OUTLINE

of the

GEOLOGIC HISTORY

of the

GRAND TRAVERSE REGION

By

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AN OUTLINE OF THE GEOLOGY OF THE GRAND TRAVERSE REGION

The four counties bordering Grand Traverse Bay with Kalkaska and Benzie counties form a unit sharing the same geologic history. The foundation of the region is a segment of the western rim of the nest of rock bowls that are the bedrock of the Southern Peninsula.

The Foundation

Through millions of years Michigan was a-building. After the iron formations and the copper bearing lavas were piled on the northern rim of the granitic bowl we call the Michigan Basin, after earth movements had lifted, compressed, folded, metamorphosed or changed, the sediments of the Huronian iron-forming age and had broken and uplifted the copper bearing lava flows of Keweenawan time, then came a time of quiet and of early life known as the Paleozoic, (primitive plants, algae, fungi, bacteria were in existence during the Huronian). During the Paleozoic, six major ocean-encroachments were made over North America, seas entered and retreated from the Michigan Basin. Each major sea ebbed and flowed several times covering the basin in whole or in part. Each time of major encroachment has a name: Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian. Likewise the sediments of each minor sea has been given a name. At least 54 layers of strata of sediments were deposited. Into each sea sediments were washed from the lands and spread upon the sea floor. Also vast quantities of minerals were dissolved from the rocks and carried to the sea. Thus more food became available and plants and later animals flourished in the seas. When they died their bodies were buried in the mud and there in time "petrified" or were fossilized. In each suceeding sea a higher form of life flourished and increased in numbers. Each sea ebbed and flowed, at times covering all the basin, at other times covering only part of the basin. But at all times sediments were deposited and the compacted hardened sediments of one sea became the floor of its successor. Because the land from which the sediments were derived was not all alike, sediments were different and when compacted to rocks made sandstones, shales, limestone. At first, during the Cambrian and Ordovician time, few and only primitive plants were on the land, and animals lived only in the sea. During the Silurian, plants left the sea for the land and developed roots. Then soils began to form as the dead bodies of plants mixed with broken rocks and new chemical processes produced changes and so soil. At the close of Silurian time the climate changed so that much evaporation took place and hundreds of feet of salt were deposited. Erosion removed much of the early formed rock so that today the northern rims of the rock bowls outcrop in the Northern Peninsula from the oldest -- the Cambrian sandstones, bordering Lake Superior to the younger Silurian limestones bordering lakes Michigan and Huron. Ordovician limestones and shales outcrop between Cambrian and Silurian in the central part of the eastern half of the Northern Peninsula.

Devonian time followed the Silurian and like the Silurian was a time of warm shallow seas with myriads of corals, snails, clams, brachiopods and other shelled creatures living in the sea and primitive plants living on the land. The Devonian was a time of many incursions and ebbing of the seas, thus many layers of sediments were laid down that compacted to many rock strata and became the petrified cemeteries of the life of the sea. The rocks of the Devonian and succeeding Mississippian time are the foundations of the Grand Traverse Region.

