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# *Guide to Mineral Collecting in Minnesota*



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# *Guide to*
# *Mineral Collecting in Minnesota*

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Mineral Collectors Paradise--Minnesota's North Shore

Mineral collecting is a hobby that appeals to more than six million Americans. Rocks and minerals provide many of the clues to what we know about nature. Our knowledge of the age of the earth, the nature of prehistoric life, and the record of the great ice ages comes from what we can determine from the study of rock strata.

This booklet is about the rocks and minerals found in Minnesota. It is intended for the general public, particularly for those individuals that are just awakening to or are renewing an earlier interest in rocks. We hope to point the beginner in a direction that will provide an interesting and rewarding hobby. To do this we offer some essential background on rocks and minerals and a detailed guide to many of Minnesota's more attractive rock and mineral specimens.

Although the terms *minerals* and *rocks* are often used interchangeably, it is not entirely correct to do so. Minerals are distinct chemical species. Each mineral has its own chemical formula and crystal structure. Indeed, minerals are often referred to as crystals, especially if they exhibit crystal faces. Rocks, on the other hand, are aggregates of several minerals. Just as minerals are composed of certain specified elements, each rock type is composed of a certain group of minerals. For example, the rock *granite* is composed chiefly of the minerals quartz and feldspar.

About 2,000 distinct mineral species are known although less than 100 are considered common or abundant. Collectors are interested in gathering these minerals for a variety of reasons. Some collectors are students of systematic mineralogy and assemble suites of minerals in a manner similar to stamp collecting. Some even aspire to obtaining nearly all of the 2,000 mineral species. Others are interested only in minerals exhibiting good crystal form. One type of collector specializes in *micromounts*, that is, in collecting tiny perfect crystals. Many are interested primarily in semi-precious gem rocks and minerals that may be cut, polished, or faceted to bring out their natural beauty. A small group collects rocks and minerals that have been fashioned by primitive man into implements such as axes, arrowheads, spearheads and peacepipes (see pages 6 and 15 ).

## IDENTIFYING MINERALS

Collectors of all types should learn to identify as many minerals as possible. There are several scientific tests that aid in mineral identification. Because each mineral has a distinct chemical composition and crystal structure, each has distinct physical properties such as hardness, shape or form, streak, luster, specific gravity, cleavage and, to a certain extent, color.

### Hardness

Hardness is the quality of resistance to scratching. Gem stones must possess reasonable hardness, otherwise they are too easily marred or disfigured. For comparison a hardness scale known as Mohs scale is used. Ten minerals, each representative of a certain hardness, form this scale:

1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Orthoclase
7. Quartz
8. Topaz
9. Corundum
10. Diamond

Diamond is the hardest of all natural substances. If you are testing an unknown mineral and the mineral scratches orthoclase but will not scratch quartz, then its hardness lies between 6 and 7. As an added test, quartz should scratch this mineral. Two minerals of approximately the same hardness will scratch each other.

Several other materials can be used in lieu of a mineral hardness set:

Hardness 1 & 2 -- can be scratched with fingernail

Hardness 3 -- will scratch fingernail; can be scratched by edge of a penny

Hardness 4 -- will scratch a penny; can be easily scratched by a knife

Hardness 5 -- barely scratched by knife; will not scratch most glass

Hardness 6 -- will scratch glass

Hardness 7 -- will scratch a knife

Hardness 8 -- will scratch quartz

## Specific Gravity

Specific gravity is the weight of a mineral as compared to the weight of an equal volume of water. It can be used as an aid in distinguishing minerals. Pure gold has a specific gravity of 19.3, whereas pyrite has a specific gravity of about 5; thus, gold is nearly 4 times as heavy as an equal volume of pyrite.

## Streak

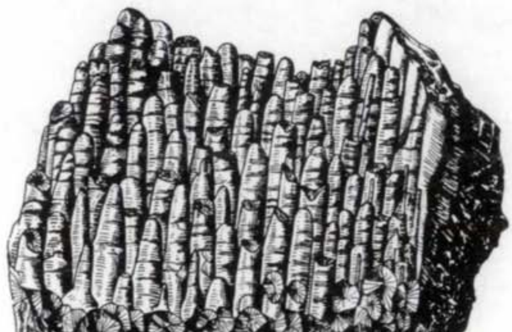
Streak is the color of the powdered mineral obtained when the mineral is rubbed against a flat piece of unglazed, white porcelain. Among the iron minerals, magnetite leaves a black streak, hematite a red streak, and goethite a yellowish-brown streak. Pyrite, which is brass-yellow in color, leaves a black streak.

## Shape and Form

Mineral *shape* or *form* has two entirely different meanings. *Crystal form* means the type of crystal faces occur-

Striated Pyrite Cube

ing on a mineral. Because each mineral has a distinct crystal structure, only certain kinds of crystal faces can form. For example, pyrite commonly crystallizes in the shape of a cube, as shown above. This external shape is controlled by the arrangement of atoms in the crystal. *Shape* and *form* are also used to describe the general external appearance of a mineral with respect to the shape of other things. For example, one of the common shapes of hematite and goethite is called kidney ore or reniform structure. Some of the common forms found in minerals include: fibrous, radiating, botryoidal, stalactitic and dendritic.



Stalactic Goethite

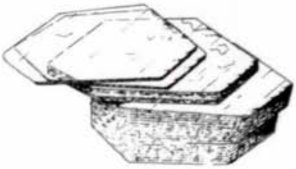
Botryoidal Goethite

## Cleavage

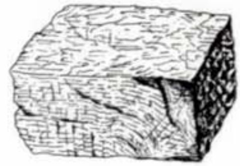
Cleavage is the way a mineral splits. If it splits with a smooth, flat surface, the mineral has good cleavage. Cleavage is further described by the number of different directions or planes along which it cleaves. As illustrated on page 6 , mica has a single cleavage plane; feldspar splits in two directions, calcite in three, fluorite in four. Many minerals including quartz do not have any cleavage direction. Quartz breaks similar to glass, with a shell-like, conchoidal fracture.

## Color

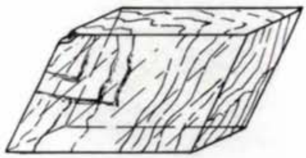
Color, luster, transparency, reflectivity, index of refraction, and fluorescense result from the interaction of the electrons in the mineral with light waves. These optical characteristics determine the natural beauty of a mineral. Great differences in color can be found in a single mineral species and the property of color must be used with caution as an aid to identification. In metallic minerals,



Muscovite Mica

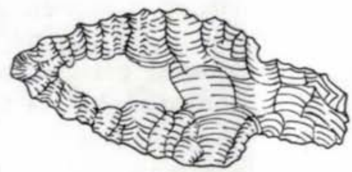


Feldspar



Calcite

Fluorite



Quartz

color is far more uniform than in nonmetallic minerals. Therefore, color is a safer guide for the identification of metallic minerals.

## Luster

Luster is a property governed by the manner in which light is reflected from the surface of a mineral. The luster is called vitreous when the reflection is similar to that shown bv broken glass. Adamantine luster is that particular bright reflection shown by diamond. Metallic luster needs no description.

The mineral identification chart on pages 22 and 23 lists many of the common minerals of Minnesota that are of interest to the mineral collector, and describes the physical properties that are useful aids in their identification.

