day synonyms determined from standard works, but guided by probable Michigan species are given in the right-hand column:

Zaphrentis	Lophophyllum profundum
Crinoid stems	Crinoid stems
Chonetes sp.	Chonetes granulifer
Productus manus	Marginifera missouriensis
Spirifer cameratus	Neospirifer cameratus
Spirigera sp.	Composita subtilita
Myalina sp.	Myalina sp.
Bellerophon sp.	Pharkidonotus percarinatus
Platyceras sp.	Platyceras sp.
Orthoceras sp.	Pseudorthoceras knoxense
Nautilus latus or winslowi	Temnocheilis latus or winslowi

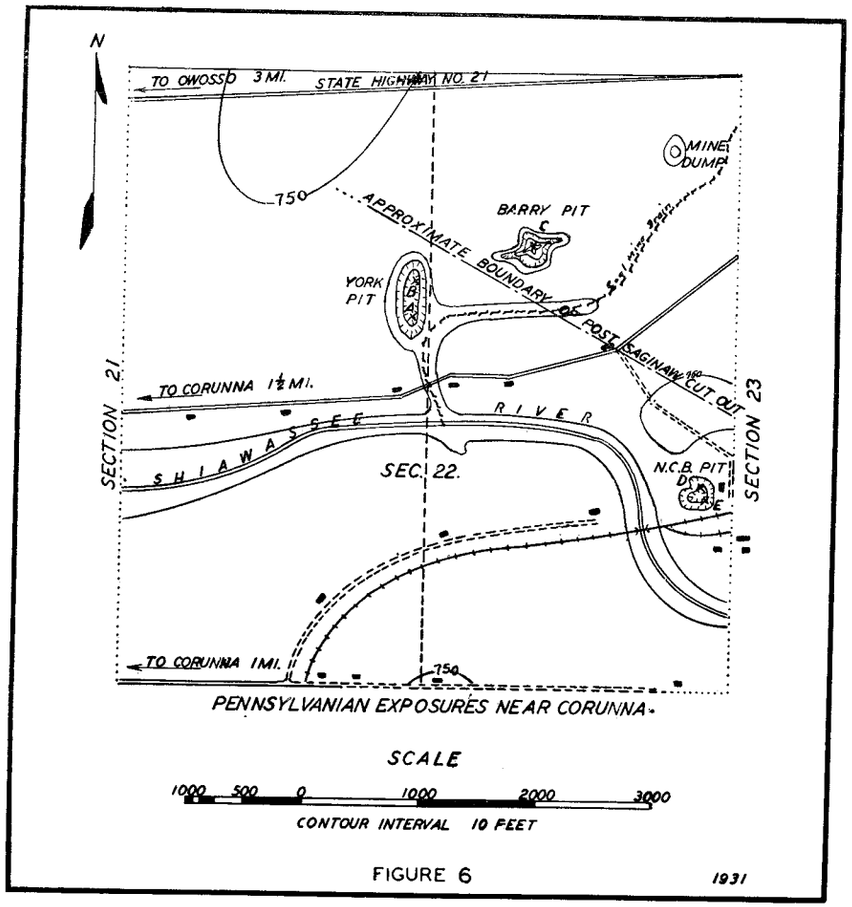


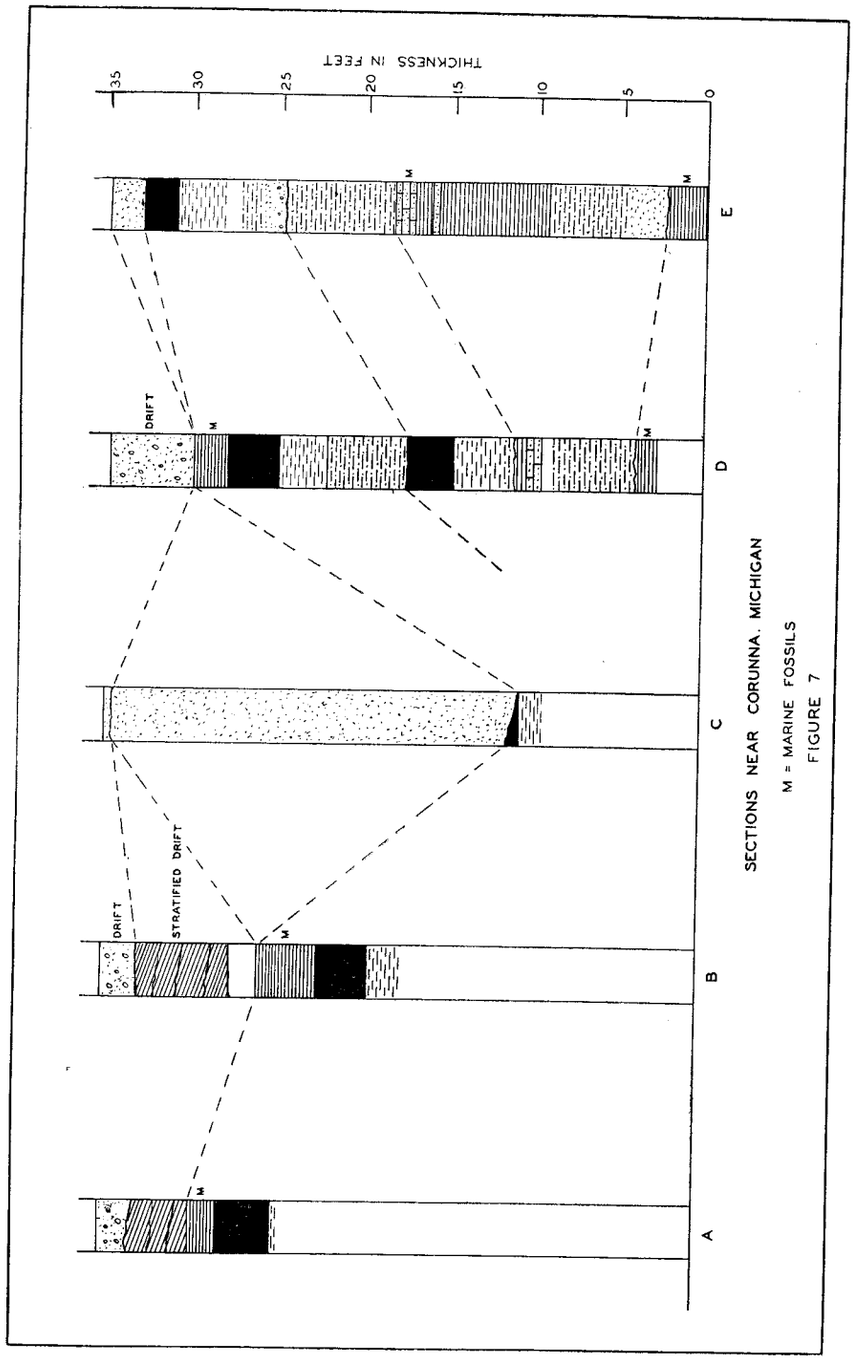
FIGURE 6 1931

The outcrops mentioned by Winchell and Rominger are now concealed, but it is probable that the limestone bed is close to the surface, giving the Verne member in this area an elevation of about 660 feet. (Figure 4, column 4).

Other outcrops of Pennsylvanian beds are mentioned by Winchell (1861, p. 124) as occurring at Chesaning, and at several places along the Shiawassee River. However, I have found none of those outcrops reported below Corunna.

Exposures of the Saginaw Group may be observed in the shale pit of the New Corunna Brick Company, section 22, T. 7 N., R. 3 E., and the recent excavations made in local coal stripping operations about two miles northeast of the center of the town of Corunna. A sketch map showing the area dealt with (Figure 6) is reproduced here. The map is an enlargement made from the U. S. Geological Survey topographic sheet, Corunna quadrangle, and illustrates the level character of the district. The location of the pits is indicated. Several sections were measured, five of which are reproduced (Figure 7). The most complete sequence of strata can be seen at the south end of the shale pit of the New Corunna Brick Company (Figure 7, column E). Details of the section are given below:

Overlying Bed	Grand River Group	*Thickness*
8	Sandstone	2.0 feet
7	Lignitic coal, lower part very shaly (overlain by "Lingula" shale at north end of pit)	2.0 feet
6	Light gray, somewhat sandy, micaceous underclay, grading downwards into sandy shales which overlie lentil of sandstone conglomeratic at base. In north end of quarry the sandstone is fine-grained and argillaceous and contains many remains of *Cordaites*	6.5 feet
5	Thinly bedded, light colored sandy shale, containing elliptical clay ironstone septaria with calcite and gypsum veinlets. In north end of quarry a black shale, resembling shale at base of quarry, is found above the sandy shales	6.5 feet
4	Thin stratum of reddish weathering hard calcareous sandstone containing imperfectly preserved and fragmentary fossils	1.0 feet
3	Fissile, dark gray shales	8.0 feet



SECTIONS NEAR CORUNNA, MICHIGAN
M = MARINE FOSSILS
FIGURE 7

2	Arenaceous shales overlying light gray to white micaceous, medium grained sandstone. In north end of pit, a sandstone lentil in the upper sandy shales, contains 2 species of Megalopteris	7.0 feet
1	Black, compact plastic shale containing *Lingula carbonaria* and the foraminifera *Psammophis* sp. and *Cornuspira* sp. probably overlying coal seam mentioned by Brown (1926 p. 373)	2.0 feet

An analysis of this section shows that it may be subdivided into four cyclical formations. The upper part of the first, or *A*. formation is represented by bed 1; formation *B* includes the overlying strata of 2, 3, and 4, which have a thickness of 16 feet; formation *C* is represented by the succeeding six and a half feet of sandy shales with the black shale included in bed 5, and formation *D* includes beds 6 and 7.

The fossils found in bed 4 are mainly pelecypoda with a few gastropoda. Their imperfect preservation and fragmentary condition render even generic identifications doubtful. The genera *Astartella, Pleurophorus,* and *Macrochilina* may be represented.

The beds are easily traced along the east side of the shale pit from south to north. Strata of beds assigned to cycles "C" and "D" thin and disappear northward. That the disappearance is at least in part due to erosion is clearly evident in the coal beds belonging to cycle "C" and shown in column D, Figure 7. One can readily see that that seam beveled within a distance of 50 feet. The upper strata dip with the inclination of the unconformity, and at the northern end of the pit, a black shale, containing a recurrence of *Lingula carbonaria,* caps the coal of cycle "D". About 2000 feet northward, in the pit of the Barry Coal Company, the "D" coal, overlain by the *Lingula* shale and underlain by its characteristic underclay, is observed about 24 feet below the surface of the plain (Figure 7, C). A coarse grained sandstone, probably bed 8 and like it assigned provisionally to the Grand River group, unconformably overlies the coal, and farther north it overlies the underclay.

The sections in the York pit (Figure 7, columns A and B) show a rise of "D" coal from north to south. The coal at the south end of the York pit is almost at the same elevation as the same bed in the north end of the New Corunna Brick Company pit. A line drawn between these two locations gives the approximate trend of one of the valleys of Saginaw time, which appeared to influence the localization of erosion during Grand River time. A similar occurrence of superimposed unconformities is also illustrated at Grand Ledge.

The absence of an undoubted suggestion of the Verne fauna from this

locality makes correlation with other sections highly speculative. The *"Lingula"* horizons are unreliable markers and of little value in inter-areal correlation since in one area, the Grand Ledge district, as many as three such horizons have been found. A plant horizon containing apparently identical species of *Megalopteris* as those found in the lowermost beds in the Grand Ledge section, however, points to general similarity in age. The lithology, particularly of beds 3 and 4, formation "B" and bed 5 of formation "C" on the other hand, is decidedly different from anything at Grand Ledge and more like that of some beds in the Williamston section.

Outcrops of sandstone also appear upstream along the banks of the Shiawassee River in section 36, T. 7 N., R. 3 E. The sandstones are flaggy, buff-weathering, and medium grained, and are about four feet thick. They contain considerable mica, and are more like the sandstones of the Saginaw than of the Grand River formation.

Clinton County. The outcrops noted in Clinton County are along both banks of the Grand River for a distance of at least two and one-half miles below the Eaton-Clinton County line. The beds can be correlated with those at Grand Ledge. From the nature of the underclay and the lithologic character and contained fauna of the black shale above the coal, the seam is assigned to the cycle E of the Grand Ledge section. (Figure 5, columns 7, 8, 9). A marked dip, perhaps only a local one, is noted. A few mines were operated in 1932, but in the past many more were worked. Coal was also dredged from the river bottom about 1000 feet north of the county line.

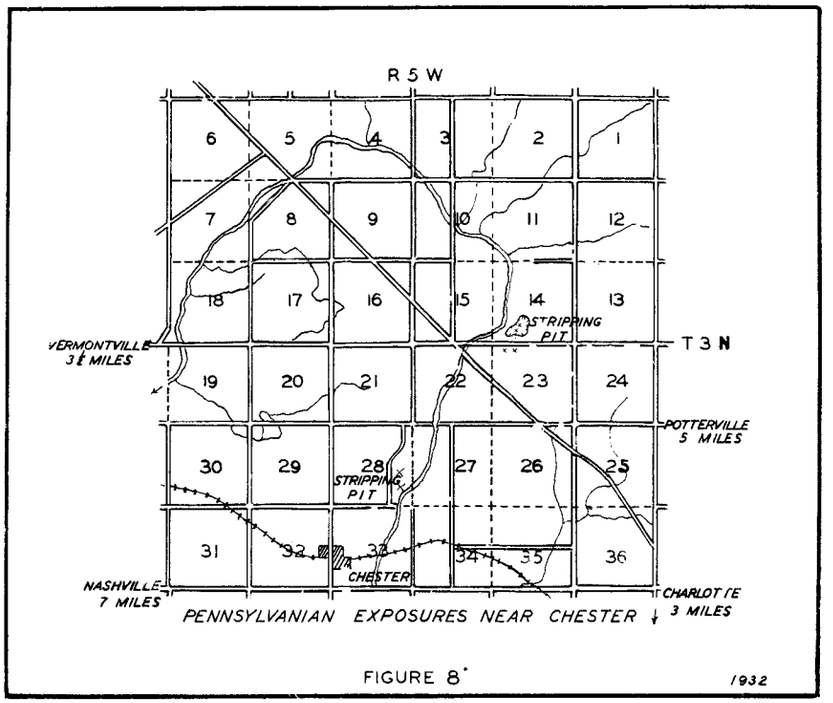
An outcrop of the fossiliferous limestone of the Verne cyclical formation is twelve feet above river level (Figure 5, column 10) close to the Grand River where it crosses the section line between sections 32 and 33, T. 5 N., R. 4 W.

