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H. A. BUEHLER, Director and State Geologist

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The Geology of Jackson County

BY

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ASSISTED BY
M. Albertson and J. W. Benne

1917

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Missouri Bureau of Geology and Mines,

Rolla, Mo., February 1, 1917.

To the President, Governor Frederick D. Gardner, and the Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen—I have the honor to transmit herewith a report on the Geology and Mineral Resources of Jackson County by Mr. Walter Edward McCourt, assisted by Mr. M. Albertson and Mr. J. W. Bennett.

Respectfully submitted,

H. A. BUEHLER,

Director and State Geologist.

ACKNOWLEDGMENTS

The Missouri Bureau of Geology and Mines is indebted to the citizens of the county and Kansas City, who have uniformly shown an interest in the work incident to the preparation of this report, and many of whom have materially aided in gathering information. Special mention is due Messrs. John Bovard, S. J. Hatch, S. J. Hare and H. F. Holden of Kansas City; Mr. Louis Knoche of Martin City; Mr. Hanlon of Lees Summit; the City Engineer of Kansas City, the County Highway Engineer, and the officers of the Park Board.

INTRODUCTION

The Pennsylvanian formations underlie an area of about 24,000 square miles in the northern and western parts of the state. They were first studied by Broadhead, who, in 1872, published[1] a description containing many excellent sections along the Missouri River and its chief tributaries, designating the various beds by numbers. The same formations underlie large areas in Kansas and Iowa, and, with later detailed work on the part of the Geological Surveys of those states, the various members were given local names. As the work was done in widely separated areas without correlating the different regions, two or more names for the same member were frequently used. This is true of most of the members occurring in Jackson county.

In 1915, the Missouri Bureau of Geology and Mines, in co-operation with the United States Geological Survey, issued a general report on the Stratigraphy of the Pennsylvanian, to which the reader is referred for details regarding the nomenclature.

This report is accompanied by two geological maps, one of the county, on a scale of one inch per mile, and one of Kansas City, on a scale of three inches per mile. Accurate topographic maps of the county not being available, the present geological map was made with the use of comparatively few bench marks to show accurate elevations.

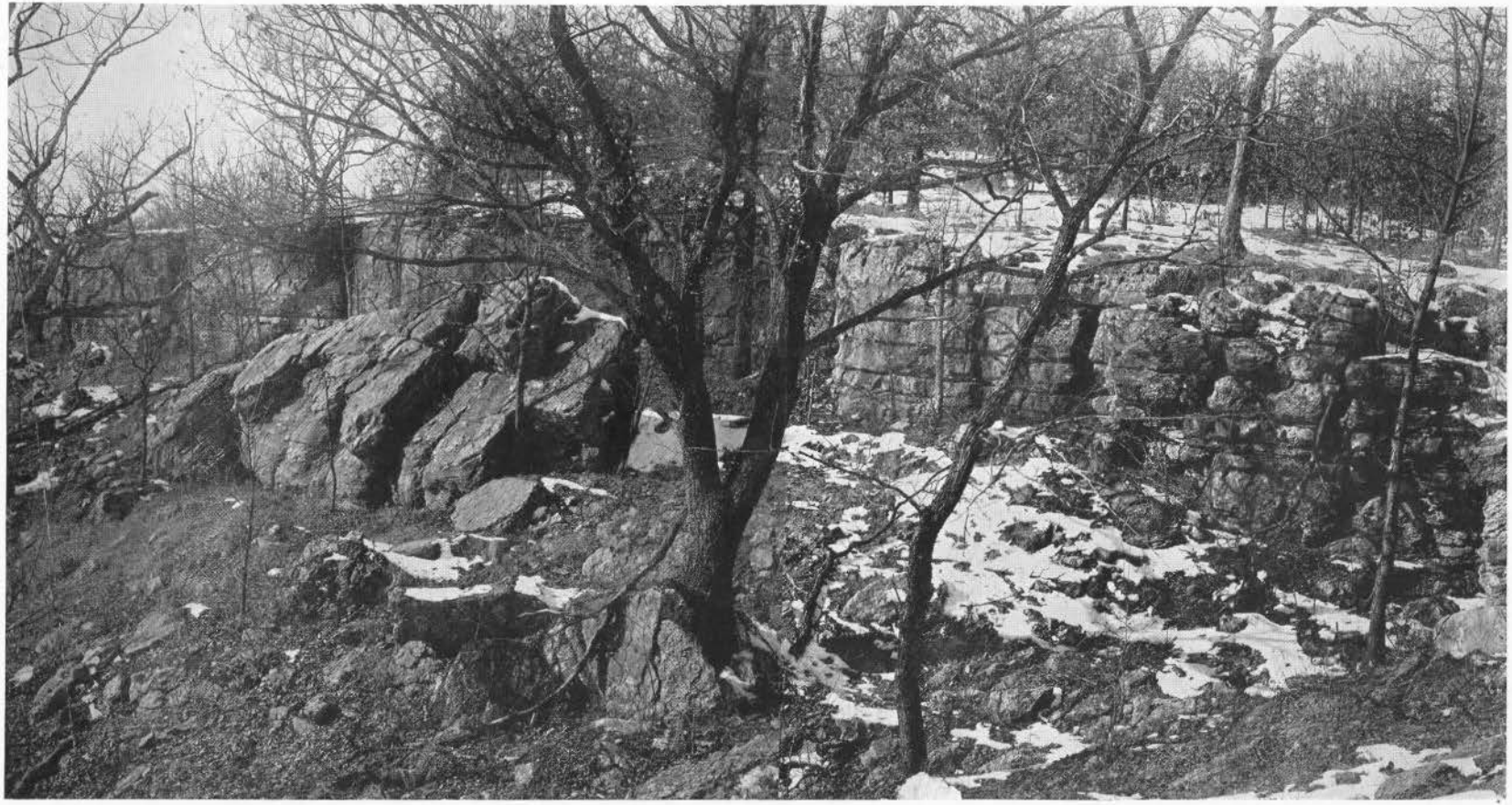
The "Coal Measures" are composed chiefly of alternate beds of shale and limestone, few of which, in Jackson county, attain a thickness of more than thirty feet. The surface distribution and occurrence of these members materially affects many engineering problems, such as street and road improvements, the digging of water and sewer conduits, as well as excavation work for large or important buildings. The geologic maps indicate the areal distribution of the various formations. In the northern part of the county a considerable thickness of the surface clay, known as loess, covers the older formations. It has been impossible to determine in such places just what for-

[1]Broadhead, G. C., Geol. Survey of Missouri: Iron Ores and Coal Fields, 1872, Pt. 2, 1873.

mations underlie this clay, as there was much erosion prior to its deposition. This is especially true of the northeastern portion of the county where there are only a few outcrops of the Bethany Falls and underlying limestones and where the hills are apparently composed of loess. Where this is the condition, the geologic boundaries on the map are dotted.

In a number of instances, the limestone and shale members not being of sufficient thickness to be mapped independently, two or more are shown on the maps under one pattern.

H. A. BUEHLER.



Typical escarpment of Bethany Falls limestone.

CHAPTER I.

GEOGRAPHY.

LOCATION AND AREA.

Jackson county, situated in the northwest corner of that part of the state south of Missouri River, is bounded on the north by the river and touches the Kansas state line on the west. On the south is Cass county, and on the east are Lafayette and Johnson counties. Due to the meanders of Missouri River, the north-south dimension varies. It is 18 miles at the Kansas line, 27 miles east of the center, and 22 miles at the eastern border. The east-west dimension is approximately 27 miles.

The county, which has an area of 607 square miles or 388,840 acres, is roughly bounded by parallels 38° 50′ and 39° 10′ north and meridians 94° 10′ and 94° 40′ west. With reference to township and range, it comprises townships 47, 48, 49, and parts of 50 and 51 north, in the western half of range 29, and ranges 30, 31, 32, and 33 west of the 5th principal meridian.

HISTORY AND DEVELOPMENT.

Exploration[1] *and settlement.*—As far as history tells us, among the first white men to view the region that is now Jackson county, was the party of Sieur de Bourgmont, which in 1724 marched from Fort Orleans, a French outpost on an island in the Missouri River near the mouth of the Grand. De Bourgmont followed a trail which ran more or less parallel to the river as far as an Indian village at the mouth of the Kansas, where he crossed the river in canoes to the Indian village "Canzes." It is believed by some historians that his return trip was made south of the river.

What is now Jackson county was originally a portion of the country owned by the Osage Indians. On October 10, 1808, after the Louisiana Purchase, which made this United States territory, the Osages perfected a treaty with the United States

[1]Historical notes prepared by Dr. E. M. Shepard, Springfield, Mo.

at Ft. Osage, now called Sibley, situated on the Missouri River, about 25 miles east of Kansas City, by which they ceded all that portion of southern Missouri lying east of a line extending from Ft. Osage due south to Arkansas River, and north of the Arkansas to its mouth; west of the Mississippi to the mouth of the Missouri, following that river back to the original starting point. For this vast area covering practically all of the Ozark country, the Osages received $1,200 in cash and $1,500 in merchandise. Thus, a strip five miles wide on the east side of Jackson county became a part of the United States from 1808, but the remainder of the county belonged to the Osages until June 2, 1825, when they relinquished all their lands remaining in Missouri and Arkansas and a portion of their Kansas possessions, recognizing the right of the United States to use all navigable rivers in what was left of their original territory. For this they were to receive $7,000 yearly for seven years.*

The first occupation of what is now Jackson county by white men was at the present site of Sibley, on Missouri River. Houck[1] states that Captain Clemson with 81 men reached this point October 2, 1808, where they were soon joined by General Clark with 80 mounted militia. The troops at once erected a fort at a narrow point on the river on a high bluff 70 feet above high water mark, thus commanding a fine view up and down the stream. This fortification they called Ft. Osage. Breckenridge, in 1811, notes a farm, that of Mr. Audrain, above the Boonslick settlement, where, in 1810, in partnership with his brother, he cleared some land near Fort Osage. These two men were probably the first settlers in Jackson county.

The area now constituting Jackson county was a part of Howard county, which, as organized in 1816, included all of Missouri west of a line extending north from the mouth of the Osage River and all the territory between the Osage and Missouri rivers. In 1818 that part of Howard county south of the Missouri was organized as Cooper county. Cooper was divided in 1820 and the western half was named Lillard county with Mount Vernon (near Northrup, Lafayette county) as the county seat. On December 15, 1826, Jackson county was organized, but included also Cass and Bates counties. On September 14, 1835, the last two, under the name of Van Buren, were taken from Jackson, reducing the county to its present size.

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*Eighteenth Annual Report of the U. S. Bureau of American Ethnology, Pt. 2, p. 676.
[1]Houck, Louis, Hist. of Missouri, vol. III, p. 147.

After the organization of the county, December 5, 1826, settlers began to arrive in increasing numbers and soon towns were established. The Santa Fe trail began at Old Franklin and later started 100 miles farther west, at Independence, founded in 1827, which was a more favorable place for starting caravans to New Mexico. The development of Westport, now a part of Kansas City, dates from 1833.

Westport, however, not being on the river, freight was brought overland to it from the river landing. This river landing was the most western point from which merchandise could be shipped overland to the southwest. The trail from here had the advantage over routes starting farther up the river, in that it avoided crossing large streams. The landing's early growth followed from its favorable site at the junction of the natural highways, the Kaw and Missouri rivers. The valleys of these streams later furnished easy water-level grades for the first railroads and the trade of the country was soon directed to this point. Soon Westport landing, now Kansas City, became the market and distributing point for a large territory. Timely bridging of the Missouri river made it possible for the country north of the river to contribute to the development of Kansas City, and it also gave the natural trade routes of the south and west a free outlet to the north, as well as to the east, thus insuring the later rapid development of the community.

Population.—Jackson is the most populous county in the state, having, according to the census of 1910, 283,522 inhabitants; Kansas City has 248,381, and Independence, the county seat, 9,859. The third largest place is Lees Summit with a population of 1,435. Blue Springs and Oak Grove each has between 500 and 1,000, while Buckner, Dodson, Grandview, Greenwood, Hickman Mills, Martin City, Mount Washington, Raytown, Sibley, and Sugar Creek range between 200 and 500. Adams, Atherton, Belvidere, Cement City, Cockrell, Courtney, Dallas, Delaven, Grain Valley, Hicks City, Hiller, Holmes Park, Lake City, Levasy, Little Blue, Lonejack, New Santa Fe, Pink Hill, Red Bridge, Selsa, Sni Mills, Tarsney, Twyman, and Vale are small villages, for the most part, with fewer than 100 inhabitants.

Industries.—As Kansas City is the center of the lower Missouri valley, and as it is the largest city of this fertile region, it not only has many industries dependent on agriculture, but also leads in a large number of these industries. As a mule, live-

stock, hay, and grain market, in the sale of agricultural implements, in meat-packing and flour output, and in the poultry and egg business, Kansas City either leads or ranks very high among the cities of the United States. As a manufacturing center, on the other hand, her place is tenth in value of factory output; but the geographic advantages of the city must naturally increase this at a rapid rate.

The industries dependent on local natural resources are rock quarrying for crushed stone for rip-rap, and for building and foundations, shale mining for brick, for sewer pipe, and for drain tile, etc., sand and gravel dredging, and formerly coal mining on a small scale. Natural gas and a minor quantity of petroleum exist at shallow depths within the city limits.

In this county, as in other counties of the Missouri Valley, the industries are chiefly agricultural. Some manufacturing at Independence, a large oil refinery at Sugar Creek, and a portland cement plant at Cement City, are the chief exceptions. Though general farming is the rule, the raising of thoroughbred stock, dairying, and truck gardening are steadily increasing. The fertility of the soil is amply proven by the fine type of farms and farm buildings to be seen throughout the county.

TRANSPORTATION.

Railroads.—Jackson county is well supplied with railroads leading from all directions toward Kansas City, following, for the most part, the valleys. Kansas City is one of the principal railroad centers of the country. Several railroads, including the Chicago, Burlington & Quincy; the Chicago, Milwaukee & St. Paul; Wabash; the Rock Island, St. Joseph & Grand Island; and the Quincy, Omaha & Kansas City cross the river at the north edge of the city. The Lexington branch of the Missouri Pacific occupies the abandoned channel of the Little Blue and extends to Independence where it joins the main line. The Chicago & Alton, entering east of Oak Grove, traverses the central part of the county. In the south-central part, the Missouri Pacific and the Chicago, Rock Island & Pacific cross the divide at Lees Summit, pass through the Little Blue Valley and then on to Independence and Kansas City. The Kansas City Southern and the St. Louis & San Francisco follow the divide past Grandview, and proceed thence to the valley of the Big Blue; while another branch of the Missouri Pacific enters the county

at the south in the Big Blue valley and follows the course of that stream to the city.

The location of the new Union Station in the old valley of Turkey creek makes use of a natural path across the city and provides an easy outlet both to the east and west.

River transportation.—Missouri River played an important part in the early development of Jackson county and Kansas City, but river traffic decreased rapidly with the increase of railroad facilities. At the present time, however, there is a consistent effort being made to revive river traffic. The Kansas City and Missouri River Navigation Company has a line of barges operating between Kansas City and St. Louis, and with further improvement of the channel of Missouri River an increased tonnage will no doubt be transported by water.

Highways.—The rock roads and graded highways through all parts of Jackson county, and the beautiful system of boulevards which link Kansas City with the suburbs, give the county a high rank in good roads. There are now about 350 miles of rock roads and the mileage is being constantly increased. A factor of prime importance in Jackson county road making is the abundance of limestone which can usually be obtained within a short distance of any road that is to be improved.

CLIMATE.[1]

"The climate of Jackson county differs but slightly from that of other parts of central and northern Missouri. The annual mean temperature is slightly lower both in winter and summer and the average annual rainfall slightly less than in the eastern and central parts of the state. On the other hand, the period between the average date of the last killing frost in spring and the first killing frost in autumn is slightly longer.

The following table, compiled from the records of the Weather Bureau, shows the normal monthly, seasonal, and annual temperature and precipitation at Kansas City:

[1]Sweet, A. T., Krusekopf, H., and Dunn, J. E., Soil Survey of Jackson County, Missouri: Advance Sheets—Field Operations of the Bureau of Soils, 1910, pp. 8-9, 1912.

NORMAL MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE AND PRECIPITATION AT KANSAS CITY, MO.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	34	70	—13	1.4	1.7	1.4	4.7
January	30	69	—17	1.3	.4	4.1	5.6
February	29	76	—22	1.8	1.4	1.1	8.0
Winter	31	.....	.....	4.5	3.5	6.6	18.3
March	41	88	2	2.5	3.7	4.5	4.1
April	56	90	22	3.0	4.2	3.8	1.0
May	65	90	36	5.1	.8	7.7	.0
Spring	54	.....	.....	10.6	8.7	16.0	5.1
June	74	100	48	4.4	2.5	6.0	.0
July	78	106	54	5.0	2.8	4.9	.0
August	76	103	46	4.0	2.6	5.0	.0
Summer	76	.....	.....	13.4	7.9	15.9	.0
September	69	101	35	3.9	1.8	4.5	.0
October	58	91	26	2.3	2.2	4.4	.4
November	43	79	4	1.7	.6	2.7	1.3
Fall	57	.....	.....	7.9	4.6	11.6	1.7
Year	54	106	—22	36.4	24.7	50.1	25.1

From the above table it will be noted that the mean annual precipitation is 36.4 inches, and that the average for the months from April to September is more than twice as much as for the remaining months of the year. The rainfall is ample, however, if proper means are taken to conserve the moisture, to produce large yields of all crops grown in the area.

The average date of the last killing frost in spring at Kansas City for a period of 20 years is April 10, and of the first killing frost in autumn October 23, making an average growing season of 195 days. This is sufficiently long for practically all crops grown in the area. Fruit, while sometimes injured by heavy frosts following periods of warm weather in late winter or early spring, is rarely an entire failure. Two or more crops of vegetables are raised on the same ground in the truck gardens, and the climate, as a whole, is well suited to general farming."

Upland plain topography, Swope Park.

CHAPTER II.

TOPOGRAPHY.

GENERAL FEATURES.

Jackson county is situated about midway between the Ozark Plateau and the Great Plains in the intervening prairie region, known as the Scarped Plains. The rocks of this region consist of beds of unequal hardness and thickness, dipping gently away from the Ozark uplift. Erosion of these rocks has produced a series of plains and escarpments that trend in general northeast and southwest, although in Jackson county the influence of the Missouri has to some extent reversed the direction.

The relief thus produced is not essentially different from that of other areas in the Missouri Valley, where the surface has not been modified by glaciation. The general surface is a rolling upland with a typical dendritic drainage system emptying into the Missouri, the master stream of the region.

The general elevation of the upland divides ranges from about 1,090 feet above sea level along the divide in the southern part of the county, to between 900 and 1,000 feet along the crest of the river bluffs. The average altitude is close to 1,000 feet.[2] The highest point in the county (1,086 feet) that has been determined is at Bowler triangulation station, southwest of Lees Summit, in the NW. ¼, SW. ¼, Sec. 18, T. 47 N., R. 31 W. The lowest point, about 688 feet, is at water level on Missouri River in the northeast corner of the county. The maximum relief is therefore about 400 feet. The flood plain of the Missouri lies between 700 and 750 feet above sea level.

A number of accurate bench marks have been established within the county by the United States Coast and Geodetic Survey, and the Missouri River Commission. These, together with elevations of railroad stations, are given at the end of this chapter.

[2]The general topography of Jackson County is shown by 50 foot contours on the Kansas City, Independence, Harrisonville, and Olathe sheets of the U. S. Geol. Survey. These sheets are now regarded as reconnaissance maps.

UPLANDS.

Near the southern border of Jackson county is the main upland divide that separates the streams flowing north into the Missouri and those flowing southeast into the Osage. In the eastern part of the county near Hicks City and Lonejack this divide is narrow, but to the west it widens somewhat and becomes more level. It remains within or near the county border to the southwest corner where it turns to the south around the heads of the Big Blue and beyond the area described in this report. The district along the crest of this divide is for the most part open prairie country.

Stretching to the north from the main divide are similar smaller ones, capped mainly by the members of the Kansas City formation. These finger out into wooded ridges that separate the smaller valleys of the dendritic drainage systems. The crest of the divide west of the Big Blue lies chiefly in Kansas but it enters Missouri in Kansas City and extends to the North bluff, broken, however, by the old valley across Kansas City.

The divide between the Big and the Little Blue stretches unbroken from the south border of the county to the Missouri bluffs north of Independence, where, at Cement City, one of its branches terminates in a bluff nearly 300 feet high. Prior to glaciation this divide continued on to the east, but it has since been severed by the valley now occupied by the Little Blue, the upland between Lake City and Atherton now being entirely surrounded by alluvial bottoms.

Another branch stretches north from the main divide between the Little Blue and the Sniabar. From Blue Springs this curves to the northeast. The ridges into which this fingers on the east form, with the mesa-like table-lands near Sni Mills and Oak Grove, the "Sniabar hills," one of the roughest districts in Jackson county.

The general aspect of the uplands is similar in all parts of the county. They are nearly flat or gently undulating on the crests of the divides, but become rolling to hilly in the vicinity of the main streams.

In the eastern part of the county the uplands are capped by the Winterset limestone, locally with a thin covering of the overlying shale. In the western part of the county the Iola limestone, a bed about 100 feet higher stratigraphically, is the

Fig. 1. Upland plain showing characteristic breaks.

Fig. 2. Meander Big Blue River.

principal factor in upholding the more or less level crests. Locally, the thin limestones between the Winterset and the Iola produce benches on the slopes. In Kansas City there is a small remnant of a still higher plain, capped by the Plattsburg limestone, a ledge about 65 feet above the Iola. This may be seen in and near Penn Valley Park.

Bethany Falls Escarpment.—The most noticeable topographic feature in the county is the Bethany Falls escarpment which bounds the upland plain. Following the courses of the main streams the escarpment is rather low in the valley of the Big Blue, higher in the valley of the Little Blue, and forms a prominent feature of the rough area northeast of Blue Springs. The limestone itself can be traced in an almost continuous outcrop for many miles where the entire thickness, approximately 20 feet, is commonly exposed in a low cliff. The Bethany Falls is a massive limestone underlain by soft shale which weathers easily, causing large blocks of the limestone to break from the parent ledge along the prominent jointing planes. A typical view of the outcrop is shown in Plate 1. The area in the immediate vicinity of the escarpment being usually too rough for farming is left in timber, while the more level areas above and below are ordinarily in cultivation.

In connection with this escarpment there are a few places where solution has been a factor of minor importance. Along the Missouri Pacific Railway, about 2½ miles northwest of Lees Summit (near center of Sec. 25, T. 48, R. 32 W.) is a small cave with three openings. (See Plate XVII.) This cave which follows a vertical joint, is about 10 feet high and 20 feet wide at the bottom. It is located at the mouth of a small hollow opening out into Cedar creek and has evidently captured the drainage of the hollow. The cave is not continuous, as it has broken through in one place and is, literally, a natural bridge, having furnished a crossing for an old road along the side of Cedar creek. Sink holes noted in the district near Hickman Mills, are probably the direct result of underground solution.

Secondary plane.—In the eastern part of the county there is a secondary plain extending away from the foot of the Bethany Falls escarpment. It lies approximately 100 feet below the ridge areas, and while narrow in the southeastern part of the county, widens rapidly north of Oak Grove. It has been formed by the comparatively rapid erosion of the soft Pleasanton shale. Its surface in Jackson county is not unlike that of the higher

ridges, but in the bordering counties on the east and south it becomes almost level.

Effect of loess and drift.—Toward the northern edge of the county where the loess has been deposited in considerable thickness, there is a gradual change in the aspect of the uplands. From rolling, they become billowy, and closer to the main streams the branches have cut deep gash-like valleys, forming a topographic feature peculiar to this formation. The drift has but little effect on the topographic features of the county.

VALLEYS.

Missouri Valley.—Missouri River flows through a valley from two to five miles wide; its width increasing generally from west to east. The flat flood plain lies from 150 to 300 feet below the uplands. The alluvial filling, as is shown by borings, has a depth of approximately 100 feet, indicating that the valley formerly was considerably deeper than at present and that the overloaded stream is now building its flood plain higher.

In Jackson county there are six tracts of flood plain, including the "west bottoms" (in reality, a part of the flood plain of Kansas River), and "east bottoms" at Kansas City, and larger areas at or near Courtney, Atherton, Sibley and Levasy.

Tributary valleys.—The lower stretches of the main tributary valleys, those of the Big Blue, the Little Blue and the Sniabar, are cut about as deep as the Missouri. Up stream the valleys narrow, the alluvium becomes thin, while at the head waters of these streams there are no alluvial deposits.

Abandoned valleys.—There are two abandoned valleys in Jackson county, one in the northeastern part of the county and one in Kansas City.

The Buckner valley, stretching from the Little Blue eastward to the Missouri, furnishes an outlet for the Lexington branch of the Missouri Pacific Railway in the vicinities of Lake City, Buckner, and Levasy. It corresponds in size with the valley of the Little Blue to the south and it has obviously been occupied by that stream at some stage of its history. It is now partially drained by Prairie creek into the Little Blue and by Fire Prairie creek directly into the Missouri. These creeks formerly headed into a lake at the corner of townships 49 and 50 N., ranges 30 and 31 W., but this lake has since been drained.

Lowland plain of Missouri River, east bottoms, Kansas City.

The rather level floor of the valley has in general an elevation of 750 feet above sea level. In detail it is uneven because of the low sandy ridges which rise from the surrounding bottoms which are nearly level. The axes of the ridges parallel the direction of the valley. The material forming these ridges apparently consists of redeposited loess with here and there a covering of sand. This sand contains grains of quartz, quartzite and other minerals to which the Little Blue had no access, but which are common in the drift. The allivium in the valley is 71 feet thick near Buckner and at least 60 feet near Lake City.

Stretching across the northern part of Kansas City from Turkey creek to the Big Blue valley in the northeast corner of the city is a small, abandoned and partially filled valley. This valley furnishes the site for the new Union Station and an outlet to the east and west for the principal lines of transportation. Through natural and artificial agencies it has become filled to some extent and its original depth and the elevation of its floors are matters of inference. As it now exists it has an elevation of less than 760 feet above sea level at the eastern end, rising to about 840 feet at the middle and falling again to about 750 feet at the western end. Borings in the vicinity of the new station site indicate that bed rock lies at least 50 feet below the present level of the valley, and borings near Turkey creek pumping station show 65 feet of alluvial material.

The valley appears to have once been occupied by Turkey creek. If this was the case, the bed-rock floor must be below the level of that creek throughout the length of the valley.

TOPOGRAPHY OF KANSAS CITY.

The topography of Kansas City comprises the upland plain, in part modified by loess, and the alluvial plain. It is chiefly a high plain reaching in places an elevation of 280 to 300 feet above Missouri River. This upland has been shaped by drainage tributary to the Kaw, Missouri and Big Blue rivers, the flood-plains of which border the city on the northwest, north and east.

The high plain is divided into three parts. The abandoned valley of Turkey creek, which extends from the present mouth of Turkey creek northeastward across the northern part of the city, separates the northern and central uplands, and the valley of Brush creek, through the center of the city, separates the cen-

tral and southern uplands. The northern upland rises to a maximum elevation of 280 feet above Missouri River and is bounded for almost the entire length of its western and northern sides by the steep, rocky, and picturesque bluff of the Missouri valley. A short canyon has been cut into the edge of the bluff in North Terrace Park, and the continuity of the bluff is broken at the northwest corner of the city, where the slope from the plain below to the upland at Ninth street, is gradual. To the south and east of the northern upland the slopes, in comparison with those of the north and west bluff, are quite gradual; but bordering the abandoned valley of Turkey creek and the Blue, descents of 60 to 150 feet within five to eight blocks are not uncommon. For example, the elevation at Summit and Twenty-fourth streets is 40 feet above the river, and at Seventeenth street it is 180 feet. This northern upland is surmounted by a typical loess ridge.

The central upland attains an elevation of 280 feet above the river in the western part of the Roanoke region, and but slightly less in the eastern part. It is somewhat larger than the northern upland and shows more dissection around its border. This divide is the watershed of the old valley on the north, the Big Blue on the east, and Brush creek on the south. The higher parts are, in the main, fairly even-topped, but toward the border, especially facing the Blue and part of Brush creek, the upland has been cut by the short feeders to produce the relief known familiarly as "breaks." The northwest corner toward Turkey creek likewise shows a rough outline.

The southern upland, which is the largest of the three, reaches an elevation near the southwest corner of the city of 300 feet above the river. This area is more prairie-like than the other two and is marked by long slopes toward Brush creek on the north toward Blue Valley on the east and southeast. Rock outcrops are not so numerous as in other parts of the city, but near the Blue and lower Brush creek exposures are common, for here the streams have cut the border of the plain into irregular hills. The billowy landscape produced by the thin loess covering is a conspicuous feature of both this and the central upland.

The topography of Kansas City has had a remarkable effect upon its industrial development. The proximity of upland and bottomland has caused certain enterprises, especially those adapted to one type of topography or the other, to be

largely confined to certain areas. The level bottom land furnishes space for railroads, their yards and repair shops, for manufacturing plants, and for the switching facilities necessary to link producer and shipper. The surplus of the large fertile tract north of the city is being used for truck gardening, though each year witnesses a decrease in the acreage available for this purpose.

The abandoned valley described on a previous page forms a natural highway across the city, permitting easy communication to both east and west.

The more healthful and attractive upland has naturally become the business and residential district. The low slopes connecting the upland and lowland in the northwestern part of the city and along the north side of the old valley, with their easy grades for hauling both to railroad terminals and the retail district, have provided admirable sites for wholesale districts.

The relation of topography and development does not stop with these utilitarian features. Certain parts of the city were recognized as being too rough for any of the purposes mentioned above. These have furnished the sites of the North Terrace, West Terrace, Penn Valley and other parts of the justly famous park and boulevard system of Kansas City.

DRAINAGE.

Streams.—The entire drainage of Jackson county is received either directly or indirectly by Missouri River, which stream forms its northern boundary. All of the area north of the divide extending through Lees Summit and Lonejack is directly controlled by the master stream. The run-off from the small remaining part, about 55 square miles, is carried to the south, chiefly through Big, Prairie, and Crawford creeks. These streams empty into Grand river, a tributary of the Osage, and are thus indirect affluents of the Missouri.

Between the east and west boundaries of Jackson county, the Missouri varies from a quarter of a mile to a mile in width. Its channel length, between the same points, is about 45 miles, whereas the valley it occupies is only 30 miles long, indicating that the river meanders about one mile in every two of its length. At Kansas City, the low water stage is about 722 feet above sea level and at the northeast corner of the county about 688 feet, showing a gradient of approximately 0.75 of a foot per mile. The normal range between high and low water at Kan-

sas City is 27 feet, but during the flood of 1844 the normal high water mark was exceeded by 9 feet.

The term Missouri is said to be derived from an Indian tribal name meaning "Muddy water," and very commonly the river is referred to as the "Big Muddy." That the name has been well chosen is obvious from the following statement. For[1] the period between April 1 and December 31, 1905 (inclusive), the river at Kansas City carried an average daily load of 567,500 tons of sediment in suspension and 102,000 tons of dissolved mineral matter.

Its larger tributaries in Jackson county are the Blue or Big Blue, and Little Blue rivers, Fire Prairie, and Sniabar creeks. Kansas River, or the Kaw, as it is frequently termed, with one small affluent, Turkey creek, touches the western edge of Kansas City. Rock, Sugar and Mill creeks, near Independence, Sleepy branch, near Atherton, and Sugar creek midway between Atherton and Sibley, are all minor tributaries to the Missouri.

The larger streams of western Missouri and eastern Kansas possess in common many characteristic features which are well developed along the Blues and along Sniabar and Fire Prairie creeks. Their banks are relatively high and steep for streams of their size and in general are composed only of fine silt and mud. Their channels are deep, rapids occurring only between long stretches. They possess comparatively wide flood plains through the greater part of their courses and meandering is common and in many places intricate.

The Big Blue heads in Kansas and enters the county at the southwest corner. It flows northeastward, draining the western part and empties into the Missouri in northeast Kansas City. Indian creek, a tributary, rises in Kansas, enters the county about seven miles north of the southwest corner, and flows generally eastward to the Big Blue. Brush creek enters the county from the west at Kansas City and flows eastward to the Big Blue across the south-central part of the city. A third tributary to the Big Blue is Round Grove creek, which rises near Raytown, east of the main stream. The other eastern tributaries are short streams with steep gradients.

The elevation of the water surface of Big Blue, where it enters the county, is about 850 feet above sea level and where it empties into the Missouri, about 715 feet.

[1]Parker, N. H., Quality of the Water Supplies of Kansas, U. S., Geol. Survey, Water-Supply Paper 273, pp. 203-204, 1911.

Low-water level of Little Blue is about 950 feet above sea level at the south county line and 700 feet at its mouth. Over half the fall is south of Vale, where the Rock Island railroad crosses this stream.

Prairie creek and Fire Prairie creek drain the northeastern corner of the county, including the old valley, in which are located Lake City, Buckner, and Levasy.

The Sniabar rises in the hills between Oak Grove and Lonejack. Some of the headward branches have steeper gradients than those of any other streams in the county, dropping 250 feet in three miles. In a remarkably short distance the Sniabar develops a wide flood plain, through which it meanders to the Missouri.

Lakes and marshes.—The uplands of Jackson county possess no lakes or marshes and there are but few in the bottom lands. The lake, now reduced by drainage, from which Lake City derived its name, is unique among those of the region, practically all of which are merely remnants of old stream meanders. This lake seems to owe its origin to a shifting of the surrounding sand dunes. At one time it drained both to the east and west.

Marshes formerly covered several thousand acres near Courtney, Atherton, Sibley, Buckner and Levasy, but the acreage is gradually being reduced by drainage. The marshes on the Missouri bottoms are remnants of old lakes that have been nearly but not quite filled by sediment from overflow. Those near Buckner are probably due to the imperfect drainage in the abandoned valley.

ALTITUDES.

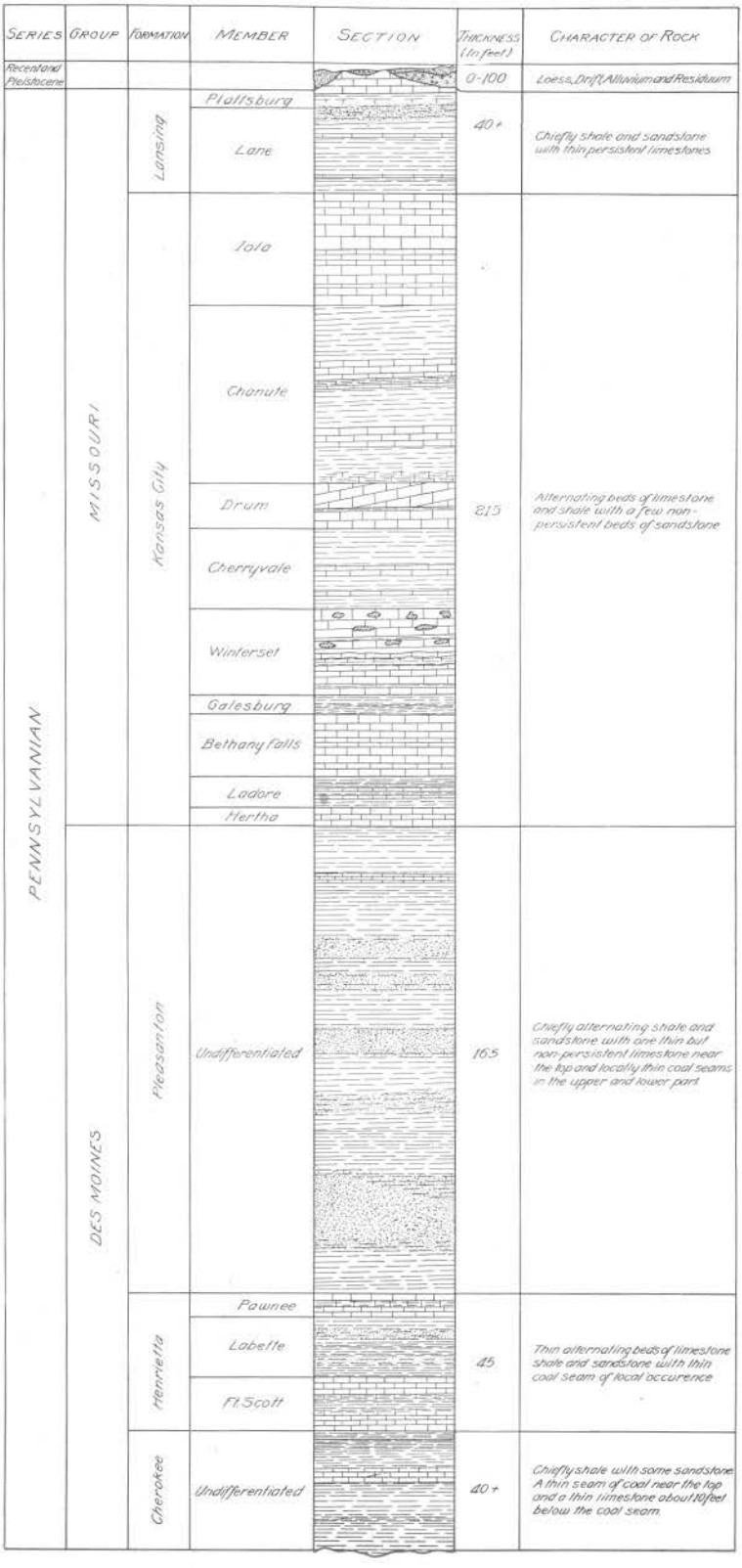
In the following pages the altitudes of a number of places in the county, including practically all of the railroad points, are given. There are two classes of data, one consisting of bench marks whose elevations have been determined to the hundredth or thousandth of a foot, the other being derived from railroad leveling which is given to the nearest foot. The elevations are of the top of the rail in front of the stations mentioned. All values are in feet above sea level.

ALTITUDES IN JACKSON COUNTY.

	Feet.
Atherton, 1,185 feet below depot, 328 feet above road crossing, 245 feet below section house, 215 feet below lowest headblock of siding and 49 feet below tool house, 49 feet north from center of track at south side of right of way fence, directly opposite and northwest from Joseph Sample's house, in bench-mark stone, lettered "B. M.":	
Copper bolt (U. S. C. E. p. b. m. 220)	729.018
Top of cap	733.076
Atherton, 2¼ miles above, near old b. m. 227, about 1½ miles below Blue Mills Landing, 328 feet south from Atchison, Topeka & Santa Fe Ry. track, 200 feet west of section line, 35 feet east from levee, on land owned by George Hendrick, near creek from spring and path leading down from Mr. Hendrick's house, 10 feet above level of bottom land, on small point of bluff, in bench-mark stone, lettered "B. M.":	
Copper bolt (U. S. C. E. p. b. m. 221)	736.734
Top of cap	740.779
Belvidere, St. L. & S. F. R. R.	981
Big Blue River, on right bank near its mouth, 98 feet up that stream from south end of Missouri Pacific Ry. bridge 69, upon pier of which bridge is located "NO. LVIII"; 2 feet outside of right of way fence, 18.5 feet back from top bank of Big Blue River:	
Copper bolt (U. S. C. E. p. b. m. 227)	734.562
Top of cap	738.621
Big Blue River, in the top of the abutment to Missouri Pacific Ry. bridge over, end of the bridge rests on a bench several feet below, bench mark is south of the track and at the southwest (upper) corner of the east abutment; bottom of a square cut, roughly lettered "U. S. □ B. M." (C. & G. S. b. m. LVIII)	748.004
Blue Mills Landing, 1,330 feet below railroad bridge 609, in small railroad cut, 72 feet below old mill at ferry landing to which road leads, 115 feet above road crossing, 7 feet north from center of track, on natural ledge, marked "U. □ S."; highest point in square (U. S. C. E. t. b. m. 465)	747.266
Blue Mills Landing, on river bank, at northeast corner of old mill (now gone), on top of a ledge of rock, 14 inches from north edge and 3 inches from east edge; marked with cross(+) (U. S. C. E. t. b. m. 466=old b. m. 33 of 1878)	732.407
Blue Mills Landing, at northeast corner of site of old mill, in river face of ledge of rock, 7.1 feet below top and 6.5 feet from east face of ledge; center of cavity from which horizontal copper bolt had been extracted (U. S. C. E. t. b. m. 467=old b. m. 228)	724.208
Blue Springs, C. & A. R. R	960
Bucker, Mo. Pac. Ry	749
Carroll, C., R. I. & P. Ry	900
Courtney, 12 feet east of southeast corner, on line with south side of depot, in southwest corner of plate of ground at angle in platform, in bench-mark stone, lettered "B. M."; copper bolt (U. S. C. E. p. b. m. 222)	732.554
Courtney station, five-eighths of a mile above, 1,400 feet above highway crossing, 15 feet below sign "Station," 10 feet from center of track, on first curve above town, at foot of bluff, on white embedded rock, marked "U. □ S."; highest point in square (U. S. C. E. t. b. m. 470)	741.826
Dodson, K. C. S. Ry.	793
Grain Valley, C. & A. R. R	790
Grandview, St. L. & S. F. R. R.	1,077
Greenwood, C., R. I. & P. Ry.	903
Greenwood, half a mile west of station, 2 feet from southeast corner of bridge 63; top of bridge seat, marked "B.+M." (M. P. R. R. 206)	919.181
Greenwood, half a mile west of, in the stone pier under the east end of the iron railroad bridge (63), north of the track and near the northeast corner of the pier, a railroad bench mark is quite near, marked "B.+M."; bottom of a square cut, roughly lettered "U. S. □ B. M." (C. & G. S. b. m. LIII)	919.155
Holmes, St. L. & S. F. R. R.	829
Independence, C. & A. R. R	929
Independence, Mo. Pac. Ry.	949
Independence, granite post in courthouse grounds, U. S. C. & G. S.	1,051.373
Independence, city directrix, U. S. C. & G. S.	1,049.680

	Feet.
Independence waterworks, 1¼ miles below pump house, half a mile below road crossing, on bluff side of track, 20 feet from center, at old Wayne Landing, on projecting point of natural ledge, marked "U. □ S."; highest point in square (U. S. C. E. t. b. m. 471)	753.676
Independence waterworks, at old Wayne Landing, five-eighths of a mile below pump house, 82 feet below group of cottonwoods, on rive side of track, 80 feet from center, 39 feet below old stone-wall foundation standing at right angles to track, on south edge of wagon road, in bench-mark stone, lettered "B. M.":	
Top of cap	736.573
Copper bolt (U. S. C. E. p. b. m. 223=71/1)	732.499
Independence, 2½ miles above, at crossing of Atchison, Topeka & Santa Fe and Missouri Pacific tracks, at foot of iron post of Santa Fe Ry. bridge standing between Missouri Pacific and Kansas City & Independence railroad tracks; top of anchor bolt through northwest corner of shoe, lettered "U. S." cut into cast pedestal, one on each side of nut to anchor bolt (U. S. C. E. p. b. m. 226)	743.128
Jeffreys, St. L. & S. F. R. R.	934
Kansas City, city datum 0.0	723.492
Kansas City, Grand avenue, C. & A. R. R.	751
Kansas City, Fifteenth street, Mo. Pac. Ry	764
Kansas City, Manchester, Mo. Pac. Ry	755
Kansas City, Swope park, St. L. & S. F. R. R.	791
Kansas City, Leeds, St. L. & S. F. R. R.	770
Kansas City, Big Blue, C. & A. R. R.	743
Kansas City, Cecil, Mo. Pac. Ry	745
Kansas City, Weather Bureau	963
Kansas City (low water, Missouri River, Missouri River Com.)	723
Kansas City Bridge, 1 mile below, in top of stone foundation at northeast corner of four-story brick gristmill, called Zenith Mills, cross is very faintly cut and there are no letters near it (a two-story extension to the Zenith Mills has been built since the bench mark was established); cross (+) cut (old M. R. C. b. m. 241)	748.299
Kansas City Bridge, south abutment of, near east end, leaded into north face; in head of copper bolt; horizontal furrow (old M. R. C. b. m. 243)	755.025
Kansas City Bridge, on south side of first pier north of south abutment of; point of arrowhead, marked (erroneously) "High water of 1844." The face of one of the stones in the pier is dressed and lettered "High water 1844" (old M. R. C. b. m. 244)	754.503
Kansas City, on right bank at, 50 feet east of shore pier of Hannibal Bridge and 10 feet from river bank; it was called p. b. m. 230 in 1892 and is the usual form of Mo. Riv. Comm. p. b. m.:	
Copper bolt (M. R. C. 73/1)	745.983
Top of cap	750.067
Kansas City, in top of foundation at northwest corner of Union elevator; cross (+) cut (old M. R. C. b. m. 245)	745.904
Kansas City, 3½ miles below Hannibal Bridge, five-eighths of a mile southeast of Crescent elevator, about 2,295 feet north of tile factory, 120 feet S. 65° W. of Lizzie Wright's house, at northwest corner of intersection of two country roads, in bench-mark stone, lettered "B. M.":	
Copper bolt (U. S. C. E. p. b. m. 228=72/1)	734.273
Top of cap	738.345
Kansas City, 1¾ miles below Hannibal Bridge, at Kansas City distillery, at northwest corner of one-story brick fermenting house, 2.5 feet east of corner, on top of stone foundation, in northeast angle of cross; highest point (U. S. C. E. t. b. m. 478=old b. m. 240)	741.885
Kansas City, 1 mile below Hannibal Bridge, at northeast corner of Zenith Mills, on top of foundation; highest point in square (this is in same place as old b. m. 241, the masonry upon which that was located having been replaced) (U. S. C. E. t. b. m. 479)	748.233
Kansas City, seven-eighths of a mile below Hannibal Bridge, 60 feet north from Chicago & Alton R. R. track, on south side of retort room of gas works, in water table 50 inches west of southeast corner, marked "U. S. P. B. M."; top of copper bolt leaded vertically (U. S. C. E. p. b. m. 229)	748.778

	Feet.
Kansas City, on northwest corner of First and Main streets, at southeast corner of three-story brick occupied by Pabst Brewing Co.; in top of stone step; a cross (this bench was partly destroyed and a new point taken instead on same surface 2 inches nearer river, between two parallel lines cut in stone) (U. S. C. E. t. b. m. 480=old b. m. 242)	766.206
Kansas City, 50 feet east of shore pier of Hannibal Bridge, 10 feet from river bank, in bench-mark stone, lettered "U. S. P. B. M.":	
Copper bolt (U. S. C. E. p. b. m. 230=73/1)	745.983
Top of cap	750.067
Kansas City Bridge, directly under old b. m. 243, at northeast corner of abutment, on projecting stone; highest point in square (U. S. C. E. t. b. m. 481)	752.466
Kansas City, at foot of Fourth street, in stone pier of wagon bridge over tracks, north one of two small piers on river side of Missouri Pacific Ry. main track, on south face, 5 feet above ground, 9½ inches back from southwest corner of pier, marked "U. S. P. B. M."; copper bolt leaded horizontally (U. S. C. E. p. b. m. 233)	750.412
Kansas City, in same locality as p. b. m. 233, at northwest one of three iron struts forming a rectangle with south one of two small piers on river side of track, on top of capstone supporting this strut; highest point in square (U. S. C. E. t. b. m. 482)	747.567
Lake City, Mo. Pac. Ry	750
Lees Summit, in the top of the stone foundation to the brick building owned by W. B. Howard (the corner store is occupied by J. R. Spencer as a drug store, building is at the northeast corner of the intersection of the street parallel to the railroad and the first street south of the railroad station, bench mark is near the southwest corner of the building, on the front, where there is an entrance to the basement); bottom of a square cut, roughly lettered "U. S. □B. M." (C. & G. S. b. m. LIV)	1.035.625
Levasy, base of rail at depot, Missouri River Com	711.529
Little Blue, about a quarter of a mile south of the station, in the top of the stone pier under the north end of the iron railroad bridge over Little Blue Creek, near the southeast corner of the large stone which supports the bridge, on the east side of the track; bottom of square cut, roughly lettered "U. S. □ B. M." (C. & G. S. b. m. LV)	787.590
Little Blue, Mo. Pac. Ry	790
Little Blue River, 705 feet below east end of railroad bridge 605 over, 230 feet below milepost 436, 20 feet north from center of track, on rock at foot of bank, marked "U.$□."; highest point in square (U. S. C. E. t. b. m. 458)	733.594
Martin City, Mo. Pac. Ry	870
Matthews Landing, 2 miles below Sibley Bridge, east side of road, on house of D. O'Donnell, on northwest corner of foundation, on northwest quarter of cross; highest point in square (U. S. C. E. t. b. m. 445, old bench 210)	717.256
Melville, St. L. & S. F. R. R	796
Missouri City, opposite, on right bank, 8,320 feet from river, 660 feet N. 78° 45′ E. from "Wapsey" schoolhouse, on the farm of John Hiffner, on south side of fence on north side of east-west road (U. S. C. E. b. m. 69/2:	
Bolt in stone	711.04
Top of cap	715.11
Missouri City, opposite, on right bank, five-eighths of a mile above Atchison, Topeka & Santa Fe Ry. bridge over Little Blue River, 2,295 feet above road crossing, 820 feet north of railroad track, about 200 feet above a small one-story house on south side of road, 30 feet below two small plum trees growing close together on north side of wagon road, 2 feet inside of Mr. Sullivan's field, in bench-mark stone, lettered "B. M.":	
Copper bolt (U. S. C. E. p. b. m. 219=69/1)	716.383
Top of cap	720.461
New Sibley, 2¾ miles above, near river on line of Atchison, Topeka & Santa Fe Ry., 125 feet below Auld's sawmill, bluff side of track, 30 feet from center, opposite upper end of bridge 603, on line with center of road running up bluff, just above wing fence, in bench-mark stone, lettered "B. M.":	
Copper bolt (U. S. C. E. p. b. m. 218)	713.017
Top of cap	717.062
New Sibley, 3¾ miles above, at first point of bluff above Auld's sawmill, at upper end of cut, 30 feet below milepost 435, on bluff side of track 25 feet from center, 3 feet above grade, on large rock in slope, marked "U.$□."; highest point in square (U. S. C. E. t. b. m. 457)	731.48
Oak Grove, C. & A. R. R	869



Geologic section of Jackson County.