## WHERE TO COLLECT MINERALS

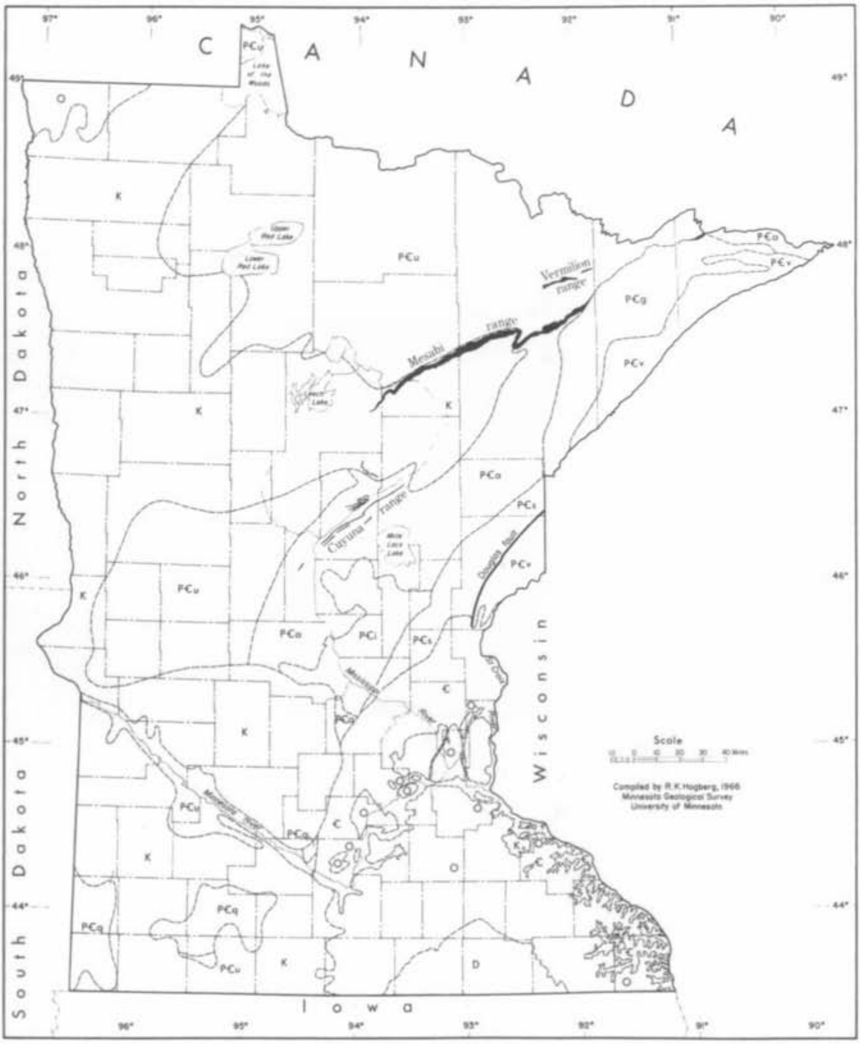
Rocks and minerals of interest crop out at many places. They are found along the North Shore of Lake Superior, on woodland trails, and in the banks of open-pit mines, quarries, and gravel pits. Nearly every day new finds are uncovered by excavation for buildings and highways in our State.

As has been mentioned, each rock type is an aggregate of minerals. Therefore, to find a particular mineral one must hunt in an area where the rocks that contain this mineral are exposed. It would thus be useful to consider the general geology of Minnesota before embarking on field collecting trips. To aid you in your study and planning, a map and explanation of the bedrock geology of Minnesota are printed on pages 8 and 9 . We suggest you color the separate rock units on the map and explanation; by doing so, the map will be more useful and meaningful.

There are three major rock types. These are igneous, sedimentary and metamorphic rocks.

### Igneous Rocks

Igneous rocks are formed by the solidification and crystallization of molten material called magma. One type, volcanic rocks, forms from magma that reaches the earth's




Bedrock Geologic Map of Minnesota

# EXPLANATION

## MESOZOIC

### Cretaceous

**K** — Sandstone and shale

(Coleraine Formation northern Minnesota; Windrow Formation southern Minnesota)

## PALEOZOIC

### Devonian

**D** — Cedar Valley Formation

(Dolomite and limestone)

### Ordovician

**O** — Dolomite, sandstone and shale

(Prarie du Chien Group, Platteville Formation, Decorah Shale, Galena Formation, Dubuque Formation, Maquoketa Formation-oldest to youngest)

### Cambrian

**€** — Sandstone and minor shale

( Dresbach Formation, Franconia Formation, St. Lawrence Formation and Jordan Sandstone-oldest to youngest)

## PRECAMBRIAN

### Keweenawan

**P€s** — Sandstone and shale

(Fond du Lac Formation and Hinckley Sandstone)

**P€g** — Duluth Gabbro Complex

(Multiple intrusions of gabbro, anorthosite and granophyre; age is 1.1 billion years)

**P€v** — North Shore Volcanic Group

(Dominantly basaltic lava flows)

### age uncertain

**P€q** — Sioux Quartzite

(Dominantly quartzite with thin beds of argillite or pipestone)

**P€i** — Penokean intrusive rocks

(Quartz diorite, quartz monzonite, granodiorite, and granite; age is 1.7 billion years)

### Animikie

**P€a** — Argillite and graywacke

(Virginia Argillite, Thomson Slate and Rove Argillite)

Iron-formation

(Biwabik Iron-formation of Mesabi range and Trommald Formation of Cuyuna district)

### Lower Precambrian

**P€u** — Undifferentiated metamorphic and intrusive rocks

(Includes Ely Greenstone, Knife Lake Group, Giants Range Granite and Vermilion Granite of northern Minnesota; Soudan Iron-formation is interbedded in the Ely Greenstone; and gneisses and intrusive igneous rocks of the Minnesota River Valley) surface before solidifying. Most of the zeolite minerals that we will describe are in the ancient lava flows along the North Shore of Lake Superior. Granite, anorthosite, and porphyry are types of igneous rocks referred to as intrusive rocks because they crystallize deep within the earth's crust. Uplift and erosion have combined to bring the intrusive rocks to the earth's surface in northeastern and central Minnesota.

## Sedimentary Rocks

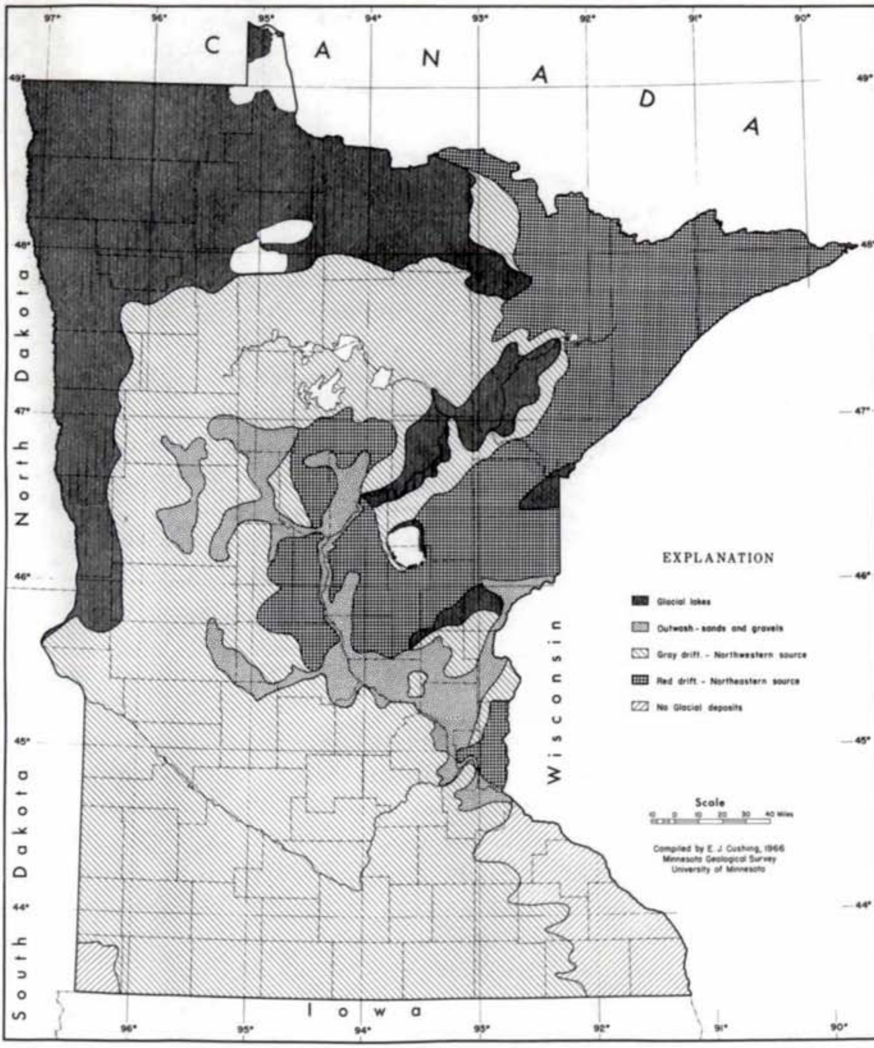
Sedimentary rocks are formed by the cementing of mineral grains that were carried and deposited by water, wind, and ice or were chemically precipitated in streams, lakes, or oceans. The weight of later sediments aids in compacting the mineral grains into a sedimentary rock. Sedimentary rocks are found most commonly in southeastern Minnesota.

