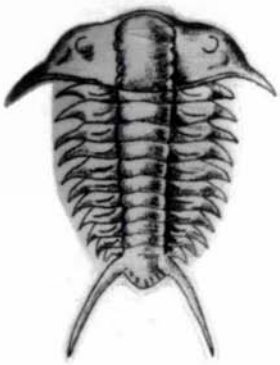
Educational Series - 1
ISSN 0544-3083

Guide to Fossil Collecting in Minnesota

Minnesota Geological Survey

Guide To Fossil Collecting in Minnesota

R. K. Hogberg, R. E. Sloan
and Sarah Tufford



First edition 1965; revised edition 1967; reprinted 1979; reprinted 1985
ISSN 0544-3083

Geologic Time Chart_Minnesota

Time	Era	Period	Events in Minnesota	Characteristic Life
0	CENOZOIC	Quaternary	Continental glaciation followed by warm period	*Age of Mammals* 
20				
40		Tertiary	No record in Minnesota	
60	MESOZOIC	Cretaceous	Sea enters Minnesota from West. Deposition of sediments.	*Age of Reptiles* 
100		Jurassic Triassic	No record in Minnesota	
200	PALEOZOIC	Permian Pennsylvanian Mississippian	No record in Minnesota	*Age of Amphibians* 
300		Devonian	Sea enters Minnesota from South. Deposition of sediments.	 *Age of Fishes*
		Silurian	No record in Minnesota	*Age of Corals* 
400		Ordovician	Seas cover Minnesota at intervals.	*Age of Straight Cephalopods* 
500		Cambrian	Deposition of sediments.	*Age of Trilobites* 
600				
			Lava flows and deposition of sediments.	
PRECAMBRIAN 4½ billion years long			Deposition of iron-rich sediments.	*First record of life* 
			Formation of mountains and igneous intrusions.	

Millions of years ago

Guide To Fossil Collecting in Minnesota

FOSSILS tell us what life was like on earth in ancient geologic time. A fossil clam, for example, lived on a sea bottom much as its modern relatives do. By finding many fossil clams, we can determine the extent of a prehistoric sea. Fossils also indicate the climates of the geologic past.

Fossils show us that life on earth has not always been the same. In fact primitive algae and bacteria have given rise to reptiles, mammals, and finally to man.

Fossils aid geologists in finding oil and other mineral deposits.

What is a fossil?

A fossil is a trace or remains of an ancient animal or plant--for example, a shell, leaf print, or worm burrow--preserved within rocks or unconsolidated material at the earth's surface. Simple, primitive life forms--algae and bacteria--have been collected by paleontologists (students of fossils) in the oldest or Precambrian rocks on Minnesota's iron ranges. We find more complex plant and animal fossils in more recently formed rocks in the southern part of our State.

How is a fossil preserved?

It is preserved because it had hard parts--shell or bone--and was quickly buried. An animal may be buried in desert sand, in swamp mud, in river silt, or in sea-floor sediments. The animal's soft parts are destroyed by bacteria. Even after being covered by layer upon layer of sand and mud, a fossil may be partially or completely destroyed: ground water may dissolve its hard parts; shifting of the sediments may crush it; mountain building forces may distort it; and solutions may replace some or all of the hard parts with new minerals. Therefore fossils are rarely found complete, but a trilobite tail, a shark tooth, or a leaf impression identifies the animal or plant. Because plant fossils are quite delicate, they are destroyed more easily than animal fossils. Hence we are most apt to find fossils where the rocks have not been disturbed since they were deposited.

Where are fossils found?

Fossils are most commonly found by beginning collectors at localities where they have tumbled down from weathered rock ledges. Also, plucking and transportation by glaciers and streams bring fossil-bearing rocks to a gravel pit or stream bank. Fossils are found in sedimentary rocks--former sands and muds. The fossiliferous sedimentary formations of Minnesota are illustrated in the figure Fossiliferous Rock Units--Minnesota, p. 4.

Geologic History of Minnesota's Fossils

About 600 million years ago the extremely long Precambrian Era was drawing to a close and the high mountain ranges and vast lava plateaus were

worn to low-lying foothills by running water. Late in the first division of Paleozoic time, the Cambrian Period, a sea advanced northward to cover southeastern Minnesota. Many animals lived in its warm, shallow waters; most common were the brachiopods and trilobites, now fossilized in rocks which once were the muddy sediments of this sea floor.

The sea moved briefly out of the State and returned to southeastern Minnesota in the Ordovician Period. Brachiopods and trilobites still lived on the bottom of the shallow sea, with cephalopods, crinoids, and sponges. After deposition of the Ordovician sediments and perhaps Silurian sediments, the sea withdrew and the rocks at the land surface were eroded. In other parts of the world, plant fossils appear for the first time in Silurian rocks. In late Devonian time, a sea covered parts of Freeborn, Mower, and Fillmore counties, Minnesota: scattered fossil remains indicate that fish lived in its waters; however, the most common Devonian fossils are brachiopods and corals.

During the late Paleozoic and most of the Mesozoic Era, Minnesota again stood above sea level. Rivers carried their sediment to the distant ocean, wearing away Minnesota's hills particle by particle, and preparing the way for a new invasion of the sea. During this long interval, dinosaurs roamed the western states; their fossil remains are found where they were caught in river sands and swamp muds. Dinosaurs probably lived in Minnesota, but our fossil record of them is poor.

Minnesota lay below the sea again in Cretaceous time. Fossil snails, clams and oysters, coiled cephalopods, and shark teeth occur in the marine Cretaceous sediments of the western Mesabi range

Fossiliferous Rock Units_Minnesota

Era	Period	Formation	Rock Type
CENOZOIC	Quaternary	Glacial deposits	tan sand and gravel; peat; clay
MESOZOIC	Cretaceous	Coleraine and Windrow	tan and gray shale; sandstone; clay
PALEOZOIC	Devonian	Cedar Valley	gray to buff limestone
	Ordovician	Maquoketa	shaly limestone
		Dubuque	limestone and shale
		Galena	limestone and shaly limestone
		Decorah	greenish gray shale
		Platteville	limestone
		Glenwood	shale
		St. Peter	yellow to white sandstone
		Prairie du Chien	gray dolomitic limestone; sandstone; pink and gray dolomite
	Cambrian	Jordan	tan to white sandstone
		St. Lawrence	gray limy siltstone
		Franconia	green sandstone; gray sandstone; green sandstone and siltstone
		Dresbach	gray sandstone; gray siltstone; gray to brown sandstone

Shark Tooth

Coral

Sponge

Bryozoan

Brachiopod

Cephalopod

Graptolite

Trilobite

area. Plants now found in the shales near New Ulm and Springfield, grew in the tidal swamps bordering the Cretaceous sea.

