2ND EDITION

Lake Superior Rocks & Minerals

Field Guide

Dan R. Lynch & Bob Lynch

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Adventure Publications
Cambridge, Minnesota

Dedication

Dan dedicates this work to his wife, Julie, for her unending support for this and every other book he's written, and to his parents, Bob and Nancy, for all that they do for him. Also, thanks to Wes Lynch, Dan's brother, for his blunt and honest critique of the first edition, which bettered the way Dan has approached all the books he's written since.

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INTRODUCTION

Anyone who has spent time on Lake Superior knows that it is more than a mere lake. As the world's largest lake by surface area, Lake Superior is more akin to a sea, and the wave-battered rocks along its shores can attest to its incredible scale and power. But those rocks are much, much older than the mighty lake—most are a billion years old or more—and it is within them that many of the region's most famed collectibles formed. From agates to copper and silver, Lake Superior's rugged shores and rivers can yield once-in-a-lifetime specimens that would thrill anyone, and thanks to the glaciers of the past Ice Ages, such finds may be just sitting on the surface, waiting to be found. Lake Superior is a destination unlike any other, thanks to the region's dramatic geological history, its picturesque backdrop of soaring cliffs and wild waves, and the potential for stunning finds.

A NOTE ABOUT THE 2ND EDITION

This edition of *Lake Superior Rocks & Minerals* incorporates numerous changes and improvements over the 2008 original. The text is entirely rewritten and is complemented by hundreds of new photos that cover a wider range of rocks and minerals. We have also redefined the region covered by the book. This edition is more closely focused on Lake Superior's shores and omits mineral species that are only found further inland; in general, this book will be most relevant to areas within 10 to 20 miles of Lake Superior. Beyond that range, this book will still remain useful, but you may begin to encounter other rocks not covered here. This way, we can better discuss all the material you'll find walking the shores or rivers of Lake Superior itself. Like the first edition, this book covers Minnesota, Wisconsin, and Michigan, but it also now includes Lake Superior's shores in Ontario, Canada, making this the complete around-the-lake rock and mineral field guide. Lastly, we will not be covering Isle Royale or Michipicoten Island here because both islands are federally protected and all collecting is illegal; we encourage our readers to help preserve these remote and wild places by respecting these laws.

We welcome new readers to explore this amazing region with us, and we thank readers of the first edition for your continued support and hope to expand your knowledge with this new edition.

IMPORTANT TERMS AND DEFINITIONS

Geology and mineralogy are topics full of terms that may initially seem complicated but are important to your understanding of the sciences. So to make this book educational for novices yet still useful for experienced collectors, we have included some technical terms in the text but we "translate" them immediately after by providing a brief definition. In this way, amateurs can learn some of the more important terms relevant to the hobby in an easy, straightforward manner. Of course, all of the geology-related terms used here are defined in the glossary found at the back of this book as well. But for those entirely new to rock and mineral collecting, there are a few very important terms you should understand not only before you begin researching and collecting minerals, but even before you read this book.

Many people may begin hunting for rocks and minerals without knowing the difference between the two. A **mineral** is the crystallized (solidified) form of an inorganic chemical compound, or combination of elements. For example, silicon dioxide, a chemical compound consisting of the elements silicon and oxygen, crystallizes, or hardens, to form quartz, one of the most abundant minerals on Earth. In contrast, a **rock** is a mass of solid material containing a mixture of many different minerals. While pure minerals exhibit very definite and testable characteristics, such as a distinct repeating shape and hardness, rocks do not and can vary greatly because of the various minerals contained within them. This can often make identification of rocks more difficult for amateurs.

Many of the important terms critical to rock hounds apply only to minerals and their crystals. A **crystal** is a solid object with a distinct shape and repeating atomic structure created when a chemical compound solidifies. In other words, when different elements come together, they form a chemical compound which will take on a very particular shape when it hardens. For example, the mineral pyrite is iron sulfide, a chemical compound consisting of iron and sulfur, which **crystallizes**, or solidifies, into the shape of a cube. A "repeating atomic structure" means that when a crystal grows, it builds upon itself. If you compared two crystals of pyrite, one an inch long and the other a foot long, they would have the same identical cubic shape. In contrast, if a mineral is not found in a well-crystallized form but rather as a solid, rough chunk comprised of tiny mineral grains, it is said to be **massive**. If a mineral typically forms **massively**, it will frequently be found as irregular pieces or masses, rather than as well-formed crystals.

Cleavage is the property of some minerals to break in a particular way when carefully struck. As solid as minerals may seem, many have planes of weakness within them derived from a mineral's molecular structure. These points of weakness are called **cleavage planes** and it is along these planes that some minerals will **cleave**, or separate, when struck. For example, the mineral galena has cubic cleavage, and even the most irregular piece of galena will fragment into perfect cubes if carefully broken.

Cleavage is a different geological property than fracture. **Fracture** is the shape or texture of a random crack or break in a rock or mineral. One of the most prominent examples discussed in this book is **conchoidal fracture**, which is the trait of some minerals to develop semi-circular or smooth, curving cracks when struck or broken. Some minerals can have both distinct fracture and cleavage patterns.

Luster is the intensity with which a mineral reflects light. The luster of a mineral is described by comparing its reflectivity to that of a known material. A mineral with "glassy" luster (also called "vitreous" luster), for example, is similar to the "shininess" of glass. The distinction of a "dull" luster is reserved for the most poorly reflective minerals, while "adamantine" describes the most brilliant (though is typically reserved for diamond). Minerals with a "metallic" luster clearly resemble metal, which can be a very diagnostic trait. But determining a mineral's luster is a subjective experience, so not all observers will necessarily agree, especially when it comes to less obvious lusters, such as "waxy," "greasy," and "earthy."

When minerals form, they do so on or in rocks. Therefore, it is important to understand the distinction between the different types of rocks if you hope to successfully find a specific mineral. **Igneous** rocks form as a result of volcanic activity and originate from magma, lava, or volcanic ash. **Magma** is hot, molten rock buried deep within the earth, and it can take extremely long periods of time to cool and harden to form a rock. **Lava**, on the other hand, is molten rock that has reached the earth's surface where it cools and solidifies into rock very rapidly. **Sedimentary** rocks typically form at the bottoms of lakes and oceans when sediment compacts and solidifies into layered masses. This sediment can contain organic matter as well as weathered fragments or grains from broken-down igneous rocks, metamorphic rocks, or other sedimentary rocks. Finally, **metamorphic** rocks develop when igneous, sedimentary, or even other metamorphic rocks are subjected to heat and/or pressure within the earth and are changed in appearance, structure, and mineral composition.

A BRIEF OVERVIEW OF THE GEOLOGY OF LAKE SUPERIOR

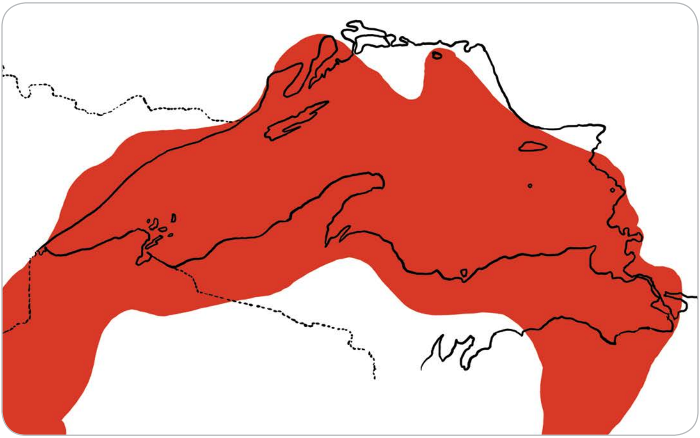
If you've visited any part of Lake Superior's rugged shores, you know that the region's amazing geology is on display everywhere you look; the lava cliffs of Minnesota's shores, Wisconsin's sandy Apostle Islands, Michigan's copper-rich Keweenaw Peninsula, and the incredibly old rocks of Ontario's expansive shoreline are just a mere sampling. Billions of years and numerous major geological events contributed to the region's unique beauty, but the Lake's very existence is owed to one event more than any other: the Midcontinent Rift.

The Midcontinent Rift

Around 1.1 billion years ago, all of Earth's continents were arranged together in one giant landmass we call Rodinia, and the region that would later become North America was then situated over the equator. As the tectonic plates—the massive sheets of rock that make up the earth's crust—beneath Rodinia began to move and separate, the continent started to split apart and a massive tear, called a rift, slowly opened across the landscape. The rock weakened, allowing volcanic activity to spring up along the length of the rift, and molten rock from deep within the earth rose to fill the void as it widened, cooling to form volcanic rock as it reached the surface. But ultimately, the rift failed. It's uncertain exactly why the spreading ceased, but a leading theory is that the Midcontinent Rift was unable to spread further apart due to stronger tectonic movements occurring farther to the east. The opposing movement pushed against the Midcontinent Rift and effectively "pinched" it, stopping it from spreading further. If the Midcontinent Rift had continued, the continent would have split into two parts separated by a sea, as is happening today with the Red Sea, which lies in an active rift system separating Saudi Arabia from Egypt.

