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CHARLES D. WALCOTT, DIRECTOR

THE

DISSEMINATED LEAD ORES

OF

SOUTHEASTERN MISSOURI

BY

ARTHUR WINSLOW

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ST. LOUIS, MO., *May 27, 1895.*

SIR: I have the honor to transmit herewith my report on the disseminated lead ores of southeastern Missouri.

The results contained in this report are the product of investigations conducted during the past three months. These investigations were in extension of the work on which was based my report, as State geologist of Missouri, on the lead and zinc deposits of the whole State. The principal contributions which the present report makes to our knowledge of the district relate to the structure and the general areal geology. The outlines of the formations as represented on the map have never before been defined, and the structure as recorded in the drill-hole results and expressed in the cross-sections has never before been presented. In addition, the most recent progress in mining is recorded, and the general distribution of the ore as revealed by drilling is outlined.

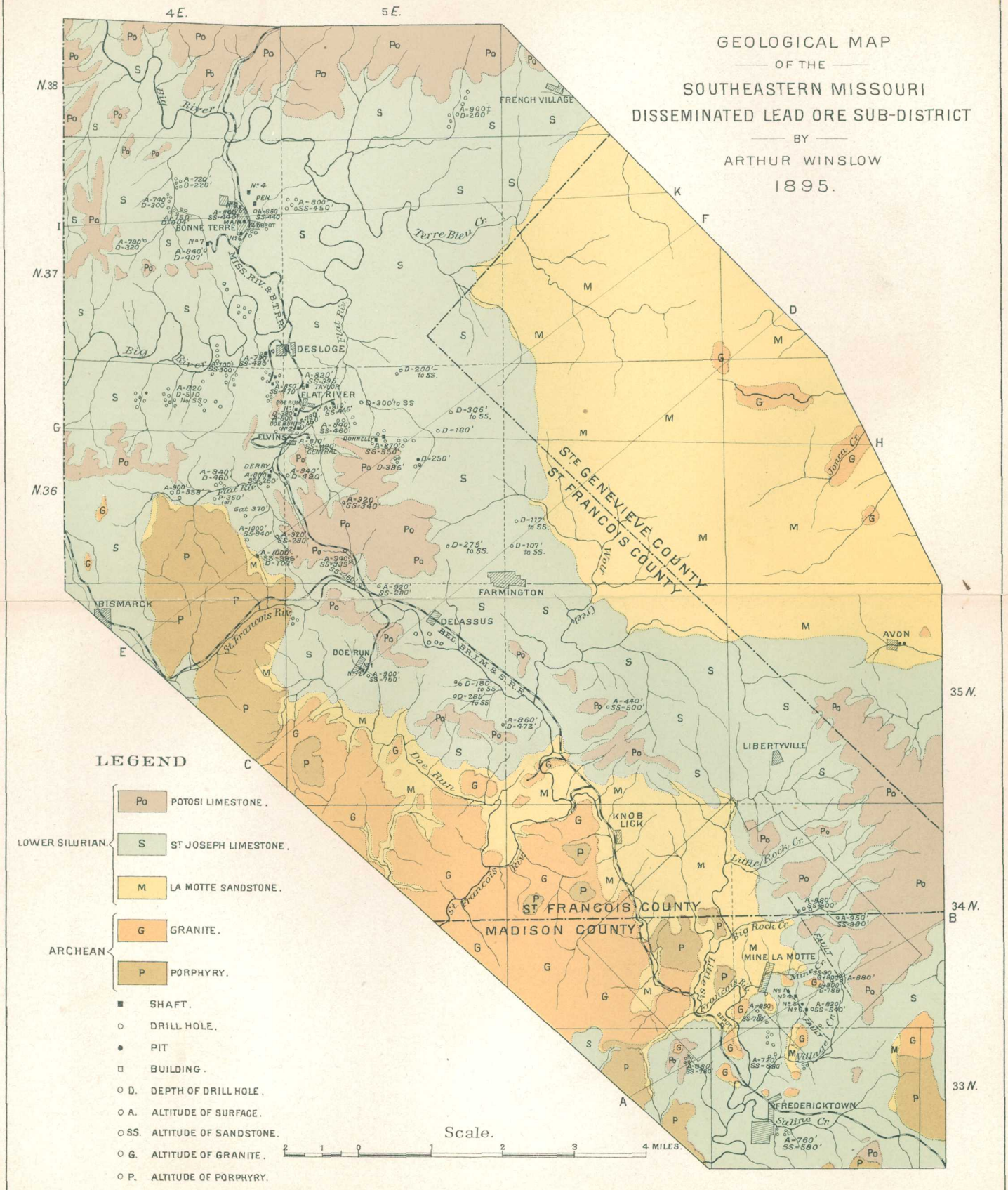
In order, however, that the report may stand by itself as a short treatise on this important lead district, I have not restricted myself to the mere presentation of that which is new, but have rounded this out with brief descriptions abstracted from my recently published report above referred to. Much local detail there included, however, is here omitted, and for such supplementary matter the reader is referred to that report.

In conclusion, I desire to express my indebtedness for assistance in the prosecution of the work, and for information contributed, to Mr. Arthur Thacher, superintendent of the Central mine; Mr. O. M. Bilharz, assistant superintendent of the Doe Run mines; Mr. Frank Schulte, of Fredericktown; Mr. George J. Cole, secretary of the Derby Lead Company; Mr. D. Bauman, of Farmington; and ex-Governor H. C. Brockmeyer, of St. Louis.

Very respectfully, your obedient servant,

ARTHUR WINSLOW.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.



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THE DISSEMINATED LEAD ORES OF SOUTHEASTERN MISSOURI.

By Arthur Winslow.

LOCATION AND AREA.

The disseminated lead ores of Missouri are encountered within 60 miles south of St. Louis and within 25 miles west of the Mississippi River. They belong to the southeastern lead and zinc district of the State. The area in which these ores have been developed is about 35 miles long in a northerly-southerly direction and about 25 miles broad from east to west; it lies principally in St. François County, but the northern portion of Madison County and a little of eastern St. Genevieve County are included. Only 13 mines have been opened in these ores; the mines are somewhat widely separated, and may be grouped into four camps, as follows:

At Bonne Terre: The St. Joseph Lead Company's mine, five separate openings.

In the Flat River camp: The mine of the Desloge Consolidated Lead Company, including two openings; the Taylor mine of the Flat River Lead Company; the mines of the Doe Run Lead Company, including two openings; the mine of the Central Lead Company; the Crawley shaft of the St. Joseph Lead Company; the Donnelly Lead Company's mine; the Leadington Lead Company's mine; and the Derby Lead Company's shaft, which is now being sunk.

At Doe Run: The Doe Run Lead Company's mine.

At Mine La Motte: The mine of the Mine La Motte estate, four separate openings.

In addition, the diggings at Avon may be included.

Other ore bodies have been exploited by drilling, and numerous occurrences of sparsely disseminated ores have been revealed, but there are also great areas which are practically barren.

HISTORY OF MINING.

Lead mining in southeastern Missouri has been in progress nearly two hundred years, beginning about 1720. But the mining of disseminated ores on the scale now seen is of recent date, beginning scarcely thirty years ago. It is true that before the middle of the eighteenth century disseminated lead ores were dug at Mine La Motte, but they were difficult to work and smelt, and preference was given to the massive galena found in surface clays and in crevices in the rock. Featherstonhaugh[1] describes the quarrying here of disseminated ore

[1] Geological Report of the Examination made in 1834 of the Elevated Country between the Missouri and Red Rivers, Washington, 1835.

in 1836. Up to 1878, however, the mining of this deposit was crude and interrupted, the excavations consisting of pits in the loose surface materials or of shallow shafts sunk to strike the ore in the rock immediately beneath the surface.

Austin, in 1804, refers to a find of galena in small particles in a soft gray limestone on Big River. At the Avon mines work was begun about 1848, and was sustained for a few years. After a long intermission operations were resumed in 1874, but the mine was soon after finally abandoned. The whole output is reported to have amounted to about 1,200 tons of ore. Shortly before the war, at the site of Bonne Terre, Francis LaGrave found, with a churn drill, disseminated lead ore at a depth of 80 feet.

But the beginning of the present mining era was essentially post-bellum. In 1864 the St. Joseph Lead Company acquired possession of its Bonne Terre lands and began preparations for systematic mining. During the first few years there were many obstacles to overcome, and the production up to 1870 did not amount to much over 1,200 tons of lead. The diamond drill was introduced here in 1869 and did much to advance operations. By 1874 the annual output had reached 1,300 tons of lead, and many improvements had been made. Now the annual production of this company is nearly 15,000 tons of lead; a large concentrating plant with a capacity of 1,000 tons of rock per twenty-four hours is in operation, together with smelting works at Herculaneum, a supplementary railway 50 miles long, and other incidental establishments.

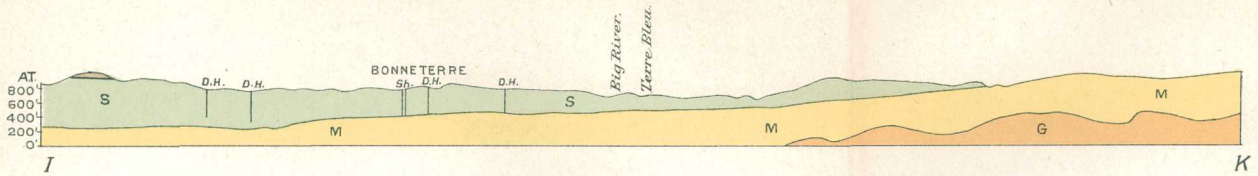
At Mine La Motte systematic work was begun after 1878; deep shafts were sunk, and since then a concentrating mill and furnaces have been erected. About one-third of the total output has been mined since that date.

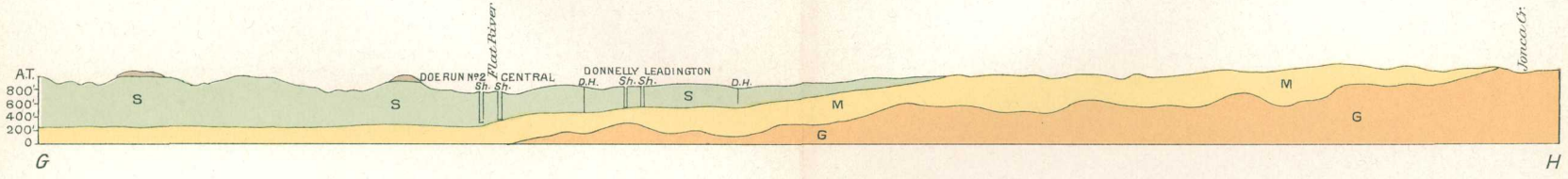
The Doe Run deposit was the next in order of development; but the first prospect shaft was not sunk there until 1885. Within two or three years after that date the mine was opened and the mill and furnaces were erected.

