conularia*.

In no other locality in the county were Nos. 2 and 3 observed. The whole Devonian, indeed, as it occurs in this isolated area, presents marked lithological differences from its equivalent in the knobs and ridges farther south, where the following section occurs :—

No. 5—Near the top of the hill a gray, crystalline limestone, containing several species of *Spirifer*, *Atrypa gregarea*, *Strophomena depressa*, and a species of *Avicula*. 13 feet.

4—Hard, dense, bluish-gray, thin-bedded limestone, with few fossils. *Strophomena depressa*. 18 feet.

3—Dark-brown and drab, impure limestone, with thin partings of clay shale, containing *Atrypa reticularis*. 11 feet.

2—Argillaceous, brown and drab shales. 12 feet.

1—Fine, hard, white, oölitic limestone, weathering to brown and red color, with *Zaphrentis cornicula*, *Atrypa reticularis* and fragments of *Crinoid* stems.

In Sec. 13, T. 50, R. 1, E., the Nos. 2 and 3 appear near the top of the knob, beneath the Chouteau limestone and over the Onondaga, as in the above section. The high ridge in Sec. 14 is capped by the Onondaga limestone, while, to the east in the next township, the Hamilton again appears cropping out of the knobs at Yellow Gap, with a total thickness of about twenty-five feet.

Along the line of fault through the county the Hamilton beds were recognized at many points, but owing to the scarcity of good exposures, except at the crossing of the main streams, few extended sections could be obtained.

East of Bob's Creek, near Snow Hill, the thin-bedded blue and drab argillaceous limestone (No. 3 of the section last given) forms the base of the bluffs, the coarse crystalline beds of the Chouteau form the top of the ridge, with an interval of 20 feet of covered slope between. North-west of Snow Hill the limestone appears in the ravines, which cut into the easy-sloping hills, and beyond it forms the bluffs on Sugar Creek, dipping under the Chouteau limestone. At the crossing of Fort Spring Branch, by the uplift, the Hamilton beds are seen rising rapidly in the bluffs toward the north-east, exposing a thickness of about twenty feet. North from this point, along the uplift, they crop out occasionally in the dividing ridge between Fort Spring Branch and Mill Creek. On the latter stream, in Sec. 32 of T. 51, R. 1. W., the following beds occur:—

Thin-bedded, gray and drab limestone, with a few specimens of *Atrypa reticularis*, and a *Spirifer* resembling *S. medialis.* 6 feet.

Olive-green and blue argillaceous shales, containing a species of *Heliophyllum.* 18 feet.

In T. 51, R. 2, W., these beds crop out at several points on the northern slope of the high land in Secs. 23 and 24, and on Sulphur Fork, in Sec. 22, it forms, in part, the bluffs, with an exposure of nearly thirty feet, of which the upper twelve feet consist of a thin-bedded blue limestone. West of this, the limestone appears in the gentle slopes south of Sulphur Fork. It weathers less readily than the shales below, and often stands out in relief on the slopes, while the presence of the shales is marked by the easy slopes and wet clay-soil. Skirting along the north side of the ridges, the formation passes out of the county at Louisville, cropping out in the banks of Indian Creek, and rising gradually toward the north from beneath the Chouteau limestone.

Very few fossils occur in any part of this formation. Most of them, however, are characteristic Hamilton species, and, with its lithological resemblance to beds referred to this group, in other parts of Missouri, serve to mark its geological position.

Vermicular Shales and Sandstones.—This group appears in Lincoln County at several points, and generally consists of a thin-bedded, argillaceous sandstone, more or less filled with vermicular cavities on the weathered surface; and of argillaceous shales with thin layers of limestone interstratified.

Near the Mississippi bluffs, south of Bryant's Creek, these beds occur to a thickness of twenty-five feet, and the following section, taken at that point, shows the character of the beds and their relation to the adjacent formations.

No. 11—Thin-bedded, buff-colored limestone, containing *Spirifer*, *Productus*, and an *Avicula.* 15 feet.

10—Thin, shaly sandstone, with a few fucoidal markings. 8 feet.

9—The same as above, but more argillaceous. 5 feet.

8—Oölitic limestone, dark gray. 2½ feet.

No. 7—Dark-brown, impure shales, with fucoidal markings in great abundance. 6 feet.

6—Impure oölitic limestone, somewhat arenaceous and containing iron pyrites. 7 inches.

5—Dark-brown, argillaceous shales. 1 foot.

4—Oölitic limestone, same as No. 6. 5 inches.

3—Greenish-gray, argillaceous shales, with fucoids. 2 feet.

2—Blue and drab arenaceous shales. 10 feet.

1—Black slate, with *Lingula spatulata.* 7 feet.

These beds are seen cropping out at intervals in the base of the bluffs beneath the buff-colored Chouteau limestone, but they cannot be traced for any great distance.

The next outcrop of the Vermicular group appears in the bluffs where the line of fault intersects. As will be seen by reference to the section, along the bluffs, the shales and sandstone of this formation rest unconformably against the Saccharoidal sandstone and 1st Magnesian limestone at an angle of about 35°, while on the south side of the small branch the Chouteau and Encrinital limestones dip at an angle of 70° to 80°. The lower part of the formation consists of twenty-one feet of drab and bluish-gray argillaceous shales, containing concretions of pyrites and argillaceous iron-ore and fucoid stems in great abundance, with a few specimens of *Cauda galli.* Above these shales there is a thickness of about twenty-eight feet of argillaceous sandstone, with the characteristic vermicular cavities on the weathered surface, interstratified with which occur beds of arenaceous shale and of purer granular sandstone. These beds appear at intervals in the covered slope, though not sufficiently well exposed to afford a detailed section, and along the branch to the south they may be traced for several hundred yards, but are soon lost sight of in the hills, where the branch bends to the south.

On the upper part of McLean's Creek these beds appear again, and seem to have been continuous in their outcrop from the bluffs, though the dip is considerably less. In T. 50, R. 1, E., near the head of Bob's Creek, these beds crop out of the hillside on the west side of the creek. The thickness of the sandstone is not more than twenty feet, and is more uniform than as seen in the bluffs, being a dull-brown, fine-grained argillaceous sandstone, in beds from ten to thirty inches thick. The Chouteau forms the summit of the ridges at this point. Following the line of fault, this formation appears in the slopes where the rocks are laid bare, and may be traced as far as Fort Spring Branch, from which place to Sulphur Fork it does not appear; but from the latter stream to the county line it was recognized at many points, the shales of the lower part affording easy slopes and wet clay-soil, and contrasting with the sharper outline of the upper beds.

The Chouteau Limestone.—This formation occupies an important position in the county, appearing at the summits of several knobs in the north-east, and also along the line of fault from the bluffs of the Mississippi, near Cap au Gres, to the north-western limit of the county at Louisville. Three beds of limestone have been referred to this formation, the lowest, however, with some hesitation, from its resemblance lithologically to the underlying Hamilton, and from the scarcity of distinguishing fossils. Such as were obtained in the lowest member were quite common to the upper bed, and it is therefore classed with them.

These beds consist of, 1st. A coarse, crystalline, somewhat earthy limestone, changing occasionally to a light-brown, saccharoidal limestone, in which occur a species of *Productus*, a *Spirifer*, probably *S. Marionensis*, *Chonetes ornata*, and a few *Crinoid* stems.

2d. A dark, bluish-gray, compact, thick-bedded, silicious limestone, with occasional geodes and cavities filled with crystals of calcite; contains very few fossils—the *Productus* mentioned above, with *Chonetes ornata* and an *Avicula*.

3d. A thin-bedded, drab and bluish, compact, brittle limestone, with a few scattered masses of calcite.

In the north-western part of T. 51, R. 2, E., the second member caps the bluffs and ridges between Bryant's Crĕek and Little Bill's Branch. It is here of a dull, yellowish-brown color, and where exposed in the Mississippi bluffs, of a buff color. The layers are from ten inches to three feet thick, and the whole thickness twenty-three feet. Beneath this limestone twenty-eight feet of thin-bedded, light, buff-colored limestones appear, and below this the sandy and argillaceous shales, which probably represent the Vermicular group.

As already mentioned, the strata at this point rise quite rapidly toward the north and west; the upper beds of the Chouteau giving out in the tops of the hills and ridges, about a mile west of the bluffs. The yellowish or buff-colored beds appear along the bluffs to the south, as far as Little Bill's Branch, where, owing to a fault, the upper beds of the Trenton are found resting against them. In the top of the highest ridges the first member of the Chouteau appears, about six feet in thickness, overlying the thick, buff-colored beds. It is a coarse, white or yellowish-gray, crystalline limestone, containing *Spirifer Marionensis? Chonetes ornata*, and a species of *Mytilus*, also of *Productus*.

In the three knobs south of New Hope, the three members of the Chouteau are exposed. The top of the most northerly knob is capped by the coarse crystalline limestone, eleven feet thick, the lower part of which passes into a light-brown, fine crystalline limestone. Nodules of chert appear occasionally in this bed, of a dull red color. In Sec. 13 this crystalline, heavy-bedded limestone also occurs, cropping out from beneath the covered top, and exposing a thickness of eight feet, the lower five feet finer grained and darker in color. The knob in Sec. 12 is not high enough to take in the first member, and the second forms the surface-rock at the summit. The latter differs considerably in lithological characters from its equivalent in the bluffs, being here a compact, thick-bedded, silico-magnesian limestone of a drab color. The greatest thickness observed was twenty-one feet. Very few fossils occur. *Productus*, *Avicula* and an *Orthis* like *O. Michelini* were recognized.

Below this, the third member appears—a thin-bedded, shaly limestone, from eighteen to twenty-five feet thick. This limestone is of a bluish-gray or drab color, very hard and compact, and contains *Productus*, *Strophomena rugosa*, an *Avicula*, and a trilobite of the genus *Phillipsia*, together with some indistinct specimens of *Cauda galli*.

On the North Fork of Cuivre River, where it enters the county, in the north-west quarter of Sec. 30, T. 51, R. 2, W., the Chouteau limestone appears in the bluffs underlying the Encrinital, and consists of—

No. 3—Coarse, crystalline, white limestone. 6 feet.

2—Fine, crystalline, light-drab, earthy limestone, weathering to a buff-color. 10 feet.

1—Thin-bedded, compact, shaly limestone. 12 feet.

The upper bed was not fully exposed, owing to the covering of the slope.

The Encrinital occupies the upper part of the bluffs, which are quite high, while the Chouteau forms the lower part. A gentle dip toward the south-east causes the latter to disappear near the section-line, between 29 and 30. Reappearing in Sec. 28, it rises rapidly toward the north, along Sulphur Fork, and within half a mile reaches the tops of the hills and ridges. Following down the Cuivre, it gives way to the Encrinital, owing to a great bend toward the south and beyond. A northerly sweep brings it to the surface for half a mile, but it is confined to the bed of the Fork and lower part of the bluffs, exposing a thickness of about seven feet.

In T. 50, R. 1, W., it appears again on North Cuivre and Wilson's Creek, and is well exposed in the "Big Cut" of the St. L. and K. R. R. About three feet of the upper coarse beds occur here, changing rapidly into the thick-bedded, nearly compact silicious magnesian limestone of the second member, observed elsewhere. The thickness of this is eighteen feet, and is succeeded by the thin shaly beds in the bottom of Wilson's Creek, and the small branches which enter the Cuivre from the north-east.

In the next township, on the east, these beds crop out at intervals in the hills on both sides of the Sugar Creek, dipping at an angle of 12° to 15° to the south-west, and along the line of fault toward Snow Hill, are seen in an occasional outcrop on the covered slopes. Near the above village the lower beds form the main bluffs, and incline slightly to the south-west, the Encrinital capping the ridges beyond.

In T. 49, R. 2, E., the Chouteau beds may be traced from the north-eastern corner in a direction a little south of east to the Mississippi bluffs. There are no good exposures, however, except in the second branch, which cuts through the bluffs north of McLane's Creek, where the following beds appear:—

Thick-bedded, bluish gray, earthy limestone, weathering to a lighter color, and containing disseminated masses of calcite. 15 feet.

Dark drab, thin-bedded, shaly limestone, irregularly stratified, containing *Fenestella*, *Chonetes*, an *Avicula* like *A. Cooperensis*, and *Cauda galli*. 11 feet.

The dip is 65° to 70° S. 40° W.

In the face of the Mississippi bluffs the lowest member does not appear, and the group is represented by fifteen feet of coarse, gray and light-brown limestones, succeeded by twenty-five feet of dull-yellow earthy limestone in beds from one to three feet thick, but very much broken and jointed. Crystals of calcite occur in cavities in this limestone, and occasional nodules of chert. The whole formation dips conformably with the Encrinital limestone, at an angle of about 80° S. 40° W. A break in the bluffs on the north side of this outcrop conceals the nature and position of the beds for a distance of two hundred feet, and on the other side of the branch the Vermicular sandstone and shales appear, rising toward the north-east.

The second member of the Chouteau limestone, as it occurs at this point, has very much the same lithological characters as in the north-eastern part of the county, in the bluffs south of Bryant's Creek—a dull-yellow and buff-colored earthy limestone, quite different in appearance from the darker and more compact beds in the interior of the county. This difference seems to be due to the manner in which the beds are exposed to the weather, as well as to a different chemical constitution, rendering some of them more susceptible to such influences as oxidation and hydration. In some cases, where the lighter color appears on the exposed surface, a fresh fracture reveals something of the dark color and compactness usual to these beds in other localities.

In Sec. 15, T. 49, R. 1, W., the upper beds of the Chouteau appear in the bottom of the Cuivre River, cropping out from beneath the Encrinital limestone, which has here a strong local dip to the south-east.

THE ENCRINITAL LIMESTONE.

This member of the Subcarboniferous series occupies a very conspicuous place in the geology of Lincoln County, having a total thickness of nearly two hundred feet, and forming the surface-rock over a very large part of the southern and south-western half of the county.

It first appears on the east side of the county, in the Mississippi bluffs, at the great fault where its strata, with a thickness of over a hundred and fifty feet, are upturned at an angle of 70° to 80°, and this is the only exposure of the formation along the entire line of bluff.

South of the line of fault, and beyond its immediate influence, there is a slight dip in the strata to the north-east, which is perceptible also as far west as the Cuivre River. This dip brings the Encrinital limestone to the surface again, from beneath the overlying formations in T. 48 and 49, R. 1, E.; and from there it forms the surface-rock as far west as Warren County.

North of Moscow it appears in the bold perpendicular bluffs along the Cuivre, a coarse, gray, thin-bedded, crystalline limestone, with lenticular nodules and thin layers of chert near the top, succeeded by heavy beds of gray and buff-colored crystalline limestone, some of the beds composed entirely of fragments and joints of crinoid stems cemented together with carbonate of lime. These lower beds, where exposed to the weather in the bluffs, become soft and crumbling, forming irregular holes and often large caves, and staining the surrounding soil with oxide of iron. Of fossils, the most abundant are *Spirifer striatus*, a *Productus*, and *Orthis Michelini*, with a large number of *Crinoids*. Much of the chert contains very perfect impressions of some of these fossils, particularly the crinoids. In many cases the internal structure, with all its delicate markings, is fully retained.

At Frenchman's Bluff there is a fine exposure of these beds, dipping at an angle of about 10° to the south-east. About sixty feet of them form the escarpment on the south side of the river, and by the gradual rise up the river the lower brown and earthy beds soon appear. These consist of dull-yellow and brown limestones in layers from one to three feet thick, with transparent crystals of calcite scattered through the mass, and containing a few fossils, of which *Spirifer striatus* and *Crinoids* are the most common. Further up the river the heavy-bedded, dark-blue and drab, compact limestone of the Chouteau group is exposed, with a thickness of over twenty feet beneath the Encrinital limestone. To the east of this, along the river, a very slight dip in the contrary direction is observed, and the Chouteau limestone soon passes out of sight. On the North Fork of the Cuivre, as far as the middle of T. 50, R. 1, W. at Wilson's Creek, the Encrinital forms the high bluffs and hills. At that place the Chouteau again appears, owing to the rise in the strata in approaching the line of fault.

Following along the West Fork of the Cuivre, the bluffs are high and bold, made up of the middle beds of the Encrinital, which dip gently to the west, while the upper beds appear in the higher hills and ridges. Near the mouth of the Lead Creek the Archimedes limestone forms the tops of the ridges over the Encrinital, and higher up that stream the latter disappears entirely. Keeping to the west along the West Fork, however, the Archimedes is soon replaced by the Encrinital, forming bluffs over a hundred feet high, weathered and worn into curious architectural forms, and with many caves, some of which are very extensive, and contain saltpetre in small quantities.

The Eagle Fork of the Cuivre or Big Creek passes through this formation along its entire length. From its junction with the Cuivre on the east, the strata rise very slowly toward the west, and in T. 48, R. 1, W., the coarse, crystalline, cherty limestones of the middle beds form the surface-rock and appear in the high bluffs. West of this township they dip as slowly to the west, though in many places local disturbances were observed. In these middle beds there occur, interstratified with the coarse and crinoidal limestone, thin layers of light-blue and gray, fine crystalline limestones, with occasional thin clay partings. These appear on the Corn Creek, and are well exposed at Brown's Quarry, near Troy, furnishing a moderately good flagging, and the thicker layers serving for building-stone.

All along the line of fault the Encrinital limestone appears, dipping at a varying angle from this line, generally toward the south and south-west. It occurs in the higher hills and ridges near, overlying the Chouteau limestone.

Of the fossils met with in this formation the crinoids are far the most abundant, fragments of the heads and stems occurring in almost every bed, and the lower division especially. Well-preserved specimens appear mostly of the genera *Actinocrinus* and *Platycrinus*. Of brachiopods, *Spirifers* occur in great numbers, and some of them unusually large, *Spirifer striatus* notably so. *Productus punctatus* and *P. semireticulatus* are very common, also a species of *Chonetes*. Of gasteropods, *Euomphalus* alone was recognized. *Fenestella* is found in nearly all the beds, some very beautifully preserved in the chert nodules.

The peculiar structure known as *stylolite* is very common in this limestone, especially in the middle beds. This appears generally as a long series of parallel columns or flutings penetrating the beds often to a depth of several inches, and always at right angles to the plane of stratification. Prof. Swallow has given it the name of *suture-joint*, from its resemblance to the sutures of the cranium. Other names have been applied to this structure, and theories suggested as to its origin, among others *crystalite*, supposing it to have resulted from the crystallization of some salt of soda, which was subsequently dissolved, leaving the moulds to be filled with sediment from above. *Lignelite* was a name much used at one time, and suggested from its resemblance to woody fibre, and perhaps from the belief that it was mineralized wood. *Stylolite* is the name by which it is now generally known—a diminutive from the Greek στῦλος, a column—and its origin is ascribed to pressure exerted upon the beds while in a plastic state, resulting in a slipping or pressing together of the material. In the Clinton beds of Ohio similar forms occur, exhibiting strong evidences of the great pressure exerted in their formation. Some of them show at one extremity the characteristic impression of some fossil form, and a cross-section taken at any part of the column is found to be exactly similar to the outline of the fossil, proving the latter to have been forced into the plastic material, and with its rough outlines producing the peculiar striation and fluting observed in the *stylolite*.

The Archimedes Limestone.—In the south-eastern part of the county the Archimedes beds outcrop in a narrow strip, beginning at the Mississippi bluffs near Monroe, and, passing west and north-west along the Cuivre as far as Moscow, turn away north through T. 49, R. 1, E., to the centre, and thence east, disappearing in the north-eastern corner of the township. This crescent-shaped outcrop is due to the general inclination of all the strata in this region toward the north-east, the Archimedes beds being brought to the surface on the south-western slopes of the hills and ridges from beneath the St. Louis limestone and the overlying coal-measures.

The formation consists of light-blue and gray, generally thin-bedded, fine crystalline and compact limestones, with some argillaceous and sandy shales interstratified. The lower beds contain nodules and layers of chert, while in the middle and upper are found geodes of various sizes, from less than an inch to five inches in diameter, consisting of a chalcedony crust lined with crystals of quartz or calcite, or both.

The village of Chain-of-Rocks takes its name from the outcrop of these beds along the banks of the Cuivre at that point. The following is a section:—

No. 5—Covered slope, with chert gravel and loose geodes. 20 feet.

4—Drab, even-bedded, crystalline limestone, in layers three to ten inches thick, containing two species of *Productus* and a *Zaphrentis*. 10 feet.

No. 3—Light-gray, thicker-bedded subcrystalline limestone. 8 feet.

2—Dull-yellow, granular, thin-bedded limestone. 6 feet.

1—Light-blue, fine crystalline, with occasional nodules of chert. 10 feet.

In several wells dug in the top of the hill there were found, according to report, brown and blue shales, with layers of loose shelly limestone at a depth of fifteen or twenty feet. Along the covered surface in the water-worn troughs, loose geodes occur in great abundance, washed out of the soil and decomposing limestone beds above. The contained minerals are usually quartz and calcite, the latter merely crystalline in structure or in well-developed rhombohedra and scalenohedra lining, the interior of a shell of compact quartz or chalcedony. In a few instances iron pyrites and minute crystals of galena were observed.

East of Chain-of-Rocks the Archimedes is seen cropping out at a few points in the covered hills, but not sufficiently defined to afford sections. In the Mississippi bluffs, north of the Cuivre River, it forms the perpendicular wall at the top, and appears at intervals in the covered slopes below, as follows :—

No. 3—Bluish-gray, thin-bedded, fine crystalline limestone, with geodes. 8 feet, the lower part changing gradually into

2—Brown, thin-bedded, argillaceous limestone, with blue and gray shales interstratified. 12 feet.

1—Covered slope, gray, fine-grained limestone, appearing at intervals to the Mississippi bottom. 23 feet.

Following the bluffs north, these beds are seen descending gradually, and in Sec. 2, T. 48, R. 2, E., covered by the dense light-drab beds of the St. Louis limestone.

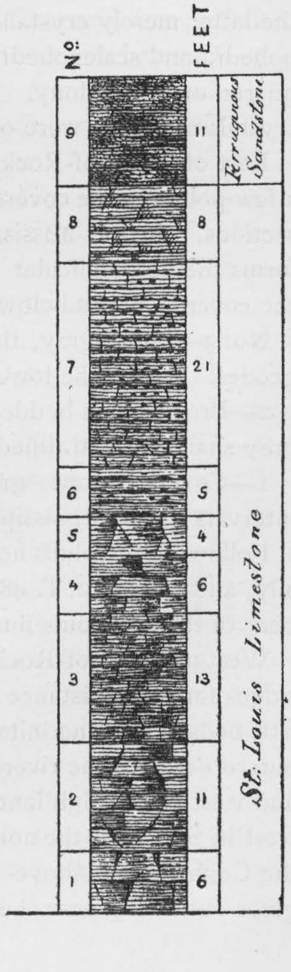
West of Chain-of-Rocks the Archimedes appears in high hills and ridges for some distance along the Cuivre River, with the characteristic beds of the Encrinital, forming the bed-rock below. The line of outcrop crosses the river in Sec. 24, T. 48, R. 1, E., and passes south and west in the high lands, north of the Big Creek, turning north-west in Sec. 21 to the north-west corner of the township. Crossing the Cuivre again above Moscow, it turns off north and east, and gives out finally near the line of fault.

Near the old mill, at Moscow, the lower beds are exposed along the river, and fossils occur in great numbers; several species of *Spirifer* and of *Productus*, also *Fenestella* and *Archimedipora*, the latter being unusually large and well-developed specimens.

In the high land between North and West Forks of Cuivre, about the head-waters of Lead Creek, the Archimedes limestone covers an extended area, and attains a thickness of about fifty feet. It differs but little in character or mode of occurrence from the same beds already described.

The St. Louis Limestone.—This formation is limited in its development to the south-eastern part of the county, forming the base of the main ridges covered by the Coal-measures, and extending from the Mississippi bluffs nearly to the Cuivre on the west.

Fig. 73.



It is represented by beds of hard, compact limestone of a light-blue and drab color, and dull, yellow, silicious, magnesian limestone, with thin layers of argillaceous shale interstratified. The following section, taken on Bob's Creek, in Sec. 32, T. 49, R. 2, E., shows in greater detail the character of the group:—

No. 9—Ferruginous sandstone.

8—Light-drab, compact limestone, with smooth, conchoidal fracture, in thin beds traversed by delicate veins of calcite.

7—Bluish-gray, close, crystalline, cherty limestone, in layers from four to twenty inches thick, with thin beds of argillaceous and sandy shales.

6—Light-gray, subcrystalline, in thicker beds, with seams and nodules of dark-colored chert, containing *Lithostrotion Canadensis*, *Productus semireticulatus*, and a *Spirifer*.

5—Light-drab, compact limestone, resembling No. 8.

4—Bluish-gray, fine crystalline, very hard limestone.

No. 3—Impure, dull-brown, thin-bedded limestone, with layers of light, buff-colored, sandy shales interstratified.

2—Light, yellowish gray, close-grained, magnesian limestone.

1—Light-drab, compact limestone, with smooth conchoidal fracture.

This section was seen in part at many places along Bob's Creek, in the high ridges capped by the Coal-measures. The lower beds appear higher up on Bob's Creek, in the base of the hills and overlying the Archimedes limestone, as will be seen in the following section, taken in Sec. 14, T. 49, R. 1, E. on a small branch :—

No. 9—Top of ridge covered with a red gravel, etc. 18 feet.

8—Light-gray, fine crystalline silicious limestone, with occasional layers of dark-colored chert, containing *Lithostrotion*, *Productus*, *Spirifer*, and *Fenestella*. 4 feet.

7—Covered slope. 18 feet.

6—Light, yellowish-gray magnesian limestone. 5 feet.

5—Gray, compact limestone, with smooth conchoidal fracture. 6 feet.

4—Drab, thin-bedded limestone, with layers of shale interstratified, containing a species of *Melonites* and *Crinoid* stems. 12 feet.

3—Light-brown, impure magnesian limestone, seen at intervals in covered slope.

2—Light, bluish-gray, compact limestone, with cherty layers. 5 feet.

1—Thin-bedded, bluish-white, silicious limestone, with geodes.

The rise in the strata toward the north, near the line of fault, increasing gradually in that direction, carries the St. Louis limestone into the tops of the ridges, and beyond it gives place to the Archimedes. This inclination only occurs along the line of fault, the general dip, as already observed, being N. 20° E.

The formation first appears in the bluffs of the Mississippi, two miles south of Bob's Creek, the lower buff and brown magnesian beds occupying the upper part of the ridges overlying the Archimedes limestone. Descending gradually, it forms the main part of the bluff on the south side of Bob's Creek, cropping out at intervals in the lower-covered slopes, and in the perpendicular wall at the top. North of the creek the light-drab, compact limestone, like

No. 5 of the first section, forms the upper part of the bluff, while the impure gray and brown, with interstratified shales, make up the base. These in time disappear, giving place to still higher beds, until the line of fault is reached, where the upper beds rest at an angle of about 15° against the nearly vertical strata of the encrinital, as may be seen in the general section along the bluffs.

The Ferruginous Sandstone.—This formation crops out over a limited area beneath the Coal-measures, in the high ridges of T. 48 and 49, R. 1 and 2, E. It consists of ten to eighteen feet of dull-yellow or reddish brown, impure, friable sandstone, in part of coarse grain, and in heavy beds, but generally in thin layers, regularly stratified, fine-grained, and more or less argillaceous. It is found in all cases resting conformably upon the St. Louis limestone, and, with the exception of a small isolated area in south-west quarter of Sec. 32, T. 49, R. 2, E., is overlaid by the Coal-measures. This area is near the south-eastern extremity of the main ridge between Bob's Creek and Cuivre River, two hundred feet or more above the level of the latter. Near the top of the ridge there is an exposure of about fifteen feet of rather coarse, crumbling, reddish-yellow and brown sandstone, in beds from one to three feet thick in the upper part, changing to fine-grained, friable, argillaceous layers below, the whole resting upon the well-marked beds of the St. Louis limestone. To the south-east of this, another small area of this sandstone occurs in a higher portion of the ridge, overlaid by less than twenty feet of the Coal-measures. The sandstone crops out in the Chain-of-Rocks road, which passes near, and the total observed thickness was eighteen feet.

To the north-west along this main ridge, between Bob's Creek and Cuivre River, the Ferruginous sandstone appears at many points cropping out beneath the Coal-measures, which occupy the highest portions. In the edge of Highland Prairie, which occupies a large part of Sec. 31, and passes north-west into Secs. 25 and 36 of T. 49, R. 1, E., the sandstone appears at intervals at the heads of small branches, varying in thickness from twelve to eighteen feet. Near the line between Secs. 25 and 26 a break in the ridge brings the St. Louis limestone to the surface, separating the Highland Prairie from the main ridge on the north-west, but beyond the break the gradual elevation of the land soon exposes the sandstone and overlying Coal-measures.

At Meadows's coal-bank, on the north-east side of the ridge, there is an exposure of eleven feet of thin-bedded, fine-grained, argillaceous sandstone, and on the farm of Mr. F. W. Rose its most westerly outcrop occurs with a thickness of eight feet, and at a distance of ten feet below the hydraulic limestone of the Coal-measures, the usual intervening beds of shale and coal not appearing.

Near the top of the dividing ridge between Bob's Creek and Brushy Fork, the Ferruginous sandstone crops out at many points, and underlies the Coal-measures which form the summit of the ridge. The observed thickness was from seven to ten feet, and consists of a dull-brown, thin-bedded, argillaceous sandstone, with concretions of iron-ore.

In Sec. 7, T. 49, R. 2, E., it appears again, underlying the Coal-measures, near the top of a small hill, with an exposure of seven feet.

A few fragments of vegetable remains, resembling *Calamites*, are the only fossil forms occurring in this formation.

Coal-Measures.—This division of the Carboniferous series is represented in Lincoln County under two forms—the regular undisturbed lower measures in the south-eastern part of the county, and the irregular isolated deposits in the western, the latter of which will be more fully described in the report on the Economic Geology of the county.

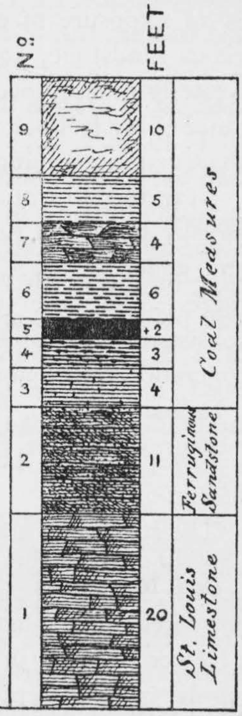
The regular Coal formation, like the Ferruginous sandstone, is limited in its development to T. 48 and 49, R. 1 and 2, E., and consists of several small areas occupying the highest ridges, namely, that lying between Bob's Creek and Cuivre River, between Bob's Creek and Brushy Fork, and that on the north side of the latter stream, near the head-waters of McLean's Creek. The first of these areas has its most northerly outcrop near the line between Secs. 22 and 27, T. 49, R. 1, E., where the hydraulic limestone appears in the edge of the ridge. From this point it runs south through the eastern half of Sec. 27, with an average width of a quarter to half a mile, thence east through the south half of Sec. 26, terminating near the section-line.

The following section, taken at Meadows's bank, shows the character of the beds and their relation to the adjacent formations.

No. 9—Covered hill-top.

8—Brown shale—arenaceous.

Fig. 74.



No. 7—Hydraulic limestone—very hard and compact, of a bluish-gray color, with dark-blue spots and veins of calcite scattered through the mass, and containing *Athyris subtilita* in abundance, together with *Chonetes mesoloba*, *Productus semireticulatus* and a species of *Spirifer*.

6—Black slate.

5—Coal.

4—Fire-clay.

3—Yellow, arenaceous shale.

2—Ferruginous sandstone.

1—St. Louis limestone.

The hydraulic limestone is the most characteristic bed of the series, and is often the only indication of the occurrence of the formation, its great hardness causing it to stand out in bold relief where the other and softer beds have been washed away or covered by detritus.

On the south side of the ridge in the south-middle of Sec. 26 there is an exposure of eighteen feet of green and red shales, with nodules of iron-ore over the hydraulic limestone.

In the Highland Prairie, which forms the second Coal-measure area, no coal has been taken out, but the hydraulic limestone appears as the surface-rock, and at several places small fragments of coal were obtained in the beds of branches below the limestone. The coal, as it occurs at the Meadows's bank, probably underlies the whole prairie.

To the south-east, along the same ridge, in the south-east quarter of Sec. 32, T. 49, R. 2, E., there is a small knob of a few acres extent capped by the Coal-measures, as follows:—

No. 5—Covered top. 5 feet.

4—Hydraulic limestone. 3 feet.

3—Clay and black dirt. 15 feet.

2—Ferruginous sandstone. 18 feet.

1—St. Louis limestone, forming the main body of the ridge.

The fourth area has its northern outcrop in the north-eastern corner of Sec. 13, T. 49, R. 1, E., and stretches away south through the western half of the section, with an average width of a quarter of a mile. Thence sweeping off to the east, through the middle of Sec. 24, it crosses the township line into the south half of Sec. 19, of T. 49, R. 2, E., south of the village of Chantilly, covering nearly half the section, and terminating in the extreme south-eastern corner, on the land of Milner M. Tucker, where the hydraulic limestone and a few inches of black dirt are to be seen in the lane running on the north and south section-line. Coal was seen at but two points in this area ; in the north-west quarter of Sec. 24, T. 49, R. 1, E., a few hundred feet south of the Troy and Cap au Gres road, and in the south-east quarter of the same section. The hydraulic limestone, however, forms the surface-rock, and crops out frequently in the edge of the ridge, marking the presence of the formation.

The remaining area occupies the top of a small knob in the south-east quarter of Sec. 7, T. 49, R. 2, E., and covers an extent of about thirty acres. No coal or shales appear, but the hydraulic limestone crops out near the top of the hill, three feet and a half in thickness ; below which, after an interval of twenty feet, coarse, thick beds of the Ferruginous sandstone, seven feet, succeeded by the St. Louis limestone.

Quaternary.—Of the four subdivisions of this system three are fully represented in Lincoln County, namely, Bluff or Loess, Bottom Prairie, and Alluvium, while a few bowlders scattered about on the hills or in the deep ravines are the only evidences of the occurrence of the drift. No accumulated deposits of true drift-material were observed in any part of the country.

In Sec. 8, T. 48, R. 1, E., on the Troy and Wentzville road, a large bowlder of feldspathic granite, two feet and a half in its greatest diameter, lies imbedded in the soil on the top of a high ridge ; and in various other localities smaller bowlders are found, but unaccompanied by gravel or finer material of the true drift. Most of these bowlders are of granite, hornblendic gneiss, hornblende-rock, quartzite, diorite, red sandstone, resembling the Potsdam sandstone, and one was found of milky quartz, with fine crystals of black tourmaline.

The Bluff or Loess formation is exposed in many parts of the county, especially in the eastern border, where it reaches a thickness of fifty to seventy-five feet. It is generally of a dull-yellow, ash-colored, brown or even bright-red argillaceous or sandy marl, imperfectly stratified, and, where weathered, exhibiting a columnar structure. In the south-east it covers the rock-bluffs and forms the main part of the hills in the valley of Cuivre ; and along the eastern side of the range of high knobs it is well developed, giving character to the soils and rendering them among the best in the county for the production of fruits and grain. West of this range the formation is not so general in its distribution nor so fully developed.

Of organic remains, several species of *Helix* occur frequently.

The Bottom Prairie extends over the great Mississippi bottom, which forms the eastern border of the county, from two to three miles wide. It is cut into, for a considerable depth, by the streams which flow down from the uplands and empty into the Mississippi. A section taken half a mile from the bluffs on Cuivre shows :—

Soil. 2½ feet.
Light-gray, sandy clay. 4 feet.
Dark-brown and black vegetable mould. 1½ feet.
Bluish, calcareous clay. 2 feet.
Dark-gray, and irregularly stratified. 3 feet.
Yellow sand, stratified. 8 feet.

A section taken of the bank on Sandy Creek is as follows :—

Soil. 2 feet.
Light-yellow, sandy loam. 3 feet 10 inches.
Dark, vegetable mould, with sand. 1 foot.
Dark-blue clay, in thin layers. 2 feet.
Gray and brown sands, irregularly stratified. 4 feet.
Light-yellow, regularly stratified sand. 6 feet.

Aside from the soils which constitute the upper and latest deposits, and occur in all parts of the county, there appear, especially in the valleys of the streams, beds of pebbles, sand, clay and vegetable mould. These materials, derived from older superficial deposits or from the rocks through which the streams have cut their channels, have been transported to a greater or less distance by the currents, and form now the broad prairies of the Mississippi bottom on the eastern border of the county, and the smaller but no less fertile wood-plains of Cuivre River and its main branches. In the beds of nearly all the streams and ravines, small pebbles lie scattered about, or in beds several feet thick. These pebbles are almost entirely of chert, though fragments of limestone occur as well, and vary in size from that of a walnut to pieces six or eight inches in diameter. The chert is smooth, though more or less angular, and has been derived from neighboring beds of cherty limestone, through which the streams run, and which cover so large an area of the county; or from similar beds forming the surface-rock at an earlier time, and which have now disappeared through erosion, leaving the more indestructible cherty fragments. Many of these fragments contain the impressions of fossils, and are in all respects similar to the nodules of chert occurring in the Subcarboniferous limestones.

Sand and clay form an important part of the alluvial bottoms, occurring stratified in more or less regular layers. The former shows very distinctly, in many places, the peculiar broken structure produced by rippling waters or the gentle ebb and flow of currents and waves over a shallow bottom.

In some of the broad bottoms along Cuivre River and other large streams the alluvium is distinctly terraced. At the crossing of Cuivre in Sec. 14, T. 49, R. 1, W., where the bottom is about half a mile wide, there are three well-marked terraces, ten, six, and four feet high respectively, and these may be traced for a distance of nearly two miles south along the bottom.

CHAPTER VIII.

COAL.

THE existence of coal in Lincoln County has been known for many years, and has excited considerable interest, not only in the county itself, but among many operators and manufacturers in adjacent parts of the State who were desirous of obtaining a suitable and cheap fuel for smelting and manufacturing purposes. But although a considerable amount of coal has been taken out in various places for home consumption, and search made in others, it may be said that no systematic examination had, up to the present time, been made to prove the extent and value of the deposits.

As has already been stated in a previous part of this report, the coal occurs in this county under two conditions :—

I. That found regularly stratified, with undisturbed beds, which, from their stratigraphical position and the character of the contained fossils, are to be recognized as belonging to the lower series of the regular Coal-measure formation.

II. The irregular, isolated beds of coal occurring in the banks of streams and ravines, exhibiting signs of disturbance, and associated with a comparatively small amount of the usual accompanying beds of the Coal-measures.

The coal referred to the first division has already been described as to its mode of occurrence, and the limits of the areas underlaid by it have been marked out. Although these areas in which coal will be found are of considerable extent, there is but one place at which the coal has been taken out, namely: at Meadows's bank, in the high ridge west of Bob's Creek, in the north-west quarter of Sec. 27, T. 49, R. 1, E. During the past twelve or thirteen years coal has been obtained at intervals, amounting altogether to about three thousand bushels.

The seam varies in thickness from fifteen to twenty-five inches, and is covered by four feet of compact, hard, hydraulic limestone, with, in some places, a few inches of black slate intervening. One or two openings have been made in the edge of the hill at the outcrop, and a low entry, the thickness of the coal and slate in height, worked into the hill for a distance of one hundred and twenty or thirty feet. The coal itself is a soft, caking, bituminous coal, jointed with planes perpendicular to the stratification, is rather tender when exposed, and contains considerable sulphur.

Below are two analyses of this coal, made by Mr. Chauvenet. No. 1 is from the top of the seam and No. 2 from the bottom.

	No. 1.	No. 2.
Water	6.30	6.75
Volatile Matter	39.20	36.80
Fixed Carbon	44.30	42.00
Ash	10.20	14.45

Color of ash in both, light brown.

Sulphur, 4.91. Iron (metallic), 4.44.

At no other place could specimens be got for analysis, and possibly it might prove elsewhere to be of better quality; but it is improbable that it will be found much thicker. There are many points where the coal could be obtained, and its character determined, with little labor and small cost; and those having land on the outcrop of the Coal-measures, already indicated on the map, might easily make the trial.

Coal from the Meadows bank is used for household purposes in the neighborhood, and to a large extent by the blacksmiths. The demand for it is necessarily somewhat limited.

The deposits of coal which have attracted the most attention in the county belong to the second division, as given above, occurring at many places in the excavated valleys, side branches and ravines, as isolated beds unconnected with one another, but exhibiting the same general characters and associations. These beds are often of great thickness as compared with the regular coal-seams, reaching as high as twenty-five feet in some cases, and showing more or less signs of disturbance in the irregularity of the dip and the smooth and polished surfaces of slicken-sides.

With this great thickness of coal there is always a remarkably small representation of the usual accompanying Coal-measure strata. The few inches of shale or slate interstratified with, and rarely a few feet above, the coal, contrasts strongly with the great thickness of these beds in the regular coal-measures.

Another marked feature of these deposits is the relation they bear to the prevailing rock of the region, which is in all cases one of the limestones of the subcarboniferous series, and most commonly the Encrinital. These limestones, identified by their well-marked and characteristic fossils, form the walls of the basins and depressions in which the coal-beds are found, and crop out in the banks and slopes above the level of the coal, and in fact on all sides of it. The occurrence of these limestones, then, at the side or below the coal, marks the limits of the beds, since the limestones were formed before the coal, and it is useless to seek in or beneath them. Appearing as the coal does, however, in the banks of streams and ravines, it was, perhaps, not unnatural for the miners and others interested to mistake it for the outcrop of true seam-coal underlying the higher prairie-land.

With but few exceptions, these coal deposits occur in the main valley, or in the ravines of tributary branches of Coon Creek, which drains the south-western part of the county between the West Fork of the Cuivre and Big Creek, entering the latter from the north-west in the south-west quarter of Sec. 22, T. 48, R. 1, W. At many places, where excavations were made and coal taken out, in former years, but little is to be seen of the character and position of the beds, the pits and entries being either filled with water or closed by the falling in of the loose gravel and soil. The relation of these beds, however, to the prevailing limestone strata, is generally well marked. A more detailed description of them and of the exposed beds will furnish a better idea of the character of the deposits, and perhaps lead to a fuller understanding of their origin.

Linn's Bank.—The lowest point on Coon Creek where coal has been found is on the land of Mr. Jacob Linn, in the north-east quarter of Sec. 18, T. 48, R. 1, W. It occurs in the ravine of a small side-branch, about fifty feet above the level of the creek, and three hundred yards distant. The branch is but little over a quarter of a mile in length, and flows in a narrow and deep channel cut in the undisturbed beds of the Encrinital limestone, which crops out on all sides, and within ten feet of the coal-pit in the bottom of the branch. This pit was sunk two years ago to a depth of twelve feet, passing through the following strata :—

No. 5—Soil and gravel. 1 foot 6 inches.

4—Gray shale, with impressions of fern-leaves and stems, among which were noted species of *Neuropteris*, *Pecopteris* and *Sphenophyllum*. 3 feet.

3—Rotten coal, of which only a few small pieces were to be seen. 2 feet 1 inch.

2—Black shale, with a species of *Neuropteris*, very abundant. 3 feet.

1—Coal. 2 feet 6 inches.

Across the bed of the branch, about fifty feet distant, a pit was sunk, and the coarse, brown, fossiliferous beds of the Encrinital limestone reached, while two hundred feet down the stream two feet of coal were obtained. The limestone crops out of the banks and in the bed of the branch, showing the deposit to be very limited in extent, and a large part has already been cut out by the waters. A few bushels were taken out in sinking the pits, but the coal proved to be of very inferior quality, owing probably to the continued exposure to the surface-waters.

Heady's Bank.—On or near the Martin branch several deposits of coal and shale appear. The first is about three hundred yards up a side-branch, known as Heady's branch, which flows in from the prairie on the south-west. Two pits have been sunk in the bottom of this branch, about two hundred feet apart, one near the foot of the bluff and the other at the edge of the present bed of the stream. The latter is now filled with water, but the following section is reported to have been obtained :—

	Feet.	Inches.
Alluvial bottom	5	
Black slate	1	6
Coal	2	6
Black slate		6
Coal	4	

The bottom of the branch is eighty or a hundred feet wide at this point, and the bluffs and slopes rise forty to fifty feet to the prairie above, the Encrinital limestone cropping out at intervals.

The second opening was made in the fall of 1870, by the Lincoln County Coal Company, on a fork of the branch and near the foot of the bluff. The depth of the shaft is twenty feet, in which there appears gray and black slate and two layers of coal, amounting altogether to twelve feet. Boring was begun in the bottom of the shaft, but abandoned after reaching the limestone, a few feet below the coal. The exact limits of this bed of coal cannot be determined, owing to the alluvial covering; but the outcrop of the Encrinital limestone in the bluffs shows that it is confined to the bottom of the branch. It is highly probable, also, that a large part of the formation has been cut out by the stream, while much of the coal that is left will have become deteriorated by exposure, not having a sufficiently impervious covering.