	Feet.
Raytown, C., R. I. & P. Ry.	951
Redbridge, Mo. Pac. Ry.	807
Selsa, C. & A. R. R.	766
Sibley (low water, Missouri River) (Missouri River Commission)	692
Sibley, 1 mile below station, at south end of Atchison, Topeka & Santa Fe Ry. bridge across river, 108 feet back from top of river bank, 75 feet east and 23 feet north of northwest corner of land pier, at foot of bluff, in bench-mark stone, lettered "B. M.":	
Copper bolt (U. S. C. E. p. b. m. 215)	715.015
Top of cap	719.067
Sibley, on right bank in land pier of Atchison, Topeka & Santa Fe Ry. bridge, at top and southwest corner of pier, 6 inches back from each beveled edge; top of copper bolt leaded vertically, marked "U. S. P. B. M." (U. S. C. E. p. b. m. 216)	746.104
Sibley, on bottom land just above, 2,800 feet north of bridge over small creek at foot of bluff where t. b. m. 452 is located, 400 feet south of Keller and Angel's house, 360 feet north of small box culvert and road running east through field at east edge of brush on west side of north-south county road, 1½ feet east of fence; top of cap over old b. m. 68/1 (U. S. C. E. p. b. m. 217)	708.417
South Lee, C., R. I. & P. Ry.	983
Vale, C., R. I. & P. Ry.	801
Wayne, between railroad track and river, at southwest corner of pump house of Independence waterworks, on south face, 65 inches above ground, 5 inches east of west corner; copper bolt leaded horizontally, marked "U. S. P. B. M." (U. S. C. E. p. b. m. 224)	746.127
Wayne, about 2,460 feet below Atchison, Topeka & Santa Fe Ry. bridge 616 over Rock Creek, 525 feet above bridge 615, between two small ravines which are about 850 feet apart, 48 feet south from center of track, 2 feet north of right of way fence, in bench-mark stone, lettered "B. M.":	
Copper bolt (U. S. C. E. p. b. m. 225)	748.165
Top of cap	752.220

CHAPTER III.

GEOLOGY.

STRATIGRAPHY.

The consolidated rocks outcropping in Jackson county are of the sedimentary type and consist largely of interbedded limestone, shale and sandstone. They belong to the Pennsylvanian series of the Carboniferous ("Coal Measures"), and are nearly everywhere overlain by unconsolidated surficial deposits of Quaternary age or by residual soil that has resulted from the weathering and decay of the rocks themselves.

The following table shows in tabulated form the major divisions of the geologic time scale and the relations of the formations outcropping in Jackson county:

DIVISIONS OF GEOLOGIC TIME.		FORMATIONS OUTCROPPING IN JACKSON COUNTY.	
Cenozoic	Quaternary	Recent	Alluvium
		Pleistocene	Loess
			Drift
	Tertiary		
Mesozoic	Cretaceous		
	Jurassic		
	Triassic		
Paleozoic	Carboniferous	Pennsylvanian	Lansing
			Kansas City
			Pleasanton
	Devonian		Henrietta
	Silurian		Cherokee
	Ordovician		
	Cambrian		
Proterozoic	Algonkian		
Archeozoic	Archean		

PRE-PENNSYLVANIAN FORMATIONS.

Formations older than the Pennsylvanian do not outcrop in this county, and information regarding the deep-lying rocks has been obtained solely from the records of deep borings. As the regional dip of the strata in western Missouri and eastern Kansas is slightly north of west, successively older formations appear at the surface in the Ozark region to the south and south-

east. A knowledge of the character of these formations has made comparisons and general correlations possible.

The complete succession of the older sedimentary rocks was penetrated by the deep boring at Raytown which encountered the underlying granite at a depth of 2,348 feet. The general character and thickness of the various strata are shown in the following log:

RECORD OF DIAMOND DRILL HOLE ABOUT ONE MILE SOUTHEAST OF KANSAS CITY (SEC. 7, T. 48 N., R. 32 W.) DRILLED IN 1886. RECORD FURNISHED BY S. J. HATCH; ALTITUDE REPORTED, 870 FEET.

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Pennsylvanian:				
Kansas City formation:				
Shale, light-colored	32	—	32	—
Limestone	2	—	34	—
Shale, blue	17	6	51	6
Limestone (Winterset)	15	3	66	9
Shale, slaty	3	2	69	11
Limestone (Bethany Falls)	22	9	92	8
Shale, slaty	4	7	97	3
Limestone (Hertha)	15	—	112	3
Pleasanton formation:				
Shale, some parts gritty	94	9	207	—
Coal		2	207	2
Shale, some parts gritty	61	3	268	5
Henrietta formation:				
Limestone	8	7	277	—
Shale, slaty	11	—	288	—
Limestone	4	—	292	—
Slate		10	292	10
Coal	1	6	294	4
Fireclay, hard	5	8	300	—
Limestone	5	—	305	—
Slaty shale	14	2	319	2
Limestone	4	3	323	5
Cherokee shale:				
"Slate"	1	1	324	6
Coal (Lexington)	1	2	325	8
"Slate" (Lexington)		8	326	4
Coal (Lexington)		9	327	1
Limestone	12	9	339	10
Shale	12	2	352	—
Limestone, hard ("Rhomboidal")	3	6	355	6
"Slate," black	3	—	358	6
Coal (Summit)	1	3	359	9
Fireclay	2	7	362	4
Limestone	7	1	369	5
Shale	4	—	373	5
Limestone	4	3	377	8
"Slate"	3	—	380	8
Coal (Mulky)	1	—	381	8
Fireclay	5	8	387	4
Sandstone	11	10	399	2
Sandstone, streaks of "slate" or shale	32	3	431	5
Shale, slaty	15	4	446	9
"Slate" and shale	5	6	452	3
Coal (Bevier)	1	8	453	11
Shale and "slate"	49	—	502	11
"Slate"	6	—	508	11

RECORD OF DIAMOND DRILL HOLE—Continued.

	Thickness.		Depth.	
Cherokee Shale—*Continued.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	1	4	510	3
Limestone	8	—	518	3
"Slate" and shale	6	—	524	3
Coal		10	525	1
Limestone	18	6	543	7
Sandstone, showing of oil	16	2	559	9
Shaly sands	23	2	582	11
Shale, sandy, micaceous	37	7	620	6
Shale, sandy, streaks of "slate"	33	2	653	8
Sandstone	15	7	669	3
Shale, sandy	24	—	693	3
Shale	15	—	708	3
Sandstone, coarse, salt water	43	9	752	—
Mississippian:				
Burlington-Keokuk:				
Limestone, shelly in places, with shale partings	73	—	825	—
Limestone, light-colored, flinty layers	260	—	1085	—
Kinderhook group (?):				
Limestone, dark, with shelly layers	100	—	1185	—
Sand, dark, reddish	15	—	1200	—
Ordovician:				
Joachim (?): *a*				
Limestone, bluish, fine-grained, shelly in places	57	—	1257	—
St. Peter:				
Sandstone, white at top, reddish at bottom	64	—	1321	—
Cambro-Ordovician:				
Limestone, gray and brown	129	—	1450	—
Limestone, shelly and clayey	10	—	1460	—
Limestone, light, coarse, porous	160	—	1620	—
Limestone, shelly	20	—	1640	—
Sandstone, white	16	—	1656	—
Limestone, light, flinty, porous; water disappeared or was lost	74	—	1730	—
Limestone, gray, clayey and sandy	20	—	1750	—
Limestone, gray, hard, fine-grained	70	—	1820	—
Sandstone, gray, hard, fine-grained	15	—	1835	—
Limestone, gritty, porous, crystalline, in places white and flinty	215	—	2050	—
Sandstone, hard, coarse	50	—	2100	—
Cambrian:				
Limestone, with seams of gray and brown shale	40	—	2140	—
Limestone, dark, and light, fine-grained	110	—	2250	—
Sandstone, hard, coarse	98	—	2348	—
Pre-Cambrian:				
Granite	53	—	2401	—

a Correlation of Ordovician, Cambro-Ordovician and Cambrian strata by E. O. Ulrich in U. S. Geol. Survey Bull. 298, pp. 239-240. Quoted by E. M. Shepard, Underground Waters of Missouri; U. S. Geol. Survey Water Supply Paper 195, p. 86, 1907.

Comparison of the section as given in the above log with that outcropping in the Ozark region, indicates that there has been a considerable thinning of the strata below the St. Peter sandstone, but the lack of horizon markers has made a detailed correlation of the formations impossible. Directly underneath the St. Peter, the Jefferson City formation appears to be present

in normal thickness, extending probably to the first prominent sandstone bed which may be correlated as a part of the Roubidoux. Below this the limestone cannot be divided into separate formations. The sandstone overlying the granite may be correlated with the La Motte, as it occupies the same stratigraphic position that this formation does where it has been observed in southeast Missouri.

The limestone directly overlying the St. Peter, designated Joachim (?) by Ulrich, may represent that formation or it should possibly be correlated as Devonian. Other drill holes in northwest Missouri indicate the presence of considerable Devonian but the absence of the Joachim formation.

The lower part of the Mississippian series is well represented by the limestone underlying the shales and sandstones of the Cherokee. The upper part of the series, which is found in southeast Missouri, is not represented in the section as given. The general character of the Mississippian is also shown in drill records, Nos. 5, 7, 12, and 32, given under "Gas and Oil," and in one of those under "Water Resources."

The strata comprising the lower portion of the Cherokee are also given in the drill records cited above. Although they indicate considerable local variation, they show that the formation possesses the same general character throughout the county.

PENNSYLVANIAN SERIES.

The Pennsylvanian formations were among the earliest to be studied by the Missouri Geological Survey, and Broadhead[1] in 1873, published an excellent section showing the stratigraphic succession, each stratum being designated by a number. Later the Iowa, Kansas, Missouri and United States Geological Surveys studied individual areas in greater detail. Recently, the Missouri Bureau of Geology and Mines, in co-operation with the United States Geological Survey, published a report on the stratigraphy of the Pennsylvanian[2] in Missouri and the nomenclature used in this volume is discussed in detail in that report.

Of the eight formations of the Pennsylvanian series in Missouri, five are represented in Jackson county. In ascending order these are Cherokee shale, Henrietta formation, Pleasanton formation, Kansas City formation, and Lansing formation. The

[1]Broadhead, G. C., Iron Ores and Coal Fields: Mo. Geol. Survey, pt. 2, 1873.

[2]Hinds, Henry, and Greene, F. C., Stratigraphy of the Pennsylvanian Series in Missouri; Missouri Bureau of Geology and Mines, 2d ser., vol. XIII, 407 pp., 1915.

remaining three, the Douglas, Shawnee, and Wabaunsee formation, outcrop in the counties to the northwest.

The formations exposed consist of alternating beds of limestone, shale, and sandstone, many of which are persistent units. Due to this fact, they have been divided into members as shown in the following table. Although comparatively thin, most of these members are shown on the geological maps accompanying this report.

PENNSYLVANIAN SERIES IN JACKSON COUNTY, MISSOURI.

Formation.	Member.	Thickness.
		Feet.
Lansing	Plattsburg limestone	
	Lane shale with Farley limestone bed	70
Kansas City	Iola limestone	
	Chanute shale with Raytown and Cement City limestone beds	
	Drum limestone	
	Cherryvale shale	
	Winterset limestone	215
	Galesburg shale	
	Bethany Falls limestone	
	Ladore shale	
	Hertha limestone	
Pleasanton	Not subdivided	165
Henrietta	Pawnee limestone	
	Labette shale	45
	Fort Scott limestone	
Cherokee *a*	Not subdivided	435
		930

*a*Only upper part exposed in Jackson County.

CHEROKEE SHALE.

Name and definition.—The Cherokee shale derives its name from Cherokee county, Kansas. It includes all beds between the base of the Pennsylvanian series and the limestone over the Lexington coal. The formation rests unconformably on the underlying Mississippian, which differs from the Cherokee in consisting chiefly of hard, light-colored, cherty, crystalline limestone.

Distribution.—Although the Cherokee underlies the whole of Jackson county, it appears at the surface only along the Sniabar in the extreme eastern part, and outcrops were seen only along the branch of the Sniabar which crosses diagonally Secs.

17 and 20, T. 49 N., R. 29 W., where there appears to be a slight upward arching of the strata. The upper part, approximately 40 feet, is above drainage and is but poorly exposed, due to the covering of talus and loess.

Characteristics.—According to the log of deep borings in and near the county, the formation has a thickness of 270 to 476 feet, averaging about 440 feet. The range in thickness is due chiefly to the unconformity at the base. Drill records show the Cherokee shale to consist, as the formation name indicates, chiefly of shale, though it contains much sandstone. In general, the sand content increases toward the base, and in certain logs, beds of sandstone 75 to 105 feet thick are reported. Coal, clay, and limestone constitute minor portions. The strata as a rule are nonpersistent and irregular, with the possible exception of a few coal beds in the upper 100 feet. In drillings of which careful records have been made, the Bevier and Lower Ardmore coal beds and the limestone between them, may usually be detected. The general nature and variations in the formation may be seen by referring to the logs of deep wells given in chapter IV, under coal, water, gas, and oil.

The upper part of the Cherokee, which occurs above drainage in Jackson county, is poorly exposed and exhibits but few details of the stratigraphy. It is, however, well exposed in and near Lexington, in Lafayette county, where Norwood[1] constructed a generalized section, which, slightly modified, is as follows:

GENERALIZED SECTION OF THE UPPER PART OF THE CHEROKEE SHALE IN AND NEAR LEXINGTON.

No.	Stratum.	Thickness.	
		Ft.	*in.*
1	Shale (black), bituminous	1	2
2	Coal, slaty } Lexington {	—	5
3	Coal, good } {	1	9
4	Underclay and shale	4	6
5	Limestone, gray and blue, thickbedded, fossiliferous, abounding in a small Fusulina on account of which the rock presents a very pretty appearance when fractured. It is easily recognized by this peculiarity	4	—
6	Shale, blue, drab, red and yellow, argillaceous	21	—
7	Limestone, blue, pyritiferous, hard, in one bed, shelly on top, containing small univalves on the surface ("Rhomboidal")	1	3
8	Shale (black), bituminous, containing Lingulidiscina missouriensis	2	4
9	Shale, dark, calcareous, pyritiferous, and fossiliferous. Locally there occurs a concretionary bed of black, bituminous limestone containing fossils	4	—

[1]Norwood, C. J., General section (at Lexington): Geol. Survey of Missouri, Iron ores and coal fields, 1872, pt. 2, pp. 50-52, 1873.

GENERALIZED SECTION OF THE UPPER PART OF THE CHEROKEE SHALE IN AND NEAR LEXINGTON—Continued.

No.	Stratum.	Thickness.	
		Ft.	*in.*
10	Coal (Summit)	—	7
11	Shale, drab, and nodules of limestone	4	—
12	Limestone, rough, concretionary, pyritiferous	1	4
13	Shale, dark-blue, and limestone nodules	2	—
14	Limestone, greenish-gray, upper part fossiliferous (lowest rock seen at Lexington)	2	—
15	Hard tough band	—	8
16	Shale, black, slaty, hard, full of globular concretions and a few large bituminous limestone concretions	5	6
17	Coal (Mulky)	1	9
18	Shale	—	—
		58	3

Near the Sniabar in the SE. ¼ SW. ¼ sec. 17, T. 49 N., R. 29 W., the gentle slope south of the creek contains sandy shale and fragments of sandstone that are believed to represent the 21-foot shale interval, No. 6 of the above section. The bottom of this shale is not exposed, but it is estimated to be about 10 feet above water level in the nearby creek, the unexposed interval probably containing Nos. 7-11 of the above section. Overlying the shale, at the same locality, are limestone fragments, which represent the "sump-rock" of the Lexington coal (No. 5). The fragments have weathered to a reddish-brown, but were originally undoubtedly blue or gray. The rock is fine-grained, contains minute flecks of calcite, and is more or less argillaceous and dolomitic. Resting on this limestone, though not exposed, is a layer of underclay commonly 1½ to 5 feet thick. Above this is the Lexington coal which is exposed at only one place, about three miles north of Oak Grove (NW. ¼ NE. ¼ sec. 29, T. 49 N., R. 29 W.), where 8 inches of coal were seen. Whether this is the entire thickness or merely the upper bench is not known, but it is probably the latter, as the Lexington commonly occurs in two benches a few miles to the east in Lafayette county where it is mined. The top of the Cherokee at the same place consists of 20 inches of black, slaty shale which grades upward through dark to gray.

Drilling in the western part of Jackson county indicates that the general succession of strata in the upper part of the Cherokee remains about as given in the foregoing section, but with slight changes in thickness. The Mulky coal, thin or ab-

sent in some places, is reported 20 inches thick in others. Where the coal is absent the limestone cap-rock, No. 14 of the foregoing section, is commonly absent also, though the slaty shale seems persistent. Similarly, the Summit coal is reported to be either absent or up to 14 inches thick, the underclay here and there up to 12 feet thick, and both the roof shale and caprock varying in thickness from place to place. In the deep well near Raytown the "sump-rock" of the Lexington was found to be 12 feet, thickening at the expense of the underlying shale and overlying clay; in other places it is seemingly present as limestone nodules, reported by drillers variously under such terms as "nodules," "limeshale," or "soft limestone." The Lexington coal horizon is reported barren in some wells, present in others, while in the Raytown well it is as much as 31 inches thick, the upper bench being 14 inches, the lower 9, and the parting 8 inches thick. The roof shale, which seems to be absent wherever the coal horizon is barren, is of about the same thickness as in the section above where present.

Fauna.—No fossils were collected from the Cherokee of Jackson county during the course of the present survey.

HENRIETTA FORMATION.

Name and definition.—The name Henrietta, so called from a former postoffice in Johnson county, Missouri, was proposed by Marbut for the Fort Scott limestone, Labette shale and Pawnee limestone, which lie between the Cherokee shale below and the Pleasanton formation above. The Henrietta corresponds to the lower portion of the Marmaton formation of Kansas geologists and includes much of the Appanoose formation of the Iowa geologists, and is the "Middle Coal Measures" of the older Missouri geologists.

Distribution.—The Henrietta formation appears at the surface in the northeastern part of the county along the Missouri River, Fire Prairie, and Sniabar creeks. It has been replaced by alluvium in much of the Missouri trough east of Sibley and is known to be absent in the old valley now occupied by Fire Prairie creek as far west as section 29, T. 50 N., R. 30 W. At Sibley, as is shown by borings made in locating the Santa Fe railroad bridge, the river alluvium rests on the lower member of the formation over a wide stretch of the valley. In the remainder of the county the Henrietta is more or less deeply

buried beneath the younger formations, but has been penetrated in numerous places by deep wells.

Characteristics.—In the eastern part of Jackson and in western Lafayette county the Henrietta is commonly about 45 feet thick. In the logs of deep wells bored in the western part of Jackson the thickness, as correlated, varies considerably, though in accurately recorded logs it is about the same as in the east.

The Henrietta consists of thin alternating beds of limestone, shale, sandstone and coal. These beds have been grouped in descending order into the Pawnee limestone, Labette shale, and Fort Scott limestone. Individually, however, these members are so thin that no attempt has been made to show them separately on the geologic map.

FORT SCOTT LIMESTONE.

Name and definition.—The Fort Scott limestone, named from Fort Scott, Kansas, consists, at the type locality, of an upper and a lower bed of limestone and an intervening bed of shale. At Fort Scott the upper bed alone is as thick as the entire member in Jackson county.

Distribution.—The Fort Scott is exposed only along the Sniabar and a small tributary of that stream north of Oak Grove, the complete succession not outcropping in Jackson county.

Characteristics.—The following section is slightly modified from that measured by Norwood at Lexington, Lafayette county:[1]

SECTION OF FORT SCOTT LIMESTONE AT LEXINGTON, MO.

No.	Stratum.	Thickness.	
		Ft.	*in.*
1	Limestone, drab, shelly on top, thick-bedded, good for building	3	6
2	Limestone, shaly and rough, fossiliferous	3	6
3	Shales and thin beds of limestone, fossiliferous	3	—
4	Shales, dark blue and drab, with nodules of limestone, fossiliferous	3	6
5	Limestone, dull blue and yellowish drab, fossiliferous	5	—
		18	6

As shown by the above section, the member consists of limestone at the top and bottom with a shale bed separating

[1]Norwood, C. J., General section (at Lexington): Geol. Survey of Missouri Iron Ores and Coal Fields, 1872, pt. 2, p. 50, 1873.

them. The lower limestone, which is 7½ feet thick, is exposed on the south side of the creek in the NE. ¼ sec. 20, T. 49 N., R. 29 W. It has rather a dark bluish-gray color but weathers brownish-gray to buff and brown, the surface showing cracks filled with limonite which also penetrates the outer half inch of the rock. On a weathered surface, many of the fossils retain the original gray color. The lower part is thin-bedded with wavy partings, but the upper two or three feet consists of two beds. As a rule, it is dense and fine-grained, argillaceous and slightly pyritiferous. Calcite occurs in the fossils, in small bodies, and in minute flakes, and the fossils themselves are fairly abundant, the most conspicuous being the coral *Chaetetes milleporaceus*, which forms beds up to an inch thick in the upper part of the layer.

The shale overlying the caprock of the Lexington coal is poorly exposed in a talus slope on the bank of the creek in the SE. ¼ sec. 28, T. 49 N., R. 29 W. It is about 7 feet thick.

On this same slope there is exposed, though poorly, in a single layer, 1½ feet thick, what is seemingly the upper limestone of the Fort Scott. It is bluish-gray, but the exposed surface has weathered to a deep-buff to a depth of several inches. It is fine-grained and even-textured except for the occurrence of thin sheets of *Chaetetes milloporaceus*, some Echinocrinus spines and many Fusulinas. These fossils seem to be characteristic of this bed as Norwood noted them also at Lexington.

Fauna.—Fossils, other than those already mentioned, were not collected from the Fort Scott member.

LABETTE SHALE.

Name and definition.—The name Labette, derived from Labette, Kansas, is applied to the shales and sandstones between the Fort Scott and the Pawnee limestones.

Distribution.—The distribution of the Labette shale practically coincides with that of the Henrietta formation as shown on the geologic map of the county.

Characteristics.—The middle member of the Henrietta formation is more irregular than the other two. It consists chiefly of sandstone and shale, and contains here and there a thin bed of coal. As far as is known, the entire succession is not exposed in the county. The following description is based on outcrops and drill records in Jackson county and on observations in Lafayette county. The thickness of the Labette is known to

range between 15 and 37½ feet and possibly between even wider limits. Norwood's section at Lexington, Lafayette county, is as follows:[1]

SECTION OF LABETTE SHALE AT LEXINGTON, MO.

No.	Stratum.	Thickness.	
		Ft.	*in.*
1	Shale, drab, green, and dark	6	—
2	Sandstone, brown and gray, hard, in one thick bed	4	—
3	Shale, olive and red, argillaceous	2	3
4	Clay, black and blue with thin streaks of coal 6 inches thick in places, but absent in others	—	6
5	Shale, buff and olive, also red, argillaceous and arenaceous	8	—
		20	9

In Jackson county the beds below the sandstone are not exposed, but borings show them to be similar to the Lexington section, though the thickness is extremely variable, while the coal, absent in many places, is reported 18 inches thick in the Raytown well. The sandstone near the top of the member outcrops at many places in the northeastern part of the county, and both outcrop observations and drill records indicate more than the usual variation in the thickness of this bed. South of Levasy there is an outcrop 12 feet thick; near Independence it is reported to be 13½ feet thick; at Randolph, Clay county, according to the record of a diamond-drill boring, it attains a thickness of 66 feet; while in many other wells it is entirely absent. The color is blue or gray, but in common with other sandstones, it becomes yellow or brown upon weathering. In places the upper part is rather firmly cemented by the calcareous material, while in others it is soft and shaly. The lower part is commonly shaly and the whole bed is micaceous.

The interval between the top of this sandstone and the base of the Pawnee contains in some places 5 or 6 feet of shale, but in others the Pawnee rests directly on the sandstone. The shale in the interval is drab, gray, green, and red, with here and there nodules of gray limestone.

Fauna.—No fossils have been collected from this member in Jackson county.

[1]Idem., pp. 50-52.

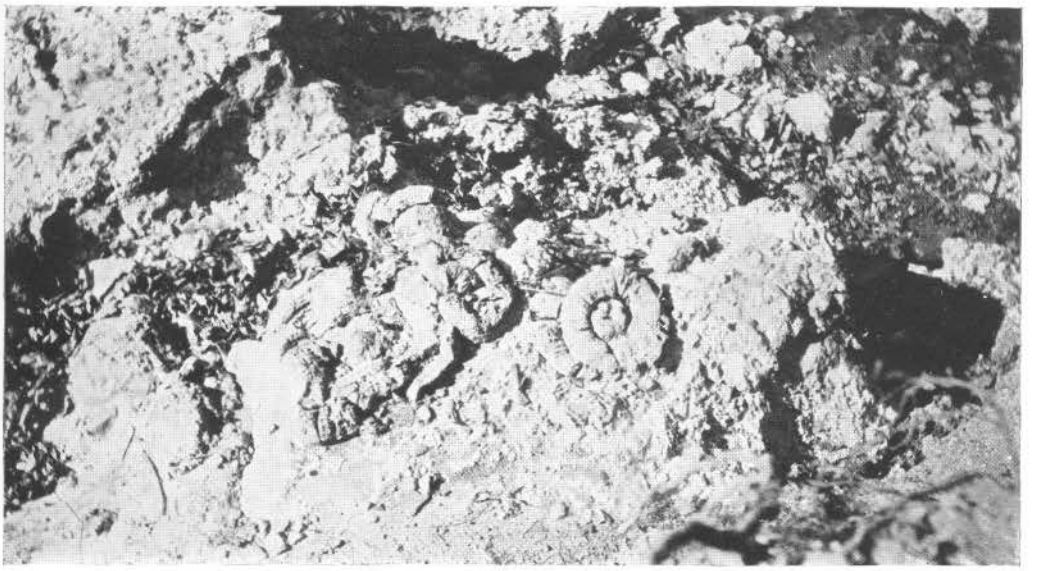


Fig. 1. Chaetetes in Pawnee limestone.

Fig. 2. Hertha limestone and La Dore shale near Leeds.

PAWNEE LIMESTONE.

Name and definition.—The uppermost member of the Henrietta formation received its name from the exposures along Pawnee creek, Bourbon county, Kansas.

Distribution.—The Pawnee is locally exposed along the Sniabar from the east county line nearly to the Chicago & Alton railroad bridge. It occurs in the northeast corner of the county in the Missouri bluffs and for about two miles along the river near Sibley. One mile below the Santa Fe bridge it forms the river bank.

Characteristics.—As exposed in Jackson county, the Pawnee consists of two beds of limestone with an intervening shale, the whole aggregating about 8 feet.

The lower limestone has a thickness of from 2½ to 3 feet, and is a veritable fossil coral reef composed, to a large extent, of colonies of *Chaetetes milleporaceus* which occur in hemispherical and conical masses (See Pl. VI, Fig. 1). These masses in places attain a diameter of three feet. The fossiliferous remains are cemented by material that has been washed between the colonies and has later been solidified to a fine-grained, noncrystalline, gray to iron-stained mass.

The middle shale, 3 to 3½ feet thick, is gray, green, and red, containing in places a black layer. It is somewhat clayey except near the top where it is calcareous. The calcareous layer is fossiliferous and is characterized by segments of large crinoid stems.

The upper limestone bed, 2 to 3 feet thick, is somewhat argillaceous and ferruginous, and is gray in color, weathering to a deep buff. It consists of one or two layers and varies from a fine-grained, noncrystalline and unfossiliferous rock to one which contains much disseminated calcite and many fossils. The coral *Chaetetes milleporaceus* is present in thin sheets in contrast to the large heads found in the lower bed of the Pawnee. The distinguishing feature of the upper bed of the Pawnee, however, is its mode of weathering, large and small rounded grooves, pits and perforations marking the surface.

Fauna.—Aside from Chaetetes, fossils are not abundant in the Pawnee limestone in Jackson county. Two small collections yielded the following species:

FAUNA OF THE PAWNEE LIMESTONE.

Marginifera splendens.
Chonetes flemingi.
Spiriferina kentuckyensis.
Schizostoma subquadratus.
Bellerophon (?) sp.

The upper part of the shale between the two beds of limestone contains crinoid stems, some of which are nearly an inch in diameter.

PLEASANTON FORMATION.

Name and definition.—The name Pleasanton, derived from the town of that name in eastern Kansas, was originally applied by Haworth[1] to the strata between the Pawnee limestone and the limestone then called the Erie, which is designated in this report as the Hertha. Later detailed work in Kansas demonstrated the presence of several persistent beds and the formation has been divided into five members. In descending order these are Pleasanton shale, Coffeyville limestone, Walnut shale, Altamount limestone, and Bandera shale. In Jackson county and in northern Missouri and Iowa, limestones such as would afford a basis for subdivision have not proven persistent over wide areas as in Kansas; the term Pleasanton is therefore used as in the original application.

Distribution.—The Pleasanton formation outcrops in the eastern and northeastern parts of the county, including practically all of the drainage areas of Sniabar, Fire Prairie, and Prairie creeks. It is exposed in narrow belts along the valleys of the Big Blue and Little Blue throughout almost their entire lengths, and also along the shorter streams in the northern portion of the county. In the southeastern part it outcrops along the tributaries draining south into Big creek.

Characteristics.—In deep-well logs in the western part of the county the thickness of the Pleasanton ranges from 150 to 204 feet with an average (based on 28 logs) of about 170 feet. To the east the formation thins slightly and, according to Marbut,[2] has in Lafayette county an average thickness of 150 feet.

The Pleasanton commonly outcrops in wooded bluffs or sodded slopes—both unfavorable for detailed measurements. Railroad and highway cuts show the upper part, and along the streams there are small, disconnected sections, ranging from the top to the bottom of the formation, which usually do not show over 30 or 40 feet of strata. Under these conditions it is difficult to make accurate generalizations, especially since the sec-

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[1]Haworth, E., Kansas Univ. Quart., vol. 3, p. 274, 1895.

[2]Marbut, G. F., Geological description of the Lexington sheet: Geol. Survey of Missouri, vol. 12, pt. 2, p. 214, 1898.

tions obtained from deep wells in the western part of the county, if the logs are correctly reported, show the formation to have little regularity.

The following generalized section largely combines data from outcrops and drill records:

GENERALIZED SECTION OF THE PLEASANTON FORMATION IN JACKSON COUNTY.

No.	Stratum.	Thickness.
		Feet.
1	Shale, blue, drab, gray, green, and red, sandy in places, 14 to 28 feet, average about	16
2	Limestone, sandy, and calcareous sandstone, Broadhead's No. 72, 0 to 8 feet, average about	2
3	Shale, and sandstone in alternating beds, about	100
4	Shale or clay, red, 2 to 9 thick where present, average	5
5	Shale, red at base, with a prominent bed of sandstone in places, 22 to 50 feet, average	40
	Average thickness in county	163

Beds near the base of the formation are exposed along the east bank of the Sniabar in the center of sec. 18, T. 49 N., R. 29 W., and along the Missouri east of Sibley. South of the Chicago & Alton Railroad on the Sniabar, the basal beds, probably 15 or 20 feet thick (Pawnee not exposed), consist of clay and shale, gray clay overlain near the base, by black, blue, and reddish shale that becomes greenish-gray at the top. This shale is mostly firm and brittle with a slaty texture. It is overlain by 10 feet of gray, fine-grained micaceous sandstone which has been quarried for walls. In a natural face it is brown and thin-bedded, but in the quarry, ledges up to six inches thick have been obtained. It is more firmly cemented than many Pennsylvanian sandstones and in mode of outcrop resembles a limestone.

Near the center of sec. 18, T. 49 N., R. 48 W., is an excellent outcrop of the basal Pleasanton. Soft, gray shale, three feet thick, underlies 30 feet or more of gray thin-bedded shaly sandstone. The sandstone is hard, gray, fine-grained, micaceous, and highly calcareous. The upper and lower surfaces of each layer are marked by small holes and grooves which are probably worm borings. Near the base is a lenticular layer of coarsely crystalline limestone having a maximum thickness of two feet. This limestone is light-gray but weathers to brown. It contains numerous small pieces of coal, small pebbles and

grains of clear quartz which give it a conglomeratic appearance. The only fossils observed are fragments of crinoids stems.

The sandstone flagging described above corresponds closely in description with the Bandera flagging of southeastern Kansas and since both beds are at the same stratigraphic level, they may possibly be of the same age. Because of the calcareous nature of this sandstone, drillers have in a number of cases reported it as limestone. The shale between the sandstone and the Pawnee locally contains a thin coal bed. So far as is known, this does not outcrop in the county, though it has been reported in one or two wells and has been found in Lafayette county on the east and in Cass county on the south.

On the road just north of the Chicago & Alton railroad (on the line between secs. 25 and 36, T. 49 N., R. 30 W.), there are 10 or 15 feet of brown, cross-bedded sandstone, which seemingly rests directly on the Pawnee limestone. Though fine-grained, it is coarser and also less micaceous than most of the Pleasanton sandstones. It is probable that this sandstone is not of early Pleasanton age, its lithologic characteristics and relations suggesting that it may be the equivalent of the Warrensburg sandstone which outcrops only a few miles to the east in Lafayette county.

The Pleasanton for about 100 feet above the basal sandstone consists of poorly exposed alternating beds of shale and soft sandstone. According to well records, they contain thin local limestones and coals. In the hills south of Oak Grove, the upper part of this 100 feet is massive, brown sandstone at least 27 feet thick. At 29 to 50 feet above the base of the Pleasanton, there has been found in each of 21 wells, a bed of red clay or shale, 2 to 12 feet thick. It averages 5 feet thick and its base lies at an average distance of 40 feet above the Pawnee limestone. It has been found at many widely separated places in and near Jackson county and is evidently fairly persistent.

Above this 100-foot interval of shale and sandstone is a more or less persistent bed of sandy, fossiliferous limestone (Broadhead's No. 72), lying 14 to 28 feet below the top of the formation. It is exposed in sec. 3, T. 47 N., R. 32 W.; in sec. 34, T. 48 N., R. 32 W.; at the Rock Island tunnel near Vale in sec. 27, T. 48 N., R. 32 W., and for about one mile south along the same railroad; on Cowherd creek in sec. 11, T. 48 N., R. 32 W.; southwest of Oak Grove, near top of hill, north of road in the SW. ¼ NE. ¼ sec. 1, T. 48 N., R. 30 W.; and at a few

other places. It is absent in many places but attains a thickness of 8 feet in others, this maximum being in the vicinity of Vale, where the upper part consists of a mass of *Myalina subquadrata* and other shells in a gray, sandy, calcareous matrix which becomes reddish and which falls to fragments upon exposure. The lower part is a gray, thin-bedded calcareous sandstone. The fossils noted above are covered with a rough, gray, calcareous coating from which they are not easily separated. Where this member is thin it is not fossiliferous. In the eastern part of the county the upper part of the Pleasanton is chiefly clay shale and commonly contains a layer tinted with red and green. Farther west it consists of sandy shale, thin beds of sandstone and concretionary masses of gray or greenish sandy limestone. In adjoining counties there is a thin coal bed near the top of the Pleasanton, but so far as is known this does not occur in Jackson county.

Fauna.—The sandy limestone near the top of the Pleasanton contains the following species, collected by F. C. Greene:

FAUNA OF SANDY LIMESTONE NEAR TOP OF PLEASANTON.

Serpulopsis insita	Myalina subquadrata.
Spirifer cameratus.	Myalina sp.
Composita subtilita	Allerisma termjnale
Edmondia sp.	Pleurophorus occidentalis
Myalina kansasensis (?)	Gastropod sp. (large)

The above list undoubtedly comprises only a few of the total number of species in this bed. The fauna is molluscan and the specimens are notable for their large size. *Myalina subquadrata* is the most abundant.

KANSAS CITY FORMATION.

Name and definition.—The name Kansas City was first used by Hinds[1] and afterward more fully defined by Hinds and Greene.[2] The formation is the lower part of the Pottawatomie formation of the Kansas University Geological Survey, and with the overlying Lansing, is the exact equivalent of the Pottawatomie. The type locality is at Kansas City, where many excellent outcrops display the entire section. The formation is subdivided on a lithologic basis into nine members which, in descending order, are as follows:

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[1]Hinds, Henry, Coal Deposits of Missouri; Missouri Bureau of Geology and Mines, vol. II, 2nd ser., p. 7, 1912.

[2]Hinds, Henry, and Greene, F. C., Stratigraphy of the Pennsylvanian Series in Missouri, vol. 13, 2nd ser., 407 pp., 1915.

MEMBERS OF KANSAS CITY FORMATION.

Iola limestone
Chanute shale (bearing the Raytown and Cement City limestone beds)
Drum limestone
Cherryvale shale
Winterset limestone
Galesburg shale
Bethany Falls limestone
Ladore shale
Hertha limestone

Distribution.—The Kansas City formation underlies the entire county, with the exception of the areas in the eastern part from which it has been eroded. It is not exposed where overlain by the Lansing formation.

In the area drained by Big and the Little Blue rivers, all the members of the formation are present, and outcrops of some part of the succession are to be seen along almost any drainage line. In the eastern portion of the county, where the Pleasanton occupies the larger part of the area, the lower members of the Kansas City usually cap the ridges and mounds, giving rise to an escarpment.

Characteristics.—All of the members of the Kansas City formation do not outcrop at any point and the entire thickness can only be obtained by the comparison of partial sections exposed in the same general area. In Kansas City where the Iola limestone, the upper member, has not undergone erosion, the thickness is about 225 feet. In the region around Independence it is about 200 feet. No measurements could be obtained in the southern part of the county, but the thickness there is probably between 200 and 210 feet. The average thickness in the county, where all members are present, is about 215 feet.

As shown in the following table, there is a considerable variation in the individual beds, but the compensation between beds is usually of such a nature that the total thickness of the formation is not affected.

Broadhead's number.	Member.	Thickness. Minimum.	Maximum.	Average.	Member total.
		Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*
	Iola limestone:				
98	Limestone (normal thickness where top has not been removed by erosion)	— —	— —	43 —	43 —
	Chanute shale:				
97	Shale	7 —	25 —	18 2	
96	Limestone (Raytown)	— —	— —	6 —	
	Shale and limestone	— —	— —	1 2	
95, 94, 93	Shale	— 1	5 —	1 6	
92	Limestone	1 10	2 —	1 2	
91	Shale	8 7	24 —	16 4	
90	Limestone (Cement City)	4 2	13 6	8 5	
89, 88	Shale	8 2	26 —	14 7	64 4
	Drum limestone:				
87a-b	Limestone, oolitic	— —	15 8	3 9	
	Shale	— 1	1 6	— 5	
	Limestone	3 —	6 —	4 5	8 7
	Cherryvale shale:				
86	Shale	14 4	18 —	15 —	
—	Limestone and shale	1 —	1 7	1 3	
—	Shale	2 9	4 9	3 9	
85d	Limestone	— 10	1 6	1 3	
85 b-c	Shale	2 —	7 —	4 5	25 8
	Winterset limestone:				
85a	Limestone	7 2	10 6	9 1	
	Limestone	2 7	3 9	3 1	
—	Shale	1 3	2 6	1 8	
84	Limestone	4 8	5 4	5 —	
	Limestone	2 8	3 8	3 —	
—	Shale	— 4	— 6	— 5	
83	Limestone	4 6	5 —	4 8	
83	Shale	— 2	— 5	— 3	
82	Limestone	1 —	1 6	1 3	28 5
	Galesburg shale:				
81a-c	Shale	2 6	9 —	5 11	5 11
	Bethany Falls limestone:				
80	Limestone	15 —	24 —	20 —	20 —
	Ladore shale:				
77a-b	Shale	2 —	7 —	4 —	
76a-c	Limestone and shale	1 4	5 3	3 —	
75	Shale	1 —	15 —	3 11	10 11
	Hertha limestone:				
74	Limestone	3 4	13 8	6 —	6 —
	Average total of formation				215 —

The most complete sections outcrop along the river bluffs between Kansas City and Cement City, the succession from or below the Bethany Falls to the middle or upper part of the Iola being exposed at several places.