## Metamorphic Rocks

Metamorphic rocks, which contain many minerals not present in the other two rock types, are formed by the transformation of pre-existing rocks by heat and pressure. Staurolite, illustrated on page 36, and garnet are examples of minerals found primarily in metamorphic rocks. Metamorphic rocks may be found in all but the southeastern part of the State.

## Glacial Drift

Knowledge of the glacial history of Minnesota is particularly useful to agate collectors. The spread of the great ice sheets over the State during the Pleistocene Epoch constructed the present topography or the *face* of Minnesota, as shown on the back cover. During the last or Wisconsin Stage, which began about 40,000 years ago, mile-high ice sheets entered and retreated from the State during five separate phases and along four distinct routes. The early Wis-




Surficial (Glacial) Geologic Map of Minnesota consin Age ice sheets traveled via the Red Lakes, Rainy Lake, and the Lake Superior-Minneapolis lowland routes. Later, ice advanced down the Red River of the North and the Minnesota River lowland into Iowa with sublobes advancing into the Minneapolis-St. Paul and Mesabi Range areas. For approximately 4,000 years, from 11,000 to 7,000 years ago, the waters of the famous Lake Agassiz covered large parts of northwestern Minnesota. During the melting of the last glacial ice, other smaller lakes covered areas of northeastern Minnesota.

Glacial ice that moved into Minnesota from the northwest picked up and later deposited fragments of shale and limestone as well as other rocks. The resulting glacial deposits, called drift, are gray or buff, generally clayey, and have substantial amounts of calcium carbonate. In contrast, the glaciers that overrode northeastern Minnesota picked up rocks that now form a red sandy drift that contains little clay and has a wide variety of interesting igneous and siliceous rocks, including agates. Therefore, the best hunting ground for agates is in the *red drift* deposited by the ice sheets from the Lake Superior area. These deposits are delineated on the surficial map on the preceeding page.

## A Nonrenewable Resource

Collectors are reminded that access to many gravel pits, quarries and mines may be limited. The owners are concerned both about personal injury to collectors and damage to their property. Permission should always be sought before entering private property. Collecting is prohibited in State and National Parks, which were developed to protect the natural treasures they contain.

In a later section on mineral localities in Minnesota we have indicated that some minerals are abundant at certain sites. It is evident that the minerals become less abundant each year as collectors visit the sites. If collectors take more than they can use from these localities, the supply of many Minnesota minerals will soon be exhausted. Minerals are a *nonrenewable resource*. The young collectors that we all hope to inspire may find nothing left when they are ready to go into the field unless steps are taken to conserve some of the minerals at the better collecting localities.

If you find something you believe to be rare or in some other way of exceptional interest, show it to a more advanced collector. He may suggest that you submit it to the University for positive identification by X-ray or petrographic analysis. In the past, outstanding amateurs have been involved in many new mineral discoveries. The hours spent by amateurs in searching and collecting are much greater than that spent by the few professional mineralogists in the State.

## COLLECTING AND PREPARING SPECIMENS

A few items of equipment are necessary for collecting minerals in the field. Because most specimens are found as part of a rock mass, a geologic hammer or pick is an essential tool. Many collectors carry a heavy sledge hammer and a light-weight trimming hammer. A geologic pick has a square head with either a chisel or pick edge opposite. A cold chisel, also a useful tool, is used with a hammer to

pry apart large chunks of rock or to help separate good crystals from the rock. Safety glasses or some form of eye protection should be used. Extreme care must be taken to prevent injury to hands as well as damage to crystals.

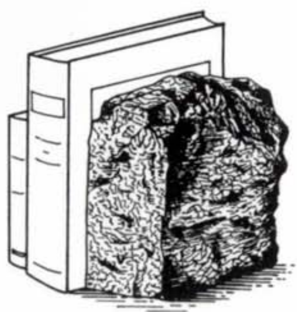
For identifying small crystals or for studying cleavage a 10-power hand lens is indispensable. When collecting in *iron-ore country*, a magnet is standard equipment. Many collectors find a streak plate (unglazed porcelain) useful in the field. Others prefer to do most testing after returning home. A good canvas collecting bag will give long service as an aid in getting the sometimes hard-won specimens home.

Old hand collectors and professional mineralogists and geologists have learned the wise practice of carrying a field notebook and labels into the field. The date of the trip, the locality, the number and kinds of rocks and minerals collected, and other relevant information should be noted in the field notebook. Field labels can be simply pieces of paper or cardboard with the itemized data concerning the specimen. A small supply of such labels is included on the last two pages of this booklet. The label, when properly filled out, is wrapped with each specimen or group collected. Experienced collectors always carry a supply of newsprint for wrapping specimens. Proper labeling and note taking are important. A specimen without locality information has lost much of its scientific value. Remember: the smallest note is better than the best memory.

Systematic mineral collectors invariably have a good place to store minerals and often have a display cabinet for their prize specimens. The material collected in the field should be prepared for the collection as soon as possible. This includes trimming away excess material, cleaning, and proper labeling and cataloging for storage or display. A small spot of white enamel may be placed on an inconspicuous part of the specimen. A catalog number in india ink may then be written on the spot and the specimen remains forever tied to its label or file-card number.

For many mineral hobbyists the real interest is in what can be done with the material that is collected. These people take pleasure in cutting and polishing gem material. Because of the hardness of most gem materials, either diamond or silicon carbide wheels are required to cut and shape them. Many Minnesota rocks and minerals can be used to make beautiful cabochons to be mounted and worn in rings, pendants, broaches, and other forms of jewelry. Some hobbyists make flat cabinet specimens by cutting and polishing a flat surface to lend brilliance to, and bring out the details of, the colors and textures of the materials. Another lapidary approach is to mass-polish gem minerals in a tumble barrel. This process is limited to small -- up to one inch -- specimens but it is a good way to finish the small agates one finds. It takes about 500 hours to polish a batch in tnis manner. A small three-pound tumbler will handle about 250 individual pieces. Cutting and polishing need not be limited to jewelry items. Book-ends, paper-weights, mosaics and similar objects can be made from many Minnesota rocks and minerals such as those illustrated below.

Agate



Feldspar

Pipestone

## Quartz Minerals

Quartz presents to the world a fantastic variety of appearances, variegated in color and texture, and marked by a brilliant luster. Mankind has been attracted to this attractive and useful mineral since the Old Stone Age, when primitive man used flint, jasper, and other quartz minerals in fabricating tools and weapons. When man learned the art of cutting and polishing agate, carnelian, and similar materials , he fashioned them into beads and other ornaments.