Martin's Bank.—Still higher up the Martin branch, near the middle of south-west quarter of Sec. 12, on the Martin farm, coal is to be seen cropping out in the present bed of the stream for a distance of nearly fifty feet. In the fall of 1870 a pit was sunk in the bottom at the edge of the stream, and five feet of coal was found, after passing through seven feet of soil and gravel and one foot of black slate. At its outcrop in the branch, the coal dips a few degrees to the west, and in the pit, which is now filled up, it is said to dip to the north. Coal has been taken out from time to time and used in the neighborhood.

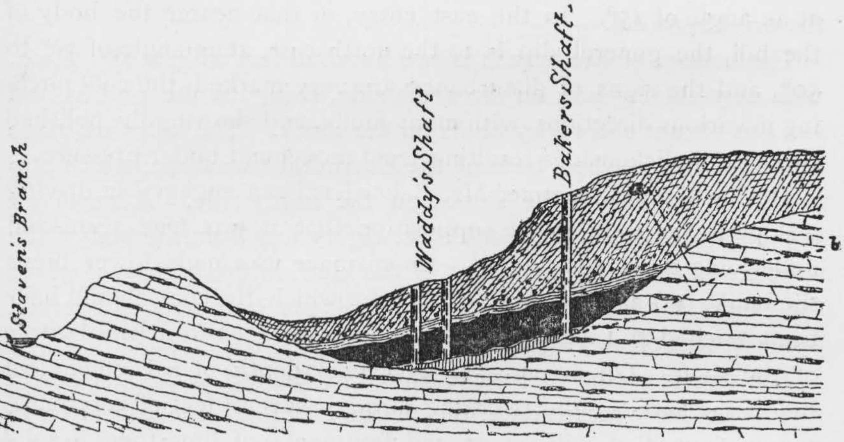
The bottom of the branch is two hundred feet wide at this place, with easy-sloping hills on the north side, rising to the prairie, and low but abrupt and rocky bluffs on the south. The latter are made up of the undisturbed beds of the Encrinital limestone, which also appear at intervals in the slopes on the north side. A small pit was dug recently on the south side, eighty feet from the bed of the stream and thirty from the foot of the bluff, in the bottom of which the cherty, fossiliferous, Encrinital limestone is to be seen overlaid by eight feet of chert-gravel.

The stream seems to have changed its channel in the bottom at a comparatively recent date, the marks of an old one appearing to the south of the present, and, having worked through the alluvial deposit to the coal, is now rapidly cutting out and washing it away.

Johnson's Bank.—This is on the north fork of the Martin branch, a short distance south-east of the middle of Section 11. A rude shaft was put down, some years ago, in the high sloping bank on the south side of the fork, to a depth of eighteen feet, and eight feet of coal found overlaid by six feet of shale. No information could be obtained of the character of the coal. Outcroppings of Encrinital limestone in the bank on both sides, and within fifty feet of the coal, also in the ridge above, show that the deposit is quite limited, and is doubtless the remains of a larger bed occupying the valley of the stream.

Passing up the valley of Coon Creek, the next occurrence of coal of any importance is near the head of the Slaven's branch, which rises in the prairie in the north-east quarter of Sec. 36, T. 49, R. 2, W., and enters Coon Creek near the centre of Sec. 1, T. 48, R. 2, W. In the ravine, at a point of the prairie formed by two forks of the Slaven's branch, coal has been taken out in considerable quantities from the Waddy and Baker banks, and at this place, perhaps, better than at any other in the county, is the true character of this class of deposits to be seen—that the coal is not in true seams in the regular Coal-measure formation, but as isolated masses in depressions in the Subcarboniferous limestone. The following sketch shows the mode of occurrence of the coal at this place, and the position of the pits :—

Fig. 75.



The Waddy Bank was opened some years ago, and about a thousand bushels of coal have since been taken out. Near the foot of the slope from the prairie, and about a hundred and twenty feet from the main fork of the branch, two pits were sunk to the coal, which lies at a depth of eight to ten feet below the surface, with a thickness of five and a half to seven feet, and overlaid by a few inches to two feet of black slate. The coal has a general dip of about 5° toward the south-west; but varies considerably in different parts of the pits, both as to direction and intensity. It is of fair quality, and has been used largely by neighboring blacksmiths; at present, however, the pits are full of water and the coal neglected. The analyses of the Baker coal, given further on, will show more fully the character of this coal.

Baker's Bank.—At a distance of about eighty feet from the Waddy pits, and at a level of twenty one feet above, is the opening of the Baker shaft, which was sunk in the summer of 1871.

The following section appears there:—

Clay and chert gravel, 19 feet; Black slate, 3 to 8 inches; Coal, 8 to 10 feet; Fire-clay, 4 feet.

Encrinital limestone in broken masses at the bottom.

The black slate appears in some places above the coal, and at others soft clay, filled with angular chert from the Encrinital limestone, rests upon the coal. Two entries have been worked in the coal, a distance of ten feet each from the bottom of the shaft, one south-east and the other west-north-west. In the west entry the coal is eight feet two inches thick, and dips at the hill to the west at an angle of 25°. In the east entry, or that nearer the body of the hill, the general dip is to the north-east, at an angle of 40° to 50°, and the signs of disturbance are very marked, the coal pitching in various directions, with many faults, and showing the polished surfaces or slickensides resulting from movement under pressure.

During the past summer Mr. Baker has been engaged in driving a slope to the coal, on the supposition that it was true seam-coal underlying the whole prairie. An entrance was made lower down the bank, (*a*,) and a direction taken by which the coal should have been reached at a distance of forty feet north-east from the bottom of the shaft. On arriving at a vertical depth of seventeen feet below the surface, after working through several feet of very hard, tough clay, filled with chert and fragments of limestone, a solid ledge of limestone was struck, (the dotted line *b*,) which proved to be the face of the rock-bluff at the edge of the channel cut out by the south fork of the branch.

The whole amount of coal at this place is contained in an area of one hundred and fifteen feet square, in part of a small basin due in some measure to a disturbance of the limestone, shown in the sketch, but mostly to subsequent erosion. The Encrinital limestone is to be seen cropping out on the north, west and south sides of the coal-bed, while that reached by the slope shows the limited extent of the coal toward the east. For those who persist in regarding the limestone as the "cap-rock," or that overlying the coal, it is only necessary that the east entry be driven through the coal a distance of thirty feet or less to prove that the coal gives out over the limestone, and in no case passes under the limestone *in place*.

The following are the results of analyses of this coal made by Mr. Chauvenet: No. 1, average sample; No. 2, from the bottom coal:—

	No. 1.	No. 2.
Water	8.75	8.50
Volatile matter	38.67	39.50
Fixed Carbon	46.93	46.45
Ash	5.65	5.55

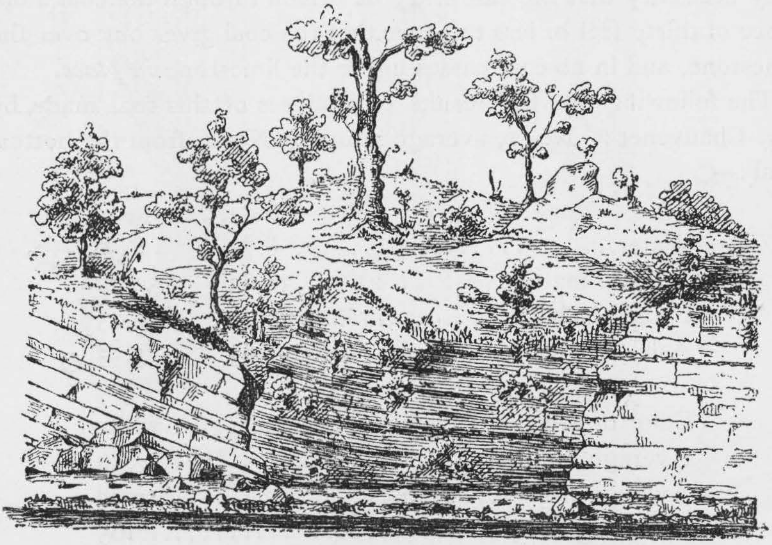
Color of Ash	white
Average Sulphur	2.632
Average Iron	trace
Specific gravity	1.165

A curious feature of this coal is the almost total absence of iron, though the amount of sulphur is over two and a half per cent. No investigations have as yet been made to ascertain under what conditions the sulphur is present when not combined with iron, but it would seem most probable, especially in the case of the Baker coal, that the sulphur is present to a great extent in the form of *gypsum*, or hydrous sulphate of lime. From the occurrence of these deposits in depressions or excavated basins in the limestone, the coal would be constantly subjected to the action of the surface-water, and that passing over and through the decomposing limestone. The sulphur, if present in the form of iron pyrites, would be oxidized, and the sulphate of lime formed. Scales of the sulphate as well as of the carbonate of lime do occur frequently in the joints, coating exposed surfaces of the coal in question.

The Baker coal has been used largely in the county for household purposes, and in the blacksmith's forge.

Half-way down the Slaven's branch, on the east side, coal-measure shales of a light, greenish-gray color, and containing fragments of *Neuropteris*, occur in the bank, enclosed on both sides by the Encrinital limestone. The following sketch shows the relation of the beds :—

Fig. 76.



SKETCH ON SLAVEN'S BRANCH

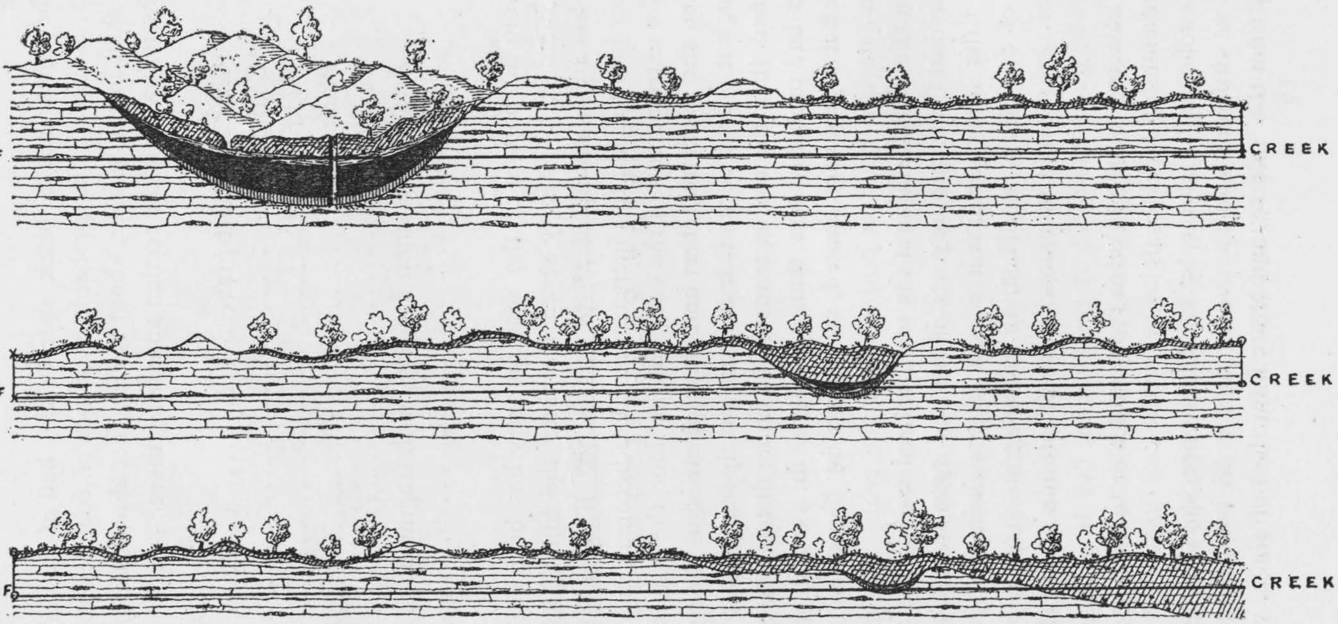
On the north side the limestone strata dip toward the south-west, but on the lower side they are nearly horizontal. The shale is somewhat disturbed in places, but is in general nearly horizontal. This bed of shale seems to have lodged in a cut in the limestone, and been protected there from erosion by the solid walls on both sides.

Link's Bank.—This is the most extensive of all the coal deposits of the kind in the county. It is situated upon the stream known as the Link branch, which heads in the prairie in the north-west corner of Sec. 35, T. 49, R. 2, W., flowing south crosses the Mexico Road, and enters Coon Creek near the middle of the south section-line of 35.

The accompanying sketch represents a section along this branch, from near its head to a point below the coal-bank.

The Encrinital limestone is the surface-rock of the region, and the coal or coal-shale and slate occur in several basins in the west side of the branch. In the upper are a few feet of shale, with nodules

Fig. 77.



SECTION OF LINK'S BRANCH OF COON CREEK

Scale. 120 feet to the inch

of iron-ore, in the middle basin fifteen inches of coal with two feet of shale overlying it and eighteen inches of fire-clay beneath, while in the third basin lies the bed of coal now worked at the Link bank.

The appearance of black slate in the bed of the branch at this place, indicating the probable existence of coal, led to the sinking of a shaft in the hillside, about twenty feet above the branch.

The following is the section appearing there :—

	Feet.
Clay and chert-gravel	11
Coal	2
Light-gray shales	4
Black slate	3
Coal	16
And in the sump fire-clay, with fragments of limestone	6

From the bottom of the shaft an entry has been cut in the coal one hundred and ninety-seven feet into the hill S. 88° W. The coal has a general dip of 7° to 10° S. 30° E. near the shaft, but farther into the hill this increases and also becomes more irregular. At the extreme end of the entry, in the floor, the coal is very much broken and distorted, chert and clay appearing as though thrust up through it. It is very evident from the appearance at this part of the bed that the coal extends but a short distance beyond in that direction, probably less than ten feet. In its extent along the branch it is also very limited, the Encrinital limestone outcropping in undisturbed beds on both sides of the coal. The distance between these enclosing walls is two hundred feet.

The coal from various parts of the bed differs somewhat in character; the upper seven feet consist of an ordinary soft, bituminous coal of dull lustre, and contain considerable sulphur; the middle portion, four feet in thickness, is a soft bituminous of bright, pitchy lustre—a good gas-coal; at the bottom, five to six feet of harder coal, cleaving readily in planes perpendicular to the line of bedding, and resembling block-coal.

The following analyses, by Mr. Chauvenet, show the composition of these different layers; Nos. 1 and 2 are from the top, Nos. 3 and 4 from the middle, and No. 5 from the bottom :—

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Water	7.85	8.17	8.25	8.40	7.90
Volatile matter	32.75	32.58	34.55	35.22	33.90
Fixed Carbon	46.25	46.50	47.50	46.33	49.00
Ash	12.65	12.75	9.70	10.05	9.20

Color of ash, light-gray, and brown with pink tinge.

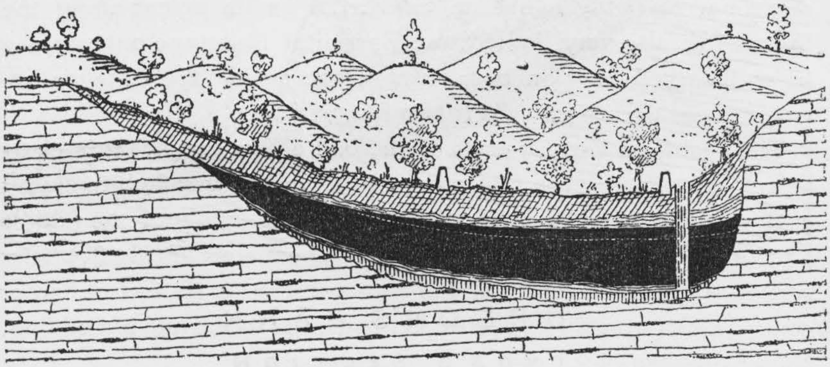
Sulphur in average sample = 2.036
Iron " " " = .707
Specific gravity = 1.255

It will be observed that there is here also much less iron than the sulphur present in the coal requires as bisulphuret of iron or iron pyrites. For the .707 per cent. of iron, only .806 per cent. of sulphur would be required, leaving 1.230 per cent. of sulphur in some other combination than with iron, and, as in the case of the Baker coal, this is probably with lime, as sulphate.

The Link bank is the only one in the county which has been systematically worked: the shaft is seven by ten feet and well timbered, and the entry seven by nine, and a hundred and ninety-seven feet long. There is also an eight-horse-power portable steam-engine, together with hoisting and pumping apparatus. Several thousand bushels of coal have already been taken out and used in the county for household and blacksmithing purposes.

The Upson Bank.—On the Upson farm, now part of the Lin-

Fig. 78.



UPSON'S BANK

LONGITUDINAL SECTION

coln County Coal Company's property, there occurs another small coal-bed, which was opened in 1868, and a few hundred bushels taken out. The coal and accompanying shale and slate occupy a small basin, in the Encrinital limestone, on the south bank of Coon Creek, in the north-western part of Sec. 3, T. 49, R. 2, W.

Fig. 78 is a longitudinal section through the coal.

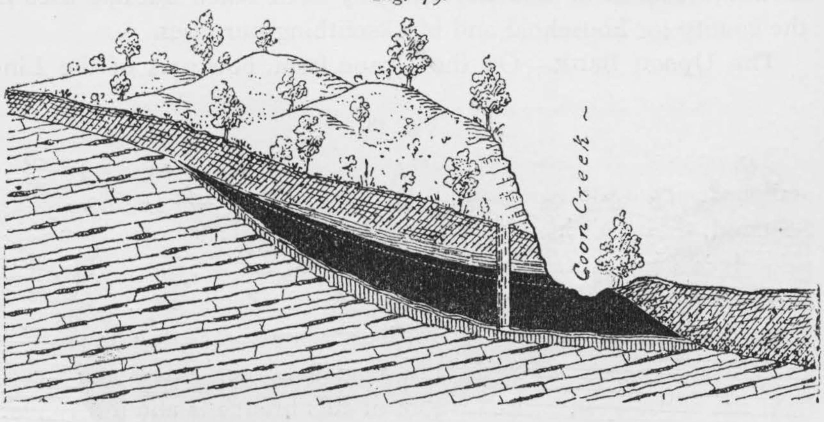
The coal was first seen in the bed of the creek, where it was eleven feet thick, the upper two and a half feet being a cannel. A shaft was afterwards sunk in the bottom terrace, and fourteen and a half feet of coal obtained, at a depth of seven feet from the surface. The shaft is now full of water, but Mr. Upson reports the following section as appearing in the shaft :—

	Feet.	Inches.
Soil and chert-gravel................	5	
Black slate...........................	2	
Cannel coal...........................	2	6
Bituminous coal......................	12	

Patches of fire-clay and black slate below.

This is a sketch of a cross-section taken at this place :—

Fig. 79.



UPSON'S BANK

CROSS SECTION

Two entries were subsequently made in the bank, the first near the shaft and the second sixty feet to the east. In the first coal was found, and followed back into the hill a distance of thirty feet.

In the second entry no cannel was found, and the soft bituminous was only three feet thick at the opening, increasing to six feet at a distance of twenty. Higher up the bank two pits were sunk to ascertain the extent of the coal. In the pit back of the first entry, coal was found at a depth of seven feet, but in the other, thirty-five feet to the east, the limestone was reached at a depth of twenty feet without finding coal. The dip of the coal was said to be one in ten to the west.

The exact limits of the basin are not seen on the creek, but the Encrinital limestone appears on both sides of the coal, with an interval of two hundred and fifty feet. On the west side a bluff twenty feet high occurs within fifteen feet of the shaft, the limestone dipping at an angle of 15° to S. 50° E. In the bed of the creek the limestone also appears on the west side of the coal, with the same general dip, and forms a shield to the coal, protecting it from the erosive action of the running water.

Owing to the condition of the opening, only a few specimens of the cannel coal could be obtained, of which the following is an analysis by Mr. Chauvenet :—

Water	1.15
Volatile matter	41.25
Fixed carbon	49.60
Ash	8.00
Color of ash	very pale brown

The amount of fixed carbon is very large for a typical cannel, making it resemble more nearly in composition the splint coals of Scotland, though it has the structure and appearance of a true cannel. It is compact and without banded structure, has a smooth, conchoidal fracture, and is of a dull, grayish-black color.

On the opposite side of Coon Creek from the Upson bank, and about four hundred yards distant, a small branch enters the creek from the north-west. The bottom of this branch is about fifty feet wide, and the banks rise abruptly to a height of forty feet on both sides, with the Encrinital limestone cropping out at intervals. A few years ago, a hole was bored in the bottom on the west side to a depth of twenty-six feet, of which twenty-one feet were in coal, with four feet of black slate above. On the opposite side of the branch a pit was sunk, and twenty-two feet of coal obtained, while one hundred feet to the south only four feet of coal were found. About six hundred bushels of coal were taken out when these pits were first opened ; they are now, however, filled up, and nothing is to be seen of the character of the coal. The whole deposit seems to be the remnant of some larger one left in the ravine, and protected by the limestone bluffs, on both sides, from the erosion which has swept away the main body of the coal. The channel of the branch was probably on the east side of the bottom at some previous time, and cut out the greater part of the coal there, leaving but the four feet found in the second pit, or even less, farther east.

On the land of Wm. Elmore, near the centre of Sec. 3, T. 48, R. 2, W., on the south side of Coon Creek, there occurs another pocket, from which coal was taken out twenty-five years ago. In the slope of the bank a small depression marks the place where an entry was made to the coal, and fifty feet west of this a pit was dug two years ago by the Lincoln County Coal Company, and a small amount of coal taken out. The whole deposit occupies a triangular-shaped basin, bounded by high and steep banks, from which the Encrinital limestone crops out, and which meet at a distance of about three hundred feet back from the creek. A small branch flows down from the prairie through this valley, and has in places washed away the soil, disclosing the black slate below. The width of this basin on Coon Creek is about one hundred and eighty feet. How much of it is occupied by the coal it is impossible, without boring, to tell.

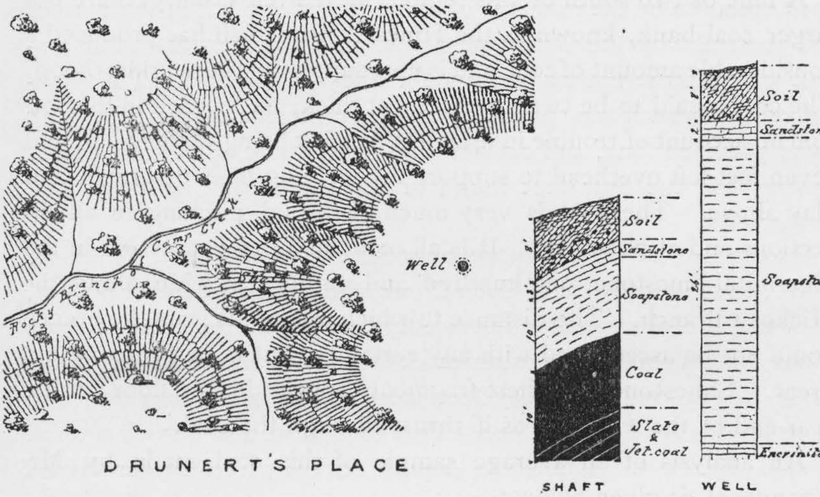
In Sec. --, T. 4, R.—, W., black slate is seen cropping out in the high bank on the south side of Coon Creek. Coal may also occur at this place, but it will be in limited quantities, as the Encrinital limestone crops out of the bank, with an interval of only one hundred feet between.

At several places along the bottoms of Coon Creek, shale and slate of the coal-measures have been found, and a number of pits have been sunk in search of coal. These places are indicated on the map of that region accompanying this report. In a few of these pits coal has been found, but in thin beds and of very inferior quality.

In other parts of the county, deposits of coal similar to these already described have been found, and worked to some extent.

The sketch below represents the occurrence of coal at Drunert's farm, in the north-west quarter of Sec. 12, T. 48, R. 3, W.

Fig. 80.



The shaft was sunk about half-way down the slope from the prairie to the bottom of Rocky Branch, where a light-gray shale crops out. The well, a section of which is given above, was dug on the top of the prairie, and the Encrinital limestone found at the bottom. This limestone crops out in the slopes of the ravine, on three sides of the shaft, at a distance of one to three hundred feet, showing the deposit to be quite limited in extent.

In Sec. 25, T. 48, R. 2, W., at the head of a branch running north into Big Creek, and one mile from the latter, coal was taken out, but it was found to be a very small deposit.

The bed of the stream is narrow at this place, and the banks rise rapidly to the prairie above. Coal and shale appear in the bed of the branch, the former being only a few inches thick, and very much distorted. A shaft was sunk many years ago, in which, it is reported, eighteen inches of coal was found, of very good quality. An entry was worked into the hill a distance of twenty feet, and the coal at that point was cut off by the limestone.

In the north-east quarter of Sec. 35, on the Thurman tract, a bed of coal seven feet thick was worked for a short time. At other places also, in this neighborhood, small deposits occur, which have at various times furnished coal, from a few bushels to several wagon-loads in amount. They occur generally near the heads of the small branches running into Big Creek, and are very limited in extent, the Encrinital limestone cropping out near them.

A mile or two south of this region, in Warren County, there is a larger coal-bank, known as the Hines Bank, which has produced a considerable amount of coal, and is now supplying the neighborhood. The coal is said to be twenty-three feet thick, six feet left in the bottom on account of trouble in draining, ten feet being worked out, and seven feet left overhead to support the yielding beds of gravel and clay above. The coal is very much disturbed, pitching in all directions and at all angles. It is all contained in a depression in the Encrinital limestone, one hundred and eighty feet wide, along the Hickory Branch. The distance to which it extends from the branch could not be ascertained with any certainty, but it is probably not great. Limestone and chert fragments appear in the floor at the rear end of the working, as if thrust through the coal.

An analysis of an average sample of this coal, made by Mr. Chauvenet, is given below :—

Water	6.75
Volatile matter	36.40
Fixed carbon	45.75
Ash	11.10
Color of ash	reddish brown
Sulphur	2.23
Iron (metallic)	5.21

In the eastern part of the county, in Sec. 4, T. 49, R. 1, E., coal has been found on the land of Mr. I. I. Alexander, but in very small quantity. It occurs in the bed of a small branch, accompanied with a few inches of slate. The limestone appears on all sides of and within a few feet of it, showing it to be very limited in extent. This is the only deposit of this kind found on the east side of Cuivre River.

From the description here given of this interesting class of coal deposits, the following general features may be noted :—

1st. The occurrence of the coal in isolated masses, often of great thickness, associated with thin strata of shales, slate and fire-clay, containing a few fossils, but identical with those of the coal-measures.

2d. These beds of coal are only found along the valleys of streams and branches, either in the bottoms or in the sloping banks.

3d. They occur in depressions or previously excavated basins and cuts in the Subcarboniferous limestone.

4th. The coal and accompanying strata are always more or less disturbed from their original horizontal position.

It would appear, then, that the Coal-measure formation at one time covered a very much larger area in Lincoln County than at present, occupying previously excavated basins or troughs in the Subcarboniferous limestone, corresponding in general with the present main valleys, though broader and less deeply cut; or perhaps filling a greater basin, of which the great anticlinal arch running north and south through the county formed the eastern rim; or even that the formation was continuous with that in Illinois, and covered what is now part of the Mississippi valley. Whatever might have been the extent of this coal-area, it was doubtless much greater than it is at present, and the main part has been removed by aqueous erosion. Along favorable lines of drainage, streams found and subsequently cut for themselves deep channels through the soft and easily decomposed strata of the Coal-measures. Gradually, by the undermining of the beds, the coal, etc., above, would slide or fall down the slopes in masses, inclining at various angles. By the continued action of the eroding waters most of the formation would be swept away, leaving only such portions as happened to have lodged in side-cuts and troughs, and were protected by the more durable walls of limestone on both sides—as we now find them.

With regard to the amount and value of the coal of Lincoln County, it must be said that they have been somewhat overestimated. The volume of coal in the largest deposits, namely, Link's, Upson's, and Baker's, may be determined approximately by a measurement of their basins as limited by the Encrinital limestone and the probable average thickness of the coal. By allowing one cubic yard to the ton, there will result for—

Link's	22,220	tons of coal.
Upson's	7,460	"
Baker's	3,730	"

These are the maximum amounts, and probably are somewhat over the true figures. The deposits are separated from each other by a distance of one to three miles, and are six to eight miles from the nearest railroad (now in course of construction). There is sufficient coal of good quality to supply the home wants of the county for some time to come, and for such purposes it can be profitably used. The incurring of a great expense, however, in the construction of a branch railroad, and extensive mining operations for such an amount of coal, the best of which contains from six to twelve per cent. of ash and over two per cent. of sulphur, would be, to say the least, unwise. Already a large amount of money has been expended without resulting in any substantial benefit to the county. The "Lincoln County Coal Company" has about twelve thousand acres—mostly of prairie-land—and has been engaged during the past two years in boring for coal on the prairie, to a depth of nearly four hundred feet in the Encrinital limestone, which is, geologically, over five hundred feet *below* the Coal-measures. The "Lincoln County Coal-Mining and Transportation Company," holding a large tract of land, has made preliminary surveys for a line of railroad from Pendleton on the St. L., K. and N. R. R., through the above-described coal region, to Cap au Gres on the Mississippi, a distance of thirty miles or more, for the better development of their coal property.

The excitement has thus been kept up for several years, and an undue importance attached to the coal deposits by the inhabitants of the county, while there are other stores that await development. Occupying such a favorable position on the Mississippi, traversed by two independent lines of railroad, and all within seventy miles of a great and insatiable market, Lincoln County will find in her fertile soils a more certain source of wealth and prosperity. With a reasonable display of energy, and with labor properly directed, she ought soon to occupy an important position as an agricultural county, and such as will compensate her largely for the loss of those stores of which she has been deprived by erosive agency.

Iron-Ore.—Iron-ore of excellent quality occurs in Lincoln County to a considerable extent, but the character of the deposits renders it improbable that it can ever be the source of an extended industry. After the completion of the railroads now in process of construction through the county, however, and with the consequent increased facilities of transportation, a large part of this ore may be profitably shipped to neighboring metallurgical centres, and there command a good price.

These ores may be divided into two general classes, according to their character and their modes of occurrence.

I. Brown, hydrous oxides, occurring in crevices and irregular cavities in the Upper Trenton limestone.

II. Compact red hematite, in loose masses, scattered over the surface in various parts of the county.

The ores of Class I. are limited to T. 50, R. 1, W., as far as observed. On the land known as the Morris tract, several excavations were made a year ago, in one of which a considerable amount of ore was found. This occurs on a ridge north of Fort Spring Branch, in the Receptaculite limestone of the Upper Trenton. A section of the strata at this place has already been given, on page 237.

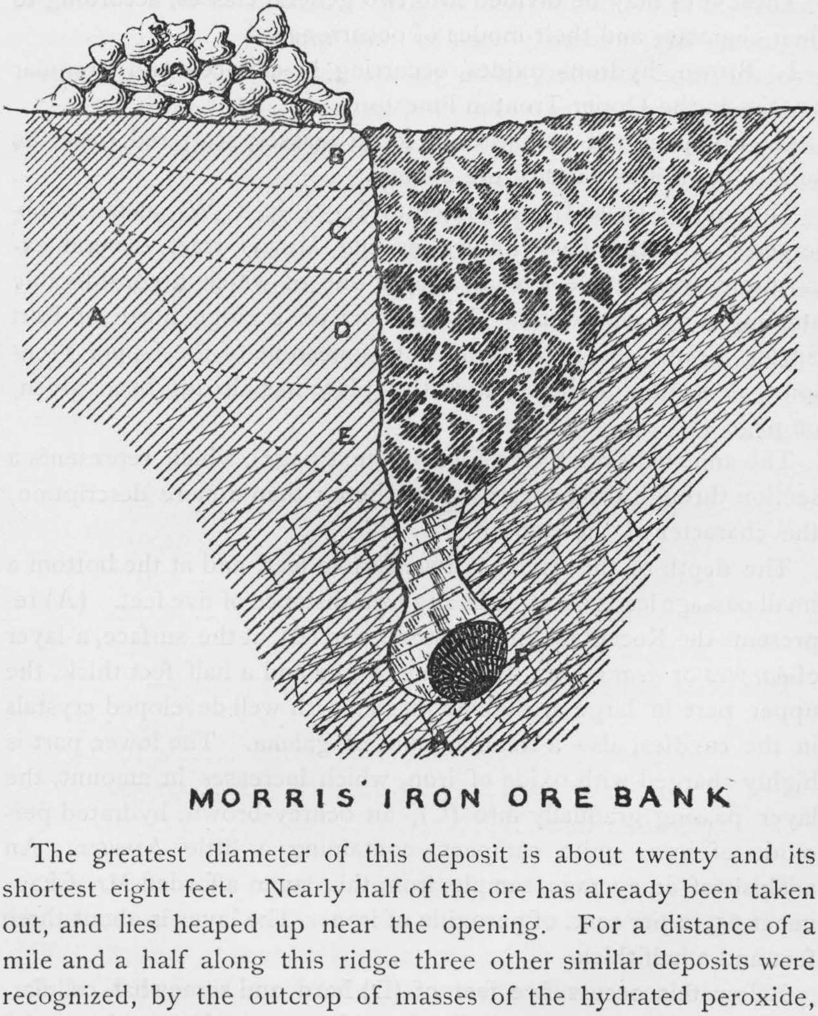
The annexed sketch (see Fig. 81, next page), which represents a section through the bed, will show, better than a mere description, the character of the deposit.

The depth of the cavity is twenty-two feet, and at the bottom a small passage leads off at right angles a distance of five feet. (A) represents the Receptaculite limestone, and (B), at the surface, a layer of *barytes* or *heavy-spar*, from one to one and a half feet thick, the upper part in large crystalline masses with well-developed crystals in the cavities, also a small amount of galena. The lower part is highly charged with oxide of iron, which increases in amount, the layer passing gradually into (C), an ochrey-brown, hydrated peroxide of iron, quite compact, containing a little *barytes*. An analysis of an average sample from this layer afforded Mr. Chauvenet 63.12 per cent. of peroxide of iron. The layer is about three feet and a half thick.

Below this occurs five feet of (D) hard and somewhat cellular, dark-brown peroxide, with slightly iridescent surface, and containing compact, bright-red peroxide intermixed. It contains, by analysis, 79.64 per cent. peroxide of iron and 15.42 per cent. of insoluble matter, mostly silica. This layer passes gradually into (E), a very hard, cellular, dark-brown and red hematite mixed, containing in some of the cells a thin, ochrey deposit. It extends to the limestone below, and has a thickness of about seven feet.

The amount of peroxide of iron reaches as high as 84.30 per cent.

Fig. 81.



MORRIS' IRON ORE BANK

The greatest diameter of this deposit is about twenty and its shortest eight feet. Nearly half of the ore has already been taken out, and lies heaped up near the opening. For a distance of a mile and a half along this ridge three other similar deposits were recognized, by the outcrop of masses of the hydrated peroxide, but they are all limited in extent. This region is within two miles of the St. Louis & Keokuk Railroad, now being constructed.

The ores placed in Class II. occur in many parts of the county, as will be seen by reference to the map, but they are most abundant in that part between Big Dry Branch and Lead Creek. The ore is a hard, compact, red hematite, found in pieces, more or less flat in shape, from one to three inches thick and weighing from one to one hundred pounds. These fragments lie scattered over the surface in broad, imperfectly defined streams, generally independent of the present topography, though a larger amount is often found accumulated in the ravines and beds of streams. In such places the fragments are generally smaller and more or less completely smoothed and rounded, while on the ridges larger pieces occur, with well-defined edges and angles, on the top of the ground or distributed through the soil and gravel down to the limestone, but in no case in the latter. The underlying limestone is generally the Archimedes, though it is frequently the Encrinital. There is no direct connection between the ore and the limestone. Many pits have been sunk where the ore is most thickly scattered, and it is found to give out on reaching the limestone.

The ore, though in some cases rather too silicious, is generally of excellent quality, as appears in an analysis made by Mr. Chauvenet of an average sample :—

	(No. 1.)
Insoluble silicious matter	7.55
Peroxide of iron	91.95
Sulphur	0.017
Phosphorus	0.010
Metallic iron	64.36 per cent.

Two other samples from different localities afforded—

	(No. 2.)	(No. 3.)
Insoluble silicious matter	11.66	4.10
Peroxide of iron	86.56	92.32
(Metallic iron)	(60.59)	(66.72)

This ore is spread over many square miles of surface, and in varying quantities ; at some places a few scattered masses occur, and at others the yield would be over a hundred tons to the acre. The greater part occurs within five or six miles of the St. L. & K. R. R., and much of it considerably nearer. At some time it may be found profitable to gather this ore and ship it to neighboring iron-works, and this could be done with but little expense. A large outlay for the utilization of this material would not be justifiable.

These fragmentary masses of iron-ore seem to have been derived from some higher formation, in which the original beds of ore existed. Whether this formation was one of the upper limestones of the Subcarboniferous series or the Ferruginous sandstone, or of the Coal-measures, it would be difficult to determine ; it was, however, more recent than the lower Archimedes limestone.

This formation, which originally contained the beds of ore, has since passed away through the action of erosive agencies, leaving the heavy and more durable ore behind. From the sharp and well-defined outlines of the fragments it is very improbable that this ore could have been transported any distance.

Lead.—The opinion is prevalent in Lincoln County that lead occurs there in large quantities. Stories are still told, by old inhabitants, of large deposits seen when the county was first settled. The Indians were said to have had knowledge of these, and to have brought into the settlements several hundred pounds of lead at a time, but were unwilling to disclose the places at which it was obtained. It is supposed that the north-western was the favored part of the county in this respect, and the name of Lead Creek was given by the early settlers to one of the streams in that region.

There seem to be no indications, however, of the existence of lead in any great quantity. Small crystals of galena were occasionally observed in the silicious and calcareous geodes of the Archimedes limestone, also in the Receptaculite limestone of the Upper Trenton, associated with heavy-spar, as at the Morris iron-ore shaft, already described. A careful search at the latter place afforded only a few ounces of galena, although the heavy-spar occurs in considerable quantity, covering the deposit of iron-ore.

Building Material.—Abundant and excellent material for building purposes occurs in the county, though little has as yet been done toward utilizing it.

In various parts of the Trenton limestone there are beds from which stone of almost any required size, pleasing in appearance and durable, might be obtained. The beds of the Lower Trenton are generally not so thick as in the upper, being from ten to twenty-five inches thick. They are of light-gray or drab color, fine crys talline, or very compact, in some cases resembling a marble. At Dameron's, in T. 51, R. 1, E., and north-east quarter Sec. 16, on a small branch of Bryant's Creek, is a quarry worked in these beds. There are four workable layers, each ten to fifteen inches thick, exposed in the quarry face, of a light yellowish-gray color, very hard and compact, and with a smooth, conchoidal fracture. The quarry has been opened about twelve years, but owing to the very limited demand for the stone in the neighborhood but little has been done in developing it. Some years ago a lime-kiln was erected for the purpose of producing lime from this stone, but the attempt failed, the limestone being too silicious.

Some of the beds of the Upper Trenton would furnish desirable building-stone of any size, of bluish-gray and sometimes nearly white crystalline limestone. On Fort Spring Branch, in T. 50, R. 1, W., there is a fine exposure of these beds sixty feet thick, also in the Mississippi bluffs south of Bill's Branch. Some of the layers are thin and shelly, but in the main the beds are thick and massive.

The impure magnesian beds of the upper part of the Hudson group, as they occur in the knobs of the north-eastern part of the county, are quarried for *fire-rock*. The stone, when first taken out, is soft and earthy, of a light yellowish color, resembling the 1st Magnesian. It is not sufficiently firm in texture to make a durable building-stone for outside work, but serves very well for chimneys and fireplaces. The upper part of the Chouteau and the thin bed of Onondaga limestone are also used for this purpose, in the north-eastern townships.

The Encrinital limestone affords a large amount of suitable building material, the coarse, crystalline, gray and buff-colored, thick beds, being well adapted for the purposes of ordinary masonry, and the purer, white crystalline making a handsome and durable ornamental building-stone. At Heady's quarry, Sec. 10, T. 48, R. 1, W., these latter beds are worked. They consist of four layers of hard, white, crystalline limestone, with some crinoid stems scattered through the mass. The thickness of these layers is, beginning with the lowest, ten, fourteen, eight and sixteen inches, and are exposed in the quarry for a distance of fifty feet.

At Smith's quarry, half a mile north of the mouth of Big Creek, this formation is worked. The stone is gray crystalline, firm and homogeneous in texture, and occurs in two layers, ten and fourteen inches thick. This stone is used for the construction of the railroad bridge across Cuivre River.

Brown's quarry, near Troy, is worked in the thin, argillaceous beds of the middle Encrinital. A moderately good flagging is obtained, also from the thicker beds good foundation stone.

There are many other small quarries opened in the Encrinital limestone in various parts of the county, but the material is only used in limited quantities in the neighborhood.

The Archimedes limestone furnishes good building-stone, and the largest quarry is worked in it on Mr. John Birkhead's land, in T. 49, R. 1, E. The stone is a conglomerate limestone, very firm in texture, and occurring in three layers from six to ten inches thick. This is used largely in Troy for basework, sills and capstones.

North of Moscow, on the west bank of the Cuivre, a quarry has been opened forty feet long, with an exposure of twelve feet of hard, crystalline, bluish-gray limestone, in layers from six to fifteen inches thick. There are many places where stone could be got of much greater thickness, but for local building purposes the thinner and more easily worked beds seem to be preferred.

In the St. Louis limestone no systematic quarrying has been done in the county, though stone of almost any dimensions and of excellent quality might readily be obtained from it. The ridges along Bob's Creek and Bushy Fork are points very favorably situated for developing good quarries ; also in the Mississippi bluffs south of Bob's Creek.

Lime, etc.—The county is plentifully supplied with limestone suitable for making quick-lime of excellent quality. In the Trenton, Encrinital, Archimedes and St. Louis limestones there are many beds of nearly pure carbonate of lime. Nothing has been done as yet in the manufacture of lime on an extended scale, only a sufficient amount being produced to meet a limited local demand.

In the regular Coal-measure series a hydraulic limestone occurs, with a thickness of four to six feet. The following is an analysis made of it by Mr. Chauvenet :—

Silica	21.35
Peroxide of iron	1.79
Lime	42.16
Magnesia	0.66
Carbonic acid	34.14
	100.10

The amount of carbonate of lime is rather large, in proportion to the carbonate of magnesia present, to make a good hydraulic limestone; there is a notable absence of alumina also. From practical tests already made, this lime is found to have hydraulic properties, though in an inferior degree. Samples from other localities have yet to be examined, and these may prove to be of better quality.

Clays.—Fire-clays occur with most of the coal-beds in the county, though generally in limited quantities. That found at Baker's shaft has attracted some interest, being from four to five feet thick. An analysis afforded Mr. Chauvenet—

Silica	34.40
Alumina and traces of iron	18.62
Lime	15.27
Magnesia	6.25
Loss by ignition, water and carbonic acid	23.08
	97.62
Loss, including alkalies	2.38

The small percentage of silica and alumina in this clay renders it unfit for fire-brick. Its composition is more nearly that of common brick-clay. At Meadows's bank, in the regular coal-field, fire-clay occurs under the coal several feet in thickness, which seems to be better adapted for the making of a good fire-brick.

In several places a white, soft clay occurs in small depressions and cavities in the limestone, or along the beds of streams. It seems to have resulted from the decomposition of the chert and surrounding limestone. Two analyses are given below of samples obtained from near the Morris shaft, in the Receptaculite limestone, and from Mr. Colbert's land, where it is associated with the Encrinital limestone:—

	(Morris.)	(Colbert.)
Hygroscopic water	1.46	2.14
Combined "	3.05	4.83
Silica	72.35	65.35
Alumina	15.86	21.20
Iron	2.25	2.05
Magnesia	1.48	1.27
Lime	1.09	0.52
Loss, including alkalies	2.46	2.64
	100.	100.

These clays are used occasionally as a whitewash.

Glass-Sand.—The Saccharoidal sandstone, as it occurs in some parts of the county, will furnish abundant and excellent material for the manufacture of the best quality of glass. Along the Mississippi bluffs and on Sandy Creek it is generally more or less colored by oxide of iron, but in the interior of the county, on the upper branches of Mill Creek, it is exposed in heavy beds and of great purity.

A specimen taken from an exposed bluff on the South Branch, in Sec. 33, T. 51, R. 1, W., afforded Mr. Chauvenet the following:—

Silica	99.55
Alumina	0.33
Iron	trace
Lime	0.08
Water	0.015
	99.975

The formation has at this place a thickness of thirty-five feet, and is, with the exception of a few feet at the top, all of pure white sand. Its outcrop and general features have been given already in a previous part of this report. Vast quantities can be obtained within three miles of a station on the St. Louis & Keokuk Railroad.

CHAPTER IX.

GEOLOGY OF LIVINGSTON COUNTY.

BY

G. C. BROADHEAD.

LIVINGSTON COUNTY has an area of about 532 square miles. Its surface is either very gently undulating or rolling. The area of broken land is very limited. West of the East Fork of Grand River, in Township 59, the county is somewhat broken for the distance of one mile and a half from the bluffs, also near the heads of the various streams in Township 59, Range 25 ; but none of the hills exceed 120 feet in height. The south-east part of the county, lying west of Grand, for the distance of a mile is somewhat broken, but not so much as the north-west part, for the hills are less than 100 feet in height. On the east side of Medicine Creek, near Collins's mill, and on the west, near Slagel's old mill, the country is somewhat hilly, but the hills do not exceed 60 feet in height. The most broken portion of the county, and where the hills are highest, is in Range 25 on the south side of the west fork of Grand River, extending from a half-mile to three-quarters from the river, at which distance the hills attain an elevation of 225 feet above the river ; southward it is gently rolling.