The fauna collected includes the following species:

Marginifera missouriensis (G.)
Trepospira illinoisensis (W.)
Pseudorthoceras Knoxense (McC.)

Eaton County: In addition to the Grand Ledge exposures, already described (pp. 177-184) a few other outcrops are known in Eaton County.

Outcrops of coal along the valley of the Thornapple River in the vicinity of Chester were reported by Rominger, in his report on the Geology of the Lower Peninsula (1876, p. 130). The locality was visited in 1928 and again in 1932, at the time of active coal-stripping operations. Two exposures were observed, one near the section line between sections 14 and 23, T. 3 N., R. 5 W., and the other in the southeast quarter of section 28 of the same township (see Fig. 8).



The more northerly of the two localities is about 8 miles southwest of Grand Ledge and is on the eastern side of the Thornapple Valley. The coal averages about 3 feet in thickness, and, where observed, was overlain directly by glacial drift. The underclay is soft, and resembles somewhat the highest coal seam of the Grand Ledge section. Exposures of the coal may be seen along the road between sections 14 and 23, and also in the excavations made by coal stripping operations.

The second locality is about 1½ miles southwest, on the western side of the valley. The entire thickness of the section exposed was about eight feet. Descriptions of the beds follow:

Overlying bed	Drift	Maximum observed thickness
5	Light, slightly sandy shale	2.0 feet
4	Black, compact plastic shale with *Lingula carbonaria*	1.0 feet
3	Coal, canneloid at base	1.3 feet
2	Sandy underclay with *Stigmaria* rootlets	3.5 feet
1	Fine grained sandstone with many *Cordaites* leaves	2.5 feet

The beds exposed here, like those to the north, displayed a marked inclination to the north. In the limited exposures a dip of five feet in fifteen was observed.

Although but a small part of the stratigraphic section can be observed at either locality, it is very likely that the beds are the same. They are, therefore, tentatively correlated. It is probable that extension of mining activities to the northeast may show that these beds are present in the Grand Ledge area.

Outcrops in the vicinity of Eaton Rapids, Dimondale, and Potterville have been reported by Winchell (1861, p. 121), Rominger (1876, p. 130), and Lane (1902, p. 121). None of these was observed, however, although a search was made for them. It is probable that the dams along the Grand River near some of the towns mentioned above, have raised the water level sufficiently to conceal the outcrops mentioned by Rominger and Lane. Slumping, followed by growth of vegetation, may account for the absence of exposures near Potterville. That bed rock is close to the

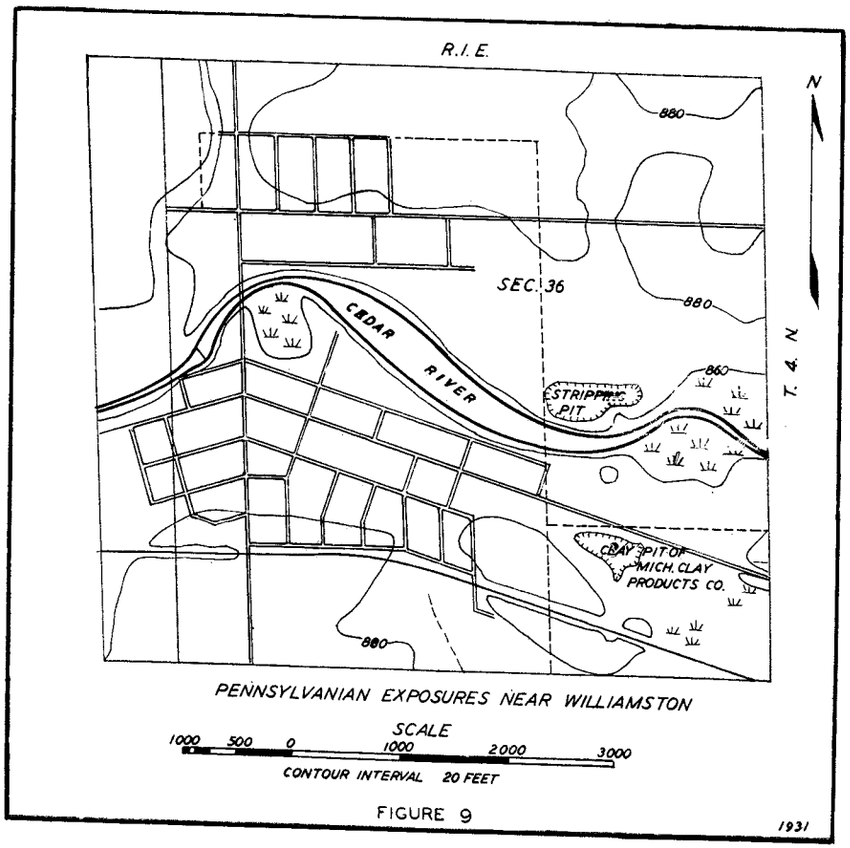


FIGURE 9

surface is indicated by blocks of sandstone thrown out on the banks of a drainage ditch in section 26, T. 3 N., R. 4 W.

Ingham County—Several outcrop localities within Ingham County are mentioned by Lane (1902, pp. 121, 205-218). Many of these are along the Grand River and are concealed since the erection of recent bridges and dams. One outcrop mentioned by Winchell in Locke township could not be located, (Winchell, 1861, p. 121), although a search was made for it.

In the excavation made to find a suitable foundation for the Capital Bank Tower in Lansing, sandstone was struck at a depth of 55 feet immediately below the glacial drift. Samples taken from below the drift were light gray, medium grained micaceous sandstones, characteristic of the Saginaw group.

The most extensive exposures of Pennsylvanian strata in Ingham County are near Williamston (Fig. 9), where quarrying operations have been carried on within recent years by the Michigan Clay Products Company. At the time of my visit the beds were exposed in an east-west direction for a distance of about 600 feet. A small anticline with a north-south strike exposes some of the older beds near the center of the quarry; thus giving a total exposure of about 60 feet of shales and sandstones.

Overlying bed	Drift	Maximum observed thickness
15	Steeply dipping, white to light gray, medium grained micaceous sandstones and shales exposed in channel cut into underlying strata	10.0 feet
14	Black fissile shale	1.5 feet
13	Very dark gray, clay ironstone stratum with rectangular fracture partly filled with sphalerite. Uppermost layer with scattered specimens of *Anthracomya* sp. as at Grand Ledge	0.5 feet
12	Black irregularly stratified compact shale	3.0 feet
11	Coal and carbonaceous shale	0.2 feet
10	Sandy underclay grading into light gray shale below	1.5 feet
9	Coal and highly carbonaceous shale	0.1 feet
8	Sandy underclay about four inches thick with fragments of *Stigmaria* overlying white, soft, underclay with oolitic texture succeeding to light gray, soft underclay. Lower boundary indefinite because of gradation into the underlying shale	2.5 feet

7	Black moderately fissile shales containing numerous elliptical clay ironstone nodules	4.0 feet
6	Light gray to white underclay with irregular nodular masses indurated by ferruginous cement. The nodular masses have an oolitic texture. This bed has a variable thickness	3.0 feet
5	Coal with cubical fracture and tendency also to break into slabby layers. This bed is cut off in a short distance by an unconformity	1.7 feet
4	White soft underclay with rusty streaks	4.0 feet
3	Gray, flaky shale with numerous nodules having septarian structure, the septaria formed in part by sphalerite	11.0 feet
2	White, soft underclay	3.5 feet
1	Black, compact plastic shale with a visible thickness of	5.0 feet

The Williamston section can be subdivided into six cyclical formations. The first, or *A*, cyclical formation is represented only by bed 1; formation *B* includes beds 2 and 3 with a thickness of about 10 feet; formation *C* consists of beds 4 and 5 with an observed thickness of somewhat less than 10 feet, and is separated from formation *D* by a fairly well marked unconformity. Formation *D*, made of beds 6 and 7, is only six feet thick. Formation *E* consists of beds 8 and 9, less than three feet thick, and beds 10, 11, 12, 13, and 14, which together have a total thickness of about seven feet, make up formation *F*. The beds of the higher formations are sometimes cut off entirely by the unconformity at the base of the channel shales and sandstones which represent formation *G*.

The anticlinal structure observed in the section is in part at least dependent upon an unconformity. This is illustrated by a series of columnar sections (Fig. 10) made on the north side of the shale pit, which show that beds of the lower and upper cyclical formations, such as *B* and *D*, have less inclination on the eastern limb than do the beds of the intervening formation *C*.

Some of the beds are exposed on the north side of the river by the recent (1933) coal stripping operations. The upper beds here are sandstone (Fig. 10, column E), and they replace unconformably the beds of cycles *D*, *E*, and *F*, (Figure 10, column D), the sandstone at times resting directly upon the coal of cycle *C*. The beveling of older strata produced during the erosional interval preceding the deposition of sandstone is plainly observable in the western part of the pit.

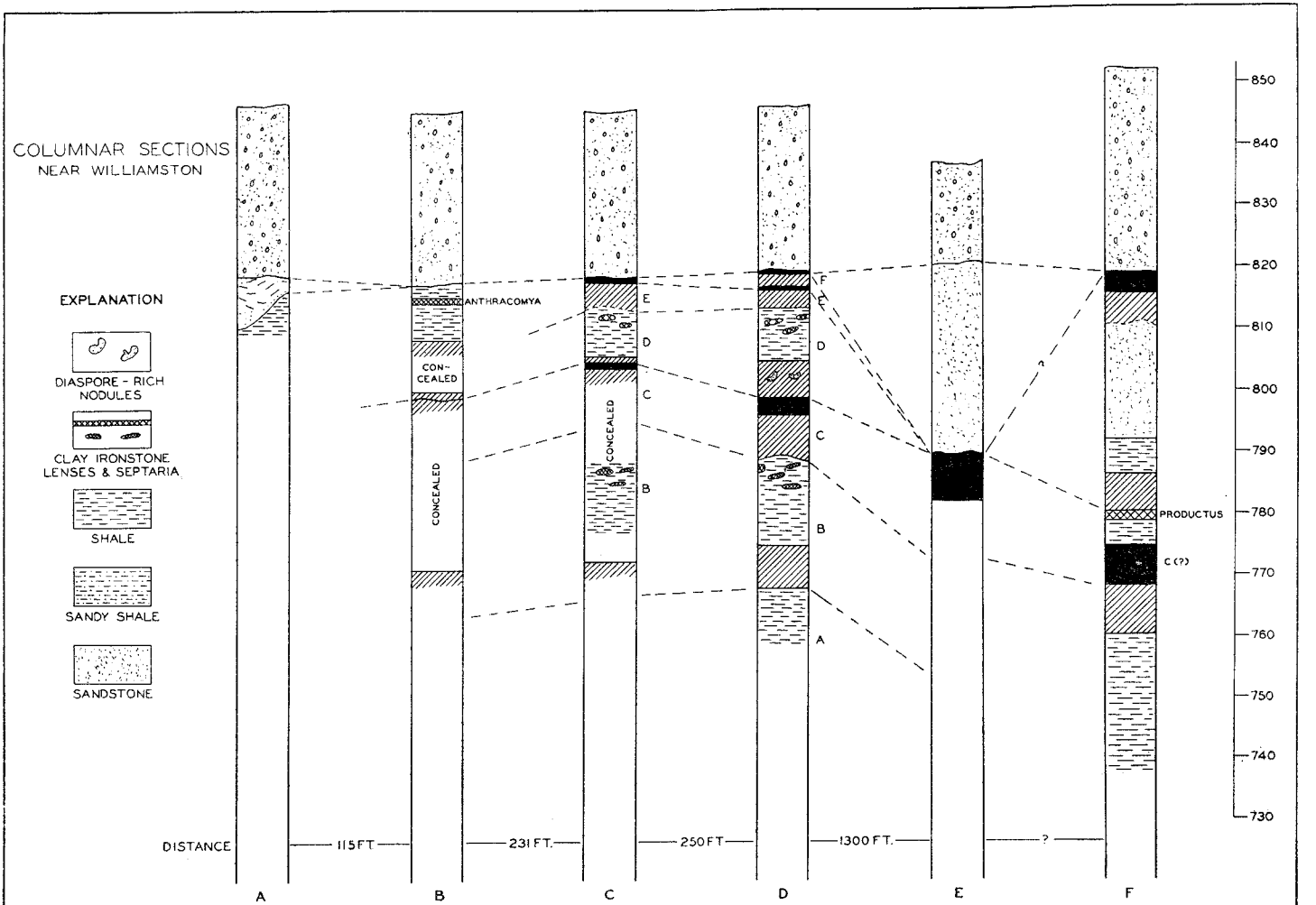


FIGURE 10

Columnar Sections measured near Williamston, Ingham County.

