Minnesota Geological Survey
Field Trip No. 1



# A GEOLOGICAL FIELD TRIP IN THE ROCHESTER, MINNESOTA, AREA

October 5, 1968

Minnesota Geological Survey
Minneapolis, Minnesota

Minnesota Geological Survey
Field Trip No. 1

# A GEOLOGICAL FIELD TRIP IN THE ROCHESTER, MINNESOTA, AREA



Text prepared by
George S. Austin

## ACKNOWLEDGEMENTS

The Minnesota Geological Survey would like to thank the Quarve and Anderson and the Rochester Sand and Gravel companies for allowing us to visit their quarries. Many people in the Rochester area including David Dunn, Director of Rochester Parks; Gordon Jeager of the Post-Bulletin; and Bernie Kirchoff of Rochester Lapidary Supply Company have given us the benefit of their counsel. We would also like to thank Dr. R. C. Bright and Dr. G. F. Webers for assisting on the field trip.

CONTENTS

# INTRODUCTION

The Minnesota Geological Survey invites non-geologists to examine the rocks and fossils in the Rochester area on this field trip. We welcome all persons regardless of their backgrounds in geology and hope that this guidebook will help make what is seen here more understandable. If any word or explanation is not clear to you, please ask any of the geologists on the trip to explain it to you.

One of the basic terms used in geology is formation. A formation is a rock unit that was deposited under essentially uniform conditions and therefore has more or less uniform characteristics. It must be mappable--that is, thick enough and found over a sufficiently large enough are to be mapped--to quality as a formation. For example, if we should find a moderately persistent layer of rock 100 feet thick and composed almost entirely of clay-size material that has thick sandstones both above and below it, this unit would be sufficiently distinctive and thick to be called a formation. The place where a formation is first described is called its type locality. At the type locality is the type section, or exposure of the rock unit which was first described by a geologist and thereby characterizes the formation. Formation names are taken from the geographic place near the rock's type locality. Thus the name given to 25 to 30 feet of shale (composed of consolidated mud) near the town of Decorah, Iowa, is the Decorah Formation.

A formation may be divided into smaller units called members. Members are rock units within formations that have distinctive characteristics. They are local in their distribution and are a result of relatively minor changes in the environment of deposition.

Each of the formations, and most of their members, found in the Rochester area are described in this guide book. These rock units, with the oldest on the bottom and the youngest on top, are:

| | | |
|---|---|---|
| Middle Ordovician | Galena Formation | |
| | Stewartville Member | |
| | Prosser Member | second and restricted transgressive sequence |
| | Cummingsville Member | |
| | Decorah Formation | |
| | Platteville Formation | |
| | Carimona Member | |
| | McGregor Member | first transgressive sequence |
| | Pecatonica Member | |
| | Glenwood Formation | |
| | St. Peter Sandstone | |
| | ~~~~~~~~~~ | a break in deposition |
| Lower Ordovician | Prairie du Chien Formation | |
| | Shakopee Member | |
| | New Richmond Member | |
| | Oneota Member | |

The Ordovician is a unit of geologic time which began about 500 million years ago and ended about 440 million years ago. The Ordovician seas in which these formations were deposited have long since drained away, and erosion by the Zumbro River has exposed the sedimentary rocks down to the Prairie du Chien Formation in the Rochester area.

The sediments deposited on the bottom of the Ordovician sea were laid down in a cyclic fashion. As the sea advanced over the land, sandy sediments were first deposited. As the water became deeper and the

shore line moved farther away, fine muds were laid down on top of the sands. Subsequently, the muds from the land area were covered by limy muds formed from material precipitated from sea water. After the third type of sediment, the sea retreated and a new sedimentary cycle began. We will see two such cycles of sediments formed by the transgressive, or advancing, Ordovician sea on this field trip.

## GEOLOGY

The purpose of this section of the guide book is to help us understand what we see and what to look for when examining rock exposures, or outcrops. This section should be skimmed first to gain an understanding of the concepts involved and then referred to again when you are at the various outcrops. The text starts with the oldest formation in the sequence and works upward to the youngest. The field trip, on the other hand, begins with the youngest formation and works downward to the oldest.

### Prairie du Chien Formation

In 1906 the entire sequence of lower Ordovician rocks of northeastern Iowa was designated Prairie du Chien. The Prairie du Chien Formation has three members in southeastern Minnesota: the Oneota Dolomite at the bottom, the New Richmond Sandstone in the middle, and the Shakopee Dolomite at the top. The Shakopee Dolomite is the only member exposed in the immediate Rochester area, but all of the members

can be seen to the east in Whitewater State Park.

Dolomite is both a mineral and a rock name. The structure of the mineral dolomite consists of alternating layers of magnesium carbonate ($MgCO_3$) and calcium carbonate ($CaCO_3$), and the formula for the mineral is generally written ($MgCa(CO_3)_2$. A rock composed primarily of the mineral dolomite also is called dolomite, although there are some geologists who prefer the term "dolostone."

Shakopee Dolomite Member - The term "Shakopee Dolomite" was introduced in 1874, and the type section is found among exposures near the town of Shakopee, Minnesota. This member is the oldest rock unit that we will see on this field trip and is about 200 feet thick in the area.

The Shakopee Dolomite has a wide range of sedimentary features which are characteristic of a shallow water depositional environment. Typical Shakopee Dolomite is fine- to medium-grained; individual crystals of the mineral dolomite are from 1/8 to 1/2 mm in diameter. It is light brownish-gray to buff in color and thin-to-thick bedded; layers or beds of dolomite range in thickness up to several feet. Light gray-to-green shale beds (consolidated mud) separate some of the beds of dolomite. The Shakopee has a substantial proportion of sand scattered through the dolomite, and has some sandstone beds or layers which may be several inches to several feet thick. It also has round sand-size grains of carbonate called oolites, which were formed by gentle agitation of the limy sediment on the bottom of the shallow Ordovician sea. Some of the oolites have been dissolved by ground water, leaving small round holes

in the rock. Others have been replaced by silica at some time after their formation. Chert, a tough, gray silica mineral, is found in layers or in lens-like bodies in the Shakopee Dolomite. Another interesting feature of the Shakopee Dolomite is the presence of some flat-pebble conglomerates. A conglomerate is essentially cemented gravel-size material, and a flat-pebble conglomerate has larger particles that are elongate and flattened in the bedding plane. The conglomeratic layers were formed from pieces of partly consolidated carbonate, which were loosened from the bottom of the Ordovician sea during storms and redeposited the limy mud and subsequently hardened.