Minnesota has been above sea level from the close of the Cretaceous to the present day. Sands, gravels, clays, and silts picked up, carried, and deposited by the Pleistocene continental ice sheets now mantle the rocks formed earlier in the geologic history of the State. In fact, a large part of our present landscape is a result of different types and thicknesses, and subsequent erosion of glacial materials. Mammoth, mastodon, and bison were abundant animals in the Pleistocene Period. Pollen and spores collected from buried peat deposits identify the plants and trees that lived in Minnesota between ice sheet advances. The oldest man-made tools found in the State are about 10,000 years old. As you can see, man has lived in Minnesota for a very short time, geologically speaking.

FINDING AND COLLECTING FOSSILS

Not all sedimentary rocks contain fossils. The St. Peter Sandstone, for example, is formed of sand rolled about by waves to such a degree that all fossils were destroyed. Even in highly fossiliferous rocks, the fossils are easier to see and collect from weathered outcrops in stream valleys, in highway and railroad cuts, and in old quarries. The Geologic Map (p.20-21) should help you locate outcrops of fossiliferous rocks.

Always be sure to ask permission before collecting on private property.

Very little equipment is necessary to the fossil collector. Here is a check list for your expeditions:

1. Brick-layer's hammer or geologic hammer.
2. Chisels, at least one large and one small.
3. Magnifying glass or hand lens.
4. Collecting bags of sturdy paper or cloth.
5. Tissue paper for wrapping small and delicate specimens.
6. Labels to note locality, formation, date, and collector (see record and labels, p. 37-41).
7. Pencil or pen.
8. Maps--a state highway map will help you locate collecting sites. For more detail, topographic maps may be obtained from the U. S. Geological Survey in Washington, D.C. Geologic maps, where completed, are available from the Minnesota Geological Survey.

The Geologic Map shows where a formation may be encountered below the surface soils, sands, and gravels, or cropping out along streams. Symbols on the map are abbreviations for formation names given in full in the explanation. To get the full value of this map, each formation should be colored to set it off from formations above and below.

After you collect your fossils, you may wish to clean them. Scrub the tough ones with vegetable brush, soap, and water. Bits of rock hiding parts of a specimen can be removed with a small chisel; use a mounted pin for detailed work. Broken specimens are easily repaired with household cement. A coating of clear fingernail polish holds crumbly specimens together.

Reference materials listed on pages 29 and 30 of this booklet are suggested for those who wish to learn more about geology and paleontology. Also, descriptions of specific fossil - collecting localities are given in the Appendix (p. 31 - 36).

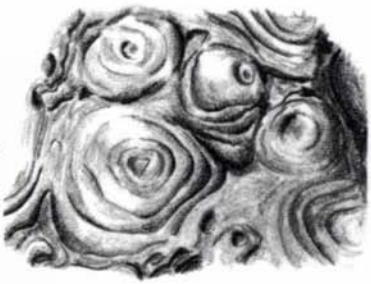
FOSSILS OF MINNESOTA

Marine Plant Fossils

Algae

Algae are small plant-like organisms: modern algae form green scum on ponds in summer. Some ancient forms built large biscuits or domes of limestone. These fossil algal structures may be seen in outcrops of the Ordovician Prairie du Chien Formation along the Mississippi River in southeastern Minnesota.

Structures much like these Ordovician algal domes also occur in the Precambrian iron-rich rocks of the Mesabi range. They are among the world's oldest known fossils--about 2 billion years old.

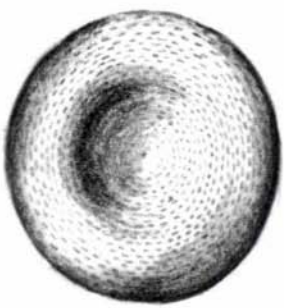


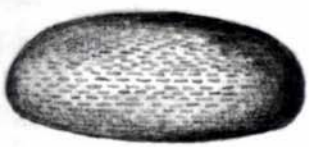
Cryptozoan (Ord.) 1/10x

Animal Fossils

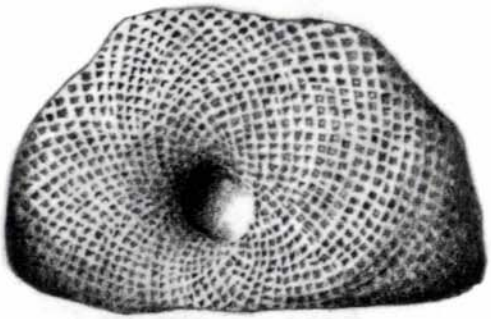
Sponge-like animals

Fossil sponges, like many of those living today, had hard skeletons of calcium carbonate or silica. These skeletons account for their preservation. Sponges are very old, ranging from the Precambrian to the present day. They are found in many geologic formations: all lived attached to the bottom of shallow seas.





Ischadites (Ord.) 1x



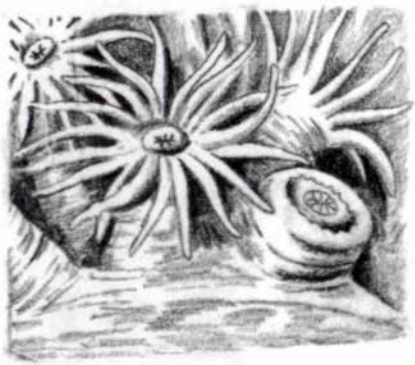
Receptaculites (Ord.) 1/4x

The two "sponges" found in Minnesota are both Receptaculids, the so-called "sunflower corals." Actually their classification as sponges is problematical. Receptaculites and Ischadites are common in the Ordovician Galena Formation of the southeastern part of the State.

Corals (Phylum Coelenterata, class Anthozoa)

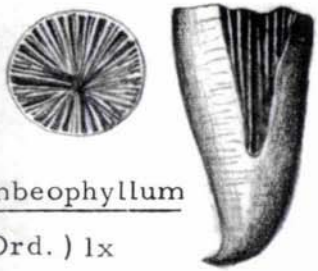
Corals first appear as fossils in Ordovician rocks. They grew in the warm shallow sea which covered portions of southeastern Minnesota in both the Ordovician and Devonian Periods. Many looked much like the modern coral colonies of warm ocean areas; others occurred as horn-shaped individuals, the solitary horn or cup corals.

Corals are relatively common fossils as their hard skeletons are easily preserved. Some occur in the Ordovician Prairie du Chien Formation of Minnesota but are difficult to collect from very hard



Modern Corals life size

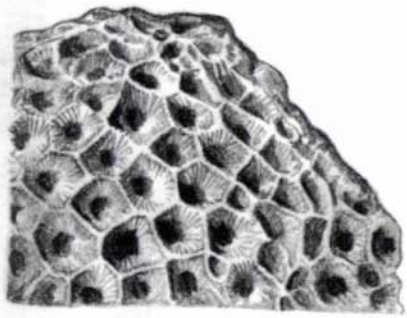
dolomitic rock. The Devonian Cedar Valley Limestone, which crops out chiefly in Mower and Fillmore counties, provides better collecting sites. Of the solitary corals, Lambeophyllum occurs in the Platteville and Decorah Formations; its relative Streptelasma, in the Galena and Maquoketa Formations. Heliophyllum and Hexagonaria are found in the Devonian. Two common colonial corals in the Galena Formation and Cedar Valley Limestone are Halysites, occurring as chains of small tubes growing side by side and Favosites, as a honeycomb mass.