The Kansas City formation consists of limestone and shale with a very few beds of sandstone. The individual beds range

from a few inches to 43 feet thick, but there are only five beds lithologically homogeneous in ten feet or more of their thickness. In Kansas City over one-half the section is limestone, most of the remainder being shale, much of which contains limestone nodules and lenses. To the southeast of Kansas City the proportion of shale increases. Three lenticular beds of sandstone are known and another, whose relations are not quite clear, occurs near Lees Summit, but it occupies a very small area.

The limestones are, as a rule, gray or blue, weathering buff or brown, and are thin-bedded, fine-grained and fossiliferous. Oolite has been found at three horizons and chert chiefly at one. The limestones on the whole are uniform in thickness and lithologic characteristics. There are, however, changes from place to place, but not of such a nature as to cause confusion in identification to one familiar with the section. The most variable element is the oolite. Where there is a variation in the thickness of the limestone the upper portion shows the chief irregularities, the lower portion being quite uniform. Usually the section shows a reciprocal compensation in the thickness of the overlying shale. Near the top of the formation a number of the limestones, either wholly or in part, have a mottled appearance, due in part at least to the material which consists chiefly of what is believed to be some undescribed species of sponge or marine algae. The upper portion of the Bethany Falls is also mottled, due to a variation in color of the limestone.

The shales are commonly gray, greenish or blue-gray, becoming gray or yellowish on exposure. One bed locally contains a red layer. There are three beds of black slaty shale and others approach this color and texture. The thicker beds are commonly fine-grained and argillaceous, but two of them locally become sandy and pass into sandstone. Limestone lenses and nodules are common in certain beds. The shales exhibit few differences in thickness other than that of compensation noted above and a slight increase to the southeast.

The sandstones are local in distribution and are thin-bedded and shaly except one near Lees Summit which is massive and conglomeratic at the base. This appears to be of the channel type of deposit.

HERTHA LIMESTONE.

Name and definition.—The Hertha limestone is the lowest member of the Kansas City formation and is the same as Broad-

head's number 74. The name was given by Adams[1] to the limestone exposed at Hertha, Kansas, just above the Pleasanton shale. It is the lower member of his Bronson formation which has been called the Erie limestone and the "Triple system." Locally, the Hertha is known as the "Chocolate Rock" because of its dark color when weathered. It has also been called the Ferruginous limestone for the same reason.

Distribution.—The Hertha limestone is coextensive with the Kansas City formation, although it does not outcrop in many places, being masked by talus from the overlying member.

Characteristics.—The Hertha ranges from 3 to 13 feet in thickness. In a railroad cut one-half mile south of Leeds it attains the greatest thickness known in the county. In Swope Park and along Brush creek east of the bridge on Prospect avenue, as well as near Red Bridge, the range is between 8 and 10 feet. In the southern and eastern parts of the county, it is not over 5 feet, a minimum of 3 feet being noted in the hills south of Oak Grove. Drillers often do not discriminate carefully between the Hertha and the limestone in the overlying Ladore shale, and thicknesses of from 15 to 16 feet of limestone at the Hertha horizon are reported. As a rule, the lower portion of the member, including from four to six feet, is uniform, the variation in thickness being largely in the upper portion.

In an unweathered condition the Hertha is light-gray, but upon exposure the lower part becomes a deep reddish-brown. Locally, the whole ledge remains gray with the exception of the partings, which become tinged with buff. The lower part has one or two shaly partings which in any single outcrop are rather uniform. The upper part is more or less nodular, ranging from a consolidated rock with irregular partings of shale to a mass of nodules imbedded in shale and passing into the overlying Ladore shale. From the base upward, the member is increasingly argillaceous. Calcite is present replacing fossils in the lower part, which portion of the member also contains specks of pyrite.

The lower part is dense and fine-grained and under a hand lens exhibits a sugary texture. The upper part is less dense and calcite is rare. The lower portion contains small irregular spots of clay. On an unweathered surface they are greenish-

[1]Adams, H. I., Stratigraphy and paleontology of the Upper Carboniferous rocks of the Kansas section: U. S. Geol. Survey Bull. 211, p. 35, 1903.

gray, but become buff on weathering, the argillaceous material finally washing out leaving small irregular cavities at the surface.

Fauna.—The following fossils have been found at different localities in the county:

FAUNA OF THE HERTHA LIMESTONE.

Axophyllum infundibulum	Marginifera splendens
Lophophyllum profundum	Spirifer cameratus
Fistulipora nodulifera	Ambocœlia planiconvexa
Rhombopora lepidodendroides	Spiriferina kentuckyensis
Chonetes verneuilianus	Composita subtilita

In places the lower surface of the Hertha is rich in corals. In examining collections made along the Kansas City Southern tracks near the Swope Park zoo, Dr. Girty found, in addition to the Axophyllum listed above, four other species which may be undescribed forms.

LADORE SHALE.

Name and definition.—The Ladore shale, which occupies the interval between the Hertha limestone below and the Bethany Falls above, is equivalent to numbers 75 to 77b of Broadhead's section, the name being derived from Ladore, Kansas.

Distribution.—The Ladore shale, like the Hertha limestone, underlies an area almost coextensive with that of the Kansas City formation, but it outcrops in the base of the escarpment formed by the overlying Bethany Falls limestone. Owing to the talus of the latter it is not well exposed in the south and southwestern parts of the county, but in the valleys to the north and east, exposures are numerous. Where masked by the detritus the presence of this member is indicated by the fissile bituminous layers or by the black residium left after disintegration.

Characteristics.—Ordinarily, this member is about 7 feet thick, as noted on Town creek and Fifty-first street, on the rock road between secs. 6 and 7, T. 49 N., R. 30 W., and in sec. 6, T. 49 N., R. 32 W. On Brush creek east of the bridge on Prospect avenue it is slightly less than 6 feet; while at Leeds, in the old Crebo quarry, the measurement is over 8 feet. Exposures in the vicinity of Red Bridge in T. 47 N., R. 33 W., show a thickness of 8 to 10 feet; in the cuts along the Rock Island railroad northwest of Lees Summit, there is a variation of from 6 to 10 feet, and south of Oak Grove it is 23 feet thick.

This member, as shown in the following typical sections, consists of shale and thin limestones.

SECTION ON PROSPECT AVENUE, BRUSH CREEK, EAST OF BRIDGE.

Stratum.	Thickness.
	Ft. in.
Bethany Falls:	
Limestone	6+ —
Ladore:	
Shale, soft, argillaceous	2 —
Shale, black, slaty	1 3
Limestone, blue, hard	1 4
Shale and thin limestone	1 4
Hertha:	
Limestone	10 —

SECTION NEAR RED BRIDGE, T. 47 N., R. 33 W.

Stratum.	Thickness.
	Ft. in.
Bethany Falls:	
Limestone	— —
Ladore:	
Shale	2 —
Shale, black, slaty	1 6
Limestone	1–2 —
Shale	4 —
Hertha:	
Limestone	8–9 —

SECTION AT RAILROAD CUT, ONE-HALF MILE SOUTH OF LEEDS.

Stratum.	Thickness
	Ft. in.
Soil	1 —
Bethany Falls:	
Limestone	6 —
Ladore:	
Shale, gray	2 6
Shale, black, slaty	1 6
Limestone, fine-grained	1 3
Shale	4 —
Hertha:	
Limestone	13 —

SECTION AT CENTER OF SEC. 29, T. 50 N., R. 29 W.

Stratum.	Thickness.
	Ft. in.
Bethany Falls:	
Limestone	— —
Ladore:	
Shale	3 —
Shale, black, slaty	1 —
Shale	2 —

SECTION AT CENTER OF SEC. 29, T. 50 N., R. 29 W.—Continued.

Stratum.	Thickness.
	Ft. in.
Ladore—Continued.	
Limestone	1 3
Shale, buff, nodular	1 —
Limestone	3 —
Shale, buff	1 —
Hertha:	
Limestone	— —

The black slaty layer which consists of hard, fissile shale, is persistent throughout the county and, because of its resistance to weathering, usually projects beyond the other beds. The thin limestones are dark gray, fine-grained and argillaceous, and are not prominent in exposures.

Phosphatic, fossiliferous concretions are common in the black shale. In the southeastern part of the county the lower shale is sandy or replaced by sandstone. This is true also of the member in some of the counties in the northeast.

Fauna.—The limestones in the middle of the Ladore are very fossiliferous, and the following species were collected from this horizon by F. C. Greene:

FAUNA OF THE LIMESTONES IN THE MIDDLE OF THE LADORE SHALE.

Fistulipora sp.
Batostomella sp.
Septopora biserialis
Derbya crassa
Meekella striaticostata
Chonetes verneuilianus
Spirifer cameratus
Spiriferina kentuckyensis
Composita subtilita

The most notable feature of this fauna is the large number of long stems of the bryozoan Batostomella. Forms resembling *Rhombopora lepidodendroides*, *Batostomella polyspinosa*, *B. greeniana*, *B. greeniana var. regularis*, and *B. leia* are common and seemingly intergrade as regards surface characters. Fistulipora is also common and specimens showing features of *F. nodulifera*, *F. carbonaria*, and *F. zonata* were obtained. These nodes have become extended into branches, some of which seem to be identical with *Cyclotrypa*(?) *barberi*.

In the black shale at the top of the Ladore are phosphatic concretions which, according to F. C. Greene, contain many specimens of *Lingula carbonaria* and *Lingulidiscina missouriensis*, and three of four undetermined species.

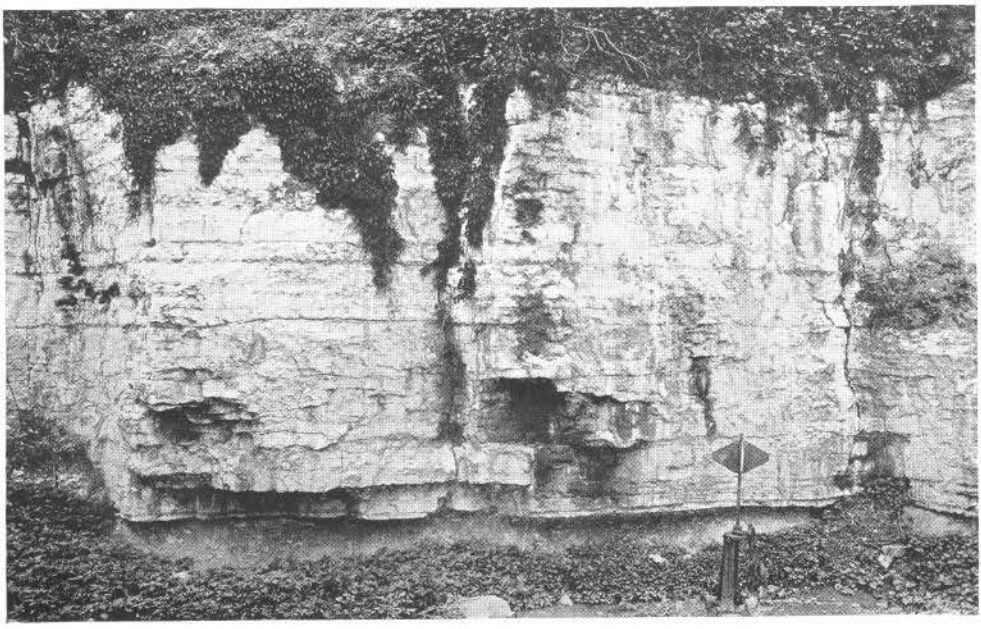


Fig. 1. Bethany Falls limestone, Southwest Blvd.

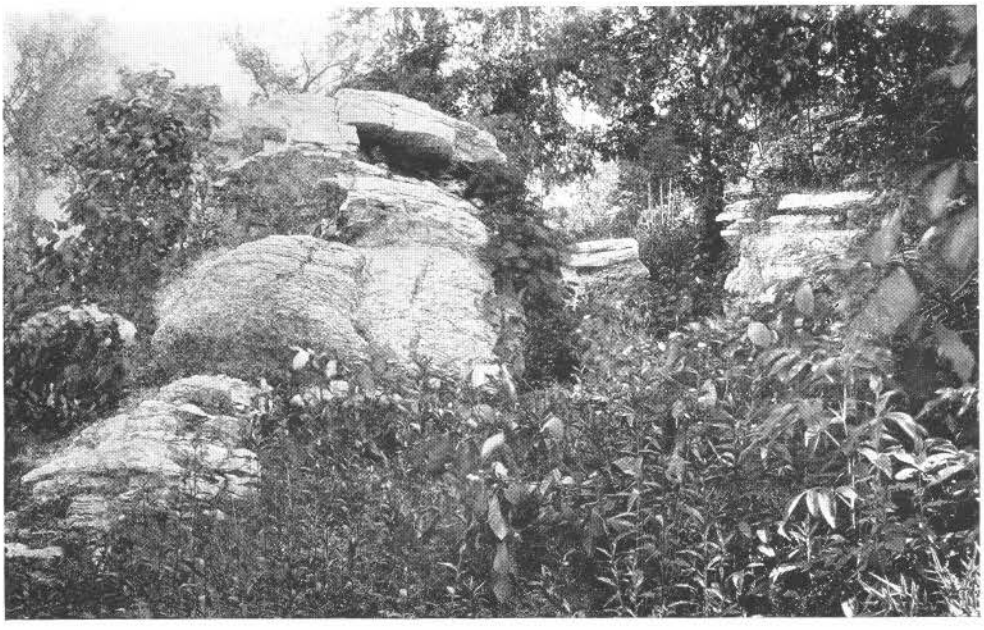


Fig. 2. Weathering Bethany Falls limestone.

BETHANY FALLS LIMESTONE.

Name and definition.—This member was one of the first in the western interior coal region to receive a geographic name. The name was applied by Broadhead in 1865 after studying the typical exposure at the falls of Big creek near Bethany, Harrison county. The Bethany Falls comprises the limestone between the Ladore and Cherryvale and corresponds to numbers 78 to 80 of Broadhead's general section.

Distribution.—As it is exposed in an almost continuous escarpment, the Bethany Falls forms the most striking topographic feature in the county. Its distribution is well shown on the geologic map which illustrates the narrow outcrop of the member. This outcrop, in the form of an almost continuous bluff, measures several hundred miles in the narrow width of the county. East of the main outcrop the limestone is found on the tops of some of the Sniabar hills, forming outliers in the Pleasanton lowland of the Sniabar valley.

The character of its outcrop is distinct from that of any other member. The ledge is massive and is cut by vertical joints. These features, in conjunction with the soft Ladore shale below, which weathers rapidly, cause large blocks to become detached from the parent ledge and slide down the slope. (See Plate I.) The upper surface of the ledge is often barren of soil for some distance back from the escarpment and in places is covered with the cactus, prickly pear (Optunia).

Characteristics.—The thickness of the Bethany Falls ranges between 15 and 24 feet, averaging 20 feet. Many outcrops, owing to the ease with which the upper part is eroded, do not exhibit the complete thickness.

The lower part of this member is made up of gray, crystalline limestone which weathers along irregular bedding planes to beds of a few inches to one foot thick. The upper half or more is of a mottled gray color and is finely crystalline and dense. At the top the member consists of a mass of poorly cemented nodules which soon separate upon exposure, giving the reduced thickness above mentioned.

The massive character of the ledge is well shown in Fig. 1, Plate VII, while the nodular character of the weathered surface of the upper portion is indicated in Fig. 2, Plate VII. Two sets of vertical joints, striking northeast and northwest, occur at intervals of from 5 to 20 feet, breaking the member into large blocks.

Fauna.—The following species have been collected from the Bethany Falls, chiefly in and near Kansas City:

Fusulinella sp.
Axophyllum rude
Lophophyllum profundum
Lophophyllum westii
Monilipora prosseri
Echinocrinus sp.
Fistulipora carbonaria
Fistulipora nodulifera
Stenopora carbonaria
Polypora sp.
Septopora biserialis
Pinnatipora trilineata
Pinnatipora sp.
Rhombopora sp.
Derbya crassa
Derbya sp.
Meekella striaticostata
Chonetes verneuilianus
Productus americanus
Productus costatus
Productus pertenuis
Productus semireticulatus
Marginifera splendens
Spirifer cameratus
Squamularia perplexa
Spiriferina kentuckyensis
Hustedia mormoni
Composita subtilita
Schizostoma catilloides
Platyceras parvum
Primitia sp.

GALESBURG SHALE.

Name and definition.—This member was named from outcrops at Galesburg, Kansas, and corresponds to Nos. 81a to 81c in Broadhead's general section.

Distribution.—The Galesburg is usually protected by the Winterset limestone above and limited by the Bethany Falls below; therefore, it does not outcrop over extensive areas, but follows closely the ribbon-like distribution of the Bethany Falls. Outcrops of the Galesburg may be noted in many localities where the Bethany is seen, but it is best exposed in quarries where this limestone is worked.

Characteristics.—This shale member varies from 4 to 10 feet in thickness, but most commonly measures from 5 to 7 feet. Near the oil refinery on Sugar creek, the interval between the Bethany Falls and Winterset is 10 feet; at Holmes Park in sec. 26, T. 48 N., R. 33 W., and at Dodson Hill, it is 8 feet; while northeast of Lees Summit, along the Rock Island railroad and north of Independence, it is 9 feet. Additional variations may be noted in the sections given below, which also indicate the characteristics of the members:

SECTION IN QUARRY AT CEMENT CITY.

Stratum.	Thickness.
	Ft. *in.*
Winterset:	
Limestone	— —
Galesburg:	
Shale, gray, clayey at top; black, firm and slaty below	2–6 —
Clay shale, dark at top, gray below; contains limestone nodules at base; varies in thickness from 1 inch to	2 —
Bethany Falls:	
Limestone, nodular	— —

SECTION IN OLD QUARRY ONE-HALF MILE SOUTH OF ATHERTON (N. W. ¼ N. W. ¼, SEC. 11, T. 50 N., R. 31 W.).

Stratum.	Thickness
	Feet.
Winterset:	
Limestone	10
Galesburg:	
Clay	4
Shale, black, slaty	1
Clay shale	3
Bethany Falls:	
Limestone	20

SECTION NORTH OF INDEPENDENCE ALONG THE SANTA FE RAILROAD.

Stratum.	Thickness.
	Feet.
Winterset:	
Limestone	10
Galesburg:	
Clay shale	3
Shale, black, slaty	2
Bethany Falls:	
Limestone	20

SECTION AT BASE OF HILL NEAR TWENTY-NINTH STREET AND SOUTHWEST BOULEVARD.

Stratum.	Thickness.	
	Ft.	*in.*
Winterset:		
Limestone	—	—
Galesburg:		
Shale, dark	—	8
Shale, black, firm, slaty, contains a few small flattened concretions	2	—
Clay, dark, gray, thickness variable, about	2	—
Bethany Falls:		
Limestone	—	—

SECTION AT SWOPE PARKWAY EAST OF PROSPECT AVENUE.

Stratum.	Thickness.	
	Ft.	*in.*
Winterset:		
Limestone	—	—
Galesburg:		
Shale, dark gray, soft	—	7
Shale, black, fine, slaty, grading into above	2	—
Shale, black, soft	—	1
Limestone, speckled gray, fossiliferous, oolitic, irregularly bedded	1	—
Shale, black, calcareous, with slaty cleavage	—	2
Limestone, gray, crumbly when weathered but hard when fresh, probably argillaceous	1	7
Bethany Falls:		
Limestone	—	—

Fauna.—Fossils are rare in the Galesburg shale, though careful search would undoubtedly reveal them. The black shale probably contains a fauna similar to that in the Ladore black shale.

WINTERSET LIMESTONE.

Name and definition.—For many years the literature bearing on Jackson county contained the names Mound Valley limestone, Galesburg shale, and Dennis Limestone, referring to the lower, middle and upper parts, respectively, of the Winterset. Later, however, field work disclosed the fact that these three names were applied to a single member at Kansas City, which is the equivalent of the limestone termed the Winterset, so called from outcrops near Winterset, Iowa. As the latter name had priority it was adopted. As here used, it applies to several beds of limestone and interstratified thin layers of shale lying between the Galesburg and Cherryvale shales, and corresponds to numbers 82 to 85a of Broadhead's general section. Locally, the Winterset is known as the "Chert ledge."

Distribution.—Good exposures of this member are to be seen only in the quarries, natural outcrops being masked by a covering of soil derived largely from the shales above. Outcrops may be seen in the lower parts of the bluffs of Kansas City and along the valleys of the Big and the Little Blue. Near the headwaters of these streams the Winterset is, as a rule, indicated only by the presence of residual cherts.

This member is the surface formation over a large part of T. 47, 48, and 49 N., R. 30 W., as well as in T. 49 N., R. 31 W. The soils contain an abundance of chert in the regions northeast and northwest of Blue Springs; in the vicinity of Tarsney; east, northeast and southeast of Lonejack; and southeast of Greenwood. As a matter of fact, the chert-filled soils lying above the Bethany Falls escarpment almost invariably indicate the presence of the Winterset. In the eastern part of the county there are a greater number of exposures than in the western. Most of the long, narrow ridges pointing toward the Little Blue from the west and east, especially in T. 49 N., R. 31 and 32 W., and T. 48 N., R. 32 W., are capped by the Winterset. The same is true of the ridges projecting north into the Little Blue and the Prairie valleys in T. 49 N., R. 30 and 31 W., T. 50 N., R. 30 W., and the narrow tongues extending eastward into Sniabar valley in T. 47, 48 and 49 N., R. 30 W. Some of the Sniabar hills in T. 47 N., R. 29 W., are likewise capped by the Winterset.

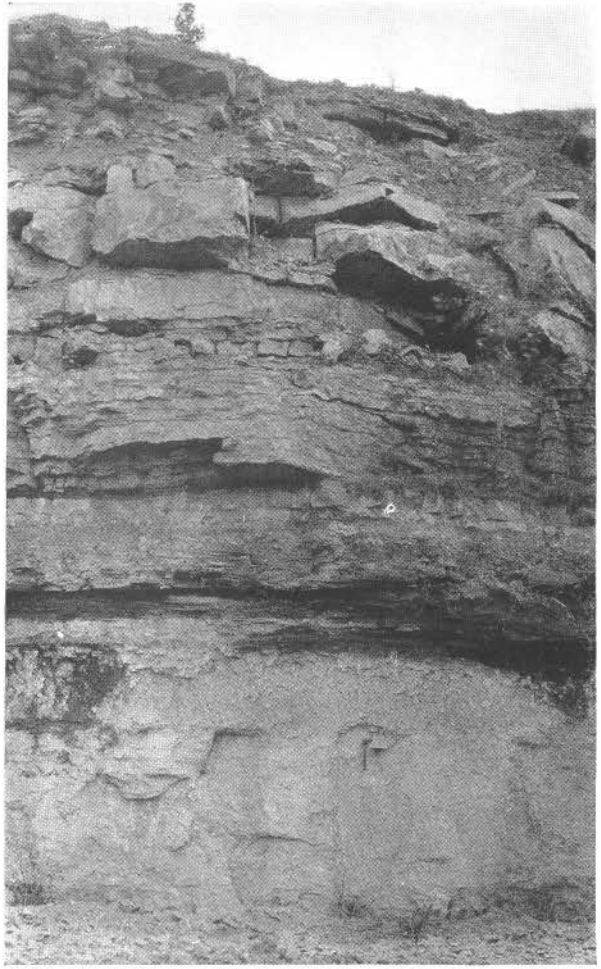


Fig. 1. Lower part of Winterset limestone, Galesburg shale and Bethany Falls limestone.

Fig. 2. Upper part of Winterset limestone.

Characteristics.—Normally, the Winterset has a thickness of about 30 feet. Complete exposures of the succession are not found in many places, for, where these strata comprise the surface formation, the upper beds have usually been removed by erosion.

The member consists essentially of crystalline limestone, separated near the center by a layer of shale 2 to 3 feet thick. The upper portion contains nodules of black chert by which the ledge is easily recognized. The following sections show the general composition of the Winterset:

SECTION AT SWOPE PARKWAY EAST OF PROSPECT AVENUE.

Stratum.	Thickness.	
	Ft.	*in.*
Winterset:		
Limestone, blue to gray color; upper 4 feet contains much black chert in nodules and irregular masses	7	—
Shale, dark, hard when fresh but crumbles readily on exposure	1	—
Limestone, light-colored, in several beds; contains chert in the middle portion	6	4
Shale, buff to gray color, soft	—	4
Limestone, gray, very fossiliferous; consists of several beds, and contains chert	3	6
Shale, black, soft	—	6
Limestone, light gray; splits into thin beds where exposed	4	3
Shale, dark blue, soft	—	3
Limestone, gray, argillaceous; in two layers	1	5

SECTION OF THE LOWER PART OF THE WINTERSET AT SOUTHWEST BOULEVARD AND TWENTY-NINTH STREET.

Stratum.	Thickness.	
	Ft.	*in.*
Winterset:		
Limestone, with some chert; lower part whitish	6	—
Shale, and thin limestone	—	7
Limestone, gray, with some chert	2	4
Clay shale	—	6
Limestone, gray, fossiliferous; in beds one foot thick	5	—
Limestone, argillaceous	—	4
Shale	—	5
Limestone, in two layers; lower part argillaceous	1	6

SECTION OF THE WINTERSET AT CEMENT CITY.

Stratum.	Thickness.	
	Ft.	*in.*
Winterset:		
Limestone, argillaceous	12	—
Shale	1	3
Limestone	8	6
Shale	—	6
Limestone	5	—
Shale	—	3
Limestone, grading into shale	1	—

SECTION AT HOLMES' PARK.

Stratum.	Thickness.
	Feet.
Soil	10
Winterset:	
Limestone with chert near top	8
Shale	3
Limestone with shale partings	10
Galesburg:	
Shale	10

The heavy ledge of limestone near the base, which is underlain by a thin shale and a thin limestone, is usually about 5 feet thick and splits up into layers about one foot thick. It is gray, fossiliferous, fairly dense, and occasionally contains some chert, although this material is not so prevalent here as toward the top of the member. Overlying this ledge and separated from it by a thin shale parting, is a two-foot bed of similar limestone, which, in places, carries chert. Occasionally, the shale parting is absent and the ledge shows no distinct separation. Again, a thin shale is often present beneath the next higher ledge which is from 6 to 8 feet thick. In some places in Kansas City, as at Twenty-ninth and Southwest boulevard, this ledge shows a sharp change in texture about half way from the top and is peculiarly marked by the presence of chert having the appearance of turkey tracks. The three ledges of limestone thus described constitute what might be called the lower portion of the Winterset.

The upper portion, 12 to 15 feet in thickness, is separated from the lower by 2 to 3 feet of shale. The black chert which occurs as nodules and thin beds, especially near the top, is characteristic of the Winterset. These nodules, however, are not always confined to the upper part, nor are they always present, for some exposures show only argillaceous limestone. The chert is mostly black or blue in color. This portion of the member, as shown in Fig. 2, Plate VIII, separates into irregular beds along shaly bedding planes. The rock is bluish on fresh exposure, but changes to gray where weathered.

Some outcrops show the top of the Winterset to be oolitic and cross-bedded. An exposure north of Seventy-fifth street between Agnes and Waldrond presents 5 to 6 feet of cross-bedded, oolitic limestone underlying the beds containing the black chert. In sec. 16, T. 47 N., R. 33 W., 8 feet of oolitic

limestone overlie chert-bearing limestone, and in sec. 29, T. 48 N., R. 33 W., just west of the Big Blue, the following section of the upper portion of the Winterset is exposed:

SECTION WEST OF BIG BLUE RIVER IN SEC. 29, T. 48 N., R. 33 W.

Stratum.	Thickness.
Winterset:	*Feet.*
Limestone, gray, oolitic and cross-bedded	4
Limestone, irregularly bedded, with black and blue chert	4
Limestone, blue, crystalline	4

Fauna.—The upper layers have furnished a fauna chiefly of mollusks which is unique among American Carboniferous faunas. Some species attain very large dimensions, one of the cephalopods measuring 1¼ feet across the disc.[1] The following species were found in the Winterset chiefly in or near Kansas City, the first list including the species from the lower part of the formation, the second being from the upper beds.

FAUNA OF THE LOWER PART OF THE WINTERSET LIMESTONE.

Axophyllum rude
Michelinia eugeneæ
Echinocrinus sp.
Fistulipora nodulifera
Stenopora carbonaria
Fenestella perelegans
Fenestella sp.
Polypora elliptica
Septopora biserialis
Pinnatipora multipora
Rhombopora lepidodendroides
Lingula sp.
Derbya crassa
Derbya sp.
Meekella striaticostata
Chonetes granulifer
Chonetes verneuilianus
Productus americanus
Productus cora
Productus costatus
Productus pertenuis
Productus semireticulatus
Productus sp.
Pustula nebraskensis
Marginifera splendens
Dielasma bovidens
Spirifer cameratus
Ambocœlia planiconvexa
Squamularia perplexa
Spiriferina kentuckyensis
Hustedia mormoni
Composita subtilita
Aviculipecten interlineatus
Conocardium sp.
Bellerophon sp.
Pleurotomaria sp.
Naticopsis ventrica
Platyceras parvum
Griffithides scitulus
Phillipsia major
Ostracod sp.
Lophophyllum profundum
Spirorbis carbonaria
Echinocrinus sp.
Fistulipora nodulifera
Fistulipora sp.
Fenestella sp.
Polypora sp.
Septopora biserialis
Lingula carbonaria
Aviculipecten sp.
Deltopecten aff. occidentalis
Deltopecten occidentalis
Acanthopecten carboniferus
Lima retifera
Pleurophorus (?) sp.
Allerisma granosum
Allerisma terminale
Allerisma sp.
Lingula umbonata
Orbiculoidea sp.
Derbya broadheadi
Derbya sp.
Chonetes verneuilianus
Productus americanus
Productus cora
Productus costatus
Productus semireticulatus

[1] One of the best, if not the best collection of Kansas City fossils is that of Mr. Sid. J. Hare, deposited in the museum of the Kansas City Public Library. This contains a very complete set of Winterset species as well as the crinoids of the upper Chanute shale.

FAUNA OF THE UPPER PART OF THE WINTERSET LIMESTONE—Continued.

Pustula nebraskensis
Pustula semipunctata
Putsula symmetrica
Marginifera splendens
Dielasma bovidens
Spirifer cameratus
Spiriferina kentuckyensis
Cliothyridina orbicularis
Composita subtilita
Solenomya anodontoides
Solenomya parallela
Solenomya trapezoides
Sanguinolites costatus
Clinopistha radiata var. levis
Sedgwickia topekensis
Edmondia ovata
Edmondia sp.
Nuculopsis ventricosa
Aviculipinna sp.
Pinna peracuta
Pteria longa
Bakewellia(?) sp.
Monopteria longispina
Levidentalium(?) sp.
Bellerophon crassus
Bellerophon sp.
Euphemus nodocarinatus
Pharkodonotus percarinatus
Pleurotomaria broadheadi
Pleurotomaria sp.
Worthenia tabulata
Euconospira bicarinata
Murchisonia 2 sp.
Straparollus sp.
Schizostoma catilloides
Phymatifer pernodosus
Naticopsis(?) monilifera
Naticopsis subovata
Naticopsis sp.
Loxonema sp.
Macrocheilina(?) sp.
Sphærodoma medialis
Soleniscus(?) sp.
Orthoceras sp.
Pseudorthoceras knoxense
Ephippioceras ferratum
Coloceras gobatum
Metacoceras sangamonensis
Metacoceras sculptile(?)
Tainoceras occidentale
Domatoceras lasallense
Asymptoceras capax
Cyrtoceras sp.
Titanoceras ponderosum
(Endolobus) missouiensis
Monopteria sp.
Pseudomonotis kansasensis(?)
Pseudomonotis tenuistriata
Myalina ampla
Myalina kansasensis
Myalina subquadrata
Schizodus wheeleri
Schizodus sp.
Aviculipecten fasciculatus
(Nautilus) planorbiformis
(Nautilus) planovolvis
(Nautilus) sp.
Goniatites sp.
Phillipsia major
Bairdia sp.
Petalodus distructor
Fish tooth indet.

CHERRYVALE SHALE.

Name and definition.—The Cherryvale shale, named from exposures at Cherryvale, Kansas, embraces Broadhead's numbers 85b to 86, and fills the interval between the Winterset limestone below and Drum limestone above. The Drum limestone has not been traced from its type locality in southeastern Kansas, and the correlation is made on paleontological grounds. However, the line of separation is distinct in Jackson county.

Distribution.—As this member weathers easily, there are consequently but few exposures except in quarry faces or in shale pits. It does not occur in the eastern part of the county, and if present in the northeastern area, is so covered with loess as to be obscured. This is also the case on the divide in Twps. 47, 48, and 49 N., R. 30 W., the crest of which is topographically high enough to include this member as the upper formation. Along the borders of the Little Blue it underlies considerable areas, forming very gentle slopes. Farther west, in the Big Blue valley, it is topographically lower and, because of the more precipitous slopes, its outcrop is narrower.

Characteristics.—Sections measured in Kansas City show that the thickness of the Cherryvale shale varies from 23 to 33 feet. The relative positions of the Winterset and Drum limestones indicate a similar variation throughout the county, although there are no measureable exposures of the entire thickness.

This member consists of shale, throughout the lower half of which there are thin beds and lenses of limestone which vary from place to place both in number and in thickness. In many localities, the base of the member is marked by bituminous shale or a thin seam of coal. The upper portion does not contain any limestone and is composed of blue, homogeneous shale. The shale of the lower portion ranges from a blue to a grayish-yellow where weathered, and contains dark bituminous layers. The interbedded limestone is gray in color and crystalline in texture.

The following sections indicate variations in thickness and in the character of the strata:

SECTION IN QUARRY AT FIRST AND MICHIGAN STREETS.

Stratum.	Thickness.	
	Ft.	*in.*
Drum:		
Limestone, oolitic	8	4
Limestone, hard	4	9
Cherryvale:		
Shale, dark blue	12	4
Limestone, coarse; composed largely of small shells	1	7
Shale, blue	2	—
Shale, light to dark, thinly bedded	2	2
Limestone, blue, weathers to deep buff, hard	1	6
Shale, gray	2	8
Coal	—	2
Shale, bituminous	—	8
Winterset (upper portion):		
Limestone, cherty	2	4

SECTION IN QUARRY AT CEMENT CITY.

Stratum.	Thickness.	
	Ft.	*in.*
Drum:		
Limestone	—	—
Cherryvale:		
Shale, blue	17	—
Limestone	1	6
Shale	2	—
Limestone	1	—
Shale	7	—

SECTION AT WEST BLUFF AND TWELFTH STREETS.

Stratum.	Thickness.
	Ft. *in.*
Drum (lower portion):	
Limestone	5 —
Cherryvale:	
Covered; probably shale	16 —
Limestone	— 6
Shale	— 6
Shale, with limestone lenses in first seven feet	12 —
Winterset (upper portion):	
Limestone	2 —

Fauna.—The Cherryvale shale, particularly at the base, is locally rather fossiliferous.

FAUNA OF THE CHERRYVALE SHALE.

Lophophyllum distortum
Serpulopsis insita
Eupachycrinus sp.
Batostomella polyspinosa
Derbya crassa
Derbya crassa var.
Chonetes verneuilianus
Productus semireticulatus
Pustula nebraskensis
Marginifera splendens
Bellerophon stevensianus
Pharkidonatus percarinatus
Pharkidonatus percarinatus var. tricarinatus
Pleurotomaria sp.
Loxonema sp.
Platyceras parvum
Pseudorthoceras knoxense
Hollinia emaciata var. occidentalis(?)
Bairdia beedei
Cytherella aff. benniei

DRUM LIMESTONE.

Name and definition.—The type locality of the Drum limestone is on Drum creek in Montgomery county, Kansas. As this creek is a considerable distance from Jackson county, Mo., the member has not been traced in detail between the two places, the correlation being made on paleontologic grounds. At and near the type locality the Drum comprises one to several beds of limestone, and future work may prove that it includes a part or all of the limestone now considered as beds of the Chanute shale member. As here used, the term "Drum" applies to the limestone resting upon the thick shale bed at the top of the Cherryvale, and includes Broadhead's numbers 87a-b. In Kansas City the lower part of the Drum is known among quarrymen as the "Bull ledge," the upper part as the "Oolitic ledge," the two being separated by a few inches of shale.

Distribution.—As the Drum is very thin it has been shown on the county map with the Cherryvale shale. It is present at practically all the places shown by the "Cv" pattern except some of the small detached areas. It is shown separately on the Kansas City map. Though the lower part ("Bull ledge")

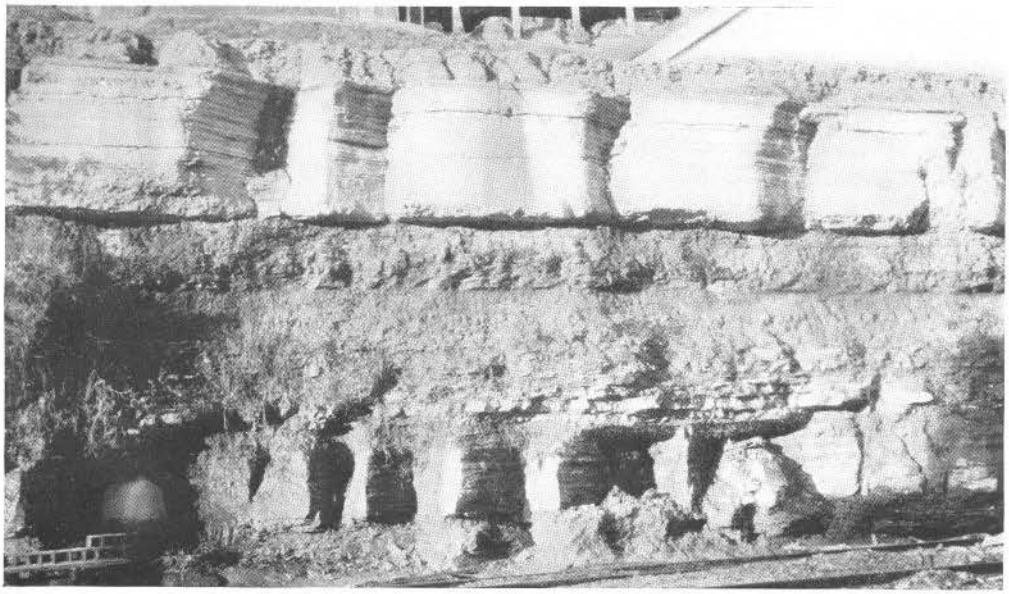


Fig. 1. Drum limestone, Chanute shale and Cement City limestone. Terminal railroad, near 20th and Brooklyn.

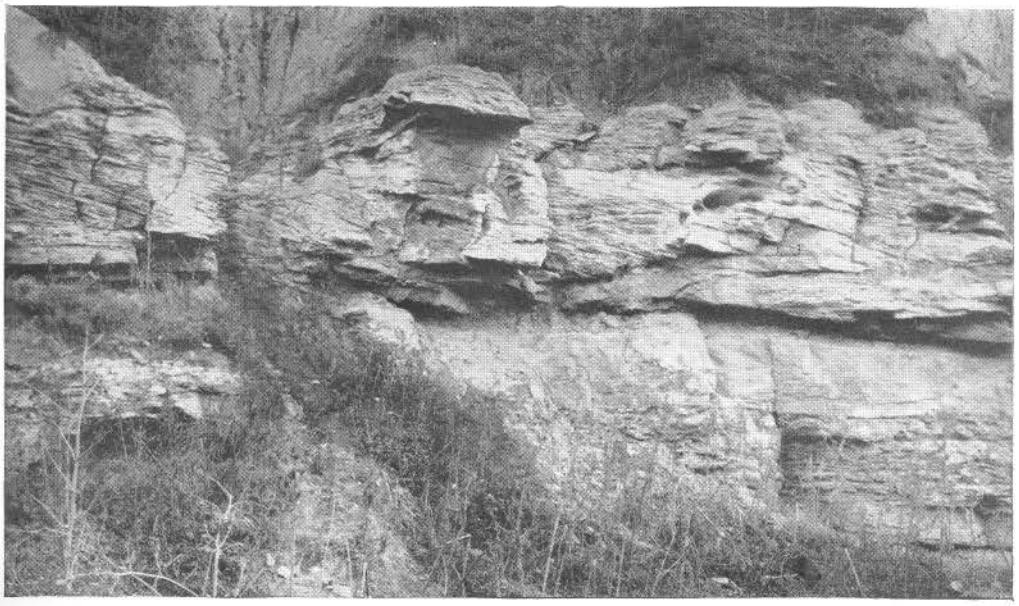


Fig. 2. Drum limestone, 6th and West Bluff.

is persistent, good exposures of it are rare east of the area tributary to the Big Blue. The upper oolitic part is exposed at many places in Kansas City and along the Big Blue valley from near Hickman Mills to Grand View. The oolite is absent in the central part of Kansas City and in the eastern part of the Drum area, the most eastern outcrop of it noted being in sec. 34, T. 50 N., R. 32 W.

Characteristics.—Ranging from 6 to 20 feet in thickness, this limestone is the most variable of any exposed in the county. The lower portion or "Bull ledge" has a rather uniform thickness of from 3 to 5 feet, the variation occurring chiefly in the oolitic ledge. The oolitic ledge is absent in the central part of Kansas City, while to the south it is well developed, and along the west bluff reaches a thickness of 14 feet.

The lower portion is a gray, fine-grained limestone that breaks with a conchoidal fracture, and weathers buff. It contains small geodes and crystals of calcite.

The upper portion consists chiefly of small gray oolites which are frequently cemented or replaced by limonite, thus giving the rock a buff color. This ledge is cross-bedded and the rock splits easily along these bedded planes. Fossils are abundant, showing especially on the weathered face. The organic content varies in different areas, but seems to be made up of both dwarf anf normal-sized fossil forms.

Fauna.—The fauna of the Drum as known at present is chiefly that of the oolite in Kansas City. The Rev. John Bennett has identified more than 100 species, which comprise most of the common Pennsylvanian forms. The Kansas City trilobites come principally from the oolite at Garfield street and the North Bluff.

FAUNA OF THE DRUM LIMESTONE.

Axophyllum rude
Campophyllum torquium
Lophophyllum distortum
Fistulipora nodulifera
Batostomella greeniana var. regularis
Stenopora carbonaria
Fenestella perelegans
Fenestella tenax
Polypora elliptica
Polypora sp.
Septopora biserialis
Rhombopora lepidodendroides
Lingulidiscina missouriensis
Derbya broadheadi
Derbya sp.
Chonetes verneuilianus
Productus americanus
Productus semireticulatus
Pustula nebraskensis
Pseudomonotis sp.
Myalina kansasensis
Myalina subquadrata
Myalina swallowi
Schizodus sp.
Aviculipecten fasciculatus
Aviculipecten interlineatus
Aviculipecten sculptilis
Deltopecten coxanus
Deltopecten mccoyi
Deltopecten occidentalis
Deltopecten sp.
Acanthopecten carboniferus
Streblopteria tenuilineata
Lima retifera
Modiola subelliptica

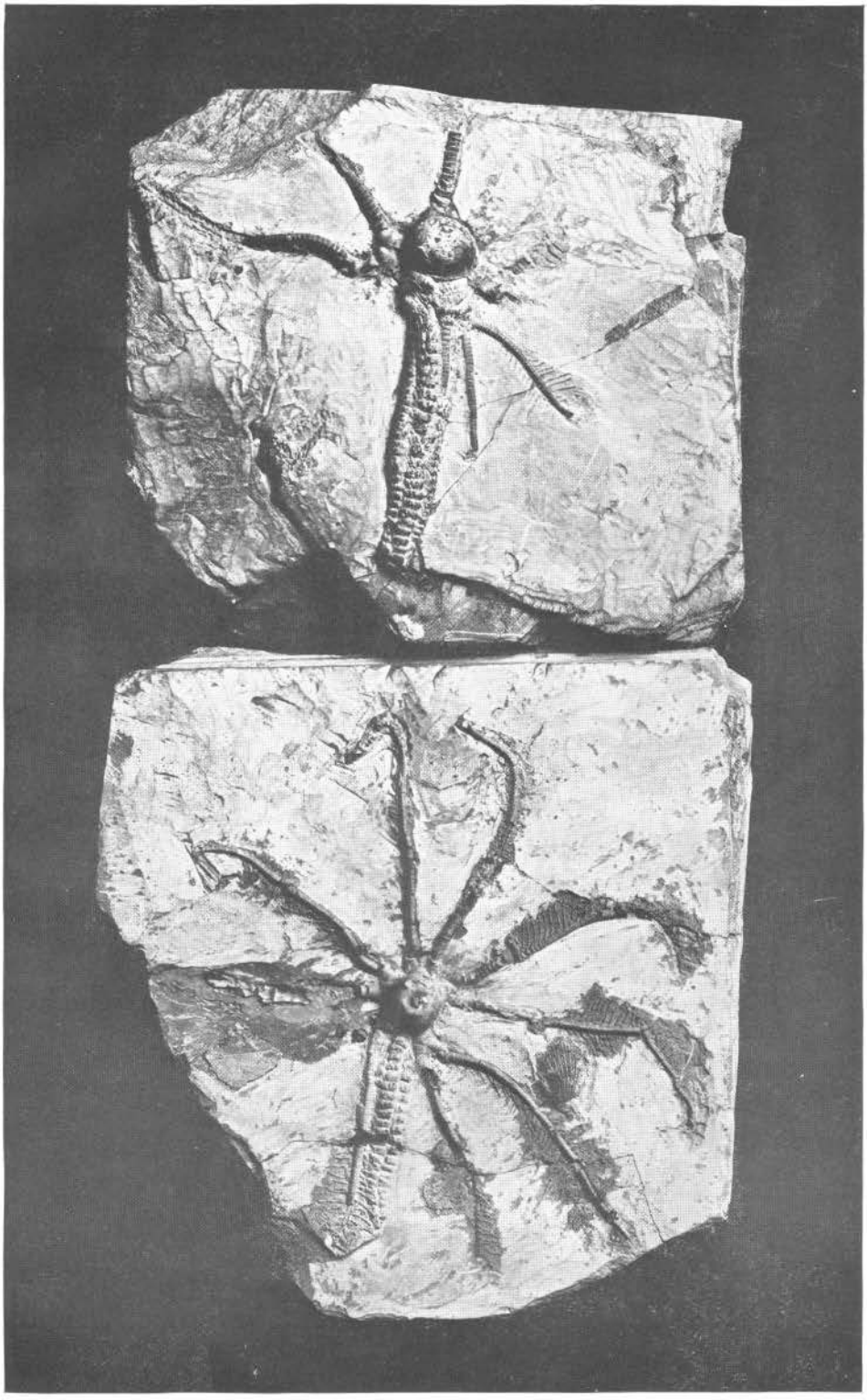
FAUNA OF THE DRUM LIMESTONE—Continued.

