TABLE H.—ANALYSES BY BRADLEY* & REED.

Number	1	2	3	4	5	6	7	8	9	10	11
Location	St. Charles.	Standard.	Valley, Bay City.	New Hope, Jackson.	Trumbull, Jackson.	Wenona, Bay City.	Pere Marquette, Reed.	Pere Marquette, Bradley.	Sebewaing.	Mich. Coal Mining Co., West Bay City.	Mich. Coal Mining Co., West Bay City.
Sp. Gr.	1.216	1.19	.....	1.2315	1.28	1.202	.....	.....	.....	.....	.....
Moisture	7.55	5.54	1.7	5.53	3.04	2.06	6.33	5.963	1.483	1.48	1.850
Volatile Comb	37.56	33.077	35.25	44.63	39.80	41.4	33.90	34.682	36.429	36.18	34.117
Fixed Carbon	54.08	59.28	53.55	44.97	.....	51.89	57.88	57.375	50.384	54.17	56.633
Ash	.97	2.1	9.5	5.	.....	4.65	1.89	1.998	11.704	8.17	7.400
Sum	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
Total S	.2 1-6	2.0 1-3	undet.	2.0 1-6	.....	2.0 4-9	.....	.....	.....	.....	.....
Ratio of fixed carbon to combustible	.59	.642	.613	.502	.....	.556	.631	.624	.581	.600	.60

* Some of these analyses prepared for a thesis for the degree of M. A. at Alma College.

TABLE I.—RECENT ANALYSES (MAINLY TESTED CALORIMETRICALLY).

Number	1	2	3	4	5	6	7	8	9	10	11	12
Location	Saginaw coal.	"Slack."	*Saginaw.	Saginaw.	Saginaw.	Saginaw.	Saginaw.	Saginaw.	Robt. Gage Coal Co., St. Charles No. 4.	Robt. Gage Coal Co., St. Charles Lump.	Bone coal.	St. Charles Coal Co. Upper coal.
Moisture	7.60	.875	12.39	12.51	.....	.....	.....	.....	1.72	2.37	8.08	4.84
Volatile Comb	37.895	38.765	30.47	30.38	34.78	34.61	35.27	35.21	33.74	36.18	30.74	40.13
Fixed Carbon	50.73	48.80	55.92	55.89	63.83	63.99	64.73	64.79	57.29	58.99	49.29	51.49
Ash	3.77	11.56	1.22	1.22	1.39	1.40	.....	.....	7.25	2.46	11.89	3.54
Sum	99.995	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
Total S	.99	2.32	.....	.....	.....	.....	.....	.....	.....	.....	.885	2.22
Total combustible	88.625	87.565	86.39	86.27	98.61	98.60	100.	100.	91.03	95.17	80.03	91.62
Ratio of fixed carbon	.573	.558	.646	.647	.....	.....	.....	.....	.628	.619	.615	.558
Obs. Calorimet	12,521	.....	11,692	11,663	13,345	13,331	13,522	13,519	†12,508	‡13,438	.....	.....
Calculated from analysis	.....	.....	12,600	.....	.....	.....	.....	.....	13,290	13,900	.....	.....

*Moisture part of the coal, not superficial, burned up rapidly, soon exhausted. Sample taken by T. Pray, Jr., Dec. 1899, Mahler and Carpenter calorimeters used.

† 27.068 to 27.736 grams of lead reduced per gram coal.

‡ 27.38 to 27.34 grams of lead reduced per gram coal.

TABLE J.—SUPPLEMENTARY ANALYSES.

Number	1	2	3	4	5	6	7	8	9
Location	Goetz No. 3.	Massillon No. 1.	Michigan Mine.	Old Monitor.	G. Coal No. 1.	G. Coal No. 2.	Flushing No. 1.	Flushing No. 2.	Flushing No. 3.
Moisture	5.44	2.68	9.57	10.03	3.76	6.50	2.91	2.94	2.37
Volatile Comb	37.71	46.68	40.93	35.36	37.05	33.98	40.60	40.73	40.68
Fixed Carbon	48.43	40.93	46.13	49.94	50.10	40.60	54.35	54.06	50.82
Ash	8.42	9.71	4.35	4.67	9.09	18.92	2.14	2.27	6.13
Sum	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
Total S	.59	3.08	.98	1.12	3.72	1.79	1.12	1.58	3.14
Total combustible	86.14	87.61	87.06	85.30	87.15	84.58	94.95	94.79	91.50
Ratio of fixed carbon to it	.557	.467	.530	.585	.575	.474	.573	.570	.556

In "Mining and Metallurgy for Oct. 1, 1901, p. 565, we find in regard to calorimetric tests that Dr. Langbein, of Nieder Lössnitz, has constructed a new apparatus for that purpose. He publishes 150 complete chemical and calorimetric experiments of heating materials, and 153 purely calorimetric experiments, which he has carried out as a supplement to his experiments, in evaporation. The accompanying table is the result of his experiments.—British Foreign Office Reports, Annual Series, No 2,671.

	Calorimetric Units	
	From	To
Sawdust briquettes	3,400	4,100
Peat	2,700	4,800
Lignite	1,900	3,100
Briquettes	4,600	5,400
Bohemian brown coal	3,600	5,500
Coal from Silesia	5,300	7,500
" " Saxony	5,400	7,200
" " Saar district	5,800	7,700
" " Westphalia	6,600	7,900
" " Great Britain	6,000	7,800
Coal briquettes	6,100	7,700
Anthracite	7,600	8,100
Crude coke	3,500	4,000
Coal coke	5,600	7,400
paraffin oil	9,800	9,840
Petroleum	10,300	10,330

These tests may be compared with Table II.

TABLE K.—PEAT ANALYSES BY W. H. ALLEN.

Number	1	2	3	4	5	6	7	8	9-9	10	11	12
Location	Michigan.	Michigan.	Michigan.	Michigan.	Michigan.	Michigan.	Canada.	Canada.	Canada.	Mixed.	Michigan.	Michigan.
Moisture and Volatile Comb.	57.	59.25	52.5	69.75	58.5	63.25	51.	60.	49.	58.65	63.03	60.25
Fixed Carbon	30.	25.75	32.75	37.6	31.75	28.	26.	24.	19.	21.6	30.95	31.25
Ash	13.	15.	14.75	2.65	9.75	8.75	23.	15.	32.	19.75	6.02	8.50
Sum	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

§ 17. Conclusions.

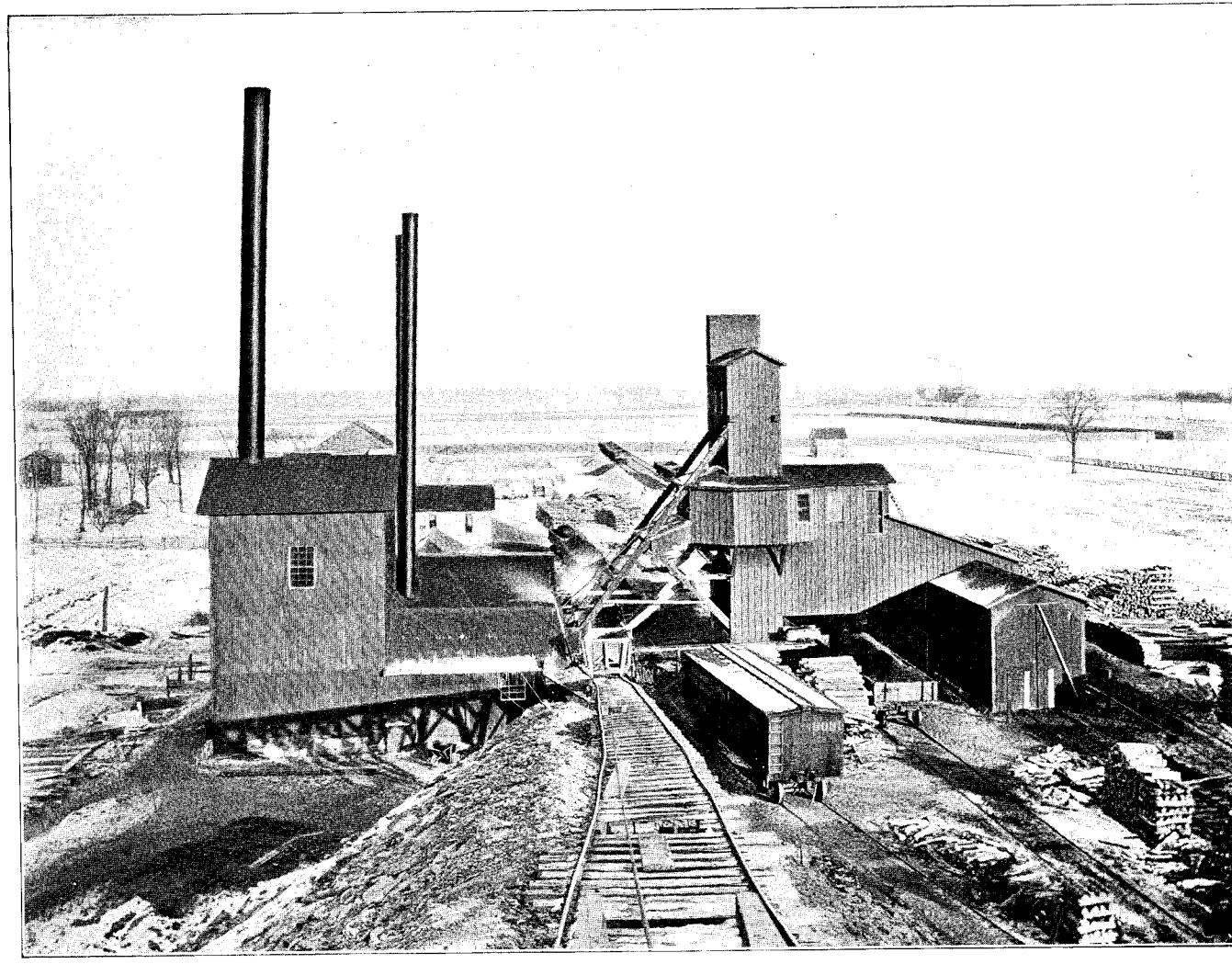
Summing up the analytical tests and results of this chapter we may come to the following conclusions: There are but three seams, of the seven or eight existing, which have yet been worked enough to give us some idea of their character. They are all bituminous coals, rather high in moisture and inclined to be gas coals, and to pass into low grade cannel coal.

The uppermost of these three seams, the Upper Verne or Monitor seam, is the only one which appears to be at all gassy. It is a coking coal, duller than the next lower seam, and containing more charcoal, and a medium amount of sulphur. The roof is a Lingula shale. The ratio of fixed carbon in combustible runs up to .57.

The next seam, the Lower Verne, is generally not far below, often near enough to be mined with it; it is also a coking coal, but is high in sulphur and ash. The roof is frequently fossiliferous and calcareous. The ratio of fixed carbon is lower, often less than .50.

The third seam, the Saginaw seam, is higher in moisture and fixed carbon than the previous seams, but contains much less ash and sulphur, in fact, very small quantities, but is not what is ordinarily classed as a coking coal. It is a good heating coal, but rather quick. The temperature of the chimney gases should be kept low, to avoid loss of heat in the evaporation of the moisture contained. For the Saginaw seam the best analyses give a ratio of fixed carbon to total combustible of 0.61, while in the Verne coals this ratio is usually near 0.50, but is more variable.

None of the coals as yet appear to be very well adapted for the burning of Portland cement, which is said to require a coal that is at the same time rich in volatile combustible and poor in sulphur. The cream of the Upper Verne coal, compare J1 and J3, meets most nearly these requirements.



THE FLAT SAGINAW VALLEY. VIEW SOUTH FROM DUMP OF SAGINAW MINE.

CHAPTER V.

THE EROSION AND DISTURBANCE OF COAL.

§ 1. Recent channels.

After the formation of the coal beds, they have been cut into and partly carried away, not only by the now open channels of the present rivers, but also by channels which are now filled with unconsolidated materials, gravel, sand, till, etc., and by still earlier channels which are filled with rocks, usually sandstone.

We have then to discuss three kinds of channels, open channels, gravel channels or "washouts," and sandstone channels.

Open channels or valleys exposing the coal on their sides are neither numerous or deep, and this fact is one reason why the coal basin has been so tardy in development.*

Beginning on the east of Saginaw Bay and going around the basin with the hands of a clock, in describing such channels, we find that on Coats Creek, near Tuscola, coal is said to have been used many years ago from exposures in the bank, and sandstones occur in the bed of Cass River a short way above town. The Flint River near Flushing (Sec. 4 and Sec. 22), and the Shiawassee from above Corunna, at intervals down to Saginaw county, show exposures of coal measures. The Cedar and Grand Rivers show exposures at intervals from Williamston to six miles below Grand Ledge, and Grand River and the adjacent streams around Dimondale, Eaton Rapids, Chelsea and Jackson, expose some glimpses of the coal measures. There is a glimpse or two of coal measure sandstones at Ionia and as far northwest as Kent county, but thence there are no bedrock exposures until we get clear around to the Rifle River in Arenac county at Omer and above. The center of the coal basin is heavily covered with drift.

Except in the comparatively small mines of Grand Ledge, the valleys are in no case so deep that coal exposed on the side of

*R. R. Lansing. Exposition of the mineral coal of Michigan, pamphlet, Detroit, 1854; describing the earlier known exposures, especially those on Cedar River.

them can be effectively worked. It follows that there are no important self-draining coal mines. The States to the south, on the other hand, like Ohio, have deeper river valleys, and the coal was extensively exposed on the sides of the hill, where it could be worked cheaply and easily.

§ 2. Drift filled channels.

The States farther south have been somewhat covered with drift, but Michigan has been doubly plastered over; first rough coated with till and gravels washed directly from the great ice sheet which overspread it not so long ago from the northeast; then given a finishing coat up to nearly 200 feet above the present lake level by the deposits of the Great Lake system when the water was dammed up by the great ice sheet to the north, so that it flowed from a lake in the Saginaw valley across the peninsula to Lake Michigan, then ultimately to the Mississippi.

The smoothness of the resulting topography is well illustrated by the view from the top of the dump of the Saginaw coal mine, Plate V.

Before the period of the ice sheet, the land surface stood higher, and steep channels 100 to 150 feet deep and more were carved in coal measures. The cross-section of the Woodville mine, Fig. 4, reveals very clearly such a channel, which would have exposed the coal nicely before the glacial time.

Numerous other channels have been revealed by boring. One channel which skirts the east side of the Bayport limestone in Huron county is fully described in the report on that county.*

Leaving the county near its southwest corner it passes close to Unionville in Tuscola county, then flows west, crosses into Bay county, is well marked in Portsmouth and going south through Frankenlust township, probably enters Saginaw county in Kochville or Zilwaukee townships, thence goes southwest as far as Paines, receiving a tributary from South Saginaw. Then it passes west towards Alma, receiving a branch from Auburn and Midland, where the depth of drift varies from less than 200′ to 300′ or more.

The general course of some of the main channels is indicated by the bends of the rock contours of Plate I, but there must be many smaller tributaries not as yet located.

If this mantle of drift were stripped off it would be as easy to find the coal as in southern Ohio or Kentucky. As it is now, a

*Part II of Vol. VII of these reports.

great element of uncertainty in the development and estimate of the amount of coal in a given tract is added. The closer the coal is found to the rock surface in preliminary boring, the more likely of course it is that one of these channels may be found cutting down to or through the coal. The Woodville section indicates, what is probably the fact, that they are often narrow and steep walled. Probably the general form of the rock surface is pretty flat and gently sloping to the middle of the basin, but engraved with steep-sided valleys.

It has been recently suggested in Mines and Minerals* that coal is likely to rise toward its outcrops, especially when underlain by fire-clay, and the cause suggested is the weathering and swelling of the beds when exposed to the weather.

This suggested principle holds true at Grand Ledge and a number of other points in other states which I have visited, and beside the reasons given for it in Mines and Minerals it may be due to the fact that erosion proceeds most rapidly along faults and anticlinals.

The figure of the section at the Woodville shaft, p. 33, indicates a similar relation of the coal to the old drift-filled channels, and similar relationships may be observed in the Pere Marquette No. 1 shaft and in Bay county. It seems, therefore, as though we might accept the following practical rule as of some value:

Toward an outcrop or washout, the coal is likely to rise.

§ 3. Sandstone channels.

Besides the channels just mentioned we find others which have cut out the coal and are filled with compact sandstone.† These do not weaken the roof as do the former, but both classes make much trouble by letting in water. For instance, the mine of the St. Charles Coal Co. is so close under a heavy sandstone, that it is quite wet.

These channels indicate that before the time of the ice sheet, in fact, probably soon after the coal was formed, stream channels were cut into the coal measures and then filled up again with sandstone formed from the deposits. In Holcroft's plan of part of the Porter coal mine (p. 48) and in some other cases we can see clearly from the shape of the cross section that the sandstone channel really came down from above and cut out the coal.

*By Charles Catlett, January, 1901; also Am. Inst. Min. Eng.
†Keyes, Iowa, 1894, pp. 181-186.

Keyes* in one of his figures shows a sandstone cutting out the coal very much in the same shape as at the Porter mine. The erosion is also indicated at the Porter mine by the fragments of coal in the sandstone. Numerous records of borings seem to show where such sandstones appear in a series of records and replace the coal, but mere borings may be ambiguous. For when, as in the old East Saginaw well, we find 78 feet of sandstone replacing the shales and coal that occur in the O'Donnell Spencer well and the Saginaw coal mine not three miles off, while at these latter points there is a well marked sandrock 34 feet thick or so just beneath the coals, it is not at all certain whether the East Saginaw sandstone is such a channel as we have been describing or whether the coal and shale series was not, as I am more inclined to think, laid down unconformably in a hollow in the sandstone, just as we find swamps between the sand ridges of the present lake shore. We have to search for reliable indications as to whether the sandstone which cuts out the coal connects with the beds above or below it. In the particular case of the Saginaw and Pere Marquette No. 1 mines, a careful study of numerous records convinces me that the coal rises up and laps upon and into the sandstone which occurs to the north and east for the first 50 feet or so below the surface, and that the coal was formed as a pocket or swamp in that formation against a sand ridge. Probable indications of real sandstone channels are also frequent, as when Mr. Liken near Sebewaing, put down a well for water,† and found three feet of coal 36 feet from a previous boring which at the same level was in the midst of over 20 feet of sandstone.

I think that where the want is produced by a sandstone cutting down from above it is likely to be less extensive than otherwise.

The rock channels besides being described by Keyes as cited, are well described by Stevenson in Pennsylvania, who is really pioneer in detailed description of bituminous coal sections.

§ 4. Faults or displacements.

Coal beds are liable to be disturbed or interrupted and deteriorated, e. g., by the following features:

(a) Faults, i. e., displacements which are almost always "normal," i. e., the surfaces of displacement slope toward the

*Loc. cit. Fig. 20.
†Vol. VII of these reports, Part II, p. 149.

side on which the coal dropped, so that the coal may be imagined to have slid down. See the figure of the fault at Sebewaing (Fig. 3, p. 31). This is likely to be the side of the thicker coal. The fault lines are frequently occupied by—

(b) Clay seams or veins (perhaps occupying the fissures made by the faults) which traverse the coal.

(c) "Sulphur partings," that is, veins or seams charged with sulphide of iron.

(d) "Spar seams," that is, veins or seams filled with some white material, generally either calcite, which effervesces in vinegar, or gypsum, which does not.

There are other phenomena which are sometimes called faults, for almost anything which prevents the miner from finding the coal where he expects it, he is liable to consider and call a fault, including not only displacements such as we have mentioned, but rolls, horsebacks, sandstone bars and channels.

In such a broad sense it would be better to use a term like "want" or "trouble." The geologist, however, limits the use of the term faults, and applies it only to those cracks in the earth's surface by which the coal has been displaced and the beds above and below as well. In the Jackson coal mines we have such displacements and there is one well developed in the mine of the Sebewaing Coal Co. (Fig. 3). Here the coal rises more sharply as we approach the fault, and this is often the case. The motion and slipping along the fault place has polished off smoothly shining surfaces in the coal and slates, sometimes as bright as jet, which are called slickensides.

Along the fault line, which has a dip of about 65°, there are open holes, apparently water channels, which appear to have been dissolved out by underground waters working along the cracks and dissolving the pyrite.

The actual throw at the fault is but two feet or so. The Iowa faults are described by Keyes as follows: Seldom with more than a few feet throw, the majority normal, with a grade 15° to 45° from vertical, the two faces of the rubbed fracture very dense and highly polished. Frequently there are a number of faults parallel to each other. In some instances, in passing from a hard to a soft medium the line of fracture is bent away from a normal to the contact plane like a ray of light, passing out of water. Reversed

or thrust faults, Gresley's* "Slack" or "soot" veins are little known in Michigan, but there are said to be a few around Jackson.

§ 5. Veins.

(a) Clay-filled veins, "clay seams," "mud seams."

The phenomena known by above names have been quite fully described and figured by W. S. Gresley,† and but little is known of them in Michigan, so that we need not dwell on them here. In the majority of cases, perhaps, they are fillings of shrinkage cracks, and one may be described in a general way as a more or less vertical, crooked, tortuous, often branching, ragged-sided wall or dike intersecting a seam of coal, composed of compact indurated clayey materials or a mixed debris of rocks forming a breccia or conglomerate mass, varying in width from a mere streak or film of clay to as much as 15 feet, but averaging about 10 inches. It may have any direction, may extend a few yards only or run a mile or more before being lost to sight. It may branch and even reunite vertically and horizontally, and the adjacent coal may be toughened, twisted, and spoiled or displaced. In this latter case the clay vein probably occupies the fissure of a fault. It "may form part of a network of veins and may extend indefinitely above and below the coals." Though Gresley says that the direction of the clay veins is irrespective of other structural features of the coal, some of his figures (6, 7, and 16) suggest that those which he figures are divided into two systems, which, though more or less irregular, are at an angle to each other which is bisected by the cleat of the coal, as torsion cracks of a substance twisted under pressure are bisected by the direction of pressure. These figures would then indicate that in such cases the cracks were opened by a twisting of the coal seams, while under such a pressure that clay was forced into the cracks, and a "cleat" produced.

Other figures given by Gresley indicate that in the cases they represent the clay seams figured were due to the shrinkage of the coal, under a pressure that forced the clay into the cracks as they opened.

(b) Spar veins are more likely to be smooth coated, following the cleat or joint planes of the coal. They are generally white, in strong contrast to the dark coal, and are usually not over a fraction of an inch thick.

*Bull. Geol. Soc. Am., 1898, Vol. IX, p. 47.
†Bull. Geol. Soc. Am., 1898, Vol. IX, pp. 35-38.

(c) "Sulphur partings."

These are pyritic streaks, i. e., streaks of sulphide of iron, either in the shape of pyrite or the similar but more easily decomposable mineral marcasite. When they cross the coal nearly vertically they are probably veins following faults, but they also occur in streaks parallel to the bedding. While in some cases they correspond to the faults, in other cases no disturbance is noted. Holcroft's plans of the Jackson coal district show them abundantly.

The "sulphur" was once sold for 5 cents more per ton than the coal to an acid and fertilizer factory at Jackson, and one of the open fields is the economic utilization of the waste pyrite of the Lower Verne seam around Bay City.

In connection with the waste bitterns for potash, and the slaughter-house refuse for phosphorus, I imagine a successful fertilizer business could be built up.

It might also be used for cheap large scale disinfection.

§ 6. Horsebacks or bars.

Keyes* gives a figure of a horseback in the sense of a ridge rising from beneath the coal, that is from the footwall, which is remarkably sharp. He defines a "roll" as a place where the roof occupies a portion of the seam. It may be a mere indentation or nearly replace it, i. e., be a "pinch," and may occur in connection with a clay seam or fracture, which fact he also mentions.†

On the other hand, Stevenson‡ calls "horsebacks" what Keyes calls "rolls" and we have called "channels," coming down from the roof and cutting out a greater or less thickness of clay, while rolls he defines as swells of the under clay. It will be observed that Keyes and Stevenson are diametrically opposites in their definition. They may both conform to local usage, but miners are not scientifically precise in their use of language and steer clear of barren spots, no matter by what names they are called, so that in very many cases we are not certain of the nature of the intercepting beds. For instance, between the Standard mine on Section 6, Bridgeport township, south of Saginaw, and the Pere Marquette No. 1 and Saginaw mines coal basin, there is an area where the coal seam of those mines does not appear, being said to be cut out by a big sandstone, which is said to come in from the roof. It is really not certain, however, whether it is a channel or a bar; my

*Iowa, 1894, p. 206.
†Iowa, 1894, pp. 189-266.
‡Penn., KKK, p. 295.

own impression is that it is a bar, as there is a rapid rise to the south approaching it in the mine, running up to 5° or 6°.

It seems certainly more natural to speak of a rising up of the foot-wall as a horseback. When we can be certain which we have, it will be better to avoid ambiguity and speak of channels and bars, and otherwise to speak generally of "wants," a miner's term for places where the coal is wanting.

We may picture the formation of bars as follows: Suppose the shore of Saginaw Bay to be depressed and buried, and covered with later deposits. The swamps behind the sand ridges would in course of time become thin coal seams, and the sand dune ridges and oak islands would become sandstone bars and horsebacks.

Other bars might be due to uneven pressure and settling with faulting. If clearly made out we should call them fault blocks rather than bars.

CHAPTER VI.

THE DEVELOPMENT OF COAL.

§ 1. Peculiarities of occurrence as affecting development.

There are some peculiarities in the occurrence of coal in Lower Michigan which have retarded and will affect its future development.

As we have said, practically all the coal lies below water level, and mainly in artesian well country. Ample provision must therefore be made for economical pumping. Care must be taken to steer clear of porous beds and fissures, and artesian wells. The water from an artesian well whose casing burst was a considerable annoyance to the Sebewaing Coal Company. The water has flooded their mine since this report was first written. For the same reasons slopes or inclines leading down to the coal will probably not be advantageous, as the water will find its way in too much, and though they have been tried at Jackson, Elk, Williamston and Corunna, have not been successful. The amount of water to be handled has* been a great source of annoyance and failure, and it is important that the shafts for pumping should be put down in the lowest parts of the coal, so that the water may run to the pumps. This requires careful preliminary testing, and the test holes should be plugged, lest they aid the circulation of water and make necessary more pumping.

The presence of numerous deep drift channels also makes the work of development uncertain. They are to be carefully avoided, since near them the roof is likely to be treacherous, and often the weakness of the roof prevents success. Thus the true value and best method of working an area of coal lands cannot be determined without an expensive series of preliminary borings.

The strata are quite a little disturbed and uneven, and though Lawton† is somewhat within the truth in saying that there is but

*Lawton, 1881, p. 24.
†Lawton, 1895, p. 173, and other places.

one workable seam, "never over four feet deep," and averaging $2\frac{1}{2}$ to 3, it is true that the beds are prevailingly thin.

On the other hand, fire-damp and coal dust explosions are almost unknown, and other noxious gases are not troublesome.

§ 2. Principles to guide explorations.

Summing the results of our inquiry, we may lay down with some caution the following practical principles, which should be compared with those laid down by Winchell:*

(1). A good place to begin preliminary explorations is a belt a few miles (five to fifteen) within the limits of the coal basin as marked on Plate I. Nearer the center some of the coal beds are liable to have run out (though there may be higher later formed ones of which we have no knowledge), and the drift and depth to coal is greater. Nearer the margin the coal is more likely to be cut out by some channel and the base of the coal series is soon reached, but—

(2). A coal bed once located, though not thick enough to work, may often thicken, especially in that direction parallel to the margin of the basin, in which it grows deeper, so that it may be followed by borings to where it will be worth working.

(3). Generally speaking, the coal will rise toward the margin, except for minor undulations. But shafts should not be located until the property is so proved up by borings that they may be located at the lowest point of the coal.

(4). Hitherto almost all the work has been done on the southeast side of the basin. A line from Sebewaing to Jackson, and one from the Wolverine Mine, near Bay City, toward Grand Ledge, would be very nearly parallel, and would include practically every mine in the state that has produced coal in commercial quantity. The little that has been done at Standish, and around the Rifle River, at Hubbard, Pinconning and Rhodes, has not been more than sufficient to show that coal exists there. Montcalm county and the valley of the upper Muskegon are promising regions entirely undeveloped, for the rumors of coal found there seem to refer entirely to coal in the drift.