Lambeophyllum

(Ord.) 1x

Heliophyllum (Dev.) 1x



Hexagonaria (Dev.) 1/2x

Favosites (Dev.) 2/3x

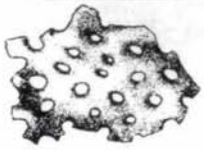
Halysites (Ord.-Dev.)

2/3x

Bryozoans (Phylum Bryozoa)

Bryozoans are referred to as "moss animals" because they resemble plants. Their colonies form biscuit-like masses or crusts on shells; they may also resemble twigs or leaves. Most fossil forms occur in marine sediments, but some modern forms live in fresh water. Bryozoans are abundant as fossils from Ordovician and later rocks. They are especially common in the limestone beds of the Decorah Formation of southeastern Minnesota.

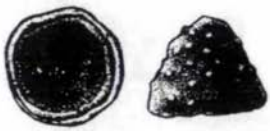
The most common types of Bryozoans found in Minnesota are Stictoporella, Rhinidictya, Batostoma, Prasopora and Hallopora.



Stictoporella
(Ord.) 1x

Rhinidictya
(Ord.) 1x

Batostoma
(Ord.) 1x



Prasopora
(Ord.) 1x

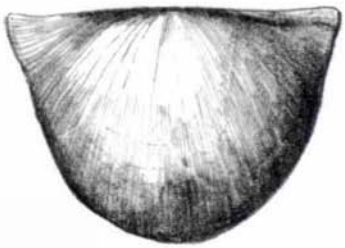
Hallopora
(Ord.) 1x

Brachiopods (Phylum Brachiopoda)

Brachiopods have been common on shallow sea floors since the beginning of the Cambrian period. The brachiopod animal is enclosed in two shells or valves, one larger than the other. The valves are hinged together at one end and near the hinge is a hole in one shell for a fleshy tube or stalk. The animal attaches itself by this stalk to solid objects on the sea floor.

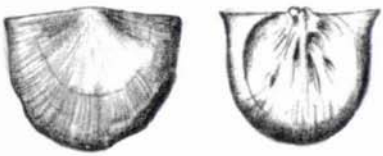
Most of the brachiopods found in Minnesota are of Ordovician age. They include Sowerbyella, Strophomena, Lepidocyclus, Rafinesquina, Lingula, Plaesiomys, Platystrophia and Resserella. The Platteville, Decorah, and Galena Formations provide good collecting in the Twin Cities near Rochester, and throughout southeastern Minnesota.

Sowerbyella (Ord.) 1x

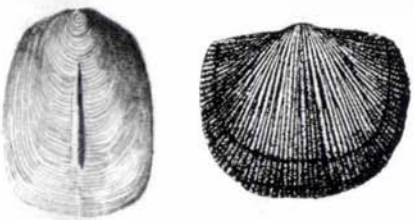


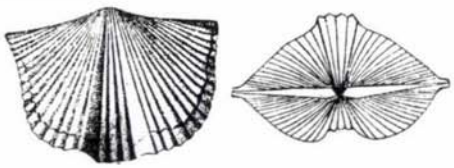
Strophomena (Ord.) 1x

Lepidocyclus (Ord.) 2/3x

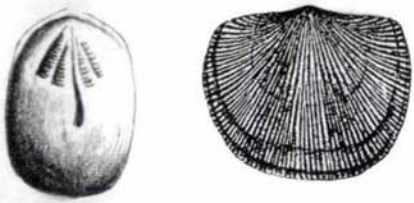


Rafinesquina (Ord.) 2/3x





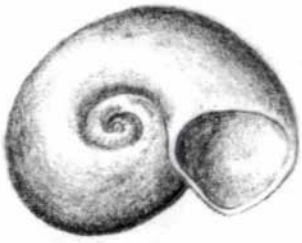
Platystrophia (Ord.) 1x



Lingula (Camb.-Rec.) 1x

Plaesiomys (Ord.) 1x

Resserella (Ord.) 1x



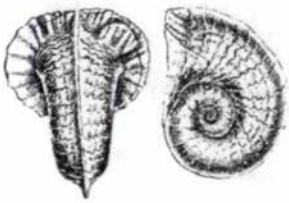
Maclurites (Ord.) 1/2x

Clathrospira
(Ord.) 1x

Trochonema
(Ord.) 1x

Lophospira
(Ord.) 1x

Ophiletina
(Ord.) 1x



Phragmolites
(Ord.) 1x

Sinuites
(Ord.) 1x

Cyrtolites
(Ord.) 1x

Snails (Phylum Mollusca, class Gastropoda)

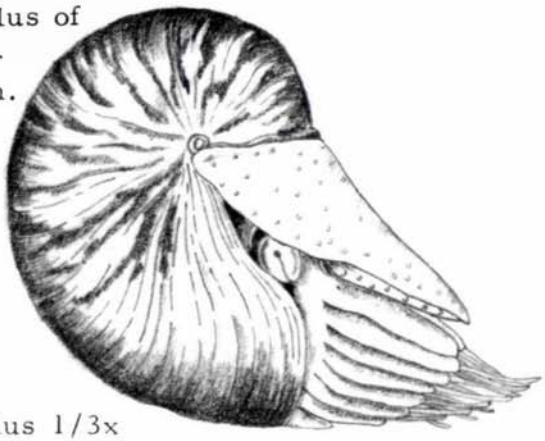
The gastropods or snails are an old and highly varied group of molluscs. They have a single shell that is generally coiled and often ornamented with bumps or spikes. Paleozoic snails were sea-dwellers, although some Mesozoic and later types moved into fresh water and even onto land.

Fossil snails can be found in the Prairie du Chien Formation, but the specimens are poor and hard to recover. Collecting is better in the Platteville, Decorah, and Galena Formations.

Gastropods found in Minnesota include: Maclurites, Clathrospira, Trochonema, Lophospira, Ophiletina, Phragmolites, Sinuites, and Cyrtolites.

Cephalopods (Phylum Mollusca, class Cephalopoda)

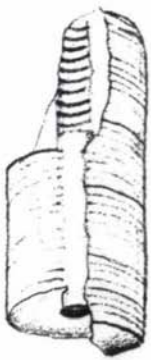
The cephalopods found as fossils in Minnesota are relatives of the "pearly" or "chambered" nautilus of the present day southwestern Pacific Ocean. The animal lives in a coiled shell--as it grows, it seals off parts of the shell leaving a series of empty chambers.