A. South side of highway, west end of shale pit, Michigan Clay Products Company.
B. North side of pit, 115 feet east of section A.
C. North side of pit, 230 feet east of section B.
D. North side of pit, 250 feet east of section C.
E. North side of river. Coal stripping pit.
F. Rominger's Section (Rominger, 1876, p. 135)

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No trace of the Verne fauna was noted in the sections described above. It is interesting to note, however, that Rominger (1876, p. 135) reports a *Lingula,* a *Discina,* and *Productus* and compressed lamellibranchs from a shaft near Williamston. I have seen shale specimens in the Museum of Paleontology of the University of Michigan, labeled Williamston. The shales have numerous specimens of *Orbiculoidea missouriensis* (S.) and crushed specimens of a relatively large *Anthracomya.* Although these two fossils have little stratigraphic significance, Rominger's mention of *Productus,* perhaps a *Marginifera missouriensis,* does suggest the Verne fauna.[1] Rominger's section (Fig. 10, Col. F.) is given below, and compared graphically with my sections in Figure 10:

Rominger's section (Rominger, 1876, p. 135)

Overlying bed—Drift	—15 feet
—Coal seam	—20 inches
—Fire clay with seams of sand rock	—12 feet
—Black shale	— 3 feet
—White, soft fire-clay	— 3 feet
—Kidney ore	— 6 inches
—Black, slate-like shale containing *Lingula,* etc.	— 2 feet
—Coal from	— 3 to 3½ feet
—fire clay	— 4 feet
—Gray shales	—12 feet

I suggest a correlation of Rominger's lower coal seam with the coal of formation *C,* since inquiries in the neighorhood of Williamston indicate that the coal of formation *C* was the one mined most extensively in the past. The absence of a fauna above that coal in the shale pits is readily explained by the unconformity at the base of formation *D.* If this correlation be correct it makes formation *C* of Williamston equivalent to formation *F* of Grand Ledge. The strata of formations *D, E, F,* and *G* would include, therefore, some of the youngest beds of the Saginaw exposed in Michigan.

The *Productus* horizon mentioned by Rominger is at an estimated elevation of about 830 feet above sea level. Its relation to the Verne limestone in Eaton, Shiawassee, Saginaw, and Bay counties is shown in Figure 4, Column 6.

Coal also is in section 33, T. 3 N., R. 1 W., where it was exposed in a drainage ditch. An excavation in this locality is said to have exposed two seams of coal, each about 45 inches thick and separated by a thin shale

[1]In the spring of 1934 Prof. S. G. Bergquist of Michigan State College, discovered two thin seams of spore coal in a recently opened pit near Williamston. Samples were examined by Dr. George Sprunk, formerly with the Pittsburgh Experiment Station of the Bureau of Mines, who reported a similarity between the spores of the Williamston coal and the Pottsville Elkhorn coal.

parting. The report could not be verified because the excavation had been filled. In the winter of 1934 some coal was mined from the northern part of the section.

Jackson County—Beds assigned to the Saginaw group were formerly exposed within the city of Jackson (Rominger, 1876, p. 123), but those outcrops are now concealed by buildings. A quarry north of the city of Jackson in section 11, T. 2 S., R. 1 W., and near the confluence of Portage River with Grand River, (Figure 1) exposes a series of shares interbedded with a minor amount of sandstone. The shales were formerly worked by the American Vitrified Products Company. The oldest beds are in the northeastern part of the quarry, which was partly filled with water at the time the exposures were visited. The beds have a gentle inclination toward the south, and may be an example of secondary dip since limestones assigned to the Bayport formation of the Mississippian, outcrop and at a higher elevation one quarter mile north, and at a lower elevation about 3 miles south.

A section was measured by tracing beds from one part of the quarry to the other. The details of the section are given below:

Overlying bed	Drift	5.0 feet
12	Thin ledges of light gray, fine-grained micaceous sandstone containing about one percent zircon	9.5 feet
11	Concealed. Talus shows light and dark gray shales	10.0 feet
10	Clay ironstone layer	0.5 feet
9	Light gray shale, grading into bed 8, the contact irregular	1.5 feet
8	Black, compact shale with 6-inch clay ironstone parting	5.5 feet
7	Black shale with clay ironstone layers	1.5 feet
6	Coal	0.3 feet
5	Light gray, soft underclay with carbonaceous residue	2.5 feet
4	Black, somewhat fissile shale	0.5 feet
3	Hard, fine-grained sandstone	0.5 feet
2	Light gray, somewhat sandy, nodular underclay with fragments of *Stigmaria* near top	3.0 feet
1	Dark gray, thinly-bedded compact shale with clay ironstone layer near base	6.0 feet

Materials thrown out from the deepest part of the quarry show that the lowermost strata are made up of black shale with many clusters of crystals of iron pyrite.

The exposed section indicates at least three and possibly four cycles of sedimentation. The upper part of the first, or *A* cyclical formation, is the underclay bed 2. Cyclical formation *B* includes 3 to 10, the last two of which appear to be the weathered product of bed 8. Shale of marine origin is probably represented by bed 8. Although no fossils were obtained from it, the lithologic characters of this shale are very similar to the "Lingula" layers of other localities. If this interpretation is correct, the concealed area, bed 11 of the section, together with beds showing evidences of being weathered products, namely beds 9 and 10, must represent cyclical formation *C*. The lower beds of cyclical formation *D*, are represented by bed 12.

Specimens of highly argillaceous limestone containing *Lingula carbonaria,* and now in the collections of the Museum of Paleontology at the University of Michigan, and labeled Blackman, Jackson County, may be from a locality near that mentioned above, since Blackman is the name given to T. 2 S., R. 1 W. The brachiopod *Lingula* indicates the presence of marine, or at least brackish water conditions in this area during Pennsylvanian time, but does not aid in correlating the sections in Jackson County with sections to the north.

Rominger (1876, p. 127) records the occurrence of *Lingula* and some compressed shells of lamellibranches from Jackson. Specimens of shale in the Museum of Paleontology of the University of Michigan, labeled Jackson, Jackson County, contain *Lingula carbonaria,* and Rominger's specimens probably belonged to the same species. The compressed lamellibranchs referred to by Rominger are either lost or else were never deposited in any collection available to me. They may have been specimens of *Anthracomya,* which is commonly found in a crushed condition, and not necessarily individuals of the Verne fauna (Lane, 1902, p. 43).

Several abandoned mines in Jackson County were visited, and collections of sandstone, shale and coal samples were made from the dumps. One of the abandoned mines, known as the Sam Graham mine, is also one of the Woodville mines, being located in the NE¼ section 25, T. 2 S., R. 2 W. The sandstone samples are assigned to the Woodville formation. The shales, although burned to brick-like consistency, are typical of the shales of the Saginaw formation, and contain plant remains, among which is a species of *Lepidodendron* and one of *Cordaites.*

Other Counties—Most of the counties which are partly or wholly underlain by beds belonging to the Saginaw group, do not possess any outcrops. These counties are not referred to in this report since there are no existing records. Descriptions of developments and borings within the coal basin are given in Lane's report (Lane, 1902, p. 157-220).

Chapter IV

GRAND RIVER GROUP

NAME

The Pennsylvanian formations in Michigan which are stratigraphically higher than beds of the Saginaw group, have been variously called Woodville, Ionia, and Red Beds. Of these three terms, Woodville has undoubted priority, and its history is briefly reviewed.

Woodville is the name by which Winchell (1861, pp. 115 and 125) provisionally designated the "friable, rather coarse, quartzose sandstone stained to a variable extent with oxide of iron" which he found to be "the capping stone of the coal measures." The type locality was the "good exposure in the cut of the side track from the (Woodville) mine to the Central Railroad." The name has no reference to the village of Woodville, in Newaygo County, but to the old Woodville mine in Jackson County.

Rominger (1876, pp. 122, 128, 129) did not retain Winchell's term and grouped all beds younger than the Bayport under the term Coal Measures. At a later date the name Woodville sandstone was revived by Lane (1895, p. 15), because he thought the coal series ended with a sandstone often enough to justify its separation. In his coal report Lane (1902, pp. 40, 41, 175, 195) uses the name Woodville sandstone, although indicating in most cases that a doubt existed in his mind concerning the intra-state correlations that he made. In an article on the geological column of Michigan, Lane (1909, p. 83) retained the name Woodville sandstone, although he states that Ionia would be a better name for the sandstone which caps the Saginaw group in the central part of the coal basin. Other authors since Lane's time have continued to use the term Woodville, although with such doubt as to partially justify Rominger's scepticism regarding its propriety. Lately the term has been abandoned by R. B. Newcombe (1931) in the classification of formations shown on his map of the Southern Peninsula of Michigan, but it is still recognized by the U. S. Geological Survey and is being used on the geologic map of the United States which is in course of publication (Miser, H. D., 1932).

The principal difficulty with the term Woodville sandstone is in connection with Winchell's definition that it is the capping stone of the Coal Measures, or Saginaw group, as the series is called in this report. It is not known certainly whether the Woodville sandstone at the type locality represents a lentil of limited distribution which should be grouped with the sandstones of the Saginaw group—which Rominger must have

thought might be the case—or whether the Woodville sandstone is a formation younger than any member of the Saginaw group, as the sandstones outcropping in the vicinity of Ionia seem to be. The use of the term Ionia would meet with less objection. However, to apply the name Ionia to sandstones, such as those outcropping near Grand Ledge, would either imply correlation, or else involve the use of the term in a group sense. Rather than introduce new difficulties of nomenclature, I, therefore, propose the term GRAND RIVER GROUP, and define it so as to include the massive, crossbedded, coarse grained sandstones which contain little or no mica, and which are frequently iron stained on fresh fracture.

The group includes the Woodville sandstone, the Eaton sandstone, and the Ionia sandstone.

EATON SANDSTONE

The name Eaton sandstone is proposed for the uppermost sandstones forming the bluffs or ledges along the valley of the Grand River and its tributaries in the vicinity of Grand Ledge in the northern part of Eaton County. The beds are post-Saginaw in age, but their true stratigraphic relations to the Woodville sandstone, the Ionia sandstone, or other strata of the Grand River group cannot be determined.

IONIA SANDSTONE

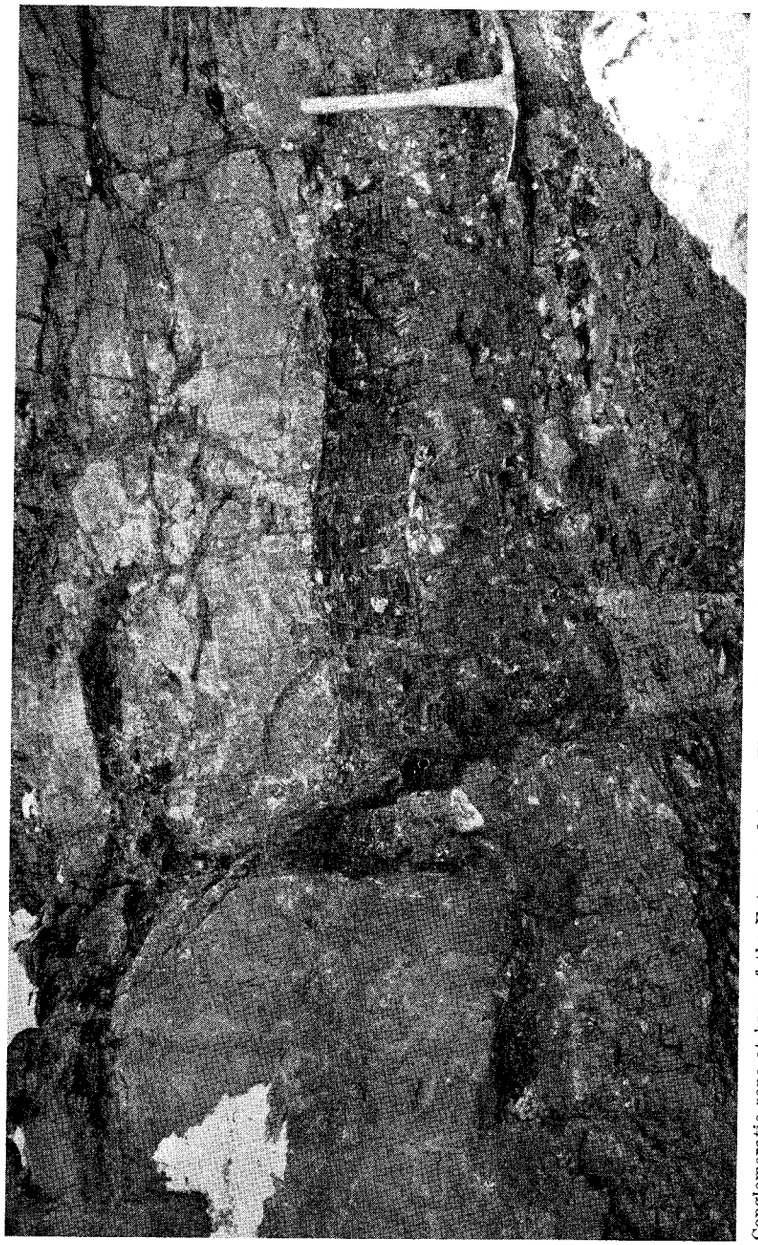
The name Ionia sandstone was originally suggested by Lane (1909, p. 83) for the sandstone which caps the Saginaw group in the central part of southern Michigan. The name is familiar to Michigan geologists and can well be applied to the cross-bedded, coarse grained, vari-colored sandstones outcropping in the valley of the Grand River near Ionia. Ionia sandstone overlies the shales and micaceous sandstones of the Saginaw group.

The Grand River group overlies the shales and light-colored, typically micaceous sandstones of the Saginaw group, and underlies the shale and gypsum beds in the upper part of Newcombe's Red Beds (Newcombe, 1931.) Formations of Grand River group are exposed in mines and quarries, and natural outcrops in the valley and drainage basin of the Grand River, from the vicinity of Jackson to that of Ionia.

SOURCES OF STUDY

Information on the Grand River group has been gained from literature and from specimens collected from several localities within the State. The chief outcrop localities of the Grand River Group are shown on a map included in this report. (Figure 3).

PLATE V



Conglomeratic zone at base of the Eaton sandstone. The pebbles consist of nodules derived from the Saginaw underclay. A long band and many lenticular streaks of coal may be seen.

STRATIGRAPHIC RELATIONS

The relations of the Grand River group to the Saginaw group has already been given. It is known, however, that the Saginaw group is not always capped by a sandstone, since mines in Saginaw county (Smith, 1917, p. 225) and wells drilled in Roscommon and Ogemaw counties have struck shale and gypsum beds just above shales and sandstones assigned to the Saginaw group. Where the gypsum beds have been reported in association with a Grand River sandstone, (Smith, 1917, p. 225) that sandstone underlies the shale and gypsum. The shale and gypsum series does not outcrop in Michigan. Newcombe (1932) refers to this series as the "Red Beds." I have had no opportunity to study this series and hesitate to include it in the Grand River group, because of the marked difference in lithology.

