MISSOURI BUREAU OF GEOLOGY AND MINES.
E. R. BUCKLEY, Ph. D., Director and State Geologist.

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THE

Geology of Morgan County

BY

C. F. MARBUT.

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LETTER OF TRANSMITTAL.

BUREAU OF GEOLOGY AND MINES,
ROLLA, Mo. December 1, 1907.

To the President, Governor Joseph W. Folk, and the Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen—It is my pleasure to transmit to you a detailed report on "The Geology of Morgan County," by Professor C. F. Marbut, prepared in accordance with instructions issued by the preceding Board of Managers.

This is the third of a series of detailed county geological reports which it has been planned to issue covering the counties in the State for which geological reports of this character have not been published.

There has been some delay in the issuance of this report, owing to other duties which commanded most of the time of the author.

I remain, very respectfully,

Your obedient sir,

E. R. BUCKLEY,
Director and State Geologist.

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ACKNOWLEDGMENTS

The author desires to acknowledge the uniform kindness and interest manifested by the people of Morgan county toward the members of the Survey party and in the work of the Survey. We were treated with uniform kindness by everyone with whom we came in contact.

Special acknowledgments are due Mr. D. E. Eaton, formerly County Surveyor, and Mr. George B. Clark of Versailles, for assistance rendered.

To the two young men, Mr. A. T. Sweet and Mr. Otto Veatch, who were geological aids in the field, no small part of the credit for this work is due. The report is based to a considerable extent on their notes and more than half of the southern part of the County was mapped by them.

INTRODUCTION.

The field work for this report was begun several years ago and has been continued for a short time each summer up to the present year. This is one of a group of three counties, situated on the north flank of the Ozark plateau, which was selected for the purpose of studying in detail the Ozark stratigraphy.

Since the publication of the report on "The Geology of Miller County," which is Vol. I, of this series, reconnoissance work has been carried on in many parts of the Ozark region, throwing additional light on the broad aspects of the geology of the region as a whole.

The difficulty experienced by Professor Marbut in recognizing the boundaries or contacts of the formations as mapped in Miller county by Ball and Smith is a condition which everywhere confronts one in a detailed study of the Ozark region. Nevertheless, there still appears to have been ample justification in thus separating the Ozark series into formations having more or less indefinite and arbitrary boundaries. The groups of beds making up the various formations may be clearly recognized almost anywhere in the Ozark region where the succession is represented in its entirety, although there may be some difficulty in locating the boundaries between these formations.

The formation called St. Elizabeth, in the Miller county report, is in this volume called Roubidoux. Further, the Gunter sandstone is no longer mapped as a separate formation, but is now included in the Gasconade, of which it is considered the basal member. These changes in nomenclature are the outcome of an attempt to harmonize the work of the Federal and State Geological Surveys.

It will be observed that in this report the author has given no special attention to the brecciated or conglomeratic masses, termed "Saline Creek cave-conglomerate" in the report on Miller county. This does not mean that they are absent, but that they were not considered of sufficient importance to deserve special notice. The

author's attention was called to this formation in the field and its significance fully explained. It was my intention that this deposit should be described in the same manner as any of the other fragmentary deposits found associated with the Cambrian strata. It is especially interesting as evidence of post-Cambrian solution with subsequent filling.

It is believed that the author has presented a clear exposition of the economic resources of the county. From his observations there appears to be very little hope of any extensive mining developments in the county. Such deposits of lead and zinc ore as have been found, occurred near the surface, gradually decreasing in richness with depth. It appears that as soon as the solid rock is reached nothing but thin stringers of ore continue below, and that these eventually die out.

These deposits are excellent examples of ore bodies formed by descending solutions.

Morgan county has suffered greatly by the attempt on the part of certain real estate men to exploit as "coal lands," tracts containing occasional pockets of coal. There are no extensive coal fields in this county, and the sooner the public accept this as a fact, the better it will be for the people of Morgan county and for the would-be investor. The coal which occurs in pockets is well worth exploiting for local consumption, and for this purpose it is a valuable local asset; but it is not sufficiently extensive to warrant the installation of modern machinery for mining and handling.

The people of this country should not be deluded into believing that all poor farming land, if it be hilly, contains valuable deposits of minerals. Because a country is hilly and barren is no reason for believing that it is rich in minerals.

The deposits of lead, zinc, coal, clay, barite and iron should be exploited wherever they occur in quantity sufficient to pay for mining. It is a mistake, however, to exaggerate the importance of any deposit; it is harmful to the country and only serves to hinder developments.

It is hoped that this volume will serve as a guide to those who desire to investigate the resources of Morgan county.

E. R. BUCKLEY,
State Geologist.

GENERAL VIEW OF GRASSY OPEN WOODLANDS.
Proctor Creek Basin.

CHAPTER I.

PHYSIOGRAPHY AND FORESTRY.

Location, Outline and Area.—Morgan county lies a little southwest of the central part of the state. The latitude of its southern boundary is about 38° 10′ and that of its northern boundary 38° 40′. The longtitude of its eastern boundary is about 92° 40′, and its western 92° 2′. Its neighboring counties are from the north around by the east, Cooper, Moniteau, Miller, Camden and Benton.

The county boundaries have no relation whatever to natural features excepting for a few miles at the eastern end of the south line and for an equally short distance at the western end of the same line. The rest of the boundary line runs in right lines, following section and township lines excepting across the northeastern part where the line runs northwestward and southeastward. Along the south line of the county the Osage river offers an admirable natural boundary, but it was not placed in this position.

The shape of the county is more irregular than that of most counties in the state. By far the greater number are rectangular or nearly so. Practically all the counties which do not have a rectangular shape are Missouri and Mississippi river border counties and those in the second tier from the river.

Not all the counties, however, which lie in this position, have irregular shapes. The rectangular shape of the Missouri counties is determined by the rectangular system of land lines in the state and the smoothness of the county. When there are no dominating natural objects to determine the position and course of the county lines, the latter run with the land survey lines. Where the trend of dominating natural features coincides with the trend of the land survey lines there is no deviation of the county lines from their usual north-south and east-west courses. It is only when the dominating natural features trend in either a northwest-southeast or in a northeast-southwest course that the county boundaries deviate from the usual course and the county outlines become irregular. The great rivers, in the absence of mountain ranges, are the

main and almost the only natural features within or along the boundaries of the state of Missouri which are of sufficient prominence to cause the deviation of the county lines from the usual courses.

Most of the Mississippi river border counties are irregular in shape because of the general southeastward course of that stream and the tendency of each county to run its lines parallel and perpendicular to the river. The course of the Missouri river across the state is nearly due eastward in two stretches with a southeastward stretch connecting them. Morgan county is in the second tier of counties back from this southeastward stretch. Moniteau county lies along the river with its lines parallel and perpendicular to the river. This necessitated the truncation of the northeastern corner of Morgan county. The size of Morgan county is about an average of the counties of the state, its area being about 650 square miles.

The following sketch map shows the position, shape and size of the county.

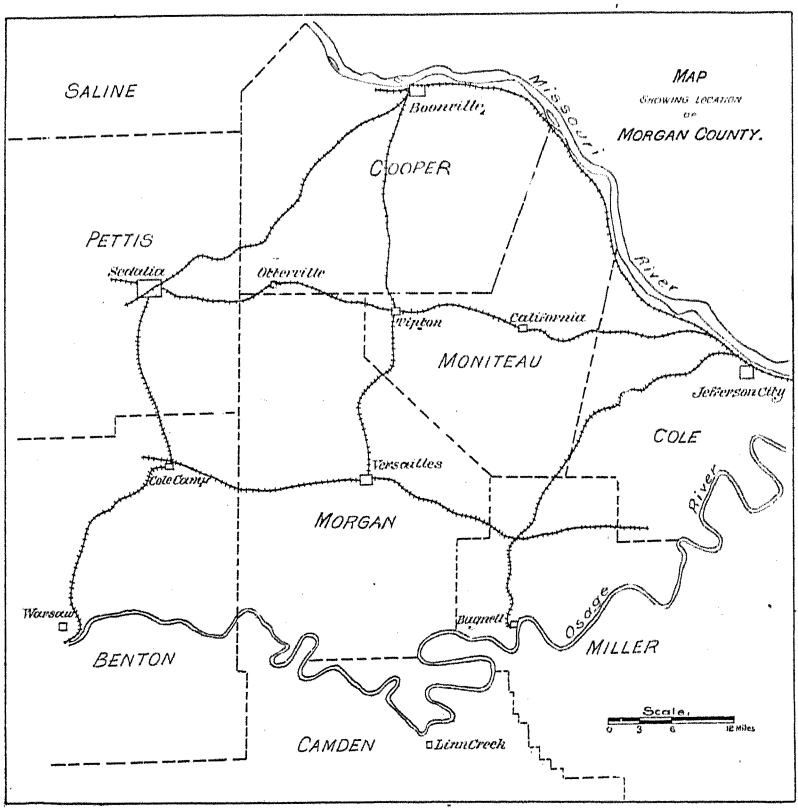
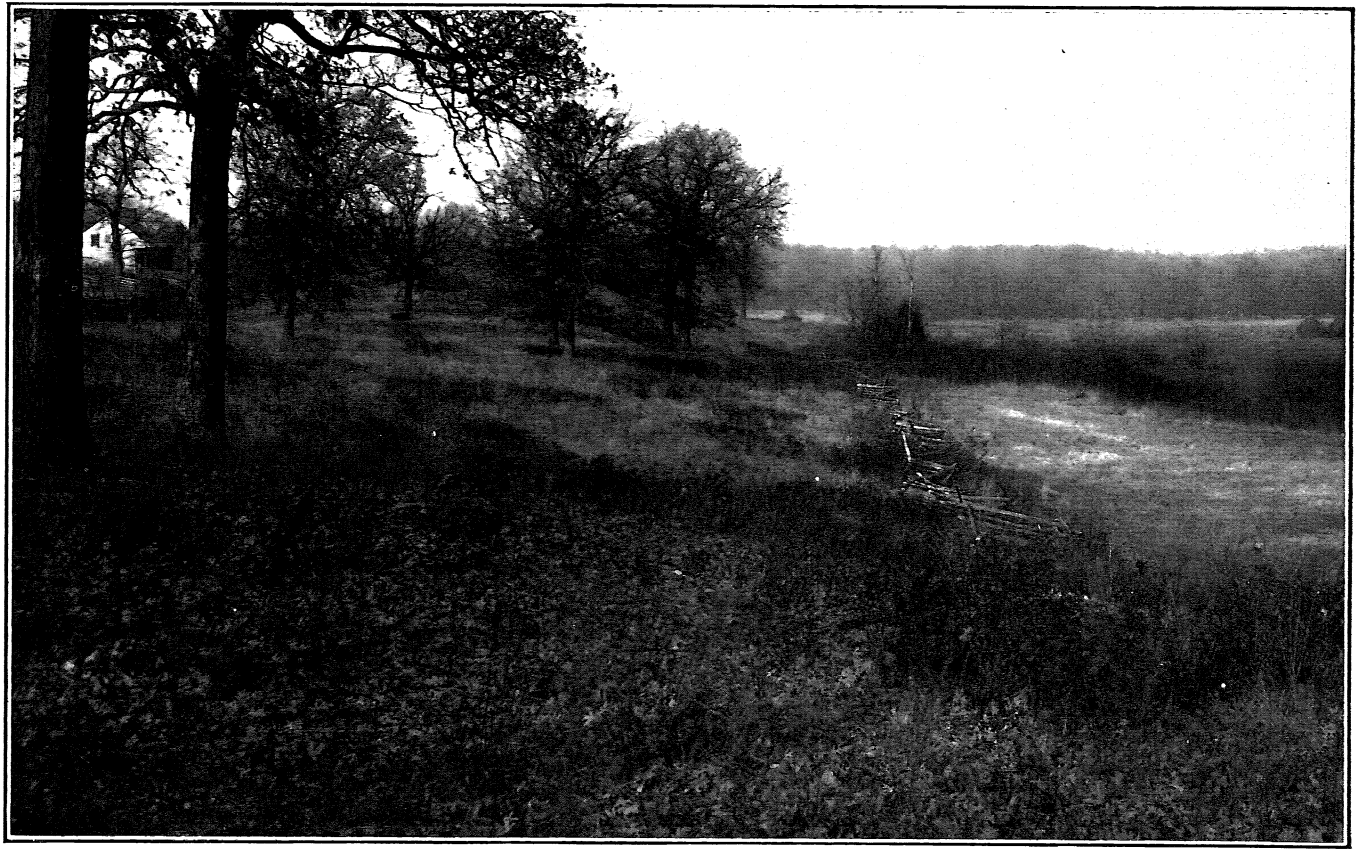


Figure 1.



GENTLE SLOPES OF UPPER MILL CREEK VALLEY.
Sec. 20, T. 40 N., R. 17 W.

PHYSIOGRAPHY.

Topography.—The surface of Morgan county consists of a slightly warped plain with valleys. Across it runs two lines of maximum elevation, one due to crustal movements, the other to erosion. The former line has a northwest-southeast course entering the county in the southeastern part of township 40 N., range 18 W. From this locality it follows the watershed between Gravois creek on one side and Proctor and Buffalo creeks on the other. Northwest of the heads of these streams it becomes gradually less noticeable, until it disappears entirely in the northwestern part of the county. The highest point on this line is near where it is crossed by the other line of maximum elevation. This is about three miles northwest of the Buffalo mines, where the elevation reaches a maximum of 1,165 feet A. T. Southeast of this the highest point is about 1,150 feet A. T. Elsewhere the elevation varies from 1,000 to the maximum given above.

The other line of maximum elevation is merely the main watershed of the county. It is not due to land movement, at least not directly, but merely marks the present status of a drainage conquest that has been going on since the existing drainage of this part of the state became well estsablished. It is a slowly shifting divide, being continually driven farther and farther northward by the activity of the southward flowing streams. Its general course is east and west, although much less direct than that of the other line. Its elevation, excepting where it is crossed by the line above described, is about 1,000 feet above sea level. North of this line, there is a gradual slope of the upland plain northward or, where influenced by the northwest-southeast line, northeastward.

South of this line there is a sudden drop of about 100 feet, except on the watersheds, and thence southward the country remains at about the same elevation. This sudden drop and the lower elevation of the country south of the main watershed is without much doubt due to recent erosion. The original plain before dissection was higher than that portion lying on and north of the main watershed at the present time. How far southward it continued to rise or would rise, had it not been reduced by erosion, is impossible to determine, although it probably extended to the south line of the county. Except for erosion the topography of Morgan county would consist of a gently northward sloping plain warped by a low ridge running northwest and southeast along the existing Buffalo-Proctor-Gravois watershed.

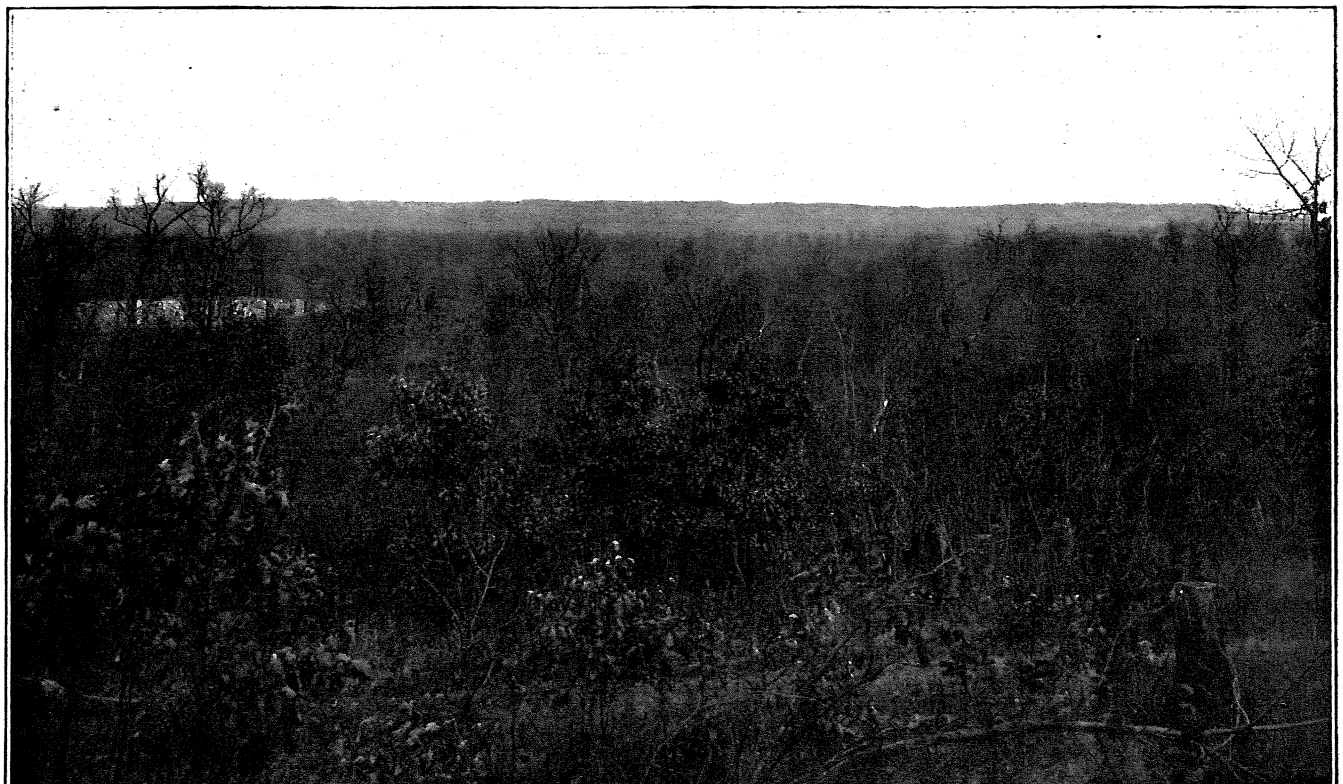
The whole of the county lies on the northern, or rather the northwestern, slope of the Ozark region, and the original northward sloping plain just referred to above is nothing more than a portion of the structural slope of the region. The continuity of this slope is interrupted in the southern part of Morgan county by the dissected belt adjacent to the Osage river and for the northern part of the county by that of the tributaries of Moreau and LaMine rivers, as well as by the uplift referred to above.

The main topographic features of the county therefore consist of an area or belt of dissected country in the southern part and a plain of much less pronounced dissection in the northern part of the county. The latter is a slightly modified portion of the original structural slope of the Ozark region, one in which the modification by dissection has not been sufficient to destroy the evidence of its relation to the region as a whole. The former is a profoundly modified portion of the same region, in which the erosion has been sufficient not only to dissect it completely, but to change the direction of its general slope. It is only its position therefore that determines its original character. Both these features, the plain and the dissected area with the ridge which interrupts the surface of both extend beyond the boundaries of Morgan county. The ridge extends southeastward into Camden county; the plain exists on the crest of the Ozark region south of the Osage river; and the Osage dissected belt extends far to the southeast and to the west of Morgan county.

The Dissection.—The whole of the area lying south of the main watershed of the county is maturely dissected, no areas of undissected even upland exist. The main ridge tops, while not level, are not made up of a succession of hills and saddles. The dissection has reduced them to narrow belts, but has not extended across them yet. The whole region is one of rugged hills, and widely branching, dendritic drainage lines. The depth of the dissection reaches a local average of about 250 to 300 feet.

Along a belt of varying width, extending from the main watershed northward for a few miles, the dissection is very shallow and not intricate. The country still remains approximately in the condition of the whole county before dissection. It is a smooth or gently undulating prairie.

Northwardly, however, the streams draining it cut deeper and their tributaries become more and more numerous, until they produce another area of complete dissection over the northwestern part



VIEW EASTWARD ACROSS PROCTOR CREEK FROM SEC. 7, T. 40 N., R. 18 W.

The steep westward slope of the Proctor Anticline is seen in the distance.

of the county, except that part lying north of LaMine river. Narrow belts along the two main branches of Moreau river are well dissected also. The dissection in the northern part of the county is much less deep however than that in the southern.

The streams have shallow valleys rarely reaching 100 feet, and the valley bottoms, except those of the small creeks, have strips of flat alluvium varying in width from a few hundred feet to a quarter of a mile.

The LaMine river-Richland creek region of the northwestern part of the county is much more thoroughly dissected than the northeastern portion or the central belt along the main watershed. Parts of this corner of the county approach the southern half of the county in thoroughness, though not in depth of dissection. The many branches of Richland creek and Haw creek, all unite to form LaMine river which takes a short but meandering course to the Missouri river. They are able to cut their valleys down to considerable depth therefore.

The streams draining the northeastern part of the county on the other hand, reach the Missouri through the Moreau river, which has a very long course before reaching a large stream or one with a low grade. The distance in a direct line from the head of the Moreau to that of the mouth of the stream is much greater than that from the head of Richland creek to the mouth of the LaMine. The actual distance, however, along the Moreau is much greater than that of a straight line on account of the excessively meandering course of that stream. The LaMine has a meandering course also, but not to the extent of the Moreau. The head of the Moreau is about twice as far from its mouth as the head of Richland creek from the mouth of the LaMine. The dissection at a given distance from the head of the Moreau cannot be so deep, therefore, as at a corresponding point on Richland creek. The result is that the Moreau country is less deeply and less completely dissected than that drained by Richland creek.

The line between the central belt of smooth undissected country, and the dissected portion of the northern part of the county is not a sharp one. The same streams drain both areas. They have their beginning on the southern border of the former so that within it they are all very small. At first their slope is not much greater than the slight northward slope of the country. Across it, therefore, their valleys remain shallow. It is only by their gradual slope northward and the somewhat less slope of the upland in this

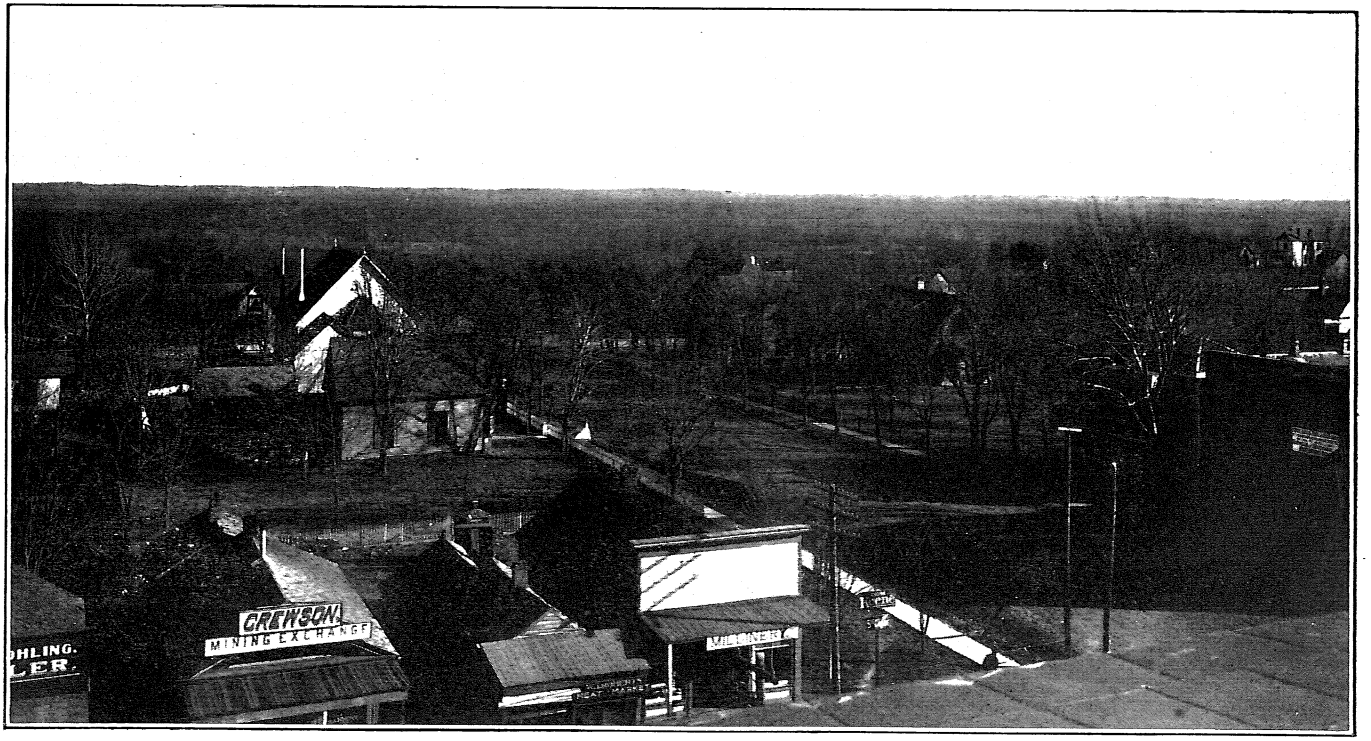
direction that they are enabled to dissect the country. The change from the shallow valleys of the central plain into and through the dissected area lower down stream is gradual though much more rapid along Richland than along Moreau creek.

The streams in the central belt are not younger than in the dissected belt in the northern part of the county. Even in the former they have reached grade and have developed flood plains which are continuous with those of the same stream further down. The flood plains near the heads of the streams are nearly as high as the prairie itself, and since the Moreau grade is less rapid than that of Richland creek, there is a wider belt of undissected country on the Moreau side of the county than on the Richland side.

The boundary line between the central smooth belt and the southern dissected area is very sharp and distinct. All the streams flowing southward plunge down suddenly from the level of the high prairie. They head in steep narrow hollows, often not more than 175 feet deep, but on account of the steepness of their descent and the sharp contrast between them and the streams flowing into the Moreau on the north, the depth appears to be greater. Their shallowness, however, does not lessen their sharpness, while the dissection on this side is everywhere sharp, it is not everywhere equally so, toward the western part of the county it is less so than in the eastern part. That part of it reached by the tributaries of Gravois creek is sharp. That reached by the tributaries of Buffalo creek is somewhat less so.

The dissection south of the central area is sharp and complete from the heads of the streams. None of the drainage of the central belt is southward, therefore, the sharpness and thoroughness of the dissection, as well as its greater depth than in the northern part of the county, are due to the shortness of the streams from their heads to the Osage river, which is the master stream in this part of the county and whose bed is as low as that of the Missouri due north of the northern part of the county. The Osage, however, lies within the county, while the Missouri is 40 miles north of it. All the southward flowing streams, therefore, have great advantage over those flowing northward. Hence the great contrast in depth and completeness of dissection on opposite sides of the Missouri-Osage watershed.

Maximum Local Relief.—The greatest difference between the level of a valley and the top of the adjacent hills in the southern



VIEW SOUTHEASTWARD FROM VERSAILLES.

The High Ridge is seen to Drop to the Lower Grade Plain Level just to Right of Middle of the View.

part of the county is a little more than five hundred feet. This occurs in the southwestern part of the county between the level of the mouth of Proctor creek and the top of the hill at the head of east Proctor on and near the Versailles and Proctor road. It will be remembered that this is along the line of the northwest southeast ridge described under the head of the upland surface. Proctor creek valley is the deepest valley in the county. Eastward and westward, the upland slopes down to a lower level, while the creeks all being at grade and all graded with respect to the Osage river, have valley bottoms at very nearly the same level. The local relief over most of the southern part of the county is less than three hundred feet and more than two hundred.