As the volcanic rocks that were formed during the rifting event began to cool and the volcanic activity beneath them subsided, the rocks contracted and collapsed, slumping downward and creating a wide trough along the rift's length. This sunken body of rock then collected water, and with water comes sediment—the granular fragments of worn-down rocks and minerals. Over the next billion years, the sediments collecting in the basin hardened to form sedimentary rocks that continued to build up, burying all evidence of the Midcontinent Rift for eons.

The Midcontinent Rift (red) across the region today



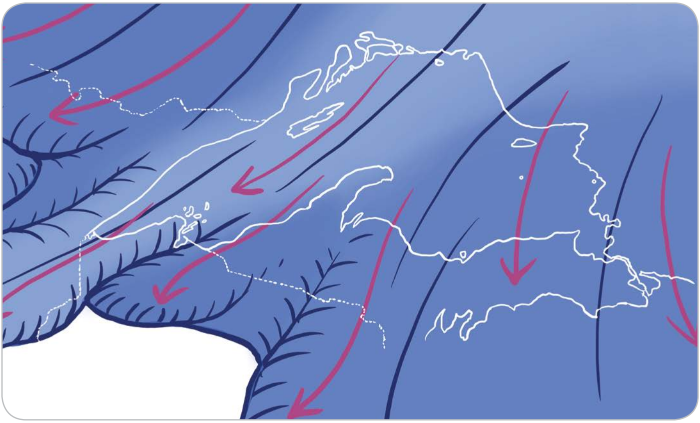
Hydrothermal Activity and Collectible Minerals

In most volcanically active regions, groundwater is heated and enriched with dissolved minerals and can then rise through the overlying rock as steam. This is called hydrothermal activity, and as the water percolates through existing rocks it can collect in cavities and cracks. As the water accumulates, the minerals within it can also accumulate and then crystallize. This process occurred during the Midcontinent Rift, and this is particularly relevant to collectors because many of Lake Superior's most desirable minerals formed this way, including agates, copper, and copper ores (ores are minerals that can be mined and processed to free the valuable metals they contain). Most of the time, the rock that hosts these collectible minerals is the same igneous rock produced in the volcanic event, but not always; in Michigan, copper is famously found deposited in older sedimentary rocks. And the heat and steam from hydrothermal activity not only deposits new minerals in rock cavities, but it can also begin to alter and change the rocks themselves.

The Ice Ages and the Glaciers

Over a billion years have passed since the Midcontinent Rift. In that time, the continents changed shape and shifted positions on the planet, life appeared on dry land, and later, the dinosaurs appeared and disappeared. Eventually, around 200,000 years ago, early humans began their great migration from Africa to all corners of the earth. All the while, the planet's climate was in constant flux. Much of this had to do with changes in the composition of Earth's atmosphere, causing both warm, wet periods as well as cold, icy ones. Periods of lower global temperatures are often called Ice Ages, and are characterized by glaciation, or the presence of glaciers.

Glaciers are enormous, thick sheets of ice that form when snow compacts, often near the poles or at high elevations, and then slowly grow in size. Every continent has seen glaciation, especially during the last Ice Age, and North America's ice sheets achieved incredible size. Their continued growth in the cold, northern reaches of Canada



General path of glacial movement during the last Ice Age

caused them to "flow" slowly southward; as the climate warmed, they began to melt and retreat northward. There have been numerous Ice Ages on Earth, but we have the most evidence of the last one, which began around 110,000 years ago and lasted until just 10,000 years ago. The glaciers produced during this most recent Ice Age were up to a mile thick, and their immense weight crushed and pulverized the rock below them. As the crushed rock was incorporated into the ice, its abrasiveness increased, and over 100,000 years the repeated advance and retreat of the glaciers scoured away most of the soft sedimentary rocks that once filled the Midcontinent Rift basin. Then, as the Ice Age waned and global temperatures rose, the glaciers began to melt and retreat for the last time, leaving billions of gallons of water behind, which both formed the region's countless small lakes and filled the great basin we know today as Lake Superior.

The glaciers are responsible for exposing many of the surface rocks in the region and, in turn, for making many of the Lake's most collectible minerals accessible. As they scoured their way across the landscape, the glaciers removed all plant life and soft overlying rocks, revealing the hard, volcanic Midcontinent Rift rocks below. This is important to collectors because the Rift's rocks are the geological home to valuable collectibles like agates and copper. Without the excavation work done by the glaciers, these beloved collectibles would still be out of reach.

As the glaciers crushed underlying rocks, rock fragments were incorporated into the ice, causing the glaciers to spread rocks far and wide. This is why we find many Lake Superior rocks and minerals—especially agates—far from their original source; they were deposited when the glaciers melted. For example, many of the speckled cobbles you'll find all along Lake Superior's southern shores originated much farther north, in a massive rock formation known as the Canadian Shield.

The Canadian Shield

The Canadian Shield is an enormous area of exposed rock connecting the Great Lakes region to the Arctic Ocean. Representing the ancient core of North America and once the deeply buried "roots"

Canadian Shield (red)

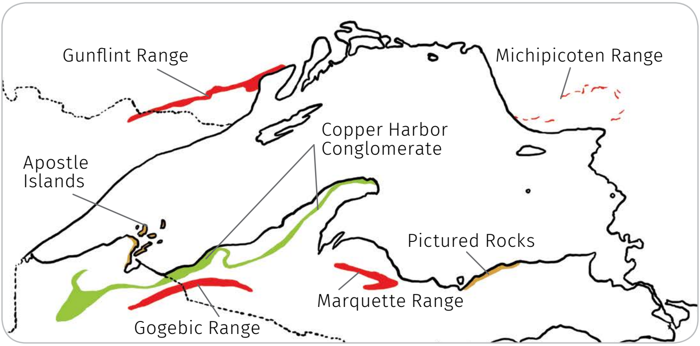
of a long-gone mountain range, the nearly 5-million-square-mile expanse of rock was pushed up to the surface, and then deeply weathered and smoothed by glaciers. The rocks of the Canadian Shield are largely coarse-grained igneous rocks, such as granite, and metamorphic rocks derived from them. As a whole, the Shield is nearly 4 billion years old. It is through these ancient rocks that the Midcontinent Rift tried to separate, and much of the northern shores of Lake Superior are comprised of exposed Shield rocks today. Fragments of Canadian Shield rocks were also scattered far to the south by the glaciers.

Iron Ranges and Sedimentary Rocks

Long before the Midcontinent Rift occurred, an ancient sea covered what is now the Lake Superior region. Beginning around 2.5 billion years ago, sediments from Earth's barren, lifeless land readily washed into this sea and collected near its shores. Over time, the sediments—which were rich with iron—compressed and hardened, forming a hard, tightly layered sedimentary rock known as Banded Iron Formation (read more on page 93). These ancient, iron-rich shorelines are still present in the Lake Superior region today as Iron Ranges, most of which have seen some amount of mining activity in recent decades.

There are several Iron Ranges in the wider Lake Superior region, but only a few are close enough to the Lake to be relevant to area rock hounds: the Gunflint Range in northern Minnesota and southern Ontario, the Gogebic Range in Wisconsin and Michigan, the Marquette Range in Michigan, and the Michipicoten Range in Ontario (though the Michipicoten Range did not form the same way as the other ranges mentioned here, it still produces similar rocks and minerals). These areas are geologically important, both scientifically and economically, and will receive much attention in any book about Lake Superior's rocks.

There are some other important Lake Superior sedimentary rock formations worthy of note. The Copper Harbor Conglomerate, found



along the northwestern shores of the Keweenaw Peninsula in Michigan and extending into Wisconsin, formed from the rivers that once emptied into the basin formed by the Midcontinent Rift rocks. This rock formation consists of round cobbles and pebbles locked together by finer-grained sediments (a rock called conglomerate, see page 119 for more), and is important not only because of its size and prominence in Michigan, but also because later hydrothermal activity injected copper and other minerals into the rock. Similarly, further east in Michigan and Wisconsin, a younger body of sedimentary rock, known as the Nonesuch Shale, also saw the introduction of copper, which was deposited as broad, flat sheets between the layers in the rock.