For the most part the Shakopee Dolomite is not very fossiliferous, or fossil-bearing. After deposition and consolidation, the carbonate members of the Prairie du Chien Formation were altered to the dolomite we see today. Exchange of magnesium for some of the calcium ions and the resulting adjustment in the structure of the carbonate blurred or destroyed all but the thick-walled fossils. Gastropods, or snails, are the most common group of Lower Ordovician fossils that are found. The gastropods Hormotoma, Ophileta, and Raphistomina are sometimes found in exposures. Local disruptions in the relatively flat bedding of the Shakopee can be traced to ancient life. Some folds in the beds are caused by algae which extracted calcium from the sea water and used it in their structure to form low mounds on the local ocean bottom. Later deposition of additional limy mud over algal structures and consolidation of the mud caused swells in the bedding.

Another evidence of life at the time of Shakopee deposition is the presence of the mineral glauconite, which is found as individual grains scattered through some of the dolomite. Glauconite is a green iron silica-bearing mineral said to result from the alteration of the feces of marine worms.

The fossil assemblages and sedimentary structures in the rock indicate that it was deposited in a shallow, warm sea. The sea had substantial life in it, even though little evidence of this life remains. Although the environment was dominantly a carbonate-producing one, frequent shifts in currents brought in minor amounts of sand and clay; the environment of deposition was similar to the one found today off the Bahamas. Later alteration of the limy sediment produced the dolomite we see today.

## St. Peter Sandstone

In 1847 outcrops of sandstone at the junction of the Mississippi River and the St. Peter River, which was later renamed the Minnesota River, were named as the type section for the St. Peter Sandstone. Although most of the exposures are found in the north-central states, the St. Peter is found as far south as Missouri and Kansas and as far east as Ohio and Kentucky. The St. Peter is about 75 feet thick in the Rochester area.

The St. Peter Sandstone is overall a remarkably uniform sandstone. It is composed of more than 99 percent quartz ($SiO_2$), and 90 percent of the grains are in the fine-sand range, with grains ranging in diameter from 1/4 to 1/8 mm. The sandstone generally is white to buff, but can be orange with increasing amounts of iron oxide or have a green tint where

a high proportion of green clay is present. The iron oxide stain results from the alteration of pyrite (iron sulfide), which is found in small amounts throughout the sandstone but is most abundant near the top of the formation.

The sand grains of the St. Peter Formation are pitted and frosted from the repeated banging together as they were moved about before being deposited. This type of grain surface is found typically on sand deposited in a beach environment, where the sand is moved by both wind and water. As there is no strong cement between the grains, the sandstone is friable; that is, it breaks apart easily. Because of its friable nature, the St. Peter normally does not stand well with steep slopes. If water is not allowed to run over the surface of the St. Peter, the relatively small amount of iron oxide and clay present in the formation is sufficient to bind the grains together and keep slopes stable.

The St. Peter is a transgressive sandstone; that is, as it was deposited the sea was advancing onto the land. The sea, which earlier had retreated after depositing the lower Ordovician Prairie du Chien Formation, returned and covered the sandy shorelines. The St. Peter is virtually unfossiliferous, because few shells could endure the washing of the waves on the Ordovician beach, but those fossils that have been found show that the St. Peter is older toward the south. Therefore, it is concluded that the sea advanced from the south toward the north.

## Glenwood Formation

In 1906 an exposure of shale and sandy shale, 15 feet thick, that lies above the St. Peter Sandstone in Glenwood Township, Winneshiek County, Iowa, was designated as the type section of the Glenwood Formation. The formation does not exceed 20 feet in thickness in Minnesota and is between 2 and 4 feet thick in the Rochester area. It is dominantly a green fissile shale. Fissility is the ability to split easily along closely spaced parallel planes. Some sandstone layers are present locally. Where the shale has a brown color and is limy, it breaks with a blocky habit. The line or contact between the underlying St. Peter and the Glenwood may be difficult to locate accurately because of the mixing of St. Peter sand with shale at the base of the Glenwood. The simplest, and probably most accurate, solution is to put the contact between the St. Peter and Glenwood formations at the point where the sandstone of the St. Peter is replaced by shaly sandstone of the Glenwood.

The Glenwood Formation contains almost no large fossils. There is, however, an abundance of microscopic fossils which indicate that worms probably destroyed the shells of larger animals before the mud was consolidated. Black pebbles of phosphatic material, which are found near the base of the formation, are thought either to be rock material or phosphatic deposits around organic material.

The Glenwood represents the second stage of sediments resulting from a transgressing sea. As the Ordovician sea advanced over the land,

pushing the beach environment farther to the north and west, only finer particles could be transported from the land areas to the ocean basin. As a consequence, the sand of the St. Peter and lower Glenwood was supplanted by muds.

## Platteville Formation

Exposures of limestone near Platteville, in southwestern Wisconsin, were designated as the type locality of the Platteville Formation in 1906. The Platteville Formation lies between the shales of the Glenwood Formation below and the Decorah Formation above. Although the formation is relatively thin, having a maximum thickness of about 30 feet in Minnesota, it is quite persistent laterally and covers much of the southeastern part of the state. The Platteville Formation is composed of alternating units of limestone, made up of the mineral calcite ($CaCO_3$), and dolomitic limestone in which some of the calcium has been replaced by magnesium. In the Rochester area, the Platteville Formation is about 21 feet thick and is divided into three members. The Pecatonica is the oldest, followed by the McGregor, with the Carimona at the top.

Pecatonica Member - In 1894 exposures of carbonate rock in the Pecatonica Valley north of the Illinois-Wisconsin state line were designated the type locality for the Pecatonica Member. At Rochester, the member is a sandy dolomitic limestone that is 3.5 to 4 feet thick. It is light buff to medium gray in color, hard, and near the base contains

clay; the lower part locally is iron stained. The brachiopod Őpikina and the graptolite Climacograptus are two of the fossils found in the member. The Pecatonica may contain small black or dark blue pellets or granules which are composed of phosphatic material. Many exposures contain irregular blue-gray lines which are called corrosion zones by geologists and represent depositional breaks. The color, the sand, and the corrosion zones all aid in distinguishing the Pecatonica from the overlying McGregor Member of the Platteville Formation.

As the sea deepened and spread over the land area, little of the material from the shore could be carried by the currents to the center of the basin. In this area of the ocean most of the sediments formed were limy muds, resulting both from the precipitation of calcium carbonate from the ocean waters and from the skeletal remains of animal and plant life which removed calcium carbonate from the water. Some sand was brought in by currents, but the environment was mainly one producing carbonate sediments. The Pecatonica then represents the start of the third stage of sediments resulting from the transgressing sea, a time when the sea was broad and land was far away.