Local differences of dissection occur within this region that are almost as marked as that between the northern and southern parts of the county. These differences are due to the different lengths of the streams doing the work. Proctor creek has a narrow drainage basin. Its tributaries are all short. Therefore, they plunge down rapidly from the high ridges, especially the one on the east side of the creek which is highest. These tributaries are but little more than a mile or so in length. East of Proctor creek, the master stream is Gravois. All the drainage therefore from within about two miles of Proctor creek on the east, flows into the Gravois, a distance of about eight miles. These eastward flowing streams, therefore, must have shallow valleys in their upper courses because their length is so great they cannot cut deep at their heads. This is particularly the case with Mill and Soap creeks, and also, but to a less degree, of Brushy creek and all its branches. North of Brushy, the main valley of the Gravois lies so much farther to the west than it does farther south that its tributaries, like Locust creek cut down rather rapidly from their heads.

Mill and Soap creek valleys are about 200 feet deep where they enter the Gravois near Gladstone, but their rise westward being more rapid than that of the upland they soon become shallow, open troughs with alluvial strips along the stream. Their rise continues gradual to the ridge at their heads. Their upper valleys are so shallow and the slopes so gentle that a large area of country around their heads is level enough to be cultivated, if done intelligently. On account of the stony nature of the soil, however, much of it will not be put under the plow for a long time.

if ever. This is the smoothest part of the southern half of the county, considered as a whole.

The streams west of Proctor creek flow southward directly to the Osage river rather than westward away from Proctor creek to some master stream like the Gravois on the east. There is therefore not such a great contrast between the valleys on this side, nor are there any wide high valleys like those of Mill and Soap creeks on the other side of Proctor.

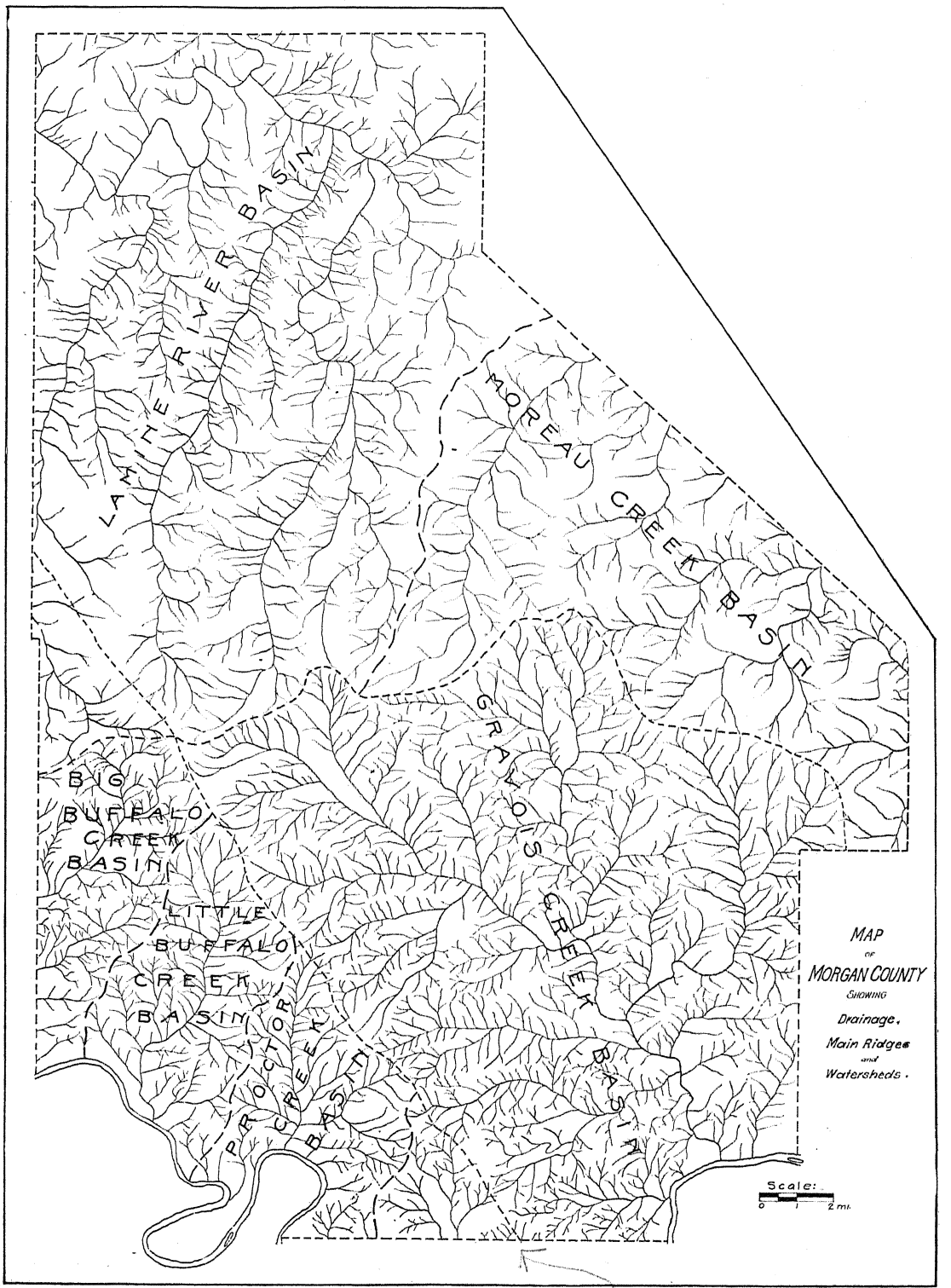
The two streams within the area of the county whose valleys lie west of Proctor creek are the two Buffalo creeks. The local relief along Little Buffalo, although the smaller stream of the two, is considerably greater than along Big Buffalo. The reason, however, is not far to seek. Little Buffalo valley lies nearer Proctor creek and the high country along the Proctor anticline. It lies high up, so to speak, on the western slope of the ridge made by the anticline. Big Buffalo on the other hand lies farther west where the upland is lower. They both cut their valleys down to the same level, that of the Osage flood plain. Little Buffalo having cut its valley into the highest country, has, therefore, the deepest valley.

STAGES OF EROSION.

The Ozark region consists of a plateau with valleys cut into it. Its elevation, while not absolutely uniform, is so nearly uniform over a wide area of country that leveling instruments are required to determine that it is not level. The main watershed ridges for most of the region are remarkably constant in elevation. Those near the center of the region are a little higher than those nearer the margin. In the central part of the region, the main watershed ridges have an elevation ranging from 1,000 to 1,500 feet above sea level.

The Osage-Missouri watershed running through Morgan county stands at approximately 1,000 feet. In the extreme eastern part of the county, it is a little less and where the Proctor ridge intersects it, it is about 150 feet more. This latter elevation is exceptional. None of the other watershed ridges in the whole region are intersected with such features.

In the southwestern and central western parts of the region, the Ozark upland consists of remnants of two plateaus, one lying at the level of the long ridges along the main watershed already named. They are narrow and for most of the region constitute a



Proctor Anticline

relatively small portion of its total area. The other plateau consists of belts of irregular width lying between those just named, and at a lower elevation. They lie along the main streams of the region, but far above the existing valley bottoms. These, like the first, are dissected. Their width varies with the size of the stream along which they lie, from nothing up to twenty miles or possibly in some cases a little more.

The difference in level between these two members of the plateau, varies according to the locality, seemingly reaching a maximum in the southern part of the state and decreasing northward. In Morgan county, which is in the northern part of the Ozark region, this difference, as is indicated by the facts found elewhere in the Ozarks, is small. In fact it is difficult to identify it at all.

Since Morgan county lies in the northern part of the Ozark region, we should expect the two members of the plateau upland or the two levels, so to speak, to approach each other in elevation or to coincide entirely. Over the greater part of Morgan county there is no striking difference in the upland levels and no sudden changes of level sufficiently marked to attract the attention of the ordinary observer. It is only with close scrutiny, aided with a knowledge of the conditions existing elsewhere in the Ozark region, that the two plains can be identified in this county. When all the evidence is collected and correlated, however, it seems sufficient to establish without question the fact of their existence.

This evidence is both geologic and morphologic. The whole area of Osage drainage, except the ridge made by the Proctor anticline, lies slightly lower than the level of the high prairie north of it. As shown above, this country, but for erosion would stand higher than the prairie to the north of it since the initial surface, or at least the surface resulting from the action of the constructional forces that have been operating in the region, rose toward the south. The difference of level between the high prairie along the main watershed and the upland area of Osage drainage south of it is a little less than 100 feet. The drop from the one level to the other is sudden, especially around the head of the main southward flowing streams, but the main watershed ridges descend more gradually. The latter are remnants, therefore, that have never been completely reduced to the upland level of the country on either side of them. The distinctly lower country within the Osage drainage basin lies in belts along the main

streams which flow southward. These belts are now completely dissected by the existing drainage to a depth of about 250 feet.

The geological evidence of the existence of a high level grade plain in the region consists of high level gravels along the two main streams of the county. On the Osage river thoroughly rounded chert gravel beds are found at a level of about 250 feet above the modern flood plain of the river. These beds all lie within the meander belt of the river valley but on level portions of the neck of highland extending into the bends. Their position makes it clear that their existence is due to the formation of a high flood plain on which the gravel has been left.

Over the greater part of the northern half of the county, the dissection is so slight and all the topographic features are so faint, that very little trace of more than one stage in the dissection of the region can be seen. The valleys near the watershed are simply gentle depressions without steep slopes. Low bluffs appear along the streams further down, very low at first but gradually becoming higher until the maximum is reached on the north line of the county.

The only high gradation plain lying above the tops of these bluffs and below the higher upland of the region is an imperfect grade plain, lying about 100 feet above the level of the LaMine river flood plain and 50 to 60 feet below the upland level. It is partly strewn with imperfectly rounded chert gravel, not essentially unlike the gravel now existing in the channel of the creek. The plain is a little more than a mile in width. This however, does not seem to correspond to the grade plain of high level gravels in the southern part of the county.

Plate IV. is a view from the Court House at Versailles looking southeastward. It brings out the drop from the higher level of the upper plateau to the lower one seen in profile in the center of the view.

Abandoned Valleys. (*Meanders*).—The topography of Morgan county, like that of the rest of south Missouri is mature. The larger streams are all graded. On account of the abundance of chert gravel and the almost complete absence of any load of fine-grained material the grades on the smaller streams are rather steep. That of Gravois creek from Swanwick Mill to its mouth is about 15 feet per mile, while that of a stream of equal size in the northern part of the state is usually about 6 feet per mile. One of the consequences of this steep grade is the excessive effect of

floods. The steepness of the grade gives the stream, when flooded, an extremely strong current. The alluvial soil, unlike the tough clay alluvium of the northern part of the state, is very friable and therefore easily eroded. The bottom land fields, are constantly in danger of being washed away, leaving barren gravel bars in their places. In fact in many places the gravel belt down through which the water of the streams finds its way during low water is in some place half as wide as the valley, giving to the valleys an especially barren and rugged appearance. Young sycamore saplings and bottom land brush grow in clumps, on these bars but are bent, twisted and broken in the annual floods, so that they always present a ragged appearance. A few attempts have been made in places to control this destructive spreading of the channel, but apparently without success. Considerable work was done on the Swanwick place, several years ago, but the only record of it at the present time is the existence, far out in the midst of the gravel bars, of some large posts that were intended to hold embankments.

Such conditions obtain only below the point where the stream has reached grade and developed a slight floodplain, and above where the stream is affected by the backwater from the Osage river during floods. These broad gravel bars have their greatest development on Gravois creek. They exist on Big Buffalo and to a very slight extent on Little Buffalo. They do not exist on the Osage river. The channel of the latter stream has a gravel bottom but the banks are of alluvium and the channel is deep and narrow compared to the size of the stream. It does not wash extensive gravel bars out over the fields. It changes its channel rarely and when in flood the water spreading out over the bottom lands has a relatively gentle current. The Osage carries a considerable load of sand, silt and clay all of which have been utilized in the building up of the flood-plains.

LaMine river, coming from the prairies of Pettis and Benton counties where the soil is rather deep and where there are not enough flint boulders to prevent erosion, has no gravel bars in its valley. The channel is deep and relatively narrow for the size of the stream with mud banks and gravel bottom. The Morgan county tributaries of LaMine river are like the latter in the absence of broad wastes of gravel bars like those along the Gravois, although the channels are not deep. Of the streams draining local Morgan county or closely adjacent territory, those north of the main watershed have well defined channels, with gravel bottoms,

but without broad stretches of bars on either side of the stream. Those south of the watershed have both gravel bottoms and bars but Gravois creek has them to a much greater extent than any of the others. The drainage basin of Gravois creek lies wholly within the area of the Roubidoux formation which is the most cherty of the formations of the county. The streams flowing into LaMine river drain the Jefferson City limestone area which carries a small amount of chert.

The Osage river, like all large streams, is affected only to a relatively slight extent by local influences. It affects the character of the local streams rather than being affected by them.

The Osage and LaMine rivers both have strongly meandering valleys. In the case of the latter, they are typical upland meanders with steep bluffs on the lower and on the convex sides of the bend with gradual slopes to the upland on the upper and on the concave sides of the bend. On the Osage the steep bluffs lies in the same position relative to the bend of the river as on the LaMine. There is also a slope extending down gradually from the general upland level to the level of the river flood-plain on the concave side of the river. In the case of the LaMine, therefore the top of the slope lies near the outer boundary of the meander belt. On the Osage, this is not the case. The upland extends in some cases well into the meanders before the downward slope begins. The meander belt is wider than the belt bounded on either side by the tops of the gradual slopes rising on the inside or concave side of the river bend.

Such conditions are favorable to the formation of cut-offs, the stream cutting through the neck of land between two adjacent bends, abandoning the valley running around the bend and leaving an isolated hill with the abandoned valley on three sides and the, at first, narrow valley of the river made by the cut-off. Neither the Osage nor the LaMine have formed such cut-offs in the area of Morgan county. Gravois creek at the present time has no well developed meanders. It is merely a crooked stream. In the vicinity of Gladstone, however, it formerly had a series of about three symmetrical curves. The creek has straightened its course, however, by cutting across the three necks abandoning the three curving valleys. The upper cut off was formed not alone by the work of the Gravois sapping opposite sides of the neck, but that creek was aided and the cut-off hastened by Bogue creek whose valley lay in such a position that it opened into the Gravois valley at the

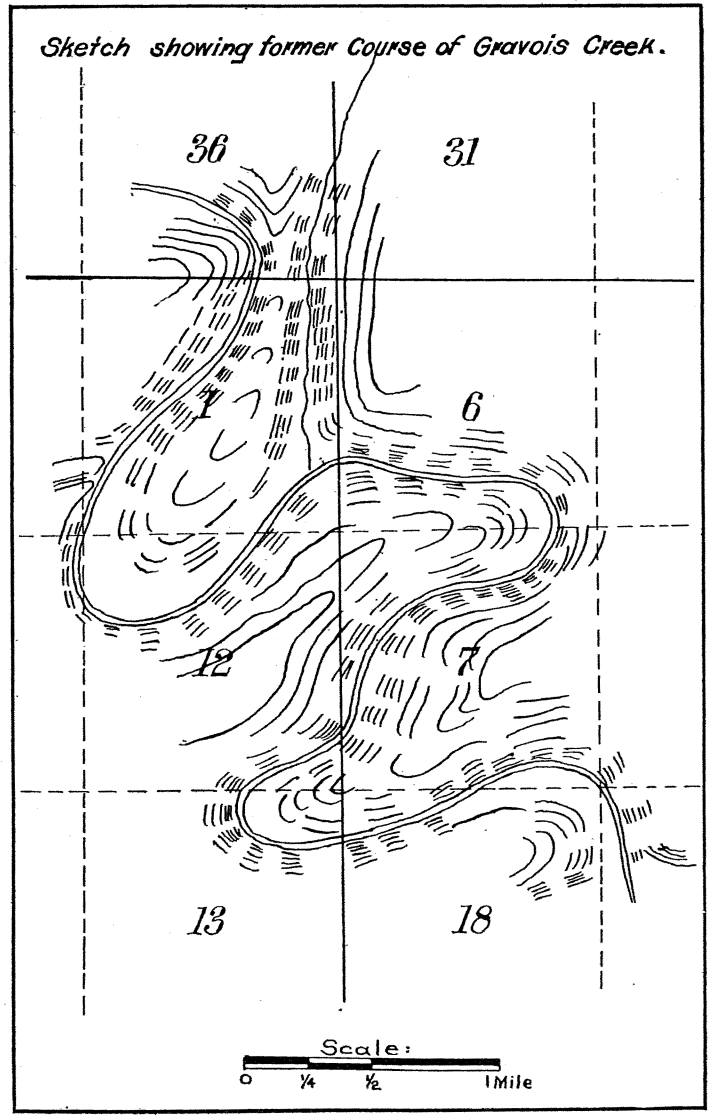


Figure 1.

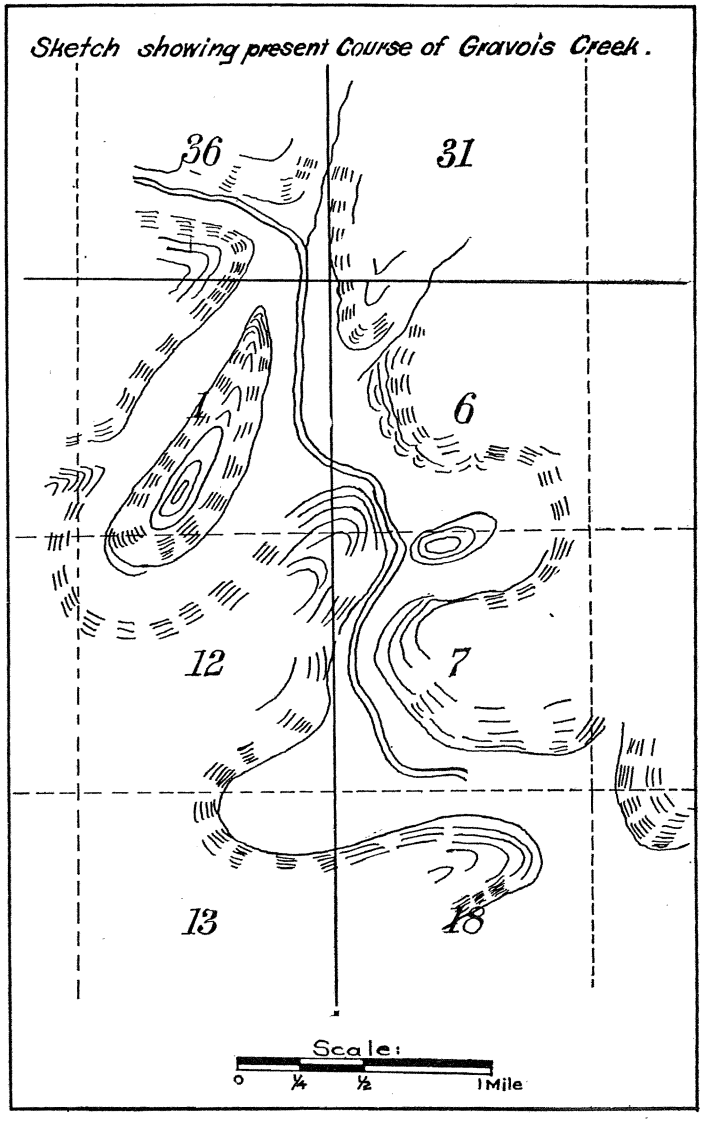


Figure 2.

end of the lower bend, but lay only a short distance from the Gravois at the upper bend. The Gravois by sapping on the convex side of the upper bend, cut into Bogue creek and then occupied the short valley of the latter stream across the neck to the end of the lower curve. The other cut-offs were made by the Gravois itself cutting the neck. The original arrangement of the streams in this vicinity is shown in Figure 1, Plate VI., while the existing arrangement is shown in Figure 2.

In this case the first cut off to form was probably the upper one. This threw the stream more directly against the neck of land in the next one and thus hastened the formation of a cut off there.

FORESTRY.

The smooth rolling part of Morgan county was prairie when first seen by white men. In fact the whole of the northern portion of the county, except the stream valleys and the ravines.

The southern part of the county, the dissected region, had a dense growth of timber in the river and creek valleys, but the hills were sparsely timbered. The original timber outside the bottom lands was almost exclusively oak and consisted of rather large trees, standing well apart from each other with no underbrush between. It was a typical oak opening growth, not dense enough to check the wild grasses which covered the ground with a luxuriant growth; the seed stalks reaching in the summer a height of from six to ten feet.

This was burned each autumn or spring, probably once yearly, the fire killing all young trees that dared to start. The lack of undergrowth was without doubt wholly or principally due to this annual burning of the grass. The best proof of this is the fact that undergrowth has sprung up since white man settled in the country and stopped the annual burning of the grass. It is in the smoother portions, also, where white man has been most interested in the checking of the fires that the undergrowth has grown up thickest. In the rougher regions and those parts of the county far from railroads, fires were not so early checked and the undergrowth has not yet developed to any considerable extent. In the Proctor hills and many other portions of the southern part of the county, the original open character of the forest still remains.

Probably the shade made by the original large trees aided somewhat in keeping down the younger growth.

The character of the original forest and the changes that have taken place since the occupation of the region by white man, are the same in Morgan county as in the Ozark region as a whole. Originally, the whole region had a very sparse growth of timber, even in the creek bottoms in many places. When the annual fires were stopped, young timber started up at once and developed with remarkable rapidity. This took place not only in those parts where there was an original sparse growth of timber, but many areas that were originally grass covered prairies later became covered with a dense growth of young trees.

Simultaneous with the dense growth of young timber has come the killing out of the original blue stem grass which had so luxuriant a growth on the prairies and in the open woods. This has not been effected wholly by the growth of timber. On some of the prairies of the southwestern part of the state where the original sod has not been broken with the plow and where timber growth has not developed, the grass has been almost killed out by too much grazing. For the Ozark region proper and for southern Morgan county, the growth of timber has, however, been the chief factor in killing the grass. The timber growth of Morgan county consists of the ordinary dry upland oak growth of the Ozark region. On the drier and more stony ridges and on the southern slopes, black oak is the main growth, with post oak as second in importance. On the clay covered ridges and on the northward facing slopes, white oak constitutes an important part of the growth.

The upland timber is nowhere of especially vigorous growth. In the southern part of the county, it cannot be called scrubby, but the growth is only of moderate vigor. In isolated places in all parts of the timbered portion of the county, there are areas of scrub growth but they are not large. They occur either on the narrow clay covered ridges in the northwestern part of the county or in places where the rock lies near the surface. The growth in such places is chiefly post oak.

The bottom land timber consists of elm, walnut, sycamore, hackberry, wild cherry, burr oak, shingle oak, (grows also on uplands), hickory, plum and a great many shrubs and vines.

The merchantable timber has been cut from a greater part of the area. In the extreme southern part of the county, there is a small amount of timber still standing that is suitable for cutting into boards and framing materials. Most of it is being cut for railroad ties. The greater part of the original timber went the same

way. Most of it was made into ties, hauled to the Osage river and rafted down to Bagnell in Miller county and from thence shipped by rail. A great many ties have been taken out of Morgan county in this way. The industry is still carried on, but on a much smaller scale than formerly. The timber in the northern part of the county and that in the northern part of the southern dissected belt is valueless at the present time for any purpose except for cord wood. Within this area, there are scattered trees that can be made into railroad ties. That is practically the only merchant-table timber now being taken out.

Ten to fifteen years ago, the time of the greatest development of the railroad tie industry, the annual sale of ties at Proctor was very large.

CHAPTER II.

GENERAL GEOLOGY.

Morgan county lies wholly within the Ozark region of Missouri. Lithologically this is primarily a region of carbonate rocks. Beds of detrital siliceous rock occur in a few places and igneous rocks occur over a relatively small area but they constitute an exceedingly small proportion to the total rock mass of the region. In Morgan county the detrital siliceous rocks occur in even smaller proportion than in the region as a whole. Igneous rocks do not occur in the county.

The carbonate rocks of the region are, with the exception of a rim or band around its outer border, rarely lime carbonate but are nearly everywhere impregnated with magnesium carbonate. The proportions of magnesium carbonate run from nothing up to about 45 per cent or sufficient to warrant calling the rock, in the latter case, a dolomite. Of all the analyses that have been made, however, only a very few show so high a percentage of magnesium carbonate so that where no analysis of a particular rock exists, the presumption is in favor of its being a magnesian limestone rather than a dolomite. In this report the carbonate rocks older than the Devonian in the absence of chemical analyses are described as magnesian limestones.

These rocks vary from practically pure carbonates through argillaceous and siliceous rocks, to calcareous shales on the one hand and calcareous sandstones on the other. The amount of shale is no where very great, and in Morgan county, altho it exists, its quantity is extremely small. Calcareous sandstones are more abundant than the shale but do not constitute a large proportion of the total rock mass. The rocks are mainly argillaceous limestones, the proportion of impurity being very small in all but the upper formation. A great amount of the rock is nearly pure carbonate.

Chert occurs in all the carbonate rocks of the Ozarks region, abundantly in most of them, very sparingly in a few. It occurs as beds, either continuous for large areas or discontinuous in nodules and in masses. It may either completely or only partly re-

place the limestone. In the latter case the chert may occur as an open frame work with the unchanged limestone as a filler or the chert may occur in isolated spots and may be pure or contain a large percentage of unreplaced carbonate.

In Morgan county chert is abundant in all the rocks of the main formations except in the oldest and the youngest formations. In the former chert is rare, in the latter it occurs in relatively small quantities. The characteristics of the chert, the amount, thickness of the beds, purity and structure of the mass, are different in the different formations so that within certain limits the chert may be used as a means of identification of the formations. In addition to the magnesian limestones, the few thin sandstone beds and the few laminae of shale, there are, in Morgan county, many small isolated areas of massive sandstone, a few small occurrences of pure limestone and many occurrences of carbonaceous shale and coal, very few of which are in place.

The absolute ages of the respective formations of the Ozark region have not yet been determined with certainty. The limestone, or the main rock beds of the region have been called Silurian, Siluro-Cambrian, Cambro-Silurian, Cambro-Ordovician and also divided into Cambrian and Silurian at different periods in the history of geological investigation in Missouri. The older geologists placed them in the Lower Silurian period, considering them the equivalent of Halls Calciferous sand rock in New York. Keyes placed the whole series in the Cambrian, while Ball and Smith placed the lower chert-free limestone of the series in the Cambrian and the rest they grouped as undifferentiated Cambro-Ordovician. The older geologists,—Broadhead and others who had occasion to refer to these rocks between the period of the first Geological Survey,—1855—and the Winslow Survey,—1892,—referred to the series as Siluro-Cambrian or Cambro-Silurian.

All these changes in assignment in age of these limestones have been based on insufficient data. None of them have been based on a careful study of abundant and typical fossils. The fossils for a reliable determination of the ages of these beds have never been collected and it is not certain that they exist.* Fossils

*During the last three years, Dr. E. O. Ulrich, of the U. S. Geological Survey, has made extensive collections of the fauna occurring in the formations of the Ozark region. These collections have been supplemented with those made by assistants in this Bureau. As a result of a preliminary examination of these collections Dr. Ulrich has expressed himself as believing that the base of the St. Peters sandstone marks the contact between the Upper Cambrian and Ordovician series over a greater part of the region.—E. R. Buckley.

occur sparingly but they belong to species that have a wide range geologically.

Keyes placed practically the whole Ozark series of limestones in the Cambrain because of the supposed existence of an unconformity at the base of the St. Peters (Crystal City) sandstone whose position is geologically well above the whole limestone series of Morgan county.