North of Chillicothe the county attains an elevation of 155 feet above Grand River. Everywhere else the slopes are very gentle ; the country is gently undulating, and lies well for beautiful farms. The bottoms are wide, those of Grand River and Shoal Creek flat, and are from two to three miles in width, flanked on one side by low bluffs, and on the other rising almost imperceptibly by gentle slopes to the neighboring uplands. The bottoms of Medicine Creek are from one to one and a half miles in width ; those of the other streams are much narrower. Those on the west side of Grand River, in Township 59, Range 25, have scarcely any bottoms, but have steep bluffs.

Timber and Prairie.—There is a good deal of timber in this county, some of a very good kind. The best and most abundant supplies of timber lie between the East and West Forks of Grand River, where the growth is black oak, small white oak, shell-bark hickory, red-chestnut oak, white oak, also crabapple, coffee-tree, red-bud, ash, blackberry, raspberry, gooseberry, *Celastrus scandens* or bitter-sweet, mulberry, *Cornus asperifolia*, white elm, red elm, prickly ash, hazel, black-haw, pignut-hickory, sumach, coralberry. Near the edges of the prairies are pin oak, hazel, plum, and *Cornus asperifolia*, or rough-leaved dogwood, also wild cherry, laurel oak, rose, coralberry. On prairies *Phlox Walteri*, *Viola delphinifolia*, *V. lanceolata*, and on sandy bottoms *V. sagittata*. A few pecan trees were observed on Grand River bottoms; none were observed in any county north. In other parts of the county the timber is mostly confined to the vicinity of the streams.

The prairie generally extends over the ridges and often across the wide flat bottoms.

The following is a list of trees, shrubs, and some plants seen in Livingston County:—

Crabapple.
Wild ginger.
White ash.
Prickly ash.
Red birch.
Blackberry.
Dewberry.
Buckeye.
Box elder.
Bitter sweet.
Button bush.
Coralberry.
Black cherry.
Choke cherry.
Coffee tree.
Red root.
Adder's tongue.
Common elder.
White elm.
Red elm.
Winter grape.
Greenbrier.
Spanish oak.
Laurel oak.
Hackberry.
Hazel.
Black haw.
Red haw.
Gooseberry.
Shell-bark hickory.
Thick shell-bark hickory.
Pignut hickory.
Pecan hickory.
Honeysuckle.
Blue flag.
Iron weed.
Honey locust.
Linden.
Sugar maple.
White maple.
Mulberry.
White oak.
Burr oak.
Post oak.
Small white oak.
Red-chestnut oak.
Chinquepin oak.
Black oak.

Jacob's ladder.	Red oak.
Rose.	Pin oak.
Raspberry.	Serviceberry.
Sycamore.	Wahoo.
Sumach.	Thorn.
Poison oak.	Black walnut.
Fragrant sumach.	Willow.
Geranium maculatum.	Cornus asperifolia.
Viola (5 species).	Phlox (2 sp.).

Streams.—Grand River flows through the county from north-west to south-east; near the centre of the county it receives the West Fork. These streams are broad and deep, and cannot generally be forded. Medicine Creek in the east, and Shoal Creek in the south-west, are both large streams, and are often too full to be easily forded. They furnish good power for water-mills. There are many other small streams, but their utility is insignificant.

Geology.—*Quaternary Deposits.*—The *Alluvium* was recognized in the rich soils and the river deposits.

Bottom Prairie includes the dark and ferruginous clay of the extensive bottom lands.

The Bluff or *Loess* may include the subsoil of the uplands.

Drift.—At Spring Hill we observed forty feet of sand, clay and bowlders, the upper part probably "bluff," the lower part composed of ferruginous sand and loose conglomerate of trappean rocks, limestone, sandstone, and pieces of coal—the interstices filled with fine-grained sand. A portion of the conglomerate is derived from the underlying rocks. On the main road, three miles west of Spring Hill, a section of a well was reported to be—

1st. 4 feet coarse red sand.

2d. 20 feet dark-brown and ash-colored clay and sand, with small pebbles and bowlders.

Upper Carboniferous.—The rocks in this county belong to the lower part of the Upper Coal-measures and the middle and lower part of the Middle Coal-series of Missouri, and include beds from No. 84 to near No. 33 of the General Section, and comprise a total thickness of 485 feet, which is of much greater thickness than the corresponding rocks on the Missouri River.

GENERAL SECTION OF LIVINGSTON COUNTY.

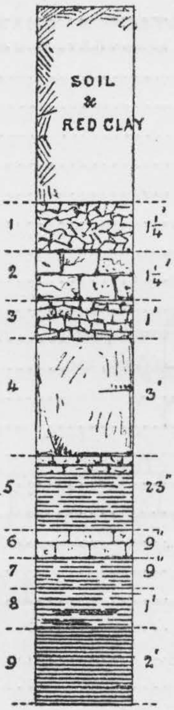
No.		No. in Gen. Sec. on Mo. Riv.
1—2½ feet nodular and fine-grained limestone marble bed		84
2—3 feet limestone, bluish, irregular layers,		83
3—2 feet buff shales and limestone		
4—9 inches even layers of limestone		82
5—1 foot 9 inches shale		81*c*
6—2 feet bituminous shale		81*b*
7—3 feet nodular limestone	*Bethany Falls Limestone, locally called Cotton Rock.*	80
8—8 feet 5 inches oölitic limestone		79
9—10 feet limestone		78
10—5 feet blue shales		77*b*
11—1 foot 6 inches bituminous shales		77*a*
12—10 inches limestone		76
13—10 feet shaly slope		75
14—7 feet ferruginous limestone		74
15—14 feet shales		73
16—6 inches coal		*c* 70
17—2 feet shales		*b* 70
18—3 inches coal		*a* 70
19—194 feet shales and sandstone		69 & 65
20—a few inches to 10 inches of coal—limestone		64
21—2 feet fire-clay		58 & 59
22—4 feet limestone—at Utica		57
23—4 feet shales (red and green at Collier's)		56
24—4 feet limestone		55
25—30 feet sandstone and shales, blue, buff and red shales at lower part		53
26—4 feet 4 inches blue limestone, contains *Fusulina*, *Archæocidaris*, etc		52
27—18 inches bituminous shales		
28—8 inches pyritiferous shales		
29—3 inches coal (near Lexington coal)		
30—4 feet fire-clay		
31—80 feet slope—at Bedford		
32—15 feet sandstone		
33—10 to 12 inches coal		
34—3 feet sandy clay, with roots of *Stigmaria ficoides*		
35—9 to 12 feet shaly sandstone		
36—4¾ inches coal		
37—1 foot 6 inches gray fire-clay		
38—6 inches brown clay		
39—4 feet rough limestone		
40—7½ feet argillaceous shales		
41—2 feet 6 inches irregularly-bedded limestone; many fossils		40?
42—14 feet argillaceous shales		
43—6 to 8 inches dark, fucoidal, even or concretionary limestone, ferruginous		

No.	No. in Gen. Sec. on Mo. Riv.
44—31 inches bituminous shales	38 ?
45—1 to 4 feet clay	36 ?
46—20 inches coal	35 ?
47—4 feet 6 inches clay and shales	34 ?
48—1 foot soft nodular blue and green limestone	
49—4 feet shales	33 ?

The following is a section of the upper rocks of the section observed on the Hannibal & St. Jos. Railroad, near Kirtley's (Nos. 1, 2, 3 = No. 1 of Gen. Sec.):—

Fig. 82.

SECTION ON H. & ST. J. R. R. NEAR KIRTLY'S LIVINGSTON COUNTY



No. 1—$1\frac{1}{4}$ feet nodular limestone.

2—$1\frac{1}{4}$ feet even-bedded limestone, sometimes nodular.

3—1 foot nodular limestone.

4—3 feet limestone (= No. 2 of Gen. Sec.).

5—23 inches buff shales, with two 2-inch layers of limestone near the upper part (= No. 3, Gen. Sec.).

6—9 inches even layers of limestone (= No. 4, Gen. Sec.).

7—9 inches olive inclining to buff shales.

8—1 foot blue argillaceous shales, with dark streaks.

9—2 feet bituminous shales (= No. 6, Gen. Sec.).

No. 2 of Gen. Sec. contains *Prod. costatus*, *P. splendens*, *Athyris subtilita* and *Sp. cameratus*.

No. 3 contains *Prod. splendens*, *Athyris*, *Sp. Kentuckensis*, *Hemipronites crassus*, *Rhombopora lepidodendroides* and *Lophophyllum proliferum*.

The rocks here seem to be about horizontal; one mile west they dip 9° course S. 30° W., mag.

No. 9 occurs on the railroad near the west county line—is best developed in railroad cut west of Utica and near Spring Hill; on

Bear Creek it occurs as a fine-grained, grayish-blue limestone, with brown windings, which cause it to present a vermicular appearance. The latter form is well developed in Grundy County, between Trenton and Edinburgh. These irregular, hollow, vermiform windings are probably owing to the former presence of a winding fucoid. The hollows are generally colored brown.

At E. KIRTLEY'S QUARRY, on west half of the south-west quarter of Sec. 14, Township 57, Range 25, we find—

No. 1—Slope, in which is seen masses of limestone.

2—4 feet shaly débris.

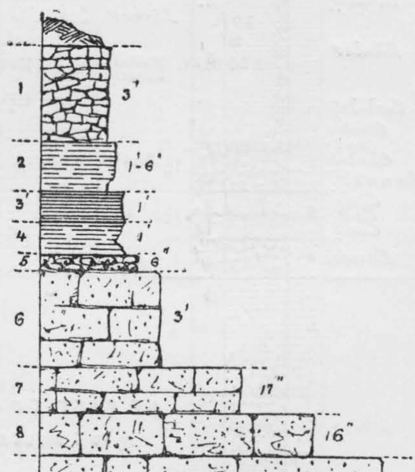
3—2½ feet nodular and shelly-drab limestone.

4—6 feet 10 inches gray silicious oölitic limestone ; generally works easily ; has been used at Grand River bridge, near Utica.

Another quarry of Mr. Kirtley's, on west half of north-west quarter Sec. 14, has been worked quite extensively. The following section gives the thickness of each bed of rock there seen :—

Fig. 83.

KIRTLEY'S QUARRY
LIVINGSTON CO.



No. 1—3 feet outcrop of irregular-bedded nodular limestone.

2—1 foot 6 inches olive and drab shales.

3—1 foot bituminous shales.

4—1 foot dark clay-shales.

5—6 inches nodular limestone (= No. 7 of Gen. Sec.).

6—3 feet gray oölitic limestone.

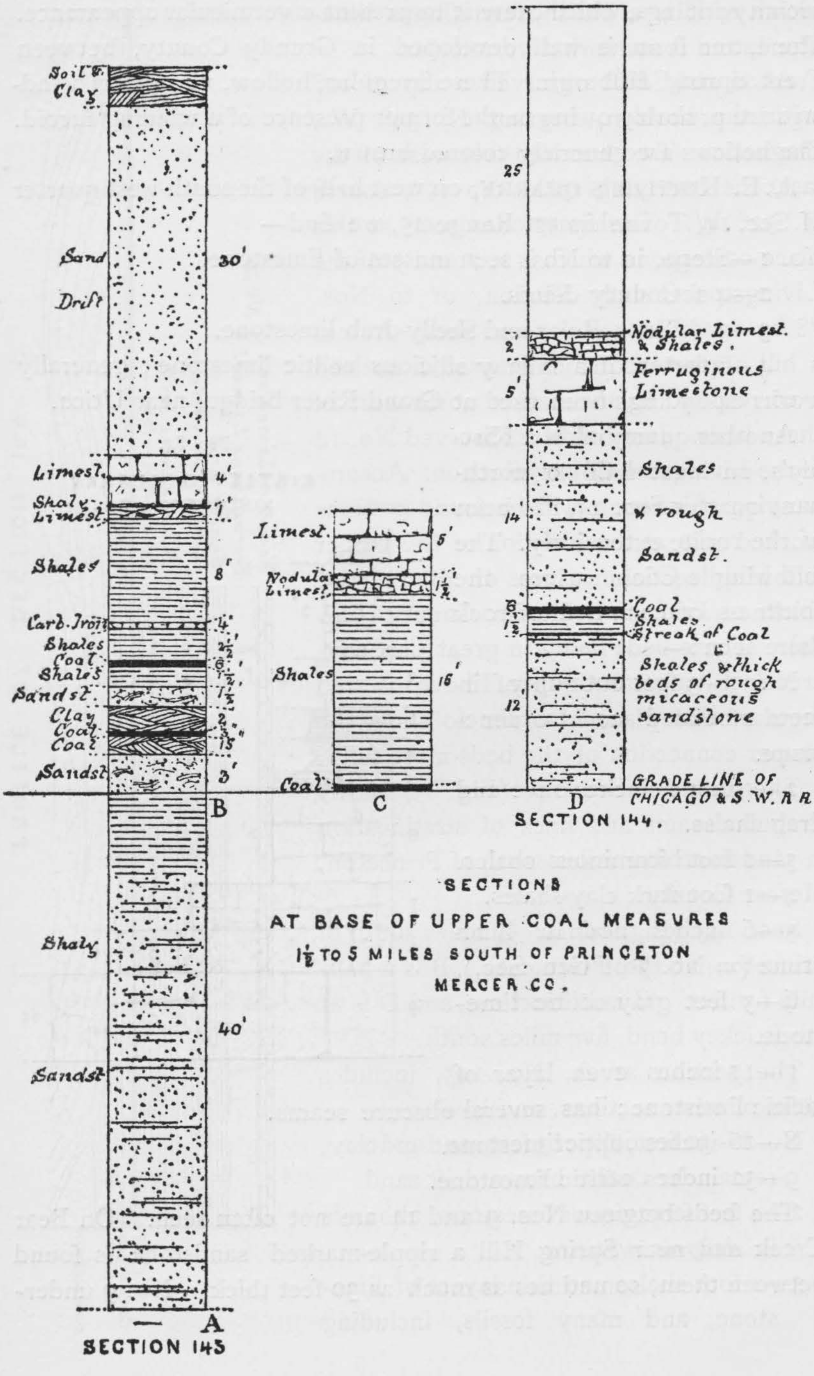
7—17 inches even layer of oölitic limestone ; has several obscure seams.

8—16 inches oölitic limestone.

9—32 inches oölitic limestone.

The beds between Nos. 9 and 14 are not often seen. On Bear Creek and near Spring Hill a ripple-marked sandstone is found between them, sometimes as much as 30 feet thick. No. 9 under-

Fig. 84.


Soil & Clay
Sand
Drift
30'
Limest.
4'
Shaly Limest.
1'
Shales
8'
Carb. Iron
4'
Shales
2½'
Coal
6"
Shales
1½'
Sandst.
1½'
Clay
2'
Coal
Coal
15
Sandst.
3'
Shaly
Sandst.
40'
A
SECTION 143
B
Limest.
5'
Nodular Limest.
1½'
Shales
16'
Coal
C
25
Nodular Limest. & Shales.
2
Ferruginous Limestone
5'
Shales
14
& rough
Sandst.
Coal
6"
Shales
1½
Streak of Coal
Shales & thick beds of rough micaceous sandstone
12
GRADE LINE OF CHICAGO & S. W. R.R.
D
SECTION 144.
SECTIONS
AT BASE OF UPPER COAL MEASURES
1½ TO 5 MILES SOUTH OF PRINCETON
MERCER CO.

lies No. 14; is seen at Spring Hill and vicinity; it is a bluish, ferruginous limestone, and is somewhat vermicular.

At Spring Hill observed a dip of 10° with the horizon, bearing N. 34° W., magnetic. Two hundred feet west of the last, the overlying rocks dip 15°, course N. 52° W. The limestones seen at this place correspond to Nos. 2, 7 and 9 of the Livingston County Section, or to Nos. 78 to 83 of Mo. Riv. Gen. Sec. Across a hill a quarter of a mile east, I noticed a corresponding inclination north-west of these beds. Just below I observed No. 14 of the Livingston County Section. Accompanying this report will be found sections of the rocks at the junction of the Upper and Middle Coal-measures on the railroad south of Princeton, Mercer County (Fig. 84). These beds being in great part covered in Livingston County, I have inserted them at this place in order to show the proper connection of the beds more fully.

The profile of Sec. 144 (Fig. 85) shows irregular seams and lines of stratification in sandstone five miles south of Princeton, Mercer County.

Sec. 143 (Fig. 84) is 1½ miles south of Princeton, at the Pratt cut. B is a half-mile further. C is in next cut, and D is at the Brickey bend, five miles south.

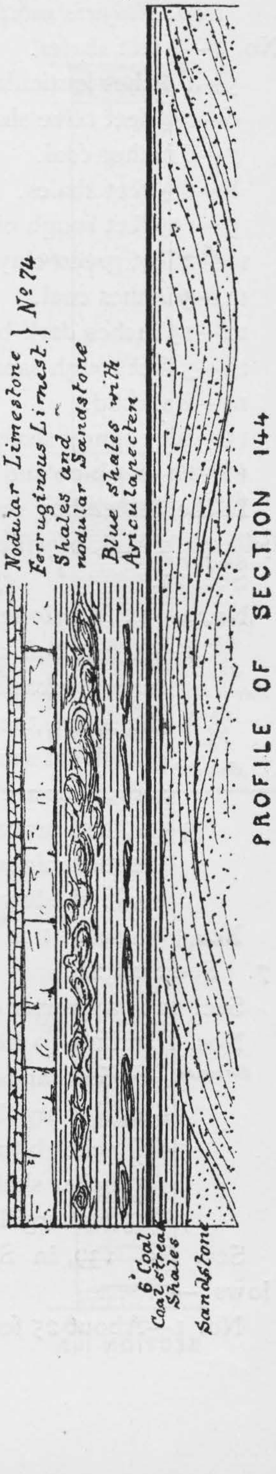
The section at A, No. 143, includes rocks of other sections, and is—

No. 1—30 feet, upper 3 feet sand and clay, remainder coarse brown drift sand.

2—4 feet ferruginous limestone, abounds in *Athyris subtilita*.

3—1 foot shales and thin layers of limestone, and many fossils, including

Fig. 85.



Rhombopora lepidodendroides, *Chonetes Verneuiliana*, *Ch. mesoloba*, *Athyris subtilita* and *Spirifer* (*Martinia*) *planoconvexus*.

No. 4—8 feet shales.

5—4 inches lenticular concretionary bed of carbonate of iron.

6—2½ feet olive shales.

7—6 inches coal.

8—1½ feet shales.

9—1½ feet rough olive-colored sandstone.

10—2 feet green clay.

11—3 inches coal.

12—15 inches dark-blue clay.

13—3 feet rough sandstone to railroad.

14—Railroad.

15—Blue sandy shales.

16—40 feet blue and gray shaly sandstone.

In the descending series, the next lowest rocks were observed at Gillaspie's Mill, of which the following is a section :—

Sec. 21.

No. 1—12 feet slope, white oak, young hickory, red bud, etc.

2—86 feet buff and gray sandstone; on the upper 30 feet observed occasional outcrops and many tumbled masses of the same, then 25 feet thick beds, brown, speckled, with occasional shaly partings; this is mostly soft, nevertheless some beds are firm and hard, almost semi-altered = No. 19.

3—24 feet, probably all shales; near the middle, one and a half feet bituminous shale crops out, of which 6 inches is shaly coal; the lower 11 feet all shales.

No. 3 of Sec. 21 is probably contained in Sec. 22, Nos. 5 and 7. See Sec. 22.

Sec. 22 is a quarter of a mile up-stream, and as follows :—

Nos. 1 and 2—19 feet slope, with bluff clays.

3—10 feet sandstone.

4—14 feet argillaceous shales.

5—6 inches bituminous shales.

6—3 inches shaly coal.

7—23 feet argillaceous shales.

Sec. No. 139, in Sec. 10, Township 57, Range 25, is as follows :—

No. 1—About 25 feet slope.

No. 2—Outcrop of brownish limestone, No. 14 of Livingston Sec.

3—160 feet long, gentle slope to bluff of Grand River.

4—51 feet of sandstone, mostly in thin flags—*Cordaites* and large *calamites* about 4 feet from the bottom.

5—10 inches crumbling coal.

6—1 inch soft black shale, containing *Cordaites.*

7—5 feet to water in West Fork of Grand River.

The following Sec. No. 134, at Graham's Mill, on East Fork of Grand River, includes some of the rocks of the last section :—

No. 1—21 feet slope, with sand, clay and pebbles of drift.

2—113 feet thinly-stratified, micaceous sandstone and shales; some beds have carbonaceous partings.

3—14 inches bituminous shales.

4—8 inches blue shales.

5—5½ feet sandy and clay shales, with occasional ochrey stains and concretions of iron pyrites.

6—4 inches thin laminæ of semi-bituminous shales with *Cordaites* and carbonaceous stains.

7—10½ inches good bituminous coal.

8—1 foot fire-clay.

9—5 feet 10 inches roughly-bedded, drab limestone, containing *Ch. mesoloba* and *Meekella* at top, *Pro. Prattenianus* and *P. costatus* in lower part.

10—13 inches, upper 6 inches shaly limestone, abounding in *Prod. costatus;* below are pyritiferous shales.

11—4 feet blue shales.

The strata are somewhat irregular at this place, and dip about 12° course S. 45° W., mag.

Sec. 141, at Utica :—

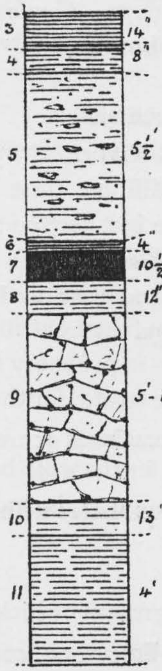
No. 1—Slope.

2—Shales, 15 or 20 feet seen.

3—8 inches blue, sandy limestone, weathers brown; contains many fossils, including *Pleurotomaria sphærulata*, *Euomphalus rugosus*, *Macrocheilus* resembling *M. medialis* but larger; *Nautilus ferratus*, *Polyphemopsis peracuta*, *Pleurotomaria tumida*, *Lophophyllum proliferum*, a fish-tooth and *fucoids*.

4—52 feet shales and thin layers of sandstone, to the water in river; contains carbonate of iron and some ochreous concretions. A thin stratum of bituminous shale and coal is also said to exist here, but if so, was covered by débris of above.

Fig. 86.



LOWER PART OF SECTION 134 AT GRAHAM'S MILL

No. 5—1 foot 4 inches to 4½ feet limestone, coarse drab ; contains *Athyris*, *Chonetes Smithii*, *Ch. mesoloba*, *Pro. semireticulatus*, *Sp. Kentuckensis*, large *Crinoid* stems, *Sp. cameratus* and a few pebbles, *Discina* and *Lophophyllum*.

6—3 feet drab, ochreous shales.

7—4 feet ash-blue limestone, weathers brown, rough on top, somewhat oölitic, near middle gray, blue and drab, mottled brown and blue ; contains a few angular fragments of dark chert, and also contains *Sp. cameratus*, *Pleurotomaria*, *P. cortatus*, *Bellerophon*, *Archæocidaris*.

8—16 feet sandy shales to water in the river.

There is an apparent fault in the strata here. Near the old milldam the limestones are above water, as seen in the above description, but 150 feet up-stream they dip, then suddenly disappear.

The following section at Collier's Mill, on Medicine Creek, may include some beds seen at Utica :—

Sec. 146.

No. 1—10 feet slope, bluff and drift.

2—11 feet soft, brown sandstone.

3—16 inches clay shales.

4—4 inches coal smut.

5—5 feet alternations of green and buff shales, and nodular limestone, containing many fossils, including *Meekella striatocostata*, *Hemipronites crassus*, *Chonetes granulifera*, *Chonetes mesoloba*, *Athyris subtilita*, *Prod. punctatus*, *Prod. muricatus*, *P. costatus, Sp. cameratus, Sp. Kentuckensis, Sp. lineatus, Prod. semireticulatus, P. Nebrascensis, P. Prattenianus* and *Lophophyllum proliferum.*

No. 6—1½ feet outcrop of brown and drab limestone; two layers seen.

7—6½ feet shaly slope, some red and green shales.

8—3 feet limestone, fine-grained, silicious, greenish-drab; weathers brown.

9—1 foot green shales.

10—1 foot alternations of green and purple shales.

11—5 feet micaceous, sandy shales.

South-east from this, 190 feet, coal has been taken out in a ravine at about 10 feet above water in the creek; this is probably the same coal of No. 4, indicating a breaking down of the strata, for there is no apparent dip at the mill.

The following, at L. T. COLLIER'S QUARRY, in the west half of the south-west quarter of Sec. 29, Township 58, Range 22, includes rocks which are probably a little lower in the series:—

Sec. 147.

No. 1—25 feet gentle slope, soil covered with growth of hickory, etc.

2—3 feet bands of blue, buff and red shales.

3—10½ inches hard, blue limestone, in a very even bed.

4—18 inches like the last, even bedded, fine grained.

5—1 foot slope.

6—16 inches bluish gray limestone.

7—1½ feet bituminous shales.

8—10 inches dark, ash-colored shales; contains *Prod. muricatus* and *Chonetes mesoloba.*

9—3 inches shaly coal.

10—4 feet fire-clay.

Nos. 3 and 4 contain *Athyris subtilita, Spirifer* (*Martinia*) *plano-convexus, Fusulina cylindrica* and a wavy-lined coral.

The following section, at SLAGEL'S OLD MILL, on Medicine Creek, three miles above Collier's:—

Sec. 148.

No. 1—10 feet bluff and drift; at bottom is an outcrop of masses of brown and buff limestone.

2—12 feet blue and buff shales.

3—4 inches band of yellow ochre.

No. 4—3 feet blue, argillaceous shales.

5—2½ feet hard, blue limestone, shelly at top, weathers brown; contains *Crinoid* stems, *Athyris*, *Sp. lineatus*, *Platyostoma*, *Pleurotomaria tumida*, *Euomphalus rugosus*.

6—7½ feet blue and yellow banded argillaceous shales.

7—8 feet sandy shales, lower part somewhat pyritiferous; contains ironstone concretions.

8—3 inches bituminous shales.

9—2 inches coal.

10—1 foot dark-colored sandy clay, with *Stigmaria ficoides*.

11—2 feet soft sandstone, 3 feet to creek.

Section 150, 2 miles east of Avelin, on high ground, is as follows:—

No. 1—25 feet gentle slope.

2—4 feet light-gray or drab limestone, subcrystalline; contains *Chætetes milleporaceus*, *Athyris subtilita*, *Spirifer* (*Martinia*) *lineatus*, *Meekella striato-costata*, *Entolium aviculatum* and *Macrocheilus*; this, I think, is equivalent to No. 64 of Pacific Railroad Section and No. 24 of Lexington County Section.

3—30 feet slope.

4—20 inches hard, blue, even-bedded limestone, in two ten-inch layers; contains *Fusulina cylindrica*.

5—10 inches bituminous shales.

No. 4 of this section is undoubtedly equivalent to No. 55 of General Section along the Pacific Railroad, and is also equivalent to quarry rocks at Ch. Marster's and 3 and 4 of Section 147, at L. T. Collier's quarry. A connection of this section with lower rocks was obtained at Bedford. Near the hill-top was seen limestone corresponding to No. 2 of last section, then 100 feet long slope to 15 feet outcrop of sandstone, resting on coal, corresponding to 33 of Livingston County Section.

The section made at COLLIER'S MILL, on Medicine Creek, probably includes equivalent beds to those at Utica.

The rocks lying below the last-named occur on Grand River and Toe String Creek, south-east of this; a description of which will be found under the head of Economical Geology.

Economical Geology.

The workable coal-fields of this county may be divided into two divisions, the upper coal lying on and near Grand River, west of Utica, and including two or three thin seams of coal; and the lower, lying along and near Grand River below Bedford, in Township 56, Ranges 21 and 22, and including about three beds.

Utica Coal-Beds.—At J. McMurray's coal-bank, in the south-east quarter of the north-east quarter of Sec. 10, Township 57, Range 25, I observed ten inches of coal, varying sometimes to a few inches in thickness, and at irregular elevations above the river—a local rise of 9 feet in 135 feet going west. The coal is several feet above the water, with shaly sandstone below, and sandstone with carbonaceous scales between the beds overlying it.

At James Clark's Coal-Bank, in the north-east quarter of Sec. 8, Township 57, Range 25, observed, in part, the following:—

No. 1—30 feet slope micaceous, fucoidal sandstone at the lower part.

2—Outcrop of bluish-drab limestone, containing *Syringapora*.

3—67 feet slope.

4—8 inches to 15 inches coal (not seen).

5—6 inches fire-clay.

6—5 feet slope.

7—4 inches brownish-yellow, soft sandstone.

8—4 and 5 feet argillaceous shales.

9—2½ feet bituminous shales, abounding in pyritiferous fossils.

10—40 to 50 feet blue, brown and white, soft sandstone.

This description is partly from my notes and in part from those of Mr. C. G. Wheeler, who visited the locality in 1860. Neither of us saw the coal, as the mining had been discontinued. Several pits have been dug, but are now all filled up. The geological position of the coal is in the upper part of the Middle Coal-measures, probably near No. 68 of my General Section of the Coal-measures.

About 12,000 bushels of coal are said to have been taken out of the coal-bank spoken of above.

William Dean's coal-bed on Grand River, above Utica, is said to be 14 inches in thickness; but I doubt its being quite so thick, as its equivalent, seen at other places, was thin, of tolerably good quality. It is probably the same bed as that at Murray's; when visited it was covered by shaly débris.

At **John Stone's** coal-bed, in the north-east quarter of the north-west quarter of Sec. 18, Township 57, Range 24, Mr. Wheeler obtained the following section:—

No. 1—10 feet slope.

2—17 feet ferruginous, spotted, micaceous sandstone; has many round cavities filled with soft, sandy and ferruginous matter; traversed by many vertical seams.

3—10 feet slope.

4—2 feet brown shales.

5—1 foot bituminous shales.

6—1½ feet brown arenaceous limestone.

7—4 feet shales.

8—1 to 3 feet pyritiferous shales, containing seams of impure coal and vegetable impressions.

9—9 inches good bituminous coal, probably the same as Dean's coal.

10—1 inch fire-clay.

11—4½ feet slope.

12—4 feet concretionary limestone.

13—2½ feet shales and nodules of limestone.

14—4 feet slope.

A very good quality of coal was observed at Graham's Mill, but it is of irregular thickness, varying from 6 to 10½ inches. An analysis by Mr. Chauvenet gives—

Water	5.38
Volatile	42.27
Fixed carbon	44.98
Ash	7.37

Ash, color pale brown.

COX'S COAL, in the west half of the north-east quarter Sec. 11, T. 58, R. 24—

No. 1—3 to 4 feet sandstone, soft, and in layers from 4 to 10 inches thick.

2—7 feet sandy and clay shales, with ferns.

3—Said to be 10 to 27 inches coal.

No. 4—A few feet of fire-clay.

5—Rough limestone.

Mr. Cox has drifted 80 to 90 feet into the hill; the bottom of the entry is about 4 feet above the branch. About 300 yards north-east of this Mr. C. has dug out coal at several places by sinking shafts about 8 feet.

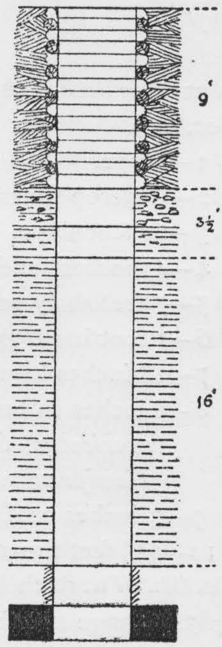
Mr. Cox has made good pottery of the shales overlying the coal; the furnace was lined with the soft, banded sandstone obtained ten feet above the coal. The fire has indurated and glazed some of it.

COLLIER'S COAL.—Two shafts have been dug a short distance from Collier's mill, relatively 12 and 14 feet deep. The pits were filled up, but I was informed that the coal was 15 inches thick. I regard this, that of Cox's, and that at Graham's mill, as the same bed.

About a mile from Collier's mill Mr. L. T. Collier has sunk a shaft on the east half of south-east quarter Sec. 30, T. 58, R. 22, a section of which is—

Fig. 87.

L. T. COLLIER'S SHAFT LIVINGSTON CO.



No. 1—9 feet clay and shales, cribbed.

2—3½ feet ochrey and blue clay shales, upper two feet mostly ochrey.

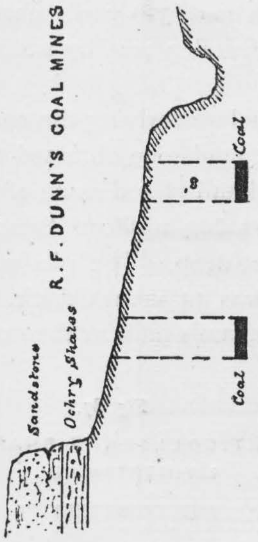
3—16 feet dark clay shales.

The bottom of the pit filled with fallen débris, so I could not see the coal. Mr. Collier showed me a specimen obtained from this place, of black, shining, bituminous coal; the coal here is probably the same as that at Collier's mill.

On COL. R. F. DUNN'S LAND (see Fig. 88), in east half of south-west quarter Sec. 23, T. 58, R. 24, some mining has been done; the coal said to be 6 inches thick, with 20 inches of bituminous shales overlying it; next above I noticed ochrey shales, with sandstone; still higher, nodular limestone underlies the coal, from which it is separated by 1 foot dark clay. Both the coal and the shales show evidences of existence of the plant-remains.

At Anton Good's, in Sec. 19, Township 56, Range 23, some shafts and borings have been made in search of coal, of which this is the result:—

Fig. 88.



No. 1—8 feet shaft.

2—32 feet to slate. At 31 feet below top is 2 feet of fire-clay.

3—Shale and rock to bottom; stopped at 60 feet depth.

In No. 1 we find *Hemipronites*, *P. Pratteniamus*, *Athyris subtilita*, *Prod. Rogersi*, *P. costatus*, *Sp. cameratus*, *Chonetes mesoloba*, *Sp. lineatus*. (This is probably the same as Sec. 134–9.)

A half-mile east a shaft was sunk 18 feet through sandstone; upper part buff, lower part gray.

No. 2. 6 feet in bore, beginning in sulphur stain through slate, then 2½ feet coal; red clay under the coal.

A section here is as follows:—

Sec. 149.

No. 1—Slope.

2—Outcrop limestone.

3—20 feet slope.

4—43 inches sandstone in one thick bed.

5—7 feet shaly sandstone.

6—1 foot hard, gray and brown sandstone.

7—18 inches bituminous shales.

8—8 inches calcareo-pyritiferous shales; abounds in fossils: *P. muricatus*, *Sp. cameratus*, *Sp.* (*Martinia*) *planoconvexus*, *Hemipronites crassus*.

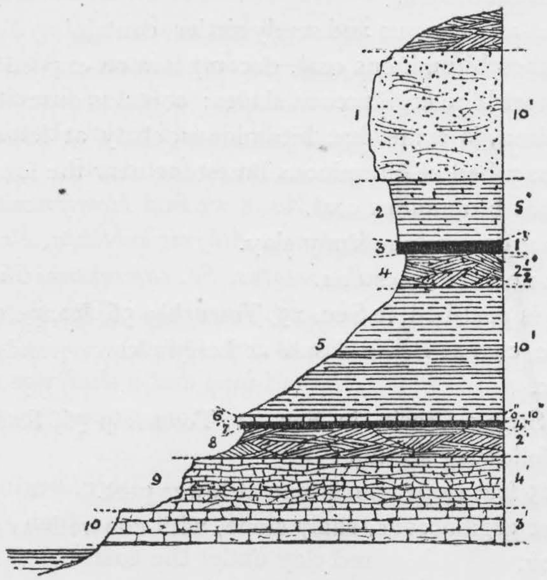
9—3 inches coal.

10—1½ feet fire-clay.

On Ch. Wurster's land, in north-west one-quarter Sec. 26, Township 56, Range 22, observed 14 inches of hard, black, shining coal cropping out at the edge of the water in Toe String Creek; contains a little iron pyrites in lower part. Mr. W. says it is sometimes 18 inches thick. Only one foot of dark-blue shales, containing *Discina*, was observed over it. The underclay contains *Stigmaria*.

Lower Coal-Fields.—The following section occurs at Bedford :—

Fig. 89.



SECTION AT BEDFORD
LIVINGSTON CO

Soil and drift.

Clay.

No. 1—Sandstone 10 or more feet, resting on

2—5 feet sandy and argillaceous shales.

3—1 foot good bituminous coal.

4—2½ feet fire-clay, sandy, with stigmaria ficoides.

5—10 feet shales, bituminous at bottom ; contains several concretionary layers of carb. iron.

6—0 to 10 inches deep-blue pyritiferous limestone ; contains *P. muricatus*, *Sp. cameratus*, *Chonetes* and *Lophophyllum.*

7—4 inches bituminous coal ; has yellow sulphur incrustations.

8—2 feet fire-clay.

9—4 feet nodular limestone.

10—3 feet even layers of silico-calcareous rock, with bands of shales ; contains *Sp. cameratus*, *Athyris*, *Prod. semireticulatus.*

On a small creek, three-quarters of a mile south-west, I obtained the following section :—

Sec. 14.

No. 1—Slope.

2—10 feet sandstone.

3—16 feet argillaceous and sandy shales, containing *Septaria.*

4—14 inches bituminous coal, decomposes on exposure.

5—12½ feet blue argillaceous shales; contains concretions of carbonate of iron, is somewhat bituminous, shaly at lower part, and also contains a bed of bituminous limestone near the lower part.

6—4 inches bituminous coal.

7—2 feet greenish-blue shaly clay.

8—2 feet nodular limestone.

W. Perry's coal-bed, in Sec. 25, Township 56, Range 22, is 1 foot thick. The coal at Bedford and at Perry's corresponds to No. 33 of Gen. Sec.

On Toe String Creek, in Sec. 31, Township 56, Range 21, obtained the following section :—

No. 1—25 feet slope, sandstone at lower part.

2—10 feet argillaceous, shaly slope, with concretions of ochreous oxide of iron.

3—1 foot buff-drab limestone, weathers buff-brown; contains *Crinoid* stems, *Lophophyllum proliferum*, a species of *fucoid Chondrites, Pr. æquicostatus, Rhynchonella Osagensis, Pr. splendens, Spirifer cameratus.*

4—9 feet 45° slope, argillaceous shales at lower part.

5—10 inches concretionary bed of ferruginous limestone, dark blue and very hard within, forms a thick, decomposing, ferruginous crust on outside; contains *Sp. lineatus, Pr. muricatus* = No. 43 of Livingston County Section.

6—2 feet bituminous shales; contains numerous small, flattened, spherical concretions of sulphate of iron.

7—5 inches variegated dark-blue and yellow argillaceous shale.

8—3 feet thinly laminated, bluish-green, argillaceous shale.

9—16 inches bituminous coal, good quality = No. 46 of Livingston County Section.

10—3½ feet fire-clay, blue and buff mottled, nodular concretionary limestone at lower part.

This coal is easy of access.

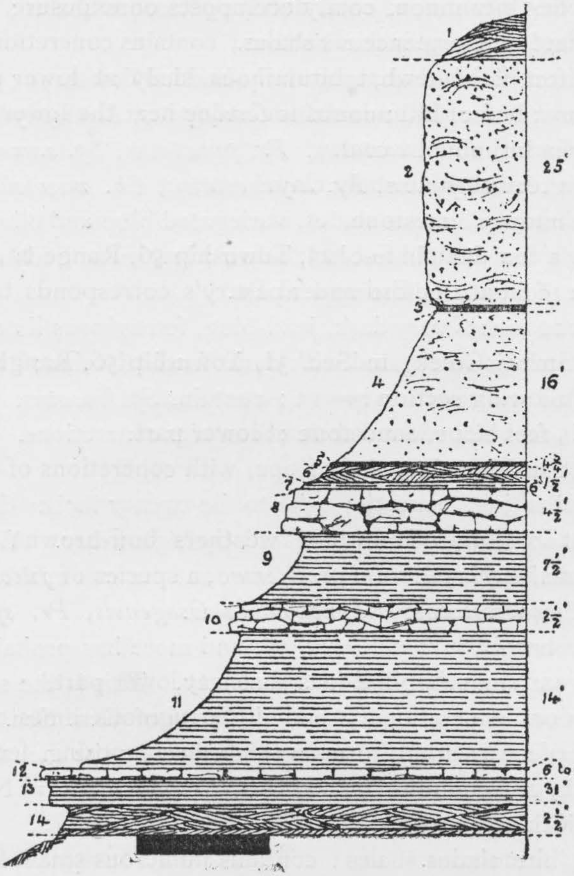
The following section was obtained at

WM. LEATON'S COAL-BANK, on the right bank of Grand River, in the north half of the north-east quarter of Sec. 29, T. 56, R. 21 :—

No. 1—Slope.

2—25 feet sandstone.

Fig. 90.



SECTION 152
AT W^M LEATON'S COAL BANK
LIVINGSTON CO

3—Coal outcrop.

4—16 feet brown, speckled, mostly thinly laminated micaceous sandstone—6 feet ; then argillaceous and sandy shales in thin laminæ, dark olive above, blue, black and slightly bituminous at bottom.

5—4¾ inches bituminous coal.

6—1½ feet gray fire-clay.

No. 7—6 inches brown ochrey clay, with selenite crystals.

8—4½ feet very rough nodular limestone; at top it is interpolated with much brown oxide of iron; more even-bedded below; fracture shows pea-green.

9—7½ feet pea-green, sandy and argillaceous shales; 1 foot of red and green near the bottom.

10—2½ feet bluish-drab, irregularly-bedded limestone; weathers brown; is fucoidal; contains *Caulerpites*, *Lophophyllum*, *Pr. muricatus*, *Prod. costatus*, *Pr. punctatus*, *Sp. cameratus*, a large *Aviculopecten*, *Pr. æquicostatus*, *Ch. mesoloba*.

11—14 feet argillaceous shales, variegated blue and olive above, with a few deep blue-black below; lenticular beds of carbonate of iron near the upper part.

12—6 to 10 inches very dark, lead-blue, ferruginous limestone at bottom; is variegated with dark fucoidal veins; is evenly jointed and weathers brown; contains *Sp. lineatus*.

13—31 inches bituminous shale; contains concretions.

14—2½ feet blue clay.

The coal lies just beneath; said to be twenty inches thick, but when I visited the place it was covered by high water. When Mr. Wheeler examined it the water was low, and he was enabled to see the coal. Below the coal is 4 feet of shales.

This bed has been much worked, and more has probably been used than from any other bed in the county. This is the same bed as that seen on Toe String Creek and No. 46 of Gen. Sec.

Coal equivalent to that of Leaton's is mined at the mouth of Toe String Creek, of which the following Sec. 153:—

No. 2—18 inches limestone.

3—13½ feet shales.

4—6 inches black-blue, concretionary and pyritiferous, fucoidal limestone.

5—32 inches bituminous shales.

6—4 inches to 42 inches clay shale; varies in thickness.

7—20 inches coal.

8—4½ feet clay shales.

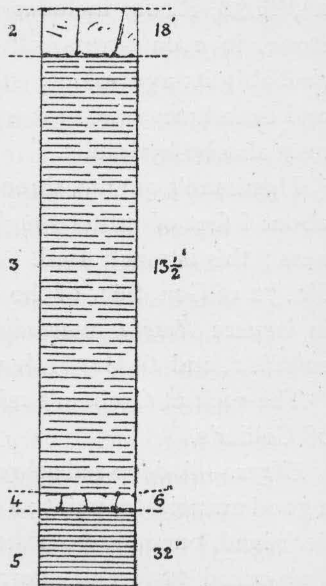
9—1 foot nodular, soft, shaly, bluish limestone.

10—4 feet shales to water in Grand River.

The lower six inches of this coal contains a great deal of iron pyrites, and is also traversed by white veins of carbonate of lime.

This coal crops out at various places on Toe String Creek for a mile from its mouth, also at the corner of the county, on Grand River, at Edmondson's ferry. At the latter place the rocks present an irregular dip of from ten to twenty degrees nearly due south-east.

Fig. 91.



SECTION 153
LIVINGSTON CO.

On Medicine Creek coal has been found at several places. Half a mile north of Collier's mill some has been taken out, and two and a half miles up-stream I noticed several pits, but they were so full of débris that I could not see the coal. I was told that its general thickness was about nine inches.

No other minerals in any amount have been discovered in this county.

Building-Rock.—I have elsewhere included a description of the best building-rock of this county; I will now only briefly notice them. The best quarries are those of Mr. Kirtley, ten miles west of Chillicothe and about one mile north of the Hannibal & St. Jos. Railroad. The rock is a silicious oölitic limestone; occurs generally in thick beds, but some are thin, and afford a strong and superior building-rock. There is about nine feet thickness of it.

The sandstone at Gillaspie's mill occurs in thick and thin strata, and is also an excellent material for building.