(5). Over most of the coal basin there is an extra heavy coating of unconsolidated materials (drift), and probably the coal measures have suffered heavy erosion. Hence exploring for coal alone

*1861 report, p. 157.

will be too expensive to pay, until we have more definite knowledge than at present, so that it is very important that careful records be kept and preserved of borings for all other purposes, e. g., artesian water and brominiferous brines, which are likely to occur in this region.

This is especially true of the northwest region, where the surface drift is apparently over 300 feet deep.

§ 3. Methods of testing and developing.

We pass next to consider methods of explorations and testing. The one that might be thought of first, viz., sinking a shaft, is the last to be used, and in fact need not often be resorted to, until it is time to begin mining. The first method suggested is that of digging wells or test pits, as they are called in the iron country. As a general thing, however, any coal reached by shallow pits will not be conveniently workable—the coal will dip away from the shaft and be wet, and very likely have a poor roof.

The methods of exploring suited to the iron or copper country, or to putting down wells in unconsolidated deposits, are of no use save in exceptional circumstances. When previous explorations have made it probable that only soft shales in the way of rock overlie the coal, and when the overlying drift is not very thick and very bouldery, dug wells may be used. Bored wells (in clay) and driven wells (in sand) will find their main utility in tracing out cheaply the form of the surface of the bed rock where there is danger of gravel channels. When there is a probability of encountering an embarrassing quicksand it may often be a good thing to use the scouring process (by which a strong stream of water washes out the sand ahead of the casing as it is tapped down) until the casing is extended to bed rock, after which it will be easy to begin drilling.

The main reliance is upon drilled wells, and we may divide drills into two classes, churn drills, with an up and down motion (percussion drills), and rotary drills.

Churn Drills.—The churn drills are the kind commonly used by drillers in putting down artesian wells for farmers, saline wells, etc., and are usually the first thing at hand and in many cases the cheapest. Most incidental explorations will have been done with them, and the records are well worth keeping. Their chief disadvantage is that the drillings from a churn drill (which is worked by dropping the tools down frequently upon the rock while they

are slowly rotated) come up as fine as powder or meal, with the parts from different layers more or less mixed, so that it is difficult to determine the exact qualities of the rock, and exceedingly easy to confound with the coal more or less of the black shale roof that almost invariably comes above it. By reaming out a small hole to somewhat larger size, somewhat coarser samples may be obtained, and I am informed by those experienced, that they can recognize with their hand on the cable the peculiar crunch of the coal under the drill, owing to its greater brittleness, when it is struck, and by then turning the drill exactly 90° between each stroke, and "quartering" the coal, they can get larger fragments. So that if they also hoist and bale out with the sand pump at every few inches on passing coal, or use so called "jetting" tools which wash out the meal continuously, they can get a very fair idea of the coal. But there is a great weight of responsibility both on the skill and on the integrity of the driller.

There are two styles of churn drill, according as a cable is used to lower the tools or a series of poles. The former gives rather cleaner samples, for the poles tend to knock off more pieces of the rock along the way down. But the poles have the great advantage that on nearing the coal, they can be changed from a churn drill into a rotary drill.

The cost of putting down a single two-inch hole for a farmer's well two hundred feet or so, around Saginaw, has got down to 50 cents a foot or so of late. It used to be considerably more, and the real cost varies greatly according to the particular difficulties encountered. A driller must allow a good margin for contracts on the first few holes in a new district. Limestone or pyrite take very much more time than sandstone or shale, and accidents of one sort or another seem to take half the time of drilling a well. The cost to a company owning their own machine and putting in many holes where the formation is well known, I understand may be not over 25 cents to 35 cents a foot.

Rotary Drills.—The simplest form of rotary drill is probably the crown drill—a length of gas pipe, with notches like saw teeth filed in the cutting end, or a tempered steel drill of the same shape. In sandstone explorations nice cores have been taken out 3 to 4 inches in diameter by a chilled steel drill, at a lower cost for fifty feet or so than the churn drill. In this form ordinary gas pipe is rotated, while beneath it have been dropped angular frag-

ments of an especially hardened steel or "adamant." Practically it is a method of grinding one's way down. Mr. Etzold's explorations for the Michigan Coal and Mining Co. were largely by this method.

As coal is very brittle large cores must be taken if it is expected to get them up whole.

The diamond drill has the edge of the round bit armed with black diamonds, known as carbons or bort, set alternately on the inner and outer side. These drills are at present very expensive ($1,000 to $2,000). It has been but little used, the 907 foot hole at Corunna* being the chief instance. Mr. N. P. Bradley also put down a hole near Bay City, described p. 170. The diamond drill is most effective in a hard and uniform rock, like hard pyritic sandstone, and is especially to be recommended for very hard rock, but is not to be recommended when the rock is soft and sticky, or especially when of very irregular hardness, breaking away in angular bits that jam, like some conglomerates and cherty limestones. Cores 1½ inch in diameter cost somewhere about $1.00 a foot. In sandstone and shale the cost has been as low as 44 cents a foot, and progress as rapid as 30 feet a day.† The relatively least expensive depth is, when the diamond drill is used, about 600 feet.

In all rotary drills the drill is forced into and against the rock, and the hole is more likely to be crooked than where the drill is dropped.

It is obvious that no one form of drill that we have mentioned has all the advantages under all circumstances, and the subject is so far out of the line of our main purpose that the remarks alone serve merely to remind one of the expense and desirability of exploration,‡ the advantage which a man educated to the business has in choosing the method best adapted to the circumstances, and finally to suggest to driller, land owner or explorer a wider range of investigation and choice of that which will serve his need than might otherwise occur to him.

If it is merely a question of following the coal into the valley or "swamp," or of determining the amount of roof and presence of channels, a churn drill in an experienced and reliable hand should suffice. If the quality of the coal or adjacent beds is in question,

*Vol. V, of these reports, Plate XII; also Lawton, 1885, p. 176.
†See Mines and Minerals, Jan., 1900, also Vol. VI, Part I, of these reports.
‡See The Michigan Miner, No. 2, Jan. 1899, p. 10.

a crown drill or a drill that will give a three or four inch core at least should be employed, and I should recommend taking at least one core before sinking a shaft.

Sinking Shafts.—So far as concerns sinking shafts, we must refer to any treatise on mining, as it is too large a subject to try to summarize. We need only add that in the district under consideration workmen have often encountered dangerous flows of water in putting down wells, so that preparations must be made to fight water and timber closely. In putting down shafts against water it has often been found advantageous to put down two shafts together not far apart, running first one and then the other ahead a few feet, and pumping vigorously in the other one. There is no loss in this in coal mining, for two shafts are needed for ventilation and safety anyway.

§ 4. Incidental development and information.

It is obvious from what has been said that the heavy expense of the necessary preliminary explorations prevents the development of many coal bodies, which once located could be worked at a profit, and many of the borings for water and brine would, if properly watched and recorded, give valuable information as to the presence of coal. But the following conversation is typical:

"Say, don't you remember that you brought in some coal to me when you put down that last salt well for me some years ago?"

"Yes, and you said, 'What are you giving us?' and suggested that I had dropped it down."

"Well, do you remember how far down it was and how thick?"

"No, I can't say now, but my machine is right near here, and we can run her down and see very easy any time you like."

Some of the better well drillers keep a careful record of all their holes for whatever purpose, but no record is as good as a set of samples, for there may arise some entirely unforeseen questions as to a particular quality of a fire-clay, of the presence of clays, iron ore, or zinc ore, which no one thinks of now (any more than the saw mill owner, hard pressed to get rid of his slabs, used to care for a small bed of steam coal), but which may later be of practical value. If records, and especially if accurate tubes of samples such as adorns the corridor of the Alma Sanitarium, had been kept of all the wells which have been put down, it would be possible to save thousands of dollars in fruitless explorations, by guiding explorations in future, so that the right spots for shafts may be

sooner found. Not only this, but there would be a fund of information concerning many other raw materials destined to become of economic value.

Beside borings there are other sources of information so indirect and technical in their character as to belong to the professional geologists. The presence of coal in surface deposits, if in the till, indicates coal to the north-northeast and not directly beneath, but if abundant and coarse, not far off, if in river sands in the rock or till up-stream. Again, the well waters are often more highly sulphated in the Coal Measures.

Role of the Geological Survey.—Now the part of the State Survey is to put together, and aid and guide the collection and preservation of this information. Two and two of knowledge together often make more than four. A well that shows no coal may show some bed recognizable in other wells that do contain coal, by which we may infer that it has not gone far enough and the coal is still beneath, or perhaps that it is cut out by a channel, and may so guide us in farther search. If one studies the reports of great mining States like Pennsylvania, where the publications of the Geological Survey run into the hundred, he will find that a vast amount of the data is furnished by private exploration. The natural exposures in our coal basin are very much fewer, and it is to be presumed that my predecessors have largely made what can be made from them. And yet there is a great deal more to be known about the geology and natural resources of the Saginaw Valley, and each year many wells are sunk which would throw light. The State Survey cannot undertake the work of the private explorer, in finding out the value of the land of a particular private individual. But the State may play the part of a vast cooperative society, and if it can guide him in putting in his work and money to best advantage, and in return receive information which is of no exclusive advantage to himself, possibly of no immediate practical value to anybody, which will in due time enable the State Survey to help some later investigator as it has helped him, an important function as far as the economic development of the State is concerned will have been accomplished. Its relations to educational and purely scientific interests we do not touch.

§ 5. Promoter and land owner.

We are now prepared to better understand the use of the "man who wants an option," whom we have agreed to call for

short the promoter. The coal under a piece of land may not pay to work by itself. Prof. Pumpelly has shown very clearly that large coal mines mine more economically, and pay a larger percentage of the selling price of their coal to the workmen. Land should then be gathered into aggregates for working, large enough to give a chance for the most economical mining. Moreover, before any mining is done there must be considerable exploratory work, to determine how best to mine the coal, where the lowest spots best for sinking shafts may be, and where are the channels cutting out the coal which should be avoided. But no man can be expected to go to the expense of exploring and drilling for coal, unless assured that some of the increased value which will come to all the land around a successful exploration will be to his benefit. In all this there is no question of over-reaching anyone. It is a plain business proposition. This gathering of the coal rights of land into developable tracts is the work of the promoter.

How should such offers be met?

In the first place unitedly. Owners of adjoining tracts should agree on options or terms to the same party, or if they choose should co-operate in a company for developing their lands themselves. If certain owners stand off and refuse to unite with their neighbors, the very best places for shafts, and the most economical mining, may be impracticable. Suppose for instance a want or channel runs diagonally through a quarter section so as to isolate in one corner a few acres of good thick coal. That coal might be profitably developed and taken out in connection with the coal on the adjacent farm, but if that is leased to a different party or the neighbor refuses to lease, it becomes practically worthless, except to one man who can later name his own price.*

On the other hand, if a few big companies get hold of all the land except a few small pieces not worth working separately, they can force the remaining owners to take about what they choose to offer. This has been very notably the case in the Mesabi iron range in Minnesota. A few companies control the situation. This is an age of combination, and combined action will prove most successful. The owner who, not having land enough for independent working, refuses to unite in joint negotiation with his

*Near St. Charles there is some coal on the N. E. corner of the N. W. quarter of Sec. 17, which could best be handled through the Somers No. 2 shaft, and perhaps is only worth handling through it.

neighbors, may injure them, but is far more likely to damage himself.

Secondly, the promoter should be met fairly. He is about to risk some money in exploring, and if one wishes to aid in the progress of the country, and give men of moderate means a chance to have a share in it, one should not demand too much money in advance for coal rights, provided the terms in case the explorations are satisfactory give a fair and customary share of the profit to the land owner, either in the shape of royalty on the output, or a lump sum for the sale of the coal rights. But what is too much? And what is a fair share? These are difficult questions to answer, for much depends on local conditions, but we shall try to throw some light on them in the remaining sections.

It is well to remember that a considerable sum of money must be spent in preliminary testing, and, if that proves promising, in preliminary equipment, before any returns are realized, and it is obvious that in making, for example, present cash payments for coal rights, a large margin of prospective profit must be allowed, to tempt a man to incur cash outlay. Without much doubt the most satisfactory plan is to have the land owner assume part of the risk and have his profits depend upon the success of the venture, by making the payment to him come (outside a small cash payment to bind the bargain and as a guarantee of genuine work), in the shape of royalties, i. e., a fixed sum per ton for each ton of coal mined. This has been the almost universal rule in Michigan, the royalties running from 6 to 15 cents per ton. The more certain the amount and the greater the thickness of the coal, the higher the royalty that may fairly be demanded. Probably 8 cents is the most common figure.

§ 6. Labor value of coal.

The value of coal as of everything else depends on two factors, the cost of production, and the scarcity of the material. It is the last value only which the land owner possesses, and with which we wish to deal, and yet we cannot easily separate the two sources of value. The scarcity is almost invariably in any article, certainly so in coal, not absolute, but the scarcity of sources of supply that will yield the coal so that it can be laid down in a given market, say Bay City, at a given cost.

To make the matter more practical, the scarcity value of Michigan coal is the difference between the cost of the production, and

the cost (including labor in the mines *and* transportation, etc.), of delivering coal from States where there is more than they know what to do with, like Ohio and Pennsylvania, of the same grade in the same market. This is with the proviso that, as at present, there is not enough of the local coal produced to supply the demand for soft coal, and some imported coal is needed to make up the difference. If and when the mines in the neighborhood of Saginaw can supply more coal than the local market can take up, the price will fall, until one of two things will happen. Either the mines or parts of mines producing at greatest expense (on account of narrowness of seam, amount of water to pump, insufficient transportation facilities, poor roof, etc.), will shut down, as the price has fallen where they can make no profit, or the surplus coal will be sent away and replace Ohio coal elsewhere until the market is made large enough to take the supply. The farther it goes south, the greater will be the freight charges, and the less the amount which the mine will receive. For instance, at Lansing Hocking Valley and Saginaw Valley are in close competition, at about $2.05 per ton. The freight charges on the former are $1.40 per ton, on the latter $0.70 per ton. The mine in one case gets 65 cents, in the other $1.35 per ton, and if it costs the same to mine the scarcity value would be 70 cents a ton. But as I have in the next section remarked, it costs nearly 1.30 a ton to mine coal in Michigan, leaving only five cents margin of advantage of position to the Michigan coal. Until the freight rates are revised, therefore, Michigan coal cannot go much farther south, unless the average cost of mining decreases.

Before the independent mines producing coal more expensively are shut down, the laborers, unless they are effectively organized, will be ground down to the last notch, and the easiest mined coal gouged out. Finally the mines which are unwisely planned, or worked with insufficient capital, or on an uneconomically small scale, which Prof. Pumpelly has shown is generally true of the small mines, will have to shut down. In short, first the laborers and then the small operators, or vice versa, depending on which is best organized, will suffer. This is the process known in the financial columns of the papers as "getting the business into strong hands." In other words the control of the production becomes vested in a few men, who directly through a trust or indirectly by a general understanding, determine how much coal can be mined each year to best advantage, and can afford, as they

work on a large scale, to keep reserves of coal until later and shut down the mines they can least profitably work.

It is plain that the first alternative suggested, that of crowding the weaker mines to the wall, is not pleasant. It produces the misery, the constant strife between workmen who must fight for a living wage, and operators who *must* grind if they keep in business, with frequent strikes and the bloodshed and misery that may attend them. Yet this was the normal or rather the regular way of keeping down the production in the States to the south of us, where there is vastly more coal than the country can consume, and here we find the coal mine operators of one district subscribing to the strike funds of another, practically paying the workmen to strike, that thereby they may keep down a rival production.*

Now it is obvious that by this policy of every man for himself and the devil take the hindmost, the value of coal lands as such is reduced down to nothing. It is only those tracts exceptionally rich and near the railroads or market that are worth anything, and that in proportion to these exceptional advantages. It is obvious, also, that labor cost will be whittled down to the lowest point.

Finally, from a geological point of view most important, it leads to a development of the resources that is a synonym for wastes. Instead of the coal being mined cleanly, the richest and handiest parts are gouged out, much left for pillars, as little timbering as possible done, and the rest left, perhaps in such condition that it can never be safely or profitably worked, certainly so that the total expense will be much greater than had a good job been done at first.

Let us get some figures of coal which we may be sure will be nearly minimum from those over-productive regions. Mr. W. J. Nicolls† gives the following items of cost as typical in the bituminous coal fields of Pennsylvania:

	Cents.	Cents.
5 per cent interest on capital invested	5	
Cost of haulage	7	
Cost of deadwork, drifts, shafts, etc	3	
Cost of superintendence	2	
Office expenses	3	20
Contract price to miners (35 to 40 cents)	35	55
Royalty per 2,000 lbs	10	65

*Mineral Industry, 1897, p. 163, "the chief cause of the strike was that in a large part of the western bituminous fields, mine work is not regular, and the miners' wages are thereby reduced to a very low point. The existing coal mines of the United States could probably supply a demand 50 per cent greater than at present."

†Story of American coals, 1897.

The average selling price per ton of 2,240 lbs.* was 70 cents, or say 62.5 cents per 2,000 lbs., showing 2.5 cents loss on every ton raised. In other words, unless there was some profit from slack ignored by Nicolls, the royalty was too much.

According to Mineral Industry, 1897, the price of coal averaged in 1896 and 1897 respectively, 78 and 77 cents in Ohio, 66 and 67 cents in Pennsylvania. It is doubtful if there is a ten cent margin for profit and royalty and interest on capital at those figures. Orton, speaking for Ohio, says†: "Our coal will never be properly mined or properly burned so long as it costs at the mine less than $1 per ton. The question of waste demands immediate and serious consideration."

It will be noticed that the wages to miners are reckoned by the ton, and a weighman employed partially by the company and partially by the men, keeps track of the product of each miner. But there is a "fruitful source of discord"‡ in the method of weighing the coal, as to whether it should be screened so as to remove the dirt and small coal before weighing or not, and if so how coarse the mesh of the screen should be. As the screened coarse lump coal is worth a good deal more than the screenings or "slack," (see Plate VI), and the size of the coal depends largely on the care of the men in getting it out and handling it, the operators used to insist on the coal being screened and paid only for that passing over a certain sized mesh. Since, however, there has sprung up quite a demand for the smaller sizes of coal, pea coal, and buckwheat and so forth, the operators have begun to find much profit in this smaller sized coal, more if they could get it for nothing than in the larger, and to encourage its production, and many a controversy has turned on the size of the screen. In Sebewaing in the summer of 1897 there was a strike, the men demanding a $\frac{7}{8}$ inch screen, instead of $1\frac{3}{4}$ inch as theretofore. It was settled, as seems to be the general tendency, by paying for the coal by weight before screening, or as it is called, "run of the mine." At present, however, the use of the $\frac{7}{8}$ inch screen is universal in Michigan for basing wages. From a paper we gather the following statement of wages paid at Virden in connection with the notorious strike of 1898:

*There is always a juggling in figures in coal over the long ton of 2,240 lbs. and the short one of 2,000 lbs. It is a pity that the metric ton, which is practically the long ton, is not introduced to the exclusion of all others.

†Orton, Ohio, 1893, p. 269.

‡Orton, Ohio, 1886, p. 155.

CARS OF LUMP AND SLACK AT STANDARD MINE.

"Prior to the summer of 1897 the pay was 25 cents a ton, mine run. Some men had worked at 55 cents a ton, screened coal, which was about equal to 28 cents a ton, mine run, though the relative value of wages per ton, mine run, and screened coal, varies greatly in different mines, as some coal is much more fragile than others. In the strike the miners demanded 40 cents per ton, mine run."

The only remedy the operator has against workmen's carelessness in blowing the coal to pieces, in case the wages are based on the run of the mine, is to dock, fine or discharge them. On the other hand, various parts of the same mine vary so in brittleness that payments by amount of screened coal are very irregular and uncertain.

We notice from above figures that the rate of wages in the West is higher than in Pennsylvania, so that we must replace the 35 to 40 cents a ton, mine run, (?) by at least 50 cents, to find the labor cost of mining in Lower Michigan.*

Something should also be added for the extra amount of water which will have to be handled, and we shall find from 75 cents to one dollar as probably what should be the minimum cost of mining coal in Lower Michigan. I doubt if this is attained in any mine; $1.30 is nearer the mark still. The labor commissioner's report makes it $1.38 in 1900. But of course much also depends upon the thickness of the seam. In Missouri a 22-inch coal seam is mined for four cents a bushel, i. e., one dollar per ton of 2,000 pounds clean coal, while in the Osage district a 14-inch coal costs about a cent more a bushel ($1.25) in consideration of the difficulty of mining. As the entries and drift must be about the same height, no matter how thin the coal, the expense of deadwork† will also remain constant per acre, i. e., increase proportionally to the thinning of the coal when divided by the tonnage produced. It is said that a coal seam four or five feet thick can be worked as economically as one thicker, but as the seam becomes thinner the cost rapidly rises, and somewhere between one foot and two feet comes the thickness where it ceases to pay, depending on the price of coal, its freedom from sulphur, and other desirable properties. In Ohio‡ for every three inches decrease in thickness below four feet the miner was paid five cents per ton additional, down to two feet, no coal being mined except in rare cases below this thickness.

*A few years ago in Jackson and Corunna, according to Lawton's 1882 report, they were paying the miners 90 cents a ton for coal, and the cost was $1.30 a ton, not including royalty. The scale price for 1901 is 86 cents per ton for pick mining of screened coal. See Michigan Miner, April, 1901, for complete scale.

†Lifting the fire-clay, taking out weak roof, known as draw slate, etc.

‡Orton, 1884, p. 347.

From the fact that in Missouri seams 14, 20 and 22 inches thick are worked and seams averaging two feet thick are assumed to make a profit of ten cents a ton at $1.30, we may infer that there the limit of working is about a foot and a half, costing about $1.30 to mine. The average thickness of the coal seams of Newcastle, England, is, according to the Encyclopedia Americana, three feet, and of the Pennsylvania bituminous area three and thirty-three one-hundredths feet. So we see, comparing the cost in Pennsylvania given above, that taking a three foot seam as a standard, the cost of mining is somewhere about inversely proportional to the thickness of the coal. If it cost 70 cents a ton to mine a three foot seam it would cost $1.40 or thereabouts to mine a foot and a half seam and $2.10 to mine a foot seam. (At Grand Ledge they were in 1899 paying $1.10, mine run, per ton to the miners and selling the coal for $2.00. The seam is about a foot and a half thick and there did not seem to be much profit in the business. In 1901 the price of coal was from $2.30 to $2.00 and the miners, each delivering his own car to the shaft or tipple, received 30 cents per car of 500 lbs.) Now as the price of bituminous coal ranges in the Saginaw Valley between $1.40 and $2.10,* we are not surprised to find that beds 15 inches and 18 inches thick have been picked into here and there, but never put on the market in a large way. Taking the selling price to be as given above on the average $1.42½, if we assume the royalty or profit to have been 10 to 15 cents a ton, which the report of the Mineral Commissioners indicate as a prevailing figure† the cost will be $1.30, exactly what Lawton reports the cost of working at Corunna. But the probability is that the thickness of the coal mined averaged not over three feet. So it would not be safe to figure at present in Michigan on a cost of less than $1.30 a foot for two and a half to three foot seam, though *if* the roof was good and sandstone "wants" and channels and faults not too abundant, and if the water could be easily handled, the cost might be cut down by nearly one-half.

§ 7. Scarcity value of coal.

We have discussed the cost of producing coal and we have seen that the thickness of the seam makes much difference, that while

*In 1887, $1.41; in 1896, $1.44, according to Mineral Industry, 1897, p. 161; according to D. A. Patterson in 1898, $1.44; in 1897, $1.46, and in 1896, $1.62 at the mine. The report of the Commissioner of Labor for 1900 and 1901 makes the cost per ton for the entire output; in 1899, $1.31; in 1900, $1.38.

†Lawton, 1186; Knight, 1895, but in the Saginaw Valley, in spite of the better quality of coal there, 8 cents is a more prevalent figure.

a three or four foot seam may not cost more than 70 cents a ton to mine, the thinner the seam the more the price will rise until a seam about a foot and a half thick will cost as much to mine as to ship from outside. We have pointed out the evils of over-production also. We now come to the question, how much coal is there in Michigan of the various thicknesses? Is it possible to break the market with coal, or must we to do this draw on coal so thin that it will be cheaper to import from Pennsylvania and Ohio.

The coal basin of Michigan has been supposed to cover from 6,500 to 8,000 square miles.*

As I have before remarked, its extent under the northern highlands is quite uncertain. Coal is well known to occur in Arenac county. Mr. Holcroft's men found coal fragments around the headwaters of the Tittabawassee and Salt Rivers, and Mr. T. T. Bates of Traverse City reports that his woodsmen found a ledge (boulder?) containing coal as far north as Roscommon county, and the wells at Gladwin and Big Rapids indicate that the coal extends considerably to the north of them. It certainly stops considerably south of Grayling. From the map (Plate I) we may estimate the area of the whole basin, including the Parma sandstone, as 11,234 square miles, though this estimate may be 500 square miles out of the way. But by no means all of this is underlain with coal. We have to allow, as have geologists in other States, for various kinds of erosion which have cut out the coal, and not only for the loss through sandstone and drift channels, but for the coal made unworkable thereby. Orton in Ohio allowed 10 per cent. Any estimate can at the present state of affairs be but crude, but if I take a number of fairly reliable drill records from the various geological reports, those of the Saginaw Board of Trade and private sources, many put down for coal and likely to exaggerate it, but others for salt, etc., likely to neglect it, I find the following results: Out of 110 holes put down in the coal basin, 43 have not any coal reported (39 per cent.), 7 have coal seams, but probably less than a foot thick (6.3 per cent), 11 between one and two feet of coal (10 per cent), 20 between two and three feet (18.2 per cent), 12 between three and four feet (10.8 per cent), 17 over four (15.5 per cent). From this we may provisionally infer that 61 per cent of the basin

*6,500 Keyes, Iowa, 1892; 6,700, according to A. Winchell, 1861, and U. S. G. S. 18th Annual Report, part 5, p. 353; 7,000 Mineral Industry, 1892; 8,000 Rominger, Geol. Sur. Mich. III, Pt. I, p. 345; 13,350 H. D. Rogers in Harper's Monthly XXIX, 1864, p. 163, Holmes, Mines and Minerals, September, 1893, 9,810 square miles.

is underlain with coal, but only about one-third of the basin with workable coal. Some drillers of experience tell me that even this is an over-estimate and only one hole in five or six is worth anything. To the figures given I may add from more recent data, that of 234 holes put down west of Bay City 46 (19.7 per cent.), show less than a foot of coal, 30 (12.8 per cent), between one and two feet, 65 (27.8 per cent), between two and three feet, 66 (28.2 per cent), between three and four feet, 29 (11.5 per cent), over four feet. These holes will give too high an average because where one hole has struck good coal, a number have been put down near it. On the other hand, they would hardly average to go half through the coal measures, so that there is undoubtedly some coal which they do not show. This coal will average 2.86 feet (west of Bay City, 2.4 feet) thick, or for the whole basin 1.75 feet thick. But if we take into account only the coal two feet thick or over, and allow but 1,000 tons to the acre to be yielded (and though modern practice can do much better, not much better is done in Michigan), and assume the area of the coal basin to be only 6,500 miles, we still have indicated 8,025,600,000 tons, nearly half in workable seams.* The greatest uncertainty in the situation is undoubtedly along the northern rim of the basin, where there may be much more coal than can be anticipated, or much less. One thing, however, is practically certain, the depth of drift and the consequent expense of development will be much greater. I think also that preglacial erosion will prove to be greater.

Now let us see what consumption we may count upon. The population of the coal basin was, by the census of 1890, 752,695, of the State, 2,093,899, and as the population of the State doubled in the interval 1870-1890, there must be about 1,000,000 people in the coal basin now. In 1900 the population of the state proved to be only 2,420,982. The consumption of bituminous coal in the United States was in 1889, 85,383,059 tons, valued at $94,000,000; in 1890, 95,961,595 tons; in 1897, 147,557,980 tons; in 1899, 191,456,350; in 1900, 220,592,239 tons of 2,000 pounds†, while the population was in 1890 63,069,756 and in 1897 was supposed to be about 70,000,000. The census of 1900 made it 76,304,799. Thus for the United States in general two to three tons of coal were used per inhabitant, and

*Even this may be too large, yet Pennsylvania with 9,000 square miles coal area is estimated in the Encyclopedia Americana to have 33,547,000,000 tons of bituminous coal, four times as much with an area of coal measures not 50 per cent greater and with only about twice the average thickness of the coal seam.