Finally, while the glaciers scoured, crushed, and swept away untold amounts of soft sedimentary rocks, many were able to survive the Ice Ages. Two prominent examples are the Apostle Islands of Wisconsin and the Pictured Rocks National Lakeshore of Michigan. While both areas are nationally protected lakeshores where collecting is prohibited (with the exception of Madeline Island), they consist of incredible sandstone formations that were worn and sculpted by the glaciers and by Lake Superior itself, but they still survive to this day. These rock formations, which originated on ancient seafloors, are a stark contrast to the volcanically formed cliffs and ledgerock so common around Lake Superior.

While the geological processes and rock formations mentioned here are just a sampling of the incredible history of the region, they are all part of what makes Lake Superior a rock hound's destination. And thanks to the glaciers, much of the region's most desirable rocks and minerals are just lying on the surface, waiting to be found on your next walk along the water's edge.

PRECAUTIONS AND PREPARATIONS

It should come as no surprise that rock and mineral collecting can bring with it some dangers and legal concerns. It is always your responsibility to know where you can legally collect, which minerals may be hazardous to your health, and what to bring with you to ensure your safety. Here we will detail some of these issues.

Protected and Private Land

The Lake Superior region has several nationally protected parks and monuments as well as Native American reservations, and it is illegal to collect anything on those sites. For example, Isle Royale is a National Park, and Michipicoten Island is a Provincial Park, and both are federally protected, making collecting there illegal in all cases. Some state parks may allow collecting but only if you have obtained proper permits—others forbid collecting entirely. It is up to you to do the research before you go out hunting. We encourage collectors to obey the law and leave designated natural spaces wild and untouched for generations to come. It is always your responsibility to know whether or not the area in which you are collecting is protected.

As in any state, many places around Lake Superior are privately owned, including areas of wilderness that may not have obvious signage. Needless to say, you are trespassing if you collect on private property and the penalty may be worse than just a fine. In addition, property lines and owners change frequently, so just because a landowner gave you permission to collect on their property last year doesn't mean the new owner will like you on their property this year. Always be aware of where you are.

Dangers of Rivers, Rock Piles, and the Mighty Lake

When in the field, vigilance and caution are key to remaining safe. Many gravel pits and mine dumps present amazing collecting opportunities if you're granted permission to collect there, but may have large rock piles or pit walls that are unstable and prone to collapse. Never go beneath overhanging rock, and keep clear of unstable rock walls. Rivers also present their own dangers, and even though the water's surface may look calm, strong currents may be present. It doesn't take very much moving water to make you lose your footing completely. The same goes for Lake Superior itself; sudden rip-currents can sweep you off your feet and carry you hundreds of feet out into the lake. If you're wading in the lake, never go out to where the water is past your knees, and always step slowly and carefully as sudden deep spots are very common. Lastly, remember that Lake Superior is no mere pond; it is famously temperamental, and sudden wind, waves, and storms can arise seemingly out of nowhere. Do not under any circumstances canoe or kayak out into the lake if you do not have sufficient life-saving experience, especially sea-kayak experience. Every year, inexperienced tourists need to be rescued from sudden extreme weather or exposure to Lake Superior's frigid water.

Equipment and Supplies

When you set out to collect rocks and minerals, there are a few items you don't want to forget. No matter where you are collecting, leather gloves are a good idea, as are knee pads if you plan to spend a lot of time on the ground. If you think you'll be breaking rock, bring your rock hammer (not a nail hammer) and eye protection. If the weather is hot and sunny, take the proper precautions and use sunblock,

and bring sunglasses, a hat, as well as ample drinking water. Lastly, bringing a global positioning system (GPS) device or smartphone is a great way to prevent getting lost, but remember that more remote areas around the lake may have little to no cellular signal. And if you plan to be near or in water, be sure to put your electronics in a sealed plastic bag, just in case.

Collecting Etiquette

Too often, popular collecting sites are closed by landowners or local governments due to litter, trespassing, and vandalism. In many of these cases, the landowners may have been kind enough to allow collectors onto their land, but when people would rather trespass than to simply ask for permission, then we all lose. When collecting, never go onto private property unless you've obtained prior permission, and be courteous; don't dig indiscriminately and don't take more than you need. And by sharing specimens, information, and your enthusiasm, you're likely to be invited back. To ensure great collecting sites for future rock hounds, dig carefully and leave the location cleaner than you found it.

DANGEROUS MINERALS AND PROTECTED ARTIFACTS OF LAKE SUPERIOR

Potentially Hazardous Minerals

The vast majority of minerals in the Lake Superior region are very safe to handle and collect. But a handful pose a health risk under certain conditions. Potentially hazardous minerals included in this book are identified with the symbol shown above, of which there are only a few examples:

- Amphibole group (page 89)—a few varieties are asbestos; asbestiform minerals form as delicate, flexible fiber-like crystals that can become airborne and inhaled, posing a cancer risk; these varieties are rare in this region

- Algodonite and Domeykite (page 87)—contain arsenic; wash your hands after handling

With the above minerals, the primary threat to your health comes with cutting and polishing them, or any other activity that creates dust. Inhaling dust produced by these and any other minerals can be very detrimental to your lungs and respiratory health, potentially introducing toxic particles into your body and can eventually cause cancer. Thankfully, dust inhalation is easily avoided by wearing the proper mask and eye protection.

Artifacts

The Lake Superior region had been occupied by indigenous peoples for thousands of years before settlers arrived. As a result, countless artifacts such as arrowheads and grinding stones have been found throughout the area. But it is important to remember that it is illegal in all cases to disturb or collect these artifacts. They may hold considerable scientific and cultural value, and all finds should be left in place, photographed/recorded and reported to the Bureau of Land Management. Any collecting or tampering with artifacts may incur fines or other penalties.

For more information, contact the Bureau of Land Management's Northeastern States Field Office, which has jurisdiction over Minnesota, Wisconsin, and Michigan, by calling 414-297-4400, or by visiting www.blm.gov.

In Ontario, to report artifacts or other significant discoveries, contact the Ontario Ministry of Heritage by calling 1-888-997-9015, or by visiting www.mtc.gov.on.ca. The Ontario Archaeological Society is another option: www.ontarioarchaeology.org

HARDNESS AND STREAK

There are two important techniques everyone wishing to identify minerals should know: hardness and streak tests. All minerals will yield results in both tests, which makes these tests indispensable to collectors.

The measure of how resistant a mineral is to abrasion is called hardness. The most common hardness scale, called the Mohs Hardness Scale, ranges from 1 to 10, with 10 being the hardest. An example of a mineral with a hardness of 1 is talc; it is a chalky mineral that can easily be scratched by your fingernail. An example of a mineral with a hardness of 10 is diamond, which is the hardest naturally occurring substance on Earth and will scratch every other mineral. Most minerals fall somewhere in the range of 2 to 7 on the Mohs Hardness Scale, so learning how to perform a hardness test (also known as a scratch test) is critical. Common tools used in a hardness test include your fingernail, a U.S. nickel (coin), a piece of glass and a steel pocket knife. There are also hardness kits you can purchase that have a tool of each hardness.

To perform a scratch test, you simply scratch a mineral with a tool of a known hardness—for example, we know a typical steel knife has a hardness of about 5.5. If the mineral is not scratched, you will then move to a tool of greater hardness until the mineral is scratched. If a tool that is 6.5 in hardness scratches your specimen, but a 5.5 did not, you can conclude that your mineral is a 6 in hardness. Two tips to consider: As you will be putting a scratch on the specimen, perform the test on the backside of the piece (or, better yet, on a lower-quality specimen of the same mineral), and start with tools softer in hardness and work your way up. On page 22, you'll find a chart that shows which tools will scratch a mineral of a particular hardness.

The second test every amateur geologist and rock collector should know is streak. When a mineral is crushed or powdered, it will have a distinct color—this color is the same as the streak color. When a mineral is rubbed along a streak plate, it will leave behind a powdery stripe of color, called the streak. This is an important test to perform because sometimes the streak color will differ greatly from the mineral itself. Hematite, for example, is a dark, metallic and gray mineral, yet its streak is a rusty red color. Streak plates are sold in some rock and mineral shops, but if you cannot find one, a simple unglazed piece of porcelain from a hardware store will work. But there are two things to remember about streak tests: If the mineral is harder than the streak plate, it will not produce a streak and will instead scratch the plate itself. Secondly, don't bother testing rocks for streak; they are made up of many different minerals and won't produce a consistent color.

Tools from a hardness test kit

THE MOHS HARDNESS SCALE

The Mohs Hardness Scale is the most common measure of mineral hardness. This scale ranges from 1 to 10, from softest to hardest. Ten minerals commonly associated with the scale are listed here, as well as some common tools used to determine a mineral's hardness. If a mineral is scratched by a tool of a known hardness, then you know it is softer than that tool.