McGregor Member - In 1935 exposures near the northeastern Iowa town of McGregor were designated the type locality for the McGregor Member of the Platteville Formation. The McGregor is typically a thin-to thick bedded bluish gray to light gray, very fine-grained limestone with carbonate grains ranging in diameter from 1/8 to 1/16 mm. It has

narrow shaly zones that weather rapidly and alternate with more resistant beds of carbonate that are as much as 6 inches thick. In the field trip area, it is about 12 feet thick. Because the shaly material was deposited irregularly, the beds have irregular surfaces which produce a crinkly bedding.

Fossils commonly found in the McGregor Member include the brachiopods *Campylorthis*, *Opikina*, *Pionodema*, *Protozyga*, *Lingula*, and *Rafinesquina*, and the coral *Lambeophyllum*. The fossils are generally found most easily by looking at the top surface of individual crinkly beds.

The McGregor Member is distinguished from the Pecatonica by being slightly different in color, by having thin crinkly bedding, and by being a limestone rather than a dolomite or dolomitic limestone. It contains a small amount of phosphatic material but no sand except perhaps at the base. The bottom two inches can be somewhat dolomitic and sandy.

Carimona Member - The Carimona Member was named in 1955 for an exposure in a quarry near Carimona, Minnesota. It is a light gray to buff or dark gray, very fine-grained dolomitic limestone that is thin-to-medium bedded; beds are as much as 10 inches thick. Limestone layers are separated by limy, yellow-brown shale. Phosphatic pellets similar to those found in the other members of the Platteville Formation also occur in the Carimona. A thin bed of creamy to bright yellow bentonite

is present about 1.5 feet above the base and 5.5 feet below the top of the member. Bentonite is an altered volcanic ash that represents a time marker because it was deposited in a very short time, geologically speaking. Immediately beneath the bentonite is a thin layer of brown shale which has a petroliferous odor and is known as the "Oil Shale." In the Rochester area the base is marked by a corrosion zone. Fossils found in the Carimona Member include the brachiopods Pionodema, Protozyga, Strophomena, and Doleroides, the bryozoan Monticuliporella, the trilobites Eomonorachus and Isotelus, and the cephalopod Endocerus.

The sea which had advanced far to the north and west during the deposition of the McGregor Member of the Platteville shows signs of retreating during the time of deposition of the Carimona Member. The influx of muds, which later consolidated into shale, shows that the environment in Carimona time was not as carbonate-producing as during McGregor time, and thus foreshadows the deposition of shales which characterize the overlying Decorah Formation.

## Decorah Formation

The green shale above the Platteville Formation is the Decorah Formation. The formation was named in 1906, and the type section is located in northeastern Iowa near the town of Decorah. The Decorah has been divided into members, but they will not be discussed on this field trip because of the difficulty of identifying them without careful study. In the Rochester area the Decorah Formation is a limy,

greenish-gray shale about 47 feet thick. The shale has both fissile and blocky layers and contains numerous layers of limestone. Most of these limestones are composed almost entirely of fossils, and are said to be coquinoid or are called a coquina. Recrystallization or re-organization of the calcite molecules has blurred the fossil boundaries within the limestone, but many good specimens are found on the surface of the coquinas. A bentonite, or altered volcanic ash, can be found 5 feet above the base of the formation.

Fossils are found both in the coquinoid limestone and in the shale itself. When hunting for fossils, pick a spot where rain has washed the surface. It will have removed the shale from around the fossils and cleaned the surfaces of the conquina, thus making it unnecessary to dig for specimens. There are many fossil groups found in the Decorah Formation, but only a partial list is included here. Brachiopods include Doleroides, Pionodema, Strophomena, Rhynchotrema, Zygospira, Resserella, Sowerbyella, Öpikina, and Hesperorthis. Bryozoans found are Batostoma, Escharopora, Rhinidictya, Strictoporella, Homotrypella, Pachydictya, Phyllodictya, Subretopora, Homotrypa, and Prasopora. Trilobites which may be found are Eomonorachus, Bumastus, and Ceraurus, and gastropods present are Hormotoma and Phragmolites. The cephalopod Endocerus may also be present.

The volume of muds being dumped into the ocean basin was increased during deposition of the Decorah Formation. The sea shore was not as

far away as at the time of deposition of the Carimona Member of the Platteville Formation or, alternately, perhaps the source area supplying the muds was higher and subject to greater erosion. In any case, vast quantities of mud were dumped into the Ordovician sea and currents scattered it over the bottom. The nearest land lay to the west of where the Decorah is presently exposed, and maximum uplift of the land or maximum recession of the sea occurred shortly after the beginning of the influx of Decorah muds. There were brief times, however, when the sea water was clear and life abounded on the sea floor, forming the coquinoid limestones. Renewed mud influx in time engulfed and buried the coquinas.

The sea did not withdraw after the Platteville Formation was deposited as it had after the lower Ordovician sediments were laid down. No sandstone first stage is found between the Platteville and the Decorah Formation. The Decorah, therefore, without a sandstone unit beneath it, is the first rock unit of a restricted transgressive sequence.

## Galena Formation

In 1851 gray and drab friable limestones above the shale of the Decorah Formation at various localities in Illinois, Iowa, and Wisconsin were identified as "Galena." Galena, Illinois, has long been accepted as the type locality.

In the Rochester area, the Galena Formation is composed of shaly limestones and dolomites and has a thickness of about 200 feet. The

base is placed just above the top coquina of the Decorah Formation. The contact may be marked by a concentration of the cap-shaped bryozoan Prasopora or by brassy oolites in the top of the Decorah. Brassy oolites are small yellow-brown pellets of clay with a coating of iron oxide. In the Rochester area the bottom two feet of the Galena Formation is a shale with lenses of fine-grained limestone. The bottom thick limestone bed of the Galena which lies above the shale is a gray limestone but has a yellowish-brown shaly base. Large irregular shaped masses of pyrite, or iron sulfide, are found just beneath a corrosion zone in this bottom limestone. The upper contact of the formation is placed at the bottom of the first prominent shale bed of the overlying Dubuque Formation. The Dubuque Formation is not present at any of our stops. The bottom member of the Galena is called the Cummingsville Member, and is composed of interbedded limy shales and limestone. The middle member is the Prosser and is a limestone. The upper member or Stewartville Member is a dolomite. All three members are exposed in the Rochester area.