The diverse modes of formation and consequent dissimilar appearances of quartz minerals, coupled with their wide occurrence, has given rise to a bewildering number of names ranging from agate and amethyst to zonite. Quartz minerals

Ouartz Crystals

occur in all three major rock types, igneous, sedimentary and metamorphic, but find their greatest development in low-temperature chemical sediments deposited from percolating waters. These varieties are microcrystalline or cryptocrystalline and include chalcedony, carnelian, agate, onyx, jasper, flint, and chert.

All quartz family minerals are composed of silicon dioxide ($SiO_2$) and owe their variety of colors to trace amounts of impurities. The types of quartz common to Minnesota include the following:

Crystals

Large terminated crystals of quartz are rare in Minnesota. Druzy masses may be found in a number of rocks along fractures or in vugs (as illustrated on page 16). The common, milky white, *shoe-button* variety found in the glacial drift is of disappointing gem quality.

Amethyst

This form of lavendar to purple quartz is found locally in geodes and in cavities in agates. It has been collected from veins, cracks, and crevices in rocks in the area of the Gunflint Trail.

Lake Superior Agate

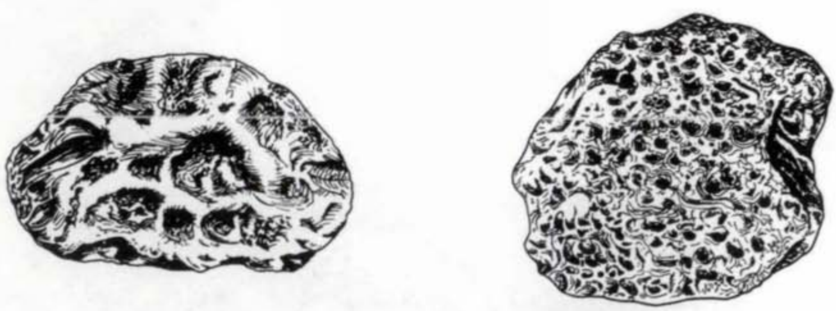
Lake Superior Agate

This variety was carried here by the glaciers that flowed from central Canada. This highly-sought agate is not found in all drifts, but is restricted to the red or Lake

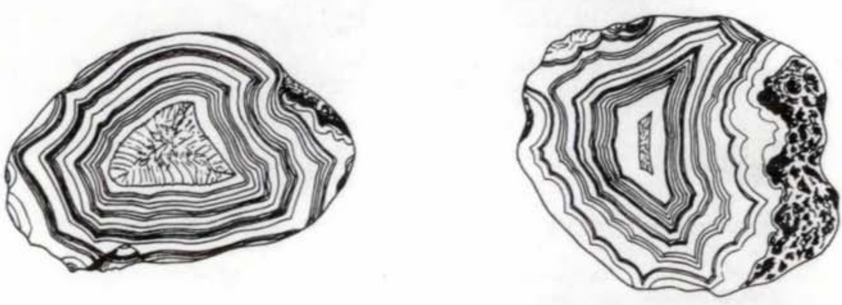
Superior drift (refer to map on page 11). When scouting in an unfamiliar area, look first for the more abundant sand-sized agates. If they are present, the large ones will also be present.

The drawings below show banded or *fortification* agates of the Lake Superior type. The color is basically red with white bands. Banding results from rhythmic deposition of silica gel from percolating waters which enter cavities in various rocks. Banding may be extremely varied, regular and rhythmic, or absent. Because of the transparency and luster of agates, it is easier to locate them when the search area is in direct sunlight.

In the illustrations below you will note that one half of each pair shows an unpolished exterior surface. This is



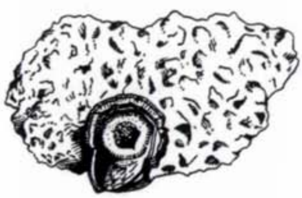
Lake Superior Agates



usually the only part exposed in the field, and it is important to be able to recognize this dull, slightly waxy and pitted surface, which retains the imprint of the cavity in which it formed.

## Paradise Beach Agate

This tiny, well-formed agate is a *made in Minnesota* product. You may chip this variety from its enclosing amygdaloid in the basalt along the North Shore of Lake Superior approximately thirteen miles east of Grand Marais. It is generally red-orange with strong white banding, and specimens are rarely larger than one's thumb.



Paradise Beach Agate

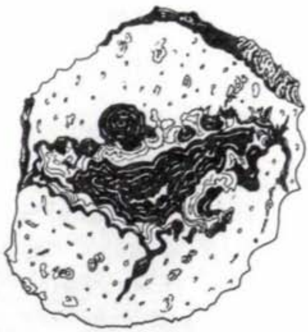
## Cold-Water Agate

This variety develops in cavities in weathered limestone, and is recovered as water-worn fragments along the dry washes of the Zumbro River at Mazeppa, Minnesota. It is commonly associated with drusy quartz.

## Thunder Egg Agate

Concretionary nodules whose center portion is composed of red and white banded agate may be found weathering from the hillside 300 feet north of U. S. Highway 61 near the Highway Patrol Target Range at Five Mile Rock, east of Grand Marais.

Thunder Egg Agate

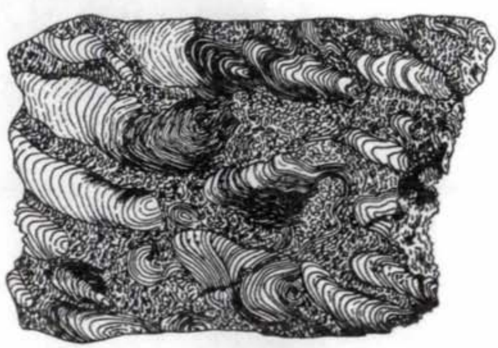


(rough)

(cut & polished)

Jasper

In a general way, jasper includes all the red and reddish-brown varieties of microcrystalline quartz. It is quite abundant in Minnesota and, when sufficiently attractive, is in demand for lapidary work. The patterns, textures, and colors show wide variation, and jasper has been given several subvariety names. In Minnesota one of these is the Mary Ellen Jasper, named for its occurrence in the Mary Ellen Mine on the Mesabi Range, one mile west of Biwabik, on State Highway 35. This subvariety is a beautiful red to pink material containing red to white swirls of



Mary Ellen Jasper

Precambrian fossil algae. If it isn't too porous it will take a high polish. Jasper grades into flint and chert. These varieties make excellent arrowheads, but are not suitable for jewelry. Any of the glacial drifts may produce jasper. One jasper commonly recovered from glacial deposits is a flecked or freckled deep red to egg plant-purple colored variety.

Binghamite

Binghamite is composed of quartz and fibrous silicates with inclusions of goethite or hematite. Material of gem quality, which is usually red or yellow, exhibits a chatoyant luster similar to African Tiger's-eye. Small specimens of red Binghamite can be found on the dump of the Portsmouth Mine at Ironton and from other Cuyuna Range localities.

Silkstone

A similar but more opaque and more coarsely fibrous rock than Binghamite, known as silkstone, is commonly found in the same veins. Generally silkstone is brown, yellow, grayish-green, grayish-blue, or any combination of these. It has a marked wavy chatoyancy and is commonly associated with asbestos. Silkstone is found sparingly at the Arco Mine and other localities on the Cuyuna Range.