Hardness	Example Mineral	Tool
1	Talc	
2	Gypsum	
2.5		Fingernail
3	Calcite	
3.5		U.S. nickel, brass
4	Fluorite	
5	Apatite	
5.5		Glass, steel knife
6	Orthoclase feldspar	
6.5		Streak plate
7	Quartz	
7.5		Hardened steel file
8	Topaz	
9	Corundum	
9.5		Silicon carbide
10	Diamond	

For example, if a mineral is scratched by a U.S. nickel (coin) but not by your fingernail, you can conclude that its hardness is 3, equal to that of calcite. If a mineral is harder than 6.5, or the hardness of a streak plate, it will instead scratch the streak plate itself (unless impure or weathered to a softer state).

QUICK IDENTIFICATION GUIDE

Use this quick identification guide to help you determine which rock or mineral you may have found. Listed here are the primary color groups followed by some basic characteristics of the rocks and minerals of Lake Superior, as well as the page number where you can read more. While the most common traits for each rock or mineral are listed here, be aware that your specimen may differ greatly.

WHITE OR COLORLESS

	If white or colorless and...	then try...
	Abundant, soft veins or masses in rocks, often in blocky shapes or steeply pointed six-sided crystals	calcite, page 99
	Chalky, soft nodules with a spiderweb- or cauliflower-like exterior texture	datolite, page 133
	Small, hard, brittle translucent fragments with a "frosted" appearance and even, uniform thickness	junk (glass), page 167
	Abundant, very hard, translucent six-sided crystals or masses within cavities or as rounded pebbles	quartz, page 197
	Very hard rock that resembles quartz but has a grainy texture when broken	quartzite, page 203
	Small, soft, translucent crystals shaped like faceted balls, grown clustered together	zeolite group (analcime), page 227

Quick Identification Guide (continued)

	If gray or black and...	then try...
	Hard grains or rectangular masses, often with a lustrous silky sheen, found embedded in coarse-grained rocks	amphibole group, page 89
	Glassy, coarse-grained, greenish gray, light-colored rock found rarely on Minnesota's shores	anorthosite, page 91
	Very abundant, dark, fine-grained rock often containing gas bubbles lined with minerals	basalt, page 97
	Very hard, common, opaque masses with waxy surfaces and very sharp edges when broken	chert, page 109
	Dark gray, dense rock containing fine to medium grains, often with light-colored flecks or spots	diabase, page 135
	Dark, greenish black, coarse-grained rock found primarily on Minnesota's shores	gabbro, page 149
	Fairly soft, dense, medium-gray rock composed of tightly packed tiny grains of varying size	graywacke, page 159
	Heavy, glassy, very dark, opaque material with countless round bubbles, often with rusty surfaces	junk, page 167
	Small, brightly lustrous, flaky crystals, usually embedded in coarse-grained rocks like granite	mica, page 179

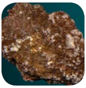
GRAY OR BLACK

(continued)	**If gray or black and…**	**then try…**
	Fairly soft, dense, medium-gray rocks containing perfectly round holes or pockets that seem “out of place”	omarolluks, page 159
	Fairly hard, glassy, elongated masses or blocky crystals embedded in dark rocks, especially gabbro	pyroxene group, page 195
	Dull, dark gray veins or masses within quartz or rock that are malleable and reveal silvery metal when scratched	silver, page 213
	Dense, heavy, dark gray, sometimes layered rock that is very hard and sticks to a magnet	taconite, page 217
	Opaque dark brownish-black masses or crusts found on or near copper	tenorite, page 219

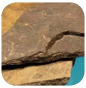
TAN OR BROWN

	If tan or brown and…	**then try…**
	Flat, thin, plate-like crystals that are very brittle and heavy for their size, usually opaque but may be translucent	baryte, page 95
	Very hard, translucent, waxy masses, often in ball-like shapes; forms very sharp edges when broken	chalcedony, page 103

Quick Identification Guide *(continued)*

(continued)	**If tan or brown and...**	**then try...**
	Soft, gritty, crumbly material that becomes sticky when wet; may form odd, globular masses	clay, page 115
	Hard, uniquely round or blob-like masses, usually found in or near sedimentary rocks along rivers	concretions, page 117
	Soft nodules with a rough or cauliflower-like exterior, usually with a chalky, lighter colored interior	datolite, page 133
	Very common, hard, dull to glassy blocks or masses found primarily within coarse-grained rocks	feldspar, page 139
	Soft, light-colored rocks containing odd patterns resembling gauze, seashells, or snail shells	fossils, page 145
	Soft, chalky rock that can be easily scratched with a pocket knife and fizzes in vinegar	limestone, page 171
	Hard, often layered rocks exhibiting traits typical of sedimentary rocks but of higher hardness or density	metasedimentary rocks, page 177
	Extremely fine-grained rocks that are dense, gritty, and generally soft; may exhibit some layering	mudstone or siltstone, page 181
	Very hard rock that resembles quartz but has a grainy texture when broken	quartzite, page 203

TAN OR BROWN

(continued)	**If tan or brown and...**	**then try...**
	Light brown to reddish brown, hard, fine-grained rock; may contain colored bands or hollow gas bubbles	rhyolite, page 205
	Rough, gritty, sometimes crumbly rock composed of tiny sand grains cemented together	sandstone, page 207
	Soft, fine-grained rock consisting of flat, parallel layers that can be separated with a knife	shale, page 211

GREEN OR BLUE

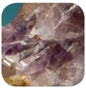
	If green or blue and...	**then try...**
	Very soft, dark-green masses, usually as crusts or linings within cavities in dark rocks	chlorite group, page 111
	Soft, often chalky, light blue masses or crusts alongside copper and/or green malachite	chrysocolla, page 113
	Hard, yellow-green, pistachio-colored masses or crusts; less commonly as elongated, grooved crystals	epidote, page 137
	Soft, glassy, translucent crystals or veins that break in angular shapes	fluorite, page 143
	Tiny, very rare, elongated, vivid blue crystals, usually embedded within calcite	kinoite, page 169

Quick Identification Guide (continued)

GREEN OR BLUE

(continued)	**If green or blue and...**	**then try...**
	Soft, vivid green, chalky crusts or fibrous masses grown on or with copper or chalcopyrite	malachite, page 175
	Very soft, blue-green, dull masses or linings within cavities in rock	mica group, page 179
	Hard, glassy, pale green masses or rounded clusters of short bladed crystals, often with calcite	prehnite, page 187
	Fairly soft, opaque green nodules, usually in basalt, with a fibrous or spiderweb pattern; in Michigan	pumpellyite (greenstone), page 191
	Soft, translucent, bluish green waxy or glassy masses, most often found in Minnesota	zeolite group (lintonite), page 231

PURPLE OR PINK

	If purple or pink and...	**then try...**
	Very hard, glassy, translucent purple masses or crystals	amethyst, page 201
	Soft, glassy, translucent crystals, crusts or veins that break in angular shapes	fluorite, page 143
	Very soft, crumbly and splintery pink or salmon-colored crystals with an elongated shape, often with calcite	zeolite group, page 223

RED OR ORANGE

	If red or orange and...	then try...
	Very hard, translucent, waxy masses, often with mottled coloration; forms very sharp edges when broken	chalcedony, page 103
	Fairly soft, dull to glassy or nearly metallic red to orange-red crusts or masses on or with copper	cuprite, page 131
	Hard, typically opaque, angular crystals or linings inside cavities within rocks, especially basalt	feldspar group, page 139
	Very hard, rounded, ball-like crystals embedded in rocks like granite, gneiss, or schist	garnet group, page 151
	Soft, dusty, rusty red coatings or masses that may reveal a metallic black color when scratched or broken	hematite, page 161
	Very hard, dense, opaque, colorful masses with rough texture and sharp edges when broken, but smooth and waxy when weathered	jasper, page 165
	Light reddish brown, hard, fine-grained rock; may contain colored bands or hollow gas bubbles	rhyolite, page 205
	Soft, very small, delicate plate-like crystals clustered together in cavities; sometimes has a wheat-sheaf shape	zeolite group (stilbite), page 233

Quick Identification Guide (continued)

YELLOW

	If yellow and...	then try...
	Very hard, rounded, ball-like crystals in cavities within dark rocks, often alongside epidote	garnet group, page 151
	Opaque, chalky, rust-colored coatings or crusts atop other minerals, especially metallic minerals	limonite, page 155
	Hard, glassy, greenish yellow, translucent grains or masses within dark rocks like gabbro	olivine group, page 183