Ball and Smith placed the lowest of the series of limestones in Morgan county, the coarsely crystalline chert free limestone,* in the Cambrian, because of the existence of an undoubted unconformity at its top as was shown by Winslow in 1893.

No decisive local criteria for determining the age or ages of these limestones was found in the survey of this county. No fossils of value for stratigraphic purposes were found. The work of other persons in other parts of the region indicate that the placing of the lower chert free limestone in the Cambrian is probably right, though placing of the rest in the Ordovician is not so certainly well founded. Beecher* has shown on the basis of fossils submitted to him by Nason and others, that certain beds, occurring in St. Francois county on the same horizon probably as the top of the lower chert free limestone of Morgan county, are of undoubted Cambrian age. **The age, however, of the rocks lying immediately above these both in Morgan and St. Francois counties has not been determined in either locality. While therefore there can be no longer any doubt about the age of the lowest bed, the age of the upper bed is wholly unknown. The line therefore between the Cambrian and Ordovician as drawn on the accompanying map merely separates Cambrian rocks from rocks of unknown age.

Above these limestones of undetermined age occur the limestones of Devonian age. These occur only in the northwestern portion of the county. Higher still, the limestones of the Mississippian series of the Carboniferous occur and these are followed upward by the sandstone occurring in fragments as stated above. Still higher, but seldom in place, occur the shales and coal beds of the Pennsylvanian (Coal Measures).

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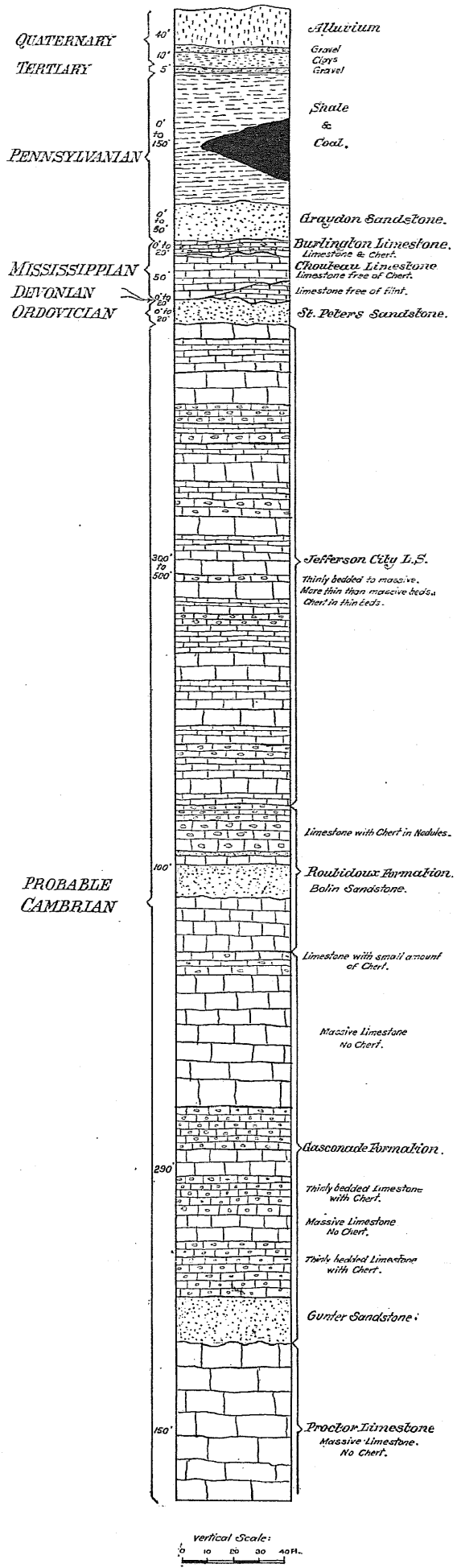
*American Jr. of Science, Vol. 12, p. 359, 4th series, 1901.

**The late investigations of this Bureau seem to indicate that the formations, from which Nason obtained the fossils which were submitted to Beecher, are older than any of those occurring in Morgan county. The Proctor formation is supposed to overlie the Potosi, while between the Potosi and the Bonne Terra occurs the Elvins. It was from the Elvins and Bonne Terre formations that Nason obtained the fossils above referred to. The succession in southeastern Missouri will be fully described in a subsequent volume of the reports of this Bureau.—E. R. Buckley.

GENERAL GEOLOGICAL SECTION OF MORGAN COUNTY.



The formations found in Morgan county numbered from the top downward are as follows:

1. Modern Alluvium.
2. High level gravels.
3. Pleistocene clays.
4. Lafayette gravels.
5. Pennsylvanian shales and coal.
6. Graydon sandstone.
7. Burlington limestone.
8. Chouteau limestone.
9. Devonian limestone.
10. St. Peters sandstone.
11. Jefferson City formation.
12. Roubidoux formation.
13. Gasconade formation.
    (Including Gunter sandstone.)
14. Proctor formation.

Cenozoic.	Recent.		Alluvium. High level gravels on Osage and LaMine.
	Pleistocene.		Surface clays,
	Tertiary (?)	Lafayette (?)	Upland gravels.
Paleozoic.	Carboniferous.	Pennsylvanian.	Shales, Coals.
			Sandstone.
		Mississippian.	Burlington limestone.
			Chouteau limestone.
	Devonian.	Devonian limestone.	Devonian limestone.
	Ordovician.	St. Peters.	Sandstone.
	Probable Upper Cambrian.	Jefferson City formation.	Magnesian limestone.
		Roubidoux formation.	Cotton rock. Bolin sandstone member. Cherty magnesian limestone and chert.
		Gasconade formation.	Massive crystalline magnesian limestone. Massive and thin bedded limestone and chert. Gunter sandstone member.
		Proctor.	Magnesian limestone.

The rocks of Missouri petrologically are of three kinds. (1) Pre-Cambrian igneous, (2) a great series of lower and middle Palaeozoic limestones, magnesian limestones and dolomites, and a series of upper Palaeozoic shales, sandstones and limestones. Igneous rocks, limestones, shales and sandstones constitute the great body of Missouri rocks. They are not mixed indiscriminately

together but each group occupies a definite position geographically and geologically. In the limestone group there are occasional sandstone and shale layers, but their thickness, compared to the total thickness of the rocks of the group is small. In the shale-sandstone group there are limestone layers and the proportion is greater than that of shale and sandstone in the other groups, but shale and sandstone are the dominant rocks.

The igneous rocks are, of course, the lowest, the limestone group occurring next in order of age, while the shale-sandstone group is the youngest.

The igneous group lies in that part of Missouri known as the Ozark region. The limestone group is within the Ozark region. So far as Missouri is concerned, these are the main Ozark rocks. The shales and sandstones are the rocks underlying the prairies. The igneous rocks make up a very small proportion of the total area of the Ozark region so that it is not misstating the facts to say that magnesian limestone is the typical Ozark rock.

The structure of Morgan county is simple. The folding is of the simplest kind and developed to a very slight degree. It consists of broad low dome-like anticlines and shallow synclines with a northwest-southeast trend.

There is still less development of true faulting than of folding in Morgan county. Slight displacements of a few feet are frequent and of very slight extent due probably in many cases at least to solution and are therefore superficial.

Morgan county lies wholly within the Ozark region and within the limestone part of the region. The crystalline rocks lie buried under a thousand feet or more of limestone, and the shales that originally overlay the region have been eroded away except where they have been accidentally preserved in extremely small areas of a few hundred square feet. The geology of the county therefore concerns a series of cherty magnesian limestone beds lying not far from horizontal. There are thin sandstone beds, and there is slight folding.

While the geology is extremely simple, the working out of the details is rendered somewhat difficult chiefly because of this simplicity. Fossils are not abundant. Fossils are known to occur but the author knows of no horizons in which they occur so abundantly that they can be traced easily. The rocks are so nearly alike in texture and composition that it is difficult to find characteristics pronounced and persistent enough to serve as bases of

differentiation and for detection and identification everywhere within the region.

The whole series consists of cherty magnesian limestones with thin sandstone beds. The limestone beds are not uniformly cherty. In some the percentage of chert is low, in others very high. The amount of chert varies, however, not simply from bed to bed, but from place to place in the same bed. Except for rather broad work, the presence or absence of chert therefore is unsafe as a basis of identification except with very careful work, and where the results are checked by other features. In a broad general way, the chert content of the limestones may be used and has been used as a means of identification. The very lowest rock found in the region is almost entirely free from it. This is succeeded upward by a thin sandstone, then a limestone with rather high chert content. Above this is another series of beds with relatively little chert succeeded above by the most highly cherty of all the beds. Above this lies a thin sandstone and then a rather thick series with a relatively low percentage of chert.

The character of the chert and its manner of occurrence are not the same in the different horizons in which it occurs. It varies from nodular, through brecciated masses to large homogeneous masses, sometimes oolitic. The character of the chert is fairly persistent along the same horizon, though the quantity is not.

The lithologic character of the magnesian limestone varies also from bed to bed, but it seems to be one of the most persistent characters in horizontal extent to be found in the rocks of the county. The rocks vary from fine grained, soft, white "cotton rock" alternating with gray, crystalline, magnesian limestones and occasional beds of calcareous to black shale in the higher beds, through finely crystalline limestone magnesian limestones on the middle horizons to more coarsely crystalline limestones at the base of the section in the county. The lower beds are all crystalline. The middle beds consist of alternate layers of coarsely crystalline and finely crystalline magnesian limestone while the higher beds have a large proportion of non-crystalline or finely crystalline beds or "cotton rock".

These differences in chert content and in crystalline character are serviceable in general classification on broad lines, but they make the establishment of a detailed classification and the location of boundary lines on the ground difficult.

In a series of rocks of this character the occurrence in con-

tact of two easily recognizable rocks of totally different composition serves as the best basis of classifying the rocks of the region simply because such a line can be located and traced in the field. Where fossils are absent or where they occur so sparingly as to make classification difficult or uncertain, the chief use of differentiation and of tracing out of boundary lines is for the purpose of determining the details of the structure.

Such a classification and differentiation of the rocks of a region has no age significance more than to indicate that one series of rocks of the region is younger or older than another series of the same region. They have no relation whatever to the rocks of other regions. This sort of differentiation as already stated is easy where there are sharp contrasts in the lithological character of the rocks. In Morgan county there are two horizons at which sudden changes in the kind of rock take place. There are two sandstone beds that are persistent enough to be worth consideration as traceable beds. The lower one is persistent, the upper one is not persistent over the whole of the region, but is so over a large portion of it. It happens also that these sandstone beds lie on horizons separating limestones of different lithological characteristics. These sandstone horizons within the area in which they are persistent, are probably the most easily identified horizons within the county. Along the eastern part of the county, the upper bed does not exist in places and nowhere is thicker than a mere band. The horizon here would have to be determined by the lithological character of the limestones. That horizon, however, is as easily determined by that means as by any other.

One of these sandstone horizons, the lower one, has been used as a plane of differentiation of the limestone. The other has not been so used. It is thought by the writer of this report, that, although the sandstone bed is not persistent its horizon would have been as good for the purpose as the one adopted and fully as easily identified and traced on the ground. The horizon of separation adopted in this report has been selected, merely because the geological map of Miller county bounding Morgan on the east has been published and in it this horizon rather than that of the sandstone has been adopted. It is desirable that the same horizons, solely for the sake of uniformity, should be adopted in both counties. The differentiation is not on the basis of fossils but on that of lithological character and its value lies in its utilization as a means of bringing out the structure.

Any character therefore, that is sufficiently persistent may properly be made use of as a means of recording the distribution of the beds. By the use of lithologic characters in an area made up almost exclusively of limestones, like the Morgan county area, there is always the possibility that any horizon so established may not run parallel to the bed, and therefore fail to show the structure.

The thickness of the Morgan county formations is approximately as given in the following table:

1.	Alluvium and recent gravel	40 ft.	
2.	High level gravels	15 "	
3.	Pleistocene (?) clays	10 "	
4.	Lafayette (?) gravels	5 "	
5.	Pennsylvanian shale and coal	150 "	
6.	Graydon sandstone	25 "	
7.	Burlington limestone	20 "	
8.	Chouteau limestone	25 "	
9.	Devonian limestone	15 "	
10.	St. Peters (?) sandstone		
11.	Jefferson City formation	250 "	
12.	Roubidoux formation	100 "	
13.	Gasconade formation	260 "	
14.	Proctor formation	150 "	exposed.

The thickness of the Coal Measure rocks and the St. Peters sandstone is not given. Neither formation is, anywhere within the county, to be found in a wholly undisturbed position. Both seemingly occur at nearly all horizons, always lying at steep angles or else so badily disturbed that the angle at which they lie cannot be determined. In the deepest of the pockets in which Coal Measure rock occurs, its thickness is probably not less than 150 feet.

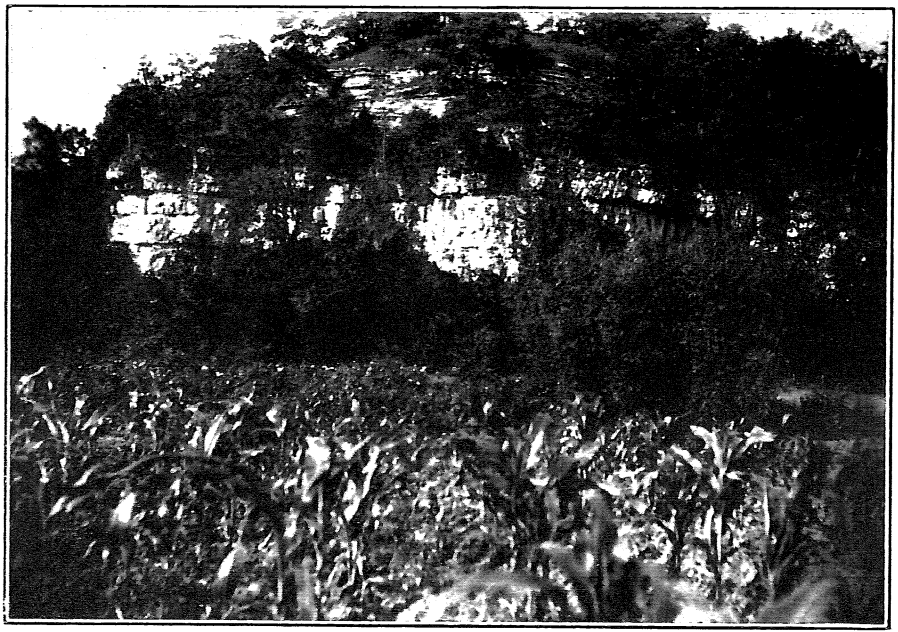
CHAPTER III.

DETAILED DESCRIPTION OF THE PROCTOR FORMATION.

Character.—This is the lowest formation outcropping within the county. Of its total thickness only a very small portion is exposed and that is the top only. It consists of a coarse grained, crystalline, somewhat porous gray magnesian limestone almost entirely free from chert. In only one or two places was any chert at all found in it and this in small quantities. On its outcrop it is strongly pitted with rather coarse pits. Like all limestones without chert or other insoluble constituents the soil overlying it is thin. It is readily soluble and where it is exposed over large areas of country, it presents to agencies of solution all the characteristics necessary for the formation of caves and springs. In Morgan county it occurs on steep hillsides only and has a limited geographical extent so that these characteristics are not prominent. Its bedding is usually massive through great thickness though there are some layers slightly less crystalline and silghtly thinner bedded and more broken up with joints.

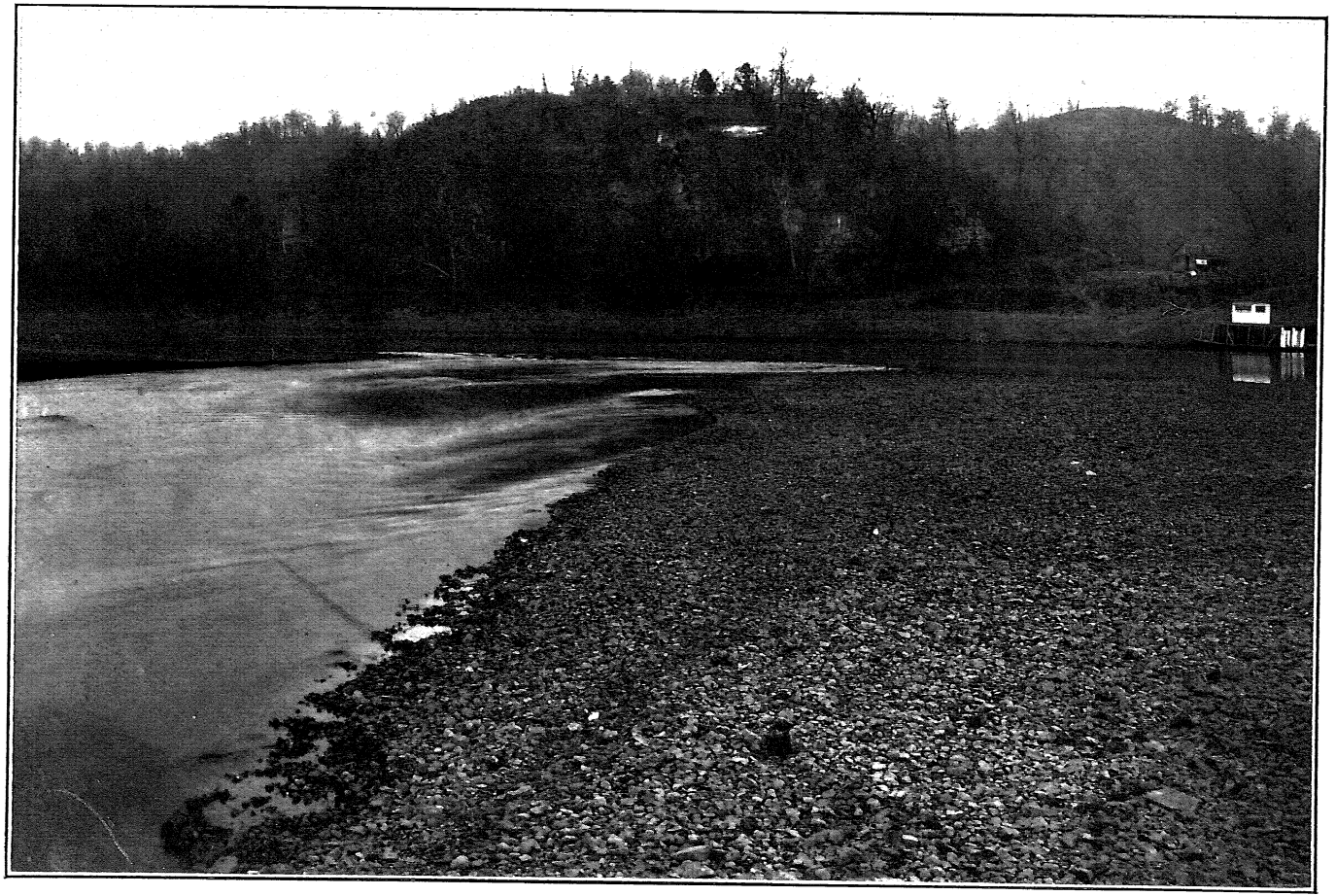
Thickness.—The total thickness of this formation under the area covered by Morgan county, is not known. There has been no boring in the county to determine it but a diamond drill hole sunk in Camden county, just across the Osage river from the mouth of Proctor creek was bored to a depth of about 900 feet. At the bottom of the hole the cores consisted of calcareous sandstone with what seemed to be fragments of decomposed porphyry. The bottom of the drill hole was not far from the bottom of the formation. The top of the drill hole was a little less than 100 feet below the top of the limestone. According to Major Rush, the driller of the hole, the rock was uniform from the beginning down to near the bottom of the hole.

Occurrence.—This formation occurs only along the Osage river, on Proctor creek and on Gravois creek. On Gravois creek it rises above the water level in the southeastern part of Sec. 35, T. 41N., R. 17W., and is exposed continuously up to the mouth of



PROCTOR LIMESTONE CAPPED WITH GUNTER SANDSTONE.

Mouth of Proctor Creek.



GUNTER SANDSTONE CAPPING BLUFF ALONG OSAGE RIVER.
At Mouth of Proctor Creek.

Indian creek. Its maximum exposure here is about 35 feet. About 10 feet below the top of the limestone along the bluff here is one of the rare beds of chert occurring in this limestone. The chert bed is about a foot in thickness. Up the creek from this point the formation does not occur. It is not met with again east of Huff branch in section 25, township 40N., Range 18W. At the locality on Gravois creek the creek crosses a very low anticline running northwestward and southeastward. South of this the rocks dip rapidly enough to keep the Proctor limestone below the level of the Osage river. Another anticline, but a much more important one, runs northwestward from the southern part of Camden county into Morgan county, entering the latter near the range line between ranges 17 and 18. This brings the Proctor limestone up above the drainage level along the Osage river on both sides of the Proctor bend. It occurs also along the eastward part of the next bend above the Proctor bend in sections 26, 25, 24, 23 and 14, township 40N., Range 19W. It extends up Proctor creek to the mouth of east fork and up east Proctor to the center of Sec. 9. It appears again higher up the creek a short distance west of where the wagon road turns northward up the hill in Sec. 3. It does not extend up west Proctor above the junction with east Proctor. It does not occur at any other locality within the county.

CHAPTER IV.

THE GASCONADE FORMATION.

The Gasconade formation consists of two members, the upper a magnesian limestone and the lower a sandstone. The formation as a whole is known as the Gasconade, while the sandstone member has been called the Gunter.

The Gunter sandstone. The contact of the Proctor limestone with the Gunter sandstone member is an unconformable one. The unconformity is erosional, however, rather than structural. There was no folding of the Proctor limestone preceding the deposition of the sandstone. The erosion also was either very slight or very great. There is no basal conglomerate at the base of the sandstone and the sandstone itself presents practically the same character as higher up in the section. The unconformity in Morgan county expresses itself merely as an uneveness of contact. Since the sandstone layer is a water carrier, the uneveness could probably have been produced by the solvent action of water running along the contact after the deposition of the sandstone. At Ha Ha Tonka, however, where the contact is unusually well exposed the sandstone includes a boulder of limestone. Ball and Smith in their report on Miller county also mention having found water worn fragments of dolomite in this sandstone. The unevenness or unconformity was probably produced by marine solution and slight erosion of the limestone during a time when the top of the limestone lay near the level of the sea. The sandstone was then deposited on this surface. A temporary uplift of the limestone before the deposition of the sandstone would have caused the erosion of valleys in the former. Nothing of the kind has yet been found altho the contact has been seen by several geologists and at several different places. A longer duration of the uplift giving time for base leveling is hardly tenable on account of the total absence of anything like a basal conglomerate at the bottom of the sandstone. The erosion was evidently effected chiefly by solution.

In the southeastern corner of Morgan county about a quarter

of a mile above the mouth of Lick Branch, the base of the sandstone is better exposed than at any other locality yet discovered in the county. Here the lower two and a half feet of the sandstone is soft with greenish shaly material containing quartzitic, concretionary nodules. This gives the whole layer a gnarled appearance. Above this the sandstone is cross-bedded but free of nodules or almost so. In the vicinity of Proctor the sandstone is cross-bedded also, but a rather larger proportion of it is horizontally bedded and has a rather flagstone appearance. It is quarried at Proctor for local foundation and other walls and serves the purpose admirably.

Distribution.—The Gunter sandstone was found overlying the Proctor limestone in all the localities where that formation was found. In addition to these the sandstone is found at several places where the limestone is not exposed. The locality in Lick branch above cited is one of these. The other localities are all in the deep hollows entering Proctor creek from the east where the sandstone has been brought up to the level of the beds of the hollows along the line of the Proctor anticline.

Thickness.—On Lick Branch, the sandstone is about 15 feet thick. Westward it thickens and in the vicinity of Proctor it is about twenty-five feet thick. Northeast of Proctor on the head of Mill creek, a drill hole penetrated a thickness of about thirty-five feet of the sandstone.

The Magnesian limestone member of the Gasconade.—The Gunter sandstone grades rather abruptly upward into the magnesian limestone member of the Gasconade. This part of the formation has a wide distribution in the southern part of Morgan county and is the dominant formation over the central part of the Ozark region. It has two main areas of distribution in Missouri, an easterly one in which Reynolds county is the center and a northwesterly one with Camden county as the center. Morgan county lies partly within the latter area.

Lithological Characteristics.—The Gasconade limestone presents remarkably uniform lithological characters over a wide area of country. It consists of crystalline magnesian limestone usually gray in color in which massive and thin beds alternate. The thin beds are slightly finer grained than the massive ones. Alternating with the limestone beds are beds of chert sometimes brecciated and often several feet thick. It rarely occurs either in nodules or in small lenses. Neither does oolitic chert occur to any considerable extent, if at all, in this formation.

The thinly bedded limestone layers in this formation are full of joints, causing them to weather more rapidly than the more massive beds. Where both are exposed in cliffs the former recede rapidly leaving the latter overhanging.

The Gasconade limestone in Morgan county is readily divisible into two benches. The lower one consists of alternating massive and thinner bedded, much jointed limestone as described above, with a large amount of chert. The upper bench has a greater proportion of massive coarsely crystalline beds and contains much less chert. Over considerable areas chert is almost entirely absent from this part of the formation. The rock is so coarsely crystalline that upon disintegration the calcite and dolomite crystals, without rather close examination, may readily be mistaken for sand and the weathered surface of the limestone looks very much like sandstone.

The exposures are not sufficiently numerous to determine whether this character is maintained through the area. The central part of the county has the most typical development. In the eastern part of the county and also in the western part, the massive beds do not seem to be so highly crystalline. There is, however, much less chert in the upper division of this formation, even here, than in the lower. In the Osage river bluff just below the mouth of Big Buffalo creek the upper beds do not seem to be very different from the lower. Such a place, however, is not an ideal place to observe such characters. The bed of one of the small creeks where the limestone is worn smooth and where the surface is fresh is a better place.

Distribution—The Gasconade is the predominant formation over most of the southern part of the county. The next overlying formation extends in long tongues southward from the central part of the county, down the long ridges between the streams flowing into the Osage river into the main area of the Gasconade limestone. In the valleys the Gasconade limestone, on the other hand, extends in long tongues northward and northwestward into the area mainly occupied by higher formations. The lower cherty member occurs in all the bluffs of the Osage river and up Gravois creek to the neighborhood of the Swanwick Mill. It runs up Indian creek to the big bend in section 19 and is found in the hollows around the heads of all the branches of Proctor creek. It lies considerable higher here than elsewhere on account of the anticline running northwestward across the heads of east Proctor

creek. On Little Buffalo it extends up to the neighborhood of section 11.

The upper chert free member of this formation, runs across the county east and west in a zigzag belt immediately north of that of the lower member. It is found on Indian creek between section 19 and the forks of the creek on the southern boundary of section 5 though not so typically developed here as elsewhere. It occurs on the hillsides around the head of Bogue creek and Lick branch where its presence is shown by the "balds." These are barren limestone surfaces in places where the topography is such that the chert free soil, resulting from the disintegration of the formation, is washed off as rapidly as it is formed. These are not of frequent occurrence in localities where the overlying Roubidoux formation is present and typically developed. The chert and cherty soil from the latter drift down over it enough to hold some soil in place. The "balds" do not occur in the central and western parts of the county.