Silkstone

(rough)

(cut & polished)

# TABLE FOR DETERMINATION OF COMMON MINNESOTA MINERALS

| MINERAL | COMPOSITION | HARDNESS | CLEAVAGE OR FRACTURE | STREAK | COLOR | LUSTER | SPECIFIC GRAVITY | OTHER PROPERTIES |
|---|---|---|---|---|---|---|---|---|
| Quartz | $SiO_2$ | 7.0 | conchoidal | white | colorless | vitreous | 2.6 | impurities produce a variety of colored quartz |
| Thomsonite | $NaCa_2Al_5Si_5O_{20} \cdot 6H_2O$ | 5.5 | planar | white | white to green | vitreous | 2.3 | habit prismatic to radial |
| Hovlandite (Xonotlite) | $CaSiO_3 \cdot 2H_2O$ | 6.5 | planar | white | white to pink | vitreous | 2.7 | habit fibrous |
| Pectolite | $NaCa_2Si_3O_8(OH)$ | 5.0 | 2-directions | white | white to gray | subvitreous | 2.8 | luster may be silky, habit fibrous |
| Prehnite | $Ca_2Al_2Si_3O_{10}(OH)_2$ | 6.0-6.5 | weak planar | white | light green | vitreous | 2.9 | tabular groups have cock's comb appearance |
| Hematite | $Fe_2O_3$ | 5.5 | uneven fracture | red | red, gray, black | dull to bright metallic | 5.2 | appearance varies widely |
| Goethite | $HFeO_2$ | 5.0 | planar | yellowish-brown | yellowish-to blackish-brown | dull to adamantine | 4.3 | habit may be reniform, radial, bladed, etc. |
| Magnetite | $Fe_3O_4$ | 6.0 | uneven | black | black | dull to bright metallic | 5.2 | magnetic; habit octahedral |
| Ilmenite | $FeTiO_3$ | 5.5 | conchoidal fracture | black | black | submetallic to metallic | 4.7 | distinguished from magnetite only by lack of magnetism |
| Pyrite | $FeS_2$ | 6.5 | uneven | greenish-black | brass yellow | metallic | 5.0 | habit varied, striated cubes to pyritohedra |
| Pyrrhotite | $FeS$ | 4.0 | uneven | gray black | bronze yellow | metallic | 4.6 | tarnishes yellowish-brown; weakly magnetic |
| Arsenopyrite | $FeAsS$ | 5.5 | uneven | grayish-black | silver white to steel gray | metallic | 6.0 | wedge-shaped crystals; emits garlic-like odor when struck |
| Siderite | $FeCO_3$ | 4.0 | rhombohedral | white | reddish-brown | vitreous | 4.0 | rhombohedral habit |
| Pyrolusite | $MnO_2$ | 2.0 - 6.0 | 2-directions | black | iron gray to black | metallic | 5.0 | commonly soft enough to soil fingers |
| Manganite | $MnO(OH)$ | 4.0 | planar | brown to black | steel gray to iron black | submetallic | 4.3 | prismatic crystals, commonly striated |
| Groutite | $HMnO_2$ | 3.5 | planar | brownish-black | jet black | submetallic | 4.1 | curved, wedge-shaped crystals |
| Rhodochrosite | $MnCO_3$ | 4.0 | rhombohedral | white | pink to gray | vitreous | 3.7 | distinct crystals uncommon; cleaved fragments common |
| Calcite | $CaCO_3$ | 3.0 | rhombohedral | white | commonly white or colorless | vitreous | 2.7 | wide variety of forms and habits common |
| Native Copper | Cu | 2.5 - 3.0 | uneven | metallic | copper to brown | metallic | 8.9 | distorted crystals, plates, and wire-like form |
| Staurolite | Fe silicate | 7.0 | uneven | gray | brown | vitreous | 3.7 | cruciform twins common |
| Garnet | silicate | 7.0 | subconchoidal fracture | white | wide variety | vitreous | 3.6-4.3 | dodecahedral habit; color depends on composition; commonly reddish-brown |

## Basanite

This dense, velvety-black variety of fine-grained jaspery quartz has been collected and used by man since ancient times. It was the *touch stone* or *Lydian Stone* that the early Greeks used to *"assay"* gold and other precious metals. Its hard black surface provided an excellent background for comparing the streaks of metals drawn across it. Different alloys give different streak colors on its surface, and gold-plated objects quickly show a change in streak as the base metal begins to show through. Basanite is found in Minnesota on the beach at Grand Marais as polished, water-worn pebbles as much as one inch in diameter. The pebbles resemble similar water-worn pebbles of black basalt; basanite can be distinguished, however, by its greater hardness.

## Zeolites and Associated Minerals

The zeolites are a group of hydrous aluminum silicates of sodium, calcium, and potassium. The water of hydration is peculiar in that it is lost gradually and continuously on heating without destroying the crystal structure. Moreover, the water thus lost is readily regained upon exposure to water. The zeolites also possess the property of alkali ion-exchange -- the basis for their use as water softeners. Zeolites are commonly found as good crystals, but are rather soft and have a hardness varying from about 3.5 to 5.5.

Thomsonite

## Thomsonite

The most colorful occurrence of this gem mineral is found in Minnesota rocks. Pink and white thomsonite, commonly forming radial patterns giving the appearance of little "blood shot" eyes, occurs in vesicle fillings -- as

amygdules --within the basaltic lava flows that outcrop along the North Shore, about 5 miles southwest of Grand Marais, near Good Harbor Bay. These specimens may be collected from the beach sands or directly from the host basalt. Unfortunately, most good radial thomsonite localities are now closed to the public or are on private land. Other fibrous, sheaf-like, thomsonite may be found in the beach sands at Tofte, Minnesota. These specimens are of a white non-gem variety. A more or less structureless variety of thomsonite, exhibiting no apparent radial or fibrous pattern, may be recovered -- along with agate -- on the beach at the Cook-Lake County line. Also at this locality, white to pink amygdules, commonly flecked like birds eggs, may be collected. Thomsonite is one of the hardest of the zeolites, having a hardness greater than 5. Thomsonite nodules are often cut into attractive gem stones.

## Lintonite

This green to grayish-green variety of thomsonite is associated with the other varieties of thomsonite at most of the localities described above. Because of its translucency, size, and shape, it has the appearance of a *jelly bean*. Thread-like inclusions often spoil the cutting qualities of this mineral.

## Other Zeolites

Systematic mineral collectors will also find the zeolites, stilbite and heulandite, in cavities in the basaltic rocks along the North Shore. In addition, the zeolites laumontite and analcite have been found with native copper in the Snake River district near Pine City.

## Hovlandite

Hovlandite is a variety of xonotlite, not a true zeolite. However, it is often grouped with the zeolites because of its matted fibrous appearance and its occurrence as a secondary mineral in basic igneous rocks. Hovlandite is found as white needles and rarely as fans of pink fibers distributed throughout a green diabase containing black pyrŏxene crystals. Veins and water-worn pebbles of this material can be found near the Grand Marais sanitation plant. In some specimens the entire mass will cut and polish well.

Hovlandite

## Pectolite

This silicate mineral also is not a zeolite, but is found in association with zeolites as cavity fillings or in veins within the gabbroic and basaltic rocks of the North Shore. Its white, silky, needle-like crystals are easily separated and are sufficiently sharp to puncture the skin of the unwary. The mineral is subtranslucent and grayish-white, and has a silky to subvitreous luster.

## Epidote

Tiny, bright, pistachio-green crystals of epidote can also be found in cavities in the basalts of the North Shore, and occasionally within rocks of the glacial drift.

## Prehnite

Another secondary silicate mineral found in vugs in the basic igneous rocks of Good Harbor Bay and other areas along the North Shore is prehnite. This pale-green mineral is hard (6 to 6.5) and commonly has a cock's comb shape. It is also found in water-worn pebbles. Some of the prehnite is flecked with native copper.