Modern Nautilus 1/3x

Cephalopods occur in the Ordovician limestones of Minnesota, particularly the Platteville Formation. Many Ordovician cephalopods have straight shells which may be as large as 1 foot in diameter and 14 feet long. Coiled cephalopods (ammonites) are found in the Cretaceous rocks of the western Mesabi range. Common Ordovician cephalopods found in Minnesota are: Zitteloceras, Endoceras, Nanno, and Spyroceras.

Zitteloceras
(Ord.) 1x



Endoceras
(Ord.) 1/5 x

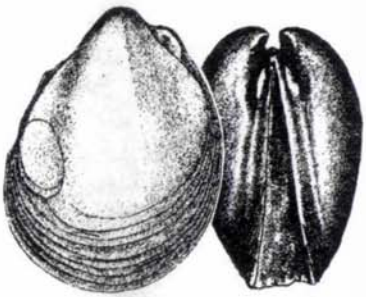
Nanno
(Ord.) 1x

Spyroceras
(Ord.) 1x

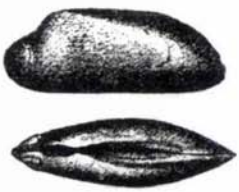
Clams and oysters (Phylum Mollusca, class Pelecypoda)

Clams are an old and conservative group of animals. Most live on shallow sea floors, although some live in fresh water. All clams have two shells, one the mirror image of the other (compare with brachiopods). Oysters, mussels, and scallops are special types of clams.

Clams have been abundant since the Ordovician Period. Vanuxemia, Orthodesma, Pterinea, Modiolopsis and Ctenodonta may be found in the Ordovician limestones of southeastern Minnesota.



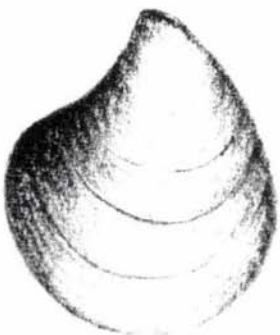
Vanuxemia (Ord.) 1x



Orthodesma (Ord.) 1x

Modiolopsis (Ord.) 1x

Pterinea (Ord.) 2/3x



Ctenodonta (Ord.) 2x

Oysters originated in the Mesozoic Era, and the Cretaceous rocks of the western Mesabi region contain Ostrea and Exogyra.

Ostrea

(Trias.-Rec.) 2/3x

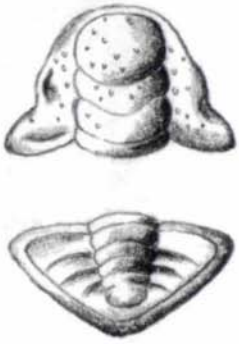
Exogyra

(Jur.-Cret.) 2/3x

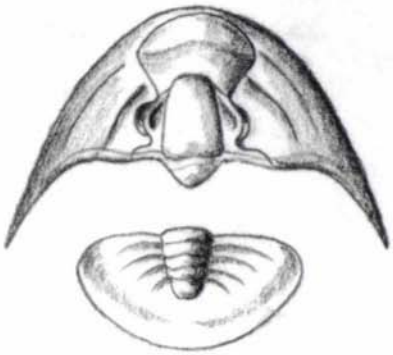
Trilobites (Phylum Arthropoda, class Trilobita)

Among the most common fossils of the Paleozoic rocks of Minnesota are the trilobites, a group of arthropods that are now extinct. Trilobites lived as scavengers and hunters on the floor of Paleozoic seas. They had hard, segmented shields covering and protecting their soft bodies like armor; furrows divided them lengthwise into 3 lobes. As the animal grew, it molted or changed its armor for a new and larger shield. Therefore, the most common trilobite fossils are the molted parts of the head and tail armor.

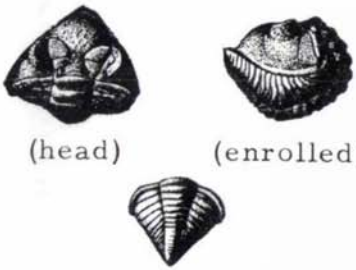
The Cambrian Franconia Formation, cropping out along the St. Croix and Mississippi rivers contains numerous fragments of Ptychaspis, Idahoia and many other trilobites. Dikelocephalus is common in the overlying St. Lawrence Formation in the same areas. Ceraurus, Eomonorachus, Isotelus, and Bumastus characterize Ordovician rocks in southeastern Minnesota.



Ptychaspis (Camb.) 1x

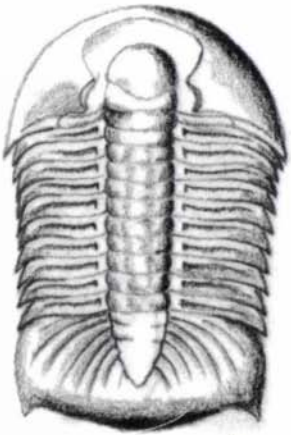


Idahoia (Camb.) 1/2x

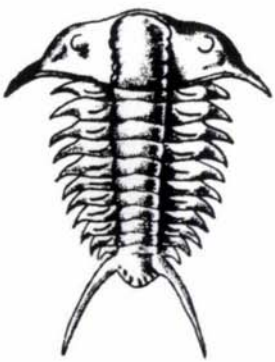


(head) (enrolled) (tail)

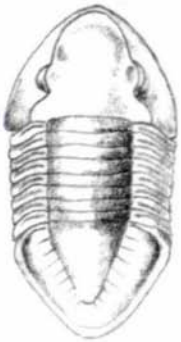
Eomonorachus
(Ord.) 2x



Dikelocephalus (Camb.)
1/2x



Ceraurus (Ord.) 1/2x



Isotelus (Ord.) 1/3x

Bumastus
(Ord.) 1x

Ostracodes (Phylum Arthropoda, class Crustacea)

Ostracodes are very tiny and ancient relatives of crabs, shrimp, and crayfish. The animal is enclosed in a pair of shells that may be ornamented in a variety of ways. Ostracodes are very abundant in both fresh and salt water.

Ostracodes are important fossils to the petroleum geologist because they are helpful in tracing oil- and gas-bearing beds from well to well. Most are too small to be seen with the naked eye. Primitia, Leperditia, and Bollia can be found in the Ordovician limestone and shale of southeastern Minnesota.