The formation is especially well developed high up on Gravois creek in the south central and southeastern parts of township 42N., Range 18W, and is fairly typically developed on Little Gravois from near James Mill southward for about three miles. On Mill and Soap creeks, bed rock is rarely seen. This is chiefly because of the low gradient of these streams due to their considerable length compared with their size. The lower chertly member of the formation occupies the lower slopes and underlies the alluvium in the valleys, rising very nearly at the same rate up stream as the grade of the stream. The upper slopes therefore and tops of the ridges, all except the very highest, are underlain by the non-cherty or upper member of the formation. The soil therefore in this vicinity has a smaller proportion of chert fragments in it than in any other area in the southern part of the county of equal size. There is enough chert from the overlying Roubidoux formation intermixed with the soil of the limestone to hold it in place. The limestone weathers down into gradual slopes also and the soil has all the fertility of a typical limestone soil. The valley slopes are therefore gradual giving the whole country a beautiful rolling character. The valleys of Mill and Soap creeks are among the most beautiful small valleys of south Missouri. Much of the uplands adjacent to the valleys can be cultivated. This character is maintained up to the heads of the streams, nearly on top of the ridge overlooking Proctor creek valley. Along Proctor creek the existence of this

member of the Gasconade formation is shown in the clayey almost chert free soil on a bench lying 200 to 250 feet above the creek. It occurs especially well developed on Little Buffalo creek from Section 11 up to the Buffalo mines and a short distance beyond. On Big Buffalo and Minnow branch it is not well shown on account of the widespread occurrence in this region of the Roubidoux formation which overlies it or covers the slope with loose chert.

Chert in the Gasconade.—As stated above, the chert of the Gasconade formation is most abundant in its lower portion. Oolitic chert does not occur in this formation. It is brecciated only in rare instances. The most common forms in which it occurs are "curly," "festoon" and "coral-like" masses. In all the forms the masses are very porous. In the "curly" forms the open spaces are circular in shape on the broken surface and may be somewhat irregular or cylindrical or globular in cubic dimensions. On the broken surface of a large fragment the arrangement of the coloring matter and impurities are such as to give a curly like appearance to the structure looking somewhat like the imperfect replacement of a limestone full of gasteropods.

In the "festoon" forms the material is arranged like a series of festoons one above another, all welded together, or held together at the ends in a solid mass of chert.

These masses occur in the lower part of the Gasconade limestone over a large area of the Ozark region in and beyond Morgan county with remarkable persistence.

The coral-like masses look not unlike masses of certain species of Diphyphyllum when weathered out and lying around on the surface. It is the most abundant of the three kinds of chert. The curly variety is most abundant just below massive chert free limestone.

In addition to the three kinds of chert named above, there is more or less amorphous chert occurring in nodules and in layers and small irregular masses. In places the thinly bedded layers of the lower part of the Gasconade limestone were replaced by chert only in spots before erosion brought them within the zone of rapid decay. The small masses of chert thus formed, which would have finally combined into large masses of "curly" chert, are dropped out in the weathering of the unreplaced limestone matrix.

Relation between Limestone & Chert in Gasconade Formation. in Sec. 33, T. 42 N., R. 17 W.

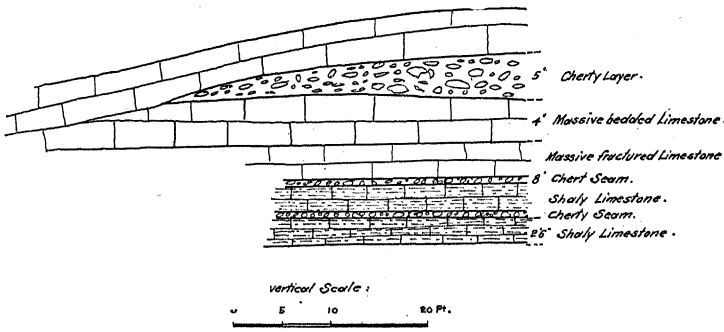


Figure 2.

The chert may occur either in the thinly bedded layers of the lower member of the Gasconade limestone or in the massive layers. If it occurs in the latter, it is apt to be more persistent horizontally than where it occurs in the thin beds. In the latter it may occur as a brecciated bed of considerable extent horizontally or it may occur as a simple mass or as a body of almost any shape determined by the shape of the cavity in the limestone in which it occurs.

DETAILED COLUMNAR SECTIONS
of the Gasconade Formation from various localities in the county.

GASCONADE FORMATION. N.W. cor. Sec. 19, T. 40 N., R. 16 W.

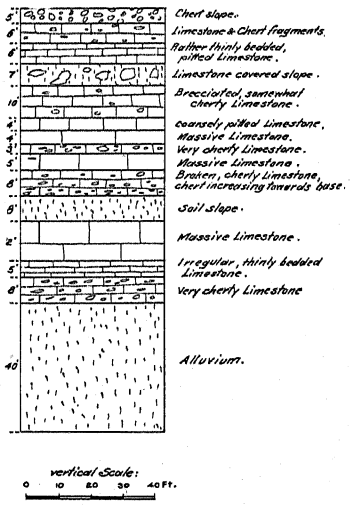


Figure 3.

Gasconade Formation. in Sec 5, T. 41 N., R. 16 W.

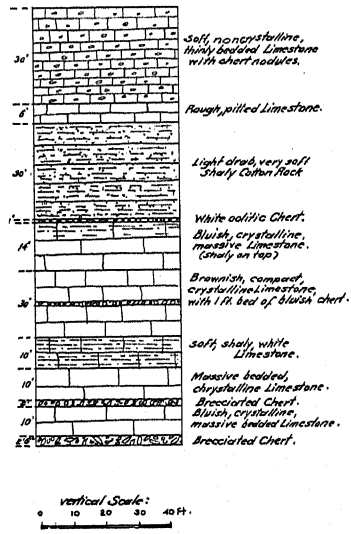


Figure 4.

Gasconade Formation.
in N.W.¼, N.E.¼ Sec.14, T.41N., R.17W.

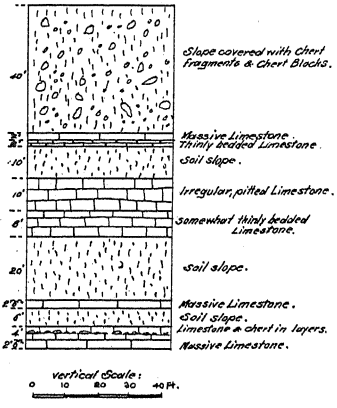


Figure 5.

Gasconade Formation.
Detailed Section of Bluff S.W. of Gravois Cr.
in N.W.¼, S.E.¼, Sec. 7, T. 41 N., R. 17 W.

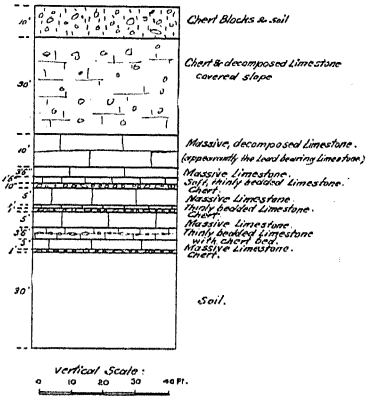


Figure 6.

Gasconade Formation.
Detailed Section S.W. from
near center Sec.7, T.41N., R.16W

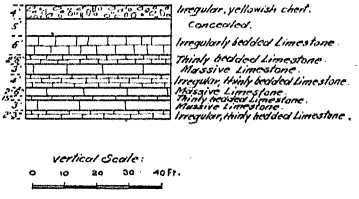


Figure 7.

Gasconade Formation.
in N.W.¼, S.E.¼ Sec.7, T.41N., R.17W.

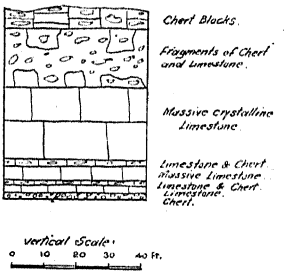


Figure 8.

CHAPTER V.

THE ROUBIDOUX FORMATION.

This formation was first described by Ball and Smith* under the name of the St. Elizabeth. They describe it as a series of beds of complex and nonpersistent character lying between the Gasconade and the Jefferson City formations. It includes the second sandstone of Swallow and portions of the 2nd and 3rd Magnesian limestones lying adjacent to it.

In some places the base of the formation is described as a sandstone bed, but for the rest of the area the base of the formation is described as heavily bedded, rugged brecciated chert. The top bed is described as a cellular, honey-combed, chert bed. The sandstone described as the base of the formation does not occur in that part of Miller county adjoining Morgan county and its base there is a somewhat undetermined horizon. In Morgan county the crystalline limestones characteristic of the Gasconade formation extend up to, perhaps in some instances above, the base of the St. Elizabeth as described by Ball and Smith. There is a thin sandstone bed along the line of Morgan and Miller counties, which is not mentioned by Ball and Smith in their report on Miller county. Heavy beds of brecciated chert, such as are referred to by Ball and Smith, occur abundantly in Morgan county, not only in the Roubidoux formation, but in the lower part of the Gasconade as well. In fact, brecciated chert beds are extremely common in the whole series of cherty beds in the Ozark region. There is, however, in Morgan county a very heavy bed of brecciated chert rather persistent which is probably the one referred to. Along the Miller-Morgan boundary, the contact line on the geological map of Miller county, lies some feet below the horizon of this bed of chert in the adjacent parts of Morgan county. There is no sudden change in the limestone in Morgan county, so that that cannot be made use of in differentiating the formations. Within the Roubidoux formation, or within that part of the Ozark section differentiated by

*Mo. Geol. Survey, 2nd Series, Vol. I, pp. 50-68.

Ball and Smith as the St. Elizabeth, a very important and persistent change in the character of the limestones does take place, but it appears to be too high to serve in locating the base of the formation as described by them. In the Ozark region, everywhere, there is a well defined Gasconade limestone. In its lower part there is a large amount of chert. Its upper part consists of free limestones. Above the Gasconade limestone chert becomes again abundant. The limestone beds gradually become less crystalline and less massively bedded upward above the reappearance of the chert and finally they pass into a series of alternating beds of crystalline limestone, fine grained limestone ("cotton rock") and calcareous shale. This series of rocks continues upward to the St. Peters sandstone. This gradation is especially true for Morgan county.

In the absence of a more definite means of locating the base of the formation, I place it for Morgan county at the base of the upper series of abundantly cherty limestones. This horizon is determined wholly upon the basis of the amount of chert in the limestone and may not be persistent over a wide area of country.

In Morgan county the limestone and sandstone beds are fully as persistent in extent, laterally, as the beds in either the Gasconade or the Jefferson City formations. The beds of sandstone are somewhat more numerous than in the Gasconade formation but less so than in the Jefferson City formation. The chert beds are more numerous and somewhat thicker than in the Gasconade formation and considerably thicker than in the Jefferson City formation. The chert is mainly brecciated, occasionally massive in the lower part of the formation, while in the upper part it occurs in nodules with concentric structure, in layers without definite internal structure and in oölitic beds and nodules. The limestone beds range from moderately thick, rather fine grained and crystalline, through soft non-crystalline "cotton rock," to thin layers of shale. The cotton rock, which forms an important constituent of the Jefferson City limestone, appears first about 40 feet above the base of the Roubidoux formation. Thence upward to and above the highest rocks of the Ozark series in Morgan county cotton rock is a very important constituent.

There is one sandstone bed consisting of two layers of sandstone separated by from 8 to 15 feet of limestone and chert that is persistent over a large part of the area of the county except where eroded away. In fact, it is only along the extreme eastern

Chert.

Limestone.

Chert.

Chert.

RELATION OF CHERT AND LIMESTONE.
Middle of East Side of Sec. 18, T. 42 N., R. 17 W.

side of the county where it is not found. It consists of gray to reddish sand not thoroughly rounded, rather firmly cemented with iron or calcite except where it is cemented locally into a quartzite.

This is probably the same sandstone as the one described by Ball and Smith under the name of Bolin Creek sandstone from the southern part of Miller county. It has not been proved by actual tracing on the ground to be identical with the latter, but its geological relations are apparently the same so that name is used for it.

This sandstone dips westward and passes beneath the Osage river level at the mouth of Cole Camp creek in Benton county. In the deep wells at Clinton it was encountered at a depth of 525 feet, which is about 175 feet above sea level. On Mt. Alfter it lies about 850 feet above sea level. The distance between Mt. Alfter and Clinton is 40 miles. Its average dip therefore is about 16 feet per mile, about one-fifth of one degree. Its distribution is shown on the map and need not be discussed here.

Other thin beds of sandstone occur in the Roubidoux formation, but their thickness is too small to enable them to be traced any great distance.

The top of the Roubidoux formation is even more difficult to identify in Morgan county than is its base. The only reference by Ball and Smith to the top of the formation is one in which they state that "In most places the St. Elizabeth and Jefferson City formations grade into each other through sandstones, conglomeritic sandstones, shales and cotton rock. The upper bed of the St. Elizabeth formation over a considerable area is the very cellular, honeycombed chert above referred to*."

In Morgan county there is not a conglomeritic sandstone in the whole upper part of the section. Sandstones, shales and cotton rock occur in both formations, as they do in Miller county, so that their occurrence lend no aid to the determination. The most careful examination in a great number of localities, of almost every hollow crossing the St. Elizabeth formation in Mogran county, failed to discover a bed of cellular chert that was persistent enough to be used as a horizon line in a scheme of classification. Even if such a bed should exist, it could not legitimately be used for such determination, for there is no horizon above the Bolin sandstone on opposite sides of which the rocks differ in any essential respect.

The only thing to be done is to take an arbitrary line about

*Mo. Geol. Survey, 2nd Series, Vol. I, pp. 60-61.

120 feet above the base of the formation and consider that the top of the formation. This is what I have done.

There are two varieties of magnesian limestone in the Roubidoux formation. One is crystalline the other is not. The crystalline beds vary somewhat in coarseness, being on the whole, however, rather fine grained. They are, as a rule, when compared with the more massive beds of the Gasconade formation, rather thinly bedded. They never become shaly. The beds range from a few inches to about two feet in thickness. They very rarely contain chert nodules or fragments within the beds such as occur so abundantly in the thinly bedded much jointed beds of the Gasconade limestone. They occur most abundantly in the lower part of the formation. Higher up they alternate with the fine grained beds or cotton rock. The gradation from the coarsely crystalline, massive, bedded limestones of the lower and upper Gasconade through more thinly bedded, and finer grained crystalline limestones in the lower Roubidoux, to the fine grained cotton rock of the middle and upper Roubidoux is a constant feature of the geology of the county everywhere. While this general statement is true, yet it is not demonstrated that some beds at one locality are crystalline, while at another the same beds have not changed to cotton rock.

The crystalline beds may be porous or they may be compact. In the former the cavities are usually lined with a white powder giving them a spotted appearance on the fracture face. The cotton rock is soft, fine grained non-crystalline and thinly bedded, with occasional beds of shale of a few inches in thickness between beds. They are free from chert in any form either as beds or nodules. Chert occurs only in association with the more crystalline layers which alternate with the cotton rock.

The chert in the Roubidoux formation is either cryptocrystalline or oolitic. The former variety is very much like the Gasconade chert. It may occur in beds or nodules and may occur in a brecciated or non-brecciated form. The brecciated beds occur more abundantly in the lower part of the formation though they are not confined to that.

The oolitic chert is most abundant in the middle and upper parts of the formation. It occurs in beds and in nodules. It occurs as nodules enclosed in more massive chert and also separately. In one or two localities, oolitic chert has been found as much as 75 feet below the horizon of the Bolin sandstone. In this latter case, however, heavy beds of chert occurred 100 feet below

that horizon placing the base of the Roubidoux at this locality 40 to 60 feet lower than at other places.

The structure of the Roubidoux formation is the same as that of the beds beneath it. Every force strong enough to deform its beds would deform those of the formations beneath and above it. It is unnecessary to discuss its structure separate from that of the region as a whole.

Distribution—The Roubidoux formation occurs in a belt running approximately across the county east and west nearly through the middle. It occurs chiefly within the area of the Osage river drainage basin. North of the main watershed of the county in the northwestern part, there are certain beds of rock that resemble somewhat the limestones of the Roubidoux formation. With these beds are associated some thin beds of sandstone. There is no means, however, of demonstrating the identity of these beds with the beds south of the watershed which we call the Roubidoux beds. The absence of thick beds of brecciated chert makes it practically certain that at least the lower part of the Roubidoux formation is not exposed in this part of the county. The rocks of all this region are colored as Jefferson City limestone on the map, though some of the lowest beds on Richland creek may belong to the Roubidoux.

Economic Value.—This formation as a whole, has a smaller value as a man supporting factor than any other formation of equal extent in the county. Its soils are poor and it has no mineral resources of any value. These matters are discussed more fully under the head of "Soils" and "Mineral Resources."

The Bolin Sandstone.—There are two beds of sandstone separated by an interval of slightly varying thickness ranging from 8 to 20 feet filled with chert and limestone beds. The two beds are persistent and, so far as could be determined from very careful work in the field, unbroken over the whole western and northwestern part of the county except where eroded away or covered by higher rocks. Places occur in this part of the county, to be sure, where the sandstone cannot be found even along its horizon, but such places are only those where all the rocks are covered. The true bedded character is equally or even more persistent than the thickness of the sandstone. On Mt. Alfter, there are two ledges an upper one of about 10 feet in thickness, and a lower one somewhat thinner. The distance between them is only about 10 feet. Northeastward and northward from this point, the blocks occur

over the surface abundantly wherever the surface of the land crosses the horizon of the sandstone. The fragments are found all along the Big Buffalo and Minnow Branch hills, high up in the hills along the Little Buffalo and Proctor creeks and around the heads of Gravois and Little Gravois creeks. Around the head of the northwesterly branches of Gravois creek and the extreme heads of some of the northeasterly branches of Big Buffalo, it was not located. This is due to the fact that its horizon is raised so high by the Proctor anticline that the sandstone is either eroded away or raised to about the prairie level and covered with chert and soil accummulations. East of Gravois creek and its drainage area, the sandstone thins out. In fact it is not known to occur in the extreme northeasterly hollows which drain into Little Gravois. It occurs in the hollows opening into the east fork of Little Gravois in sections 15 and 22, T.42N., R.17W. They become thinner eastward and by the time the horizon passes beneath the bed of the hollow, the sandstones are only about a foot thick. North of this on the head of the east fork of Little Gravois, the sandstone was not located at all.

The Bolin sandstone is not known to occur anywhere within the drainage area of Indian creek. In one or two places, chiefly in Sec. 33, T. 42N., R. 16W., and in Sec. 4, T. 41N., R. 16W., thin lenses of sandstone were found at or near the horizon where it should occur. Further south careful search in the hollows opening into Indian creek from the east failed to discover the sandstone as a continuous bed. On the ridge, and in the heads of hollows on both sides of it, between Indian creek and the lower part of Little Gravois in Secs. 1 and 2, T. 41N., R. 17W., sandstone blocks occur on the horizon of the sandstone and at one locality in Sec. 2, the sandstone was found in place, but only the bottom bed and it was only two feet in thickness. This is the most easterly exposure of the sandstone known in Morgan county.

In the northern part of the county a few thin sandstone beds were found and carefully mapped, but they furnished no evidence by which they could be identified with the Bolin sandstone. The ridge along the watershed is everywhere either too high for the extension across it of the horizon of the sandstone or else the latter if it occurs is buried under an accumulation of surface material. The continuity of outcrop is broken and since the limestone and chert are so much alike from the horizon of the sand-

stone upward, the identification of the sandstone on the north side of the watershed is very difficult.

The following detailed sections show the character of the Roubidoux formation at two localities.

Section of Bluff on the Osage River.
in N.W.¼, N.E.¼ Sec. 29, T. 40 N., R. 18 W.

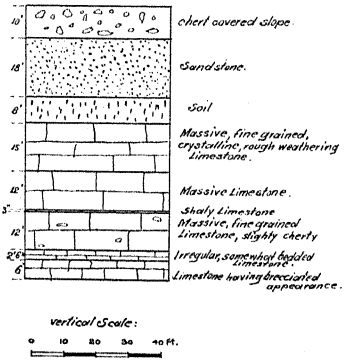


Figure 9.

Detail Section near Mouth of Ravine.
across S.W.¼ Sec. 5 and
part of S.E.¼ Sec. 6, T. 41 N., R. 16 W.

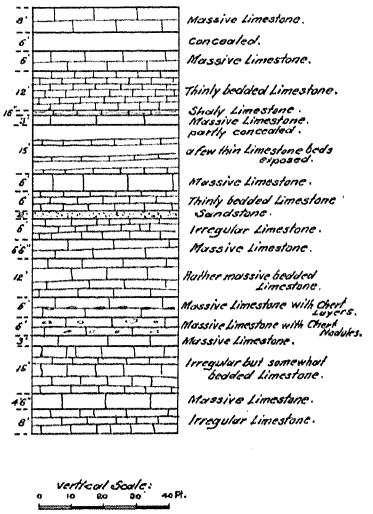


Figure 10.

CHAPTER VI.

THE JEFFERSON CITY FORMATION.

The Jefferson City formation consists of a series of alternating crystalline and fine grained noncrystalline (cotton rock), magnesian limestones, shales, sandstones and massive brecciated and oolite cherts.

It lies mainly in that part of the county lying north of the main Osage-Missouri watershed, but it extends south down the ridges between the southward flowing streams in long branching and narrowing projections. In the area north of the main watershed, it occurs to the exclusion of all the other formations of the Ozark series, with the possible exception of the Roubidoux formation in the deeper valleys. In the northern and northeastern parts of the county, there is no formation, in place, higher than the Jefferson City. In the northwestern part of the county, younger formations occur above the Jefferson City.

Owing to the difficulty of locating the exact horizon of the base of the formation, its thickness is difficult to determine. It is thickest in the northeastern corner of the county and along the eastern side, as far south as Excelsior, its thickness is about the same. In the neighborhood of Barnetts station, the thickness is about 250 feet. North of this the country slopes northeastward and the dip of the rock is in the same direction and about equal to the slope of the country. In the northeastern part of the county, therefore, the minimum estimate for the thickness of the formation is about 300 feet and the maximum is about 450 feet.

Owing to the extension of the fading end of the Proctor anticline into the northwestern part of the county, the thickness of the Jefferson City formation is not as great there as in the northeastern corner. The base of the formation, however, is probably not exposed. It follows therefore that the Ozark series is not exposed north of the main watershed of the county with the exception of the Jefferson City limestone. Its thickness in the northwestern part of the county is about 250 feet.

In the northern part of the county, there is no marked change

in the character of the beds, none, at least, exposed, serving as a plane of separation between the Roubidoux and the Jefferson City formations. This is true also south of the main watershed but on the latter side, the Bolin sandstone horizon along the greater part of its outcrop can be easily located and the top of the Roubidoux determined from that. In the northern part of the county, there is no sandstone bed that can be correlated with the Bolin sandstone either on stratigraphic or lithologic grounds. The dip of the beds, if continued northward from the main watershed at the same rate that they have south of it, would depress the Bolin sandstone at least 50 feet below the level of Moreau creek floodplain.

If the Proctor anticline were continued northwestward on the same course which it has in the southern part of the county, it would cross Haw creek about where that stream crosses the county line from Benton into Morgan county. If it were as pronounced a feature here as it is farther southeast, the Bolin sandstone and the Roubidoux formation would undoubtedly be brought up high enough to be exposed.

These beds are, however, not exposed along that stream or if they occur they are so modified that they cannot be identified as such. There is some evidence based on conditions found in Benton county that the Proctor anticline turns to a more westerly course before reaching the county line and crosses that line near the head of Haw creek. The fold seems to become considerably weaker also after it passes the Buffalo Mines so that there is no reason to expect the exposure of the Roubiboux beds in the northwestern part of the county because of the existnce of the fold.

The Jefferson City formation consists of alternating beds of gray crystalline limestone with or without chert, soft white, fine grained, jointed, thin bedded and definitely bedded, magnesian limestone, (the typical cotton rock), and soft grayish, finely crystalline to amorphus, clearly bedded limestone weathering in concentric layers and cracking into irregular pieces usually with conchoidal surfaces, but without joint planes, and chert beds. The gray crystalline limestone beds look very much like the medium grained beds in the Roubidoux and Gasconade limestones. Chert occurs in and associated with the crystalline beds only. It is wholly absent, or usually so, from either the cotton rock or the darker fine grained limestone. In the crystalline limestone, the chert occurs in nodules within a massive bed, as angular fragments

in a massive bed giving it the appearance of a breccia or in beds between the layers. The nodules are usually concentric in structure and banded. They are rarely oolitic though occasionally so. The chert occurring in beds may or may not be oolitic. It may occur also in large porous masses which, when broken, show a granular fracture surface. This same variety occurs also as nodules which are rather abundant in places and may in places be hollow forming imperfect grades. These nodules may occur in the soft, fine grained limestone though they have not been seen occurring in the cotton rock beds. The chert beds may be wholly without apparent internal structure in which case they are approximately of uniform thickness or they may consist of masses of large concretionary structure up to six feet in diameter. The limestone, in which these masses occur, is usually the more thinly bedded and less crystalline phase. The layers of limestone have suffered deformation sufficient to cause them to fit around the concretionary mass, seemingly therefore continuing the concentric arrangement beyond the mass of chert. This chert is rarely if ever oolitic.

The limestone beds in the Jefferson City formation are essentially the same in character as those of the Roubidoux. In both they consist of alternate beds of cotton rock and crystalline limestone. In the Jefferson City formation, however, the cotton rock constituent is much more abundant than that of the crystalline constituent. The cotton rock is more abundant in the upper beds of the Jefferson City limestone than in the lower.

The thin phase described as occurring in the Jefferson City formation, the fine grained, indistinctly bedded or at least not thinly bedded, subcrystalline limestone with conchoidal fracture, does not occur in the Roubidoux. It is merely a transition phase between the two other phases.

Beds of brecciated chert occur in the Jefferson City limestone as well as in the Roubidoux. In the Jefferson City formation, these brecciated masses contain fragments of oolitic, crystalline and banded chert as well as concretionary nodules both broken and unbroken. Each kind of chert was formed in different beds of limestone and in different parts of the same bed. The beds of chert are often as much as 18 inches to 2 feet in thickness. The nodules, where they occur in place in the limestone beds constitute only a small part of the rock and the oolitic fragments are clearly fragments formed elsewhere and brought to their present position through destructive forces. In other words, these brec-

ciated chert beds are made up of fragments of chert formed under other conditions and in another place and brought together into their present position through forces operating since the formation of the limestone beds. They are not fragmental deposits contemporaneous with the limestones. They can be the result of the removal by solution of the beds of limestone in which the chert occurred in nodules and in thin unbroken beds and the consequent accumulation of the chert in the cavity along with the settling of the overlying beds so that no cavity has been left. The chert fragments have been cemented into a breccia. The fact that many of these beds of brecciated chert occur beneath layers of crystalline limestone and on top of layers of cotton rock, points to the accuracy of this interpretation. The cotton rock is a much more impervious bed than the crystalline limestone. The top of such a bed would therefore be a place along which water would circulate. It would also be a solution plane. The crystalline limestone being nearly pure carbonate would be dissolved out. Incomplete stages in the process occur abundantly. In many beds solution has gone far enough to partially condense the chert and where the chert occurs in round concretionary nodules their concentration produces a rock which at first sight looks like a bed of waterworn chert pebbles. In every case so far found, however, the breaking of the apparent pebbles shows the concentric concretionary structure. The existence of fragments of the limestone cemented into the mass without rounding but with stratification planes turned at all angles shows conclusively the origin of the rock.

