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REPORT OF PROGRESS

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GEOLOGICAL SURVEY,

BY G. C. SWALLOW.

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GEOLOGICAL ROOMS, STATE UNIVERSITY,  
COLUMBIA, MISSOURI, December 30, 1860. }

HON. B. F. MASSEY, *Secretary of State*:—

SIR: In compliance with the law providing for the Geological Survey of the State, I herewith submit my Fifth Report of the progress and condition of that Survey.

Very Respectfully,

Your Obedient Servant,

G. C. SWALLOW,  
*State Geologist.*

## REPORT OF PROGRESS.

Since my Fourth Report of Progress, in Dec. 1858, the labors of the Geological Survey have progressed regularly and rapidly towards completion; and the work is now in such a state of advancement that it can be easily completed in 1862, the time specified in my last Report. Our examinations of the two last years more than sustain our high estimates of the agricultural, mineral and manufacturing resources of our favored State.

Since my last report, Mr. H. U. ULFFERS has been appointed Draughtsman and Assistant Geologist, in place of Mr. R. B. PRICE, resigned; Dr. JOHN LOCKE, Assistant Geologist, to fill the vacancy created by the appointment of Dr. NORWOOD to the State University; and Mr. P. C. SWALLOW, Assistant Geologist. The corps now stands:

- Dr. A. LITTON, Chemist;
- Dr. JOHN LOCKE, Assistant Geologist;
- Mr. G. C. BROADHEAD, Assistant Geologist;
- Mr. H. U. ULFFERS, Draughtsman and Assistant Geologist;
- Mr. G. C. WHEELER, Assistant Geologist;
- Mr. P. C. SWALLOW, Assistant Geologist;

Besides these, one cook and one teamster are employed for each company, while in the field, making the whole force on active duty eleven.— Their devotion, industry and skill deserve the highest commendation. Nothing but a few instances of temporary sickness, from exposure in camp life, has interrupted our labors for the past two years.

During these two years, Dr. LITTON'S work in the Survey has been confined entirely to the laboratory, in making analyses of soils, ores, and other minerals, rocks, and mineral waters; of which he has made a large number of most thorough and accurate analyses.

The whole number of quantitative analyses made by Dr. LITTON is:

Soils.....	36
Iron ores.....	22
Lead ores.....	32
Copper ores.....	4
Zinc ores.....	2
Mineral waters.....	25
Sands and sandstones.....	11
Clays.....	49
Limestones.....	59
Not classified.....	12
Total.....	252

The whole number of qualitative analyses made by him is nearly as great as the quantitative.

Dr. NORWOOD has been engaged in the labors of the Survey since my last report, up to August last, when he entered upon his duties in the State University. During that time, he made the surveys of Pettis, Johnson, Henry, St. Clair, Jackson, Cass, and a part of Benton, Hickory and Bates. He has also prepared materials for the maps and reports on those counties, and assisted in arranging, classifying and labeling the specimens of rocks, minerals and fossils collected in those counties. In these labors he was assisted by Mr. P. C. SWALLOW.

Dr. JOHN LOCKE joined the Survey in October last, when he took charge of my company, and made the survey of Ray and a half of Clinton. Since the weather became too inclement for field operations, he has prepared the materials, and made up the maps, sections and reports of the work in those counties. In this work he has been assisted by Messrs. WHEELER and ULFFERS.

Mr. G. C. BROADHEAD has been constantly engaged in the labors of the Survey during the two past years. He had the charge of my company nearly all the time while completing the surveys of Lincoln, Pike, St. Charles, Ralls, Monroe, Randolph, Shelby, Knox, Adair and Linn, and making the surveys of Mercer, Sullivan, Harrison, Grundy and Daviess.

In this work he was assisted by Messrs. PRICE, WHEELER, and LINN. During the last fall, in charge of Dr. NORWOOD's company, he made the surveys of DeKalb, Gentry and Nodaway, and finished Atchison, Holt and Andrew. In these he was assisted by Mr. P. C. SWALLOW. Mr. BROADHEAD has also made out many of the county maps and reports of the counties examined.

Messrs. WHEELER and ULFFERS have finished the examination of Chariton and Carroll, and made some examinations in Howard.

Mr. WHEELER made several analyses of coal during the last winter, besides assisting in other office work. Since the field work closed this season, he has been engaged making up the sections and reports of Chariton county.