Allerisma terminale
Allerisma subelegans
Pleurophorus subcostatus
Pustula semipunctata
Pustula symmetrica
Marginiferus splendens
Dielasma bovidens
Spirifer cameratus
Squamularia perplexa
Spiriferina kentuckyensis
Hustedia mormoni
Cliothyridina orbicularis
Composita subtilita
Sanguinolites costatus
Prothyris elegans
Edmondia aspinwallensis
Edmondia nebraskensis
Nucula parva
Nucula parva var.
Nuculopsis ventricosa
Leda arata
Leda bellistriata
Leda meekana
Parallelodon obsoletus
Parallelodon sp.
Pinna sp.
Conocardium missouriensis
Conocardium parrishi
Pteria longa
Pteria ohioensis
Pteria sulcata
Monopteria alata
Pleurophorus tropidophorus
Pleurophorus sp.
Cypricardinia carbonaria
Astartella concentrica
Dentalium sp.
Bellerophon crassus
Bellerophon sp.
Bucanopsis bella
Bucanopsis perlata
Bucanopsis textiliformis
Pleurotomaria pratteni
Pleurotomaria sp.
Phanerotrema grayvillense
Euconospira bicarinata
Trepospira sphærulata
Worthenia speciosa
Worthiena tabulata
Naticopsis nana
Naticopsis scintilla
Naticopsis ventrica
Loxonema(?) n. sp.
Zygopleura nana
Zygopleura teres
Bulimorpha aff. chrysalis
Bulimorpha minuta
Aclisina aff. quadricarinata
Trachydomia nodosa
Trachydomia wheeleri
Platyceras parvum
Monopteria gibbosa
Monopteria longispina
Monopteria marian
Pseudomonotis hawni
Pseudomonotis cf. hawni
Pseudomonotis equestria
Pseudomonotis robusta
Pseudomonotis tenuistriata
Pseudorthoceras knoxense
Orthoceras sp.
Ephippioceras ferratum
Metacoceras sangamonense
Titanoceras ponderosum
(Nautilus) planivolvis
Phillipsia major
Phillipsia nodocostata
Griffithides(?) sp.

CHANUTE SHALE.

Name and definition.—This shale, for which the name "Thayer" has been used in certain publications, is called Chanute from the town of that name in southeastern Kansas. As here used the term Chanute applies to all the beds between the Drum and the Iola limestones, including two prominent limestone beds, the Cement City and the Raytown. These may be a part of the Drum of southeastern Kansas. Locally, quarrymen designate the Cement City as the "Building ledge," and the Raytown as the "Calico."

Distribution.—This member covers portions of the western and southwestern parts of the county, but it is entirely absent from the eastern and northeastern portions. It is not present in R. 29 E., and is found only over small parts of Tws. 47, 48 and 49 N., R. 30 W., and Tws. 48, 49 and 50 N., R. 31 W. In the south-central part of the county it covers considerable terri-



54 Crinoids (graphiocrinus harei) upper Chanute shale, Kansas City.

tory, although there are but few outcrops. The included limestones, however, are locally indicated by ridges and benches. The Chanute tops the main divide between the north and south drainage, is the highest member in the divide between East Fork and the Little Blue, and it is also the surface formation on some of the divides between the Sniabar and East Fork. Along the Big Blue and the lower course of the Little Blue, it has less areal extent than in the southern part of the county, but outcrops are numerous. Northward, between the Big and the Little Blue, it spreads out and tops the divide between the Little Blue and the Missouri. The most complete sections of the member are exposed along the Big Blue and in the bluffs and quarries of Kansas City.

Characteristics.—The Chanute ranges from 54 to 80 feet in thickness. This variation is due chiefly to the thickening and thinning in the shale beds, for the limestones are fairly uniform throughout the county. Measurements of the member show 75 feet at the new Union Station, 65 to 67 feet along the West Bluff, 60 feet neat Electric Park, 66 feet in sec. 34, T. 50 N., R. 32 W., and 60 feet north of Hickman Mills and near Grandview.

The general nature of the Chanute shale is shown in the following generalized section:

GENERALIZED SECTION OF THE CHANUTE SHALE.

Stratum.	Thickness.
	Ft. *in.*
1. Shale, blue to blue-gray, weathering brownish, locally sandy or with thin beds of sandstone. Contains scattered, flattened concretions and locally is very fossiliferous; 7 ft. to 25 ft. thick, average	18 2
2. Limestone (Raytown or "Calico"); fine-grained, shows much calcite filling fossil casts, peculiarly mottled. Top portion has a gray color. Varies in thickness from 4 ft. to 7 ft., average	6 —
3. Shale, gray, calcareous, contains dark-gray, coarse-grained crinoidal and crystalline limestone. Proportion of shale and limestone varies	1 2
4. Shale, gray at top, grading down to black, soft or slaty shale with light shale at base. At the very top is a *Conularis crustula* horizon, carrying small, more or less spherical concretions. The black and slaty shale is very irregular in distribution and thickness. The shale at the base is marked by fucoids or worm borings. The thickness varies from less than an inch to 5 ft., depending largely on the presence or absence of the slaty shale, average	1 6
5. Limestone, dense dark-purplish gray with irregular markings of darker crystalline calcite	1 2
6. Shale, gray, black, greenish-gray, red, yellow, and buff, the colors usually arranged in thick layers, calcareous at top or bottom where there are commonly thin layers or nodules of impure limestone, locally sandy; thickness varies from 8 ft. in northern Kansas City to more than 24 ft. near South Lee, average	16 4

GENERALIZED SECTION OF THE CHANUTE SHALE—Continued.

Stratum.	Thickness.
	Ft. in.
7. Limestone (Cement City or "Building ledge"), gray, weathering to a light buff. Weathers to a thin-bedded outcrop, but is rather heavy-bedded where quarried. Thickness varies from 4 ft. at South Lee to 13 ft. in Kansas City, average	8 6
8. Shale, at top, several thin layers gray, green, and black; lower part calcareous with limestone nodules and layers of limestone, greenish to purplish-gray, weathering to light-gray or buff; thickness dependent on amount of oolite present in Drum limestone below and ranges from 8 ft. to 26 ft., average	14 7
Average total	67 4

The following local sections show the variations in the thickness as well as the general succession:

SECTION IN SEC. 36, T. 48 N., R. 33 W.

Stratum.	Thickness.
Iola:	*Feet.*
Limestone	10
Chanute:	
Covered	20
Limestone (Raytown)	8
Covered	25
Limestone (Cement City)	5
Shale	10
Drum:	
Limestone	—

SECTION IN SEC. 34, T. 50 N., R. 32 W.

Stratum.	Thickness.
Iola:	*Feet.*
Limestone	—
Chanute:	
Shale remnant	22
Limestone (Raytown)	7
Shale	17
Limestone (Cement City)	8
Shale	12
Drum:	
Limestone	3

SECTION AT WEST BLUFF AND TWELFTH STREETS.

Stratum.	Thickness.	
	Ft.	*in.*
Iola:		
Limestone	—	—
Chanute:		
Covered (shale)	28	—
Limestone (Raytown)	6	—
Shale, dark, containing thin bituminous layer	4	7
Limestone	1	—
Shale and covered	8	7
Limestone (Cement City)	13	6
Shale, upper portion; thinly bedded limestone and shale below	8	5
Limestone, gray, fine-grained	2	—
Shale, light	1	5
Drum:		
Limestone, oolitic	2	10

SECTION EXPOSED ON TWENTIETH STREET BETWEEN EUCLID AND WOODLAND.

Stratum.	Thickness.	
	Ft.	*in.*
Iola:		
Limestone	—	—
Chanute:		
Shale	19	—
Limestone (Raytown)	6	—
Shale	—	6
Limestone	—	4
Shale	—	6
Limestone	1	8
Shale, blue	13	—
Shale, red	3	—
Shale, green, with some limestone lenses	7	4
Limestone (Cement City)	8	6

The shale between the Drum and the Cement City limestones does not vary in thickness as much as do the other shale divisions. It averages 10 feet, and ranges from 9 to 12 feet. Normally, it consists of two parts, an upper horizon of greenish to bluish shale and a lower horizon of yellowish shale, which contains calcareous concretions, and thin lenses and nodules of limestone. In several exposures, as in sec. 29, T. 49 N., R. 32 W., and in the West Bluff, the upper part contains a thin layer of bituminous shale.

The Cement City, locally called the "Building ledge," because of its extensive use in Kansas City for rubble, is from 9 to 13 feet thick. It is the most commonly exposed ledge in Kansas City, and ordinarily has a drab color, though some beds are blue. Along the bedding planes and joints it weathers to a deep yellow. Characteristically, it is made up of an upper

portion which is easily broken into thin beds; and a lower, argillaceous portion which is blue. The stone splits irregularly along wavy bedding planes. It is crystalline for the most part, but contains large fossils, geodes, "dries," and calcite seams. Major joints striking northeast and northwest occur from 6 to 12 feet apart, and are commonly filled with clay. Fig. 1, Plate IX, shows an excellent outcrop of this limestone.

The interval between the Cement City and the Raytown limestones varies from 10 to 23 feet. The lower three-quarters is an irregularly colored, green, blue, red, and yellow shale which at some places contains calcareous concretions. Usually the red shale occurs in an irregular band through the middle, dividing an upper blue from a lower green and buff shale. The top portion of the interval, measuring 3 to 6 feet, is composed of irregular beds of thin shale and limestone, and, as noted near the terminus of the Thirty-first street car line and at points in Kansas City, contains sandy layers and thin sandstones.

The Raytown limestone derived its local name "Calico" from its curious texture and color. The color is irregularly gray, blue, buff, and reddish, and the texture is quite variable because of the presence of large fossils and interwebbed veins of calcite. Weathering causes stains and blotches to appear along the irregular seams of the rock and produces a decidedly rough surface. The Raytown is persistently 5 to 6 feet thick and may be seen in a number of localities in the south part of the county, notably in sec. 36, T. 48 N., R. 33 W., secs. 8 and 15, T. 47 N., R. 33 W., and in secs. 35 and 36, T. 49 N., R. 31 W. Fig. 2, Plate XI, shows the texture of this limestone.

The shale interval between the Raytown and the Iola limestone is from 5 to 25 feet thick. It is the thickest in the northern part of Kansas City, thins toward the southern part of the city, but thickens again toward the southern part of the county. Eastward from the city it also thins, but becomes thicker in the vicinity of Lees Summit. Some of the variations may be seen from the sections give above and from measurements which follow: Eight feet in sec. 9, T. 47 N., R. 32 W.; 12 feet in sec. 15, T. 47 N., R. 33 W.; 20 feet at various localities in T. 47 N., R. 32 W.; 15 to 20 feet at Hickman Mills and Grandview; and 21 feet at Twenty-third and West Bluff. The shale is free from limestone lenses but contains considerable sandy material in some exposures, and at a few places it bears concretionary nodules close to Raytown. The color is blue where freshly exposed and yellow where weathered.

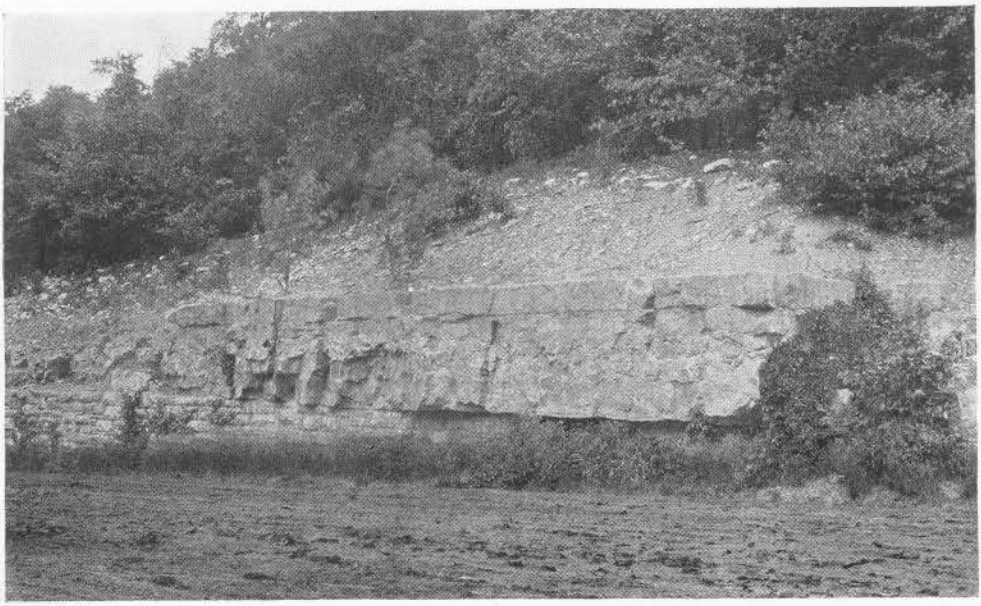


Fig. 1. Raytown limestone, Penn Valley Park.

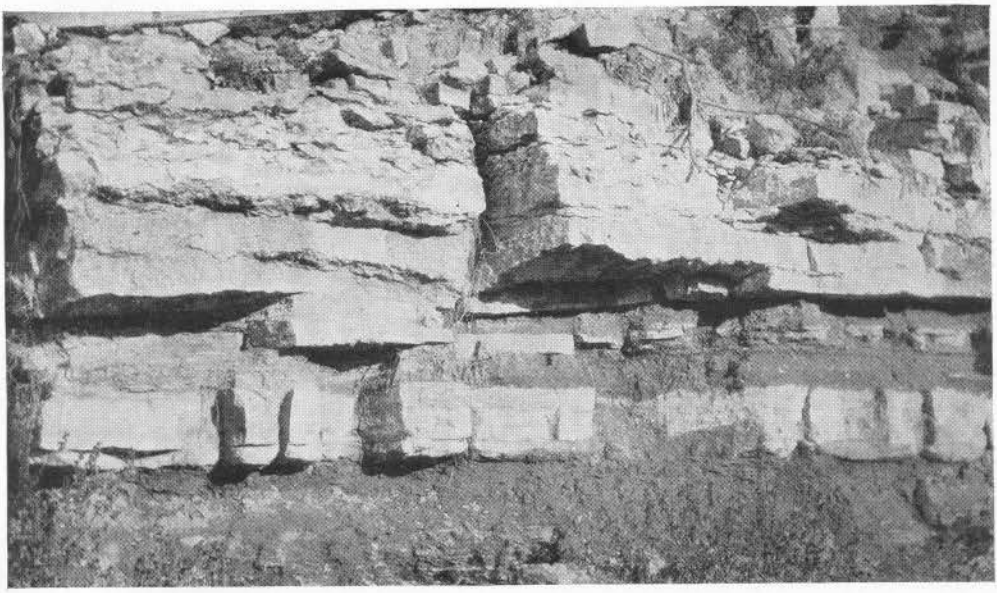


Fig. 2. Raytown limestone.

An outcrop of conglomerate and sandstone occurs on the south side of the Rock Island railroad about one mile northwest of South Lee and the same distance southwest of Lees Summit. The sandstone, which is more than 20 feet thick, is underlain by 5 feet of calcareous conglomerate. The area surrounding being largely sodded and of gentle slope, the relation of these beds to the other formations cannot be determined. The relations are apparently similar to those of the channel sandstone deposits of Johnson county.

Fauna.—The shale at the top of the Chanute furnished the famous Kansas City crinoids, most of which were found while excavating for the Emery, Bird and Thayer building. Mr. Sid J. Hare, the discoverer of the crinoids, states that they occur principally in colonies, chiefly about 8 feet from the base of the bed. Locally, other fossils, chiefly mollusks, are fairly abundant and, like the crinoids, are well preserved.

The calcareous shales and shaly limestone at the very base of the Chanute contain many specimens of *Campophyllum torquium*, which is by far the most abundant species. Specimens of *Pharkidonatus percarinatus* and *Worthenia tabulata*(?) were found and doubtless other species occur. At a higher horizon in the basal shale bed there is locally a layer characterized by the abundance of *Deltopecten occidentalis* and *Jonesina gregaria*. In the greenish and black shales at the top is a fauna of thin and fragile-shelled brachiopods, among which F. C. Greene noted the following species: *Lingula carbonaria*, *Lingulidiscina missouriensis*, *Chonetes verneuilianus*, *Productus pertenuis*, *Pugnax osagensis*, and *Ambocoelia planiconvexa*.

The Cement City limestone, though commonly appearing to be rather unfossiliferous, contains a large number of species, of which locally *Campophyllum torquium* is so conspicuous that the bed has been termed the "*Campophyllum torquium* ledge."

FAUNA OF THE CEMENT CITY LIMESTONE AT KANSAS CITY.

Axophyllum rude
Axophyllum sp. F
Lophophyllum profundum
Lophophyllum sp.
Campophyllum torquium
Michelinia eugeneæ
Monilopora prosseri
Cyathocrinus stillativus
Hydreionocrinus acanthophorus
Hydreionocrinus mucrospinus
Hydreionocrinus pentagonus
Hydreionocrinus sp.
Cromyocrinus sangamonensis
Fistulipora carbonaria
Fistulipora nodulifera
Derbya crassa
Meekella striaticostata
Chonetes verneuilianus
Productus costatus
Productus semireticulatus
Pustula nebraskensis
Pustula semipunctata
Pustula symmetrica
Merginifera splendens
Tegulifera kansasensis
Dielasma bovidens

FAUNA OF THE CEMENT CITY LIMESTONE AT KANSAS CITY—Continued.

Spirifer cameratus
Ambocœlia planiconvexa
Squamularia perplexa
Spiriferina kentuckyensis
Cyclotrypa barberi
Batostomella greeniana var. regularis
Tabulipora distans(?)
Stenopora carbonaria
Liopora subnodosa
Chainodictyon laxum
Fenestella limbata
Fenestella sp.
Polypora elliptica
Polypora submarginata
Polypora sp.
Pinnatipora sp.
Septopora biserialis
Acanthocladia pinnati
Rhombocladia delicata
Rhombopora lepidodendroides
Rhombopora sp.
Cystodictya inequimarginata
Hustedia mormoni
Cliothyridina orbicularis
Composita subtilita
Edmondia sp.
Pinna peracuta
Myalina kansasensis
Myalina subquadrata
Deltopecten occidentalis
Acanthopecten carboniferus
Pleurotomaria missouriensis
Pleurotomaria 2 sp.
Euconospira bicarinata
Naticopsis sp.
Gastropod sp.
Platyceras parvum
Phillipsia major
Griffithides sp.
Fish tooth indet.

The shale above the Cement City limestone appears to be rather barren of fossils except near the top, where a local lens of limestone contains on its upper shaly surface many crushed specimens of *Pustula nebraskensis*, with *Productus cora* and *Spirifer cameratus* in less abundance.

The sandy phase has furnished from a locality on the south side of Brush creek at Main street some fossil tracks supposed to be those of amphibians. Butts[1] has described six species as follows: *Notalcerta missouriensis*, *N. jacksonensis*, *Crucipes parva*, *Duovestigia scala*, *Punctatumvestigium circuliformis*, and *Notamphibia magna*.

Limestone No. 5 of the generalized section contains several species that are rare at other horizons. They stand out from the vertical faces of the layer in weathered-out joints. The following is a complete list of the species found by F. C. Greene in Kansas City and to the north in southern Platte county. Those marked by an asterisk occur at Kansas City, and a detailed search would probably reveal the remainder.

FAUNA OF LIMESTONE No. 5 OF CHANUTE SHALE SECTION.

Cœlocladia spinosa(?)
*Heterocœlia beedei
Lophophyllum profundum(?)
Pugnax osagensis
*Squamularia perplexa
Composita subtilita
*Bellurophon crassus
Pleorotomaria(?) spironema
Orestes intertextus
*Naticopsis altonensis
Zygopleura sp.
Trachydomia nodosa
Trachydomia wheeleri
Metacoceras cornutum var. carinatum(?)
*Nautiloid

The black shale above limestone No. 5 has so far proved barren of fossils, but where it grades up into light-colored shale,

[1]Butts, Edward, Kansas City Scientist, vol. 5, pp. 17-19, 4 figs., and p. 44, 2 figs., 1891.

Trepospira sphaerulata, *Phanerotrema grayvillense*, and other gastropods are locally common. At the top of this shale is the *Conularia crustula* horizon already mentioned.

The Raytown limestone bed is notable for the large size of its fossils. The following species have been collected at Kansas City:

FAUNA OF THE RAYTOWN LIMESTONE AT KANSAS CITY.

Axophyllum rude
Lophophyllum distortum
Lophophyllum profumdum
Campophyllum torquium
Hydreionocrinus mucrospinus
Echinocrinus sp.
Fistulipora nodulifera
Stenopora sp.
Fenestella Kansasensis.
Fenestella perelegans
Polypora elliptica
Polypora triangularis
Septopora biserialis
Septopora interporata
Pinnatopora sp.
Rhombocladia delicata
Rhombopora lepidodendroides
Rhombopora sp.
Cystodictya inequimarginata
Derbya robusta
Derbya sp.
Meekella striaticostata
Rhipidomella pecosi
Chonetes verneuilianus
Productus cora
Productus costatus
Productus semireticulatus
Pustula nebraskensis
Pustula semipunctata
Pustula symmetrica
Marginifera splendens
Pugnax osagensis
Dielasma bovidens
Spirifer cameratus
Ambocœlia planiconvexa
Squamularia perplexa
Spiriferina kentuckyensis
Hustedia mormoni
Composita subtilita
Chænomya sp.
Pinna sp.
Aviculipecten interlineatus
Deltopecton occidentalis
Acanthopecten carboniferus
Platyceras parvum
Endolobus missouriensis
Ostracod sp.

The upper shale of the Chanute is notable particularly for the crinoids, but it contains many other species as shown in the following list:

FAUNA OF THE UPPER SHALE BED OF THE CHANUTE SHALE IN AND NEAR KANSAS CITY.

Lophophyllum profundum
Conularia crustula
Pachlyocrinus(?) sp.
Zeacrinus robustus
Hydreionocrinus crassidiscus
Hydreionocrinus granuliferus
Hydreionocrinus noduliferus
Hydreionocrinus pentagonus
Hydreionocrinus subsinuatus
Ulocrinus buttsi
Ulocrinus kansasensis
Eupachycrinus harei
Eupachycrinus magister
Eupachycrinus parvus
Eupachycrinus sphæralis
Graphiocrinus angulatus
Graphiocrinus harydactylis
Graphiocrinus basilicus
Graphiocrinus harei
Graphiocrinus lykinsi
Graphiocrinus magnificus
Delocrinus craigi
Delocrinus hemisphericus
Delocrinus missouriensis
Delocrinus noduliferus
Erisocrinus toddanus
Erisocrinus typus
Fistulipora nodulifera
Tabulipora ohioensis
(Stenopora) spinulosa
Polypora sp.
Septopora biserialis
Rhombopora lepidodendroides
Lingula umbonata
Lingulidiscina convexa
Derbya crassa
Rhipidomella pecosi
Chonetes verneuilianus
Productus costatus
Productus pertenuis
Pustula nebraskensis
Pustula symmetrica
Marginifera splendens
Dielasma bovidens
Spirifer cameratus
Squamularia perplexa

FAUNA OF THE UPPER SHALE BED OF THE CHANUTE SHALE IN AND NEAR KANSAS CITY—Continued.

Spiriferina kentuckyensis
Hustedia mormoni
Composita subtilita
Edmondia nebraskensis
Edmondia aspinwallensis
Nucula anodontoides(?)
Leda arata
Leda bellistriata
Yoldia cf. knoxensis
Yoldia sp.
Aviculipinna americana
Aviculipinna illinoisense
Pteria longa
Monopteria gibbosa
Monopteria sp.
Myalina kansasensis
Myalina swallowi
Myalina sp.
Schizodus cf. affinis
Schizodus harei
Schizodus wheeleri
Aviculipecten sp.
Deltopecten occidentalis
Entolium aviculatum(?)
Streblopteria tenuilineata
Lima retifer
Modiola subelliptica
Plagioglypta meekana
Bellerophon sp.
Patellostium montfortianum
Euphemus carbonarius
Bucanopsis meekana
Pharkidonotus percarinatus
Pharkidonotus percarinatus var. tricarinatus
Pleurotomaria carbonaria
Pleurotomaria(?) sp.
Murchisonia missouriensis
Phanerotrema grayvillense
Trepospira sphærulata
Sphærodoma primogenia
Orthoceras sp.
Pseudorthoceras knoxense
Metacoceras cornutum
Metacoceras cornutum var.
Tainoceras occidentalis
Nautiloid
Phillipsia major

IOLA LIMESTONE.

Name and definition.—The Iola limestone is the uppermost member of the Kansas City formation. It overlies the Chanute shale and corresponds to number 98 of Broadhead's section. Because of its wide use for crushed stone in Kansas City and Independence, it is locally known as the "Crusher ledge." The name Iola was applied to this limestone by Haworth and Kirk* in 1894 because of its extensive exposure at Iola, Kansas.

Distribution.—The Iola is the surface formation over a large part of the western half of the county. It caps the high divide south and southwest of Lees Summit, though in this area outcrops are rare. The long narrow divide between the Big and the Little Blue extending from the county line to three miles beyond Independence is also capped by this limestone. Outcrops are abundant along the Big Blue and along the Kansas state line, where it occurs on the tops of the hills. Small outliers are found bordering the Missouri in T. 50 N., R. 32 W. In Kansas City the Iola forms the picturesque escarpment along the crest of the North and West bluffs and is exposed at some of the higher points in the city.

Characteristics.—The Iola is the thickest limestone in the county, having a maximum of 43 feet; but, because it is commonly a surface member, the top portion has been removed by erosion in many places and only the middle and lower portions

*Haworth, E., and Kirk, M. Z., Kansas Univ. Quart., vol. 3, p. 109.

Iola limestone, Cliff Drive, North Terrace Park.

remain. Locally and at different horizons it contains a large amount of chert which is commonly strewn over the ground in the residium formed by the weathering of the limestone. The lowest four feet of the Iola is a hard, crystalline, fossiliferous, gray limestone split into beds by irregular bedding planes which contain some clay; the next 3 feet is soft, argillaceous, and shaly, and weathers to a light buff color; above this is 7 feet of hard limestone, similar to the lowest beds just described. The upper portion consists of crystalline gray limestone which splits into thin beds along irregular bedding planes. The soft layer, because of its similarity to shale, may be mistaken for the top of the Chanute. Upon weathering, the stone takes on a blotchy, yellowish color and tends to split along wavy lines. Chert in the form of small yellowish nodules is locally present near the top of the member in the southeastern part of the county. The upper two feet are thin-bedded and mottled in color, weathering to shaly nodules. A cliff outcrop of the Iola is shown in Plate XII.

Fauna.—The fauna of the Iola limestone is shown in the following table:

FAUNA OF THE IOLA LIMESTONE AT KANSAS CITY.

Sponge sp.
Axophyllum rude
Lophophyllum distortum
Lophophyllum profundum
Campophyllum torquium
Michelinia eugeneæ
Spirorbis carbonaria
Serpulopsis insita
Delocrinus craigi
Delocrinus hemisphericus
Echinocrinus triserrata(?)
Fistulipora nodulifera
(Stenopora) carbonaria
Chainodictyon laxum
Fenestalla kansasensis
Fenestella limbata
Fenestella ovatipora
Productus pertenuis
Productus semireticulatus
Pustula nebraskensis
Pustula semipunctata
Marginifera splendens
Marginifera wabashensis
Pugnax osagensis
Dielasma bovidens
Spirifer cameratus
Ambocœlia planiconvexa
Squamularia perplexa
Spiriferina kentuckyensis
Hustedia mormoni
Cliothyridina orbicularis
Composita subtilita
Sanguinolites costatus
Solenomya sp.
Fenestella perelegans
Fenestella remota
Polypora elliptica
Polypora flexuosa
Polypora submarginata
Polypora triangularis
Thamniscus tenuiramus
Septopora biserialis
Septopora interporata
Pinnatopora pyriformipora
Pinnatopra trilineata
Pinnatopora whitei
Rhombocladia delicata
Rhombopora lepidodendroides
Rhabdomeson americanum
Streblotrypa striatopora
Cystidictya divisa
Cystidictya inequimarginata
Lingulidiscina convexa
Lingulidiscina missouriensis
Crania modesta
Rhipidomella pecosi
Derbya bennetti(?)
Derbya broadheadi
Derbya keokuk(?)
Derbya sp.
Meekella striaticostata
Chonetes verneuilianus
Productus americanus
Productus cora
Productus costatus
Edmondia sp.
Leda bellistriata
Parallelodon sp.

FAUNA OF THE IOLA LIMESTONE AT KANSAS CITY—Continued.

Pinna sp.
Conocardium parrishi(?)
Pteria sulcata
Myalina kansasensis
(Aviculipecten) interlineatus
Pernipecten aviculatus(?)
Deltopecten mccoyi
Deltopecten occidentalis
Acanthopecten carboniferus
Lima retifera
Allerisma granosum
Allerisma terminale
Cypricardinia carbonaria(?)
Patellostium montfortianum
Bucanopsis meekana
Gastropod sp.
Platyceras parvum
Orthoceras sp.
Nautiloid sp.
Ostracods several sp.
Cyclus communis
Cyclus packardi
Cyclus permarginatus
Cyclus limbatus
Cyclus minutus
Phillipsia major
Phillipsia sp.

LANSING FORMATION.

Name and definition.—The Lansing formation consists of four members which, in descending order, are Stanton limestone, Vilas shale, Plattsburg limestone, Lane shale. The name is derived from Lansing, Kansas, and together with the Kansas City, it comprises the Pottawatomie formation as described by the Kansas Geological Survey. Of the four members, only the Lane shale and the lower portion of the Plattsburg are represented in Jackson county.

Distribution.—As is shown on the accompanying map, the Lansing underlies six irregular areas in Kansas City. To a large extent it is covered with loess or other surficial deposits; in fact, due to the absence of outcrops, the southernmost area in the southwestern corner of the city is located on topographic relations only. Although not so shown on the map, it is possible that the lower members of the Lansing also underlie the divide between the Big and the Little Blue in the vicinity of Grandview.

Characteristics.—In contrast with the underlying Kansas City formation, which is largely limestone, the Lansing as exposed in Jackson county is chiefly shale and sandstone, with a minor amount of limestone. The section is poorly exposed, but, generalized, it is essentially as follows:

GENERALIZED SECTION OF LANSING FORMATION IN JACKSON COUNTY.

Stratum.	Thickness.	
	Ft.	*in.*
Plattsburg limestone:		
Limestone, with shale partings	7	—
Lane shale:		
Shale, sandy, and argillaceous limestone	3	9
Shale, sandy	3	—
Shale, and sandstone (thin beds)	24	—
Limestone, conglomeratic	1	8
Shale, sandy	20	—
Limestone	2	—
Shale and sandstone	70	5

LANE SHALE.

Name and definition.—The Lane shale overlies the Iola limestone and contains a limestone lentil known as the Farley limestone, the whole member embracing Broadhead's numbers 99 to 107. Haworth[1] gives this name to the shale because of its exposure at Lane, Kansas, while the Farley lentil is named from Farley, Mo.

Distribution.—The distribution of the Lane shale coincides with that of the Lansing formation which has already been discussed. The maximum thickness is about 65 feet.

Characteristics.—The following section indicates the general nature of the strata comprising the Lane shale. Variations are common and except in the limestones the material differs in various parts of the areas where outcrops are to be seen.

SECTION OF THE LANE SHALE IN PENN VALLEY PARK, KANSAS CITY.

Stratum.	Thickness	
	Ft.	*in.*
Limestone, gray, argillaceous, composed of fossils and fossil fragments, 3 in. to..	—	6
Shale, gray, calcareous and arenaceous	1	—
Shale, greenish, soft	—	3
Limestone, buff to gray, cellular, argillaceous	2	—
Shale, dark-gray to greenish, clayey at top and bottom, sandy in middle	3	—
Shale, and sandstone. At base, gray, sandy, shale, grading through shaly sandstone to massive sandstone at top. Sandstone, gray to yellow, micaceous.	24	—
Limestone (upper bench of Farley), dark-gray, hard, oolitic conglomerate, crystalline and arenaceous. The oolites are oval or flattened. Large areas of the surface are colored brown by limonite and on the interior it occurs in specks and small irregular bodies	8	—
Shale, gray, arenaceous, partly covered	20	—
Limestone (lower bench of Farley), brownish-gray, composed of large fossils in a matrix of fossil fragments	1	9
Shale, gray, clayey	8	6
	62	8

On the North Bluff near Prospect street there are present the lower 12 feet of the Lane. At the base is gray, sandy, micaceous shale, and brown, micaceous, medium coarse to fine-grained sandstone. The sandstone contains fragments of shale and casts of stems and leaves of plants. An uncommon phenomenon of weathering may be seen at this place, the sandstone just mentioned being closely downfolded into a solution crevice in the underlying Iola limestone.

[1]Haworth, E., and Kirk, M. Z., The Neosho River section; Kansas Univ. Quart., vol. 2, p. 109, 1894.

In the same vicinity the lower bench of the Farley is 3 feet thick and 12 feet above the Iola. Near the east end of the Twelfth street viaduct this bed is 1½ feet thick and only 7 feet above the Iola. In both localities the underlying shale is sandy.

North of Jackson in Clay and Platte counties the lower shale bed of the Lane increases to as much as 30 feet, with a compensating decrease in the thickness of the shale between the two limestone beds, allowing the latter to become in many places practically one bed of two or more layers. Of the Lane shale above the upper limestone, there is but one small area of outcrop, from which a section has already been given.

Fauna.—Girty reports *Pseodomonotis hawni* and *Myalina kansasensia* from the Farley limestone bed in Penn Valley Park.

PLATTSBURG LIMESTONE.

Name and definition.—The highest member of the Pennsylvanian series in Jackson county was named from outcrops at Plattsburg, Clinton county, Mo., in 1862. Subsequently, a number of names were proposed from Kansas localities with the result that the Missouri name was lost sight of for the time being. The names Garnett, Carlyle, Pequia, and Allen have been used at different times, but it has since been demonstrated that the name Plattsburg has priority.

Distribution.—The only localities where the Plattsburg is known to outcrop are at Main and Thirtieth streets, Wyandotte and Thirtieth streets, and Baltimore and Thirty-first streets. In addition to these outcrops, blocks of the Plattsburg limestone were noted on the slope of North Terrace Park, where they have fallen from their true position above. The Plattsburg also probably underlies parts of the Roanoke area.

Characteristics.—The normal thickness of the Plattsburg limestone in the counties adjoining Jackson on the north, is about 18 feet, which was probably the original thickness in Jackson county, as the member is known to be rather uniform. However, weathering has removed the upper part in the Kansas City area, leaving only the lower 6 or 7 feet.

Not much can be said of the characteristics of the Plattsburg in this area because of the scarcity of outcrops. The two sections given below show that it is irregular, seamed with clay partings, and quite variable in texture.

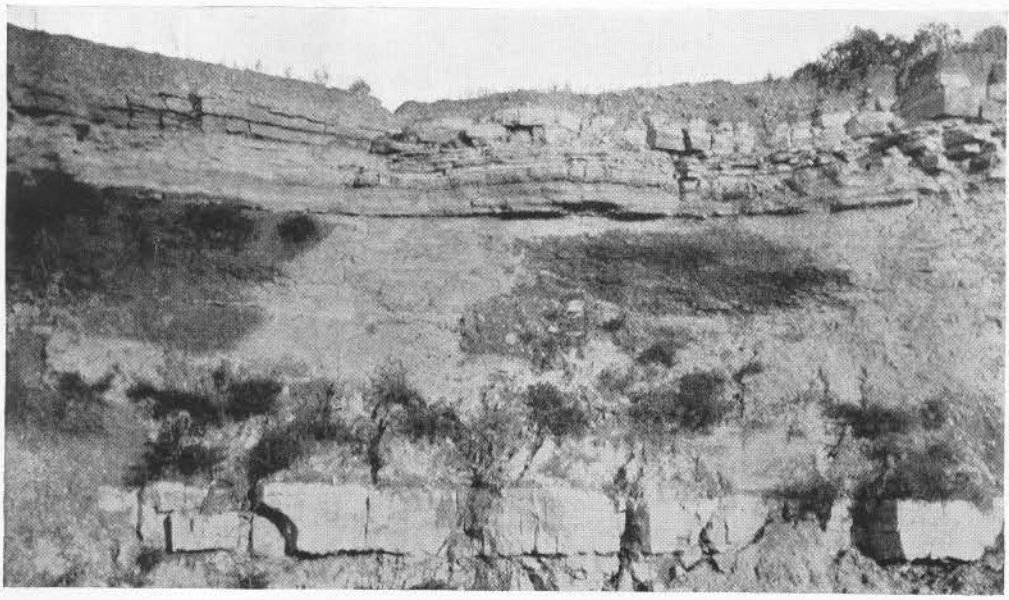


Fig. 1. Chanute shale, upper part.

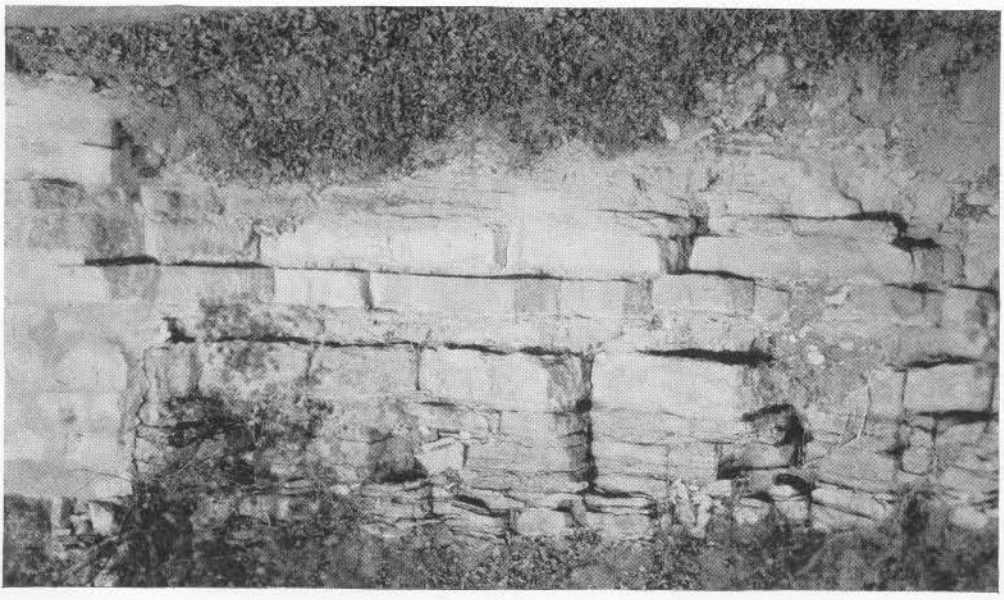


Fig. 2. Plattsburg limestone, 30th and Wyandotte.

SECTION OF PLATTSBURG LIMESTONE AT MAIN AND THIRTIETH STREETS.

Stratum.	Thickness.
	Ft. in.
Soil	13 —
Chert fragments	— 3-5
Limestone, yellow, soft	2 —
Limestone, hard	— 10
Shale	— 6
Limestone, yellow, soft	— 6
Limestone, gray, hard	— 9
Shale	— 3
Limestone, gray, hard, oolitic	— 10
Limestone, nodular, and shale	3+—

SECTION OF PLATTSBURG LIMESTONE AT BALTIMORE AND THIRTY-FIRST STREETS.

Stratum.	Thickness
	Ft. in.
Limestone, yellow Limestone, gray, hard Shale Limestone, yellow, thinly bedded	3 —
Limestone, blue, fine-grained	— 9
Shale	— 4
Limestone, oolitic and fossiliferous	1 —
Limestone, nodular	3 —
Shale, sandy	2 6

Fauna.—The following fossils were collected by F. C. Greene at Thirty-first and Main streets:

FAUNA OF THE PLATTSBURG LIMESTONE AT KANSAS CITY.

Batostomella greeniana
Batostomella greeniana var. regularis
Septopora biserialis
Derbya crassa
Spiriferina kentuckyensis
Hustedia mormoni
Composita subtilita

QUATERNARY SYSTEM.

The consolidated rocks of Jackson county are to a large extent overlain by much younger unconsolidated materials. These deposits consist of glacial drift and loess of the Pleistocene, and alluvium and terrace deposits of Recent age.

PLEISTOCENE SERIES.

During Pleistocene time the northern portion of the United States, including part of Missouri, was invaded by several successive ice sheets, some of which reached the Missouri river and in places slightly beyond. During the movement the ice scraped

from the surface loose gravel and earth, ultimately depositing it in an unassorted mass, termed drift or till. The drift of Jackson county is believed to present one glacial invasion, known as the Kansan. A preglacial stage is indicated by a rounded boulder bed in the western part of Kansas City. A later stage of the Pleistocene is shown by the occurrence of loess chiefly along the Missouri river where it overlies the drift.

PRE-GLACIAL BOULDER BED.

This deposit has been termed pre-glacial, since it underlies the drift in the neighboring counties, Clay and Platte.

The deposit flanks the east side of the hill known as Graystone Heights between Turkey creek and Kansas River. The base has an elevation of about 800 feet above sea level and rests on the Winterset, although to the west it rests on higher ledges. Test borings show a maximum thickness of 31 feet, although the vertical distance between the base and the highest outcrop is approximately 75 feet.

In Clay and Platte counties a pre-glacial valley stretching from Weston to east of Smithville contains a deposit similar to that on Graystone Heights, but the more complete exposures in the counties mentioned show it to grade upward through gravel and coarse sand to very fine sand. There, as in Jackson county, it rests on Pennsylvanian strata, and in addition is overlain unconformably by typical glacial boulder clay.

The pre-glacial deposits consist chiefly of boulders of local limestone with a minor amount of sand and gravel in thin, irregularly distributed beds. There are a few small rounded boulders of granite, quartzite, and other foreign rocks, together with masses of shale which can be assigned to their exact horizon in the Kansas City section. The limestone boulders range in size up to 5 or 6 feet in diameter and in shape from sub-angular to rounded, practically all the smaller sizes being rounded. (See Plate XIV.) The deposit is not stratified except in the case of the small sand and gravel beds, but it presents ample evidence of having been worked over by water; and, as already mentioned, similar material in Clay and Platte counties exhibits a decrease in coarseness from bottom to top, where the underlying rock has been exposed.

DRIFT.

Drift outcrops along the river bluff in the northern part of Kansas City and in the region between Buckner and Sibley.