†Eleventh Census report, and Mineral Industry for 1892 and 1897.

at this rate we could consume two to three million tons of coal in the coal basin alone. I have not been able to find what the consumption really is, but surely much less. A vast amount of coal is consumed in a few industrial centers like Pittsburg, which raises the average for the United States. The Saginaw Valley has no city of the first rank, and the use of wood, slabs, etc., for fuel is hardly out of date. But as wood ceases to be used as steam fuel, and as glass, Portland cement, sugar and other large industries come in, we may expect the consumption of coal in the future to grow much faster than does the population. We can get minimum figures by taking the annual product for 1890, 74,974 tons, and adding to it amounts shipped in* by lake that year, viz., to Bay City, 84,000 tons; to Detroit, 90,000 tons; to Port Huron, 37,200 tons, and to Grand Haven about as much, i. e., about 300,000 tons. There was probably at least as much shipped by rail and to smaller ports, which we cannot estimate, but we see that the per capita consumption of coal was still quite low, probably not much more than half a ton per head of bituminous coal, and we see also that the domestic supply is but a fraction of that. Thus if coal can be produced in Michigan so as to drive out imported Ohio and Pennsylvania coal, there is a large market, and with proper industrial development there ought to be a chance to produce twice as much coal as at present without seriously breaking the price, provided the Ohio coal is sold as close as it can be and rates on shipping it in are not lowered. They are now only half to a third that charged for Michigan coal per ton mile, so that it is probable that the adjustment will be the other way, in favor of Michigan coal. However, there will always be some importation of varieties of coal having some especially desirable quality. It must also be remembered that lake freights are so low (25 cents to Cleveland) that the great coal shipping ports of Lake Erie are but a few miles off by rail.

Ohio and Pennsylvania have immensely larger resources of coal,† so that if owing to any temporary glut of the Michigan market or strike there, our coal were to be exported thither it would be a sheer carrying of coals to Newcastle.

Thus we must look north and west of our own State (or possibly we might supply the Sudbury district in Canada) for our market.

*U. S. Navy Department 1892, "Coaling, Repairing and Docking facilities of the ports of the world," p. 8.
†Ohio, 1884, p. 155.

The above estimates of the quantity of Michigan coal allow for a waste of over a third in mining, and, if the resources of the State are husbanded and not given over to that form of development which is really squandering, greater waste can be largely avoided. The plan of a part of the Porter coal mine in Jackson (Fig. 5) shows the wastefulness of the old room or chamber system of mining and the amount of coal left in pillars, for only the part unhatched was mined out. A foot of coal over an acre would yield,* as coal varies from 1,240 to 1,340 ounces per cubic foot in specific weight, on an average 1,752 tons. But it was not so long ago common to estimate only 1,000 tons to the acre, i. e., only 56½ per cent of the theoretically possible was available.

In Missouri, Winslow† figures on obtaining 1,250 out of a theoretical 1,700, i. e., five-eighths.

In Bristol, England, 1,500 tons to the acre are expected. Orton claimed that in 1884 the best practice gained but ⅔ of the theoretical amount. Agreeing with him, Professor Sperr of the Michigan College of Mines tells me that it was the custom to leave 40 per cent of the coal underground, and when some years ago the engineer of the Columbus, Hocking Valley & Toledo R. R. read a paper before the Ohio Society of Engineers, in which he claimed that 85 per cent could be saved, it was received with jeering incredulity. But now up to 95 per cent is saved, and in his estimates in 1893 Orton‡ allows only 20 per cent for mining loss. The leases of the railroad above mentioned provided that the lessor should mine all the coal. In England a distinct improvement in the amount of coal gained has been obtained by making the leases payable per foot per acre and not per ton extracted.

But for such good and economical mining it is necessary that there should be a profit on the coal. If the price falls too low the cheapest method of mining, no matter how much the waste, must be adopted. It is for this reason that Professor Orton was led to say, as above quoted, that no coal was ever properly mined or burned in Ohio at less than $1.00 a ton.

The method of saving the coal most thoroughly is known as the long-wall system of mining, which in its application to the mining of thin seams with a weak roof is described by Winslow.§ It is probable that we cannot do quite as well in Michigan, as the shat-

*See tests of specific gravity in Table A.
†Mo., 1891, p. 49.
‡Orton, Ohio, 1893, preface p. x. estimates for Ohio 12,000,000,000 tons *above* drainage.
§Mo., 1891, App. A., p. 176.

tering of the roof in caving would in many cases let in too much water. Again the long wall system to be effectively worked, requires a rather steady production, which very few Michigan mines have as yet attained.

As we have said a good deal concerning the waste of coal and other possible evils of a possible over-production, and as some one may blame us for not suggesting any remedies in case such evils appear, we shall mention those remedies that suggest themselves as possible now, before any party feelings can be excited, for there is no immediate call for the application of any of them.

1. State ownership of the coal mines and control of the output as in Rhenish Prussia. This works very well.

2. Combination of the producers to fix output. This is generally known as a trust. No purely local combination could so check the output as to raise prices much above their present level, as the competition of imported coal is so great. Ohio coal now comes as far as Flint. This plan has been practically adopted by the chiefs of the anthracite trade and is preferable to unrestricted competition. Many of the mines near Saginaw now sell through one agent.

3. Regulation by a State supervisor, who should on the basis of the amount of coal consumed the previous year, and allowing a normal rate of increase of consumption, assign to each operating company its due proportion of the output, according to the amount of productive territory which it controlled, or number of producing shafts, making allowances for local demands or exports. This third plan has never been put in operation, so far as I know, but it would be practically a pool or trust with the pooling officer a State official. He should be a man of judicial and scientific character, and his duties would be in line with those of the Commissioners of Mineral and Labor Statistics, or the new Coal Mine Inspector, and if planned and worked, like the State Salt Inspection, with the good will of all parties, it would be a blessing all around. It would require a rare combination of abilities in the commissioner, and the chances are that he would soon find himself in hot water. Such a commissioner should try to keep the price up to a point where coal could be mined without actual loss down to $1\frac{1}{2}$ feet thick, and yet down below the price of imported coal. As the price of coal is likely to remain much less in Ohio and Pennsylvania than in Michigan and freight rates are low, he

could hardly even by mistake or corruption so limit the production as to produce extortionate rates.

We may sum the situation up as follows:

(1). Local production is at present only a fraction of local consumption (in 1896, 83,150 tons; 1897, 188,638 tons; in 1898, 290,711 tons; in 1899, 600,000 tons; for 12 months ending Dec. 1, 1900, 843,476 tons, but is very rapidly increasing. This original statement may be still true, though a good deal of our coal now crosses Lake Michigan.

(2). If the industrial development is such that the local consumption becomes equal to that of the United States per capita, a four-fold increase of production will be taken care of.

(3). But even 1,000,000 tons per annum, which will be reached in 1901, would imply but the mining out of a quarter section of four foot coal, so that over-production is quite possible.

(4). The total product of the past (1,861,444 tons, up to 1898), is not an appreciable fraction of the resources.

(5). The local product should look to the local market, north and west.*

(6). Probably a sudden four-fold increase of present production would overstock the market.

PRODUCTION OF COAL IN MICHIGAN FOR 1900, BY COUNTIES.†

County.	Production. Short ton.	Value.
Bay	190,814	$283,184
Eaton	4,530	8,770
Genesee	300	300
Huron	5,953	11,142
Jackson	23,317	43,388
Saginaw	601,112	872,486
Shiawassee	23,449	40,413
Total	849,475	$1,259,683

PRODUCTION OF COAL IN MICHIGAN, 1880-1900.*

Year.	Production Short ton.	Value.
1880	129,053	Not given
1881	130,130	" "
1882	135,339	" "
1883	71,296	" "
1884	36,712	" "
1885	45,178	$75,000
1886	60,434	90,651
1887	71,461	107,191
1888	81,407	135,221
1889	67,431	115,011
1890	74,977	149,195
1891	80,307	133,387
1892	77,990	121,314
1893	45,979	82,462
1894	70,022	103,049
1895	112,322	180,016
1896	92,882	150,631
1897	223,592	325,416
1898	315,722	462,711
1899	624,708	870,152
1900	849,475	1,259,683
	3,396,417	

*Events have verified this statement.

†From U. S. Geol. Survey, and State Labor Commissioner, whose bulletins one should see for latest statistical data. Product for year ending December 1, 1901, 1,004,104 tons.

§ 8. Value of coal royalties.

We are now within sight of the answer to our question: What is the value of the coal under the land?

If the land is in the basin and the chance is the same as for the basin in general an acre would contain 44.5 per cent of land with coal over two feet thick. This would for the whole area average 1.56 feet thick. Supposing this to cost $1.30 a ton and sell for $1.40 a ton, we could reckon on a profit of ten cents a ton, and allowing 2,500 tons to the acre to be available (1,600 tons per foot per acre) we should have $250 as the value of the coal beneath an acre.

But this cannot be taken as its cash value, for the price may fall below $1.40 and the cost may be above or below $1.30. It is better to mine a little thick coal than the same amount spread out. Finally, and most important, by no possibility can the coal be all taken out immediately and the present value of $250 to be paid in installments through a series of years is by no means the same as $250 cash in hand. So that before we discuss its present cash value we must consider a little more closely the value of coal in the shape of royalties.

We have said above that under certain doubtful suppositions the coal may be worth so much a ton. If the coal is thicker it is worth more, if thinner less. The more information we have on this point the less of speculation and more of certainty the investment becomes. The more uncertain an investment the larger must be the prospective profit to tempt one into it, and thus we cannot expect a man to pay the full speculative value of land. The more exploratory borings have been made the nearer we may expect to get the value indicated by the borings, and the higher the royalty which may fairly be demanded. These borings are part of the initial deadwork. The Michigan Miner says that one company has expended $10,000 in borings alone.* So let us turn from theoretical and hypothetical data, and see what men have been practically willing to give. We have noticed that in Pennsylvania Nicolls assumes a royalty of ten cents a ton, and we find away off in Missouri Winslow assuming the same rate as the landowner's profit†. The Commissioners of Mineral Statistics give the royalties at Jackson and Corunna‡ at 10 to 15 cents for screened coal. I am told that

*January, 1899, p. 10.
†Mo., 1891, p. 49.
‡Lawton, 1885, 1886, Knight, 1895.

at Grand Ledge 15 cents a ton is sometimes demanded. Some years ago in Ohio* they were paying 15 to 30 cents royalty on lump coal when they were paying miners 35 cents a ton (four cents more when the seam was less than four feet thick for every two inches below four feet). In Pennsylvania the Girard estate which holds some very fine anthracite coal lands, reports a royalty of 30½ cents and the Encyclopedia Americana reports as a common form of lease 25 cents a ton royalty, with 50,000 tons a year to be mined and fifteen years term of lease. Mines and Minerals quotes Pennsylvania bituminous coal lands at from $25 to $50 an acre, with royalties for non-coking coal from 5 cents to 12½ cents a ton. Mr. Ward says that 5 cents is a common rate.

As to whether the royalty is based on the ton of screened coal or not, we come upon the very same source of dissatisfaction, between the fee owner, and the operator who pays the royalty, that we found between operator and workmen. The operator has not the same reason for demanding payment to be only per screened ton and it will be found better if the royalty is upon the run of the mine. Five cents a ton, "mine run," will nearly or quite equal eight cents a ton on screened coal, though the proportions vary in different mines. It will then be more to the operator's interest to see that the coal comes out in as good condition as possible. Whereas, if there is a good demand for screenings and he gets them free of payment to the fee owner or miner, it might pay him to let the coal be smashed up, thus losing value for the fee owner, miner and community. Documents leasing the right to mine coal under a royalty† often provide that all the coal be taken (down to a reasonable thickness) and royalty be paid on the same. Otherwise there will be a temptation as the margin of profit dwindles to leave much of the coal in pillars where it cannot be extracted later, to save timbering, to the loss of the fee owner and the community. For this reason English authorities prefer‡ leasing coal by the acre, rather than by the ton, for it produces "better results for the landowner and closer working by the operator, and of course a greater yield per acre."

To see that the operator does thus mine all the coal requires a survey from time to time (usually monthly; the old work does not all have to be done over again). But the extra cost is well repaid,

*Orton, Ohio, 1884, p. 775.
†Seeman and Peters of Saginaw print a variety of forms of blank leases.
‡Encyclopedia Americana, p. 226.

and progressive States require the filing of mine maps in any case, since if more than one company has worked or is working in a district there is serious danger of fatal accidents from breaking into old water or gas filled workings.* Moreover the position of exploratory borings and artesian wells should be marked on the map for avoidance.

The question may arise as to other minerals or substances of value found in mining. For instance at one time they paid five cents a ton more for sulphide of iron in Jackson, than for coal. The fire-clay beneath the coal may also be of value. Ordinarily the presence of sulphide of iron will hurt the coal more than its independent value will amount to, and usually a certain amount of fire-clay will have to be taken in the deadwork to make entries high enough for hauling, unless the coal seam is extra thick, and the operator may well make all he can to eke out the profits of narrow seams. Other substances, such as iron ore, may at times have some value, but ordinarily the mineral rights for other substances than coal may be included with the coal.

It may be asked whether since the profits increase rapidly with the thickness up to four feet, the royalty should not also. While this is theoretically true, and in England they do thus survey the coal and lease it by the foot per acre, the extra expense of such a survey is considerable. A rough adjustment might be made according to the preliminary borings by decreasing or increasing the thickness of the coal which it was allowable to leave so that the average thickness of that taken should be two and one-half to three feet. Of course, if the coal were well known to be thick, a proportionally large royalty could be obtained.

It is, however, not uncommon to grade the royalty to be paid according to the selling price of the product, and this is eminently fair. In Appendix A is given part of a lease given in the iron business providing for a sliding scale royalty, which the Cleveland-Cliffs Company permit me to publish.

It is also the custom, as has been noticed above, to provide that the leaseholder shall mine or at least pay royalty on not less than a certain number of tons each year, so as to insure the fee-holder some steady income. It is obvious, however, that a large number of operators leasing independently of each other might be led to

*The Sebewaing district is already in this predicament, and if the Pere Marquette No. 1, which is now shut down had not been mapped, it might be awkward for the Saginaw mine.

thus guarantee an output larger than the market could possibly take, and thus bring on the evils of over-production cited above. So that it is for the best interest of all to make this amount small, or waive it altogether if the price falls too low. As it is to the interest of the operator to go ahead and get back the money invested in plant and deadwork as soon as possible, it will not ordinarily be necessary to force him ahead, while the exigencies of mining may make it more economical to mine now here and now there.

§ 9. Present worth of coal rights and royalties.

We come at last to consider what is the present worth or value of these royalties and leases for a term of years; in other words, of a body of coal which cannot be at once turned into cash. Suppose I am to get $100 in a year. What is it worth to me now? Obviously the sum of money which at the current rate of interest will yield me $100 in a year, i. e., $95.24 at five per cent; but as there is a certain advantage in having my $95.24 now, for I might prefer to spend it, or use it to save house rent, or in some other way in which it would earn more than five per cent, or at least I thought so, and as a bird in the hand is worth two in the bush, I should be likely to prefer the cash in hand unless the rate of interest were very good. Applying this to buying coal rights, we must also remember that many coal operators would be willing to go shares in profits in the shape of royalties on prospective profits, who would not have the cash to buy outright, or if they did would think they could earn a larger rate of interest upon it otherwise. Moreover, there is not nearly the risk involved in leasing on a royalty as in buying the land outright, and as men of smaller means can enter the competition for land it will often be more keen than for land to be bought outright. Thus a large discount from the value of coal as indicated by the customary royalties will usually be necessary to find its present worth.

Much also depends upon how quickly the coal can be mined. If the coal can all be mined in five years the return from royalties will be sooner and the present worth greater than if it takes the more ordinary term of a coal lease—15 to 25 years. The Star mine at Jackson was leased for a 30-year term at 15 cents royalty.

The following little table shows the present worth at five per cent of a royalty of ten cents a ton on 100 tons of coal, provided this royalty is divided into equal payments over a term of years, for various terms up to 60 years.

For other rates of interest the time over which the payments must be stretched to have a given present worth is in a rough way proportional to the rate of interest, e. g., if the rate of interest assumed were eight per cent and the payments distributed over (40÷8x5) 25 years their present worth would be about $4.29.

TABLE OF PRESENT WORTHS. FIVE PER CENT.*

Terms of years.	Present worth of $10 distributed in equal payments.
5	$8 66
10	7 72
15	6 92
20	6 22
25	5 64
30	5 13
35	4 68
40	4 29
45	3 95
50	3 65
55	3 39
60	3 16

Now let us see what prices have been offered outright for coal lands.

Mines and Minerals had this to say in August, 1900: "Bituminous coal lands such as you describe sell in Pennsylvania at the present time for $25 to $50 an acre." . . . There are a great many royalty leases in this State and the royalties on bituminous coal, non-coking, vary from 5 to 12½ cents per ton. Coking coal royalties are higher, and we know of one such royalty of 17½ cents a ton.

In Missouri where Winslow estimates profits at ten cents per ton mined and 2,500 tons to the acre, coal rights are said to be† but a few dollars, seldom over $5.00 an acre. The United States‡

*The formulæ used are, if (y) is present worth, (c) total payment equally distributed over a term of years (x), and (i) the rate of interest:

$$y = \frac{c}{ix}\left(1 - \frac{1}{(1+i)^x}\right)$$

and if (u) is present worth at rate of interest (r) for the term of years (v), and if

$$v = x\,[\log(1+i) \div \log(1+r)\,] = \text{nearly } x\,(i \div r)$$

then:

$$u = y\,[\,i \log(1+r) \div r \log(1+i)\,] = \text{nearly } y.$$

From these formulæ it follows that the present worth if the rate of interest allowed is twice as great will be very nearly the same as though the payment were distributed over twice the period, and in the same ratio for other rates of interest. The table can also be used supposing that the royalties were paid at more frequent intervals, by replacing years by number of payments, and the interest that is earned between payments. For instance the present worth of a royalty of ten cents a ton payable semi-annually in equal installments for a term of ten years on 100 tons of coal would be at five per cent semi-annually $6.22, the total payments on the royalty being $10. Finally for longer terms than sixty payments the value of the present worth is nearly the total payment divided by the rate of interest and the number of payments.

†Mo., 1891, p. 50.

‡Law of Minerals and Mining in the U. S., p. 549.

demands for public coal lands $20 an acre if within 15 miles of a railroad, $10 if not within that distance. In Michigan offers of $7.00 an acre are known to me. Now this last offer would mean at 5 per cent an equivalent to only 34 cents total royalty or 10 cents a ton royalty on 3.5 tons of coal per acre, and the production would last at this rate at 2,500 tons to the acre, 714 years. This production may seem absurdly small, and yet if we stop and think, it is far more than the pro rata share of the production or for that matter the consumption of the Lower Peninsula, for if we take the productive area of the coal basin as but 4,000 square miles, i. e., 2,550,000 acres, we see that the present production or consumption is but a fraction of a ton per acre. If, in other words, all the land of the coal basin were leased at 30 cents per acre royalty, the *lessors* would be bound to lose heavily. Thus for a tract to be worth for the coal rights $7.00 an acre the buyer must depend upon exceptional advantages as shown in borings or other explorations, and on nearness to market. As long as the consumption is at the rate of only about a tenth of a ton per acre of coal land the present value of land for coal cannot average more than 20 to 30 cents an acre. The present value of any particular tract will vary from that, according as it is favored in nearness to market and shipping facilities, and as it is likely as shown by borings, etc., to be better or worse than the average, and the general value of coal lands will rise as the consumption of coal increases.

APPENDIX A TO CHAPTER VI.

Extract from form of lease of Cleveland-Cliffs Mining Co., illustrating provisions for royalties on a sliding scale:

Royalty per ton.—*Fourth.* The second party shall promptly pay at the times hereinafter named, to the party of the first part, its successors or assigns, royalty on all iron ore, mined and removed from said premises or used thereon, during the existence of this lease, at the rate of not less than seven (7) cents per ton of 2,240 pounds, which royalty will vary with the price of the ore either market or actual as per schedule below. If the average market price of ore of like kind and quality at Cleveland, Ohio, upon dock at Lake Erie ports, for the three months preceding the month of payment, is from one dollar and fifty cents ($1.50) to one dollar and fifty-nine cents ($1.59) inclusive, then the royalty shall be eight

(8) cents per ton; if such market price is from one dollar and sixty cents ($1.60) to one dollar and sixty-nine ($1.69) per ton inclusive, such royalty shall be nine (9) cents per ton, and so on according with the schedule of royalty; but if the lessee shall have actually contracted in good faith to sell ore from said premises, then the royalty on the quantity so contracted for or sold shall be determined by the actual prices of such contracts, it being understood that each grade of ore produced shall be treated by itself, and the royalty figured thereon, and that except on ore actually sold, the royalty shall be determined by the Cleveland market price for the like kind and grades as above provided.

Price based on Cleveland delivery.—It is further understood that royalties are always to be based on Cleveland prices, whether governed by the market or by actual sale, and if the ore is to be delivered at any place other than Cleveland, the difference in freight rates, if any, shall be added to or deducted from such contract price to determine the rate of royalty.

Examining records.—The second part.. hereby agree.. that said first party shall at all reasonable times, through its officers or agents, have full and free access to the books and accounts of said second part.. in order to determine the prices at which ore mined from the leased premises has been actually and in good faith sold by the second part...

Copy of sales contract to be furnished.—Said second part.. further agree.. that each and all of.. sales contracts of said ore shall be executed in a sufficient number of original parts so that one original of every said sales contract can be furnished to the first party and that .... will immediately on entering into any such contract, furnish said first party with such original part.

Arbitration.—In case any dispute arises between the parties hereto, as to market price of ores prevailing at Cleveland, Ohio, at any time, or as to the good faith of any sale of ore made by said second part.., then, and in that event, all such disputes shall be left to the decision of three arbitrators, one to be chosen by each of the parties hereto on ten days written notice to the other party of its desire for such arbitration and before the expiration of said ten days, and in case of failure of either party to so choose within the time limited, then the other party shall have the right to select an arbitrator in lieu of the one so failed to be appointed by the other party, and any two arbitrators so chosen shall choose a

third, and an award of any two arbitrators so chosen (which award shall be rendered in writing within a reasonable time after their appointment) shall be final and binding upon the parties hereto.

SCHEDULE OF ROYALTIES.

Price.		Royalty.	Price.		Royalty.	Price.		Royalty.
From	To		From	To		From	To	
	$1.49	7c	$2.10	$2.14	16c	$2.55	$2.59	25c
$1.50	1.59	8	2.15	2.19	17	2.60	2.64	26
1.60	1.69	9	2.20	2.24	18	2.65	2.69	27
1.70	1.79	10	2.25	2.29	19	2.70	2.74	28
1.80	1.89	11	2.30	2.34	20	2.75	2.79	29
1.90	1.94	12	2.35	2.39	21	2.80	2.84	30
1.95	1.99	13	2.40	2.44	22	2.85	2.89	31
2.00	2.04	14	2.45	2.49	23	2.90	2.94	32
2.05	2.09	15	2.50	2.54	24	2.95	2.99	33

The above progression is to continue so that one cent additional royalty will be required for each additional five cents increase in price.

Seeman and Peters of Saginaw carry a number of forms of blank coal leases.

CHAPTER VII.

DEVELOPMENTS AND BORINGS.

The synoptical list of unpublished records and borings which appeared in the original report as printed in the Michigan Miner is here expanded by additions. The order of description is by counties, beginning at the north and west and proceeding south and east.

Missaukee County.—According to J. Smeltzer, wells down to 250 feet deep are all in unconsolidated deposits. No wells are known to penetrate rock and the extent of the coal measures is unknown.

Roscommon County.—Several authorities report coal found, e. g., T. T. Bates of Traverse City, and 4 to 10 inches of coal only 8 feet down, but on the other hand most wells down even to over 100 feet are in unconsolidated deposits, and there are no reliable reports as to the extent of the coal. The abundance of coal in the drift shows that it must occur in the bedrock near by to the north and east.

Ogemaw County.—Rose City wells down to 260 feet show only unconsolidated deposits.

At 60 feet depth coal one foot thick is said to have been reached by the drill on the farm of Wm. Hodges, T. 22 N., R. 3 E.

In the extreme southwest township Mr. U. R. Loranger has put down three holes, of which the deepest probably passed at 277 feet 6 inches down into the sandstone beneath the coal series. A strong flow of water, which is said to have 25 feet head, was encountered in No. 1. The abundance of sandstone may be taken to indicate that the hole is close to the margin of the coal series. Only the southwest corner of this county probably lies in the coal measures.

HOLE NO. 1. (George's Lake.)

All surface (Pleistocene) deposits.

S. W. ¼ of N. W. ¼, Sec. 18, T. 21 N., R. 1 E., Ogemaw county:

	Feet.	Feet.
Yellow clay	4	4
Blue clay	15	19
Sand and gravel	21	40
Sand	20	110
Gray clay, soapstone	60	170
Gravelly clay	6	175
Sand	39	214

HOLE NO. 2. (Edwards Lake.)

S. W. of N. E. of Sec. 28, T. 21 N., R. 1 E.:

	Feet.	Feet.
Sandy clay	48	48
Sand	112	160
Red clay	10	170
Red sand	35	205
Red sandrock	6	211
Fire-clay	6″	211′ 6″
Red sandrock	3′ 6″	215
Blue shale	1	216
Gray rock	22	238

HOLE NO. 3. (Chapman Lake.)

N. W. of S. E. of Sec. 32, T. 21 N., R. 1 E.:

	Feet.	Feet.
Stony clay	5	5
Gray clay	20	25
Gravel	5	30
Sand	65	95
Sandy clay	50	145
Sand	20	165
Gravelly clay	15	180
Red sand	10	190
White sandrock	5	195
Gray rock	3	198
White sandrock	2′ 6″	200′ 6″
Gray rock	1′ 6″	202′
White sandrock	73	275
Dark gray rock	2′ 6″	277′ 6″
Black shale	6″	278
Conglomerate rock (very hard)	4	282
Gray sandrock	3	285
Gray rock	30	315
Gray sandrock	3	285
Gray rock	30	315
White sandrock	88′ 4″	403′ 4″

Iosco County.—Black shale is reported from several of the Tawas City wells, and has given rise to the impression that coal is in the county, but the position of the Alabaster gypsum beds, and of the Arenac county limestones, shows that these cannot be the coal measures.

The coal supposed to have been found in the Oscoda salt wells is also black shale.

Lake County.—Wells are driven down to 150 feet deep in surface deposits. There are no records of rock wells.

Osceola County.—Wells even 300 feet deep do not touch rock and the extent of the coal measures is unknown.

Coal is however found quite abundantly in the drift, especially on the Middle Branch of the Muskegon in the N. E. part of the county.*

Clare County.—Near Harrison one well 102 feet deep is said to reach bedrock, but I doubt it. Most wells, even deep ones, are in unconsolidated deposits. At Clare a well 275 feet deep stops in quicksand and has failed to reach bedrock, and on Sec. 16, T. 17 N., R. 4 W., Mr. W. H. Shepherd went 270 feet mainly through gravel and sand, with specks of coal, without reaching bedrock. The probability of good coal somewhere in this county is great. It is probably very deep.

Gladwin County.—The Gladwin City water-works put down a well by Z. T. Mason, 275 feet to rock, striking a brown sandstone about 100 feet thick, which may be the same as Winchell's upper or Woodville sandstone, one of the upper sandstones above quite a series of the coal measures. On passing through it a black shale which turned the water bitter was struck, probably a coal horizon.

A large piece of drift coal was found 12 feet down, on Sec. 3, T. 19 N., R. 2 W.

Section 25, T. 17 N., R. 2 W., four miles south of Rhodes, Estey, Calkins and Sears are said to have put down a well 300 feet by the same driller, yielding a good boiler water, which rose within 12 feet of the surface, passing through strata as follows:

85	85	Clay.
90	5	Boulders.
140	50	Hardpan and red clay.
165	25	Blue shale rock.
170	5	Coal, but as this well was put down for water, not coal, this may not be closely accurate.
300	130	Shale, sandstone, etc.