LITHOLOGIC AND OTHER CHARACTERS

The Grand River group consists predominantly of coarse sandstone, although conglomeratic beds are present near the base. The basal conglomerates have irregular fragments of coal, shale, and clay ironstone included in a sandstone matrix. (Plate V). The sandstones consist chiefly of quartz with a siliceous or ferruginous cement. Subordinate feldspar, and a small amount of heavy minerals are also present. Tourmaline and zircon are the most common of the heavy minerals. Many of the heavy mineral grains show well formed crystal outlines.

The lower beds of the Grand River group are believed to be exposed in the vicinity of Grand Ledge, where the contact is markedly irregular. The formation seems to have a localized occurrence. This may be illustrated in the vicinity of Grand Ledge and also near Ionia, where a well just south of the city (Smith, 1917, p. 225) starting at 660 feet above sea level, struck gypsum at 93 feet and red sandstone at 97 feet below the surface, although about four miles east red sandstone outcrops in the flats of the Grand River at an elevation of a little over 660 feet above sea level. The sandstone beds near Ionia are about 80 feet thick (Rominger, 1876, p. 134). Erosion on a large scale is indicated here if we assume the gypsum to be younger than the Grand River group. Red colors appear to be characteristic. In the sandstones capping strata of the Saginaw group at Grand Ledge individual beds show rusty layers alternating with layers of white sandstone, seeming to indicate that the color originated contemporaneous with the formation of the sediment, and was not due to post-Pleistocene weathering. This feature is in strong contrast to the gray and light buff sandstones of the Saginaw group.

Inner and outer molds and thin carbonized residues of such plants as Calamites and Lepidodendron are scattered through the lower beds. I

have never found any plant remains in the upper beds near Ionia, although they have been reported. (Rominger, 1876, p. 134). From the fragmentary character of the fossils found in the Eaton sandstone it is possible that most of them were transported to the sites of burial.

The various characters of the Grand River sandstones indicate a fresh water origin. I am inclined to believe that much of the formation is due to river deposition, and that some of the beds are channel sandstones. The sediments were deposited under climatic conditions which differed considerably from conditions which obtained during the deposition of the Saginaw group, and the changed climates are reflected in the brown and red colors of the younger formation. Distribution of the Grand River sandstones is probably largely dependent upon the trends of post Saginaw valleys.

THICKNESS

The thickness of the Grand River group (Woodville sandstone) has been variously estimated by different authors. Winchell (1861, p. 115) gives 30 feet for a mine close to the type locality and Rominger (1876, p. 134) cites 80 to 110 feet for the sandstones near Ionia. Rominger's assistant (Lane, 1902, p. 195), reported from memory a thickness of 143 feet in a well a few miles east of Ionia. In a report on deep borings, Lane (1895, plate 73) gives an estimate of 304 feet but in his report on the geological column of Michigan the thickness given for the Woodville is 80 feet. The columnar section on the 1916 edition of the geological map of Michigan gives 100 to 110 feet (Allen, 1916). Most of the later publications, including Newcombe (1928, p. 157) give 80 to 95 feet. The last estimate will be used in this report, with the implication that it applies to any single section.

CORRELATION

The Grand River (Woodville) has for some time been correlated with the Conemaugh (Lane, 1909, p. 83). This correlation was based largely on the prevalence of sandstone in the Conemaugh. At present there seems some likelihood that an inter-basin correlation based upon more than lithological evidence is possible. The few plant remains found in the basal sandstone at Grand Ledge and other localities have not been described. From their occurrence as inner and outer molds it is probable that they are not derived from the Saginaw group, but that they represent plants which grew contemporaneously with the deposition of Grand River sediments. I have never found plant fossils in the sandstones near Ionia, but if such are found they would have added significance.

Correlation of the sandstones within the State is also a difficult matter. The original statement by Winchell (1861, p. 126) that the Woodville occurs in the Woodville mine in Jackson, in Ionia County, at Corunna, and Owosso, as well as the type locality, never seems to have been carefully checked. I have attempted to trace some continuity between the sandstones at the southern end of the basin with sandstones near Ionia by an examination of well samples. The problem is a difficult one, since most drillers do not save samples until they reach the Mississippian formations. In general the statement of Winchell's referred to above is substantiated. To the occurrences mentioned I would add those of Grand Ledge, evidence being put forward for this correlation under the discussion of local details.

WOODVILLE SANDSTONE

Jackson County—The exposure of sandstone which Winchell chose as the type locality of the Woodville formation can no longer be observed. Winchell gives a section measured in a mine shaft close to the type locality (Winchell, 1861, p. 115) and this is reproduced here for the sake of reference.

E	Superficial materials	12 feet
D	Woodville sandstone	30 feet
C	Shales, dark, bituminous, with 6 feet of fine light colored clay	43 feet
B	Bituminous coal	4 feet
A	Underclays	3 feet

The elevation of the contact between beds *C* and *D*, judging from the general elevation of that area, is about 925 feet.

I collected samples from the dump of an abandoned mine, which, from its situation in the northeast quarter of section 25, T. 2 S., R. 1 W., must be close to the original Woodville mine. The samples studied are moderately coarse grained and consist principally of quartz intermixed with minor amounts of carbonaceous and argillaceous particles. Little or no mica is present. Some specimens display reddish and purplish red colorations, and resemble some of the beds in the quarries near Ionia.

EATON SANDSTONE

Eaton County—The coarse grained porous sandstones outcropping in the vicinity of Grand Ledge have a maximum thickness of 50 feet. The sandstones are separable into two divisions, a lower massive and an upper bedded. Between the two a shale parting is sometimes present. In the quarry of the American Vitrified Products Company the lower beds are

PLATE VI

Shale boulder at the base of the Eaton sandstone. It overlies undisturbed shale of the Saginaw Group.

distinctly cut off by an unconformity and replaced by shale which seems to have filled a small channel. The upper beds overlie the lower sandstone in one locality, and where these are cut off overlie the channel shale. It is not always feasible to map the two divisions separately and they appear under one symbol on the map (Fig. 3). The lower sandstones, however, have a limited distribution. The lower contact is highly undulating and appears to correspond to the slopes of the valleys (Kelly, 1932), the elevation of the contact varying between 795 and 830 feet above sea level.

The lower beds of the sandstone are conglomeratic and characterized by fragments of shale, coal, and nodules. (Plate VI). The upper bedded sandstones are more uniformly distributed, and where absent give evidence that absence was due to comparatively recent erosion. They appear to have been deposited after the initial topographical irregularities were filled. The texture and composition of both the lower and upper sandstones is very similar. Quartz, the principal constituent, is mixed with a little decomposed feldspar and from 5 to 10 percent of decomposed silicates occur as mud and silt between the sand grains. Iron oxide as a cement forms up to 5 percent of the rock. On weathered surfaces the rock appears a rusty brown, but on fresh fracture the glassy quartz alternates with white silicates and rusty red grains of quartz, giving the rock a fine mottled appearance. Some beds show distinct grouping of colorless or white grains, and of rust colored grains. Tourmaline and zircon are both found in small amounts.

The outcrops of this sandstone extend along the valley slopes into Clinton County. A small outcrop occurs in the bed of a creek discharging into Looking Glass River, in section 14, T. 5 N., R. 4 W. The lithology is similar to the Eaton sandstone at Grand Ledge.

Ionia County—Sandstone is quarried on the flats of the Grand River east of the city of Ionia in the west half of section 23, T. 7 N., R. 6 W. The quarries extend over a distance of about 2000 feet in a north-south direction, but the outcrops are only partly accessible since the pits are partially filled with water. The upper beds of the quarry are massive, but the beds at water level show marked cross-bedding, a structure brought out distinctly by the purplish-red coloration. Evidence of contemporaneous erosion is mentioned by Rominger (1876, p. 134). The sandstones are coarse and friable, although Rominger states that after quarrying they are more strongly indurated. The most peculiar character is the mottled and variegated coloring of some of the beds. The ground-mass is white, but purplish and red laminae are quite common. Quartz is the predominant mineral constituent. Under the microscope most of the grains appear clear and glassy, but some are coated with a film of ferruginous cement. Angular grains of zircon are relatively abundant.

This sandstone differs radically from the other sandstones referred to the Grand River group. Well records give a thickness of 80 feet for the formation, but no samples from the base of this sandstone are available for comparison with samples near the surface. The base, judging from Rominger's figures (1876, p. 134), is computed to be at an elevation of about 580 feet, and therefore considerably lower than the massive sandstones near Grand Ledge. Unless regional dips account for their depth, this seems to imply very deep post-Saginaw erosion in this locality. The lower beds may be the stratigraphic equivalent of the Eaton sandstone. If such a correlation is proved the name Ionia should take precedence over Eaton, because it is better known and was suggested at an earlier date.

No other sandstone outcrops within the county are known. The wells south of Ionia, however, report a few feet of red sandstone overlying the Saginaw and underlying gypsum and shale. The red sandstone may represent the Ionia, and if so, appears to imply that it too was subject to erosion before the deposition of the gypsum series.

Shiawassee County—The upper sandstone beds exposed in the quarry of the New Corunna Brick Company near Corunna are about two feet thick. The basal layer is conglomeratic. The upper layer is a coarse-grained sandstone consisting of quartz grains held together by a cement of iron oxide and argillaceous material. A little mica is present and tourmaline is comparatively common. The rock has a resemblance to the Eaton sandstone at Grand Ledge and is tentatively included in the Grand River group.

The elevation of the lower contact of the sandstone is about 765 feet above sea level, but within a distance of a quarter of a mile the same contact was observed 25 feet lower (Fig. 5, column C).

Other Counties—A large area in central Michigan is underlain by sandstones, shales, and gypsum assigned to the "Red Beds" (Newcombe, 1931). So far as I am aware, however, there are no exposures of the Grand River group in counties other than those described.

STRUCTURE

Several authors, (Lane, 1902, p. 30; Smith, 1912, p. 263; Newcombe, 1928, p. 156) have stated that the beds of the Saginaw group do not share in the basinward dip of the pre-Pennsylvanian formations. I do not agree with this statement entirely but believe that the beds of the Pennsylvanian do reflect a structure that cannot be adequately explained by primary dips alone.

There is reason to believe, as was shown under the discussion of stratigraphy, that the limestone member of the Saginaw formation, to which the name Verne is applied, and the unconformable boundary between the

Saginaw and Grand River groups can be recognized wherever encountered. I have noted the available evidence concerning the elevation of the Verne limestone and the Saginaw-Grand River contact in several counties.

The data are scanty, but what there are indicate that a low area, roughly parallel to the axis of Saginaw Bay was in existence during Pennsylvanian time. It is interesting to note that this statement supports Winchell's conclusions (1861, p. 125) that the center of the coal basin lay along the axis of Saginaw Bay. The indication supports in a general way the conclusions drawn by R. B. Newcombe (1932) that post-Devonian folding in Michigan differs in trend from that of pre-Devonian time. The folding initiated perhaps in Mississippian time was probably continued in post-Verne time. This seems to be indicated in the great difference in elevation between the Verne limestone at Grand Ledge and the same limestone in the Saginaw valley. This is partly borne out by observations made on the joint system in the Grand Ledge area. The master joints have average trends of about N. 50 E. and N. 50 W. respectively. The dips of the joint surfaces approach the vertical. The joint system suggests shear planes due to a deformation involving torsion which took place subsequent to the deposition of the Eaton sandstone.

Recent work on the structure of the coal seam of cycle B of the Grand Ledge section by Messrs. Gordon Pringle, Gaylord Walker, and Rex Grant indicate an alignment of small pitching folds in a northeasterly direction. The absence of a haphazard arrangement of the folds may be due to unequal settling along some pre-Pennsylvanian ridge. The structures of the Pennsylvanian beds may reflect indirectly structures of the older systems. These minor folds are superimposed upon a regional structure, in which the beds have a northwest dip of about one-half degree.

In addition to the general northeast-southwest regional structure mentioned, the Pennsylvanian strata show numerous minor structures which are undoubtedly due to deposition upon an irregular surface and later settling and compaction of sediments. Examples of such structures are cited at Grand Ledge and Williamston.

REGISTER OF LOCALITIES GIVEN IN FIGURE 2 AND TABLE 2

A. Michigan Geological Survey No. 18978. Wolverine No. 3 Mine, Room 23, entry 4 W. of south part, S.E. corner, N.E. quarter, section 12, township 14 N., range 3 E.

B. Michigan Geological Survey No. 18999. United City Coal Mine, section 17, township 14 N., range 5 E. This locality is the same as No. 3 of the faunal list (Table 3) and No. 3 of the map (Fig. 2).

C. Michigan Geological Survey No. 18998. Bay Coal Shaft No. 2, S.E. quarter, section 4, township 13 N., range 4 E. Locality the same as No. 9 of figure 2 and Table 3.

D. Michigan Geological Survey No. 18997. Pittsburgh Shaft, quarter line section 15, township 13 N., range 4 E. Locality the same as No. 11 of figure 2 and Table 3.

E. Michigan Geological Survey No. 18989. Standard Mine, section 6, township 11 N., range 5 E. Locality the same as No. 14 of figure 2 and Table 3.

F. Michigan Mine, Black Pearl Shaft, near St. Charles. Locality near that of No. 15 of figure 3 and Table 3.

G. St. Charles Coal Company, near St. Charles. Locality near that of No. 15 of figure 2 and Table 3.

H. J. H. Somers No. 2 Shaft, near St. Charles. Locality near that of No. 15 of figure 2 and Table 3.

I. Big Chief Mine, St. Charles. Collector, C. A. Arnold. Locality near that of figure 2 and Table 3.

J. Owosso Coal Company, Owosso, Michigan.

K. New Corunna Brick Company, S.E. quarter, section 22, township 7 N., range 3 E. Locality the same as that of No. 22 of figure 2 and Table 3.