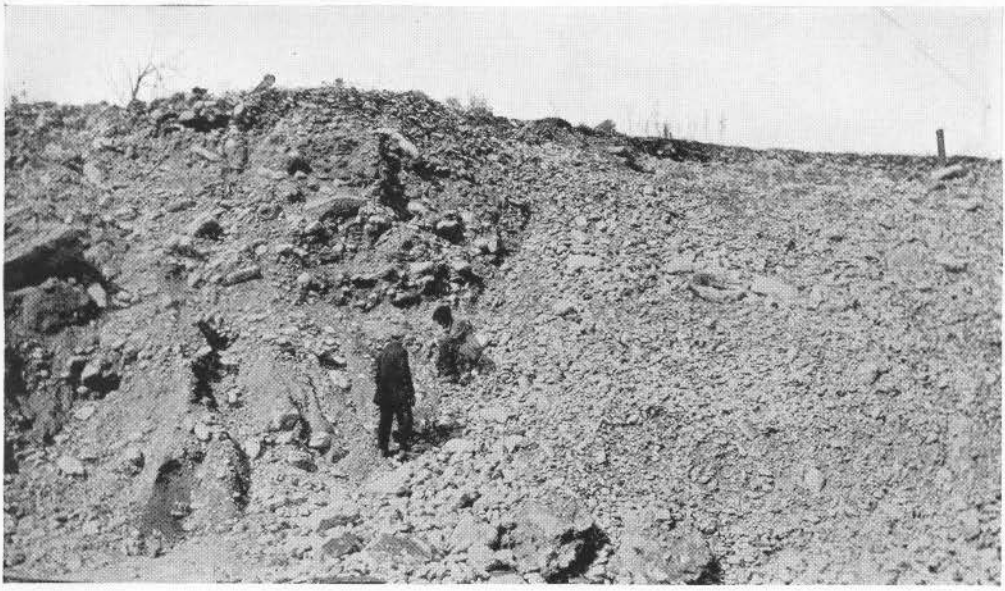


Fig. 1. Boulder bed, Graystone Heights.

 Fig. 2. Drift overlying the Winterset limestone, north bluff at Lydia street.

At the foot of Lydia street in Kansas City, it has an apparent thickness of 50 feet and probably in the Buckner-Sibley area it is even thicker.

The chief deposits are found north of the old abandoned valleys (described under physiography); in fact, no drift has been found on the divide between Big and Little Blue rivers or south of these abandoned valleys. It is possible, therefore, that the ice sheet pushed across the Missouri valley at the two areas mentioned, and in doing so forced drainage along the routes of the valleys which were later abandoned.

The drift consists chiefly of boulder clay; that is, clay which contains much sand, gravel and boulders. When dry it is gray in color except along the many irregular joints, where it has weathered to brown through oxidation of the iron. When damp, as it often is in natural exposure, it is a dark bluish-gray to nearly black. Pebbles and boulders of both northern and local rocks, though abundant, form a very minor proportion of the mass. At the foot of Lydia street the drift contains a small bed of coarse yellow sand lens-shaped in cross-section, while higher in the bluff is a deposit of nonstratified sand and boulder clay. In the sand are pockets of clay, pebbles and boulders.

Todd[1] records glacial striae in two places in and near Kansas City.

"Near Harlem, opposite Kansas City, a fine example of scored surface exists on a ledge about 130 feet above the level of the river; some of the striations have directions south 7, 19 and 24 degrees west, while others, very clearly shown, are south 51 degrees east. These cover the upper side of the limestone in a quarry which was opened to obtain material for protecting the railroad from the encroachment of the Missouri river nearby. In the eastern part of Kansas City, a little west of the corner of Ferrier avenue and Fourth street, glacial scratches on the rocks were found about one hundred feet above the river running south and south 6 degrees east."

Although no evidence of a Pleistocene mammalian fauna was found during the field work several occurrences have been reported. According to Hare[2] there have been discovered, *Mastodon giganteus* (Mammut americanum), represented by teeth and fragments of bones; ruminants, represented by molars; and

[1]Todd, J. E., Formation of the Quarternary deposits; Missouri Geol. Survey, vol. 10, p. 121, 1896.

[2]Hare, S. J., A list of Kansas City fossils, 4 sheets, no date.

small rodents, represented by incisors. Mr. Hare also states that two mastodon teeth and the bones of an elk, bear and other species were found near the intersection of Fourth and Lydia streets. West[1] reports the discovery of a mastodon tusk on Campbell street 150 feet north of Independence avenue in one foot of "sandy clay," with pebbles and boulders of granite, greenstone, quartzite, kidney ore, quartz, etc., and states that "Several feet of obscurely stratified drift sand, with pebbles and boulders are found in the gully below this." Ballard[2] mentions the finding of a mastodon tusk and bones in an old lick 20 miles east of Kansas City. Todd[3] found a bison tooth incrusted with a calcareous material in the intermixed loess and till at the foot of Lydia street.

LOESS.

The yellowish to brownish, fine-grained silt or loam found in the United States, chiefly bordering the valleys of the Missouri and Mississippi rivers, has been designated as loess. It is younger than the drift upon which it rests, but is considered of Pleistocene age.

In Jackson county it forms a heavy covering over most of the northern edge and occupies a belt north of a line extending from the southern city limits of Kansas City, eastward to the Little Blue, then northeast to Adams, and from there east to Lake City and the county line. The southern limit is very difficult to determine because of the admixture of the loess with the covering of residual soil which at places has practically the same appearance. In this belt the greater thickness occurs along the bluffs of Missouri river where in places it is over a hundred feet from the base to the top of the deposit. Observations made largely from artificial excavations in Kansas City show the loess to average about 16 feet thick to a distance of three miles from the river, dropping to practically nothing in the next two miles.

Along the bluffs the loess is a light yellowish-brown, very fine-grained silt, becoming to the south darker and clayey. Aside from concretions and fossils it is remarkably uniform in texture.

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[1]West, H. H., Report of discovery of mastodon tusk; Kansas City (Western) Review of Science and Industry, vol. 1, pp. 336-7, Aug., 1877.

[2]Ballard, F. A., Mastodon remains found in Jackson County, Mo.; Kansas City, Rev. Sci. and Ind., vol. 3, pp. 643-644, 1880.

[3]Todd, J. E., Formations of the Quaternary deposits: Missouri Geol. Survey, vol. 10, p. 135.

Chamberlain and Salisbury,[1] who have studied the typical bluff loess at type points, give the following statement concerning the size and composition of the materials composing it: "Of 87,-135 particles from Kansas City, about 4 per cent measured over .0025 mm., and a little more than one per cent above .005 mm. They range up to .1 mm., and particles above .05 are not rare." They give the following chemical analysis:

ANALYSIS OF LOESS FROM KANSAS CITY.

Analyst, R. B. Riggs, U. S. Geol. Survey laboratory.

	Per cent.
Silica (SiO_2)	74.46
Alumina (Al_2O_3)	12.26
Iron (Ferric) (Fe_2O_3)	3.25
Iron (Ferrous) (FeO)	.12
Titanium (TiO_2)	.14
Phosphorus (P_2O_5)	.09
Manganese (MnO)	.02
Lime (CaO)	.69
Magnesia (MgO)	1.12
Soda (Na_2O)	1.43
Potash (K_2O)	1.83
Water (H_2O)	2.70*a*
Carbon dioxide (CO_2)	.49
Carbon (C) Organic	.12
Sulphur trioxide (SO_3)	.06
Chlorine (Cl)	.05
Total	99.83

a Contains H of organic matter. Dried at 100° C.

There have been detected, besides the preponderating quartz, particles of orthoclase and plagioclase feldspar, biotite and muscovite micas, hornblende, augite, magnetite, dolomite, and calcite. It will be noted that the minerals listed above are common constituents of the rocks occurring in the glacial drifts.

Away from the river the loess becomes darker and finer probably because it has been mixed with residual clay. The United States Bureau of Soils gives the following mechanical analysis of the Marshall silt loam, the soil and subsoil derived from this phase of the loess:[2]

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[1]Chamberlain, T. C., and Salisbury, R. D., Preliminary paper on the driftless area of the upper Mississippi Valley; U. S. Geol. Survey, Sixth Ann. Rept., pp. 279-282, 1885.

[2]Sweet, A. T., Krusekopf, H., and Dunn, J. E., Soil Survey of Jackson County, Missouri; Advance Field Operations Sheets of the Bureau of Soils, 1910, p. 33, 1912.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
23680, 24327	Soil	0.0	0.1	0.2	0.4	2.5	73.4	23.3
23681, 24328	Subsoil	.0	.1	.2	.4	2.9	69.1	27.3

Concretions of calcium carbonate and clay are common in the bluff loess, ranging in size up to several inches in diameter and in shape from spherical and irregularly rounded to spindle and dumb-bell-like forms. The surface is usually gray, while the interior is gray or light brown and contains small quartz pebbles and specks of mica and other material. The smaller concretions are solid but by far the most of them are hollow, a feature which appears to have been caused by the wedging apart of a number of radiating cracks.

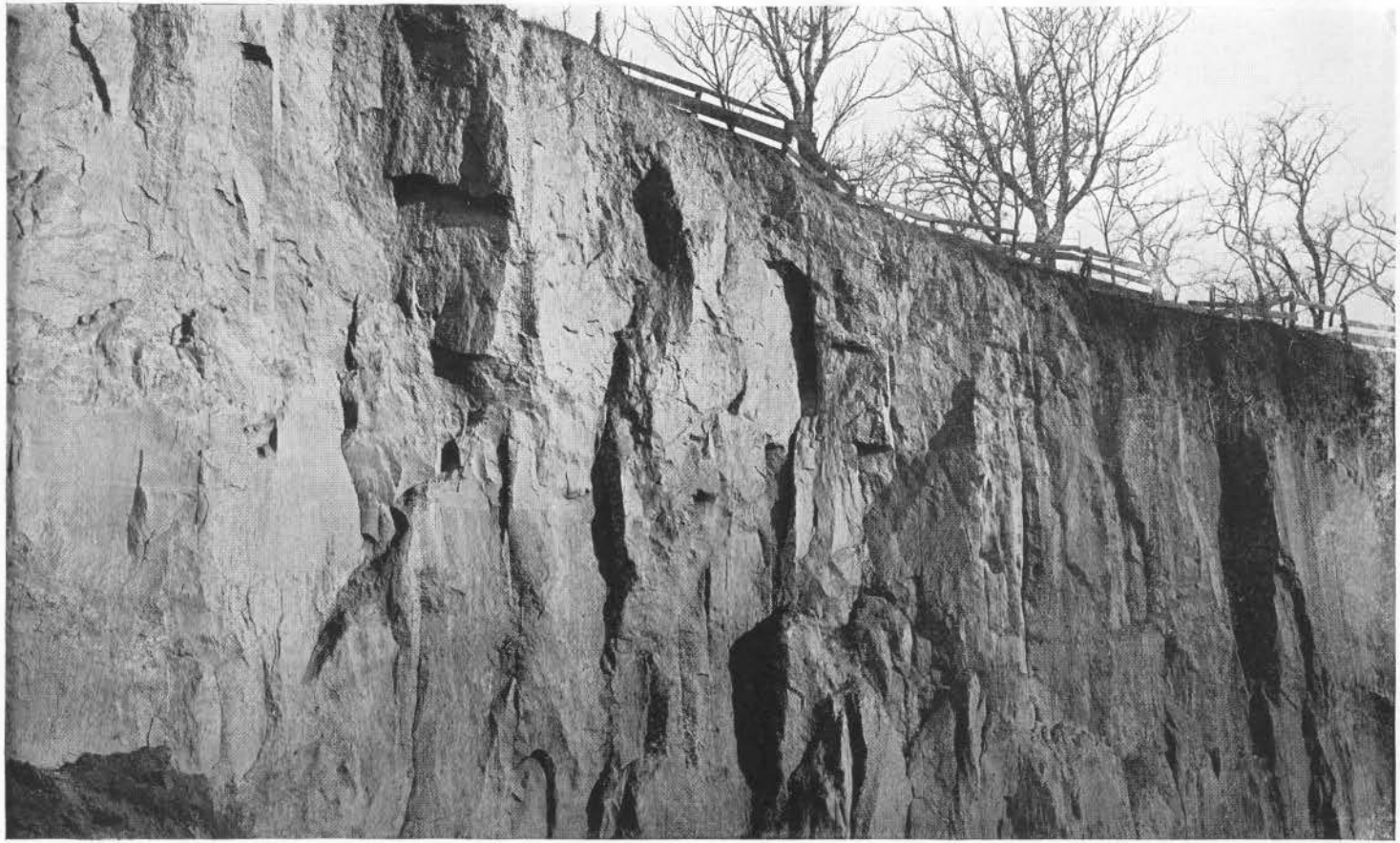
The loess along the bluffs also contains many gastropod (snail) shells, among which Dr. W. H. Dall of the United States National Museum identified the following terrestrial species in collections made in Kansas City and at Weston a few miles northwest in Platte county, Missouri:

	Kansas City.	Weston.
Pyramidula alternata Say	×	×
Pyramidula cronkihitei anthonyi Pils	×	×
Succinea avara Say (?)	×	—
Succinea lineata W. G. B	—	×
Halicina occulta Say (?)	×	×
Zonitoides arboreus Say	×	×
Polygyra thyroides bucculenta Gld	×	—
Cochlicopa lubrica Mull	×	—
Pupoides procera Gld	—	×
Bifiſaria armifera Say	—	×

RECENT DEPOSITS.

As is shown on the accompanying geological maps, the alluvial or recent deposits occupy the valleys of the principal streams. They consist chiefly of clay, sand, gravel and boulders, largely unassorted. "Gumbo" or black clay occurs locally, and in the northern part of the county there is considerable reworked loess that may be classified as alluvium.

In general, the thickness of the deposits increases with the width of the flood plain. In the valley of the Missouri the alluvium is nearly 100 feet thick. A well sunk in the abandoned



Characteristic bluff exposure of loess.

valley now occupied by Fire Prairie creek, NW. ¼ NE. ¼ sec. 29, T. 50 N., R. 30 W., passed through 71 feet of alluvium.

While the alluvium of the tributary streams is composed of weathered materials derived from the local formations, that of the Missouri is derived largely from beyond the limits of Jackson county and contains, especially, fragments of lignite which do not occur in the local stream beds.

Valleys in the northern part of Jackson county contain deposits of loess-like material, which, though possibly in part original, is believed to be largely derived from the loess on the surrounding hills and slopes. As the streams in many cases have had access to but little material except loess, it is difficult, consequently, to determine in some cases whether the deposit is original or secondary.

The Big Blue, Little Blue, Sniabar and Fire Prairie flood plains contain deposits locally known as "gumbo," and mapped by the United States Bureau of Soils as "Wabash Clay"[1]. The description is as follows: "The Wabash clay is typically developed over only a part of its area in Jackson county. A light phase of the soil occurs and the area of the phase is greater than that of the typical soil, the respective measurements being 5,760 and 4,922 acres. The typical soil is a dark bluish-gray or black clay of uniform color and texture to a depth of 15 to 18 inches, where it grades into a gray clay slightly lighter in texture reaching to a depth of three feet or more. This soil is very heavy and sticky and difficult to cultivate when wet. When dry, it cracks badly, the fissures often extending to the subsoil.

The Wabash clay is found in the low poorly-drained portions of the valleys and has been formed by depositions from overflow and backwater, the currents of which would carry only the finer silt and clay soil particles. Standing water has also helped in breaking down the soil into still finer particles."

In the original state (in which much of it still remains) the gumbo was covered with a growth of wild prairie grass.

In the abandoned valley near Lake City and Buckner are a number of small mounds or ridges with their long axes parallel to that of the valley. They rise to a maximum of 25 to 30 feet above the level of the bottom.

The material forming these ridges is chiefly sand and a clay-like deposit that resembles loess but which is coarser. The latter may be reworked loess; at least some of the sand has

[1]Sweet, A. T., Krusekopf, H., and Dunn, J. E., Soil Survey of Jackson, pp. 26-27.

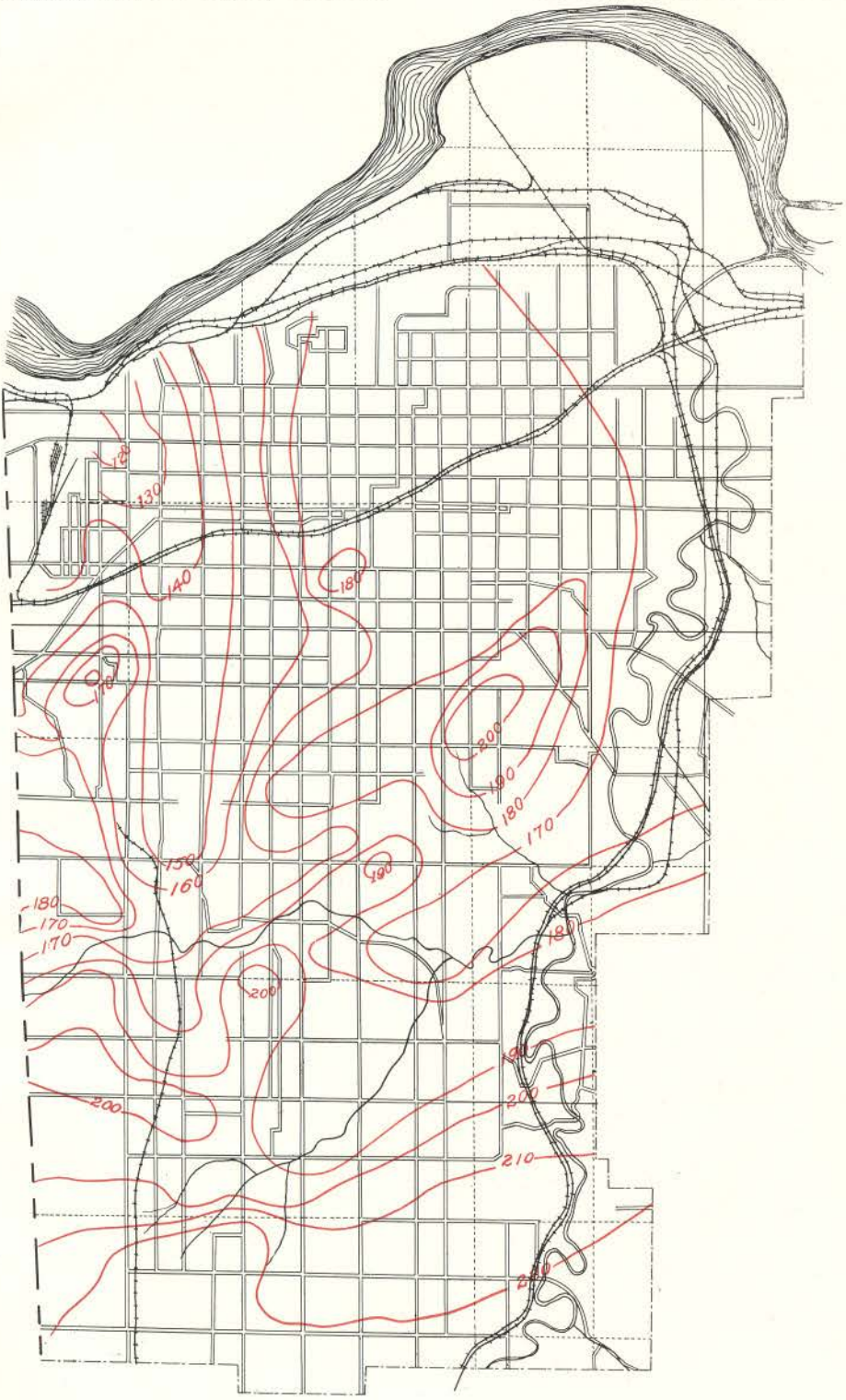
accumulated or has been assorted by wind action. It is very fine-grained, light brown, and is chiefly composed of both angular and rounded grains of transparent but iron-stained quartz. The abundance of magnetite and the presence of other minerals indicate some source of the sand other than that of the region tributary to the Little Blue. It is possible that these mounds may be remnants of an old terrace.

STRUCTURE.

The rocks of Jackson county, in common with those of other counties northwest of the Ozark uplift, dip to the northwest. The dip is approximately N. 60° W., but the degree of dip is so low that in most of the county the rocks appear to be level so far as the eye can discover. It is only when comparative elevations on a given stratum are used that the dip can be detected. The Bethany Falls limestone dips from an elevation of about 1,000 feet above sea level near Lonejack to 740 feet at the Hannibal bridge at Kansas City, 260 feet in 29 miles, or less than 10 feet per mile. On the mound near the northeast corner of the county, the same bed is at an elevation of about 900 feet, dipping 160 feet to the Hannibal bridge in 27 miles or less than 6 feet per mile. From Martin City the dip to the same point is 100 feet in 16 miles, about 6 feet per mile.

It is probable that this general dip is modified by low anticlines, synclines and domes, but the lack of an accurate topographic base prevented a detailed study of the structure outside of Kansas City. There are, however, no apparent structures such as would indicate pronounced folding.

While the general dip is so low as to cause the rocks to appear level, there are a few places where the rocks dip quite steeply and are faulted. The most notable is 2½ miles west of Lees Summit, near the point where the creek at that place crosses the line between secs. 2 and 11, T. 47 N., R. 32 W. In the creek bed south of this point the Hertha is sharply folded and fractured, the axes of the folds striking N. 25° W. (magnetic), the fractures containing veins of calcite. On the west side of the creek the Hertha and Pleasanton are faulted at four places within a few feet. A short distance north along the Rock Island railroad, the Bethany Falls and Winterset limestones are faulted, the throw being 7 feet. The fault strikes N. 23° W. (magnetic) and the fault dips 47° S. 67° W. (magnetic).



Structure sheet, Kansas City; structure based on elevations of Raytown limestone.

In Kansas City where precise elevations, established by the city engineering department, are available, the details of structure have been determined with a fair degree of accuracy. This has been done by means of "structure contours." An easily recognized stratum, in this case the top of the Raytown (Calico) limestone, was selected and the elevation of this datum plotted on a map of the city. The elevation used is, in most cases, that of an outcrop, but where the stratum does not outcrop, the elevation has been computed from other beds whose relations to the selected stratum are known. The elevations were plotted, after which lines were drawn through points of equal elevation, as shown on Plate XVI. This map has no connection whatever with the surface relief, but represents the hypothetical surface of the Raytown limestone, restored where the bed has been removed by erosion, and laid bare where the bed is now covered by overlying members.

Structure contours serve two purposes, that of showing the structure and that of furnishing a means of estimating the depth to any stratum where its relation to the key stratum is known and where the surface elevation is known.

Whether the structure of some stratum which is 200 or 300 feet lower, stratigraphically, than the Raytown is the same as the Raytown, is a question that cannot be answered definitely. It is probable, however, that the main structural features of the lower beds are the same but that they become less accentuated with increasing depth; in other words, the Bethany Falls limestone, for example, may be expected to be arched where the Raytown is arched, but the degree of arching is probably less.

The structure based on the Raytown limestone is shown in Plate XVI. From the southern part of the city to the northwest corner the general dip is 100 feet. A syncline crosses the western part of the city from the northwest corner, being rather sharply defined at the north but gradually dying out at the south. The greatest deformation is 50 feet and the width varies from one to two miles. Nearly at right angles is a series of minor folds with rarely a deformation of more than 35 feet and with a general strike of N. 70° E. This superimposition has resulted in dome-like structures where anticlinal axes cross, in the widening of the main synclinal trough where crossed by synclines, and in narrowing, where crossed by the minor anticlines. The small domes formed by this structural feature would probably prove the most favorable points to drill for oil or gas.

GEOLOGIC HISTORY.

PRE-PENNSYLVANIAN TIME.

The surface formations in Jackson county represent but a relatively short part of the entire geologic history of the region. They record the constructive and destructive processes active during the periods of their deposition, but they deeply cover the formations which contain the records of all the preceding history. For this reason, the long series of events leading up to the Pennsylvanian time must be interpreted from scant information furnished by a few deep borings and from distant outcrops of the covered formations which appear at the surface in the Ozark region. These rocks no doubt were deposited under the same general conditions as were those deeply buried formations penetrated in the Raytown boring in which the underlying granite floor was reached at a depth of 2,348 feet.

The granite, which is the oldest rock of the Ozark region, composed the first land surface, of which we have definite knowledge, over the area. The granite remained above sea level for an era of immense duration, during which it suffered weathering and erosion, thus forming the source of material for the first sediments to be laid down above it. The topography of the granite surface was of extreme irregularity, even mountainous in places, and the first encroaching sea probably covered only the valleys and lower elevations.

From the time of the first invading sea in the middle Cambrian epoch, through the remainder of the Cambrian and well into the Ordovician period, conditions were changed from essentially those of weathering and erosion to those of sedimentation. The earliest sea varied greatly in depth because of the irregularity of the floor, and there is little doubt that many of the granite peaks remained as Islands high above the water. The coarse, poorly assorted sandstone found resting on the granite in the Raytown boring was laid down in this sea, and the succeeding thick magnesian limestones with three important sandstones, were deposited under similar conditions, although at times the area was warped above the water for short periods. About 900 feet of these sediments lie deeply buried beneath the surface of Jackson county.

The Cambrian period ended with the region well above sea level and with the limestone surface carved by erosion into

hills and valleys. Consequently, when the land subsided again during the following Ordovician period, the St. Peter sandstone was laid down upon an uneven floor. This sandstone, originally deposited over a considerable part of the Ozark region, was subsequently eroded from nearly all but the eastern, northern and northwestern slopes. It apparently has been removed from the western slopes but underlies Jackson county probably as a persistent layer. During Ordovician times, later than the St. Peter epoch, the advancing and receding seas deposited several thick limestones capped by a shale bed. These beds were removed over the higher part of the region prior to the removal of the St. Peter sandstone, and now underlie even less of its area than does the sandstone. The Raytown boring shows less than 70 feet of limestone that can be credited, and then only doubtfully, to Ordovician deposition.

To what extent erosion has destroyed the record of sedimentation during the following Silurian and Devonian periods cannot be definitely told. To the north at Forest City, a deep boring reveals several hundred feet of Devonian, and still farther north at Nebraska City, over 1,300 feet have been similarly recorded. No Silurian, and but few exposures of Devonian limestone and shale occur on the northwest slope of the Ozarks, while in the Raytown boring less than 100 feet of sediment at most can be related to either of these periods. It seems probable, therefore, that the area now occupied by Jackson county was a land surface subject to erosion during the greater part of these two periods.

Following Devonian times, the Mississippian period was introduced by a land submergence of such considerable extent and widespread occurrence that practically all but the higher peaks of the Ozark region were inundated. During the gradual advance of the sea, mud and sand from the highlands were washed into the shallow waters, giving rise to the extensive initial shale deposits of the Mississippian period. Later, the seas supported an abundance of marine life, became clearer, and in them were deposited the thick, cherty, fossiliferous limestones which still uphold the border plain of the Ozark region. The crystalline, crinoidal limestones of these seas have been penetrated by several deep borings in Jackson county, and their thickness and cherty character, in contrast to the shales and sandstones of the Pennsylvanian deposits resting upon them, mark their identity. The Mississippian period was not one of

continued submergence, however, for during the latter part of it the region was again elevated to a land surface and the processes of erosion succeeded those of deposition. The duration of the interval before another submergence was of such extent that well-developed drainage systems were established in the region. The pure limestones succumbed readily to solution, with the result that large sink-holes were formed in great numbers and the less soluble cherts were left strewn as a mantle over the surface. Such conditions characterized the Mississippian surface over Jackson county.

PENNSYLVANIAN EPOCH.

Pennsylvanian time was one of ever-changing conditions, as is evidenced by the great number of shale, sandstone and relatively thin limestone beds interlayered at a number of horizons with coal seams. It was essentially a period of shallow seas that advanced and withdrew with slight oscillations of the land surface which rested at intervals so near water level as to produce great swamp-like areas. The climate was tropical and humid and supported a luxuriant growth of vegetation which thrived in greatest profusion under the ideal conditions offered during the marshy intervals. At these times occurred the considerable accumulations of vegetable matter which was protected by water from ordinary decay, and which was later buried by sand and clay. Through a long gradual change this material formed the coal beds occurring at various horizons in the Pennsylvanian. Aside from the coal beds, plant remains are commonly found at many horizons in the shales and sandstones.

During the late Mississippian and the early Pennsylvanian erosion interval, the first Pennsylvanian sea was advancing from the southwest and finally covered Jackson county and the surrounding region. With the advent of this sea began the deposition of the Cherokee sediments. The larger part of the sedimentation of this epoch was characterized by the great inwash of sand and mud from the adjacent land areas, and from these materials the first several hundred feet of Pennsylvanian strata were largely built. A few times during this epoch life flourished in the sea sufficiently to offer the calcareous material for thin limestone beds; but as these beds constitute but a small part of the Cherokee sediments they represent the exceptional conditions of the epoch.

That the surface rose and fell many times and that at intervals it stood close to sea level, thus producing immense swampy tracts, is evidenced by the coal beds formed. At least five intervals of widespread swamp conditions prevailed during which the vegetation, later converted into the Lexington, Summit, Mulky, Bevier and other lower coal seams, accumulated. Such conditions constitute one of the most fortunate phases of Cherokee history, as they gave us practically all of the workable coal beds in the state.

At the end of Cherokee time conditions changed, limestone sedimentation becoming dominant over that of shale. During Henrietta time the influx of mud and sand diminished at intervals for long stages during which the seas cleared and life in them became abundant. Corals flourished and some of the limestones of this division are veritable coral reefs composed largely of the species *Chaetetes milleporaceus*. Crustal movement, however, which elevated the land areas from time to time, caused fresh influxes of sand and mud, thus changing the prevailingly clear Henrietta seas to clouded muddy waters and offering the requisite conditions for the deposition of the lesser amount of shale composing the formation.

In the succeeding Pleasanton, mud and sand again became the main types of deposit. Neither plant nor animal life was able to establish itself for the time necessary to produce notable deposits of carbonaceous or calcareous materials. The shallow seas were almost continually muddy, and the adjacent land areas probably stood higher than in the preceding epoch. Toward the end of the Pleasanton time, crustal elevation which raised an extensive surface above the water is believed to have occurred. On this new surface drainage systems established themselves, the large streams cutting deeply into the formation. These stream-cut channels were soon filled, chiefly with sand which later hardened to sandstones now recognized by their character and by the discontinuity of the bordering strata. The Warrensburg sandstone channel to the east of Jackson county appears to represent the master stream of a large area during the time described, and the peculiar sandstone outcropping near Oak Grove probably owes its origin to the filling of a tributary valley.

Pleasanton time was brought to a close by the inauguration of conditions very similar to those that prevailed during the deposition of the Henrietta beds. During the following Kansas

City epoch, as during Henrietta time, the seas, though probably shallow, teemed with life, and conditions favorable to limestone formation characterized the greater part of the epoch. Fusilinas, corals, crinoids, sea urchins, brachiopods, bryozoans, pelecypods, gastropods and other forms secreting calcareous shells or skeletons abounded in the clear seas, all contributing to the formation of the limestones of this period. The congenial conditions these clear seas offered to living forms are the more emphasized by the fact that at intervening stages quantities of mud and sand were washed into the waters, causing life to be at least partly exterminated. During these intervals the lesser amounts of shale and sandstone now found separating the limestones were formed. At times during the Kansas City epoch vegetation flourished, but the intervals were short, as is evidenced by black carbonaceous shales or very thin seams of coal found in the rocks. These conditions, however, indicate that swamp-like areas prevailed in the region of Jackson county during parts of the Kansas City epoch.

From the end of the Kansas City time until the Pennsylvanian sea finally withdrew from the region, conditions alternated between those favorable to the accumulation of calcareous ooze, to those of mud, or of sand, these to be later hardened into limestone, shale or sandstone. During most of this time conditions were unfavorable for luxuriant vegetation and such swamp areas as may have existed were probably small.

Toward the close of the Pennsylvanian, the principal event which affected the area in which Jackson county is situated was the gradual upwarping of the Ozark region. As a result of this pronounced crustal deformation, the seas were forced to retreat slowly to the northwest, completely withdrawing from the region south of Missouri River long before the close of Pennsylvanian time. The retreat of this sea marks the final withdrawal of sea waters from the area of Jackson county, for its surface has never since been submerged.

Throughout the entire Mesozoic era, representing millions of years, the erosive processes which started at the end of Pennsylvanian time, probably continued in this area. At least no record remains of any submergence, and the closest approach of any Mesozoic sea was many miles to the west. This prolonged erosion is supposed to have reduced the surface of the region, possibly to base level, and no doubt it removed a considerable portion of the Pennsylvanian sediment from the area of Jackson county.

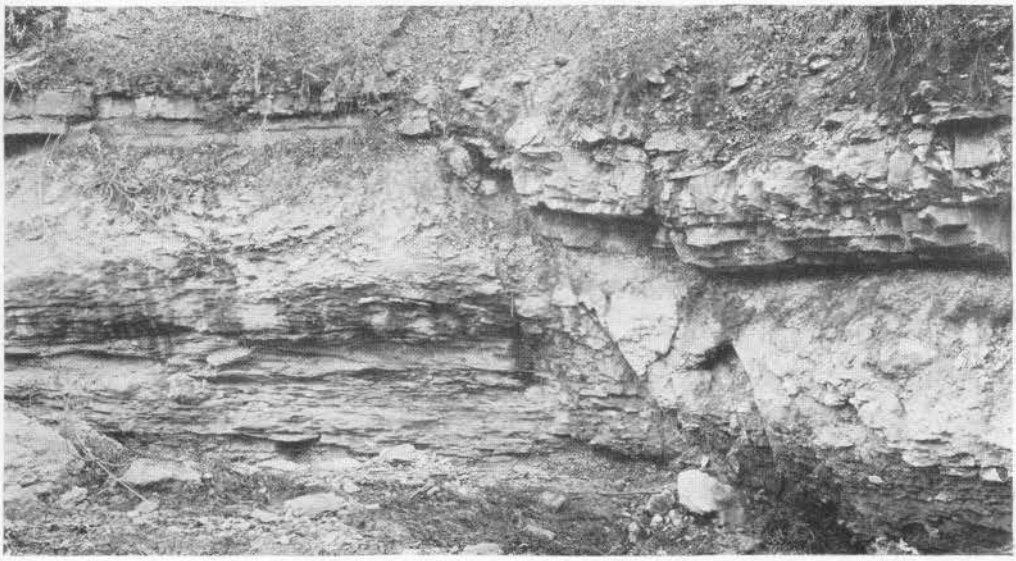


Fig. 1. Faulting in Hertha limestone.

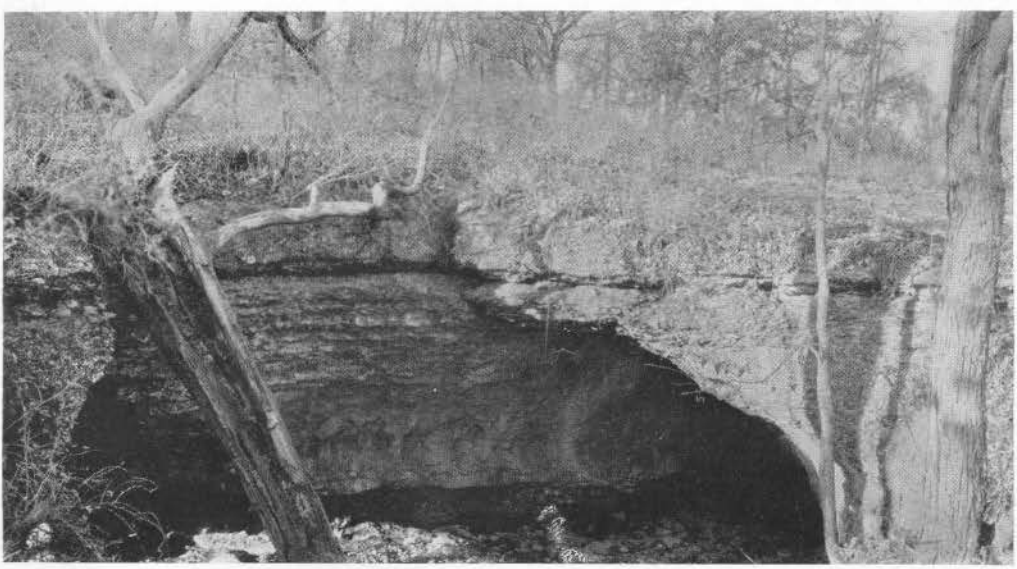


Fig. 2. Cave, Bethany Falls limestone, near Lees Summit.

Some of the topographic features of the county, such as the wellmarked escarpments, probably began to develop during the Mesozoic era and partly assumed their present forms during the following Tertiary epoch, through which erosional conditions continued.

In a region underlain by rocks which are of unequal hardness and which dip at a low angle, equal rainfall should produce a series of ridges parallel with each other and trending in a transverse direction to the dip. Each ridge should have a short, steep slope (an escarpment) on one side and a long, gentle slope (a plain) on the other, the latter extending away from the escarpment in the direction of the regional dip. This theoretical condition, if applied to Jackson county, would imply escarpments trending from southwest to northeast with plains sloping in a northwesterly direction from their crests. These features do exist, but as actually formed by nature the escarpments and separating plains do not everywhere approach ideal conditions. The Bethany Falls escarpment, for example, passes generally southwest to northeast, but follows a sinuous course, is indented and cut through by streams and in places even trends in a northwest direction. The plains are more of less dissected, causing local surface irregularities, and their continuity is much broken by streams. However, the theoretical conditions outlined above are those under which the topography of the country was developed, and it seems probable that this development has been in continuous progress since the withdrawal of the final Pennsylvanian sea.

During the Tertiary epoch there are indications that the drainage was to the east, the waters finally emptying into the Great Mississippi embayment of that epoch. There was probably a large eastward-flowing river in or near the present valley of the Kansas, which continued eastward from Kansas City in the present Missouri valley. Turkey creek then flowed across the site of Kansas City, joining the Big Blue near its mouth. The latter stream seems to have followed its present course as far back as Tertiary times. The Little Blue occupied the present abandoned Buckner valley, and the Sniabar probably had its present course.

PLEISTOCENE EPOCH.

At the beginning of the Pleistocene epoch, the valley now occupied by the Missouri had been cut down at least to the level

of the present flood plain, as is shown by the presence of glacial drift at that level.

A detailed discussion of the causes and events leading up to glaciation need not be given. The first ice sheet, the Nebraskan, did not reach this far south, but the streams caused by its melting probably were responsible for the boulder bed on Graystone Heights. The succeeding ice sheet, the Kansan, pushed down from the north, scraping off soil and loose rocks, leveling hills and filling valleys, finally reaching approximately to the north line of Jackson county. In its journey across Canada and the northern states boulders of many kinds of rocks foreign to Jackson county were picked up and carried south. These, with the accompanying clay and sand, constitute the glacial drift.

When the ice front pushed south, it came to the large river that occupied the present Kansas and lower Missouri valleys. The ice front was probably lobed and it seems that two of these lobed pushed across the river, one into the northern part of Kansas City and one into the region near Sibley, at first damming back the streams and then forcing them across low points on the divides. The Kansas was in this way forced into the former valley of Turkey creek, and the Missouri across the divide near Atherton into that of the Little Blue.

With the melting of the Kansan glacier, the Jackson county region was freed from ice, and it was not affected by the later ice sheets of the Pleistocene. The upper Missouri, which before glaciation joined the lower Missouri near Brunswick, was shifted shortly after glaciation to its present position and now joins the lower Missouri at Kansas City. The new streams thus formed received large quantities of water from the melting of later ice sheets in the northern states. Turkey creek took advantage of the new opening into the Kansas and abandoned its pre-glacial valley. A similar phenomenon took place in the case of the Little Blue, and it now empties into the Missouri near Atherton instead of at Levasy.

One other event of especial importance took place during the Pleistocene. At a time when the ice had withdrawn far enough to the north to restore climatic conditions similar to those now obtaining in the region, a fine silt, the loess, was derived from some unknown source in the north and distributed by the Missouri River along most of its course. From the valley, the loess was blown on to the neighboring hills by winds

which seem to have been chiefly from the west or northwest. (A close determination of the time of this event cannot be made, but as already mentioned, the climate had again become temperate, as shown by the multitude of small shells occurring in the loess.) Though the shells are of species now inhabiting the region, the loess is considered by most authorities to have been deposited during the Pleistocene.

RECENT EPOCH.

The history of the region during recent times has not differed materially from that of the close of the Pleistocene. The smaller streams combined to remove the residual soil and loess, to widen their flood plains, and to deposit their loads in the Missouri. This stream, already overloaded, seems now to be continually aggrading its valley. The ease with which the loess is eroded is undoubtedly an important factor in the silting-up of the Missouri.

CHAPTER IV.

MINERAL RESOURCES.

The mineral resources of Jackson county are exclusively nonmetallic, consisting chiefly of clay and shale, limestone, sand, gravel, oil and gas, coal, water, and soil. The value of the total production of these, exclusive of soil, in 1915, was approximately $1,249,302. Clay and shale, which are used largely for the manufacture of sewer pipe, common, front, and vitrified brick, supplied products worth $390,298. Limestone, in its various uses, as crushed rock for concrete, railroad ballast, road metal, rip-rap, rough building, rubble, paving, and cement manufacture, yielded approximately $829,507. A very small quantity of oil and gas was produced and consumed locally. Sand and gravel are obtained largely from Missouri river, and are used mostly for molding, paving, and building purposes. Coal has been mined in Kansas City in the Brush creek valley, but operations were discontinued in 1904. The mineral and table waters used in 1915 were valued at $6,965. The county lies in one of the richest agricultural districts in the state, and the various soils have been described and mapped by the Bureau of Soils of the United States Department of Agriculture, in co-operation with the University of Missouri Agricultural Experiment station.

In the study of the economic resources of the county, samples of the more important formations were collected and tested, and data were obtained concerning the other resources. The results of this investigation will be found in succeeding pages.

CLAY AND SHALE.

The shales and various clays, including the loess, glacial, alluvial and residual deposits furnish an inexhaustible supply of raw material suitable for the manufacture of brick, paving block, and drain tile.

The shales and loess, at present the commercial sources of clay, are used by eight companies, six of which are in Kansas City. The total value of the output of all grades of ware, including common, vitrified, front, and fire brick, fire proofing,

sewer pipe, drain tile, conduits, coping and terra cotta, was $390,298 in 1915. This production includes 9,450,000 common brick which were valued at $60,360. A number of the products given in the list above are manufactured in Kansas City, though the raw materials are not obtained in Jackson county.

On the following pages are given tests and analyses of representative samples of such shale and limestone horizons as are of sufficient thickness and areal extent to be of commercial value.

PLEASANTON FORMATION.

Samples of shale from the Pleasanton formation were collected at a number of localities where good exposures of from 25 to 30 feet in thickness were available. The shale is normally of a bluish color where fresh, but changes to a yellowish tint where weathered. In places sandy layers and thin sandstones occur near the top.

Below are given the laboratory numbers, localities, chemical analyses, physical and burning tests of the samples collected:

Lab. No.	Locality.
3	One and one-half miles east of Greenwood; fresh sample from new road cut; near top of member.
4	One and one-half miles northwest of Lonejack; fresh sample from stream cut; near top of member.
7	Four miles northeast of Lees Summit; fresh sample from bluff of East fork; about 20 feet from top of member.
17	One and one-half miles east of Courtney; partially weathered; sample from stream bank; middle part of member.
18	Two miles northwest of Sni Mills; weathered sample from gully along road; lower part of member.
21	One mile west of Pink Hill; weathered sample from roadside; lower portion of member.

CHEMICAL ANALYSES.

Laboratory number.	3	4	7	17	18	21
Silica	54.10	59.31	55.26	61.09	63.23	54.10
Alumina	22.96	15.18	21.06	18.70	17.50	23.33
Iron Oxide	5.55	3.08	8.68	6.07	5.37	7.27
Lime	1.57	4.64	0.56	0.16	0.82	1.06
Magnesia	3.54	3.02	3.29	3.30	2.36	2.72
Potash	4.27	3.18	3.35	3.17	2.80	4.15
Soda	1.22	3.09	1.19	2.52	2.70	2.59
Moisture	1.36	0.94	0.72	0.18	0.34	2.52
Loss on ignition	5.84	7.48	6.37	5.12	5.34	2.32
Totals	100.41	99.92	100.48	100.31	100.46	100.06

PHYSICAL TESTS.

Lab. No.	Color, raw clay.	Per cent water for molding.	Average per cent air shrinkage.	Tensile strength, raw clay. Pounds per square inch.		
				Minimum.	Maximum.	Average.
3	Grayish blue.....	31.99	5.81	92	152	115
4	Grayish blue.....	26.49	6.33	133	168	145
7	Grayish blue.....	31.25	2.07	61	74	66
17	Yellowish gray.....	26.04	4.33	54	72	62
18	Yellow.....	23.36	4.71	77	104	93
21	Yellow.....	26.78	5.85	84	131	110

BURNING TESTS.