Only 50 feet away was put down a hole in May, 1899, W. E. Caster, Driller.

Estey, Mich. Hole 50 feet east of tank.

Surface clay	100	100
Hardpan	5	105
Gravel	32	137
Light slate	4	141
Dark slate	1	142
Coal	1	143
Black slate	2	145
Sandrock	9	154
Blue sand shale	11	165
Light sandrock	2	167
Dark slate	15	182
Coal	1.5	183.5
Light slate	4	187.5
Sandrock	6	193.5
Light slate	7	200.5
Dark slate	9	209.5
Sand shale	9	218.5
Black slate	10	228.5

*Evart Review, Aug. 16, 1901.

This record was furnished through W. H. Teed, Esq., and is not unlike those on Sec. 10, T. 17 N., R. 3 E. of Bay county, where we have coal with black slate above it at about 140 feet, and another at 180 to 190 feet, and down to 219 feet we are still in the coal measures.

Arenac County.—In the river at Omer (See 15, T. 19 N., R. 5 E.) coal measure sandstones with signs of vegetation are exposed in the Rifle River, and there is said to be five feet of coal 86 feet down not far from Omer, but it is doubtful. On Sec. 1 of the same township and southeast therefrom Eocarboniferous limestones like those at Bayport are well developed. Up the Rifle River beds of the coal measures are exposed at intervals and have been more or less explored. The Lingula shales are shown. See Vol. III of these reports by C. Rominger, pp. 141 to 143, for account of explorations up the river to Sec. 3 of T. 19 N., R. 4 E.

Coal is said to have been found in T. 20 N., R. 6 E., near Turner, but with no roof.

In 1875 was the great Rifle River excitement. In the Saginaw Evening News for July 23, 1898, are some interesting letters regarding the matter. The statement is made that from Clyde to Pinconning, nearly every boring encountered coal from 30 inches to 8 feet thick. This is not likely.

In 1885* a shaft was put down near Sterling to a thin coal at 50 feet depth. A small seam is also said to have been struck on the farm of Mr. Firth at 125 feet depth.

At Standish Rominger describes a well:

52		52	Drift.
79		27	Sandrock.
106		27	Blue arenaceous shales with seams of iron pyrites and narrow bands of coal.
107 ft.	1 in.	1 ft.	1 in. Coal.
121	1	14	Blue shales and fire-clay.
123	1	2	Sandrock and
129	1	6	Shale, was continued down, according to Rominger passing a thicker bed of coal, to 360 feet.

There are a number of deep flowing wells, and one well put down for brine to 1,900 feet. Mr. C. Jenkins of Jackson says there is but 5½ inches of coal at 178 feet at Standish. The general thickness and character of the coal series in this part of the county appears to be like that in Bay county, but perhaps with thinner seams. A report on Arenac county is in preparation by W. M. Gregory, which we hope to make a part of Vol. IX.

*Lawton, 1885, p. 177.

Newaygo County.—According to Mr. F. Wright of Fremont, no wells have struck bedrock in this county, even though over 300 feet deep, and at Newaygo one is 335 feet deep (i. e., bedrock is less than 330 feet above tide). Coal is, however, said to be not infrequently found in the unconsolidated deposits of the drift, which indicates the near presence of coal in the Muskegon Valley. This is confirmed by the Big Rapids well. There are also reports of sandstones exposed on the northern tributaries of the Lower Muskegon, but they may be of recent formation.

Near the southeast corner of the county at Grove, a well 260 feet deep has failed to reach bedrock. It is probable that the drift is very thick all over the county.

Mecosta County.—The only well known to penetrate the bedrock in this county, and there are many 200 feet deep or more, is the Red Cross well, put down by C. S. Nims for Mr. A. L. Clark, at Big Rapids. The depth to bedrock is given as 473 (also reported 500 and 600) feet. Flows of mineral water were noted at 600, 799, 831 and 1,300 feet. The casing is now down to 900 feet, and the mineral water resembles very strongly those of Alma and Midland. It is unreliably reported that $4\frac{1}{2}$ feet of coal occurred at about 600 feet. Bottles purporting to be samples of the strata were disowned by Mr. Nims, but appear on the whole to be from coal measure rocks. The depths of the flows of mineral water and of the Marshall seem to be parallel to those at Midland.

So far as this well indicates the coal is likely to occur under both Newaygo and Mecosta counties. Some drilling up the valley of the Muskegon, toward Evart would be an interesting speculation. Some fine flows would be encountered, and probably deep drift, quite possibly also thick coal.

Isabella County.—This county is without doubt near the center of the coal basin, and the coal measure series should attain its greatest thickness. But no well has penetrated the bedrock extensively. Generally speaking, wells find plenty of water, often flowing, at a depth of 75 to 200 feet and a number of deeper wells have not struck bedrock.

At Mount Pleasant, Dr. Getchell, originally boring for water, has put down on lots 3, 4 and 6, of block 31, a number of wells with the following results:

No. 1.		
At 50 ft.		No water.
65		Water in quicksand.
To 68	3	Hardpan or rock.
73	5	Very hard rock (limestone).
79	6	**Coal.**
84	5	Hard rock.
95	9	Sand, etc.
100	5	Water gravel.

No. 2 at the back of the same lot was the same as No. 1 to 68 feet, then not as hard, then between 73 and 79 feet there was but little coal, and at 80 feet with one foot at the bottom.

No. 3, across the way, 70 to 80 feet deep, did not show any coal to speak of. The question as to whether this is really coal in place, which is suggested by the presence of sand and gravel under it, is pressed by the fact that at the water-works just west a well 355 feet was put down by L. J. Lincoln without reaching bedrock, and there is a new test well about half a mile south 205 feet deep, and a well of F. Prince a little east of north 300 feet deep, all of which are said to be in the unconsolidated deposits. So that while coal may be expected near Mount Pleasant and it is said to be found loose in Chippewa River, and is also reported to be only 30 feet down on Sec. 22, T. 14 N., R. 3 W., it seems likely that the Getchell wells are not in solid rock. Any farther exploration should certainly be to the east.

There has been some drilling for coal on the Upper Chippewa, by Pickand, on Sec. 28, T. 14 N., R. 5 W., said to be only 60 feet deep, and unimportant, and also at Weidman, by S. Weidmann. Reports as to results are unsatisfactory.

Bedrock is presumably very deep.

Midland County.—At Midland there are about seven deep wells to the Marshall, i. e., 1,300 feet deep, more or less. Those to the northwest reach the bedrock sooner than those to the southeast, but at Coleman, a well went through 72 feet hardpan and 204 feet of quicksand without reaching bedrock, while it is said that 2½ miles east one reached bedrock at 280 feet. According to Z. T. Mason, the Larkin well (reported in part in Vol. V) found 6 feet of coal, just at the very top of the rock at 200 feet depth, and P. J. Reardon's mineral well is said to be 198 feet deep and just to rock. On the other hand, the wells of H. H. Dow and the Midland Chemical Company go 285 feet to 300 feet to the rock, and the following record, which shows no coal, is an example of them:

285	285	Pleistocene.	Surface deposits.
318	33	Coal Measures.	Micaceous white sandstone, fresh water.
345	27		Black soft shale.
420	65		Sandstone, brine at 420.
455	35		Hard shale.
525	70		Sandstone.
575	50		Hard shale.
582	7		Hard sandstone.
700	118		Black shale.
745	45		Calcareous ($Fe\ CO_3$) shale.
810	65		Black shale.
		Parma.	
920	110		White sandstone.
		Grand Rapids.	
970	50		Argillaceous limestone.
1050	80		Plaster bed, fairly pure anhydrite.
1130	80		Calcareous shale.
1205	75		Limestone.
1305	100	Marshall.	White sandstone somewhat ferruginous.

The black shales in above record may correspond to coal horizons nearer the margin of the basin.

Near Smith's Crossing, however, only four miles away, a coal field is just being developed, of which the following record may give an idea. It seems probable that these coals are the same as that of the Wolverine Coal Co. in Bay county (T. 14 N., R. 3 E.), and that they belong to the Verne coals.

Smith's Crossing, Midland Twp., Section 35 (Northeast quarter), T. 14 N., R. 2 E., elevation about 620 feet A. T.

Farm of Dougald Currie.

Clay	20 ft	20 ft
Sand	10	30
Clay	16	46
Quicksand	12	58
Clay	44	102
Sandrock	18	120
White rock	0 ft 10 in	120 ft 10 in
Red rock	2	122 10
White rock	2	124 10
Red rock	8	132 10
White rock	35	167 10
Coal	1	168 10
White rock	2 ft 6 in	171 ft 4 in
Coal	3 6	174 10
White rock	10	184 10
Sandrock, partly slate rock	10	194 10
White rock	21 11	205 9

A small vein of water passed through yielded a tablespoonful to a cup of salt (16 tablespoons to a cup), i. e., 5 to 10% of salts.

If the Smith Crossing coals at 168 to 174 feet are the main coal seam of the Bay county field, the Verne coals, then it is probable that the coal at 200 feet or so around Midland corresponds to the same horizon, which is probably equally deep near the Amelith shaft, so that the rest of the strata shown in the Midland section are additions to the base of the coal measures.

Further tests are said to show that the "coal" is slaty.

At Barnes', about 7 miles west, in T. 14 N., R. 1 E., rock is said

to have been struck at 206 feet, with considerable coal above it up to 171 feet.

Near Sanford, T. 15 N., R. 1 W., was the old State salt well which is referred to in the Michigan Legislative documents, between 1840 and 1842, which was to have been 300 feet deep, but was really but 100 to 200, I understand.

In the same township were two borings by J. Russell, as follows:

On Sec. 4, T. 15 N., R. 1 W., June 3d, 1895.

Sand	16 ft	
Blue clay	21	37 ft
Quicksand	4	41
Clay, hard	25	66
Hardpan and gravel	37	103
Boulders	12	115
Clay and gravel	18	133
Boulders	10	143
Red clay	33	176
Sand and gravel	6	182
Sand and slate rock	5	187
Brown slate	4	191
Red sandrock	5	196
Sand and slate mixed	5	201
Water sandrock	47	248
Sandy fire-clay	4	252

On Sec. 27, T. 15 N., R. 1 W., April 22d, 1895.

Sand	7 ft			
Reddish clay	9		16 ft	
Blue clay	3		19	
Quicksand	2		21	
Blue clay, hard	20		41	
Sand	4		45	
Hardpan and gravel	12		57	
Very hard blue stone	—		—	
Gravelly hardpan	17		74	
Soft red clay	6		80	
Sand and gravelly hardpan	37		117	
Red clay	17		134	
Alabaster or white rock	5 ft	6 in	139 ft	6 in
Red clay	24	6	164	
Loose sandrock	1		165	
Red clay	13		178	
Red sandrock	18		196	
Soap or soft slate	5		201	
Hard slate	3		204	
Sandy fire-clay	15		219	
Dark slate	9	10	228	10
Poor coal		2	229	
Rotten black slate	1		230	
Light slate	3	6	233	6
Hard dark rock	1	6	235	
Light slate	5		240	
Water sandrock	14	1	254	1

Northeast of Midland, near Hubbard, explorations have been made for coal on Sections 24 and 25, T. 15 N., R. 2 E. The figures given me do not check exactly, but are about as follows:

Well No. 1, by J. Coreyell, for Midland business men, on McDonald farm, S. $\frac{1}{2}$ of S. W. $\frac{1}{4}$, Sec. 24, T. 15 N., R. 2 E.

Sand	5 ft	6 in			
Light clay	77		82 ft	6 in	
Blue clay	5		97	6	
Gravel	6		93	6	
Hardpan	97		190	6	
Gravel	2		192	6	
Hardpan	48		240	6	
Gravel	1		241	6	
Hardpan	8		249	6	
Black slate	4		253	6	
Slate	14		267	6	
Coal	0	11	268	5	

Well No. 2, on the Waldo farm (100 N., 800 W.), W. ½ of S. E. ¼, Sec. 25, T. 15 N., R. 2 E.:

Light clay	78 ft				
Hardpan	24		102 ft		
Sand	15		117		
Hardpan	5		122		
Blue clay	40		162		
Hardpan	7		169		
Sand and gravel	22		191		
Hardpan	4		195		
Sand and gravel	5		200		
Slate	25		225		
Coal	2 ft	8 in	227 ft	8 in	
Fire-clay and blue clay	11		238	8	

Well No. 3, on Chas. Knorr farm (300 N., 400 W.), S. E. of S. E. of Sec. 25, T. 15 N., R. 2 E.:

Clay	80 ft	80 ft
Hardpan	22	102
Gravel	1	103
Hardpan	34	137
Gravel	2	139
Blue clay	15	154
Hardpan	10	164
Sand and gravel, with water	6	170
Hardpan	4	174
Quicksand	4	178
Sand and gravel	4	182
Hardpan	2	184
Sand, gravel and boulder	4	188
Hardpan	2	186
Sandstone	2	188
Sand and gravel	10	198
Hardpan	3	201

Well No. 4, Waldo farm (500 N., 1200 W.), S. W. ½ of Sec. 25, T. 15 N., R. 2 E.:

Clay	84 ft		84 ft		
Hardpan	51		135		
Sand	25		160		
Gravel	8		168		
Blue clay	10		178		
Sand and gravel	12		190		
Hardpan	8		198		
Slate	40		238		
Coal	1 ft	6 in	239 ft	6 in	

Well No. 5, on Gerstacher farm (1000 N., 1500 W.), S. ¼ of N. W. ¼ of Sec. 25, T. 15 N., R. 2 E.:

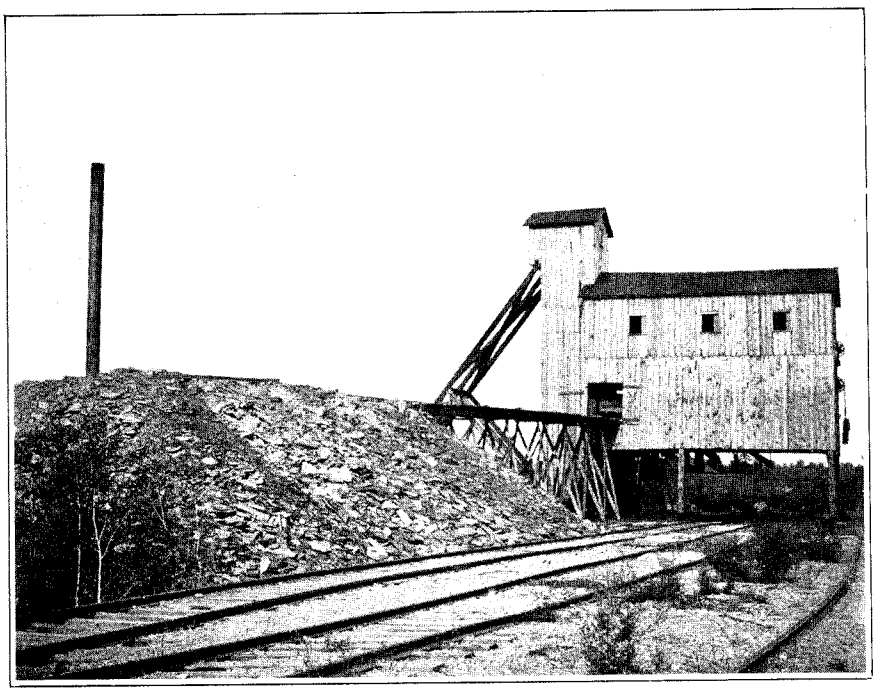
Clay	88 ft	88 ft
Sand	2	90
Hardpan	34	124
Blue clay	10	134
Sand	5	139
Hardpan	63	202
Gravel, very coarse	6	208
Sand and gravel	6	214
Hardpan	10	224
Sand and gravel	6	230
Hardpan	4	234
Slate	38	272
Coal	2 ft 3 in	274 ft 3 in

These holes were put down by J. Coreyell, for a syndicate of Midland business men, and show about 200 feet of drift. The upper 70 or 80 feet are always of solid clay, probably lake clays which were deposited beneath the waters of the former great lake system, and will be found all over the Saginaw Valley. About 200 feet of drift seems to be the prevalent thickness in this region, outside of the valleys in the bedrock. There is a bed of coal two feet or less thick, at a depth of 230 to 240 feet. It seems quite likely that this is one of the Verne coals, at the same horizon as the 140 foot coal at Monitor, Bay county, for the country is probably higher and the indications are that the strata get deeper to the north and west around here. One hole went 257 feet and was still in drift.

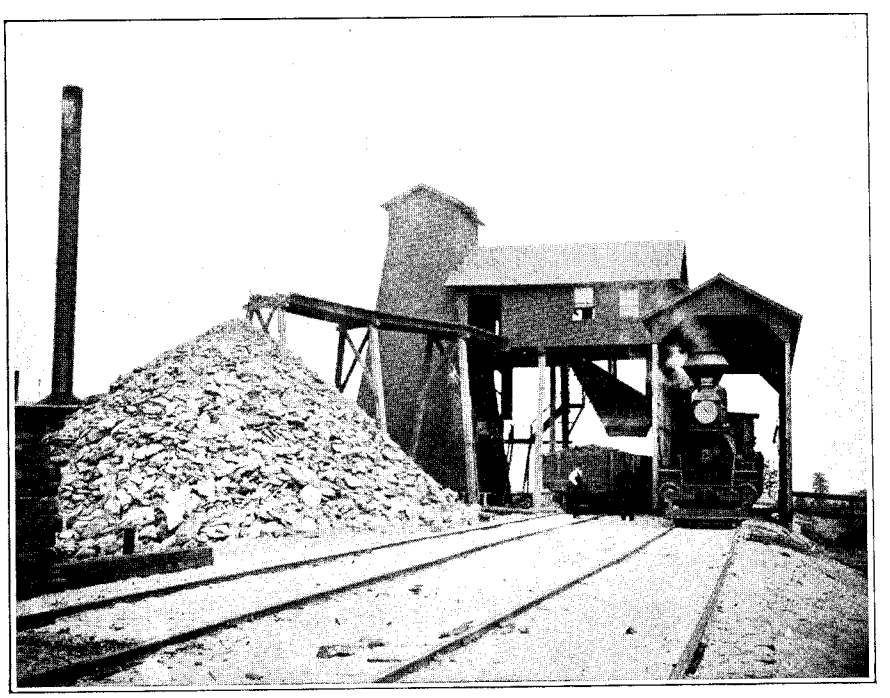
Evidently the coal seams of Bay county extend into Midland county.

Bay County.—Coal probably underlies all of this county, but there is a brown sandstone which appears at the top of the series which I suspect lies in valleys and troughs cut out of the coal. For instance, Mr. Z. T. Mason reports the following well in Garfield township, 5½ miles due west from Lengsville, Sec. 26, T. 16 N., R. 3 E.

At top muck, then to 80 feet clay, beneath it stones and gravel, level of Linwood flows, then fire-clay and hardpan, 135 feet to bedrock; thence to 300 feet mainly brown sandstone, with a really soft water rising to within 5 feet of the surface. Contrasting this with neighboring wells, it seems likely that the sandstone cuts out and replaces part of the coal series. Other wells show a varied succession of beds, with a number of coal horizons; for instance, the following wells of Mr. Mansfield, on Sec. 10, T. 17 N., R. 3 E., and old borings by Mr. Holcroft on Sections 28 and 34 of the same township, which like wells at Estey in Gladwin county show coal horizons at about 140 feet and 180 feet and give promising successions of beds for the first two hundred feet or more.



TIPPLE OF MICHIGAN COAL CO., SAINT CHARLES.



TIPPLE OF VALLEY COAL CO., BAY CITY.

There are a very large number of coal records in this county which will be used in preparation of a county report. They are too many to include here, and some are not for publication yet. This remark applies also to Saginaw county.

The general record of the Bay City salt wells is given in Vol. V, but there is considerable variation in the depth of the Marshall, due to its undulations. Wells to rock run 80 to 90 feet deep.

Land of J. Mansfield, Sec. 10, T. 17 N., R. 3 E., S. E. ¼.

No. 2 is 1 foot higher than No. 1

No. 3 is 9 feet higher than No. 1.

NO. 1.

Clay	80		80	
Sand	4		84	
Hardpan	8		92	
Black shale	2		94	
Blue shale	20		114	
Gray shale	18		132	
Black shale	2		134	
Coal		6″	134½	
Blue shale	15′	6″	150	
Gray shale	10		160	
Sandrock	5		165	
Coal		5″	165′	5″
Black shale	9′	6″	174′	11″
Coal		6″	175′	5″
Blue shale	10		185′	5″

NO. 2.

Clay	82		82	
Hardpan	9		91	
Black shale	1′	6″	92′	6″
Blue shale	15		107′	6″
Hardpan	**15′**	**6″**	**123′**	
Sandrock	8		131	
Hardpan	10		141	
Sandrock	40′	6″	181′	6″
Coal		11½″	192′	5½″
Sandrock	14		206′	5½″
Blue shale	2		208′	5½″
Sandrock		6″	208′	11½″
Coal		2″	209′	1½″
Blue shale	3		212′	1½″
Sandrock	**6**		**218′**	**1½″**
Blue shale	1		219′	1½″
Sandrock				

NO. 3.

Clay	36		36	
Gravel	1		37	
Red gravel	1		38	
Clay	52		90	
Black shale	2		92	
Hardpan	4		96	
Black shale	3		99	
Slate rock	4		103	
White shale	3		106	
Blue shale	21		127	
Black shale	2′	9″	129′	9″
Coal		8″	130′	5″
Blue shale	25′	7″	156	
Sandrock	24		180	
Coal		3″	180′	3″
Sandrock	5		185′	3″

Porter borings, Sec. 34, T. 17 N., R. 3 E., about 100 feet west of the center line and 5 feet north of the Pinconning and Glencoe logging R. R. track:

No. 1.

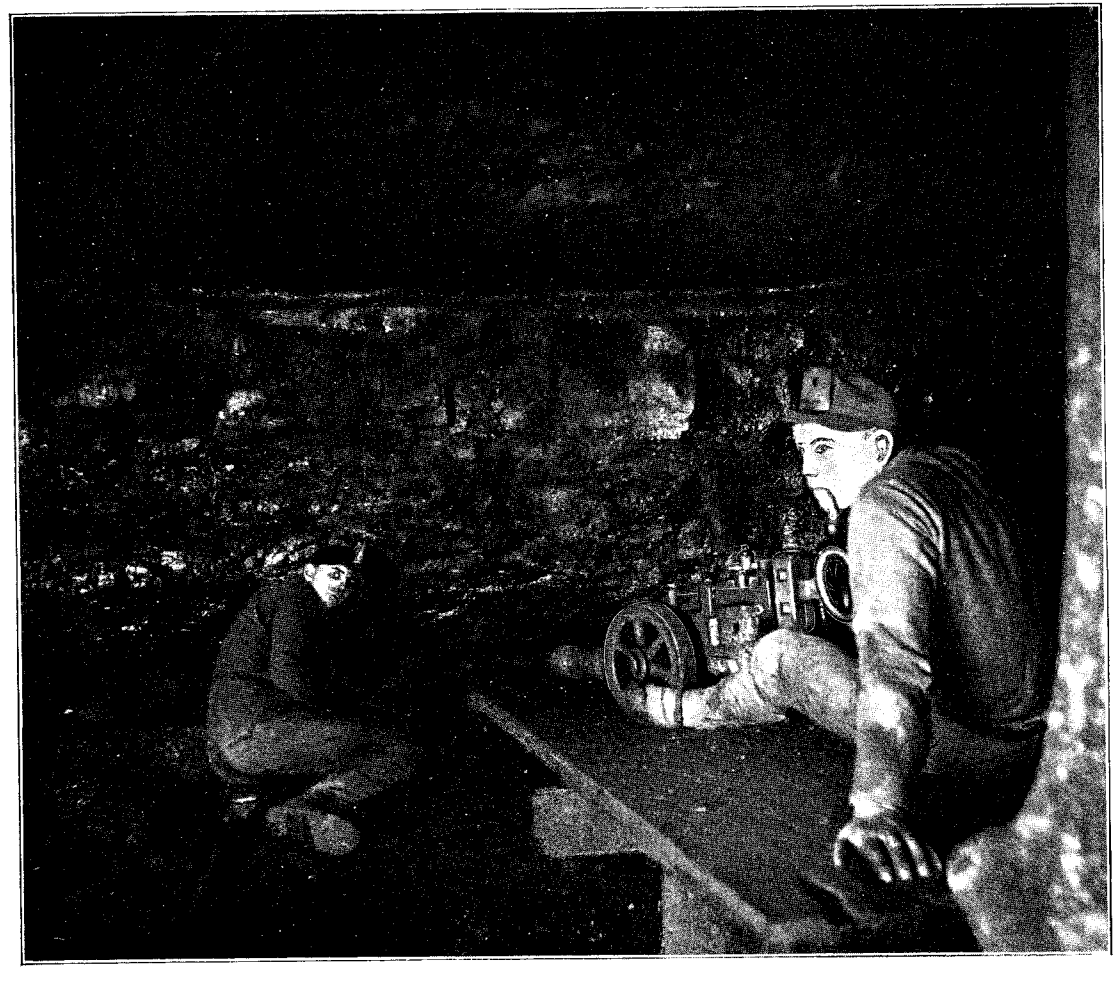
Sand	6	6
"Clay containing gravel stones, coarse gravelly clay," i. e., till, "hard to drill, dried specimens looked like arenaceous fire-clay	102	108
Hard arenaceous fire-clay, sand predominating	13	121
Argillaceous sandrock	1	122
Light blue shale	(13′ 6″?)	136′ 6″
Coal	1′ 1″	137′ 7″
Arenaceous fire-clay	8′ 11″	146′ 6″

NO. 2.

(Sec. 28 or 33, T. 17 N., R. 3 E.?) about a mile west farther up the road:

Soil	8″	8″
Sand, ochrish colored	7′ 4″	8′
Clay, stiff gray and hard when dry	42	50
Clay, occasional blue streaks	11	61
Clay, fine grained, gray and hard when dry	26	87
Clay, fine grained, pinkish when wet	1	88
Clay, light blue	6	94
Clay, brown hard	6	100
Clay, bluish, a little sandy	7	107
Sandrock, ⅛ argillaceous	6	113
Shale, a piece of coal came up at about 114 feet depth	2′ 6″	115′ 6″
Breccia, hard, sand, clay and gravel cemented, ground runs between this and next, as is supposed	4′ 11″	120′ 5″
Shale, a layer of coal embedded in this shale about 2″ thick and about 7″ from the bottom. Tubing about 6½′ from bottom	27	147′ 5″

When we come to the southern part of the county it has been pretty thoroughly bored up for the first one or two hundred feet. We have between two and three hundred records, and there are, of course, a great many which we do not have. Many, perhaps most, of the records go only so far as to develop the upper or Verne coals, which are usually between 110 feet and 150 feet down and are shown in the sections of Plate IX. These seem to be comparatively level and persistent, and easier to trace, independent of the fact that we have many more holes through them. But there are some holes which help to show the lower measures as well. For instance, the following record, by Goff Paul, 1,000 paces north, 15 paces west, in Section 3 of Bangor, Township 14 N., R 5 E.:



AIR COAL CUTTING MACHINE, WENONA MINE.

Sand	11		0	
Clay	71		82	
Hardpan (till)	3		85	
Quicksand and gravel	5		90	
Quicksand and fire gravel	70		160	
Slate	9		169	
Hard rock	**6′**	**3″**	**175′**	**3″**
Black slate	11′	7″	186′	10″
Coal D. (middle rider)	2′	1″	188′	11″
Fire-clay	27		215′	11″
Slate with streaks of hardrock, i. e., in part probably nodules of siderite	60′	4″	276′	3″
Black slate (C′)	11	0	287′	3″
Hard rock	3		290′	3″
Black slate	4		294′	3″
Coal C. (Saginaw seam)	1′	2″	295′	5″
Fire-clay	30		325′	5″
Hard rock	2		327′	5″
Slate	20		347′	5″
Black slate	7		354′	5″
Coal (Lower rider)	0′	7″	355′	
Fire-clay	18′	7″	373′	7″
Hard rock (limestone?)	4′	8″	377′	3″
Slate	22		400′	3″
Black slate	13		413′	3″
Coal (Lower coal)	1′	9″	415	
Fire-clay	27		442	
Eocarboniferous:				
Hard rock	23		465	

According to reports through Shearer Bros., the Saginaw seam, coal C of the above record, is in places thick enough to work ($4\frac{1}{2}$ feet), in this region.