Primitia (Ord.) 12x

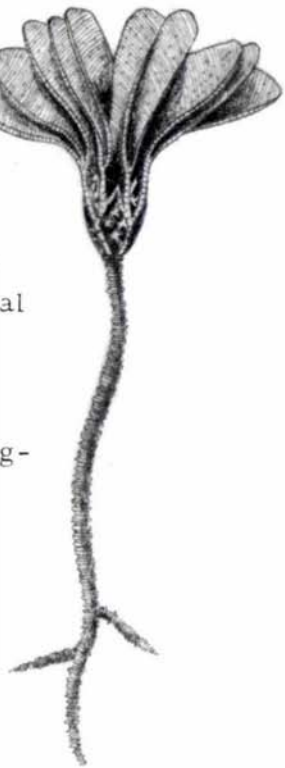
Bollia (Ord.) 18x

Leperditia (Ord.) 3x

Sea lilies (Phylum Echinodermata, class Crinoidea)

Crinoids are commonly called sea lilies, but they are really animals related to the starfish and sea urchins. Crinoids were very numerous on the bottom of shallow seas throughout the Paleozoic and Mesozoic Eras, beginning in Middle Cambrian time. The animal is enclosed in a cup-shaped skeleton made of many plates closely fitted together. Usually five arms extend outward from the top of this cup. The animal attaches itself by a "stem" to the sea bottom. When the animal dies the stem and cup fall apart. Common fossils in the Platteville and Galena Formations near the Twin Cities and Rochester are ring-like pieces of the jointed stem as well as calcareous plates.

Crinoid columnals 1x

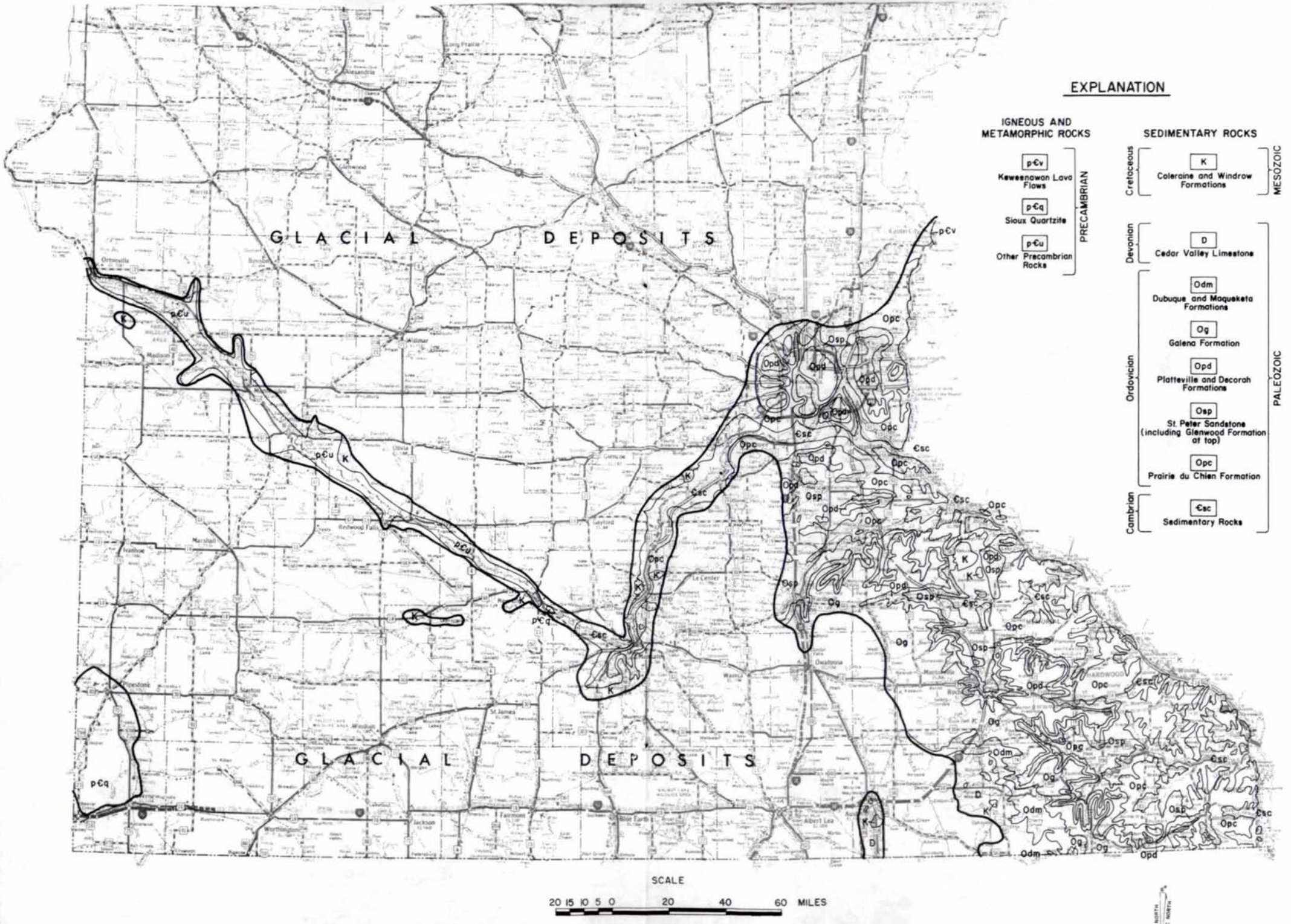


Glyptocrinus (Ord.) 1/2x

Glyptocrinus is a common genus of the Crinoidea.

Graptolites (Phylum Protochordata, class Graptolithina)

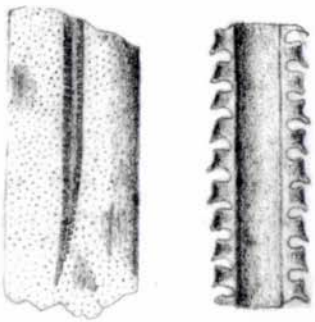
These puzzling creatures formed colonies of thin branches, the earlier forms attached to hard objects on the sea floor, later ones floated with branches hanging down. Small cups along the branches



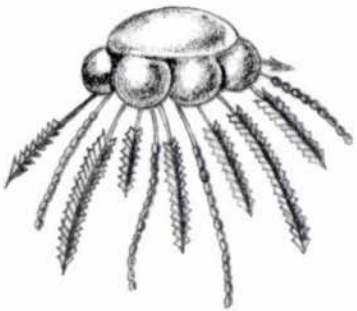
Geologic Map, southern Minnesota

housed the individual animals. They appeared as fossils in the Cambrian and became extinct in the Mississippian. The fossils consist of flattened films resembling pencil marks on slabs of rock.

They are found in the St. Lawrence Formation (Cambrian) along the St. Croix River and in the Platteville Formation (Ordovician) in the Twin Cities area. Some also occur in the Galena Formation of southeastern Minnesota.