Laboratory number.	3	4	7	17	18	21
Cone 010—1742° F.						
Per cent fire shrinkage..	0.66	0.00	0.33	0.00	0.00	1.66
Color.....	Light salmon.	Buff salmon.	Light salmon.	Buff salmon.	Salmon.	Salmon.
Cone 05—1922° F.						
Per cent fire shrinkage..	6.66	0.33	4.66	2.66	2.33	7.00
Color.....	Deep salmon, steel hard.	Light salmon.	Deep salmon, steel hard.	Gray salmon.	Deep salmon.	Deep salmon, steel hard.
Cone 02—2030° F.						
Per cent fire shrinkage..	8.66	2.00	10.00	8.00	7.66	8.66
Color.....	Brown red.	Gray brown.	Brown red.	Brown red, steel hard.	Red, steel hard.	Brown red.
Cone 1—2102° F.						
Per cent fire shrinkage..	9.00	5.66	——	8.66	——	9.00
Color.....	Brown red.	Brown, steel hard.	Brown, partially viscous.	Brown.	Brown red.	Brown red.
Cone 5—2246° F.						
Per cent fire shrinkage..	——	——	——	——	——	——
Color.....	Viscous.		Viscous.	Viscous.	Partially viscous.	Partially viscous.

The Pleasanton shale varies in its composition not only laterally but vertically, as may be seen by comparing the analyses. Numbers 3 and 4 were collected near the top of the member, 7 and 17 farther down, and 18 and 21 even lower in the succession in the eastern part of the county. The samples, as would be expected in clays which vary in grain and composition, differ in plasticity as shown by the percentages of water required to mold them. The air shrinkage varies from 4.33 per cent to 6.33, with the exception of 7, which shrinks 2.07 per cent. The tensile strength is weak, only one sample, (4), showing more than 100 pounds, whereas 17 tested as low as 54 pounds. In the handling of weak ware, there might be considerable danger of breakage.

Though there are some differences in shade, the colors of the burned products are much alike, beginning with a salmon

at 1700 degrees F., and attaining a red-brown at 2000 to 2100 degrees. Number 4 maintains a lighter color in the early burning, doubtless produced by the interaction of the lime and the iron oxide, for this sample has not only the lowest percentage of iron but also the highest percentage of lime. Number 7 burns earliest to the deeper color (at 2000 degrees), probably because it has the highest percentage of iron. In the samples in general, a fair hardness is reached at 1900 degrees, good vitrification at 2000 degrees, and viscosity at 2200 degrees, while the average total shrinkage at vitrification is not more than 13 per cent. A too high shrinkage, obvious in some samples, could have been reduced by mixing the sandy layers of this shale with the better grades.

The Diamond plant of the Hydraulic Pressed Brick Company at Fifty-sixth street and Elmwood avenue has in the past used this shale for paving brick and block. When the plant was visited in 1910, the shale was being mined at a depth of 65 feet below the valley floor and conveyed to the surface by means of a slope. Forty acres have been mined out by the room and pillar method, in which pillars 12 feet thick were left and rooms 20 feet wide were mined. A thickness of 19 feet of shale containing some concretionary nodules and an 18-inch layer of sandy shale furnushed the material for the plant. The shale is ground in two dry pans, molded on stiff mud machines, end cut, dried by exhaust steam, and burned in downdraft kilns. Some of the brick are repressed. There are eight kilns, 4 with a capacity of 80,000 and 4 with a capacity of 160,000.

According to the superintendent, Mr. Boering, the brick and block are burned to vitrification at 2000 degrees F. Incipient fusion takes place at 1800 degrees, complete vitrification at 2000 degrees, and viscosity at 2200 degrees. The strength varies from 107 to 130 pounds per square inch. The following analysis shows the composition of the shale: Silica, 54.8 per cent; alumina, 23.73 per cent; iron oxide, 8.67 per cent; lime, 0.64 per cent; magnesia, 2.23 per cent; alkalies, 3.80 per cent, and combined water, 6.00 per cent.

Recently a shaft was sunk in the valley to a depth of about 200 feet, and a shale bed beneath the Pleasanton is being used. A test shaft, located on the hill west of the plant and starting at the top of the Bethany Falls limestone, furnished, according to Mr. Boering, the following section:

LOG OF THE TEST SHAFT AT THE DIAMOND PLANT OF THE HYDRAULIC PRESSED BRICK COMPANY.

Stratum.	Thickness.	Depth.
	Feet.	*Feet.*
Kansas City formation:		
Limestone (Bethany Falls)	22	22
Shale, slaty	4	26
Limestone (Hertha)	16	42
Pleasanton formation:		
Sandstone	7	49
Shale	4	53
Sandstone	1.5	54.5
Shale	12.5	67
Sandstone	6	73
Shale	39	112
Sandstone	2	114
Shale	16	130
Sandstone	1.5	131.5
Shale, light-colored	10.5	142
Sandstone	6	148
Shale	6	154
Shale, red	2	156
Sandstone	12.5	168.5
Shale	22	190.5
Sandstone	8	198.5
Shale	8	206.5
Henrietta formation:		
Limestone	6	212.5
Shale	4	216.5
Limestone, shelly	5	221.5
Shale	4	225.5
Rock, hard	6	231.5
Sandstone, rotten, oil rock	4	235.5
Shale, light-colored	4	239.5
Shale, blue	7	246.5
Limestone	—	—

The shale from 235.5 to 246.5 feet is used at the plant.

CHERRYVALE SHALE.

The Cherryvale is poorly exposed except in the bluffs of Kansas City and in places where it has been quarried for use in the manufacture of common brick. This member, ranges from about 20 to 30 feet in thickness, but only the upper portion is available for commercial purposes. The lower portion consists of interbedded limestone, shale, and bituminous layers, which cannot be separated economically.

Below are given the laboratory numbers, localities, chemical analyses, physical and burning tests on samples of the Cherryvale:

Lab. No.	
32	From the cement plant at Cement City; fresh sample from the lower portion of the shale.
34	From the same locality; fresh sample from the upper portion.
41	From the Lyle Brick yard at Second and Highland; fresh sample from upper portion.

CHEMICAL ANALYSES.

Laboratory number.	32	34	41
Silica	49.18	52.78	55.38
Alumina	25.52	16.92	23.05
Iron Oxide	0.28	7.26	3.91
Lime	7.24	5.37	1.50
Magnesia	2.67	2.09	2.80
Potash	2.68	3.40	3.10
Soda	0.89	1.65	2.01
Moisture	01.2	1.64	1.39
Loss on ignition	11.00	9.32	7.30
Totals	100.48	100.43	100.44

PHYSICAL TESTS.

Lab. No.	Color, raw clay.	Per cent water for molding.	Average per cent air shrinkage.	Tensile strength, raw clay. Pounds per square inch.		
				Minimum.	Maximum.	Average.
32	Gray	23.61	5.47	116	146	128
34	Gray	27.53	6.50	120	149	133
41	Gray-blue	27.97	5.37	89	138	119

BURNING TESTS.

Laboratory number.	32	34	41
Cone 010—1742° F:			
Per cent fire shrinkage	0.00	0.33	3.00
Color	Buff salmon.	Buff salmon.	
Cone 05—1922° F:			
Per cent fire shrinkage	0.00	0.66	——
Color	Whitish salmon.	Salmon, steel hard.	Salmon, swelled, steel hard.
Cone 1—2102° F:			
Per cent fire shrinkage	——	——	——
Color	Speckled yellow-brown, partly swelled.	Partially viscous.	Viscous.

The chemical analyses indicate the variable composition of this shale. Number 32 is high in lime, as is to be expected where there are thin layers of limestone present. Number 34, on the other hand, is high in iron, and 41 is low in lime. The chemical composition has had a decided effect on the color of the burned ware. Because of the interacting effect of the iron and lime, number 32 burned almost white and 34 light salmon; and No. 41 burned to a good salmon at a low, and to a deep red at a higher temperature. This series shows very well the interpretation that can be made from a chemical analysis—how clays which are similar in physical appearance may turn out very differently under the burning tests. The clay is quite plastic, and the air shrinkage averages a little less than 6 per cent. The bricks become well hardened at 1900 to 2000 degrees F., and melt at about 2100 degrees F. The fire shrinkage is small. The clay is suitable to the manufacture of common brick and, in some cases, might possibly be used for vitrified ware, though this is not recommended because both the temperature of melting and of vitrification are low and close together.

Along the North Bluff, the Lyle Rock Company and the Flanagan Bros. are manufacturing brick from the upper portion of this shale. The section at the Flanagan yard has been given in the general description of the Cherryvale and the section at the Lyle plant is shown below:

SECTION AT THE LYLE PLANT.

Stratum.	Thickness.
	Feet.
Soil	10
Chanute:	
Limestone (Raytown)	5
Shale, yellow	10
Limestone (Cement City)	8
Shale, black to blue	5
Shale, yellow, ocherous	3
Drum:	
Limestone (Oolitic and Bull ledge)	15
Cherryvale:	
Shale, blue (used at the plant)	16

Mr. J. G. Ruppell, manager at the Lyle plant, stated that the three updraft, open-top, gas kilns have a capacity of 240,000 brick. The shale is ground and pressed dry, the one press having a capacity of 24,000. Not infrequently, surface clay is mixed with the shale. The ware is common and front brick,

unvitrified, of a light red to salmon color when burned from 1800 to 2000 degrees F. At the Flanagan plant, there are four updraft, open-top, gas kilns with a capacity of 200,000, and one dry-press machine with a capacity of 24,000.

CHANUTE SHALE.

The Chanute shale member is divided into three shale parts by the two persistent limestones, the Raytown ("Calico"), and Cement City ("Building ledge").

The various divisions of shale are of sufficient thickness to be used commercially, especially where quarrying of the intervening limestones is carried on at the same time.

The following are the laboratory numbers, localities, chemical analyses, physical and burning tests of samples of the Chanute shale:

Lab. No.	
8	Rock Island Railroad cut, ½ mile northwest of Lees Summit station; partially weathered shale below Cement City limestone.
14	Independence Brick and Shale Company yard, east of Independence; fresh sample from pit.
26	Doarn yard, West Bluff; fresh quarry face; shale between Raytown and Iola.
27	Same locality; weathered exposure.
37	Lyle yard, Second and Highland; yellow, weathered shale, between Cement City and Raytown limestones.
39	Same locality; fresh sample of bluish shale; between Drum and Cement City limestones.

CHEMICAL ANALYSES.

Laboratory number.	8	26	27	37	39
Silica	52.93	52.21	54.13	50.58	59.93
Alumina	22.71	22.67	22.88	16.52	19.04
Iron Oxide	5.92	7.26	7.00	4.98	3.59
Lime	1.52	1.63	1.29	8.58	1.50
Magnesia	3.37	2.30	2.64	2.35	3.37
Potash	2.95	2.89	2.53	2.84	3.02
Soda	1.89	1.12	0.68	1.25	2.07
Moisture	0.55	2.68	1.15	2.64	1.70
Loss on ignition	7.62	7.35	7.22	10.54	5.49
Totals	99.46	100.11	99.52	100.28	99.71

PHYSICAL TESTS.

Lab. No.	Color, raw clay.	Per cent water for molding.	Average per cent air shrinkage.	Tensile strength—raw clay. Pounds per square inch.		
				Minimum.	Maximum.	Average.
8	Grayish-blue.....	29.61	5.77	84	102	94
14	Grayish-blue.....	27.53	4.81	99	132	113
26	Yellowish-blue.....	28.72	6.29	109	157	140
27	Grayish-blue.....	28.27	4.91	114	135	127
37	Yellow.....	30.80	7.44	129	186	156
39	Grayish-blue.....	27.83	6.18	112	170	134

BURNING TESTS.

Laboratory number.	8	14	26	27	37	39
Cone 010—1742° F.						
Per cent fire shrinkage..	0.66	0.33	0.66	0.33	0.33	0.66
Color.....	Buff salmon.	Light salmon.	Salmon.	Buff.	Salmon.	Buff salmon.
Cone 05—1922° F.						
Per cent fire shrinkage..	——	4.00	7.33	——	2.66	——
Color.....	Steel hard, swelled.	Dark salmon, steel hard.	Red, steel hard.	Salmon, steel hard, partially swelled.	Red, steel hard.	Gray red, steel hard, partially swelled.
Cone 02—2030° F.						
Per cent fire shrinkage..	——	——	——	——	——	——
Color.....		Partially swelled.	Brown red, swelled.		Brown, partially viscous.	Partially viscous.
Cone 1—2102° F.						
Per cent fire shrinkage..	——	——	——	——	——	——
Color.....	Swelled, partially viscous.	Viscous.	Brown red, partially viscous.	Viscous.	Viscous.	Viscous.

The calcareous nature of some of the layers between the Calico and the Building ledge is shown very well in the analysis of No. 37. The unweathered shale is grayish to blue, though some of it, as numbers 26 and 37 especially where weathered, is yellow. The shale varies from plastic to very plastic and the air shrinkage ranges from below 5 to above 7 per cent. With the exception of number 8, which broke at an average of 94 pounds, the strength is exceptionally good, being on an average nearly 140 pounds. The clay burns to shades of salmon. The bricks become fairly hard at 1900 degrees F., vitrified at about 1950, and viscous at 2100 degrees.

Selection of these shales will enable a manufacturer to produce good common brick. In the neighborhood of Kansas City, the Chanute is easily accessible, especially since its two limestone

ledges may be quarried at the same time for the better grades of rubble. The Flanagan and Lyle plants combine quarrying with brick manufacturing.

The Independence Shale and Brick Company has a small plant east of Independence. The shale, when ground in a dry pan, molded on a stiff-mud machine, dried by exhaust heat, and burned in a circular, down-draft kiln with coal fuel, produces a mottled, yellowish to brown, common brick that is used locally. The bed is about 10 feet thick and is overlain by several feet of surface clay, the shale and the clay being mixed in the dry pan. The capacity of one kiln is 95,000.

James Doarn operates a yard on the top of the bluff at Twenty-third street, the product of which is sold to the Hydraulic Pressed Brick Company. The clay is pressed dry on a four-brick, 20,000-capacity machine, burned with gas in three updraft, open-top kilns, each with a capacity of 175,000. The brick is burned to 1600 degrees F., and has a salmon to a light-red color. The surface clay is often mixed with the blue shale quarried at this plant. The general nature of the exposure is as follows:

SECTION AT JAMES DOARN'S BRICK YARD.

Stratum.	Thickness.
	Feet.
Soil	2
Loess	5
Iola:	
Limestone remnant	5
Chanute:	
Shale, blue; used at plant	21
Limestone (Raytown)	6

Exposures of the Chanute shale occur in the quarry of the Lyle Rock Company at Second and Highland, but it is not used in the plant. At Forty-seventh and Main streets, however, the company is using the shale. Three updraft gas kilns and one dry-press machine make up the equipment. The section in this quarry is shown below:

SECTION IN CLAY PIT OF LYLE ROCK COMPANY, AT FORTY-SEVENTH AND MAIN STREETS.

Stratum.	Thickness.
Iola:	*Ft. in.*
Limestone (Crusher ledge)	6+—

SECTION IN CLAY PIT OF LYLE ROCK COMPANY, AT FORTY-SEVENTH AND MAIN STREETS—Continued.

Stratum.	Thickness.
	Ft. *in.*
Chanute:	
Shale, yellow	7 —
Limestone (Raytown)	5 10
Shale	— 8
Limestone, blue, hard	2 —
Shale, mostly blue near top but reddish, green, and yellowish toward the bottom; contains calcareous concretions; used at plant	22 —
Limestone (Cement City)	12 —

The clay used is highly calcareous, containing nodular calcareous concretions, especially near the bottom. These concretions, which can be screened out, produce in the burned brick a number of white specks and may cause spalling and cracking.

LOESS.

The loess contains a large amount of fine sand and has a characteristic yellow or brownish color. It is usually more sandy near the streams and in the valleys where it has been rewashed, but becomes more impure as it passes into the residual soil.

Below are given the laboratory numbers, localities, chemical analyses, physical and burning tests of two samples:

Lab. No.	Locality.
25	Doarn yard, West Bluff and Twenty-third street; near top.
42	Second and Lydia streets; lower part of bluff.

CHEMICAL ANALYSES.

Laboratory number.	25	42
Silica	70.11	73.38
Alumina	14.25	11.61
Iron Oxide	4.02	3.47
Lime	1.53	0.61
Magnesia	1.32	1.34
Potash	2.03	2.98
Soda	1.09	1.05
Moisture	2.48	1.61
Loss on ignition	3.50	3.92
Totals	100.33	99.97

PHYSICAL TESTS.

Lab. No.	Color, raw clay.	Per cent water for molding.	Average per cent air shrinkage.	Tensile strength—raw clay. Pounds per square inch.		
				Minimum.	Maximum.	Average.
25	Light brown.....	21.58	6.12	151	194	173
42	Light brown.....	24.35	6.41	153	186	171

BURNING TESTS.

Laboratory number.	25	42
Cone 101—1742° F:		
Per cent fire shrinkage.....	0.00	0.00
Color.....	Salmon.	Salmon.
Cone 05—1922° F:		
Per cent fire shrinkage.....	0.33	0.66
Color.....	Deep salmon.	Red.
Cone 02—2030° F:		
Per cent fire shrinkage.....	4.00	1.66
Color.....	Brown red, steel hard.	Brown red, steel hard.
Cone 1—2102° F:		
Per cent fire shrinkage.....	6.00	3.33
Color.....	Brown red.	Brown red.
Cone 5—2246° F:		
Per cent fire shrinkage.....	——	3.33
Color.....	Viscous.	Brown, partially viscous.

Loess unburned is yellowish to brown in color; when burned at a low temperature is silver and at vitrification is red-brown. The plasticity is lean, the clay requiring an average of about 23 per cent of water to mix it. Its strength exceeds 170 pounds per square inch, and the average air shrinkage is a little more than 6 per cent. It burns hard at 2000 degrees F., is vitrified at about 2150 degrees, and melts at 2300 degrees. The thickness, extent, and accessibility of the loess and the good color of the burned ware indicate that it could be more widely used for brick manufacture than it is at present.

The Hydraulic Pressed Brick Company's plant at Seventeenth and Askew streets presses the loess dry on a five-brick machine having a capacity of 25,000, and burns it in a down-draft kiln to a good salmon-colored brick.

QUARRYING INDUSTRY.

The total value of the quarry products in 1915 was $380,305, the output being chiefly rubble and crushed rock. Most of the ledges of limestone described under the chapter on Geology are suitable for these purposes, but are not available for cut stone or fancy building due to the irregular bedding and poor working qualities of the ledges. The yellowish to brown color of some ledges, due to oxidation, makes the stone adaptable to the rustic type of building, which probably accounts for the dominant character of this construction in many parts of Kansas City.

Many quarries have been opened throughout the city and county. The general chemical character of the various ledges is given in table of chemical analyses on page 150.

HERTHA LIMESTONE.

There are comparatively few quarries in the Hertha, although small openings have been made in the eastern part of the county where it outcrops without much overburden. One of the chief openings in this ledge was the Crebo quarry, one mile south of Leeds on the Missouri Pacific railroad. At this point the Hertha attains a thickness of 13 feet, probably the maximum in the county.

The member is in one-foot beds and, due to the presence of vertical joints, large blocks are easily quarried. The stone has a granular texture and is gray in color on fresh fracture, but on exposure soon assumes a reddish tinge. This tint gives rise to the name "Ferruginous." Dimension stone could easily be quarried where the Hertha lies close to the surface, and it would serve as a fairly good material for local purposes. Its change of color and limited distribution militate against its use other than as a local stone. Many of the older road and railroad bridges in the eastern part of the country, as well as steps and foundations of many of the farm houses, have been constructed of this stone.

BETHANY FALLS LIMESTONE.

The Bethany Falls is one of the most important limestone horizons in the county. Normally, this ledge has a thickness of from 20 to 24 feet, but erosion along much of the outcropping portion has removed the upper beds.

Fig. 1. Quarry, Cherryvale shale and Drum limestone.

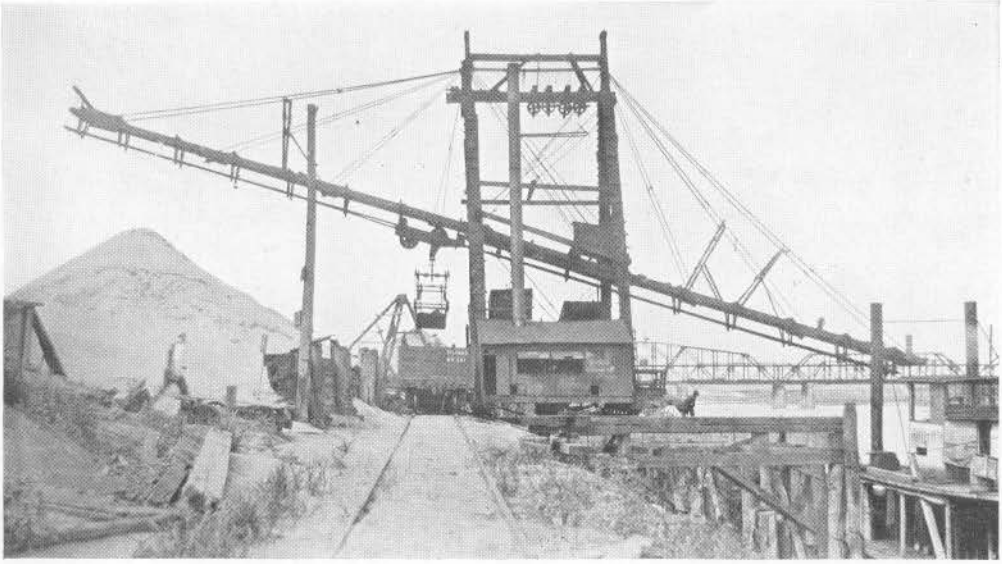


Fig. 2. Sand plant, Stewart Peck Sand Company, Kansas City.

The upper portion is grayish to white, mottled, nodular in structure, and quite thinly bedded. Where exposed it crumbles easily to form a loose mass. The lower portion is more even-grained and firm, but upon exposure it also splits into thin beds.

Some of the quarries in the Bethany Falls have furnished rough building stone and rubble, but most of them have provided crushed rock.

Specimens of the Bethany Falls limestone from the Knapp quarry at Sheffield, tested in the laboratory of the Missouri Bureau of Geology and Mines,[1] showed the following results:

Specific gravity	2.672
Porosity	3.150%
Absorption	1.189%
Weight per cubic foot	163.6 pounds.
Tensile strength	713.25 pounds per square inch.
Crushing strength	13,140.6 pounds per square inch on bed;
	12,710.0 pounds per square inch on edge.
Transverse strength	1,644.5 pounds per square inch.
Crushing strength of samples subjected to freezing test	14,250.7 pounds per square inch.

In building rock roads throughout the county, the contractors make a practice of opening a convenient rock ledge, setting up a portable crusher and crushing enough material to serve for a small section of the road. When that section is completed, the outfit is moved to another place. The Bethany Falls limestone, because of its many outcrops in an escarpment, has been much utilized in this way, as many abandoned openings testify.

A number of the larger crushing plants in the city and in the county, among which may be mentioned the Dolese plant at Greenwood, the crusher on Mill creek, the crusher on the Chicago & Alton railroad near Selsa, and the McTernin-Halpin plant on Swope Parkway, are using rock from this ledge for concrete and railroad ballast. A smaller part of the output of some of the other quarries in the city, as the Lyon opening on Swope Parkway, is used for rubble. The accessibility and the thickness of this limestone combine to make it quite suitable for quarrying.

WINTERSET LIMESTONE.

While the Winterset has sufficient thickness for commercial use, it is in general poorly adapted for rubble and does not pro-

[1]Buckley, E. R., and Buehler, H. A., Quarrying industry of Missouri: Missouri Bureau of Geology and Mines, vol. 2, 2nd series, p. 241, 1904.

duce crushed stone of as good quality as do other ledges. The upper part is quite cherty, and usually the beds are argillaceous.

It is occasionally quarried in conjunction with the underlying limestone, but few quarries, except those utilized for road purposes, have been opened in this member alone.

DRUM LIMESTONE.

The upper and the lower parts of the Drum are quarried extensively, each producing stone quite different in character from the other.

The Bull ledge, which derives its name from the fact that it is difficult to work, is gray, compact, and fine-grained, and contains some geodes and irregular veins of calcite. It splits into layers one foot thick, and where exposed, weathers to a yellow color along the seams.

The Oolitic ledge is grayish, coarsely granular, fossiliferous, porous, and sometimes shows geodes and irregular veins of calcite. Where exposed it becomes darker in tint and, in many cases, shows brown blotches of iron oxide. It often shows cross-bedding near the top and splits readily along stratification planes. It is, perhaps, the best grade of building stone quarried in Kansas City, and is used for rubble, sills, caps, and coursing. Three quarries along the North Bluff, the Lyle Rock Company at Second and Highland, Flanagan Brothers at First and Michigan, and the Johnson quarry at North Bluff, east of Elmwood, are operating in this member.

Laboratory tests[1] of oolitic stone from the Lyle Rock Company's quarry at Second and Highland showed the following results:

Specific gravity	2.681	
Porosity	9.148%	
Absorption	3.756%	
Weight per cubic foot	151.3	pounds.
Tensile strength	941.0	pounds per square inch.
Crushing strength	13,124.0	pounds per square inch on bed;
	10,449.0	pounds per square inch on edge.
Crushing strength of samples subjected to freezing test	9,644.7	pounds per square inch.

CEMENT CITY AND RAYTOWN LIMESTONES.

The Cement City, known locally as the Building ledge, and the Raytown, called the Calico, are important quarry ledges, especially in Kansas City.

[1]Buckley, E. R., and Buehler, H. A., Quarrying industry of Missouri: Missouri Bureau of Geology and Mines, vol. 2, p. 237, 1904.

The building ledge is about 9 feet thick, though in places it attains a thickness of 13 feet. About 7 feet of the upper portion is grayish, fairly crystalline, somewhat fossiliferous limestone which splits into thin layers, while the lower portion is more bluish in color and is argillaceous. It commonly contains nodular masses and veins of calcite, splits into wavy bedding planes where exposed, and becomes discolored in blotches or along the stratification planes. The major joints, which often contain clay, aid in the quarrying of the stone.

The Building ledge is the most extensively quarried stone in the city, furnishing building stone and rubble for the rustic masonry so common in the bungalow type of house construction. The lower portion has been used for curbing, but it is poorly adapted to this purpose, for, when set on edge, it readily splits and flakes along the bed.

The Raytown is persistently about 6 feet thick and quite irregular in appearance. It derives its local name, Calico, from the intricate veined effects produced by differences in color and texture of various parts of the stone. Interwebbed fissures of calcite, large fossils, irregular masses, with their diversity of gray, whitish, and reddish tinges, give the stone a curious appearance. Because of these irregularities the weathered stone has a rough surface. It is somewhat more difficult to work than the Building ledge and consequently has not been so extensively quarried. However, it has been used for rubble and crushed rock.

IOLA LIMESTONE.

The Iola limestone is the surface formation over a large part of the western half and the south central portion of the county. It is by far the thickest ledge of limestone, ranging from a mere remnant where it has been eroded, to a maximum of 43 feet along the bluffs in the northern part of the city and on the high divide between the two Blues.

It has a rough appearance and varies in color from a gray to a blotchy yellow. In many places it is irregularly veined and nodular because of calcite concretions. In the southwestern part of the county about New Santa Fe and Martin City, it bears yellow chert in the upper layers. The lower part contains argillaceous, thinly-bedded layers which crumble readily. Where weathered, the upper portion has somewhat the appearance of the Building ledge, with which it is often confused.

It has been used to some extent, especially in the quarries at Independence, for rubble and foundation stone, but its chief use has been crushed rock. This has given rise to the local name of "Crusher" ledge.

LIME.

The various ledges of limestone as already described are in general too impure to burn to a white lime. The strata usually carry clay along the bedding planes and weather yellow, showing the presence of iron, a small percentage of which will make the lime unfit for finishing purposes. Most of the stone, however, would produce lime suitable for agricultural purposes. The comparative purity of the different beds is shown by the chemical analyses, from which it may de deduced that the Bethany Falls ledge would produce the best lime.

In the early days small kilns were erected in Kansas City and a local supply of lime manufactured. However, no rock is utilized for this purpose at the present time.

PORTLAND CEMENT.

Although a number of the members of the Kansas City formation are suitable for use in the manufacture of portland cement, the Bethany Falls and Iola limestones, with the underlying shales, are the best sources of cement materials. The Iola lies above the Chanute and the Bethany Falls above the Pleasanton. In the eastern part of the county the Bethany Falls and the Pleasanton are commonly exposed, while in the western part the Iola and the Chanute are usually the top formations.

The chemical composition, however, is only one factor to be considered. Of equal importance is the matter of (1) amount of raw materials available, (2) the amount of stripping, (3) transportation facilities and market.

KANSAS CITY PORTLAND CEMENT WORKS.

The Kansas City Portland Cement Works of the Union Sand and Material Company is located at Cement City, on the Santa Fe railroad north of Independence. The plant, as shown in Plate XXI, is situated at the base of the river bluff in which all the strata from the Pleasanton up to the Iola are exposed.

The raw materials are now obtained chiefly from drifts driven in the Bethany Falls limestone to the lower half of the

Fig. 1. Quarry, Kansas City Portland Cement Works, Kansas City.

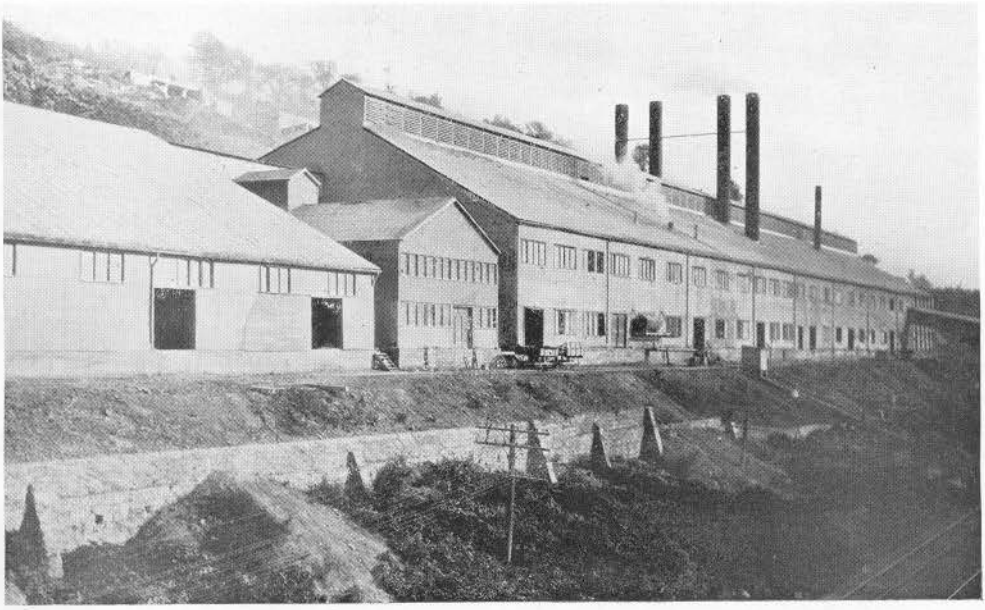


 Fig. 2. Cement plant, Kansas City Portland Cement Works, Cement City.

Winterset. Formerly the various ledges were quarried from the face of the bluff, which has a height of from 55 to 100 feet. The variable composition of the different strata made it extremely difficult to keep a proper mix to the raw materials and drifting on a single level gives much more uniform results.

The drifts are 35 feet high, 50 feet wide, and run parallel, separated by 30-foot pillars. Before it is mixed, the rock is placed in what are known as "low rock" and "high rock" bins. The upper 14 feet of the face, consisting of Galesburg shale, and the lower part of the Winterset are quite argillaceous, and are placed in the low-rock storage while the Bethany Falls, which is comparatively pure, is placed in the high-rock bins.

The following section and analysis furnished by Mr. P. F. Belfour indicates the composition of the materials up to and including part of the Drum limestone:

SECTION AT THE UNION SAND AND MATERIAL COMPANY'S QUARRY.

Stratum.	Analysis number.	Thickness.	
		Ft.	*in.*
Soil (clay)	1	—	—
Drum (lower portion):			
Limestone	2	6	—
Cherryvale:			
Shale	3	17	—
Limestone	4	1	6
Shale	5	2	—
Limestone	6	1	6
Shale	7	7	—
Winterset:			
Limestone, argillaceous	8	12	—
Shale	9	1	3
Limestone	10	1	6
Limestone	11	2	—
Limestone	12	2	—
Limestone	13	3	—
Shale, gray	14	—	6
Limestone	15	5	—
Shale, slaty	16	—	3
Limestone, grading into shale	17	1	—
Galesburg:			
Shale, black	18	2	—
Shale, gray, crumbly	19	2	—
Bethany Falls:			
Limestone, shaly, conglomeratic	20	2	—
Limestone	21	21	2

Number.	Vol. M.	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	$MgCO_3$	Total.
1	11.70	54.20	5.47	17.33	7.16	1.85	.....	.....	97.71
2	41.15	4.52	3.86		49.00	1.33	.....	.....	99.86
3	9.45	54.94	6.38	21.82	3.11	2.46	.....	.....	98.16
4	37.96	8.14	1.44	4.00	45.50	1.59	.....	.....	98.63

Number.	Vol. M.	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	$MgCO_3$	Total.
5.....	20.02	30.60	4.51	12.35	19.15	3.18	.....	.....	97.44
6.....	38.04	9.36	1.72	4.88	42.19	3.54	.....	.....	99.64
7.....	13.44	51.90	4.99	14.41	9.63	2.57	.....	.....	96.94
8.....	27.14	31.46	2.49	6.81	29.96	1.75	.....	.....	99.51
9.....	7.00	63.10	5.76	16.46	0.97	2.61	.....	.....	95.90
10.....	40.18	8.46	2.18	2.58	35.26	11.39	62.69	23.92	100.05
11.....	40.10	7.00	1.58		49.68	2.12	88.71	4.45	100.48
12.....	36.50	12.38	1.36	5.35	36.98	6.20	66.03	13.02	98.80
13.....	41.80	2.70	1.66		53.02	1.68	94.68	3.52	100.48
14.....	10.12	55.88	4.89	18.15	4.06	3.67	7.25	7.70	96.77
15.....	37.66	9.76	2.76	2.98	44.04	2.92	78.64	6.13	100.12
*16.....	12.44	51.02	4.23	16.89	7.64	2.37	13.64	4. 7	98.07
17.....	28.26	25.12	3.50	8.00	28.68	3.40	51.21	7.14	96.98
18.....	14.90	51.08	4.57	17.73	3.96	2.86	7.07	6.00	95.10
19.....	8.64	62.86	3.61	18.13	2.44	1.92	4.00	4.03	97.60
20.....	31.60	19.72	2.97	6.93	38.12	1.30	68.07	2.73	100.64
21.....	41.74	3.30	2.00		53.36	0.73	95.29	1.50	100.13

*SO_3=3.48%.

The raw material is handled, burned, and the clinker ground by the usual methods employed in a plant using rotary kilns.

SAND AND GRAVEL.

Sand and gravel are found chiefly along the Missouri and its main tributaries. A large part of the output is obtained from the Missouri, as the alluvial deposits along this stream are most suitable for commercial purposes. The deposits along most of the tributaries are more variable in composition, some being composed largely of clay.

In the old valley between Lake City and Levasy there are a number of east-west ridges composed of alluvium which contain considerable sand. At Lake City there are half a dozen elongated knolls which apparently consist of fine quartz sand and some clay. Not much can be told of the composition of the knolls, but in one or two pits where the sand has been used locally, it appears to be irregularly stratified.

Along several of the small streams tributary to the Missouri at the northeastern end of the county, there are little patches of glacial gravels and sand outcropping under the loess. These, however, are not of sufficient areal extent to prove of economic importance.

MISSOURI RIVER SAND.

The sand dredged from Missouri River is a fair quality of building sand. The coarser particles consist largely of flint, derived along the tributaries from the cherty limestones of the adjacent region. There is a small admixture of quartzite and igneous pebbles contributed from the drift. The finer portions consist chiefly of quartz sand, with considerable amounts of flint and foreign lignitic material. Bar-run samples show high silt content, but this is largely washed out in those sands secured by pumping.

The most objectionable feature of these sands is the considerable content of lignite. This lignite, while not particularly harmful in foundation and heavy concrete work, is injurious in surface work, since the expansion and contraction of the coal causes the "popping" of sidewalks and plastered walls.

The Stewart-Peck Sand Company of Kansas City is the only firm in Jackson county now engaged in dredging Missouri River sand. It secures the sand with a 10-inch centrifugal pump, tows it on barges to the plant and unloads it with a clamshell, either directly to the car, or onto stock piles. The sand is passed over ½-inch screen at the barge, but undergoes no other washing or screening. The capacity of the plant is about 50 cars a day.

By carefully selecting the bars from which sand is pumped, it is possible to put out coarse and fine grades. The description given below is of two samples pumped at Kansas City. The first is a coarse sand used for building purposes, the second a finer grade used for core sand.

Coarse sand.—This is the coarsest grade of sand secured at Kansas City from the Missouri River. The sample has been passed over ½-inch screen at the barge. As put on the market, 2.00 per cent of this sand is retained on the 10-mesh sieve, and over 90 per cent on the 60-mesh. The effective size is .32 mm., and the coefficient of uniformity is 1.90. The gravity is 2.63, and the sand has 38.5 per cent voids. It weighs 101.9 pounds per cubic foot, and shows 0.75 per cent silt.

Fine sand.—Of this sample, only one per cent is retained on the 10-mesh, and only 63 per cent on the 60-mesh. The uniformity coefficient is 2.00, the effective size .15 mm., and the specific gravity 2.64. The sand has 40 per cent voids, and

weighs 98.2 pounds per cubic foot. Washing shows .4 per cent silt.

The coarse sand is used for practically all construction work except surfacing sidewalks and plastering, for which the lignite unfits it. The finer grades are used for paving sand, core sand, engine sand and bedding sand.

The above named company and other companies secure much Kaw River sand which, being cleaner and coarser, brings a higher price on the Kansas City market.

COAL.

Although some coal has been mined in Jackson county, it cannot at present be listed among the coal-producing counties. The entire area is underlain by beds commonly not over two feet thick, but the proximity of a good market causes even beds of this thickness to be worthy of consideration. The Lexington, Mulky, and Bevier beds are the thickest and probably of greatest value.

DISTRIBUTION AND STRATIGRAPHIC RELATIONS.

Lexington coal.—This bed does not appear to be either as persistent or as regular as it does in Lafayette county on the east. In several drillings the horizon has been found barren, though in others the bed is 9 to 31 inches thick. Where the thickness is over 18 inches, a clay parting is usually present, as in the Lexington and Richmond districts. The coal is overlain by black, slaty shale, and over this is a fairly thick limestone cap-rock. Below the coal there is underclay which rests on a limestone bottom rock. These features serve to identify the bed wherever it occurs.

As the Lexington horizon lies at an average depth of 210 feet below the base of the Hertha limestone, its depth in most of the county may consequently be estimated by using the sections given in the preceding pages, in conjunction with the geologic map. In the larger valleys the Lexington horizon lies 100 to 250 feet below the surface; in the northeastern part of the county, particularly near the Missouri and along the Sniabar, the horizon is within 50 feet or less of the surface; and as mentioned under "Cherokee shale" in chapter II, it outcrops and has been mined in sec. 20, T. 49 N., R. 29 W. The bed is very thin and the mine (drifts) appears to have been abandoned many years ago.

Strata between the Lexington and Mulky beds.—Below the Lexington bottom rock there is a bed of shale and sandstone about 20 feet thick resting on a layer of limestone which varies from a few inches to 3½ feet thick ("Rhomboidal" limestone of north-central Missouri). Below the "Rhomboidal" limestone there are usually black, slaty shale, and a thin coal bed, the Summit. This bed appears to be rather persistent and its thickness ranges between 6 and 15 inches. The Summit coal, like the Lexington, rests on underclay and a limestone bottom rock. About 4 to 15 feet of shale intervene between this and the cap-rock of the Mulky coal.

Mulky coal.—The Mulky, though commonly somewhat irregular, appears to be persistent in at least the northern portion of the county where it is reported 12 to 26 inches thick. It is overlain by black, slaty shale and this in turn by limestone. The limestone cap-rock, however, is irregular in thickness and is locally absent, as is shown in the log of one of the Salisbury borings (see following pages).

Strata between the Mulky and Bevier beds.—An irregular succession of shale and sandstone having a thickness of 70 to 90 feet, separates the Mulky from the next lower bed. It is possible that one or more thin coal beds may be found in this interval, though none are known at present.

Bevier coal.—As a rule, drillings show the Bevier coal to be about 20 inches in thickness. It has a black shale roof and, like the two seams previously discussed, rests on clay and a limestone bottom rock. The Bevier coal was formerly mined at Randolph, Clay county, just north of Kansas City.

Lower beds.—Some of the deeper borings in Jackson county have passed through lower beds which, as a rule, are not thick or persistent. Logs of oil and gas borings show coal as much as 4 or 5 feet thick, but it should be remembered that the drillers of these wells, not being primarily interested in coal, frequently report the black, slaty roof shale as coal. However, as so little detailed information is available as to deeper coal beds of the county, thick beds in the lower part of the Cherokee shale may here and there be expected.

DEVELOPMENT.

Only one mine of commercial importance has ever been operated in the county. This was a shaft sunk on Parish branch north of Forty-third street (SE. Cor. SE. ¼ SW. ¼ sec.

23, T. 49 N., R. 33 W.) and about one-half mile below the mouth of Brush creek, from which it derives the name "Brush Creek Mine." It was sunk in 1891 for the Kansas City Clay and Coal Company. In the course of prospecting, a drill hole was put down to a depth of about 600 feet. The following section furnished by the manager of the company is believed to include a partial record of this drilling and possibly of the shaft, together with the higher beds in the vicinity of the company's land:

SECTION NEAR BRUSH CREEK MINE.[1]

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Loess	15	15
Pennsylvanian:		
Kansas City formation:		
Dark clay shale	25	40
Black flint (Winterset)	1	41
Hard blue limestone	20	61
Black shale and slate	3	64
Spotted limestone (Bethany Falls)	15	79
Black slate	3	82
Hard limestone ("Chocolate") (Hertha)	15	97
Pleasanton formation:		
Black slate	2	99
COAL, 1 to 6 inched (Ovid)	—	—
Fire clay, pyrytiferous	3	102
Sandstone	4	106
Shaly sandstone	—	—
Blue clay shale	28	134
Dark sulphury rock	2	136
Sandy shale	46	182
Light blue shale	20	202
Sulphury nodules and slate	2	204
COAL	—	—
Underclay	4	208
Sandstone with heavy oil in it, not a well-defined sandstone	12	220
Dark sandy shale	23	243
Mud rock	22	265
Henrietta formation:		
Limestone	5	270
Dark shale	1	271
Limestone	2	273
Purple clay shale	3	275
Limestone	9	285
COAL	—	—
Underclay, fire clay	2	287
Limy shale with pyrite as nodules and flakes	4	291
Soft dark clay shale	3	294
Hard flinty limestone	6	300
Laminated sandstone, smells of petroleum	3	303
Dark clay shale	16	319
Dark gray limestone	5	324
Cherokee shale:		
Hard black slate	3	327
COAL (Lexington)	—	—
Underclay, sandy	2	329

[1]In the notes from which this is taken, the thickness of the coal beds is omitted and no totals are given; the totals given here must therefore be considered approximate.

SECTION NEAR BRUSH CREEK MINE—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
Cherokee shale—Continued.		
Sandy shale	4	333
Limestone, white	3	336
Mud rock	9	345
Light drab shale	9	354
Dark brown limestone ("Rhomboidal")	1	355
Hard black slate	3	358
COAL (Summit)	—	—
Underclay	4	362
Lime and sulphur nuggets in clay	4	366
Light sandy shale	1	367
Mottled shale	3	370
Limestone, fine-grained, gray	4	374
Hard, slaty mud rock	1	375
Dark shale	4	379
COAL (Mulky)	—	—
Underclay, fireclay	4	383
Pyritiferous clay	6	389
Lime, pyritiferous	20	409
Mud rock	35	444
Soft sandstone, light color	14	458
Hard sandstone, light color	8	466
Black slate	2	468
COAL (Bevier)	—	—
Underclay	4	472
Limestone, gray	5	477
Black slate	1	478
COAL (Lower Ardmore)	—	—
Underclay	2	480
Hard sandy clay	6	486
Purple clay shale	15	501
Black slate	2	503
Sandstone	6	509
Gray shale	5	514
Blue clay, irony and spotted	5	519
Hard shale, sandy	7	526
Black slate	5	531
COAL	—	—
Underclay	3	534
Shale, fossiliferous	5	539
Sandy shale	27	566
Dark slate	3	569
COAL	—	—
Underclay, fireclay	6	575
Clay shale, dark olive	8	583
Sandy shale	25	608
Black slate	5	613
COAL	—	—
Underclay, fireclay	4	617
Clay shale	14	631
Dark clay shale, descendingly slaty	20	651
COAL	—	—
Underclay	7	658
Dark shale and slate	18	676
COAL	—	—
Underclay, hard sandy	10	686
Shaly sandstone, hard	12	698
Ferruginous blue shale	18	716
Gray shale and gypsum	3	719
Mississippian:		
White chert	10	729
Magnesian limestone	10+	739

The top of the shaft is said to have been at 42 feet Kansas City datum (765 feet above sea level). Two coal beds were mined at 282 and 389 feet, respectively, below the top of the shaft. As the shaft started from near the contact of the Kansas City and Pleasanton formations, it is highly probable that the upper bed was the Mulky and the lower the Bevier or Lower Ardmore.