The "hard rock" is probably mainly limestone, but sometimes perhaps nodules of siderite, pyrite, or indurated sandstone. I think that at 442 feet the Eocarboniferous formation is reached. According to Rominger's report the Parma sandstone is not marked at Kawkawlin, but gypsum was encountered at 400 feet. If such is the case, we may infer that the floor of the coal measures rises from the old Bay City city well (Plate VI of Vol. V) to the north, and so 442 feet of the boring just cited may correspond to 565 feet of that. I understand that it is true also in following the salt rock down the river toward Essexville that it rises. The deep wells around Munger (that by Moses Thrash, for instance) show a heavy sandstone containing a very salt brine at varying depths from 348 to 265 feet down, which I take to be the base of the coal measures, in which case we may infer that the basement on which the coal measures rests rises in that direction also.

Not far away, on Section 36, a hole bored for N. P. Bradley with the Bullock diamond core drill gave the following record,* in which the base of the coal measures seems to come in at about 367 feet,

*Which I owe to the courtesy of the owner and the Sullivan machine Co., of Chicago.

and there are unusually many coals in the lower part of the series and the Verne coals appear to be absent.

Record of hole for N. B. Bradley with Bullock diamond core drill (3 inch) near Bay City, Mich.

(Sec. 36?, T. 14 N., R. 6 E., near headwaters of Quannecussee.)

Date, 1889.	Time worked. Hours.	Formations.	Amount drilled.	Core saved.
June 7 to 13	.....	Driving casing (Boulder core)	80′	4′ 6″
June 15	10	Drilling and churning	5′ 85′	1′
June 17	10	Drilling and churning	3′ 88′	2′
June 18	10	Drilling with bit	17′ 105′	10′
June 19	10	Drilling with bit	15′ 120′	11′
June 20	10	Drilling—pipe	10′ 130′	8′
June 21	10	Dark shale	10′ 140′	8′
		Light shale	3′ 143′	2′
June 22	10	Sandstone	12′ 155′	10′
		Dark shale	3′ 158′	2′
		Sandstone	3′ 161′	2′
June 24	10	Sand and shale	12′ 173′	10′
June 25	10	Sandstone	6′ 179′	4′
		Black shale	4′ 183′	3′
		Gray slate rock	8′ 191′	7′
June 26	10	Gray slate rock	4′ 195′	3′
		Black shale	4′ 199′	3′
		Black shale and sand	9′ 208′	8′
		Drove 7′ 4″ pipe.		
June 27	10	Black shale and sandstone	7′ 215′	6′ 6″
		Sandstone	2′ 217′	2′
June 28	10	Sandstone mixed	13′ 230′	12′ 6″
June 29	10	Black shale and fire-clay	7′ 237′	6′
July 1	10	Black shale	3′ 240′	
		Fire-clay	3′ 243′	13′
		Sand and shale	5′ 248′	
		Dark shale	2′ 250′	
July 2	10	Dark shale	6′ 256′	
		Coal	1′ 257′	
		Sand white mixed	4′ 261′	
		Fire-clay	5′ 266′	16′
July 3	10	Dark shale	18′ 284′	18′
July 4	10	Dark shale	8′ 292′	
		Coal	1′ 293′	
		Dark shale	2′ 295′	
		Sandstone	8′ 9″ 303′ 9″	19′
July 5	10	Fire-clay and shale	4′ 307′ 9″	
		Coal	6″ 308′ 3″	4″
		Sand and shale	6′ 314′ 3″	11′
July 6	10	Black shale	5′ 6″ 319′ 3″	
		Black shale and clay	4′ 323′ 9″	
July 8	10	Black jack	3′ 326′ 9″	
		Coal	6″ 327′ 3″	
		Soft white clay	5′ 6″ 332′ 9″	8′
July 9	10	Black shale	10′ 342′ 9″	
July 10	10	Sand and shale mixed	3′ 345′ 9″	12′
July 11	10	Dark shale	11′ 356′ 9″	10′
		Black jack	3′ 359′ 9″	
		Coal	1′ 360′ 9″	
		White sandstone	3′ 363′ 9″	
July 13	10	Blue shale and sand	3′ 366′ 9″	2′
		TOP OF PARMA?		
		Iron pyrites	1′ 367′ 9″	
		Blue sand with grit	6′ 373′ 9″	9′
July 15	10	Sand	13′ 386′ 9″	10′
July 16	10	Sandstone pins	20′ 406′ 9″	12′
July 17	10	Same	20′ 426′ 9″	12′
July 18	10	Hard quartz	23′ 449′ 9″	16′
July 19 and 20	10	Setting bit and replacing rods.		
July 22	10	Sandstone	10′ 459′ 9″	7′
July 23 and 24	10	Sandstone	4′ 463′ 9″	3′
July 26	.....	Repairing pump.		
July 27	10	Sandstone	10′ 473′ 9″	9′
July 29	10	Lime and quartz	10′ 483′ 9″	9′
July 30	10	Same	12′ 495′ 9″	11′

The four coals of the report just given from Mr. Goff Paul on Section 3, Bangor Township, may be traced more or less continuously in Sec. 3, 4 and 10, rising to the south until the lower coal is only about 304 feet down. The lower rider (which here is the thicker seam) is only a few (six) feet above. At the center of Section 10 the base of the coal measures appears to be but 267 feet down, but in general it is near 400 feet down. These records do not show the Verne coals and their rider, and the records must be supplemented (p. 106) by those of the Handy Bros. and Wenona mine, which are less than a mile away.

In Section 19 another deep boring, not far from the Central and Michigan Mines on Sec. 25, enables us to see something of the lower formation here, to-wit:

Well of Peter Miller, W. ½ of N. E. ¼, Sec. 19.

Clay	81	81
Blue slate	29	110
Hard, sandy lime rock	7	117
Dark slate	20	137
Coal (Lower Verne)	2′ 4″	139′ 4″
Fire-clay	9	148′ 4″
Slate	**23**	**171′ 4″**
Hard rock	3′ 2″	174′ 6″
Dark slate	37′ 8″	212′ 2″
Black slate	5′ 9″	217′ 11″
Coal (Saginaw seam?)	2′ 10″	220′ 9″
Fire-clay	3′ 2″	223′ 11″
Blue slate	27	250′ 11″
Light slate	19	269′ 11″
Hard rock	3′ 7″	273′ 6″
Dark slate	21	294′ 6″
Black slate	4′ 5″	298′ 11″
Coal (Lower seam)	1′ 2″	300′ 1″
Black slate	2′ 1″	302′ 2″
Fire-clay	4′ 9″	306′ 11″
Hard sandrock	26′	332′ 11″

From this it is but little over a mile to the mines on Sec. 25 of the Central and the Michigan Mining Co. Thence southwest we can, through records furnished by the kindness of Mr. U. R. Loranger, trace the Verne coals quite continuously to the shaft of the Valley Coal Co. and the Amelith Shaft of the Pittsburg Coal Co., and thence to the Bay No. 1 and No. 2, the Monitor and Wolverine mines. The borings are, however, deep enough only to show the undulations and splits of the Verne group of coals, which sometimes split into three or four thin seams, and are usually from 110 to 190 feet down, 130 to 140 feet being common figures. (See Plate IX.)

The base of the coal series still appears to be not far from 400 feet down, say 388 to 444 feet, so that we appear to be still on the marginal shelf, Fig. 1, which borders the southeast side of the basin.

Huron County.—The coal in Huron county is practically confined to Sebewaing township. (See Fig. 9.) Streaks of coal and coal fossils are found elsewhere, as in the grindstone quarries, but there is no probability of finding coal, even though four feet of coal is said to have been found on the farm of James Chesney at 65 feet depth. The neighborhood of Sebewaing has been very thoroughly bored, and many wells have gone far beneath the coal to the Marshall sandstone to get flows. For detailed records see Vol. VII, Part II, p. 143 and following pages of the Huron county report, and also the column on p. 86 of Water Supply paper No. 31. The J. C. Likens Coal Co. has been recently organized, and is said to strike four feet of coal at 103 feet. There are but 40 to 60 feet of surface deposits immediately beneath Sebewaing, mainly lake clays, and two coal seams are found in the first 120 feet, though the lower one is not usually over 80 to 90 feet deep. The natural dip of the coal measures brings them to the rock surface a mile or two north and northeast of Sebewaing, while south and southeast they are cut out by a river channel which is filled with 150 feet or more of drift, and runs through Sections 15, 21, 20, 29, 31, T. 15 N., R. 9 E. The following record is as full and complete as any, but is only 30 feet from a well in which no coal was recorded:

J. C. Liken well, Sec. 18, Sebewaing. N. E. ¼ Sec. 18, T. 15 N., R. 9 E., May 19th, 1896.

Surface	51		51	
Pleistocene.				
Clay	1		52	
Sand and gravel	2		54	
Loose sandrock	2		56	
Coal measures.				
Hard rock	18′		74′	
Dark sandrock		6″	74′	6″
Coal about	1′	6″	76′	
Sandrock	6′		82′	
Slate	3′	8″	85′	8″
Bottom slate	1′	4″	87′	
Parma.				
Sandrock	13		100	
Grand Rapids.				
Light slate or sandy fire-clay	96		196	
Hard dark rock	24		220	
Slate	20		240	
Hard lime rock	8		248	
Napoleon, i. e. Upper Marshall.				
Sandrock	55		303	

Montcalm County.—The coal measures probably underlie the whole of this county, but we have absolutely no definite information concerning them. Coal has been reported, but under conditions that render it probable that it was in the surface deposits, in T. 10 N., R. 8 W., and at Amble, T. 12 N., R. 9 W., on the farm of

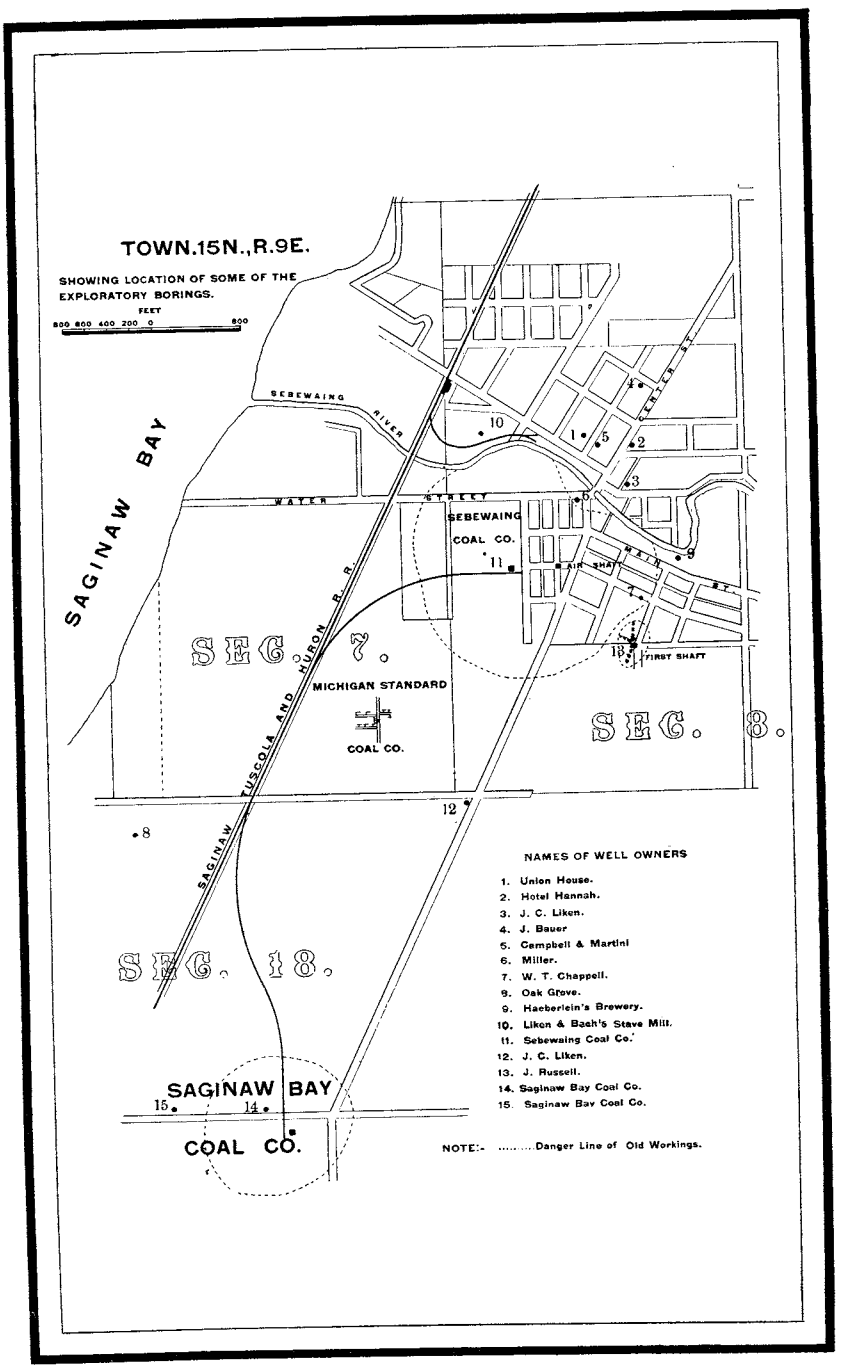


Fig. 9. Sketch map of Sebewaing coal region, Town. 15 N., R. 9 E., showing location of some of the exploratory borings.

N. Olsen, for the well was put down 360 feet by C. A. Denton, the driller, without reaching bedrock. Another well on Sec. 11, T. 11 N., R. 10 W., three-quarters of a mile S. E. of Maple Hill, 320 feet deep did not reach bedrock.

Gratiot County.—The drift seems to lie deep but irregularly over the northern part, as though heavily cut up by river valleys. For instance, it is but 335 feet to rock at the Harrington House, St. Louis, while at Alma it is 500 feet. The record of the old St. Louis magnetic well, which only went through drift, is given by Winchell in detail (Am. Ass. for the Adv. of Sci., 1875, B. p. 31). The new Harrington House well has three casings and can yield three waters, the first an 8-inch, stopping at 100 feet in a nest of boulders; the second 6-inch, stopping at the level of the magnetic mineral water well at 255 feet in a nest of boulders with lots of water. Then there is a 4-inch pipe to 335 feet, the bedrock, which is red sandstone. Thence it is mainly white sandstone down to 599 feet, when they entered a white shale and stopped. The old St. Louis salt well, 1,314 feet deep, put down by Hardenburgh and Sager, was almost the same—surface deposits 337 feet, then 200 feet mainly sandstone.

Some thin coal has been found around Ashley at about 170 feet to 190 feet and deeper, but the bedrock surface here to is very irregular, from 50 feet dropping to over 200 feet in a mile or two north.

The Ithaca well has been given in p. 63, Vol. V. Several additional similar wells have been put down since.

On the farm of M. White at North Star coal is reported at 205 feet, and at 296 feet two miles east of Ithaca, on Wm. Dusch's farm, but bedrock was struck only a short distance above, at 292 feet.

The Alma well (Sec. 34, T. 14 N., R. 3 W., about 755 A. T.) is represented by a fairly full set of samples and an abstract of the record, summarized from that preserved by Prof. C. A. Davis, is as follows:

ALMA WELL.

Pleistocene.		
Clay and gravel with quicksand and water at 60 feet and 3 feet gravel at 157 feet	475′	475′
Sand and gravel	25′	500′
Woodville?		
Feldspathic sandstone (335-590 at St. Louis)	50′	550′
Coal measures.		
Pyritiferous black shale, coal horizon	25′	575′
Blue shale	40′	615′
White shale	22′	637′
Pebbly sandstone	38′	675′
Shale sometimes black, coal reported	35′	710′
Parma.		
Pyritic sandstone	80′	790′
Grand Rapids.		
Blue and black sandy shales	70′	860′
Blue and white gypsum	35′	895′
Bituminous, dolomitic red or blue or argillaceous limestones (cement rock or hydraulic)	120′	1015′
U. Marshall or Napoleon.		
Clean white sandstone	85′	1100′
L. Marshall.		
Red sandy shale	200′	1300′
Blue shale	20′	1320′
Red shales	200′	1500′
Coldwater.		
Blue shales	75′	1575′
Fine grained grit, no water	200′	1500′
Dark shales	70′	1675′
Blue shales, somewhat sandy down to 2,000 ft	595′	2250′
Berea Shale.		
Black shale	25′	2300′
Devonian.		
Blue shales	60′	2360′
Ohio Shale.		
Black shale	260′	2620′
Black shale with harder streaks	130′	2750′
Traverse.		
Dolomitic limestone	30′	2780′
Blue shale	20′	2800′
Sandy limestone, dolomitic	61′	2861′

Saginaw County.—So much boring has been done here that we can give but a few sample records. The deepest well of which samples are preserved is one put down February 10, 1862, by the Ann Arbor and Saginaw R. R. Co., at (Salina) South Saginaw, probably on the east side of Saginaw River, a little south of the center of Sec. 35, T. 12 N., R. 4 E., somewhere near where the F. & P. M. Belt Line bridge is. Corresponding horizons are about 50 feet deeper than at the old first well, as recorded by Dr. Lathrop. It is noteworthy that in neither of these wells does the gypsum bed which we find at Bay City, Midland and Alma occur, and the interval from Parma to Marshall is less. We may give the record of the Salina well briefly as follows:

*See also Water Supply Paper of the U. S. Geol. Sur., No. 31, Fig. 2.

Pleistocene.		
Surface deposits	90′	90′
Yellow limestone	30′	120′
Blue calcareous shale	115′	235′
Marly limestone	70′	305′
Bituminous black shales (coal horizon)	13′	318′
Green shale	22′	340′
Parma?		
White sandstone	145′	485′
Black shale	8′	493′
Unconformity?		
Grand Rapids.		
Arenaceous limestone	32′	525′
Impure sandstone	20′	545′
Calcareous green shale	25′	570′
Green shale	95′	665′
Argillaceous dolomite	25′	690′
U. Marshall or Napoleon.		
Leaves off in clean sandstone	25′	715′

We have also a detailed diagram of a salt well drilled by F. H. Mason, Bay City, for Gov. A. T. Bliss, Saginaw, at Carrollton Mill, drawn by A. C. McKinnon, Bay City.

5	5	Sand.
95	90	Blue clay.
120	25	Hardpan.
		6 in. pipe to here.
150	30	Limerock.
190	40	Sandy shale.
290	100	Sandrock.
300	10	Black shale.
375	75	Blue shale. Unconformity?
400	25	Sandy lime. Upper salt rock or Parma? Somewhere here there was a cavity where the drill dropped.
430	30	Sandrock.
480	50	Sandy shale.
540	60	Blue shale.
570	30	Sandy lime.
590	20	Blue shale.
592	2	Sandrock, 5¼ inch hole to here, where they probably shut off the gypsum.
625	33	Blue shale.
650	25	Limerock, very hard.
750	100	Sandrock, known as salt rock, that brine flows through; 4 in. hole to bottom. Napoleon sandrock.

There appears to be a dip of some 40 feet in the Eocarboniferous strata from Carrollton to South Saginaw, but the salt wells are deeper at Zilwaukee and deeper yet at Bay City. Thus we must have passed over an upward flexure in the Eocarboniferous, the top of which probably crosses the river on Sec. 24, T. 12 N., R. 4 E., near the Wylie Bros. wells.

The wells of the Brewer Lumber Co. and those at Mershon are but little over 700 feet deep, and the saline at the Germain factory, near the west ¼ post of Sec. 29, T. 12 N., R. 5 E., on ground nearly 20 feet higher, is said to be but 750 feet deep.

Below 398 feet in the First or Potter well, or 375 feet in the Bliss well, and 525 feet in the South Saginaw well, we are clearly in the Grand Rapids,—Eocarboniferous.

On the other hand, passing to the southeast, we find the South Saginaw wells deeper, 820 feet, and at Garfield and at St. Charles,

as we have previously stated (p. 38) the Napoleon sandstone and the base of the coal measures are somewhat lower than at Saginaw. There is probably, therefore, something of an extra rise at Saginaw, of the Eocarboniferous strata, beside a general pitch to the northwest. To the southeast, toward Bridgeport, the Napoleon seems to rise but slowly, while the coal measures, judging from the wells of Hon. Henry M. Youmans, are at least 200 feet thick.

At Blackmar the Napoleon appears to be between 360 and 450 feet down, but there is no indication of the Michigan series above, or at any rate no line was drawn between it and the coal measures. Moreover, Mr. Higgins' explorations found on Herpel's farm, about four miles away, near the center of Section 7, T. 10 N., R. 5 E., at least 200 feet of coal measures, as follows:

Test hole No. 6.	64 ft.	6 in.	64 ft.	6 in.
Surface				
Sandrock, which replaces a coal at 67 feet	28	6	93	
		6	93	6
Black slate	26	6	120	
Gray shale	23		143	
Sandrock	1		144	
Gray shale		6	144	6
Coal	1		145	6
Fire-clay	8		153	6
Light gray shale	5	6	159	
Dark gray shale	15		174	
Sandrock	11		185	
Gray shale		2	185	2
Coal	6		191	2
White shale	7		198	2
Black shale	4		202	2
White rock (hard, probably limestone)	5		207	2
Sandrock				

Also Mr. With's well in Tuscola county (which see), on the same general strike line, shows at least 279 feet of coal measures. Apparently, therefore, the Michigan series has really dropped out and the unconformity at the base of the coal series to which we have called attention is well marked. We cannot, therefore, use the stratigraphy of the Eocarboniferous "salt rocks" as a guide to our coal correlations, and since some of the lower coals may be more irregularly laid down upon this eroded surface than the upper, as indeed they are said to be in Indiana, Iowa and similar States, it will be well to begin our correlations at the top.

The coals which occur near the surface around Munger, as may be seen from the table and correlation with the deep holes south of the Wenona and Handy Bros. Mines (Plate IX), appear to correspond to the Verne coals.

Section near Munger Station, 594 A. T.:

O. W. Blodgett's general section.		Blodgett's deepest, back of store.			Moses Thrash.		
Quicksand	16' to 18'	Surface	89'	89'	Clay	73'	
Clay, blue or red solid	70' to 90'	Sandrock	2'	137'	Conglomerate	28'	101'
Gravel	6' to 8'	Shale	2' 6"	139' 6"	Slate	32'	133'
Hardpan	2'	Slate	1' 6"	141'	Sandstone and slate	22'	155'
Bedrock at about	98'	Black slate	1' 1"	142' 1"	Whitish yellow shale	22'	177'
2 miles east of Munger 3½ feet of coal with no roof.							
Coal indications at (F)	142'	Coal F	1' 9"	143' 10"	"Graphite" i.e. soft black shale	10'	187'
Sandy fire-clay	10'	Fire-clay		158' 8"	Coal and slate D	9'	196'
Coal at (E)	155'	Coal E	1' 5"	160' 1"	Hard conglomerate	37'	233'
Sandrock 6" to 1' coal at	175'	Fire-clay, light, no grit		161'	Coal and black slate C	15'	248'
Fire-clay (D)		Salty sandrock	58'	219'	Sandrock	3'	251'
Dark sandrock with salt water, at about	180'	Bl'k sandy shale	31'	250'	Whitish slate	54'	305'
for	40' to 50'	Dark sandrock	10'	260'	Blue slate	25'	330'
Shale	8' to 10'	Sandy shale	5'	265'	Coal B	2'	332'
Very salt sandrock.		Sandrock, very salt	32'	297'	Conglomerate	10'	342'
					Coal A	6'	348'
					Sandstone	60'	408'

Now, Mr. Blodgett has traced them more or less intermittently down nearly to the county line, where at 115 feet and 151 feet there appear to be coal horizons, as well as lower down at 177 feet to 184 feet, just above a well-marked sandstone. We pick them up in Saginaw county in the well of Wm. Mayberry, on the S. W. ¼ of the N. E. ¼ of Sec. 3:

White clay	20	20
Blue clay	80	100
Soft rock	14	114
Hard rock	1	115
Coal (fresh water)	2' 6"	117' 6"
Rock	23	140' 6"
Coal	3	143' 6"
Hard rock with a brackish water	10	153' 6"

It is reported that there is coal in another well on the place at 200 feet depth, and extensive persistent and water-bearing sandstone for over 200 feet.

An imperfect record or two help to bridge the gap of two miles to the basin of coal which has been proved up around Arthur. From the records, for which we have to thank J. W. Messner, we select three:

NO. 3.

Red clay	18	18
Blue clay	54	72
Hardpan	6	78
Blue rock	5	83
Slate	1	84
Coal (Verne)	3' 3"	87' 3"
Fire-clay	1' 1"	88' 4"

This coal occurs as thick as 42 inches, is usually from 90 feet to

100 feet down, and sometimes there are two, as in the following hole.

NO. 4.

Red clay	18	18
Blue clay	56	74
Hardpan	8	82
Blue rock	9	91
Slate	0′ 6″	91′ 6″
Coal (Upper Verne) F	0′ 10″	92′ 4″
Fire-clay	3′	95′ 4″
Blue rock	3′	98′ 4″
Slate	1′	99′ 4″
Coal (Lower Verne) E	2′ 6″	101′ 10″
Fire-clay	3′ 8″	105′ 6″
Blue rock	19	124′ 6″
Sandrock	11	135′ 6″
Blue rock	6	141′ 6″
Slate rock	0′ 6″	142
Coal (Middle rider?) D	1′ 4″	143′ 4″
Blue rock	8′ 4″	151′ 8″
White rock	9′ 6″	161′ 2″
Blue rock	7′ 6″	168′ 8″
Slate rock	1	169′ 8″
Coal (Saginaw seam) C	1′ 6″	171′ 2″

NO. 5.

Red clay	15	15
Blue clay	56	71
Hardpan	9	80
Blue rock	6	86
Sandrock	3	89
Slate	3	92
Coal (Verne) F	1′ 8″	93′ 8″
Fire-clay	2	95′ 8″
Sandrock	24	119′ 8″
Blue rock	20	139′ 8″
Slate	3	142′ 8″
Blue rock	7	149′ 8″
Sandrock	18	167′ 8″
Blue rock	8	175′ 8″
Slate	3	178′ 8″
Coal (Saginaw?) C	1′ 9″	180′ 5″
Fire-clay	4′ 6″	184′ 11″
Sandrock	12	196′ 11″
Blue rock	2	198′ 11″
Slate	2	200′ 11″
Fire-clay	2	202′ 11″

The following is a test well (No. 6) on the Oliver farm, Sec. 15, at Arthur, by J. Russell:

Red clay	16′	
Blue clay, firm	35′	51′
Blue clay, very soft	23′	74′
Hardpan	30′	104′
Loose sandrock	15′	119′
Black slate	2′ 6″	121′ 6″
Coal	2′ 2″	123′ 9″
Sandy fire-clay	1′ 9″	125′ 5″
	125 ft. 5 in.	

It is plain that the Blumfield correlations are rather artificial, especially that of the Middle Rider. It is possible that the thickest seam rolls between 100 feet and 140 feet depth and is continuous. From some points of view it is more likely that D of the record just cited is the Lower Verne and the coals above the Upper Verne and Upper Rider respectively.

The development of the mine of the Barnard Coal Co. will prob-

ably settle the question. This mine is on the N. E. ¼ of the N. W. ¼ of Sec. 18, T. 12 N., R. 6 E., and the coal is about 140 feet deep. No tests of this coal, known as the Uncle Henry,* are yet known to me, however.

The following record of a hole put down by J. Russell for J. B. Peter on an adjacent forty-acre lot, the S. W. ¼ of the N. W. ¼, Sec. 18, T. 12 N., R. 6 E., shows the section down to the coal:

September 22, 1894.

Red clay	12′	12′
Blue clay	60′	72′
Hardpan and boulders	4′	76′
Hard sandrock	3′ 6″	79′ 6″
Sandy fire-clay	6′	85′ 6″
Black shale	3′ 3″	88′ 9″
Coal	1′ 6″	90′ 3″
Soft light slate	1′	91′ 3″
Soft dark slate	10′ 11″	102′ 2″
Harder dark slate	4′	106′ 2″
Coal	1′ 5″	107′ 7″
Light slate	5′ 5″	113′
Hard black slate	10′ 7″	123′ 7″
Coal, good	2′ 2″	125′ 9″
Coal, poor	1′ 11″	127′ 8″
Bottom slate	2′ 6″	130′ 2″

If the three coals here shown are correlated with D, E, and F of Arthur and Munger, then the Barnard or "Uncle Henry" coal is the Middle Rider. In some ways it would be more natural to consider it the more persistent Lower Verne. But the quality is said to be better than in that seam.