There are no thick beds of sandstone in the Jefferson City formation. The thickness rarely exceeds three feet. It is usually about one foot. A few lenses were found in which a maximum thickness of three feet was reached, but such beds could rarely be traced more than a hundred yards. The beds of sandstone in the formation are as persistent as beds of the same thickness in the other formations of the county. In fact they seem to be more persistent than the thin bed found in the Gasconade formation in the southeastern part of the county.

In tracing the outcrop of these beds, many stretches were found along which the beds could not be located. The same statement, however, can be made of beds of the same thickness in any of the other formations of the county or in any other region. Thin and inconspicous beds are always hard to trace and these beds furnish no exception to the rule.

Sandstone lenses are not abundant in the region. Only a few were found. The limestone beds are rarely sandy.

In the northwestern and north central parts of the county, there are two sandstone beds in the Jefferson City formation which are persistent. These outcrop on the upper Moreau north of Versailles and along the many branches of Richland creek. Along the latter stream, these beds can be traced from near the head of the stream down to where it joins Flat creek to form LaMine river. They are exposed also along the lower part of Haw creek. Along the upper part of this stream as well as the upper part of the Gabriel fork of Richland creek, these beds were not located with certainty. The data that were obtained in this region were not sufficient to determine whether these beds thinned out in this direction or passed below the stream level. Judging from the position of the rocks of the region in general, the former is probably the true explanation of their absence. On Gabriel Fork of Richland creek, they can easily be traced from the vicinity of Florence to the mouth of the stream and beyond. On Richland creek they first appeared above the stream bed about two miles south of the Hubbard and Moore coal mine in Secs. 33 and 34, T. 43N., R. 18W. From this point northward, they could usually be located if carefully sought. They were traced by Veatch over the region lying between Syracuse and Richland creek, as well as that lying along the north side of Flat creek above the mouth of Richland creek.

Throughout this region these sandstone beds are a little less than 100 feet apart vertically.

As a proportional part of the total thickness of rock in the Jefferson City formation, these sandstone beds are of no importance on account of their thickness. As guides in determining the exact lie of the rocks, they are of great importance. They differ from the other rocks of the formation so much that they can usually be readily located and traced. This is not the case with any of the other beds of the formation.

The planes of stratification in the sandstone beds are often wavy. They are curved and bent in a pile or layer of a great many sheets of that material that had been pressed down and made to conform to the irregularities of a very uneven surface. The strata were laid down on a plane surface and afterward deformed by the uneven or irregular solution of the underlying limestone and the settling of the sandstone into conformity with the uneven surface thus produced. This is seen in most of the thin sandstone beds ly-

ing between layers of limestone wherever they occur in the Ozark region. The limestones immediately underlying a bed of sandstone are subjected to solution to a greater extent than elsewhere on account of the passage of water along the sandstone bed.

While exposures of the rocks of the Jefferson City formation are abundant, at none of them in Morgan county is there a great thickness of the rocks shown. The following sections, however, will give a rather clear idea of the relative proportions of the different kinds of rocks described above.

The crystalline beds may be either compact or vesicular. The latter variety are rather abundant throughout the whole extent of the formation, not only in Morgan county, but elsewhere. The vesicular cavities occupy about one fifth of the total volume of the rock. They are irregular in shape, with a rough surface and are partly filled with a white siliceous powder. The vesicles usually have no definite arrangement. They may on the other hand be arranged more or less along the stratification planes bringing out the latter and giving the rock a banded appearance.

DETAILED COLUMNAR SECTION OF THE JEFFERSON CITY FORMATION.

Jefferson City Formation.

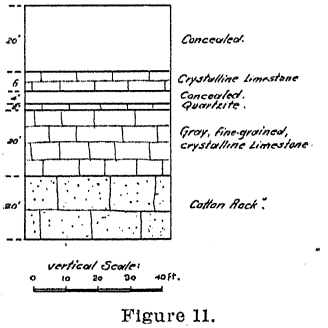


Figure 11.

Jefferson City Formation.

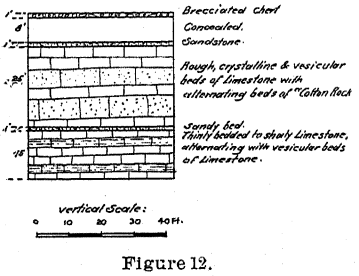


Figure 12.

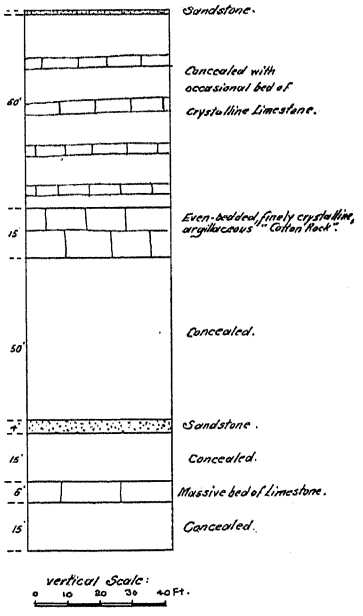


Figure 13.

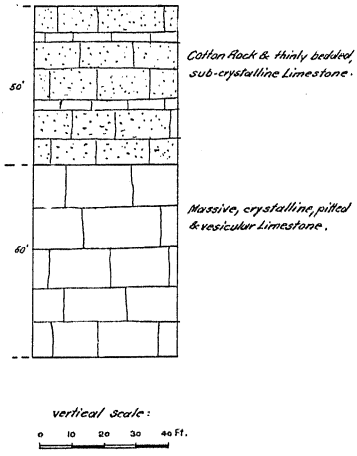


Figure 14.

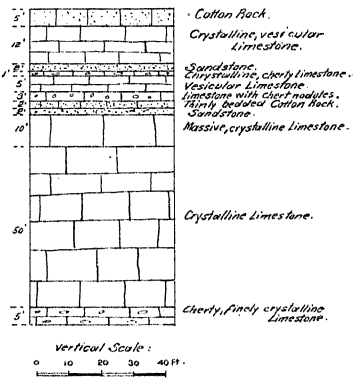


Figure 15.

CHAPTER VII.

THE ST. PETERS SANDSTONE.

Scattered over a large part of the northern half of the county, there are a great many occurrences of masses of sandstone none of them in place. They range in size from small boulders up to masses of many hundred cubic feet in contents. They rarely show any structure or bedding, but where these are present, they show that the masses lie out of the horizontal position. They are rather coarse in grain and are usually stained with oxide of iron. Where the exposure is sufficient, they are often seen to be associated with whitish clay which may be merely the residue from the enclosing limestones which were dissolved out to give room for the sandstone block or may have been let down with the sandstone from an overlying bed of clay. The occurrence of fragments of limestone and chert in the clay point somewhat faintly to the conclusion that the former is the true source of the clay. There are two possible sources from which these sandstones may have been derived. They may be masses of St. Peters sandstone that have been left from a time when this formation extended over the whole county or they may be Coal Measure sandstone left from a time when the Coal Measures still covered Morgan county. Fossils are wholly absent from them so far as they have been studied. They do not occur in place so that their stratigraphic associations can be determined. The only means we have of determining their age, is their lithologic character and their geographic position.

As was pointed out by Ball* in his report on Miller county (1) the Coal Measure sandstones of this region are characterized by a great many polygonal markings on the surfaces of the fragments. (2) The Coal Measure sandstone of the southern part of Morgan county is distributed in more or less clearly defined belts and it is often associated with black shale pockets.

The sandstone fragments and masses lying scattered over the northern half of the county do not occur in belts, they are not char-

*Mo. Geo. Survey, 2nd Series, Vol I, p.

acterized by polygonal markings and very few of them are associated with black shale pockets.

Probably some of the many thousands of scattered sandstone fragments of the northern half of the county, are of Coal Measure age. The large masses, however, and the groups of smaller boulders are most closely related to the St. Peters sandstone both lithologically and geographically and it is with this formation that they are correlated. It is one of the well known facts of Ozarkian Geology that fragments of this sandstone are now found as far as fifty miles from the present position of the main outcrop of the bed. Over the whole region lying east of the Gasconade river, south of the Missouri and north of the Meramec, these fragments are very abundant and many of them cover several acres. Morgan county is but little farther removed from the present outcrop of this formation, than much of this territory. Many and probably most of the important occurrences of these fragments are located on the accompanying geological map but no attempt has been made to locate every occurrence regardless of size. None of them are known to be in place. They have all been brought to their present position by the solution of the underlying limestones and the settling of the sandstone into the solution cavities.

CHAPTER VIII.

THE DEVONIAN AND CARBONIFEROUS.

DEVONIAN.

It has long been known that Devonian limestone patches occurred in places beneath the Carboniferous limestones around the northwestern corner of the Ozark region. They have been found in Boone, Cooper, Pettis and Moniteau but up to the present time such occurrences have not been reported from Morgan county. Recent geological work has, however, established their indentity in a discontinuous belt running across the northwestern corner of Morgan county.

The rock consists of a very fine grained massive compact bluish limestone weathering to a white color. It is so massive that the weathering takes the form of the erosion of basins and holes in the surface of the limestone rather than disintegration along the bedding planes of the rock. Crinoid stems, brachiopods and other forms of fossil remains which are so abundant in the overlying Mississippian limestones are absent from this Devonian rock. The only fossil found in it, at least without a very close examination, is a loose growing compound coral which is very abundant.

The maximum thickness of this rock is probably not more than 10 feet. In places it disappears entirely. It seems to be merely a series of remnants of an originally very extended and thick limestone formation which was nearly eroded away before the deposition of the Mississippian limestone.

MISSISSIPPIAN.

Two formations of the Lower Carboniferous rocks occur in place. Their occurrence is restricted to the extreme northwestern part of the county, the "Little Morgan" of the local nomenclature, that part lying north and west of Flat creek-LaMine river. There are other occurrences of these limestones in the county, but nowhere else do they occur in place.

Chouteau Limestone.—The lowest of the Mississippian formations exposed in Morgan county is the Chouteau limestone. The region in which it occurs is a prairie region with a smooth or undulating topography and a thick layer of soil and rock debris.

Therefore the underlying rocks are not well exposed. Very few outcrops were found. These were sufficient, however, to show the character of the rocks of the formation and their general distribution. The rocks of the formation here belong to the thinly bedded rather than to the massive phase which characterizes them at the type locality in Cooper county and on James river in Greene county. The formation consists of alternating layers of fine grained, crystalline limestone, varying from two inches to a foot or more in thickness, and thin layers of half an inch or less of shale. These alternate with thicker beds of soft somewhat earthy limestone. The formation carries little or no chert. Fossils are extremely rare, except at a few localities where they occur embedded in the rock so thoroughly that they are very hard to collect. The total thickness of the formation cannot be seen at any point though exposures are abundant enough to show that the total thickness cannot be far from 25 feet.

The Chouteau limestone was not found even in fragments in any other part of the county.

Burlington Limestone.—This formation is the most easily recognized and the most wide spread in its distribution of any member of the Mississippian series. Its lithological and paleontological characters maintain a striking uniformity over the whole area in which it occurs. In Morgan county it presents its typical coarse grained, massive, bedded, cherty and fossiliferous character. Its distribution is extremely limited. It occurs only in a few isolated places in the extreme northwestern part of the county. Where the formation is found in place, it lies in troughs in the underlying Chouteau limestone. Where the same formation occurs in other parts of the county, no Chouteau limestone has been found associated with it. This can mean therefore nothing more nor less than the erosion of the Chouteau limestone before the deposition of the Burlington. In the southern part of the county it was entirely eroded away, while in the northwestern part it was left in place but with valleys cut into it. The Burlington is therefore unconformable on the Chouteau as well as on the other rocks of the county. It has not been found in place however, on any other rocks than the Chouteau. That it once covered the whole of the county lying directly on the Ozark series without the intervening Chouteau is conclusively shown by the wide spread occurrence of fragments of the formation over the whole of the area of the county. These fragments vary in size from a few cubic feet to

many thousands of cubic feet. In no single instance has one of these occurrences been found in place. They lie in all sorts of positions from small loose fragments on the surface to large masses showing the bedding having often the appearance of being in place and having been preserved from erosion by occurring in synclines. In every case where such occurrences were carefully examined the disturbance was only local and often affected the fragment of Burlington limestone alone. In some cases, however, the disturbance affected the top layers of the underlying beds, but never extended deep. In all cases the underlying beds lay wholly undisturbed only a few feet away from the disturbed block of Burlington limestone. Beneath the Burlington fragment where the exposure was clear, or associated with it in other cases, there is almost universally an occurrence of more or less clay and rock fragments which have resulted from the disintegration and solution of the limestone. In other words, the Burlington fragments have been let down into the Ozark limestones by the local solution of the latter before the overlying Burlington was eroded away and have by this means been preserved from erosion. They have nothing whatever to do with folding. They are standing illustrations of the great amount of solution and resultant settling into the solution cavities of the overlying rocks that are constantly going on in limestone regions. A great many of these occurrences are shown on the map but no claim is made that all of them have been located and placed on the map.

These outlying occurrences of the Burlington limestone have the typical lithological and palaeontological characters which mark the rocks of this formation wherever they occur in the state. They are coarse grained, crystalline, gray limestone with abundant crinoid stems. There is no indication whatever of the approach toward an old Mississippian shore line. The Burlington limestone is unconformable on the underlying formations and is itself overlain unconformably by the Coal Measure sandstone. Before the deposition of the Burlington limestone, the Chouteau seems to have been eroded from the area of most of the county, or else was never deposited there, and most of the Burlington was eroded from the county before the Coal Measure deposition was begun.

PENNSYLVANIAN (COAL MEASURES).

The Coal Measure rocks of Morgan county consist of sandstone, shale and coal. All occurrences of the rocks of this formation in the county are small in area and few are in their original position.

Most of them lie in disturbed attitudes, in some places the dips approaching 90°. Their relation to the underlying rocks is very much the same as that of the Burlington limestone to the underlying rocks, in the southern and central parts of the county. They lie, even where they occupy their original position, immediately on the Cambrian magnesian limestone, the Burlington limestone being absent. In one case a mass of Burlington limestone is closely associated with a small area of Coal Measure rocks but it seems to be merely a fragment.

In all cases where the contact has been observed the Coal Measure beds overlie unconformably the underlying rock. Where the beds have not been disturbed this unconformity is seen to be an erosional one. In those cases where the Coal Measure beds lie in disturbed attitudes, the actual contact with the underlying beds has not been observed. There is no doubt however of the former being unconformable, if not discordant with the latter, because of the wide time interval between the two series of beds.

The Coal Measure rocks of Morgan county occur in four separate areas. These I shall designate as the Locust creek, Mill creek, Versailles-Indian creek and the Richland creek areas. The Locust and Mill creek areas consist of sandstone and the others consist mainly of shales and coal. In each area the Coal Measure rocks occur only in a number of very small, isolated patches.

The Graydon Sandstone.—The sandstone of the Locust and Mill creek areas is thought, on account of its lithological and stratigraphic characters and relations, to be the equivalent of certain sandstones occurring in Miller county. These Miller county rocks have been referred by Ball to the age of the Graydon sandstone of Greene county on account of similarity of lithologic and stratigraphic characters. In each case, in Greene, Miller and Morgan counties, this sandstone represents the return, each in its own locality, to estuarine conditions, the forerunner of marine conditions after a long time during which land conditions had prevailed. Each represents the sandstone filling that was laid in valleys and depressions of an old land surface. To the extent, therefore that their conditions of sedimentation were alike these occurrences of sandstone are alike and to that extent is their correlation justifiable. They are not necessarily, however, exactly equivalent to each other in age. The Morgan county occurrences carry no fossils, or at least none have been discovered, whereby their ages can be more accurately determined.

GRAYDON SANDSTONE.
S. W. ¼, N. W. ¼, Sec. 9., T. 41 N., R. 18 W.

The Locust Creek Area—The Coal Measure rocks of this region occur in a belt of small patches which runs southeastward in a remarkably straight course for a part of its length. It begins near the center of section 6 not far from the head of Locust creek and extends entirely across the township. For nearly three miles its course is straight and the occurrences confined to the direct line of the course with no outliers. Near the middle of the township its main course changes slightly to the southeast and at the same time the occurrences along the line of the course become less regular. Scattering outliers appear also so that its belt like character is much less evident. From the beginning of the course in section 6, to the eastern side of section 9, the individual occurrences are much longer in the direction of the belt than across it. The structure and bedding is not, in every case, easily determined but in some of them the beds lie in a horizontal position while in others they are strongly tilted and in one or two cases they lie nearly vertical. This is notably the case with the occurrence lying across the point of land between two hollows in the center of the north half of section 8. In the first occurrence in section 6, the bedding does not seem to lie horizontal. In these cases, all of which lie along or near hollows, it seems probably that their disturbed attitudes is due to solution of the underlying limestone and the settling of the sandstone into the cavity. The limestones when they can be seen are always horizontal. In sections 14 and 15, the occurrences are all seemingly in place and where their bedding planes can be determined the sandstone lies horizontal. In a few cases there are exhibited thin layers of conglomerates and coarse sand beds near the base of the sandstone. The pebbles are invariably of chert. Some of these occurrences show that they were deposited on slopes and in a few cases they lie around the heads of hollows, with horizontal bedding, but the mass being thick on the inside and thinning out with the rise of the hill on the outside showing that the modern hollow lies in the position of a Carboniferous ravine of much the same character as the existing one. This is true of the occurrences on the section line near the middle of the east side of section 15 and also of one in the N. E. ¼ S. W. ¼, Sec. 18, T. 41N., R. 17, W. The other occurrences in this part of the belt show no striking features.

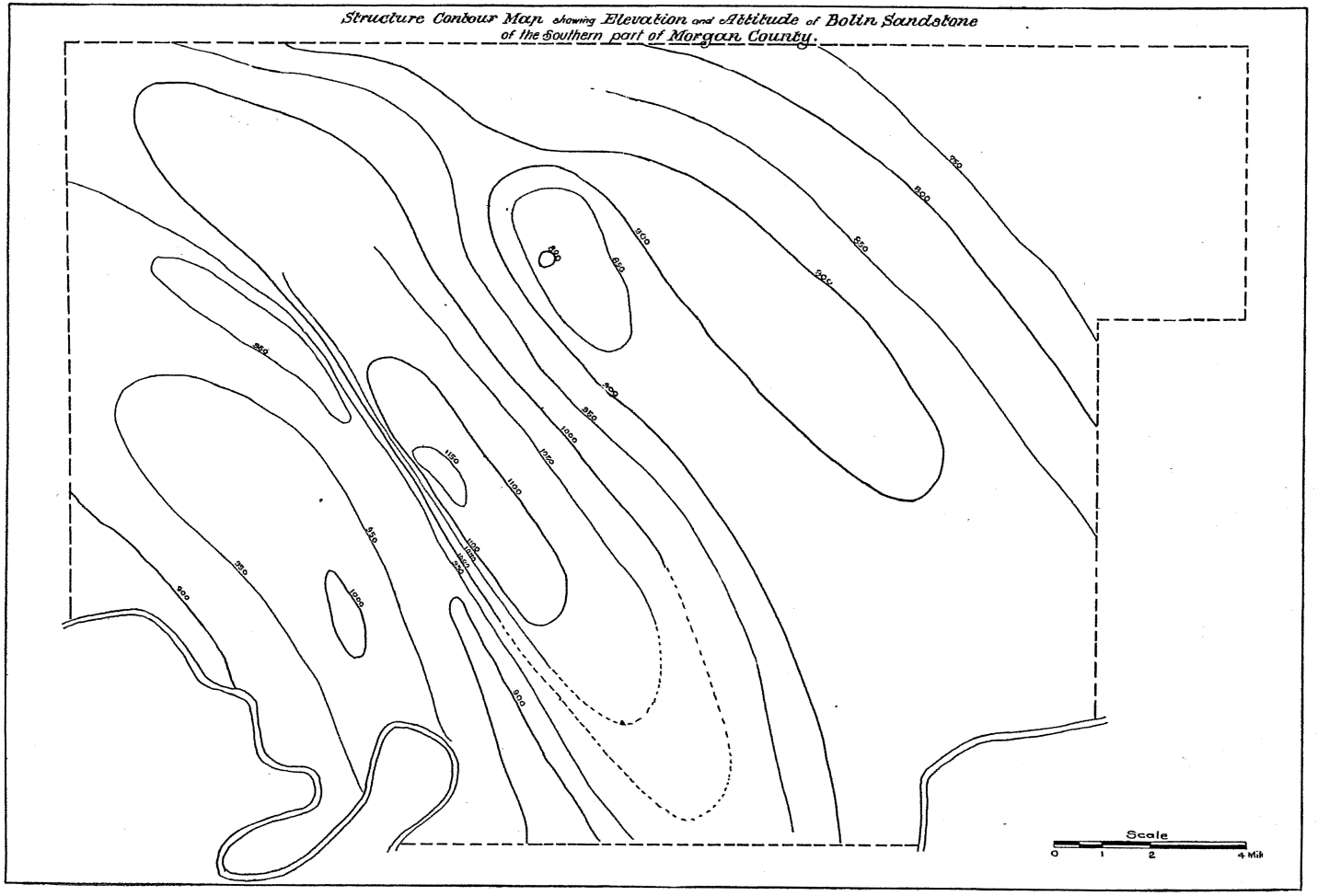
Where this belt crosses the ridge between Locust and Brushy creeks in the southeastern part of section 9, it has a decided effect

on the elevation. The elevation of the ridge is here at least 70 feet lower than it is further east and nearly 200 feet lower than it is further west.

The Mill Creek Area—It is probable that the Mill creek group of Graydon sandstone occurrences should be included under the Locust creek belt. Their connection is indicated, somewhat faintly it is true, by the occurrence of scattering patches between the two localities. The Mill Creek occurrences lie in section 15, T. 40N., R. 17, W and in the adjoining part of section 16. There are only a few occurrences the main one of which consists of a string of four large masses which apparently were originally one having been separated by weathering along joints. They lie on top of a flat ridge and stand 25 to 30 feet above the surface of the land around them. The largest mass is about 250 feet long, 25 feet in horizontal cross dimensions and 30 feet high. It is much broken by vertical jointing and its base lies barely below the level of the surrounding surface. It presents the appearance of a thick bed of sandstone standing vertical. Close inspection of its base, however, reveals faint stratification which lies horizontal. The other occurrences are less striking than this, but essentially like it except the two small ones in section 16. These are merely large masses which show no bedding. They lie on the hillside and probably not in their original place and position. In the vicinity of these last occurrences and around them there are scattering pebbles of well worn chert. They lie on the hillside well above the creek and are too well rounded to be creek pebbles even if they were found in its channel. They have undoubtedly weathered out of the basal bed of the sandstone.

Origin.—The distribution of those occurrences of this sandstone along Locust creek suggests at first sight their existence along the bottom of a syncline and their preservation for that reason. The fact that the underlying limestones show no inclination toward this belt from either side makes that explanation of their distribution untenable. A few of these occurrences seemingly lie in a tilted position as has been stated already. The fact, however, that only a few, and not all of them lie in this position indicates that their occurrence could not be due to faulting or to any other disturbance which extended throughout the whole extent of the belt. The occurrences of some of these fragments in disturbed attitudes and of others in undisturbed ones indicate that the disturbance is local while the distribution as a belt is due to conditions of

Structure Contour Map showing Elevation and Attitude of Bolin Sandstone of the Southern part of Morgan County.



deposition rather than later disturbance. It is perfectly evident to any one who has studied the geology of the Ozark region that the occurrence of faults of small throw are very difficult of detection on account of the uniform character of the rocks in the country. Such a fault may possibly occur along the line of this belt but that an important fault occurs along this line is wholly lacking in evidence.

There can be very little doubt that this line is the line of an old Carboniferous valley which became filled with sandstone when Coal Measure deposition began in the region. Being a low belt in the limestone it became after the post-Carboniferous uplift of the region a belt to which the ground water drained through its sandstone filling. This caused a greater solution of the underlying limestones along this belt than elsewhere and a greater disturbance of the rocks due to the consequent settling into the solution cavities. Hence probably arose the local disturbances of the sandstones along this belt.

The gap in the Locust-Brushy creek ridge points also to the existence of a valley in the pre-Carboniferous limestones along this line.

Some of the occurrences in Brushy and Mill creeks are to be regarded as scattered occurrences left here and there along the belt of the old valley rather than along its axis. The rest of these occurrences represent fragments left still adhering to the slopes of the old valley or in ravines tributary to the old valley, which post-Carboniferous erosion has not yet removed.

Shale and Coal.—All other occurrences of Coal Measure rock, not including the fragments of sandstone which lie scattered over the surface of the whole northern part of the county, some of which may be of Coal Measure age, consist of shale and coal, or at most only thin layers of sandstone. In every case without an exception, those occurrences that were examined showed more or less disturbance of the bed. In a few cases the disturbance is slight, but in most cases it is considerable, the beds lying at steep angles up to 60° or in extreme cases a little more. In every case, however, the limestone beds on which these deposits lie, which were exposed in many cases only a few feet away or at most only a few hundred feet away, lie horizontal or nearly so.

In every case the known extent of these occurrences is very small. While the exact boundaries can very rarely be determined yet a maximum boundary can be determined and in nearly every

case, even allowing for the existence of the maximum area, the total areal extent can amount to only a few hundred square rods.

There are a great number of these occurrences in Morgan county. In many of them, there is nothing more to be found than a mass of shale fragments, smut or merely white clay. Many of them are located on the accompanying map but no claim is made that they have all been found and located, nor in fact are all the occurrences located that were found or reported by residents of the county, while the work was going on. The individual occurrences have in most cases no significant relation to the general geology of the county. They are merely accidental, determined by subterranean solution and settling. While the individual occurrences as such have no broad significance yet their occurrence in areas or belts probably shows the position of sags in the land surface that was depressed when Coal Measure deposition began in this region. As has already been stated above, those sags or basins would have a tendency to draw the underground drainage into and along them, thus causing a greater underground solution along these belts than elsewhere. The Coal Measure rocks were thickest along these lines also and other conditions being equal, they would be eroded away from these areas last, or, what amounts to the same, they would exist here longer than elsewhere giving still greater opportunity for underground erosion to undermine them and let them settle into a position safe from surface erosion for a long time.

The relation of these deposits to the existing drainage is also significant. Other things being equal the Coal Measure rocks would linger longest on the existing watershed because erosion is less rapid there. The encroachment of the ravines on this watershed, especially where the ravine heads are sharp and deep will inevitably undermine parts of this remnant and cause it to settle either into the bottom of the ravine or along the slopes. It is a very significant fact that every single occurrence of coal or Coal Measure shale, where it occurs in any significant quantity, found in the county lies either at the head of a ravine or on its slope not far from its head. In every such case where the position of the shale or coal beds could be determined, they dipped toward the axis of the ravine. It is not at all impossible that some occurrences do exist in which this is not the case, but the survey note books have no record of such. The existing ravines were in many cases lines of underground drainage. They have been such, however,

only since the inauguration of the existing drainage cycle which is probably not older than the Kansan glacial period. The disturbed attitude of these Coal Measure pockets is therefore of very recent making.

The Stover coal bank shows the least disturbance of any of the localities examined. The beds, however, rise toward the sides of the deposit rather steeply, although it is possible that this rise is merely the original slope of deposition though it seems to be too steep. The further fact that the beds, excepting the coal, are of approximately the same thickness from one side of the deposit to the other seems to be evidence sufficient to show settling. The upper beds are turned up at the sides of the deposit and disappear by being cut off by erosion rather than by thinning. The coal thins toward the sides but whether it thins out completely before the surface is reached or whether it is cut off by erosion could not be determined at the time of examination.

