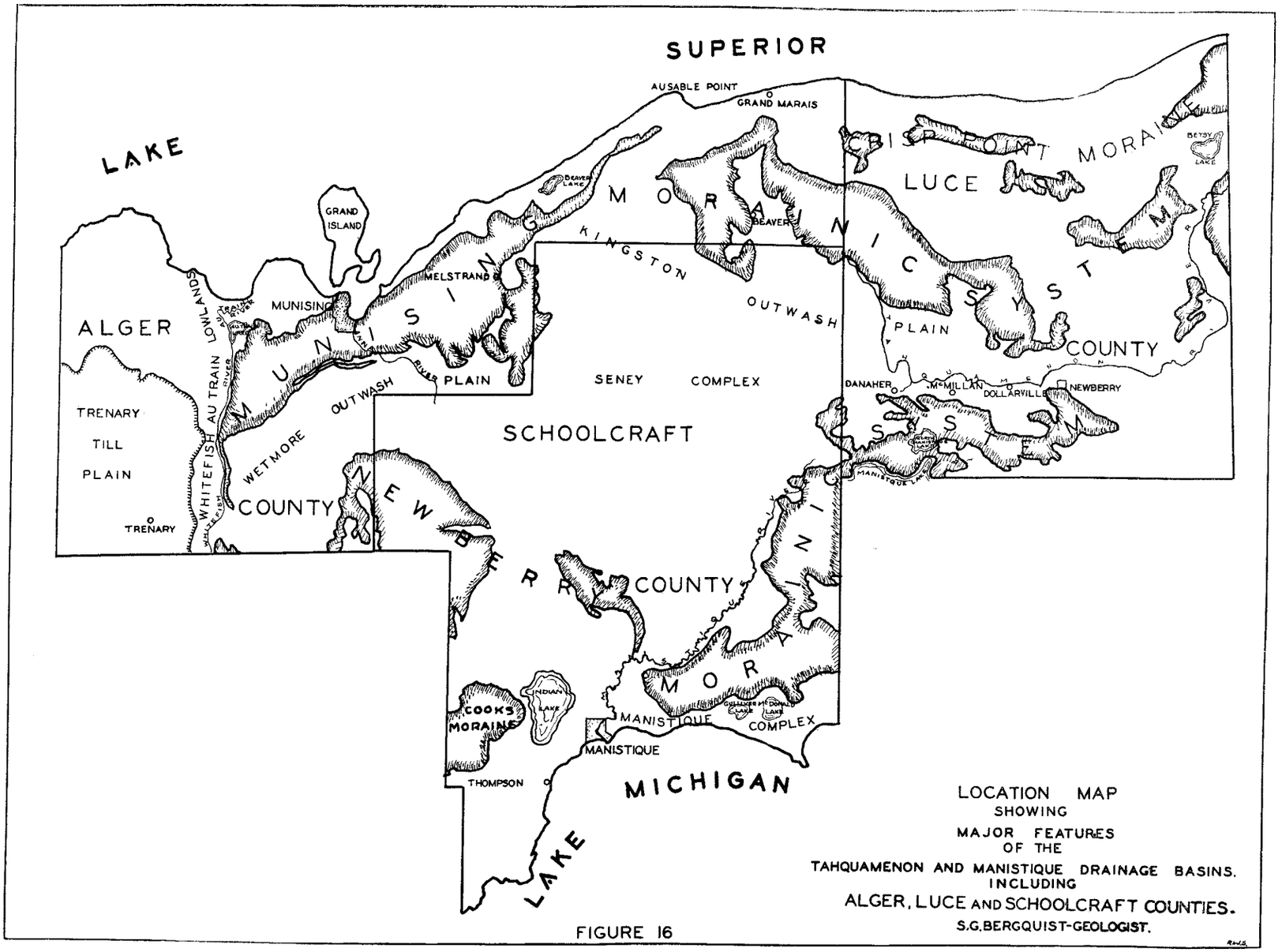

LOCATION MAP
SHOWING
MAJOR FEATURES
OF THE
TAHQUAMENON AND MANISTIQUE DRAINAGE BASINS.
INCLUDING
ALGER, LUCE AND SCHOOLCRAFT COUNTIES.
S.G. BERGQUIST-GEOLOGIST.

FIGURE 16

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INDEX

PART II

THE PENNSYLVANIAN SYSTEM OF MICHIGAN

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Michigan State College

PENNSYLVANIAN SYSTEM IN MICHIGAN

by

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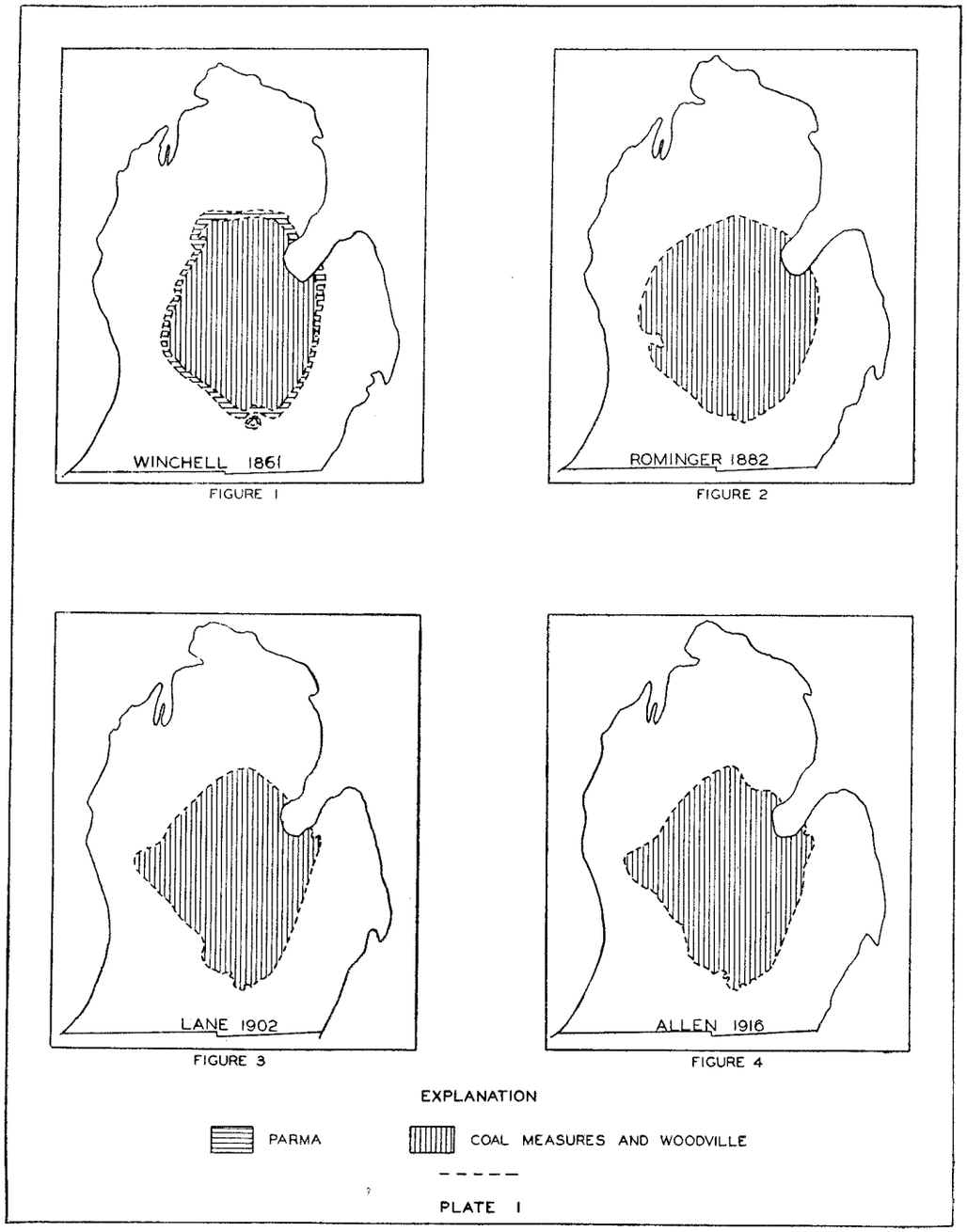


Maps of Southern Peninsula of Michigan showing distribution of Pennsylvanian strata according to Winchell, Rominger, Lane, Allen.

PENNSYLVANIAN SYSTEM IN MICHIGAN

Chapter I

INTRODUCTION

EXTENT OF WORK

The following report is based upon the results of a study which began in 1928, and which has extended with interruptions to the present (1936). The work involved some time in the field collecting samples from outcrops, quarries, and the dumps of coal mines, but consisted mainly of a laboratory study of fossil and rock samples, collected by earlier workers as well as by the writer.

ACKNOWLEDGMENTS

The writer is under obligations to Dr. Richard A. Smith, State Geologist of Michigan, and Dr. E. C. Case of the Department of Geology at the University of Michigan, under whose joint direction the work has been pursued. Dr. Case placed the collections of Pennsylvanian material in the Museum of Paleontology at the writer's disposal and has frequently assisted with helpful advice. Prof. G. M. Ehlers of the Department of Geology and Paleontology at the University of Michigan and Dr. R. B. Newcombe, recently of the State Geological Survey, have also furnished helpful advice and constructive criticism on paleontological and stratigraphical problems. Collections of study material have been lent through the courtesy of the University of Chicago, Ohio State University, and McGill University, and acknowledgment is here made to the curators of those institutions. Assistance in the verification and identification of species of fossils has been received from Dr. G. H. Girty of the United States Geological Survey, Dr. C. O. Dunbar and Dr. J. B. Knight of Yale University, Dr. J. Marvin Weller of the Illinois State Geological Survey, and Dr. K. F. Mather of Harvard University. Several students at Michigan State College,—among whom may be mentioned Mr. Gordon Pringle, Mr. Rex Grant, and Mr. Gaylord Walker—frequently rendered valuable assistance in the field.

PURPOSE OF WORK

The purpose of the work was threefold: (1) To determine from faunal studies the age of those post-Mississippian formations of Michigan known

as the Parma, Saginaw, and Woodville, which are commonly assigned to the Pennsylvanian System; (2) to correlate the geological section of Michigan with the geological sections of neighboring states; and (3) to describe the strata of the Michigan section, and to determine, if possible, methods of recognizing and of separating the individual formations and members from each other.