CH. WURSTER'S QUARRY, in the south-east quarter of the north-east quarter Sec. 22, T. 56, R. 22, is a very even-bedded blue limestone, occurring in two layers of nine and eleven inches, and admits of fine polish.

L. T. COLLIER'S quarry, in west half of south-west quarter Sec. 29, T. 58, R. 22, includes beds of 10½, 16, and 18 inches limestone, in even layers, closely resembling that of Wurster's, and probably its equivalent. At Utica are thick, rough beds of blue and drab limestone, that answers very well for coarse masonry, and may also be hydraulic.

Herriman's quarry, three miles north-west of Chillicothe, includes about 6 feet of rather rough-bedded limestone, but of good thickness; this is much used. I suppose the rock to be equivalent to No. 72 of Gen. Sec. of the Upper Coal-measures. The fossils seen in it were *Retzia punctulifera*, *P. costatus*, *P. splendens*, *Athyris subtilita*, and *Lophophyllum proliferum*.

The rock at Graham's mill may be hydraulic, as also may be that of Collier's.

Clays.—A deep-red ochrey clay, seen at Collier's mill, would afford a good material for paint; a similar but paler red was observed on Collier's land, one mile from the mill. In Collier's shaft, near this place, I observed 10 feet of alternations of yellow ochre bands, with blue shales; beneath it is 4 inches good band of bright yellow ochre.

At W. Leaton's coal-bank there is 6 inches of brown ochre, containing selenite crystals.

There are good beds of fire-clay under most of the coal-beds, particularly those on lower Grand River.

Bands and concretionary beds of carbonate of iron occur in shales on lower Grand River.

SOIL.—The soil is generally very rich; those portions of the county which I have mentioned as broken contain the only tracts of poor land, and the area is quite limited; the soil of the latter is light mulatto, and often sandy for a few inches in depth. The soil throughout most of the county is dark and rich, and varies from one foot to two and a half feet in depth. Near the western part of the county it has much lime in its composition, resulting from the disintegration of limestone.

The slopes generally are so very gentle that the county seems admirably adapted for grasses and meadows.

The bottom lands are wide and flat, and have very dark and deep soil, but are often too wet for cultivation. Good crops of corn are raised. Wheat has not succeeded so well during late years. Fruit succeeds tolerably well.

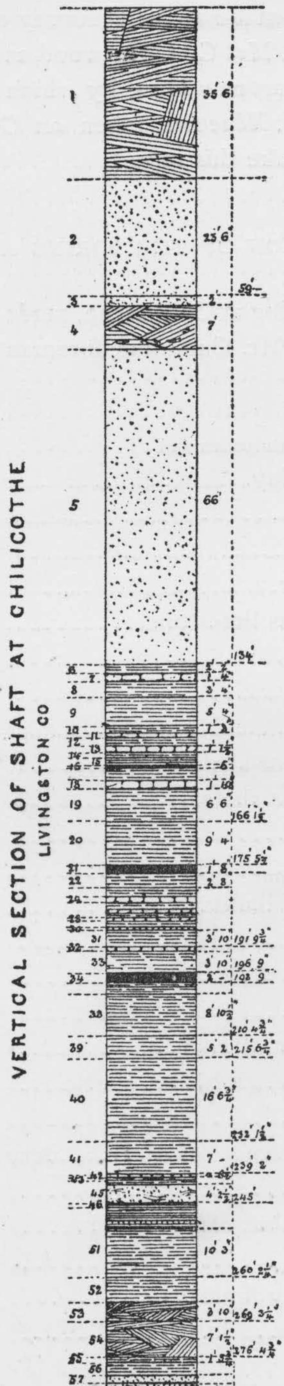
Before closing, I would state: with the assistance of H. A. Alffers and P. C. Swallow, I made a partial survey of this county in April, 1861. In July, 1872, Mr. C. J. Norwood assisted me in correcting old surveys and making new ones, by which assistance, and that of the notes of Mr. C. J. Wheeler, taken on Grand River in 1860, I am now enabled to make this report.

VERTICAL SECTION OF THE BORING AT CHILLICOTHE.

A section of the boring at Chillicothe, made by Messrs. Johnson & Co., and furnished by Mr. Cummins, foreman in charge, is added:—

No.	Nature of strata penetrated.	Thickness. Ft.	Thickness. In.	Depth from surface. Ft.	Depth from surface. In.
1	Soil and yellow clay	35	6		
2	Dry sand	23	6	59	
3	Wet, gray sand	2		61	
4	Blue bowlder-clay	7		68	
5	Soft sand	66		134	
6	Gray shale	2	2	136	2
7	Gray limestone	1	4	137	6
8	Gray shale	3	4	140	10
9	Dark shale	5	4	146	2
10	Blue shale	1	3	147	5
11	Hard limestone	1	5½	148	10½
12	Dark shale	2	2½	151	1
13	Hard limestone	1	1½	152	2½
14	Soft shale	1	2	153	4½
15	Hard slate	1	6	154	10½
16	Coal		6	155	4½
17	Shale	2	5	157	9½
18	Gray limestone	1	10	159	7½
19	Gray shale	6	6	166	1½
20	Shale	9	4	175	5½
21	Black smut	1	8	177	1½
22	Gray shale	2	8	179	9½
23	Dark shale	1	8½	181	6
24	Limestone	1	4	182	10
25	Gray shale	1	4½	184	2½

Fig. 92.



No.	Nature of strata penetrated.	Thickness. Ft.	In.	Depth from surface. Ft.	In.
26	—Limestone		9½	185	
27	—Gray shale		8½	185	8½
28	—Limestone		6	186	2½
29	—Gray shales	1	6	187	8½
30	—Hard band		2½	187	11
31	—Gray shales	3	10¾	191	9¾
32	—Blue limestone	1	0¾	192	10½
33	—Shale	3	10½	196	9
34	—Black smut	2		198	9
35	—Soft shale—dark	1	6¼	200	3¼
36	—Hard, dark shale		2	200	5¼
37	—Soft, dark shale	1	1¼	201	6½
38	—Shale—blue	8	10¼	210	4¾
39	—Red shale	5	2	215	6¾
40	—Dark shale	16	6¾	232	1½
41	—Blue shale	7	0½	239	2
42	—Hard, argillaceous limestone		6½	239	8½
43	—Gray shale		3	239	11½
44	—Soft shale		10	240	9½
45	—Gray sandstone	4	2½	245	
46	—Brown, bituminous shale		9¼	245	9¼
47	—Black, bituminous shale	2	7½	248	4¾
48	—Calcareous band		3½	248	8¼
49	—Dark, soft shale		7¼	249	3½
50	—Hard, calcareous band		7¾	249	11¼
51	—Dark shale	10	3	260	2¼
52	—Gray, calcareous shale	5	2¾	265	5
53	—Fire-clay	3	10¼	269	3¼
54	—Clay and particles of coal	7	1½	276	4¾
55	—Sandy shale and black bitum. particles	1	5¾	277	10½
56	—Clay shale	2	6¾	280	5¼
57	—Dark-gray, micaceous sand-rock, very hard	1	5¾	281	11
58	—Hard band and blue clay partings	1	8¾	283	7¾
59	—Hard, blue shale	2		285	7¾
60	—Argillaceous, gray limestone	1	6	287	1¾
61	—Dark, sandy shale	1	2½	288	4¼

No.	Nature of strata penetrated.	Thickness. Ft.	In.	Depth from surface. Ft.	In.
62—	Sand rock—light color	2		290	4¼
63—	Blue shale		9¾	291	2
64—	Dark-blue shale, with 1½ inches coal	2	5	293	7
65—	Pure sand rock	1	5	295	
66—	Blue limestone, passing into hard gray at bottom	3	0½	298	0½
67—	Clay		4	298	4½
	Particles of coal		0½	298	5

CHAPTER X.

GEOLOGY OF CLAY COUNTY.

BY G. C. BRODHEAD.

TOPOGRAPHY.

THIS county contains an area of 405 square miles. The bluffs along the Missouri River are not so high as those in Platte County; they vary from 100 to 190 feet in height, and, indeed, are often much lower. The western and southern portions of the county are often quite hilly near the streams; but in the northern and eastern portions the slopes rise very gently from the bottoms to the uplands; and the uplands rise and swell with beautiful undulations.

Timber and Prairie.—The following table comprises a list of the trees and shrubs of this county:—

Crabapple, white ash, prickly ash, blackberry, box elder, button bush, coralberry, mulberry, cotton-tree, burr oak, post oak, red chestnut oak, chinquepin oak, white oak, sycamore, pin oak, red root, elder, red elm, white elm, greenbrier, hackberry, black oak, red oak, red bud, raspberry (occasionally), pawpaw, American hazel, black haw, hawthorn, gooseberry, shell-bark hickory, thick shell-bark hickory, bullnut hickory, pignut hickory, *Cornus asperifolia*, *Cornus sericea*, laurel oak, *Rosa setigera*, honeysuckle, ironwood, honey locust, linden, sugar maple, white maple, sumach, poison oak, serviceberry (rare), staff-tree or wahoo, thorn (*Cratægus*), black walnut.

The southern half of the county is nearly all timber-land, much of it heavily timbered. The north half probably consists of about one-fifth prairie. The timber consists mostly of elm, ash, linden, white oak, rock-chestnut oak, hickory, laurel oak, pawpaw, hazel, sumach, red oak, *Cornus*, and black walnut. Near the prairies we have mostly laurel oak, elm, cherry, hazel, sumach, persimmon ; post oak and fragrant sumach occur in the eastern part of the county ; at no point west were they seen.

Streams.—Fishing River drains more than one-fourth of this county. Big Shoal and Smith's Fork of Platte are both considerable streams, but none of them afford power enough to be of advantage in water-mills. Fine springs are not very abundant. Springs are often seen issuing from beneath No. 76 ; but ordinarily this county is well supplied with water, and by digging wells it can easily be reached.

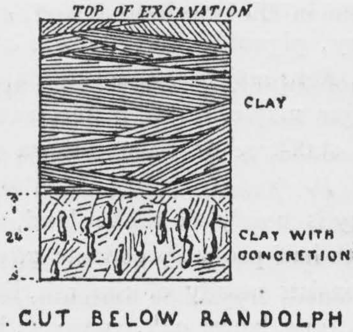
Geology.—*Quaternary Deposits.*—This includes the soils and alluvial deposits, prairie, clays, bluff and drift. The *alluvium* is thicker and better developed on the Missouri River. Bottom prairie is well marked on Fishing River and tributaries ; at mouth of Williams Creek it appears thus :—

No. 1—8 feet dark soil and alluvium.

2—15 feet clay, with brown ochreous concretions, equivalent to bottom prairie of Prof. Swallow.

Bluff.—Eighty feet of this formation was observed along the Missouri bluffs. It scarcely differs from the same formation as seen in Platte and Buchanan. The bluff formation often contains considerable quantities of calcareous concretions ; generally roundish, but of all shapes and sizes, from less than an inch to a foot or more, and often disposed together, as if deposited on a nearly level surface. The accompanying is a sketch of their arrangement in railroad cut below Randolph :—

Fig. 93.



R.R. CUT BELOW RANDOLPH
CLAY CO.

These concretions are very calcareous, and may be hydraulic.

Drift.—This is sparingly developed in this county.

Upper Carboniferous. — These rocks include from No. 112 to near 66 of Missouri River Section, and include about 404 feet of coal-measures, composed of sandstones, limestones, and shales, with probably no coal-seam over 2 or 3 inches in thickness. The rocks preserve a tolerably regular dip a very little north of west, amounting to about 190 feet along the Missouri River. The highest rock seen in this county is probably equivalent to No. 112 of Missouri River Section. The position of the lowest is below No. 171. No. 112 was observed on the hills north of Liberty, and in the west and north-west part of the county; on the head-waters of Williams Creek I observed 5 feet outcrop of bluish and ashy-gray limestone. From 111 to 110 there is about 56 feet shale, including 8 inches of bituminous shale near the middle.

No. 109 is 22 feet of Plattsburgh limestone; it is mostly ashy-blue, containing chert near the upper part, and near the lower a dark or ash-colored brittle limestone, with many fine fossils: *Pr. punctatus*, *Pr. Americanus* (Sw.), *Spirifer cameratus*, *Allorisma*, *Discina*, *Pleurotomaria* and a beautiful *Bryozoa*.

This limestone crops out on the hills at Liberty. At William Jewell College it is 6 inches thick, and consists of a bluish gray and buff, coarse-grained limestone, weathering brown. It abounds here in *Pr. Americanus*, *Allorisma*, *Myalina*, *Pinna*, *Athyris*, *Bryozoa*, *Fusulina* and arms of *Archæocidaris*, and contains a *Nautilus*.

No. 3 (of same Sec.) is 2 feet of fossiliferous, calcareous sandstone = No. 109.

No. 4—20 feet sandy shales = 103.

5—Outcrop of even-bedded, thinly-stratified, brownish-gray, shelly limestone.

6—5 feet shaly slope.

7—2 feet dark-brown, sandy limestone, containing *Myalina*.

8—13 feet sandy shales = 99.

No. 100 is seen on Williamson Creek, 2 feet thick.

Nos. 99 to 96, = 91 feet, occur in the south-west part of the county.

No. 96. One half-mile east of LIBERTY the section appears thus:—

No. 2—5 feet tolerably even-bedded, ashy-gray limestone; contains many fossils: *Pr. costatus*, *Pr. punctatus*, *Meekella striato-costata*, *Pr. Rogersi*, *Bryozoa*, etc.

3—27 feet shaly slope—15′ to 25′ of red shales; at the lower part is a tumbled mass of fine-grained, crystalline limestone, with a saccharoidal appearance.

4—1 foot of dark limestone = No. 90.

No. 90 is quarried in the bluffs opposite Harlem, where it occurs as a tolerably even-bedded, fine-grained, light-drab limestone, variegated with specks of calcite, and containing *Campophyllum torquium*, *Crinoid* stems, *Pr. splendens*, *Athyris subtilita*, *Lophophyllum proliferum* and *Fistulopora nodulifera*.

No. 5—6 feet slope.

6—Buff limestone and hornstone = 87.

No. 90 is 3 feet thick near the west county line, and is a fine-grained gray or drab limestone.

No. 88 consists of five or six feet of shales.

No. 87 is 11 feet to 13 feet: three-quarters of a mile north-east of Liberty it appears as 13 feet of limestone, divided thus:—

The upper four feet is a fine-grained, compact, buff limestone; has a lithographic appearance, and contains reniform concretions and lenticular beds of chert.

The next is 5 feet coarse, brownish-gray, oölitic limestone: the lower part is ashy-blue, with buff, shaly partings. Fossils are exceedingly rare. This rock is seen on the Missouri bluffs, in the western part of the county, and in the neighborhood of Liberty. A very good quarry of the lower oölitic beds occurs in the bluffs opposite Harlem.

No. 86 consists of 19 feet of dark olive and blue, argillaceous shales.

No. 85 consists of 13 feet deep-blue limestone, with blue chert. On the Missouri bluffs, near the west line of Clay County, the upper part consists of hard crystalline limestone, with lenticular beds of blue chert, containing small lamella branch fossils in the lower part; and at the bottom 4′ deep-blue concretionary, argillaceous limestone, in shales, containing impressions of plants. Three-quarters of a mile north-east of Liberty the section appears thus:—

No. 1—2′ thinly-laminated, blue, silicious limestone, interstratified with blue chert, and containing many beautiful univalves silicified; also some impressions of plants and carbonaceous stains.

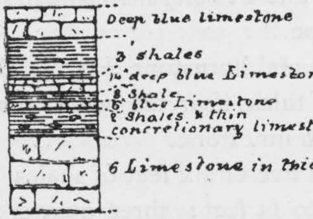
2—2¼′ blue silicious limestone, with beds of blue hornstone in lenticular strata; vegetable impressions.

3—8′ blue limestone, with many fossil plants; also *Myalina subquadrata*, *Myalina Kansasensis*, *Pinna*, *Orthoceras*, etc.

One-half of a mile east of Liberty it appears thus:—

No. 84 is lithologically divided into two portions: the upper five or six feet in two beds; the top bed of 2′ 6″, of buff drab, and the lower very fine-grained, compact, flesh, dove or fawn colored, with

Fig. 94.



½ MILE EAST OF LIBERTY
CLAY CO

many particles of calc-spar disseminated through it; below the last is found No. 83, consisting of 11′ of light-gray, white, and bluish-drab crystalline limestone, weathering whitish buff, and containing *Pr. costatus*, *Pr. Prattenianus*, *Pr. splendens*, and *Pr. punctatus.*

No. 81 is 5½ feet blue and bituminous shales, divided thus:—

No. 1—1′ clay shale.

2—2½ feet bituminous shale = 81^b.

3—1′ dark, argillaceous shales, containing many small, round, calcareous concretions = 81^a.

4—1′ 6″ dark-blue clay shales = 81^a.

78 and 80 consist of 12′ to 21′ "Bethany Falls" limestone. At Randolph it is 16 feet thick, of which the upper 7′ (No. 80) is brittle, shelly, and fucoidal, fine-grained, dove-colored, the lower part bluish gray, and contains *Pr. costatus* and *Pr. splendens.* This rock I have called "Bethany Falls Limestone," because it seems to be the same seen at Bethany, Harrison County, where it is well marked as forming *falls* across the stream.

Sec. No. 189, taken at NORTH MISSOURI JUNCTION, exhibits very plainly the different beds from No. 78 to No. 85, as follows:—

1—14 inches of blue limestone, containing crinoid stems, chonetes, etc.

2—2½ feet of blue clay shales.

3—4 inches black streak of rotten coal.

4—8 feet 8 inches of deep-blue cherty limestone, in irregular layers; at 3 feet from top is 10 inches of shales. The top layer is shaly, and abounds in remains of leaves of plants, probably *Cordaites*,

21

on which are often found reposing univalves belonging most probably to the genera *Pleurotomaria*, *Murchisonia* and *Loxonema*. This shaly, black band passes into the next subordinate cherty beds. The fossils are generally of white chert composition on outer crust, and blue within ; the chert layers deep-blue within, changing to decomposing white on the exterior surface. The contained fossils include *Murchisonia? Naticopsis Pricei, Platyostoma Peoriensis, Bellerophon percarinatus, Bell. Montfortiana, Pleurotomaria spherulata, Bell. carbonarius, Pinna peracuta, Myalina Kansasensis, M. subquadrata, Pseudomonotis? Lingula* ——, *Athyris subtilita, Hemipronites crassus, Productus symmetricus, P. Rogersii, Phillipsia, Bryozoa, Nautilus, Rhombopora lepidodendroides.*

5—9 feet 4 inches limestone in two thick beds, lower ash-blue.

6—5 inches blue shale.

7—5 feet 8 inches limestone in irregular layers ; gray contains *Prod. costatus, P. punctatus, P. splendens, Chonetes* ——, *Crinoid* stems.

8—5 inches blue shales.

9—14 inches hard, light-gray and somewhat concretionary limestone ; contains *Myalina Swallovi*, *Prod. splendens*, and *Athyris subtilita*, equivalent to No. 82 of Gen. Sec.

10—11 inches blue shale.

11—19 inches bituminous shales.

12—2 feet blue clay shales.

13—20 feet 8 inches Bethany Falls limestone ; contains *P. costatus, Athyris subtilita, Spirifer cameratus, Meekella striatopora* and *Syringapora multattenuata.*

14—2 feet blue shales.

15—5 feet slope, talus of above to railroad track.

Sec. 187, just above Liberty Landing, is as follows :—

No. 1—10 feet limestone.

2—1 foot blue shales.

3—6 feet 4 inches bluish-gray limestone.

4—2½ feet bituminous shales.

5—2 feet blue shales.

6—4 feet nodular limestone.

7—13 inches whitish, oölitic limestone.

8—14 feet 8 inches fucoidal limestone.

9—6 feet bluish-drab limestone, irregularly bedded.

No. 10—26 inches blue clay shales; springs issue from this.

11—16 inches bituminous shales.

12—18 inches dull, blue pyritiferous limestone, small calcite streaks are common.

13—7 inches blue shales.

14—6 inches concretionary limestone; many fossils, including *Meekella striato-costata*, *Hemipronites crassus*, *Sp. lineatus*, *Athyris subtilita*, *Chonetes*, *Crinoid* stems, *Rhombopora lepidodendroides*, *Lophophyllum*, etc.

15—2 feet 6 inches blue clay shales.

16—4 feet gray limestone, weathers brown.

17—2 feet 16 inches hard, coarse-grained, gray limestone; contains *Sp. cameratus*, *Crinoid* stems, *Athyris subtilita*, and a coral.

No. 77 = 2′ to 4′ blue and bituminous shale.

The section at RANDOLPH discloses—

2½ feet argillaceous shales.

1½ feet bituminous shales.

No. 76, at Randolph, appears as 16″ of ashy-blue limestone; three and a half miles east of Liberty it is 9″ thick, and jointed perpendicularly.

Nos. 76, *a* and *b*, at Randolph, exhibit 2′ 6″ nodular limestone and shales, very fossiliferous; containing *Meekella striato-costata*, *Pr. Pratteniamus*, *Chonetes*, *Rhombopora* and *Hemipronites crassus*, and *Aviculopecten*.

No. 74 is 6′ bluish-gray and buff silico-ferruginous limestone; weathers brown; contains *Pr. splendens*. Below this I observed 40 feet, consisting in upper part of 20′ sandy shales, with calcareous beds near the base, containing Myalina and *Pr. Norwoodii*. The lower part is sandstone.

The following Sec. 23 on East Fork of Fishing River, at crossing of Richmond and Liberty road, includes some of the lower beds:—

No. 1—Bluff.

2—11 feet limestone; nodular on top, even and gray below; has brown stains at lower part, and resembles "Bethany Falls limestone."

3—11′ slope, on which is an outcrop of even-bedded, brownish-gray and bluish-drab limestone; brown stains.

4—5′ limestone; resembles No. 2.

No. 5—53′ slope, mostly sandy shales.

6—1′ gray limestone.

7—27′ sandy shales.

The following section, taken on Williams Creek near Greenville, is probably above the last :—

No. 1—6′ gray limestone, containing many small *Producti*, *Athyris*, etc.

2—30′ to 35′ slope.

3—4′ outcrop of drab, silicious, fine-grained limestone. No fossils, but at lower part is a grayish bed, abounding in *Bryozoa*, *Pr. Norwoodii*, *Pr. splendens*.

4—16′ blue shales.

5—6′ shaly limestone, abounding in *Spr.* (*Martinia*) *planoconvexus* and *Spr. Kentuckensis*.

6—1′ 6″ jointed rhomboidal limestone.

7—14′ shales.

8—3″ dark, ashy, shaly limestone.

9—10′ shales and beds of nodular, bluish-drab, argillaceous limestone.

10—6′ shales, with *Chonetes* and *Pr. splendens* at top.

11—9′ limestone, rough-looking at top ; for two feet below is irregularly bedded ; bluish gray, with small *Productus*.

The following section, on Camp Creek, may include rocks a short distance below the Plattsburgh limestone :—

No. 1—Slope ; on lower part hickory, laurel oak, cornus, etc.

2—7′ irregular bed of limestone ; color gray ; contains a winding coral.

3—10′ shaly slope.

3½—2′ rough-looking, drab limestone.

4—9′ shales.

5—3′ limestone, abounding in *Bryozoa* and remains of corals.

6—8′ shales.

7—2′ bituminous shales.

8—6″ blue limestone ; somewhat resembles No. 2.

9—10′ slope.

10—Limestone in creek.

Economical Geology.

Good timber, useful for most purposes, abounds in this county, especially in the southern half, as also on all the streams, and includes hickory, red oak, red-chestnut oak, burr oak, laurel oak, ash, sugar-tree, cottonwood and cherry, hackberry, black walnut, elm, honey locust, and coffee-tree.

Building Materials.—Quarries of rock, good for ordinary building purposes, occur along the bluffs of all the streams. No. 108 is quarried at Liberty, and is much used for building. No. 90 affords a beautiful building material, and would also make good lime; it is seen near Liberty. In the bluffs, north of Harlem, No. 87 occurs in good thick beds for building purposes; it is easy to work, and durable. In the railroad cut, near Liberty, the oölitic part of No. 87 affords a bed of good building-rock. No. 84 probably affords as good a material for building as any rock in the county.

Three-quarters of a mile east of Liberty the upper part occurs in very good and thick beds; also near Randolph, and in the bluffs at Missouri City, it would be useful for work requiring large dimension stone; the lower beds are thin, white and gray colors, and work easily.

The upper part of No. 78 could be quarried in large, thick blocks, is very durable, but probably is too brittle to be very useful; the lower beds are thinner and more easily worked; it is seen on the Missouri bluffs from Randolph to Missouri City, also on Big Shoal Creek and Fishing River. The beds of limestone below the last-named are not often easily attained, on account of the débris from the sandstone and shales which often overlie them. Limestone, useful for burning into lime, is found nearly everywhere. Sandstone occurs in the bluffs of most of the streams; it is often too soft and shaly to be used for many purposes.

Coal.—No beds of workable coal have yet been found in this county, nor will there ever be any found of sufficient thickness to be worked. No useful minerals exist in Clay County. A thin seam of coal has been seen in the bluffs at Missouri City, but not of sufficient thickness to be worked.

Soil.—Most of the land in this county is rich. A small part of the county east of Williams Creek is rather poor, but supports a growth of post oak, black oak, white oak, black hickory and fragrant sumach. Some of the land also, near Wilkerson's Creek, Raccoon Creek and Smith's fork of Platte, is not very good. Aside from this, the rest of the county consists of good land, and some tracts are very rich.

But the soil of this county cannot be said to be as rich as that of Platte or even a part of Buchanan. Aside from these two counties, I think that Clay may be favorably compared with any other in the State. Hemp is a staple crop ; the best lands often produce 1,000 lbs. per acre.

Of the lands in the north-east part of the county, the bottoms produce good hemp crops, the hills corn and grass ; the new lands producing 50 bushels of corn per acre. For several years prior to 1861 the wheat crop was inferior. The best lands will produce 75 bushels of corn per acre. This county is good for apples, but peaches do not *every* year succeed well. Blue grass seems to flourish well everywhere. The hills based on the bluff soil are often covered with a beautiful green carpet of blue grass.

CHAPTER XI.

GEOLOGY OF PLATTE COUNTY.

BY

G. C. BROADHEAD.

PLATTE COUNTY has an area of 405 square miles. It is somewhat triangular in shape, the north and east sides forming a right angle, the Missouri River occupying the place of an irregular hypothenuse.

Topography.—The Missouri bottoms average about two miles in width. The bluffs vary from 150 to 300 feet in height. The highest, one and a half miles above Iatan, is 335 feet high, and three miles above Weston the bluffs are 311 feet high; their profile is formed in several terraces which can often be traced for miles. The bluffs on Platte River are from 70 to 130 feet in height, and near Platte City are much lower (from 40 to 60 feet); its bottoms are not often more than a quarter to a half-mile wide. The bluffs on Todd's Creek, near its mouth, are about 90 feet, and three miles up-stream they are fifty feet in height. Near the heads of the streams flowing toward the Missouri, the slopes are gentle, becoming steeper, and the hills higher, as we approach the river bluffs. Adjacent to the other streams the country is hilly and gently rolling, becoming more undulating as we approach the uplands, which are gently undulating and rolling, sloping just enough to form most desirable farming lands. Township 52, Range 34, is very gently undulating, also T. 54, R's 34 and 35.

Timber and Prairie.—The area of prairie is but limited, comprising about one-fourth of Township 52, Range 34, a small area in north-east and south-east, and about a quarter of Township 54, Range 34. The remainder of the county is mostly heavily timbered, comprising principally linden, elm, ash, honey locust, coffee-tree, rock-chestnut oak, black walnut, pawpaw, red oak, etc. Sugar trees abound in the north-west part of the county; white oak is very rarely seen.

The following is a list of the trees and shrubs seen in the county:—

Amorpha fruticosa.	Crabapple.
White ash.	Prickly ash.
Blackberry.	Buckeye.
Coralberry.	Black cherry.
Coffee-tree.	Cottonwood.
Red root.	*Cornus asperifolia.*
Cornus sericea ("Kinnikinnick").	Common elder.
	Grape.
American elm.	Hackberry.
Greenbrier.	Black haw.
Hazel.	Shell-bark hickory.
Gooseberry.	Ironwood.
Thick shell-bark hickory.	Linden.
Honey locust.	White maple.
Sugar maple.	White oak.
Mulberry.	Rock-chestnut oak.
Burr oak.	Red oak.
Black oak.	Red bud.
Laurel oak.	Raspberry.
Prairie rose.	Sumach (2 sp.).
Sycamore.	Virginia creeper.
Rhus Toxicodendron, or poison oak.	Red root.
	Staff-tree, or wahoo.
Black walnut.	Pawpaw.

Streams and Supplies of Water.—The streams in this county are mostly quite clear and running. Platte River possesses sufficient water-power to keep several mills at work during the whole year.

Good springs are found nearly everywhere. Wherever No. 112 occurs near the base of hills, good springs are seen flowing from beneath. Good springs abound along Platte River and the Missouri bluffs.

A quarter of a mile below Parkville there is a fall of 16 feet in height, over which the water passes clear as crystal, and, splashing on the rocks below, forms a beautiful, transparent basin of water.

Geology.—*Quaternary Formations—Alluvium.*—This formation does not materially differ from similar formations seen in other counties; it is well developed along the Missouri.

Bottom Prairie.—The Platte River bottoms consist chiefly of a deposit of dark, stiff clay.

Bluff, or Loess.—This formation is best developed on the Missouri hills. The street excavations in Weston exhibit it very favorably. It seems mostly to be a finely comminuted brown-ash clay, which is sometimes sandy. Mastodon teeth have been found on Line Creek. The bank of the creek here appears thus:—

No. 1. 10 to 12 feet of brown clay.

2—5 to 6 feet dark-brown clay, with some sand.

3—A few feet of pebbles.

4—Blue clay; the tooth probably came from lower beds of this section.

Drift.—Three and a half miles above Weston I noticed, immediately underlying the bluff marls, about 36 feet, consisting mostly of granite bowlders, coal-measure limestone, quartzite and greenstone intermingled with clay and sand.

Coal Series.—The rocks in Platte County all belong to the Upper Coal-measures, and include about 685 feet, from No. 160 to 85 of Missouri River Section inclusive. Their dip is north-west, and shows a total dip, from the south-east corner to the north-west corner of the county, of a little over 500 feet. Along the north end of the county, from Union Mills, on Platte River, to the Missouri bluffs, they show a dip of 400 feet. From Parkville due north to Union Mills the strata are nearly level. The rocks of the county include about 207 feet of limestone, 117 feet of sandstone, and the remainder consists mostly of shales. In describing the different beds of rock, I have thought it best to use the numbers corresponding to those of my General Section.

The following section includes all the rocks seen in this county:—

No.	No. in Gen. Sec.
1—5 feet buff limestone	160
2—30 feet slope	
3—6 inches coarse, gray, shaly limestone, contains tuteumergle	152
4—4 feet argillo-calcareous shales	151
5—35 feet irregularly-bedded cherty limestone	150
6—4½ feet blue and bituminous shales	148 & 149
7—2 feet even-bedded, hard, blue limestone	147

No.	No. in Gen. Sec.
8—12 feet shales	146
9—8 feet buff limestone	143
10—30 feet slope—sandy shales	142
11—5 feet red shales—good paint-bed	139
12—7 feet even-bedded ferruginous limestone	137
13—65 feet—probably all shales, contains 1 foot coal near the lower part	
14—Red shales	130
15—4 feet limestone	128
16—27 feet shales	
17—29 feet sandy and argillaceous shales, with concretions of carbonate of iron	127
18—2½ feet blue, shaly limestone and shales, abounding in fossils	129
19—16 feet blue or olive shales	125
20—8 inches drab sandstone	124
21—10 inches black shales, with plants and thin laminæ of coal	123
22—6 feet sandy shales	122
23—18 feet gray limestone	121
24—56 feet slope, mostly shales and sandstone at lower part	
25—12 feet argillaceous shales, at one place replaced by 16 feet of sandstone—coal-seam here	
26—2 feet 9 inches ashy limestone—arenaceous	115
27—1 foot 6 inches green argillaceous shales	
28—3 feet ochreous limestone	113
29—13½ feet gray limestone, contains archæocidaris	112
30—5 feet blue and bituminous shales	111
31—1½ feet argillaceous shales	
32—4 feet even-bedded blue limestone, Pr. Rogersii abounds	110
33—1 foot shale	
34—10 feet ripple-marked sandstone	109
35—4 feet sandy shales	
36—20 feet Plattsburgh limestone—many fine fossils	108
37—3 feet calcareous sandstone	107
38—16 feet sandy shales	
39—16 to 38 feet sandstone, ripple-marked	103
40—Shaly at lower part of above	101
41—3 feet brownish-gray limestone, sometimes oölitic	100
42—33 feet sandy shales	99
43—13 feet gray limestone	98
44—25 feet shales	97
45—6 feet ashy-gray limestone, with large Productus	96
46—24 feet slope, includes blue and bituminous shales	
47—10 feet greenish limestone, contains Campophyllum	90
48—4 feet pea-green, argillaceous shales	
49—15 feet fine-grained, silicious and cherty limestone	
50—10 feet shaly slope, 4 feet shales at top	89
51—6 inches argillaceous shales	
52—6 inches to 1 foot even-bedded, dark, shaly limestone	

No.	No. in Gen. Sec.
53—7 feet shaly slope	86
54—10 inches hard, deep-blue limestone	
55—7 feet shales	
56—4 feet deep-blue limestone, with deep-blue chert	85
57—4 feet deep-blue, concretionary, argillaceous limestone and shales	85

No. 160 occurs in the north-west part of the county, on top of hills north of Short Creek ; it is tolerably fine-grained, buff limestone five or six feet in thickness.

No. 152, as occurring in this county, is an even-bedded, coarse, ashy-blue or gray, shelly and shaly limestone, breaks very rough and irregularly in a vertical direction ; it was only observed near Iatan and Block's Mills.

No. 97 is 4 feet argillo-calcareous shales, and contains a thin bed of fibrous carbonate of lime and iron, or "cone in cone" (*tuten mergel*), which seems to be formed of a series of cones whose bases are the upper and lower surfaces of the stratum, and whose vertices interlock between.

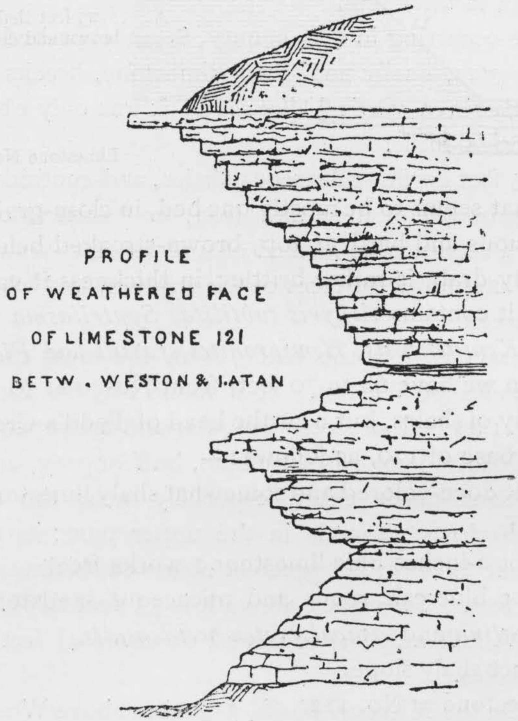
No. 150 occurs high in the bluffs, from the west county line to within three miles of Weston. It is found high in the bluffs in T. 54, R. 36, W. ; its beds are very irregular and are separated by thin bands of buff shales ; color is ashy blue, buff or gray, and weathers buff; it contains much chert, especially near the upper part. *Fusulina cylindrica* abounds in the upper part ; its thickness is generally about 20 feet ; its greatest observed thickness just below Iatan is 22½ feet. Two miles above it is 35 feet thick.

No. 148. A half-mile below Iatan I observed 4½ feet of blue and bituminous shales.

No. 143. On the Missouri bluffs, 3½ miles above Weston, at Sec. 7 (=17 of 1872), I noticed 5 feet of a thick-bedded, brown limestone cropping out at an elevation of 220 feet above the bottoms ; contains but few fossils ; I observed an *Allorisma*. At this place are exposed 200 feet, mostly shales, from No. 143 to 122, including a thin coal-seam, several layers of carbonate of iron, two beds of red shales, and 9 inches of coal. A copy of the section here will be found in my general descriptive Section of Upper Coal-measures.

No. 126 was observed four miles north of Weston, near the St. Joseph Road, abounding in many fossils ; it was also observed just above Iatan, and on the upper slope at Weston. I suppose it to occupy a position very near the shale beds near Gentryville, Gentry County, which so abounded in *Nuculana* and *Astartella*. It is argillaceous and calcareous, dark ash and blue; its fossils include *Myalina subquadrata*, *Bellerophon carbonarius*, *B. Grayvillensis*, *B. Meekii*, *B. percarinatus*, *Loxonema*, *Pleurotomaria*, *Sphærulata*, *Bellerophon* ——, *Nautilus nodoso-dorsatus*, *Pinna*, *Astartella vera*, *Leda Oweni* and *Edmondia Nebrascensis*.

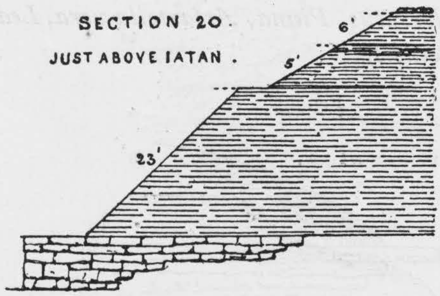
Fig. 95.



Concretionary bed of septaria and ochre.
6 feet shales.
No. 126. Stratum of calcareous shales, with fossils.
5 feet of clay shales.

In descending the river, No. 121 is first seen one mile above Iatan. Following down the bluffs, it gradually is seen higher; two miles below it is 30 feet above the railroad; one mile further about grade; from this point to Weston it gradually rises to an elevation of 83 feet, from which it undulates near the same elevation to Beverly. Large tumbled masses are often found below, sometimes of great size, and many are often seen at intervals along a certain horizon, causing one almost to think they form a bed in place. It

Fig. 96.



occurs in what seems to be mostly one bed, in close-grained, gray or whitish, silicious and hard at top, brown-streaked below, weathers dark and ashy-drab, is rather brittle ; in thickness it varies from 14 to 18 feet ; it contains *Athyris subtilita, Syntrilasma hemiplicata, Spiriferina Kentuckensis, Hemipronites crassus* and *Pleurotomaria.*

At Weston we have 68 to 70 feet, from Nos. 121 to 112, consisting principally of shales, but near the head of Todd's Creek I noticed rocks at the base of 120, as follows :—

No. 2—2 feet dove-colored and somewhat shaly limestone ; weathers buff.

3—1 foot 2 inches blue limestone ; works free.

4—1 foot blue calcareous and micaceous sandstone ; contains *Myalina* and *Aviculopecten occidentalis.*

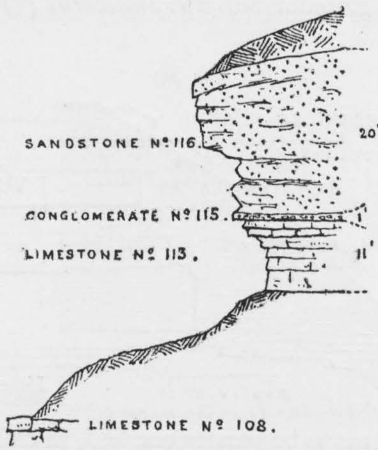
5—10 feet shaly slope.

6—Limestone = No. 112.

A section on the Missouri bluff, near Waldron, Fig. 97, shows an absence of the last-named strata. In their place we find 10 feet of very thick-bedded brown sandstone, containing some concretions of iron-ore and a few flag-like plant-remains, and resting immediately on No. 113. The lower part is seen one mile above, and a quarter-mile below, occurring as a coarse conglomerate.

No. 115 is 3 feet of blue arenaceous limestone, containing *Chonetes Verneuiliana, Athyris subtilita, Myalina subquadrata, Aviculopecten carbonarius, Hemipronites crassus, Prod. Prattenianus,* and *Bryozoa.* Below No. 115, and resting on 113, we have at Weston 1 to 3 feet shales.

Fig. 97.



SECTION
NEAR HILLTOP AT WALDRON.

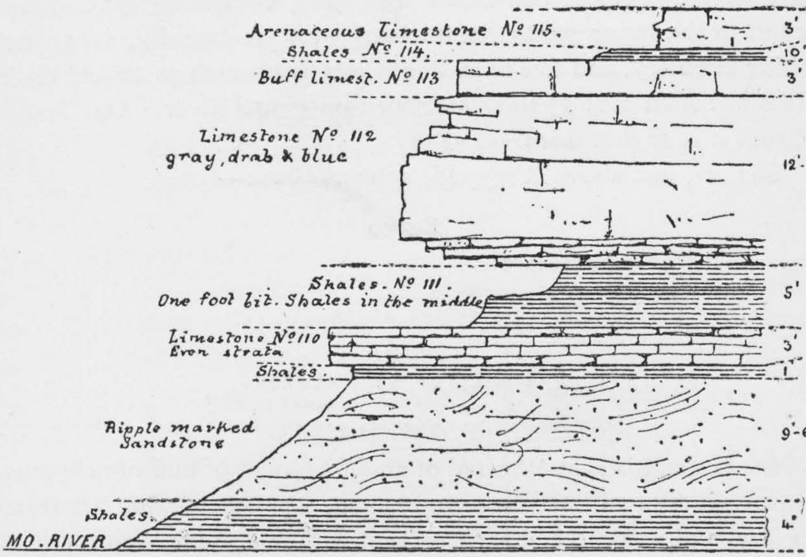
No. 113 consists, at Weston, of about 3½ feet of buff or ochreous brown limestone in one bed, and having a pot-metal ring; it rests on 112 and is nearly always present with it. Near Waldron it is 6 feet thick. No. 112. In the railroad cut above Weston is seen 5 feet of fine-grained limestone, in even 6-inch layers, reddish or fleshy-gray, with specks of pellucid calc-spar disseminated, and generally brownish near the top; I noticed *Productus splendens*, *Sp. Kentuckensis*, *Fusulina*, *Archæocidaris*, and fragments of *Crinoid* stems. Below Weston it is 13 feet thick. Sec. 14, west of Platte City, shows the upper 2 feet a yellowish brown, then 1½ feet shelly and shaly; below, the beds are fleshy-gray, with some beds nearly a pure white. From Weston, south-east along the bluffs, it thickens; at Farley it crowns the hill-tops; across Platte it rises rapidly in the bluffs, forming the highest well-marked rock east of Platte River. It contains but few fossils, of which *Athyris subtilita* is the most abundant.

The following section, Fig. 98, at Rialto, includes strata from No. 109 to No. 115 inclusive:—

No. 110 occurs in very even layers. On Todd's Creek it was observed 3 feet thick; west of Brush Creek, 4 feet thick, with sandy shales below, and 6 inches of argillaceous shales overlying it. Its fossils are *Pr. Nebrascensis*, *Pr. æquicostatus*, *Syntrilasma hemi-*

plicata, *Athyris subtilita*, *Meekella striato-costata*, *Hemipronites crassus*, *Allorisma granosa* and *Pr. punctatus*; *Prod. Nebrascensis* abounds.

Fig. 98.



SECTION AT RIALTO
PLATTE CO.

No. 109. Below Weston we have 9½ feet of ripple-marked sandstone, concretionary and calcareous, resting on 4 feet of sandy shales. Near Farley it is seen 17 feet thick. Following up Platte River we find this thinner, and at Skinner's Mill only 7 feet thick, consisting mostly of argillaceous shales. It thus seems to vary very much both in thickness and constituency.

No. 108. A series of rocks well marked and abounding near Plattsburgh, in Clinton County, is called, for sake of distinction, "Plattsburgh Limestone." This includes—

1—1 to 3 feet of buff, drab and shaly, fine-grained limestone, with a pot-metal ring.

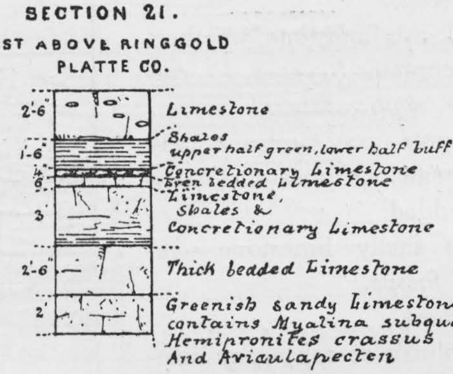
2—13 to 22 feet of limestone, with two thin beds of dark-colored and bituminous shale, and with blue chert in the middle.

3—3 feet of calcareous sandstone = No. 107.

The 2d first appears one and a half miles above Farley; from thence it rises rapidly in the bluffs for twelve miles below, at which point it is nearly 100 feet above the base ; it then recedes to the uplands, back. Along Platte River it mostly crops out near the base of its bluffs, occasionally rising in them ; from the south part of Township 53 to Union Mills it is the highest rock. It is generally an ashy-gray or bluish-ash limestone, containing grayish-blue chert in the upper part. It thickens south-eastwardly, is 13 feet thick at Farley, and five miles south-east is as much as 20 feet thick. It is not often over 13 to 14 feet thick on Platte River. On Todd's Creek it is 22 feet thick.