Working west toward Saginaw, there are indications and records of coal horizons at no great depth all along, but the first boring of considerable depth and accurate record that we have is that of W. T. Chappell, on the farm of D. A. McDonald, on the S. W. ¼ of the N. W. ¼ of Sec. 16, T. 12 N., R. 5 E., as follows:

Clay	81′	81′
Hardpan	6′	87′
Sand and gravel	4′	91′
Sandrock	21′ 6″	112′ 6″
Gray shale	4′	116′ 6″
Sandrock	61′ 6″	178′
Slate	6″	178′ 6″
Coal (Saginaw seam)	4″	187′ 10″
Fire-clay	0′ 8″	179′ 6″
Sandrock	2′	181′ 6″
Dark clay shale	46′	227′ 6″
Light clay shale	6″	228′
Gray shale	44′ 6″	273′ 6″
Sandrock	18′	291′ 6″
Coal and rock (lowest coal)	8′	299′ 6″
Fire-clay	1′	300′ 6″
Sandrock	1′ 6″	302′

According to Mr. Henriett, the driller, a well which he put down 539 feet on the N. E. ¼ of Sec. 14, near by (T. 12 N., R. 5 E.), struck

*There is a Barnard Coal Co., *limited*, in West Saginaw.

somewhere between 313 feet and 340 feet a rock with a 32° salt brine, which must almost certainly be the bottom of the series (292′-398′ of the first well). Consequently, we may infer that the McDonald well is pretty nearly through the coal series, and the lowest coal struck is the lowest of the series.

Not very far away there is a well nearly equally deep. The record (the Gage farm on Sec. 9, T. 12 N., R. 5 E.) is interesting, for it shows no heavy top sandstone nor coal, as follows:

	Feet.	Feet.
Clay	86	86
Hardpan	2	88
Sand and gravel	2	90
Soft shale	12	102
Gray shale	69	171
Sandstone	2	173
Gray shale	10	183
Black shale	2	185
Gray shale	8	193
Black shale	15	208
Brown shale	13	221
Gray shale	17	238
Sandstone	18	256
Gray shale	2	258
Blue shale	10	268
Gray shale	12	280
Hard rock	1	281
Soft shale	11	292

At McDonald's we find mainly sandstone down to 178 feet. This sandstone probably appears also on Sec. 21, two miles south in Heavenrich's borings (from about 90 feet to 150 feet), where it is nearly clean enough for a glass sand. I think we are safe in assuming it continues to the Schaitberger and Eastman farms on Sec. 29, Wiggins' place on Sec. 33, and the Kochner farm on Sec. 3, T. 14 N., R. 5 E., though there it is split up with thin seams of coal.

It appears also to be the first rock met in the old salt well and in almost all the wells in the northeast part of Saginaw, e. g., that of the Bearinger Block, and the numerous city wells, which find abundant water in the first 150 feet or less, so that I think we can trace it without break in continuity to the upper part of Eddy's well, near the river, 700 feet south of Genesee Ave. bridge, through a city well at the corner of Michigan Ave. and Davenport, which is in a heavy sandstone, and another at the corner of Michigan Ave. and Clark St. (coarse sandstone from bedrock at 91 feet to the bottom at 141 feet).

The lower vein of coal was found in all three holes, but variously split up. When we consider that the salt wells near by are less than 750 feet deep, we may be reasonably sure that this well is

nearly through the coal-bearing series, and that the coal at 282 feet is not that of the Chappell-Fordney mine.

The Eddy well record is as follows:

NO. 1.

Surface sand	28′	28′
Clay	54′	82′
Hardpan	48′	130′
White sandrock	41′	171′
Dark sandrock	12′	183′
Black shale (Saginaw seam)	8′	191′
Sandrock	1′	192′
Hard slate	4′	196′
Limerock	2′ 6″	198′ 6″
Slate and sandrock	4′ 6″	203′
Coal (Lower rider)	0′ 5″	203′ 5″
Fire-clay	7′	210′ 5″
Dark blue shale	64′ 5″	274′ 10″
Dark slate	4′ 6″	279′ 4″
Coal (Lower coal)	3′ 3″	282′ 7″
Shale and sand	6′	288′ 7″

Thus the correlation suggested with the first salt well seems proper.

Eddy's well brings us within two miles of the important coal basin of West Saginaw, in which the Pere Marquette No. 2, Chappell-Fordney and Riverside mines are located. If we go any further southwest, however, the upper sandstone is absolutely gone from the records with no trace. It apparently does not thin out to a feather edge, as if it rose above the coal basin. Especially on the east side are holes which show the sharp line. Neither does it dip down beneath the coal basin, at least there is no thick sandstone in the first two hundred feet or more. The fact that the salt wells deepen to the south makes it unlikely that the sandstone has, either by a fault or fold, passed above the line of the bedrock surface. The only alternative seems to be that it drops suddenly out, being a bar behind which the upper coals of the East Saginaw coal basin were formed, as shown in Plate IX.

As soon as we leave this capping sandstone the bedrock surface seems to dip to the west and the amount of drift becomes greater.

The Barnard,* Chappell-Fordney, Pere Marquette No. 2, Riverside, and Imperial mines are in the Saginaw seam. The three first are in the city limits of West Saginaw, the Riverside is opposite on the south bank of the Tittabawassee, while the Imperial is on Sec. 7 of James Tp.

*This is the Barnard Coal Co., limited, which has a shaft on the west side of Saginaw river. The tipple of the Pere Marquette shaft was transported there bodily. Besides there is the Barnard Coal Co. operating about 6 miles east. Their coal is known as "Uncle Henry" coal.

A typical section in West Saginaw is the following:

	Feet.	Feet.
Clay	94	94
Hardpan	8	102

(The surface deposits are often over 150 and sometimes over 180 feet thick. The maximum depth within two miles of Saginaw is probably not less than 250 feet. In such cases of course the upper beds are cleaned out.)

Slate	18′	120′
Coal (Verne)	0′ 3″	120′ 3″
Fire-clay	2′	122′ 3″
Gray shale	7′	129′ 3″
Slate	4′	133′ 3″
Fire-clay	6′	139′ 3″
Slate	5′	144′ 3″
Fire-clay	10′	154′ 3″
Sandy shale	4′	158′ 3″
Fire-clay	2′	160′ 3″
Slate	8′ 5″	168′ 8″
Coal (Saginaw seam)	2′ 7″	171′ 3″

(This is the one mined. It is more usually near 200′ deep where thick enough to work.)

Fire-clay	24′	195′ 3″
Sandy shale	6′	201′ 3″
Slate	11′	212′
Sandy shale	2′	214′
Slate	7′	221′
Sandy shale	8′	224′
Slate	14′	243′
Fire-clay	1′	224′

There are usually one or two coals, in the first 140 feet, of the type of the Verne coals, and when the Saginaw seam is extra deep—190 to 200 feet, there is apt to be some coal at about 160 feet. Two coals are said to be traceable in a general way, though with varying thickness, across James township and past Garfield to St. Charles, and there are enough holes to be pretty sure of their connection, with occasional barren areas, all over Sections 21, 22, 27, 28, 33, and 34. A Section E—W to Paines Station is shown in Plate IX.

The Saginaw seam appears to be the lowest coal seam shown in the boring of the Saginaw Board of Trade (S. G. Higgins' report) the record of which runs as follows, and was put down near the Palmerton Woodenware factory near the south end of the city, near the corner of Holmes and Brant streets (1,000 paces N., 200 W., Sec. 34, T. 12 N., R. 4 E.):

Test hole No. 10.

Lake Clays—		
Clay	70′	70′
Hardpan	2′	72′
Glacial Deposits—		
Sand and gravel	7′	79′
Hardpan	12′	91′
Sand and gravel	3′	94′
Hardpan	9′	103′
Sand and gravel	3′	106′

Test hole No. 10.—*Continued.*

Coal Measures—				
Blue shale	4′		110′	
Gray shale	1′	6″	111′	6″
Black slate		6″	112′	
Coal (Verne)	1′		113′	
Gray shale	3′		116′	
Sand and gravel	1′		117′	
Gray shale	23′		140′	
Coal (Middle rider)		6″	140′	6″
Fire-clay	5′		145′	6″
Light gray shale	4′		149′	6″
Sandrock	5′		154′	6″
Light gray shale	26′	6″	181′	
Coal (Saginaw seam)		4″	181′	4″
Fire-clay	4′		185′	4″
Sandrock	2′		187′	4″
Gray shale	20′		207′	4″
Sandrock	13′		220′	4″
Dark gray shale	5′		225′	4″
Light gray shale	33′	4″	258′	8″

This is but little over half a mile from the Chappell-Fordney mine. It is very curious that the samples of the South Saginaw well should show so little coal when they are between the well just recorded and the Saginaw coal mine shaft (See Plate V), the record of the exploratory boring of which ran as follows:

Clay	54′		54′	
Sand and gravel, which turned out in the shaft to be a diagonal streak of a few inches	3′		57′	
Clay	37′		94′	
Sand	4′		98′	
Hardpan to bedrock	5′		103′	
Slate	1′		104′	
Coal		1″	104′	1″
Gray shale	18′		122′	1″
Slate	6′	6″	128′	7″
Coal		4″	129′	11″
Hard sandy clay	1′		129′	11″
Gray shale	5′		134′	11″
Strong black slate	12′	2″	147′	1″
Coal, this is the coal mined	3′	3″	150′	4″
Fire-clay	18′		168′	4″
Sandrock	34′		202′	4″
This sandstone may replace the lower coal.				
Sandy shale	3′		205′	4″
Slate	16′		221′	4″

This is a little south and about 1,700 feet east of the north quarter post of Sec. 31, T. 12 N., R. 5 E.

Though considerably higher I take the coal mined on the east side to be the same seam as that on the west side. The coal seams on the east side appear much nearer together and the main seam rises rapidly to the Pere Marquette No. 1 shaft near the center of Section 32, where it is but 135 feet down. Within one-half mile to the east it rises 22 feet more and comes too near the surface to

be profitably workable, being in points on J. Stimson's farm covered by only four feet of soft roof.

Here we have the curious phenomenon of coal seams running up and abutting against a sandstone while a mile or two north their supposed equivalents appear to lie under it. This sandstone we may imagine to have been a northward travelling sand dune or bank—for this implies that the conditions of sandstone formation were gradually transferred from the former place to the latter, if we suppose the coal strictly contemporaneous. On the S. W. of Section 21, a mile and more south, are a number of holes drilled by M. and C. Heavenrich. Beneath the usual amount of drift, 95 to 102 feet, comes first a white sandrock, almost suited for glass sand, apparently the same as that first met in the McDonald wells on Section 14. This continues to 150 feet or more. Then in the next 30 feet are two or three quite persistent coal seams. Less than a mile away at Mrs. G. Schaitberger's place in the W. $\frac{1}{2}$ of the S. W. $\frac{1}{4}$ of Section 29 we find the drift slightly deeper (115 feet), and the sandstone still present down to 145 feet. The Eastman farm, on the S. E. $\frac{1}{4}$ of Sec. 29 also shows the same sandstone from 103 to 156 feet, but with a foot of shale at 148 feet.

But the well of the O'Donnel Spencer Co., near the crossing of Genesee Ave. and the Pere Marquette R. R. (S. E. $\frac{1}{4}$ of Sec. 30) less than a mile away is entirely different, to-wit (A. M. McMillan, driller):

	Feet.	Feet.
Clay	72	72
Hardpan	43	115
Black shale	4	119
Coal	1	120
Soapstone	2½	122½
Coal	2½	125
Soapstone	45	170
Hard sandstone	3	173
Water bearing sandstone	6½	179½

This is the well that started the coal fields of Saginaw.

Again the well on J. Stimson's place in the N. E. $\frac{1}{4}$ of Sec. 32, not much west of the Pere Marquette R. R., begins in shale and soon strikes the coal mined in the Pere Marquette No. 1 shaft.

When the Eocarboniferous ceased to be a land surface, at the old salt well, sandstone was first formed there, apparently. The conditions of sandstone building seem to have moved to Carrollton and then back to the first salt well, where they were at the time of the Saginaw seam.

Returning to the Palmerton Woodenware factory on Sec. 34, we follow the Saginaw seam down on the Fitzhugh farm (Sec. 3 and Sec. 4, T. 11 N., R. 4 E.), where the Riverside mine is located, and the seam reaches 41 and 42 inches at about 182 feet, and there is also a seam at 158 to 163 feet. We cross, however, a deep gravel filled channel (or "washout") which at the Merrill bridge is over 150 feet to rock. It is a branch of the main channel, which is 250 feet or more deep between Shattuckville and Paines. One minor channel runs east towards the Standard mine, another runs south on Section 10. Another channel runs N. E. from Section 7, where the Imperial Coal Co. have a shaft about 180 feet deep in a basin of coal. Thence it is about two miles to the following well on Sec. 24, T. 11 N., R. 3 W.:

Surface	44′		44′	
Hardpan	20′		64′	
Gray slate	7′		71′	
Sandrock	8′		79′	
Gray shale	5′		84′	
Gray slate	13′		97′	
Coal (Upper Verne)	1′	8″	98′	8″
Fire-clay	2′		100′	8″
Gray slate	4′	4″	105′	
Sandrock	17′		122′	
Coal (Lower Verne)		6″	122′	6″
Fire-clay	6′		128′	6″
Black slate	6′	6″	135′	
Fire-clay	3′		138′	
Sandrock	1′	6″	139′	6″
Fire-clay	3′	6″	143′	
Gray shale	1′		144′	
Blue slate		6″	144′	6″
Gray slate	10′		154′	6″
Sandrock	12′		166′	6″
Gray slate	3′	6″	170′	
Black slate (Middle rider?)		6″	170′	6″
Gray slate	10′	6″	181′	
Black slate	4′		185′	
Coal (Saginaw seam)	1′	2″	186′	2″
Fire-clay	2′		188′	2″
Sandrock	9′		197′	2″

These three coal horizons can be followed in a series of borings on Prairie Farm to the south through Sec. 25, and 26, though frequently one or the other drops out. There is, as at St. Charles, at times "cannel coal" on top of the Saginaw seam. Coal also appears at 160 to 180 feet depth, a little above the Saginaw seam—the Middle Rider. The nearest record to the Verne mine on Sec. 23, which shows the coals in fair shape is the following on Sec. 16. (See Plate IX, section C.)

Clay	27′		27′	
Hardpan	3′		30′	
Sand	2′		32′	
Hard clay	14′		46′	
Gray slate	20′		66′	
Slate	10′		76′	
Sandy shale	10′		86′	
Sandrock	37′	6″	123′	6″
Coal (Lower Verne)		6″	124′	
Fire-clay	7′		131′	
Gray shale	9′		140′	
Sandrock	21′		161′	
Slate	9′		170′	
Coal		2″	170′	2″
Sandrock	15′		185′	2″
Gray shale	4′		189′	2″
Slate	15′	6″	204′	8″
Coal (Saginaw seam perhaps)		8″	205′	4″
Fire-clay	5′		210′	4″
Gray shale	6′		216′	4″
Slate	6′		222′	4″
Poor coal	1′		223′	4″
Slate	3′		226′	4″
Fire-clay	2′		228′	4″
Sandrock	2′		230′	4″

This brings us but two miles from the Verne mine, the section of which has been given.

About the same distance away we strike the explorations around Foster's. On Section 12 of Albee, there are the Verne coals probably at 86′ 9″ (1′ 3″) and 103′ 9″ (6″) and another, probably the Middle Rider, at 156′ 6″ (1 foot).

On the farm of Mr. Herpel (Sec. 7, T. 10 N., R. 4 E.), Mr. Higgins gives the following records:

Surface	64′	6″	64′	6″
Sandrock	28′	6″	93′	
Black slate (Lower Verne)		6″	93′	6″
A mile north there was 2 in. at 67′ 8″and 3″ at 93′ 5″				
Gray shale	26′	6″	120′	
Sandrock	23′		143′	
Gray shale	1′		144′	
Coal		6″	144′	6″
(At 145′ a mile north there was two inches of coal).				
Fire-clay	1′		145′	6″
Light gray shale	8′		153′	6″
Dark gray shale	5′	6″	159′	
Sandrock	15′		174′	
Gray shale	11′		185′	
Coal (Saginaw seam)		2″	185′	2″
White shale	6′		191′	2″
Black slate	7′		198′	2″
Hard white rock	4′		202′	2″
Sandrock	5′		207′	2″

Returning to the Prairie farm records and working southwest on Sec. 12, we have the following record:

Clay	47′		47′	
Sand and gravel	9′		56′	
Gray shale	52′		108′	
Sandrock	35′		143′	
Gray shale	6′		149′	
Sandrock	51′		200′	
Fire-clay	3′		203′	
Slate	10′		213′	
Coal		3″	213′	3″
Fire-clay	4′		217′	3″
Slate	16′		233′	3″
Coal		4″	233′	7″
Fire-clay	2′		235′	7″
Gray sandrock	1′		236′	7″

This is a hole of interest, not showing the Verne coals, but showing a heavy sandstone which is quite widespread around St. Charles, and is close above the Saginaw seam in the mine of the St. Charles Coal Co.

This sandstone is not persistent, for on the N. half of the S. W. ¼ of Sec. 15 we have borings of the Robert Gage Coal Co. The following is extra deep:

Clay	25′		25′	
Hardpan	16′		41′	
Slate	58′		99′	
Coal (Upper Verne?)		8″	99′	8″
Other holes in the same 80 acres show a few inches of coal at 97′ 3″ and 106′ 10″ and 114′ 6″.				
Fire-clay	12′		111′	8″
Sandy shale	40′		151′	8″
Light shale	15′	7″	167′	3″
Coal (Saginaw seam?)	**2′**	**9″**	**170′**	
Other holes show 9″ of coal at 153′ 3″ and 2′ 5″ at 157′ 7″.				
Other holes show 3′ 10″ at 168′ 10″ and 3′ 3″ at 166′ 5″, etc., north at the Robert Gage shaft it is down to 180′ again.				
Fire-clay	15′		185′	
Slate	20′		205′	
Fire-clay	7′		212′	
Sandrock	15′		227′	

On the southwest ¼ of the northwest ¼ of Sec. 16, the sandstone we were speaking of reappears, however, as shown in this boring:

	Feet.	Feet.
Clay	22	22
Hardpan and gravel	18	40
Sand	4	44
Hardpan	8	52
Light slate	63	115
Sandrock, with streaks of slate	**72**	187
Dark slate	4	191
Sandrock	7	198
Slate	3	201
Coal (Saginaw seam)	4	205
Sandy fire-clay	9	214

This is close to J. H. Somers No. 2 shaft and a little over half a mile from that of the St. Charles Coal Co.

In this mine the sandstone was generally parted from the coal by a few inches of black slate, but to the north of the shaft the coal rises 22′ in 150′ and runs right into the sandstone. There are little streaks of coal and pebbles of Fe CO_3 in the sandstone which varies from 30′ to 100′ thick. Such rolls account for the depth of the seam varying from 166′ to 200′ and a little more.

Similar pebbles of Fe CO_3 are found in a sandstone at Williamston and elsewhere.

None of the above records show the Lower Verne well developed, but in the Robert Gage shaft near the west ¼ post of Section 15, T. 10 N., R. 3 E., there were three small coal seams above

the main Saginaw seam, and in the shaft of the Michigan mine near the north ¼ post of Sec. 8 (Black Pearl, Plate VII), where the main seam is about 190 feet down, there were 20″ to 30″ of coal at 128′, which were mined at first but spoiled the quality of the coal, for it contained much more sulphur than the lower coal. The same seam occurs in the J. H. Somers No. 1 shaft on Sec. 3. It is said to be more pockety and irregular. The following test holes by the Higgins committee show this in the record. No. 11 is about 10 rods west and No. 13 is about 30 rods north of No. 12.

No. 11.			No. 12.			No. 13.		
Sand	8′	8′	10′		10′			
Clay	13′	21′	20′		30′			
Gravel	1′	22′	1′	sand	31′			
Clay	25′	47′	17′		48′			
Gravel and sand	1′	48′	1′	sand	49′	50′		50′
Blue shale	37′	85′	46′	clay and shale.	95′	4′		54′
Hardpan and gravel	2′	87′	10′	gray rock	105′	6′	black shale.	60′
Light gray shale	13′	100′						
Sandrock	12′	112′	25′		130′	8′	white shale.	68′
Coal	2″							
Upper Verne?								
Gray shale	2′	114′ 2″	6′		136′	35′		103′
			2″	slate	136′ 2″			
Coal	2″	114′ 6″	2′ 3″		138′ 5″	2″		103′ 2′
Lower Verne?								
Fire-clay & sandrock	22′	146′ 4″	5′		143′ 5″	6′		109′ 2″
Gray shale	2′ 6″	148′ 10″	11′		154′ 5″	30′		139′ 2″
Black slate	3′	151′ 10″	1′		155′ 5″	4′		143′ 2″
Place of Middle Rider?						8″	coal	143′ 10″
Gray shale	4′	155′ 10″	26′		181′ 5″	36′		179′ 10″
Dark gray shale	3′	158′ 10″						
Light gray shale	14′	172′ 10″						
Brown slate	7′	179′ 10″	6′		187′ 5″	2″		180′
Black slate	6″	180′ 4″						
Coal (Saginaw seam)	2′	182′ 4″	2′		189′ 5″	6″		180′ 6′
Salt	1′	183′ 4″						
Fire-clay	1′	184′ 4″	6″		189′ 11″	2′ 6″		183′

It is said that southwest of No. 12 the upper coal is 18 inches thick; that 40 rods east it is about 2 feet thick, and that 30 rods east of south there is 2′ 6″ at 123′ 2″.

Before leaving St. Charles it is well to call attention again to the fact that the seam now worked is not the lowest of the coal measures. Unfortunately I have no accurate record of the beds below exposed in the salt wells recently put down, but I am authoritatively informed that from 500′ down there was a good deal of the limerock of the Eocarboniferous (as at Garfield), and at about 425′ the last coal seam was struck, a few inches thick, while the Napoleon is from 700′ to 810′.

Thus the lower seams are present as they are around Bay City, though as yet we know very little about their thickness.

The Saginaw seam can be followed north from St. Charles and west from the Prairie farm explorations already mentioned, varying in thickness but at about the same level or deeper. The upper coals also persist, as is shown by the following record of a hole close to the old salt well at Garfield, A. W. Johnson, driller.

Surface sand	2′	2′
Blue clay	15′	17′
Hardpan	42′	59′
Sandrock	8′	67′
Sandy shale	63′	130′
Coal (Upper Verne)	1′ 6″	131′ 6″
Fire-clay	2′	133′ 6″
Slate	5′	138′ 6″
Coal (Lower Verne)	**4″**	**138′ 10″**
Sandy fire-clay	12′	150′ 10″
Sandrock	2′	152′ 10″
Water bubbled up and the casing was magnetic so that calipers clung to it.		
Slate	45′	197′ 10″
Sandrock	14′	211′ 10″

This possibly may not have gone quite far enough to strike the Saginaw coal, which appears in a hole a mile east on the S. W. ¼ of Sec. 15, T. 11 N., R. 3 E., whose record runs:

Blue clay	40′	40′
Hardpan	20′	60′
Very hard rock	8″	60′ 8″
Soft sandrock	1′ 6″	62′ 2″
Gravel	2′	64′ 2″
Bedrock here—		
Sandy shale	70′	134′ 2″
Verne coals absent—		
Light slate	30′	164′ 2″
Dark slate	20′	184′ 2″
Coal	2′ 8″	186′ 10″

These two holes are quite comparable with the hole on Sec. 24, T. 11 N., R. 3 E., whose record we have cited just above.

If we go much farther north the bedrock surface begins to drop off into the deep channel which runs west from Saginaw. For instance at Paines we have the following record:

	Feet.	Feet.
Surface to bedrock	208	208
Coal, perhaps the Saginaw seam	2	210
Soft sandstone	32	242
Soft sandstone	20	262
Dark shale	28	290
Sandstone	32	322
Black shale	30	352
(Probably the horizon of the lower coal.)		
Fire-clay	2′ 6″	354′ 6″

Four miles north it usually runs from 225′ to 240′ to bedrock. In the west part of the county the bedrock surface is deep.

For this reason the northwest part of the county has been comparatively little explored. The following, however, is the well put down by J. H. Whitney on the N. ½ of the S. W. ¼ of Sec. 24, T. 12 N., R. 1 E. No. 1 was put down on the S. W. ¼ of the S. W. ¼ of Sec. 26.

Clay	8′		8′	
Sand		6″	8′	6″
Clay	26′	6″	35′	
Sand	20′		55′	
Clay	16′		71′	
Sand	5′		76′	
Soft clay	54′		130′	
Sand	7′		137′	
Soft clay	25′		162′	
Clay	2′		164′	
Dry sand and gravel	16′		180′	
Clay	15′		195′	
Sand	2′		197′	
Sandrock	8′		205′	
Gray soft shale	1′		206′	
Sandrock	3′		209′	
Sandy shale	2′	6″	211′	6″
Sandrock	3′	6″	215′	
Gray shale	5′		220′	
Sandrock	4′		224′	
Coal (possibly the Saginaw seam)	1′	9″	225′	9″
Sandrock	4′	3″	230′	
Sandy white shale	9′		239′	
Sandrock	20′		260′	
Sandy shale	30′		290′	
Sandrock	30′		320′	
White sandy shale	20′		340′	
White sandrock	7′		347′	
Dark gray shale	6′		353′	
Dark sandrock	5′		358′	
Dark shale	5′		363′	
Sandrock	1′		364′	
Gray shale	3′		367′	
White sandrock	2′	6″	399′	6″

Thus in passing west though we know that the Eocarboniferous strata are dipping that way, we can find no more trace of a general dip of the coal-bearing series than we did in Bay county. The general level of the country is rising.

In the southeast part of the county the distance to bedrock is not usually great, some 60 to 100 feet, and sandstone with plenty of water is soon obtained. Some coal is found, but apparently not enough to attract investment.

Tuscola County.—A detailed report upon this county is in preparation by C. A. Davis, to which reference must be made for more detailed information. There is quite a little coal around Unionville at 118 to 130 feet.

On the other side of the valley, which cuts out the coal southeast of Sebewaing, we find the coal reappearing and extending through Columbia and even into Elmwood. This is shown, for instance, by the well of T. McCarty on the southeast quarter of Sec. 24, T. 14 N., R. 9 E., in which under about 84 feet of blue clay and 14 feet of sandstone, 3 feet of coal was said to have been met. I saw some of the coal. There was water in the sandstone.

The coal beds seem to be mainly confined to the part of the county northwest of the Cass, though there may be isolated patches to the south in T. 10 N., R. 7 and 8 E., especially since two foot seams of coal are reported from Vassar at 82 feet and 126 feet.

The recent well at Caro, 15 feet above Cass River, struck under 113 feet of surface deposits, a limestone which appears to be Eocarboniferous, and very much like the Bayport limestone, though there are two feet of black shale at 240 feet, the record being (A. J. Scott, driller):

Drift	113 ft	113 ft
Limestone, compact, pyritiferous	7	120
Green shale	25	145
White sandstone, with water	40	185
Dolomitic limestone	5	190
White sandstone	50	240
Black shale	2	242
Calcareous sandstone	10	252
Black shale	1	253
Sandstone, greenish white, kaolitic, with coaly specks and calcareous layers	29	282

The flow is strong and the water very slightly brackish.