L. Grand Ledge district, sections 4, 5, 8, 9, township 4 N., range 4 W. Locality same as No. 24 of figure 2 and Table 3.

M. S.E. quarter, section 28, township 3 N., range 5 W., Eaton County. Collector, W. A. Kelly. Locality the same as that of No. 25 of figure 2 and Table 3.

N. Dump of Sam Graham Mine, N.E. quarter, section 36, township 2 S., range 2 W. Collector, W. A. Kelly.

O. Vicinity of Jackson, Jackson County. Locality probably the same as No. 28 of figure 2 and Table 3.

P. Unknown locality.

REGISTER OF LOCALITIES GIVEN IN FIGURE 2 AND TABLE 3

1. Section 3, township 19 N., range 4 E., Arenac County.
2. Wenona Beach Mine, section 33 or 34, township 15 N., range 5 E.
3. Michigan Geological Survey No. 18999. United City Coal Mine, Section 17, township 14 N., range 5 E.
4. Michigan Geological Survey No. 18993. Monitor Shaft, S.W. corner, SE. quarter, section 28, township 14 N., range 4 E.
5. Michigan Standard Coal and Mining Company, section 25, township 14 N., range 4 E.
6. Central Coal and Mining Company, section 30, township 14 N., range 5 E.
7. Michigan Geological Survey No. 18994. Central Mine Shaft. S.E. corner section 25, township 14 N., range 4 E.
8. Michigan Geological Survey No. 18995-6. Michigan Coal and Mining Company. S.E. quarter, section 25, township 14 N., range 4 E.
9. Michigan Geological Survey No. 18998. Bay Coal Shaft No. 2, S.E. quarter, section 4, township 13 N., range 4 E.
10. Michigan Geological Survey No. 18992. Valley Coal and Mining Company, S.E. corner, N.E. quarter, section 1, township 13 N., range 4 E.
11. Michigan Geological Survey No. 18997. Pittsburgh Shaft, quarterline, section 15, township 13 N., range 4 E.
12. Michigan Mine, Bay County. Specific location lacking. It may be the same as Number 8.
13. Uncle Henry Mine No. 2, Mine Dump, section 6, township 12 N., range 6 E. Collector, W. A. Kelly.
14. Michigan Geological Survey No. 18989. Standard Mine, section 6, township 11 N., range 5 E.
15. Somers Mine No. 1, near St. Charles.
16. Michigan Geological Survey No. 18983. Verne Mine, section 23, township 10 N., range 4 E.
17. Left bank of Cass River, one-half mile below bridge at Tuscola, section 29, township 11 N., range 7 E. Collector, W. A. Kelly.
18. Right bank of Flint River, near center of section 22, township 8 N., range 5 E. Collector, W. A. Kelly.
19. N.W. quarter, section 26, township 8 N., range 5 E. Collector, Alexander Winchell.
20. Mine dump near mouth of Six Mile Creek, section 18, township 8 N., range 3 E.
21. Strip mines in Section 22, township 7 N., range 3 E.
22. New Corunna Brick Company, S.E. quarter, section 22, township 7 N., range 3 E.
23. Grand River roof of mine and also outcrop near section line between sections 32 and 33, township 5 N., range 4 W.
24. Grand Ledge district, sections 4, 5, 8, 9, township 4 N., range 4 W. Collector, W. A. Kelly. The specimens indicated by a star were never observed by the author, but are reported by J. A. Cushman and J. A. Waters.
25. S.E. quarter, section 28, township 3 N., range 5 W., Eaton County. Collector, W. A. Kelly.
26. Williamston, Michigan. Collector, probably Rominger. Also, Shale pit of Michigan Clay Products Company. N.E. quarter, section 1, township 3 N., range 1 E., east side of Williamston, Michigan. Collector, W. A. Kelly.
27. Blackman, Jackson County. Collector unknown.
28. Vicinity of Jackson, Jackson County. Specimens cited in report by Rominger (1876).
29. Looking Glass River, section 14, T. 5 N., R. 4 W.
30. East one-half, section 33, T. 3 N., R. 1 W.
31. S. W. ¼, section 24, T. 1 N., R. 5 W.
32. Section 15, T. 1 S, R. 1 W.

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PART III

THE TRENTON AND BLACK RIVER ROCKS OF MICHIGAN

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Published as a part of the annual report of the Michigan Geological Survey Division,
Department of Conservation, for 1936

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THE TRENTON AND BLACK RIVER ROCKS OF MICHIGAN

ACKNOWLEDGEMENTS

The writer is indebted to several persons for assistance in the preparation of this report. To Professor E. C. Case, who directed the investigation, for help in the field work and in the preparation of the manuscript. Many of the correlations proposed in this paper were suggested in field conferences by Dr. E. O. Ulrich whose wide knowledge of stratigraphic relations in different areas was of the utmost value in the work. To Dr. R. A. Smith, the State Geologist of Michigan, through whom the funds were made available for carrying on the field work.

HISTORICAL REVIEW

James Hall. "Report on the Geology of the Lake Superior Land District," Foster and Whitney, Part Two, 1851. Pages 140-151. The most valuable part of this report is that dealing with the Ordovician section exposed along the Escanaba River. A general description of the rocks is given beginning at the mouth of the river and extending for several miles along the meanders of the stream. The changing attitude of the beds and lithologic and faunal differences were noted. Fossils were collected at numerous points along the river and these enabled Hall to correlate the beds with the typical New York section; the Chazy, Birdseye, Black River and Trenton horizons were recognized. It is easy to recognize today, from Hall's descriptions, several of the important points that were studied. The Trenton limestone exposed near the mouths of Rapid River and Ford River are briefly described and correlated with equivalent exposures along the Escanaba. The Ordovician rocks exposed along the lower course of the Menominee River and the eastern shore of Green Bay are briefly discussed. The report is very valuable because it outlines for the first time the general succession of Black River and Trenton rocks in Northern Michigan.

Alexander Winchell. "First Biennial Report of Progress of the Geological Survey of Michigan". 1861. Chapters 3 and 4 are devoted to a "General Sketch of the Geology of Michigan and its Connection with Surrounding Districts". A short discussion of the Trenton is given on pages 52-53, in which the following paragraph appears: "The Trenton Group forms a belt about 4 miles wide extending west-northwest across St. Joseph's Island, reappearing in the high bluffs opposite Little Sailor Encampment Island, and extending thence across the middle of Great

Sailor Encampment Island. From here it stretches west in a gradually widening belt, which, bending around to the southwest, lies with its southern border on the west shore of Little Bay de Noquet and Green Bay, whence it continues across Wisconsin into northern Illinois".

Dr. Carl Rominger. "Paleozoic Rocks", published by the Michigan Geological Survey in 1873. Pages 56-71. Dr. Rominger examined in particular the rocks exposed on St. Joseph's Island, along the Escanaba River, and on the west branch of the Whitefish River. The paper deals with the Trenton in a very general way and no detailed sections are described. The rocks along the Escanaba River were studied for several miles above the mouth of the stream and the general succession of beds was determined together with the important lithologic changes. Fossils were collected at several localities and several faunal lists are given. The numerous broad undulations in the rocks along the river were noticed as well as the general southeasterly dip of the beds. The total thickness of the Escanaba River section was estimated at about 100 feet.

E. C. Case and W. I. Robinson. Michigan Geological and Biological Survey. Publication 18, Geological Series 15. Pages 167-181. "The Geology of Limestone Mountain and Sherman Hill in Houghton County, Michigan".

In this paper the authors describe the geology and paleontology of three outliers of Paleozoic rocks lying half a mile east of the village of Hazel, Michigan. The generalized section includes rocks of Black River, Trenton, and Richmond age. The Upper Buff, Upper Black River, Upper Blue and Decorah of the Limestone Mountain section are represented by the same formations along the Escanaba River. Faunal lists are given for the various horizons.

GENERAL DISTRIBUTION AND ATTITUDE OF THE ROCKS

The principal outcrops of Black River and Trenton rocks in the Northern Peninsula of Michigan are found within a belt about 20 miles wide extending in a general northeasterly direction past the towns of Escanaba and Rapid River, with the eastern edge of the belt bordering the western side of Little Bay de Noc. The rock is close to the surface over the whole region but glacial drift and wooded areas cover it in most places. North and east of the town of Trenary the country becomes swampy and outcrops are exceedingly rare although the beds are apparently continuous beneath the surface and reappear at the eastern end of the peninsula on Drummond Island. A number of exposures are in shallow ditches along the roads but show only the upper surface of the rock. Typical fossils fortunately are found at most of the places and the beds may be placed in their proper stratigraphic positions. Very excellent outcrops are

afforded by a few quarries where the rock may be studied in great detail.

The best section is found in Delta County along the Escanaba River. Up stream from about 2 miles above the mouth of the river the rocks are almost continuously exposed for 20 miles along the meanders of the stream. The river flows over rock for the entire distance. The general dip of the beds is down stream or southeastward although in many places local dips are northwestward. In general stratigraphically lower beds appear upstream, but the same beds may reappear at several places along the river due to the numerous undulations in the rock. These flexures are probably the result of deposition upon an uneven sea bottom and to settling of the sediment after deposition. The nature of the bottom upon which the early Paleozoic sediments were deposited may be inferred from a study of the pre-Cambrian surface wherever it is exposed in Northern Michigan. This surface is always irregular and could easily account for many of the undulations in the Ordovician rocks along the Escanaba River and for the flexures in the beds of the Richmond formation above the Trenton.

RELATION OF THE TRENTON TO THE RICHMOND

The contact between the Trenton and the Richmond is not exposed at any of the known localities. The lowest member of the Richmond formation in Michigan is the thin-bedded, dark brown, Bill's Creek shale, described by the author in a paper on "The Richmond Formation of Michigan".[1] This shale has been correlated with the Maquoketa. The highest observed member of the Trenton is an uneven-bedded, argillaceous and dolomitic limestone. The Bill's Creek shale is exposed along Haymeadow Creek, about 10 miles northeast of Rapid River, Delta County, Michigan, and the Trenton limestone is found along the Whitefish River about a mile and a half west of the shale outcrop on the edge of the Hiawatha National Forest. The dip of the rocks in both places is very flat and the covered interval between the base of the Richmond and the top of the Trenton cannot be very great, probably not more than 5 feet. It is altogether probable that the Bill's Creek beds rest directly upon the Trenton although the exact nature of the contact is in doubt. However, it is reasonably certain that the contact is a disconformable one.

DETAILED DESCRIPTIONS OF SECTIONS

Black River

Exposure at Bony Falls (Loc. 9), Section 1, T. 41 N., R. 24 W., Delta County.

[1]Contributions from the Museum of Geology of the University of Michigan. Vol. 2, No. 8. July 15, 1926.

The Escanaba River at Bony Falls (Fig. 1) formerly tumbled over a ledge of rock and formed a waterfall about 30 feet high. The construction of a hydro-electric power plant diverted the water from the eastern part of this escarpment and produced an excellent exposure of the Black River. The rock at this location is stratigraphically the lowest part of the Black River section exposed along the river. The beds are nearly horizontal with a slight dip to the southeast. Above the dam the banks of the stream are low and muddy with no outcrops; below the dam the rocks are exposed in the vertical banks of the river for 200 yards. Outcrops are seldom found any distance back from the river because of the soil covering and the wooded nature of the country.

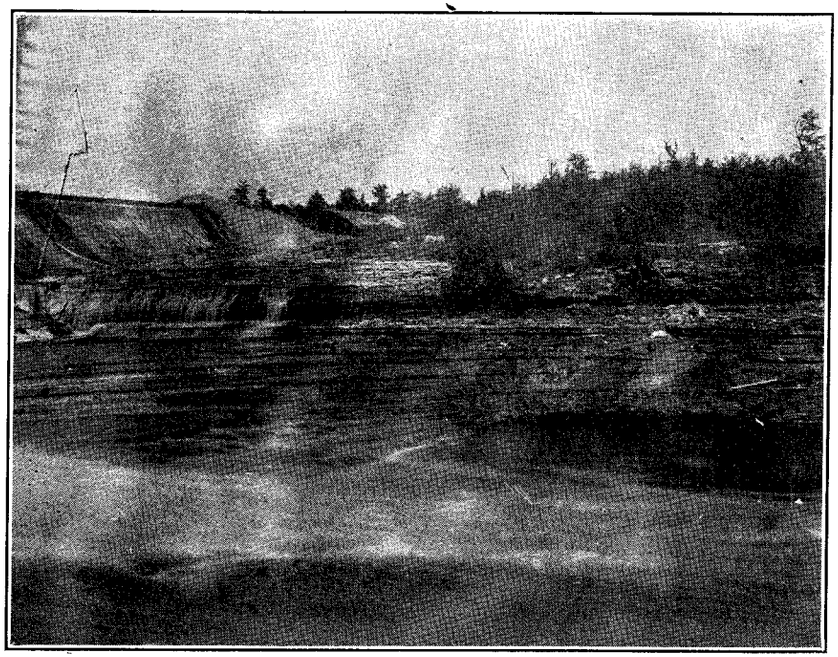

Fig. 1. Black River rocks exposed at Bony Falls, Michigan. Location 9.

Top of section	Feet	Inches
10. Limestone, argillaceous, buff colored. Equivalent to the Upper Buff of Wisconsin	2	0
9. Limestone, relatively pure, fine grained, laminated beds, with irregular partings of sandy interlaminations. Top layer thickest, with irregular contact with zone 10. *Columnaria halli*	4	0

Top of section	Feet	Inches
8. Resembles zone 9, but lower in magnesium; moderately fine grained, weathers with rough upper surface. Very fossiliferous. Fucoid in lower part. Mississippi Valley type of Platteville this far down in the section	0	21
7. Pure limestone, similar to zone 8. Many crinoid columns. First appearance of normal form of *Orthis tricenaria*	3	0
6. Limestone similar to that in zone 7 but with abundant Fucoid. *Stromatocerium rugosum* (Black River of New York form). Lower one foot contains long forms of *Strophomena incurvata* (Lowville of New York forms) Unconformity due to subaerial erosion. Much missing.	2	0
5. Irregularly bedded limestone, upper surface pitted, planed off across the pits or borings. Fauna as in zone 6. Many crinoid columns. *Solenopora sp.* in top 2 feet. Typical Lowville ends here. Bentonite layer at top	5	0
4. Argillaceous limestone in layers 2 to 8 inches thick, with very irregular lower surface. Intraformational conglomerate. Ripple marks of oscillating type just below conglomerate	8	0
3. Fine grained, gray, argillaceous limestone, irregularly bedded. Nodular surface as above	6	0
2. Highly magnesian, blue, mostly fine grained, finely crystalline limestone. Lower 6 feet mottled with pink and green. *Actinoceras* and *Cycloceras*. The beds beveled by erosion	7	6
1. Blue limestone (Platteville). Not seen in position but blasted out of river below dam.		