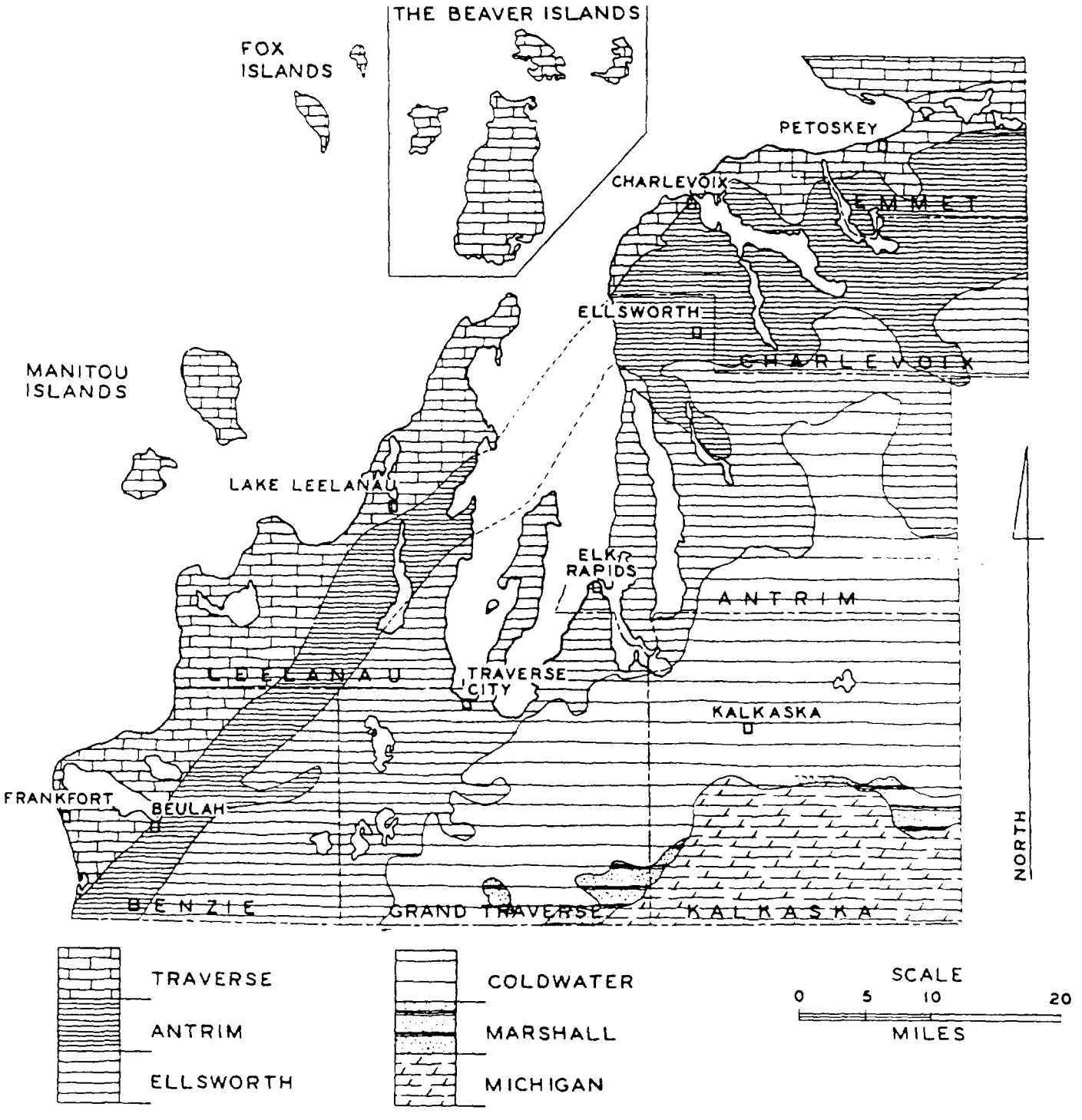

Figure 1. Geologic Map of the Grand Traverse Region.

The oldest rocks underlying the region are the Devonian limestones, 1,700 feet thick which border Lake Michigan and are exposed along the shore in Charlevoix County (fig. 1). In Devonian time the seas were warm and shallow and the sediments brought to the sea were largely of soluble lime or lime in solution. This furnished an ideal home for corals (fig. 2e), "moss animals" or bryozoa, brachiopods, the ancestors of the clams, snails, and some trilobites. Some of the corals were solitary, free swimming animals that built a horn- or cup-shaped shell (fig. 2a) about their bodies. Other corals and bryozoa lived in colonies and built great coral and bryozoan reefs. You can see them in the limestone quarries of Charlevoix County. In time the seas departed, the lime muds that had been built around the reefs and deposited on the sea floor, compacted to rock - limestone. And slowly the shells were petrified (fig. 2). Some original shells remain, some shells were replaced - molecule by molecule with calcite, the mineral of lime, so that the form remains. So slowly did the muds settle that impressions and molds of shells were not destroyed. All of these may be found in the Devonian Traverse rocks exposed at the following places, where you can stage fossil hunts:

Along the lake shore, Evangeline Township, SW Section 6, T 33 N, R 6 W.
Road cut, ledges and bluffs along Lake Michigan. Norwood Township, T 33 N, R 9 W.
Small pits, Norwood Township, N½ Section 26, T 33 N, R 9 W.
Shore bluffs near Bay Shore, old Northern Lime Co. quarry, Hayes Twp., Section 1, T 34 N, R 7 W.
Abandoned Superior Quarry at 9 Mile Point, Hayes Township.
Along shore from 9 Mile Point for 2½ miles, Hayes Township.
Along shore Big Rock Point.
Charlevoix Rock Products quarries, Charlevoix Township, T 34 N, R 8 W.
Ledges and bluffs along shore from South Point for 1 mile southwest.
Abandoned Wolverine Lime Quarry, Section 29, Charlevoix Township.
Abandoned city quarry, Section 33, T 34 N, R 8 W. Charlevoix Township. City dump.
South side of the road, junction of Highways 31 and 131, eroded gully, and creek bed in Emmett County.