The thickness increases probably quite fast to the northwest. The following record, by J. Russell on Sec. 4, T. 13 N., R. 9 E., is a rather full one and the base of the coal-bearing series appears to be at 170′ 3″:

Red clay	11′	11′
Blue clay	49′	60′
Hardpan	15′	75′
Soap rock	14′ 6″	89′ 6″
Hard streak	6″	90′
Water here.		
Slate rock	27′	117′
More water.		
Black slate rock	11′	128′
Light slate rock	2′	130′
Dark sandrock	5′ 6″	135′ 6″
Hard black slate	6″	136′
Sandrock	4′	140′
Black and white rock mixed	1′	141′
Fire-clay or white rock	3′	144′
Black and white rock mixed	1′	145′
Sandrock	9″	145′ 9″
Coal	1′ 8″	147′ 5″
Dark slate rock	1′	148′ 5″
Light slate rock	1′	149′ 5″
Fire-clay or white rock	1′ 2″	150′ 7″
Light slate rock	1′ 1″	152′ 8″
Dark slate rock	6′ 7″	159′ 3″
Light slate rock	11′	170′ 3″
Eocarboniferous.		
Lime rock	20′	190′ 3″
Sandrock	18′	208′ 3″

The base varies a good deal with the depth. When the Eocarboniferous limestones do not come until a considerable depth, heavy sandstone sometimes occurs, with some coal above or below it.

This is illustrated in the following records:

	Sec. 18, T. 14 N., R. 9 E.		Sec. 18, T. 14 N., R. 9 E.	
Clay	67′	67′	68′	68′
Hardpan	10′	77′	7′	75′
Sandrock	25′	102′	99′ 4″	174′ 4″
Slate	13′	115′		
Coal				
Sandrock	55′	170′		
Coal			3′ 1″	177′ 5″
Hard gray sandrock	18′	188′		
Slate rock	5′	193′	6′	183′ 5″
Light slate	6′ 7″	199′ 7″	Sandrock 4′	187′ 5″
			Lime 4′	191′ 5″

Compare also the following record No. 8 of Mr. Higgins' series of tests:

Surface	47′		47′
Blue shale	7′		54′
Light gray shale	2′		56′
Dark gray shale (Verne coal horizon?)	21′		77′
Sandrock	112′		199′
Gray shale with layers of coal (Saginaw seam)	3′		202′
Soft fire-clay		6″	
Hard fire-clay	3′		206′
Red sandstone with layers fire-clay	18′		224′

A large amount of records in Tuscola county have been preserved, more than can be printed here.

This is a fair illustration of the tests around Tuscola, which Mr. Zagelmeyer says run up to 80 feet of drift, then 160 feet of white sandrock, then 6 to 22 inches of coal under the sandrock. This sandrock probably outcrops in the river, and coal also occurs above it; which is probably one of the Verne coals.

It is not far, however, to F. With's well, near the S. W. corner of Sec. 30, T. 12 N., R. 7 E., where this thick sandstone has begun to break up, though water comes in freely at 150 to 200 feet. The record is:

Clay	56′		56′	
Hardpan	28′		84′	
Sandy shale	32′	4″	116′	4″
Blue shale	12′	4″	128′	8″
Black shale	1′	4″	130′	
Gray shale	24′		154′	
Black shale	1′		155′	
Hard sandy shale, water along here	11′		166′	
Gray shale	6′		172′	
Very hard sandy shale	18′		190′	
Sand not so hard	12′	8″	202′	8″
Gray shale	1′	4″	204′	
Hard sandrock	8′		212′	
Black shale (Horizon of Saginaw seam?)		10″	212′	10″
Sandrock	2′	2″	215′	
Black shale	2′	4″	217′	4″
Fire-clay	2′	8″	220′	
Hard sandrock	6′		226′	
Black slate	1′		227′	
Fire-clay	2′		229′	
Blue shale	3′		232′	
Coal (Lower Rider or Saginaw)		8″	232′	8″
Fire-clay	2′	1″	234′	9″
Blue shale	3′	3″	238′	
Hardrock	1′		239′	
Blue shale	9′		248′	
Black slate (Lower Rider)	2′		250′	
Fire-clay	4′		254′	
Blue shale (Lower coal)	21′		275′	
Black slate	3′		278′	
Fire-clay	1′		279′	
Sandrock	1′		280′	

The heavy sandstone we have referred to, it is easy to mistake for the basal sandstone or Parma sandstone, which indeed it may merge into near the margin of the basin, and I have referred it to the Parma sometimes. But more numerous records show that the

sandstone zigzags through the formation as we have seen around Saginaw.

Coal has been found down to Elva and there may be some other pockets beyond. Near Millington on the old Blanchard farm 3 feet 7 inches of coal is reported at 190 feet. Around Unionville, near which there appears to be a dislocation and to the northwest of the Cass River, most wells show at least small seams of coal at various depths, but the records, while very numerous, are hardly near enough yet to connect the different coals with any precision, especially if there are faults.

Records in the southeast part of the county in Kingston show clearly that no coal is to be expected there.

Sanilac County.—This county has been reported by Dr. C. H. Gordon, Vol. VII, Part III.

The rocks appear to be entirely Eocarboniferous, and while fossil plants akin to those of the coal measures may be found, and indeed coaly streaks, there is little possibility of anything approaching a workable deposit of coal, and explorations for it are not worth while.

Kent County.—No coal has ever been struck in place in this county, so far as I know, but considering that we have at Grand Rapids beds almost identical with those at Bay Port, it would be natural to expect coal corresponding to the Sebewaing coal in the northeast part of the county heavily buried under drift, unless, as is probable, the bedrock surface dips to the northeast from Grand Rapids, somewhat following the dip of the limestone, for in a well at Saranac there is 227 feet of drift, and the bedrock surface is but 417 feet A. T. The coal series is very likely confined to the east bank of the valley thus made.

Ionia County.—The deep valley indicated by bedrock at 417 A. T. at Saranac probably runs nearly N. and S. into Barry county. Then the bedrock surface rises upon an escarpment of coal measure sandstones until it outcrops near Ionia and Grand Ledge.

On Sec. 26, Ionia township, T. 7 N., R. 6 E., Mr. Jas. Horrocks has put down two deep wells. Of the one put down in April, 1900, he gives the following record:

Surface and sandstone (Woodville?)	75′			75′	
Blue slate	20′			95′	
Black slate	5′			100′	
Coal	2′	2″		102′	2″
Fire-clay		6″		102′	8″
Fine grit stone	8′			110′	8″
Blue slate	20′			130′	8″
Small seams, slate, coal, fire-clay, etc	43′	8″		174′	4″
Coal	0′	8″		175′	
Small seams, slate, coal, fire-clay, etc. (Casing 200′ 1″).	71′			246′	
White sandrock, the Parma	87′			343′	

Sandstone with a strong flow of water.
Another well on the same section is 540 feet deep.

A well for Henry Pierce in South Ionia is said to have gone through (the record is obviously very imperfect):

Iron ore (water)	3′	6″	at	60′	
Coal, slaty	1′	2″	at	150′	
Hard coal (? black slate or limestone)	10′			160′	
Soft coal	1′	2″		161′	2″
Fire-clay	7′			168′	

Combining these with a well for M. W. Yeomans, Rominger's notes, and report of an old well by L. J. Lincoln, by his assistant, from memory, we get the following general idea of the strata:

Surface drift, up to 140 feet.

Sandstone, quarried, variegated red and white, probably Winchell's Woodville, replacing more or less normal coal series, up to 143 feet.

Shales and fire-clay with two or more seams of coal often over a foot thick, from 40 up to 175 feet.

Heavy white sandstones with artesian flows more than 100 feet thick, the Parma, down at 250 to 400 feet depth.

Red sandstone and very salt water at 700 to 800 feet (Marshall?).

Coal is reported a number of times near Ionia at about 200 feet depth.

Wells at Hubbardston 240 and 275 feet deep show that the surface deposits are nearly that thick, the bedrock being sandstone.

Clinton County.—A well in Lebanon township (8 N., R. 4 W.) shows 294 feet of drift here, with coal measure rocks beneath.

The most complete record is that of the St. Johns water-works well given by L. J. Lincoln below, in which down to 608 feet neither coal nor black shale was mentioned. I suspect that part of the sandrock ? of this well may be really limestone or dolomite. Another well put down in 1901 has a quite different record. Some figures from it are given on the extreme right.

St. Johns water-works well, T. 7 N., R. 2 W. Record No. 2:

	Feet.	Feet.	New well.
Blue clay	19	19	
Pipe clay	12	31	
Clay and hardpan	61	92	
Stony and hardpan	19	111	
Granite boulder	2½	113	
Soft clay	10	123	
Gravel and hardpan	13	136	
Hardpan	5	141	152
Base of Drift or Pleistocene—			
Red sandrock	5	146	172
Sandrock	20	166	
Gray sandrock	17	183	
Yellow sandrock	17	200	
To shale rock	14	214	
Shale rock	3	217	
Slate rock	26	243	
Blue sandrock	21	264	
Yellow sandrock	23	287	
Yellow hard and lighter	51	338	
Sandrock	6	344	
Hard blue sandrock	44	388	
Water rock	23	411	
Blue sand, harder	45	456	
Slate	12	468	375
Top of Parma sandstone—			
White sand	10	478	
Water rock sand	17	495	
Blue packed sand	22	517	
White water rock	10	527	525
Blue sand	13	540	
Perhaps beginning of Eocarboniferous limestone series, Upper Grand Rapids.			
Hard strata	10′ 4″	541′ 4″	
Blue sand to white	18′	559′ 4″	
	3′	562′ 4″	
Hard blue sandrock	27′	589′ 4″	
Blue shale and sandrock (Very hard.)	19′	608′ 4″	

The Kniffin well,* however, whose record is given in connection with analysis of the coal, is only three miles or so away, and shows two seams of coal, which appear to have been eroded away at St. Johns. These coals are very likely the Verne coals, and may connect with the coals worked at Grand Ledge and Corunna. In this case it is not at all impossible that the series of sandstones below, may, as at Ionia, split and make room for lower coals.

On the Brown farm near the southeast corner of Sec. 26, T. 5 N., R. 4 W., a coal shaft 52 feet deep, sunk about 1891, was a failure, largely owing to the water encountered, the section being:

Surface (till?)	12′	12′
Very porous sandrock	10′	22′
White sandrock and fire-clay	23′	45′
Slate	7′	52′
Coal	18″ to	27″
Fire-clay		54′

Eastward the drift is thicker, on Sec. 24, T. 5 N., R. 1 W., 110 feet to rock.

The Pratt mine of the Grand Ledge district (which see) is just over the line in this county and is the only mine working in the county.

*Pages 105 and 115.

A good coal seam is said to have been found at 330 feet depth at Elsie, and the depth is not unlikely, for it is clear that going northeast the thickness of the coal-bearing series thickens from about 250 feet to 500 or more. The St. Johns well may be entirely in the coal series, and certainly does not get down in the Michigan or Lower Grand Rapids group of gypsum, limestone, shales and salt water.

At Maple Rapids, about 640 feet A. T., much lower than St. Johns, we have the following record:

Hardpan	25		25	
Blue clay	3		28	
Stones	8		36	
Blue clay	28		64	
Hardpan	5		69	
Sand with water	1		70	
Blue clay	6		76	
Sand	1		77	
Brown clay	7		84	
Gravel	2		86	
Red sand (water)	82		168	
Gray rock	14		182	
Red sandstone (hematite)	2		184	
Dark shale	31		215	
Red shale	3		218	
Soapstone	29		244	
Light shale	17		261	
Coal		2″	261′	2″
Light shale	33′	10″	295	
White sandstone (water)	39		334	

In a second test a 46 inch seam of coaly shale was struck at 325 feet depth on the farm of Hon. F. W. Redfern.

Shiawassee County.—Owosso and Corunna are one of the best known and steadiest coal districts, fully reported by Rominger in Vol. III. Additional information is given in the reports of C. D. Lawton, when mineral commissioner, and in Vol. V.

Most of the mining has been confined to the east central part of Caledonia township. (See description given with the analyses of the coals of the Owosso and Corunna Coal companies.) The two coals worked in this neighborhood not more than 80 feet down are probably the Verne coals, for there is coal found down to 216 feet, and, as Plate XII of Vol. V shows, there is at least 231 feet of coal measures, excluding the basal sandstone. The coal found at 180 feet depth at the D., G. H. & M. station at Milwaukee, though but six inches thick, may represent the Saginaw seam. W. F. Ward of the Owosso Coal Co. is said to have discovered three and one-half feet of good coal at 195 feet. Continued explorations have developed the coal northeast and north, while to the south of Corunna the wells show almost exclusively sandstones, e. g., at the schoolhouse one-half mile southwest of Corunna:

	Feet.	Feet.
Blue clay	12	12
Sand and gravel	15	27
Rest of surface deposits gray hardpan	63	90
Black slate	5	95
Sandstone	227+	322+

The series to the north contains more shale, which comes in, splitting up the sandstone as shown by comparing the record just given with Plate XII of Vol. V, or with the following:

Westhaven Township.

Sandy clay	51		51	
Sandrock	4		65	
Fire-clay	3		58	
Gray rock	3		61	
White sandrock	13′	2″	74′	2″
Coal		10″	75	
Fire-clay	3		78	
Gray rock	6		84	
Coal	1′	3″	85′	3″
Fire-clay	2′	6″	87′	9″
Gray slate	2′	3″	90	
Fire-clay	7		97	
Slate	12′	3″	109′	3″
Coal (Lower Verne?)	3		112′	3″
Fire-clay	3′	9″	116	
Gray slate	19		135	
Black slate	3′	6″	138′	6″
Gray shale	14		152′	6″
Black slate	10		162′	6″
Gray rock	8		170′	6″
White sandrock	7		177′	6″
Black shale	13		190′	6″
White sandrock	10		209′	6″

Right in the town of Corunna, Sec. 28, we have, according to Mr. W. F. Fowler:

	Court House.		Hotel.	
Clay	16′	16′		
Sand and gravel	4′	20′		
Hardpan (till)	62′	82′		42′
Fire-clay	4′	86′		
Shale	10′	96′	60′	102′
Sandstone	144′+	240′+	134′	236′
With water of Sp. Gr.	1.001		1.003	

The sandstone at the bottom is apparently continuous with that at 55′-135′ in Plate XII, Vol. V, and apparently as we pass south the lower coal and shale seams thin out and the sandstones come together.

From Owosso north the depth of the drift is quite variable, as there are numerous channels in the rock surface. Right in Owosso bedrock nearly outcrops and again is 100 feet deep. Kincaid's mine struck a gravel filled channel.

In the township north of New Haven, outcrops occur near Six-mile Creek, but only a few miles away it is very deep to bedrock. The channel probably goes northwest.

Off toward Venice and Hazelton townships (T. 7 and 8 N., R. 4 E.), coal continues in varying thickness, and explorations to a depth of 412 feet, have also been undertaken around the mouth of

Six-mile creek, near the exposures of the upper coal beds which Rominger and Winchell described. This depth carries it into the basal Parma sandstone.*

The following record from Durand, where the general reports are that wells to rock are from 50 to 175 feet deep, say 120 feet deep and more, that McBride has a flowing well 140 feet deep, and that a well 400 feet deep got salt water is interesting, but difficult to interpret.

It seems likely that the bedrock is really at 109 feet instead of 238 feet, as given, and that the "water-bearing gravel, hardpan and stones" of the record is really a conglomerate. This is indicated by the fact that wells 178 feet deep yield a water with much less lime and more soda than water from shallower wells. Then the black shales beneath are those which have been noted in several other cases near the top of the Grand Rapids group, or more likely the unconformity at the base of the coal measures extends here down to the Marshall—compare the records around Flint.

DURAND WELL RECORD.

	a	b	a	b	
Pleistocene.					
Surface clays	12′	12′	12′	12′	
Quicksand	7′	7′	19′	19′	First water.
Gravel	4′	4′	23′	23′	
Hardpan	18′	19′	41′	42′	
Gravel	2′	2′	43′	44′	Second water, used at Light Works.
Hardpan	19′	20′	62′	64′	
Gravel	1′	1′	63′	65′	
Hardpan	15′	15′	78′	80′	
Blue clay	10′	10′	88′	90′	
Hardpan	10′	10′	98′	100′	
Gravel	2′	2′	100′	102′	
Hardpan	9′	7′	109′	109′	
Brown shale	65′	34′	174′	143′	
Parma or Napoleon. 8 in. casing to 176 ft.					
Water bearing gravel. If this is really under shale it must be a conglomerate.	4′	4′	178′	147′	
Hardpan and stones... Iron casing 208 feet.	60′	62′	238′	209′	
Grand Rapids or Lower Marshall. 6 in. casing to 267′ 89′ farther.					
Black shale..... Well plugged at 332 feet.	103′	107′	341′	316′	
Blue shale	2′	13′	343′	329′	
Black shale	12′		355′		
Limestone	1′	1′	356′	330′	
White shale	67′	69′	423′	399′	
Green shale	10′	10′	433′	409′	
White shale	54′	55′	487′	464′	
Blue shale	20′	20′	507′	484′	
Limestone	1′	1′	508′	485′	
Blue shale	92′	95′	600′	580′	
Limestone	5′	5′	605′	585′	
White shale	14′	14′	619′	599′	
Blue shale	24′	30′	643′	629′	
Salt bearing sandstone	5′	5′	648′	634′	
Blue shale		1′		635′	

(a) Record from blue print furnished by R. R.
(b) " " files of Village Clerk. Total depth 636′; cost $1800; yielded 4 gallons a minute of brine.

*Compare Pl. XLV of Vol. V.

At Bennington, the well of Dr. Schickle is as follows:

	Feet.	Feet.
Loam	1	1
Red clay	10	11
Blue clay	50	61
Quicksand	5	66
Hardpan	20	86
Shale	14	100
Sandrock	22	122

Genesee County.—The coal beds cross the northwest corner. The coal beds reported beneath Flint may be insignificant, possibly in the Grand Rapids series, though I think that it is absent here, but the following record is clearly well within the coal measures, and is authenticated by samples:

Flushing, 300 feet west of Flint River, on N. W. ¼ of Sec. 15, T. 8 N., R. 5 E. Drillers, Deland and Robinson. Reported by E. G. Goodell.

Sept. 8 and Nov. 14, 1898.

	Feet.	Feet.
Surface sand	15	15
Clay with streaks of gravel	32	47
Quicksand	2	49
Hardpan clay (till)	2	51
"Slate" shale	2	53
Slate	15	68
"Slate"	9	77
Sandrock	9	86
Black slate (bituminous represents a coal horizon probably)	1	87
Fire-clay	3	90
Sandrock	4½	94½
"Slate" shale	4	98½
Dark shale	8¾	107¼
Shale	20¼	127½
Coal and black soft slate. This coal is probably lower than the Verne coal, and in varying thickness is quite persistent in the region	½	128
Sandrock	3	131
Shale	21	155
Hard shale	27	182
Hard shale	28	210
Slate with pyrite	6	216

Coal has also been dug in the shale pits of the Saginaw Clay M'f'g Co., near the S. W. corner of Sec. 22,* and is also said to outcrop on the river bank near the northeast corner of Sec. 4, of the same township. In the township north of Montrose a coal mine was started by a slope at Elk, but failed. Similar strata occur on Sec. 26, and appear to belong near the horizon of the Verne coals.

The seams of coal so far as at present explored, appear to be persistent but of varying thickness.

A good seam is said to have been discovered by Martin G. Hope at East Thetford to the northeast, 140 feet deep.

*See Part I of this volume, and also the analysis of the same.

At the residence of F. E. Holliday, Eighth St., Flint, eight inches of coal are said to have been found at 90 feet.

Eight feet of coal were reported at 87 feet deep on the place of Mrs. Mary Conger, Sec. 3, and nine feet in a later well, but the wells were for water and the presumption is that most of it was black shale.

It appears probable that in this county the coal is confined to the northwest of a line from Fostoria to Durand and that the coal probably occurs at less than 250 feet depth.

The record of the Oak Grove mineral well, Sec. 7, T. 7 N., R. 7 E., is reported as follows:

Casing	39′	39′
Sandstone	79′	118′
Coal	4′ 4″	122′ 4″
Sandrock	15′	137′ 4″
Slate	60′ 9″	198′ 1″
Sandrock	67′ 6″	265′ 7″

Barry County.—There has been quite a little talk of coal in this county, and the Thornapple Coal and Oil Co. formed. The coal appears, however, to be all drift coal. For instance, about 800 paces N., 1600 W., in Sec. 6, T. 2 N., R. 7 W., in the valley of High Bank creek the following section was exposed:

	Feet.	Feet.
Till and beneath it stratified clay	15	15
Quicksand	20	35

with fragments of coal quite abundant at the bottom. Underneath is clay and then quicksand is said to recur, and the occurrence of clay capping the hills over sand is quite common.

The abundance of coal in the drift indicates that coal seams are not far off, but the Nashville water-works wells are said to go through about 100 feet of sand and gravel, 40 feet of clay, and the balance 115 to 125 feet in limestone rock, though another less reliable report says that they go through sandrock down to 300 feet. Bedrock here then will be the Eocarboniferous (Upper Grand Rapids) limestone, but there may be a chance for coal to the north.

Eaton County.—At the south side of the county the record of importance to add is the following of a mineral well by L. J. Lincoln at Eaton Rapids. The first 116 feet are undoubtedly in the coal measures, and the well seems to pass into the Parma or Grand Rapids group below. Lincoln's records rarely show coal, and the unintelligible P. K. slate (poor coal) appears in a place where older

records report coal. Six miles southeast of Eaton Rapids, good coal is said to have been met.

T. 1 N., R. 3 W., Eaton Rapids:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
Old gravel	22	22
Sand gravel	5	27
	10	37
Shale rock	30	67
Shale rock	28	95
P. K. slate (?)	7	102
Fire-clay	14	116
Sand and (?)	43	159
Water sand	20	179
Gray rock	2	181
Lime rock	3	184
Mineral rock	10	194
Sandrock	11	205
Water rock	1	206

Farther north, close to the county line a core drill proved the sandstone on Van Osdall's farm N. E. $\frac{1}{4}$ of Sec. 25, T. 3 N., R. 3 E., where a quarry was projected. For 75 feet it was all sandstone. From 14 to 39 feet the samples show coarse white sandstone. Above this are slaty streaks, and at 7 to 9 feet are brown blotches, apparently pebbles of $FeCO_3$, such as occur in a sandstone over the coal at Williamston. The sandstone outcrops in the river near by.

About half-way down the river to Lansing, near Milletts, there have been explorations from an early date. A shaft for coal on the farm of Mr. Minie, Sec. 35, was put down in 1858 to 1859.

A section is given by Winchell, 1860 report, p. 124; see also Rominger III, p. 130, as follows:

Surface	5′	5′
Fire-clay, soft	2′ 8″	7′ 8″
Coal	2′ 3″	9′ 11″
Clay somewhat bituminous	4′ 3″	14′ 2″
Coal	1′ 11″	16′
Fire-clay, white and hard	5′ 8″	21′ 9″
Argillaceous shale	16′ 2″	36′ 11″
Coal	0′ 8″	37′ 7″
Argillaceous shale with some pyrite	12′	49′ 7″
Sandrock	4′ 2″	53′ 9″
Coal	4′ 1″	56′ 10″

On the other hand, a well on the farm of W. R. Locke on the same section 35, T. 4 N., R. 3 W., drilled in 1899 for Mr. W. O. Smith (Alt. 875) is reported as follows:

	Feet.	Feet.
Drift	?	
Fire-clay	?	16
Shale	15	31
Coal	2	33
Shale?	17	50

Some Ohio people are also said to have drilled here.

Two reasons for abandoning the early explorations are given—

that there was not enough roof, and that it was not thick enough to pay. Both may be correct, the one applying to the coal less than 20 feet down, the other to the lower coals, though if there were really four feet of coal at 56 feet it is hard to understand why it could not be successfully worked.

Making allowance for exaggeration, however, it still appears that in the first 60 feet are two or three coals, and only four or five miles away, in the next county, coal is found near the surface in some of the Lansing wells, and is said to have outcropped beneath some blue shale which lay below the sandstone quarry in the rapids of the Grand River, obliterated by the dam at North Lansing, a mile and a half up stream from Lansing. Within the county we find at Grand Ledge a similar section, where coal has been worked since 1839. The best section is exposed in the clay pits of the American (Grand Ledge) Sewer Pipe Co., about 1100 paces north, 500 west of the southeast corner of Sec. 3, T. 4 N., R. 4 W., as follows:

	Feet.	Feet.
Decayed sandstone	3	
Shale with streaks of $FeCO_3$	4	7
Black shale, coaly (Upper Rider)	1	8
White shale, best sewer pipe clay, bounding line with next formation below undulating as if this is an alternation of the layer below (See analysis in Vol. VIII, Part I.)	2	10
Blue shale with *Sphenophyllum cuneifolium* and nodules of $FeCO_3$, with ZnS and FeS_2	4	14

Black shale passing at east end into five inches of coal and thickening in Boyle's shaft, not far off into from 18 inches to 24 inches, apparently visible as a thin seam 4 inches or so thick, 12 feet above the main workings of C. Hodge, which are in a ravine just west.

This is also said to be the coal mined in the Pratt mine just over the county line in Clinton county on the west bank of Grand River where it is at times 30 inches thick. Harder than, and not so brittle as the next lower seam, with greater irregularity in thickness apparently. The black shale directly above contains a delicate compressed lamellibranch (cp. Anthracosia or *Macrodon carbonaria*).

The coal was also mined some years ago at a profit in a shaft by Irving Jenkins, close to the Boyle shaft. Farther southwest the whole series seem to pass into sandstone, and in another shaft the coal was found to be so split up as to be unworkable.

	Feet.	Feet.
Upper Verne	1	15
Under this coal come black and white flaking sandstones (Ashley calls them fake) sometimes quite massive, as at Hodges' drift and varying much in thickness,—usually from 10 to 20 feet thick	20	35
Next we have a lower seam of coal, Analysis (E_3) more uniform in thickness, more brittle than the upper coal, and known locally as the 18 inch or sandstone coal, quite persistent, worked by Arnold and R. F. Wilkinson (Lower Verne)	1′ 6″	36′ 6″
Below this comes the sandstone again.		

The lithological character of the section is quite variable, as well as the thickness of the different members. In Boyle's mine in one place the two coals approach so near that in taking up the foot

of the upper coal the lower is exposed. In fact, in the bluff of the river to the east of the clay pit they appear within 7 feet of each other, the upper only 9″ thick, the lower 15″.

In a clay pit on the N. W. ¼ of Sec. 11 under a heavy cross-bedded sandstone 15 feet thick comes a few inches of shales, from which most of the specimens come on which the correlation with the Mercer group was based by White.*

Then about two feet of coal rolling and dipping in one place to N., in another 10° to 15° to E.

Then 3 feet of fire-clay and shale. The coal here I take to be the upper seam.

One or the other of the coals may be traced up the river through the town, having been worked according to reports under the grist mill (upper coal). In the Island House (Mudge) well 18 inches of coal is said to have been found near the top, though Rominger reports one at 65 feet. Below for 100 feet or more and in a deeper well put down by Dr. Ball, near the river and the east line of Sec. 11, T. 4 N., R. 4 W., only sandstone is reported. From the general succession as well as the fossils associated and the character of the coals, we seem to have here an Upper Rider, the Upper Verne and the Lower Verne coals. The basal series of sandstones do not appear to be split by the coals of the Saginaw series.

The coals exposed in the deep cut of Grand River probably extend clear across the county, though covered with a heavy layer of drift, through which little or no drilling has been done. When we go south, however, into the valley of the Thornapple, exposures occur around Chester of a coal seam, at most three feet thick, as described by Rominger.†

Samples from a recent boring near Carlisle on the S. E. ¼ of Sec. 24, T. 2 N., R. 6 W., are as follows:

Surface, blue clay broken at the bottom.....	39′	39′
Black shale with thin seams of coal,—a coal horizon	11′	50′
White shale, under clay.....	3′	53′
Dark shale with some $FeCO_3$.....	2′ 6″	55′ 6″
Black and white shale	2′ 6″	58′
Blue shale	10″	58′ 10″
White sandstone	1′ 2″	60′
Black and white shale	6′ 6″	66′ 6″

*Page 44.
†Vol. III, p. 131.

We have coal measures, obviously, and it would seem worth while to go somewhat deeper, though the record of the deep well at Charlotte is not encouraging.

In the southwest part of the county around Bellevue the Eocarboniferous limestone outcrops and no coal is to be expected, and it is probable that the productive coal measures of the county are rather thin everywhere, with no indications of coal seams below the Verne (Grand Ledge) seams, except perhaps in the extreme northeast.

Ingham County.—Many records from the neighborhood of Williamston are given in Vol. III of our reports.*

In a general way it is said that there is a 44 inch bed of coal, outcroping, or but a few (13) feet below surface, so having no roof. About 48 feet below the surface is a second seam.