The rock in zone 10 is correlated with the Upper Buff of Wisconsin; the beds in Wisconsin have a thickness of 55 feet and consist of fine grained, rather heavy-bedded limestone, mottled and banded with light gray and buff, giving the whole a buff-colored appearance; chert nodules are characteristic of the upper part of the beds. The Upper Buff at Bony Falls is more argillaceous than the corresponding beds in Wisconsin and the known thickness is much less. There is no other known exposure of the Upper Buff in Michigan.

The rock of zone 10 contains few fossils other than an occasional specimen of *Leperditia fabulites*.

The contact between the rock of zone 9 and the Upper Buff above is irregular. This zone is characterized by the presence of *Columnaria*

halli; one colony measuring 5 feet in diameter was found in place, with the corallites unusually well preserved. This evidence points to the existence of a temperate climate in Michigan at that time.

Zone 8 is the typical horizon for *Leperditia fabulites* and they are here in considerable numbers although none of the specimens found are of more than medium size. Fossils are common throughout the whole zone but good specimens are not easily obtained. The rock this far down in the section represents the Mississippi Valley rather than the southeastern Wisconsin type of Platteville.

Zone 7 is very fossiliferous and is characterized by the appearance of *Pianodema sp.* and numerous specimens of *Petraea profundum.* The rock is a very pure limestone similar to that in zone 8.

Zone 6 contains an abundance of Fucoid remains and many interiors of the Lowville form of *Strophomena incurvata.*

The top of zone 5 is characterized by a very rough, pitted surface which was apparently produced by subaerial erosion, possibly by river action; this is just one of the many breaks characteristic of Black River rocks.

The fauna is very similar to that in zone 6 with the important addition of *Maclurites bigsbyi, Orthoceras sp.,* and a form of Endoceras with narrow septa and a shell that expands rapidly from 0 to 8 inches within 3 feet. This zone represents the base of the typical Lowville.

A layer of intraformational conglomerate is found 6 feet below the top of zone 4. Immediately below the conglomerate there is a layer showing ripple marks of the oscillating type.

The rock of zone 3 is very irregularly bedded and argillaceous, but that of zone 2 is dolomitic and mottled with pink, light gray, dark gray, and light brown. Occasional specimens of *Actinoceras sp.* and *Cycloceras sp.* are found.

The rock of zone 1 is below the level of the river. Great quantities of the rock have been blasted from the river bed and may be seen piled along the east bank of the stream. This zone is correlated with the Lower Blue of Wisconsin.

The whole section at Bony Falls indicates deposition in shallow water with oscillations of the sea bottom sufficient at times to bring the beds above water and produce an erosion surface such as that at the top of zone 5. The small ripple marks and the intraformational conglomerate are indications of shallow water. An occasional uplift of the neighboring land with a little rejuvenation of the streams would have been enough to furnish the argillaceous material found throughout the section. Water sufficiently clear to permit the growth of reef-forming corals prevailed during the deposition of zone 9.

Exposure at Trenary Alger County (Loc. 26).

The Black River rocks (Fig. 2) are exposed just south of town in a railroad cut, in a quarry west of the road and along the road south of the quarry, (U. S. Highway 41). The following is the quarry road section:

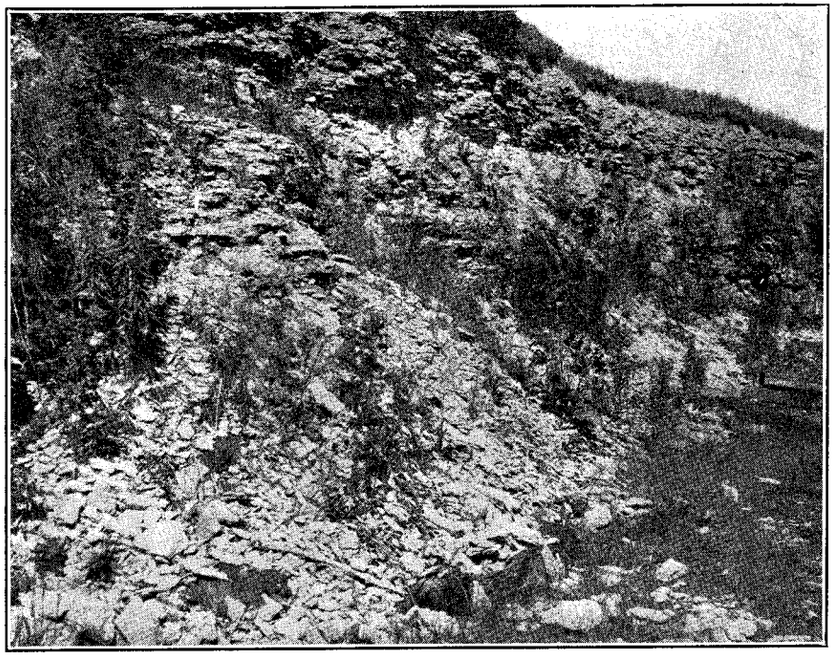

Fig. 2. Black River rock exposed along the railroad at Trenary.

Top of section		Feet	Inches
3.	Argillaceous limestone, thin, irregular bedding. Fresh surfaces light to dark gray, weathering yellowish. Dolomitic layer near bottom contains Ostracods. This zone belongs to the basal Trenton.	3	
2.	Argillaceous limestone, thin, irregular bedding. Fresh surfaces bluish green, weathering light gray to yellowish gray. Covered interval of one foot at base of zone included in total thickness. Upper Decorah	18	8

Top of Section		Feet	Inches
1.	Exposure in quarry. Argillaceous limestone, somewhat siliceous, irregular bedding, with beds from 1 inch to 1 foot thick. Fresh surfaces from light gray to bluish gray and brown. Weathers moderately dark brown. Highest pre-Decorah	10	8

There is an interval of unknown thickness between the base of the section at Trenary and the top of the section at Bony Falls. This interval is probably not very great and may not be more than 5 feet. The missing portion of the section quite likely belongs to the Upper Buff.

The quarry rock of zone 1 is much more siliceous than that in any other part of the section and the bedding in general is thicker and more regular in the upper part. The beds contain very few fossils, most of them being poorly preserved casts of *Strophomena incurvata*. The rock in this zone is correlated with the highest pre-Decorah and is considered the equivalent of the Vanuxemia beds in Minnesota.

A covered interval of 1 foot separates the top of zone 1 from the base of zone 2; this interval probably belongs to the lower zone. The rock of zone 2 is highly argillaceous with very irregular bedding; most of the layers are thin with an occasional thicker one. This same horizon is exposed along the railroad, 100 feet southeast. Fossils are moderately abundant and are irregularly distributed in layers and lenses.

This zone is correlated with the Upper Decorah and marks the transition between the Black River and the Trenton. The basal Trenton may be recognized at Trenary and at the other exposures in Michigan by the presence of many specimens of the small brachiopod, *zygospira recurvirostris* and by a dolomitic layer containing Ostracods. The *Zygospira* appears suddenly in great abundance and is a most useful guide fossil since the Black River cannot be separated from the Trenton upon lithologic grounds.

Exposure 3/10 miles northwest of Spalding, Menominee County on U. S. Highway 2 (Loc. 42).

The rock at this locality consists of argillaceous and dolomitic limestone, non-crystalline to moderately coarsely crystalline, and varying from soft to hard. The exposure is in the shallow ditch along the road and is not extensive. A few poorly preserved fossils were found among them being *Rafinesquina minnesotense* and *Strophomena incurvata*. This rock is stratigraphically above that at Bony Falls (Loc. 9), and may be placed at the base or just below the base of the quarry rock at Trenary (Loc. 26).

Exposure 3/4 miles east of Spalding on U. S. Highway 2 (Loc. 85).

Dolomitic limestone with argillaceous lenses, finely crystalline. Fresh surfaces yellowish brown becoming dark gray after weathering. The outcrop is found in the roadside ditch and extends for ¼ mile. Fucoid markings are numerous. Glacial striae run N. 45° E. This exposure is correlated with the rock in the quarry at Trenary (Loc. 26).

Exposure 7/10 mile northwest of Spalding, near Spalding Fire Tower (Loc. 86).

Argillaceous limestone with irregular layers varying in thickness from 1 to 8 inches. Fresh surfaces light gray, brown, mottled. Weathers light gray, brown, greenish. Occasional dolomitic lenses. This location is stratigraphically higher than that at Loc. 85 and represents the same horizon as the top of the quarry at Trenary, or high middle Black River. Some fragments of greenish argillaceous limestone found near the exposure are Decorah which is probably present just beneath the soil of the adjoining field. The following fossils have been identified from Loc. 86:

Pianodema sp.
Clionychia sp.
Sinuites sp.
Eotomaria sp.
Actinoceras sp.

The Cyrtodontae found at this location are similar to those in the equivalent horizon at Minneapolis and indicate a possible overlap in that direction.

Exposure at McFarland, Southeastern Marquette County on Michigan Highway 35 (Loc. 40).

The rock is exposed in a quarry operated several years ago for road material, and consists of argillaceous and somewhat dolomitic limestone. The color of fresh surfaces is greenish blue becoming light gray and yellowish after weathering. This exposure represents the same horizon as zone 2 at Loc. 26.

Exposure at Lathrop Northwestern Delta County on Michigan Highway (Loc. 28).

The rock is exposed in a shallow quarry along the east side of the road and is similar lithologically to the rock at Loc. 40 with which it is correlated.

Exposure at Cornell, Southwestern Delta County, Black River and Trenton (Loc. 5).

This is the chief exposure of Black River and Trenton rocks in the Northern Peninsula of Michigan and extends for a mile along the eastern side of the Escanaba River north of the concrete bridge. The detailed section follows:

		Feet	Inches
Top of section			
Trenton			
6.	Argillaceous limestone, thin, irregular bedding. Color of fresh surfaces varies from light gray to dark gray and greenish, weathering gray and yellowish. Chief horizon for *Maclurites*	10	
5.	Interbedded argillaceous limestone and shale, non-crystalline to coarsely crystalline. Color of fresh surfaces light to dark gray, weathering gray and brown, mottled. Conglomerate at top. *Plesiarges* common	4	
4.	Limestone, becoming thicker and more regularly bedded. Hard, dolomitic at base. Contains a layer with uneven upper surface as though eroded	5	9
3.	Argillaceous and dolomitic limestone, irregular bedding. Lens-like interbedded gray and green shale, decreasing in amount toward top. Small *Zygospira recurvirostris* common. Base of Trenton	17	2
Black River			
2.	Argillaceous limestone and interbedded shale, hard to soft. Texture and color not uniform, varying from dark to light gray. Fucoid markings. Top of Decorah (Black River)	5	9
1.	Argillaceous limestone, mostly in thin, irregular beds. Fresh surfaces light gray to dark gray, weathers yellowish brown. Weathers with irregular upper surface	5	4

This is the only exposure along the Escanaba River where the contact between the Black River and Trenton rocks may be seen. The general dip of the rock is down stream or southeast but there are numerous undulations in the beds which produce local dips to the northwest. These

undulations appear as low anticlines and synclines and often cause the same beds to appear at several places along the river. The amount of dip varies from about 1° to 9°.

The rock forms vertical bluffs 30 feet high in some places along the stream, usually on the outside of the bend; in other places the river banks are low and swampy with very poor outcrops. At some localities the rock weathers rapidly and forms a heavy talus slope where fossils may be collected in abundance; where the material is harder fossils are very difficult to obtain. The fossils are unevenly distributed in the layers and are usually found in lenses.

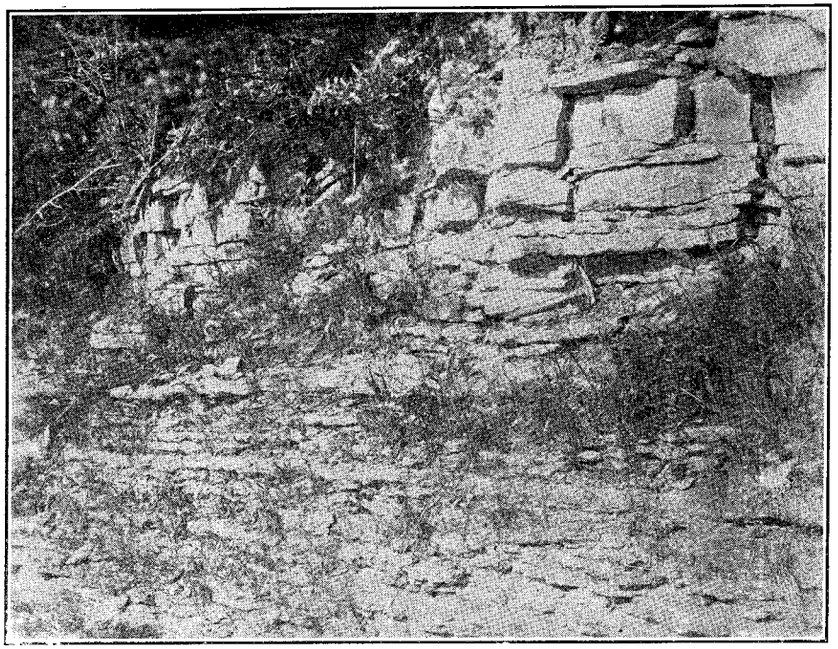

Fig. 3. Black River and Trenton exposed along the Escanaba River at Cornell, Michigan, Location 5. The hammer rests on the top of the Black River.