Mr. ULFFERS has also made three hundred drawings of new fossils, a large and beautiful section of the strata between Louisiana on the Mississippi and Weston on the Missouri; and one from the LaMine in Cooper to Kansas City, along the line of the Pacific Railroad, showing the position of the coal beds in those parts of the Missouri Coal Field, besides assisting in other office work.

Only a small portion of my own time has been devoted to field work. I have directed my own company in the more difficult portions of the work, and re-examined many localities in various portions of the State, for the purpose of settling various questions left in doubt by the previous surveys. The remainder of the time has been devoted to the office work, in arranging the specimens of rocks and minerals, and in determining their properties; in determining the names of fossils, and describing those which proved to be new; in making up estimates of the mineral deposits, and in making reports, sections and maps; in conducting the correspondence of the Survey, and in directing the work of those engaged in the various departments of the labor. By the request of the President, Engineer and Directors of the Chariton and Randolph Railroad Company, I made a survey of the country along the line of that road, and submitted a report of the same to the President and Directors in November, 1859.

The following table will show at a glance the condition and progress of the work, and the mineral deposits in the various counties of the State:









This table shows the surveys are completed in 80 counties; 13 are half done; 13 others are commenced, leaving only 7 in which but little or no work has been done; and only 33 in all to be completed, of these 13 are half done and 13 others commenced, as stated above.

It will be remembered that the law requires us to make out accurate maps of each county, on which shall be marked the mineral deposits and rock formations, in colors; also, the prairie, timber, and bottom lands. We have, in all cases where practicable, also put on these maps the bluffs and hills, streams, springs, caves, towns, post-offices, churches, school-houses, bridges, roads, and election townships and precincts. More than half of the labor and expense of the Survey has been expended upon these maps. To obtain the data for these maps, we first copied the plats of all the townships in the State (over 2000) from those in the Surveyor General's office. These plats are carried into the townships, where all the facts are added from the actual survey of the localities. The boundaries of the election townships and precincts are obtained from the County Clerks; the roads, &c., from the surveyors and others. From the data thus obtained, most accurate and elaborate county maps have been completed of forty-four counties; sixty-two others have been commenced, and the most of them nearly completed. Nineteen of these county maps have been handsomely engraved on steel, and from 7,000 to 10,000 copies of each printed, preparatory for the final reports. Over 100,000 of these maps, of seventeen counties, have been beautifully colored, as the law provides, to be used in the final reports.

These facts can but show that such a series of maps, thus made, must have cost a vast amount of labor, and that they will be invaluable, aside from the geology, for the knowledge they will give of the geography of the counties—the prairies, timber, springs, streams, bluffs and mountains, caves and bottoms, roads, post-offices, churches, school-houses, election townships and precincts, mills and towns.

As this table shows, we have also finished the reports on thirty-three counties.\* The reports on the other forty-seven counties already surveyed, are in such a state of advancement that they can be completed in a few months.

As this table also shows, coal has been found in fifty-seven counties; lead veins in thirty-seven counties; valuable deposits of iron in fifty-two counties; copper in fifteen; zinc in fifteen; cobalt in one; nickel in one; hydraulic limestone in fourteen, and good marbles in twenty-five counties.

#### COAL.

Previous to the commencement of this Survey, it was thought by Dr. OWEN,\* and other eminent geologists, that the rocks in the counties on our western border, between Bates and the Iowa line, belonged to the lower carboniferous series, which lie below all the coal beds of the country. Were

\*The fact that so many of the county reports are made out, and so many of the county maps finished and progressing towards completion, shows that a volume of these reports and maps might be published, if deemed advisable, without materially retarding the field work of the Survey. Under the circumstances, there seems to be no good reason why these reports should not be published at once.

\*See map in his report on Iowa, Minnesota, and Wisconsin, to the United States, published in 1852.



this conclusion correct, there could be no hope of finding coal in those western counties of Missouri and the eastern counties of Kansas and Nebraska. But my examinations along the Missouri river, from Council Bluffs to Jefferson City, in 1853, and Maj. Hawn's explorations along the line of the Hannibal and St. Joseph Railroad, in the following year, proved conclusively to my mind that the rocks in those counties on the Missouri above Lexington belong to the coal measures, the regular coal-bearing rocks of the West; and that the coal beds which crop out in Johnson, Lafayette and Saline, on the south, and in the valleys of Grand River and the Chariton on the north, dip beneath these western and north-western counties of our State, and the eastern counties of Kansas and Nebraska. This opinion was confirmed by my discovery of thin coal beds in Platte and Holt counties, and thicker beds on the Nemaha and Wolf rivers, in the territory west.