Sec. 21, just above Ringgold, appears thus :—

Fig. 99.



Above the arenaceous bed is 13 feet, the upper 2 feet and lower 2 feet in very thick, irregular beds ; between are thin beds, some decomposing and shaly, with buff, shaly partings between the beds ; fractures show a bluish crystalline ; the top of No. 2 is cherty. Fossils found here were *Myalina*, *Bellerophon*, *Rhombopora*, *Athyris* and *Bryozoa*.

Sec. No. 27, near the mouth of Todd's Creek :—

No. 1—10 feet slope, outcrops of gray limestone near lower part.

2—2 feet buff and drab, fine-grained, silicious limestone ; has a pot-metal ring and weathers buff.

3—15 feet mottled, ashy-blue, irregularly bedded limestone ; contains blue chert.

4—1 foot shales, mostly argillaceous, near upper part olive, middle somewhat dark bituminous, and brown at bottom.

5—10 inches tough, blue limestone.

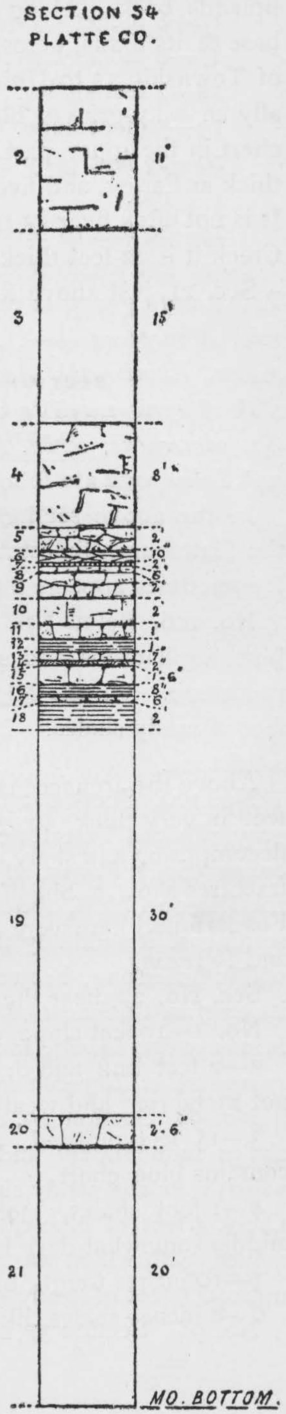
6—8 inches shales, like No. 4.

No. 7—4 feet limestone, like No. 5.

8—50 feet slope to bottoms; some outcrops of sandy shales lower down.

Sec. 34 on Missouri bluffs, near Samuel Morrow's, in north-east quarter of Section 11, Township 51, Range 35, appears thus :—

Fig. 100.



No. 1—Slope.

2—11 feet gray limestone = 112.

3—15 feet slope; comminuted sandstone is seen.

4—8 feet dark-ash limestone, weathers brown; contains *Bryozoa*, *Pr. costatus*, *Pr. æquicostatus*.

5—2 feet coarse gray and minutely cherty or silicious limestone, irregularly bedded.

6—10 inches shelly limestone — remains of fossils.

7—2 inches chert.

8—6 inches bluish or ashy-gray limestone; numerous remains of fossils leaving calc-spar lines; contains *Edmondia*, *Solenomya*, etc., etc.

9—2 feet irregularly bedded, blue, shaly limestone; weathers to brown; contains *Sp. cameratus*, *Productus Nebrascensis* and *Pr. costatus*; has thin lenticular beds of chert.

10—2 feet soft, decomposing, brown limestone.

11—1 foot brown and gray limestone; weathers brown; contains *Spirifer cameratus*.

12—1 foot dark shales.

13—7 inches limestone.

14—2 inches brown clay.

No. 15—1½ feet limestone, full of fossils; *Fusulina* abounds.

16—8 inches clay shales.

17—6 inches limestone.

18—2 feet shales.

19—30 feet slope.

20—2½ feet gray silicious limestone, in a very even bed. No. 100.

21—20 feet to Missouri bottoms.

Some fine fossils were collected from the lower members of the Plattsburgh group at this place, including *Pleurotomaria turbiniformis*, *Monoptera* ——, *Pinna peracuta*, *Nautilus occidentalis*, *Allorisma*, *Eumicrotis*, *Aviculopecten* ——, and very fine *Bryozoans*, with *Athyris subtilita* abounding in bottom bed. *Prod. costatus*, *Sp. cameratus*, *Prod. Nebrascensis*, *Prod. Prattenianus*, *Edmondia* and *Solenomya* are found in the upper beds.

In the above section all between No. 3 and No. 19 belongs to the Plattsburgh limestone. At Union Mills No. 107 is 3 feet thick; it sometimes appears like a sandy limestone.

No. 106. Below No. 109 we have, at Union Mills, 16½ feet of blue, argillaceous and sandy shales, with pockets of blue and buff sandstone. On the Missouri bluffs, above Brush Creek, is seen 16 feet of sandy shales. Next below the last is from 16 to 25 feet of sandstone.

No. 100. Section 29, on Todd's Creek, shows 2 feet of reddish gray silicious limestone in one bed; contains *Productus Americanus* (Sw.), *Pinna*, *Myalina*, *Pro. punctatus*, *Bryozoa*, etc. On the Missouri bluff, above Waldron, it is 8 feet thick, and three miles south-east it suddenly thickens into almost one bed of 11 feet of oölitic limestone, brown and gray. Near Parkville it is restored to its original thickness of 2½ to 3 feet, and just above-town it abounds in many fine fossils, including *Prod. Americanus*, *P. costatus*, *P. symmetricus*, *Bryozoa* and *My. subquadrata*.

No. 99. Section 29, on Todd's Creek, presents 15 feet of sandy shales immediately underlying No. 100. We next have 21 feet which is mostly sandy shales; near the upper part we find on Todd's Creek 4 feet of blue calcareous sandstone, abounding in small univalves, with which was associated a small Phillipsia; at lower part noticed 5 feet of sandy shales.

No. 98. Section 37, on the Missouri bluffs, near Waldron, displays

11 feet of irregularly-bedded gray limestone, which is somewhat bluish and buff toward the lower part; has brown, shaly partings, and is traversed by winding veins of calc-spar; but few fossils were observed; contains *Productus splendens*, *Athyris subtilita* and a *Goniatite*. Its layers are generally from 2 to 8 inches.

No. 97. Includes 25 feet shales.

A pretty full description of most beds seen at Parkville will be found in "General Descriptive Section of Upper Coal-Measures."

North of town we find—

No. 1—6 feet dark-olive ochrey shales, with concretionary bed of ochre 4 inches in thickness = 97.

2—6 feet limestone, drab and brown; a portion has irregular deep-green windings; contains *Pro. punctatus*, *P. costatus*, etc. = 96.

3—27 feet slope.

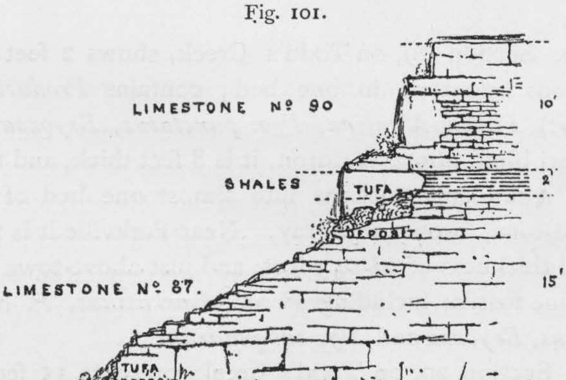
4—6 feet greenish drab, fine-grained limestone, with large fucoids and greenish shaly partings = 90.

5—4 feet deep-blue shales.

6—Drab limestone with hornstone layers = 87.

One mile below Parkville the beds from 87 to 90 are exposed at a waterfall, as shown in the following profile:—

Fig. 101.



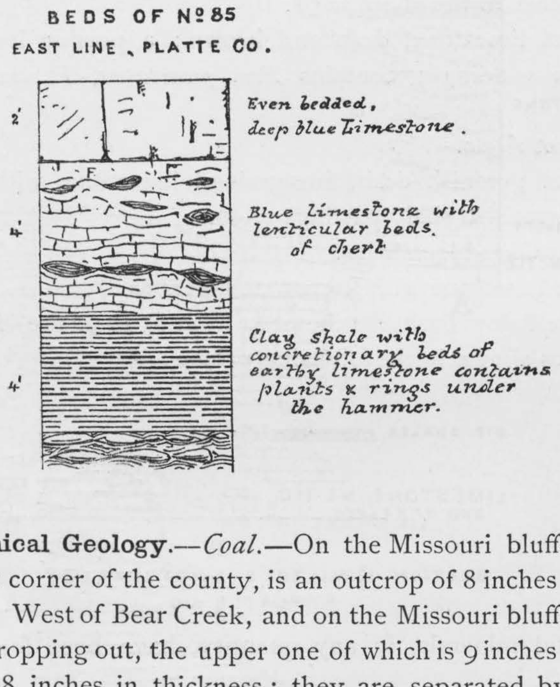
PROFILE SECTION
1 MILE BELOW PARKVILLE, PLATTE CO.

No. 90 is found above Parkville, containing campophyllum torquium.

No. 87 is from 11 to 13 feet of light-drab, brittle limestone; is fine-grained and silicious, with a lithographic appearance, generally occurring in thin layers; contains drab chert, on which are sometimes beautiful dendritic markings. Fossils are very rare; only observed a *Discina*.

No. 85. Only 4 feet was seen of fine-grained, compact, dark, ashy-blue limestone; weathers dirty sandy; has a subconchoidal fracture; crops out at base of hill one mile below Parkville. The following section, near east county line, shows arrangement of these beds.

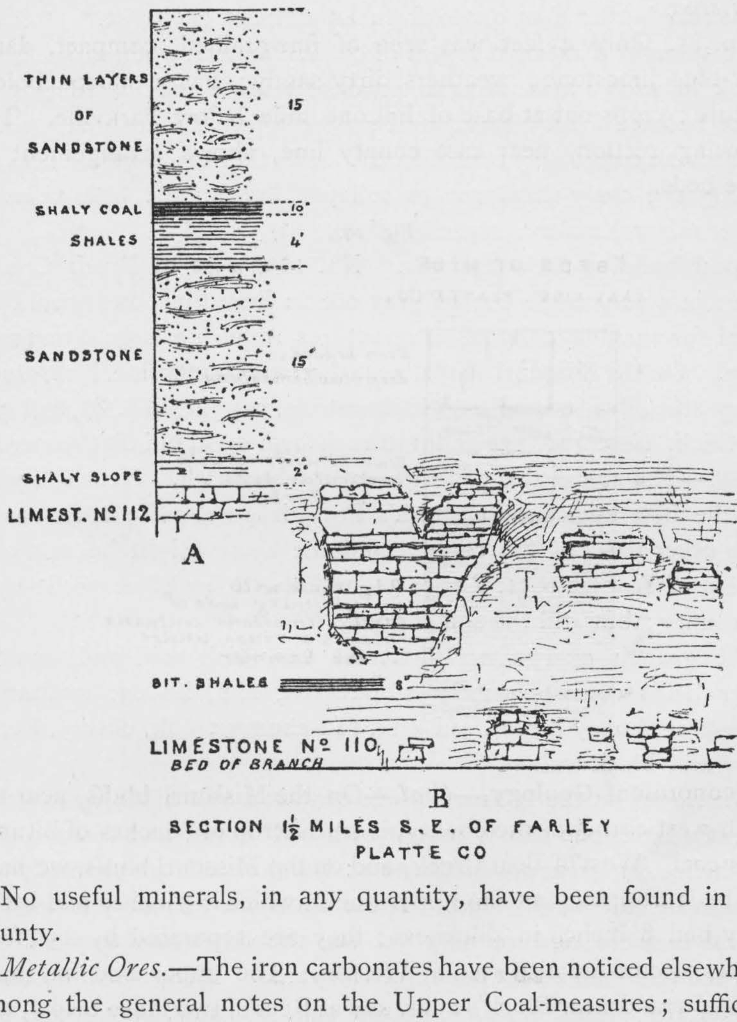
Fig. 102.



Economical Geology.—*Coal.*—On the Missouri bluffs, near the north-west corner of the county, is an outcrop of 8 inches of bituminous coal. West of Bear Creek, and on the Missouri bluffs, we have two beds cropping out, the upper one of which is 9 inches and lower shaly bed 8 inches in thickness; they are separated by 130 feet. Traces of coal are also seen at Weston. The upper bed has been worked at and near Block's mills, and at Rees's, two miles below, and the coal has been used a little, but the beds are too thin to pay very well.

One mile below Platte River ferry, and a half-mile up a branch, some coal has been taken out. Its thickness is about 10 inches, and its geological position about 21 feet above limestone No. 112, and separated from it by shales and thick-bedded sandstone—the latter equivalent to the Waldron sandstone; the coal is probably local, as not even a sign of it was observed anywhere else. A and B are 200 yards apart.

Fig. 103.



SECTION 1½ MILES S.E. OF FARLEY
PLATTE CO

No useful minerals, in any quantity, have been found in this county.

Metallic Ores.—The iron carbonates have been noticed elsewhere, among the general notes on the Upper Coal-measures; suffice it simply to state the fact, that the clay and sandy beds occasionally contain many septaria and other concretions. The localities where they were mostly observed were a few miles below Beverly, at Weston, and three miles above—at the latter place in considerable quantities. On Sugar Creek, near the line of Buchanan County, about 20 feet below a 7-inch coal-seam, numerous remains of plants, probably *Cordaites*, were observed, containing knife-edges of coal, and with numerous transverse cracks, the interstices filled with sulphuret of zinc. The surrounding rock is a sandy iron carbonate. These cracks may be called shrinkage cracks, concerning which I cannot do better than quote from an eminent geologist.* "Flattened stems of plants and layers of cortical matter, when carbonized, shrink in such a manner as to produce minute reticulated cracks. These become filled with mineral matter before the coaly substance has become completely consolidated. A further compression occurs, causing the coaly substance to collapse, leaving the little veins of harder mineral matter projecting."

Good building-rock abounds. No. 100, west of Brush Creek, occurs in a very thick bed of gray oölitic limestone, and would be useful for making columns or structures requiring large dimension stone. On the Missouri bluffs, near the east county line, I observed a very attractive, coarse, oölitic limestone, capping No. 87, and 4½ feet thick. Nos. 121, 112 and 110 each form good building material.

Soil.—The soil in this county is everywhere rich. Near Ridgely, and the hills adjacent to Smith's Fork, it is not quite as rich as in some other parts of the county, and the same might be said of a portion of Township 54, Range 34, and also a few other portions of the county; but still the soil is good.

The growth everywhere indicates very rich soil, and on the richer lands consists mostly of pawpaw, elm, linden, mulberry, coffee-tree, honey locust, red oak, red-chestnut oak, cherry, hackberry and black walnut.

The slopes on the Missouri bluffs contain a soil made up in great part of a limestone débris mixed with buff clays, and forms a rich soil, indicating great productiveness; but the bluffs are generally too steep to be easily cultivated. These bluffs are generally formed in several terraces, and we may yet see the day when they will be crowned and flanked by beautiful vineyards. The growth on them is generally pignut hickory, poison oak, pawpaw, may apple, linden, hackberry, mulberry, black walnut, red oak, *Cornus*, elm, red-chestnut oak, shell-bark hickory, greenbrier, coralberry, thorn, black haw and Virginia creeper; or nearly the same as on the uplands.

The uplands are well adapted to most crops, and lie beautifully for cultivation.

---

* J. W. Dawson, in *Am. Jour. Sc. and Arts*, 3d Series, Vol. V., No. 25, p. 22.

Hemp is the principal crop raised, and 1,000 pounds per acre is readily produced. During good seasons from 20 to 25 bushels of wheat per acre can be raised. The ordinary average yield of corn is about 50 bushels per acre, but the best lands can easily be made to produce 75 bushels, and some persons think that 100 bushels can be raised.

Fruit succeeds well—peaches nearly every year, but the trees die out in about five years. Probably no county in the State possesses superior advantages to Platte ; it contains such a large quantity of rich land, is so well watered, abounds also in good timber, including most kinds that are useful.

Partial surveys of this county were made in May, 1861, and May, 1872. In the first examination I was assisted by P. C. Swallow and H. A. Ulffers, in the last by Chas. J. Norwood.

CHAPTER XII.

GEOLOGY OF BUCHANAN COUNTY.

BY G. C. BROADHEAD.

BUCHANAN COUNTY has an area of about 400 square miles. It is bounded on the north by Andrew County, on the east by Dekalb and Clinton, by Platte on the south, and is separated from Kansas by the broad Missouri on the west. Its surface is agreeably diversified with hill and dale, high and steep bluffs and low and gentle declivities, and also gently-undulating surfaces. Along the north line we have wide bottoms merging by very gentle slopes into the neighboring hills ; but as we approach the Missouri bluffs the hills seem higher, or, more properly speaking, the streams cut deeper and the slopes are more steep. In crossing the county at any point from east to west, we observe a corresponding change. The country drained by the Platte River and its tributaries is mostly gently undulating, with low hills near the streams. The hills on Malden Creek sometimes attain a height of 85 feet. On Platte River they are not often over 50 to 75 feet, but a few miles south of the Hannibal and St. Joseph R.R. they are as much as 100 feet in height. Near Contrary and Sugar Creeks they sometimes attain an elevation of 140 feet, and the country adjacent is quite broken. On Blacksnake Creek the hills are from 75 to 100 feet high. The Missouri bluffs near the north county line are about 145 feet high, and appear to retain that elevation, sometimes higher and sometimes lower, until they pass southward of St. Joseph. King's Hill, two miles south, is 255 feet above the bottoms. A bluff on Sec. 14, T. 56, R. 36, is 310 feet high. The bluff in Sec. 22, T. 55, R. 37, is 250 feet in height. The other bluffs along the river approach these in height, but are much lower. The tops of these hills are probably of the same elevation as most of the interior uplands. The Missouri bottoms are wide, flat, and often marshy.

Timber and Prairie.—The area of prairie is but small. The eastern and northern portions of the county are mostly prairie ; near and on the "divide" it consists mostly of prairie, or of thickets covering what was formerly prairie. The country near Platte River, for several miles east and west, and lying south of line between Township 56 and Township 57, is heavily timbered ; also most of the southern and western portions of the county. A cottonwood was observed on the Missouri bottom 19 feet in circumference at 5 feet above-ground.

The trees and shrubs in the county may include the following :—

Crabapple.	Red elm.
Prickly ash.	White ash.
Buckeye.	Blackberry.
Coralberry.	Box elder.
Black cherry.	Greenbrier.
Choke cherry.	Hackberry.
Coffee-tree.	Black haw.
Cottonwood.	Hawthorn.
Red root.	Gooseberry.
Panicled dogwood or rough-leaved.	Shell-bark hickory.
	Thick shell-bark hickory.
Kinnikinnick.	Pignut hickory.
Elder.	Honey locust.
Red elm.	Ironwood.
Hazel.	Honeysuckle.
Summer grape.	Linden.
Frost grape.	Sugar-tree.
River grape.	White maple.
Wahoo.	Mulberry.
Virginia creeper.	Burr oak.
White oak.	Black oak.
Red-chestnut oak.	Pin oak.
Red oak.	Redbud.
Laurel oak.	Raspberry.
Prairie Rose.	Sumach.
Sycamore.	Black walnut.
Poison oak.	American elm.

White oak is rarely found, and Chinquipin oak is scarcely seen excepting in the northern and eastern parts of the county.

Springs and Streams.

There are some good springs in this county, and water can be easily reached by digging. Wells and cisterns are more common. The streams are generally clear and running.

Scientific Geology.

Superficial Deposits.—The alluvium is best developed on the Missouri bottoms.

Bottom Prairie.—The washings on flat grounds at St. Joseph expose about 20 feet of dark clay. Similar clays are seen on Platte River.

The "Bluff" or "Loess" is well exposed on the Missouri bluffs near St. Joseph, where it rises in steep and often gently-sloping peaks, covered mostly with grass. It is generally a finely-comminuted brown ash-clay, and where a few feet from the surface, exposed by washings, is always perpendicularly jointed. In King's hill, below St. Joseph, it has at the lower part 8 feet of finely-comminuted brown sand resting on 2 feet of white calcareous concretions. The fossils found were *Helicina occulta*, *Succinia* and *Helix*. The drift occurs immediately beneath the bluff, but I observed no good exposure of it in the county. Bowlders of granite and quartzite were occasionally found.

Upper Carboniferous.

The rocks in this county belong to the Upper Coal series, and include a total thickness of about 470 feet, from a bluff limestone, equivalent to No. 160 Gen. Sec., to No. 108 or Plattsburgh limestone inclusive, of which there is 125 feet of limestone, 11 feet bituminous shales, the remainder consisting of sandstone, sandy and argillaceous shales. The prevailing dip of rocks is a very little north of west.

On the head-waters of Sugar and Contrary Creeks, Mr. Ulffers observed the following section, which includes some of the highest rocks seen in this county :—

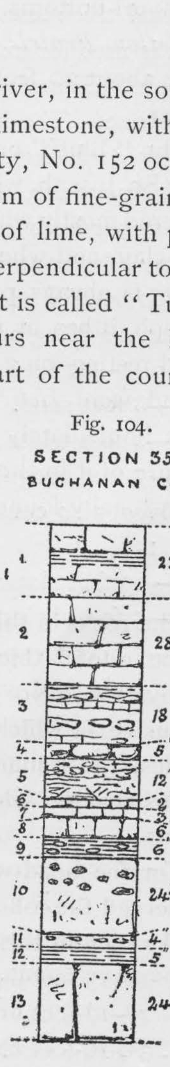
No. 1—15 feet light-buff limestone ; contains *Fusulina*, etc.
2—17 feet argillaceous shales.
3—16 feet cherty limestone.

No. 4—2 feet argillaceous shales.
5—1 ½ feet bituminous shales.
6—1 foot hard, blue limestone.
7—14 feet argillaceous shales.
8—4 feet light-buff, compact limestone.
9—7 feet argillaceous shales.
10—2 feet buff, shaly limestone.
11—36 feet red and blue argillaceous shales.
12—6 inches shaly, bituminous coal.
13—18 feet argillaceous and sandy shales.
14—5 feet sandstone and sandy shales.

No. 160 was observed in bluffs back from the river, in the southwest corner of the county; it occurs as a buff limestone, with 35 feet slope below, to No. 150. In the same vicinity, No. 152 occurs as a dark-gray limestone, containing a thin stratum of fine-grained, very dark-green, fibrous, argillaceous carbonate of lime, with probably some carbonate of iron, the fibres nearly perpendicular to the horizontal surface, and interlocking, forming what is called "Tuteu mergel," or "Cone in Cone." No. 150 occurs near the hill-tops on the Missouri bluffs, in the northern part of the county, and occupies that horizon on the Missouri bluffs as far as the south county line; its greatest observed thickness was 23 feet, at Rushville. It is a buff-brown near the top, with *Productus Rogersi*, *Chonetes Smithii*, *Syringapora*, *Fusulina cylindrica*, *Athyris subtilita;* below, it is very irregularly bedded, and contains chert, especially in the upper portion. The beds of limestone are not often over 6 inches to 1 foot in thickness, and are separated by buff clay. The annexed section, No. 35, at Beatty's quarry, near St. Joseph, exhibits most of the beds of No. 150:

Fig. 104.

SECTION 35. BUCHANAN CO.



No. 1—23 inches limestone and shales.
2—28 inches limestone.
3—18 inches concretionary limestone and buff shales.
4—5 inches concretionary limestone.
5—1 foot nodular limestone, chert, and brown shales.

No. 6—2 inches limestone.

7—3 inches limestone.

8—6 inches limestone.

9—6 inches brown shales and limestone nodules.

10—2 feet limestone; contains some dark chert concretions in upper part.

11—4 inches shales and limestone nodules.

12—5 inches shales.

13—2 feet limestone.

Total thickness of beds exposed here was about 14½ feet. The rock is used for making lime, and curbing and macadamizing in St. Joseph. Bituminous shale is found in a pit about 10 feet below the limestone. The lower beds of limestone abound in fossils, mainly *Orthis carbonaria;* also contains *Retzia punctulifera, Rhynchonella Osagensis, Athyris subtilita, Productus splendens, Schizodus.* The upper beds abound in *Fusulina cylindrica* and *Athyris subtilita;* also contain *Hemipronites crassus, Orthis carbonaria, Spirifer* (*Martinia*) *planoconvexus,* and *Crinoid* stems.

Sec. on King's hill, below St. Joseph, is as follows:—

No. 1—72 feet bluff formation, finely comminuted marly clays.

2—8 feet sand.
3—2 feet white, calcareous, concretionary bed. } Bluff.

4—7 feet irregularly-bedded limestone; abounds in *Fusulina cylindrica,* also contains *Athyris, Retzia, Orthis carbonaria;* cherty. No. 150.

5—19 feet slope.

6—5 feet shales.

7—7 feet deep-brown limestone (No. 143), upper 2 feet shaly, light drab; below is ferruginous, and contains but few fossils—*Chonetes, Hemipronites, Aviculopecten, P. splendens.*

8—35 feet slope; tumbled sandstone, at lower part containing plants—*Lepidostrobus,* etc.

9—8 feet shales, bottom 2 feet green, with 1½ feet red just above.

10—7 feet ferruginous limestone, upper 2 feet shelly, with iron-oxide crust. No. 137.

11—48 feet slope, mostly shales; in lower shales are some iron-stone concretions.

12—Outcrop of shaly limestone, abounding in fossils.

13—5 feet shaly slope.

14—10 feet red and green clay shales ; at bottom we find 4 feet of ochrey green clay, with occasional thin bands of yellow ochre concretions, and streaks of ochre.

15—4 feet limestone.

16—30 feet shales.

A buff limestone, equivalent to No. 143, was observed on King's hill ; No. 137 is seen on Platte River bluffs, two miles south of Hannibal & St. Jos. Railroad, cropping out 10 feet in thickness, and containing *Myalina*, *Aviculopecten*, *Pinna*, *Athyris subtilita*, *Productus Rogersi*, *Bryozoa*. Just below the last-named rock is 80 feet slope, which is probably nearly all shales. On the Missouri bluffs these shales are 60 to 76 feet in thickness, with sometimes a thin seam of coal. Near the upper end of Sugar Creek Lake we have—

No. 1—Top slope.

2—18 feet of limestone, fracture buff and drab, weathering brown ; contains occasional lenticular beds of concretionary deep-blue chert ; has brown shaly partings, and contains *Athyris subtilita*, *Sp. lineatus*, *Sp. cameratus*, *Retzia punctulifera*, *Chonetes*, *Prod. Rogersi*, *Allorisma granosa*, *Pleurotomaria*, *Crinoid* stems, *Macrodon* and *Fusulina cylindrica*.

3—77 feet shaly slope ; shales near the lower part.

4—Outcrop of coal.

5—40 feet slope to railroad.

Three miles above Rushville we have—

No. 1—Limestone, No. 150.

2—95 feet slope.

3—4 feet even-bedded, shelly, dark ash-colored limestone (128), at about 25 feet above the grade of railroad, and forming a fine waterfall (Fig. 105).

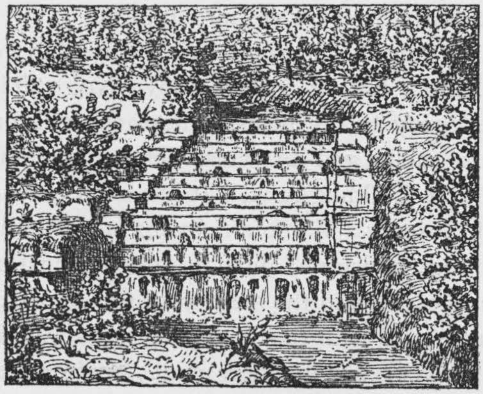
Approaching St. Joseph from the south, we find the last-named limestone quarried near the foot of the hill, and also north-west on King's hill, and in the next succeeding hill it is seen 30 feet above the bottoms, with 30 feet of shales lying below it.

Section 31, 2½ miles below St. Joseph, is as follows :—

No. 1—72 feet bluff clay ; contains some round calcareous concretions.

No. 2—6 feet sandy shale.

Fig. 105.



OUTCROP OF No. 128.
12 MILES SOUTH OF ST. JOSEPH.

No. 3—5 feet limestone, upper part shelly, ferruginous, lower 3 feet thick, even bed; can be quarried in 2-feet layers.

No. 4—53 feet slope.

No. 5—5 feet shales.

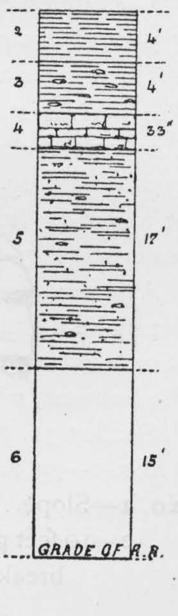
No. 6—5 feet shales, good red ochre at bottom.

No. 7—4 feet even bed of limestone.

Our section, ½ mile below junction of Hannibal & St. Joseph Railroad, is as follows (Fig. 106):—

Fig. 106.

SECTION 32
BUCHANAN CO.



Sec. 32.

No. 1—Bluff.

2—4 feet red shales; paint-bed.

3—4 feet green and yellow ochrey shales.

4—33 inches limestone, upper part gray; the middle abounds in *Fusulina;* lower part deep brown, middle is fine grained.

5—17 feet sandy, ochrey shales.

6—15 feet slope to railroad.

One-quarter mile below the last we find—

No. 1—Outcrop of shaly limestone, with *Allorisma, Hemipronites crassus, Astartella vera, Nuculana bellastriata, Myalina subquadrata, Bell. Kansasensis.*

2—15 feet slope.

No. 3—Red and green shales.

4—4 feet limestone = 128 ; very good building-rock.

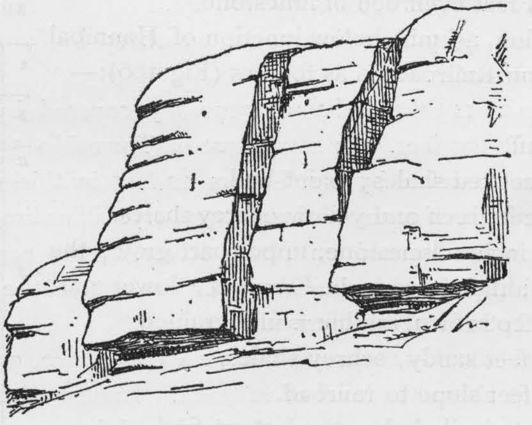
5—30 feet shales, to level of railroad grade.

The general section at King's hill will be found in general report.

Ascending King's hill, at 63 feet above No. 128 is found 7 feet of thick-bedded gray and brownish limestone, with but few fossils. Its upper part is shelly and brownish ochrey, but affords a good, strong and durable building-rock. It has been extensively used in buildings at St. Joseph. We found overlying it tumbled masses of buff and brown soft sandstone, and hard green sandstone, containing remains of plant-leaves and the stem of a tree, probably a *Lepidostrobus.* Intermingled with this overlying mass was some deep-red clay, apparently very suitable for paint; sixteen feet still higher is found 7 feet of ferruginous limestone, and 24 feet above the last are seen outcrops of No. 150. All these layers have been extensively quarried for various purposes of building in St. Joseph. The last named is quarried in the hills north of St. Joseph for lime and for paving.

One and a half miles along the bluff above St. Joseph our section is this :—

Fig. 107.



OUTCROP OF No. 137.
ABOVE ST. JOSEPH, BUCHANAN CO.

No. 1—Slope.

2—10 feet gray limestone, slightly ferruginous, in one solid bed ; breaks in small angular fragments. No. 137. (Fig. 107.)

No. 3—92 feet slope to railroad, 35° for half way, then 30°; the lower 40 feet seems to be principally sandy shales.

No. 2 corresponds to No. 143; in its manner of weathering resembles No. 78. Three miles above St. Joseph it is 90 feet above No. 128.

At bridge on Platte River, rocks were observed, which I refer to those from 126 to 121, of which the following is a correct section :—

Sec. 4.

No. 2—6 inches even-bedded, dark-gray limestone; contains *Sp. cameratus*, *Athyris subtilita*, *Nucula*, *Fusulina cylindrica*, *Bryozoa*.

3—6 feet brownish-buff, sandy limestone, some of it silicious, and with sandy shaly partings—thin bedded.

4—2½ feet green shales.

5—10 inches limestone, mottled drab and brown; contains *Myalina* and *Allorisma*.

6—1 foot grayish drab and brown, irregularly bedded, coarser than No. 5;—irregularly wavy-cracked.

7—2 feet gray limestone; contains *Archæocidaris*.

8—3 feet ashy-blue, ferruginous limestone, weathers brown; contains *Pr. splendens*, *Athyris subtilita*, a coral *Bryozoa*, *Crinoid* stems, *Bellerophon*, etc.

9—3 feet ashy-blue limestone, weathers buff; contains *Sp. cameratus*.

From 120 to 113 the rocks are generally covered by débris, and include about 100 feet. In south-east of Township 55, Range 34, No. 112 was observed by Mr. Ulffers 12 feet in thickness, consisting of thick beds of coarse, colored, semi-crystalline limestone. The lowest rock was observed on Platte River, in the eastern part of the county; it is a blue limestone, equivalent to the Plattsburgh series; 12 feet of it was observed.

Minerals.—Coal.—Opposite Sugar Creek Lake, coal crops out about 30 feet above the level of railroad. Limestone No. 150 is in bluff 77 feet above. The same bed of coal is seen a mile below Hall's Station, on Mr. Hinman's land. Section here is Sec. 19 :—

No. 1—104 feet slope from hill-top.

2—5 feet drift.

3—3 feet blue, sandy shales.

3½—3 feet coarse, shaly, ferruginous sandstone.

No. 4—1 inch shaly coal.

5—8 inches deep-blue, shaly clay, with thin laminæ of coal; contains ferns.

6—6 inches coal.

7—Fire-clay.

8—67 feet to foot of hill.

OPPOSITE HALL'S STATION, the coal has been opened at several places; one on railroad land, worked by Jacob Gross, appears thus:—

3 feet rough-bedded, yellow sandstone.

8 inches sandy clay.

1¾ inches shale and thin laminæ of coal.

2½ inches coal.

1½ inches blue clay.

6 inches good coal.

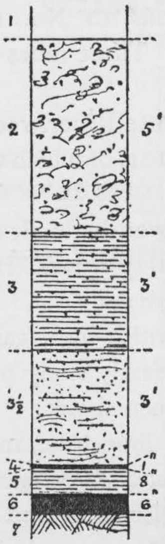
1½ inches blue clay.

3 inches good coal.

Fire-clay.

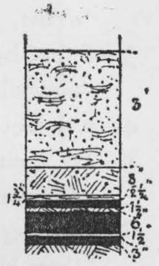
Fig. 108.

104 feet to hill-top.



SECTION 1 MILE BELOW HALL'S STATION

Fig. 109.



SECTION OPPOSITE HALL'S STATION

BUCHANAN CO.

An analysis of a specimen of this coal, from Niagara, Andrew County, gives—

Water	8.94
Volatile	34.75
F. carbon	45.38
Ash	10.93

Color of ash, light-red brown.

Section No. 30:—

No. 1—93 feet 40° to 45° slope.

2—Limestone outcrop.

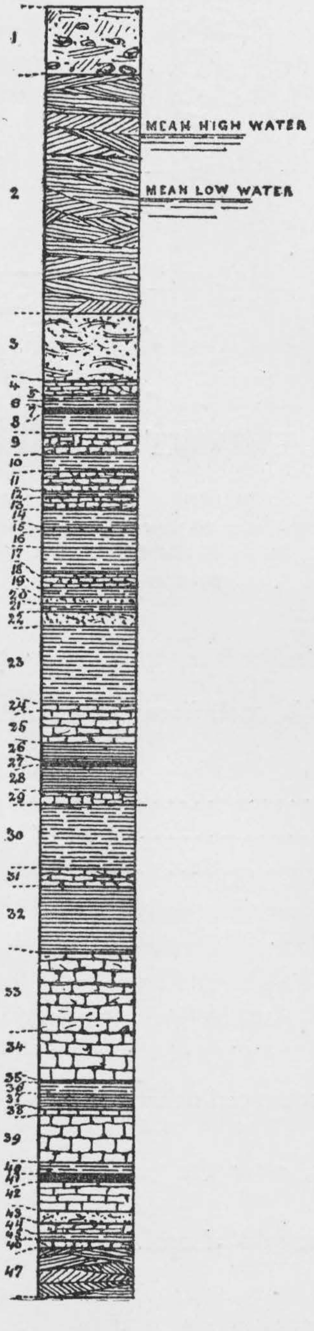
3—52 feet to bottom of coal; some red ochrey clay appears on slope 8 feet above coal.

On south fork of Sugar Creek, near the south county line, Sec. 24:—

No. 1—3 feet olive shales, with streaks of coal.

23

Fig. 110.
SECTION
OF BORING AT ST. JOSEPH.
BUCHANAN CO.



No. 2—7 inches bituminous coal.
3—26 feet shales; concretionary bed in lower part, with remains of striated plants.
4—15 to 20 feet slope.
5—Outcrop of ferruginous limestone; fracture dark bluish, ash shelly, and rough breakings.

In the north-east of the south-west of Sec. 1, T. 55, R. 26, Mr. Ulffers observed 6 inches of shaly coal and shales.

Mr. P. C. Swallow observed 4 inches of bituminous coal in Sec. 23, T. 45, R. 36, and in Sec. 32 coal is also said to have been found, on the head-waters of Bee Creek, a few miles south-west of Sparta. These beds are thin and poor, and not worth working.

Annexed is a section and description of the boring at St. Joseph. The first coal from the top is no doubt equivalent to No. 123 of Gen. Sec. The next coal below, marked 1½ feet, must be equivalent to No. 118. The lowest, marked 2½ feet, is probably near No. 98, more likely below that member. Considerable thickness of bituminous shale may be included.

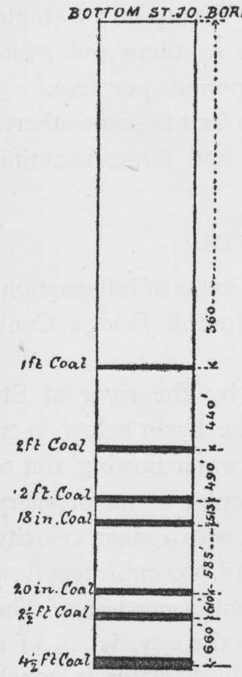
The annexed is the section of boring at St. Joseph:—

No. 1—21 feet soil, bowlders and sandy clay.
2—74 feet blue clay.
3—21 feet sandstone.
4—4 feet limestone.

No. 5—2 feet soapstone.
6—2 feet slate.
7—1$\frac{5}{6}$ feet coal.
8—6 feet black slate.
9—7 feet limestone.
10—5 feet slate.
11—6 feet limestone.
12—2 feet slate.
13—4½ feet limestone.
14—5½ feet slate.
15—1 foot limestone.
16—6 feet slate.
17—8 feet slate.
18—4½ feet limestone.
19—3 feet soapstone.
20—2½ feet gray sandstone.
21—2½ feet soapstone.
22—4$\frac{5}{6}$ feet gray limestone.
23—24 feet slate.
24—2 feet limestone.
25—10 feet limestone.
26—5½ feet slate.
27—1½ feet coal.
28—8 feet slate.
29—4 feet limestone.
30—20 feet shale.
31—6 feet limestone.
32—20 feet slate.
33—25 feet limestone.
34—15 feet limestone.
35—10 inches coal.
36—3$\frac{4}{5}$ feet soapstone.
37—4½ feet slate.
38—1½ feet limestone.
39—15 feet limestone.
40—3 feet soapstone.
41—2½ feet coal.
42—9 feet limestone.
43—4 feet sandstone.

No. 44—3 feet limestone.
45—2½ feet slate.
46—2½ feet limestone.
47—15 feet blue clay.
Total depth, 402.3 feet.

Fig. 111.



SECTION SHOWING POSITION OF COALS BELOW BOTTOM OF ST. JOSEPH BORING.

In the above section I have retained the same descriptive names of strata as on the section furnished to me.

From careful comparisons of my sections, I find that the bottom of the "bore" still lacks about 440 feet of reaching the "Lexington coal," which would be the first coal of any considerable thickness that would be reached. Other valuable coal-beds would lie still lower. Annexed is a section commencing at bottom of St. Joseph "bore" and extending downward, showing the depth at which certain coals would be reached and the thickness of the seams.

These remarks concerning coal-beds can be applied, with but slight variation, to localities in the adjoining counties of Platte, Clinton, Dekalb, and southern parts of Gentry County. In each of these counties thin surface outcrops are seen, but they are not valuable.

Soil.—The soil in this county is generally rich. Poor land occupies a small part of the area. On the west side of Platte River, above Agency Ford, the soil on some of the higher ridges is rather thin, and we here occasionally see chinquepin oak and black oak. We also find it in the southern part of the county. West of Platte River is white oak, black oak and chinquepin oak. In the other portions of the county the soil is very rich, and there is probably but little difference between the several qualities of land. The soil on the uplands varies in depth from one to two and a half feet. Near the prairies we find plum, cherry, sumach, elm and hazel.

Agriculture.—During a few years previous to 1861, wheat did not yield as well as formerly. In good seasons 20 to 25 bushels per acre have been raised, and in the south part of the county 35 to 40 bushels are said to have been raised: 20 to 25 bushels may be said to be a very good average. Of corn, 60 bushels are generally raised, and during good seasons, and with proper care, 70 to 80 bushels per acre can be easily raised. Potatoes, rye, oats, barley, Hungarian grass and spring wheat grow well. Hemp is the staple crop, and the rich elm and linden lands in the southern and western parts of the county will readily yield 1,000 pounds per acre.

Fruit.—This county is not so well adapted to fruit as some others. Blue grass grows everywhere spontaneously, and forms beautiful green pastures.

ST. JOSEPH BRIDGE SURVEYS.

Before closing, I would add a few interesting items of information, chiefly obtained from the Reports of "St. Joseph Bridge Company." *

The annual rain-fall in the basin drained by the river at St. Joseph averages 19½ inches, while that of the basin below is 26 inches, thus showing that three-fourths of the water flowing out of the Missouri River at its mouth passes St. Joseph; at an ordinary spring flood 170,000 cubic feet pass in a second, with a mean velocity of $3\frac{8}{10}$ miles per hour, while at low water but 18,000 cubic feet flow in the same time, with a mean velocity of $2\frac{6}{10}$ miles per hour. The fall in the low-water channel, for 7 miles below the city, is $\frac{82}{100}$ of a foot per mile. The axis of the current at high water is much shorter than at low water, and has a fall of over one foot per mile. At low water the channel opposite the city is from 400 to 500 feet wide, and 15 to 30 feet deep. The difference of high and low water is 23 feet.

At the greatest flood, the narrowest channel opposite the city will be 1,420 feet wide. Rock is found at an average of 43 feet below low water, and at no point deeper than 48 feet.

The bed of the river is fine sand on top, with layers of stiff, hard clay and coarse sand near the bed-rock; resting on the bed-rock was found a 2 to 5 feet bed, consisting of medium-sized and thorough-

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* Rep. of Prelim. Surv. of Missouri River in vicinity of St. Joseph. E. D. Mason.
1st An. Rep. Ch. Eng. St. Joseph Bridge, 1872.
Desc. Method of Founding Piers, etc. W. S. Pope, 1872.

ly water-worn bowlders mixed with coarse sand ; the bowlders composed of red and gray granite, quartz, gneiss, trap, conglomerate, agate, with some fine quartz specimens containing gold. Some specimens of conglomerate shown me seemed to be of smoothly-rounded pebbles firmly cemented with river-sand. At a depth of 40 feet pieces of brick and fragments of coal have been taken out, showing that, in comparatively recent times, the scour has reached that depth.

The excavations were made to a depth of about 40 feet below the bed of the river, including the upper 30 feet of coarse and fine sand, then 5 feet stiff, blue clay, and lastly a deposit of gravel and bowlders, through which flows a stream of clear, pure water, entirely different from that of the river. While ice at the surface was 2 feet thick, and the mercury below zero, the water from this spring had a uniform temperature of 54 degrees.

The bed-rock is said to be a smooth, hard, whitish-gray limestone. I have no doubt of its being equivalent to limestone No. 121 of my General Section.

A partial survey of this county was made by me in 1871.

CHAPTER XIII.

GEOLOGY OF HOLT COUNTY.

BY G. C. BROADHEAD.

Topography.—The Missouri bottoms occupy more than one-third of the area of the county, and above T. 60 they are at least 10 miles in width. Southward they are narrower. The bluffs attain a height of from 125 to 200 feet, with occasional intervals of low hills. After leaving the Missouri bluffs about two miles, the country becomes less hilly, and soon passes into a beautiful rolling country. From the mouth of the Nodaway river, for ten miles north, the adjacent hills are high and the country broken.