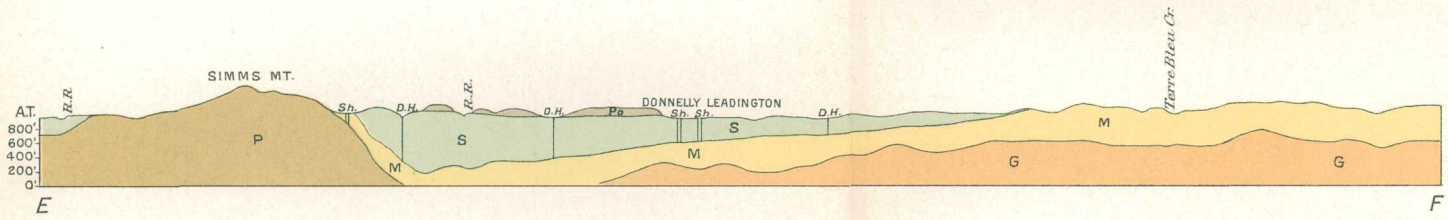
The Flat River mines were the last opened in disseminated ores. Most of the diamond drilling has been done since 1888, and there was no deep shaft operating these ores before 1890, though a large number had been sunk for crevice mineral, and on the present Desloge property the old Bogy shaft, sunk in the early seventies, reached a depth of about 220 feet. Practically all of the developments of this camp have, therefore, been made during the last five years.

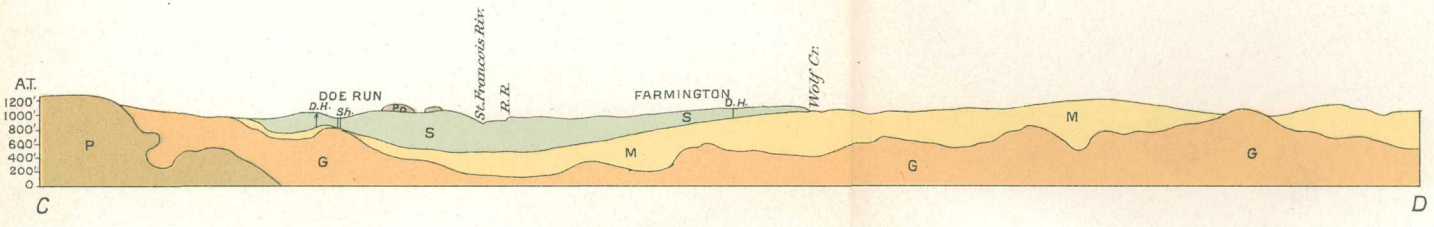
TOPOGRAPHY.

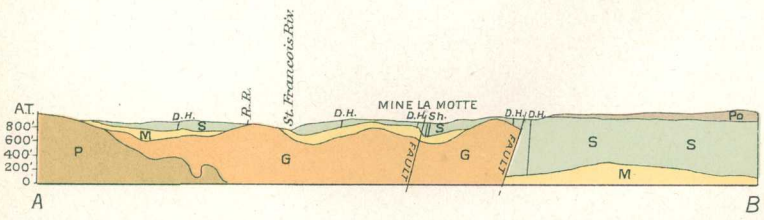
The topography of the country in which the disseminated lead ores are found is hilly, but not mountainous. The writer has described it as intermediate between the highland type of the Archean area which flanks it on the southwest and the plateau type which prevails in south-











LEGEND.

POTOSI LIMESTONE.	Po	LOWER SILURIAN.
ST JOSEPH LIMESTONE.	S	
LA MOTTE LIMESTONE.	M	
GRANITE.	G	ARCHEAN.
PORPHYRY	P	

CROSS SECTIONS

TO ACCOMPANY

GEOLOGICAL MAP OF SOUTHEASTERN MISSOURI

BY

ARTHUR WINSLOW

Scale.

2 1 0 2 4 6 MILES.

Lith. A. Hoen & Co. Baltimore.

western Missouri, where there are deep valleys between flat uplands or long, level-crested ridges. Occurring in a country of nearly horizontal strata, the forms and distribution of the features of relief have no marked relation to geologic structure; they are of irregular distribution and of widely varying shapes and dimensions. The extremes of altitude, excluding the Archean hills, are 1,200 and 600 feet above tide, while locally the tops of the hills are generally not more than 200 feet above the valleys.

The hills are mostly covered with timber, principally oaks, of medium or small size and of little value except for local uses.

The larger streams have narrow flood-plains which are cultivated, but the farming lands are generally over the minor hills and slopes lying between the streams and the summits.

STRATIGRAPHY AND LITHOLOGY.

The rocks of this portion of southeastern Missouri belong to the following formations:

Lower Silurian	Potosi limestone.
	St. Joseph limestone.
	La Motte sandstone.
	Iron Mountain conglomerate.
Archean	Granites and porphyries.

The distribution of these formations is shown on the accompanying geological map (Pl. I). The clastic rocks are placed in the Lower Silurian for reasons given in detail in the writer's recent report on the lead and zinc deposits of Missouri.[1] The possibility still remains that there may be a faunal break which will admit of some of the lower strata being classed as Cambrian, though there is nothing in the stratigraphy to suggest it. This must, therefore, be left to the paleontologists, and owing to the great dearth of fossils the problem is not an easy one for them to solve.

ARCHEAN.

The Archean rocks undoubtedly underlie the whole country, but they crop out within the mining area only in the vicinity of Mine La Motte. Southwest of that mine is the border of the main Archean area of the State, as shown on the map. Outliers are found on the eastern margin of the area mapped, in St. Genevieve County, but these are really beyond the limits of the disseminated ores as here defined. We have, hence, little to do with these rocks; their connection with the ore deposits is of but a general nature. The only localities where they are in close association are at Mine La Motte and at Doe Run.

The porphyries are generally red or brown, and are composed principally of quartz and feldspar, with small grains of iron oxide scattered through the ground-mass. The texture is fine-grained and homogeneous, and, under the microscope, is holocrystalline; larger porphyritic crystals of quartz or feldspar occur scattered through the base. The wavy lines

[1] Missouri Geological Survey, Vol. VI, 1894, Lead and Zinc Deposits, Chap. IX.

known as "flowage structure" are also present. The rock is frequently brecciated, the fragments themselves being composed of porphyry.

The granites are mostly of a pink color. The constituent minerals are principally quartz and feldspar. Black mica occurs in a few places, but it is not evenly disseminated. Hornblende is very rarely found. In texture the granites frequently approach the porphyritic, the feldspar occurring as a ground-mass in which the quartz crystals are embedded. In other cases the constituent crystals of quartz and feldspar are clearly separable, and occur in nearly equal proportions.

Regarding the relations of the granites and porphyries, the conclusion has been reached by Mr. Haworth that they were "formed from the same or similar molten magmas, and that their differences in texture are probably due to their solidifying under different physical conditions, and, secondarily, to a slight lack of homogeneity in the magmas."

IRON MOUNTAIN CONGLOMERATE.

This formation, which derives its name from its development at Iron Mountain, in association with the iron ores, is of very irregular distribution, consisting of bowlders and large pebbles of Archean rocks occupying depressions and hollows in the old land surface. It is encountered underground in the workings at Doe Run; but it is often absent, the La Motte sandstone then resting directly on the crystallines. Outcrops have nowhere been observed within the area under consideration, and hence the formation is not shown on the map. Its thickness is very variable, attaining perhaps 50 or 100 feet in places, and from that dwindling down to nothing. In all probability the deposit never extended far from the shore-line. At Doe Run the bowlders and pebbles consist of granite and diabase, while the matrix is principally limestone, which often is very chloritic and contains disseminated galena. The rock lies in depressions of the granite floor or massed against steep walls.

LA MOTTE SANDSTONE.

This rock underlies nearly the entire area represented on the map, but is exposed only around the Archean outcrops—where it extends up the old hillslopes—and over the eastern portion, in St. Genevieve County, where the Farmington anticline brings it to the surface. In St. Genevieve County it was described by Shumard as the Second Sandstone, and, strange to say, was placed over the St. Joseph limestone to the west, which was classed as Third Magnesian.[1] Preconceived ideas probably prejudiced observation, and further, as the field work was in St. Genevieve County and proceeded from east to west, the sections best displaying the relations of these formations were probably not examined. Had the geology of St. François County been carefully studied the mistake could not have been made.

[1] Report Missouri Geologial Survey, 1855–1871, p. 299.

The thickness of this formation within the mining area is very variable; it tapers out up the slopes of the old Archean hills, while in closely adjoining depressions it may be 200 feet thick. Thus, at Mine La Motte it has been drilled into to a depth of 250 feet and the bottom not reached. Near the southeastern end of Simms Mountain a shaft was sunk in it to a depth of 100 feet. These are both in proximity to Archean outcrops. The thickness away from such, in the larger basins, has not been determined. It probably amounts to as much as 400 feet, if not more.

The distribution of this sandstone was, apparently, largely determined by two conditions, i. e., the proximity of granite and the slope of the Archean floor. Porphyries have very little free quartz, and consequently sandstones are not readily derived from them. Granites abound in free quartz, and must be regarded as the principal sources of supply. Hence we find the La Motte sandstone in greatest abundance about the granite areas. Where the slopes from the old shore-line were steep sandstone sediments could not gather, but sank to the basins, and in such cases were completely covered by the later-formed limestones.

This sandstone generally occurs in thick, massive beds, though it is sometimes thinly bedded or flaggy near the top. It is usually composed of grains of quartz in a matrix of smaller quartz grains. Sometimes the matrix is limy, and at the top of the formation the rock grades into a sandy limestone, and beds of limestone alternate with beds of sandstone. Near the base it is often of coarse texture, containing layers of grit and small quartz pebbles; also decomposed porphyry and granite, and pebbles of those rocks when near Archean areas. It sometimes contains chlorite, but is never micaceous. It is usually soft and friable, and often false bedded. The color is generally yellow or reddish, sometimes white. The quartz grains are often enlarged secondarily, but not always.

The following are illustrative sections of this formation:

Record of drill hole No. 211, Mine La Motte.

	Feet.
1. Surface clay	13
2. Limestone, white, sandy	2
3. Sandstone, black, yellow, and white	10
4. Sandstone, white	12
5. Sandstone, yellow	28
6. Sandstone, white and yellow beds	178
7. Sandstone, pink	21
8. Sandstone, almost red	9
Total	273

Record of drill hole No. 51C, Bonne Terre.