Fossil Graptolite (Ord.) 2x, 10x



Living Graptolite (Ord.) 1x

Conodonts

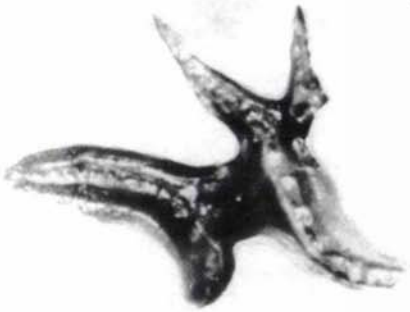
Conodonts are tiny tooth- or horn-shaped fossils. Their relationship to other animals is not known. They occur in great numbers in formations from the Glenwood Formation to the Dubuque Formation. They are easily collected from limestone as the enclosing rock may be dissolved away in acetic acid. A few ounces of rock may yield several hundred fossils. Although visible to the naked eye, some magnification is necessary to observe the detailed characteristics of these fossils.

Minnesota conodonts include: Ozarkodina, Panderodus, Chirognathus, Amorphognathus and Bryantodina.

Ozarkodina
(Ord.) 60x

Panderodus
(Ord.) 60x

Chirognathus
(Ord.) 60x

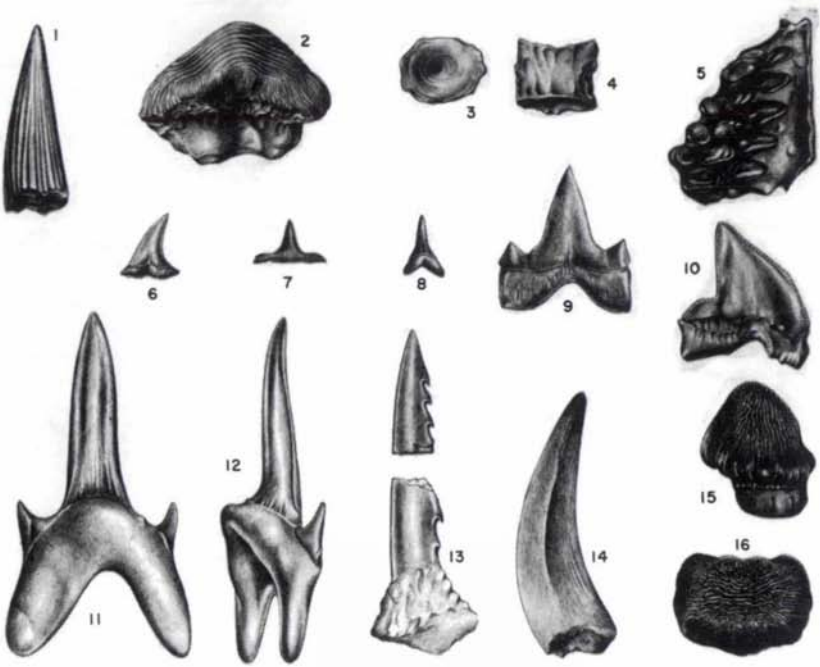


Amorphognathus
(Ord.) 60x

Bryantodina
(Ord.) 60x

Vertebrate fossils

The vertebrate fossils found in Minnesota are of recent origin compared with the other fossils discussed. Shark teeth are found in the Cretaceous deposits of the western Mesabi range and near Springfield, and in the upper Minnesota River valley in southwestern Minnesota.

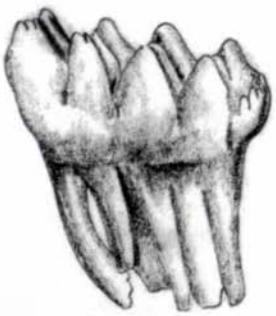


Fish teeth and bones from Cretaceous rocks, Big Stone County (1x)

1. Ichthyodectes - tooth from a six foot tarpon
2, 15, 16. Ptychodus - an extinct clam crushing shark
3, 4. vertebra from a small bony fish
5. Pycnodus - teeth from a small bony fish
6, 8. Squatina - teeth from an angel shark
7. Synechodus - a primitive shark
9, 11, 12, 14. Mackerel sharks: (9) Otodus, (11, 12) Isurus and (14) Lamna
10. Squalicorax - related to tiger sharks
13. Onchopristus - bill tooth from a sawfish

The Pleistocene sands, gravels, and clays deposited by glaciers yield teeth and bones of the mastodon and woolly mammoth, bison, musk oxen, and giant beaver. Similar fossils occur in old peat and lake beds in the mantle of glacial drift.

Mammoth Tooth
(Pleist.) 1/6x



Mastodon Tooth
(Pleist.) 1/6x

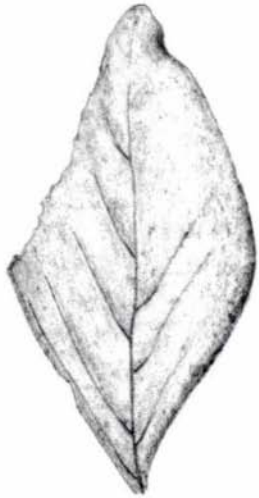
Plant Fossils

A few plant fossils can be found in Cretaceous rocks that formed in swamps marginal to the Cretaceous sea. Fossil leaves and stems occur in shale along the Minnesota River valley from near New Ulm to Morton, and near Springfield, Minnesota (p. 26).

Wood, leaves, and peat found within the glacial drift indicate that plant life thrived during the intervals between advances of the ice sheets. Pollen and spores of these plants also are found in buried lake deposits (p. 26).

Petrified wood, although uncommon in Minnesota, is found in adjacent states. Colloidal silica deposited by water has taken the place of wood cells preserving portions of the original structure in great detail.

Laurus (Cret.) 1/2x



Populus (Cret.) 1/2x

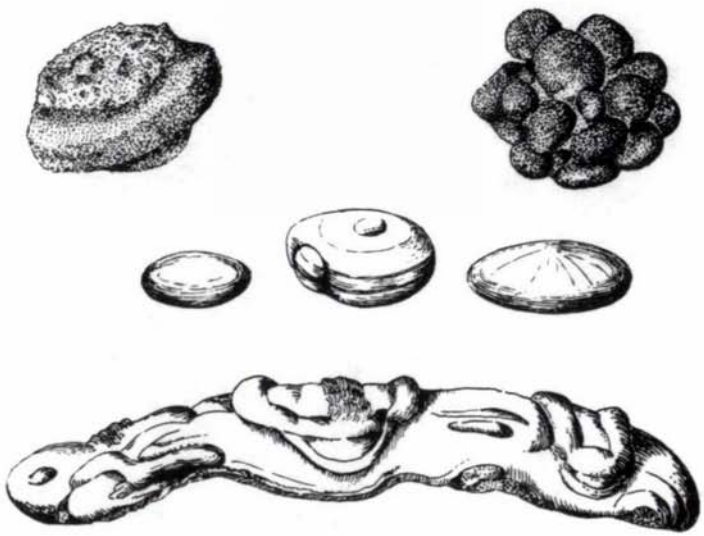
Betula (Pleist.) 1000x

Pinus (Pleist.) 250x

Fossil-like Materials

Fossil-like materials occur in the glacial drift. The clay balls are concretionary, layer upon layer, accumulations of clay minerals in a clay rich till--a layer of widely varied composition deposited directly by the glacial ice. They may also be associated with concentrations of the mineral pyrite or "fools gold." Calcium carbonate concretions are formed also in the drift layer by precipitation from calcium bicarbonate-bearing waters. The precipitated materials have many shapes and forms.