The most famous of the fossils is "the Petoskey stone". The stone is a fragment of one of the great coral reefs built in the warm sea from Charlevoix to Alpena, which now as a rock is exposed in Charlevoix, Cheboygan and Alpena counties. Each little cell in the "Petoskey stone"was the home of an individual coral (or polyp), named Hexagonaria. Hexagonaria was a colony coral and built coral "heads" that measure from one or two inches to feet in diameter. Many small specimens are complete colonies and at the base show the original individual coral cell from which the colony developed by branching reproduction and by building upward. Since the lime of the original coral was replaced by harder crystalline calcite (the mineral of lime) and in places by silica (the mineral of sand and glass) the "Petoskey stone" can be easily cut and carved and takes a high polish.

So much of the Traverse limestone has been scraped into the glacial drift that the ground water is very limy and where it comes to the surface and evaporates, lime is deposited. In Lime Lake, Cleveland Township, T 29 N, R 13 W., Leelanau County, marl is deposited in the lake. Along the shore one can find marl pebbles which on being broken open reveal a snail shell encased in lime and slowly becoming fossilized just as their ancestors were.

The northern tip of Leelanau County has a rubble shore of Traverse limestone rocks and a well there found the bedrock at 20-foot depth.

The numerous quarries that have been opened in the limestone show the economic value of the rock. But another value of the limestone is that it is a reservoir of petroleum. Bacteria acted upon the dead corals and other creatures and separated fats from other organic matter. In time these fats by other bacterial action and chemical changes and pressures became petroleum preserved in the pores of coral limestone.

Lapping up on the limestones from the southeast are the black Antrim shales, so named because shale is at the surface in several places in Antrim County. These shales are Devonian at the base but the top may be of the next geologic age - the Mississippian. They average as much as 100 feet in thickness. Exposures of black Antrim shale may be found along the shore of Lake Michigan in Torch Lake township and several places in Banks Township.

Many exposures of Ellsworth shale overlying the Antrim were originally classified as Antrim, but closer studies have led to their separation and the upper green shales were named Ellsworth. In Charlevoix County the Antrim shale is at the surface in Wilson, South Arm, Melrose, Evangeline and Norwood townships. Along the Lake Michigan shore near Norwood and along the north shore of Lake Charlevoix shore near Kamp Kairphree the exposed Antrim contains large balls or concretions of the mineral anthraconite, commonly called "stinkstone" as it emits a fetid odor of petroleum when struck a sharp blow with a hammer.

The first of the Mississippian rocks are the green Ellsworth shales that outcrop near Ellsworth - were quarried there and so were named for the town. They may be from 100 to 400 feet thick in the region. Above them are 800 to 1,000 feet of blue-gray Coldwater shales underlying 140 feet of Marshall sandstones. Over the Marshall are 90 feet of limestone, shales and gypsums of the youngest Mississippian rocks - the Michigan formation. All strata slope to the southeast and all thicken towards the center of the Michigan Basin, which with increasing weight of the sediments, slowly warped downward during the long Paleozoic time. Thus a complete section is only in Kalkaska and southern Grand Traverse County. Younger strata thin to the west as they lap up on the next older rock, so that the western exposures are the oldest rock - the Traverse limestone of Devonian age.

The deepest well drilled in the area, the Ohio Chamberlain No. 1 in the SW$\frac{1}{4}$ NE$\frac{1}{4}$ Section 14, T 31 N, R 8 W penetrated 6,150 feet of glacial drift and rock and ended in the Ordovician St. Peter sandstone not far above the Cambrian sandstones. In this well the Detroit River oil bearing Devonian rock is at a depth of 1,245 feet or 508 feet below sea level. The deepest well in Kalkaska County is 4,623 feet deep, but in it the Detroit River formation was penetrated at 2,946 feet or 1,790 feet below sea level or over 1,200 feet lower than in Antrim County. Also the first rock penetrated in Antrim County is the Ellsworth shale. In the Kalkaska well the first rock is the Marshall sandstone and the Ellsworth is 966 feet deeper. This shows the slope or dip of the strata. Figure 2 shows where these rocks would be at the surface if they had not all been buried under a mixed mass of rock of all varieties, sizes and shapes that was deposited during the last rock forming episode in the history of Michigan (fig. 7). Only the Traverse, Antrim and Ellsworth are at the surface, the younger rock formations are buried by glacial drift.

end of advance. Where the glacier was stagnant the ice slowly melted or disappeared by evaporation and its load of drift remained where the ice had been. This deposit is ground moraine. On the ground moraine in Charlevoix, Antrim, and Leelanau counties are long narrow hills known as drumlins. All are oriented from north northwest to south southeast. Their origin is a puzzle. Several hypotheses have been advanced to account for their origin, all agree that they are in some way connected with stagnation, dump, readvance of the glacier, that a moving mass of ice streamlined the hills.