The detailed description of these occurrences is wholly unnecessary. The more important ones are located on the map. Suffice it to say that they are all intimately associated with the existing drainage, as stated above, occur in certain rather well defined areas and do not occur in place but have been brought from above by the solution of the underlying rocks and the settling into the cavities thus formed. A few of them will be more fully described under the head of Economic Geology.

CHAPTER IX.

THE TERTIARY, QUATERNARY AND RECENT.

Lafayette Gravels.—The gravel beds placed provisionally in the Lafayette occur in place only on the highest points of the county, or where erosion has not reached them. They consist exclusively of chert and quartzite pebbles, not perfectly rounded, yet well worn, of a reddish color and rather small size. The average size will not run more than an inch in diameter. They are imbedded in a very tough reddish clay that is difficult to handle and almost impervious to water.

The distribution of these beds is not well worked out. Their occurrence is inconspicuous, so much so that they were not discovered until recently. They have been found in place at only two localities. One of these is in the southwestern part of the town of Versailles where they have been exposed in opening up a clay pit, the other is about a mile west of town where they are exposed in a railway cut and also in another clay pit. In many other localities along the main watershed of the county, there are areas of flat wet land showing signs of being underlain with some kind of impervious material which may be the gravel bed and its clay matrix. The maximum thickness of the bed is not more than three or four feet.

Pleistocene.—Meek* referred to the occurrence, in the valley of Gravois creek in Morgan county, of a "solitary granite boulder," but he does not describe its location. This was not found during the progress of the work here described nor were any other occurrences noted. Ball and Smith** describe the occurrence in Miller county of a group of foreign boulders whose occurrence is undoubtedly due to glacial action, either directly or indirectly. The glacial border in Missouri has been studied very little. We have accepted more or less without question the location, by the earlier geologists, of this boundary approximately along the Missouri river. No studies have been published which have been sufficient to convince me that the boundary does not lie some distance south of

*Geol. Survey of Missouri, 1855-71, p. 139.

**Geol. Survey of Missouri, Vol. I, 2nd Series, p. 119-121.

the river. There is some evidence accumulated in recent years that rather extensive deposits of glacial age, if not of glacial origin, extend considerably south of the river. On the high plateaus of a large part of the Ozark region lying north of the St. Louis and San Francisco railway and east of the Gasconade river, there is a whitish clay full of very small chert fragments not well rounded but very smooth. This clay is wholly unlike the residuary clay of the region, in appearance at least, and the large chert fragments found so abundantly in the latter are wholly absent from it.

The same deposit with very similar character is found in a few places on high parts of the upland of the northern part of Morgan county. It is whitish in color and contains abundant small smooth chert fragments. It has not been carefully examined for the occurrence of crystalline fragments. It seems to be so different in character from the residuary material, that it must be different in origin from the latter. This deposit consists at present of a layer of silt at top, usually about 12 to 16 inches thick underlain by a tough clay layer of about a foot in thickness. This is often, in fact usually is, reddish to reddish brown in color and an exposure in a cut breaks into blocks approximately cubic in shape.

Beneath the red clay layer is a thick layer of mottled (yellow and blue) clay often with a gray silt layer at top. The small smooth chert fragments referred to above occur in this mottled clay. The gray silt on exposure washes out over the mottled clay giving it a whitish appearance. The thickness of the mottled clay layer varies considerably but is usually not more than six feet. Beneath it lies the gravel bed that is referred to the Lafayette in this report. In many places south of the Missouri river, on the two plateaus referred to above the gravel bed consists of well rounded pebbles while in others it consists of a layer of silghtly worn but thoroughly bleached pebbles. This succession of silt, red clay and mottled clay is exactly the same as is found over northeastern Missouri where it has always been referred to the Kansas drift of the Pleistocene. In places along the southern part of this north Missouri Pleistocene area, there is some indiçation that even the gravel bed exists along with the others. The occurrence of crystalline boulders in this and the adjoining (Miller) county suggest the possibility of the ice or at least the Pleistocene deposit border lying south of its usually accepted line. The white clays of Morgan county and other places on the northern slope of the Ozark region may prove to be another bit of evidence pointing to the same conclusion.

Recent. The recent deposits of the area consist of the valley alluvium and the residuary soils. The alluvium of the county is distributed along the streams. The map shows its distribution and makes a description of it unnecessary. It is the typical silty and gravelly alluvium found along all the main Ozark streams.

The residuary soils will be described under Economic Considerations, Chapter XI.

CHAPTER X.

GEOLOGICAL STRUCTURES.

Folding.—The accompanying map (Plate XII) shows by means of 20 foot contours the geological structure of the region. The contours are drawn on the surface of the Bolin sandstone as nearly as that surface could be determined. Its position is fairly well determined for the southern part of the county south of the main watershed but somewhat doubtful for the northern part, though the error cannot be very great even here and cannot in any way effect the general position of the beds as shown on the map. The rocks of the northern slope of the Ozark region have, in most places, a gentle northward slope. In Morgan county this marginal slope is interrupted for most of the county by a northwest-southeast line of folding which enters the county in the southeastern part of township 40N., R. 18W., and passes out of it near the head of Haw creek. It enters the county as an anticlinal fold of unusual strength for the Ozark region but it gradually fades out northwestwardly until it ceases to be a marked feature before it reaches the western limit of the county.

Plate XIII. is a cross section drawn to a uniform scale horizontally and vertically in which the relative dips are shown. In the vicinity of the Buffalo mines the westerly dips are considerably steeper than the easterly ones. Farther south they remain so to within a short distance of the south line of the county. The maximum dips are about 45 degrees.

Southeastward from this county this fold extends into and through Camden county and into the northern part of Laclede county before it finally fades out. The maximum uplift along its trend is in Camden county in the neighborhood of HaHa Tonka Springs. It is one of the original southeast northwest folds of the Ozark region. The Ozark region consists of a series of these northwest southeast folds all apparently of the same age and all having almost exactly the same trend. The number of these folds is not known but three main ones and at least two subordinate ones are

known. Their date is probably late Palaeozoic or early Mesozoic, probably Appalachian. It was long enough ago for the topographic effect of the fold to have been wiped out by erosion before the existing cycle was inaugurated. The Proctor fold in Morgan county it is true, seems to have some effect on the topography but it is only at the end of the fold where the hard bed has not been breached. The effect seems to be due to the recent uncovering of the hard bed which still extends over the top of the fold raising the surface slightly higher than elsewhere.

Strong local dips are found in many places within the county but they are all due to solution and settling of the overlying beds. They have no structural significance whatever.

Joints.—The different formations in Morgan county vary greatly in their jointing. In the Proctor limestone jointing is common though, as a rule, the exposures in the county are not ideal for observing it. The lower 100 feet of the Gasconade limestone is unevenly jointed. The thin bedded portion is very irregularly jointed and the joints are so close together that the rock is broken into very small fragments. The massive beds in this lower third of the formation are coarsely jointed there being two sets crossing each other nearly at right angles. One set, slightly more prominent than the other, trends N. 25W., the other approximately N. 70E. The most perfectly and extensively jointed series of beds in the whole section is the middle member of the Gasconade limestone. These beds are admirably exposed also in the extensive surfaces of bare limestone exposed in the beds of the creeks which cross it. The joints strike parallel to those in the lower massive beds. The other formations are not extensively jointed. The fine-grained beds of the Roubidoux and the Jefferson City formations are often much broken with cracks, but they run in all and any direction through the rock. They cannot properly be called joints, and have no significant relation to any other geological fact. They are rather due to the lithological character of the rock itself.

Very few observations were made on these rocks, because the jointing was not sufficiently well defined to attract attention.

The Graydon sandstone fragments of Morgan county are often very much broken up with joints. If there is any general direction in which most of them strike it was not discovered.

In many places in Missouri the trend of the jointing has an economic significance. This is due to the fact that lead and other

minerals are often deposited along the enlarged joint cracks in quantities sufficient to make the mining of them profitable in a small way. This is the case in Morgan county to a limited extent only. In a few cases ore has been found in joint cracks, in most cases in the middle member of the Gasconade limestone.

Unconformities.—The unconformities of Morgan county are all erosional unconformities. In no case was there sufficient folding of an older series between its deposition and that of the next overlying one to cause any marked discordance of bedding. It is possible that local discordances exist caused by the solution and settling down of an older series before the deposition of the overlying series. Such an occurrence was not discovered, however. As has been stated above the greater part of the solution and settling has taken place since the inauguration of the existing geographic cycle, long after all the rocks in the county were deposited.

The unconformity between the Proctor limestone and the Gunter sandstone was first noticed by Winslow and referred to in his report on the Lead and Zinc deposits of Missouri. Though he did not call it an unconformity, he merely referred to the irregular contact of the sandstone on the underlying limestone and stated that it might be due to the plunging action of the water during the depositing of the sandstone. The only other publication in which it has been described is the Geology of Miller county in which it is described as an unconformity. The irregularities referred to are small rarely amounting to more than two or three feet and even this amount is unusual. Fragments of the underlying limestone are rarely included in the sandstone. The lower two feet of the sandstone has a great many quartzite concretions, but no pebbles. The best known occurrence, probably, of a limestone boulder in the sandstone is in the bluff overhanging the HaHa-TonKa Spring gorge in Camden county.

The thickness of the sandstone varies from about 15 to 35 feet within the area of Morgan county but the rate of variation is very slow. It is not sufficient to be attributed to erosion valleys in the Proctor limestone.

It seems to the writer to be a matter well worthy of consideration whether the irregularities found in this contact could not be produced by solution of the limestone and the sandstone cement and the shifting of the sand loosened by this means into the cavities dissolved in the limestone surface. If the Proctor limestone had been uplifted above sea level after its formation and before the

deposition of the sandstone, a soil must have been formed on its surface. This soil would have been made up chiefly of clay and limestone fragments. When it sank again to receive the Gunter sandstone, it seems to me impossible for the waves to have been strong enough to have removed the soil down to the solid rock and not strong enough to form rounded limestone pebbles. If such had been formed they would now exist along the contact. They were not found in this county, although reported by Ball and Smith as occurring in Miller county.

An alternative hypothesis to this would account for the irregularities of the Proctor limestone by marine erosion before the deposition of the sandstone. According to this hypothesis the limestone was never uplifted and never formed a land surface. It lay too near the surface of the sea for the accumulation on it of organic remains and too far away from a land area for the accumulation of detrital material.

The Chouteau Limestone—Jefferson City Limestone Unconformity.—The hiatus existing between these two formations is a long one. The Jefferson City limestone is of Lower Silurian age* and the Chouteau is of Lower Carboniferous age. The hiatus includes the whole of Silurian and Devonian time and a portion of Ordovician time. The unconformity, however, if defined in terms or degree of discordance of the beds is very slight or nothing. It is, as in the other case, an erosion unconformity. The original southward extent of the Chouteau limestone is not known. It has not been found south of the La Mine river, either in place or in fragments. The undoubted marine character of the limestone north of the La Mine makes it practically certain that its extent was wide spread over a large part if not over the whole of the Ozark region. Its outcrop around the region is continuous with the other Mississippian limestones and the rock is uniformly marine in character, although sometimes associated with an underlying, or in places an overlying, shale. This latter, however, carries marine fossils.

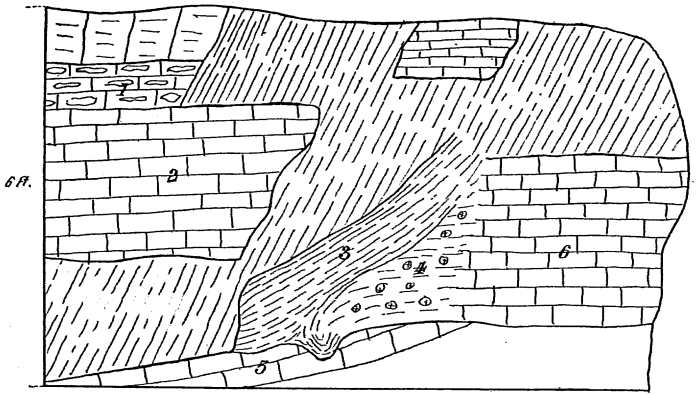
The Chouteau-Burlington Unconformity.—There is considerable doubt as to the existence of an unconformity at the junction

*The Jefferson City formation is probably of Cambrian age instead of Lower Lilurian. —E. R. Buckley.

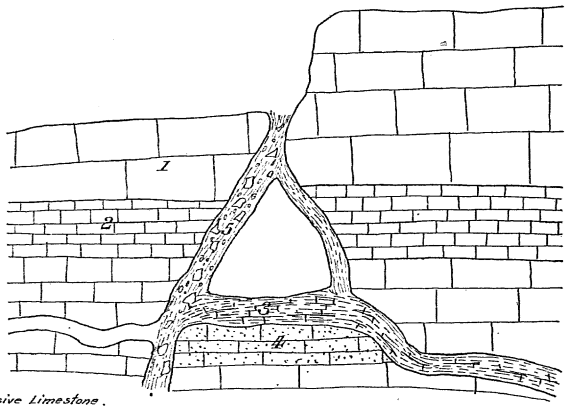
The St. Peters and older Formations Unconformity.—The St. Peters sandstone wherever observed appears to overlie unconformably the older formations. It is not well exhibited in this county, but there is every indication that the relations are the same as those observed in Franklin and Jefferson counties where an unmistakable unconformity exists.—E. R. Buckley.

Breaking and Faulting due to Solution.

Middle East Line Sec. 28, T. 42 N., R. 17 W.



1. Thin-bedded Chert
2. " " Limestone.
3. Black Shale.
4. Black Shale, Soil and oolitic chert.
5. Massive Sandy Limestone
6. Cherty Limestone



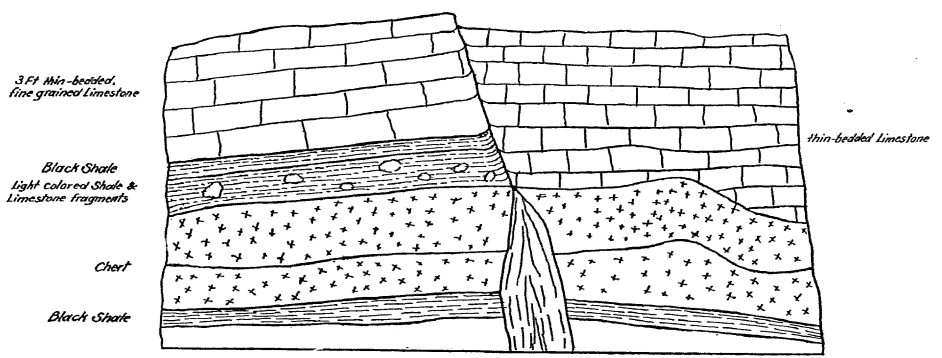
1. Massive Limestone.
2. Thinly bedded Limestone.
3. Black Shaly Limestone.
4. Colton Rock
5. Black Shale containing Limestone & chert fragments.

Result of Solution.

in N.W. 1/4 Sec. 10, T. 42 N., R. 17 W.

Faulting in Jefferson City Limestone due to Solution.

S.W. cor. Sec. 15, T. 42 N., R. 17 W.



FAULTING DUE TO SOLUTION.

of these two formations. The absence of the Chouteau limestone from the small occurrences of the Burlington in the southern part of the county would indicate that in this part of the county the latter limestone was deposited directly on the older formations after the erosion of the Chouteau. One of Veatch's sections in the railway cut in the northwestern part of the county, indicates the same thing (Fig. 16). The absence of such an unconformity, however, in any other portion of the state is strong evidence against its occurrence here. If it does occur here, it is doubtless due to movements taking place along the Proctor anticline.

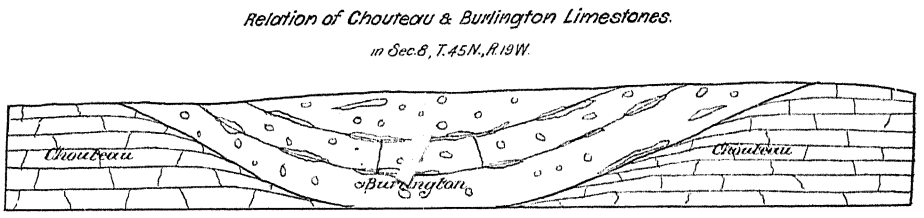


Figure 16.

The Coal Measure—Burlington and Older Limestone Unconformity.—The relations of the sandstone correlated in this report with the Graydon sandstone and the underlying rock is easily determined to be an unconformable one. As stated under the description of that formation, it lies as a filling in erosion valleys in the old rocks. The relations, however, of the other Coal Measure rocks to the underlying formations are not so easily determined. In all cases where the contact is exposed the rocks are thrown out of their natural position by solution and settling. In the case of the Stover coal deposit, however, although the contact is not exposed yet, the relations existing seem to be partly at least due to original deposition in a depression in the older rock. Aside from these considerations, the wide discrepancies in age of the rocks renders any farther discussion of their relations unnecessary. A wide hiatus exists and the lower rocks were subjected to prolonged erosion before the deposition of the Coal Measures.

CHAPTER XI.

ECONOMIC CONSIDERATIONS.

The subject of mining is a very attractive one to the people of Morgan county. Much of the southern part of the county is rough, making cultivation difficult and the soil, although by no means sterile, does not yield abundant returns under the haphazard treatment that is often given it by the American farmer. The northern half of the county is much smoother and the soil much better so that the people of that part of the county have not felt themselves under the necessity of finding some means of adding to the income from their farms. The interest in mining in Morgan county, as in many other places, is a function of the fertility of the soil increasing in an inverse ratio to the increase in fertility. The occurrence of lead ore at various places in the county attracted the attention of the people to mining and the occurrence of coal pockets in which the coal occurs in phenomenally thick bodies serves to keep up this interest, not so much a result of actual mining operations as the result of vigorous advertisement by real estate men.

Lead, zinc, coal, iron, barite and clay occur in Morgan county and all have been mined to a greater or less extent. The history and conditions of mining these various minerals is given below under the discussion of the mineral concerned.

Suffice it to say here that the only mining at the present time is that of coal, clay and barite.

LEAD AND ZINC.

Lead mining was begun in Morgan county on a small scale as early as 1858. No furnace for smelting it had been erected at that time and probably very little if any ore was shipped. Very soon afterwards, however, furnaces were erected and the pig lead was shipped by boat down the Osage and Missouri rivers to St. Louis, and hauled to the railway at Otterville. The industry did not develop to any great extent, however, until after the Civil war. In Meek's report on Morgan county written between 1855 and 1860,

he states that the number of localities where loose fragments of lead ore had been found in the county were so numerous that the mere mention of them all would be extremely tedious. He names about a dozen localities where some mining had actually been carried on and states the approximate amount of ore mined up to that time so far as he could learn. It is probable that before the outbreak of the civil war, some 200,000 to 250,000 pounds of lead ore had been raised in Morgan county.

During the Civil war and for a few years afterward, mining, as well as most other industrial operations, was suspended. The next report on the Morgan county mining industry was published in 1874 but the report* was written the year previous. At that time there were seven furnaces in operation within the county boundaries either continuously or intermittently and the author described fifty localities at which mining was then being carried on or had been carried on recently. From many of these places a production running well up into the hundreds of thousands of pounds, had been reached. This development of the mining industry seems to have begun about 1870 and probably reached its highest stage of productiveness in 1874. In 1873 the author of the report above cited states that the product of the mines of the county from July 1st to December of 1873, was more than one million pounds of galena. The accompanying map shows the location of these mines.

The next official examination of Morgan county mining industry and geology was made in 1902-04 of which this paper is the report.

During the summer of 1902, no ore was being shipped from the county and none was being smelted within the county. There were no smelters in existence in the county at that time, there are none now and have been none for several years past. In the summer of 1902, a small amount of prospecting was being done in a sporadic way by farm hands and other laborers on their own account but in none of the localities was any ore discovered and the work was abandoned within a few weeks. Again in the summer of 1903, some prospecting was being done. A New York company leased the old Buffalo mines and spent considerable money in an attempt to sink a shaft in the bottom of the old mine, but after a few months the work was abandoned.

In the following summer, a small amount of work was being done in surface prospecting in the neighborhood of the old Buffalo mine and some more pretentious work was being carried on in the

*Report, Mo. Geol. Survey, 1873-1874, pp. 534-555.

neighborhood of the old Crystal mine in Sec. 19, T. 42, R. 18. In none of these cases has any ore been discovered more than just enough to encourage the prospectors in keeping up the work. At the present time (July 1907) some prospecting is being carried on at the Crystal mine by the same parties who were doing the work in 1904. A little work is reported from Indian creek also, but no ore is being raised at either place. According to Mr. George B. Clark of Versailles, mining declined very rapidly after 1875. From 1871 to 1875, a great deal of ore was raised, but after the latter date, the production dropped rapidly and has never recovered.

Mr. Clark states that of the fifty mines described in the report cited above, only about ten or eleven of them were important producers. In the following list each of these important mines is indicated by italics. The locality of each mine, the occurrence of the ore and the geological horizon of the ore are described.

Johnson-Davidson Diggings.—Sec. 26, T. 40N., R. 17W. The ore was found as "float" or loose pieces of galena in cherty surface clay from 6 to 10 feet below the surface. The horizon of the ore is near the top of the Gasconade limestone.

Band Diggings.—Loose galena in red clay with occasional fragments of barite. Ore was not distributed uniformily through the clay of the region, but ran in belts of a few feet in width about 300 feet in length and in a northwest-southeast course. In places vertical seams or veins and horizontal sheets ran into the solid limestone, but in every case they were too thin to mine profitably.

The ore occurred in the upper coarse grained beds of the Gasconade limestone.

Lower Indian Creek Mines.—The ore occurred altogether in residual clay either above the solid rock, derived from the upper coarse grained beds of the Gasconade limestone or in irregular openings in the same limestone or under a cap of the cherty, shaly beds occurring in the same series of rocks.

Madole Diggings.—Loose galena in the clay filling of an old cave in two northwest-southeast crevices. Occurred in the top beds of the Gasconade limestone.

Doph Diggings.—W. ½ of E. ½ Sec. 18, T. 41N., R. 16W. Ore occurred as a vein of galena and barite in the limestone. Was followed downward to a depth of about 70 feet. Vein could be traced a distance of about a quarter of a mile. Occurred in the upper part of the Gasconade limestone.

Granby Diggings.—West ½ Sec. 30, T. 41N., R. 16W. Shallow diggings but exact occurrence of the ore could not be determined. Ore occurred in the upper bed of the Gasconade limestone.

Kelsey Diggings.—S. E. ¼ of the S. E. ¼ Sec. 5, T. 41N., R. 16W. Ore is said to have occurred as seams and sheets in the limestone. Poduction was small. The ore occurred in the Roubidoux formation.

Strong Diggings.—N. W. ¼ of the N. W. ¼ Sec. 27, T. 42N., R. 16W. Ore occurred in red surface clay derived from the disintegration of the upper beds of the Roubidoux formation. Only a few thousand pounds of ore raised.

O'Brien Diggings.—N. ½ of the S. W. ¼ Sec. 17, T. 41N., R. 17W. and E. ½, N. E. ¼, Sec. 24, T. 41N., R. 18W. Ore occurred in the surface clay and was mined in shallow diggings. The clay is derived from the disintegration of the upper beds of the Gasconade limestone.

Brushy Diggings.—S. E. ¼ Sec. 12, T. 41N., R. 18W. Ore is found in red clay derived from the highest coarse grained bed of the Gasconade limestone. It occurred chiefly along a terrace-like "break" in the slope of the hill immediately below the basal chert bed of the Roubidoux formation. Fragments of barite were found occasionally associated with the lead.

Gray Horse Diggings.—N. E. ¼ of the N. W. ¼ Sec. 13, T. 41N., R. 18W. Ore occurred in the same way and on the same geological horizon as at the Brushy Diggings.

New Joplin Diggings.—S. E. ¼ of the N. W. ¼ Sec. 13, T. 41N., R. 18W. Occurrence the same as at the Brushy Diggings.

Caldwell Diggings.—N. E. ¼ of the N. E. ¼ Sec. 14, T. 41N., R. 18W. Occurrence essentially the same as at the Brushy Diggings.

Blow Diggings.—S. W. ¼ Sec. 23, T. 41N., R. 18W. Occurrence essentially as at the Brushy Diggings.

Wild Cat Diggings.—N. W. ¼ of the S. W. ¼, Sec. 12, T. 41N., R. 18W. Occurrence essentially the same as at the Brushy Diggings.

Wilson Diggings.—W. ½ of the S. E. ¼ Sec. 12, T. 41N., R 19W. Lead ore occurred as seams in chert and limestone. This ore occurred in the lower part of the Roubidoux.

Buffalo Mine.—S. E. ¼ of the N. W. ¼ Sec. 1, T. 41N., R. 19W. This was the most important mine that has ever been developed in Morgan county. The ore occurred in a "circle."

Johnson Diggings.—Sec. 1, T. 41N., R. 19 W. These mines were on the same tract as the Buffalo mine and on the same hillside. They were also in almost the same beds of rock since at this locality the rocks all dip southwestward and these mines lay along the strike of the beds southwest of the Buffalo mine. The ore occurred, however, in the clay and among the boulders of decomposition of the coarse grained beds of the upper portion of the Gasconade limestone. No circle was ever discovered here.

Potter No. 1, Stover, Clark and Simmons Diggings.—All located in Sections 20 and 21, T. 42N., R. 18W., and as a group were known as the Rocky Ford mines. The ore in all of them occurred in the red residuary clay and in crevices and thin seams in the rock underneath the clay. The rock is the coarse grained limestone of the upper part of the Gasconade. Barite occurred along with the ore but not in great abundance.

Potter No. 2 and Wolf Den Diggings.—These were located in the N. W. ¼ of Sec. 31, T. 42N., R. 18 W. and in the S. W. ¼ of the N. W. ¼ of Sec. 30, T. 42N., R. 18W., respectively. In both the ore occurred in the red surface clay with thin seams in the rock beneath but not rich enough to mine. The rock belongs to the upper part of the Gasconade group. The production was small in both.

Ferguson Diggings.—In the S. W. ¼ of Sec. 28, T. 42N., R. 18W. The ore occurred in a crevice from 6 to 12 feet wide filled with fragments of the adjoining limestone and red residual clay with fragments and crystals of galena and barite. The barite in some cases enclosed crystals of galena. The crevice was traced along the surface about 30 feet. It dipped from 45° to 60° but the direction of dip and the strike is not stated in the description. It is all covered at the present time. The wall rock of the crevice is the upper part of the Gasconade limestone.

Argenbright and Fair Diggings.—Located on the S. E. ¼ of the S. E. ¼ and the S. E. ¼ of the N. E. ¼ respectively of Sec. 18, T. 42N., R. 18W. In both the ore occurred as loose or float galena in red surface clay derived from the coarse grained beds of the upper part of the Gasconade limestone.

Merritt Diggings.—S. W. ¼ of the N. W. ¼ of Sec. 23, T. 42N., R. 18W. The ore occurred in irregular crevices and cavities in the limestone which lies near the division line between the Gasconade and the Roubidoux formations. It lies above the main massive coarse grained beds of the Gasconade limestone and

in beds showing the essential characteristic of those beds of the Roubidoux formation lying below the Bolin sandstone.

Neilson Diggings.—N. W. ¼ of the N. E. ¼ of Sec. 6, T. 41N., R. 17W. The ore occurred as float galena in red surface clay derived from the disintegration of the upper beds of the Gasconade limestone.