	Feet.
1. Limestone, no core, drilled with a solid bit	277
2. Limestone, magnesian, coarse-textured, crystalline, with galena disseminated at intervals and also lining small cavities; a good deal of chlorite; no chert	60
3. Limestone, like above, more dense, highly chloritic, somewhat shaly; some galena	5

	Feet.
4. Shale, dark and drab colored; a little galena near the base	4
5. Limestone, magnesian	5
6. Limestone, sandy, very granular, pitted, highly chloritic; little galena, with pyrite disseminated in small grains	9
7. Sandstone, like the last, less chloritic, more sandy, containing not much more than enough lime to cement the grains together	8
8. Limestone and sandstone, consisting of alternations of sandy magnesian limestone and of limy sandstone; white and drab; in part coarse and granular, elsewhere dense and shaly, but always sandy; little chlorite; some pyrite at 411 feet; no galena; limestone less porous than higher up	86
9. Sandstone, brown to red, soft, friable; grains rounded and not enlarged secondarily; containing little or no lime, but with a matrix of very fine sand.	20
Total	474

Record of shaft at foot of Simms Mountain, middle of N W. ¼ sec. 36, T. 36 N., R. 4 E.

	Feet.
1. Soil and clay	5
2. Sandstone, yellow	2
3. Sandstone, blue	8
4. Sandstone, yellow	12
5. Sandstone, gray, with porphyry pebbles	3
6. Sandstone, blue	5
7. Sandstone, gray, with hard granite pebbles	10
8. Sandstone, white	20
9. Sandstone and conglomerate, with sandstone pebbles	7
10. Sandstone, white	22
11. Conglomerate, with granite or porphyry	1
12. Granite, red, with upper 9 feet soft, lower 3 feet hard	12
Total	107

Record of drill hole No. 9, Series II, Doe Run.

	Feet.
1. Surface clay	49
2. Limestone, gray	89
3. Sandstone	56
4. Limestone, gray	8
5. Sandstone	5
6. Decomposed granite and limestone	4
7. Granite, hard	5
Total	216

ST. JOSEPH LIMESTONE.

This formation also underlies the larger part of the area, and is the prevailing surface rock. Like the Mine La Motte sandstone, it also wedges out up the old hillslopes, and in shallow basins it is of much diminished thickness. Thus, just north of Knob Lick the Potosi limestone is almost, if not immediately, in contact with the La Motte sandstone, because of the nearness of the granite floor to the surface. At Mine La Motte the thickness from the sandstone to the overlying Potosi limestone is estimated to be about 200 feet, while around Flat

River and Bonne Terre it is somewhere near 600 feet, which is probably about the maximum.

This limestone occurs normally in massive beds, but it is sometimes thinly bedded and flaggy, especially near the base as exposed along the eastern edge of St. François County, and also in the upper part as exposed along Flat River. Shale beds are also included; such are encountered near the base of the section at Mine La Motte, near the base and top at Bonne Terre, and in the upper part along Flat River and southward to the St. François River. They seem at places to be quite widespread, and elsewhere very limited. They are of blue and greenish colors.

The texture of the St. Joseph limestone is normally granular, the rock consisting of closely compacted crystals of dolomite, sometimes mixed with calcite. It is often minutely vesicular, with dolomite crystals lining the cavities. Sometimes it is fine-grained. The color is light or dark gray, the latter particularly in the ore-bearing portions; on weathering, the rock often acquires a yellow color.

In composition it is a limestone with a large percentage of magnesia, though generally less than in a theoretical dolomite. It contains more or less silica, especially near the base, where grains of sand are visible and the rock grades into a sandstone. It also often contains much chlorite, in places sufficient to give the rock a decidedly green color. This mineral is especially abundant in the exposed lower beds of eastern St. François and of western St. Genevieve counties, and the drill cores show it to be prevalent in the basal beds along Flat River. No chert or drusy quartz is found in this formation.

Typical sections of this formation are as follows:

Record of drill hole No. 93, Mine La Motte.

	Feet.
1. Clay	8
2. Limestone, yellow	5
3. Limestone, gray	106
4. Limestone, gray, pink, white, and black alternating	64
5. Limestone, black	96
6. Slate and sand, dark	5
7. Limestone, gray	3
8. Sandstone, white	3
Total	290

Record of drill hole No. 530, Mine La Motte.

	Feet.
1. Clay	8
2. Limestone, lower part slaty	14
3. Limestone, black	44
4. Limestone, gray and white	8
5. Limestone, "Black," with galena	38
6. Limestone, gray and black	5
7. Limestone, "White," with galena	45
8. Sandstone	8
Total	170

Record of drill hole No. 46, Bonne Terre.

	Feet.
1. Soil and clay	9
2. Limestone, brown	51
3. Limestone, black	13
4. Limestone, with specks of galena	9
5. Limestone, yellow	14
6. Limestone, dark and light colored layers alternating	51
7. Limestone, black	10
8. Limestone, with a little galena	11
9. Limestone, with a seam of calcite	14
10. Limestone, with a little galena	10
11. Limestone, showing a seam of galena	9
12. Limestone, rich in galena	5
13. Limestone, with little galena	9
14. Limestone, dense, hard	42
15. Shale	15
16. Limestone, hard, white	10
17. Limestone, dark-colored and softer	36
18. Limestone, porous, much chlorite	1
19. Limestone, with disseminated galena	3
20. Limestone, a little galena and chlorite	30
21. Galena, rich	1
22. Limestone, little galena	18
23. Limestone, no galena, very green	32
24. Soft clay and brown rock	2
25. Limestone, very green, with white spots like marble	14
26. Sandstone	19
Total	441

Record of Rohan drill hole No. 2, Bonne Terre.

	Feet.
1. Limestone, shaly	17
2. Limestone, buff-colored	143
3. Limestone, grayish, some shale	140
4. Limestone, gray, shaly near bottom	93
5. Limestone, considerable chlorite	11
Total	404

Record of drill hole No. 2, Central Lead Company.

	Feet.
1. Surface clay	4
2. Limestone, yellow and variegated	106
3. Limestone, gray	55
4. Limestone, gray, with some specks of galena and 2 inches of richly disseminated ore at base	15
5. Limestone, gray, with small specks of galena	40
6. Limestone, gray, with galena in seams	126
7. Limestone, gray, with seams of shale and disseminated galena	8
8. Limestone, gray, with seams of shale, and rich in galena	2
9. Limestone, dark, coarse texture, rich in galena	14
10. Limestone, light color, coarse texture, some galena	4
11. Limestone, sandy, white, no galena	4
Total	378

Record of drill hole No. 1, on the Mitchell land: SW. corner of SE.¼ sec. 29, T. 36 N., R. 5 E.

	Feet.
1. Limestone, cherty	105
2. Shale or "slate"	247
3. Limestone, no chert	120
Total (hole abandoned at this depth)	472

Record of drill hole No. 2, on the Hunt land: NE.¼ of NE.¼ sec. 32, T. 36 N., R. 5 E.

	Feet.
1. Shale and limestone, no chert	200
2. Limestone	280
3. Limestone, with galena	135
4. Sandstone.	
Total	615

In the holes sunk on the Derby Lead Company's land and vicinity, Mr. George J. Cole reports that shale or slate, interspersed with layers of limestone, from 144 to 160 feet thick in all, was encountered.

POTOSI LIMESTONE.

The rocks of this formation are found principally west and north of the area here treated of, and they occur within it only over the hills. The upper limits of the formation are, therefore, not reached, and it is probable that no sharp line of separation between it and the underlying St. Joseph limestone exists; hence the full thickness can not be given. At Mine La Motte Mr. Mills has placed the thickness of his "cherty" limestone—which is essentially the same as the Potosi—at 270 feet, and this is probably as great a thickness as it attains anywhere within the limits of the area shown on the accompanying map.[1]

These limestones are essentially the same as those of the St. Joseph formation, the difference between the two formations being in the prevalence of chert and drusy quartz in the Potosi. These are found principally in a residuary form, scattered through the clays and other materials which cover the surface; but they are also found in the rock, though not so abundantly as the profusion over the surface might lead one to expect.

Two principal forms of chert are distinguishable, the one dense, intensely hard, nearly white, with a conchoidal fracture, in appearance not unlike some varieties of porphyry, sometimes found in blocks 6 feet and more in diameter; the other, the drusy quartz known as "mineral blossom." The latter is found in great abundance over the surface in gnarled, irregularly shaped masses, both large and small; it consists of layers of amorphous chalcedonic silica covered with quartz crystals on the free surfaces. In the solid rock it is found lining cavities, in the forms of pipes and sheets; it is intimately mixed with the limestone, and was probably formed by a segregating action at an early stage in

[1] Geological Report on the Mine La Motte Estate, by James E. Mills, New York, 1877.

the history of the latter. There is no direct connection between this rock and the occurrence of ore; their association is simply a coincidence, but it was seized upon by the early settlers as a possible suggestion, which has been handed down.

The way in which these residuary cherts are found over the surface leads to the conclusion that they are not uniformly distributed through the formation, but are segregated in patches of greater or less extent, and that they have a quite variable vertical as well as horizontal distribution. Moreover, these remains are so imperishable that they may cover the surface in great profusion long after all of the limestone in which they were contained has been disintegrated and removed. It is impossible in many instances to determine whether this is the case or not. Hence, in mapping the formation the best that can be done is to outline those areas over which the profusion of chert remains is so great, and the topographic conditions are such, as to warrant the belief that they are in place and not transported.

STRUCTURE.

The structure of the area is so simple, and is so clearly expressed in the geological maps and cross-sections, that little need be said here.

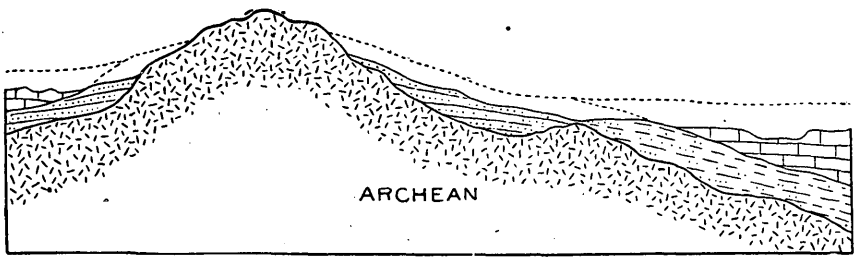


FIG. 1.—Diagram illustrating conditions of sedimentation.