HISTORICAL REVIEW

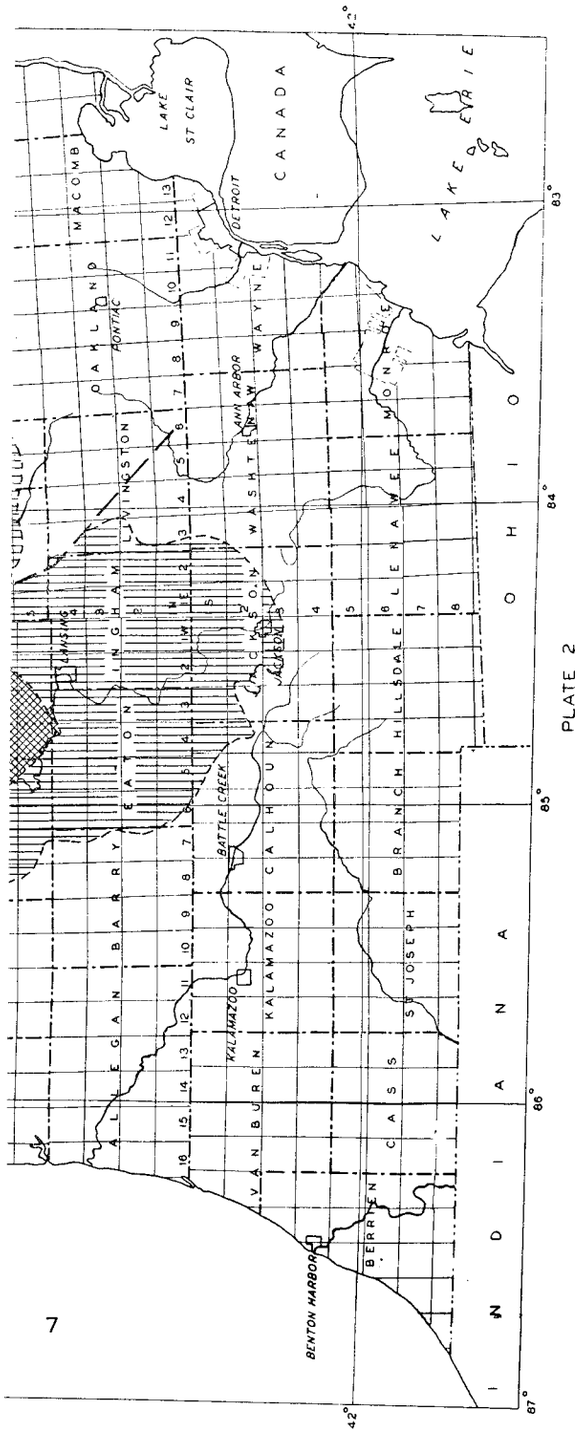
Investigation of the coal bearing and associated formations in Michigan has been carried on since the discovery of coal west of Jackson in 1835. A review of this earlier work is contained in a paper by Kelly (1931) and is summarized briefly below.

During the period from 1838 to 1841, the work on the coal-bearing formations was done by Douglass Houghton, C. C. Douglass, and Bela Hubbard. Each of these men over-estimated the area underlain by Pennsylvanian rocks, usually because each included rocks other than Pennsylvanian. It is probable that Houghton included the Antrim shale with the Pennsylvanian.

From 1861 to 1882 investigation was carried on by Alexander Winchell, Carl Rominger, and C. D. Lawton. These men under-estimated the area underlain by the Pennsylvanian (Plate I, Fig. 1 and Fig. 2) but their work was of a more detailed character than that of their predecessors. To Winchell we are indebted for a threefold subdivision of the Pennsylvanian, a sub-division which has continued up to the present. To Rominger we are indebted for many descriptions of geologic sections exposed throughout the State.

The investigation of the Pennsylvanian system received an impetus toward the end of the last century and the results of the work of several men over a period of about 15 years was embodied in the report on the Coal Measures of Michigan by A. C. Lane (1902). (Plate I, Figure 1). The report contains important information on the stratigraphy and important references of the fossil lists compiled by David White and G. H. Girty. A correlation of beds of the Pennsylvanian is made, and conclusions reached which are in general substantiated by the present work.

Lane's work was modified and amplified in the years following 1902 by W. M. Gregory (1902, 1912), W. F. Cooper (1906, 1909), R. A. Smith (1912), (Plate I, Fig. 4) and W. A. Kelly (1930, 1931, 1933). Detailed study of the Pennsylvanian flora of Michigan was made by Dr. C. A. Arnold of the University of Michigan (1934). Considerable unpublished information was gathered by R. B. Newcombe when on the State Geological Survey as the result of the campaign of drilling which has gone on in this State within recent years. As a result of this work



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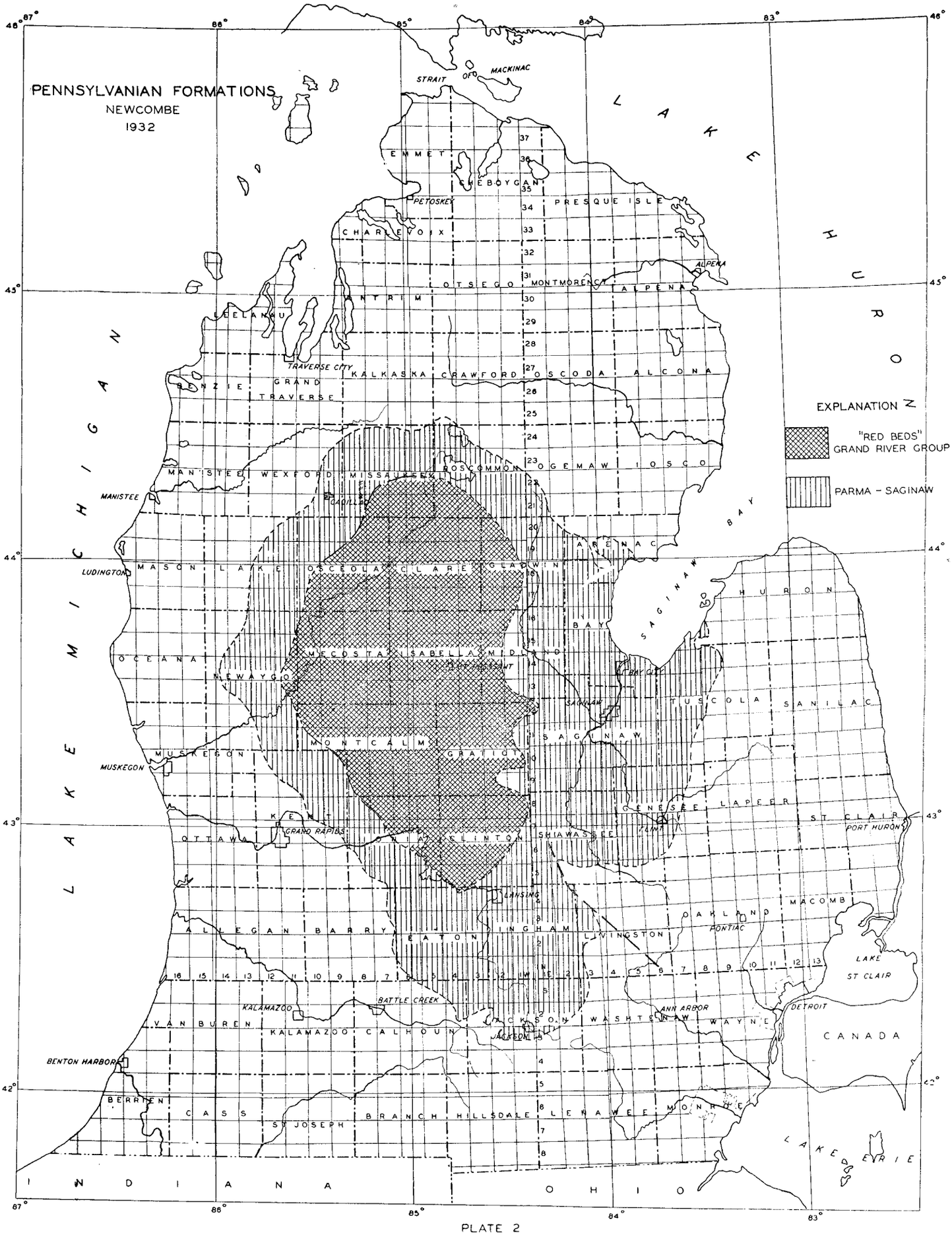

PLATE 2

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our knowledge of the boundary between the Mississipian and Pennsylvanian has been considerably modified (Plate II, Figure 2*). The principal changes between Newcombe's map and the map edition of 1916 may be noted in Missaukee, Osceola, Lake, Newaygo, and Kent counties on the west; Livingston, Shiawassee, and Genesee on the east; and Arenac on the north. In addition, the younger formations of the Pennsylvanian are separated from the Saginaw and Parma. The extent of the area may be described as being from Jackson County on the south to the southern part of Crawford County on the north and from Tuscola County on the east to the western part of Newaygo County on the west.

SOURCES OF INFORMATION

Outcrops of Pennsylvanian strata are rare. The largest area of outcrop is in the vicinity of Grand Ledge. Maps showing outcrops and significant mine localities in the State accompany this report. (Figs. 1, 2, 4, 6, 8, 9).

Partial compensation for the lack of outcrops is the number of mine shafts originally sunk within the State, principally in Saginaw and Bay counties. Collections from a few of these mine shafts were made and preserved in the State Geological Survey and University of Michigan collections. For most of the mines information is lacking, and cannot be obtained now because the greater number of the mines have been abandoned.

Drilling in the State since 1926 has furnished considerable data on the extent and lithology of the Pennsylvanian strata and it is chiefly due to the study of well samples, that more accurate information has been obtained concerning the Mississippian-Pennsylvanian boundary.

STRATIGRAPHY

CLASSIFICATION OF FORMATIONS

The Pennsylvanian system of Michigan has been commonly subdivided into three formations—the Parma, Saginaw, and Woodville, a classification which we owe to Winchell (1861), a former State Geologist. Since Winchell's time several geologists, notably Rominger, have not believed in the three-fold subdivision. I am inclined to minimize the importance of the Parma, and to doubt the correlations with the typical Parma which have been made. This question is dealt with under the heading "Parma Sandstone."

**Editor's Note:* Later modifications (1936) are indicated on Figure 3, which shows the boundaries of the Pennsylvanian after Martin 1936.

TABLE I.—PENNSYLVANIAN NOMENCLATURE IN MICHIGAN

1	1861 Winchell	Wood-ville	Coal Measures	Parma
2	1876 Romin-ger		Coal Meas-ures	
3	1895 Lane	Wood-ville	Jack-son Coal Group	Parma
4	1901 Lane		SAGINAW SERIES Upper Rider Upper Verne Coal Lower Verne Coal Middle Rider Saginaw Coal Lower Rider Lower Coal	Parma
5	1905 Cooper	Woodville Absent in Bay County	SAGINAW Salzburg Rider Salzburg Coal Upper Rider Upper Verne Coal Lower Verne Rider Lower Verne Coal Middle Rider Saginaw Coal Lower Rider Lower Coal Bangor Rider Bangor Coal	Parma
6	1908 Cooper	Woodville Absent in Tuscola County	SAGINAW Reese Coal Unionville Coal Salzburg Rider Salzburg Coal Upper 1 Rider Lower Verne Rider Lower Verne Coal Middle Rider Saginaw Coal Lower Rider Lower Coal Bangor Rider Bangor Coal	Parma Doubtfully Represented in Tuscola County
7	1910 Lane	Wood-ville Ionia Sug-gested	Saginaw	Parma
8	1912 Smith	Wood-ville	Saginaw	Parma
9	1931 New-combe	"Red Beds" Wood-ville	Saginaw	Parma
10	1933 Kelly	Grand River Group "Red Beds" Ionia SS Eaton SS Woodville SS	SAGINAW GROUP Post-Verne Cyclical Formations Verne Pre-Verne Cyclical Formations	Parma Probably Restricted to Southern Area

The Saginaw formation could quite readily be considered a group in the sense that that term is used by the United States Geological Survey (Walcott, 1903, p. 27). It is composed of many minor or cyclical formations, some of which can be correlated in local districts. It is chiefly because of the value of these minor cyclical formations in correlation that they deserve further mention, and are described under the section dealing with the Saginaw Group. The apparent difference between two or more coal seams is often much less than the difference between the beds associated with them; hence if familiarity with the minor formations is possible, its recognition elsewhere might enable one to predict the presence of a second coal seam below the one being mined. One of these cyclical formations contains a marine member, the fossils of which have been recognized at various localities from the Bay City area to Grand Ledge. For the coal seam below this marine member, Lane used the name Lower Verne Coal (Table 1, column 4). I propose to revive the term "Verne," restricting it to the cyclical formation containing the shaly limestone member which was formerly exposed in the Verne mine, Saginaw County, and to beds correlated with that cyclical formation. Samples from the old Verne mine are in the Museum of Paleontology, at Ann Arbor.