When the glacial ice melted rapidly, at the front of either advancing or halted glacier, the rapidly flowing meltwaters washed away from the ice front, washing out, sorting and depositing the glacial debris, filling hollows with glacial drift, leaving boulders near the ice front moraine and depositing successively finer and finer material farther from the ice front as the carrying power of the outflowing meltwater decreased. Some outwash plains, as those in Grand Traverse County were built as high as the moraines. Others have scattered boulders believed to have been ice-rafted on the outwash. Winds blowing off the icecap further sorted the outwash material by blowing away the fine clays and sands and leaving the outwash with a gravelly surface. Thus a morainic unit in order of deposition is: moraine, outwash in front of the moraine, ground moraine back of the moraine. A readvance of the ice could push a moraine over either outwash or ground moraine (till plains) and an outwash could be built over a ground moraine.

The last advance of the Ice Age glacier is known as the Wisconsin. We know little of the earlier ice sheets as the Wisconsin ice erased and buried their records as it gathered its load of rock debris from the bedrock and from the drift left by its three predecessors. Its front became lobed as the ice reached the valleys of the pre-glacial rivers where the ice could move faster. Thus a lobe was pressed into the river valley, now the bed of Lake Michigan, and from it smaller lobes were pushed into the Little Traverse and Grand Traverse Bays and the channels of Charlevoix, Torch, Elk, Glen, Platte and Crystal lakes. The ice was thicker in these valleys than on the uplands, lasted longer and did more work. A lobe from the ice mass that entered the Lake Huron valley advanced in the Saginaw basin area and another lobe came in the Lake Erie valley. Eventually the Lake Michigan, Saginaw and Huron-Erie lobes united south of Michigan and advanced to the Shelbyville moraine in central Illinois, Ohio and as far east as Long Island, New York.

The retreat of the Wisconsin ice was marked by many halts and slight readvances with building of recessional moraines. The retreat was pulsating in halt and readvance. The glacier did not move uniformly, in some places it stagnated, in others a small lobe or tongue advanced, in other places retreat was rapid. The whole story was written by the disposition of the glacial debris in moraines, ground moraine, outwash and lake plains.

In places the melt water could not escape across the moraine and was pounded between moraine and glacier front and thus began the long story of each of the Great Lakes, that enlarged from small ice-border lakes to the five great lakes of today. In places slabs or large vertical masses of ice were left stranded in moraine, ground moraine or outwash plain. They became covered and protected by glacial debris. When they melted centuries later, pits were left that filled with water and made lakes like the Manistee lakes of Kalkaska County and the lakes of Grand Traverse and eastern Benzie County.

Figure 3. First halt of Lake Michigan glacial lobe in Grand Traverse region. Lake Border moraine. Manistee River outwash plain.

water flowed to the river, the Boardman became smaller and then cut the inner Mancelona plain leaving the earlier plain as terraces along the valley.

After a long time of stagnation, during which the glacial drift was dropped and built the ground moraine (fig. 6) in Charlevoix, Grand Traverse and Leelanau counties, the glacier front retreated into Lake Michigan - perhaps to the Manitou, Fox, Beaver Islands. What happened then is still a matter of controversy. In the area , the long narrow drumlins, a quarter of a mile to a mile and a quarter in length and ranging from low swells to hills 50 to 70 feet high are the notable feature of the landscape. They undoubtedly were carved by the ice - but how, when? A red veneer of glacial drift and lake clay is found in many places. Most geologists now call this the Valders drift. Some geologists believe it was left by a thin sheet of ice that moved into the area from the northwest, built no moraines but carried a mass of red glacial drift. Little lakes formed by ponding of meltwaters along its border were filled with red sediments and then unsorted drift was plastered over the earlier moraines. The drumlins and the red drift are still unsolved problems.

Finally the ice left the area. The glacial lakes in the Superior, Michigan, and Huron basins united as one great lake we call Lake Algonquin. It overflowed the eastern half of the Northern Peninsula and the northern part of the Grand Traverse region became an archipelago (fig. 5). Beach lines and shore formations show how far the lakes came inland occupying depressions and building beaches at 605 feet above sea level in the moraine. In some places Lake Algonquin cut cliffs in the bordering moraines like the cliffs back of Herring Lake, at Beulah, Sleeping Bear and Pyramid Points. When Algonquin was at high level, the winds built dunes along its shore. Sleeping Bear dune is a remnant.