One controlling condition to be borne constantly in mind is that the sedimentary rocks have been laid down upon a very uneven floor, and in large part in quite shallow basins in which numerous islands of Archean crystallines occurred. This is especially the case over the southern portion, about Mine La Motte. Local inclinations of the rocks have thereby been produced which resemble dips caused by flexing, whereas they are in fact merely the results of sedimentation upon a sloping floor. Another outcome of these preexisting conditions is a great variability in the character, and especially in the thickness, of the strata, and some anomalies in distribution arise. Thus the basal La Motte sandstone, clinging to the Archean floor, may extend much farther up a submerged hillslope than does the overlying St. Joseph limestone, and may hence be topographically much above the latter in closely adjoining localities, as is illustrated in fig. 1. Or, again, over a shallow marginal platform covered with the sandstone of shore origin the St. Joseph limestone may never have spread itself, but may have

been confined to the depths of the basin beyond, while the later-formed and higher Potosi limestone may extend over the platform and thus be directly in contact with the sandstone without any erosion period having intervened. This is illustrated in fig. 2. Other combinations will suggest themselves without further elaboration, and the observer must be constantly on guard lest they mislead him.

The general structure of the area is seen to be that of a great basin between the main Archean area to the southwest and the granite outliers of St. Genevieve County to the east. This depression may be in part a product of flexing, but it is to be considered in the main a basin of erosion dating from Algonkian or Cambrian time. The shape of this basin we have been able to define with some degree of accuracy from the results of deep drillings in search of ore. The distribution of these drill holes is shown on the geological map (Pl. I), and in each case the altitude of the surface and of the underlying sandstone is noted. A study of these notes and of the colored cross-sections (Pl. II) accompanying the map will reveal the fact that the trough of the basin follows approximately a line running from the Derby shaft on Flat River south-

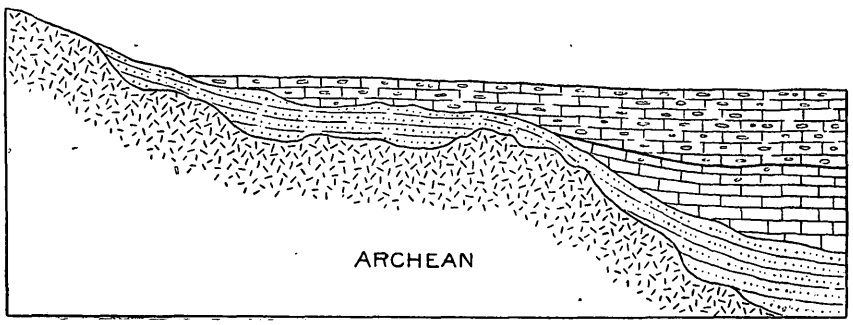


FIG. 2.—Diagram illustrating conditions of sedimentation.

ward to Delassus, and thence toward Knob Lick, where it is interrupted by the granite archipelago near that place, and apparently transferred northward so as traverse the northern part of the Mine La Motte estate. The bottom of this trough, or, more exactly, the surface of the sandstone along its axis, is about 250 feet above tide on Flat River and south of there to the St. François River. The deepest point known is in the northeast corner of the Mine La Motte estate, where the sandstone floor is only 90 feet above tide. Thence it probably deepens southeastward.

The only faults of magnitude which have been recognized traverse the Mine La Motte estate. Two have been located there, running parallel to each other in a northwesterly-southeasterly direction. Of these, the minor one, known as the Main fault, traverses the mines. It consists of a series of short throws, or step faults, aggregating within the limits of the map from 25 to 150 feet, increasing southeastward. It is

described in detail in the report of the Missouri Geological Survey,[1] and the description will not be repeated here. The other is much more extensive; the throw where it crosses Big Rock Creek is about 300 feet, and 2 miles southeast of that point it is nearly 700 feet. Both of these faults are represented in the maps and cross-sections of the La Motte mine. It is probable that other faults will be located in the future, very likely continuations of those described; but even these the writer is inclined to ascribe more to the nature of the original floor and to the conditions of deposition than to movements of rupture. The Main fault is parallel to the axis of a local basin of which the granite walls are probably very steep; the consolidation of the sediments by pressure of overlying deposits would naturally cause a breaking and slipping of the beds along a line parallel to the unyielding walls. The other fault, north of the Main fault, is apparently parallel to and just beyond the edge of a platform of Archean rocks from which there is probably a steep slope of the old surface. This, together with the consolidation of the sediments, may have produced a fracture or series of fractures along this line. That the slopes of the Algonkian land surface were often very steep is evident in many places. The depth of the sandstone, as shown by the drill-hole notes, within a mile east of Simms Mountain is proof of this; and, again, north of Flat River, at the northern extremity of the mountain, a hole 550 feet deep did not reach the sandstone, though that rock crops out within 600 feet south, whence the slope must be at least 45°.

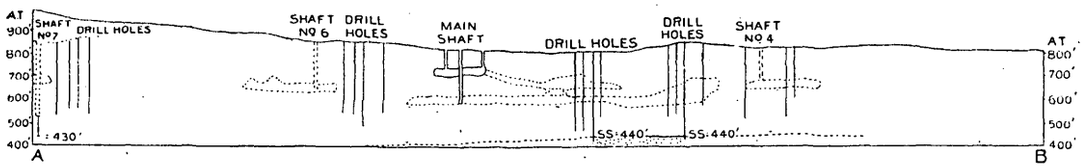
THE MINES.

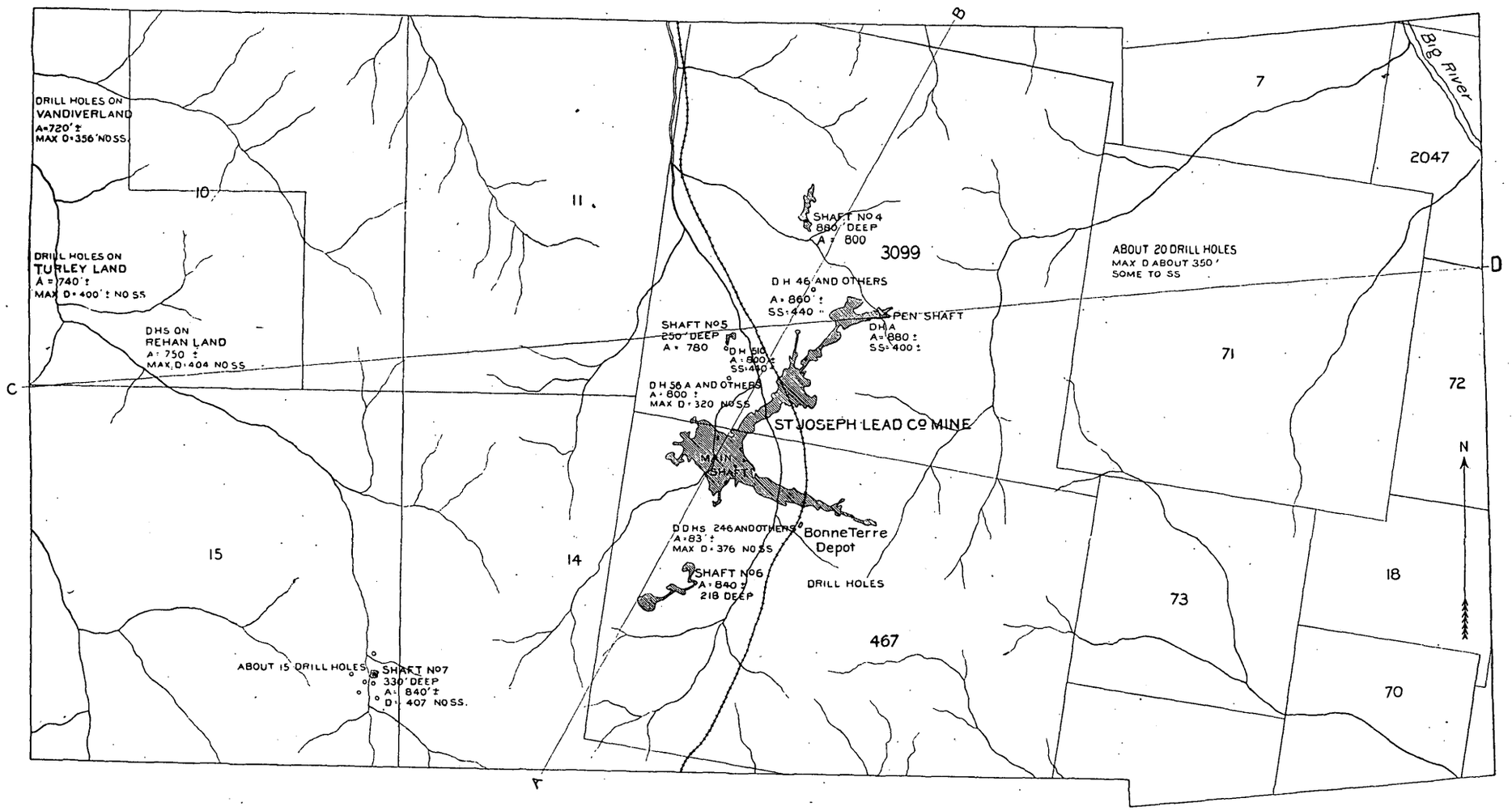
A list of the mines in disseminated ores is given on page 9 of this report. On the accompanying mine maps (Pls. III to VI) an attempt is made to show their exact locations and the extent of developments to date.

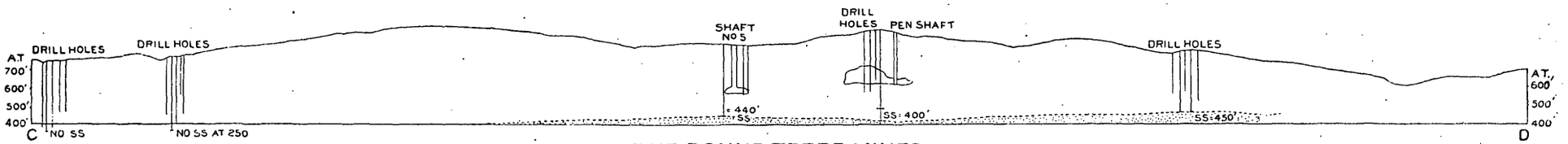
BONNE TERRE MINES.

The St. Joseph Lead Company's mines are situated at Bonne Terre. Five separate openings may be distinguished. The first, worked by the main shaft and by a number of other shafts, is by far the most extensive. It is nearly three-fourths of a mile long and over half a mile wide. Five different levels are distinguished at depths of 80, 118, 158, 205, and 230 feet. Ore is found, thus, practically from the surface down to 250 feet; in fact, in the early days of mining the disseminated ore was taken out here in an open cut. Shaft No. 4 is 280 feet deep and the workings are quite small, as is shown on the map. Shaft No. 5 is 250 feet deep and only a small area has been mined out at the bottom. Shaft No. 6 is 218 feet deep. The drift is at the bottom, and the excavation, though larger than that of Nos. 4 or 5, is still quite small as compared with the main mine. Shaft No. 7 is 330 feet deep. It is a new opening. Ore was found at a depth of 170 feet and was excavated for a distance of about

[1] Vol. VIII, 1894, Lead and Zinc Deposits, p. 657.