The Galena represents the third stage in the development of sediments laid down by a transgressive sea, but is only the second unit of rocks in this restricted sequence. It corresponds in position to the Platteville Formation as a carbonate unit overlying a shaly unit.

Cummingsville Member - The bottom member of the Galena Formation, the Cummingsville Member, was first described in 1955. It is a yellowish brown shaly limestone with thin, crinkly bedding. The thin beds are grouped into massive units separated from one another by shaly beds. When the Cummingsville is weathered, the shaly units erode more rapidly than the limestones, producing a characteristic serrated profile.

The Cummingsville does not have the quantity or variety of fossils of the Decorah Formation. The brachiopods Resserella and Sowerbyella are the dominant fossils but are not as abundant as in the overlying Prosser Member of the Galena. Other brachiopods include Holtedahlina, Öpikina, Platystophia, Rafinesquina, Rhynchotrema, Strophomena, and Plaesiomys. The sponge-like fossil Receptaculites occurs throughout the member except at the base. Bryozoans found include Aspidopora and Phyllodictya. The gastropods Hormotoma and Ectomaria are present. A coral Streptelasma and the trilobite Illaenus are also found.

The dominantly carbonate rocks of the Galena Formation succeeded the shale of the Decorah Formation with the formation of the Cummingsville Member. The Cummingsville does contain much shale and represents a more or less transitional rock unit between the more carbonate-rich members of the Galena and the shales of the Decorah.

Prosser Member - The Prosser Member of the Galena Formation was first described in 1897, and the type locality is near Wykoff in Fillmore County. The member is composed of as much as 180 feet of yellowish

to light olive-gray limestone. In the Rochester area it is about 80 feet thick and composed of very fine-grained limestone; the grains range in diameter from 1/8 to 1/16 mm. Thin, gray, shaly layers separate massive groups of thin beds of limestone.

The Prosser Member is the most fossiliferous, or fossil-bearing member of the Galena, with most of the fossils occurring in the shaly layers. The brachiopod *Sowerbyella* is the most common. Other brachiopods include *Rafinesquina*, *Resserella*, *Strophomena*, *Lingula*, and *Vellamo*. The sponge-like fossil *Ischadites*, the pelecypod *Byssonychia*, and the horn coral *Streptelasma* are found in this rock unit.

The Prosser Member shows the continuing trend of deposition of less mud, free from land sources, that started at the base of the Galena Formation. The percentage of carbonate is higher than in the Cummingsville, but there is a relatively large amount of silt in the Prosser.

Stewartville Member - The Stewartville Member of the Galena Formation was first described in 1897 near both Wykoff, in Fillmore County, and Stewartville, which is south of Rochester. The Stewartville is a pale yellowish gray to grayish yellow dolomite and weathers to a yellowish orange color. It is generally very fine-grained, and the bedding is thin and crinkly. The thin beds are grouped together to form massive units that are separated from one another by more prominent and smoother bedding planes. The rock is mottled when freshly exposed and pitted

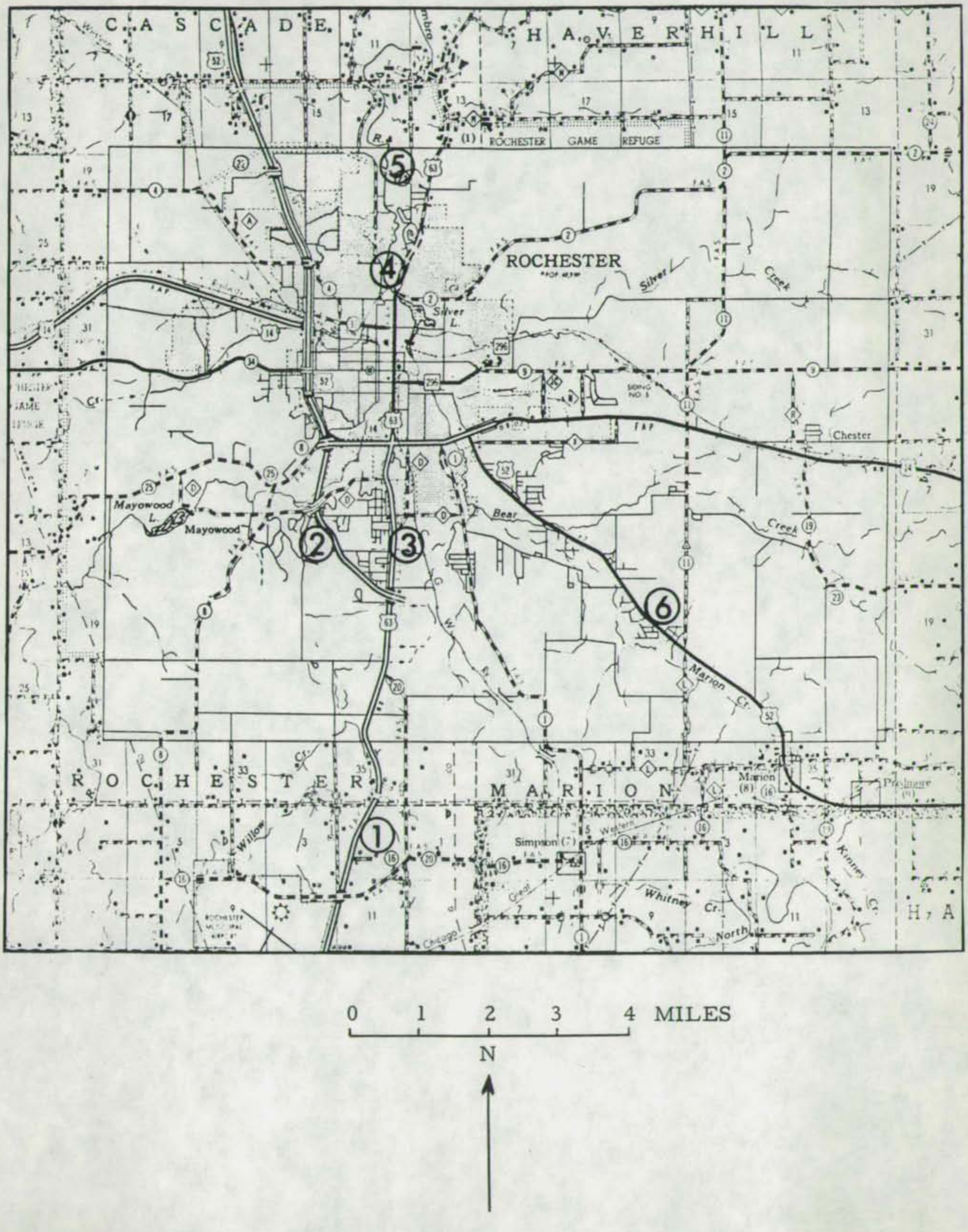
in the same manner when weathered.