## The Iron Minerals

Much of the romance in the mineral history of Minnesota is bound up in the lore of the Mesabi Range: the story of the Seven Iron Men; the record tonnages of reddish-brown material sent eastward on ships; the rise of magnetic taconite as the king of Minnesota iron ores. Iron is the fourth most abundant element in the earth's crust (after oxygen, silicon, and aluminum). Considering the total mass of the planet earth, iron is probably the most abundant element. No wonder that large deposits of this useful element are numerous. It is Minnesota's fortune that geological events in the far-distant past -- approximately 2.0 billion years ago -- were favorable for the deposition of the great thicknesses of sedimentary iron-formations or *taconites*.

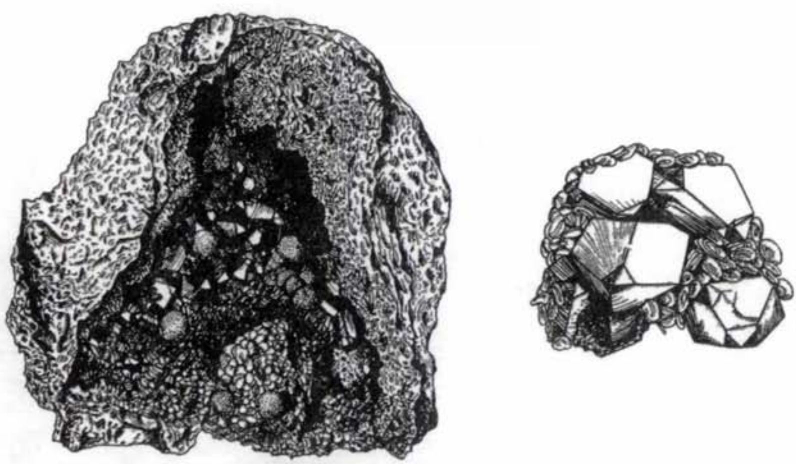
Magnetic Taconite

Taconite can be either magnetic or non-magnetic. The magnetic taconite, the type presently used by the iron industry consists of dark gray to black layers of magnetite alternating with somewhat thicker and lighter colored quartzite layers as illustrated above. After crushing to a fine powder, the magnetite is separated from the silica by electromagnets. Then small quantities of bentonite clay and coal are added to the magnetite powder. The mixture is then rolled into marble-sized pellets which are roasted to gain sufficient strength for shipment to the steel mills. The non-magnetic variety consists of hematite, iron silicates or iron carbonate layers alternating with the quartzite layers. These rocks are not presently being exploited in Minnesota.

The three major iron oxide minerals are magnetite, hematite, and goethite. They may be distinguished most readily by their streaks. Magnetite has a black streak, hematite has a red streak, and goethite has a brown to yellowish-brown streak.

Magnetite

This heavy black variety of iron oxide is attracted by a magnet. It is the common ore mineral of the taconite indus-

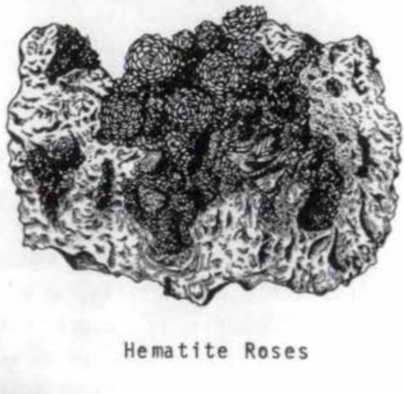


Magnetite Crystals

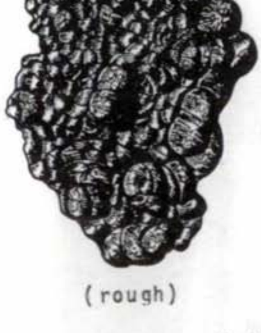
try. Some magnetite with well-oriented crystals will act as a natural magnet or *lodestone* and strongly attract iron objects. High quality lodestone is not found in Minnesota. The black grains of the "black sand" along the North Shore of Lake Superior are predominantly magnetite. Magnetite-rich sands occur sparingly in the glacial drift deposited by Lake Superior ice sheets.

Hematite

This abundant mineral occurs in a variety of shapes and forms, ranging from the very hard metallic-black reniform types to the shiny luster of specularite to the bright-red, earthy varieties. Whatever the color, the streak always is red. The name hematite is derived from the Greek word for blood. All three Minnesota iron ranges, the Mesabi, the Cuyuna, and the Vermilion, (see map on back cover)



Hematite Roses



(rough)

(cut & polished)

Botryoidal Hematite

contain a great diversity of hematite varieties. Gem hematite is rare except as water-worn pebbles from the Cretaceous overburden of mines near Grand Rapids on the Mesabi Range. Martite, a variety of hematite derived from the oxidation of magnetite, commonly retains the external form of the original magnetite crystals.

## Goethite

This mineral, a hydrated form of iron oxide, is the major constituent in limonite. Limonite is dominantly an earthy iron oxyhydroxide with additional capillary water. In massive form this material constitutes the common iron ocher. It occurs in both the Mesabi and Cuyuna Ranges, and in the Fillmore County District in southern Minnesota. Well-crystallized goethite develops many interesting commonly fibrous forms, including the mammillary and stalactitic types (see page 4 ). Its streak is brown to yellowish-brown.

## Pyrite

The *fool's gold* of prospector's lore, pyrite, is a brassy-yellow metallic iron sulfide. It is much harder than gold; in fact it will scratch a knife blade. Pyrite crystallizes in the cubic system and often is found as nearly perfect cubes. Pyrite cubes are available in the dump of the Portsmouth Mine at Ironton and also in one deposit near Glen Lake in Aitkin County. Pyrite is unstable in the presence of moist air and slowly oxidizes to goethite. It tarnishes to a brass yellow color similar to pyrite.

## Pyrrhotite

This mineral is weakly magnetic iron sulfide that is easily mistaken for pyrite. Pyrrhotite can be distinguished from pyrite by its lower hardness, its weak magnetism, and its brown tarnish. It occurs in small amounts in the Duluth Gabbro Complex and in parts of the magnetic taconite near the eastern end of the Mesabi Range.

Pyrite Cubes

## Ilmenite

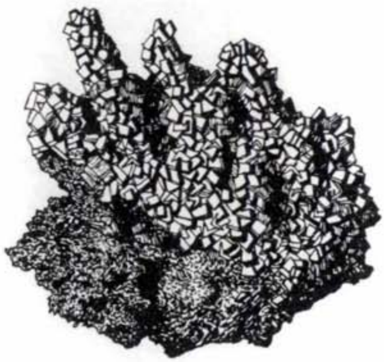
This mineral is an oxide of iron and titanium. It is black and metallic, and can be distinguished from magnetite only by its lack of magnetism. Ilmenite occurs with magnetite and is a common constituent of the dark gray igneous rocks of the Duluth Gabbro Complex of northeastern Minnesota. It occurs as nearly pure masses along the northern margin of the complex in Lake and Cook counties.

## Arsenopyrite

Arsenopyrite is a silvery-white mineral composed of iron, arsenic, and sulfur. It can be found in veins at the west end of Loon Lake in Cook County and in rectangular forms in the Roberts Mine of the Cuyuna Range. The latter specimens make good polished flat-cabinet exhibits. Arsenopyrite may tarnish to a brass yellow color similar to pyrite.

## Siderite

The iron carbonate, siderite, occurs in the Biwabic Iron-formation of the Mesabi Range as massive aggregates of tiny crystals. It is softer (4) than a knife blade and generally is tan or brownish in color. As shown on page 32 siderite has perfect rhombohedral cleavage.



Siderite Rhombs

## The Manganese Minerals

Many chemical elements impart a characteristic color to minerals. Iron silicates are commonly green; iron oxides are mainly red, black, or brown. Manganese characteristically imparts a pink color to the silicates or carbonates, and black or gray colors to the oxides.