THE BONNE TERRE MINES

A = ALTITUDE OF SURFACE
SS = ALTITUDE OF SANDSTONE
D = DEPTH

▪ = SHAFT
o = DRILL HOLE

SCALE

0 1/4 1/2 3/4 1 1 1/4 1 1/2 MILES

50 feet on all sides of the shaft. Between this depth and the bottom, where drifts are now being started, more or less galena was found almost continuously. A drill hole sunk here to a depth of 407 feet did not reach the La Motte sandstone, but shale and chlorite were encountered at that depth, which indicate that the sandstone is not far distant. The sections given on pp. 13–14 illustrate the character of the rocks encountered here. In general, the upper hundred feet or so contain more or less shale, and the magnesian limestone is, in part, thinly bedded and flaggy; under this are some 200 feet of thicker-bedded, massive limestone, in which the ore occurs; below this, again, there is argillaceous shale for about 30 feet, followed by 100 feet or more of magnesian limestone, which is sandy to a greater or less extent and contains also some thin layers of shale; this is followed by the basal sandstone. As is shown on the cross-sections of the mine map (Pl. III), the La Motte sandstone is at a depth of 400 or 440 feet beneath the surface, and appears to dip slightly southward. The production of the St. Joseph Lead Company during 1894 amounted to 15,826 tons of lead; the total output from this camp up to the end of that year aggregated, in round numbers, as much as 215,000 tons of lead.

FLAT RIVER MINES.

The mines of this camp are all very recent openings, and the developments are consequently quite small. They bid fair, however, to attain the dimensions of the Bonne Terre mines before very long.

The Desloge Consolidated Lead Company's mine consists at present of three shafts, which are located on the map. Of these shafts, No. 2 is the only one worked as yet. Two runs of ore have been drifted on here. The bottom of the lower run is at a depth of about 320 feet, and the face of the drift is in places as much as 60 feet high. The upper run is between the depths of 190 and 270 feet. The sandstone is at about 380 feet, and some little galena is found between it and the lower level. Shaft No. 1 is the old Bogy shaft, and connects with No. 2 by a tunnel. Shaft No. 3 has just been sunk to a depth of nearly 300 feet, and will soon be operated. The rock passed through in these shafts is almost entirely limestone, little shale being noted. Much chlorite was found, especially in shaft No. 3. The sandstone floor is nearly horizontal. The mine is equipped with a large concentrating mill having a present capacity of 350 tons per day and an anticipated capacity of about double that amount. Four furnaces are in operation, and all the preparations are for a large output.

The Flat River Lead Company's mine, or the Taylor shaft, is yet in embryo. The shaft is 308 feet deep, and an incline extending thence 200 feet northward reaches 23 feet deeper. The first ore was encountered at a depth of about 160 feet, and from there to the bottom disseminated galena was passed through at frequent intervals, in yellow, white, and gray limestone. No shale is recorded in the section of the

shaft. Sandstone is reached in drill holes at a depth of about 425 feet. It is thus over 70 feet lower than at the Desloge shaft, and it must consequently rise in that direction. On the other hand, as will be seen later, the sandstone is here also about 50 feet lower than at the Crawley shaft to the east. Consequently, the Taylor shaft must be somewhere near the center of a basin. Much water has been encountered here, which has obstructed mining, and undoubtedly its central location in this trough is the reason for this, as the water comes from below.

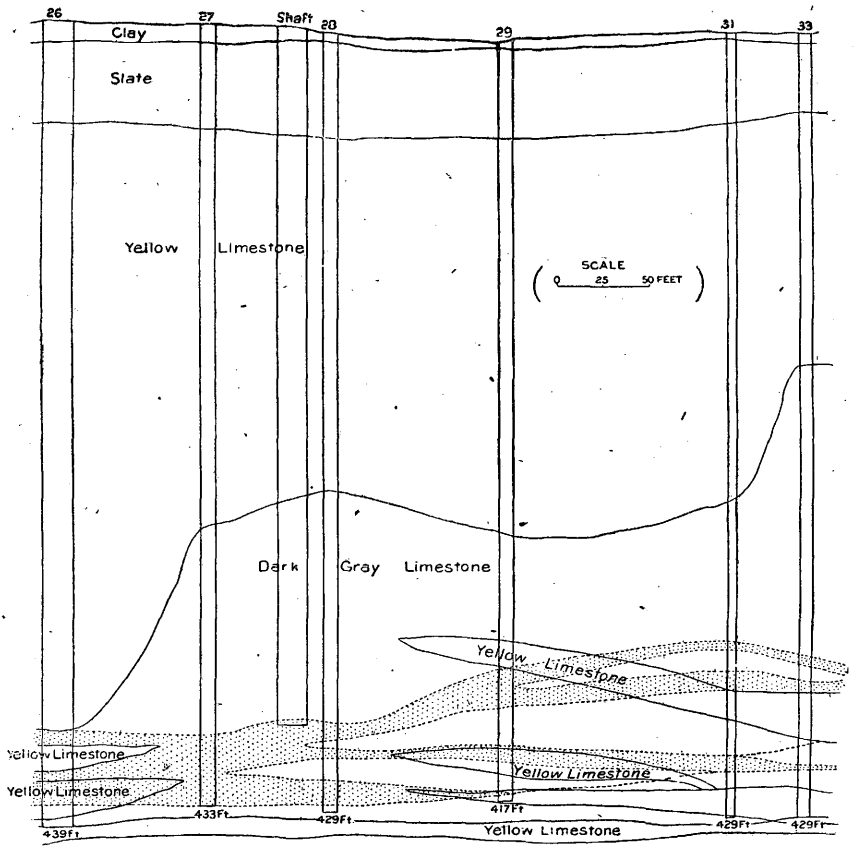
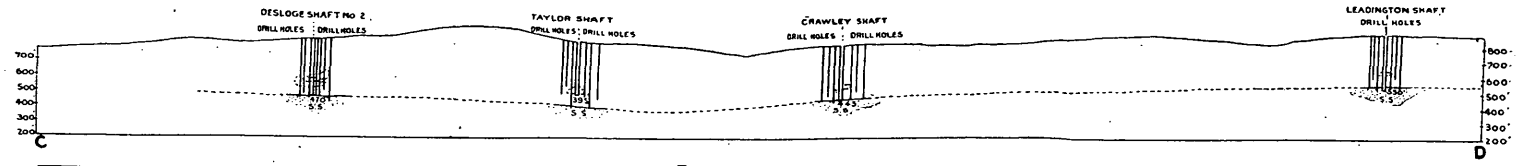
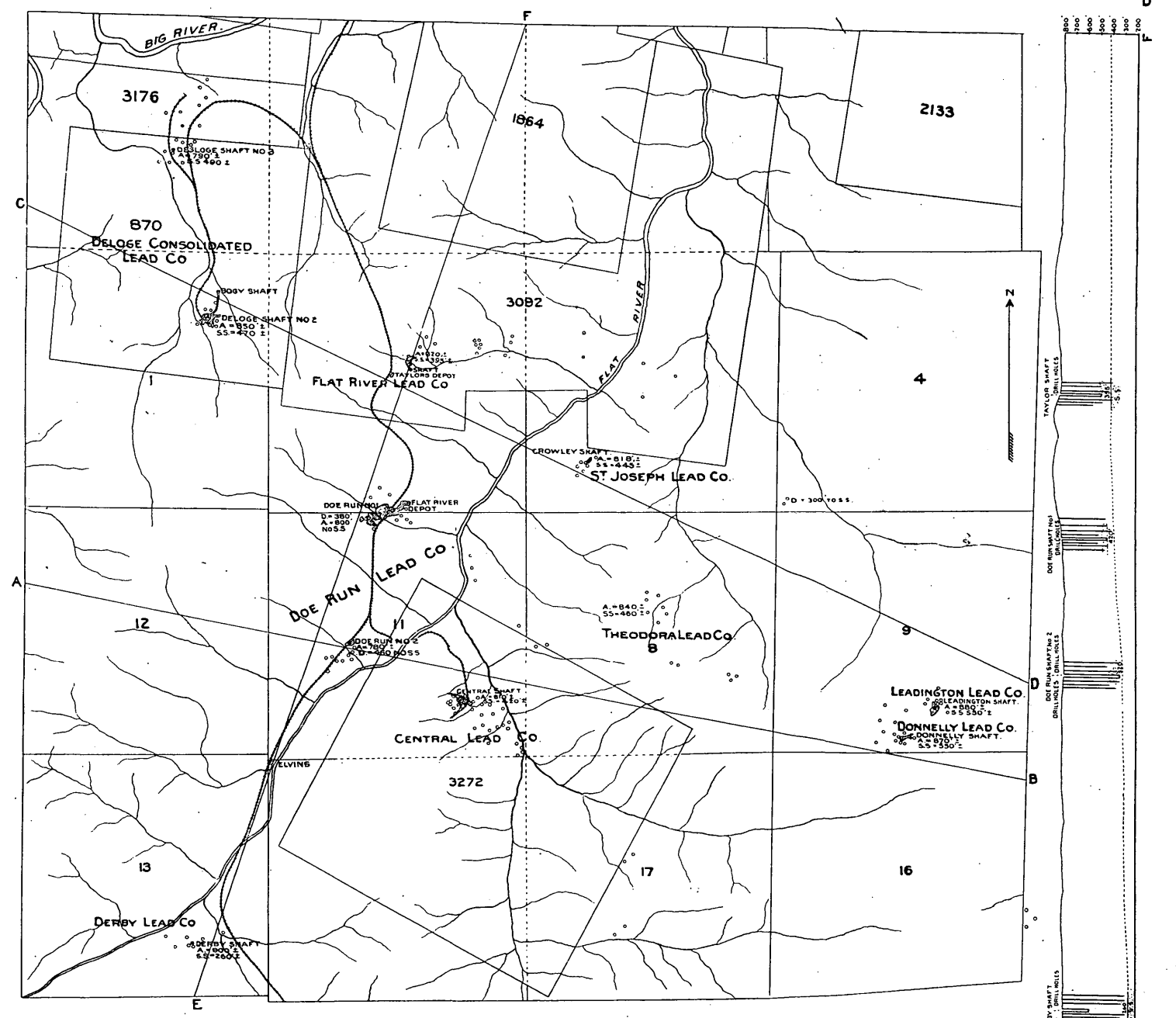


FIG. 3.—Cross-section through drill holes at Doe Run shaft.