Evidence is presented elsewhere in this report (see pp. 177, 190) to show that the Verne limestone is a comparatively persistent member, and that it will make a convenient place to divide the Saginaw group into the pre-and post-Verne cyclical formations (Table 1, column 10).

The common tendency among geologists today is to call all post-Saginaw formations either Woodville or Ionia. However, either term, particularly Woodville, implies correlation of all beds younger than Saginaw when there are few facts to substantiate such correlation. This report proposes that the name Grand River, used in a group sense, include the various formations, which stratigraphic evidence indicates are younger than Saginaw, though not strictly to be correlated with each other as occupying the same position in the geologic time scale. The Grand River group would include the Woodville sandstone, the Ionia sandstone, a name suggested by Lane, the Eaton sandstone, a name proposed in this paper, and any other formations correlated with them.

Chapter II

PARMA SANDSTONE

NAME

The name Parma sandstone was proposed by Alexander Winchell (1861, p. 112), for a "white, or slightly yellowish, quartzose, glistening sandstone, containing occasional traces of terrestrial vegetation." This sandstone lies below the micaceous sandstones, shales, and coal beds of the Saginaw group. The name Parma is taken from the outcrop localities near the town of Parma.

Rominger did not adopt the division, Parma sandstone, and maintained that if the term was adopted we would "rarely have an opportunity to identify it with any degree of certainty." (Rominger, 1876, p. 128). Lane (1895, p. 15), however, revived the term, and it has been in favor since 1895.

SOURCES OF STUDY

Outcrops of Parma sandstone are found at various places in Jackson County and at one locality in Calhoun County (Figure 1). Samples of Parma sandstone have been observed in well cuttings from many counties throughout the central part of the Southern Peninsula.

STRATIGRAPHIC RELATIONS

The Parma sandstone directly overlies the Bayport limestone and is usually the basal member of the Pennsylvanian system in Michigan. The Parma does not possess as wide a distribution as the overlying beds of the Saginaw group, and in several places (Lane, 1909, p. 85) appears to have been eroded away before the deposition of the Saginaw. A contact such as this, that is one in which strata known to be present elsewhere are missing is called an *uncomformity.* An unconformity frequently brings beds of unlike character in contact showing no gradation of one into the other. The unconformable contact is irregular, the boundaries not necessarily being parallel to the bedding planes above or below. Sometimes the uncomformity cuts across bedding planes at a sharp angle and is frequently mistaken for a fault.

LITHOLOGIC AND OTHER CHARACTERS

The lithology of the Parma is described in several publications of the Michigan Geological Survey. The authors emphasize the white sandstone, phases of which are conglomeratic. The sandstones are cleaner than those of the overlying Saginaw group, and are ordinarily much better cemented, and more persistent in distribution. They are predominately quartzose, with tourmaline and zircon the most common of the heavy minerals. Weak brines containing chlorides and sulphates of sodium, calcium, and magnesium, but relatively high in calcium sulphate, are associated with the formation. Winchell mentions the occurrence of a fossil plant, *Calamites,* in an outcrop along Rice Creek. Beds of dark shale have been included in the Parma.

THICKNESS

The thickness of the Parma varies from 0 to 220 feet. (Newcombe, 1928, p. 156). The formation in the vicinity of the type locality (Parma, Jackson Co.) is about 50 feet thick. The thickest sections reported are in Shiawassee County. Records of wells drilled near the center of the area underlain by Pennsylvanian outcrops, such as those in the Mount Pleasant area, indicate thicknesses ranging from a few feet to over 100 feet. This reported variability in thickness may be due not only to the irregular surface of the subjacent Mississippian formations, but also to the difficulty in distinguishing between the Parma and the Saginaw in well samples.

CORRELATION

The unconformity between the shales, limestones, and gypsum beds of the Michigan and Bayport formations, and the sandstones of the Parma provides a natural boundary between the Mississippian and the Pennsylvanian.

Within Michigan any sandstone or conglomerate below the lowest shale of the Saginaw group is assigned to the Parma. Although this is a convenient place to draw the boundary, it should be borne in mind that in most cases the true boundary may lie somewhere in the sandstone beneath. The cyclical repetition of sandstone and shales in the Saginaw group would imply that the oldest shale of the Saginaw represents only the upper member of a cyclical formation. Many well logs indicate a break in sedimentation in sandstones which are below the lowest shale of the Saginaw, and in such logs perhaps only the lower part should be classed as Parma.

The lowermost sandstones of any Pennsylvanian section need not necessarily always be Parma. They may have been deposited at the same time as some of the Saginaw shales and would be therefore stratigraphic equivalents. The sandstone might have been deposited along the edges of the basin only, rather than at the bottom of a series of beds out in

the basin, i. e. the sandstones might have been marginal rather than basal. This idea was apparently held by Lane (1909, p. 87), who stated that the sandstones on the margin of the basin, that is near Parma, might very likely be contemporary with shales in the center. However, the logs of wells in Midland County near the center of the area underlain by Pennsylvanian rocks, indicate thicknesses from 15 feet to nearly 400 feet of sandstone, whereas a log from Ionia nearer the Mississippian-Pennsylvanian boundary did not log any Parma.[1]

These are but a few examples and it seems difficult to reconcile such apparent discrepancies. One is inclined to believe that too great dependency is placed upon stratigraphic position in making correlation of the Parma. The black shale which intervenes between the Bayport and the lowermost sandstone member of the Pennsylvanian in Saginaw County might be assigned to the Saginaw group as well as to a pre-Parma formation, to which Newcombe (1928, footnote on p. 183), refers it. Although these correlations may be supported by lithological peculiarities, one should bear in mind that beds having characters supposedly peculiar to the Parma, have been reported by Lane in the Saginaw group from wells in Lansing (1909, footnote to p. 87), and again by Kelly from outcrops near Grand Ledge (1933, p. 80).

I am inclined to the belief that the Parma is of restricted occurrence, and that the use of the term in the central and northern parts of the area underlain by Pennsylvanian strata is attended with doubt. It has been stated by Weller (1930, p. 105) that "extreme variation, both vertical and lateral, has been considered a feature of general prevalence in Pennsylvanian deposits." Although such an hypothesis may explain conditions in some areas, it should not be considered a blanket explanation. Neither should the hypothesis be made to cover all the variations of the so-called Parma. Weller (1930, p. 101) also states that "recent observations in Illinois indicate that unconformities within the Pennsylvanian system are more numerous than has been suspected," and from a detailed study made of the outcrops near Grand Ledge the writer (Kelly, 1933) has come to the same conclusion. This gives us an alternative hypothesis which may account for the lowermost sandstones of the Pennsylvanian since any one of these sandstones might have been deposited during one of the cycles of sedimentation during Saginaw time. The view may also be held that the Parma sandstone, in a restricted sense, may not be older, or even as old, as some of the lower beds of the Saginaw group which are found north of Jackson County.

[1]These figures obtained from records filed in the offices of the Department of Conservation.

LOCAL DETAILS

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of Devereaux, a station on the New York Central Railroad, section 6, T. 2 S., R. 3 W. Loose blocks of the standstone occur in the fields near Rice Creek and rock in place may be seen about 150 feet southwest of the Rice

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[1]These figures obtained from records filed in the offices of the Department of Conservation.

LOCAL DETAILS

Jackson County: A characteristic exposure of the Parma sandstone may be seen in the Old Titus Quarry. This is northeast of the town of Parma in the NW¼ of section 29, T. 2 S., R. 2 W. The outcrop is about 200 feet long and forms a long, low knoll. The visible section is about 4 feet thick. Any former exposures of rock along the lower slopes of the hill are now concealed. The rock is a clean, very pale yellow, medium grained sandstone, with crossbedding distinctly shown, the dip being in a southwesterly direction, or about opposite to the regional dip of the formation.

Somewhat farther east in section 27, T. 2 S., R. 2 W., outcrops are along the roadside, a short distance north of the railroad. These can be traced northward intermittently for a distance of about one-half mile almost to the top of the hill, giving a partial exposure of about 20 feet of rock. It is probable that the hill is the topographic expression of the underlying sandstone, since its trend agrees with the trend of the outcrops of the Parma.

A better exposure is along the sides of Sandstone Creek about one-quarter mile east in Section 34. Massive, gray weathering, medium grained, clean sandstones outcrop in an exposure showing about five feet of rock. There seems little doubt that all of these sandstone exposures belong to the Parma.

Sandstone very similar in character to that exposed near Parma also outcrops along the main highway between Jackson and Lansing, about one quarter mile south of Bentley Corners, in section 10, T. 2 S., R. 1 W.

The old workings known as Fisk's quarry north of Albion, Calhoun County, are about one mile south of Rice Creek. Rominger, in reference to this quarry, quotes a well driller who stated that the sandstones overlie a coal seam three feet in thickness, and that this in turn overlies other sandstones. (Rominger, 1876, p. 129). Rominger therefore believed it probable that these exposures belonged to Winchell's Woodville. No confirmatory evidence of the well driller's remarks is known, and it is more probable that Winchell and not Rominger is correct.

The same or similar sandstones are found along the roadside north of sec. 20, T. 2 S., R. 3 W., only a short distance from the Rice Creek and Fisk quarry localities. Aligned with the outcrop in the adjacent county,—Calhoun—one may see the general trend agreeing with that of the outcrops in the Parma district. (Fig. 1).

Other outcrops of what appear to be Parma sandstone are found south of Devereaux, a station on the New York Central Railroad, section 6, T. 2 S., R. 3 W. Loose blocks of the standstone occur in the fields near Rice Creek and rock in place may be seen about 150 feet southwest of the Rice

Creek highway bridge in section 18, T. 2 S., R. 3 W. A few plants found at this locality by Winchell furnish the only paleontological evidence of the Pennsylvanian age of the Parma. The determinations are by Winchell and all the specimens are referred to *Calamites*.

Calhoun County: Exposure of soft, friable, mica-free sandstones are at the section corner between sections 1, 2, 11, and 12, T. 2 S., R. 4 W., about 1½ miles west of Devereaux. The weathered surface is brown, but on fresh fracture the rock is light gray to pale buff. Some of the beds are distinctly cross-bedded. It appears very similar to the sandstone exposed in the old Titus quarry northeast of Parma.

The locality is on a hill which Leverett's map indicates as a recessional moraine. Recent work along the road is responsible for exposing the sandstone. The hill is a continuation of the ridge noted northeast of Parma.

Other Counties: The Parma has been reported by drillers and observed in well cuttings from many counties throughout the central part of the Southern Peninsula. Many of these records are cited in publications of the Michigan Geological Survey dealing with the results of deep borings. Outcrops of the sandstone are reported in Arenac County in the northeastern section of the area underlain by the Pennsylvanian. I have visited the outcrops but have tentatively included them with the Saginaw group, and deal with them elsewhere (see p. 184).