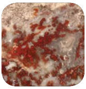
METALLIC

	If metallic and...	then try...
	Rare, brittle veins, often in quartz, usually silvery to brassy in color and may have an iridescent surface	algodonite or domeykite, page 87
	Soft, brittle, dark colored veins or masses; scarce and only found in copper-rich regions	chalcocite, page 105
	Fairly soft, brightly lustrous, brassy masses or veins embedded in rock, sometimes with green malachite	chalcopyrite, page 107
	Soft, malleable reddish orange metal; usually coated in green, blue, red, or black mineral crusts	copper, page 121
	Dark brown, rusty crusts or masses, sometimes with a fibrous cross-section; often coated in limonite	goethite, page 155

METALLIC

	(continued) **If metallic and...**	**then try...**
	Soft, malleable masses consisting of both copper and silver	copper-silver combination, page 129
	Abundant, fairly hard mineral that is dark gray when fresh, but usually has a rusty red coating when weathered	hematite, page 161
	Tiny, black, highly lustrous and slightly magnetic grains in dark rocks, especially gabbro	ilmenite, page 163
	Very soft, lightweight globular masses found on shores	junk (aluminum), page 167
	Black, fairly hard masses or grains that bond strongly with a magnet; most often found in dark rocks	magnetite, page 173
	Hard, brassy yellow to brownish cube-shaped crystals, masses, or veins; often found in sedimentary rocks	pyrite, page 193
	Soft, malleable silvery veins or masses within rock or quartz, usually coated in a dull gray surface material	silver, page 213

Quick Identification Guide (continued)

	If multicolored or banded and...	then try...
	Very hard, waxy, ball-like masses containing ring-like banding within	agates, page 39
	Very hard, rounded masses containing parallel layering (often below some ring-like banding) within	gravitationally banded agate, page 57
	Very hard, dense, opaque masses that have a similar appearance to both agates and jasper	jasp-agate, page 61
	Very hard masses containing ring-like agate banding as well as ample mineral growths that resemble moss	moss agate, page 65
	Very hard masses containing ring-like agate banding as well as circular, radiating structures	sagenitic agate, page 71
	Very hard masses containing some tan or gray agate banding and lots of opaque, white, “crackled” quartz	skip-an-atom agate, page 73
	Very hard veins of lace-like banded structures, often with lots of calcite, found near Thunder Bay, Ontario	Thunder Bay agate, page 75
	Round, dense rocks containing pockets of very hard, reddish agate banding within; found in Minnesota	thunder egg, page 77
	Very hard, waxy, rounded masses containing agate banding and tube-like structures throughout	tube or stalk agate, page 79

(continued)	If multicolored and banded and...	then try...
	Very hard, dense rock consisting of parallel layers of red jasper and metallic hematite or magnetite	banded iron formation, page 93
	Rock that appears to consist of smaller rounded or angular rock fragments cemented together	conglomerate or breccia, page 119
	Quite hard, dense rocks containing somewhat coarse mineral grains that run in a generally parallel direction	gneiss, page 153
	Abundant coarse-grained rocks with mottled coloration, generally with light and dark colored spots	granite and granitoids, page 157
	Very hard, opaque masses with sharp edges when broken, but smooth and waxy when weathered	jasper, page 165
	Material that consists of tightly packed rock fragments locked together by a very hard, fine-grained cement	junk (concrete), page 167
	Tightly layered, tough rocks that appear similar to sedimentary rocks but are harder	metasedimentary rocks, page 177
	Extremely fine-grained rocks that are dense, gritty, and generally soft with near-parallel layering	mudstone or siltstone, page 181

Quick Identification Guide *(continued)*

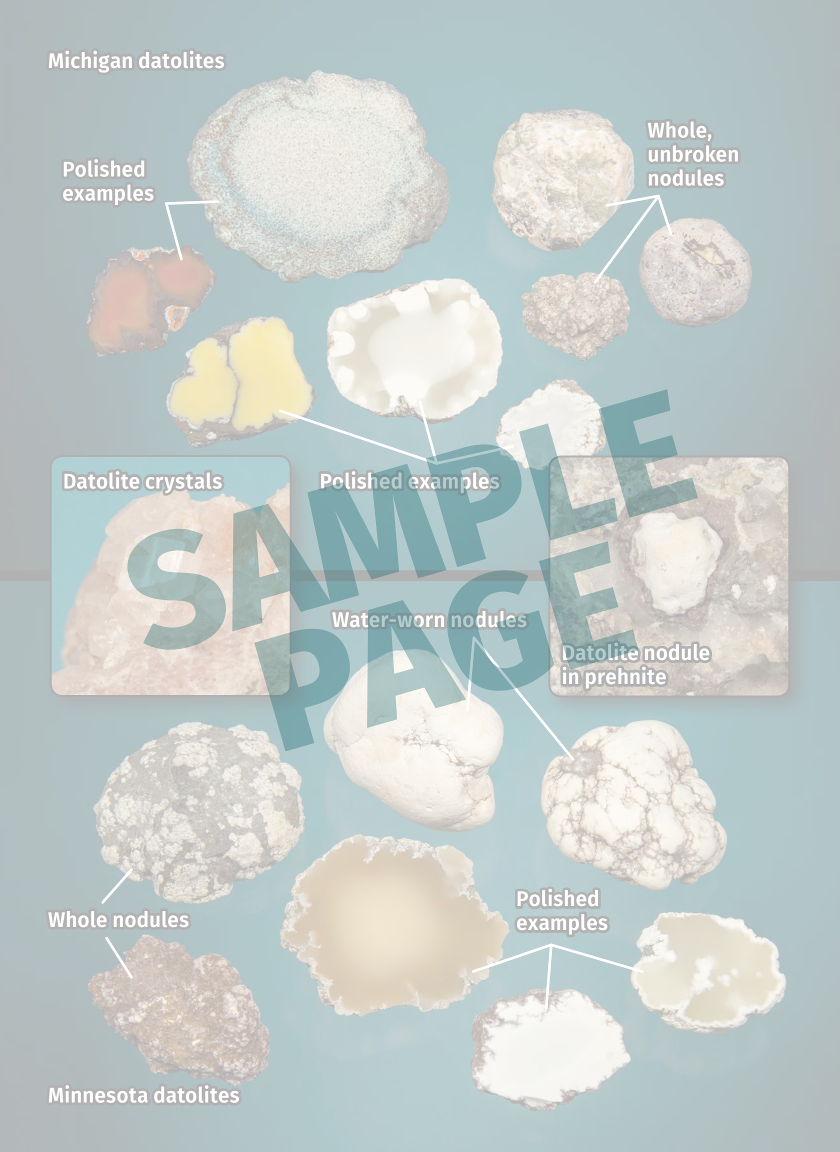
MULTICOLORED OR BANDED

(continued)	**If multicolored and banded and...**	**then try...**
	Rocks containing large, well-formed blocky crystals suspended in an otherwise finer grained mass	porphyry, page 185
	Coarse, very hard rock that is predominantly white but contains angular red and brown fragments	puddingstone, page 189
	Rough, gritty, sometimes crumbly rock composed of tiny sand grains cemented together	sandstone, page 207
	Dense rock with tight layers of distinct minerals, often with lustrous, "glittery" mica flakes and pyrite	schist, page 209
	Jasper or chert containing layers arranged in wavy or rounded, arching shapes	stromatolites, page 147
	Gray speckled coarse-grained rock, often with orange feldspars; some grains glow under UV light	syenite, page 215
	Green and orange or pink coarse-grained rock resembling granite	unakite, page 221
	Fairly soft radial arrangements of needle-like crystals, often with circular bands, within vesicles	zeolite group (thomsonite), page 235

A Final Note About Rock and Mineral Identification

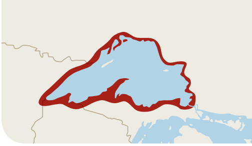
When using this book to identify your rock and mineral discoveries, always remember that your specimens can (and likely will) differ greatly than those pictured. Rock and mineral identification isn't always easy, and when a specimen is weathered or altered by external forces, it can appear completely different than it "should." The photos in this book are meant as a general guide; learning the key characteristics of each rock or mineral and which traits are constant, such as hardness and crystal shape, will bring you the most success. With a basic understanding of quartz, for example, you'll be able to identify even the most poorly formed specimens.

Many of the Lake Superior region's rocks are also incredibly ancient. Eons of erosion from wind, waves, ice, and chemicals have dramatically changed the appearance of many rocks, which can make identification difficult. Take this specimen of a rock called gabbro, for example. Externally, it appears somewhat light-colored with what look like dots of rust all over it. But upon breaking it in half, you can see that the unweathered interior is darker and more crystalline in appearance. The interior reveals how typical gabbro should look, but if all you had to go by was the exterior, you'd likely have trouble identifying this common rock.