Wyant Spring Diggings.—Located in the S. E. ¼ of the N. W. ¼ of Sec. 32, T. 42N., R. 17W. The ore occurred here in a belt or rather in two parallel belts running northwestward along a slope. Galena occurred loose in the surface clay which was here from 10 to 20 feet thick. Beneath the clay in the rock were crevices from six inches to two feet in width in the solid limestone which contained black clay, fragments of black shale, chert and fragments of limestone with galena adhering to the limestone of the walls and the fragments. The fissures are widened joint cracks occurring in the upper coarse grained beds of the Gasconade. The ore, as well as its association, is much like that of the mines along Brushy creek, described above (Brushy, Gray Horse, New Joplin, etc.)

Schultze Diggings.—N. E. ¼ of the N. E. ¼ Sec. 33, T. 42N., R. 17W. The ore occurred as specks and pockets of galena in the limestone and loose pieces in the clay. It is somewhat doubtful as to its exact horizon. It lies near the boundary between the Gasconade and Roubidoux but probably in the bottom beds of the latter.

Spurlock, Townley and Moreland Diggings.—These mines were located in the N. W. ¼ of the S. E. ¼ of Sec. 24. The N. W. ¼ of the N. W. ¼ of Sec. 23 and the N. ½ of Sec. 22, respectively of T. 42N., R. 17W. The ore occurred as loose pieces in clay and disintegrated limestone and as seams in the limestone. The rock whose disintegration furnished the clay is the upper part of the Roubidoux formation.

New Granby Diggings.—S. ½ of the S. W. ¼ Sec. 9, T. 42N., R. 17W. The ore occurred in red and yellowish clay overlying the limestone to a thickness of 15 to 25 feet. The main body of the ore, except that which had drifted down the slope occurred in one case in a belt about 30 feet wide and 80 feet long, and in another case in an area about 70 by 100 feet. Both deposits may be the remnants of "circles" that occurred in the limestone above the existing hilltop and have been let down to their present position by disintegration. In the settling from their former higher position, they became considerably distorted. The ore occurred in clay

lying on top of a ridge and along the horizon of the top of the Roubidoux group, though it probably belongs to the Jefferson City formation rather than the Roubidoux.

The Gum Spring Diggings.—Located at the foot of the hill on which the New Granby diggings occur. The ore was in surface clay and without much doubt drifted down the slope from the latter deposits.

African and Versailles Diggings.—These mines were located in the N. E. ¼ of the S. W. ¼ of Sec. 5, T. 42N., R. 17W. The ore occurred in red clay immediately above the limestone. The rock is Jefferson City limestone.

Gabrielle Diggings.—N. W. ¼ of the N. E. ¼ of Sec. 17, T. 33N., R. 18W. Situated on a gradual westerly slope of a small ravine. The ore occurred chiefly in the surface clay only a few feet from the surface. The underlying rock, however, is disintegrated broken and thrown out of position down to a considerable depth. Along with the broken and disturbed limestone masses, occurs black Coal Measure shale which has fallen or settled down from a much higher position. In one case reported by Schmidt the shale occurs alongside a vertical wall of broken limestone so that a shaft sunk at this place had limestone on one side and Coal Measure shale standing vertical on the other.

The rock in the vicinity belongs to the upper part of the Roubidoux formation or to the lower part of the Jefferson City limestone.

Perry Ross Diggings.—S. W. ¼ Sec. 10, T. 43N., R. 18W. Ore was said to have been disseminated in the limestone. Production was small. The rock of the region is the lower part of the Jefferson City limestone.

Price Mill Diggings.—E. ½ of the S. E. ¼ Sec. 35, T. 44N., R. 19W. The ore occurred in veins with barite in the solid limestone of a bluff of Richland creek. Production small. Ore occurred in the lower part of the Jefferson City limestone.

Otter Diggings.—Center of Sec. 36., T. 44N., R. 19W. Small amount of loose galena in the clay among the boulders of coarse grained limestone derived from the weathering of the Jefferson City limestone.

Stucker Diggings.—N. W. ¼ of the S. W. ¼ of Sec. 25, T. 44N., R. 19W. Ore occurred as small fragments of galena and blende disseminated through a structureless mass of "gumbo." The latter was a tough clay evidently derived from Coal Measure shale with more or less intermixture of the disintegrated and par-

tially disintegrated limestone of the wall rock. The deposit lies in the valley of Richland creek and a shaft has been sunk into it to a depth of nearly 150 feet without striking the solid rock. Prospecting was being carried on at this place in 1903, but very little ore was being raised and none was being shipped. The limestone in the neighboring hills is the Jefferson City formation. This is undoubtedly one of those deposits similar if not identical with the "Circles." It is essentially a vertical shaft in the horizontal limestone of unknown depth and diameter filled with the debris of originally overlying beds of rock in which galena and blende has been deposited.

Twin Spring Diggings.—S. E. ¼ of the N. E. ¼ Sec. 19, T. 45N., R. 18W. Ore occurred in crevices and cavities in the limestone along the bluff of Richland creek, beneath five to fifteen feet of residuary clay. The limestone belongs to the Jefferson City group. Barite is occasionally found associated with the limestone. A thin vein occurred in the bluff of the creek.

Wear Diggings.—S. E. ¼ Sec. 34, T. 45N., R. 19W. The ore occurred as loose fragments of galena and barite among limestone boulders of disintegration occurring beneath 30 to 50 feet of residuary chert and clay. The rock of the region is the Jefferson City formation.

Zollinger Diggings.—These diggings were located in the same section as the Wear diggings in the same geological formation and the ore occurred in the same way.

Coodray Diggings.—N. W. ¼ of the S. W. ¼ of Sec. 22, T. 45N., R. 19W. The ore occurred among broken masses of limetone beneath 10 to 30 feet of residuary clay and chert. Some crevices filled with black clay and crystals of blende were encountered also. The rocks belong to the Jefferson City formation.

Edward Diggings.—S. E. ¼ of the S. E. ¼ of Sec. 15, T. 45N., R. 19W. The ore, barite in this case, occurred in essentially the same way as in the last two.

Excelsior Diggings.—N. E. ¼ of the N. E. ¼ of Sec. 19, T. 43N., R. 16 W. Ore occurred as loose galena in clay. The ore occurred well up in the Jefferson City formation.

Bluff Spring Mine.—N. W. ¼ of the N. W. ¼ of Sec. 12, T. 44N., R. 17W. These mines were being operated in the summer of 1903 and some ore being shipped. The ore is almost exclusively zinc. It occurs as "pebble" ore or as small roundish crystals and fragments in veins and crevices and in the clay of broken and disintegrated cotton rock. Part of the clay may be derived from Coal

Measure shales and clays, though this is not evident because of the close similarity of the gray Coal Measure shale when disintegrated to the disintegration products of cotton rock. The ore occurs in the lower beds of the Jefferson City formation and the upper beds of the Roubidoux. The ore is mined from a shaft 100 feet deep.

(It is reported that this mine has produced something over $100,000 worth of ore since first discovered. Figure 17 is a cross-section of this mine showing the character of the deposit and its relation to the enclosing formation as furnished by J. P. Hamilton, former superintendent.*)

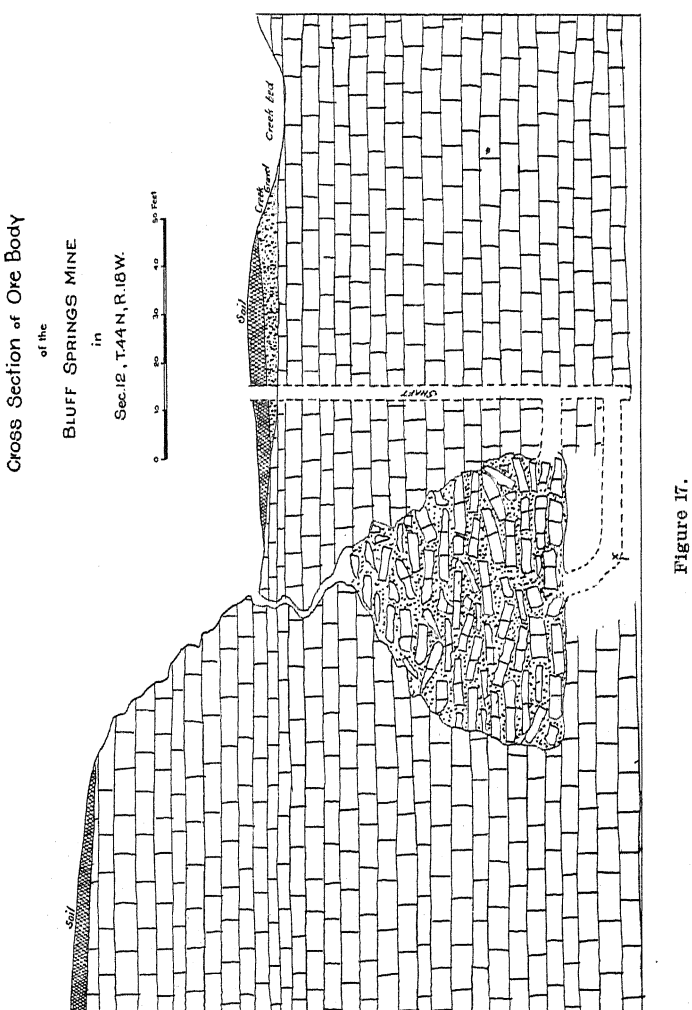


Figure 17.

*By E. R. Buckley.

Miscellaneous.—Zinc ore is found in small quantities in the joint cracks of coal in many of the coal pockets of the county, though not in sufficient quantity to pay for mining it for the zinc alone. In a few cases a small amount has been picked out of the coal and shipped but the production has been insignificant and will continue to be so.

From the above list it is shown that the lead and zinc ores occurring within Morgan county are in the following geological formations:

1. Coal Measures.
2. The Jefferson City formation.
3. The Roubidoux formation.
4. The Gasconade formation.

The barren formations are the Proctor limestone and the Gunter sandstone in addition to the recent formations.

By far the greater number of the mines are in the Gasconade limestone. Their geological distribution is as follows:

1. In the Coal Measures—no paying mines but a considerable number of occurrences in small quantities.
2. In the Gasconade formation about 25 occurrences.
3. In the Roubidoux formation about 5 occurrences.
4. In the Jefferson City formation about 15 occurrences.

The position of the ore with reference to the surface clay and the solid or bed rock beneath is as follows:

1. Occurrences in the residuary clay above the limestone..... 21
2. Occurrences in residuary clay in which the ore had a definite trend (this list is probably not complete)..... 2
3. Occurrences in clay filled veins between solid walls of limestone..... 3
4. Occurrences in clay occupying caves and cavities in the solid limestone..... 2
5. Occurrences in veins in the limestone free from clay..... 8
6. "Circle" deposits 4

There is no essential difference between numbers 3 and 5, the apparent difference being the result of surface weathering.

In most cases there is no data to indicate whether the ore found in residuary clay occurred in definite belts or not. In many cases, however, when the underlying limestone was struck a net work of small veins was found in the joint cracks of the solid limestone, but always too lean to mine. In a few cases in which the ore occurred in the clay in belts, a crevice was found in the solid rock beneath trending with the ore above and containing some ore but not sufficient to make mining profitable.

There is not a single case in the county where mining on veins, crevices or in the solid rock is known to have paid. Considerable money has been spent and some is still being spent in prospecting such occurrences, but the first paying one has yet to be discovered.

The ore which has paid occurred invariably in the residuary clay and in "circles" or other cavities in the limestone, but in every case of the latter the ore has not persisted to any considerable depth, usually to about 100 feet.

It is unnecessary in this place to discuss the theories of ore deposition. Such discussions can be found in many books which are of easy access. So far as the conditions in Morgan county are concerned, they would be of little value. The significant facts that are to be borne in mind concerning the lead and zinc deposits of Morgan county are:

1. The ore production, after it began, increased slowly until about 1872, then with phenomenal rapidity until about 1874 and then decreased with equally great rapidity and ceased altogether within a year or two. Since that time the production has been practically nothing. In the meantime, however, considerable prospecting has been done and is still being done, but, so far, without any positive result.

2. The ore without an exception, so far as paying ore is concerned occurred only in the residual surface clay, surface crevices or "circles," all of which failed in depth.

The most evident conclusion to be drawn from such facts is that the lead and zinc ore of Morgan county is only the result of surface accumulation from the degradation of originally somewhat higher veins and pockets and that, being shallow, easily discovered and mined, most of the deposits have already been worked out. Future discoveries will be confined chiefly to small surface deposits which so far have escaped detection. These remarks apply especially to the conditions obtaining chiefly in the Gasconade limestone and the Roubidoux formation and to a very slight extent to the Jefferson City formation. In the latter case, it is not at all impossible that other "circles" exist in the county than those already discovered and that they may be uncovered in the future. This is, however, a mere possibility rather than a probability.

Only one "circle" has been discovered in the Gasconade limestone of the county and indeed, this is the only one known in this formation in the state. That was the Buffalo mine. This was located well up, in fact practically on top of the Proctor anticline where the coarse grained beds of the Gasconade limestone were turned up at a low angle, sufficient, however, to facilitate downward circulation. Such circles are possible at other places along this same anticline and along its flanks or in other places where the same beds of rock are well exposed, but their discovery without

the expenditure of more time, energy and money than the ore in them would be worth is a mere matter of chance. Their existence is doubtful. Their locality, granting their existence, is still more doubtful. The beds of rock surrounding them are more out of place near them than elsewhere so that they furnish no clue to their existence.

Not a single vein within the county, after it had passed a few feet into the solid rock has been rich enough to mine. On the basis, therefore, of our past experience, prospecting on them does not offer much encouragement. After a careful survey of the county in the preparation of this report, the conclusion reached as a result of past experience is fully confirmed. I would suggest to him who insists on prospecting that, for float ore, he search those places where the coarse grained beds of the Gasconade limestone occur beneath the surface clay. and especially along hillsides where they are overlain by the massive chert beds at the base of the Roubidoux formation. These beds can be recognized by their gray color on a fresh fracture, their coarse grain, their bluish stain where they outcrop in the bluffs and by their disintegration into a coarse "sand." The "sand" grains, however, are not hard and round.

As stated above, there is very little for the prospector for a "circle" to base his work on. The occurrence of the characteristic "gumbo" clay that is often found in these deposits is of some value, though slight, and the occurrence of pockets of Coal Measure (black) shale is of still less value. These, however, are about the only guides that exist on the surface. In most cases where the prospector has passed through the residuary clay and encountered the solid rock, where it occurs in unbroken and sound layers, there is small chance of finding ore in workable deposits.

Over a large part of south Missouri, Morgan county included, there is considerable interest manifested by the people in the occurrence of disseminated lead ore such as occurs in the great lead mines of southeastern Missouri. The formation in which this ore occurs in southeastern Missouri, underlies Morgan county at an unknown depth. Only one drill hole that can give us any data concerning the position of the underlying formations in Morgan county has ever been bored in the northern part of the Ozark region. This is a diamond drill hole bored by Major Rusk about eight years ago in Camden county, but just across the Osage river from the mouth of Proctor creek and so near to the Morgan county line that its data is applicable to Morgan as well as Camden coun-

ty. The top of the drill hole lies about 50 feet below the horizon of the Gunter Sandstone. The drill passed through crystalline limestone, with thin shaly layers near the bottom, to a depth of 900 feet where a conglomerate with crystalline pebbles was struck and the drilling stopped. No ore was encountered.

The fact that no ore was encountered in the only prospect hole that has ever been bored does not prove the absence of the ore from the whole county. Even in southeastern Missouri where ore is abundant, there are many barren spots, in many areas there is more barren than productive ground. It does prove, however, that the formation equivalent to that which bears the disseminated galena of S. E. Missouri lies deep below the surface and that prospecting it will be an expensive matter. It cannot be attempted by the man without a great deal of capital.

There is no evidence whatever that the formation in this part of the state carries ore. The only reason why anyone might conclude to prospect it is the fact that the same formation is ore bearing at another, although distant, point in the state.

The veins of ore which have been referred to in the description of the mines have none of them been followed downward until the crevice in which the ore occurs disappears completely. The ore failed in a short distance and work stopped. It has not been demonstrated therefore, that these do not carry ore in depth. The fact that ore occurs in them near the surface and fails a short distance below is of some value as evidence against the occurrence of ore at great depth, while there is no corresponding evidence in favor of its occurrence to offset it, except the mere existence of the crevices. This however is not of much value.

IRON.

Fragments of iron ore occur scattered over the surface in a few places in the southeastern part of the county. The deposits are usually small, however, and not abundant. They consist of limonite, no hematite being found. Iron ore has never been mined in Morgan county profitably. The fragments now found have formed in small cavities in the limestone and, in all cases, the conditions indicate a very small quantity. The massive chert breccia of the lower part of the Roubidoux is sometimes cemented with iron but not abundantly enough to make an iron ore. There is no evidence to lead one to suspect that the iron mining industry will ever amount to much in Morgan county.

COAL.

The popular interest in coal land and coal mining in Morgan county is greater than the interest in lead mining. In fact the sales of mining land for several years back have been almost exclusively coal land. These sales, however, affect the real estate dealers and a few large land holders rather than the people as a whole. The famous coal deposits and their surrounding lands are now owned in large tracts by a few individuals. The Stover mine and the tract of land on which it lies has been for several years the object of the large coal land deals. It has changed hands several times within the last ten years, yet very little mining has been done in that time. The former excuse for inactivity was the lack of transportation. Five years ago the Chicago, Rock Island and Pacific Railway was built through the county and passed within four miles of the mine. Shortly after the road was put into operation, a company was organized to operate the coal property and build a spur to it from the railway. Work on the spur was soon begun and about three to three and a half miles were graded and made ready for the ties and rails when the work was suddenly stopped. For several months before the stopping of the work on the spur, the company had several drills running on their property. The drilling was stopped when the work on the railway was stopped. The company is said to have instituted a suit against the former owner of the property on the ground of misrepresentation. The suit is now pending.

About two years ago a deal was carried through by one of the local real estate firms in which another one of the noted mines of the county changed hands. The mine which has been owned and worked on a small scale for several years by Messrs. Hubbard and Moore of Versailles, was sold to a company of Memphis capitalists. They continue to operate the mine and a spur has been built to within half a mile of the mine from the Rock Island railway at Versailles, a distance of about four miles.

Every deposit of coal in Morgan county is of such limited areal extent that the term pocket is entirely applicable. This fact has been known for years and attention has been called to it in every geological report that in any way concerned the county since 1855. The exact areal extent of such deposit has not been known so long and in some cases is not even known now. Yet a maximum area can be given in most cases and that is small. This fact is known not only to scientific men, but also to practically every intelligent

resident of the county who has given the matter any attention. Notwithstanding this, these pockets have been made use of by unscrupulous land agents for the purpose of selling large areas of hilly woodland to unsuspecting persons at a price far above their actual value.

While the scientific man cannot endorse such methods, yet he is unable to feel any deep sympathy for the man who allows himself to be so badly cheated. There is no excuse for it except his own carelessness, credulity and foolish sense of superiority. He could find out the truth at no other cost than a two cent stamp by consulting the State Bureau of Geology and Mines. It seems a waste of time to state again what has been stated already many times, yet it may catch some innocent man's eye. "These deposits have in the aggregate a considerable quantity of coal, yet it is practically certain that this quantity is not sufficient in any case or in any great number of cases to warrant the necessary expense to mine them on a large scale." This statement is based not only on the past history of attempts to mine in Morgan county, but on the history of attempts to mine such deposits in other places in this state.

They will continue to furnish a considerable supply of coal for local use, where it does not come into competition with cheaply mined coal.

It is probably not out of the way to repeat here the statement made under the description of the Coal Measure rocks of the county that not only the coal deposits but every single occurrence of Coal Measure rocks of any kind in the county is small in areal extent and also in a more or less disturbed attitude.

The Stover Coal Mine.—This mine is located in the S. E ¼ of the N. E. ¼ of Sec. 6, T. 41N., R. 16W. It lies in the head of a ravine which drains southwestward into Indian creek. The bottom of the coal bed in the bottom of the ravine lies about 820 feet above sea level. The coal lies in a trough shape rather than lens shape with the axis of the trough lying along the hollow in which the deposit occurs. The coal is thick under the axis of the trough and thins as it rises on either side. It is not well enough exposed at the sides to determine whether the thinning is altogether from the bottom or from both sides, though the indications are that it is chiefly from the sides and that a considerable part of its trough like shape is due to deposition originally in a trough. The shale overlying the coal sags down from each side, and the same layer of shale extends from the middle or axis of the trough up the

STOVER COAL MINE.

sides as far as the exposures are good, maintaining essential parallelism with the top of the coal and with the stratification in the coal, showing that part of the trough shape is probably due to settling into the hollow subsequent to the deposition of the coal.

The upper edges of the trough both of coal and shale have been cut off at the south end by erosion so that the width of the deposit it not shown. Its exact width further north where the hill is higher could not be determined though it cannot be much wider for lack of room. The rise of the hill is not sufficient and the rate of thinning would soon cause the coal to disappear upward.

The axis of the trough seems to pitch southward down the hollow. This, however, is not absolutely certain since the distance along the axis where the bottom is exposed is very short. The shale over the middle of the trough is about eight feet thick but thickens considerably northward. The exact amount of shale at the north end, however, is not known, though it is not far from 30 feet.

The position, thickness and width of the coal at the north end are not exactly known. The area has been thoroughly drilled twice, but we were unable to get the exact and detailed data. We did learn, however, that the maximum length of the deposit is about 900 feet and the maximum width about 300 feet. At the south end the width is about 200 feet.

The maximum thickness of coal is about 70 feet. The coal is of the bituminous variety and the quality is good. It contains a very small percentage of pyrite and contains very little waste in the form of shale bands.

Placing the average thickness of the coal at 25 feet, the Stover coal deposit will contain approximately 5,600,000 cubic feet of coal. If each cubic foot weighs 85 pounds, the average weight of bituminous coal, it will contain about 240,000 tons of coal. This is the total amount. It is extremely doubtful if all of it can be won in mining.

The cost of mining will not be less than $1.00 per ton, the interest on the capital invested in the property, as well as the original cost of property, including the four miles of spur and other necessary expenses, will have to be paid for out of what is left after deducting $240,000 from the amount realized from the coal.

Ordinary bituminous coal at the pit sells in Missouri for less than $2.00 per ton on an average. It requires but very little calculation to show that the mining of the deposit on a large scale

would be a disastrous undertaking financially. Figure 18 is a map of the underground workings of this coal bank, which was surveyed several years ago.

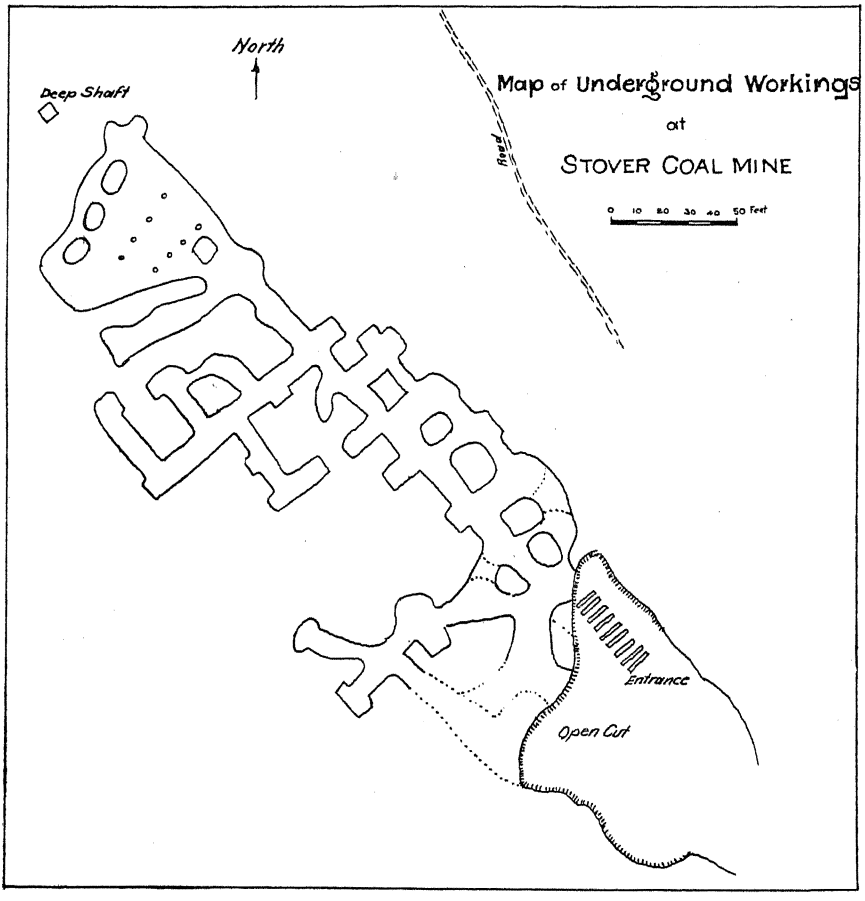


Figure 18.

The Hubbard and Moore Coal Mine.—This mine is located in the S. W. ¼ of the S. W. ¼ of Sec. 22, T. 43N., R. 18W. Like the Stover deposit, this also is located at the head of a hollow. The hollow here, however, is much less steep than the one in which the Stover deposit lies. The coal bed lies in what is merely a flat sag.

The exact attitude of the coal bed in the whole area of this deposit is unknown. At the time of examination, only the edge of the bed could be seen. The coal bed is much more disturbed in position than at the Stover bank. The latter bed rarely dips, where exposed, more than ten degrees while the dip of the bed at the Hubbard and Moore mine is 30° to 40°. The thickness of

the bed at the latter place is uniform, also, as far as exposed. It is a bed rather than a lens or trough. Its present attitude is apparently due wholly to disturbance since it was deposited rather than partly due to disturbance and partly due to deposition in a small depression as at Stover.

The thickness of the coal is about 20 feet, varying a few feet each way. The upper 15 feet is cannel coal, the lower 3 to 5 feet is bituminous coal. Above the coal occurs a black fissile shale which passes upward into clay. Beneath the coal occurs black shale with sand and clay lenses. The coal outcrops at the surface along the eastern side of the deposit and dips westward at angles varying from 32° to 37°. Within 50 or 60 feet along the dip, the coal seam flattens out considerably. The lowest dip encountered was 8°. The western side of the deposit had not been located at the time of examination, or if so, no record of it could be obtained. The surface is flat for some distance in that direction and no rock beds are exposed. Chert fragments are abundant not more than 200 feet west of the eastern outcrop of the coal. East and north of the coal outcrop, the land rises abruptly 3 to 5 feet and the surface is covered with chert fragments with no other rock exposed. South of the mine no rock is exposed until the main hollow is reached, a distance of about 200 feet, where horizontally bedded magnesian limestone outcrops.

Fig. 19 is a map of the surface of an area about 350 feet square, including the mine and the outcrop of the coal bed. This map shows by contours the surface of the ground and the bottom of the coal bed.