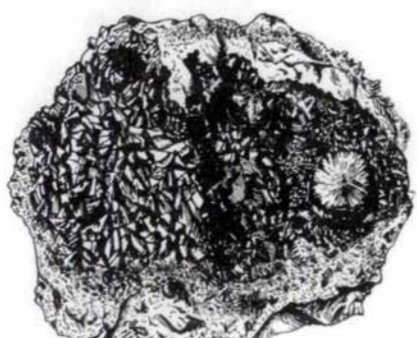
Manganese is of major importance in the manufacture of steel. It improves the rolling and forging properties as well as the hardness of steel, acting at the same time as a deoxidizing and desulfurizing agent. Geologically, the genesis of manganese oxide ores is similar to the iron ores, and Minnesota's Cuyuna Range is well known as a source of manganiferous iron ores.

### Pyrolusite

This mineral is most easily recognized as steel-gray to black, metallic, needle-like crystal masses in mines on the Cuyuna Range. When in unaltered *museum-quality* crystals, pyrolusite is very hard (up to 6.5) and is called polianite. However, it is more commonly found in a softer (1 to 2.5) form that will soil the fingers black. In addition to the needle-like crystals, pyrolusite may occur as pseudomorphs after manganite, in reniform coatings, in concretionary forms, and as the well-known dendritic growths on fracture surfaces of rocks. Lacy, dendritic stains on limestone pebbles may be recovered from the glacial drift, particularly near Lauderdale, a suburb of Minneapolis-St. Paul. Pyrolusite is often called *black oxide of manganese* and is essentially pure manganese dioxide. The streak is black or bluish-black.

### Manganite

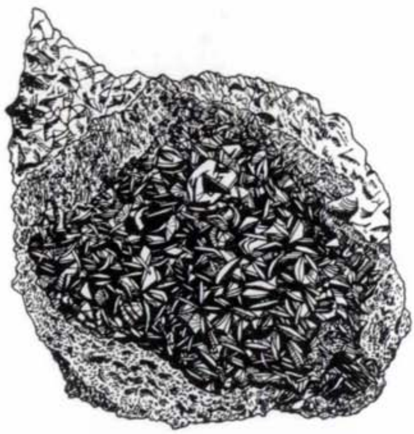
This hydrated oxide of manganese is found as prismatic crystal groups in pockets or vugs in more massive manganese ore. The black crystals may be striated and have a brownish-black streak. With the loss of its constituent water, it alters to pyrolusite. It occurs in the Roberts Mine dump one mile north of the village of Cuyuna, Minnesota.



Manganite

### Psilomelane

This hard hydrous manganese oxide is a true mineral species although it invariably occurs as fine-grained, massive material in botryoidal, reniform, or stalactitic forms rather than as individual crystals. In these shapes it strongly resembles similar forms of black goethite and hematite. However, psilomelane will have a black rather than the yellowish-brown or red streaks of the iron minerals. It is both widely distributed and plentiful wherever manganese ores are found.



Groutite

Groutite

Groutite, a hydrous manganese oxide, was first identified as a new mineral from the Sagamore Pit on the Cuyuna Range, and was named by Professor John W. Gruner after the late Professor F. F. Grout of the University of Minnesota. It is very difficult to distinguish from manganite in color, luster, streak, hardness, or specific gravity. It is found as wedge-shaped crystals that line vugs in manganese ore. The crystals have a high submetallic luster and give a dark brown streak. Brilliant reflections may be observed from perfect cleavage surfaces.

Ramsdellite

The collector of rare minerals may be interested in this exceedingly rare manganese dioxide. It has been reported from the Monroe-Tener Mine near Chisholm, on the Mesabi Range, where it occurs as clusters of radiating, shiny-black crystals about 6 mm. long in a dull gray matrix. It must be noted that these crystal aggregates are quite delicate and fall apart easily.

### Rhodochrosite

The manganese carbonate, rhodochrosite, is not a common mineral, but specimens with a beautiful pink color are sought as semi-gem material. Its relatively low hardness of 4 prevents it from being classed as a gem mineral. In common with other rhombohedral carbonates such as calcite, it has perfect cleavages in three directions. Impure gray rhodochrosite is moderately abundant in rocks of the Cuyuna District, but the rose-red variety is scarce. Rose-colored rhodochrosite may be found in veins in the overburden in some Cuyuna Mines and in the dump at the Hopkins Mine at Crosby-Ironton.

## Miscellaneous Minerals and Rocks

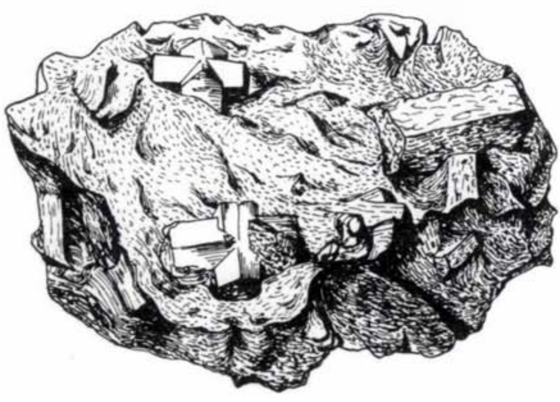
### Native Copper

Copper is the only metal found abundantly in the native state. It is a major ore in lavas of the Keweenawan Peninsula of Michigan. Rocks of similar age and type occur in Minnesota, and have been prospected for this mineral. Minor amounts of copper have been recovered from drill cores and mines in the vicinity of Pine City and in the Knife River area northeast of Duluth. Native copper is light-rose in color on a freshly-broken surfaces but changes quickly to copper-red and eventually to brown or even green when exposed to weathering. It is both ductile and malleable. It may be rarely found in the glacial drifts of the Cuyuna District, the upper St. Croix Valley, the Kettle River area, and southern Minnesota.

### Calcite

More than a hundred different crystal habits and varieties have been described for this mineral. Crystals are common, but rhombohedral cleavage fragments are observed most frequently (see page 6). Calcite may be colorless, white, blue, green or nearly any color of the spectrum. It has a white or slightly grayish streak and some is fluorescent. Clear cleavage fragments are doubly refracting. Calcite of optical quality has been obtained from a cavernous zone of basalt in Iceland, hence the common name Iceland Spar for optical grade material. Calcite is an abundant and widely distributed mineral in the earth's crust. It is the major constituent of limestone, marble, and chalk.

Calcite crystals are abundant as fillings in cracks within the basalts along the North Shore and in veinlets and vugs in the limestone beds of southeastern Minnesota. It can be distinguished from quartz by being softer, having a hardness of 3, and by effervescing with weak hydrochloric acid or even vinegar.



Staurolite Crystals

Staurolite

Staurolite, an iron silicate, is best known for the variety of twinned crystals formed in abundance in metamorphic rocks. Cruciform twins, including the *fairy cross*, and X-shaped twins are common. The name *staurolite* is derived from the Greek, *stauros* meaning cross and *lithos* meaning stone. The mineral is brown and has a gray streak. It is abundant below the power dam west of Royalton. At this locality cruciform twins are rare and commonly malformed, but they can be improved by lapidary work. Single crystals may be collected from either the schists at the base of the dam or from the river sands below. Additional outcrops of staurolite-bearing schists occur farther up the Mississippi River toward Little Falls.

## Pipestone

Catlinite or pipestone is the name given to the tough indurated clays interbedded in the Precambrian Sioux Quartzite,which crops out in both Rock and Pipestone counties. This mahogany-red material is the "*pipestone*" of the American Indian tribes. The catlinite bed at Pipestone is about 16 inches thick and is composed chiefly of soft hydrous layer silicates, including sericite mica. In places it is replaced by a yellowish mineral, pyrophyllite. Catlinite may be shaped easily with a knife blade when freshly quarried (see page 15 ).