The upper bed was from 18 to 26 inches in thickness and the lower about 24 inches. The lower bed was worked by the long-wall method for a distance of 700 to 1,000 feet from the shaft. It is said that the mine generated so much gas, that, after having been operated intermittently until 1904, it was finally abandoned because of this.

The Independence Coal Mining Company did some prospecting on the Mark Salisbury farm 2½ miles east of Independence, but so far as is known, no other development work has been done. The following drill records show the thickness of the coal in this area. The coal seams have been correlated as far as possible:

RECORD OF DRILL HOLE ON SALISBURY FARM.

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Pleistocene and Recent:				
Soil and clay	27	—	27	—
Pennsylvanian:				
Pleasanton formation:				
Soapstone	74	—	101	—
COAL	—	6	101	6
Fireclay	1	6	103	—
Shale	7	6	110	6
Oil sand	8	—	118	6
Soapstone	7	6	126	—
Slate, Shale, dark	9	2	137	10
Rock (limestone?)	3	4	141	2
Shale, black	4	6	145	8
Oil sand	13	6	159	2
Shale, light	9	6	168	8
COAL	1	—	169	8
Soapstone, black	3	—	172	8
Shale	6	—	178	8
Rock (limestone?)	3	6	182	2
Soapstone	4	—	186	2
Rock (limestone?)	10	—	196	2
Cherokee shale:				
Slate and COAL (Lexington)	2	6	198	8
Rock (limestone?)	4	6	203	2
Soapstone	19	—	222	2
Shale, hard, sandy	1	—	223	2
Slate	1	6	224	8
Soapstone	1	6	226	2
COAL (Summit)	1	—	227	2

RECORD OF DRILL HOLE ON SALISBURY FARM—Continued.

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Cherokee shale—Continued.				
Fireclay	3	6	230	8
Rock (limestone?)	1	—	231	8
Fireclay	3	8	235	4
Soapstone	10	8	246	—
Slate	2	—	248	—
COAL (Mulky)	2	2	250	2
Fireclay	2	7	252	9

RECORD OF DRILL HOLE ON SALISBURY FARM.
(Sec. 6, T. 49 N., R. 31 W.)

	Thickness.		Depth.	
Pleistocene and Recent:	*Ft.*	*in.*	*Ft.*	*in.*
Soil	40	—	40	—
Pennsylvanian:				
Pleasanton formation:				
Soapstone	25	—	65	—
Sandstone and trace of oil	13	—	78	—
Shale	12	—	90	—
Limestone	4	—	94	—
Soapstone, dark	3	—	97	—
Shale	16	—	113	—
Henrietta formation:				
Limestone	17	—	130	—
Shale	15	—	145	—
Limestone	7	—	152	—
Soapstone	4	—	156	—
Lmestone, hard	11	—	167	—
Cherokee shale:				
Shale, strong flow of water	2	6	169	6
Clay	1	6	171	—
Limestone, hard	4	—	175	—
Shale and soapstone	18	—	193	—
COAL (Summit)	1	2	194	2
Clay	1	6	195	8
Rock, hard	3	—	198	8
Soapstone	14	—	212	8
Limestone	2	—	214	8
Slate	—	6	215	2
COAL (Mulky)	2	—	217	2
Clay	1	6	218	8
Shale, sandy	40	—	258	8
Rock, hard	3	—	261	8
Slate	1	—	262	8
Soapstone, dark, sandy	24	—	286	8

Coal has been mined at two places in Clay county just across Missouri River from Jackson county. The Bevier bed was mined at Randolph and the Lexington bed is mined at Missouri City. A detailed account of these mines will be found in volume 11 of the reports of this Bureau, "The Coal Deposits of Missouri," by Henry Hinds.

GAS AND OIL.

The amount of gas and oil produced in Jackson county at present is not commercially important. Gas is used at a number of localities for domestic purposes, especially for illuminating, and has occasionally been used in manufacturing enterprises. Oil has been produced from a few wells in southern part of the county.

Area.—The wells have been drilled chiefly in the western third of the county and in the northern part of Cass county. So far as is known, no wells in the eastern part of the county have encountered gas in sufficient quantities to be used.

Horizons.—The principal gas-bearing horizons are the Henrietta and the upper part of the Cherokee. Minor amounts of gas are found near the base of the Pleasanton, commonly in the lower 20 feet, and from 100 to 300 feet below the top of the Cherokee; there are, therefore, about 400 feet of strata in which gas may be encountered. In several wells gas has been found at three or four different levels. The showings of oil may be at other levels in the same well or in the gas-bearing bed. No oil or gas in any of the wells in Jackson county have been encountered below the base of the Pennsylvanian.

Occurrence.—In nearly all the wells the gas has been found in sandstone, but in a few it is reported in black slaty shale ("slate") and in very few others in coal beds. It is known that the coal in the Brush creek mine was very gaseous. Water, usually salty, has been found both above and below the gas horizons.

It is not the purpose of this report to discuss at length the theory of the origin and accumulation of oil and gas. These fuels are supposed to have originated from the decomposition and distillation of certain portions of organisms, animal and vegetable, now embedded in the oil and gas-bearing rocks. The accumulation depends on the presence of porous beds which are overlain by impervious layers and all of which have been more or less folded.

Gas.—The first gas wells in the county were drilled soon after the close of the war in the late 60's. The first drilling of which there is a reliable record was put down near the old Union Depot in or before 1872. The number of wells drilled and the proportion of them that produced gas (the oil has been little

more than "showings") are unknown, but a summary of available data indicates that 100 to 150 wells have been drilled and that probably 100 of these have been productive. However, a large number of unproductive wells may have been drilled but not recorded.

The initial rock pressure as reported is usually between 50 and 100 pounds and flows of 500,000 cubic feet per day have been obtained. The supply usually diminishes gradually and lasts only a few years. Most of the wells are on farms, where the gas is used for illuminating or heating purposes. At Sheffield several manufacturing plants have sunk a series of wells and have used the product for running gas engines. Mr. Louis H. Knoche furnishes Martin City at the rate of 160,000 to 642,000 cubic feet of gas per month, the supply coming from one well.

The town of Belton, two miles south of Jackson county, is also partially supplied with natural gas. Between 1902 and 1906 about 15 wells were drilled in this vicinity just west and north of the town. Six of these were owned and operated by Mr. George Scott, and four by Mr. A. D. Goodbar. At the height of production prior to 1910, Mr. Scott supplied about 50 families with gas, the product of two or three wells immediately west of town. Mr. Goodbar furnished about 25 families, the production coming from one well three-fourths mile north of town. Several of these wells have been producing continuously since the date of drilling, ten to fifteen years ago. One of the first wells of this group, drilled about 1902, and located at the west edge of Belton on the property of Mr. C. M. Mahan, still has a good pressure and yields a small flow of oil and water. Most of the wells, however, have been destroyed by allowing water to enter the sands through improper casing and the gas production from one or two wells is now consumed at less than a dozen residences.

The gas sand is encountered at a depth between 300 and 450 feet, according to surface location. The well operated by Mr. Goodbar is 445 feet deep. Those of Mr. Scott vary from 300 to 400 feet. One well was sunk 660 feet, at which depth an exceptionally strong pressure of gas was encountered.

The present gas pressure is from 60 to 65 pounds, although when first opened the pressure was from 65 to 80 pounds. The strongest pressure recorded in the district was that in the 660-foot well which at first registered 180 pounds. The gas in this well was encountered in a coarse "pebble" sand and possessed

sufficient pressure to throw water twice as high as the derrick. In the other wells "The gas sand is fine-grained and is from 8 to 12 feet in thickness."

As is shown on the small structural map, plate XVI, the general distribution of the wells in Kansas City in which gas has been encountered does not indicate a segregation along the crests of the anticlines. It is thought, however, that the areas showing the dome structures would prove the most favorable for prospecting. Detailed structural mapping around Belton shows that the wells yielding both gas and oil in that vicinity bear a distinct relationship to the structure of the region.

Oil.—The well of the Walker Laundry Company in Kansas City and a well at the "Garland flats" are reported to have produced some oil.

The greatest development, however, has been in the district extending from Belvidere Station to near Belton, Cass county. The following report was made on this district in 1909 by Hughes: "There are ten wells located in the SW. ¼, sec. 36, T. 47 N., R. 33 W., on the farm of Mr. L. E. Mahan near Belvidere and one-half mile north of the Cass-Jackson line, which have produced oil. Mr. Mahan states that the wells will, when kept cleaned, produce about two barrels every 24 hours. The first well drilled was a flowing one and for several months produced about three barrels per day. At present all oil produced has to be pumped."

At Belton, "Mr. Goodbar reports a past production of about 100 barrels of oil per year from one of his wells in which the water pressure had become greater than the gas pressure. Oil was obtained by pumping water to the surface and then 'skimming off the oil.' " An analysis of the Belton oil made in 1902 is as follows:[1]

ANALYSIS OF PETROLEUM FROM BELTON, MO.

Constituent.	Per cent.
Light oil between kerosene and gasoline	10
Burning oil (kerosene)	19
Lubricating oil with paraffin base	53
Residium, consisting of 10 per cent tar and 8 per cent paraffin, with only a trace of inorganic matter	18
Total	100

[1]U. S. Geol. Survey, Mineral Resources, 1902, p. 566, 1904. Prof. Frankporter.

The wells near Belvidere when visited in 1912 were producing 1½ barrels per day. The tract had at that time become the property of Messrs. Scruggs and Johnson, and included eight wells 300 to 500 feet deep. In addition to these, Mr. Scruggs drilled another well for water, striking gas at 160 feet and a flow of oil at 310 feet. About 1½ miles southeast of the wells mentioned above, a small production was obtained from one well on the Rosier farm, in Cass county. Oil from this well was sold locally to farmers for several years. During the period of greatest production of the Scruggs and Johnson wells, Mr. Mahan reports average sales of 300 barrels per month.

The following table and records present a summary of all available data covering wells that have been drilled for oil or gas or have encountered these fuels. Other records will be found under the heads of "Unexposed Rocks," "Coal," and "Underground Waters."

DATA OF OIL AND GAS WELLS IN JACKSON COUNTY.

No.	Name of owner.	Location.	Date drilled.	Depth in feet.	Elevation at mouth of well.	Driller.	Remarks.
1	Walker Laundry Co	Twelfth and Oak streets		405	900+		Oil at 326', about 1 bbl. per month.
2	Prier Brass Works	Fifteenth and Big Blue River, Sheffield		300	740+	G. A. Rivers	Gas at 119'-122' and 166'-178'.
3	J. M. Ridge	Twentieth and Woodland	1883	450	885+	T. W. Wright	Gas at 282'. One of first wells drilled. Flow lasted 8 or 10 years.
4	Kansas City House of Correction	On grounds, NE. ½, NW. ½ sec. 30, T. 49 N., R. 32 W.		510	766		Gas at 187'. Pressure 125-150 lbs., showing of oil at 84'-108'.
5		SW. ½, SE. ½, sec. 20, T. 49 N., R. 32 W		967	923		Gas at 438'-480', pressure 60-80 lbs.
6	Mastin No. 2	Wyandotte and Armour	1888	478	938	J. R. Nickerson	Gas at 478'.
7	Mastin No. 3	Central and Wyandotte, south of Armour	1888	1,002	943	J. R. Nickerson	Dry hole.
	Buckner Oil and Gas Co	NW. ¼, NE. ¼, sec. 29, T. 50 N., R. 30 W		487	750+		Gas at 487'.
9	Scruggs and Johnson	W. ½, NW. ¼, sec. 36, T. 47 N., R. 33 W		368-379		David Waskam (?)	8 or 10 wells on this tract. Each produced 2 bbls. of oil per day. Oil sand near bottom of wells.
10	Hydraulic-Press Brick Co	Fifty-sixth and Big Blue Valley	1900	631	760+		Gas at 212'; 36,000 cu. ft. per 24 hours.
11	St. James Hotel	Walnut and Missouri avenue		525½	925	T. W. Wright	Gas at 361'-370'.
12	H. L. McElroy	Mount Washington		1,205	985	J. R. Nickerson	Gas horizons not recorded.
13	J. P. Kanoky No. 4	Fairland Heights, near Independence		451		G. A. Rivers	Gas at 2 levels, oil at 3 levels.
14	J. P. Kanoky No. 5	Fairland Heights, near Independence		308		G. A. Rivers	Oil sand 181'-186'; gas sand 350'-358'.
15	L. H. Knocke	SE. ¼ sec. 20, T. 47 N., R. 33 W	1906	274-547			Principal gas supply at 274', pressure 65 lbs. In 1909 there were 8 producing wells.
16		Fairland Heights, near Independence	1910	693		G. A. Rivers	Gas at 4 levels, oil at 3 levels.
17		Sec. 1, T. 46 N., R. 33 W., just over the county line in Cass county		459		David Waskam	Two gas sands, oil at bottom.
18	Witte Gas Engine Works	Sixteenth and Oakland		304	750+	G. A. Rivers	Gas at 2 levels.
19	J. N. Dietz	Thirty-third and Holly	Prior to 1888	601½	920		Gas at 2 levels.
20	W. E. Minor	Near Red Bridge	1911	565	925	L. Dietrich	Two gas sands, total pressure of 250 lbs. Another well on same farm drilled in 1905.
21	W. S. Dickey, No. 1	Fifty-second and Holmes	1912	437	920	L. Dietrich	Gas in black shale, 375'-379'.
22	W. S. Dickey, No. 2	Fifty-first and Holmes	1912	856	925	L. Dietrich	Drilled for water.
23	W. S. Dickey, No. 3	In block bounded by 51st, 52nd, Holmes and Rockhill	1912	539	930	L. Dietrich	Dry hole.
24	W. S. Dickey, No. 4	In block bounded by 51st, 52nd, Holmes and Rockhill	1912	500	900	L. Dietrich	Dry hole.

25	W. S. Dickey, No. 5	Fifty-second and Troost	1912	493	920	L. Dietrich	Gas in black shale, 445'-450'; and in sand, 491'-495'.
26	Kansas City Park Commissioners	Swope Park, northeast of District foreman's house	1905	1,125	828		Drilled for water, gas at 304'-315'.
27	No. 1	Rosedale Kan., at Kansas City Rolling Mill Co	Prior to 1979	345	800+		Gas in black shale, 274'-280' and 300'-308'.
28	No. 2	Rosedale, Kan., more than ½ mi. nearer Kansas City than No. 1	Prior to 1879	320' 9"	780+		Gas in black shale at 219' and 314'.
29	No. 3	Rosedale, Kan., ½ mi. S. W. of No. 1	Prior to 1879	430' 4"	800+		Gas in black shale, 408'-412'.
30	No. 4	Rosedale, Kan., ¼ mi. N. of No. 1	Prior to 1879	330' 6"	790+		Gas in black shale, 234'-236'.
31	J. A. Paulin	½ mi. S. E. of Argentine, Kan		323			Gas 211'-229', 25,000 cu. ft. per day; also at 305'-323'.
32		Near old Union Depot	1872 or earlier.	758	785		Bituminous sandy clay, 176'-180'; bitumen rose to surface. "Rock oil" in limestone, 273'-291'.
33	Ed. H. Witte	3 mi. S. of Independence, on Raytown road	1914	492	1,000+	J. O. Foster	Produced salt water.
34	Swift Packing Co	West of Kansas River, north of Kansas avenue	1914	350	750+	Geo. Austin	Drilled for water. Gas, 2 bbls. oil per day.
35	D. M. Proctor	Seventy-fourth and Mercier	1915	736	1,015	B. F. Adamson	Drilled for water. Gas at 494'-502'.
36	Jones Store Co	Thirteenth and Walnut			865+		Drilled for water, but used for gas.
37	Howard Vrooman	Twenty-eighth and Park	1905	455	950+	J. H. Williams	Yield 410,000 cu ft., initial pressure 200 lbs.; has dwindled.
38	W. H. Collins	Colonnade Apts. on Armour Blvd		475			Yield 500,000 cu. ft., but soon dwindled.
39	H. P. Williams	8th and Troost, in rear of Dresden flats, N. E. corner		406	965+		Yield strong at first, but soon dwindled.
40	Kansas City Water Dept	Turkey creek pumping station	1905		750+		Gas struck, but drowned out by water.
41		Electric Park					No information.
42	Cottingham	Thirteenth and Brooklyn			885+		No information.
43	E. Kellerstraus	Eighty-fifth and Holmes					No information.
44	Mrs. W. A. Gosnell	Thirty-fifth and Agnes			960+		House heated.
45	J. Woods Merrill	Brush creek, under Williams St. bridge		550	780+		Capped and not used.
46	Mastin, No. 4	On Main, S. of Armour	1888	1,086	948	J. R. Nickerson	No other information.
47	Mastin, No. 5	East of Main, N. of Armour	1888	610	983	J. R. Nickerson	4' coal at 235'. No other information.
48	Young, No. 1	Twenty-fifth and Vine	Prior to 1890		845	J. R. Nickerson	Two gas sands, coal at 787'.
49	Young, No. 2	Twenty-fifth and Vine	Prior to 1890		845	J. R. Nickerson	Two gas sands. One well over 1,000 ft. deep.
50	A. Chadwick, No. 1	Jefferson and Twenty-second		351	775	J. R. Nickerson	Gas, coal at 235'.
51	A. Chadwick, No. 2	Jefferson and Twenty-second, 200' W. of No. 1		360	792	J. R. Nickerson	Gas.
52	Norton, No. 1	Twenty-ninth and Highland			953	J. R. Nickerson	No other information.
53	Kansas City N. G. & F. Co., No. 1	In center of block between Lydia, Tracy, 23rd and 24th			900+		No other information.

DATA OF OIL AND GAS WELLS IN JACKSON COUNTY—Continued.

No.	Name of owner.	Location.	Date drilled.	Depth in feet.	Elevation at mouth of well.	Driller.	Remarks.
54	Kansas City N. G. & F. Co., No. 2	225′ S. and 175′ W. of the S. W. corner of 24th and Lydia	.....	.....	910+	.....	No other information.
55	Kansas City N. G. & F. Co., No. 3	330′ S. and 200′ W. of same corner	.....	.....	910+	.....	No other information.
56	Kansas City N. G. & F. Co., No. 4	480′ S. and 200′ W. of same corner	.....	.....	910+	.....	No other information.
57	Kansas City N. G. & F. Co., No. 5	210′ N. and 125′ W. of S. W. corner of 25th and Tracy	.....	.....	920+	.....	No other information.
58	Kansas City N. G. & F. Co., No. 6	420′ N. and 100′ W. of same corner; 2416 Tracy	.....	300	915+	.....	Pressure low.
59	Kansas City N. G. & F. Co., No. 7	Center of block, between Forest, Tracy, 23rd and 24th	.....	.....	980+	.....	No other information.
60	Midland Bldg	Seventh and Walnut	.....	.....	860+	.....	No information.
61	Kansas City Bolt and Nut Co	Sheffield	.....	.....	.....	C. L. Bloom	Several wells—gas from 250′-260′. Total flow 40,000 cu. ft. per day. Until 1910 operated a gas engine.
62	Independence Nat. Gas and Coal Co.	Independence	.....	.....	.....	.....	Many wells—no other information.
63	.....	Seventeenth and McGee	.....	400	830	Wm. Tobener	Good gasser—lasted several years.
64	.....	Grand Ave., between 14th and 15th	.....	.....	850+	.....	Little gas; struck salt water that came within 12′ of top.
65	.....	Garland flats	.....	600	.....	.....	Produced 5-6 bbl. of oil, but gave little gas.
66	R. H. Tobener	.....	.....	344	.....	.....	Gas well—salt water at 344′.
67	Lawrence Realty Co	.....	.....	.....	.....	.....	Producing gas well.
68	Lawrence Realty Co	.....	.....	.....	.....	.....	Producing gas well.
69	W. D. Johnson	.....	1912	300-325	.....	.....	One gas well, 5 or 6 oil wells; all weak flow, but gas well has supplied farm house for past three years.

1. RECORD OF WELL AT WALKER LAUNDRY COMPANY.

(Twelfth and Oak streets, Kansas City.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Earth	32	32
Pennsylvanian:		
Kansas City formation:		
Limestone	60	92
Shale	5	97
Limestone	25	122
Shale	5	127
Limestone	73	200
Pleasanton and Henrietta:		
Shale	67	267
GAS SAND	14	281
Shale	6	287
Red shale	12	299
GAS SAND	4	303
White sand	10	313
OIL SAND	13	326
Shale	47	373
GAS SAND	8	381
Shale	10	391
Limestone	4	395
Sand and salt water	10	405

2. RECORD OF WELL AT PRIER BRASS WORKS.

(Fifteenth and Big Blue River, Kansas City.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil	10	10
Sand	35	45
Gravel	8	53
Pennsylvanian:		
Pleasanton formation:		
Shale	20	73
Limestone	4	77
Shale	15	92
Red shale	5	97
Limestone	10	107
Shale	10	117
Henrietta and Cherokee:		
Limestone	2	119
GAS SAND	3	122
Lime	7	129
Shale	12	141
Limestone	5	146
Shale	8	154
Limestone	2	156
Shale	10	166
GAS SAND	12	178
Log missing	122	300

3. RECORD OF WELL OF DR. I. M. RIDGE.

(At Twentieth and Woodland streets, Kansas City.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil	10	10
Pennsylvanian:		
Kansas City formation:		
Limestone (Raytown)	5	15
Sandstone	20	35
Limestone, shaly (Cement City)	5	40
Limestone, solid (Cement City)	9	49
Sandstone	6	55
Limestone (Drum)	10	65
Sandstone	18	83
Limestone	2	85
Sandstone	7	92
Flint layers (Winterset)	12	104
Slate (Winterset)	2	106
Limestone (Winterset)	10	116
Shale, dark	7	123
Limestone (Bethany Falls)	24	147
Sandstone	5	152
Limestone (Hertha)	2	154
Pleasanton formation:		
Sandstone	10	164
Shale and limestone	3	167
Sandstone	84	251
Shale and limestone	8	259
Sandstone, GAS at 282	35	294
Shale and limestone	20	314
Sandstone	14	328
Coal	1	329
Henrietta formation:		
Limestone	5	334
Sandstone	8	342
Limestone	3	345
Sandstone	5	350
Slate, black, GAS and salt water	3	353
Sandstone	5	358
Limestone and sandstone	28	386
Cherokee shale:[1]		
Sandstone	8	394
Limestone	4	398
Shale, coal, GAS	4	402
Sandstone	6	408
Limestone	3	411
Sandstone	14	425
Limestone	1	426
Shale, bituminous, salt water	2	428
Limestone	8	436

[1]Contact approximately determined.

4. RECORD OF WELL ON HOUSE OF CORRECTION GROUNDS.
(N. E. ¼, N. W. ¼, Sec. 30, T. 49 N., R. 32 W.)

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Pleistocene and Recent:				
Earth	14	6	14	6
Pennsylvanian:				
Pleasanton formation:				
Yellow shale	2	—	16	6
Fire clay	35	—	51	6
Limestone, hard	9	—	60	6
Fire clay, light to dark	7	—	67	6
Brown umber, good	4	6	72	—
Sandy limestone, hard	2	—	74	—
Limestone, hard	36	—	110	—
Soapstone	6	—	116	—
Henrietta formation:				
Limestone, very hard	8	—	124	—
Fire clay, dark, shaly	1	—	125	—
Limestone	6	—	131	—
Fire clay, dark	6	6	137	6
Limestone	8	6	146	—
Shale, light	5	—	151	—
Shale, dark	6	—	157	—
Sandstone	4	—	161	—
Cherokee formation:				
Black slate, with salt water	—	6	161	6
Coal, first vein	1	6	163	—
Fire clay	2	—	165	—
Limestone	3	—	168	—
Soapstone	17	—	185	—
Sandy shells	1	—	186	—
Black slate, iron pyrites with GAS (Pressure of gas 125 to 150 lbs.)	1	—	187	—
Coal, 2nd vein, mixed with slate	4	—	191	—
Fire clay	5	—	196	—
Sandy shale	1	—	197	—
Fire clay	4	9	201	9
Slate, black	1	3	203	—
Fire clay, light to dark	66	6	269	6
Sandy shell, hard	1	—	270	6
Black shale and soapstone	2	—	272	6
Fire clay	33	—	305	6
Black slate	—	6	306	—
Coal, 3rd vein	1	—	307	—
Sandstone, soft	1	—	308	—
Sandstone, with partings of clay	6	—	314	—
Fire clay	7	—	321	—
Red rock	5	—	326	—
Fire clay	2	—	328	—
Soapstone, soft, blue	20	—	348	—
Coal, 4th vein	—	6	348	6
Fire clay	17	—	365	6
Coal, 5th vein	—	2	365	8
Fire clay	29	3	395	—
Soapstone	4	—	399	—
Fire clay	14	—	413	—
Soapstone, dark	7	—	420	—
Sandstone, soft, free	11	—	431	—
Kaolin, sandy	10	—	441	—
Sandy shale	4	—	445	—
Fire clay, shaly	7	6	452	6
Sandstone	17	—	469	6
Fire clay, dark	30	6	500	—
Shale, sandy	4	—	504	—
Fire clay	4	—	508	—
Shale, sandy crevice; salt water in crevice, strong brine, filled well to within 100 feet of top	2	—	510	—

5. LOG OF DEEP WELL, SW. ¼ SE. ¼ SEC. 20, T. 49 N., R. 32 W.

(Altitude reported about 920 feet.)

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Pleistocene and Recent:				
Soil	12	—	12	—
Pennsylvanian:				
Kansas City formation:				
Limestone (Cement City)	10	—	22	—
Shale	18	—	40	—
Limestone (Drum)	8	—	48	—
Shale, black	5	—	53	—
Fire clay, dark	6	—	59	—
Shale	10	—	69	—
Limestone (Bethany Falls and Winterset)	60	6	129	6
Shale, dark	3	—	132	6
Limestone	2	—	134	6
Shale, light	5	—	139	6
Limestone (Hertha)	15	—	154	6
Pleasanton formation:				
Shale	111	6	266	—
Shale, red	5	—	271	—
Sandstone	12	6	283	6
Shale	32	6	316	—
Henrietta formation:				
Limestone, hard	7	—	323	—
Fire clay, some water	3	—	326	—
Limestone	5	—	331	—
Shale, OIL at 344 feet	28	—	359	—
Limestone and shale	2	6	361	6
Cherokee shale:				
Shale, salt water	4	—	365	6
Fire clay	16	6	382	—
Sandstone and shale, dark	11	6	393	6
Coal, not good, has shale partings	3	6	397	—
Fire clay, some fresh water	5	—	402	—
Limestone	5	—	407	—
Fire clay	2	—	409	—
Limestone, hard	5	6	414	6
Fire clay, GAS at bottom	3	—	417	6
Shale, slaty	2	6	420	—
Shale and coal	1	—	421	—
Coal	3	6	424	6
Fire clay, some water	4	—	428	6
Shale	9	6	438	—
Not recorded, GAS with 60 to 80 pounds	42	—	480	—
Shale, OIL at bottom	20	2	500	2
Sandstone	2	3	502	5
Coal	2	7	505	—
Fire clay and shale, slaty	4	—	509	—
Limestone	1	—	510	—
Shale	—	8	510	8
Coal	3	—	513	8
Fire clay, blue	4	4	518	—
Limestone, hard	5	—	523	—
Shale, gray	18	—	541	—
Limestone (record imperfect)	3	—	541	3
Coal, little GAS (record imperfect)	10	3	551	6
Sandstone, fine, gray (record imperfect)	1	—	564	6
Shale, dark	1	6	566	—
Bone coal	3	—	569	—
Coal	4	—	573	—
Fire clay	27	—	600	—
Limestone	2	—	602	—
Fire clay	10	—	612	—

5. LOG OF DEEP WELL, SW. ¼ SE. ¼ SEC. 20, T. 49 N., R. 32 W.—Continued.

	Thickness.	Depth.
	Ft. in.	*Ft. in.*
Cherokee shale—Continued.		
Shale	28 —	640 —
Sandstone	18 —	658 —
Shale	7 10	665 10
Coal	1 8	667 6
Sandstone	16 3	683 9
Shale, dark	47 9	731 6
Mississippian:		
Limestones, various kinds	195 —	926 6
Sandstone	29 —	955 6
Shale	4 6	960 —
Limestone and sandstone	9 —	969 —

A strong flow of "sulphur" water was struck at this point and the drilling was stopped.

6. RECORD OF MASTIN NO. 2 WELL.

(Wyandotte street and Armour boulevard, Kansas City.)

	Thickness.	Depth.
	Feet.	*Feet.*
Pleistocene and Recent:		
Soils, soft clays and broken limestone	28	28
Pennsylvanian:		
Kansas City formation:		
Limestone	17	45
Shale, soft to slaty	30	75
Limestone	35	110
Limestone, sandy and flinty	10	120
Limestone	50	170
Limestone, hard	10	180
Limestone, with some partings	36	216
Pleasanton formation:		
Shale, slaty, and fire clay	14	230
Rock, red, soft	8	238
Shale, slaty	7	245
Shale	5	250
Shale, soft to slaty	50	300
Henrietta and Cherokee:		
Limestone	30	330
Shale, slaty	20	350
Sandstone	10	360
Shale, slaty	60	420
Limestone, OIL and WATER	12	432
Shale	18	450
Shale, black	23	473
Rock, shelly	4	477
GAS SAND	1	478

7. RECORD OF MASTIN WELL NO. 3, BETWEEN CENTRAL AND BROADWAY, SOUTH OF ARMOUR BOULEVARD.

Mouth of well about 942 feet above sea level. The upper part of this well is similar to Mastin well No. 2.

	Thickness.	Depth.
	Feet.	*Feet.*
No record	497	497
Pennsylvanian:		
Cherokee shale:		
Sandstone	95	592
Shale, slaty	103	695
Sandstone	10	705
Limestone and shale, slaty	45	750
Coal	3	753
Age doubtful:		
Limestone, on edge, diagonal, full of crevices	20	780
Sandstone	25	805
Limestone with shaly layers	15	820
Sandstone	10	830
Mississippian:		
Limestone, broken	130	960
Limestone, solid	42	1002

8. RECORD OF WELL OF BUCKNER OIL AND GAS COMPANY.
(NE. ¼ NE. ¼ Sec. 29, T. 50 N., R. 30 W.)

	Thickness.	Depth.
	Feet.	*Feet.*
Pleistocene and Recent:		
Soil, sand, and gravel	71	71
Pennsylvanian:		
Cherokee shale:		
Shale, light and dark	105	176
Limestone	4	180
Shale	65	245
Sandstone	5	250
Shale	66	316
Shale	40	356
Shale, sandy	95	451
Shale, black, hard	8	459
Sandstone, salt water	8	467
Shale, dark, hard	17	474
Shale, soft, GAS	3	477

9. RECORD OF WELL OF SCRUGGS & JOHNSON (MASTIN NO. 7).
(W. ½ NW. ¼ Sec. 36, T. 47 N., R. 33 W.)

	Thickness.	Depth.
	Feet.	*Feet.*
Pleistocene and Recent:		
Soil and clay	10	10
Pennsylvanian:		
Limestone	5	15
Rock, red	10	25
Shale, blue	10	35
Limestone	10	45
Shale, blue	46	91

9. RECORD OF WELL OF SCRUGGS & JOHNSON (MASTIN NO. 7)—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
Pennsylvanian—Continued.		
Limestone	33	124
Shale, bituminous, water	5	129
Shale, dark	100	229
Limestone	76	305
Shale, light	50	355
Shale, bituminous, water	5	360
Limestone	2	362
Shale, green	11	373
OIL SAND	6	379

10. RECORD OF DRILL HOLE AT PLANT OF HYDRAULIC-PRESS BRICK COMPANY.

(Located near intersection of Fifty-sixth street and Big Blue Valley. Altitude of surface about 760 feet.)

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Pleistocene and Recent:				
Drift and stiff blue clay	31	6	31	6
Shale, blue, hard, gritty	1	—	32	6
Gravel	1	6	34	—
Pennsylvanian:				
Pleasanton formation:				
Shale, blue	51	—	85	—
Shale light, 2 in. coal at top	7	6	92	6
Clay, green, red, streaks	7	6	100	—
Clay, red with green streaks	8	—	108	—
Sandstone, light	14	6	122	6
Shale, bluish, slaty	14	6	137	—
Sandstone or sandy limestone with flint	9	—	146	—
Shale, light, dark streaks	10	—	156	—
Henrietta formation:				
Limestone, light, very hard	2	—	158	—
Limestone, blue gray, rotten	20	—	178	—
Shale, light at top, dark, bituminous below	13	6	191	6
Shale, dark, bituminous	3	6	195	—
Limestone, dark, bituminous	2	6	197	6
Cherokee shale:				
Shale, slaty, GAS below (Lexington coal horizon)	1	—	198	6
Sandstone, gray, coarse, finer at bottom, salt water	8	6	207	—
Shale, ore limestone	2	—	209	—
Limestone, light clay partings	3	—	212	—
Shale, light, gritty, hard in middle, then soft, dark, oily*	19	—	231	—
Shale, slaty, coal (Summit)	3	—	234	—
Clay	10	—	244	—
Limestone, dark, shaly	6	—	250	—
Shale, dark blue, with some limestone	33	—	283	—
Shale, dark to light blue	27	—	310	—
Shale, slaty, black, hard with limestone cap	8	—	318	—
Clay	5	—	323	—
Shale, brown, fine, sandy	3	—	326	—
Shale, dark, brown, fine, sandy	14	—	340	—
Shale, black, slaty, coal (Bevier)	4	—	344	—
Clay, gritty, little limestone	2	—	346	—

*At this point the well tested 36,000 cubic feet of gas per 24 hours.

10. RECORD OF DRILL HOLE AT PLANT OF HYDRAULIC-PRESS BRICK COMPANY—Continued.

	Thickness.	Depth.
	Ft. in.	*Ft. in.*
Cherokee shale—Continued.		
Shale, slaty, coal	4 —	350 —
Sand, fine-grained at top, coarser at bottom	10 —	360 —
Clay, gritty, some limestone	13 —	373 —
Shale, slaty, and coal	2 —	375 —
Shale, blue, somewhat slaty	15 —	390 —
Shale, slaty	20 —	410 —
Shale, slaty, and coal	4 —	414 —
Clay, light blue, with little limestone	3 —	417 —
Shale, blue, hard and soft layers	11 —	428 —
Shale, black, slaty, with showing of coal and soft, white sandstone	4 —	432 —
Sandstone, soft, white, mixed with black shale	4 —	436 —
Shale, blue, sand and clay seams	5 —	441 —
Shale, light, sandy	3 —	444 —
Shale, dark, slaty	13 —	457 —
Shale, darker and more slaty	5 —	462 —
Shale, slaty, with sandstone	5 —	467 —
Sandstone, white to reddish, brown	2 —	469 —
Sandstone, white	16 —	485 —
Sandstone, white, fine-grained, compact	5 —	490 —
Sandstone, gray, coarse-grained	8 —	498 —
Shale, black, slaty, with coal and clay	4 —	502 —
Shale, dark, slaty, lower 18 feet pyritiferous	25 —	527 —
Shale, not so dark as above and contains sandy layers	16 —	543 —
Shale, like above but more sandy	11 —	554 —
Shale, dark but mixed with white clay shale to 562, gritty to 571; becomes lighter and contains pyrite to 583; lower 3 feet shows some sand	32 —	586 —
Sandstone, upper 6 ft. coarse, white, gradually getting finer to 599, coarser again to 608; from 608 to 614 sand is fine, white, micaceous and contains clay seams; at 614 it is tinged with yellow and contains slaty shale to 622 where it becomes dark brown to 626; lower 5 ft. lighter	46 —	631 —

11. RECORD OF WELL AT ST. JAMES HOTEL.
(Walnut street and Missouri avenue, Kansas City.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil and sand	32	32
Pennsylvanian:		
Kansas City formation:		
Limestone	5	37
Sandstone	8	45
Limestone, cherty	17	62
Sandstone (Winterset)	5	67
Limestone	15	82
Shale	9	91
Limestone (Bethany Falls)	12	103
Sandstone	5	108
Limestone (Hertha)	10	118
Pleasanton formation:		
Sandstone	42	160
Sandstone, fine	5	165
Sandstone	50	215
Limestone and shale	30	245

11. RECORD OF WELL AT ST. JAMES HOTEL—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
Pleasanton formation—Continued.		
Sandstone, GAS	18	263
Sandstone	13	276
Shale	10	286
Henrietta and Cherokee:		
Limestone	9	295
Sandstone	5	300
Sandstone, OIL and GAS	15	315
Sandstone	8	323
Shales, coal, GAS	2	325
Clay and sand	5	330
Limestone	5	335
Sandstone	5	340
Shale	3	343
Sandstone	13	356
Limestone	7	363
Shale, black, GAS	9	372
Limestone	1	373
Shale, black	2	375
Sandstone	15	390
Limestone	18	408
Sandstone and limestone	15	423
Sandstone	15	438
Shale, sandy	10	448
Sandstone	10	458
Limestone	1	459
Sandstone	9	468
Shale	15	483
Limestone	2	485
Shale, coal	3	488
Fire clay	3	491
Limestone	3	494
Slate	2	496
Shale, coal, water	1½	497½
Sandstone	8	505½
Limestone	8	513½
Sandstone	14	527½

Much of the sandstone reported in this record is probably shale.

12. RECORD OF WELL AT MT. WASHINGTON, NEAR INDEPENDENCE.
(Drilled for Mr. H. L. McElroy.)

	Thickness.	Depth.
	Feet.	*Feet.*
Pleistocene and Recent:		
Soil and clay	80	80
Pennsylvanian:		
Limestone, hard	30	110
Shale, gray, soft	20	130
Limestone, hard, seamed	31	161
Conglomerate (Limestone?), cherty	9	170
Limestone with shale and clay partings 2 to 15 feet thick	85	255
Sandstone, hard, "flinty"	10	265
Limestone, "laminated"	28	293
Shale, black and gray	27	320
"Rock," red	8	328
Limestone, shells and shale, in beds not over 1 foot thick	17	345
Sandstone and limestone	32	377

12. RECORD OF WELL AT MT. WASHINGTON, NEAR INDEPENDENCE—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
Pennsylvanian—Continued.		
Shale, gray and black	39	416
Sandstone, black, solid, said to resemble coal	4	420
Limestone, soft	25	445
Shale, soft	32	477
Sandstone	15	492
Shale, soft, with limestone layers	100	592
Sandstone	13	605
Shale, some layers tinged with red	100	705
Sandstone	25	730
Shale	15	745
Mississippian (?):		
Limestone (?), solid, lower 20 feet reported to lie on edge or diagonal; a crevice here caused the cuttings to be carried away	75	820
Not recorded	100	920
Clay, drab, soft and "loose" limestone	60	980
Mississippian:		
Limestone, white, soft, with partings 2 to 5 feet thick	225	1205

NOTE.—The above record is taken from a very imperfect log and closer correlations are impossible.

13. RECORD OF DR. J. P. KANOKY WELL NO. 4.
(Fairland Heights, near Independence.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil	30	30
Gravel	10	40
Pennsylvanian:		
Kansas City formation:		
Limestone (Bethany Falls)	12	52
Shale	8	60
Limestone (Hertha)	10	70
Pleasanton formation:		
Shale	3	73
Limestone	5	78
Shale	70	148
Shale	35	183
OIL SAND	5	188
Shale, red	5	193
Limestone	22	215
Shale	5	220
Shale	10	230
Henrietta formation:		
Limestone	8	238
Shale	7	245
Limestone	5	250
Shale	10	260
Limestone	5	265
OIL SAND	10	275
Cherokee shale:		
Shale	15	290
Limestone	5	295
GAS SAND	4	299
Shale	10	309

13. RECORD OF DR. J. P. KANOKY WELL NO. 4—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
Cherokee shale—Continued.		
Limestone	3	312
Shale	15	327
Limestone and shale	4	331
Shale, black, GAS	5	336
Shale	5	341
Sand	8	349
Shale	6	355
OIL SAND	75	430
Shale	5	435
Limestone	3	438
Shale, black	8	446
Shale, slaty, water	5	451

14. RECORD OF DR. J. P. KANOKY WELL NO. 5.
(Fairland Heights, near Independence.)

	Thickness.	Depth.
	Feet.	*Feet.*
Pleistocene and Recent:		
Soil	50	50
Gravel	11	61
Pennsylvanian:		
Kansas City formation:		
Shale	10	71
Limestone (Hertha)	5	76
Pleasanton formation:		
Shale	20	96
Limestone	10	106
Shale	15	121
Limestone	5	126
Shale	55	181
OIL SAND	5	186
Shale, red	8	194
Limestone	24	218
Shale	20	238
Henrietta formation:		
Limestone	10	248
Shale	7	255
Limestone	5	260
Shale	10	270
Limestone	5	275
Shale	10	285
Limestone	3	288
Cherokee shale:		
Shale	15	303
Limestone	6	309
Shale	5	314
Shale	20	334
Limestone	2	336
Limestone	3	339
Shale	12	351
Limestone	2	353
GAS SAND	8	361
Shale	10	371

15. RECORD OF WELL OF L. H. KNOCHE.
(SE. ¼ Sec. 20, T. 47 N., R. 33 W.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil	13	13
Gravel	5	18
Pennsylvanian:		
Kansas City formation:		
Limestone, gray (Bethany Falls)	14	42
Shale	5	37
Limestone	1	38
Shale	5	43
Limestone (Hertha)	12	55
Pleasanton formation:		
Shale, light	40	95
Limestone, shelly	10	105
Shale, dark	40	145
GAS SAND	5	150
Shale, light	15	165
Shale, dark	5	170
Shale, light	15	185
Shale, red	5	190
Shale, dark	32	222
Henrietta formation:		
Limestone	5	227
Shale	2	229
Limestone	5	234
Shale	4	238
Limestone	7	245
Limestone, hard	2	247
Limestone	3	250
GAS SAND	7	257
Cherokee shale:		
Shale, dark	10	267
Limestone	5	272
GAS SHALE, hard, bituminous	4	276
OIL SAND	5	281
Shale, white, sandy	32	313
Limestone	5	318
Shale, dark	20	338
OIL AND GAS SAND	27	365
Shale, dark	23	338
OIL SAND	14	402
Shale, dark	71	473
Shale, light	10	483
Shale, dark	12	495
Coal	7	502
Shale, dark	5	507
Shale, light	15	522
GAS SAND	25	547

16. RECORD OF WELL (OWNER UNKNOWN).
(Fairland Heights, near Independence.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil	30	30
Gravel	15	45

16. RECORD OF WELL (OWNER UNKNOWN)—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
Pennsylvanian:		
Kansas City formation:		
Limestone (Hertha)	8	53
Pleasanton formation:		
Shale	30	83
Limestone	5	88
Shale	45	133
Limestone	4	137
Shale	18	155
GAS and OIL SAND	10	165
Shale, red	4	169
Limestone	20	189
Shale	15	204
Henrietta formation:		
Limestone	4	208
Shale	10	218
Limestone	10	228
Shale	10	238
GAS and OIL SAND	8	246
Cherokee shale:		
Shale	5	251
Limestone	4	255
Shale	10	265
GAS SAND	6	271
Shale	3	274
Limestone	2	276
Shale	15	291
Shale	14	305
Limestone	2	307
Shale	7	314
Shale, black, slaty	4	318
Shale	5	323
OIL SAND	85	408
Shale	5	413
Limestone	3	416
Shale, black, GAS	4	420
Shale	35	455
Shale, white	10	465
Sand	15	480
Sand, water	45	525
Shale	10	535
Shale	143	678
Sand, water	15	693

17. RECORD OF WELL (OWNER UNKNOWN).

(Near Belton, Cass County, Sec. 1, T. 46 N., R. 33 W.)