Michigan datolites
Polished examples
Whole, unbroken nodules
Datolite crystals
Polished examples
Water-worn nodules
Datolite nodule in prehnite
Whole nodules
Polished examples
Minnesota datolites

Sample page

Hardness: From 1 to 10 **Streak:** Color



Primary Occurrence

Environment: A generalized indication of the types of places where this rock or mineral can commonly be found. For the purposes of this book, the primary environments listed are **shores** (both of Lake Superior and nearby inland lakes), **rivers** (encompassing riverbeds and riverbanks), **pits** (gravel pits, quarries, or other dig sites where earth has been removed), **outcrops** (any exposed bodies of rock both natural and manmade, such as where road construction has cut through a rock formation), and **mines** (primarily dumps, or waste-rock piles left over at mine sites).

What to Look for: Common and characteristic identifying traits of the rock or mineral.

Size: The general size range of the rock or mineral. The listed sizes apply more to minerals and their crystals than to rocks, which typically form as enormous masses.

Color: The colors the rock or mineral commonly exhibits.

Occurrence: The relative difficulty of finding this rock or mineral. "**Very common**" means the material is abundant and takes no effort to find if you're in the right environment. "**Common**" means the material can be found with little effort. "**Uncommon**" means the material may take a good deal of hunting to find; most minerals fall in this category. "**Rare**" means the material will take great lengths of research, time, and energy to find, and "**very rare**" means the material is so scarce that you may likely never find it.

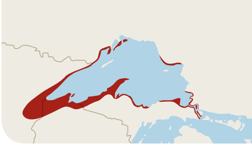
Notes: These are additional notes about the rock or mineral, including how it forms, how to identify it, how to distinguish it from similar minerals, and interesting facts about it.

Where to Look: Here you'll find specific regions or towns where you should begin your search for the rock or mineral.


Polished agate
Quartz-filled center
Agate in basalt
Waxy luster
Limonite surface coating (yellow-brown)
Typical small agate "chips" weathered from larger agates
Common beach-worn agates

Agates, general

Hardness: 6.5–7 **Streak:** White



Primary Occurrence

Environment: All environments

What to Look for: Very hard, translucent, red or brown rounded masses of waxy material containing ring-like bands within

Size: Agates range from tiny fragments to finds rarely larger than a fist

Color: Multicolored; varies greatly, but banding is primarily red, brown, yellow, white to gray, often with colorless layers

Occurrence: Uncommon

Notes: Without question, Lake Superior's most famed and popular collectibles are agates. These gemstones consist primarily of chalcedony (page 103), which is a microcrystalline variety of quartz (page 197), and they grew within cavities in rocks, most often within the vesicles (gas bubbles) in volcanic rocks. This makes them generally more-or-less ball-shaped (such formations are called nodules). Their primary defining feature is, of course, their concentric banding, but like the layers of an onion, the bands aren't revealed until weathering (usually the glaciers) has broken open the nodules. Jasper (page 165), chert (page 109), chalcedony and agates—all of which consist of microcrystalline quartz—all exhibit conchoidal fracturing (when struck, circular cracks appear), extreme hardness, and a waxy luster when found as weathered pebbles, but jasper and chert are not translucent like chalcedony and agates, and common chalcedony lacks agates' bulls-eye banding. While jasper and chert can show layering as well, their layers are usually thick, flat, parallel, and very opaque. Whole agate nodules are scarce but usually show a waxy, pockmarked surface; far more common are small, glossy, carnelian-colored fragments.

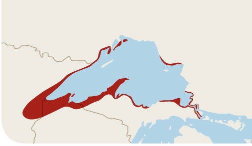
Where to Look: Opportunities to find agates are plentiful; just look where the average tourist doesn't—muddy river banks, remote beaches, and inland gravel pits (with permission).

Rough, natural adhesional banded agates with choice patterns

Polished adhesional banded agates

Agates, adhesional banded

Hardness: 6.5–7 **Streak:** White



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Size: Agates range from tiny fragments to finds rarely larger than a fist

Color: Multicolored; varies greatly, but banding is primarily red, brown, yellow, white to gray, often with colorless layers

Occurrence: Uncommon

Notes: While there are many varieties of Lake Superior agates present in the region, adhesional banded agates are among the most common and most popular. These are the quintessential agates: often perfect band-within-a-band patterns in which each inner band is adhered to and mimics the shape of the outer ones. Known among collectors as fortification agates, due to their resemblance to the concentric walls of a fort or castle, examples with bold banding of alternating color can be among the most valuable of agates. While we understand what agates are mineralogically, how they form is still somewhat of a mystery; while there are many theories, none is conclusive. But however their repeating layers form, adhesional banded agates represent an uninterrupted layering process and are considered "ideal" agates. Sometimes, due to a drop in the amount of silica (quartz material) available to a developing agate, the center of a specimen may consist of larger quartz crystals, rather than agate banding.

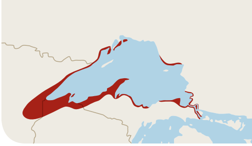
Where to Look: Some of the best and most valuable specimens have originated along Minnesota's shores, especially at inland gravel pits in the Duluth area. The northwestern shore of the Keweenaw Peninsula is lucrative as well, as is the shore from Little Girls Point westward into Wisconsin. In Ontario, the Thunder Bay area shores are worth a look.

Rough agates with amethyst (purple quartz) centers

Rough agates with smoky quartz (dark gray to black quartz) centers

Agates, colored quartz

Hardness: 6.5–7 **Streak:** White



Primary Occurrence

Environment: Shores, rivers, pits, outcrops

What to Look for: Very hard, translucent, rounded masses containing ring-like bands and purple or black quartz within

Size: Most clear examples will be an inch or two, rarely larger

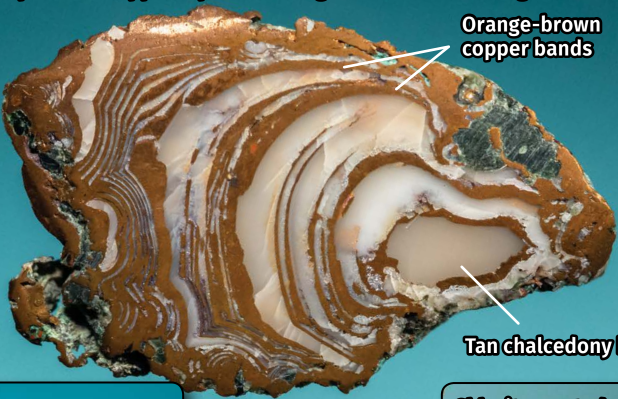
Color: Agate banding varies and is primarily red, brown, white; quartz centers are gray-brown to black, purple, rarely green

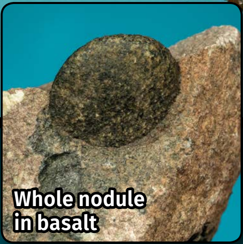
Occurrence: Uncommon to rare

Notes: Agates with a large central mass of coarsely crystallized white quartz are quite common. Since agates form their layers from the outside inward, we know that the central quartz was last to form. Chalcedony banding requires more silica (quartz material) to form than typical quartz, so these examples represent agates that used up most of the available silica when forming their banding, leaving a depleted amount that could only form coarse quartz at the center. These agates are generally less desirable by collectors—unless the quartz is colored. Purple amethyst, gray smoky quartz, brown "root beer quartz," and very rare greenish quartz are all present within agates of the region, and all are caused by chemical impurities trapped within the microscopic spaces inside the quartz's crystal structure. Coloration can vary in intensity as well as in consistency; some examples show color zoning, in which white quartz turns to colored quartz partway through. Note, however, that agates with reddish or yellowish quartz centers are generally just stained by iron impurities; the color in these agates is found in the cracks between the crystals rather than inside them.

Where to Look: Agates with colored quartz don't generally appear in any one area with more frequency than others. But areas with higher concentrations of agates will be more lucrative. Gravel pits, beaches, and rivers in the Duluth, Minnesota, area have long been excellent sources.