Moss and lichen covered rocks may also be mistaken for fossils.



Concretions 1/2x

ACKNOWLEDGEMENTS

The authors acknowledge the assistance of D. T. Wallace, G. F. Webers and T. N. Bayer in the revision of this booklet. Several of the fossil drawings for this edition are from part 1, volume 3 of the Final Report, Geology of Minnesota. The conodont microphotographs are from Special Publication 4 of the Minnesota Geological Survey. The vertebrate fossil pictures on page 24 are from Bulletin 37 of the Minnesota Geological Survey.

FURTHER READING

Buchsbaum, Ralph, 1948, Animals without backbones: Univ. of Chicago Press.

Colbert, Edwin H., 1951, The dinosaur book: New York, McGraw-Hill Book Company, Inc.

Fenton, Carroll Lane, and Fenton, Mildred Adams, 1958, The fossil book: Garden City, New York, Doubleday and Company, Inc.

_____ and _____, 1962, In prehistoric seas: London, George C. Harrap and Company, Ltd.

Matthews, William H. III, 1962, Fossils--An introduction to prehistoric life: New York, Barnes and Noble, Inc.

Moore, Raymond C., Lalicker, Cecil G., and Fischer, Alfred G., 1952, Invertebrate fossils: New York, McGraw-Hill Book Company, Inc.

_____, (ed.), 1959, Treatise on invertebrate paleontology: Lawrence, Kansas, Univ. of Kansas Press; and Geol. Soc. Am., New York.

Raymond, Percy E., 1939, Prehistoric life: Cambridge, Harvard University Press.

Schwartz, George M. (ed.), 1956, Geological Society of America Guidebook, Field Trip no. 2, Lower Paleozoic of the Upper Mississippi Valley: Geol. Soc. Am., New York.

_____, and Thiel, George A., 1963, Minnesota's rocks and waters: Minneapolis, Univ. of Minn. Press.

Shimer, H. W., and Shrock, R. R., 1944, Index fossils of North America: New York, John Wiley and Sons, Inc.

Simpson, George Gaylord, 1961, Life of the past: New Haven, Yale Univ. Press.

Sloan, R. E., and Austin, G. S., 1966, St. Paul Sheet (bedrock geology), Geologic Map of Minnesota: Minneapolis, Minn. Geol. Survey.

Stauffer, Clinton R., and Thiel, George A., 1941, The Paleozoic and related rocks of southeastern Minnesota: Minneapolis, Univ. of Minn. Press.

Winchell, N. H., and others, 1895, The geology of Minnesota Paleontology, v. 3, part 1 of the Final Report: 1885-1892, The Geological and Natural History Survey of Minnesota, Minneapolis, Harrison and Smith.

_____ and _____, 1897, The Geology of Minnesota Paleontology, v. 3, part 2 of the Final Report: 1892-1896, The Geological and Natural History Survey of Minnesota, Minneapolis, Harrison and Smith.

Many other state geological surveys publish fossil collecting guides which may be of interest. The following displays are very instructive: Science Museum of the Arts and Science Center in St. Paul, Museum of the Minneapolis Public Library, Departments of Geology, University of Minnesota, Minneapolis and Duluth, and Museum of Natural History, University of Minnesota, Minneapolis.

APPENDIX

Fossil Collecting Localities

First, a few suggestions for new fossil collectors. Permission should always be obtained before entering private land. Only fossils that can be used should be removed. By following this rule, a supply will be available for the collectors of the future.

Fossils can be collected most easily from the talus below the outcrops. Also, you can expect most of the fossil hard parts or molds you find within the rocks to be smaller than a nickel. Although fossils occur in nearly all of the stratigraphic units of southeastern Minnesota (p. 4), they are more common in certain beds of specific formations. The locations of collecting sites and a description of the fossil - bearing beds follow.

Franconia Formation

The buff and green sandstone beds of the 200 - foot thick Franconia Formation are the oldest exposed rocks in Minnesota that contain abundant fossils. The best collecting is in the 6 - inch layers of sandstone, which can be expected to contain at least one fossil - rich bed for each 20 feet of stratigraphic section. The fossils are sand molds of trilobite parts -- heads, tails and thorax segments -- which are sometimes stained a rusty red in contrast to the tan color of the enclosing sandstone.

The best localities are gullys on privately owned land along the St. Croix River from Taylors Falls south to Marine, in Chisago and Washington counties. The fossiliferous beds are in the lowest one - quarter

mile of the creek beds. Easily accessible collecting sites on public land are those below the waterfalls along Curtain Falls and Pine Point Trails in the Interstate Park at Taylors Falls.

In southern Minnesota, collecting localities for Franconia trilobites are: (1) road cuts about 10 feet above U. S. 61 near the west limit of Red Wing; (2) in Wabasha County, along U. S. 61 three miles southeast from the "Stone Pier" in Lake City to Reads Landing; (3) along U. S. 16 near Peterson in Fillmore County; and (4) along State 26 near Reno in Houston County.

Searching for trilobites probably will not be as personally rewarding as collecting brachiopods in the Middle Ordovician rocks because the trilobites are highly fragmented and sometimes difficult to identify.

St. Lawrence Formation

Trilobites occur in buff, flagstone - shaped, outcrops of the 15- to 60- foot thick St. Lawrence Formation. Large trilobites, particularly Dikelocephalus (p. 17), are found in the dolomitic siltstone beds.

Collecting sites in the St. Lawrence include: (1) a creek crossed by State 95 in the southern part of Afton, Washington County; (2) "Fairy Glen", a gully one mile north of the junction of Highways 95 and 96 in the northern part of Stillwater; and (3) Barn Bluff, in Red Wing, about five feet above the south end of U. S. 61 bridge over the Mississippi River.

Jordan Sandstone

The Jordan Sandstone commonly contains fossils, but they are difficult to locate and only rarely sufficiently preserved for collecting.

Prairie du Chien Formation

The best fossils from the 120- to 250- foot thick Prairie du Chien are in flint nodules at or near the bluff crests of the Mississippi River valley in Winona and Houston counties. The nodules must be broken to expose the snails. Poor quality snails and worm burrows are common in the lower part or the Oneota Member of the Prairie du Chien Formation.

St. Peter Sandstone

Fossils are very rare in the St. Peter.

Glenwood, Platteville, and Decorah Formations

The best fossil collecting in the State is from the Platteville and the Decorah formations. The most convenient access to the beds is at quarry sites. Quarries in the approximately 30- foot thick Platteville Formation, which generally is capped by the Decorah, can be found throughout a large area in southeastern Minnesota (p. 20, 21). The quarries can be located by either a road reconnaissance or by study of the one-inch-to-the-mile State Highway Department maps for particular counties. The Decorah Shale and the Platteville Formation are also exposed in road cuts and stream banks.