## Garnet

Many people think of garnet as a deep-red gem material. Actually garnet ranges widely in color from nearly colorless through red, green, yellow, brown, and black, depending upon its chemical composition. Garnets are silicates of calcium, magnesium, iron, aluminum, manganese, and chromium. The dodecahedron (12-sided crystal) is the common crystal form of most garnets, and good crystals are abundant in many metamorphic rocks. However, crystals of a size adequate for lapidary work or ordinary displays are rare in Minnesota. Tiny crystals can be found in the schists near Royalton, Minnesota, in boulders in the glacial drift, and in outcrops of biotite gneiss along the Minnesota River Valley.

## Anorthosite

This coarse-grained rock is composed mainly of plagioclase feldspar. It forms many of the individual small peaks in Lake County and Carlton Peak in Cook County. Many outcrops occur along Highway 61 near Silver Bay. The color varies from nearly white through a pleasant translucent green to a bluish-black. Anorthosite is not gem material, but has been used for riprap for breakwalls. The Minnesota Mining and Manufacturing Co. initially was organized to develop the northeastern Minnesota deposits.

Marble

A classical material composed of the minerals calcite or dolomite, comes in a variety of colors. Marble is used for carvings and ornamental stone work not subject to extensive wear, and often is attractive when polished. In Minnesota, an impure marble is at the surface only in the area southeast of the village of Denham.

Granite

This coarsely crystalline igneous rock is composed dominantly of feldspar, quartz, and minor amounts of mica and/or hornblende. Many different color and textural varieties are known, but pink to red colors predominate in Minnesota. Many granite quarries are located in the St. Cloud region as well as in the upper Minnesota River Valley and near Lake Mille Lacs. Note the areas of igneous rocks on the Geologic Map on page 8 . Granite pebbles and boulders occur virtually everywhere in the glacial and stream deposits of the State. Granite is hard and durable, and will take the high polish as shown on many monument stones. Attractive book ends and paper weights can be made from the many varieties found even in a single gravel pit.

Algal Structures

Beds of red and white (and in places green) massive fossilized algal structures occur in the taconites of the Mesabi Range. The beds generally are composed of uniformly fine-grained gray chert containing red laminations of jasper. These laminations form gnarled patterns or whorls and upwardly convex arches (see page 20 ). Because of its siliceous nature, this rock is quite durable and takes a high polish. It represents some of the earliest evidence of life on the earth and formed some two billion years ago. Mines near Biwabik on the Mesabi Range contain exposures of good material, and many dumps contain large blocks.

## WHERE TO FROM HERE

As a beginner's interest in rocks and minerals develops, he seeks to broaden and deepen his knowledge and to communicate with others of similar interests. There are a number of ways to accomplish these objectives. Mineral study can progress by visiting the many museums exhibiting mineralogical and geological specimens. Good modern museum exhibits are designed to do more than merely publicly display fine specimens. The geological, chemical, and physical relationships among minerals and the rest of the natural world are presented in a manner best described as an educational exhibit. The Department of Geology and Geophysics at the University of Minnesota, Minneapolis campus, the Department of Geology at the University of Minnesota, Duluth, and other public and college museums have such displays.

The University of Minnesota through its General Extension Division offers both Evening and Correspondence courses in geology and mineralogy. On occasion public schools have offered adult education classes in gem cutting and jewelry work.

Comparing notes and sharing ideas and specimens with other collectors is facilitated by joining one of the rock and mineral clubs (see Appendix). There are several advantages to belonging to a club. Association with more advanced hobbyists offers a source of guidance in developing the hobby and learning the whereabouts of first-class collecting localities. Club programs are designed to improve the knowledge and skills of the club members, and club field trips provide possibilities to visit localities that are not open to individuals.

Many mineral and equipment dealers are sincerely anxious to assist the amateur. However, one should not always expect commercial collectors of choice specimens to disclose the location of sites that may have taken them years to discover.

Rock and mineral collecting all over the world is reported in many magazines and books, some of which are listed in the Appendix.

Additional information on the geology of Minnesota can be secured from books, reports and maps of the Minnesota Geological Survey, University of Minnesota, Minneapolis campus, and the United States Geological Survey, Washington, D. C.

## ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of Arthur Anderson, Joseph Heininger, and Raymond Lulling in the preparation of this booklet.

## APPENDIX

### Minnesota-Based Mineral Clubs

Alexandria Gem and Mineral Society
Contact: Mr. Floyd Bolen, 221 Lincoln Avenue East, Alexandria

Anoka County Gem and Mineral Club
Contact: Mr. Lawrence Martell, Route 4, Anoka

Austin Gem and Mineral Society
Contact: Lee J. Gregor, 1006 Sixth Avenue N. W., Austin

Bloomington Mineral Club
Contact: Mrs. Joanne Bullock, 1639 Maryland Avenue South, St. Louis Park

Central Minnesota Mineral Society
Contact: Mr. Bernard Traut, Route 2, St. Cloud

Geological Society of Minnesota
Contact: Mr. Charles Havill, 5450 Bryant Avenue North, Minneapolis

Itasca Rock and Mineral Club
Contact: B. N. Toven, Box 611, Hill City

Lake Superior Gem and Mineral Club
Contact: Mr. George Frazer, 4528 Pitt Street, Duluth

Little Crow Mineral and Lapidary Society
Contact: Mrs. Gladys Payne, R. F. D., Willmar

3M Prospectors Club
Contact: Mr. Carl Raddatz, 244 Butler Avenue East, St. Paul

Mesabi Rock and Mineral Club
Contact: Mr. Conrad Peterson, 2607 East Third Avenue, Hibbing

Minnesota Mineral Club
Contact: Mr. William de Neui, 6600 Cornelia Drive, Minneapolis

Minnetonka Mineral Club
Contact: Mr. John Kotula, Route 2, Box 233, Mound

Otter Tail Gem and Mineral Club
Contact: Mr. Merill Gregor, Pelican Rapids

Rochester Earth Science Society
Contact: Mrs. Mildred Woltman, 906 16th Street N. E., Rochester

## References for Rock and Mineral Collectors

### Journals

"Earth Science", Downers Grove, Illinois

"Gems and Minerals", Mentone, California

"Lapidary Journal", Box 2369, San Diego, California, 922112

"The Mineralogist", Portland, Oregon

"Rocks and Minerals", Box 29, Peekskill, New York

### Books

For independent study there are a large number of good books on minerals and collecting including:

Dake, H. C., F. L. Fleener and Ben Hur Wilson, 1938, Quartz Family Minerals: McGraw-Hill Book Co., New York.

Fenton, Carroll and Mildred, 1940, The Rock Book: Doubleday, Doran and Co., New York.

Pough, Frederick H., 1953, A Field Guide to Rocks and Minerals: Houghton Miflin Co., Boston.

Sinkankas, John, 1961, Gemstones and Minerals: Van Nostrand Co., Princeton, N. W.

Sinkankas, John, 1964, Mineralogy for Amateurs: Van Nostrand Co., Princeton, N. J.

Schwartz, G. M. and Thiel, G. A., 1963, Minnesota's Rocks and Waters: University of Minnesota Press, Minneapolis.

Vanasse, Theo. C., 1951, Lake Superior Agates: Spring Valley (Wisc.) Press.

# SAMPLE LABELS

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## *Educational Series* *

| | | | Price |
|---|---|---|---|
| ES-1 | 1965. | Guide to Fossil Collecting in Minnesota | $0.25 |
| ES-2 | 1966. | Guide to Mineral Collecting in Minnesota | 0.50 |
| ES-3 | 1966. | Geologic Sketch of the Tower-Soudan State Park | 0.50 |

*Order from Minnesota Geological Survey, 220 Pillsbury Hall, University of Minnesota, Minneapolis, Minnesota, 55455

Minnesota Geological Survey

UNIVERSITY OF MINNESOTA


*Educational Series - 2*