The Stewartville Member is poorly fossiliferous. Snails (or gastropods) and cephalopods are the dominant fossil groups. The gastropods are represented by Hormotoma, Maclurites, and Trochonema and the cephalopods by Endocerus and Spyrocerus. The base of the member contains an abundance of the sponge-like animal called Receptaculites. The contact is placed at the base of a graduational zone as much as 5 feet thick which separates the pitted dolomite or limy dolomite typical of the Stewartville and the smooth gray limestone typical of the Prosser. Brachiopods in the Stewartville include Rafinesquina, Resserella, Rhynchotrema, Sowerbyella, Strophomena, and Zygospira. The coral Streptelasma has also been found here.

The Stewartville has the smallest amount of silt and clay of any member of the Galena Formation. It is composed of dolomites and limy dolomites and reflects the clear, warm ocean environment of the Ordovician. These conditions continued in the Ordovician until muds again were dumped into the sea and alternating limestones and shaly beds of the Dubuque Formation were formed.

The Dubuque Formation is not exposed in the immediate Rochester area, but the bottom of it along with the top of the Stewartville is exposed in a small quarry west of the town of Stewartville. The progression from carbonate to alternating limestones and shales in this quarry is quite evident.

SEQUENCE OF STOPS



# A GEOLOGICAL FIELD TRIP IN THE ROCHESTER, MINNESOTA, AREA

October 5, 1968

Discussion at the stops will be led by George S. Austin, Walter E. Parham, Robert C. Bright, and Gerald F. Webers

## SUMMARY

The first five stops on the field trip deal mostly with the rock units in the Rochester area, their characteristics, and the contacts between units. The sixth and last stop is primarily to collect fossils.

## LOG

The starting point is 4.0 miles south of the Rochester city limits off U. S. Highway 63. We are meeting on the frontage road between Highway 63 and a large quarry.

STOP NO. 1 U. S. HIGHWAY 63 ROAD CUT AND QUARRY.

At this stop we can see the bottom of the Stewartville or top member of the Galena Formation and most of the Prosser or middle member. The Stewartville Member and the top of the Prosser are exposed in the road cut. The quarry contains nearly a complete section of the Prosser Member with the bottom about one foot below the quarry floor.

Galena Formation - about 90 feet exposed in road cut and quarry.

Stewartville Member - 13.5 feet

Buff dolomitic limestone, mottled, and pitted by weathering. Corals, gastropods (snails), and the sponge-like animal *Receptaculites* are common. The bedding is thick to medium. A three foot transition zone is present here between the Stewartville and the underlying member.

Prosser Member - about 75 feet

Yellowish to light olive gray limestone, thick to thin bedding. Brachiopods, crinoid rings, corals and gastropods are the types of fossils found. Cracks that cut the limestone vertically are called joints. Some of these joints have been enlarged and filled with clay during the Cretaceous or early Tertiary periods, from 135 to 40 million years ago. These straight vertical cracks control rock breakage in the quarry. Most of the flat surfaces you see in the pit are joint surfaces.

Mileage

0.0 Intersection of the frontage road and U. S. 63. Go north on the highway. The Cummingsville Member, or bottom member of the Galena Formation, is exposed on either side of the road for a mile north of the intersection.

2.8 2.8 Turn left onto U. S. Highway 52 and go northwest.

3.8 1.0 On either side of the highway are the alternating limestones and limy shales of the Cummingsville Member. Farther along and beneath the Cummingsville are the shales of the Decorah Formation. The bottom of the Decorah, the Platteville, and the top of the Glenwood Formations are exposed on the left farther down the hill.

4.7 0.9 Bridge over the Zumbro River. Move into the left lane.

4.8 0.1 Turn to the left at cross-over and go back up the hill.

5.8 1.0 The lead car is stopping near the crest of the hill. Pull off the highway and onto the tarred surface. Park on the extreme right side close behind the car in front of you. Exit from the right side of your car and walk along the grassy bank up the hill to the lead car.

STOP NO. 2. GOLDEN HILL

At this road cut we can see about 110 feet of the formations from the top of the Glenwood to near the top of the Cummingsville Member of the Galena. The section includes:

Galena Formation - about 35 feet.

Cummingsville Member - about 35 feet.

Alternating layers of limestones and limy shales each up to 2 feet thick. A corrosion zone is present in the first thick limestone bed above the base of the member. Pyrite, or iron sulfide, is found in irregular patches just beneath the corrosion zone. The bottom bed of the Cummingsville is a 2-foot layer of shale with thin limestone lenses.

Decorah Formation - 47 feet.

The top of the Decorah is marked by a coquinoid limestone with brassy oolites. The base is marked by the first thick limestone of the Platteville Formation. In this road cut the entire Decorah Formation is exposed except for an interval from 7.8 to 17.4 feet above the base. Good examples of coquinas with many fossil groups can be found in the ditch at the foot of the exposure. Several large cephalopods have

been found here. Structures in the shale can be observed parallel to the bedding in the cut and at right angles to the bedding in the ditch. The bottom 7.8 feet of Decorah is exposed on the west side of the highway down the hill from the top of the formation.

Platteville Formation - 22.3 feet.

Carimona Member - 7.3 feet.

Gray to tan limestone with interbedded shales. The bottom is placed at the top of a thick gray indistinct corrosion zone about 0.4 foot thick. The white to bright yellow Carimona Bentonite is found 1.3 feet above the base of the member. Immediately below the bentonite is the "Oil Shale," a thin, dark brown fissile shale.

McGregor Member - 11.8 feet.

Gray, somewhat mottled limestone with thin crinkly beds grouped into thicker units. Black fossil hash and phosphatic pellets are present.

Pecatonica Member - 3.2 feet.

Tan dolomitic limestone. The bottom one foot is very sandy. Above the sandy dolomite is 0.6 foot of yellow-brown, very shaly limestone, and the rest is very fine-grained tan dolomitic limestone with occasional small stringers of fine-grained orange sand. There are corrosion zones at 13, 28, and 39 inches above the base of the member and the highest corrosion zone marks to top of the member.

Glenwood Formation - 1.5 feet exposed.