Cut and polished copper replacement agate with fine banding

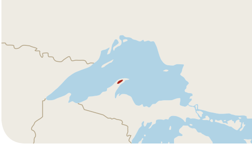




Cut and polished examples

Agates, copper replacement

Hardness: N/A **Streak:** N/A



Primary Occurrence

Environment: Mines

What to Look for: Small, dark nodules embedded in basalt that contain both agate banding and copper within

Size: Always small; specimens larger than an inch are rare

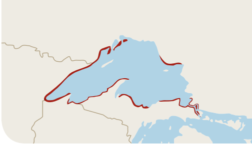
Color: Dark gray-green exteriors; agate banding is usually white to cream-colored or tan; copper is metallic red when cut

Occurrence: Very rare in Michigan; not found elsewhere

Notes: Michigan's copper replacement agates are among the rarest, most collectible, and most enigmatic of all Lake Superior agates. Called "copper agates," for short, these small agates actually contain native copper, frequently as little masses or flecks throughout, but also as agate-like bands, alternating with white or tan chalcedony layers. Agate formation is still poorly understood, but the unique and anomalous formation of copper agates only confounds the issue. It is believed, however, that the copper has replaced specific bands—likely very impure chalcedony bands that dissolved in hot groundwater, leaving band-shaped voids in which copper was later deposited—hence their name. They are generally thumbnail-size or smaller, often found as chlorite-coated nodules still embedded in their host basalt, and can also include intergrown calcite and prehnite. They are only found at certain mine dumps and must be broken free from their host rock, then carefully sawn open to see if they contain copper—many do not. But with research, patience, and great effort, these rarities can still be found.

Where to Look: A few of the copper mine dumps have produced copper agates. Dump piles and old mine sites around Kearsarge and Calumet, north of Houghton, are particularly well-known, but other locations may exist as well.


Rough eye agates
Conjoined eyes
Rough eyes
Polished eye agates



Primary Occurrence

Agates, eye

Hardness: 6.5–7 **Streak:** White

Environment: All environments

What to Look for: Very hard, translucent, red or brown rounded masses of waxy material with eye-like surface spots

Size: Eye agates are generally smaller than a golf ball

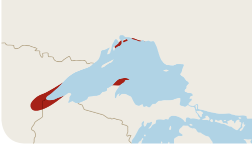
Color: Multicolored; varies greatly, but banding is primarily red, brown, yellow, white to gray, often with colorless layers

Occurrence: Uncommon

Notes: Eye agates, also called "fish eyes," are among the most endearing and popular varieties of Lake Superior agates. They bear small, perfectly circular banded spots resembling eyes on their outer surfaces. Some finds have only one "eye," but many have clustered groups of them. While they may look like orbs, they are actually hemispheres, or half-spheres, formed on the outer surface of an agate and extending inward, like a shallow bowl. Scientifically, they are enlarged spherulites; spherulites are tiny hemispheres of chalcedony that make up the thickest, outermost layer of an agate. In eye agates, certain spherulites were provided with more silica (quartz material) than they needed and continued to grow in size. This is interesting because eyes are far more common on small agates—sometimes pea-size agates will have the best eyes—indicating that a surplus of available silica will continue to affect a developing agate that has already filled its vesicle. The ends of tubes (page 79) can look like eyes, but tubes are long, cylindrical structures, often with a hollow center.

Where to Look: Eyes tend to be more common in smaller agates; any Minnesota or Wisconsin shoreline will yield little specimens among the beach cobbles. The Keweenaw Peninsula, between Eagle River and Copper Harbor, produces small agate nodules often covered with eyes.

Right inset specimen
courtesy of Bob Wright



Primary Occurrence

Agates, faulted & brecciated

Hardness: 6.5–7 **Streak:** White

Environment: Shores, rivers, pits

What to Look for: Very hard, waxy, brown masses of material containing bands or layers that appear broken or interrupted

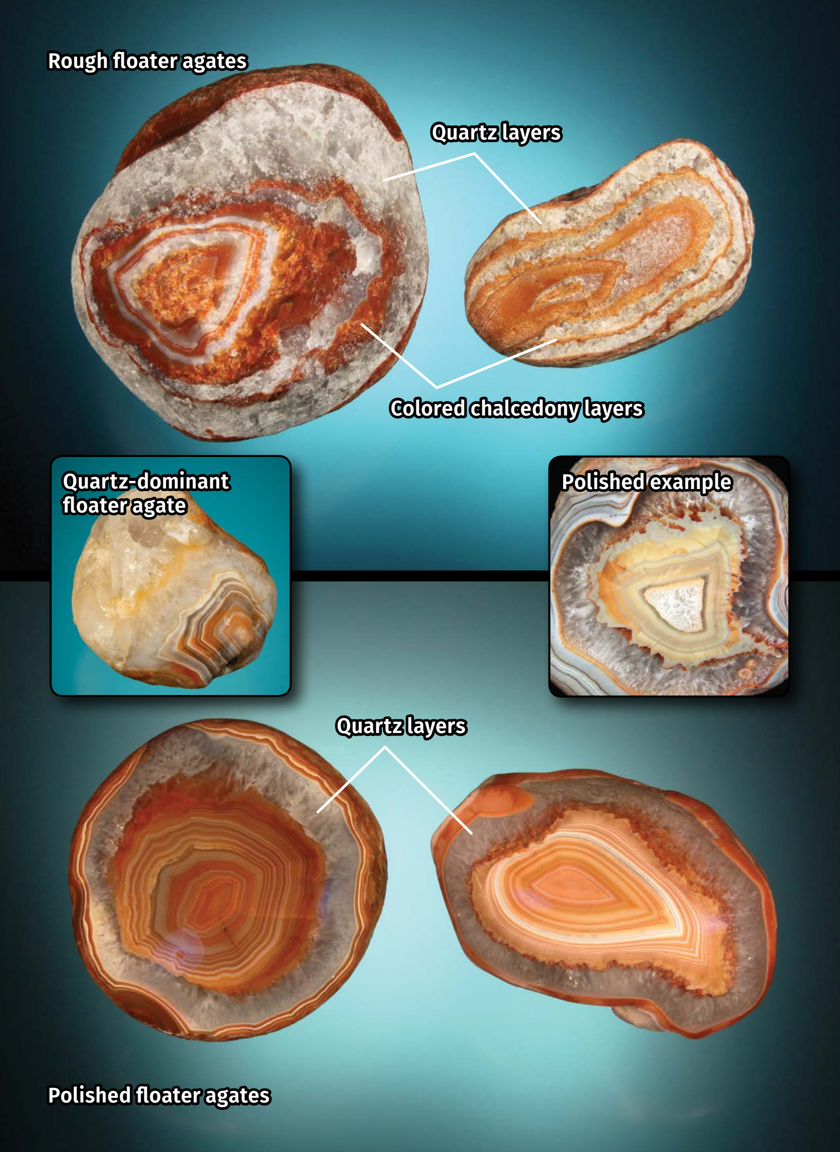
Size: Faults can occur in agates of any size, but they are most often seen in agates measuring a couple inches or more

Color: Multicolored; varies greatly, but banding is primarily red, brown, yellow, white to gray, often with colorless layers

Occurrence: Rare

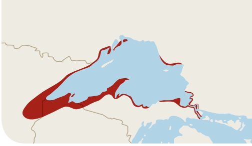
Notes: Most Lake Superior agates bear signs of their 1.1 billion years of existence—cracks, mineral stains, weathering—but some show more dramatic evidence of their harsh past. Faulted and brecciated agates are examples of agates that were damaged even before they were freed from their host rock. The region's past volcanic activity and associated earthquakes and pressure cracked and broke some nascent agates, fragmenting their banding patterns and misaligning the pieces—sometimes significantly. Later, solutions containing silica (quartz material) flowed into these partially crushed agates and hardened, "healing" the pieces back together in a solid mass. Faults are one result, and they range from finds with slightly misaligned banding segments to those where the agate pattern has large gaps and is separated by masses or veins of quartz. Breccia is the more dramatic result, showing a jumble of completely disjointed banded agate segments "floating" in quartz. Specimens with both phenomena are called "ruin agates."

Where to Look: The Keweenaw Peninsula, especially in the Copper Harbor area, is well-known for agates bearing countless faults. Elsewhere, the usual agate environments can produce rare examples; Minnesota and Wisconsin shorelines and pits, especially in the Duluth and Superior area, are lucrative.


Rough floater agates
Quartz layers
Colored chalcedony layers
Quartz-dominant floater agate
Polished example
Quartz layers
Polished floater agates

Agates, floater

Hardness: 6.5–7 **Streak:** White



Primary Occurrence

Environment: Shores, rivers, pits

What to Look for: Very hard, waxy masses of material containing colored banding as well as layers or non-central masses of quartz

Size: Floater agates are some of the largest agates; specimens larger than a softball are rare but known

Color: Multicolored; varies greatly, but banding is primarily red, brown, yellow, white to gray, often with colorless layers

Occurrence: Uncommon

Notes: It is understood that in order for an agate to form a perfect pattern, as seen in the finest adhesional banded agates (page 41) it needs an uninterrupted, steadily replenished supply of silica (quartz material) until the vesicle is filled with layered chalcedony. But if the silica supply is not constant, instead increasing and decreasing in concentration, a regular pattern will not result. It is believed that this is how floater agates formed; periods of high silica availability formed agate banding, but when the silica supply dipped, only coarsely crystallized quartz could form (quartz requires less silica to form than chalcedony and agates do). In some specimens, this fluctuation only happened once, resulting in a central “island” of banded chalcedony “floating” in a “sea” of quartz, hence their name. But in other examples, it happened multiple times, appearing as alternating chalcedony and thick quartz bands. While viewed as less valuable, floaters are still popular and can contain interesting features that can be seen under the quartz when polished.