The production of this mine in 1894 was 237 tons of lead, and its total production to date is 525 tons of lead.

The Doe Run Lead Company's mines, on Flat River, consist of two openings, numbered 1 and 2. No. 1 is now abandoned. The shaft was 380 feet deep, passing through gray magnesian limestone and frequent beds of shale. Only one run of ore was worked, and this was near the bottom of the shaft. The flooding of the mine with water from a channel which runs near the southern edge of the workings caused the abandonment of this mine. Shaft No. 2 has been opened





A. ALTITUDE OF SURFACE.
SS. ALTITUDE OF SANDSTONE.

THE FLAT RIVER MINES

D. DEPTH.
■ SHAFT. ○ DRILL HOLE.

Scale.
0 ¼ ½ ¾ 1 1¼ 1½ MILES

within the last two years. The depth to the bottom of the sump is nearly 460 feet, and no genuine sandstone was reached, though the green chloritic beds, which are close to that rock, were penetrated. Two runs of ore are distinguished—one at a depth of 430 feet, the other at 403 feet. The lower run, so far as developed, varies in thickness from 1½ to 8 feet. The upper run is not quite so thick at the shaft, but drillings show an increase to the south. These conditions are, however, very variable, as is illustrated in the accompanying cross-section of drill holes here, kindly contributed by Mr. O. M. Bilharz, the assistant superintendent. The ore, as taken out, contains about 170 pounds of galena to a mine car of rock weighing about a ton or less. The lower drift runs in a general northeasterly-southwesterly direction. Parallel to the workings on the south side is a crevice, or channel, from 5 to 40 feet from the drift, with a course about east-northeast. The flow of water from this crevice was very heavy when it was first struck, but by tapping with drill holes and cautious cutting the water was drawn off without difficulty. Where cut at one point the crevice is about a foot wide, and a fault with an upthrow of about 15 feet on the south side is reported; beyond the crevice, however, drill holes show the ore body to be at the normal level, so that the effects of the faulting are not very persistent. Yellow clay and discolored, oxidized rock fragments were found in this crevice, indicating that it connects directly with the surface. The ore from this mine is shipped for treatment directly to the works of the company at Doe Run. The shaft is well equipped for a large production.

The Central Lead Company's mine consists of one shaft 380 feet deep. The principal ore body is at the bottom, near the sandstone floor; it varies in thickness from a few feet to as much as 20 feet. Another run of ore was encountered at a depth of 240 feet, but it is of minor importance, and very little work has been done there. The sandstone is at a depth of about 390 feet, or at an altitude of 420 feet above tide; this is 100 feet above the bottom of the Doe Run shaft No. 2, and consequently the slope of the sandstone must be quite steep between the two; possibly there is some faulting over and above that exhibited along the channel in the Doe Run shaft, but there is no direct evidence of this. This mine is equipped with a good hoisting plant, shops, and a concentrating mill. It is producing now about 100 tons of concentrates per week, and the mill is being enlarged so that it will have double its present capacity. The production during 1894 was 1,719 tons of concentrates, averaging about 65 per cent of lead. The total production of the present company to the end of that year is 1,819 tons of concentrates. Crevices traverse the workings on the south side with nearly due east-and-west courses. They are not open, like the one encountered at the Doe Run No. 2 mine, but are tight, knife-edge-like seams, which are traced by the drip of the water along the roof and by occasional offsets in the rock of a few inches.

The Derby Lead Company's shaft is now being sunk, and is about 120 feet deep. The intention is to sink it to a depth of 490 feet, which will be about 40 feet into the ore body. The sandstone is here at a depth of about 540 feet. Most of the lead ore encountered in the drill holes was through the lower 100 feet.

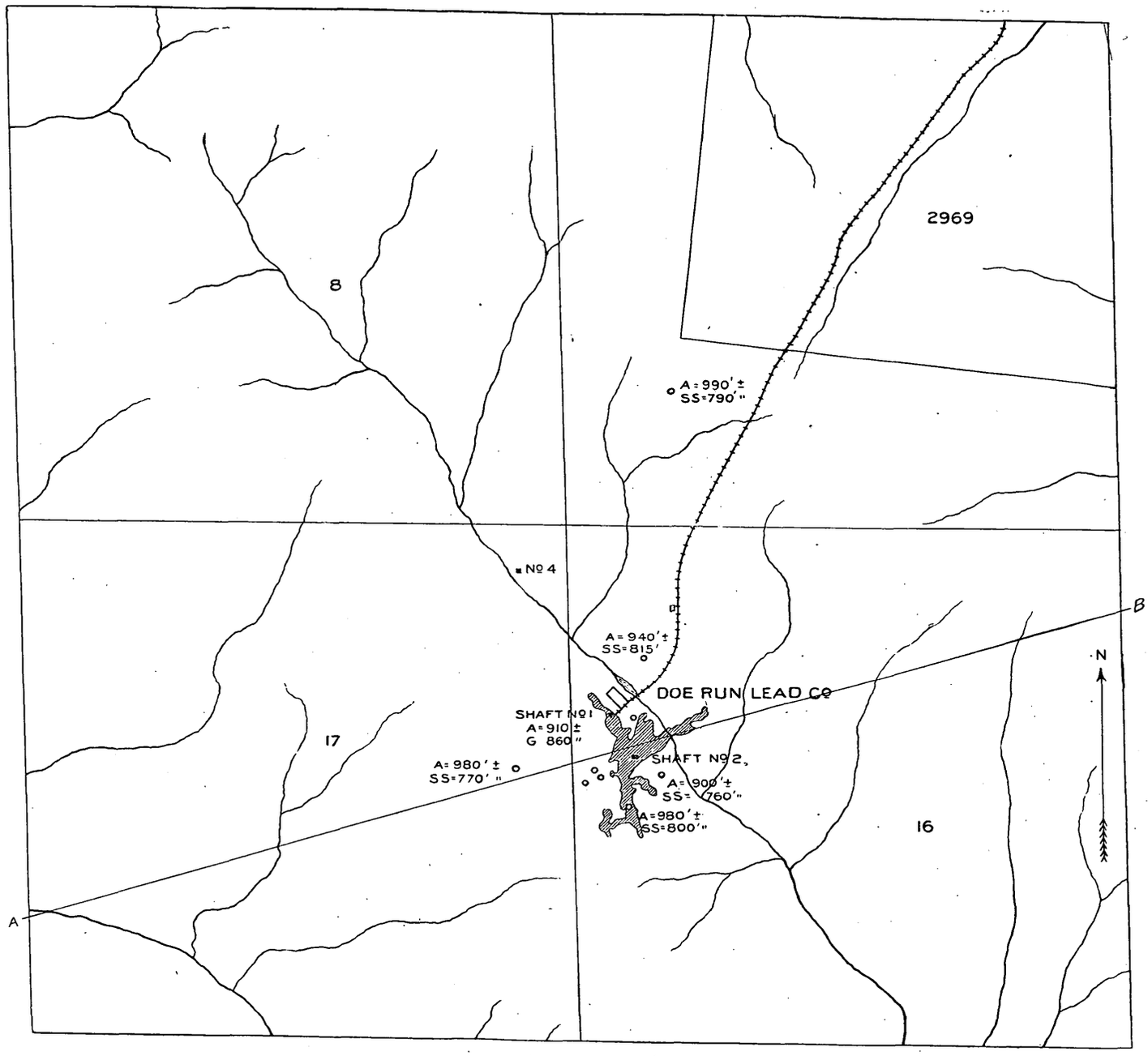
The Crawley shaft of the St. Joseph Lead Company is 365 feet deep, at which depth the sandstone was entered. An upper run of ore was encountered at 283 feet, and a drift about 100 feet long and 40 feet high has been driven in a northeasterly direction. A lower run of ore is at 360 feet, and is about 20 feet thick; the drift at this level is only about 30 feet long. A bed of pyritiferous limestone nearly 10 feet thick was passed through at a depth of about 173 feet. Very little pyrite is associated with the galena, however. A crevice, or "channel," runs along the west side of the upper ore body parallel to the course of the upper drift. The output of the shaft is shipped directly to Bonne Terre for treatment, and is included in the productions of that mine.

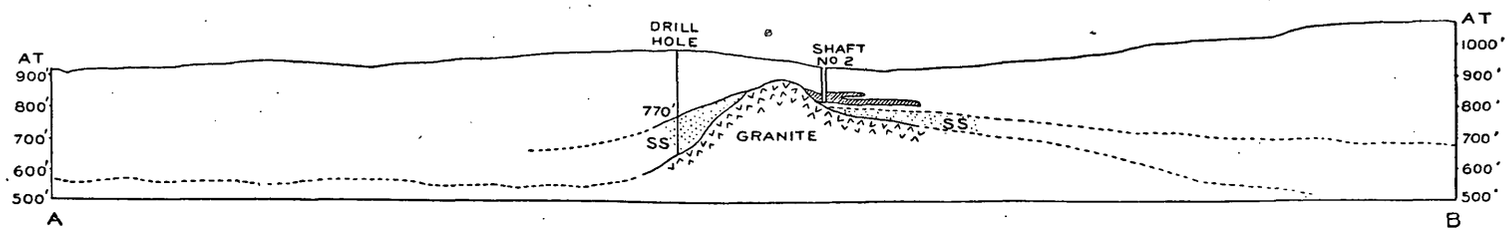
The Donnelly Lead Company's shaft is 310 feet deep, and the sandstone is struck at about 320 feet. The run of ore, which is at the bottom of the shaft, is about 10 feet thick. A drift follows this in a northeasterly direction for about 260 feet; a good deal of the cobalt-nickel sulphide, linnæite, was found in this drift. The ground is traversed by a number of crevices running a little north of east across the drift. At a depth of 125 feet an upper and smaller run of ore was passed through, in which a good deal of pyrite was found. The mine is equipped with a small concentrating mill, and the product has been hauled in wagons to Flat River. Only a small amount has been produced, however—not more than 50 tons of concentrates.

The Leadington Lead Company's shaft is 350 feet deep, and extends 20 feet into the sandstone. About 250 feet of drift has been driven at the bottom. The ore body varies from 8 to 25 feet in thickness. The mine is not now operated. It is equipped with a concentrating mill, from which there were hauled in 1894 about 350 tons of concentrates, and this is the total to date.

DOE RUN MINE.