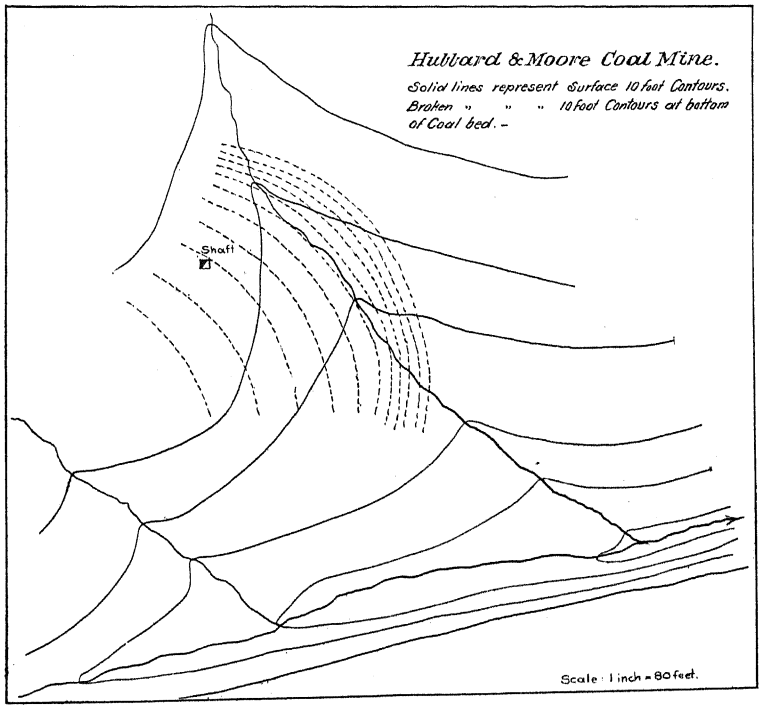


Figure 19.

The total amount of coal at this place cannot be determined from the data obtained by our examination. It is improbable, however, that the deposit extends much beyond the area that is free or nearly free from chert fragments. Several small pits have been dug just west of the western side of the chert free area. They disclosed nothing that looked like either weathered coal or shale. They were very shallow, however. East of the old mine in the head of another shallow sag, coal has recently been struck in a shaft that is now being worked. The shaft was sunk on the west side of the sag and the coal is reported to dip eastward. Its extent is not known. The sag is about 100 feet wide.

Miscellaneous Coal Deposits.—Coal was being mined at one other place in the county at the time of examination of the coal deposits in 1903. This was in the N. W. ¼ of the S. E. ¼ of Sec. 5, T. 42N., R. 17W. The coal bed here consisted of an upper layer of cannel coal and a lower one of bituminous coal. The total thickness of the two layers was about 12 to 15 feet. The exact thickness could not be determined on account of the state of the mine. The cannel coal bench was slightly thicker than the bituminous bench. The outcrop ran along the west slope of a north and south hollow and the coal dipped westward into the hill at an angle of

about 15°. The coal was visible for about 60 feet, but the ends were both covered. The mining had been carried on along the outcrop and had not gone more than 20 to 40 feet down the dip of the bed. The deeper part of the mine was abandoned and no data could be obtained concerning the conditions in this part of it. The coal is overlain by black fissile shale which grades upward into lighter colored shale.

About 250 feet south of this locality coal was mined several years ago. The mine was in the bottom of the hollow and seems to have been a strip mine, although the coal may have dipped westward as in the last case. The whole excavation was filled with water at the time of examination.

In the eastern part of the town of Versailles, in a small hollow draining southward, there is a coal mine which was abandoned years ago and no data could be obtained concerning it. The same is true of a locality in the N. E. ¼ of the S. W. ¼ of Sec. 5, T. 42N., R. 17W. The coal occurred here as elsewhere in a depression. It was mined by shaft but has been abandoned for several years.

The Chicago, Rock Island and Pacific railway company bored a deep well near the station at Versailles. It is reported around town that the driller said that he passed through several feet of coal in the drill hole, at a depth of several hundred feet. In the absence of accurate data on the subject the only thing that can be said is that such a thing is extremely improbable. The fact that no one has taken any measures to develop such a deposit, although it lies alongside the main line of a railway and on the outskirts of a city where considerable coal is consumed, is of itself rather conclusive evidence that the persons who repeat the story have really very little faith in its accuracy.

The depth given, about 400 feet, makes it more improbable. The deposit, if it exists, is bound to be a pocket. That such a pocket exists at a depth of 400 feet from the surface is so extremely improbable that it is hardly worthy of consideration. There is in this vicinity an area of about a quarter of a section in which no rock is exposed and the surface lies in a gentle sag. It is possible that it is underlain by a coal pocket and the drill, carefully used, is the best way to demonstrate it. Another such sag lies about a mile east of town along the line of the railway. What lies under it is likewise unknown.

Coal has been mined at several other places in the county, but with one exception, all of the opening had filled up or fallen in so

that nothing could be learned of them from observation and very little from report. In every case the coal was reported from ten to twenty-five feet thick, but the amount of coal mined and the area of the pocket could never be determined. The reason for the closing up of the mine could not be learned other than that the miners got tired of it or the market was too uncertain. Considerable coal in the aggregate has been taken from these deposits.

In the N. E. ¼ of the S. E. ¼ of Sec. 16, T. 43N., R. 18W., on land owned by J. K. Hudson, a bed of coal about 8 feet thick was exposed at the head of a ravine. It was merely opened sufficient to expose the bed and then work was stopped. The coal dipped northeastward, down the hollow at an angle of about 25°. Black fissile shale overlies and clay underlies the coal. Magnesian limestone was exposed in horizontal beds not more than 100 feet down the hollow from where the coal was exposed.

By far the greater number of occurrences of coal and Coal Measure shale pockets which have any perceptible relation to either the geologic or topographic features are located along the line where the central plain belt of country drops off to the steep hollows of the southward drainage. They lie just within the latter area. They are invariably found in the steep heads of the hollows draining into Gravois and the two Buffalo creeks. There seems to be a rather poorly defined belt on the upper part of Richland creek running north and south through township 43N., R. 18W. The rest of the occurrences are widely scattered over the area.

BARITE.

Since the Spring of 1906 barite mining has been revived. During the summer of 1907 mining has been pushed with considerable energy. The ore is hauled from the mines to the railway in wagons, most of it coming to Versailles. Most of it is shipped to St. Louis.

The barite occurs in essentially the same way in which the lead ore occurred and in rather close association with the lead ore. It occurs in the clay overlying the outcrop of the coarse, crystalline, chert free beds of the Gasconade formation. It occurs in leads occasionally but usually in pocket-like masses running around the hills along the outcrop of the beds just referred to.

At the present time it is being mined at four localities in the county.

The most easterly locality is in Sec. 24, T. 41N., R. 17W., where it is mined by means of a cut in the hillside. About three

miles southeast of this locality, in Sec. 4, T. 40N., R. 16W., a barite mine was opened several years ago. At this locality the barite occurs loose in clay filling a crevice in the limestone. The crevice is about six feet wide and was followed into the hill a distance of about 50 feet.

The most important mine at the present time is located near Brushy creek in the S. W. ¼ of the N. E. ¼ of Sec. 13, T. 41N., R. 18W. Its occurrence is in the residuary clay. Considerable lead ore has been mined in this vicinity.

Barite is also being mined about a quarter of a mile south of the old Buffalo mines where it is found in the clay as usual but in a northwest-southeast belt which lies parallel to the trend of the Proctor anticline. The slightly upturned edges of the crystalline limestone here give free access to percolating waters and facilitate the formation of crevices.

The last of the producing localities is in the southeast quarter of Sec. 30, T. 42N., R. 18W. The ore occurs in pockets in the residuary surface clay.

Some of the most perfect specimens of barite crystals known were found during the period of lead mining in Morgan county. They occurred chiefly in the loose clay filling crevices and cavities. The region including Cooper, Pettis, Miller, Morgan, Cole and Moniteau counties has produced a considerable quantity of these crystals. Some of the finest ones are now in the private collection of Mr. F. A. Sampson of Columbia, Missouri, and another equally good selection is owned by the Estate of Mr. O. A. Crandall of Sedalia. Barite occurs abundantly in southeastern Missouri but well crystallized specimens are rarely found.

CLAY.

Leaving the residual surface clays of the county out of consideration, the clay deposits are distributed somewhat like those of coal. There is a more or less continuous row of them along the break between the central smooth belt and the southern dissected belt.

Wheeler* describes the occurrence of chinaware, flint and plastic fire clay and potters' clay in Morgan county. At the time his report was made none of the deposits were being worked to any extent and very few were being worked at all.

Like the coal deposits the clay deposits are all pockets. There is not a continuous clay bed within the county. So far as they

*Mo. Geol. Sur., Vol. XI, Clay Deposits.

have been studied up to date all the deposits fall into two classes. 1. Flint fire clay and chinaware clay occurring in the Cambrian (?) rocks and 2. plastic fire clay and potters clay which occur in association with pockets of Coal Measure shale.

Those deposits occurring in the Cambrian (?) rocks are usually white or light in color unless tinged with red. They may or may not show distinct lines of stratification. They usually show a dip of the structure planes toward the center of the deposit and occur closely associated with the Jefferson City limestone and often also with remnants of what is undoubtedly the St. Peters sandstone. In the latter case, the clay ususually lies beneath the sandstone where the relations of the two can be determined. None of these deposits contain plastic clays. They are all, so far as their areas have been determined, known to be of small size rarely more than 200 feet in diameter, but the depth may run up to nearly half that amount.

Of the plastic clay deposits only a few of them have been opened. Most of the large shale or coal deposits seem to have clay beds associated with them but the extent and thickness have been determined in only a few cases.

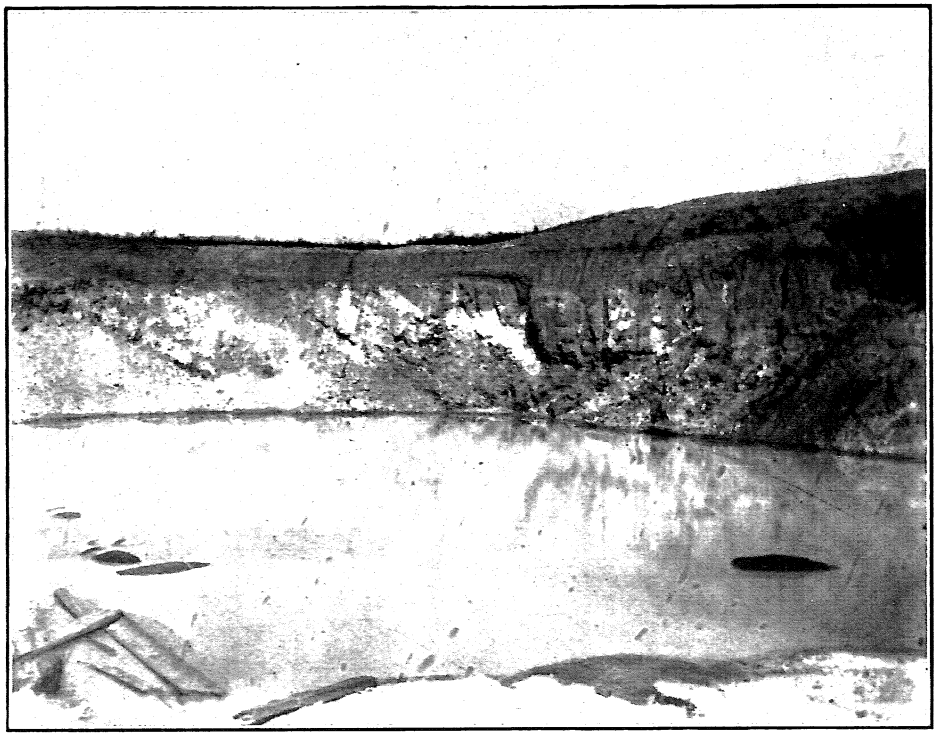
No tests of any of these clays have been made since Wheeler's work was done.

China-Ware Clays.—The only deposit of this clay that has been worked to any extent, is the Clark bank about a quarter of a mile south of the Buffalo mine. This was worked a few weeks each year for several years up to about three years ago. The remaining clay is now rather deep down in the pocket and during the nine or ten months in the year in which it is not worked, it becomes pretty well covered with wash from the sides so that the mining of the clay becomes expensive. During the last few years, it has been worked less frequently than formerly. The deposit is about fifteen miles from Versailles, the shipping point. The output has been sold entirely to the St. Louis Stamping Company for enameling purposes. The annual output when mining is carried on has been about 70,000 pounds a year according to Wheeler.

The pocket is circular in shape, about 40 feet in diameter and about the same in depth.

About a mile and half north of this locality, in the northeast corner of Sec. 5, a deposit of clay was opened up in the summer of 1904.

This clay has the same appearance as that in the Clark bank



FLINT FIRE CLAY PIT, SHOWING THE DIP OF THE BEDDING.
One mile west of Versailles.

though possibly a little less plastic. It is fine grained, rather soft, evenly banded and in places tinged red with iron oxide. The deposit occurs at the head of a ravine draining northward and the prospect holes had been sunk to a depth of about 15 feet at the time of inspection without reaching the bottom of the clay. The area of the pocket could not be determined. No tests of this clay have been made and none has been shipped.

Flint Clay.—In discussing these deposits Wheeler* says that "no flint clay is being shipped out of Morgan county but deposits exists of more or less purity and outcroppings are very favorable for the development of extensive pockets." He goes on to state that the deposits are too far from market to make them very valuable at that time. Since Wheeler's work was done, the transportation factor has been greatly improved by the building of the Rock Island railway. This, however, has not caused the development of clay mining and shipping. Two years ago, however, a well equipped plant for the manufacture of high grade brick was erected at Versailles and some of these pockets have been mined to supply it with fire clay.

These pockets of flint clay have been opened up and worked since the building of the brick plant. Two of them were within 150 feet of each other and located in the extreme northwest corner of Sec. 7, T. 42N., R. 17W. The larger deposit is about 200 feet in diameter and has been worked (June, 1906) to a depth of 15 feet, though it is not yet worked out. It occurs in association with fragments of sandstone, but the flint clay seems to lie below the sandstone.

The other pocket lying 150 feet south of this one has been completely worked out. It had the shape of an inverted cone was not more than 50 feet in diameter and bout 25 to 30 feet deep.

The third deposit that has been opened by the brick company lies in the S. E. ¼ of the S. W. ¼ of Sec. 1, T. 42N., R. 18W., about half mile west of the brick plant. The size of this deposit had not been determined at the time of examination (June, 1906). The indications point to its being a rather large one. Drill holes 20 feet deep had not passed through the deposit. The diameter is probably a little more than 100 feet. The clay is massive, has a uniform white to cream color, fine grain and conchoidal fracture. It is easily mined on account of its easy breakage. Wheeler notes the outcrop of about three feet of sandy white flint fire clay about half a mile northeast of Versailles. No change in the condition

*Op. Cite page 239.

or knowledge of this deposit has taken place since Wheeler saw it.

He notes also the occurrence of a group of deposits about 2½ miles east of Versailles and half a mile south of the Jefferson City road. None of these pockets have been mined but some drilling has been done by Mr. White, the Superintendent of the Versailles brick plant. These deposits are all located in the S. E. ¼ of the N. W. ¼ of Sec. 33, T. 43N., R. 17W. The deposits consist of flint fire clay and another slightly different clay, which Mr. White calls kaolin.

The flint clay is massive, as usual with such deposits, has a rather uniform cream to white color, is fine grained and breaks with a conchoidal fracture.

The clay called kaolin by Mr. White is white in color, fine grained to slightly granular, has rather numerous small fragments of white to bluish chert in it, and occurs in layers about an inch in thickness. There is also within the same area an occurrence of dark shaly clay which seems to be a pocket of somewhat disintegrated Coal Measure shale.

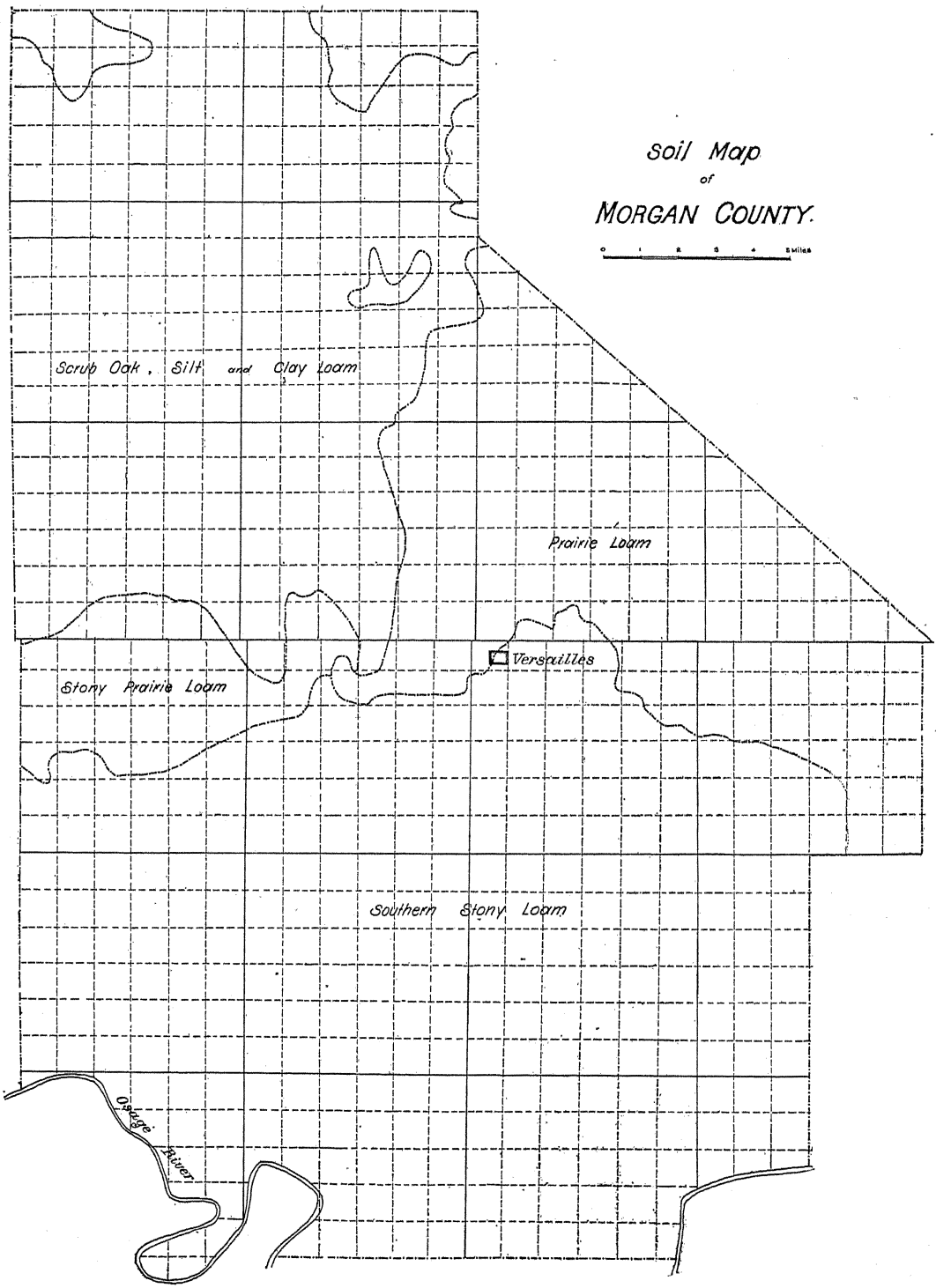
The kaolin deposits lie in the head of hollows on the south side of the tract, while the flint clay deposits lie along the main hollow on the north and at the head of a ravine further south. Large sandstone masses occur on the same tract and in close association with the clay pockets.

Nothing can be said of the size of the so-called kaolin deposits. Only shallow pits have been dug into them and no deeper drilling has been done. The main flint clay deposit seems to be a large one. It outcrops in the bank of the hollow showing a thickness of 30 to 40 feet without showing the bottom of the deposit. Drilling, according to Mr. White, indicates that it extends southward for several hundred feet. It is exposed along the hollow for a distance of more than 200 feet.

Flint clay is known to occur in the heads of some of the small hollows draining into Coffin Spring branch in Sec. 8, T. 42N., R. 18W. A few shallow pits have been sunk into some of these pockets but they are now filled up and no information could be obtained concerning them.

There are indications of the occurrence of flint clays in Sec. 20, T. 42N., R. 19W. and at several places in Sections 27 and 34, T. 42N., R. 16W. They may be looked for anywhere along the border line of the area drained southward into Gravois and Buffalo creeks.

Plastic Clays.—These are all more or less closely associated


Soil Map
of
MORGAN COUNTY.
0 1 2 3 4 5 Miles
Scrub Oak, Silt and Clay Loam
Prairie Loam
Versailles
Stony Prairie Loam
Southern Stony Loam
Osage River

with the Coal Measure pockets and may be looked for wherever the latter are found. Only two or three places have been opened and worked up to date. One of these lies in the same pit with the flint clay deposit in section 7, T. 42N., R. 17W. Apparently only the edge of this lies in the area of the latter deposit since the beds dip away from it indicating that the main part of the deposit lies beyond. The size and area of this deposit are not known. The other deposit which has been rather extensively worked lies in the bottom and along the lower slope on the east side of a ravine about 900 feet southeast of the corner of Sec. 8, T. 42N., R. 17W. The clay bed is overlain by black fissile shale and both shale and clay dip southeastward into the hill. A face of clay 15 feet in thickness is exposed. Considerable clay has been mined here and used to mix with the flint clays for making fire brick at the Versailles brick yard. Wheeler* describes an occurrence of plastic fire clay associated with Coal Measure shale one mile south of Versailles. He collected a sample which proved to be of excellent quality. No further work has been done on this deposit up to the time of inspection so that the size of the deposit is unknown.

SOIL.

The persistent mining agitation in Morgan county has resulted in injury to the permanent industries of the county. It has drawn attention, capital and labor away from agricultural development and dissipated them in fruitless attempts to develop an important mining industry. Agriculture, with its kindred industries of annual husbandry and horticulture, is the most important permanent industry that can ever be developed in the county on the foundation of the counties natural resources.

The soil of the county is not remarkable for its fertility nor is it an easily and cheaply cultivated soil. On the other hand it is by no means barren, its physical character is good and its response to careful treatment is immediate and full. Over a large part of the county the land must be handled in bodies of considerable size and considerable capital must be available for improving both the land and the equipment of a farm after the first cost of the land has been paid. It is not the place for a man to undertake agriculture who has merely enough money to pay the first cost of a 40 acre tract of land and who must depend upon his labor and the produce of the land for a living and for the improvement of his farm. Such a man will fail to make farming in Morgan county

*Op. Cite page 286.

pay as a business. He will possibly be able to make a scant living but nothing more.

The soils of Morgan county naturally fall into five classes the differentiation being based on the topography, presence or absence of timber growth and the proportion of stony material in the soil.

These five kinds of soil are:

1. Prairie loam of the northeastern-northern part of the county.
2. Scrub oak silt and clay loam.
3. Stony prairie loam.
4. Southern stony loam.
5. Alluvium.

The prairie loam of the northeastern part of the county consists of a gray to black silt loam from 6 to 12 inches deep. This passes into a grayish silt from 6 to 12 inches thick, underlain on the flat or only gently rolling areas by a 10 inch layer of rather sticky, red, silty clay. On the undulating areas the red clay layer is absent and its places is taken by a grayish clay or silt. Underneath the red or blue clay on both the flat and undulating lands there is a yellow and bluish gray mottled clay sometimes with a small percentage of rather coarse sand. The mottled clay layer extends to a depth of several feet and is succeeded downward by a red clay usually stony.

Practically all of this soil is under cultivation. It is owned to a considerable extent in rather large tracts, the owners being backed by considerable capital. A combination stock and grain growing is the main type of farming engaged in. A small colony of German speaking Swiss farmers lies in this part of the county. They are prosperous farmers. The topography is rolling. Rarely too rough to plow.

This series of soil and subsoil layers is underlain in places along the main watershed of the county by a bed of Lafayette gravel which, with its tough clay matrix acts as a hard pan. It is almost impervious to water. The areas where this is near enough to the surface to have an effect on the soil are small.

The scrub oak clay and silty clay soils occupy long narrow strips in various parts of the county. Their distribution is shown on the accompanying soil map and needs no description here. These strips occupy the flat tops of ridges.

The soil is a gray to bluish gray to grayish silt with a yellowish clay or red stony clay subsoil. It is everywhere deficient in organic matter even when first cleared, has a low nitrogen content therefore and is probably low in phosphorous.

It has an abundance of potash but on account of its low organic matter or humus content it is largely unavailable to the plant. This soil is rather inclinded to be too wet in wet weather, except where the surface drainage is better than usual, and rather dry in dry weather. Not a great deal of this soil is in cultivation. It is mostly occupied by a dense growth of post oak saplings of an average diameter of four or five inches, four feet from the ground. Mixed with these small post oaks are occasional large postoaks, a considerable number of small black jacks and scattering oaks of other species.

This soil soon "wears out" under the average treatment given it by the careless American farmer. It can be renovated by the growth and plowing under of about three crops of cow peas and the application of 500 lbs. per acre of rock phosphate or by the application of about eight tons of stable manure and 300 lbs. of phosphate rock to the acre.

This soil is underlain in places by a gravelly or stony layer that has been cemented with iron oxide or lime carbonate into a hard pan which retards both the upward and downward movement of water.

The third class of soil, the stony prairie, occupies only a small portion of Morgan county. It occurs chiefly in the western part of the county west of Richland creek and east of Haw creek and near the Rock Island railway. It consists of a gray gravelly to stony silt with a gravel usually of chert, often in fragments of six to eight inches in diameter or larger. In places the fragments consist of sandstone. In the latter case the soil is sandy rather than silty. This land is devoted to pasture chiefly. The smoother parts, where the stony material is small in quantity, are cultivated and produce under favorable seasonal conditions good crops of corn. It is rather loose for a wheat soil though some is grown. It will grow clover. So far as is known there is no hard pan under this soil.

The stony timber land soil occupies the rough dissected portions of the southern part of the county. The soil almost everywhere contains some loose chert fragments but the amount varies from a very few scattering fragments, as one extreme, to beds of angular chert fragments with a very small amount of finer material as the other extreme. The latter soil occurs on the steeper slopes and narrow ridges and the area underlain by the Roubidoux formation. The less stony portions occur along the outcrop of the upper member of the Gasconade formation.

The very stony land is covered with a growth of timber consisting chiefly of black oak with a small amount of white and postoak and black jack.

The less stony lands are covered, except when cleared, with a growth of red, white and black oak and often a rather dense undergrowth of hazel.

The stony soil is gray in color, the finer portion, or soil exclusive of stones, being a fine silt. The subsoil is a rather deep red stony clay.

There is no suggestion of any cemented layer or hard pan under this soil. As a rule, if such occurs, it is local.

The less stony phase of this soil is reddish, brownish or gray in color, is a gravelly to moderately stony silt underlain by either a deep reddish stone free residuary clay or the same clay mixed with varying proportions of stone.

This soil, except where the percentage of stone is more than 50 to 60 per cent of the total volume of material is a natural legume soil, growing clover, and cowpeas luxuriantly and with proper preparation of the ground would probably grow Alfalfa. It has no hard pan under it and, its subsoil of red clay is capable of holding moisture in considerabe abundance and will also allow the passage upward of moisture from below. The surface soil is dry, open porous and well drained, possessing the physical properties which enable a soil to respond readily to good cultivation and to fertilizers.

A large part of this land can never be utilized economically for farm land. It will be more profitable to grow timber on it. Much of it can be cleared and converted into farms but the clearing of timber and stone will be rather expensive. It will not be profitable to clear it too freely of stone, because that will cause it to wash. At the present time some of the old fields and the reddish stone free soils are rather badly washed. This is due to careless farming. It does not wash badly except where it is entirely free or nearly free of stone.

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