Post-Glacial Time

Lake Algonquin (its final outlet was down to the St. Lawrence) came to an end. The glacial epoch was ended for Michigan. Lake level dropped to 230 feet above sea level. Two small lakes left in the Lake Michigan basin were connected to a small lobe in the Lake Huron Basin by a river that cut a gorge through the Straits of Mackinac and looped northward around Mackinac Island. This is the gorge that had to be spanned by the Mackinac Bridge. But change continued. Again the basin was filled and Lake Nipissing, the ancestor of the modern Great Lakes came upon the scene. Lake waters rose rapidly to 15 ± feet above present lobe level. Like all rising waters the lake was powerful. It cut into the shores, making cliffs, destroying some of the Algonquin shore features. It went inland almost as far as Lake Algonquin and there developed shore features, shore cliffs, gravel beaches and other shore forms that we now find encircling all the lake-border lakes of the region. Lake Nippissing was larger than the modern lakes but did not cover the eastern half of the Northern Peninsula as Lake Algonquin did. Its outlet was through North Bay to the Ottawa and St. Lawrence River. Steplike terraces around Charlevoix, Intermediate, Torch, Elk, Leelanau, Glen, Platte, Crystal Lakes, the East and West Arms and other depressions bordering Lake Michigan are the ancient shores and cliffs of Lakes Algonquin and Nipissing.

Lake Nipissing came to an end. Its waters fell to a level called Algomah about which we know little in the Southern Peninsula as its few scattered beach records have not yet received sufficient study. About 3,000

Figure 5. Third halt of Lake Michigan glacial lobe in Grand Traverse region. Manistee moraine. Mancelona outwash plain and Boardman River.

years ago the continent, relieved of the weight of ice, had risen high enough so that the outlet of the lakes at Port Huron was the lowest and Lake Nipissing fell to the level of the Port Huron outlet and the three northern lakes were connected with Lakes St. Clair, Erie, Ontario, and the St. Lawrence River. The modern Great Lakes had arrived.

The wave and current action of both lakes Algonquin and Nipissing on their shores supplied abundant sand, gravel, and clay for shore currents and the wind to work with. Currents carried sediment along the shore undercutting cliff and shore and depositing sediments when they reached quiet water where sediments were dropped and bars were built across the many inlets and bays, straightening the shoreline and making such lakes as Crystal, Platte, and Glen. The bays of Benzie County were the first formed, currents carried sediments across the mouth of the bays, cutting them off from the main lake and leaving the Herring, Crystal and Platte lakes. Then the winds piled the sand of the bars into dunes.

Further north, slow release of the continent from the weight of the ice lifted the region out of water. The Algonquin and Nipissing then became the high lands, the old lake bed became the lake border lowlands of Leelanau, Grand Traverse, Antrim, and Charlevoix counties. Bars and uplift cut Glen Lake, Lake Leelanau, Elk, Torch, Charlevoix and the head of Little Traverse Bay from the main lake. Uplift was not enough to connect the Manitou, Fox and Beaver Islands with the mainland. The water was too deep for currents to build bars across the mouth of Grand Traverse Bay or of the North and South Arms.

During the slow advance of the glacier, plants and animals had retreated southward to escape the cold. Then, with retreat of the ice, they slowly returned. Forests and grasslands were developed on the glacial drift - surface of the land. Rivers took their modern courses. Small streams flowing down the north slope of the Manistee moraine, cut its headquarters southward until they tapped the Boardman and captured it and diverted the river from being a tributary of the Manistee to its modern course to the West Arm of Grand Traverse Bay and independent existence.

This brief outline of the geologic history of the Grand Traverse Region cannot include details of lakes, streams, and lands but more complete discussion may be found in the list of suggested references.

Suggested References

The Glacial and Post-Glacial History of the Platte and Crystal Lake Depression, Benzie County. Publication 45, Pt. II. Michigan Geological Survey. Department of Conservation.

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Centennial Geological Map of Michigan. Pub. 39, Geological Survey Division. Publication Room, Department of Conservation. $.50

Map of the Surface Formations of the Southern Peninsula. Pub. 49. Geological Survey Division. Publications Room, Department of Conservation. $.50

Outline of the Geologic History of Michigan. Geological Survey Division, Publication Room, Department of Conservation. Free.

Rocks and Minerals of Michigan. Pub. 42. Geological Survey Division, Publication Room, Department of Conservation. $.50.

*All five are out of print but may be borrowed from Michigan State Library.