The hills in the north-east part of the county are low, with a gently-undulating surface. Near Squaw Creek, Davis Creek and Tarkio, the hills have gentle slopes, with often marshy bases leading into the adjacent narrow bottoms. By the burrowing of gophers the bottoms of Squaw Creek and a few other streams are rendered dangerous for horses to pass over, and their banks are so steep and marshy as to render them impassable, almost, as far up as their sources.

Timber and Prairie.—South of Oregon the country consists mostly of timbered land. The Missouri bottom is about one-half timber and one-half prairie.

Near the streams in the northern part of the county but few trees are seen, and they are generally either of small growth or shrubs. On the banks is sometimes a fringe of willow, white maple, American elm, box elder, greenbrier, grape and *Cornus*. On the bottoms, black walnut, honey locust, coralberry, chokeberry, red and American elm, wahoo, sumach, *Cornus* and gooseberry occur.

The following is a list of trees and shrubs in this county :—

Crabapple, white ash, prickly ash, blackberry, bladdernut, buckeye, box elder, button bush, black cherry, choke cherry, coffee-tree, cottonwood, *Amorpha canescens*, *Am. fruticosa*, coralberry, *Cornus sericea*, *Cornus asperifolia*, gooseberry, hackberry, hazel, shell-bark hickory, thick shell-bark hickory, pignut hickory, iron-wood, honey locust, white maple, mulberry, linden, chinquepin oak, sarsaparilla, burr oak, rock-chestnut oak, scarlet oak, red oak, pin oak, pawpaw, Am. plum, rose, *Rosa lucida*, red bud, sycamore, sumach, poison oak, thorn, black walnut, red root and wahoo.

Streams and Springs.—Those streams flowing toward the Missouri run constantly. Those in the north are long and narrow, with steep and often marshy banks. Springs often issue from the base of the hills, and the lesser valleys often spread out into grassy marshes.

The streams making toward the Nodaway River do not flow during the whole year. Good springs are common along the Missouri bluffs. The supply of water in the running streams is sufficient for milling purposes during the greater part of ordinary seasons. The Nodaway is a deep stream, and always contains a large supply of water, affording ample power for milling.

Geology.—The formations include the quaternary and the Upper Carboniferous rocks.

Quaternary.—The alluvium is well developed on the banks o the Missouri, where it was observed 16 feet in thickness, composed of alternations of sand, clay and vegetable mould. The following section was made below Jones's Point :—

No. 1—2 feet comminuted sand and vegetable mould, with roots.

2—1 ½ feet dark clay, ferruginous stained ; contains *Helix*, *Pupa*, *Succinea*, etc., with roots.

3—8 feet sand ; roots occur in the upper part ; sand fine in the upper portion, coarse below.

4—2 feet brown sand ; contains a thin, dark seam, with fragments of coal.

5—2 feet dark sand.

In ponds on the Missouri bottoms I obtained *Physa*, *Succinea*, *Planorbis*, *Unio ;* many of them being intermingled with dark clay.

The **Bottom Prairie** is extensive, and consists for the most part of dark clay.

The "Bluff" forms a deep deposit on all the hills ; and on the hills and slopes near the Missouri bottoms it is very much blended with the soil. Its greatest thickness is probably more than 100 feet.

The Drift is but sparingly developed in this county.

Upper Carboniferous Rocks.—The rocks in this county belong to the upper and middle divisions of the Upper Coal-measures, and include a thickness of probably about 400 feet, three hundred feet cropping out in the Missouri bluffs, below the mouth of Nodaway River, and in the vicinity of Forest City, and about 45 or 50 feet in the northern part of the county, with a gap of probably 50 feet, or thereabouts, not seen in the bluffs for eighteen miles above Forest City. The northerly dip is light, the prevailing inclination being westward. If the rocks should preserve the same inclination of the Atchison strata, we might supply the gap (no rocks seen) by 160 feet. These figures would increase our vertical section 100 feet—too much to include without more positive evidence of the fact. Our sections of rocks seen in the county, near Nodaway River, at various points from its mouth to the north county line, include from No. 146 to No. 212, including 283 feet. On the Missouri River bluffs, to a point two miles north of Forest City, we find 35 feet more of additional rocks. These will include 121 feet of limestone, 10 inches of coal, 8 feet of bituminous shales, 40 feet of sandstone or sandy shales, 20 feet shales with limestone nodules, 38 feet clay shales; balance of space no rocks were seen. As the county section is embraced in detail in general section of the Coal-measures, I will omit it here, and in the description of the beds will refer by number to those in the General Section.

At McGuilliam's Mill, on the Big Tankei, at the edge of the Missouri bottoms, in south part of T. 63, R. 40, we find outcrops as follows:—

Sec. 80.

No. 1—Top slope.

2—1 foot blue limestone, in even layers; rings under the hammer; contains *Naticopsis*, *Fusulina*, and *Crinoid* stems.

3—23 feet gentle slope; flags of sandstone, abounding in *Pr. Prattenianus*, appear 5 feet below the top; lower down I observed nodular limestone.

4—2 feet limestone; fracture grayish blue; weathering brown. Fossils contained are *Meekella*, *Chonetes*, *Allorisma*, *Pr. semireticulatus*, var. *Calhounianus* (Sw.), *Naticopsis*, *Pinna peracuta*.

No. 5—3 feet shales, a little greenish.
6—2 feet red shales.
7—14 feet mostly sandy shale.
8—21 feet in well to shaly limestone.

From this place to within two and a half miles of Forest City no outcroppings of rock were seen.

After crossing Kimsey's Creek we again find outcrops of rocks. The following is a section one mile and a half above Forest City:—

No. 1—160 feet slope.
2—16 inches bluish-gray limestone, weathering brown; lower part weathers dark gray; a 5-inch blue bed at bottom; apparently contains a good deal of carbonate of iron; is heavy, hard and tough; fossils observed were a few univalves. No. 220.
3—2 feet blue-clay shales.
4—5 feet shaly slope.
5—17 inches hard, dull-blue limestone, sometimes weathering with a brown-ochre crust, which is often over an inch thick; contains some fine fossils, viz., *Pr. Prattenianus, Allorisma granosa, Schizodus curtus, Syntrilasma hemiplicata, Aviculopecten, Entolium aviculatum, Bellerophon Marcouanus, B. percarinatus, Pleurotomaria* like *P. carbonaria, Macrocheilus, Euomphalus rugosus,* and *Aviculopinna Americana;* a *Syntrilasma* from this place has its interior replaced by calcite, traversed by minute veins of zinc-blende. No. 218.
6—10 inches shaly sandstone.
7—2 inches coal.
8—2 feet light-blue, clay shales; ochrey at top.
9—5 feet drab sandstone.
10—5 feet drab, argillaceous shales.
11—12 feet slope.
12—3 feet dark, greenish-drab and olive, argillaceous shales.
13—5 feet 2 inches alternations of thin beds of limestone and brown calcareous shales, abounding in *Fusulina, Athyris* and other fossils. No. 210.

The lower member of the above section can be easily traced, along a terrace, from the upper end of Forest City to the eastern limit of town, and below. The underlying beds of limestone being quarried at many places, leaves it well exposed. It abounds chiefly in *Fusulina cylindrica*, which are often weathered out, and can be collected by the handful, resembling so many wheat-grains. At the upper end of Forest City these beds appear thus :—

No. 1—Shales.

2—3 inches shelly and nodular limestone.

3—1 ½ feet of brown shales and concretionary limestone nodules.

4—10 inches rough, concretionary bed of limestone.

5—10 inches of shales.

6—Even bed of blue limestone; *Athyris subtilita* abounds in upper part, *Fusulina* in the middle, Bryozoans and corals (*Rhombopora*) throughout; other fossils observed were a large variety of *Hemipronites crassus*, *Pr. symmetricus*, *Pr. semireticulatus*, *Pr. Nebrascensis*, *Retzia punctulifera*, *Spr. cameratus*, *Crinoidea* and *Fistulapora nodulifera*.

Sec. 66, at the lower end of Forest City :—

No. 1—Bluff.

2—3 feet nodular limestone and *Fusulina* shales of No. 210.

3—10 feet shales, upper 2 feet ash-colored, middle 4 feet mottled gray and yellow, lower 3 feet gray shales.

4—1 ½ feet ash-blue limestone, weathering brown. No. 199.

5—2 to 10 inches yellow shales, gray streaked.

6—1 ½ feet brown limestone. No. 197.

7—7 feet yellow shales.

8—2 ½ feet greenish-drab sandstone, rather soft; has been very much used at Forest City; is rather too soft for outdoor work, but for inside work is very suitable; a sink made of it, in which water has almost daily been placed for twelve or fifteen years, shows no perceptible integration; Mr. Joel Balwin has a mantle made entirely of it, which was put up in 1858, painted in 1860, and is sound yet; but the same stone used in the floor of his fireplace had softened, though the jams were still firm; from the base of the sandstone outcrop to the railroad is about 22 feet.

The sandstone above named occasionally crops out on the bluffs for several miles below Forest City. The best building-rock for ordinary purposes, near and in Forest City, may be found fifteen or twenty feet above the sandstone, and just below the horizon of No. 210.

Sec. 65, one half of a mile below Forest City:—

No. 1—77 feet bluff.

2—1 foot brown, shelly limestone.

3—10 feet slope.

4—1 foot brown limestone, jointed, No. 218; the fossils are *Entolium aviculatum*, *Syntrilasma hemiplicata*, *Solenopsis? Polyphemopsis peracuta*, *Poly. inornata*, *Macrocheilus*.

5—32½ feet slope; shaly sandstone is seen 4 feet from top.

6—4 feet brown shales and nodular limestone, with many fossils. No. 210.

7—1 foot ash-blue limestone, good for ordinary building. No. 209.

8—1½ feet blue shales.

9—13 inches blue limestone; a useful building-rock; may be found in all bluffs above and below Forest City for several miles; its principal fossils are *Productus Nebrascensis* and *Hemipronites crassus*, whose interior is generally replaced by clear calcite.

10—59 feet to railroad.

In Forest City the last-described limestone may be found at 35 to 40 feet above the level of the railroad track.

Sec. 55, on Sedwick and Took's land, Missouri bluffs, one mile and a half below Forest City:—

No. 1—Slope from hill-top.

2—1 foot brown or shelly limestone; contains *Hemipronites crassus*, *Pr. Prattenianus* and *Fusulina*.

3—4 inches hard, bluish-gray, spathic limestone. No. 220.

4—4 feet slope.

5—18 inches jointed and splintery limestone, color blue, upper part abounding in *Entol. aviculatum*, *Pr. Prattenianus*, etc.

6—4 feet shales.

7—16 inches sandstone.

8—30 inches bituminous slate.

9—8 inches ochrey, sandy clay.

10—4 inches coal; a few stellate forms of gypsum? on surface.

11—26 feet slope.

12—14 inches blue limestone; contains *Hemipronites crassus* and *Pr. Nebrascensis*; good building-rock. No. 209.

13—15 feet slope.

No. 14—1½ feet blue, shaly limestone. No. 199.

15—23½ feet slope.

16—3 feet ash-blue limestone, containing *Pr. splendens.* No. 186.

17—29 feet to railroad.

On the west side of Mill Creek 16 feet of limestone (No. 186) appears in the bluff, its base at 26 feet above the railroad. Further west it is not often seen, but it occupies the base of the bluff one mile below Forest City. Following the river-bluffs eastward, we find it gradually rise, until we reach the Nodaway River, where it is found as the highest rock seen, more than 160 feet above the bottoms. One mile below the point where Mill Creek enters the bottoms, we find the following section :—

No. 1—Bluff slope.

2—5 feet slope, with tumbling masses of nodular, brown and drab limestone ; contains *Chonetes*, *Retzia punctulifera*, *Pinna peracuta*, etc.

3—19 inches hard, bluish-drab limestone, somewhat mottled and spotted with ferruginous stains, which seem to occupy the outline of fossils ; contains *Allorisma.*

4—4 feet slope.

5—16 feet hard and tolerably fine-grained, bluish-gray limestone ; weathers with a rough, sandy appearance.

6—1 foot brown, shaly limestone ; contains *Pr. Nebrascensis*, *Pr. Prattenianus.* No. 199.

7—2 feet brown and blue shales, containing *Archæocidaris* and *Athyris subtilita.*

8—1½ feet brown, shelly limestone. No. 197.

9—2 feet brown, calcareous shales, containing *Athyris subtilita*, *Spr. cameratus*, *Pr. Nebrascensis* and *Archæocidaris.* No. 196.

10—3 feet greenish-buff shales.

11—2 feet coarse, green, micaceous sandstone. No. 195.

12—5 feet slope 45°.

13—1 foot blue limestone.

14—9 feet 20° slope ; a spring issues from this slope.

15—4 feet bluish and somewhat ash-colored limestone, fine grained and brittle ; contains *Spr. cameratus* and *Pr. splendens.*

One mile above Forbes the following section is exposed :—

Sec. 51.

No. 1—50 feet bluff.

2—20 feet sand, clay and bowlders.

3—18 feet clay, with large masses of sandstone, apparently near their proper place, for they are not much worn.

4—1 foot hard, deep, ash-blue limestone, with brown specks; contains *Athyris subtilita* and *Myalina subquadrata*.

5—4 feet shales and calcareous nodules, with *Athyris subtilita* and *Pr. Prattenianus*.

6—2 feet hard, tough, coarse-grained limestone; weathers brown, with a coarse, sandy appearance. No. 199.

7—5 feet shales and outcrops of brown, shelly limestone, containing *Athyris subtilita*, *Pr. Nebrascensis*, *Spr. cameratus*, *Pr. punctatus*, *Rhombopora* and *Fistulipora*.

8—16 feet slope; blue limestone at bottom.

9—5 feet shaly slope, on a terrace 25 feet in width, with outcrops of limestone at lower part.

10—15 feet limestone. No. 186.

11—4 feet slope.

12—1½ feet limestone, very good for building; even layers.

13—7 feet slope.

14—5 feet outcrop of buff and brown limestone.

15—39 feet to terrace.

16—16 feet slope to railroad.

Hill 209 feet high.

Rocks similar to those last named occur at Forbes. Below Forbes there are but few outcrops for three or four miles. One half of a mile below Forbes No. 160 is seen, resting on 15 feet of sandy shales, the latter extending to the railway below. Two miles farther down No. 154 crops out near the railroad, 3 feet thick, and appears to be a good rock for common building purposes.

Sec. 48. This is seen on Missouri bluffs one half of a mile west of Nodaway River.

No. 1—Slope; at lower part are yellowish limestone nodules.

2—10 inches hard, firm, dark ash-gray limestone.

3—44 feet slope.

4—13 inches even-bedded, brownish-gray limestone. No. 152.

5—17 inches gray, friable limestone. No. 152.

No. 6—3 feet brown, nodular limestone and shales. Top of No. 150.

7—6 feet gray, brown and drab limestone; calcite (in stalactic form) in joints; fossils are a *Myalina* on top, *Pr. Nebrascensis* in middle; contains also *Pr. punctatus, Macrocheilus, Athyris* and *Solenomya.*

8—Includes fossils lying on top of No. 9, viz.: *Pr. costatus, Spr. cameratus, Spr. Kentuckensis, Athyris subtilita, Fusulina cylindrica, Rhombopora lepidodendroides* and *Fistulapora nodulifera.*

9—16 feet 9 inches limestone in irregular layers of 4 to 10 inches, and 1½ feet in thickness, with buff, shaly partings; the fossils are *Pr. punctatus, Pr. Nebrascensis, Athyris, Allorisma, Spr. cameratus, Spr. lineatus, Bellerophon, Fusulina.* Bottom of 150.

10—3 feet olive shales to grade of railroad.

A good deal of rock has been quarried here, and used in bridge and culvert masonry on the railroad. No. 4 is undoubtedly a good rock, but the other members of the section would not rank as first-class material. No. 150 is last seen on Nodaway River, one mile from its mouth.

Ledges of No. 186 appear on the hill-top 140 feet above. Passing northward we find No. 186, resting on hill-top, as far north as the middle of T. 61. Further north but few outcrops were observed.

Some nice fossils are contained in the upper part of No. 186, in Sec. 3, T. 59, R. 37.

Near the head of Brockman's Branch No. 199 is found, containing some pretty fossils.

Section near the Mouth of Brockman's Branch:—

No. 1—25 feet slope.

2—8 feet irregularly-bedded limestone; weathers brown or buff, upper part a dark ash; corresponds to No. 186 of General Section.

3—58 feet slope, with fragments of limestone; at 28 feet from top is an outcrop of buff, earthy limestone.

4—30 feet slope, with fragments of sandy shales.

5—6 feet dark-olive, clay shales.

6—6 inches gray limestone; abounds in fossils.

No. 7—6 feet argillaceous shales; contains beds of septaria 6 inches thick; one is two feet from top, the other about the middle and a third near the bottom; abounds in *Producti*.

8—10 feet argillaceous shales, like No. 7; also containing three beds of septaria, the upper one 2 feet below the top, the next 1 foot lower, and the third is 2 feet below the second, each layer being about 2 inches thick.

Below, No. 2 of this section includes members not elsewhere recognized, but they are all important as connecting links in the General Section.

Section at Henry Kunkel's, on Nicholl's Creek, is as follows:—

No. 1—Slope.

2—5 feet shales.

3—2 inches green, fibrous "cone in cone." The specimens from this place are beautiful representations of this peculiar crystalline form. Sometimes the upper surface is weathered into beautiful miniature terraced cones.

4—1 foot limestone, abounding in fossils.

5—6 inches shales.

6—2 inches blue hornstone, full of fossil remains.

7—15 feet bluish-gray limestone, in irregular beds. No. 186.

Lower down the branch 2 feet of sandstone is seen, about 13 feet above No. 3 of the foregoing section.

Sec. 67, at A. Kunkell's Mill, on Mill Creek, near Oregon:—

No. 1—4 feet nodular limestone and shales, abounding in *Fusulina*, *Athyris* and a *Bryozoa*. No. 210.

2—16 inches limestone; abounds in *Pr. Nebrascensis* and *Hemipronites crassus*, the interior replaced by calcite. No. 206.

3—2½ feet of drab, thick-bedded shales. No. 205.

4—16 inches dark-green shales. No. 204.

5—8 inches green, nodular shales. No. 203.

6—16 inches yellow shales with green streaks. No. 202.

7—10 inches coarse, gray limestone. No. 201.

8—2½ feet light-gray shales, passing into blue below; contains rough limestone concretions. No. 200.

9—2½ feet ash-blue, rough-bedded, shelly limestone; weathers brown; the fossils are *Pr. Nebrascensis*, *Pr. Prattenianus*. No. 199.

No. 10—2 feet blue shales, shading to brown.
11—2 feet ash-blue limestone, weathers brown.
12—3 feet brown shales. No. 196.
13—4 feet sandy shales. No. 195.
14—1 foot bituminous shales. No. 194.
15—3 feet sandy shales or sandstone. No. 193.
16—21 inches gray sandstone. No. 192.
17—5 inches shales. No. 191.
18—6½ inches even bed of grayish-blue limestone, containing fine univalves. No. 190.
19—3½ feet blue shales. No. 189.
20—4 inches deep-blue limestone.
21—8 feet blue shales.
22—Limestone. No. 186.

The above section is the most complete that could be found of the beds between Nos. 210 and 186. Nos. 2, 16 and 18 are well exposed, and afford most excellent building materials. Mr. Kunkell's shaft (of which I will speak hereafter) commenced in No. 21.

Some of the upper members of the general section were concealed in the Missouri bluffs, at Forest City, but are well exposed on Rolling Branch, in the north-east part of the county, as follows :—

No. 2—Drab shales.
3—19 inches deep-blue limestone, in four beds, separated by shaly partings, the upper bed 8 inches, the next two 4 inches, and the lower 3 inches thick ; abounds in a species of *Lingula ; Pinna peracuta* and *Aviculopinna Americana* were also found ; this rock is of a dull, deep-lead blue, occurring in very even layers ; is valuable for flagging.

Two miles south of these outcrops we find beds referable to No. 199 and its correlations, as the following section shows :—

No. 1—1 foot soil.
2—6 feet drift.
3—4 feet greenish and buff calcareous shales.
4—6 inches firm bed of brown limestone.
5—1½ feet drab, calcareo-argillaceous shales.
6—3 feet ash-drab, compact limestone, in irregular beds and with shaly partings.
7—4 inches buff, shaly limestone.

No. 8—1 foot drab, calcareo-argillaceous shales.

9—2 inches brown limestone.

10—2½ feet ash-blue limestone.

ECONOMICAL GEOLOGY.

Coal.—No workable beds have yet been discovered in this county, and it is probable that none ever will be. High in the bluffs, near Forest City, a stratum is seen cropping out from two to four inches in thickness; this I refer to the bed near Nodaway River, in Nodaway County.

An analysis of this coal, by Mr. Chauvenet, from J. C. Smith's, near Quitman, Nodaway County, gives—

Water	3.53
Volatile	42.72
F. carbon	40.71
Ash	13.04
Color of ash	very light brown

At Yancton and near Rulo, in Nebraska, a bed of coal has been worked, and by judicious management it may repay tolerably well. Being only separated from Holt County by the Missouri River, it may at some future time be valuable to Missourians. This same bed crops out about ten miles below Yancton on the Iowa reserve. The following section was made at Yancton:—

No. 2—Brittle and somewhat shelly, ferruginous limestone, buff and gray; contains remains of univalves imperfectly defined.

3—2½ feet ferruginous limestone, reddish gray; weathers to brown.

4—1 foot shales.

5—1 foot thin-bedded, ferruginous limestone.

6—1 foot greenish-drab shales.

7—2 feet ferruginous limestone in thin beds.

8—3 feet bluish-drab, clay shales.

9—2½ feet purple and green, bituminous and argillaceous shales, containing ferns and other plants.

10—2 inches to 10 inches bituminous coal.

11—2 feet sandstone and sandy shales.

12—9 feet argillaceous shales.

13—8 inches carbonate of iron (ironstone), dove-color.

No. 14—4 feet clay or argillaceous shales, soft, dove or drab, to low water in Missouri River.

A specimen of coal, probably equivalent to the Yancton bed, obtained one mile below the mouth of the Big Nemaha River, at the Omaha Coal Company's mines, was analyzed by Mr. Chauvenet.

Water	4.93
Volatile	38.17
F. carbon	49.44
Ash	7.46
Color of ash	red-brown

These beds probably occur in the northern part of Holt County; if so, they are covered so deeply by the bluff as to be entirely concealed, and also too remotely removed to be available. The following is said to be a section of the strata penetrated in Mr. Kunkell's shaft and boring, one mile east of Oregon:—

Kunkell's Shaft and Bore.

No. 1—11 feet slate.
2—14 feet of limestone. No. 186 of Gen. Sec.
3—4 feet slate.
4—2 feet hard limestone. No. 184.
5—12 feet soft rock.
6—5 feet hard rock.
7—51 feet slate (shale).
8—2 feet hard rock.
9—5 feet slate.
10—5 feet hard rock.
11—4 feet slate.
12—1 foot rock.
13—12 feet "chalk" (?).
14—6 feet rock.
15—19 feet slate.
16—4½ feet rock.
17—10½ feet slate.
18—19 feet rock.
19—2 feet hard sandstone.
20—11 feet rock.

No. 21—2½ feet slate.
22—1½ feet rotten coal.
23—1 foot rock.
24—7 feet bituminous or sulphur slate, green.
25—½ foot iron pyrites.
26—13 feet slate, mixed with iron pyrites.
27—5 feet bituminous limestone.
28—1½ feet hard sandstone.
29—11¼ feet bituminous shale.
30—1½ feet sandrock.
31—4¼ feet slate.
32—11 feet slate.
33—1½ feet sandrock.
34—4 feet slate and sandrock.
35—1 foot sandrock.
36—8 feet slate and sandrock, half and half.
37—4 feet slate.
38—13 feet slate.
39—1½ feet sandrock.
40—32½ feet slate, sandy.
41—2 feet sandrock, soft.
42—3 feet slate, sandy.
43—1 foot sandstone, soft.
44—4 feet slate, soft.
45—1 foot hard rock.
46—7 feet slate.
47—½ foot rotten coal.
48—2½ feet slate and rock.
49—2 feet limestone.
50—1 foot slate, hard.
51—1 foot hard rock.
52—1 foot slate.
53—22 feet black rock.
54—1 inch coal, good.
55—8 feet black rock.
56—3 feet slate and rock.
57—10 feet slate.
58—1 foot sandstone.
59—2 feet slate.

No. 60—4½ feet slate and rock.
61—½ foot "sea-shells."
62—5 feet hard limestone.
63—4 feet limestone and slate.
64—12 feet hard rock.
65—1 foot slate.
66—5 feet limestone.
67—3 feet bituminous shale.
68—1 foot limestone.
69—5 feet slate.
70—1¼ feet poor coal.
71—¾ foot fire-clay.
72—1 foot limestone.
73—4 feet black rock.
74—6 feet slate.
75—2 feet hard limestone.
76—3 feet slate.
77—9 feet limestone.
78—2 feet slate.
79—6 feet rock and slate.
80—14 feet sandy, black limestone.
81—4 feet hard, white limestone.
82—124 feet mostly slate.
83—36 feet white, bituminous limestone.
84—4½ feet "good coal."

The shaft commenced in No. 189. The first coal of 2 feet is probably mostly bituminous shale, corresponding to the seam of coal and shale (No. 158) seen two miles north of Savannah, and represented by 5 inches of coal, at Wm. Barr's, six miles south-west of Savannah. His next, in descending order, is undoubtedly the equivalent of the coal on Niagara Creek, Andrew County, and in the Missouri bluffs, ten to twenty miles below St. Joseph. The boring terminated near No. 103, about 20 feet below the Plattsburgh limestone. (No. 108.)

The "4½ feet of coal" is more probably bituminous shales with a few intercalated seams of coal, as is seen by the specimens brought up and by my examinations. Five hundred feet more, or 1170 feet from the surface, would reach the first workable seam, or the Lexington coal.

At Forest City they would have to go about the same depth to reach workable coal.

Red Clay occurs on Tarkie, in south part of T. 63, at McGuilliam's Mill.

Grindstones.—The sandstone quarry at Forest City, although rather soft, affords a useful material for making grindstones ; it is a tolerably coarse-grained drab or gray sandstone, somewhat micaceous ; is easily quarried and works free. It is used for cappings, and door and window facings, and makes beautiful mantels and jams.

Quarries of Limestone.—There are many very good quarries near Forest City and for six miles south-east ; also on Mill Creek, Brockman's Branch and Nicholl's Creek. The texture of the stone is often fine-grained. No. 84, occurring about five miles south-east of Forest City, and on Brockman's Branch, would look well polished.

Timber.—The Missouri bottoms afford an excellent supply of good timber, including cottonwood, elm, linden, black walnut, hackberry, red oak, burr oak, honey locust. Good black oak, linden, hickory and burr oak abound on the hills in the south part of the county.

Soil.—Poor land is scarcely known in Holt County ; the broken hills near the rivers are sometimes poor, and on the prairie, between Squaw Creek and the Tarkie, the soil is rather thin.

Between Big and Little Tarkie, in T. 63, the soil is rich, and lies well for cultivation, excepting a broken strip, three-quarters of a mile in width, lying along the bluffs. A rich belt, one-quarter of a mile to one-half of a mile in width, of gently-sloping land, connects the bluffs, and extends from the north line of T. 62 to north line of T. 59. The "bluff" washed from the hills above is the principal ingredient in this soil. This land slopes off gently, and is capable of producing fine crops, and the steep hillsides, which have often 30° and 40° ascent, produce good crops of corn and wheat. South of Oregon, and lying between the Missouri bluffs and Nodaway River, the soil is based on the bluff and disintegrated limestone. The very broken country does not exceed a mile in width, while beyond, the rich, hilly, black-oak land extends for several miles. Then we have rich prairies and thicket-land. The southern portion is suitable for most crops. The upland prairies, toward the north and north-east of the county, are high, rolling, and rich, with fertile valleys between the hills.

The Bluff Knobs seem to have been left by Nature for vineyards. During recent years the wheat-crops have mostly failed. The bottoms produce from ten to fifteen barrels of corn per acre. Pumpkins and squashes grow very finely.

CHAPTER XIV.

GEOLOGY OF ATCHISON COUNTY.

BY G. C. BROADHEAD.

ATCHISON COUNTY lies in the extreme north-west corner of Missouri. It is bounded on the north by Iowa, on the east by Nodaway County, on the south by Holt County, and on the west by the Missouri River, which separates it from Nebraska. Its area is about 600 square miles.

Topography.—The bottoms of the Missouri, extending eastward across the Nishnebotna River to the bluffs beyond, range from four to eight miles in width, and include an area of 100 square miles. The hills east, for one or two miles, include a tract of country consisting of a number of groups of rounded hills, or knobs presenting a mammillary front, and rising 150 to 250 feet above the bottom-prairie. Eastward, and extending to the east line of the county, the country slopes gently to the streams ; the bottoms are tolerably wide and the uplands hilly and rolling. The Missouri bluffs are often very steep ; frequently sloping at an angle of 60°, often in every direction, they seem like miniature mountain peaks, and present a very picturesque appearance. The views from their summits are often very extensive and beautiful. Ascending them two miles west of Rockport, we see, to the northward, the wide Missouri bottom with its covering of tall prairie-grass, through which the winding Nishnebotna can be traced by its fringe of green. The prairies beyond stretch out beautifully, occasionally dotted with farms and fine fields of ripe corn. Across to the north-west appear the white houses of the town of Sonora, glistening in the sunshine, and giving a pleasant relief; beyond it is the timber near the Missouri river, and still further in the background arise, in bold relief, the hills of Nebraska. To the right and left the bare bluff hills extend in irregular, mountain-like elevations.

Timber and Prairie.—Near the Missouri are occasional tracts of heavy timber a mile or more in width. Along the Nishnebotna the timber is generally confined to the immediate vicinity of the stream ; the area of prairie-bottom therefore greatly exceeds that of the timber.

West of Linden is a large grove of timber, and southward along the bluffs there is considerable. In the neighborhood of High Creek are some groves of timber; eastward it is scarce, and groves are few and far between. One may sometimes travel ten to fifteen miles without passing near a single tree. Along the Tarkie streams are generally found a few small elm, box elder, willow, and *Cornus* trees. West of Big Tarkie, in the southern part of the county, we occasionally see small groves. The following is a list of trees and shrubs seen in this county: Crabapple, white ash, prickly ash, blackberry, box elder, wahoo, button bush, black cherry, choke cherry, coffee-tree, cottonwood, coralberry, elder, *Cornus sericea*, *Cornus asperifolia*, red elm, white elm, frost grape, river grape, Sioux grape, greenbrier, gooseberry, hackberry, *Amorpha fruticosa* (false indigo), lead plant, bladder nut, hazel, *Cassia Marylandia*, hawthorn, hickory (shell-bark and thick shell-bark), pignut hickory, bitternut hickory, ironwood, honey locust, white maple, mulberry, burr oak, linden, chinquepin, red and pin oak, paw-paw, plum, *Rosa setigera*, *Rosa suieda*, raspberry, red bud, sycamore, sumach, poison oak, Virginia creeper, black walnut, willow, red root.

On the prairie we have high grass, and in the proper season a rich flora ; but in October, 1860, at the time of my first visit, the blossoms had faded, and the beautiful *Gentiana puberula* was almost the only plant remaining in bloom. On my second visit, in June, 1872, I observed several rare and beautiful plants growing upon the mounds, including *Yucca augustifolia*, *Pentstemon grandiflora*, *Œnothera serrulata*, and *Oxytropis Lamberti*.

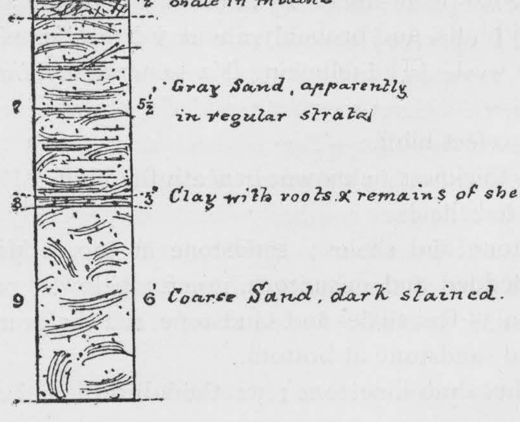
Streams and Springs.—The Nishnebotna enters the county on the north, passes within a quarter of a mile of the Missouri, thence sweeps off in a devious southerly direction, generally near the Missouri bluffs, and from four to eight miles from the Missouri River, to the south part of the county, where it unites its waters with the great Missouri ; it can be forded at only a few places in extremely dry seasons.

Within a few years prior to 1872 the builders of the Kansas City, St. Joseph and Council Bluffs R. R. have turned this river into the Missouri River at the north line of Atchison County, so that at present the old channel is limited in its supply of water. This stream abounds in fish, fresh-water shells, mostly of the genus *Unio*, including *U. teres*, *U. lachrymosa*, *U. triangularis*, *U. rectus*, *U. alatus*, *U. heros*, etc. The banks of the Tarkies are steep, and often too marshy to be easily forded. All the streams are clear and running. On Rock Creek are three mills, which run during the whole season. At Rundell's mill the water is conveyed in troughs from a neighboring spring, and falls on a wheel placed above the building, which turns the machinery within. Springs abound everywhere near the creeks and along the Missouri bluffs, generally issuing about one-third way up the bluffs.

GEOLOGY.

Quaternary Deposits.—The ALLUVIUM includes the soil and recent river deposits; it appears to be composed of alternations of clay, sand, marly clay-beds and vegetable mould. The following section was taken on the bank of the Missouri River, at North Star Landing, opposite Brownville :—

Fig. 112.



No. 7 is sometimes unconformable, and in it occur thin streaks of clay, which often thin out.

LOESS, or BLUFF.—This formation is found on all hills; is developed on the Missouri bluffs, where it forms those curiously-rounded knobs which I have before mentioned. The *Bluff* is probably from 200 to 250 feet in depth, and consists mostly of finely-comminuted, somewhat sandy and marly ash-brown clays; when worn away or dug into, it is generally jointed in a vertical direction; nodular, round, calcareous concretions are often found. The fossils found were *Helix*, *Helicina occulta* and *Succinea*. I obtained buffalo-teeth from Mr. J. Allen, who procured them ten feet beneath the surface, in a valley between the hills at Rundell's mill. They may belong to a more recent era than the bluff, and the clays of the bluff may have been washed down and have covered them.

Drift.—Beneath the *Bluff* I observed, at Rockport, a few feet of sand with bowlders of quartzite. The drift does not seem to be well marked in this county. Bowlders of quartzite, greenstone, etc., were occasionally found.

UPPER CARBONIFEROUS.

The rocks of this county belong to the upper part of the *Upper Coal Series*, and include limestones, sandstones and shales, amounting to about 180 feet in thickness, divided about as follows: 50 feet of sandstone, with only about 20 feet of limestone, the balance sandy and clay shales. They have a dip north and west amounting to about 170 feet from the south to north line of the county, along the Missouri bluffs, and probably about 360 feet across the county from east to west. The following is a general section of rocks in this county:—

No. 1—250 feet bluff.

2—Drift; thickness unknown, beneath the bluff.

3—5 feet red shales.

4—Sandstone and shales; sandstone at top, upper three feet irregularly-bedded and micaceous, green; below, 8 or 10 feet soft brown; then 35 feet shales and sandstone, red shales in upper part, thick-bedded sandstone at bottom.

5—10 inches drab limestone; weathers brown.

No. 6—3 feet 2 inches shaly limestone, containing fossils.

7—1 foot 4 inches blue, concretionary limestone, traversed by calc-spar veins.

8—2 inches sandy shales or dark-brown clay.

9—2 inches impure coal and shales, two to three inches.

10—Ochrey, sandy shale.

11—22 feet sandy shales.

12—1 foot 6 inches dark-blue shaly limestone.

13—1 foot 6 inches red and green shales, with nodules of limestone.

14—4 feet limestone, upper part nodular; weathers brown; abounds in *Fusulina*.

15—28 feet blue and drab, argillaceous shale.

16—2 feet limestone, bluish drab; contains *Bellerophon*, *Crinoid* stems, etc.

17—10 inches blue, fossiliferous shales; contains *Aviculopecten*, *Productus*, *Bryozoa*, etc.

18—2 feet 6 inches hard sandstone.

19—3 feet soft sandstone.

20—10 inches calcareous sandstone; abounds in *Myalina subquadrata* and *Pinna peracuta;* springs abound at the base.

21—6 feet blue, argillaceous shales, 6 feet to 13 feet.

22—1 foot tolerably fine-grained, blue limestone, perpendicularly jointed; weathers brown.

23—1 foot 3 inches shales.

24—10 inches buff, ochrey, decomposing limestone, jointed perpendicularly; abounds in *Prod. semireticulatus* (var. *P. Calhounianus*, Sw.).

25—2 feet buff and olive shales.

26—2 feet red shales.

27—30 feet clay and sandy shales, and concretionary layers of sandy ironstone.

28—Shelly limestone; contains *Spr.* (*Martinia*) *planoconvexus* and *Crinoid* stems.

Nos. 22 to 28 occur in the northern part of Holt County. Outcrops of rocks were observed along the Missouri bluffs, on Rock Creek, south of the middle of T. 65 on Mill Creek; and Big Tarkie, south of the middle of T. 64. On the other streams no outcrops have been discovered.

The following section appears on the Missouri bluffs, on the north line of the county, and is numbered 68 and 69.

Shaly sandstone on slope. No. 4 of Gen. Sec.

No. 1—2 feet ochrey and blue banded clay shales, in thin laminæ. No. 5 of Gen. Sec.

2—10 inches dark, dull-looking limestone; weathers brown; contains *Syntrilasma hemiplicata*, *Spr. cameratus*, *Pr. semireticulatus*.

3—2 feet limestone, rather shaly; abounds in fossils, including *Pr. Calhounianus* (Sw.), *Productus* (medium sized spec. resembling the *Pr. Calhounianus;* it may be a young individual), *Spr. planoconvexus*, *Chonetes*, *Meekella striato-costata*, *Rhynchonella Osagensis*, *Pr. Wabashensis*, *Spr. Kentuckensis*, *Bryozoa*, *Athyris subtilita*, *Crinoid* stems, *Pr. Pratteniatus*, *Spr. cameratus*. No. 7 of Gen. Sec.

4—2 inches dark-brown clay. No. 8 of Gen. Sec.

5—3 inches dark ochre and coal intercalated = 9 of Gen. Sec.

6—2 feet ochrey, sandy shales = 10 of Gen. Sec.

7—17 feet variegated ochrey and blue sandy shales.

A quarter of a mile above Hall's Bridge, on the Nishnebotna, I observed ten inches of heavy, hard, blue, pyritiferous limestone; the pyrite oxidizes near the exposed surface, and forms on the outside a thick, brown, ferruginous crust. At Rundell's Mill it occurs as the highest rock, and contains *Syntrilasma hemiplicata*, *Fusulina*, *Bryozoa*, *Chonetes*, *Spr. cameratus*, etc.

The following section, taken a quarter of a mile above Hall's Bridge, exhibits—

No. 1—Bluff.

2—1 foot hard, silico-ferruginous limestone; fracture shows a dull lead-blue color; weathers brownish.

3—3 feet greenish-drab, fine-grained sandstone; slightly micaceous; irregularly bedded.

4—1 foot very coarse-grained and tough, brown and green silico-micaceous limestone; has numerous particles of silver; mica disseminated.

5—4 feet soft, brown and buff sandstone.

6—16 feet, the upper half sandy shales, the lower, argillaceous shales.

7—2 feet shales, with nodules of brown and ferruginous limestone

(No. 7 of Gen. Sec.); contains *Syntrilasma hemiplicata*, *Chonetes*, *Prod. Calhounianus*, *Ch. Flemingii*, *Macrocheilus*, *Productus* equal to the medium size *Prod.* of No. 3, Sec. 98.

The following section was taken on Nishnebotna bluff, one mile above Pollack's:—

Section 5.

No. 1—Bluff.

2—10 feet, upper part red shales.

3—20 feet sandy shales and shaly sandstone.

4—20 feet mostly soft, coarse, micaceous sandstone; color, gray, brown and greenish gray.

5—10 feet slope to water in river.

One mile further down the bluffs we see—

Section 6.

No. 1—Bluff.

2—Limestone.

3—4 feet drab, sandy shales.

4—3 feet blue, argillaceous shales.

5—10 feet red shales, with some sandy concretions.

6—8 feet 45° slope; sandy shales appear to Missouri bottoms.

The rocks seen at Barlow's Mill, on Rock Creek, occupy a position near the middle of the Gen. Sec., and appear thus:—

No. 1—Bluff formation.

2—3 feet ashy-blue limestone; weathers drab; part is quite crystalline, and contains *Ch. Flemingii*.

3—6 feet lead-blue, argillaceous shales.

4—1 foot fine-grained, compact, ashy-blue, pyritiferous limestone, said to make good lime.

5—4 feet blue, argillaceous shales.

6—Fossils at top of No. 7, including many *Crinoid* stems, *Rhombopora lepidodendroides*, *Bellerophon*, *Ch. Smithii*, also iron pyrites.

7—2 feet ash or ashy-blue, pyritiferous limestone; brown crust on outside; contains *Pr. semireticulatus*, var. *Pr. Calhounianus* (Sw.), *Spr. cameratus*, *Pr. Prattenianus*.

AT ROCKPORT, one and a half miles south, observed the following section, which may be a continuation of the last:—

Section 10.

No. 1—76 feet bluff.

2—2 feet altered drift.

No. 3—12 feet dark drab or olive clay shales.

4—3 feet slope.

5—3 feet limestone ; upper part gray, and below yellowish gray and shaly ; weathers buff and brown ; contains *Aviculopecten*, *Myalina subquadrata*, *Bryozoa*, *Euomphalus rugosus*, *Ch. Flemingii*, *Pr. semireticulatus*, var. *Calhounianus* (Sw.), *Pr. Prattenianus*, *Nautilus nodoso-dorsatus*.

This resembles Sec. 9, No. 10, very much.

6—15 inches blue and olive shales, mostly banded olive and yellow ochrey, seldom changing to blue ; deep, dark band in lower part.

7—2 feet green, unlaminated clay.

8—2 feet green and red shales.

Two miles further down Rock Creek, at King's Mill, we have Sec. 9 = Sec. 75 of 1872 :—

No. 1—30 feet slope.

2—2 feet ferruginous limestone, abounding in *Fusulina*. No. 14.

3 & 4—28 feet olive and drab, argillaceous shales, in thick laminæ ; some variegated and banded, and contain ochrey concretions.

5—1 foot ash-blue limestone, at top shaly, with a red tinge ; contains *Bellerophon*, *Crinoid* stems, *Euomphalus rugosus*, *Ch. Flemingii*, etc. No. 16.

6—2 feet 6 inches hard sandstone, greenish at top, brown and nodular below.

7—3 feet soft, brown sandstone, and sandy, ferruginous nodules.

8—10 inches tough, blue sandstone ; weathers brown ; contains large *Myalina subquadrata* and *Pinna peracuta ;* spring at base. No. 20 of Gen. Sec.

9—6 feet blue clay shales. No. 21 of Gen. Sec.

10—1 foot blue limestone, mottled with gray specks ; jointed perpendicularly ; contains *Pr. Calhounianus*, *Pinna*, *Bryozoa*, *Meekella striato-costata* and *Syntrilasma hemiplicata*. No. 22.

At RUNDELL'S MILL, on the Missouri bluff, I obtained the following section :—

Sec. 12 (Sec. 76, 1872).

1—81 feet bluff ; contains calcareous concretions.

2—Outcrop of limestone (=4 of Gen. Sec.) ; containing *Bryozoa*, *Syntrilasma hemiplicata*, etc.

3—22 feet sandstone and sandy shales.

No. 3½—1 foot 6 inches dull and dark-looking, shaly, blue limestone.

4—1 foot 6 inches red and green shales.

5—4 feet drab limestone, nodular at top; abounds in *Fusulina*= No. 14 of Gen. Sec.

6—28 feet blue and drab, argillaceous shales (=15 of Gen. Sec.).

7—2 feet limestone; coarse-grained, shaly at top, fine-grained, bluish-drab below.

8—10 inches blue, fossiliferous shale; contains *Aviculopecten carbonarius*, *Pr. Prattenianus*, etc.

9—15 inches brown, calcareous sandstone (=19 of Gen. Sec.).

10—Soft buff and blue sandstone.

Limestone equivalent to Sec. 9, No. 2, and Sec. 12, No. 5, crops out on Tarkie Hills, in south part of T. 64, and equals 15 of Gen. Sec

At Vaugundy's Mill, on Tarkie, I observed the Fusulina limestone associated thus:—

Sec. 17 (not seen in 1872):

No. 2—5 feet, showing an outcrop of limestone containing *Fusulina*.

3—53 feet slope; soft shales at bottom.

4—10 inches dull-blue and gray, mottled, coarse, friable limestone.

5—1 foot. 6 inches shales and brown, decomposing limestone; ferruginous.

6—6 inches ferruginous limestone.

7—2 inches brown shales.

8—5 feet blue, argillaceous shales.

9—2 feet coarse, drab limestone; contains *Chonetes*.

10—5 feet to water in creek.

One half a mile south of last section the following, Sec. 78 (of 1872), appears on Tarkie, below Milton (Vaugundy's Mill):—

No. 1—Slope, bluff, and drift; a good deal of coarse sand and many small, rounded pebbles of various kinds; some large bowlders of Fusulina limestone.