The Doe Run Lead Company's mine at Doe Run is now almost idle. It was operated by two shafts, 47 and 110 feet deep, respectively. The ore was found principally between the depths of 50 and 90 feet. It lies very near the contact of the St. Joseph limestone with the Archean granite, and surfaces of the latter are exposed in the mine workings. The production of the Doe Run Company in 1894 amounted to 4,203 tons of concentrates, which yield about 65 per cent of lead. Only about one-fourth of this was from the mine at Doe Run, the remaining three-fourths coming from the company's shafts on Flat River. The total production of the company to the end of 1894 amounted to 21,300 tons of lead, of which nearly 5,000 tons came from the Flat River shafts.





THE DOE RUN MINE

A=ALTITUDE OF SURFACE SS=ALTITUDE OF SANDSTONE G=ALTITUDE OF GRANITE ▪ = SHAFT o = DRILL HOLE

SCALE

0 ¼ ½ ¾ 1 MILE

MINE LA MOTTE.

These deposits have been worked in many different ways. The earlier diggings consisted largely of open cuts. The principal underground developments of recent years have been at shafts Nos. 1 and 2, which are about 110 feet deep; at shafts Nos. 3 and 4, about 125 feet deep; at shaft No. 5, about 140 feet deep; and quite recently at shaft No. 6. These are located on the mine map (Pl. VI) and have been fully described in the writer's report of the Missouri Geological Survey. Two ore horizons are recognized, belonging to an upper "Black rock" and to a lower "White rock." Their aggregate thickness varies from 70 to 144 feet; they are sometimes separated by about 6 feet of gray limestone. The White rock is close upon the basal sandstone. The deposit occurs in a somewhat shallow basin between outcrops of granite, the axis of which pitches eastward. A fault, or a series of slips accompanied by crevices, traverses or is contiguous to the workings of the shafts, excepting No. 6; it runs in a northeasterly-southwesterly direction. The mine is equipped with a good-sized concentrating mill and with furnaces for the reduction of the ore. The production for 1894 was 2,626 tons of lead. The total yield of the Mine La Motte deposits to the end of that year was approximately 100,000 tons of lead.

AVON MINES.

The Avon mines deposit consists of galena in thin sheets and also disseminated in coarse sandstone, of which latter ore a bed about 2 feet thick was seen by the writer in 1895. The deposit is represented on the map as in the La Motte sandstone, but it belongs to the upper part of that formation, where beds of magnesian limestone alternate with beds of sandstone. The top of the uppermost sandstone stratum is here taken as the dividing line.

GENERAL DISTRIBUTION OF THE ORE.

The ore bodies thus far developed are outlined by the various mine maps, but, beyond their immediate limits, further extensions have been proved in almost all cases by careful drilling. These holes are shown on the larger-scale mine sheets (Pls. III to VI), and toward them the workings are now being extended. In addition, much drilling for purposes of prospecting has been done away from the immediate vicinity of the mines. The distribution of the holes is indicated on the colored map (Pl. I). People are naturally often reticent about divulging the results of such work, for manifest business reasons, and when results are given they must be accepted with a full ounce of precaution. The following brief notes are believed to be substantially correct so far as they go. They relate to different holes approximately located on the map:

West of the town of Bonne Terre, about 2 miles away, a number of drill holes have been put down by the St. Joseph Lead Company. Prom-

ising amounts of ore were found in these within the depths reached. About 1½ miles southwest of these is another drill hole, 320 feet deep, in which pyrite and a trace of galena were encountered at a depth of about 100 feet.

South of Bonne Terre, between shaft No. 7 and Big River, drilling has been done, and ore is reported to have been struck, but the results have not been obtained.

West of French Village, in one of the holes shown, about 3 miles away from that place, a little galena is reported to have been found, while the other holes were all barren. The holes were shallow, however, the deepest only about 265 feet deep, and none reached sandstone.

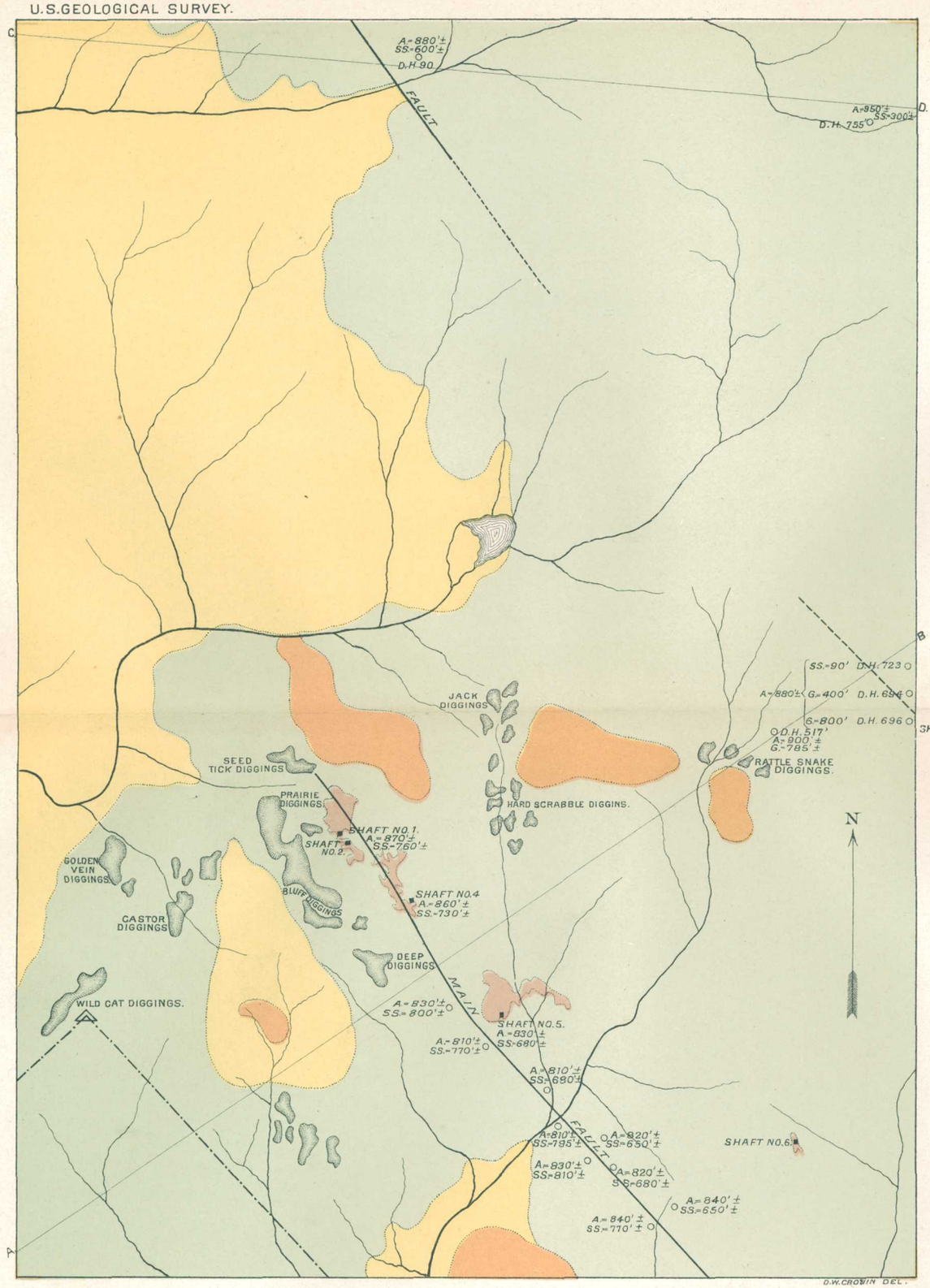
West of Flat River, and within a mile south of Big River, a number of holes have been put down. These are in the SE. ¼ sec. 5 and the SW. ¼ sec. 4, and in the SE. ¼ sec. 4, the south part of sections 3 and 2, and over adjacent grounds. Galena is reported to have been found in paying quantities in holes put down by the St. Joseph Lead Company, by H. C. Brockmeyer, and others. The maximum depth was about 510 feet and reached chloritic limestone, but not sandstone. Most of the ore was encountered between 375 feet and the bottom, but some was found all the way down. In the NE. ¼ sec. 3 recent drilling is reported to have developed a good body of lead ore at a depth of about 380 feet.

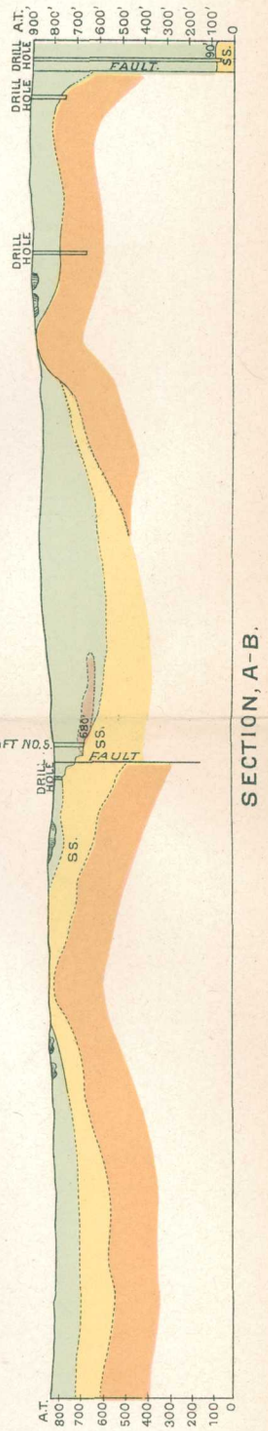
East of Flat River, on the Theodora tract, galena has been found in most of the holes put down. The ore is generally within 20 feet of the sandstone; but in one hole, situated in the midst of the others, some lead was struck at a depth of only 100 feet, and some more at about 200 feet.

North and east of the Leadington and Donnelly mines drill holes have been put down, between them and the corner of St. Genevieve County, some 4 miles distant. Some little ore has been found, but not in many holes, and according to report it disappears eastward as the sandstone outcrop is approached. About a mile southeast of these mines some drilling done a year or so ago failed to discover any considerable amount of ore, but recently a quite rich find was reported from the same tract of land.

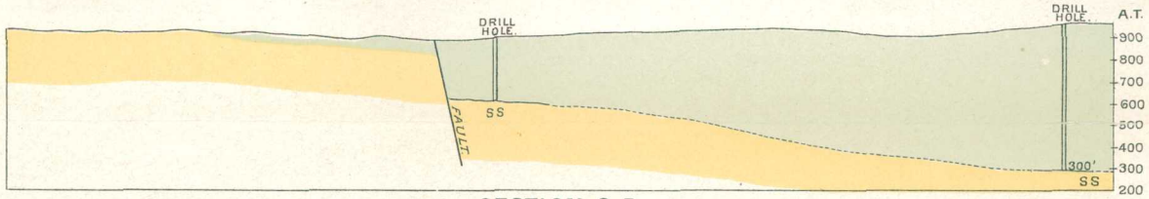
North of Simms Mountain and north of Flat River, in sections 21 and 22, several holes have been put down. One of these went to a depth of 558 feet, and neither encountered any lead nor reached sandstone. In another a little ore was struck at 470 feet, and in still another galena was scattered between the depths of 460 and 554 feet.