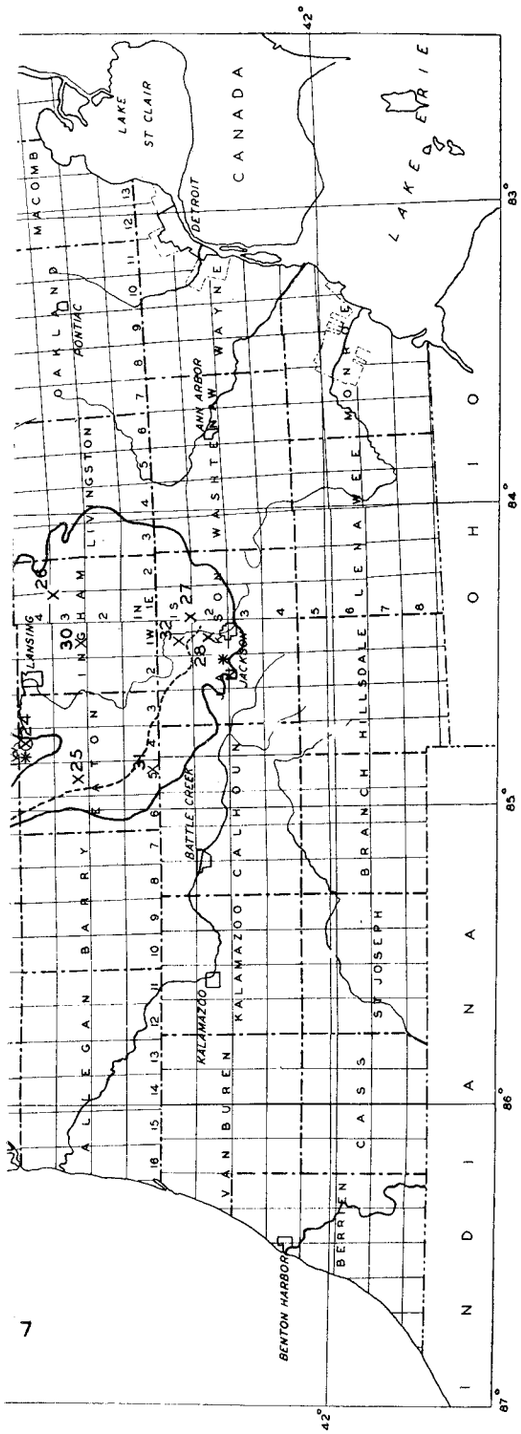

FIGURE 2

Map showing significant outcrops and mine localities of the Saginaw and Grand River Groups of Michigan. Boundaries of formations after Martin. Letters refer to the vertical columns of the floral list Table 2, and numbers to the Faunal list.

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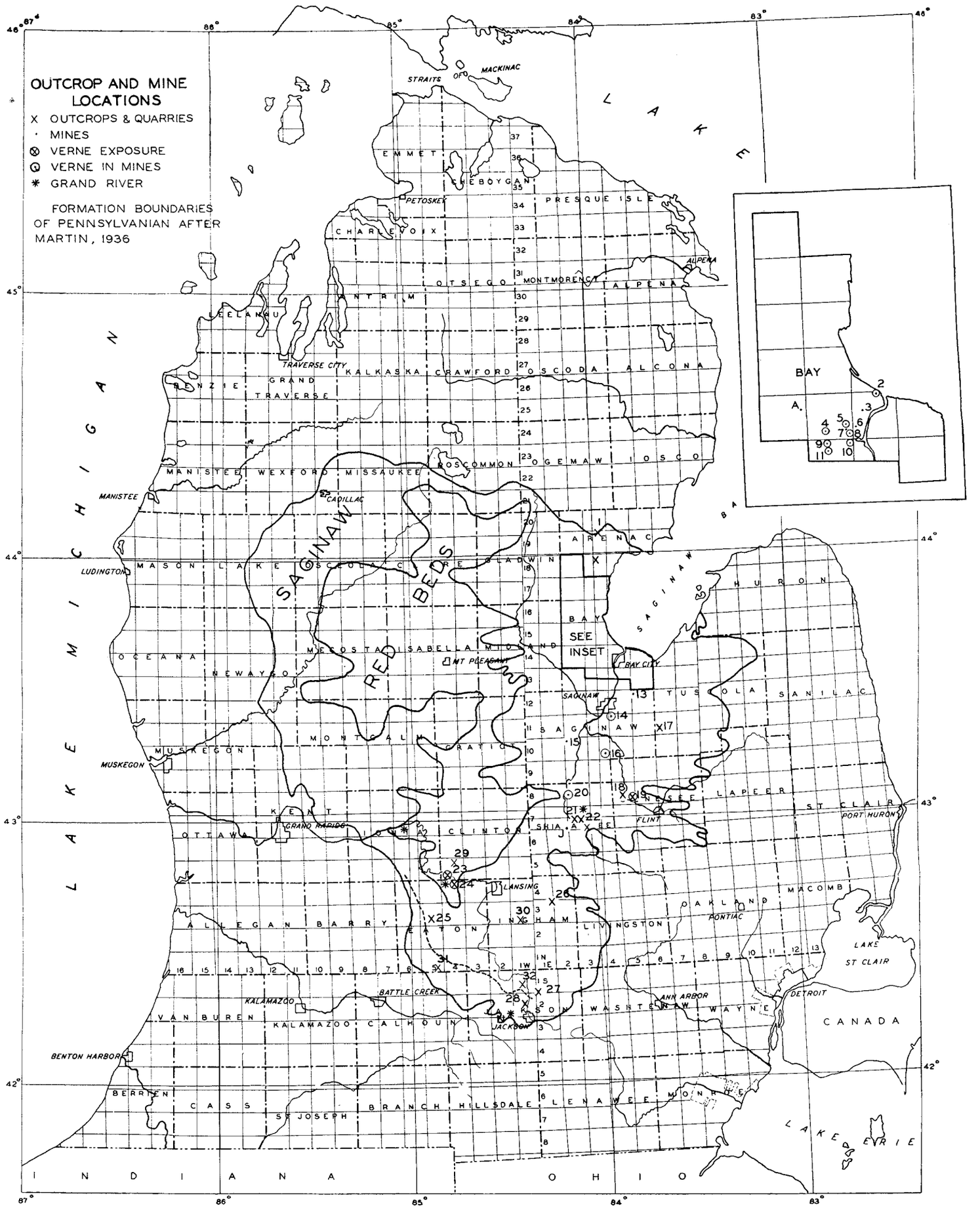

FIGURE 2

Map showing significant outcrops and mine localities of the Saginaw and Grand River Groups of Michigan. Boundaries of formations after Martin. Letters refer to the vertical columns of the floral list Table 2, and numbers to the Faunal list.

Creek highway b
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Other Counties
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the northeastern
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Saginaw group,

Chapter III

SAGINAW GROUP

NAME

The name Saginaw formation was originally suggested by A. C. Lane (1901), a former State Geologist of Michigan, to replace the term "Jackson" as applied to the coal series of Michigan. The name "Jackson" had in turn displaced "Coal Measures," the term by which the group was originally known.

SOURCES OF STUDY

No natural exposure exists in the Saginaw Valley, the type locality, but geologic sections exposed along the sides of numerous coal shafts furnished workers in the past with adequate information concerning the strata of the upper beds of this formation. I have had an opportunity to examine some specimens taken from mines within the "type locality" at the time the shafts were sunk, but have had to depend mainly upon outcrop localities to get an adequate conception of Pennsylvanian stratigraphy.

The chief outcrop localities of the Saginaw group are to be found near Grand Ledge, Eaton County, and these are described as a specific example to illustrate the general characters of the Saginaw rocks in Michigan.

STRATIGRAPHIC RELATIONS

The Saginaw group directly overlies the Parma sandstone wherever that formation is present. The contact between the two formations has already been referred to in the discussion of the stratigraphic relations of the Parma. The Saginaw group sometimes directly overlies the Bayport formation, as in the area immediately north of Jackson. In several localities the Saginaw may rest directly upon the Napoleon sandstone (Lane, 1909, p. 83).

LITHOLOGIC AND OTHER CHARACTERS

The Saginaw group is composed of material of fresh water, brackish water, and marine origin, and consists of sandstones, shales, coal, and limestones. It is true that the individual strata vary in character and thickness within relatively short distances, as stated by Smith (1912, p. 258), and others, but a detailed study of these variations indicates that

many of them are abrupt and due to cut-offs or unconformities. This fact is cited by Smith (1912, p. 258) and an illustration of a similar condition is indicated on the areal map and sections accompanying a report on the Grand Ledge District (Kelly 1933). If proper significance is attached to the many unconformities within the Saginaw group, the apparently heterogeneous association of beds may be reduced to some order, and referred to cyclical sedimentation. The working hypothesis of cyclical sedimentation developed by Weller (1930, pp. 97-135) explains most clearly the stratigraphic succession of beds in the Grand Ledge district. The typical cyclical formation consists of a basal sandstone overlain successively by sandy shale, gray shale, underclay, coal, black shale, and limestone. Frequently the upper beds of the formation are missing and the basal beds are sandy shale rather than sandstone. The most characteristic bed, the underclay, is usually present unless the entire formation has been removed by erosion. In general the cyclical formations are incomplete, an unconformity cutting off the upper members, or even beds belonging to several different cyclical formations. The inclinations of the old surfaces affected the inclination of the beds which were later deposited above them. This is well illustrated in the Grand Ledge district where strata of the Verne cycle, directly superimposed above strata of an earlier cycle, are inclined in opposite directions. This indicates clearly that in certain places regional and local dips do not correspond.

The sandstones of the Saginaw group are frequently lenticular, and nonpersistent, and possess irregular bedding. Most of the beds exposed at the surface are less than ten feet thick. In certain sections sandstone beds are of greater relative importance. Examples of such are to be noted in the vicinity of Lansing, where beds of sandstone over one hundred feet thick are reported from several wells. The texture of the sandstones is usually fine, although thin conglomeratic layers have been observed at the base of individual lentils. Red colors are not characteristic. Quartz is the principal constituent, but is associated at times with some decomposed feldspar, and usually with abundant white mica. The mica flakes are arranged with their cleavage surfaces along bedding planes. The sandstones contain less than one percent of heavy minerals. Tourmaline and zircon are the most common heavy minerals. Both well formed crystals and slightly rounded fragments occur. Fossils in the sandstones are limited to plant fragments. These various characteristics taken together point to a terrestrial origin of the sand, in which shifting currents with rapidly alternating erosion and deposition played a major part.

The shales of the Saginaw fall roughly into three groups: (a) Shales with considerable sandy material, and (b) shales with little or no sandy material, and (c) underclays. The sandy shales possess many characteristics in common with the sandstones, and examples exist where a cursory examination might readily class a given bed as a sandy shale at one time, and a shaly sandstone at another time. Plant fossils are often found in these shales, fern-like fronds, isolated pinnules, and stem fragments being the most common. Like the sandstones, these shales probably had a terrestrial origin.

The shales of the second group are ordinarily dark in color. They may, or may not, be limy. The limy shales are regularly bedded and judging from fossil evidence are closely allied in origin to the shaly limestones. The non-limy shales vary in structure from very fissile to almost structureless layers up to three feet or more in thickness. The structureless beds frequently contain nodular masses, the boundaries of which are slicken-sided. The center of a nodular mass often contains a plant fragment, and it is thought that the local slickenside resulted as the mud about the plant compacted. The common fossils of the structureless shales are the brachiopod *Lingula,* and foraminifera including *Glomospira, Trochammina,* and *Hyperammina.* The fissile and other stratified shales are non-fossiliferous, or else contain macerated shells of the pelecypod *Anthracomya.* It is probable that the "Lingula" shales accumulated in quiet areas of marine or brackish water. In the Grand Ledge district Anthracomya beds succeed plant bearing shales and are followed by beds containing a normal marine fauna suggesting a stage in progressive submergence.

Shales of the third group, the underclays, are structureless, white to light gray beds of claylike or sandy texture. They commonly contain irregular nodules of iron carbonate a few feet from the top, and are often below coal seams.

The coal beds of Michigan are ordinarily thin. Little opportunity is afforded to trace the beds over great distances. Evidence exists, and has been cited in the discussion of the sandstones, that coal beds are frequently cut off by unconformities within the Saginaw group itself. It is highly probable, therefore, that individual coal beds originally had a greater lateral extent than they now possess. This viewpoint is supported by the relatively great extent over which the 18-inch coal seam of cycle 15 has been traced in the Grand Ledge area. (Pl. III). Bartlett (1927) has subjected some of the coals to a macerating process and has found identifiable spore cases in a few samples. The discovery is of value since it may provide a method for the correlation of coal seams.