Green and yellow sand and shale. The bottom 0.2 feet are a yellow-green, medium- to fine-grained sandstone which is overlain by 1.0

foot of yellow to green fissile shale. The top 0.3 feet is a yellow sandstone.

6.9 0.9 Return to U. S. Highway 63 going south. Get into the left-hand lane immediately.

7.1 0.2 Turn left and around to go north on U. S. 63.

8.2 1.1 Turn right into sandstone quarry just north of Rochester city limits sign. Be sure to stay on hard sandstone. You can become stuck in the loose sand.

STOP NO. 3. LIBBY HILL QUARRY

In this exposure we can see about 30 feet of sandstones, shales and carbonate making up the St. Peter, Glenwood, and Platteville Formations. The Platteville-Glenwood contact is not exposed but the change in rock type from the St. Peter Sandstone upward to the shales and sands of the Glenwood is easily seen.

Platteville Formation - about 4 feet exposed.

Glenwood Formation - about 5 feet exposed. The bottom 2.5 feet is green and yellow shale with some sand. Above is one foot of greenish-yellow shaly sandstone with 0.5 feet of brown cemented sandstone at the top of the shelf just below the Platteville. The sandstone above the shale is some one foot thicker here than at stop 2 one mile to the west. Black phosphate pebbles and concretionary masses are found in sandy layers within the shale.

St. Peter Sandstone - 27 feet exposed. White to yellow-brown fine-grained sandstone. The mottling in color is due to oxidation of pyrite. Lines

separating white and yellow sandstone represent old ground water tables. The sandstone becomes coarser and more iron-rich upward toward the contact. Hard brown iron-cemented sandstone ledges are present near the top of the formation. Turn right onto U. S. Highway 63 and go north.

0.1 0.9 Turn left across U. S. 63 and into the Country Kitchen parking lot for lunch stop. We will be here for approximately one hour. You may purchase your lunch at the Country Kitchen or at the Tastee Freez or eat in your car. The cliff at the rear of the lot exposes a large part of the St. Peter Sandstone and a cap of the Glenwood and Platteville Formations. The sandstone is stable here because the shale and carbonate protect it from rain. The clay and iron oxide help to support the slope, as does the coating of clay which has washed down from above onto the surface of the sandstone. To leave the lunch stop area, drive out the same entrance by which you entered and continue north. This is a dangerous crossing and you must be careful.

10.0 0.9 Turn left at the intersection and onto U. S. Highway 52-14 and go west.

10.8 0.8 Begin turn to north following 52 and 14.

13.2 2.4 Take 19th St. NE exit. If construction of the new exit is not yet completed, take exit to 19th St. NE.

13.4 0.2 Turn right onto Elton Hills Drive NW. (If detour is still in effect, follow the signs to Elton Hills Drive NW and make the turn to the right.)

15.0 1.6 Base of the St. Peter Sandstone and the top of thw Prairie du Chien Formation. Park along the right side of the road. Be careful when exiting from your car.

<u>STOP NO. 4</u>. ELTON HILLS DRIVE ROAD CUT.

The contact between the St. Peter and the Prairie du Chien is only rarely observed because of the sandstone's tendency to slump. This exposure is one of very few in the state.

St. Peter Sandstone - 3.5 feet.

Fine-grained yellow sandstone with about 0.5 feet of green-yellow shaly sandstone at the base.

Prairie du Chien Formation

Shakopee Dolomite Member - 20 feet.

The top of the formation is marked by a brown fissile residual shale which may or may not be present. Beneath the shale is about one foot of dark brown medium- to coarse-grained dolomite which may be slightly limy. The dolomite has large cavities in which large white crystals have grown. When a calcite crystal is broken, flat surfaces called cleavages are formed. From the size of these cleavages we can see that the calcite crystals are very large. The rest of the exposure of Prairie du Chien shows the wide variation in rock type and characteristics found in the Shakopee. You can find sandstone beds up to 3 feet thick, shale layers, glauconite grains in the dolomite, sandy and oolitic chert, a fine sand composed of dolomite crystals, folds in the dolomite due to movement

when the carbonate was still soft, mud cracks, and many large calcite crystals.

15.4 0.4 At the intersection of Elton Hills Drive with U. S. Highway 63 turn left, or north, following U. S. 63.

16.4 1.0 Turn left onto 31st St. N.E. and go west.

16.6 0.2 Turn right and go north.

17.3 0.7 Turn to left at fork in the road and go northwest.

17.7 0.4 Just past a large silver storage tank with red gasoline pumps at either end, turn right and follow a gravel road down into the pit.

17.8 0.1 Park along the right side of the road.

STOP NO. 5. ROCHESTER SAND AND GRAVEL COMPANY QUARRY.

This quarry exposes about 30 feet of the Shakopee Member of the Prairie du Chien Formation. The top of the exposure is about 10 feet below the bottom of the Shakopee exposed at stop no. 4. The bedding and rock type, while quite varied vertically, is fairly consistent laterally. At this stop you can find the following: dolomite and chert with oolites, interbedded sandstones, folds due to movement while the sediments were still plastic and due to the draping of carbonates over algal structures, flat pebble conglomerates, shale layers, and large calcite crystals.

On our way to stop number 6 we will retrace our steps part way to stop no. 4.

18.4 0.6 Intersection of road to quarry and north-south country road. Go south.

18.9 0.5 Turn left onto 31st St. NE. and go east.

19.1 0.2 Intersection with U. S. Highway 63. Turn south.

20.6 1.5 After passing Silver Lake Shopping Center on the left, turn left (east) onto 14th St. NE.

21.3 0.7 Turn right (south) onto 11th Ave. NE.

22.4 1.1 Turn left (east) onto 14th St. SE.

22.5 0.1 Turn right (south) onto 15th Ave. SE.

23.3 0.8 Intersection of 15th Ave. SE. and U. S. Highways 52 and 14. Starlight Drive-in Theater on southeast corner. Go southeast on U. S. 52.

27.2 0.8 Turn left into entrance to quarry. Across the highway on south side of road is a small sign - "Langes Gardens".

STOP NO. 6. SHOP QUARRY. Decorah and Platteville Formations exposed. This stop is primarily to collect fossils. About 20 feet of the Decorah Formation and 20 feet of the Platteville are exposed in this quarry. Pick surfaces of the Decorah that have been washed by rain water. The fossils in the shale will have weathered out and the coquinas will have been cleaned up. Look at the surfaces at right angles to the bedding in the Platteville Formation and then split the rock along likely looking bedding planes. There are some brachiopods in the Platteville that have been replaced by pyrite. The shells, therefore, appear to be "made of gold."