2—21 inches ash-blue limestone; weathers brown (No. 24); contains *Pr. semireticulatus*, var. *Productus Calhounianus* (Sw.), *Crinoid* stems, *Archæocidaris aculeatus*, *Chonetes Smithii ?* and a small branching coral.

3—3 feet olive clay shales, hard and fine grained.

No. 4—10-inch band of yellow, soft, and decomposing limestone; very ochrey; shades a bright gamboge color.

5—1 foot 6 inches buff, olive shales, color bright yellow, ochrey.

6—4 inches red shales. No. 26.

7—28 feet shales, greenish and drab, with nodules of ironstone. Equal to No. 27.

8—1 foot shaly, calcareous sandstone; contains *Spr.* (*Martinia*) *planoconvexus* and *Crinoid* stems. The last equals No. 28 of Gen. Sec.

Economical Geology.—Most of the limestones are too pyritiferous to be very valuable for building purposes. The beds at Barlow's Mill abound in beautiful small crystals of *iron pyrites*. The rocks when exposed often lose their sulphur, and form on the outside a thick, brown, ochreous crust; indeed, some that are thin-bedded become ochreous throughout, and readily disintegrate. On this account few of them are sufficiently durable to make a good material for building. No. 11 is probably the best that is used for building. It is quarried on Rock Creek, on the Missouri bluffs below, and on Big Tarkie. Some of the beds of sandstone along the Missouri bluffs, for five or six miles north of Rockport road, are useful for common buildings; they are often hard, but tolerably easy to quarry. No. 17 crops out in Tarkie bluffs, and affords a useful material for neighboring buildings.

Iron-Ore.—The beds of argillaceous shale contain concretions and thin beds of carbonate of iron, but in too small a quantity to be useful.

Coal.—In Sec. 19, T. 64, R. 41, some labor has been spent for coal, but the result was fruitless. A two-inch seam was discovered, and a drift pushed in more than thirty feet; but the seam not thickening, it was abandoned. The following is a section of rocks at that place:—

Sec. 7.

No. 1—100 feet bluff formation.

2—21 feet sandstone and sandy shales.

3—4 feet calcareo-argillaceous shales = 7 of Gen. Sec.; contains many fossils: *Syntrilasma hemiplicata*, *Chonetes Flemingii*, *Spr.* (*Martinia*) *planoconvexus*, *Pr. concinnus*, *Pr. Wabashensis*, *Productus* (a small var.), *Crinoid* stems, a *Trilobite* = *Phillipsia*.

4—1 foot 4 inches blue, concretionary limestone, traversed by calc-spar veins; contains *Syntrilasma hemiplicata, Euomphalus rugosus*.

5—2 inches sandy shales.

6—2 inches impure coal and shales.

7—3 inches soft, brown sandstone.

8—12 feet to water in Nishnebotna river.

In north-east part of the county, on Manly Branch, a Fork of Mill Creek, P. C. Swallow made the following section :—

No. 1—Prairie slope.

2—1 foot blue, shaly limestone.

3—2 feet blue, argillaceous shales.

4—8 inches bituminous coal, soft and impure.

5—1 foot bituminous shale.

This is probably the equivalent of the Nodaway County coal-bed, and of No. 215 of the Missouri River Section. It is not probable that any profitable bed of coal will ever be found in this county.

The coal-measure rocks of this county occupy a high geological position. The lowest beds are higher than the Nodaway County coal, and about 1,100 feet above the base of the upper coal series, and 1,400 feet above any workable seam of coal. Coal-mining would therefore be very expensive in this county, and its citizens will have to look abroad for their supply.

Red Paint.—No. 26 will probably afford a tolerably good material for dark-red paint. It is found at Rockport, and may be found at other localities.

Soil.—The soil of this county is good, and most of it capable of producing, with ease, ten to twelve barrels of corn per acre. The bluff-land is generally too hilly to be cultivated ; but the slope from the bluffs to the bottoms is very rich, owing much of its fertility to the marly "bluff" clays which have been washed from above. This land is very good for wheat. Mr. McDonald, living in the south part of T. 66, says that in 1860 he raised 28 bushels, but the usual average is 18 bushels. Fall wheat is apt to freeze out during the winter, but under the shelter of the bluffs it succeeds nearly every year.

In the valleys, between the "bluff" hills, are often thickets of plum-bushes, which are said to produce quantities of delicious fruit. The grape flourishes here, and also on the adjacent hills and bottoms ; a wild variety, called Sioux grape, is much esteemed.

Away from the Missouri hills the country is not so good for fall wheat, but spring wheat sometimes succeeds well.

Pumpkins and squashes are produced in large quantities in this county ; most other kinds of vegetables are easily raised.

The Missouri bottoms are generally high, especially near the north part of the county, and are not often subject to overflow. The soil is generally sandy, and will produce from ten to fifteen barrels of corn per acre.

CHAPTER XV.

NODAWAY COUNTY.

BY G. C. BROADHEAD.

THE area of this county is about 791 square miles. The course of the principal streams is about north and south, and the trend of the main ridges about the same direction.

On Platte River, from the middle of T. 64, southward, the bottoms are from a half-mile to a mile in width; the hills are low and the slopes gentle. Further north the bottoms are very narrow, and gently rise into a second bottom or higher table-land, the latter gently ascending to the higher hills. Occasionally the table-land approaches the stream, where it is elevated from 30 to 50 feet above the water.

On the One Hundred and Two River, from the southern county boundary to the middle of T. 62, the bottoms are wide and the slopes gentle; from thence to Howard's Mill the bluffs approach very near the stream, and are often 90 feet high, and steep, and the country rather hilly. This character of country indicates the close proximity of limestone to the surface, which is indeed generally the case.

Further north, along this stream, the slopes are more gentle and the bottoms are wider. On the White Cloud, as far north as the middle of T. 63, the bottoms are narrow and the country somewhat hilly, but northwardly the slopes are more gentle. On the Nodaway River the bottoms are wide, and in the south part of the county the adjacent hills are quite low; north of Quitman the wide bottoms are generally on the east side of the river, and are from a half-mile to a mile in width, and adjacent slopes are very gentle. On the west side of Nodaway River, in T. 66, the hills are high and rounded, and the country rolling to the west. The banks of small streams and ravines in T. 65 and T. 66 are steep, and the crossing difficult.

East of the Platte River the country is rolling and the slopes are gentle, which is also the case between the Platte and the One Hundred and Two Rivers. Further westward the country is high and rolling, with gentle slopes. On the Florida and Sand Creeks the hills are sometimes rather steep, but the slopes are more often gentle. In the northern part of the county, between Rivers One Hundred and Two and Nodaway, the country is rolling and undulating. Maryville is located on top of the divide, west of One Hundred and Two River, and at an elevation of about 200 feet above the river bottoms. This may be said to be about the general elevation of the higher ridges above the bottom-lands of the main streams.

Timber and Prairie.—The prairie-land predominates in this county, the timber being mostly confined to the immediate vicinity of the larger streams. On the Platte River bottoms, south of the middle of T. 64, there are good bodies of timber, but northwardly we find only a fringe of willows, elms, box-elder, cottonwood, and *Cornus* growing immediately on the river-bank. On the adjacent hills are occasional thickets of hazel, chinquepin oak, and small burr oak. Similar remarks will apply to the other streams. On Nodaway is a fine grove, ranging in width from a half-mile to a mile, and reaching from the vicinity of Graham to the northern part of T. 63. We often find the Nodaway bottoms heavily timbered, but north of T. 64 timber is not so abundant. The bottoms more often, as well as the country between the streams, consist of prairie. On the bottoms of Mill Creek there are fine groves of black walnut timber.

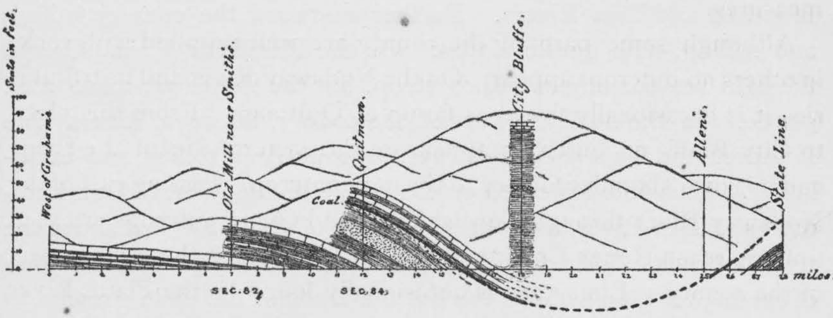
Springs and Streams.—This county is well watered ; the Platte, the One Hundred and Two and the Nodaway, three quite large streams, traverse the county from north to south ; their tributaries become dry, in places, during some seasons. On the Nodaway River there are three mills, which generally are supplied with sufficient water to keep at work during the whole season.

Good springs occur at the following localities, viz. : in Sections 22 and 27, T. 63, R. 37, we find many springs issuing from the Nodaway bluffs ; at Guilford, in Sec. 15, T. 62, R. 34 ; at Prather's, in Sec. 29, T. 63, R. 35 ; at Martins's, in north-east Sec. 26, T. 64, R. 37 ; at Shaller's, in Sec. 18, T. 66, R. 37.

Geology.—The formations in this county consist of the quaternary deposits and coal-measures.

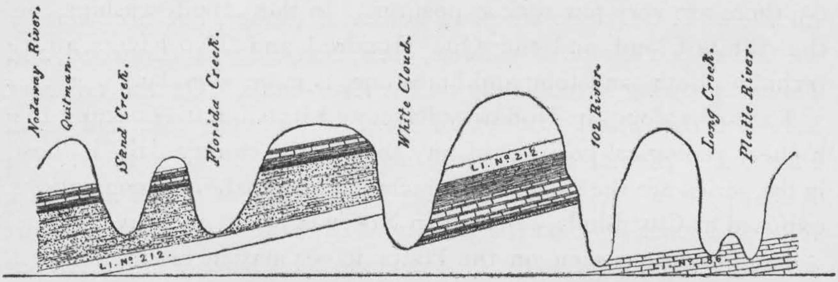
Quaternary.—The alluvial deposits are quite extensive along the

Fig. 113.



SECTION FROM NEAR GRAHAM'S TO THE NORTH COUNTY LINE, ALONG NODAWAY RIVER.

Fig. 114.



SECTION S.E. FROM QUITMAN VIA BRIDGEWATER TO PLATTE RIVER - 2 MILES N.W. OF GUILFORD

streams, and do not materially differ from similar formations in other counties of this part of Missouri.

The "bluff" formation overlies the surface of the hills, but is probably not so thick as in Atchison County.

Drift.—The "bowlder" formation is not so generally diffused, nor are there such deep deposits found as in some counties further east, nor are the bowlders large. At Lanning's Mill, in the northern part of T. 65, R. 33, are found rounded bowlders of granite, quartzite and limestone. A few pebbles are found near Graham, in the south-western portion of the county. In T. 66, on points of the hills west of Nodaway River, the soil is sandy, and many rounded pebbles are found strewn around, mostly consisting of granite, quartzite, etc.

Upper Carboniferous or Coal-measures.—The rock-strata seen in this county embrace a vertical thickness of about 230 feet of the upper members of the Upper Coal-measures, and are included between Nos. 224 and 174 of the General Section of the Upper Coal-measures.

Although some parts of the county are well supplied with rock, in others no outcrops appear. On the Nodaway River and its tributaries it is occasionally found as far up as Quitman. From this place to City Bluffs no outcrops appear on the eastern side of the river, and it is over six miles further to the next outcrop. Passing east of the Nodaway River through Townships 65 and 66, no outcrops are seen until we reach Honey Creek and the Platte River, in the eastern part of the county. Limestone is occasionally found in the Platte River bluffs, from Sec. 13, T. 64, R. 34, to Sec. 16, T. 65, R. 33; with this exception we find no other exposures in T. 64 east of the Nodaway River water-shed. On the Platte River and Long Branch, in T. 62 and 63, there are very few rock exposures. In the same townships, on the White Cloud and the One Hundred and Two Rivers, rock, including both sandstone and limestone, is more abundant.

The rocks along the Nodaway River and its tributaries occupy the highest geological position of any seen in the county: the highest in the series are the shales, with included iron carbonate concretions exposed at City Bluffs, referred to Nos. 224 to 221 inclusive.

The formations seen on the Platte River may include the lowest rocks exposed in this county. At Lanning's Mill, on the north line of Sec. 1, T. 65, R. 34, there is a low bluff of gray, blue and drab limestone, referable to No. 186 of the Gen. Section of Upper Coal-measures. Its contained fossils include *Myalina subquadrata*, *Athyris subtilita* and *Sp. cameratus*.

On the Platte River, in the south-west corner of Sec. 16, T. 65, R. 33, there is exposed 9 feet of irregularly-bedded buff limestone, containing some blue chert, the lower beds somewhat brownish. This also is probably equivalent to No. 186. Beds of limestone and sandstone are exposed on Honey Creek, near and at Mrs. Martin's, in Sec. 25, T. 64, R. 34, whose geological position is probably between Nos. 179 and 186. A quarter of a mile below Mrs. Martin's, several feet of sandstone is exposed, in layers of 5 to 7 inches, and is said to be a good rock for grindstones.

Above the Platte River bridge, probably a little north of the township line between T. 62 and 63, we have—

Sec. 92.

No. 1—12 feet slope of river terrace; outcrop of shelly limeston at the lower part, containing *Schizodus? Fusulina*, and a cast of *Bellerophon*.

2—6 inches flagstone ; even layer of strong and tough limestone, containing *Bellerophon carbonarius*.

3—4 inches like the last, but containing a small plant.

4—5 feet of shelly, gray limestone, containing remains of *Bellerophon* ——, cast of *Bell. crassus*, remains of *Nautilus* ——, *Naticopsis Altonensis*, *Athyris subtilita*, *Prod. Nebrascensis*. The remains of the fossils seem generally to be replaced by calcite, crystallized. I also observed *Myalina* and *Aviculopecten*, and *Fusulina cylindrica* was very abundant. West of this, on Long Branch, I observed an outcrop of limestone in two layers, the upper 6 inches, the lower 5 inches, separated by 6 inches of olive shales. The principal observed fossils were *Spirifer cameratus*, *Sp. lineatus*, a small *Productus*, *Prod. Rogersi*, *Athyris subtilita*, *Chonetes* ——, *Pinna peracuta*, *Murchisonia* ——, *Naticopsis* ——. A spring issues from the base of this rock. I refer these beds to No. 186 of Gen. Sec.

On east side of the One Hundred and Two River, and about 4 miles south of Bridgewater, I observed a coarse, hard, and tough, brown, ferruginous and somewhat oölitic limestone, containing but few fossils, but among them I observed *Meekella* and *Myalina Swallovi*. This limestone I refer to No. 182 of Gen. Sec., and it is probably the equivalent of the rock used in the abutments of the bridge at Barnard. The latter was quarried on west side of the Hundred and Two River, about two miles north-west. A mile and a half north we find beds exposed, belonging to No. 184 and 186. No. 186 is 8 feet thick and burned into lime. Below it, there is 2 feet of brown shales, then 3 feet of mostly olive shales, resting on ash-gray limestone. No. 184.

The last-named limestone (No. 184) contains minute calcite specks thoroughly diffused, and would doubtless appear very well if polished. A quarter of a mile north, on the One Hundred and Two River, limestone No. 186 is seen, 11½ feet thick, at 20 feet above the stream.

Less than a mile south of Bridgewater we find exposed the following :—

Sec. 89.

1—Slope.

2—1 foot 8 inches dark, chocolate-colored limestone, weathering brown.

3—10 feet shales.

4—6 feet shaly sandstone.

5—5 feet 8 inches thick-bedded, soft and hard sandstone, outer beds coarse brown, sometimes traversed by minute veins of calcite; some interior beds are indurated, bluish-gray and calcareous.

6—15 feet slope, covered with débris from above.

7—9 feet shelly limestone in river = No. 186. *Fusulina* abounds in the latter.

The last-named limestone occupies the bed of the river at Howard's Mill, at Bridgewater, and is occasionally seen up Dog Creek. Sec. 87, on Dog Creek, a half-mile up-stream, is as follows:—

No. 1—Slope.

No. 2—Loose fossils, overlying No. 3; including *Rhombopora*, *Archæocidaris*, and *Crinoideæ*.

No. 3—16 inches blue limestone, weathering brown.

No. 4—7 feet slope.

No. 5—2 feet brown shales.

No. 6—7 feet irregularly-bedded limestone (186), contains *Fusulina*, *Spr. cameratus* and *Prod. splendens*.

11—2 inches brown, ochrey shales.

12—1½ feet of gray shales.

13—2 feet green, nodular shales.

14—2 feet 4 inches yellow shales, with nodular limestone layers.

15—1 foot of suboölitic, firmly adhering, buff limestone.

16—3 feet of dull, ash-blue limestone with shaly partings, containing *Archæocidaris*, *Spirifer cameratus* and *Prod. Nebrascensis*. No. 199.

17—9 inches dark olive shales, containing *Spirifer*, *Crinoids*, etc.

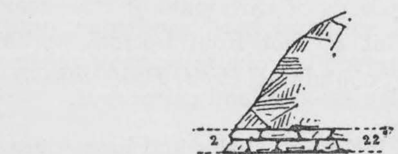
18—1 foot of dark-ash limestone, containing *Archæocidaris*, *Fistulipora nodulifera*, *Rhombopora*, *Lepidodendroides*, *Aviculopecten carboniferus*, *Scaphiocrinus hemisphericus*, *Zeacrinus?* No. 197.

Portions of the above section occur on the Nodaway River, one mile below the mouth of Sand Creek.

At Quitman we find limestone corresponding to No. 1 of the above section in the bed of the stream; the overlying rocks are the following (Fig. 115):—

Fig. 115.

SECTION AT QUITMAN
NODAWAY CO.



Sec. 84.

No. 1—Slope of bluff clays.

2—22 inches blue spathic limestone, containing *Bellerophon* (large sp.), *B. Kansasensis*, remains of a *Pleurotomaria*, and a very small gasteropod $\frac{1}{16}$ of an inch long, with six whorls.

3—2½ feet sandy shales.

4—2 feet ash-blue limestone, containing *Terebratula bovidens*, *Syntrilasma hemiplicata*, *Productus Prattenianus*, *Naticopsis Shumardi*. No. 218.

5—26 inches olive and drab shales; in the lower 1 foot are fossils, including *Sp. planoconvexus*, *Rhynchonella Osagensis*, *Euomphalus rugosus* and *Aviculopecten Coxanus*.

6—14 inches rotten coal. No. 215.

7—2½ feet gray and ochrey sandy clay, with remains of plants, *Stigmaria ficoides*, etc.

8—8 feet 5 inches sandy shales.

9—4 feet irregularly-bedded, brownish-drab sandstone.

10—7 feet sandy shales.

11—1 foot blue, argillaceous shales, containing *Aviculopecten occidentalis*. No. 213.

12—3 feet shaly slope.

13—2 feet dark-blue shales.

14—2 feet blue, compact limestone, containing *Aviculopinna Americana*, a large *Discina*, a *Lingula*, *Cordaites* and remains of other plants, and a fishtooth.

At City Bluffs, formerly known as Halsey's Ferry, on the Nodaway River, a shaft has been sunk 40 feet deep, reaching the coal of the Quitman section at 24 feet below water. Opposite the mill-dam are seen the highest rocks in this county. The section of them is the following:—

No. 1—A few feet of a porous, ferruginous limestone, closely resembling the buff limestone over the coal near Rulo and the mouth of the Big Nemaha, in Nebraska. No. 224.

No. 2—76 feet shales, containing beds of carbonate of iron near the upper part, a bed of septaria at 40 feet from bottom, and a calcareo-ferruginous bed just below, containing *Prod. Prattenianus.* Nos. 221, 222 and 223.

No. 3 is about 24 feet to the coal, including shales and limestones.

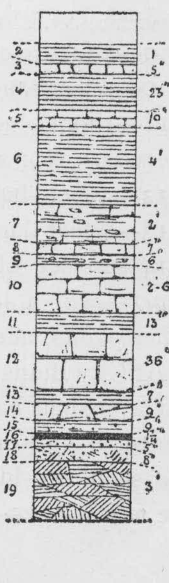
The rocks gradually rise from this northward, and at Allen's coal-bank, near north-west corner of T. 66, R. 36, we find the coal corresponding to No. 215 of Gen. Sec., about the water-line in the Nodaway River. Less than a quarter of a mile north, the deep-blue limestone, No. 212 of Gen. Sec., is in the bed of the stream, indicating a rise in that distance of 20 feet.

At Braddy's Mill, in Iowa, about a mile and a half further north, we find green shales corresponding to No. 203 of Gen. Sec., at the edge of water, indicating a rise of 37 feet in one and a half miles, without reckoning the descent of the stream in that distance. This rise must continue some distance, for the coal above named is mined at Clarinda, 12 miles north.

Sec. 88 was obtained at Dog Creek, on the land of John Lund, in the north-west of the north-west Sec. 62, T. 63, R. 35, as follows (Fig. 116):—

Fig. 116.

SECTION 88.



No. 1—Slope.

2—1 foot olive shales. No. 210.

3—5 inches ash-blue limestone. No. 209; contains *Hemipronites crassus*, *Productus splendens*, *Chonetes Smithii*, and *Rhombopora lepidodendroides*.

4—23 inches shales, upper half a dark olive, and calcareous; bituminous below; contains *Spirifer* (*Martinia*) *planoconvexus* and *Cordaites*.

5—10 inches blue limestone; containing *Hemipronites*. The interior of the fossils is crystallized calcite. Corresponds to No. 206.

6—4 feet somewhat sandy, olive and blue shales.

7—2 feet shales and nodular limestone.

8—7 inches suboölitic, coarse gray limestone. No. 201.

No. 9—6 inches nodular, calcareous shales. No. 200.

10—2½ feet coarse, shaly, ash-colored limestone. No. 199.

11—13 inches olive shales.

12—3 feet of dull, deep ash-blue limestone; weathers drab; contains *Prod. punctatus*. No. 197.

13—7 inches dark-blue calcareous shales; contains *Archæocidaris*, *Scaphiocrinus hemisphericus*. No. 196.

14—9 inches irregular bed of bluish-gray limestone; contains calcite veins and specks, and zinc-blende. *Hemipronites crassus* is also contained.

15—9 inches dark, sandy, micaceous shales. No. 195.

16—1¼ to 2⅛ inches bituminous coal.

17—5 inches even layers of regularly laminated black sandstone, slightly calcareous.

18—8 inches sandy clay. No. 193.

19—Blue fire-clay; 3 feet is exposed; said to be 6 or 7 feet thick.

Most of the rocks of the above section are exposed on Peter Collins's land, west of Bridgewater. The thin coal-seam is also seen, but I do not consider it of any economic value. This seam is represented by bituminous shales, near Oregon, Holt County.

In the quarries on Collins's land No. 210 was observed, containing *Fusulina cylindrica*, *Crinoid* stems and *Zeacrinus mucrospinus*. In No. 212 I observed *Cetenacanthus* (sp.), small *Lingula*, and *Rhynchonella Osagensis*. In No. 209 I observed *Sp. cameratus*, *Chonetes Smithii*, *Sp. Kentuckensis*, *Prod. Prattenianus*, *Retzia punctulifera*, *Crinoids*, *Rhombopora lepidodendroides*, *Ælis Swallovi*.

West of this, on White Cloud Creek, we find some of the members of the last section, including the thin coal-seam.

On Elkhorn Creek, south-east of Graham, we find about 10 feet of limestone No. 186 cropping out near the water. It is of a grayish color, the upper part brown-tinged; below is dark shaly, and reposing on blue clay shales. On the Nodaway River, west, are outcrops of limestone No. 197 and its correlated beds.

FORMATIONS ALONG AND NEAR THE NODAWAY RIVER.

In Townships 62 and 63 we find strata included from Nos. 182 to 210. On Mr. Bagby's land, near the centre of Sec. 15, T. 63, R. 37, rocks included in Sec. 81 are the following:—

No. 1—2 feet dark-olive clay shales.

No. 2—9 inches bituminous shales.

No. 3—1 foot of even-bedded, blue limestone; contains *Hemipronites crassus* and *Productus Nebrascensis*, *Prod. Pratteniauus*, *Polypora* (sp.). The interior of the *Producti* is replaced by calcite crystals. No. 206.

No. 4—2 feet blue clay shales; a lasting spring of water issues from them.

No. 5—12 to 16 inches of concretionary limestone, with carbonaceous remains of plants.

No. 6—4 to 5 feet green shales.

No. 7—Limestone in creek, having a vitreous appearance.

Three miles north-west of this, on the Nodaway River, at the Old Mill site, in Sec. 5, T. 63, R. 37, these beds are well exposed, with other correlated strata. A descriptive section is as follows:—

Sec. 82.

No. 1—2 feet deep-blue, compact limestone, in even 6 to 10-inch layers, containing *Lingula* ——, *Prothyris elegans*, *Edmondia Nebrascensis*, *Discina* ——, *Aviculopinna Americana*. (No. 212.)

2—6 inches deep ash-blue limestone; contains *Athyris subtilita*, *Prod. Nebrascensis*, *Prod. Pratteniauus*, *Edmondia Nebrascensis*, *Aviculopecten* ——, *Macrocheilus* ——, *Orthoceras cribrosum*, the *pygidium* of a *Phillipsia*, *Crinoideæ*, *Rhombopora lepidodendroides*, *Fistulipora nodulifera*, *Synocladia biserialis* and *Polypora submarginata*. No. 211.

3—4 feet buff shales and limestone, nodules abounding in fossils, including *Fusulina cylindrica*, *Rhombopora*, *Chætetes*, *Bryozoa*, *Archæocidaris*, *Crinoid* stems, *Prod. splendens*, *Terabratula bovidens*, *Retzia punctulifera* and *Spirifer*. No. 210.

4—10 inches blue limestone, full of remains of fossils, including *Hemipronites crassus* and *Rhombopora*. The Brachiopoda are generally replaced by calcite. No. 209.

5—1 foot of blue calcareous shales, full of fossils, including *Athyris subtilita*, *Prod. splendens*, *Prod. Nebrascensis* and *Orthis carbonaria*.

6—1 inch bituminous shales.

7—9 inches dark-blue shales.

8—5 inches black, bituminous shales.

9—3 inches olive shales.

10—10 inches deep-blue limestone; abounds in fossils, including *Bellerophon*, *Hemipronites* and *Edmondia*. The interior of fossils is replaced by calcite. No. 206.

As the section of rocks at Braddy's Mill is quite complete from Nos. 203 to 212, I here give it:—

1—4 inches drab or dove colored limestone; contains a tabulate or flattened Bryozoa and some pretty univalves. No. 211.

2—5 feet brown shales with concretionary limestone nodules; abounding in fossils, including *Fusulina cylindrica*, *Athyris subtilita*, *Prod. Nebrascensis*, *Prod. semireticulatus*, var. *Calhounianus*, *Chonetes granulifera*, *Spirifer cameratus*, a small spiny *Productus*, (*P. pertenius*) *Prod. punctatus*, *Polypora*, *Fistulipora nodulifera*, *Rhombopora lepidodendroides*, and fragments of *Crinoideæ*.

3—8 inches blue limestone, full of fossils similar to those in No. 2. No. 209.

4—2 inches brown shales.

5—1 foot drab-olive, calcareous shales, full of remains of fossils.

6—9 inches similar clay to the last.

7—2 inches bituminous shales.

8—13 inches blue limestone, shelly on top, and abounding in fossils, including *Hemipronites crassus*, whose interior is replaced by calcite, *Prod. Nebrascensis*, *Edmondia Nebrascensis*, *Myalina subquadrata*, *Bellerophon*. No. 206.

9—4 inches chocolate-colored, sandy, calcareous clay.

10—1 foot blue, sandy clay.

11—1 foot green, nodular shales, brown on top.

12—2 feet green shales in water. No. 203.

We perceive that the upper beds of this section correspond to the upper beds of section at Milton, Nodaway River, 20 miles south, and also correspond to the base of section at Quitman.

Nodaway Coal.—The only coal within working distance from the surface is that corresponding to No. 215 of the Gen. Sec. It is found on Nodaway River, at Allen's, within 2 miles of the Iowa line, on Mill Creek, and southward to Quitman, near Quitman, on Sand Creek, Florida Creek, and Elkhorn. In thickness it varies from 9 to 16 inches, and is of rather inferior quality, containing a large per cent. of ash.

In 1872 the coal at Allen's was hidden by fallen débris and drifted material from the stream. Our section, taken in 1860, shows the following :—

No. 1—Slope from hill above.

2—12 feet shales ; drab, with buff and brown tinge ; contains concretions of ironstone.

3—5½ feet slope, including a local drift of débris from above.

4—4½ feet dull, lead-colored limestone, possessing a rough fracture ; in two beds, the upper containing a thin spathic seam, with crystalline fibres perpendicular to stratum ; the lower, weathering brown, is pyritiferous, and does not make good lime ; contains *Entolium aviculatum* and *Eumicrotis ? Chonetes* ——, and *Athyris*. No. 218.

5—1½ feet blue and bituminous shales, containing black septaria, enclosing *Bellerophon carbonarius*, etc.

6—20 inches alternations of blue shales, with coal, as follows :—

No. 1—5½ inches good coal, a little shaly about the middle.

2—4 inches dark, lead-blue clay shales.

3—2 inches good coal.

4—3 inches blue shales.

5—6 inches good coal, with one inch clay near the middle.

6—Fire-clay.

Brick of good quality is made from the overlying shales, Nos. 2 and 3 of the section. The lower layers are the best. The clay is dug out, allowed to slake, and mixed, one-third of it, with sand and clay.

The coal reached in the shaft at City Bluffs was reported to be 16 inches thick.

On Samuel Bowman's land, in Sec. 31, T. 65, R. 37, the coal is 14 to 18 inches thick, cropping out in the branch.

The coal-mine of James C. Smith is located on the north-west of the south-west quarter, Sec. 9, T. 64, R. 37, a half-mile south of Quitman. It is reached by a horizontal entry into the hill. We find here exposed—

No. 1—2 feet spathic limestone. No. 220.

2—2 feet shales. No. 219.

3—1 foot shales with thin limestone strata.

4—16 inches limestone. No. 218.

5—2 feet clay shales, bituminous at lower part.

No. 6—12 inches coal, sometimes thickening to 16 inches.

7—2 feet clay shales.

Spirifer planoconvexus occurs in the overlying blue shales. The coal is bright, black, and tolerably hard, the top and middle harder than the bottom. It is jointed with intervening calcite-plates, and contains some iron pyrites. An analysis by Mr. Regis Chauvenet, chemist for the survey, gives—

Water	3.53
Volatile matter	42.72
Fixed Carbon	40.71
Ash	13.04
Color of ash	a very light brown

The section at Burdick's coal-bank, one mile below the mouth of Lund County, as observed by Mr. C. J. Norwood, is as follows :—

Sec. 86.

No. 1—20 feet slope.

No. 2—2 feet clay shales.

No. 3—16 inches ash-gray limestone, shelly on top; contains some fossils, *Nucula Beyrichii*, a *Goniatite*, *Murchisonia* ——, etc.

No. 4—2½ feet dark-blue clay shales.

No. 5—16 inches hard, ash-blue limestone, containing *Entolium aviculatum*, *Edmondia Nebrascensis?* *Athyris subtilita*, *Spirifer planoconvexus*, *Prod. splendens*, *Bellerophon Kansasensis*, *Crinoid* stems, *Hemipronites crassus*, *Aviculopecten occidentalis*, *Pinna peracuta*, *Edmondia reflexa*, *Lingula* ——, *Prod. Prattenianus*, *Nautilus* ——, *Polypora submarginata*. (No. 218.)

No. 6—3 feet 4 inches shales.

No. 7—11 inches coal. No. 215.

On Sand Creek, one mile east of its mouth, Mr. C. J. Norwood observed—

No. 1—Slope.

2—14 inches ash-gray limestone, somewhat splintery, abounding in fossils, many similar to some of those found at Burdick's, and also containing *Naticopsis Altonensis*, *Spirifer cameratus*, *Syntrilasma hemiplicata*, and *Euomphalus rugosus*.

3—4 inches yellow and gray argillaceous shales.

4—1 foot slaty shale.

No. 5—1 foot soft, black shale.

6—3 inches bituminous shales.

7—1 foot hard, black shales.

8—Coal, said to be 1 foot thick.

On Wm. Smith's land, in the north-west quarter of Sec. 3, T. 63, R. 37, the coal is about 6 inches in thickness, and is separated by 4 feet of shales from the limestone above.

At Ch. P. Martin's, in the north-east quarter of the north-east quarter of Sec. 26, T. 64, R. 37:—

Sec. 83.

No. 1—16 feet bluff and drift; the lower 2 feet pebbles and sand of the drift.

2—2 feet olive shales. No. 219 of Gen. Sec.

3—17 inches ash-blue limestone; weathers brown.

4—4 feet 8 inches shales, subdivided as follows:—

No. 1—16 inches olive shales, with white specks;

2—5 inches bituminous shales;

3—9 inches olive clay shales;

4—2 feet bituminous shales.

5—10 inches coal. No. 215 of Gen. Sec.

6—9½ feet lead-blue, micaceous sandstone.

7—8 feet blue, sandy shales.

8—4 feet blue, clay shales.

9—4 feet deep-blue, compact limestone, in even flags; contains *Prod. Nebrascensis*, *Pinna peracuta*, *Edmondia Nebrascensis*, *Prothyris elegans*, *Pleurophorus ? Prod. Prattenianus* and a small *Myalina*.

Coal crops out at several places in this neighborhood, in thickness varying from 9 to 12 inches. On the land of the Maryville Coal Company, in the north-east of the north-east of Sec. 25, T. 64, R. 37, it is 6 inches thick, the lower part intersected by a seam of pyrite.

By comparing the above sections we find the coal to be much thicker in the northern part of the county, and thinning as we go south. This is further verified by observations on the Missouri River bluffs, near Forest City, Holt County, where it is only from 2 to 4 inches thick. When we say that this and the coal of Andrew and Buchanan Counties are the only seams in the upper coal series of Missouri thick enough to work in a total thickness of over 1,000 feet, we may well term the upper series "Barren Measures." On the waters of Elkhorn Creek, in the north-west part of T. 63, R. 37, we find beds of limestone, whose position is over the coal, indicating its presence beneath. But nowhere east of the main divide, between waters of Nodaway River and those of One Hundred and Two River, are there any accessible beds of coal in this county worthy of notice. To reach good coal, shafts would have to be extended a long distance into the rocks below. From a careful summation of measurements, I find that from the Nodaway coal (215) the depth is about 395 feet to the 1-foot seam of Buchanan and Andrew Counties occurring in No. 134; or, 1,160 feet to the Holden coal, also of 1-foot thickness, or 1,233 feet to the Lexington coal. With these facts before us, it would be expensive work to sink a shaft in search of coal. A shaft sunk from the top of the limestone in the river at Bridgewater would only lessen the depth about 70 feet. I mention this, because it is the easiest limestone to recognize in the central and eastern portions of the county.

Soil.—The land in this county is generally very productive, and consists chiefly, especially on the high prairies, of a dark, rich loam. West of the Nodaway River, in T. 66, the soil is somewhat sandy. Near Graham, and southward, it is very rich and highly productive. Corn is the staple product. The winters are often too severe for fall wheat. Some of the best soils are said to produce, in good seasons, as much as 80 bushels of corn per acre.

The prairies and bottom-lands afford fine grazing.

During the summer season pleasant breezes prevail throughout this county and the region westward, which tend to promote health. The winter winds are sometimes quite strong.

APPENDIX A.

REPORT ON THE STRENGTH OF BUILDING MATERIALS.

BY CHAS. A. SMITH.

THE value of a stone for building purposes depends upon the strength, durability and freedom of working, and lastly the accessibility of the quarry from which it is obtained.

This last condition, of course, can only be ascertained for each individual quarry, and no further consideration will be taken of it in this connection.

By freedom of working, is meant the ease with which a fragment from the quarry is prepared for use. This can be best estimated by experience; but small pieces can be rubbed smooth upon a grindstone or an emery-wheel for comparison, the relative length of time, of course, being the index.

The only satisfactory test of durability is found in the experience of at least twenty years' exposure to the effects of the atmosphere. Various chemical processes resemble more or less the action of frost or water, but they are all deficient in the element of time. The opinion of engineers on this point seems to be, that such tests are only valuable as suggestions of the probable action of the elements. In short, stone that will not pass such tests is known to possess slight durability, while stone that will pass may or may not be durable.

The strength, however, may be accurately determined for any given specimen, and by experimenting with a sufficient number of pieces, an average value may be obtained, which will be a reliable guide in practical use.

It will be necessary to obtain a clear idea of what is meant by the strength of any material before we can attain any satisfactory understanding of the remainder of this chapter; and therefore a very brief description will be given of the theory of resistance. To illustrate: A block of stone in the wall of a building sustains pressure from above due to the weight above, and pressure from below due to the reaction of the stones beneath, and is subjected to compression which it resists by the elastic reaction of its particles: this compression is applied all over the upper and under surfaces of the block, and is transmitted from one surface to the other, by the particles of the block. The amount of force or weight upon a unit of surface is called the stress to which the block is subjected. This stress may generally be increased up to a limit at which the elastic reaction of the particles remains perfect, and beyond which it may be increased until the stone finally crushes.

By the amount of stress which can be borne without injuring the elastic reaction of the material, is measured the elastic- or proof-strength, and by the amount of stress at fracture, what is called the breaking- or ultimate-strength. These terms are used for any material, and also for tension as well as compression, care being taken to distinguish in every case.

The determination of the ultimate-strength of a piece of known size and any material, consists in loading it with weights and gradually increasing such weights until it gives way. The number of units of weight divided by the number of units of area of the surface acted upon, is the breaking-strength, usually stated in pounds on the square inch.

The determination of the proof-strength is somewhat more complex, and consists in applying a load to a piece of given size, and after release from such load, the piece is again measured; if it has remained of exactly the same size, the load is increased, applied, released, and the piece again measured. This will be repeated until it is found by measurement that the piece has changed in size, and the proof-strength will be between the two last loads. By making the increments of load small, the proof-strength will be found with any desired degree of accuracy.

The determination of the elasticity of any piece requires measurement when under stress, and is usually carried on with experiments for the proof-strength. Experiment has proved conclusively that within the proof-strength the changes of length, in a piece subjected to compression or extension, are directly proportioned to the stresses producing them; and therefore the product of the length times the stress divided by the change of length will be a constant for any given material and compressive stress, and a similar constant for tensile stress. If the elasticity is the same in tension and compression, there will be only one constant for both kinds of stress: this constant is called the "modulus of elasticity" for the given material, and is sometimes defined as the stress that would compress or extend a given piece an amount equal its entire length, if the elasticity was perfect and the same for all stresses.

The use of the "modulus of elasticity" (usually denoted by "E") is to predict the change of length any given piece will undergo when in tension or compression of known stress; for E having been determined by experiment from a sufficient number of pieces, we shall have the following proportion: The change of length is to the whole length as the stress is to E. In algebraic language these statements are very concise.

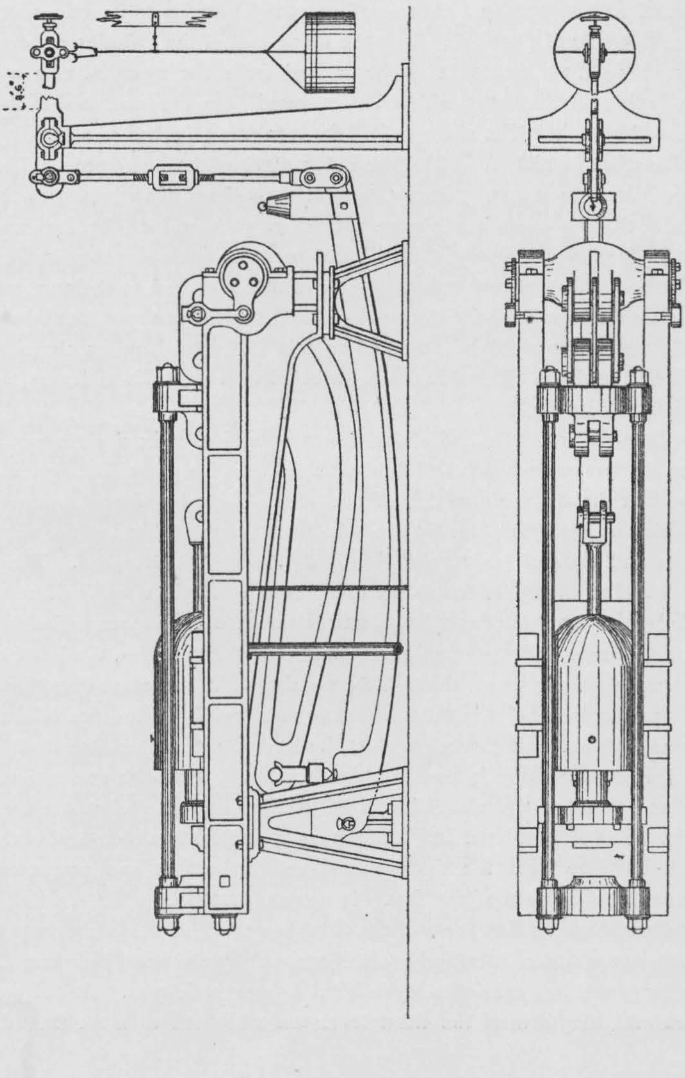
Let $E =$ modulus of elasticity, $e =$ change of length in inches, $P =$ stress in lbs. per square inch, $r =$ length in inches.

$$\frac{e}{r}=\frac{P}{E},\ E = \frac{Pr}{e},\ e = \frac{Pr}{E}.$$

The only reliable experiments on the strength of Missouri stones are part of a very extensive series of experiments made on all kinds of building materials by Capt. James B. Eades, Chief-Engineer of the Illinois & St. Louis Bridge Company, for the information of that corporation. These experiments were conducted by Col. Henry Flad, Chief-Assistant-Engineer, who designed for the purpose of prosecuting them two different testing machines. With the kind permission of these gentlemen a brief description of these machines will be given, and an abstract of such experiments as are deemed of interest in this connection.

The first or large apparatus was built by Messrs. Sheckle, Harrison & Co.,

Fig. 117.



of St. Louis, and was a beautiful piece of machinery; the power was exerted by a hydraulic press acting on the specimen at one end, and resisted by a train of levers and weights at the other end.

Upon a strong cast-iron bed (see Fig. 117), very much like the bed of a lathe, was mounted the cylinder of the hydraulic press. Two projections, one on each side, from the cylinder rested upon the bed, and were wedged between corresponding projections from the latter. The bed was about 13 feet long; the cylinder was 3 feet $3\frac{1}{2}$ inches in length, and was usually placed nearer one end of the bed than the other, but could be moved along the bed and wedged between different projections, thereby allowing specimens of various lengths to be tested. This cylinder was 24 inches in external diameter and 8 inches in thickness, and was terminated at one end by a plane-surface at right-angles to its axis, and at the other end was hemispherical; from the plane-end of the cylinder projected the ram, or plunger, $7\frac{1}{4}$ inches in diameter, and from the rounded end a rod of steel 3 inches in diameter, which was screwed into the inner end of the ram, and moved with it. The outer end of the ram was attached to a strong cross-head of cast-iron which moved on the inner edges of the bed-frame. The steel rod terminated in a strong clamp, to which couplings of various sizes could be attached. Sliding cross-heads were placed at each end of the bed and connected by four strong wrought-iron bolts or rods, each $2\frac{1}{2}$ inches in diameter. Thus the cross-head at one end was opposite that attached to the ram, and that at the other end was opposite the steel rod and couplings above mentioned.

Similar couplings could be attached to this last cross-head on the side next the cylinder, and the other side was connected with the train of levers, already mentioned, by strong links.

The plane-end of the cylinder was the compression-end; a piece was placed between the two cross-heads and fluid pumped into the press, forcing one cross-head against the specimen, which of course was forced against the other cross-head, which was held in place by the bolts from the cross-head at the other end, the links and train of levers, and finally by the weight attached. The hemispherical end of the cylinder was the tension-end. A piece was held at each of its ends by the two sets of couplings, and the motion of the ram pulled the steel rod, the specimen and the cross-head connected to the levers, the latter receiving the pull from the press, through the specimen, in the same direction as the pull of the four long bolts in the case before mentioned. The force of the press, then, was in either case exerted against the levers in the same direction.

The levers were three in number, the first being bent with one arm vertical, the other extending the whole length of the bed and curved under the press-cylinder. The second lever had its fulcrum at the compression-end of the bed, received pressure from the first, passed under the first and projected from underneath the fulcrum of the first. It was connected by a vertical link of adjustable length to the short arm of the third lever. This third lever was carried by a cast-iron standard attached to the floor, and by a vertical link from the end of the long arm was carried a cylindrical copper scale-pan. As the weight of the pan and long arm of the third lever was sufficient to move the other two levers, a counterpoise was attached near the vertical link between the second and third levers. An index attached to the scale-pan link indicated equilibrium as in an ordinary balance.