The Pennsylvanian limestones of Michigan are impure, since they contain a high percentage of shaly consituents. They have been reported from the mines of the Saginaw valley and from Grand Ledge. The beds are thin and exhibit intergradations with black limy shales. In places where

PLATE III

View of the Grand Ledge coal and its associated underclays. The pick shown is about 17 inches long. The nodular zone is about midway between the pick and the coal.

the top of the limestone is cut by an unconformity and is directly overlain by sandstone, a pronounced cone-in-cone structure is developed, seeming to indicate a relationship between such a structure and the circulation of ground water. Most of the limestones and limy shales are fossiliferous, and contain invertebrate fossils in greater abundance than other Pennsylvanian formations. Isolated fragments of plant stems are also found. Pyrite frequently replaces the shell material and, together with the abundant shaly material, suggests an origin for these beds in some partially land-locked embayment having poor vertical circulation.

THICKNESS

The average thickness given for the Saginaw group is 400 feet, and the maximum reported is 535 feet (Newcombe, 1928, p. 156). The formation is extremely variable since pre-glacial and rarely post-glacial erosion removed a considerable part of the upper beds. Apparent variations are also due to the difficulty in drawing the boundary between the Parma and the Saginaw, and the Saginaw and the overlying sandstones of the Grand River Group.

CORRELATION

The Pennsylvanian age of the shales, sandstones, and associated coal seams underlying the central part of the Southern Peninsula of Michigan was recognized as early as 1838 by Douglass Houghton (1838) who referred the strata to the Coal Measures.

About 1900 David White, after examining plant fossils collected from several mines within the State, compared the flora to the Pottsville group of West Virginia, Pennsylvania, and Ohio (Lane, 1902, footnote to p. 44). Recent work by Arnold (1933) has led him to the conclusion that the Michigan Pennsylvanian agrees in age with the Yorkian of Great Britain. The Yorkian corresponds approximately with Middle Pennsylvanian, thus making the Michigan floras late Pottsville or early Alleghany.

The invertebrate fossils (Table 3) from the Saginaw group are confined to relatively few strata. Early determinations were made by Dr. G. H. Girty, who has since kindly lent me material collected from mines which are now abandoned. A complete list of all fossils determined to date is now on file in the Michigan Geological Survey. (Tables 2 and 3). The evidences regarding the age of the Saginaw group has already been summed up in an earlier paper (Kelly, 1930, p. 135). The conclusion reached at the time, that the invertebrate fossils indicated a Lower Pennsylvanian age, has been confirmed by later work.

TABLE II

Chart Showing Fossil Plants Collected and Identified in Michigan

	Bay County				Saginaw County					Shiawassee Co.		Eaton Co.		Jackson Co.		Unknown	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
EQUISETALES																	
Calamites cf. cistriformis							x										
C. ramosus		x			x												
C. sp. indet			x		x							x					
C. suckowii							x										
Annularia sp. (galiodes ?)									*			*					
A. sphenophylloides												*					
Asterophyllites cf. longifolius					x												
A. sp.												x					
LYCOPODIALES																	
Lepidodenron aculeatum	x	x										*					
L. clypeatum															x		
L. dichotomum							x										
L. lycopodiodes												x					
L. modulatum							x										
L. obovatum					x							x*					
L. ophiurus							x										
L. rhombicum							x										
L. ?							x										
Lepidostrobus sp.							x										
Lepidostrobus variabilis	x																
Lepidophyllum cultriforme						x	x										
Sigillaria scutellata												*					
Stigmaria verrucosa		x			x		x					+					
Bothrodendron minutifolium												*					
B. cf. minutifolium		x															
SPHENOPHYLLALES																	
Sphenophyllum bifurcatum					x												
S. cuneifolium					x				*			x*					
S. emarginatum		x										*					
S. majus												*					
S. myriophyllum												*					
S. saxifragaefolium									*								

TABLE II—*Continued*

Chart Showing Fossil Plants Collected and Identified in Michigan

	Bay County				Saginaw County					Shiawassee Co.		Eaton Co.		Jackson Co.		Unknown	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
CYCADOFILICALES																	
Alethopteris decurrenns									*			*					
Cardiocarpon cuyahoga												x					
C. ovale										x							
C. bicuspidatum ohioense										x							
C. ?					x												
Caulopteris sp.					x												
Diplothmema sp.												x					
Mariopteris ? muricata		x															
M. cf. inflata										x							
Megalopteris sp.											*	*					
Neuropteris flexuosa												x*					
N. like desorii	x																
N. flexuosa																	
N. cf. harrisi												x					
N. rarinervis		x										*					
N. sp.					x												
Pecopteris dentata ?		x															
Pseudopecopteris cf. avoldensis		x															
P. ? cf. obtusiloba								x									
P. sp.												x					
Sphenopteris (crossotheca) sp.		x															
S. (palmopteris?) sp.		x															
S. trifoliolata																x	
Helerangium sp.		x															
CORDAITALES																	
Cordaites borassifolius												x					
C. like robbii										x							
C. sp.		x		x							*	*					

x—Identifications by David White.
*—Identifications by C. A. Arnold
+—Identifications by W. A. Kelly

TABLE III

Chart Showing Faunal List of Saginaw Group

	Arenac County	Bay County											Saginaw County				Tuscola County	Genesee County		Shiawassee County			Clinton County	Eaton County		Ingham County		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
FORAMINIFERA																												
Hyperammina bulbosa C and W.																												
Ammodiscus annularis (H.B.B.)																								x				
Ammodiscus sp.																								x				
Turritellella spirans C. and W.																	x											
Glomospira pusilla (G.)																								x				
Litoutuba sp.																								x				
Psammophis inversus S.																								x				
Psammophis sp.																								x				
Trochamminoides sp.																						x		x				
Endothyra bowmanni (P.)																								x				
Ammobaculites compressa C. and W.																								x				
Fusulinella sp.																								x				
Cornuspira sp.																								x				
Trochammina sp.																						x						
ANTHOZOA																								x				
Lophophyllum profundum (M.E. and H.)																				?				x				
CRINOIDEA																												
Delocrinus ? sp.																								x				
Crinoid columnals																				x				x				
BRYOZOA																												
Liopora sp.																								x				
Fenestella sp. A																												
Fenestella sp. B.																												
Polypora sp.																								x				
Septopora biseriaus var gracilis (M.)																								x				
Rhombopora sp. A.																								x				
Rhombopora sp. B.										x	x																	
Streblotrypa ? sp.																								x				
BRACHIOPODA																												
Lingula carbonaria S.		x	x	x		x	x	x		x		x									x	x	x	x	x		x	x
Lingula sp.	x	x	x			x													x	x						x		
Trigonoglossa nebrascensis (M.)																		?						x				
Orbiculoidea capuliformis (MeC.)											x					x								x				
Orbiculoidea missouriensis (S.)											x					x										x		
Orbiculoidea sp.		x																										
Crania modesta (W. and St. J.)																								x				
Schizophoria resupinoides (C.)																				x				x				
Derbya crassa (M. and W.)									x	x	x													x				
Derbya aff. bennetti (H. and C.)																				x								
Chonetes granulifer O.		x			x						x	?				x			?	x				x				
Chonetes sp.																								x				
Chonetina flemingi (N. and P.)		x														x								x				
Mesolobus mesolobus cf euampygus (G.)																				x								
Juresania nebrascensis (O.)																			?					x				
Juresania saginawensis (K.)		x		x						x						x								x				
Dictyoclostus morrowensis (M.)									x	x	x					x								x				
Dictyoclostus smithi (K.)		x			x			x		x	x					x								x				

TABLE III—*Continued*

Chart Showing Faunal List of Saginaw Group

	Arenac County	Bay County										Saginaw County				Tuscola County	Genesee County		Shiawassee County			Clinton County	Eaton County		Ingham County		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Dictyoclostus sp.											x																	
Marginifera muricalina (D. and C.)														?		x												
Marginifera missouriensis (G.)								x			x	x				x				x			x	x		?		
Marginifera aff. wabashensis (N. and P.)																x				x								
Linoproductus prattenianus (N. and P.)				x	x				x		x	x				x				x				x				
Spirifer occidentalis G.										x									x					x				
Neospirifer cameratus (M.)								x	x										x	x				x				
Ambocoelia sp.										x	x									x				x				
Punctospirifer kentuckyensis (S.)								x												x				x				
Composita subtilita (H.)																								x				
PELECYPODA																												
Edmondia ? sp.												x												x				
Nuculopsis ventricosa (H.)		x										x																
Nuculopsis sp.		x										x																
Plagiostoma ? acosta (C.)																						?		x				
Pleurophorus sp. (also) *pleurophorus oblongus* M.																								x				
Astartella compacta G.																								x				
Astartella sp.																						?						
Crenipecten foerstii H. loc. 24																								x				
Myalina pernaformis C.																				x								
Myalina sp.																			x				x					
Anthracomya sp. A.																	x						x					?
Anthracomya sp. B.												x													x			
Naiadites CF *ohioense* M.			x																						x			
GASTROPODA																												
Capulus sp.																							x					
Igoceras sp.																							x					
Platyceras sp.																			x									
Worthenia tabulata (C.)																							x					
Trepospira illinoisensis (W.)		x									x								x			x	x					
Pleurotomaria carbonaria (N. and P.)																							x					
Pharkidonotus percarinatus (C.)																			x									
Macrochilina CF *regularis* (C.)																							x					
Macrochilina CF *primigenius*																							x					
Macrochilina sp.																					?							
Soleniscus sp.															x													
Meekospira peracuta																			x									
Schizostoma catilloides																							x					
Naticopsis sp. A.																							x					
Naticopsis sp. B.																							x					
Conularia sp.																							x					
CEPHALOPODA																												
Orthoceras sp.																							x					
Pseudorthoceras knoxense (McC.)		x									x				x				?			x	x					
Temnocheilus sp.																			x				x					
Metacoceras cornutum G.											?								x									
Gastrioceras sp. Nov.																			x									

TABLE III—*Continued*
Chart Showing Faunal List of Saginaw Group

	Arenac County	Bay County												Saginaw County			Tuscola County	Genesee County		Shiawassee County			Clinton County	Eaton County		Ingham County		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
TRILOBITA																												
Griffithides																												
OSTRACODA																								x				
Paraparchites sp.																												
Amphissites sp.																								x				
PISCES																								x				
Edestus minor																												
Orychodus sp.																				x								
Rhadinichthys sp.															x													
Rhadinichthys sp.										x					x													
Fish Fragments												x												x				

A study of the fossil list (Tables 2 and 3) indicates that most of the fossils came from the limestone member outcropping in the vicinity of Grand Ledge. It is significant that many of the forms collected there are also found in the limestone overlying Lane's Lower Verne coal and that in any locality in Michigan similar faunas are known to occur only in one stratum, a limestone or calcareous shale member. The persistence of thin beds in other regions has been noted (Weller, 1930, p. 107) and it is probable, therefore, that the marine member of the Verne cyclical formation may also be persistent. On the evidence submitted above I make a tentative correlation of all the fossiliferous and calcareous shales, and have revived the term Verne to designate them. The embayment in which the Verne marine member was deposited originally extended from at least the vicinity of Bay City southwestward in a direction approximating the long axis of Saginaw Bay. The extension of the embayment outside the State of Michigan was towards Indiana, Illinois, and Iowa rather than towards Ohio.

Fossiliferous marine strata, other than the Verne are known. These are the so-called "Lingula" shales. Three of these Lingula shales underlie the Verne at Grand Ledge, another Lingula shale has been reported above the Verne limestone member (Lane, 1902, p. 43, and Cooper, 1906, p. 185). Of far more significance than the brachiopod *Lingula* are the formainifera which have been found in some of these shales (Cushman, J. A. and Waters, J. A., 1927, pp. 107-10). Considered with the cyclical repetition of beds, and the lithologic characters of the underclays, the presence of these fossiliferous members have proved of distinct value in working out the stratigraphic succession in the Grand Ledge district, and should prove serviceable in other areas.