The Black River beds at Loc. 5 contain more limestone and dolomite and somewhat less argillaceous material than the Trenton and consequently do not weather so rapidly. Fossils are not as abundant in the Black River as in the Trenton and are usually more difficult to obtain. The break between the two formations cannot be detected upon lithologic grounds but is entirely a faunal one. The relatively unfossiliferous Black River is succeeded by the more highly fossiliferous Trenton with the typical brachiopod, *Zygospira recurvirostris* at the very base.

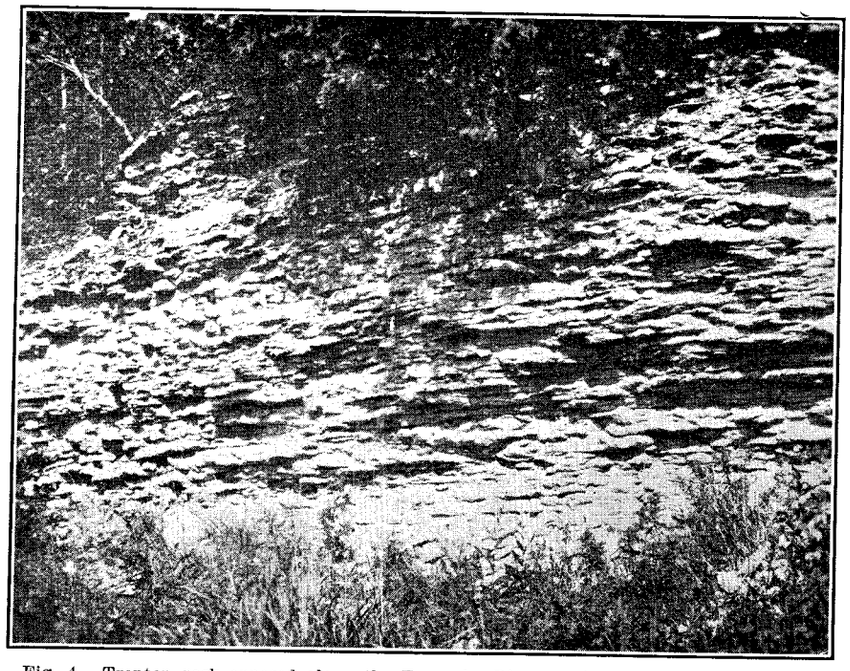

Fig. 4. Trenton rock exposed along the Escanaba River at Cornell, Michigan. Loc. 5. Zone 6. This view shows the uneven character of the bedding in much of the Trenton.

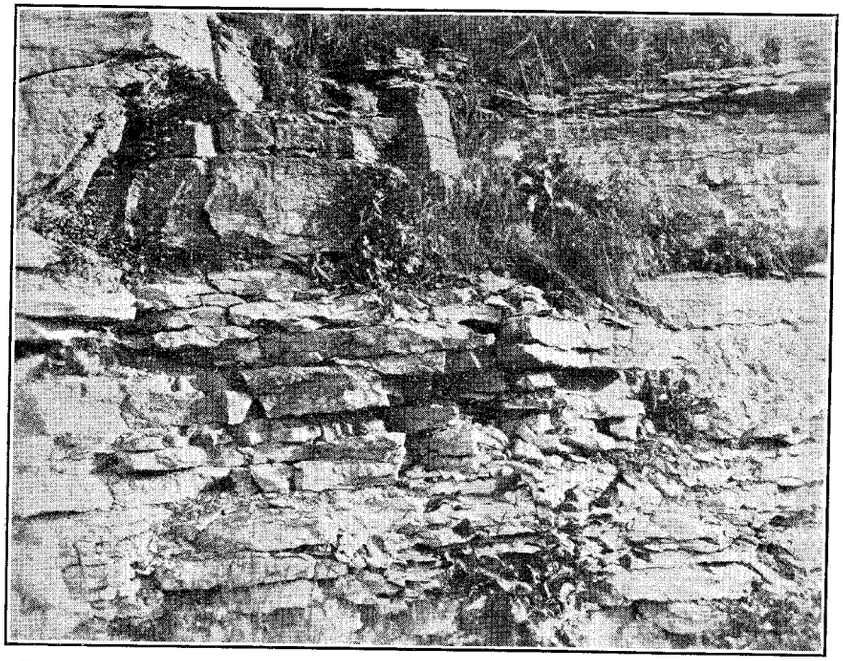

Fig. 5. Trenton rock exposed along the Escanaba River at Cornell, Michigan. Loc. 5.

A well marked layer of intraformational conglomerate occurs at Loc. 5 in zone 5 and at Loc. 8 in zone 2. This conglomerate is composed of water-worn pebbles and slabs of various sizes some of which are a foot wide. The fragments composing the conglomerate are all rounded and many of the flat slabs resemble typical shingle. In a fresh cross section through the conglomerate the pebbles are not as sharply defined as after weathering when they become conspicuous and are somewhat darker than the surrounding matrix. The pebbles often weather loose from the surrounding material. Many of the rocks have been bored by some unidentified forms, probably worms.

TRENTON

The most fossiliferous part of the Trenton is the first three or four feet immediately below the conglomerate. A change in strength of current caused deposition of the conglomerate; possibly a shallowing of the water, caused a decided change in food supply and thus a reduction in the number of individuals and species of animal life. This increase in the amount of shaly material above the conglomerate may have made conditions rather unfavorable for the existence of life.

Among the most characteristic fossils of zone 5 are the following: ***Plectambonites sericeous*** (very abundant), ***Fusispira nobilis, Clitambonites sp., Dinorthis meedsi, Orthis triceneria,*** and ***Catazyga uphami. Catazyge uphami*** is considerably more abundant in Michigan than in Minnesota.

Zone 6 (Fig. 4) contains occasional specimens of *Maclurites;* it is possible that this form goes down to the conglomerate layer but it has not been found below zone 6 at any of the localities. Fossils are not abundant in this zone.

Deposition seems to have continued somewhat longer in the zone below the conglomerate at Loc. 5 (Figs. 4, 5) than at Loc. 8, (Dam No. 2 on Escanaba River) giving about three feet more material at Loc. 5 and also a more typical development of the conglomerate zone fauna.

Exposure at Loc. 8, Dam No. 2, on Escanaba River, 3 miles north of Escanaba, Delta County.

The detailed section is as follows:

		Feet	Inches
Top of section.			
Trenton.			
6.	Argillaceous limestone in thin, irregular beds. Weathers yellowish. A little harder than zone 5 which it overhangs. *Maclurites* horizon	5	

		Feet	Inches
Top of Section Trenton			
5.	Argillaceous limestone in thin, irregular beds. Thin layers or lenses crowded with *Plectambonites sericeus*. This zone grades in color into the yellowish zone above and the greenish blue zone below	17	
4.	Argillaceous limestone in thin, irregular beds, similar to zone 5 but more shaly and dominantly bluish green in color. Layers and lenses of limestone filled with *Plectambonites sericeus*. Remainder of limestone less fossiliferous	5	2
3.	Dense limestone in layers 2 to 3 inches thick, with sharply impressed fucoid markings. Between the limestone layers is bluish green fissile shale with less sharp fucoid markings	1	
2.	Conglomerate of worn shore debris and fragments of fossils. Some of the conglomerate pebbles have been bored by some unidentified forms, probably worms. Argillaceous limestone and shale	5	6
	Zone continued downwards in bluish green, irregularly bedded shale with abundant Bryozoa and other fossils	3	9
1.	Bluish green, argillaceous limestone in irregular beds with many crinoid stems in some layers. Much less fossiliferous than the lower part of zone 2	7	11

Location 8 at Dam No. 2 offers one of the best sections of the Trenton exposed along the Escanaba River. A large amount of material chiefly from zones 1, 2 and 3 has been blasted from the bed of the river and piled along the eastern bank where it is weathering rapidly; fossils in great abundance are found in this material.

The rocks along the west side of the river stand in a nearly vertical cliff about 30 feet high and form a shallow syncline a hundred yards long. 200 yards down stream from the upper end of the exposure the rocks dip up rather steeply southeastward, down stream. 100 yards farther on the dip has flattened to about 1°. Such undulations are characteristic of the Escanaba River section.

The same conglomerate layer that occurs at Cornell (Loc. 5, zone 5) is exposed here at the top of Zone 2. The pebbles are all water worn and suggest the debris of an old shore. The most fossiliferous beds in the whole section are just below the conglomerate. This zone contains numerous specimens of *Plectambonites sericeus*. Other fossils are: *Clitambonites sp.* (not common), *Catazyga uphami* (common), *Fusispira nobilis, Dinorthis meedsi, Orthis tricenaria* and *Prasopora sp.* The reduction in individuals and number of species of fossils in the beds above the conglomerate is as marked here as at Cornell.

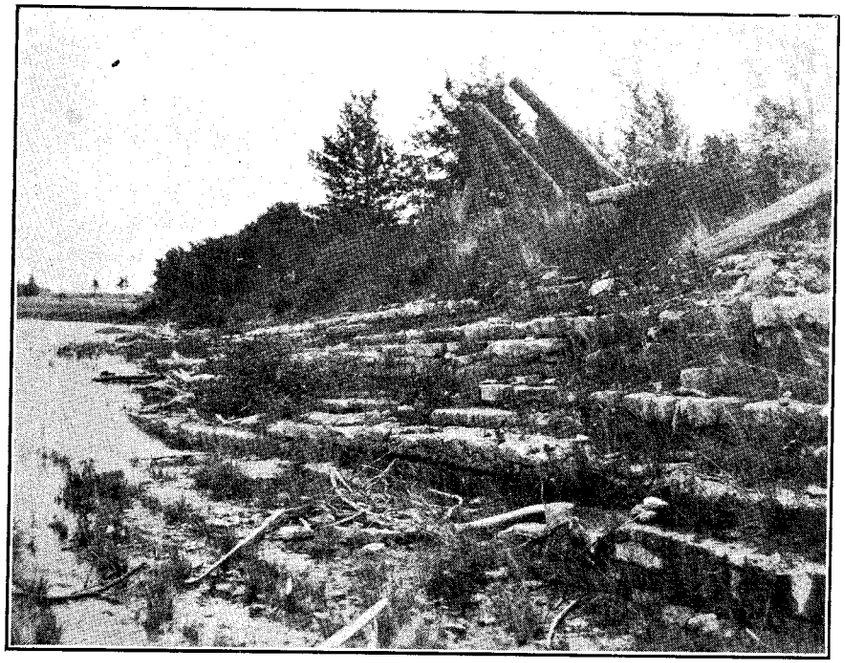

Fig. 6. Trenton rock exposed along the Escanaba River at Location 7. The dip of the rock here is down stream or to the east.

Conditions of deposition of the Trenton in general, and particularly the material at Cornell and at Loc. 8, indicate that the water was shallow and the shore at no great distance. At Loc. 8 ripple marks of the oscillation variety are common; in zone 1, ripple marks measuring 4 inches from crest to crest have been found. The rounded character of the material composing the conglomerate shows that it was probably rolled around in the shallow water near shore or formed part of the material along the beach.

Conditions were unusually favorable for the development of certain types of Bryozoa in the zone immediately below the conglomerate; an

unusual number of specimens of large, conical *Prasopora* have been found at Locs. 5 and 8, where they form a very striking element in the fauna. Some specimens were found imbedded in the shale without any very firm place of attachment; in other places they were found attached to the upper surface of the hard limestone layers. This bryozoan is more numerous in Michigan than in Minnesota.

The whole section exposed at Loc. 8 is placed within the Prosser, and according to Dr. E. O. Ulrich it is the equivalent of the Glens Falls of New York.

Location 7. (Fig. VI.) Section. Escanaba River, 1½ miles east of Cornell, Delta County.

Top		Feet	Inches
3.	Limestone, dense, massive bedded, gray, like zone 3, Loc. 10 (Groos Quarry). At the base is a thin layer of dark brown shale, weathering bluish; possibly the equivalent of the shale layer that covers the floor of the Groos Quarry	6	8
2.	Heavier, more regularly bedded limestone	8	9
1.	Argillaceous limestone in thin, irregular beds. Weathering yellowish. The *Maclurites* horizon of Locs. 5 and 8	14	9

This section overlaps the upper part of the section at Loc. 8 and the lower part of the section at Loc. 10 (Groos Quarry).

Section at Loc. 10, the Groos Quarry. (Fig. VII.) Wells Twp. five miles north of Escanaba, Delta County.

Top.		Feet	Inches
4.	Argillaceous limestone in thin, irregular layers, with dolomitic layers and lenses. A thin shaly parting layer, ¼ to 1 inch thick at the bottom, disintegrating to mud. *Mesotrypa Sp.* in the base	4	
3.	Fairly dense, gray, massive limestone. Some irregular layers especially at the top. Fossils in lenses and in the parting layers. Some layers and lenses of lithographic limestone. Zone with *Whitella sp.* 16-18 feet below top of zone. Occasional thin lenses of dark brown shale found within the first four feet above the bottom of zone	24	8
2.	Dark brown to black shale, weathering blue. Very fossiliferous. Forms the floor of the quarry	2	3
1.	Fine grained limestone, irregular bedding. Resembles zone 3. Bottom not seen	6	6

The rock of zone 4 is much more argillaceous than the rocks of zone 3 and the bedding is thinner and more irregular. This is the most fossiliferous part of the quarry although the fossils do not easily separate from the rocks. The upper surface of the rock in this zone has been heavily glaciated, the striae running N. 4° E. At the base of the zone there is a shaly layer about one inch thick which may be an old buried soil and consequently marks the position of an unconformity. The break is local and no faunal change took place during the interval of erosion.

The rock in zone 3 makes up most of the quarry face, and consists of hard, rather massive bedded limestone which breaks with a sub-conchoidal fracture. The rock from this zone is used a great deal, locally, for road material. Fossils in zone 3 are irregularly distributed in lenses and are very difficult to obtain because of the hardness of the surrounding matrix. The same *Whitella* horizon that is 20-22 feet below the top of the quarry is found at locations 12, Island in the Escanaba River northeast of Groos and 13, at the bridge across the Rapid River, at Rapid River (Fig. 8).