This opinion has been fully established by our subsequent explorations. Dr. NORWOOD's examinations in Lafayette, Jackson, Cass, Johnson, Pettis, St. Clair and Benton, show that the coal beds cropping out in those counties between the Missouri and the Osage, dip beneath the country to the west and north-west. The surveys of Mr. BROADHEAD in the northern and north-western counties, show that the coal beds in the valley of the Grand River and the Chariton, dip under the surface rocks to the west. Dr. LOCKE's explorations, as assisted by Messrs. ULFFERS and WHEELER, in the counties on the north side of the Missouri, from Howard and Randolph to Clay and Clinton, prove that all the coal beds in that region dip beneath the surface rocks in their western extension; and my own observations across the country, in various directions, all go to establish the same great fact as to the position of the coal beds in our State. And it may be set down as a fact, as well established as any fact deduced from the operation of natural causes, that the regular coal beds which crop out in St. Clair, Benton, Johnson, Saline, Lafayette, Ray, Carroll, Chariton, Randolph, Macon, Livingston, Sullivan, Adair and Putnam, do dip beneath the surface rocks, and underlie all the counties to the west of those localities.\* From St. Joseph to Kansas City, the upper workable, or Lexington bed, varies from 200 to 300 feet below the surface of the Missouri bottom, and the other thicker beds are still below.†

If a coal bed lies so low that it will not drain off at the surface, a depth of 200 or 300 feet will make but little difference in the expense of raising the coal, where large quantities are mined. Many of the best mines in the world are worked at depths much greater than these. A mine opened at Weston, or St. Joseph, could scarcely fail to yield large profits at the present prices for the coal, or even if those prices should materially decline.

We have now examined nearly all the counties in the great Coal Field of our State, and the results fully confirm what was said in our report of

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\* It is true that coal beds do sometimes thin out and disappear; but I know of no instance where a coal bed, so regular and persistent as those which crop out around the eastern edge of this coal field, thins out and disappears towards the centre of the coal basin. Should it even prove true that one or more of these beds thin out towards the west, contrary to all the experience of the past, there is no probability, and scarcely a possibility, that all of them do.

† I have this day received a note from Maj. Hawn, who is engaged with others in boring for coal at Leavenworth, K. T. He says they have penetrated 150 feet below the surface of the Missouri, and the rocks which he says they have passed through below the river surface, agree with those put down in our section as occupying that position. This company will soon prove the truth or error of our deductions.

1854, of the extent and quality of our coal beds. We have more than 27,000 square miles of coal beds, and more than 135,000,000,000 tons of coal.

**Lead.** But little work has been done in our lead regions since my last report. Some new discoveries have been made, and the mines worked have, as a whole, sustained the opinions formed of their extent and value. Doubts can no longer be entertained that many of our lead veins are *true veins*, extending down indefinitely. For the reasons governing these conclusions, I would refer to my report on the South-west Branch of the Pacific Railroad, published in 1857.

**Iron.** A few important deposits of the carbonate of iron, or *kidney ore*, have been discovered in the coal measures examined during the past two years; also a few beds of hematite, in the older rocks. But these will not be considered of much importance in a State abounding in such vast deposits of this, the most valuable of metals.

We have nothing new to add respecting the copper, zinc, cobalt and nickel of the State, as our labors have been confined mainly to the coal regions of the north and west since our last report.

**Soils.** We have collected several hundred specimens of the various varieties of soils, from all parts of the State; thirty-six of them have been analysed in the most accurate manner by Dr. LITTON. The results obtained place our soils first on the list for fertility, durability and adaptation to the various staple crops and fruits of the temperate zone.

While the unprecedented drought of the past year has proved somewhat disastrous to our farming interests, still those who have ploughed deep and cultivated thoroughly, have made good crops; and, in many cases, this has been done without a good rain for the entire season. The experiments thus far made in our State show that the crops may be increased from one-fourth to three-fourths in good years, and secured against failure in such dry seasons as the last, by judicious subsoiling and thorough cultivation.