TYPE SECTION

Grand Ledge, Eaton County

Eaton County—The outcrops exposed in the vicinity of Grand Ledge (Fig. 3) are the most extensive of the Pennsylvanian exposures within the State. Excluding the capping Eaton sandstone, which is assigned to the Grand River group, the strata have an estimated thickness of about 90 feet. The different parts of the section with their overlapping units may be observed along the bluffs of the Grand River (Pl. III, Pl. IV) and two small tributaries, and also in the shale pits operated by the American Vitrified Company, the Grand Ledge Clay Products Company, and the Grand Ledge Face Brick Company. The district is in the northwest part of T. 4 N., R. 5 W. The stratigraphy is described in detail elsewhere (Kelly, 1935).

PLATE IV

View of typical exposure of beds of the Saginaw Group near Grand Ledge, Michigan. Cyclical formations B and D are exposed, formation C being replaced by D. The coal seam is the "Grand Ledge" seam shown in Plate III.

The Grand Ledge district illustrates the difficulties which are encountered in tracing any bed from one locality to another. It is

The *"Lingula"* bed of this cyclical formation observed only on south side of the Grand River ..... 10 feet

PLATE IV

The Grand Ledge district illustrates the difficulties which are encountered in tracing any bed from one locality to another. It is probably typical of many other areas in Michigan, and since these do not possess the extensive exposures of Grand Ledge, they may present insurmountable correlation problems unless a program of shallow drilling or careful examination of the beds exposed in shafts and drifts is undertaken.

A composite section of the Grand Ledge district is given below in order to illustrate the types of rocks, their thickness, and the number of repetitions which occur in one part of the coal measures.

Cyclical Formation	*Description*	*Average Thickness*
Overlying bed	Eaton Sandstone of the Grand River Group	
G	Buff-colored, cross-bedded micaceous shales, containing numerous remains of *Cordaites*. Beds of this formation found in scattered localities in what appear to be channels excavated in the underlying formations	15 feet
F	White to light gray, medium grained micaceous sandstone lentil, shales and underclay of irregular thickness, followed by coal and carbonaceous shale with third *Lingula*. On the north side of the river the formation is represented by plant bearing shales, and *Anthracomya* shale member, and an argillaceous limestone containing a Verne fauna. This formation is imperfectly represented usually, although of wide distribution. Two cycles may also be represented	15 feet
E	Sandstone lentil and sandy shale passing into white plastic underclay, sometimes overlain by coal seam. Capping bed a black highly plastic shale containing *Lingula carbonaria* and the foraminifera, *Psammophis* sp. and *Lituotuba* sp., and also characterized by elliptical nodules. The *"Lingula"* bed of this cyclical formation observed only on south side of the Grand River	10 feet

D	Sandstone lentils, hard sandy underclay weathering dark gray, followed by friable nodular sandy underclay overlain by thin coal seam followed by shale member containing *Anthracomya*. Formation imperfectly represented in single sections	5 feet
C	Gray to white, structureless soft underclay followed by thin coal seam. This cyclical formation recognized for certain only in the quarry of the Grand Ledge Face Brick Company	5 feet
B	Irregularly laminated sandy shales followed by thick, sandy underclay containing abundant irregular iron-stained, noncalcareous nodules. Persistent coal seam, the Grand Ledge seam, about one and one-half feet thick at the top. This formation is remarkably uniform in thickness, and has been observed over the western part of the area	12 feet
A	Non-micaceous sandstone overlain by sandy shales, a thin underclay, and shales with plant bearing, clay-ironstone nodules, capped by a black, highly plastic shale containing *Lingula carbonaria* and the foraminifera, *Glomospira pusilla* and *Ammobaculities compressa*. Area underlain by this cyclical formation co-extensive with strata of formation B	5 feet

Strata thought to be older than any seen in the quarry sections, occur as isolated outcrops just west of the traffic bridge at Grand Ledge. At least two cyclical formations may be observed at the crest of a low anticlinal structure (Fig. 7, column E). The sandstone at the top of the section is similar in appearance and lithology to a sandstone occurring below the lower *Lingula* bed (Kelly, 1933, p. 80).

Only three of the cyclical formations, A, E, and F are known to have ended with a marine invasion and three of them, B, E, and F have coal seams which locally, at least, are a foot thick. A list of 58 species of fossils, comparatively few of which are common, has been collected from the limestone of cycle F, from which it has been possible to make comparisons with some of the local fossil-bearing beds found in the mine shafts of Shiawassee, Saginaw, and Bay counties.

Ammodiscus annularis (H.B.B.)
Turritellella spirans C. & W.
Endothyra bowmanni (P.)
Lophophyllum profundum (M.E. and H.)
Delocrinus sp.
Crinoid columns
Liopora sp.
Polypora sp.
Septopora biserialis var. gracilis (M.)
Rhombopora sp.
Streblotrypa sp.
Lingula carbonaria S.
Trigonoglossa nebrascensis (M)
Orbiculoidea capuliformis (McC.)
Orbiculoidea missouriensis (S.)
Crania modesta W. & St. J.
Schizophoria resupinoides (C.)
Derbya aff. bennetti H. & C.
D. crassa (M. & W.)
Chonetes granulifer O.
Juresania nebrascensis (O.)
Juresania saginawensis (K.)
Dictyoclostus morrowensis (M.)
D. smithi (K.)
Marginifera missouriensis (G.)
Linoproductus prattenianus (N. & P.)
Spirifer occidentalis G.
Neospirifer cameratus (M.)
Punctospirifer kentuckyensis (S.)
Composita subtilita (H.)
Edmondia sp.
Pleurophorus sp.
Astartella compacta G.
Astartella sp.
Crenipecten foerstii H.
Myalina pernaformis C.
Myalina sp.
Anthracomya sp.
Capulus sp.
Igoceras sp.

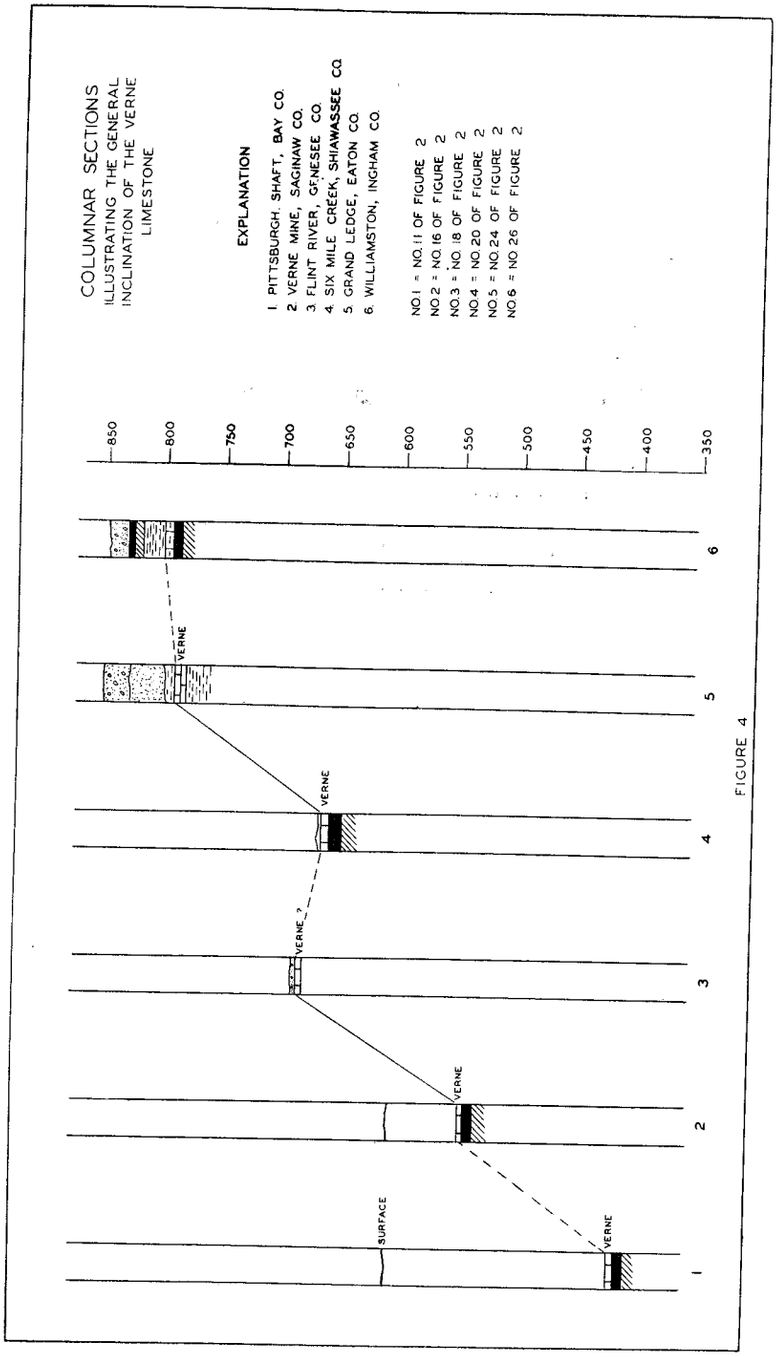


FIGURE 4

Worthenia tabulata (C.)
Trepospira illinoisensis (W.)
Pleurotomaria carbonaria N. & P.
Pharkidonotus percarinatus (C.)
Macrochilina cf. regularis (C.)
M. cf. primigenius (C.)
M. sp.
Schizostoma catilloides (C.)
Naticopsis sp. a.
Naticopsis sp. b.
Conularia sp.
Orthoceras sp.
Pseudorthoceras knoxense (McC.)
Temnocheilus sp.
Griffithides sp.
Paraparchites sp.
Amphissites sp.
Fish spines

The most significant features of the stratigraphy of the district are the many breaks in sedimentation. The unconformities which end the first four cycles are of comparatively little importance since the stratigraphic interval does not change greatly. Erosion, however, at the end of the fifth cycle of sedimentation was more profound, and more in the nature of channeling, since the beds of several cycles are sometimes cut out within a short distance. The inclination of the unconformity at the base of the sixth cyclical formation is as much as 15° to the east in the quarry of the American Vitrified Products Company and the inclination of the beds belonging to the sixth or Verne cyclical formation, accord with this dip quite closely, and thus depart considerably from the more gentle inclinations of the pre-Verne beds. In the quarry of the Grand Ledge Face Brick Company, the inclination of beds belonging to cycles A, B, C is to the east, whereas inclination of the Verne cyclical formation is strongly to the west. This illustrates the dependence of inclinations upon topography developed during pauses in sedimentation. The comparatively deep erosion of the pre-Verne cyclical formations may point to structural control, but this is an open question and would require the tracing of one of the old channels to discount or lend support to the theory. The general elevation of the Verne is in the neighborhood of 800 feet, considerably higher than in Saginaw and Bay counties. (Fig. 4, column 5).

The beds of the Verne cyclical formation are themselves overlain unconformably by strongly cross-bedded shales which have a patchy distribu-

tion. Wherever the shales are missing beds of the Verne or earlier cycles are sharply separated from overlying sandstones of the Eaton, or from glacial drift by an erosional unconformity.

Individual beds when traced downstream from Grand Ledge show that although there are minor undulations in the strata, there is evidence that the beds have a regional dip to the northwest. Thus beds which occur at an elevation of about 780 feet at Johnston's Mine (point H on Fig. 3, and column H on Fig. 5) must have had an elevation of about 840 feet at the upper part of Sandstone Creek (point B on Fig. 3, and column B on Fig. 5). The strike of the beds, as calculated from elevations on marker horizons and the contouring of the Grand Ledge coal (cyclical formation B), is approximately northeast, and the regional dip must be in the neighborhood of one half of a degree.