	Thickness.	Depth.
	Feet.	*Feet.*
Pleistocene and Recent:		
Soil	5	5
Pennsylvanian:		
Kansas City formation:		
Clay, blue	15	20
Limestone	10	30
Shale, light	10	40
Shale, blue	40	80
Limestone, very hard (Bethany Falls and Winterset)	50	130

17. RECORD OF WELL (OWNER UNKNOWN)—Continued.

	Thickness.	Depth.
Kansas City formation—Continued.	*Feet.*	*Feet.*
Shale, blue	2	132
Coal (black shale)	3	135
Limestone, white (Hertha)	20	155
Pleasanton formation:		
Shale, blue	45	200
Shale, light	68	268
Shale, blue	15	283
Shale, light	20	303
Rock, red	5	308
Limestone, very hard	10	318
Shale, blue	30	348
Henrietta and Cherokee:		
Limestone, very hard	9	357
GAS SAND	10	367
Shale	5	372
Limestone, hard	10	382
GAS SAND	8	390
Shale, light	12	402
Sand, water	10	412
Shale, dark	7	419
Shale, bituminous	5	424
Shale, light	15	439
OIL SAND	20	459

18. RECORD OF WELL OF WITTE GAS ENGINE WORKS.
(Sixteenth and Oakland streets, Kansas City.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil	15	15
Sand	10	25
Gravel	8	33
Sand	30	63
Pennsylvanian:		
Pleasanton formation:		
Limestone	1	64
Gravel	9	73
Limestone	2	75
Shale	10	85
Limestone	6	91
Shale, red	4	95
Limestone	12	107
Shale	20	127
Henrietta formation:		
Limestone	3	130
Shale	30	160
Sand, GAS	10	170
Cherokee shale:		
Shale	4	174
Sand	6	180
Shale	12	192
Sand	4	196
Shale	153	209
Limestone	5	214
Shale	18	232
Sand, GAS	15	247
Shale	20	267
Sand	8	275
Sand, OIL	29	304

19. RECORD OF WELL OF J. N. DIETZ.*
(Thirty-third and Holly avenue, Kansas City.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil	11	11
Pennsylvanian:		
Limestone, gritty	2	13
Shale	11	24
"Soapstone," blue	6	30
Limestone	26	56
Slate	9	65
Limestone	61	126
Rock, flinty	14	140
Slate	3	143
Limestone	7	150
Slate	8	158
Limestone	17	175
Slate	10	185
Sandstone, shelly	9	194
Sandstone, soft	5	199
Coal and water	1	200
Limestone	3	203
Slate	10	213
Limestone	10	223
Shale, black, GAS	7	230
Sandstone, water	4	234
Soapstone and slate	6	240
Sandstone, water	73	313
Sandstone, water, coal, and GAS	74	387
Lignite (?) and coal	21	408
Sandstone	4	412
Shale	16	428
Slate, black	2	430
Limestone	5	435
Shale, sandy	10	445
Slate, dark	2	447
Shale and soapstone	29	476
Sandstone, water	41	517
Slate, gray	13	530
Limestone	20	550
Sandstone	6	556
Shale	12½	568½
Coal	1½	570
Clay	1½	571½
Shale, black	3½	575
Slate, gray	6	581
Slate, black	13	594
Coal	2½	596½
Sandstone, gray	5	601½

*Kansas City Journal, June 3, 1888.

20. RECORD OF WELL OF DR. W. E. MINOR.
(Near Red Bridge, about 3 miles south of Kansas City.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil	2	2
Gravel	3	5

20. RECORD OF WELL OF DR. W. E. MINOR—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
Pennsylvanian:		
Kansas City formation:		
Limestone (Bethany Falls)	15	20
Slate, black	5	25
Limestone (Hertha)	10	35
Pleasanton formation:		
Shale, light	121	156
Shale, dark	10	166
Shale, red	4	170
Shale, light	41	211
Henrietta and Cherokee:		
Limestone	7	218
Shale	15	233
Limestone	6	239
Shale	22	261
Limestone	5	266
Slate, black	3	269
GAS SAND	7	276
Shale	66	343
OIL SAND	12	354
Shale	46	400
Shale, dark	10	410
Limestone	3	413
Shale, dark, sandy	82	495
Shale	32	527
Shale, black	10	537
Shale	10	547
Limestone	15	562
GAS SAND	3	565

21. RECORD OF W. S. DICKEY WELL No. 1.

(Fifty-second and Holmes streets, Kansas City, Mo.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil	6	6
Clay	7	13
Pennsylvanian:		
Kansas City formation:		
Limestone (Part of Raytown)	1	14
Blue shale	4	18
Limestone	2	20
Shale	8	28
Red mud	2	30
Shale	3	33
Limestone (Cement City)	10	43
Black shale	5	48
Light shale	5	53
Limestone (Drum)	8	61
Shale	12	73
Limestone	2	75
Shale	4	79
Limestone (Winterset)	34	113
Brown shale	5	118
Limestone (Bethany Falls)	23	141
Black shale	2	143
Limestone (Hertha)	17	160

21. RECORD OF W. S. DICKEY WELL No. 1—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
Pleasanton formation:		
Brown shale	5	165
Limestone	3	168
Shale	92	260
OIL SAND	5	265
Shale	20	285
Red rock	3	288
Limestone	4	292
Shale	43	335
Henrietta formation:		
Limestone	4	339
Shale	2	341
Limestone	4	345
Shale	10	355
Limestone	6	361
Shale	10	371
Limestone	4	375
Cherokee formation:		
Black slate, GAS	4	379
Limestone	7	386
OIL SAND	12	398
Limestone	20	418
White shale	10	428
GAS SAND	9	437

22. RECORD OF W. S. DICKEY WELL NO. 2.

(At southeast corner of Fifty-first and Holmes streets; surface altitudes about 925 feet.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil	6	6
Clay	8	14
Pennsylvanian:		
Kansas City formation:		
Limestone (part of Raytown)	1	15
Blue shale	5	20
Limestone	2	22
Shale	9	31
Red mud	1	32
Shale	5	37
Limestone (Cement City)	10	47
Blue shale	6	53
Light shale	5	58
Limestone (Drum)	9	67
Shale	18	85
Limestone (Winterset)	35	120
Shale	4	124
Limestone (Bethany Falls)	23	147
Shale	2	149
Limestone (Hertha)	17	166
Pleasanton formation:		
Shale	30	196
Limestone and water	4	200
Shale	86	286
Red mud	6	292
Limestone	12	304
Shale	38	342

22. RECORD OF W. S. DICKEY WELL NO. 2—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
Henrietta formation:		
Limestone	7	349
Shale	3	352
Limestone	4	356
Brown shale	8	364
Limestone	8	372
OIL SAND	7	379
Shale	10	389
Limestone	7	396
Cherokee shale:*		
Dark shale and water	13	409
Limestone	3	412
OIL and sand	7	499
Limestone	7	426
White shale	10	436
Sand and GAS	14	450
Black slate	12	462
White shale	20	482
Sandy shale	47	529
Limestone	7	536
Black slate	6	542
Limestone	3	545
Sand	7	552
Dark shale	10	562
White shale	10	572
Dark shale	50	622
Sand and GAS	24	646
Shale	76	722
Dark slate, water and GAS	8	730
White shale	35	765
Dark shale	35	800
Limestone	18	818
Coal	2	820
Sand and salt water	30	850
Mississippian:		
Limestone	6	856

23. RECORD OF W. S. DICKEY WELL No. 3.

(In block bounded by Fifty-first, Fifty-second, Holmes and Rock Hill streets.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil	6	6
Clay	6	12
Pennsylvanian:		
Kansas City formation:		
Limestone (Raytown)	8	20
Blue shale	8	28
Limestone	2	30
Shale	9	39
Limestone (Cement City)	12	51
Shale	9	60
Limestone (Drum)	8	68
Shale	19	87
Limestone	21	108
Shale (Winterset)	4	112
Limestone	12	124

23 RECORD OF W. S. DICKEY WELL No. 3—Continued.

	Thickness.	Depth.
Kansas City formation—Continued.	*Feet.*	*Feet.*
Shale	5	129
Limestone (Bethany Falls)	27	156
Blue shale	2	158
Limestone (Hertha)	14	172
Pleasanton formation:		
Shale	7	179
Red rock	3	182
Shale	33	215
Sand and GAS	15	230
Shale	50	280
OIL SAND	7	287
White shale	13	300
Red rock	8	308
Shale	68	376
Henrietta formation:*		
Limestone	7	383
Shale	12	395
Limestone	6	401
Cherokee shale:		
Black slate and water	4	405
Limestone	7	412
OIL SAND	9	421
Limestone	5	426
Shale	6	432
Limestone	3	435
Shale	23	458
Black slate	9	467
Shale	48	515
Sand and water	18	533
Limestone	2	535
Shale	4	539

*The Pleasanton probably includes about 25 feet of the Henrietta, as the 68 feet of shale is much above the normal thickness shown in the other wells in the same locality.

24. RECORD OF W. S. DICKEY WELL NO. 4.

(In block bounded by Fifty-first, Fifty-second, Holmes and Rock Hill streets.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil	9	9
Pennsylvanian:		
Kansas City formation:		
Limestone (Cement City)	6	15
Shale	12	27
Limestone (Drum)	12	39
Shale	18	57
Limestone	22	79
Shale (Wirterset)	4	83
Limestone	17	100
Black shale	3	103
Limestone (Bethany Falls)	19	122
Shale	2	124
Lime shells and water	3	127
Limestone (Hertha)	12	139

24. RECORD OF W. S. DICKEY WELL No. 4—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
Pleasanton formation:		
Red rock	4	143
Shale	30	173
Limestone	4	177
Shale	71	248
OIL SAND	5	253
Shale	16	269
Limestone	4	273
Shale	47	320
Henrietta formation:		
Limestone	5	325
Shale	2	327
Limestone	5	332
Shale	3	335
Limestone	6	341
Sand and GAS	8	349
Shale	4	353
Limestone	7	360
Cherokee shale:		
Shale	34	394
Limestone	2	396
Brown shale	22	418
Black slate	6	424
Shale	12	436
White shale	15	451
Sandy shale	34	485
Water sand	15	500

25. RECORD OF W. S. DICKEY WELL NO. 5.

(Corner of Fifty-second and Troost, Kansas City, Mo.)

	Thickness.	Depth.
	Feet.	*Feet.*
Pleistocene and Recent:		
Soil	18	18
Pennsylvanian:		
Kansas City formation:		
Limestone	3	21
Shale	6	27
Limestone (Cement City)	9	36
Shale	19	55
Limestone (Drum)	10	65
Shale	10	75
Limestone	22	97
Shale (Winterset)	4	101
Limestone	15	116
Shale	7	123
Limestone (Bethany Falls)	15	138
Shale	3	141
Limestone (Hertha)	20	161
Pleasanton formation:		
Shale	4	165
Red rock	6	171
Shale	20	191
Limestone	4	195
Shale	69	264
OIL SAND	7	271
Limestone	4	275
Shale	15	290

25. RECORD OF W. S. DICKEY WELL No. 5—Continued.

	Thickness.	Depth.
Pleasanton formation—Continued.	*Feet.*	*Feet.*
Red rock	4	294
Limestone	4	298
Shale	36	334
Henrietta formation:		
Limestone	6	340
Shale	12	352
Limestone	7	359
Shale	23	382
Limestone	6	388
Cherokee shale:		
Shale, dark	25	413
Limestone	6	419
Shale	8	427
Limestone	4	431
Shale (GAS)	14	445
Black shale	5	450
Shale, dark	41	491
GAS SAND	3	494

26. SEE RECORD UNDER "UNDERGROUND WATERS."

27. RECORD OF ROSEDALE WELL NO. 1.

(At plant of Kansas City Rolling Mills Co., Rosedale, Kansas.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Surface	23	23
Pennsylvanian:		
Kansas City formation:		
Limestone (Bethany Falls and Hertha)	40	63
Pleasanton formation:		
Soapstone	180	243
Henrietta and Cherokee:		
Limestone	8	251
Coal	3	254
Green shale	20	274
Black slate, GAS	6	280
Soapstone	20	300
Black slate, GAS	8	308
Green shale	20	328
Limestone	1	329
Coal	5	334
Soapstone	11	345

28. RECORD OF ROSEDALE WELL NO. 2.

(One-half mile nearer Kansas City than No. 1 (27.)

	Thickness.	Depth.
Pleistocene and Recent:	*Ft. in.*	*Ft. in.*
Surface	14 —	14 —

28. RECORD OF ROSEDALE WELL No. 2—Continued.

	Thickness.	Depth.
Pennsylvanian:	*Feet.*	*Feet.*
Kansas City formation:		
Limestone (Bethany Falls)	5 —	19 —
Soapstone	2 —	21 —
Limestone (Hertha)	10 —	31 —
Pleasanton formation:	118 —	149 —
Soapstone	3 6	152 6
Soapstone	59 —	211 6
Henrietta and Cherokee:		
Limestone	5 —	216 6
Black slate, GAS	2 6	219 —
Soapstone and limestone	15 —	234 —
Soapstone	40 —	274 —
Sand shale	1 6	275 6
Soapstone	9 —	284 6
Limestone	2 6	287 —
Soapstone	19 —	306 —
Limestone	2 4	308 4
Soapstone	4 —	312 4
Black slate, GAS	1 8	314 —
Coal	— 10	314 10
Fire clay	1 6	316 4
Limestone	4 5	320 9

29. RECORD OF ROSEDALE WELL No. 3.
(One-fourth mile southwest of well No. 27.)

	Thickness.	Depth.
Pleistocene and Recent:	*Ft. in.*	*Ft. in.*
Surface	18 —	18 —
Pennsylvanian:		
Kansas City formation:		
Limestone (Bethany Falls)	21 —	39 —
Black slate	2 —	41 —
Limestone (Hertha)	15 —	56 —
Pleasanton formation:		
Soapstone	75 —	131 —
Limestone	2 —	133 —
Soapstone	60 —	193 —
Limestone	5 —	198 —
Soapstone	35 —	233 —
Henrietta and Cherokee:		
Limestone	5 —	238 —
Soapstone	10 —	248 —
Coal	— 4	248 4
Soapstone	2 —	250 4
Sand shale, salt water	11 —	261 4
Black slate	9 —	270 4
Soapstone	6 —	276 4
Black shale	15 —	291 4
Soapstone	10 —	301 4
Limestone	1 —	302 4
Soapstone	82 —	384 4
Limestone	18 —	402 4
Soapstone	4 —	406 4
Limestone	2 —	408 4
Slate and GAS	4 —	412 4
Soapstone	2 —	414 4
Sand shale	16 —	430 4

30. RECORD OF ROSEDALE WELL NO. 4.

(One-fourth mile north of No. 27.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Surface	13	13
Pennsylvanian:		
Kansas City formation:		
Limestone (Bethany Falls)	20	33
Black shale	2	35
Limestone	5	40
Soapstone	8	48
Limestone (Hertha)	10	58
Pleasanton formation:		
Soapstone	127	185
Limestone	5	190
Soapstone and limestone	15	205
Soapstone	8	213
Limestone	4	217
Soapstone	7	224
Henrietta and Cherokee:		
Limestone	10	234
Black slate, GAS	2	236
Limestone	3	239
Black slate	8	247
Limestone	7	254
Black shale	10	264
Soapstone	5	269
Limestone	5	274
Black slate	5	279
Limestone	10	289
Black shale	5	294
Limestone	2	296
Black shale	4	300
Soapstone	6	306
Limestone	3	309
Slate	2	311
Limestone	2	313
Gray shale	3	316
Black slate	2½	318½
Coal	2	320½
Sand shale	10	330½

31. RECORD OF WELL OF J. A. PAULIN.

(One-half mile southeast of Argentine, Kansas.)

	Thickness.	Depth.
Pennsylvanian:	*Feet.*	*Feet.*
Kansas City formation:		
Limestone, clay, and dark shale	30	30
Limestone	2	32
Slate, dark, hard	8	40
Limestone, light	70	110
Pleasanton formation:		
Shale, red, soft	10	120
Shale, black, soft	7	127
Shale, dark, soft	12	139
Slate, dark, soft	6	145
Shale, green and dark, soft	64	209
Limestone, light, hard	2	211
Sand, soft, dry, GAS	18	229
Shale, soft, green	55	284

31. RECORD OF WELL OF J. A. PAULIN—Continued.

	Thickness.	Depth.
	Ft. in.	*Ft. in.*
Henrietta formation:		
Limestone, hard	21	305
Sand, top dark and hard, GAS	18	323

32. RECORD OF BORING IN KANSAS CITY NEAR OLD UNION STATION.

	Thickness.	Depth.
Pleistocene and Recent:	*Ft. in.*	*Ft. in.*
Drift	37 —	37 —
Pennsylvanian:		
Kansas City formation:		
Limestone, blue, fine-grained (Bethany Falls)	21 —	58 —
Clay, light blue	1 —	59 —
Clay, dark colored	4 —	63 —
Limestone, gray (Hertha)	13 —	76 —
Pleasanton formation:		
Clay shale, dove-colored	100 —	176 —
Clay, sandy, bituminous (bitumen rose to surface)	4 —	180 —
Clay	84 —	264 —
Henrietta formation:		
Limestone, brown, bituminous	4 —	268 —
"Soapstone"	5 —	273 —
Limestone	18 —	291 —
Clay, drab	4 —	295 —
Limestone, light buff	23 —	318 —
Cherokee shale:		
Clay and soapstone, dove-colored	24 —	342 —
Clay, arenaceous, dove-colored	23 —	365 —
Clay, dark and shelly coal	5 —	370 —
Clay, dark, blue, micaceous	25 —	395 —
Sandstone, dark blue, fine-grained	37 —	432 —
Shale, dark, salt water	2 —	433 —
Coal	— 4	433 4
Fire clay	10 —	443 4
Clay and limestone ("marlite")	5 8	449 —
Dark slate and coal, fossil plants, salt water, flowing	1 6	450 6
Coal, dense, bright	— 6	451 —
Clay and limestone	16 —	467 —
Sandstone, gray, coarse, strong brine	12 —	479 —
Sandstone gray, fine-grained	10 6	489 6
Clay, blue	3 6	493 —
Clay and soapstone	7 —	500 —
Clay, dark-gray, sandy	119 —	619 —
Shale, black	3 —	622 —
Coal	1 —	623 —
Clay, sandy	50 —	673 —
Thinly laminated dark shale and sand	6 —	679 —
Shale, black, bituminous	3 —	682 —
Coal	1 8	683 8
Clay and mud	16 4	700 —
Mud	34 10	734 10
Sandstone, dark, mottled, crystalline	10 2	745 —
Mississippian:		
Limestone, vitreous, crystalline	13 —	758 —

*Broadhead, G. C., Geol. Survey of Missouri, Iron ores and coal fields, pt. 2, p. 86, 1873.

33. RECORD OF WELL OF ED. H. WITTE.

(Three miles south of Independence, on Raytown Road.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Clay, yellowish	6	6
Pennsylvanian:		
Kansas City formation:		
Limestone, hard (Iola)	12	18
Shale, mostly blue	20	38
Limestone (Raytown)	5	43
Limestone, very hard (Raytown)	2	45
Blue shale with some shelly limestone	7	52
Shale, soapstone, bluish	5	57
Shale, red	5	62
Shale, blue	4	66
Limestone (Cement City)	6	72
Shale	26	98
Limestone, very hard (Drum)	4½	102½
Shale	13½	116
Limestone	3	119
Shale	1	120
Limestone	2	122
Shale, bluish	2	124
Limestone, hard (Winterset)	27	151
Shale, somewhat slaty, different colors, mostly blue	9	160
Limestone (Bethany Falls)	20	180
Soapstone	4	184
Limestone	5	189
Shale	3	192
Limestone (Hertha)	11	203
Pleasanton formation:		
Shale ("Big Shale")	95	298
White shale	10	308
Blue shale	4	312
Red shale	26	338
Blue shale	12	350
White shale	6	356
Henrietta formation:		
Limestone	3	359
Shale	17	376
Shale and limestone, mixed	18	394
Limestone, very hard	5	399
Cherokee shale:		
Sandy shale	3	402
Shale and sandstone, salt water	90	492

34. RECORD OF WELL OF SWIFT PACKING COMPANY.

(West of Kansas River, north of Kansas avenue.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Filled earth	4	4
Blue sandy loam	5	9
Gray sand (water)	37	46
Blue clay	3	49
Coarse sand and gravel (water)	30	79
"Concrete" gravel	3	82
Pennsylvanian:		
Pleasanton formation:		
Blue limestone	8	90

34. RECORD OF WELL OF SWIFT PACKING COMPANY—Continued.

	Thickness.	Depth.
Pleasanton formation—Continued.	*Feet.*	*Feet.*
Blue shale	28	118
Gray limestone	5	123
Blue limestone	27	150
Blue limestone	13	163
OIL SAND (2 bbls. per day)	1	164
Blue shale	11	175
Green shale	19	194
Gray shale	22	216
Blue shale	11	227
Henrietta and Cherokee:		
Gray limestone	24	251
Blue-black shale	36	287
Blue limestone	11	298
"Lignite"	2	300
Blue shale	9	309
Soft coal	1	310
Gray limestone	11	321
Gray shale	14	335
OIL, sand, and GAS	1	336
White limestone	6	342
Gray shale	8	350

35. RECORD OF WELL OF D. M. PROCTOR.

(Seventy-fourth and Mercier, Kansas City.)

	Thickness.	Depth.
Recent:	*Feet.*	*Feet.*
Soil	12	12
Pennsylvanian:		
Soft brown shale	10	22
Blue slate	75	97
Blue limestone, hard	23	120
Light slate	40	160
Gray limestone	20	180
Blue slate	30	210
Dark limestone	40	250
Dark slate	35	285
White limestone	15	300
White slate	50	350
Limestone	20	370
Dark slate	25	395
Red mud	8	403
Blue slate	20	423
White limestone	30	453
Blue slate	22	475
Black slate	19	494
Sand, little GAS	8	502
White slate	40	542
White limestone	20	562
Black slate	50	612
White slate	12	624
Gray limestone	21	645
Black, sandy slate	30	675
White slate	37	712
Black slate	20	732
White sand with soft water	4	736

32. ANALYSIS OF GAS FROM WELL AT 2416 TRACY AVENUE.*

Constituent.	Per cent.
Methane, marsh gas (CH_4)	87.20
Ethane (C_2H_6)	7.03
Carbon dioxide (CO_2)	.60
Nitrogen (N)	3.65
Oxygen (O)	.10
Carbon monoxide (CO)	.20
Helium (He)	.01
Ethylene (C_2H_4)	1.20
Other constituents	.01
Total	100.00

57. ANALYSIS OF GAS FROM WELLS OF KANSAS CITY BOLT AND NUT COMPANY.*

Constituent.	Per cent.
Methane, marsh gas (CH_4)	92.90
Carbon dioxide (CO_2)	.83
Nitrogen (N)	5.43
Oxygen (O)	.20
Carbon monoxide (CO)	.10
Helium (He)	.04
Ethylene (C_2H_4)	.50
Total	100.00

*Analysis, Hamilton P. Cady and David F. McFarland. Published in Am. Chem. Soc. Jour., vol. 29, p. 1530, 1907.

WATER RESOURCES.

The water supplies of Jackson county are derived from both surface and underground sources. The surface supplies are obtained from streams, chiefly Missouri River, or from rainfall caught in cisterns and ponds, while the underground waters are drawn from springs or wells.

SURFACE WATERS.

Missouri River.—Kansas City and Independence obtain their water supply from Missouri River, the water being purified by settling and treatment with lime and iron sulphate. In a period extending from October 4, 1906, to October 21, 1907, investigations were made as to the quality of Missouri River water in the vicinity of Kansas City.[1] During this period the

[1]Parker, N. H., quality of the water supplies of Kansas. U. S Geol. Survey, Water Supply Paper 273, pp. 209-210, 1911.

discharge of the Missouri at Kansas City ranged from 15,500 to 229,600 cubic feet per second, averaging about 76,000 cubic feet. The river carries away suspended matter at the rate of 1,000 to 2,606,000 tons per day, averaging 567,500 tons, while the dissolved matter ranged from 3,320 to 187,320 tons per day, with a daily average of 102,000 tons. The average turbidity was found to be 1,909 parts per million, and the average amount of suspended matter, 2,032 parts per million, the average coefficient of fineness being 1.04. The following is the average analysis:

AVERAGE ANALYSIS OF MISSOURI RIVER WATER TAKEN NEAR KANSAS CITY.

	Parts per million.
Silica (SiO_2)	37
Iron (Fe)	0.73
Calcium (Ca)	62
Magnesium (Mg)	18
Sodium and potassium (Na+K)	44
Bicarbonate (HCO_3)	202
Sulphates (SO_4)	135
Nitrate (NO_3)	2.2
Chlorine (Cl)	13
Total dissolved solids	426

Big Blue River.—An analysis of the water of Big Blue River at Mastin, Kansas, near Martin City, was made by the Missouri Pacific Railway.[1]

ANALYSIS OF BIG BLUE RIVER WATER TAKEN AT MASTIN, KANSAS.

	Parts per million.
Silica (SiO_2)	17
Iron (Fe)	1.3
Calcium (Ca)	95
Magnesium (Mg)	7.7
Sodium and potassium (Na+K)	4.4
Carbonate (CO_3)*	146
Sulphate (SO_4)	29
Chlorine (Cl)	5.3
Organic and volatile	19
Total solids	326

*Obtained by cumputation to ionic form; results originally stated as in hypothetical combination.

[1]Op. cit., p. 208.

Precipitation.—In normal years the precipitation in Jackson county is over 36 inches, an amount sufficient for ordinary purposes if the reservoir and catchment surfaces are of proper size.

UNDERGROUND WATERS.

Over most of Jackson county, water may be obtained by shallow-dug wells, and this is the common source of domestic and farm supplies in the districts outside of Kansas City and Independence. Springs are also an important source of water in many parts of the county, some of them being of commercial importance as producers of medicinal and table waters. Both of these sources of water supply, however, are so commonly subject to seasonal variations that many landowners prefer to drill deeper wells, considering that the larger supply to be obtained in this way will overbalance the chances of the water being highly mineralized.

Shallow wells.—Most of the shallow wells draw their water from the surficial deposits, those on the uplands obtaining it from the residual soil, those farther north from the loess and drift, and those in the draws, swales, and on the flood plains from the alluvium. In the southern part of the county the upland wells are usually 25 or 30 feet deep; occasionally some extending to a depth of 50 or 60 feet, entering the rock beneath the residual soil. The upland wells in the northern part of the county appear to be somewhat more variable in depth, but as a rule they are deeper than those in the southern part. The water enters mainly at the base of the loess or the drift, both of which are somewhat thicker than the residual soil farther south. The water in these wells is generally of good quality, and in seasons of normal rainfall the quantity is sufficient for ordinary farm or household purposes.

Wells in the valleys as a rule extend to the base of the alluvium; consequently, their depth depends largely on the thickness of the alluvium. The quality of the water is good and the supply is usually larger than is needed. In the abandoned valley at Lake City, Buckner, and Levasy, wells 60 or 70 feet deep find an abundance of good water.

Springs.—Springs are a common and much-used source of water in all parts of Jackson county. So far as is known, all have local catchment areas and none are deep-seated. While some vary more or less with the rainfall, and some are little more

than seeps during the greater portion of the year, many of them issue from near the contact between a limestone and an underlying shale, some of the largest coming from the base of the Iola limestone.

The well-jointed, black slaty shales also give rise to springs. These, however, are for the most part small and the waters from some of them emit a faint odor of hydrogen sulphide (H_2S).

As has already been said, several Jackson county springs are commercially important as producers of table and medicinal waters. Reports of production of Cusenbary Springs, Jackson Lithia Springs, Vaile Springs, and White Springs, all situated near Independence, have been made to the state in recent years.[1] A discussion of some of these and other springs in Jackson county is given in another report of this Bureau[2] and will not be repeated here. The following analyses of the water of some of the springs is given:

ANALYSES OF SPRING WATERS OF JACKSON COUNTY.

(Parts per million.)

Constituent.	1	2	3	4
Silica (SiO_2)	18.0	26.4	57.0	120
Alumina (Al_2O_3)	55.0	.6	.....	.....
Ferric oxide (Fe_2O_3)	.....	1.6	18.0	.....
Lime (CaO)	122.0	141.2	14.8	127.8
Magnesia (MgO)	14.5	28.0	2.2	85.7
Potash (K_2O)	4.9	4.7	.....	.....
Soda (Na_2O)	19.7	18.8	421.7	640.7
Lithia (Li_2O)	.....	.....	.....	2.6
Chlorine (Cl)	4.0	16.0	.....	736.7
Sulphur trioxide (SO_3)	8.3	8.3	.....	309.2
Carbon dioxide (CO_2)	223.6	296.6	562.8	49.3
Water in combination (H_2O)	47.8	58.9	115.1	.....
	527.8	595.6	1,191.6	1,964.0
Oxygen (O)	.9	3.6	.....	166.7
Mineral matter	526.9	592.0	1,191.6	1,797.3
Fixed residue	362.3	384.8	795.1	.....

1. Cusenbary Springs, near Independence (NE. ¼, SW. ¼, Sec. 33, T. 50 N., R. 32 W.).

2. Jackson Lithia Springs, near Independence (NW. ¼, Sec. 32, T. 50 N., R. 32 W.). Analyst, P. Schweitzer, Geol. of Mo., vol. 3, p. 138, 1892.

3. Greenwood Springs; flows from Bethany Falls limestone, near Greenwood. Analyst, P. S. Schweitzer, Geol. Survey of Mo., vol. 3, p. 139, 1892. Contains also some lithium (Li), a trace of potassium (K) and hydrogen sulphide (H_2S).

4. Spring of Dwight Austin, southwest of Lees Summit (NE. ¼, NW. ¼, Sec. 29, T. 47 N., R. 32 W.). Analyst, unknown, U. S. Geol. Survey Water Supply Paper 102, p. 431 1904.

[1] In the collection of mineral production statistics in co-operation with the U. S. Geol. Survey.

[2] Schweitzer, P. A., report on the Mineral Waters of Missouri: Geol. Survey of Mo., vol. 3, p. 256, 1892.

Deep wells.—The prospect of obtaining a supply of good water from deep wells in Jackson county is not encouraging. In 20 wells on which water data have been obtained, there are 12 in which the driller specifically reports salt water, and in one of the twelve a single fresh-water horizon is reported in addition. In the remaining 8 the character of the water is not mentioned, but it is extremely probable that it is salty.

The largest flow is to be obtained from the sandstones in the Cherokee shale, the sandstone at the base, where present, giving the largest volume so far as known. Under favorable structural conditions, some of the Cherokee waters will rise to a height of 700 feet or more above sea level. The well records given in chapter III and those under "Gas and Oil," furnish many data on the depth to aquifers.

The following analyses indicate the extreme salinity of three of the deep wells, but as all of them are in Kansas City, the waters cannot be said to be typical of the deep waters throughout the county.

ANALYSES OF DEEP WELL WATERS OF KANSAS CITY.

(Parts per million.)

Constituent.	1	2	3	4
Silica (SiO_2)	2	4	69.8	20.5
Alumina (Al_2O_3)	.....	.....	.....	11.1
Ferric oxide (Fe_2O_3)	.....	.....	.....	47.1
Ferrous carbonate ($FeCO_3$)	.....	.....	100.5	.....
Calcium carbonate ($CaCO_3$)	67	109	899.1	444.2
Magnesium carbonate ($MgCO_3$)	.....	.....	268.4	157.9
Sodium carbonate (Na_2CO_3)	.....	.....	144.1	261.4
Calcium sulphate ($CaSO_4$)	24	11	77.5	.....
Magnesium sulphate ($MgSO_4$)	.....	.....	.....	12.8
Calcium chloride ($CaCl_2$)	1,166	1,196	.....	246.2
Magnesium chloride ($MgCl_2$)	785	871	.....	.....
Sodium chloride (NaCl)	24,420	25,090	25,150.8	21,056.2
Potassium chloride (KCl)	370	380	.....	608.1
Carbon dioxide (CO_2) (free)	.....	.....	376.2	293.4
Mineral matter	26,834	27,661	27,086.4	23,158.9

1. W. S. Dickey well, Fifty-first and Holmes. Water from 250-foot level; partial analysis made at laboratory of the Bureau of Geology and Mines.

2. W. S. Dickey well, Fifty-first and Holmes, from 450-foot level; partial analysis made at the laboratory of the Bureau of Geology and Mines.

3. Young's medicinal well, Twenty-fifth and Vine; analysis by C. C. Hamilton, about 1890.

4. Magneso-Saline Mineral Sp.ings (well), Kensington and Cincinnati; analyses by C. C. Hamilton and R. R. Hunter, August, 1891.

RECORD OF WELL, SWOPE PARK, NORTHEAST OF DISTRICT FOREMAN'S HOUSE.

(The well was drilled in 1905 by Bailey and Waugh. The collar of the hole is 874 feet above sea level.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Gravel and soil	4	4
Soil and boulders	20	24
Pennsylvanian:		
Kansas City formation:		
Limestone, blue	90	114
Pleasanton formation:		
"Soapstone"	37	151
"Soapstone"	13	164
Limestone, white	12	176
Shale, dark	24	200
Limestone, blue	15	215
Clay, red	6	221
Shale, gray	44	265
Henrietta formation:		
Limestone, white	15	280
Shale	10	290
Limestone, white	14	304
Cherokee shale:*		
Shale, sandy, gas	11	315
Shale, black	4	319
Limestone	3	322
Shale	13	335
Limestone	10	345
Shale, sandy	10	355
Shale, blue	40	395
Limestone, salt water	4	399
Shale, blue	25	424
Shale, black	15	349
Limestone	2	441
Shale, sandy	30	471
Limestone	4	475
Shale, blue	50	525
Shale, black	20	545
Shale, white	15	560
Shale, blue	60	620
Shale, black	25	645
Sand, salt water	105	750
Mississippian:		
Limestone and flint	10	760
Limestone, white	40	800
Limestone and flint	35	835
Sand, water	25	860
Limestone and flint	40	900
Limestone	20	920
Limestone, sandy	40	960
Sandstone, water	20	980
Limestone	20	1000
Limestone and flint	30	1030
Limestone	10	1040
Shale, black	8	1048
Limestone	2	1050
Shale	3	1053
Limestone and flint	26	1079
Flint, white	16	1095
Fire clay	4	1099
Limestone	7	1106
Fire clay	9	1115
Limestone and flint	10	1125

*Contact approximately determined.

RECORD OF LONG VIEW FARM WELL NO. 1.
(About 4 miles west of Lees Summit.)

	Thickness.	Depth.
Recent:	*Feet.*	*Feet.*
Soil	4	4
Clay	6	10
Gravel	2	12
Pennsylvanian:		
Kansas City formation:		
Limestone (Bethany Falls-Hertha)	30	42
Pleasanton formation:		
Shale	12	54
Limestone	25	79
Shale	121	200
Henrietta formation:		
Limestone	12	212
OIL SAND	3	215
Shale	15	230
Water sand	6	236
Limestone	11	247
Cherokee shale:		
Shale	83	330
Road rock	6	336
Limestone	14	350
Shale	9	359
Limestone	15	374
Shale	66	440
Blue sand and salt water	4	444
Shale	110	554
Black slate	8	562
Shale	38	600
Coal	2	602
Shale	13	615
Limestone	4	619
Sand	31	650
Limestone	16	666
Blue sand, termed by driller (Mississippian limestone)	69	735

Lab. No.	Limestone Ledge.	Locality.	Calcium carbonate	Magnesium carbonate	Insoluble	Iron oxide and alumina	Moisture	Total	Remarks.
	Hertha	Crebo & Co., old quarry (near Leeds)	91.81	2.35	4.65	1.22	.....	100.03	Mo. G. S., vol. VI, 2nd series, Lime and Cement, p. 235.
1	Bethany Falls	Dolese Bros. quarry (SE. ¼, Sec. 34, T. 47 N., R. 31 W., ¼ mile S. of Greenwood)	91.34	1.36	2.82	1.52	0.13	97.15	
13	" "	Old quarry (SE. ¼, NW. ¼, Sec. 6, T. 49 N., R. 31 W.—1½ miles east of Independence)	92.98	1.45	3.49	1.68	0.16	99.76	
16	" "	Old quarry (NW. ¼, NW. ¼, Sec. 11, T. 50 N., R. 31 W.—1½ miles south of Atherton)	93.24	1.39	3.19	1.31	0.02	99.15	
19	" "	Old quarry (NE. ¼, NW. ¼, Sec. 33, T. 49 N., R. 30 W.—2 miles east of Blue Springs)	93.95	1.29	2.12	1.20	0.04	98.61	
23	" "	McTernin and Halpin quarry (Swope Parkway and Chestnut St.)	88.09	3.77	1.35	5.25	.....	98.45	
24	" "	Lyon quarry (Swope Parkway and Bellefontaine)	96.20	1.00	0.51	1.34	.....	99.05	
29	" "	Kansas City Portland Cement Works (Cement City)	94.28	1.37	0.43	1.82	.....	97.90	
	" "	Outcrop (two miles north of Lees Summit)	93.35	1.15	4.31	0.60	.....	99.41	Mo. G. S. vol. VI, 2nd series, Lime and Cement, p. 144.
	" "	Outcrop (River bluff east of oil refinery)	96.45	1.46	2.73	0.53	.....	101.17	Mo. G. S., vol. VI, 2nd series, Lime and Cement, p. 144.
	" "	Outcrop (south of Oak Grove)	96.51	0.09	3.28	0.48	.....	100.36	Mo. G. S., vol. VI, 2nd series, Lime and Cement, p. 144.
	" "	Outcrop (south of Grain Valley)	95.35	1.10	3.35	0.60	.....	100.40	Mo. G. S., vol. VI, 2nd series, Lime and Cement, p. 144.
	" "	Kansas City Portland Cement Works (Cement City)	95.29	1.50	3.30	2.00	.....	102.09	Analyzed by P. F. Belfour.
5	Winterset	Outcrop along road—lower portion (NE. ¼, SE. ¼, Sec. 14, T. 47 N., R. 30 W.—1½ miles northwest of Lone Jack)	94.30	1.54	2.29	1.00	0.14	99.27	
6	"	Old quarry—lower portion (NW. ¼, Sec. 12, T. 47 N., R. 30 W.—2 miles southwest of Lees Summit)	90.70	2.43	2.63	1.70	0.05	97.51	
9	"	Quarry—middle portion (SW. ¼, SE. ¼, Sec. 25, T. 48 N., R. 32 W.—2 miles northwest of Lees Summit)	86.60	4.57	5.54	2.65	.....	99.36	
15	"	Old quarry—lower portion (NW. ¼, NW. ¼, Sec. 11, T. 50 N., R. 31 W.—1½ miles south of Atherton)	92.71	1.20	3.25	0.93	0.20	98.29	
22	"	Old Quarry—middle portion (Swope Parkway and terminus of Blue valley car line)	90.33	1.41	3.87	3.34	.....	98.95	
33	"	Kansas City Portland Cement Works—upper portion (Cement City)	79.00	8.82	3.79	7.18	.....	98.79	
35	"	Kansas City Portland Cement Works—upper portion (Cement City)	46.96	0.46	47.32	3.79	.....	98.53	
	"	Kansas City Portland Cement Works—lower portion (Cement City)	78.64	6.13	9.76	5.74	.....	100.27	Analyzed by P. F. Belfour.
	"	Kansas City Portland Cement Works—middle portion (Cement City)	94.68	3.52	2.70	1.66	.....	102.56	Analyzed by P. F. Belfour.

	"	Kansas City Portland Cement Works—middle portion (Cement City)	62.69	23.92	8.46	4.76	.....	99.83	Analyzed by P. F. Belfour.
40	Drum.....	Lyle Rock Co. quarry—oolitic (Second and Highland streets).....	87.36	3.81	4.61	3.23	.....	99.01	
	"	Kansas City Portland Cement Works—Bull ledge (Cement City)....	87.44	2.78	4.52	3.86	.....	98.60	Analyzed by P. F. Belfour.
	"	Lyle Rock Co. quarry—Bull ledge (Second and Highland streets)....	86.40	6.36	4.73	2.61	.....	100.10	Mo. G. S., vol. VI, 2nd series, Lime and Cement, p. 144.
	"	Lyle Rock Co. quarry—oolitic (Second and Highland streets).....	92.03	3.18	2.32	2.09	.....	99.62	Mo. G. S., vol. VI, 2nd series, Lime and Cement, p. 144.
38	Cement City....	Lyle Rock Co. quarry (Second and Highland streets).....	90.90	2.50	2.54	3.67	.....	99.61	
	Cement City....	Lyle Rock Co. quarry (Second and Highland streets).....	91.04	1.52	6.56	1.07	.....	100.19	Mo. G. S., vol. VI, second series, Lime and Cement, p.144.
20	Raytown.....	Outcrop on road (SW. ¼, NW. ¼, Sec. 36, T. 49 N., R. 31 W.—Blue Springs).....	93.96	1.40	0.58	2.96	.....	98.90	
28	"	Doarn quarry (23rd street and West Bluff).....	94.07	1.20	1.02	2.36	.....	98.65	
10	Iola.....	Randall quarry—upper portion (Independence).....	91.97	3.19	1.16	0.58	0.13	98.03	
11	"	Randall quarry—middle portion (Independence).....	93.13	2.49	1.02	1.48	0.12	98.24	
12	"	Shaw quarry—near base (Independence).....	83.93	6.38	4.75	3.55	0.08	98.69	
36	"	Bluff near Kansas City Portland Cement Works (Cement City)....	91.63	3.15	0.66	4.17	.....	99.61	
	"	Southerland Stone Co. quarry (27th and Vine streets).....	94.71	2.71	2.08	0.86	.....	100.36	Mo. G. S., vol. VI, 2nd series, Lime and Cement, p. 144.
	"	Independence.....	96.13	1.24	0.99	0.66	.....	99.02	Mo. G. S., vol. VI, 2nd series, Lime and Cement, p. 144.
	"	Kansas City Portland Cement Works (Independence).....	97.42	0.52	0.94	0.99	.....	.....	Mo. G. S., vol. VI, 2nd series, Lime and Cement, p. 146.
	"	Kansas City Portland Cement Works (Independence).....	97.41	.....	0.46	0.92	.....	.....	Mo. G. S., vol. VI, 2nd series, Lime and Cement, p. 146.

SHALE.

Lab. No.	Shale Ledge.	Locality.	Silica	Alumina	Iron oxide	Lime	Magnesia	Potash	Soda	Moisture—105°	Loss on ignition + 105°	Total	Remarks.
3	Pleasanton	1½ miles east of Greenwood (SE. ¼, Sec. 34, T. 47 N., R. 31 W.)	54.10	22.96	5.55	1.57	3.54	4.27	1.22	1.36	5.84	100.41	
4	"	1½ miles N. W. of Lonejack (SE. ¼, NW. ¼, Sec. 13, T. 47 N., R. 30 W.)	59.31	15.18	3.08	4.64	3.02	3.18	3.09	0.94	7.48	99.92	
7	"	4 miles N. E. of Lees Summit (SW. ¼, SE. ¼, Sec. 22, T. 48 N., R. 31 W.)	55.26	21.06	8.68	0.56	3.29	3.35	1.19	0.72	6.37	100.48	
17	"	1 mile east of Courtney (SW. ¼, SE. ¼, Sec. 17, T. 50 N., R. 31 W.)	61.09	18.70	6.07	0.16	3.30	3.17	2.52	0.18	5.12	100.31	
18	"	2 miles N. W. of Sni Mills (SE. ¼, SE. ¼, Sec. 18, T. 48 N., R. 29 W.)	63.23	17.50	5.37	0.82	2.36	2.80	2.70	0.34	5.34	100.46	
21	"	1½ miles west Pink Hill (SW. ¼, SW. ¼, Sec. 13, T. 49 N., R. 30 W.)	54.10	23.33	7.27	1.06	2.72	4.15	2.59	2.52	2.32	100.06	
	"	Diamond Plant, Hydraulic Pressed Brick Co. (56th St. and Elmwood Ave.)	54.80	23.73	8.67	0.64	2.23	3.80	.....	.....	6.00	.....	Analysis furnished by Supt.
2	Ladore	Dolese Bros. quarry—bituminous layer (SE. ¼, Sec. 34, T. 47 N., R. 31 W.—¼ mile south of Greenwood)	37.00	14.29	7.89	4.32	2.22	3.50	1.40	1.44	28.15	100.21	
	Galesburg	Kansas City Portland Cement Works—lower portion (Cement City)	62.86	18.13	3.61	2.44	1.92	.....	.....	.....	8.64	.....	Analyzed by P. F. Belfour.
	"	Kansas City Portland Cement Works—bituminous layer (Cement City)	51.08	17.73	4.57	3.96	2.86	.....	.....	.....	14.90	.....	Analyzed by P. F. Belfour.
	"	Kansas City Portland Cement Works—top (Cement City)	25.12	8.00	3.50	28.68	3.40	.....	.....	.....	28.26	.....	Analyzed by P. F. Belfour.
31	"	Kansas City Portland Cement Works—bituminous layer (Cement City)	47.97	18.17	5.92	4.50	2.58	3.75	1.83	1.26	12.82	99.07	
32	Cherryvale	Kansas City Portland Cement Works (Cement City)	49.18	25.52	0.28	7.24	2.67	2.68	0.89	1.02	11.00	100.48	
34	"	Kansas City Portland Cement Works (Cement City)	52.78	16.92	7.26	5.37	2.09	3.40	1.65	1.64	9.32	100.43	
41	"	Lyle Rock Co. quarry (Second and Highland streets)	55.38	23.05	3.91	1.50	2.80	3.10	2.01	1.39	7.30	100.44	

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