Decorah Formation - 20 feet.

The green shale is fairly fossiliferous here with brachiopods, gastropods, bryozoa, crinoids, and corals. A bentonite, or altered volcanic ash, about 1 inch thick occurs in the shale about 5 feet above the base. This bentonite affects water seeping through the shale so that the shale

below the bentonite is wet on the surface while the shale above appears dry.

Platteville Formation - about 22 feet.

Carimona Member - 7.3 feet.

The 0.5 foot of limestone just above the Carimona Bentonite has several large cephalopods. Many brachiopods are found in this member. Particularly common is Protozygra nicolleti, which is found in layers within the limestone.

McGregor Member - 11.5 feet.

The limestone of the McGregor is more mottled than it was at stop number 2 and it has thin and crinkly beds. The thick corrosion zone that separates the Carimona and the McGregor is present as it was at stop number 2.

The Pecatonica Member of the Platteville and the Glenwood Formation have been observed here, but they are not covered in the main part of the quarry.

Stop No. 6 is the last stop on the field trip. You are free to remain as long as you like.

END OF LOG

# References

## General Geologic

Kummel, B., 1961, History of the earth: an introduction to historical geology, San Francisco, Freeman and Company, 610 p.

Schwartz, G. M., and Thiel, G. A., 1963, Minnesota's Rocks and Waters: Minneapolis, Univ. of Minn. Press, 366 p.

## Scientific

Ostrom, M. E., 1964, Pre-Cincinnatian Paleozoic cyclic sediments in the Upper Mississippi Valley: a discussion, Kansas Geol. Survey Bull. 169, p. 381-398.

Schwartz, G. M., ed., Geol. Soc. America Guidebook Series, Field Trip no. 2, 110 p.

Weiss, M. P., 1957, Upper Middle Ordovician stratigraphy of Fillmore County, Minnesota: Geol. Soc. America Bull., vol. 68, no. 8, p. 1027-1062.