LOCAL DETAILS*

Arenac County—The geology of Arenac County was reported upon by Rominger (1876, pp. 141-144) and Gregory (1902 and 1912). Pennsylvanian outcrops are almost entirely limited to sandstone, although some idea of the lithology of associated rocks may be gained from the examination of abandoned mine dumps and quarries.

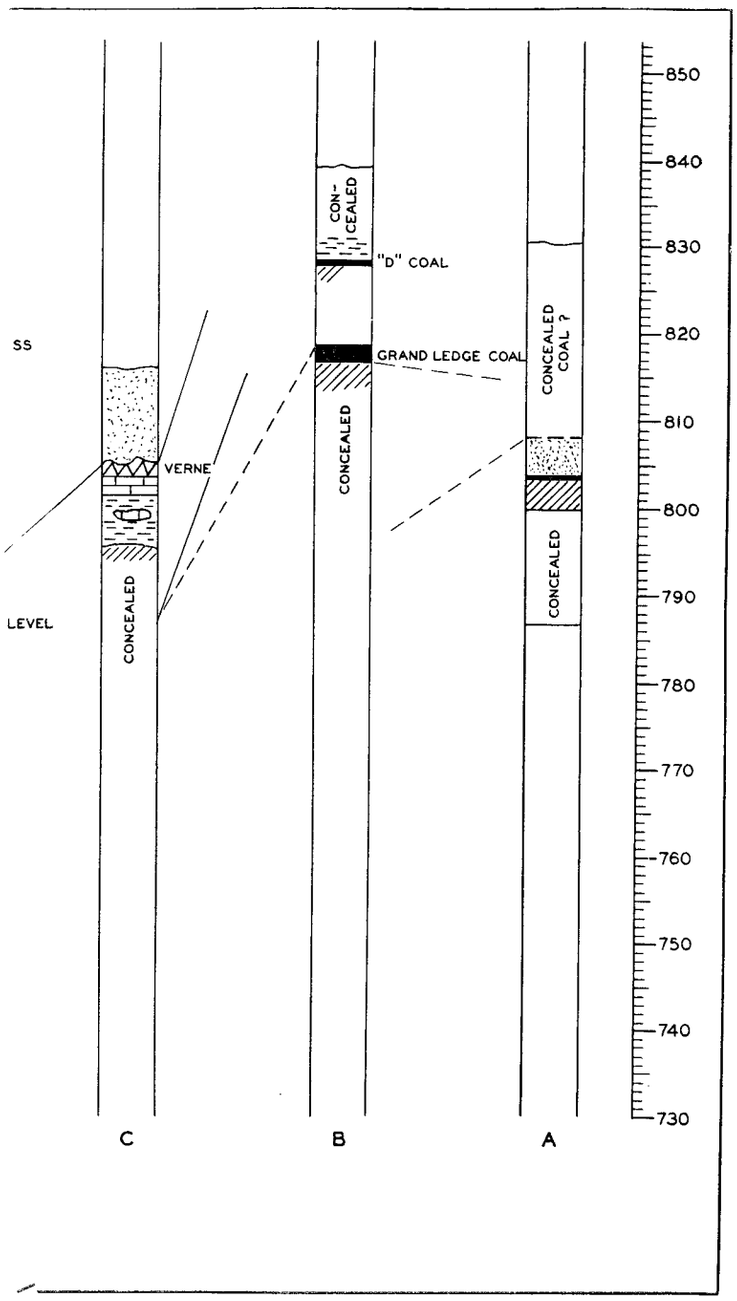
Several outcrops of sandstone are in the bed of Rifle River, in the vicinity of Omer. The outcrops are described in the report by Gregory (1912, p. 37-39), who draws attention to the fact that they resemble the Parma. They are all clean white sandstones of medium grain and contain some zircon and tourmaline. A similar sandstone outcrops in a drainage ditch south of Rifle River in section 22, T. 19 N., R. 5 E. Aside from the fact that these sandstones are near the Mississippian-Pennsylvanian boundary, and are comparatively clean, there is little reason for correlating them with the Parma whose type locality is over 100 miles distant, and which has never been certainly traced across the greater part of this broad interval.

Mine and quarry sites along the Rifle River and above Omer were also visited. In all cases, the mines and quarries were filled with water, but the shale and sandstone samples collected from the dumps were more characteristic of the Saginaw group than the rocks outcropping below Omer.

Rominger (1876, p. 142) mentions the occurrence of a small *Lingula* which may be *L. tigti,* but this brachiopod is not a good guide fossil. No other information was obtained which would allow one to make definite correlation of the beds in Arenac County with a standard section such as that in the vicinity of Grand Ledge.

*Descriptions of exposures proceed from the northern counties southward.

Geological Survey Division
Pub. 40 Geol. Ser. 34 Pt. II Fig. 5



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Outcrops of thinly bedded, medium grained, white sandstone are also in the bed of Pine River, north of Standish in section 35, T. 19 N., R. 4 E. This is a clean sandstone with a small amount of heavy mineral, the most common being zircon. It does not resemble a typical sandstone of the Saginaw group, but is more like the sandstones of the Parma. A correlation on general resemblances alone seems hazardous, and the beds are referred to the Saginaw, which we definitely know extends to this area.

Bay County—Although no outcrops are known in this county, some of the specimens collected from the old mines were deposited in the Museum of Paleontology of the University of Michigan and made available for study. Determinations of their fossil contents were made and are given below.

The localities are listed as from north to south and west to east in order that any relationship between the strata and the faunas found in the mine sections may be more apparent.

WENONA BEACH MINE, SECTION 33 OR 34, T. 15 N., R. 5 E.

This locality is represented by a fauna consisting of eleven species, determinations of which follow:

Lingula carbonaria S.
L. sp.
Orbiculoidea sp.
Chonetes granulifer O.
Chonetina flemingi (N. & P.)
Dictyoclostus smithi (K).
Juresania saginawensis (K).
Pleurophorus oblongus M.
Plagiostoma? acosta (C).
Trepospira illinoisensis (W).
Pseudorthoceras knoxense (McC)

The collection above was lent to me by Dr. G. H. Girty. The brachiopod *Lingula* is in a black, carbonaceous shale; the remainder of the fauna is in a calcareous shale. Lane (1902, p. 42) mentioned the *"Lingula"* fauna from the Wenona Mine, but does not mention the other forms. Some mixing of specimens may have occurred, and the fauna above may include specimens from the Michigan mine, Bay County, which were sent to Dr. Girty for identification.

LOCALITY 18978. WOLVERINE MINE NO. 3, SE. CORNER NE. QUARTER, SECTION 12, T. 14 N., R. 3 E.

I did not see any samples from this locality. A small flora is reported from the mine, however:

Lepididendron aculeatum Sternb.
Lepidostrobus variabilis.
Neuropteris desorii group Lx.

The determinations are by David White. (Lane, 1908, p. 19.)

LOCALITY 18999. UNITED CITY COAL MINE. SECTION 17, T. 14 N., R. 5. E.

This locality is a little over one mile southwest of the Wenona Beach Mine. Abundant specimens of *Lingula carbonaria* associated with a small ovate *Lingula* occur in a black compact shale. The collector and horizon are not given on the label accompanying the specimens.

LOCALITY 18993. MONITOR SHAFT. SW. CORNER, SE. QUARTER, SECTION 28, T. 14 N., R. 4 E.

This locality is about two miles southwest of locality 18999. It is represented by four species, which are listed below:

Lingula carbonaria S
Juresania saginawensis (K.)
Linoproductus prattenianus (N. & P.)
Naiadites ohioense (M.)

The material was collected by W. F. Cooper who states that it came from above the "Upper Verne" coal. Two distinct types of rock are represented, however. One of the types is a black, compact shale containing abundant specimens of *Lingula,* and also a pyritous nodule in which a small pelecypod resembling *Naiadites ohioense* is present. The other type is a black, slightly calcareous shale containing the two Productidae, *Juresania* and *Linoproductus.* It is believed that two horizons are indicated here, and that the slightly calcareous shale represents the Verne horizon.

A small collection of fossils obtained about one and one-half miles east of locality No. 18993 was lent to me by Dr. Girty. The exact locality given is:

MICHIGAN STANDARD COAL AND MINING CO., SECTION 25, T. 14 N., R. 4 E.

Chonetes granulifer O.
Dictyoclostus smithi (K.)
Linoproductus prattenianus (N. & P.)

The matrix is a black, calcareous shale. The horizon is probably the Verne.

CENTRAL COAL AND MINING CO., SECTION 30, T. 14 N., R. 5 E.

This locality is a short distance east of the Michigan Standard Mine. It contains specimens of *Lingula carbonaria* and a small ovate *Lingula,*

like that occurring at the Wenona Beach Mine about six miles to the northeast. The collection was lent to me by Dr. G. H. Girty.

LOCALITY 18994. CENTRAL MINE SHAFT. SE CORNER, SE QUARTER, SECTION 25, T. 14 N., R. 4 E.

Abundant specimens of *Lingula carbonaria* occur in a black, brittle, carbonaceous shale, identical with the *Lingula* shale of the locality given above. The collector, W. F. Cooper, states that it came from the "Upper Verne" coal.

LOCALITY 18995-6. MICHIGAN COAL AND MINING CO., SE QUARTER, SECTION 25, T. 14 N., R. 4 E.

Lingula carbonaria S.
Dictyoclostus smithi (K.)
Marginifera missouriensis (G.)
Neospirifer cameratus (M.)
Composita subtilita (H.)

The fossils with the exception of the *Lingula,* are in a black, compact highly argillaceous limestone, No. 18995, which strongly resembles the Verne limestone member from the Verne Mine in Saginaw County. Cooper, the collector, states that it came from above the "Lower Verne" coal. The *Lingula* shale, numbered 18996, is like the *Lingula* shales from the Wenona Beach and Monitor mines. Cooper states that it comes from above the "Upper Verne" coal, that is stratigraphically higher than the other fossils from the same mine.

Localities 18995 and 18996 are possibly from one mine, the numbers indicating different horizons. Like locality 18994, they are very close to the Michigan Standard Mine.

A collection from a locality about one mile south of the Monitor Shaft, or about one and one-half miles southwest of the Michigan Coal and Mining Company shaft, contains the fossils listed below. The locality given on the label is:

LOCALITY 18998. BAY COAL SHAFT NO. 2, SE QUARTER, SECTION 4, T. 13 N., R. 4 E.

Calamites sp.
Derbya crassa (M.&W.)
Dictyoclostus morrowensis (M.)
Linoproductus prattenianus (N.&P.)
Neospirifer cameratus (M.)

The fossils are in a black, carbonaceous and slightly calcareous shale similar to the shales from the Monitor, Michigan Standard and Michigan Coal and Mining shafts. Cooper's label states the name of the rock to be

the "Lingula black shale." However, I found no specimen of *Lingula* and the horizon very probably represents the Verne.

LOCALITY 18992. VALLEY COAL MINING COMPANY, SE CORNER, NE QUARTER SECTION 1, T. 13 N., R. 4 E.

This locality is about one and one-half miles east of the last. The fauna present is listed below:

Rhombopora sp. undt.
Lingula carbonaria S.
Derbya crassa (M.&W.)
Juresania saginawensis (K.)
Dictyoclostus morrowensis (M.)
D. smithi (K.)
Spirifer occidentalis G.
Punctospirifer kentuckyensis (S).
Rhadianichthys sp.