The most popular collecting localities from the Platteville and Decorah in the Twin Cities metro-

politan area are in St. Paul. They include (1) Shadow Falls at the end of Summit Avenue and East Mississippi River Road; (2)Hidden Falls Park, just south of the Ford Motor Company assembly plant; and (3) the clay pit of the St. Paul Brick Co., south of the Mississippi River near Lilydale. Note: These localities are dangerous; watch for falling rocks.

Localities south of the Twin Cities for collecting Middle Ordovician fossils are: (1) abandoned Platteville quarries and road cuts extending for a distance of 2 miles on southeast - trending roads beginning 1 mile south of Cannon Falls; (2) road cuts in the Decorah Shale along State 56 northwest of Wangs; and (3) county roads near the North Branch of the Zumbro River, between Wanamingo and Zumbrota -- all in Goodhue County; (4) Platteville quarries along the Straight River in Rice County, just south of State 60 and 2 miles east of downtown Fairbault; (5) Platteville quarries near Rochester -- one, 4 miles southeast of the city on U. S. 52, and another 1 mile east and one - half mile north of Olmsted 9; (6) Decorah road cuts 1 mile east of Chatfield on State 30, and banks along County 8 near Sugar Creek 1 1/2 miles west of Fountain in Fillmore County; and (7) two Platteville quarries near the railroad underpass 3 1/2 miles southwest of Spring Grove, on State 44 in Houston County.

Galena Formation

The fossils from the 150-170- foot thick limestone beds of the Galena Formation can be collected from quarries near Kasson and Mantorville in Dodge County. A few beds have well preserved specimens, particularly of the large snail Maclu-

rites (p. 12). A quarry (Rifle Hill) 1 mile north and 2 3/4 miles east of Cherry Grove on County 14 in Fillmore County and quarries near Stewartville in Olmsted County contain many good specimens.

Dubuque and Maquoketa Formations

Fillmore County has the best localities for fossil collecting in the 35- foot thick Dubuque and the 20-70- foot thick Maquoketa formations. Localities are road cuts near the top of Rifle Hill, 300 feet south of the entrance to Mystery Cave near Spring Valley, and road cuts and creek banks 1 mile west of the town of Granger, near the Iowa border.

Cedar Valley Limestone

Devonian fossils can be collected from the base of the Cedar Valley Limestone in road cuts in the topographically high portions of Spring Valley, in western Fillmore County, in abandoned quarries about 3 1/2 miles east of Ostrander along County 12, and in the large quarries 1/2 mile east and 1/2 to 1 mile north of LeRoy in Mower County.

Cretaceous Formations

Cretaceous shark teeth (p. 24) and fish bones can be collected from several localities in Minnesota. Some of the mine dumps west of Hibbing on the Mesabi Range provide good collecting. In western Minnesota Cretaceous sediments overlie and fill fractures in the Precambrian granitic and metamorphic rocks. The fossil - bearing Cretaceous sediments are well exposed in the overburden banks of several quarries near Odessa and Ortonville in Big Stone County and

Bellingham in Lac qui Parle County. Clay pits in southern Minnesota near Springfield, Brown County also provide good collecting sites.

Cretaceous leaf prints (p. 26) occur in a tan to brown shale southeast of Franklin in road cuts along Renville 19. The best and most accessible location is immediately southeast of the intersection of County 19 and County 12 in Renville County.

RECORD OF COLLECTED FOSSILS

No.	Name	Formation	Locality	Date

RECORD OF COLLECTED FOSSILS

No.	Name	Formation	Locality	Date

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

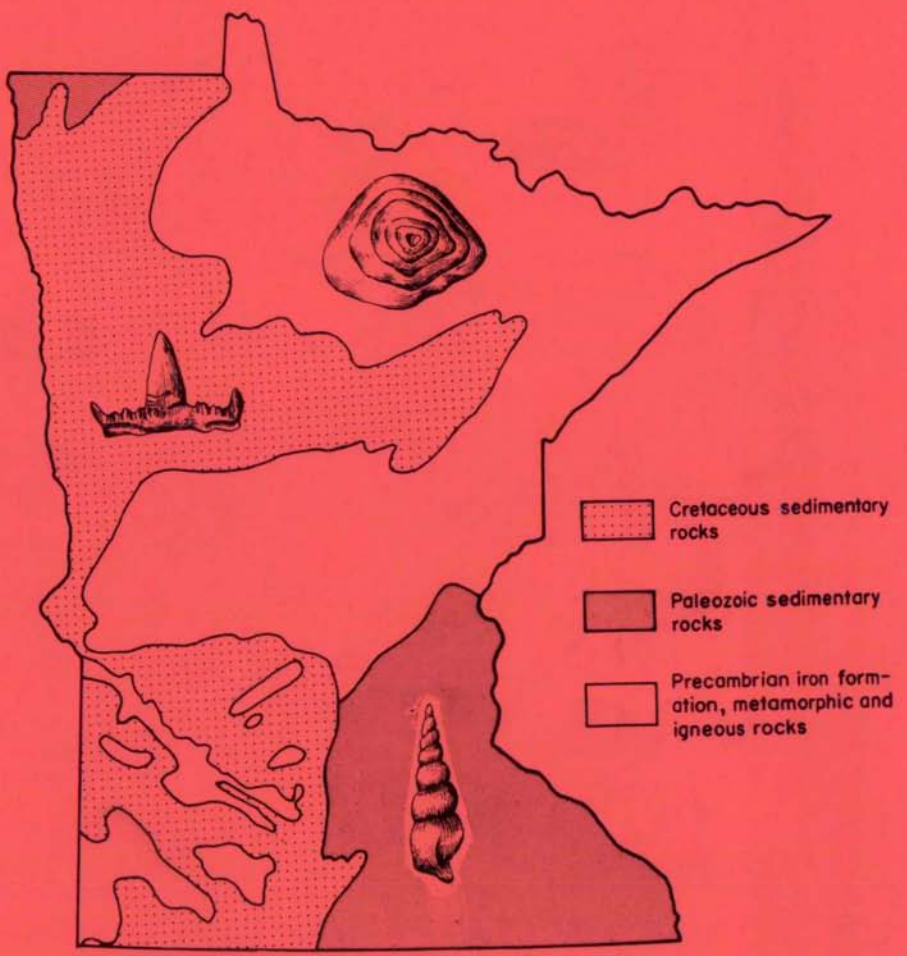
Name _____
Formation_____
Locality_____
Collector_____

Date_____ No._____

Name _____
Formation_____
Locality_____
Collector_____

Minnesota Geological Survey

UNIVERSITY OF MINNESOTA



Educational Series-1