# FOSSILS

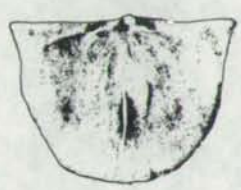
## SHAKOPEE MEMBER

Hormotoma

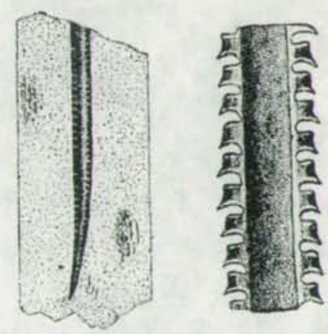
Ophileta

Raphistomina

## PECATONICA MEMBER

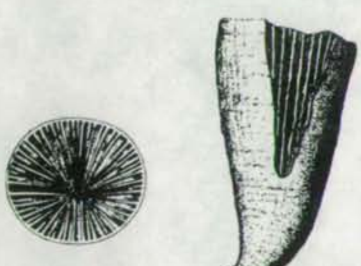


Öpikina minnesotensis



Climacograptus

## MCGREGOR MEMBER



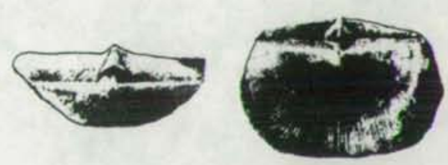
Lambeophyllum profundum


Protozyga nicolleti

Rafinesquina

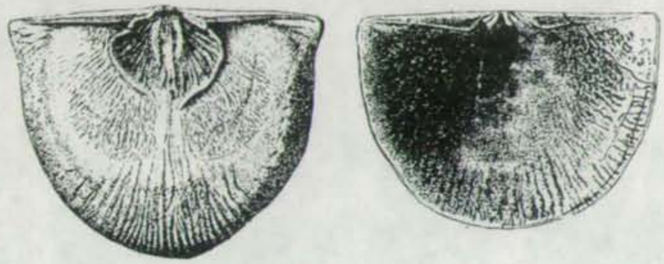
Lingula


Pionodema conradi



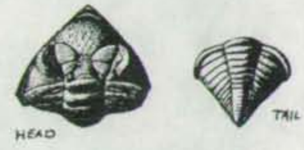
Campylorthis deflecta

## CARIMONA MEMBER



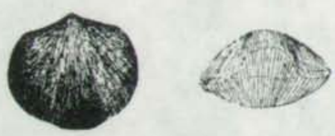
Strophomena incurvata

Monticuliporella



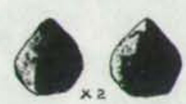

Eomonorachus intermedius

Pionodema conradi

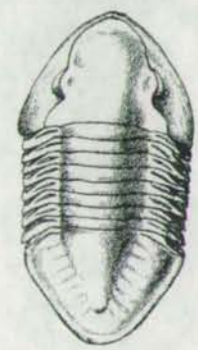


Doleroides

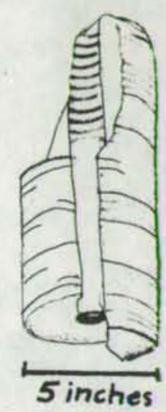
Pionodema subquata




Protozyga nicolleti



Isotelus gigas

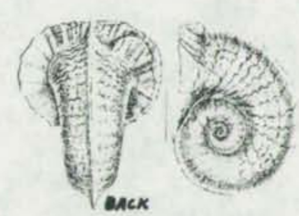



Endocerus

## DECORAH FORMATION

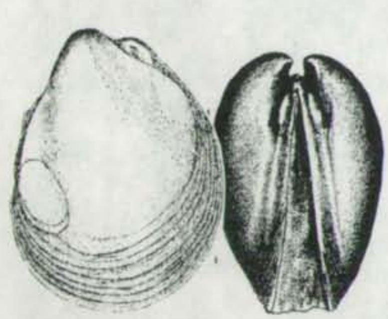
Loxoplocus

Hormotoma gracilus




Phragmolites fimbriatus

Tetranota



Vanuxemia obstusifrons

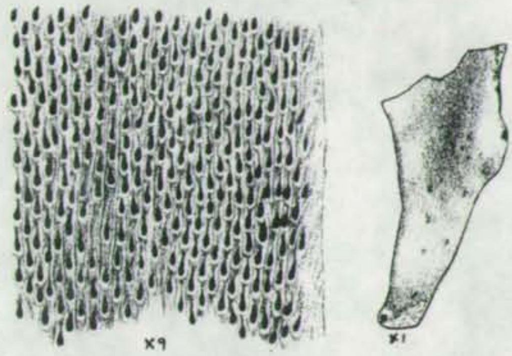
Bumastus trentonensis


Eomonorachus

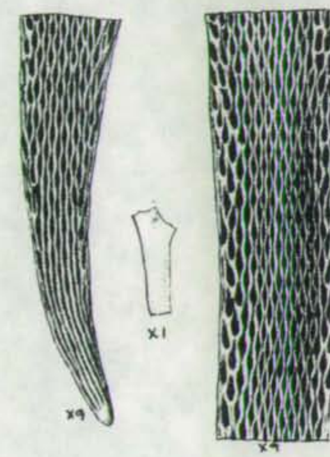
Crinoid Columnals IX

Endocerus

Batostoma



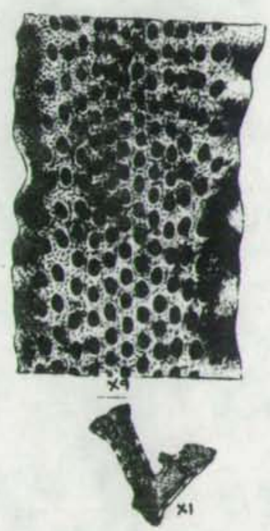

Phyllodictya




Escharopora

Hallopora
multitabulata

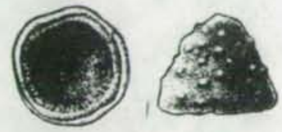

Subretepora




Pachydictya


Rhinidictya

Homotrypa



Prasopora

Strictoporella

# FOSSILS

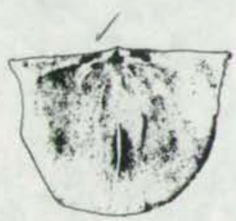
## SHAKOPEE MEMBER

Hormotoma

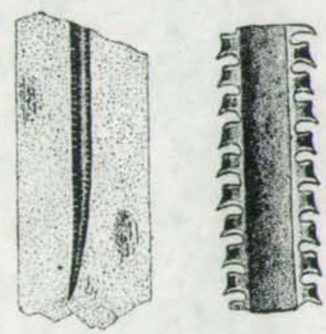
Ophileta

Raphistomina

## PECATONICA MEMBER

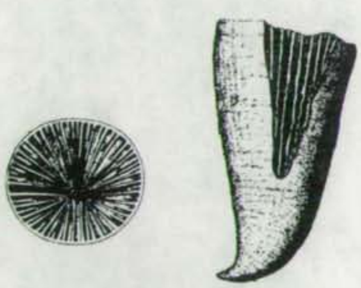


Öpikina
minnesotensis



Climacograptus

## MCGREGOR MEMBER



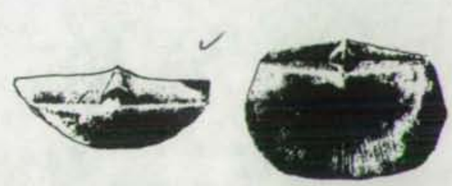
Lambeophyllum
profundum


Protozyga
nicolleti

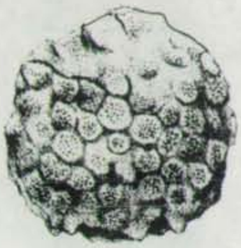
Rafinesquina

Lingula

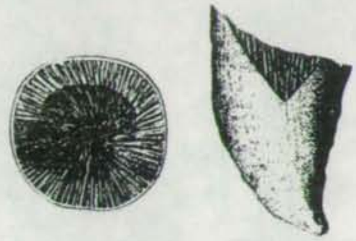

Pionodema
conradi



Campylorthis
deflecta



Aspidopora



Streptelasma corniculum

Illaenus americanus

Hormotoma

Endocerus

Ectomaria

PROSSER MEMBER

Vellamo

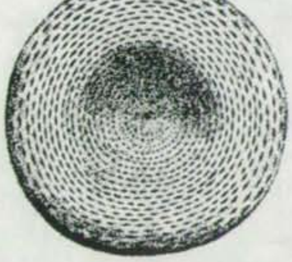
Sowerbyella

Rafinesquina

Resserella rogata

Lingula

Byssonychia



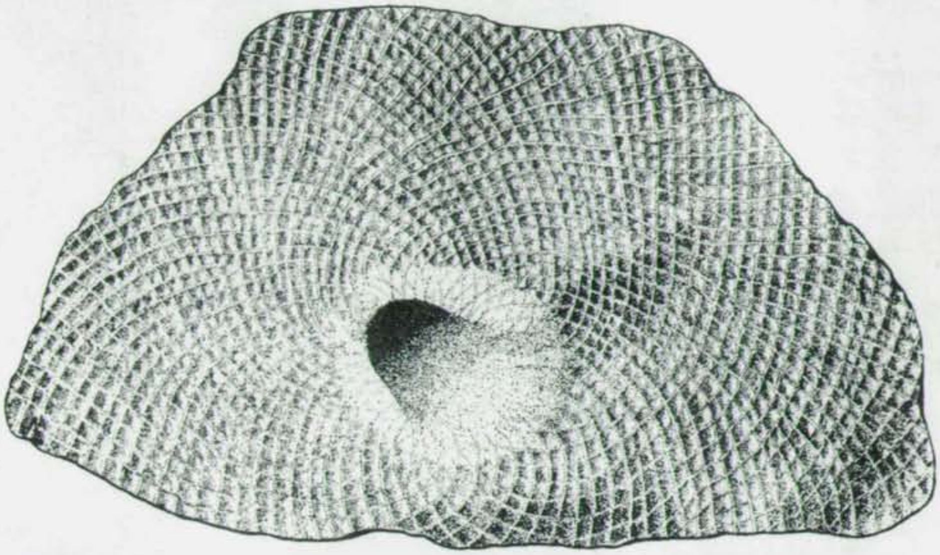
Ischadites

Flexicalymene senaria

Streptelasma corniculum

STEWARTVILLE MEMBER





Receptaculites

Strophomena

Rafinesquina


Zygospira uphami

Sowerbyella

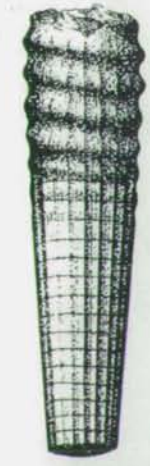
Streptelasma corniculum

Trochonema umbilicatum

Endocerus

Maclurites

Hormotoma



Spyrocerus bilineatum