As a general rule, the subsoil plough, which leaves the subsoil at the bottom, is much the best. When the subsoil is very poor or clayey, it will prove decidedly injurious to bring it to the surface before it has been stirred in its natural position for one or two years at least. On the contrary, if the subsoil be light, and rich in organic matter, as many of our black subsoils are proved to be, they may be brought to the surface with decided advantage on old ground, which has been partially exhausted. But it will do still better when it has been stirred by the subsoil plough one or more years previous to turning it up.

Under-draining with the improved mole-ploughs, particularly in the wet prairies, in some of our neighboring States, has proved highly beneficial; and there can be no doubt that these ploughs could be used with great advantage in our prairies, especially where they are disposed to be too wet. The constant supply of good water obtained by these drains is very useful in places destitute of springs and running streams.

Our examinations and analyses of our soils have shown another fact of vast importance. The subsoil in a large portion of the white-oak ridges of the central and northern parts of the State is quite as good, and in many cases even better, than the surface soil. This is particularly true on the bluffs of the Missouri river, and on the ridges running back from that stream. This remarkable fact is shown by the following analyses:

*Analysis of a Soil from a White-oak Ridge in Boone County, near the Missouri River, by Dr. Litton.*

	No. 12 A*	No. 12 B*	No. 12 C*
Water expelled by drying at 150° C.....	0.4105	0.6558	0.8030
Organic matter and water not expelled at 150° C.....	3.0957	2.6049	3.8901
Silica, etc., insoluble in hydrochloric acid.....	90.1420	90.8063	85.0571
Soluble silica.....	0.1384	0.1475	0.2187
Alumina.....	3.0654	2.9346	4.7672
Peroxide of iron.....	2.0553	2.0590	3.8814
Oxide of Manganese.....	a trace.	a trace.	a trace.
Lime.....	0.2086	0.1242	0.4722
Magnesia.....	0.3423	0.2048	0.6581
Potash.....	0.3368	0.2121	0.3895
Soda.....	0.1828	0.2925	0.1220
Phosphoric acid.....	0.0560	0.0508	0.0556
Sulphuric acid.....	0.0035	0.0346	0.0099
Chlorine.....	0.0000	0.0000	0.0276
Total.....	0.100373	100.1311	100.0.3524

An examination of these analyses will show that the subsoil contains more than the surface soil of *organic matter, soluble silica, iron, alumina, lime, magnesia, potash, soda, sulphuric acid, and chlorine*, and nearly as much of *phosphoric acid*. This, doubtless, might be expected where the surface has not been covered with grass or other vegetation, to prevent the washing away of the finer and soluble materials by the rains of the long ages since those ridges rose above the waters, in which their surface deposits were formed.

A soil from the bluffs above Boonville contained more *soluble matter, alumina, magnesia*, and more *potash*, in the subsoil than in the surface soil. These facts show the wisdom of so stirring the subsoil that the roots may penetrate them and obtain their richer stores of fertilizing materials, and thus increase the crops.

It may be proper to add, in this connection, that the soil obtained from the Grand Prairie, in Boone county, exhibited the same general result. The subsoil contained more than the surface soil of *soluble matter, alumina, magnesia, potash, soda*, and more *sulphuric acid*, and nearly as much *lime* and *phosphoric acid*. These soils usually contain more organic matter from ten to twenty inches below the surface than they do from two to six inches below. These facts show these subsoils to be as rich in fertilizing ingredients far below that portion made accessible to the roots of the crops in our ordinary modes of cultivation.

In my last report, submitted in December, 1858, I stated that the survey could be completed in four years. During the past two years, more than half of the work then remaining has been done, and the thirty-three counties still unfinished can be completed in two years, even with an appropriation \$5000 less than that made at the last regular session of the General Assembly.

The work remaining to be done in the Survey is the completion of Audrain, Boone, Buchanan, Callaway, Clay, Clinton, Livingston, and Platte, on the north of the Missouri river; and Bates, Benton, Barton, Barry, Camden, Cedar, Dade, Dallas, Dent, Dunklin, Gasconade, Hickory Howell, Iron, Jasper, McDonald, Oregon, Polk, St. Francois, Shannon, Stone, Ta-

ney, Texas, Vernon, and Webster, on the south. Some of these are nearly completed, others half done, and still others commenced; as the nature of the work and the character of the rocks directed, during the progress of the work. There also remains a careful examination of the mining region and mines, to determine more fully the character and extent of our mineral veins, which can not be done with so much accuracy and promise of success until the whole of the general geology of the State is made out, so as to show the character and position of all the mineral-bearing rocks.