The fossils were collected by W. F. Cooper, who states that the horizon of the cap rock is the "Upper Verne" coal. However, the specimens in the collection of the Museum of Paleontology of the University of Michigan show two different kinds of rock similar to those observed in specimens from the Michigan Coal and Mining Company shaft, about one mile to the north. One type, the black, brittle carbonaceous shale contains only specimens of *Lingula carbonaria*. The other, a black, slightly calcareous shale, contains the more varied Verne fauna.

LOCALITY 18997. PITTSBURGH SHAFT, QUARTER LINE, SECTION 15, T. 13 N., R. 4 E.

This locality is about one mile southwest of the last. The flora and fauna follow:

Cordaites sp. undt.
Rhombopora sp. undt.
Orbiculoidea capuliformis (McC.)
O. missouriensis (S.)
Derbya crassa (M. & W.)
Chonetes granulifer O.
Dictyoclostus morrowensis (M.)
D. smithi (K.)
D. sp. undt.
Marginifera missouriensis (G.)
Linoproductus prattenianus (N.&P.)
Punctospirifer kentuckyensis (S.)

The fossils are in a black carbonaceous and slightly calcareous shale, similar to the shales from other localities in neighboring sections identified as the Verne. W. F. Cooper states on the accompanying label that the fossils were collected from the cap rock of the "Lower Verne" coal, 200 feet below the surface. The United States Geological Survey Bay City quadrangle gives an elevation varying from 600 to 610 feet above sea level for section 28. This would give an elevation between 400 and 410 feet above sea level for the Verne horizon (Figure 4, column 1).

In addition to the faunal lists which have been tabulated one other is given by Lane (1902, p. 42) from the Michigan mine. The exact locality of this mine is not stated, but it is probably near St. Charles. The identifications are by Girty and are reproduced here for the sake of reference. The probable present day synonomy is given in the right-hand column and occurrences are listed under these names in the complete faunal list. (Table 3, column 12). The choice of synonyms has been guided largely by common Michigan forms. Where reasonable doubt exists in my choice of synonyms the occurrence is listed as questionable:

Lingula mytiloides	Lingula carbonaria S.
Chonetes flemingi	Chonetes granulifer O.
Productus prattenianus	Linoproductus prattenianus (N.&P.)
P. (Marginifera) muricatus	Marginifera missouriensis (G.)
Avicula acosta	Plagiostoma? acosta (C.)
Pleurophorus oblongus	Pleurophorus oblongus M.
Nucula ventricosa	Nuculopsis ventricosa (H.)
Trepospira sphaerulata	Trepospira illinoisensis (W.)
Orthoceras rusheuse	Pseudorthoceras knoxense (McC.)
Large nautiloid	Metacoceras cornutum G.
Fish bone	Fish bone

Excepting the specimens from the Pittsburg Shaft in section 15, T. 13 N., R. 4 E., no data bearing on the elevation of the Verne member may be obtained from labels. However, an average elevation of 440 feet above sea level is given for the "Lower Verne" coal (Cooper, 1905, p. 184) which is just below the Verne member. We cannot be sure that the "Lower Verne" coal was always correctly identified, but if Cooper's statement has any value the Verne cyclical formation in Bay County is definitely lower than the same member in counties to the south.

Saginaw County—Many mines were formerly operated in this county, but partial records obtained when the shaft was opened are preserved only from two. Small collections have also been obtained from a few of the mines which are still operating.

UNCLE HENRY MINE NO. 2, SECTION 6, T. 12 N., R. 6 E.

This mine is about seven miles northeast of Saginaw and is one of those being operated under normal conditions today. A collection of fossils

was made from the material thrown out on the dump. Among the invertebrates were macerated specimens of large *Anthracomyas* similar to some collected from Williamston (see ante under Ingham County). The stratum from which they came is not known.

LOCALITY 18989. STANDARD MINE, SECTION 6, T. 11 N., R. 5 E.

The Standard mine is about ten miles south of the Pittsburgh mine. A calcareous shale sample showed the presence of *Marginifera muricatina* D. and C. Preservation was poor and the identification is open to question. As they are preserved, however, the fossils look more like *M. muricatina* than *M. missourensis* (Girty), the more common species in Michigan.

From the Somers Mine No. 1 near St. Charles, a black compact, carbonaceous shale yielded fish fragments. These, according to Dr. E. C. Case of the University of Michigan, should be compared with species of the genera *Rhadianicthys* and *Onychodus*.

LOCALITY 18983. VERNE MINE, SECTION 23, T. 10 N., R. 4 E.

This locality is about nine miles south of the Standard Mine. Its fauna includes:

Orbiculoidea capuliformis (McC.)
O. missouriensis (S.)
Chonetes granulifer O.
Chonetina flemingi (N.&P.)
Juresania saginawensis (K.)
Dictyoclostus morrowensis (M.)
D. smithi (K.)
Marginifera muricatina (D.&C.)
M. missouriensis (G.)
Linoproductus prattenianus (N.&P.)
Pseudorthoceras knoxense (McC.)

In addition to the above Girty (Lane, 1902, p. 42) lists *Soleniscus sp.* The small collection contains the important elements of the larger fauna from Grand Ledge. The rock in which the fossils are preserved is a black, highly argillaceous limestone very similar to limestones which are about 20 miles northward in Bay County, and at Grand Ledge, about 60 miles southwest. The mine forms the type locality for the Verne cyclical formation which includes a marine member which I believe has a persistent though interrupted extension from Bay County to Eaton County.

The label accompanying the Verne mine specimens states that they were secured at a depth of 58 feet. Since the general elevation of the

area, as determined from a topographic map, is from 590 to 605 feet above sea level this depth places the Verne limestone at an elevation of 530 to 545 feet. However, the elevations of the coal bed beneath, according to Lane, (1902, pp. 175-191) indicates an elevation nearer 500 feet. In general, one might say that the Verne limestone, at least in the southern part of Saginaw County, is at a higher elevation than it is in Bay County (Figure 4, column 2.)

Tuscola County—A small exposure of shale occurs on the left bank of Cass River about one-half mile below the bridge at Tuscola in section 29, T. 11 N., R. 7 E. This is evidently the outcrop referred to by Winchell (1861, p. 120) since the Cass River does not flow in the location which he gives, namely section 29, T. 11 N., R. 9 E.

The outcrop consists of slumped shale from which a few foraminifera referred to *Ammodiscus* were obtained. Winchell also reports a *Lingula* from this locality.

Beyond suggesting the former eastern extent of the Pennsylvanian sea, this outcrop tells very little. The species of *Ammodiscus* is not identical with that occurring in the shales immediately above the Verne limestone at Grand Ledge.

Genesee County—Two outcrop localities were visited in Genesee County, one north, and the second east of the town of Flushing.

The outcrop north of Flushing is on the right bank of the river, near the center of section 22, T. 8 N., R. 5 E. The beds are exposed in a shale pit formerly worked by the Saginaw Clay Manufacturing Company. At the time of my visit the pit was filled with water. Samples were collected below the tipple on the west side of the river, and were later examined. The brackish water pelecypod, *Anthracomya* sp. A, was found in very thinly-bedded brittle dark gray shales. A fragment of the brachiopod *Trigonoglossa* was also found in some of the shale. According to the section given by Ries (1900, p. 30) these shales are near the top, overlying a so-called fire-clay and separated from the fire-clay by a seam of coal.

A cycle of sedimentation is again illustrated here, but occurring as it does in an essentially isolated position, it seems impossible to definitely fit it into either the upper or the lower part of the Saginaw group.

The eastern outcrop is located along the banks of a small creek which joins the Flint River in the northwest quarter of section 36, T. 8 N., R. 5 E. The exposures can be observed in the bed and banks of a creek for a distance of about 900 feet. They consist entirely of sandstones having a total thickness of about five feet. The upper sandstones are thinly-bedded medium grained sandstones with abundant mica along the bedding planes. Scattered clay gallen were found in some of the layers. The lower sandstones are strongly cross-bedded, the dip of cross-bedding

being about five degrees westward. Like the sandstones above, the lower sandstones also contain considerable mica.

Winchell (1861, p. 118) describes a section exposed along the Flint River in section 24, T. 8 N., R. 5 E., just north of the section line and north of the exposures described in the preceding paragraph. The locality is about 15 miles southeast of the old Verne mine. Winchell's section follows:

Superficial materials	4 feet
Black shale, containing *Lingula, Chonetes Smithii, Productus asperus* and *Spirifer cameratus*	3 feet
Sandstone tinged with iron	0 feet 7 inches
Shale	1 foot
Sandstone	0 feet 3 inches
Shale	4 feet
Sandstone	0 feet 6 inches
Shale to surface of water	0 feet 10 inches

I did not observe such complete exposures although a search was made for the reported outcrops along the river bank and the bank of the tributary creek. Fragments of black, argillaceous limestone, lithologically similar to the limestone bed in the Verne and other mines as well as at Grand Ledge, were found lying on the banks in this locality above sandstone beds. One of the limestone fragments collected by the writer yielded a small *Lingula* like that found in the Wenona and other mines. This horizon is very probably that which Winchell describes as a black shale.

Winchell's fossil list includes more than the *Lingula,* and is reproduced here for the sake of reference. The probable present day synonymy is given in the right-hand column:

Lingula	Lingula sp.
Chonetes Smithii	Chonetes granulifer
Productus asperus	Juresania nebrascensis
Spirifer cameratus	Neospirifer cameratus

All these forms are present in the black argillaceous limestone at Grand Ledge, and appear to indicate the presence of the Verne member near Flushing. The elevation of this bed is from 675 to 700 feet. (Figure 4, column 3).

Other localities have been mentioned by Winchell (1861, p. 120). He states that sandstone, not unlikely the Woodville sandstone, is found outcropping in the township of Montrose, on the borders of Saginaw County. This area is an old lake plain and showed no signs of an outcropping of sandstone. Lane (1902, p. 200) also mentions that an outcrop was reported on the river bank near the northeast corner of section 4, Flushing township. The locality was visited but no outcrop was found.

Shiawassee County—Winchell (1861, p. 123) describes outcrops along Six Mile Creek in section 18, T. 8 N., R. 3 E. about 10 miles southwest of the Verne mine and 15 miles west of the Flushing locality. The same outcrops are described by Rominger (1876, pp. 138-140). Rominger mentions a "black, shaly lime rock, visible in a thickness of four or five feet, containing numerous fossils, partly in calcified, partly in pyritous condition." I have never seen this rock outcropping in Six Mile Creek although collections of fragments answering Rominger's description have been made from the dumps of two shafts, sunk in its bed. Determinations made of specimens I have collected, and of other specimens in the Museum of Paleontology of the University of Michigan labeled New Haven township, that is T. 8 N., R. 3 E., which are believed to be from identically the same locality are given below:

Crinoid columnals
Lingula sp.
Schizophoria resupinoides (C.)
Derbya aff. bennetti
Chonetes granulifer O.
Mesolobus mesolobus var. like euampygus (G.)*
Marginifera missouriensis (G.)
M. aff. wabashensis N. & P.*
Linoproductus prattenianus (N.&P.)
Neospirifer cameratus (M.)*
Ambocoelia sp.*
Composita subtilita (H.)
Pharkidonotus percarinatus
Trepospira illinoisensis (W.)
Meekospira paracuta
Metacoceras cornutum G.
Gastrioceras sp. nov.
Edestus minor

With the exception of the *Lingula,* which is in a black, fissile carbonaceous shale, all the forms are in either a black, argillaceous limestone, similar to the limestone at Grand Ledge and the Verne and other mines, or in a black, hard, pyritized limestone. Some forms such as *Marginifera missouriensis,* are common to both types of limestone. There seems to be little doubt that this is the Verne fauna.

Rominger (1876, p. 139) also lists a comparatively large fauna from this locality. His list is given below in the left hand column, and present

*Specimens labeled "New Haven township."