This apparatus was all carried on hardened steel knife-edges, and was so perfectly balanced that the weight of an ordinary lead-pencil in the scale-pan was enough to cause motion of the levers.

The combined leverage of this train was 1999.2, and therefore a weight of 1 pound avoirdupois placed in the scale-pan could only be lifted by a force of 1999.2 lbs. acting through the levers. By admitting an error of 0.0004 this was called a ton of 2,000 lbs.

The most convenient weight was water; this was allowed to flow from a cylindrical reservoir into the copper pan. The volume leaving the reservoir measured the weight applied in the pan. This was finally read by means of a dial and revolving index, moved by a float in the reservoir; the graduation showing pounds and quarters applied in the pan, and therefore tons and quarters at the other end of the train of levers. At the commencement of every experiment the scale-pan was emptied and the reservoir filled, till the index returned to zero. This beautiful apparatus possessed a range of one hundred tons.

For the purpose of measuring the changes of length caused by known forces, there was used an exceedingly delicate arrangement (see Fig. 118). Two brass collars, C C, were fastened to the specimen by steel-pointed screws; from each collar was a projection, which carried a small rectangular bar of steel, D; these two bars were parallel, and each passed through an aperture in the other collar, with a distance of one-fourth of an inch between their nearest parallel faces. Between these bars, and at right-angles to them, was a steel roller one-fourth of an inch in diameter, E, one of the bars being pressed upon the roller by a small friction-wheel carried at the end of a delicate steel spring attached to one of the collars.

The distance between the pointed screws that held the collars to the specimen, or the equal distance between the central planes of the collars, was measured by a scale and vernier attached to the bars. If the collars were moved by the compression or extension of the specimen acted upon by the hydraulic press, the roller between the bars would be revolved by the motion of one bar relatively to the other. This rotation was measured with the aid of a graduated arc, G, a mirror attached to the top of the roller (and the face of which was a diametral plane), and a telescope, F, with a vertical "cross-hair." The centre of the graduated arc, which was of twenty-five feet radius, was also the centre of the roller. The telescope was attached to the arc, and directed radially toward the mirror, in which, of course, was seen by reflection the graduation of the arc. By means of the cross-hair an accurate reading of the arc was obtained; force having been applied to the specimen, the mirror was rotated and a second reading was taken. The difference of these two readings, of course, was a measure of twice the angle of rotation of the mirror and roller. The rotation of the mirror having been produced by rolling, was only half the amount there would have been if it had had a fixed axis; therefore the following proportion was true :—

Fig. 118.

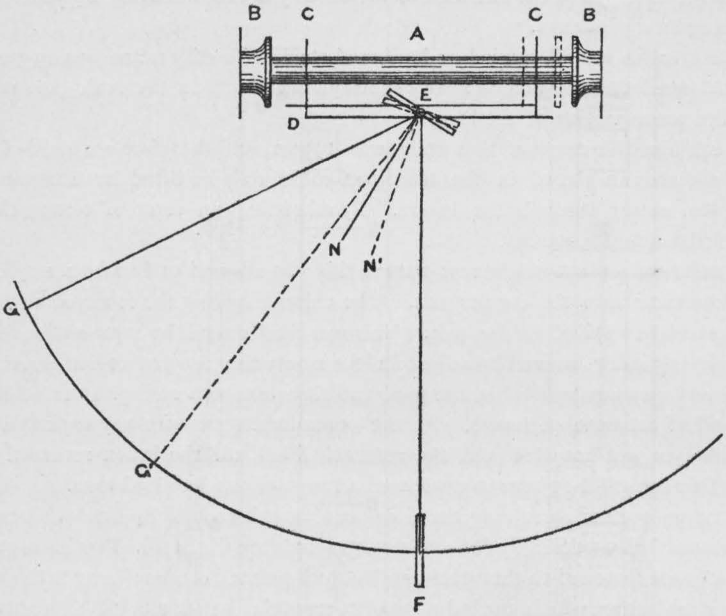


DIAGRAM OF MEASURING APPARATUS

A – *Specimen in Compression.*
B – *Crossheads.*
C – *Collars.*
D – *Steel Bars.*
E – *Roller & Mirror.*
F – *Telescope.*
G – *Graduated Arc.*
N – *Normal to Mirror.*

The dotted lines show positions after Compression.

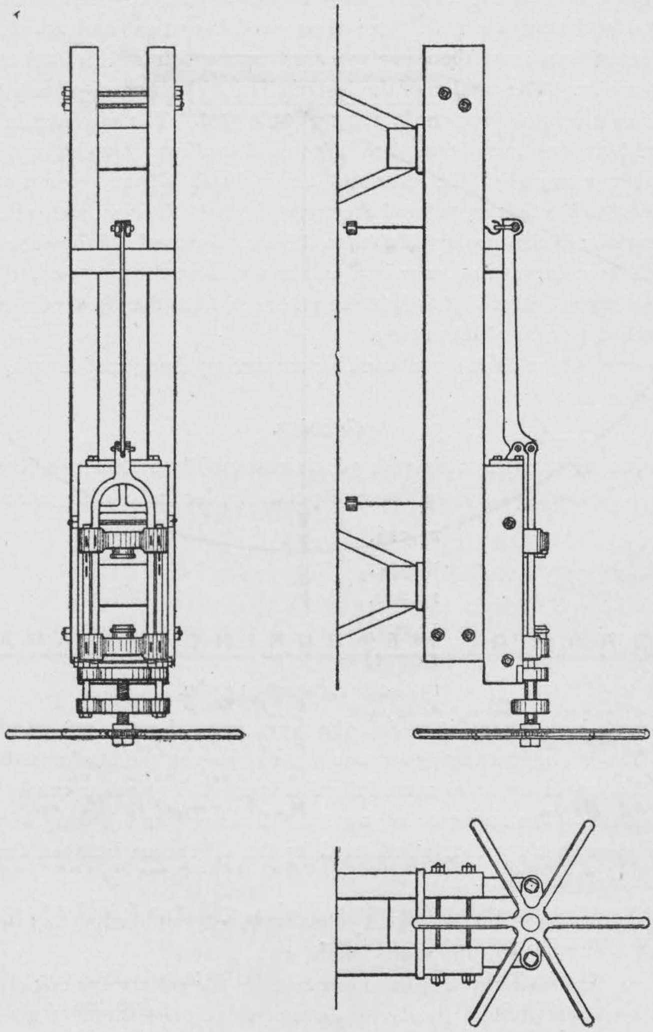
The distance moved by the bars is to the difference of readings on the arc as the radius of the roller to the radius of the arc.

From the dimensions stated, the movement of the collars was enlarged 2,400 times; the arc was graduated, as an ordinary levelling-rod, into feet, tenths, and hundredths, and by estimation to thousandths; therefore a movement of the collar of $\frac{1}{2,400,000}$ part of a foot, or $\frac{1}{200,000}$ of an inch, became distinctly visible.

This apparatus has only been excelled by Sir Joseph Whitworth in the micrometer attachments to his celebrated "Standard Inch," but possesses the advantage over that wonderful piece of mechanism, in having scarcely a possibility of wear, the surfaces being all in rolling contact, and being scarcely affected by changes of temperature.

The second or smaller machine was devised by Col. Flad for the purpose of making a series of experiments on the strength and elasticity of cements, which required a less powerful apparatus than that already described.

Fig. 119.



A horizontal steel screw (see Fig. 119) turned by four arms passes through a hard brass nut in a cast-iron cross-bar, and presses with a rounded point against a block of chilled cast-iron. At each end of the cross-bar is secured a bolt or rod of round iron, which bars are parallel and pass through the bearing-block just mentioned, and through two cross-heads. The bars can be keyed to either cross-head. There are also two other parallel bars passing through the cross-heads and keyed to either. Outside of the cross-heads, at the other end of the bars from the screws, the second set of bars are bent together and attached to a lever. The fulcrum of this lever and the bearing-block of the screw are attached to the ends of two pieces of oak-timber carried by a pair of joists, which may be rested upon any supports. The long arm of the lever is horizontal and carries a scale-pan ; the second is vertical and attached to the second set of bars ; and there is also a third arm which is horizontal and carries a counterpoise. The motion of the lever is limited by a cross-piece between the joists, upon which the long arm can rest when loaded. The specimen to be tested is placed between the two cross-heads (coupled to them if tension is to be used), and the screw turned till the lever and load is lifted. If the two sets of bars are each keyed to the first cross-head they pass through, the specimen will be acted on by tension ; if they are keyed each to the second cross-head they pass through, there will be compression, counting, in one set, from the screw-end of the bars to which they are attached, and, in the other set, from the attached lever. This machine has a range of seven tons.

The same mirror-device was used for measuring changes of length, as in the other apparatus.

Granites.

Six experiments were made with 3-inch cubes of Iron Mountain Red Granite from Gov. Brown's quarry, and gave respectively, for the crushing stress—

11,716,
16,444,
12,700,
13,000,
12,700,
13,600. Average, 13,360.

A seventh experiment, in which the faces pressed were not parallel, gave 5,780. Tin-foil or blotting-paper was placed between the iron cross-heads and the specimens, in order to more fully distribute the pressure evenly over the entire surface. The influence of careful "bearing" and placing of stones in walls is somewhat startlingly indicated by the difference between the last experiment and the others.

Three experiments with granite from Maine, cylinders 6 inches long and 2.36 inches in diameter, gave respectively—

Crushing Stress.	Modulus of Elasticity.
16,000,	5,500,000.
18,500,	6,400,000.
17,000,	5,000,000.

Two 3-inch cubes gave 13,700 and 8,500 for crushing stress. The average value of the crushing stress for the five experiments was 14,740, and for the first three the average modulus of elasticity was 5,600,000, nearly. A 3-inch cube of Richmond, Virginia, granite gave 16,400 for crushing, and 13,500,000 for the modulus.

The strength of Scotch granites from Aberdeen, as given by Rennie, is 10,914. The strength of granites given by Molesworth is 8,000, and by Rankine from 5,500 to 11,000.

Strength of Sandstones.

Two cubes of sandstone from St. Genevieve, Mo., one 3 inches and the other $4\frac{1}{8}$ inches, gave 5,330 and 5,500—an average of 5,415.

A 3-inch cube from St. Genevieve, quarry of Dodds & Sliders, gave 13,400.

A 3-inch cube from Cannelton, Ind., gave 3,700.

Rennie gives for Derby sandstone, 3,142.

Rennie gives for Dundee sandstone, 6,630.

Molesworth gives 5,000.

Weisbach gives from 1,400 to 13,000.

Rankine gives from 2,200 to 5,500.

Strength of Limestone.

Three cubes of 3 inches each, from Pike County, Mo., gave
1,300,
3,100,
2,960. Average, 2,453 for crushing stress.

Eight experiments with cylinders of Grafton, Ill., limestone (magnesian), 6 inches long, 1.1 inches in diameter, gave an average of 6,700 for crushing stress, and seven experiments gave 8,600,000, nearly, for the modulus of elasticity.

Eight experiments with cubes gave an average of 12,300 for the crushing stress.

A cube of oölitic limestone from Amien, Ill., gave 4,000.

A cube from the quarry of N. D. Munson, Quincy, Ill., gave 9,500.

The average of four experiments, each on 4-inch cubes, from Manhattan, Junction City, and Ellis, Kansas, gave 4,700, 3,050 and 1,100 respectively. These limestones were magnesian.

Molesworth gives 3,000 to 8,000.

Weisbach gives 1,500 to 6,000.

Rankine gives 4,000 to 4,500, and 5,500 for marble.

A 3-inch cube of ochre-brown marble from Cape Girardeau, Harris's quarry, gave 1,500.

A 3-inch cube from Chicago, Lamont quarry, 14,100.

A 3-inch cube of limestone from Barrett's Station, Knipper's quarry, 5,900. This quarry is near the tunnel on the Missouri Pacific R. R.

Concretes.

The average crushing stress of twenty experiments on concretes of hydraulic cement, sand, and broken limestone, with from 0.57 to 0.67 limestone, and from 0.14 to 0.17 cement, was 1,083; both Akron and Louisville cements were used, and the specimens were 6-inch cubes, which had been twelve days under water and exposed to the air for six months. These experiments were very nearly alike, and the change in cement, both in kind and in proportion, seemed not to affect the results.

Cements.

With mixtures of Akron cement and sand, of

0.33 cement, 0.67 sand	the crushing stress was	195
0.40 cement, 0.60 sand	" "	280
0.50 cement, 0.50 sand	" "	435
Pure cement	" "	1,180

The above were 12 days in water, 24 days in air, a mean of two experiments each.

114 experiments on pure Fall City (Louisville) cement gave 1,309 for the crushing and 669 for the proof stress respectively, and 702,616 for the "modulus of elasticity."

93 experiments on a mixture of equal parts cement (Fall City) and sand gave 455,356 and 647,610 for crushing stress, proof stress, and modulus of elasticity.

45 experiments on a mixture of one part cement and two parts sand gave for the crushing stress 238, for the proof stress 203, and for the modulus of elasticity 1,261,588; these had been 12 days in water and about 6 months in air. From these experiments we find that pure cements are stronger and more easily compressed than mixtures of sand and cement.

From 168 experiments on 7 cubes, 2½ inches each, the average penetration of a 1-lb. weight with sharp point falling 6 inches, was—

for { Louisville (Fall City) 0.09 inches
Akron 0.18 "

The average crushing stress was of { Louisville 444
Akron 149

The Louisville is slower setting, stronger and harder than the Akron.

Strength of Brick.

Hand-made U. S. Stamps.	Machine-made, Hydraulic Pressed. Metcalf.	Sterling.	Hodgman & Goodwin.		Remarks.
738	2021	1543		Salmon	
		930			2 Experiments.
2984	4521	7477	2026	Paving	
	4695	4220			2 Experiments.
		1970		Light-red	
		1260			2 Experiments.
2496	3487		1870*	Red	
	2905				2 Experiments.
		5006		Dark-red	
		1855			2 Experiments.
2400	5728	6621	4241	Arch	
		3670			1 Experiment.

* 4 Experiments.

The numbers above are the mean of 8 experiments each, unless noted.

Rennie gives for hand-made red brick 808, and for pale 562.

Molesworth, 1,500.

Rankine, from 550 to 1,100.

It is scarcely necessary to add that the load actually put upon the above materials is rightly kept far below the values given above.

Very Respectfully,

CHAS. A. SMITH.

PROF. R. PUMPELLY,
State Geologist.

ST. LOUIS, MO., *Jan. 8th*, 1873.

APPENDIX B.

NOTES ON SUCH ROCKS OF MISSOURI AS ADMIT OF A FINE POLISH.

BY G. C. BROADHEAD.

BEDS of limestone admitting of fine polish, and ordinarily called *marble*, may be found in the counties of St. Louis, St. Charles, Warren, Montgomery, Ralls, Callaway, Lincoln, Cooper, Pettis, Cass, Jackson, Livingston and Clay.

Coal-Measure Limestone.

Those of Cass, Jackson and Clay are gray, fine-grained, with minute specks of calcite disseminated, and occasionally varied by fossil-shells; this rock is somewhat silicious, but admits of a fine polish. Quarries of this rock occur at Pleasant Hill, Kansas City, the Missouri bluffs near Randolph, and at Missouri City. Its thickness is from 2 to 4 feet, and its geological position is No. 85 of my General Section of the Upper Coal-measures. Limestone No. 72 of the Coal-measure Section, if polished, would appear well. It is dark blue, with still darker, irregularly-winding lines. It is a very hard limestone, occurring in even layers, but does not exceed 1½ feet in thickness.

It is quarried in the northern part of Cass County, near Pleasant Hill, and near Lone Jack in Jackson County.

Lower Black River Beds.

In Ralls County, on the Peno, there is 9 feet of a fine-grained, drab, magnesian limestone, with disseminated calcite, and containing *fucoids*. In Callaway County, four miles north-east of Williamsburgh, we find 18 feet of blue, light-gray and reddish-spotted, compact or subcrystalline limestone, all more or less speckled with calc-spar. In some beds it is disseminated throughout, in others it forms thin layers. In Montgomery County, near the mouth of Clear Fork, there occurs one foot of beautifully mottled, drab limestone, shading into flesh-color.

Near Danville is a bed, 8 feet thick, of greenish-gray at one place, at another it is of a peach-blossom color; when polished this makes a very handsome "marble." If burned, it shows stronger shades of color, the dark part becoming darker and the light-colored portion white. Below this is found a septaria bed that would make an attractive marble. In Warren County, near Missouri College, we find the base of the Black River group occupied by 8 feet of subcrystalline limestone, mottled gray in the upper part, next, below, a reddish-gray, fine-grained, compact, often reddish-drab with deeper red specks, and presenting a graphic appearance. It is also sometimes found presenting a greenish shade, the lower bed greenish-white and brittle. In Sec. 1, T. 45, R. 2, W., are similar beds, of which the upper members are of a reddish color, those below of various shades of black and brown.

Some of these would undoubtedly appear well if polished. Similar beds to those found in Warren also crop out in St. Charles County, in the Missouri bluffs, near the western county line. In Lincoln County, in Sec. 16, T. 51, R. 1, E., there is a quarry of 21 feet of a gray, fine-grained limestone, with brown windings, resting on 7 feet of fine-grained limestone inclining to gray color with a pink shade, the upper 2½ feet abounding in irregular, ramified forms of calcite, which sometimes weathers out; the two lower beds are ten inches thick, and free from the faults of the upper beds. A polished specimen would probably exhibit a dull-drab color.

In Pettis County, on the Lamine River, a few miles from Sedalia, there crops out from two to four feet of a fine-grained, drab, magnesian limestone, containing many disseminated particles of calcite. This rock admits of a fine polish. Its geological position is above the 1st Magnesian limestone.

Some of the above-named rocks are rather attractive when polished; those of Warren and Montgomery are but little inferior to the Ozark marble, but they do not present such a variety of shades. In St. Louis County there are beds of very durable limestone, admitting of a fine polish and looking well in-doors.

Although most of the above-named rocks appear well when polished, none of them will retain a fine display of color after any out-door exposure.

The Marbles of South-Eastern Missouri.

In Iron County, on and near Stout's Creek, in Sec. 5, T. 33, R. 3, E., and in Sec. 31, T. 34, R. 3, E., there occurs a fine-grained, subcrystalline limestone, mostly red, variegated by veins of calc-spar; some beds incline to buff, some are gray and flesh-colored, and some variegated buff. It occurs in layers ranging from two inches to a foot in thickness.

At Farnham's quarry, in Sec. 19, T. 33, R. 4, E., is six feet of good marble, the two lower beds of 20 inches and 2 feet in thickness, variegated light drab, inclining to flesh-color. In the S. W. corner of Sec. 5, T. 32, R. 4, we have a red and flesh-colored, subcrystalline limestone, mostly in strata from ½ to 8 inches in thickness and variegated with calcite specks.

Red and flesh-colored marble is also found in Sec. 6, T. 32, R. 4, E., and in S. W. of N. E. Sec. 33, T. 33, R. 4, E., the marble-beds are 27 feet in aggregate thickness, and one bed is 14 inches thick. In Reynolds County, on Tom Suck Creek, there are thick beds of flesh-colored, subcrystalline limestone. In Madison County, near the mouth of Cedar Creek, there are very fine beds of red and variegated marble. Near the head of Cedar Creek there is ten feet of light-colored marble, variegated with buff veins. Similar beds occur also on Leatherwood Creek, and, near its mouth, on the St. François River.

As above named, the marbles of South-eastern Missouri are generally of different colors, beautifully clouded with various colors. Thus far I have seen no purely crystalline marbles, and none that are purely white.

APPENDIX C.

LIST OF FOSSILS FROM THE COAL-MEASURES OF MISSOURI, COLLECTED IN 1872.

CATALOGUED BY C. J. NORWOOD.

In the following list there are several undetermined species of Allorisma, Nautilus, Bellerophon, Murchisonia, Macrocheilus, and one or two other gasteropods, some of which are probably undescribed.

Zoöphyta.

No. 1. *Rhombopora lepidodendroides*, Meek.
2. *Fistulipora nodulifera*, Meek.
3. *Lophophyllum proliferum*, McChesney.
4. *Campophyllum torquium*, Owen.
5. *Zaphrentis ?*
6. *Chætetes milleporaceus.*
7. *Chætetes ?*
8. *Syringopora multattenuata*, McChesney.

Echinodermata.

9. *Scaphiocrinus ? hemisphæricus*, Shumard.
10. *Zeacrinus ? mucrospinus*, McChesney.
11. *Archæocidaris ?* (3 undet. sp.)

Bryozoa.

12. *Synocladia biserialis*, Swallow.
13. *Polypora submarginata*, Meek.
14. *Polypora* (sp. ?).
15. *Fenestella Shumardi*, Prout.
16. *Fenestella* (2 undet. sp.).
17. *Glauconome* (sp. ?) resembles *G. trilineata*, Meek.

Brachiopoda.

18. *Productus Nebrascensis*, Owen.
19. *Productus Prattenianus*, Norwood.
20. *Productus symmetricus*, McChesney.
21. *Productus semireticulatus*, Martin.
22. *Productus costatus*, Sowerby.
23. *Productus Norwoodii ?* * Swallow.

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* This shell Prof. Swallow describes from the Permian in Kansas. *Vide* Trans. St. Louis Acad. Sci., 1858, vol. i. p. 182.

24. *Productus Americanus*, Swallow.
25. *Productus semireticulatus* var. *Calhounianus*, Swallow.
26. *Productus punctatus*, Martin.
27. *Productus names ?* Meek and Worthen.
28. *Productus muricatus*,* Norwood and Pratten.
29. *Productus Wabashensis*,* Norwood and Pratten.
30. *Productus splendens*,* Norwood and Pratten.
31. *Productus* (sp. ?).
32. *Lingula* (2 undet. sp.).
33. *Chonetes granulifera*, Owen.
34. *Chonetes Smithii*, Norwood and Pratten.
35. *Chonetes mesoloba*, Norwood and Pratten.
36. *Chonetes Verneuiliana*, Norwood and Pratten.
37. *Chonetes glabra*, Geinitz.
38. *Chonetes* (sp. ?).
39. *Hemipronites crassus*, Meek and Hayden.
40. *Athyris subtilita*, Hall.
41. *Terebratula bovidens*, Morton.
42. *Spirifer lineatus*, Martin.
43. *Spirifer* (*Martinia*) *planoconvexus*, Shumard.
44. *Spirifer cameratus*, Morton.
45. *Spiriferina Kentuckensis*, Shumard.
46. *Retzia punctulifera*, Shumard.
47. *Rhynchonella Osagensis*, Swallow.
48. *Syntrilasma hemiplicata*, Hall.
49. *Meekella striato-costata*, Cox.
50. *Orthis carbonaria*, Swallow.
51. *Discina Missouriensis*, Shumard.
52. *Discina capuliformis ?* McChesney.
53. *Discina* (sp. ?).
54. *Orbiculoidea ?*

LAMELLIBRANCHIATA.

55. *Entolium aviculatum*, Swallow.
56. *Aviculopecten occidentalis*, Shumard.
57. *Aviculopecten Whitei*, Meek.
58. *Aviculopecten carboniferus*, Stevens.
59. *Aviculopecten Coxanus*, Meek and Worthen.
60. *Aviculopecten interlineatus*, Meek and Worthen.
61. *Aviculopecten Providencis*, Cox.
62. *Aviculopecten* (2 sp. undet.).

* This is probably *Pr. longispinus* of Sowerby. Compare the figures of de Koninck, 1842–1844, *An. Foss. Ter. Carb. Belg.*, Pl. xii. Fig. 11, a, b, and Pl. xii *bis;* Fig. 2, a, b, c, d, with the figures of Norwood and Pratten, 1854, *Jour. Acad. Nat. Sci.*, Phila., vol. iii., 2d ser., Pl. i., Fig. 5 and Fig. 6.

63. *Aviculopinna Americana*, Meek.
64. *Pinna peracuta*, Shumard.
65. *Prothyris elegans*, Meek.
66. *Pleurophorus oblongus*, Meek.
67. *Pleurophorus occidentalis*, Meek and Hayden.
68. *Pleurophorus subcostatus*, Meek and Worthen.
69. *Pleurophorus* (sp. ?).
70. *Myalina subquadrata*, Shumard.
71. *Myalina recurvirostris?* Meek and Worthen.
72. *Myalina meliniformis?* Meek and Worthen.
73. *Myalina Swallovi*, McChesney.
74. *Myalina Kansasensis*, Shumard.
75. *Chænomya Leavenworthensis*, Meek and Hayden.
76. *Chænomya Cooperi?* Meek and Hayden.
77. *Chænomya* (sp. undet.).
78. *Allorisma regularis*, Owen.
79. *Allorisma* (*Sedgwickia*) *subelegans*, Meek.
80. *Allorisma* (*Sedgwickia*) *granosa*, Shumard.
81. *Allorisma* (*Sedgwickia*) *reflexa*, Meek.
82. *Allorisma subcuneata*, Meek and Hayden.
83. *Allorisma* (3 or 4 sp. undet.).
84. *Edmondia Aspinwallensis*, Meek.
85. *Edmondia? Nebrascensis*, Geinitz.
86. *Edmondia? reflexa*, Meek.
87. *Edmondia subtruncata*, Meek.
88. *Edmondia* (2 sp. undet.).
89. *Schizodus Wheeleri*, Swallow.
90. *Schizodus curtus*, Meek and Worthen.
91. *Schizodus* (2 or 3 sp. undet.).
92. *Cardiamorpha Missouriensis*, Shumard.
93. *Cardium? Lexingtonensis*, Swallow.
94. *Astartella vera*, Hall.
95. *Nucula ventricosa*, Hall.
96. *Nucula* (sp. undet.).
97. *Nuculana bellistriata*, Stevens.
98. *Lima retifera*, Shumard.
99. *Macrodon tenuistriata?* Meek and Worthen.
100. *Solenopsis solenoides*, Geinitz.
101. *Pseudomonotis* (sp. undet.).
102. *Eumicrotis Hawni*, Meek.
103. *Eumicrotis Hawni* var. *sinuata*, Meek and Worthen.
104. *Eumicrotis* (sp. undet.).
105. *Solenomya* (sp. undet.).
106. *Yoldia* (sp. undet.).

GASTEROPODA.

107. *Pleurotomaria carbonaria*, Norwood and Pratten.
108. *Pleurotomaria tabulata*, Conrad.
109. *Pleurotomaria turbiniformis*, Meek and Worthen.
110. *Pleurotomaria Grayvillensis*, Norwood and Pratten.
111. *Pleurotomaria depressa*, Cox.
112. *Pleurotomaria sphærulata*, Conrad.
113. *Pleurotomaria* (sp. undet.).
114. *Bellerophon carbonarius*, Cox.
115. *Bellerophon ellipticus*, McChesney.
116. *Bellerophon percarinatus*, Conrad.
117. *Bellerophon Montfortianus*, Norwood and Pratten.
118. *Bellerophon Kansasensis*, Swallow.
119. *Bellerophon Marcouianus*, Geinitz.
120. *Bellerophon crassus*, Meek and Worthen.
121. *Bellerophon* (3 sp. undet.).
122. *Enomphalus rugosus*, Hall.
123. *Straparollus umbillicatus*, Meek and Worthen.
124. *Loxonema cerithiformis ?* Meek and Worthen.
125. *Loxonema rugosa ?* Meek and Worthen.
126. *Loxonema* (sp. undet.).
127. *Polyphemopsis inornata ?* Meek and Worthen.
128. *Polyphemopsis* (sp. undet.).
129. *Macrocheilus fusiformis ?* Hall.
130. *Macrocheilus inhabilis*, Morton.
131. *Macrocheilus ventricosus*, Hall.
132. *Macrocheilus medialis ?* Meek and Worthen.
133. *Macrocheilus* (2 or 3 sp. undet.).
134. *Naticopsis Altonensis*, McChesney.
135. *Naticopsis Shumardii*, McChesney.
136. *Naticopsis* (sp. undet.).
137. *Platyostoma Peoriense*, McChesney.
138. *Aclis ? Swalloviana*, Geinitz.
139. *Murchisonia* (several undet. sp.).
140. *Turritella ?*
141. *Fusulina cylindrica*, Fischer.
142. *Fusulina* (small, undet. sp.).

CEPHALAPODA.

143. *Nautilus decoratus*, Cox.
144. *Nautilus Sangamonensis*, Meek and Worthen.
145. *Nautilus occidentalis*, Swallow.
146. *Nautilus Forbesianus*, McChesney.
147. *Nautilus* (3 sp. undet.).

148. *Goniatites politus*, Shumard.
149. *Goniatites planorbiformis*, Shumard.
150. *Goniatites globulosus*, Meek and Worthen.
151. *Goniatites* (2 sp. undet.).
152. *Orthoceras cribrosum.*
153. *Orthoceras* (large undet. sp.).

CRUSTACEA.

154. *Phillipsia major*, Shumard.
155. *Phillipsia* (sp.).
156. Heads of two undet. genera of *Trilobites.*

FISHES.

157. *Petalodus destructor*, Newberry and Worthen.
158. *Deltodus angustus*, Newberry and Worthen.
159. *Peripristis semicircularis*, Newberry and Worthen.
160. *Xystrodus ? occidentalis*, St. John.
161. *Ctenacanthus ?*
162. *Cladodus* (sp. undet.).

PLANTS.

163. *Calamites* (sp. undet.).
164. *Lepidodendron* (sp. undet.).
165. *Sigillaria* (sp. undet.).
166. *Cordaites.*
167. *Stigmaria ficoides*, Brgt.
168. *Neuropterus rarinervis*, Bunb.
169. *Neuropterus pachyderma*, Lsq.
Several undetermined genera.

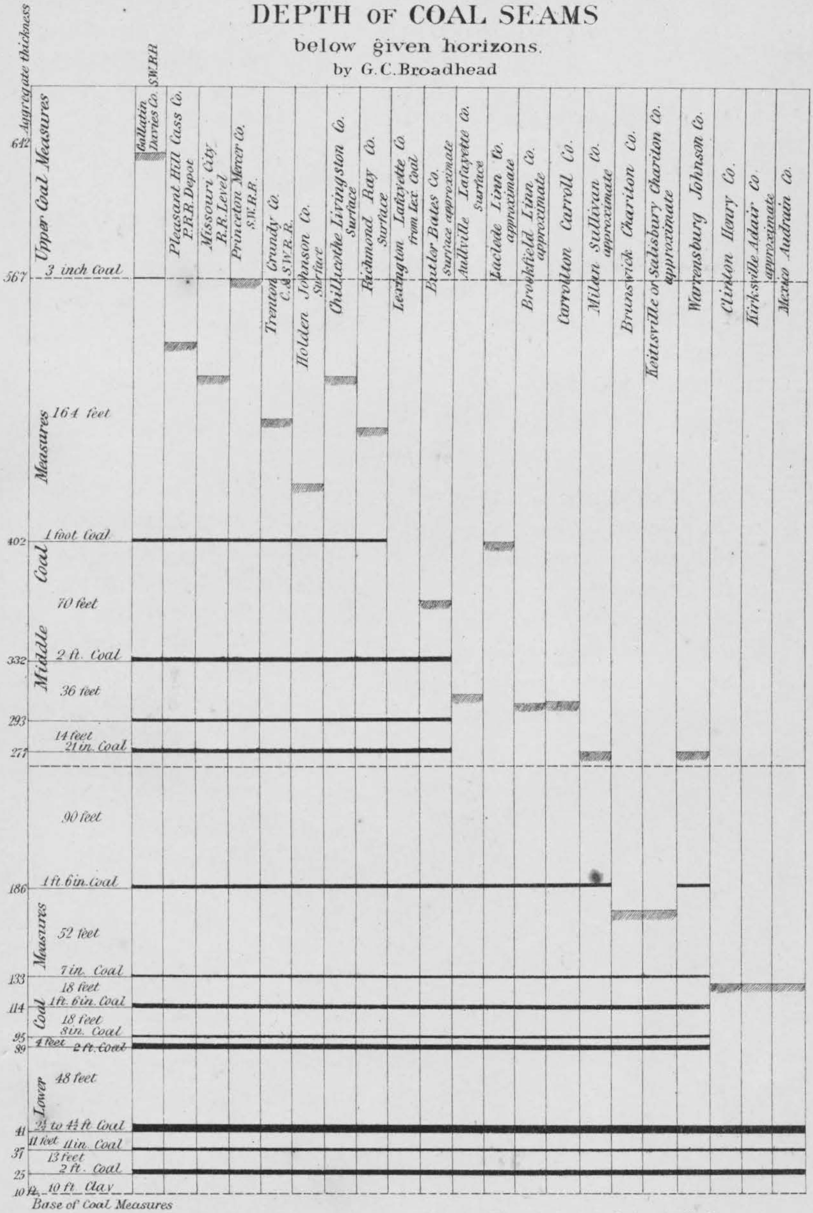
APPENDIX D.

SCHEDULE SHOWING

DEPTH OF COAL SEAMS

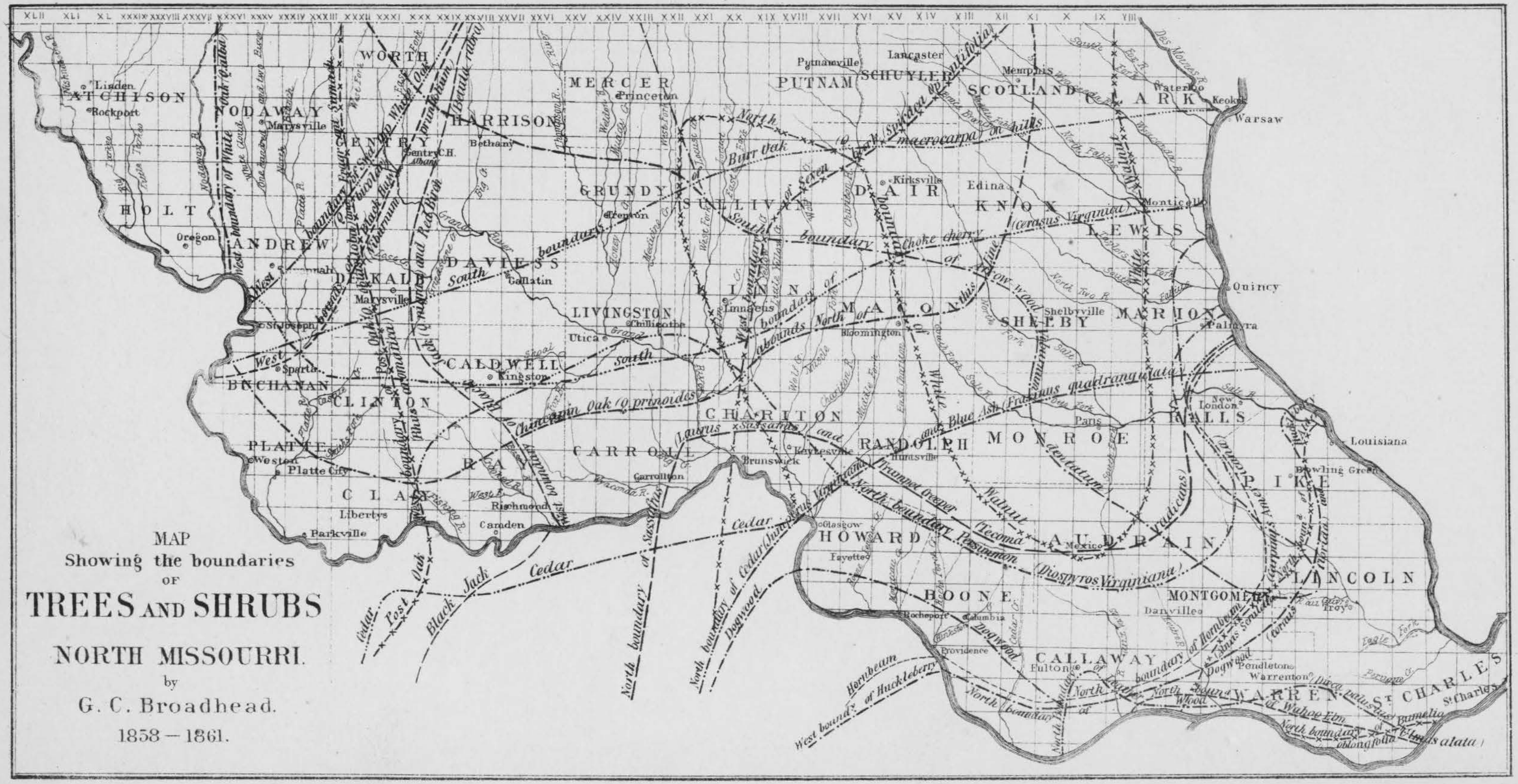
below given horizons.

by G. C. Broadhead



Note. *This table is intended as a guide for boring. The thickness of the Coal Seams and the distances between them are subject to local variations. The surface of the ground at each point is indicated thus*

APPENDIX E.



MAP
Showing the boundaries
OF
TREES AND SHRUBS
NORTH MISSOURRI.
by
G. C. Broadhead.
1858 — 1861.

INDEX.

The following Errata occur in Geological Report of Missouri Geological Survey for 1872, R. Pumpelly, Director. Printed in New York, by Julius Bien, 1873.

[Persons having the volume containing this Errata can cut this out and insert in that volume.]

PART I.

CHAPTER IV.

Page 61, line 7, instead of "one-eightieth" read "one-eighth."

Page 67, "uniform," in line 11, and "local" in line 14, from bottom, should be italics.

Page 71, line 15 from bottom, instead of "the uppermost layer of boulders" read "the outer layer of each boulder."

Page 72, line 11 from top, instead of "9.039" read "0.039."

Page 74, lines 7 and 8 from bottom, instead of "this sample consisted only of one-half inch good specular ore," read "one-half of this sample only consisted of good specular ore."

Page 77, line 9 from top, instead of "cropping" read "crossing."

Page 85, line 9 from top, instead of "the third Chapter" read "this fourth Chapter."

Page 87, line 9 trom top, instead of "chapter (III)" read "chapter (IV)."

CHAPTER V.

Page 93, line 5 from top, instead of "Chapter II and III" read "Chapters III and IV."

Page 100, line 7 from top, instead of "eastern portions" read "western portions."

Page 100, line 2 from bottom, instead of "western portion" read "eastern portion."

Page 101, line 8 from top, instead of "north-west" read "north-east."

Page 101, line 3 from bottom, instead of "Fig. 6" read Fig. 16."

Page 114, illustrations Fig. 21, the thickness of the main ore-bed should be "30 feet" instead of "40 feet."

Page 114, line 6 from bottom, instead of "nearly 40 feet" read "about 30 feet."

Page 115, line 4 from top, instead of "Fig. 11" read "Fig. 21."

Page 115, line 5 from top, instead of "Fig. 10" read "Fig. 20."

Page 115, line 11 from bottom, instead of "8 and 9" read 18 and 19."

Page 116, line 13 from bottom, instead of "Fig. 8" read "Fig. 18."

Page 117, line 9 from top, instead of "but C" read "Cut C."

Page 120, line 13 from top, instead of "Fig. 13" read "Fig. 23."

Page 120, line 4 from bottom, instead of "Fig. 13" read "Fig. 23."

Page 122, line 20 from top, instead of "Big Bogg" read "Big Bogy."

Page 124, line 8 from bottom, instead of "Chapter III" read "Chapter IV."

Page 124, line 3 from bottom, instead of "Chapter II" read "Chapter III."

Page 125, line 22 from top, instead of "Chapter V" read "Chapter VI."

Page 151, lines 2 and 3 from top, the words "Gilkerson's Ford, on Grand River, Henry county," should be stricken out.

Page 154, line 13 from top, instead of "Chapter V" read "Chapter VI."

Page 158, line 3 from bottom, instead of "Chapter V" read "Chapter VI."

Page 159, line 11 from top, instead of "layer" read "larger."

Page 160, line 14 from top, instead of "Chapter V" read "Chapter VI."

Page 160, line 17 from top, instead of "Chapter IV" read "Chapter V."

Page 165, line 1 from bottom, instead of "Chapter V" read "Chapter VI."

Page 167, line 3 from top, for "chapter V" read "chapter VI."

Page 167, line 20 from top, instead of "chapter V" read "chapter VI."

Page 169, line 3 from top, instead of "chapter I and described in chapter II," read "chapter III, and described in chapter IV."

Page 176, line 12 from top, instead of "chapter II" read "chapter III."

Page 179, line 14 from bottom, instead of "chapter IV" read "chapter VI."

Page 179, line 22 from top, instead of "Lutz" read "Lutes."

Page 183, line 12 from top, instead of "chapter V" read "chapter VI."

Page 189, line 13 from top, instead of "Mangua" read "Niangua;" instead of "Carl" read "Carroll."

Page 191, line 3 from top, instead of "Murdoch" read "Murdock."

Page 191, line 13 from top, instead of "Lutz" read "Lutes."

CHAPTER VI.

Page 194, line 12 from top, instead of "I. C." read "V. C."

Page 194, line 15 from bottom, instead of "I. A." read "III. A."

Page 197, No. 16, instead of "Big Bogg" read "Big Bogy."

Page 198, No. 32, instead of "Gilvy" read "Silvy."

Page 199, No. 47, instead of "Lutz" read "Lutes."

Page 199, No. 48, the figures "9, 2" should be stricken out in the 6th and 7th columns.

Page 199, No. 54, instead of "Leetz" read "Lutes."

Page 199, No. 56, instead of "Spion" read "Spiva."

Page 199, No. 57, instead of "Grungstown" read "Youngstown."

Page 203, No. 95, instead of "Revold" read "Ravold."

Page 208, No. 157, instead of "Jones' estate" read "James' estate."

Page 209, No. 173, instead of "—— bank, T. 39, R. 11 W., Sec. 5," read "Chrisman bank, T. 39, R. 11 W., Sec. 6."

Page 212, No. 218, instead of "Carl" read "Carroll."

PART II.

CHAPTER I.

Page 5, for "Chilhomee" read "Chilhowee."

CHAPTER II.

Page 17, for "Gilkenson's frod" read Gilkinson's ford."

Page 18, for "*Lepidastrobus*" read "*Lepidostrobus*."

Page 19, in 11th line from bottom, for "dip" read "slip."

CHAPTER III.

Page 46, 15th line from bottom, for "*castatus*" read "*costatus*."

Page 48, 4th line from top, for "vein" read "seam."

Page 51, 6th line from top, for "*Meekelea*" read "*Meekella*," and in 7th line from top, for "*castatus*" read "*costatus*."

Page 62, for "Wörsten" read "Würster."

CHAPTER IV.

Page 88, in No. 218, omit comma between "*Entolium*" and "*aviculatum*." "*Subcumata*" should be "*subcuneata*;" "*Marconianus*" should be "*Marcouanus*;" "*Fistulafora*" should be "*Fistulapora*."

Page 89, in No. 211, for "*Syncladia*" read "*Synocladia*."

Page 89, in No. 210, for "*punctalifera*" read "*punctulifera*."

Page 90, in No. 206, omit comma just after "*Pleurotomaria*."

Page 90, in No. 197, for "*microspivus*" read "*mucrospinus*."

Page 91, in No. 188, for "*Marconianis*" read "*Marcouanus*."

Page 92, in No. 152, "*Monoptira*" should be "*Monoptera*."

Page 92, in No. 150, "Chest" should be "Chert."

Page 92, in No. 150, for "*Syntriolasma*" read "*Syntrilasma*."

Page 94, in No. 21, for "*Spirifuria*" read "*Spiriferina*."

Page 94, in No. 112, omit comma after word "*productus*."

Page 94, in No. 110, for "*Syntriclasma*" read "*Syntrilasma*."

Page 94, in right hand column, opposite No. 110, for "Saul, Missouri," read "Sam'l Morrow."

Page 95, for "*eutolium*" read "*entolium*."

Page 95, in No. 98, for "*Syntuclasma*" read "*Syntrilasma*."

Page 95, in No. 96, after "*Myalina*" omit "?."

Page 96, in first column at bottom of page, for "3 feet 8 inches" read "5 feet 8 inches."

Pages 107 and 112, for "*Eutolium*" read "*Entolium*."

Pages 119 and 120, for "Jatan" read "Iatan."

Page 126, sixth line, omit the words "in *scalenohedra*."

CHAPTER VI.

Page 193, second line from top, for "fine" read "fire."

Page 199, line 3 from bottom, for "Lymington" read "Symington."

Page 205, for "Cocknell" read "Cockrell."

CHAPTER IX.

Page 290, for "Collins" read "Colliers."

Page 291, line 3, for "red chestnut" read "rock chestnut."

Page 293, in No. 20, erase word "limestone."

Page 302, for "Ch. Marster" read "Ch. Würster."

CHAPTER XIII.

Pages 361 and 373, "Tarkie" should read "Tarkio."

Page 364, line 22, for "Took" read "Zook."

CHAPTER XIV.

Page 377, in line 22 from top, for "Suieda" read "lucida."

In several places for "Tarkie" read "Tarkio."

Page 384, for "Vaugundy" read "Vangundy."

CHAPTER XV.

Page 393, line 7 from bottom, omit comma after "*Rhombopora.*"

Page 396, for "*Ælis*" read "*Aclis*;" also for "*Cetenacanthus*" read "*Ctenacanthus.*"

Page 400, for "Lund county" read "Sand Creek."

APPENDIX C.

Page 417, No. 27, for "*nanes*" read "*nanus.*"