We also have to make analyses of the remaining soils, ores and other minerals, and test by actual experiment the value of our numerous beds of hydraulic limestone, fire-clays, mineral paints, fire-rocks, marbles, etc., etc. It will be perceived that these examinations, which in the nature of the case come last, promise the most practical and useful results.

It may be proper to state a few of the reasons which seem to show the wisdom of an immediate completion of this great work.

*First.* Should the work stop where it is, the vast amount of labor done during the past eight years will be of but comparatively little value to the State and the public at large.

The number of specimens collected is very great; many thousands have been examined, classified and labeled; other thousands have been partially examined, and many others are still unpacked. These will be of but little value, unless all are carefully labeled, arranged, and sent to the institutions of learning where the law directs them to be deposited. The eighty county maps; either completed or in a state far advanced towards completion, and the reports on the several counties, in about the same state of progress; and the one hundred thousand maps already printed and colored, and the hundreds of sections made out and nearly prepared for publication, and the many volumes of field notes, all will be of little use, unless the work is completed.

*Second.* Should the work be suspended, the present company would be dispersed, and no other men or set of men could take it up and complete it, without going over a large amount of the labor already done; as a large portion of the facts and details of the work, and the relations upon which the general results depend, are recorded nowhere but in the memories of those who have done the work; nor could it be otherwise from the very nature of the case. The truth of these statements has been fully and sadly experienced in the States of Michigan, Tennessee, Mississippi, South Carolina, Maryland, New Jersey, and Vermont, in which Geological Surveys were commenced and discontinued, and afterwards recommenced; in all cases, I believe, by other men, who were compelled to go over nearly the whole ground-work again; as the labors of their predecessors had not been completed and published. Many of the States mentioned have spent money and labor enough to have completed accurate surveys, and published the results in substantial form, had they not pursued the policy of discontinuing the work from time to time, and recommencing under different men and different systems of conducting the work. And yet no one of them, save Vermont, has yet completed its Geological Survey. The Survey of New York

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\*No. 12 A, was collected from 2 to 6 inches below the surface; No. 12 B, from 10 to 12, and No. 12 C, from 18 to 20 inches below the surface, on a high ridge covered with white-oak, interspersed with a few post and black oak, white hickory, dwarf sumac, hazle, and summer grapes.

was considered the most expensive of all; but it has proved quite as economical and as advantageous; owing, in no small degree, to the fact that it was prosecuted without interruption to its completion.

*Third.* Missouri has borrowed money, setting forth her vast agricultural and mineral resources, and manufacturing and commercial advantages, as ample security for the payment of the debt when due. Men are sent forth to examine these resources; they report progress from time to time, and finally they are stopped, the work left near its completion, and no statement made of the results of the examination. Will men, capitalists, take that as an evidence that these resources do really exist? or will they rather take it as an admission that they do not exist?

*Fourth.* If we show the world our natural resources, and means of wealth and power, it cannot fail to increase our influence in securing our rights, or the most advantageous relations in this crisis of our national affairs.

*Fifth.* Although it might not be good policy to commence such a work at this time, still, since four-fifths of the money and labor needed has been expended, the question presents entirely different aspects. It is no longer a question whether the State would pay \$115,000 for such a Survey, but whether it would pay \$20,000 for it, or to complete the work and make more useful what has already been done. Nor is it a question whether it would pay \$20,000 for the work now or at some future time; but whether it would pay that now, or a sum many times larger at some future period.

But it may appear unnecessary, and even presumptuous, to adduce arguments in favor of such a work, or its completion, to the Legislators of a State, in which the four last General Assemblies have decided in favor of its utility, by making large appropriations for its commencement and continuation; and that, too, with an unanimity unprecedented in our country.

In conclusion, I would express, for myself and my fellow-laborers, our gratitude to the Executive officers, Legislators, and citizens of our State, for the continued sympathy, cooperation, and hospitality, which we have so uniformly met at their hands; and at the same time we would ask the forbearance of those who may feel that we have not done all we could, or that we have neglected some portion of the work, that has seemed to them to claim our earlier attention. We can only say we have done what we could, and that in the order which seemed to us to promise the best results.