In the bottom 4 feet of zone 3 there are occasional thin layers and lenses of dark brown shale, weathering bluish, and varying in thickness from 1-4 to 1 inch. The contact between the shale and the limestone is always sharp, with no gradation from one to the other; some of the layers of shale are very fossiliferous.

Zone 2 is one of the shale layers which covers the entire floor of the quarry and contains an abundance of fossils of the same sort as those found in zone 4. The equivalent of this shale layer has been found at locations 7 east of Cornell and 19 on the Ford River, southeast of Hyde.

The rock of zone 1 is below the floor of the quarry and is not very accessible for study but it is the same as the rock in zone 2 at location 7 where it may easily be seen.

The rock exposed at the Groos Quarry is the highest Trenton horizon that has yet been found in the area studied and probably does not lie

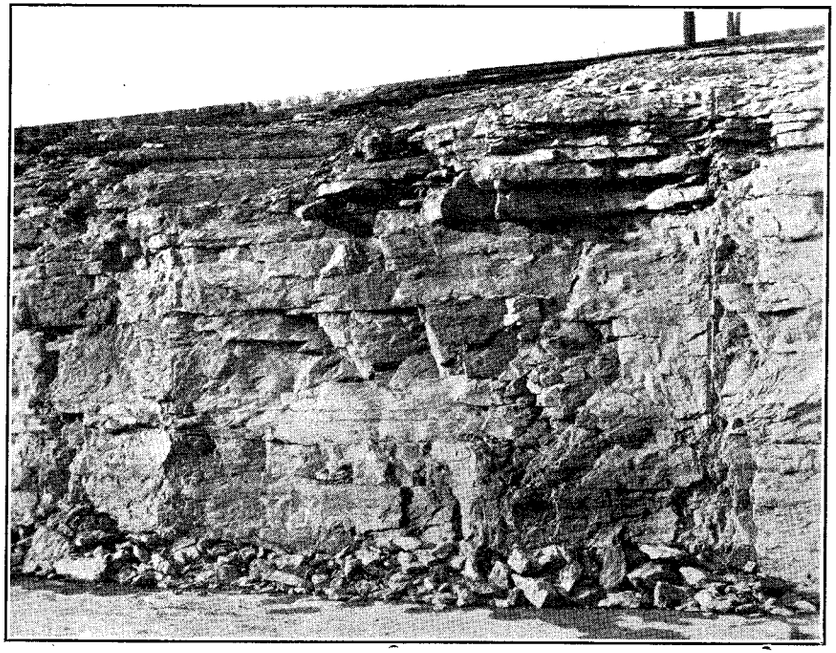

Fig. 7. Trenton rock exposed in the Groos Quarry at Location 10.

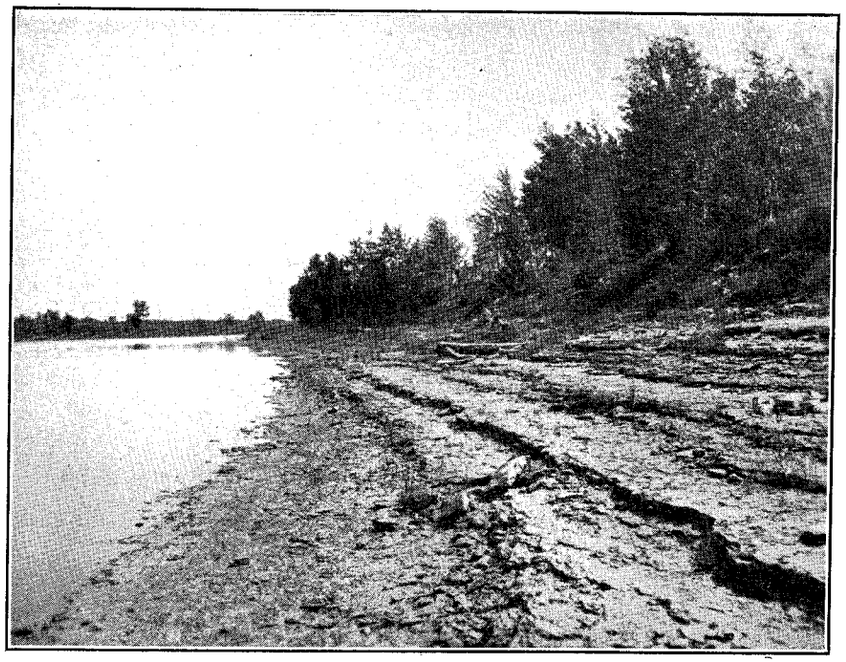

Fig. 8. Trenton rock exposed in the bed and along the bank of the Rapid River at Rapid River, Michigan, Location 13.

far below the base of the Richmond. It is correlated with the Prosser.

Location 11.

An abandoned quarry, 7 6-10 miles southeast of Cornell, Delta county, Michigan. The rock at this location is of the same horizon as that in the upper middle part of the Groos quarry, Loc. 10. The rock is lithologically the same and contains the same fauna as that at Loc. 10. The total thickness exposed is 12 feet.

Location 13.

Rapid River, Delta County, Michigan, in the bed of the Rapid River.—The rock is exposed in the bed and along the banks of the river just north of town and may be seen for 250 yards below the river bridge. The dip is slightly to the southeast, a little less than the gradient of the stream.

The rock consists of thin, irregularly bedded, argillaceous limestone with dolomitic and lithographic layers and lenses. The color varies from light to dark gray on fresh surfaces and light gray to brownish gray after weathering. The upper surface of many of the layers has a very decided nodular appearance due to the extreme irregularity of the bedding. Fossils are abundant and occur in layers and lenses; good specimens are not easily obtained.

On the east bank of the river, 200 yards below the bridge and 8 inches above the level of the river, there is a well defined layer containing numerous specimens of *Whitella sp.* The pelecypods range through a vertical thickness of about 2 inches. This is the same horizon as that found in the Groos quarry, Loc. 10. The total thickness of the rock exposed at Loc. 13 is 8 feet.

Location 12.

About ¼ mile northeast of the Groos quarry, in Delta County, a little island stands in the middle of the Escanaba River. The rock is exposed all around the sides of the island, offering especially good opportunities for study as the water in the river is often very low.

Section.

Top.		Feet	Inches
2.	Argillaceous limestone in thin, irregular beds; dolomitic lenses. Weathers yellowish	4	
1.	Argillaceous limestone with lithographic lenses; bedding thin. Weathers with rough, sharply irregular surface. Zone containing numerous specimens of *Whitella sp.* 6½ feet from top of zone	12	

The nearness of this exposure to that in the Groos Quarry, Loc. 10, makes it possible to correlate the two without difficulty. Zone 2, Loc. 12, is equivalent to zone 4, Loc. 10. Zone 1, Loc. 12, is equivalent to the upper part of zone 3, Loc. 10. The whole section is Prosser.

Location 19.

Ford River, 2 miles southeast of Hyde, Delta County, Mich. The rock at this locality consists of thin bedded, argillaceous limestone with dolomitic and lithographic layers and lenses. The color of fresh surfaces varies from light to dark gray and after weathering is mottled brown, greenish, yellowish brown. The bedding is very irregular and weathering produces rough, nodular surfaces. A thin layer of dark brown shale, ¼ to 1 inch thick, occurs 2 feet 10 inches from the top of the section. The total thickness exposed is 5 feet 4 inches. The horizon is equivalent to zone 3, Loc. 10.

Location 22.

Exposure just east of Bark River, Delta County, Mich., on the south side of the road U. S. Highway 2-41. Three feet of argillaceous limestone in thin, irregular beds. This exposure is correlated with the *Maclurites* horizon of the sections at Cornell, Loc. 5, and Loc. 8.

Location 25.

A small quarry just north of the road, ¼ mile west of Perkins, Delta County, Michigan, Highway 35. The rock consists of thin bedded, argillaceous limestone, with dolomitic and lithographic layers and lenses. Four feet of rock exposed above the water level. The horizon is the same as that of Loc. 13, Rapid River, Mich.

Location 27.

Near bridge (Trunk line bridge No. 64) across the Whitefish River, on the road between Rapid River and Trenary, Mich. The rock is exposed in the bed of the river and along the banks for 100 yards above the bridge. The horizon is the same as the middle part of the Groos Quarry, Loc. 10. Thickness exposed, 6 feet.

Location 29.

The rock is poorly exposed along the banks of the Whitefish River, 7 miles northeast of Rapid River. About ½ mile to the east the Bill's Creek shale, basal Richmond, is found along the banks of Haymeadow Creek. The country between the two exposures is flat and heavily wooded concealing the contact; but the flat dip of both the Trenton and the Richmond in this locality makes it unlikely that a large covered interval exists between the observed top of the Trenton and the base of the Bill's

Creek shale. The horizon of the rock at Loc. 29 is the same as that found in zone 4, Loc. 10.

Location 31.

The same horizon as that found at Loc. 13 occurs along both sides of the road, U. S. Highway 41, just north of the village of Masonville, Delta County, Mich. Only the upper surface of the rock is exposed but the fossils are identical with those found at Loc. 13.

Location 1.

Two miles north of Bark River, Delta County, Mich. The rock is fairly well exposed along both sides of the road and consists of argillaceous limestone in thin, irregular beds, moderately hard, dark gray on fresh surfaces, light gray to yellowish brown after weathering. This exposure is correlated with the Maclurites horizon as found at Locs. 5 and 8. Thickness 5 feet 4 inches.

Location 3.

Two miles east and 1 mile south of Wilson, Menominee County, Mich. Rock is exposed along both sides of the road and consists of argillaceous limestone in thin, irregular beds, with dolomitic lenses. Dark gray on fresh surfaces, weathering light gray and yellowish brown. Dip south 4°. This exposure is correlated with the Maclurites horizon as found at Locs. 5 and 8. Thickness 13 feet 5 inches.

Location 62.

Along the road, 2 miles southeast of Schaffer, western Delta County, on Highway M-69. This rock represents the same horizon as that found at Rapid River, Mich., Loc. 13.

Location 63.

One-half mile west of Schaffer, Mich. The three feet of rock exposed along the road at this location represents the same horizon as that found at Rapid River, Mich., Loc. 13.

Location 23.

At Brampton, Delta County, Mich., on M-35. This is a poor exposure of the same rock as that found at Rapid River, Mich., Loc. 13.

Location 14.

Along the road, 12 1-5 miles northwest of Cornell, in Marquette County, Mich. The typical *Maclurites* horizon as found at Cornell, Loc. 5, outcrops in the shallow ditches along both sides of the road. Glacial striae N. 36°-40° W. Dip 5° E.

Location 51.

Eight-tenths of a mile northwest of Faunus, Menominee, Mich., on Highway 69. Dolomitic limestone. Fresh surfaces moderately light gray to brown, weathering dark gray to dark brown. Glacial striae 49° E. Thickness 6 feet. This outcrop may represent the basal Black River and if such, it is not far above the top of the Ozarkian.

Location 30.

Exposure in the beds of the Days River, Delta County, just west of the bridge, on U. S. Highway 2-41 between Escanaba and Rapid River, Mich., about one mile southwest of Masonville. The horizon is the same as that found at Rapid River, Loc. 13.

Location 16.

Exposure along the east side of the road, 2 1-5 miles northwest of Cornell. This rock represents the *Maclurites* horizon as found at Locs. 5 and 8. Thickness 3 feet.

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TRENTON AND BLACK RIVER ROCKS OF MICHIGAN

List of numbered field stations described in the report, expeditions of 1927-28, University of Michigan.

1. Two miles north of Bark River, Michigan. Roadside exposure.
3. Two miles east and 1 mile south of Wilson, Michigan. Roadside exposure.
5. Exposure along both sides of the Escanaba River, Cornell, Michigan, north and south of the concrete bridge.
7. Exposure along the Escanaba River, 1½ miles east of Cornell, Michigan.
8. Dam No. 2 on the Escanaba River, 3 miles north of Escanaba, Michigan.
9. Bony Falls, Michigan. Exposure on the Escanaba River.
10. Groos Quarry at Groos, Michigan.
11. Quarry, 7 6-10 miles southeast of Cornell, Michigan, on the road between Cornell and Escanaba, Michigan.
12. Island in the Escanaba River, ¼ mile northeast of the Groos quarry at Loc. 10.
13. Exposure north and south of the bridge across the Rapid River at Rapid River, Michigan. Loc. 47, Michigan trip.
14. Roadside exposure, 12 1-5 miles northwest of Escanaba, Michigan.
16. Roadside exposure, 2 1-5 miles northwest of Cornell, Michigan.
19. Exposure on the Ford River, 2 miles southeast of Hyde, Michigan.
22. Exposure just east of Bark River, Michigan, along the south side of the road.
23. Roadside exposure at Brampton, Michigan.
25. Quarry, ¼ mile west of Perkins, Michigan, north side of the road.
26. Exposure in the quarry, along the highway, and along the railroad, ½ mile south of Trenary, Michigan.
27. Exposure along the Whitefish River, west of Trunk Line Bridge No. 64, on the road between Trenary and Rapid River, Michigan.
28. Quarry at Lathrop, Michigan.
29. Exposure on the Whitefish River, 7 miles northeast of Rapid River, Michigan. Loc. 38, Michigan trip.
30. Exposure on the Days River, west of bridge on road 2 miles south of Rapid River, Michigan.
31. Roadside exposure just north of Masonville, Michigan.
42. Roadside exposure, 3-10 mile northwest of Spalding, Michigan.
51. Roadside exposure, 8-10 mile northwest of Faunus, Michigan.
62. Roadside exposure 2 miles southeast of Schaffer, Michigan.
63. Roadside exposure, ½ mile west of Schaffer, Michigan.
85. Roadside exposure, ¾ mile east of Spalding, Michigan.
86. Roadside exposure, 7-10 mile northwest of Spalding, Michigan.

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