On the Derby Lead Company's land, in the S. ½ of the SE. ¼ sec. 13, in the NW. ¼ of the NW. ¼ sec. 19, and in the NE. ¼ of the NE. ¼ sec. 24, numerous deep drill holes have been put down. Ore was found in all below the depth of 450 feet. A workable body from 20 to 40 feet in thickness is reported, and galena is scattered through the rock for a depth of 80 feet or more. In the NE. corner of the NW. ¼ sec. 24 a moderate quantity of ore is reported between the depths of 461 and 537 feet. In the SE. corner of the SW. ¼ of the same section galena was found





SECTION, A-B.



SECTION, C-D.

GRANITE. SANDSTONE. OLD SURFACE DIGGINGS. UNDERGROUND MINES. LIMESTONE.

A. ALTITUDE OF SURFACE. S.S. ALTITUDE OF SANDSTONE. D. DEPTH. ■ SHAFT. ○ DRILL HOLE.

THE MINE LA MOTTE MINES.

0 1/4 1/2 3/4 1 MILE

SCALE.

Lith. A. Hoen & Co. Baltimore.

scattered through the rock between the depths of 445 and 490 feet. Nearly a mile east of the last, on the creek in the SW. corner of section 19, a good showing of ore is reported between the depths of 539 and 548 feet, and the loss of the bit prevented further drilling, though the hole was still in ore.

North of the railway junction west of Delassus a hole was put down in section 29, near the middle of the south line. No ore was found down to the depth of 472 feet, where the hole was abandoned, but Mr. George Cole, who sunk the hole, believes that lead would have been found at 625 feet. In the NE. ¼ sec. 32, just south, ore was passed through between depths of 480 and 615 feet, and in the NW. corner of section 4 and the NE. corner of section 5, a mile south of the last, similar results were obtained.

About Farmington, and in the holes immediately northeast and northwest of that place, no lead ore has been found.

About Delassus a number of drill holes were put down five or more years ago—a dozen or more within a mile or so south of the town; they were quite shallow, however, none being over 200 feet deep, and thus stopped well above the sandstone. A little galena was found between the depths of 75 and 100 feet, but nothing amounting to an ore body.

East of Doe Run between 4 and 5 miles several holes have been sunk, as indicated on the map. Of these, one sunk in the SE. corner of section 24 showed lead ore between depths of 460 and 472 feet, where drilling was stopped because of the breaking of the rod.

North of Knob Lick about 4 miles a drill hole in the NE. ¼ sec. 21 revealed no ore.

North of Mine La Motte, in the northern part of the estate, drill holes have, so far, not encountered any ore, at least not in paying quantities.

About Fredericktown a good deal of drilling has been done within the past four or five years, and ore has been found at several places, though none has so far been developed. In a hole about 3 miles southeast of the town a few specks of lead were encountered at a depth of 115 feet. On the eastern edge of the town lead was found in a number of holes, in the lower 30 feet above the sandstone. North of the town about twelve holes were put down, close to the county road, between Village Creek and Mine La Motte; they varied in depth from 35 to 71 feet to the sandstone; no lead was found in any. About a mile southeast of these, on the south side of Village Creek, more holes were sunk, reaching a depth of 180 feet; some little galena was found in these. About 4 miles northwest of the town, near the southwest corner of the Mine La Motte estate, is a bunch of drill holes of which the reports are quite promising; they range in depth up to 120 feet. The records of these holes show that the ore occurs in the lower part, perhaps 10 feet from the sandstone, and consists of a bed of limestone 10 to 15 feet thick, with the galena disseminated in it in coarse grains; some cores are quite rich.

About 5 miles southeast of Fredericktown, on the St. François River, in section 15, west of Slater Creek and about a fourth of a mile east of the river, drill holes reached depths of 180 feet; no lead ore was found in any; the deeper holes reached sandstone, while those farther north went through limestone to granite without encountering any sandstone.

THE ORE BODIES.

The typical ore is the disseminated, consisting of grains of galena intimately mixed with grains of dolomite or calcite, the galena having been introduced by the process of metasomatic interchange. Sheet galena is sometimes found in vertical crevices at higher levels, associated with disseminated ore, but it disappears or is rare at depths. The galena of the disseminated ores is sometimes distributed uniformly throughout the face of rock exposed; elsewhere the mineral is concentrated about certain centers; and, again, the grains of galena are frequently strung out along the stratification planes, sometimes so close together as to form sheets, which vary in thickness from one-tenth of an inch to several inches.

The associated minerals are few and not conspicuous. Calcite is probably the most abundant; it is found in large crystals embedded in clay, in small crystals lining cavities, and in masses embedded in the limestone. Other minerals are iron pyrite, marcasite, chalcopyrite, pyrrhotite, and the rare nickel-cobalt sulphide linnæite. These generally occur in small quantities, but occasional bunches are found, as the experience at Mine La Motte, Bonne Terre, and the Donnelly mine shows. Chlorite, an abundant mineral in the limestone, is also often mixed with the galena.

The shapes of the ore bodies are very irregular and variable; at one point the galena may occupy a bed of limestone only a foot or two in thickness, while within a short distance the impregnation may expand to 10 or 20 feet, and faces of magnificent ore nearly 100 feet thick have been opened. As a rule, no well-defined planes limit these ore bodies in any direction, but the galena contents usually fade or "lean out" into the surrounding barren rock. In some instances, however, stratification planes or crevices mark the limits of the ore.

The horizon of the ore deposits is quite variable, but on the whole they are perhaps more prevalent in the lower part of the St. Joseph limestone, just above or a short distance away from the La Motte sandstone. The ore bodies at Bonne Terre are a notable exception to this, the lowest being 200 feet above the sandstone, and they extend thence to the surface. The nearness of the ore bodies to the sandstone is more pronounced in the Flat River mines; but upper runs of ore are found also, as is illustrated in nearly all of the mines there. At Doe Run the deposit is near the bottom, and at Mine La Motte it also clings to the sandstone, but the basins are shallow in both places. About Fredericktown the ore is also found near the sandstone.

The presence of crevices, commonly called "channels," traversing all of these mines, is a significant fact. In the deep workings they are not, as a rule, open fissures, but are quite tight, and are often traceable only by the drip of the water, with sometimes lenticular expansions. They often connect with the surface, where they are generally open, filled with clay, and contain galena in sheets. Such crevices at Bonne Terre are described in great detail in the report of the Missouri Survey. Many are encountered in the main workings there. The prevailing courses are between east-west and northeast-southwest. Many are nonpersistent, while some are continuous so far as the workings extend. No master crevice or series of crevices is definable; no faulting or displacement was observed. At the Desloge mine joint crevices were seen running from east to west, and the Bogy shaft followed a crevice from top to bottom. In all of the mines of the Flat River camp such crevices traverse or are contiguous to the ore bodies, as already referred to, and all have courses nearly east and west. They are abundant at Doe Run and at Mine La Motte. They undoubtedly favor the accumulation of ore in furnishing passages for the flow of the solutions, but they can not be regarded as of the nature of profound fissures through which solutions have risen from depths. For the same reasons faults are conducive to the formation of ore, but there is only one instance of close association, i. e., at Mine La Motte.

The texture and composition of the rock has doubtless some bearing upon the ore contents. Thus, the deposits are most prevalent in the coarse, open-textured rock, and they also characterize the darker-colored varieties, which doubtless contain some organic matter. Shaly, dense beds have their influence in directing the flow of the waters which traverse them, and hence they indirectly affect the distribution of ore bodies.

The fact that the deposits of Mine La Motte and on Flat River are along or near the axes of basins suggests that there may be something in this structure favoring the accumulation of ore, and the results of drilling south of Flat River also indicate that ore occupies the center of the trough. It seems natural that this should be the case, as the waters or solutions which traverse the rocks from the surface would gravitate toward the center of a basin, and, other conditions being favorable, it would thus be also a center of accumulation. The force of this suggestion is weakened, however, by the location of the Bonne Terre, Donnelly and Leadington, and Doe Run deposits, which are well up on the sides. The absence of ore over the margin of the formation, in the lower beds which crop out just west of the St. Genevieve County sandstone area, is worthy of note.

A glance at the map shows that all of the deposits so far developed are beyond the areas of the Potosi limestone, and drill men are of the opinion that the ore does not occur in disseminated form beneath that cherty rock. This may be the case, but the fact is hardly demonstrated

yet, as inherent difficulties in drilling have prevented holes from being sunk through these rocks. If, however, it prove true that these great ore bodies as a whole are restricted to the country whence these upper rocks have been removed, or, in other words, where denudation and subaerial decay have been greatest, then this is a significant fact. It is in entire harmony with the writer's hypothesis of the origin of the ores. This hypothesis has been so fully presented in the Missouri Survey report that it will be only very briefly outlined here. It derives the deposits from the metals diffused through the country rocks, by means of the surface decomposition of the latter. Minute quantities of the metals being present in not only the limestones but the Archean rocks also, as has been demonstrated by analysis, the metals would naturally pass into solution on the decay of these rocks and be transferred in percolating waters through crevices and other openings to the underlying strata, where they would gather by segregation into deposits of various forms and kinds. In the case of the disseminated ores, the waters flowing from the underlying sandstone doubtless carry metals in solution in minute quantities, largely derived directly from the remains of decaying Archean rocks. These, on entering the limestones, find conditions (which were not afforded in the sandstone) suitable for the replacement of the country rock by galena and for the formation of ore bodies. The metal-containing waters can have found access in other ways also.

In conclusion, the maps and sections accompanying this report show very clearly the limits of the different formations, including the ore-bearing St. Joseph limestone, beyond which it is not advisable to search for disseminated ores. They also define the basins or troughs; and, though it can not be maintained that the ore deposits are confined to these, the writer recommends that these basins be given special attention in the search for ore. Moreover, it is a fact that the developed ore bodies are generally, though not invariably, under areas over which shallow surface deposits have been worked in the past; therefore, other things being equal, such localities should be given the preference. Ground which is known to be traversed by crevices or faults is also to be regarded favorably. It is of great importance to the future of this district that some systematic effort be made to collect and preserve more carefully the results of the drilling which has been done and is being constantly extended by individuals and companies. Only the most general results have been introduced here; could they be more thoroughly studied and compared, mapped and leveled, much of value could be determined which is here only suggested.

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