Rominger summarizes them as follows: "The above experiments show a uniform distribution of a coal seam about 3 feet in thickness over this whole district. Its position is often too superficial, without a proper roof, for advantageous mining. In nearly all the borings two seams of coal are found, of which the upper one is generally too narrow to be of practical value. The two seams are separated by from 15 to 20 feet of intermediate beds."

One of the exposures of the coal measure shales, etc., is shown on the farm of C. M. Phillips, Sec. 28, T. 4 N., R. 1 E., near which were some of the earliest coal diggings. Nodules of $FeCO_3$ are common, and the dump of the abandoned coal mine shows numerous fragments of a conglomerate with a white sandstone matrix and numerous pebbles of $FeCO_3$.

The two coal seams to which Rominger refers I take to be the Verne seams, and they are associated with black shales containing similar marine animals.

The following records, which I owe to Mr. W. T. Chappell, show that the Saginaw seam exists below.† The J. H. Somers Co. also found some coal down at 249 feet.

Records for W. T. Chappell, by O. A. Shadbolt, near Williamston, Ingham county:

*Part I, pp. 130, 135, 136. See also Lansing, "Exposition concerning Mineral coal in Michigan," Detroit, 1854.

†See also Michigan Miner, Vol. 3, No. 7, p. 16, June 1, 1901.

No. 1, S. W. ¼, Sec. 34, T. 4 N., R. 1 E.

Yellow sand and clay	12′		12′	
Fine sand	8′		20′	
Blue clay	25′		45′	
Hardpan	21′		66′	
Blue shale	23′		89′	
Fire-clay	10′	8″	99′	8″
Blue slate	8′		107′	8″
Coal (Upper Verne?)		4″	108′	
Black slate	8′		116′	
Gray slate	7′		123′	
Black slate	8′		131′	
Fire-clay	3′		134′	
Black slate	4′		138′	
Fire-clay	7′		145′	
Black slate	5′		150′	
Coal (Lower Verne?)		6″	150′	6″
Sandy shale	6′		156′	6″
Black slate	7′		163′	6″
Sandy shale	8′		171′	6″
Black slate	1′	6″	173′	
Gray slate	24′		197′	
Black slate	4′		201′	
Sandy shale	3′		204′	
Black slate, strong	9′		213′	
Coal (Saginaw?)	2′	6″	215′	6″
Fire-clay	6′		221′	6″
Gray slate	43′		264′	6″
Black slate	10′		274′	6″
Gray slate	14′		288′	6″
Black slate	2′	6″	291′	
Hard rock	2′	6″	293′	6″
Black slate	11′		304′	6″
Sandy shale	2′	6″	307′	
Sandrock	3′		310′	

No. 2, N. E. ¼, Sec. 3, T. 3 N., R. 1 E. About 40′ lower than No. 1, June 3, '99.

Sand	12′		12′	
Clay	6′		18′	
Sand	2′		20′	
Hardpan	7′		27′	
Black slate	3′		30′	
Fire-clay	22′		52′	
Soft black slate	7′		59′	
Coal (Upper Verne?)	1′		60′	
Fire-clay	21′		81′	
Gray slate	8′		89′	
Black slate	26′		115′	
Coal (Lower Verne?)		6″	115′	6″
Fire-clay	9′		124′	6″
Sandy strata	29′		153′	6″
Gray slate	1′	6″	155′	
Sandrock	2′		157′	
Sandy shale	8′		165′	
Sandrock	11′		176′	
Gray shale	4′		180′	
Sandrock	3′	6″	183′	6″
Sandy shale	6′		189′	6″
Sandy fire-clay	1′	6″	191′	
Gray slate	35′		226′	
Sandy shale	13′		239′	
Gray slate	7′		246′	
Black slate	11′		257′	
Coal (Saginaw?)	1′	4″	258′	4″
Fire-clay	3′		261′	4″
Sandrock	4′	6″	265′	10″

No. 3, N. W. ¼ of Sec. 33, T. 4 N., R. 2 E. Leasia farm, 160 rods W. of N. W. of No. 1 and perhaps 10′ higher.

Clay	12′		12′	
Sand	13′		25′	
Clay	25′		50′	
Hardpan	8′		58′	
Clay	12′		70′	
Hardpan	5′		75′	
Sandrock	15′		90′	
Black shale	10′		100′	
Coal (U. Verne?)	1′	4″	101′	4″
Fire-clay	2′		103′	4″
Gray shale	4′		107′	4″
Black shale	4′		111′	4″
Gray slate	2′		113′	4″
Fire-clay	2′		115′	4″
Black slate	6′		121′	4″
Sandy fire-clay	6′		127′	4″
Gray slate	5′		132′	4″
Fire-clay	2′		134′	4″
Gray slate	13′		147′	4″
Black slate	14′		161′	4″
Sandrock	2′		163′	4″
Fire-clay	3′		165′	4″
Coal		6″	165′	10″
Fire-clay	4′	6″	170′	4″
Black slate		6″	170′	10″
Coal		6″	171′	4″
Fire-clay	6′		177′	4″
Sandy shale	40′		217′	4″
Black slate	3′		220′	4″
Sandrock	10′		230′	4″

These wells of Shadbolt may be compared with the following one of L. J. Lincoln, who, it will be noticed, probably did not distinguish the coal from the slate. We see that the coal measures continue down anyway to 362 feet, and the black slate from 323 to 345 feet may very easily be the same black, coal-bearing horizon that was struck in No. 1 at 289′ to 305′.

N. W. corner, Sec. 33, T. 4 N., R 1 W., Meridian township:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
Old well	23	23
Soft clay	17	50
Clay and hardpan	40	90
Beginning of coal measures—		
Shale	15	105
Slate	95	200
Slate to sand	20	220
Sand and water	27	247
Slate	34	281
	22	303
Shale	20	323
Black slate	22	345
Soapstone	17	362
Fire-clay	35	397
Light slate	15	412
Beginning of Parma sandstone? and transition to Eocarboniferous limestone—		
Light sandrock	16	428
Lime rock	11	439
Sand	10	449
Fine sand	7	456
Fine sand	24	480
White sand	19	499
Sand to hard rock	10	509
Hard lime	5	514

Coming about an equal distance northwest to the Agricultural College, on Sec. 18, T. 4 N., R. 2 W., we have the old well put down by L. J. Lincoln in 1887, of which there were 15 bottles of samples taken—and 13 now left at the Agricultural College. By their means we may correct Lincoln's log and obtain the following record:

RECORD.

Quicksand	11	11
Clay (10-20)	9	20*
Hardpan, i. e., till, dark clay and sand	17	37*
Black shale	3	40*
(Very dark with bits of coal, other wells near by are said to have struck coal at this level).		
Fire-clay	2	42
Fire-clay and shale	42	84*
(50-76, light clay shale).		
Sandrock	118	202*
(84-155, light).*		
(152-162, sandy clay with dark bits).*		
(162-180, white sand with coal 10% or so).*		
(180-187 white sand, coarse, with coal).*		
(187-218) fine sand with iron rust, probably representing pyrite and black specks).		
Shale (?)	**33**	**235**
Sandrock	25	260*
(265-308, very fine, blue sandrock).		
Shale	40	304*
(265-308, very fine, blue sandrock)		
Sandrock	29	333*
(308-329, white sand).*		
Shale	16	349
Sand	2	351

Another well was put down near by in 1899, by Elmer E. Strope of Mason, Mich., of which the State Geological Survey have a set of samples.

Sec. 18, T. 4 N., R. 1 W., depth (p. 17 of 1900 report) 345', cost $700.00:

Sand, fine	8' 21'	29'	Comparison with other wells.
Gravel, fine	2'	31'	
Brown smooth clay	14'	45'	
Dark blue shale	37'	82'	No. 1, 37-84 with coal.
First water here.			
Fine grained white sandstone	43'	125'	
Coarse sandstone, white	35'	160'	
Flow of water			
Sandy shale	12'	172'	
Coarse white sandstone, conglomerate at 185 feet	44'	216'	
Yellow sandstone	14'	230'	119-255 feet at Industrial School.
Sandstone and coal	9'	239'	
Coarse pyritic sandstone	16'	255'	No. 1, 260.
Dark sandy shale	9'	264'	
Sandstone and siderite, very hard	12'	276'	
Sandstone and coal	4'	280'	
(Good clean samples, said to be a few inches thick) at 280 feet.			
Shale, or fire-clay	6'	286'	
Smooth shale	39'	325'	No. 1, 260-304.
Water sandstone?		343'	

*Represented by samples; descriptions in parentheses are from samples and not from Lincoln's records.

In Carpenter's paper on the use of this water as a boiler water the depth is given as 265 feet. (Trans. Am. Soc. Mich. Engineers, XI, p. 239), probably a misprint for 365 feet. Various reports made the well from 343 feet to 470 feet deep. Originally, however, it seems to have been 365 feet deep, though the report of the state board makes it 343 feet deep, cost $1,000.

In these two wells a big body of sandstone with some streaks of coal in it, separates a lower and upper body of shales.

Passing two miles and a half farther to the Industrial School in the E. ½ of the N. W. ¼ of Sec. 15, which stands about 20 feet higher, we find the record:

	Feet.	Feet.
Clay and gravel	36	36
Sand and gravel	5	41
Sandy hardpan	4	45
Lake sand and gravel	37	84
Clay, sand and gravel	16	100
Lake sand and gravel	1	101
Soft sandrock	3	104
Hard fire-clay	4	108
Soft white sandrock	13	121
Soft sandy fire-clay	15	136
Hard sandrock	119	255
Winchell says from 101 to 255 is sandstone "first water."		
Hard fire-clay alternating with beds of sandrock variable in color from whitish to blue	64	319
Cherty lime	1	320
Gray lime	4	324
Sandy fire-clay mixed with seams of hard rock	51	375
Soft sandrock	37	412
Hard gray limestone	2	414
Soft white sandrock	15	429
Blue limestone	1	430
White fire-clay	1	431
Sandrock	4	435
Fire-clay with iron pyrites	50	485
Soft sandrock	5	490
Blue limestone	16′ 6″	506′ 6″

The difference in thickness of drift corresponds practically to the difference in elevation of this and the Agricultural College wells, and we plunge at once into a sandy series which culminates about 255′ down. This record shows no coal, but King and Wigant say they found at the North Lansing railway station of the Pere Marquette:

	Feet.	Feet.
Surface with 14 feet of gravel	55	55
Sandrock with 6 inches of coal at 62 feet	18	73

Coal is also reported from a number of wells near the School for the Blind, e. g., at Christopher's, 434 Willow St., in the bed of the river, and at 430 Willow St. there is said to be 3 feet of coal; at Shadoin's, 612 Saginaw St., 5 feet thick, the section being as follows:

	Feet.	Feet.
Clay	65	65
"Soaprock" shale	14	79
Coal	5	84
Sandrock	26	110

at Watson's, 606 Saginaw St., 1 foot thick. Hon. J. Robson, 321 Walnut St., is said to have found 4 feet of coal in his well.

At the corner of Pine and Kilborn Sts. there is said to be

	Feet.
Casing	58
Black rock	2
Coal	5

At 501 Pine St., H. R. Cadwell, there is said to be 4 feet of coal at 75 feet. So that the upper coal horizons must be fairly persistent near the bedrock surface, perhaps too near to work.

Still, the coal is not continuous, as we see from a record at 318 Jefferson Ave.

	Feet.	Feet.
Red clay	16	16
Blue clay free from stones	10	26
Blue quicksand, water rises to 12 feet from the surface	6	32
Water sand	8	40
Blue clay or soaprock	25	65
Probably sandrock	11	76

When we turn to the southeastern part of Lansing we find less trace of coal.

Lincoln's record of the Condensed Milk Company's well is as follows:

	Feet.	Feet.
Sand and gravel	16	16
Sandrock	**15**	**31**
Fine sand	5	40
Water sandrock to shale	28	68
Slate	10	78
Light slate (probably the fire-clay below the coal horizon) and sand	17	95
Fine sandrock	22	117
White sandrock	21	138
Light sandrock	20	147
White sandrock	17	164
Gray sandrock	18	193
Fine sandrock	5	198

This is not far from the Industrial School, but a good deal lower, as is shown by the thinness of the drift, for the rock surface appears to be pretty flat. In fact, in the abutments of the Michigan Avenue bridge, across the Grand River, near this well, the sandstone was struck and slabs of it are preserved at the Agricultural College. Close to the bridge, too, are the water-works wells—those which are used meeting rock at about 36 to 46 feet and ranging mainly 150 to 160 feet deep. But there is one deep one at the S. W. corner of the lot, whose record, Feb. 17, 1896, from the State Republican, is as follows:

	Feet.	Feet.
Surface to rock	46	46
First eight feet soft, porous, coarse sandrock	30	76
Hard clay	2	78
Finest sandrock, plenty of water	100	178
Fire-clay	2	180
Blue sandrock	20	200
Yellowish sandrock, plenty of water	30	230
Fire-clay	2	232
Grayish rock	30	262

Gold particles were said to be found, probably pyrite or bronzy mica.

	Feet.	Feet.
Fire-clay	15	277

At 275 feet was a rock "as hard as flint, and the sand pump yielded a metal that resembled gold," i. e., pyrite.

	Feet.	Feet.
White sandstone porous	25	302
"Granite" stone, very hard	25	327
Hard white rock, with big flow of water rising within 5 feet 9 inches of surface, and much above the water	13	340

Probably through this part of the town the sandrock is the surface rock, as indicated by the following wells:

Lantz' well at the laundry, 120 feet deep, 60 feet to 80 feet to bedrock, Piatt's, behind the Downey House, 58 feet to rock and white sandstone down to 112 feet (1901).

The Downey House well recorded by Winchell* thus:

	Feet.	Feet.
Sand	4	4
Light blue clay	10	14
Sand and clay	4	18
Sand and gravel	37	55
Sandstone	7	62

continued to 500 feet, according to Rominger, or 740 feet, some say, when it became too mineral in taste and is now plugged at about 70 feet. The Hollister Block well is about 150 feet deep. The city water-works test well, now flowing close to the junction of the Cedar and Grand rivers, on Hazel street, which Mr. Stephenson tells me was mainly clean white sandrock, was 340 feet deep, and six blocks west, at the corner of Isaac and Chestnut streets, is a similar flowing well 365 feet deep.

Southwest of Lansing, in the bed of the Grand River, was a sandstone quarry, and Mr. George H. Pratt informs me that in quarrying under the sandstone a shale with coal was exposed.

Mr. Lincoln also put down a large number of wells around

*Am. Ass. Adv. Sci., 1875, B., p. 31.

Mason. As we have seen, he does *not* distinguish the coal from black slate, but from the following records we see that there are one or two coal horizons in the first hundred or hundred and fifty feet,* and one considerably lower. Somewhat below 300 feet we pass into the Eocarboniferous limestone series, so that the strata lie as deep here as 10 miles north.

Wherever black slate, brittle slate and shale appear in his records there may be more or less coal.

A heavy sandstone quite frequently separates the upper coal horizons which we may correlate with the Verne, from the lower, which we are inclined to correlate with the Saginaw as we did at Williamston, with which it seems to connect.

There is no close parallelism but merely an epoch of somewhat more disturbed condition and coarser sediment which we seem also to trace through to the north.

T. 2 N., R. 1 W., S. W. part Section 3. Record No. 20:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
Sandrock	13	13
Sand and water-pack sand	22	35
Blue sand and gravel	5	40
Shale	7	47
Shale and hard spots	5	52
First hard rock at		52
Shale	6	58
Soft sandrock	2	60
Water and sandrock	5	65
Water and hard rock	2	67

N. E. corner of N. E. quarter of section 8, block 4, Mason, Vevay township:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
		22
Slate	13	35
Light slate	19	54
Slate	21	75
Slate to sandrock	45	120
Gray sandrock	29	149
White sandrock	30	179
Sand to slate	18	197
Black slate	29	226
Fire-clay	15	241
Light slate	13	254
Lime and slate	8	262
Soft lime	6	268
Light slate	30	298
Hard rock	4	302

*See Rominger, Vol. III, Part I, p. 130.

Mason City water-works, on city lots:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
Hardpan and clay	15	15
Gravel and sand	5	20
Black shale	3	23
Light shale	15	38
Water sandrock	26	64
Water sandrock	34	98
Hard sandrock	22	120
Softer sandrock	10	130
To slate	11	141

Mason City water-works well, south of plant, No. 1: Record No. 5.

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
(Old well?)		69
Fine sand	14	81
Sand to hard rock	4	85
Gray sandrock	6	91
White sandrock	20	111
Sandrock	10	121
Blue sandrock	11	132
White sandrock	7	139

Mason City water-works well, N. E. part block 43, Record No. 7: T. 2 N., R. 1 W.

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
		3
Gravel	2	5
Water gravel	1	6
Gravel and sand	14	20
Hardpan	8	28
Hardpan and shale	4	32
Fire-clay	2	34
Black slate or shale, coal horizon	10	44
Lighter shale	10	54
Hard rocks	2	56
Sand and water	31	87
Sandrock	13	100
Slate	12	112
Sandrock	6	118
Light shale	6	124
Light sandrock	5	129
Shale	2	131

Mason City water-works well, Lot 11, block 15; Record No. 8:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
		14
Shale rock	11	25
Slate and sandrock	22	47
Sandrock	22	69

Record No. 9:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
Clay and sand	**6**	**6**
Sand, clay and gravel	25	31
Hard rock	**3**	**34**
Sandrock	7	41
White rock	14	55
Slate and sandrock	11	66
White sandrock	24	90
Gray sandrock	10	100
Sandrock	31	131
Fine sandrock	19	150
To slate	5	155

Mason City water-works, city lots, Record No. 10:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
		5
Sand, gravel and hardpan	9	14
Shale and slate	10	24
Light slate	26	50
Sandrock	15	65
Water rock	2	67

Record No. 11:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
		3
Sand and gravel	9	12
	8	20
Shale	5	25
Sand slate	10	35
Slate	12	47
Sandrock	19	66
Fine sandrock	33	99
White sandrock	60	159
Blue sand and putty (soft clay)	13	**172**

S. W. corner block 1:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
Old well	70	70
Sandrock	35	105
Sand to hard rock	17	122
Very hard sandrock	4	126
Sandrock	68	194

N. W. corner block 12, Mason:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
No record	36	36
Sand and gravel	18	54
Shale and hard rock	7	61
Black slate	8	69
Light slate	36	105
Sandrock	27	132
Slate	18	212
Black slate	21	233
Black slate to sandy spots	13	246
Slate	28	274
Light slate	14	288
Fire-clay	33	321
Hard rock	6	327
Soft to hard rock	13	340
Water sandrock	45	385

T. 2 N., R. 1 W. N. E. part block 52, city:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
		20
Black shale	33	53
Light shale	17	70
Sand and water rock	20	90
Slate	14	104
Sand and water	61	165
Sandrock	31	196
Blue sand	6	202
Sandrock	10	212
Light slate	8	220
Light slate to fire-clay	10	230
Fire-clay	9	239
Fire-clay to slate	10	249
Slate	8	257
Slate to sand	3	260
Sand and water	8	268
Light slate	3	271
Fire-clay	12	283
Light slate	6	289
Dark slate	5	294
Light slate	6	300
Fire-clay with hard spots	17	317
Water rock	49	366
Firm sandrock	20	386
Limerock	5	391

T. 2 N., R. 1 W. S. W. part of block No. 7, Steel and Holt's Addition:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
Sand	23	28
Sand and hardpan	10	38
Black slate	15	53
Slate rock	7	60
Sand and slate	½	60½
Fine sand and slate	50	110½
Blue	23	133½
Water rock	27	160½

Mason City water-works well, N. E. part block 43:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
Gravel	2	5
Water gravel	1	6
Gravel and sand	14	20
Hardpan	8	28
Hardpan and shale	4	32
Fire-clay	2	34
Black slate or shale	10	44
Lighter slate	10	54
Hard rock	2	56
Sand and water	31	87
Sandrock	13	100
Slate	12	112
Sandrock	6	118
Light shale	6	124
Light sandrock	5	129
Shale	2	131

N. W. corner, block 18, city, record No. 21:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
To gravel and sand		8
Gravel and sand	2	10
Blue clay	8	18
Hardpan	85	103
Hard limerock	8	111
Slate rock	10	121
Dark flakes	2	123
Hard limerock	44	167
Blue sandrock	10	177
Sandrock	11	188
Fine sandrock	14	202
Hard sandrock	3	205

Block 24, lot 3, Mason, Record No. 27:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
		6
To gravel	21	27
Clay	13	40
Blue clay	10	50
Fire-clay and light slate	24	74
Hard sandrock	16	90
Fine sandrock	14	104
Sand and water rock	9	113

T. 2 N., R. 1 W. E. half of Sec. 9, Vevay township:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
		3
Clay	10	13
Hardpan and gravel	18	31
To shale	2	33
Shale	2	35
Shale and slate	12	47
Slate	82	129
Sand and slate	69	198
To shale	13	211
Black shale	18	229
Light shale to hard limerock	15	244
Limerock	3	247
Light clay	23	270
Fire-clay to slate	15	285
Shale	15	300
Shale	27	327
Top of Eocarboniferous (?).		
Sand and hard rock	19	356
Sandrock	45	401

T. 2 N., R. 1 W., S. W. corner Sec. 14:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
Clay and hardpan	15	20
White clay and lumps of coal	4	24
White clay and sandstone	15	39
Light shale	23	62
Dark slate	10	72
Black shale	2	74
Slate and coal	3	77
Light slate	12	89
Slate and lime	6	95
Light slate	3	98
Fire-clay	2	100
Black slate, brittle	5	105
Sandrock	1	106
Light slate	10	116

N. E. corner Sec. 20, Vevay township, Record No. 32:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
Old well		42
Sand to gravel	21	63
Hardpan and sand	3	66
To rock	36	102
Hardpan	8	110
Slate	9	119
Light slate	9	128
Light slate and sand	17	145
Hard sandrock	8	153
Water rock	5	158
Sandrock	13	171

T. 2 N., R. 1 W., S. W. corner N. W. quarter Sec. 22:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
Old well		62
	21	83
Black slate	30	123
Black slate to sand	20	143
Sand to slate	20	163
Very hard rock	29	192
Blue sand	2	194
Fire-clay	13	207
Light slate	15	222
Dark slate	13	235
	12	247
Light and dark slate	18	265
Light and dark slate	11	276
Fire-clay	10	286
Light shale	10	296
Light slate	9	305
Light shale	9	314
Eocarboniferous limestone—		
Hard lime	4	318
Hard rock	16	334
Sand and lime	11	345
Sand and water rock	22	367
Very hard	1½	368
Lime	4	372
Sand and water	11½	384
Water	19	403
Water rock	6	409

S. W. corner Section 27 (Eden), Vevay township, Record No. 33:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
Old well		9
Clay	18	27
Hardpan	11	38
Sand and water rock	14	52
Pure clay and shale	8	60
	19	79
Sand	7	86
Hard sandrock	2	88
Water rock	16	104

T. 2 N., R. 2 W.; N. E. corner of S. E. quarter, Section 23, Aurelius township, Record No. 26:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
Old well	33	
Hardpan and rock	5	38
Slate and sand (stones)	15	53
Soap stone and clay	7	60
Slate	23	83
Sand (stone)	12	95
Slate and sand (stone)	30	125
Sand (stone) and shale	9½	134½

Coal is reported from T. 1 N., R. 2 W.

Coal has been found on the farm of J. R. Potter, Sec. 6, T. 2 N., R. 2 E., by J. McDowell at a depth of 25 feet. It is said to be three feet thick. There is no doubt that practically the whole of the county is underlain by the coal measures.

Livingston County.—The coal measures may cross the west part of this county, but the following record, by L. J. Lincoln, at Howell, can be best interpreted by supposing that the shales are in the same series as at Durand, and that perhaps some of the overlying sandstone or conglomerate was not distinguishable from the hardpan above. The bedrock first struck is probably the conglomerate at the base of the coal series, and the shales below are Lower Marshall and Coldwater.

Howell Condensed Milk Company's well, T. 3 N., R. 4 E.:

Character.	Thickness of stratum. Feet.	Total Depth. Feet.
		30
Clay	5	35
Clay and gravel	19	54
	8	62
Marl and sand	20	82
Pack sand	17	99
Pack sand to hardpan	14	113
Stony	5	118
Stony hardpan	1	119
Clay and hardpan	5	124
Hardpan	48	172
Quartz rock	4	174
Hard rock	4	178
Sandy	1	179
Sand and water	19	198
Fire-clay	11	209
Light slate	18	227
Sand and slate	5	232
Fine sand	12	244
Light slate	16	260
Light shale	19	279
Soapstone	10	289
Sand	3	292
Light shale	43	335
Black slate and brown shale	79	414
Brown shale, harder	66	480
Light shale	60	540
Slate	10	550

Calhoun County.—The coal measures may extend a little way in

the extreme northwest part of this county in Lee, Clarence and Sheridan townships, and coal is liable to be found as far as they go, as shown by wells reported only three or four miles from Albion, and given in connection with Jackson county. There are reports of coal through a number of different people here, near Boyd's farm, Sec. 13 and Sec. 24, T. 2 S., R. 4 W.

The report of four feet of coal six miles south of Marshall must be an error.

Jackson County.—This county has been quite fully described by Winchell and Rominger.

The New Hope mine on the west side of Sec. 27, T. 2 S., R. 1 W., has been already described in connection with the analyses of its coal, A5 and A6.

The Trumbull Mining Co., already referred to, on page 106, lies in continuation of the old Woodville mine to the northwest on Sec. 24, T. 2 S., R. 2 W. This coal is said to be 3 feet thick about 80 to 125 feet down.

This is a rather narrow trough and ran out toward the Michigan Central track. Mr. Robert Gage has operated on the same coal on the Laverty farm at Woodville.

The National Mining Co. did some exploring for coal on the farms of Mrs. J. Watts and E. W. Barber, southeast of Jackson Junction.

The coal lies mainly, it will be noticed, northwest of Jackson.

Coal $3\frac{1}{2}$ feet thick was said to have been found on the Daniels farm, 2 miles west of the city, where, $\frac{1}{4}$ mile from the city limits, is said to be 80 to 100 acres of coal about 3′ 3″ thick, at a depth of 105 feet. It is to be exploited by the Central City Coal Mining Co.

Some records near the Calhoun county line, which I owe to Mr. W. T. Chappell are of interest.

Well on farm of A. Burns, $3\frac{1}{2}$ miles northeast of Albion, near L. S. & M. S. R. R., O. A. Shadbolt, driller:

Dry sand	20			
Wet sand	30		50	
Clay	3		53	
Black shale	3		56	
Coal (Verne?)	1′	4″	57′	4″
Black shale	4		61′	4″
Fire-clay	3		64′	4″
Sandrock	25		89′	4″
Hard rock ($FeCO_3$?)	2		91′	4″
Sandy fire-clay	6		97′	4″
Sandrock	98		195′	4″
Coal (Saginaw?)	0′	2″	195′	6″
Sandrock	5		200′	6″

On John Holmendinger's farm, ¾ mile away:

Sand	20			
Sandrock	27		47	
Slate	6′	6″	53′	6″
Coal	0′	6″	54	
Fire-clay	8		62	
Gray slate	14		76	
Hard rock ($FeCO_3$?)	1		77	
Sandrock	73		150	
On Barnes' place—				
Sand	64		64	
Sandrock	90+		154+	

Thus it seems as though we have in Jackson county, as around Mason and Lansing, a heavy sandstone splitting the shaly coal-bearing series, with coal below sometimes as well as above. The upper series is probably that which has been mined and corresponds to the Upper Verne. In the deep wells, reported in Vol. V, the lower coal seams, the Saginaw, etc., have apparently dropped out, and the sandstones merge together as they seem to do southeast of Corunna also.

We notice, too, that most of the coal seems to lie west and northwest of the city, although one of the Emerson shafts at least was southeast. The Porter mine (Fig. 5) and other abandoned mines were right in the city. The Eureka was northeast.

The coal formation seems not infrequently to lie in hollows eroded out of the limestone which lies underneath.

For instance, southeast of the city, Poole and Emerson had a shaft in the valley, while the hill adjacent was capped with Eocarboniferous limestone on sections 12 and 13, T. 3 S., R. 1 W.

Moreover the wells near Albion just cited are considerably outside the line of strike of the Eocarboniferous limestone from Jackson to Bellevue.

INDEX TO PART II.