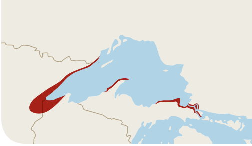
Where to Look: Floater agates are one of the most abundant types of agates, found in any typical agate setting, including almost any southern or western Lake Superior beach. Rivers and gravel pits in the Duluth, Minnesota, area are lucrative.

Cut and polished fragmented membrane agate

Polished fragmented membrane agate

Agates, fragmented membrane

Hardness: 6.5–7 **Streak:** White



Primary Occurrence

Environment: Shores, rivers, pits, outcrops

What to Look for: Very hard, waxy masses of material containing colored banding as well as curved, ribbon-like fragments

Size: These agates can occur in any size, but the characteristic fragments are typically seen in specimens an inch or more

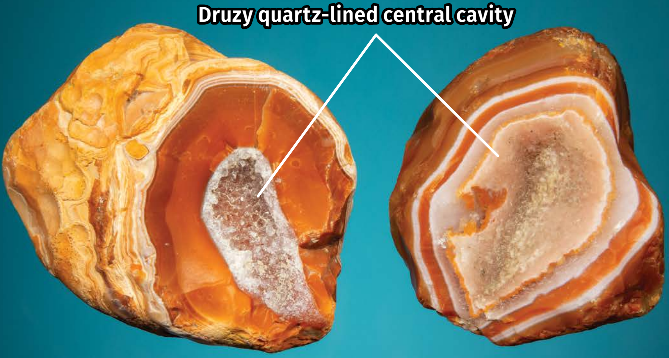
Color: Multicolored; varies greatly, but banding is primarily red, brown, yellow, white to gray, often with colorless layers

Occurrence: Uncommon

Notes: Basalt (page 97) is one of the most prevalent volcanic rocks of the Lake Superior region. It formed when lava was pushed up toward the earth's surface; in the process, gas bubbles, known as vesicles, were trapped within the rock. As the fresh rock cooled and hardened, those gases, along with hot groundwater, began to interact with the new basalt and form minerals within its cavities. Chlorite (page 111) and celadonite (page 179) were common results, grown as thin crusts or membranes that lined the inside of the vesicles. Agates could then form within this soft membrane, which usually weathers away quickly after an agate has been exposed. But sometimes, disturbances during agate formation caused the membrane to break up and sink into a developing agate. Called fragmented membrane agates, they contain curved ribbon-like fragments of the vesicle-lining minerals, often interrupting or separating banded portions. The fragments weather more easily than the agate and often appear pitted and recessed. They also often appear in just one half of an agate (presumably the bottom of the agate as it formed).

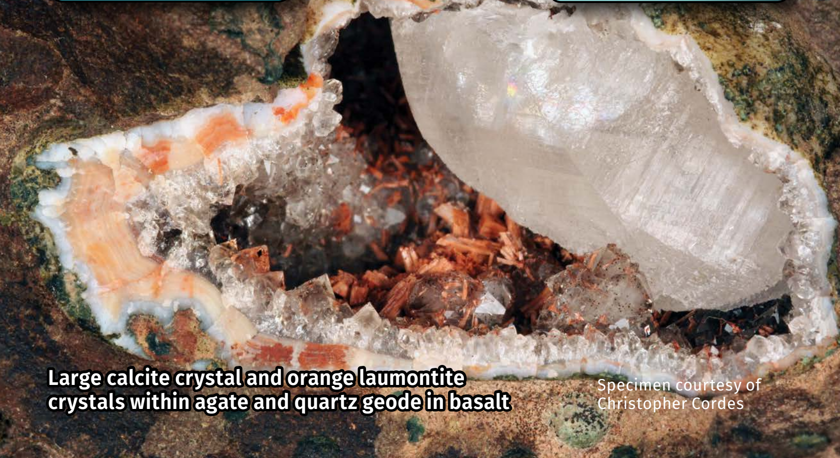
Where to Look: Fragmented membrane agates can turn up anywhere; Minnesota's shores and adjoining rivers have produced specimens, as have eastern Michigan's beaches.

Rough agate geodes




Small agate geode


Calcite (white) inside thin agate geode


Large calcite crystal and orange laumontite crystals within agate and quartz geode in basalt

Specimen courtesy of Christopher Cordes

GLOSSARY

Aggregate: An accumulation or mass of crystals

Alkaline: Substances containing alkali elements such as calcium, sodium, and potassium; having the opposite properties of acids

Alter: Chemical changes within a rock or mineral due to the addition of mineral solutions

Amphibole: A large group of important rock-forming minerals commonly found in granite and similar rocks

Amygdule: A nodular mineral formation within a vesicle; often said to be almond shaped

Associated: Minerals that often occur together due to similar chemical traits or similar processes of formation

Band: An easily identified layer within a mineral

Bed: A large, flat mass of rock, generally sedimentary

Botryoidal: Crusts of a mineral that formed in rounded masses, resembling a bunch of grapes

Breccia: A coarse-grained rock composed of broken angular rock fragments solidified together

Chalcedony: A massive, microcrystalline variety of quartz

Cleavage: The property of a mineral to break along the planes of its structure, which reflects its internal atomic organization; referred to in terms of shape or angles

Compact: Dense, tightly formed rocks or minerals

Concentric: Circular, ringed bands that share the same center, with larger rings encompassing smaller rings

Conchoidal: A circular shape, often resembling a half-moon; generally referring to fracture shape

Crust: The rigid outermost layer of the earth

Crystal: A solid body with a repeating atomic structure formed when an element or chemical compound solidifies

Cubic: A box-like structure with sides of an equal size

Dehydrate: To lose water contained within

Druse: A coating of small crystals on the surface of another rock or mineral

Dull: A mineral that is poorly reflective

Earthy: Resembling soil; dull luster and rough texture

Effervesce: When a mineral placed in an acid gives off bubbles caused by the mineral dissolving

Eruption: The ejection of volcanic materials (lava, ash, etc.) onto the earth's surface

Face: A distinct, typically smooth surface of a crystal derived from a mineral's structure

Feldspar: An extremely common and diverse group of light-colored minerals that are most prevalent within rocks and make up the majority of the earth's crust

Fibrous: Fine, rod-like crystals that resemble cloth fibers

Fluorescence: The property of a mineral to give off visible light when exposed to ultraviolet light radiation

Fracture: The way a mineral breaks or cracks when struck, often referred to in terms of shape or angles

Fault: A broad, planar crack or break in a rock, usually caused by shifting; faults can interrupt or disrupt layers and cause shifting of banded patterns

Geode: A hollow rock or mineral formation, typically exhibiting a very round, ball-like external shape and interior walls lined with minerals, namely quartz and calcite

Glacier: A large body of ice that moves under its own weight in conjunction with freezing and melting; glaciers are a defining characteristic of Ice Ages

Glassy: A mineral with a reflectivity similar to window glass, also known as "vitreous luster"

Gneiss: A rock that has been metamorphosed so that some of its minerals are aligned in parallel bands

Granitoid: Pertaining to granite or granite-like rocks

Granular: A texture or appearance of rocks or minerals that consist of grains or particles

Hexagonal: A six-sided structure

Host: A rock or mineral on or in which other rocks and minerals occur

Hydrous: Containing water

Igneous rock: Rock resulting from the cooling and solidification of molten rock material, such as magma or lava

Impurity: A foreign mineral within a host mineral that often changes properties of the host, particularly color

Inclusion: A mineral that is encased or impressed into a host mineral

Iridescence: When a mineral exhibits a rainbow-like play of color, often only at certain angles

Lava: Molten rock that has reached the earth's surface

Lava flow: An igneous rock formation that retains the general shape or appearance of when it initially hardened from flowing molten lava

Ledge rock: Hard, exposed bedrock, typically seen on Lake Superior's shores as sheets of igneous rock

Luster: The way in which a mineral reflects light off of its surface, described by its intensity

Magma: Molten rock that remains deep within the earth

Malleable: Easily bent without breaking, as in pure metals

Massive: Mineral specimens found not as individual crystals but rather as solid, compact concentrations; in geology, “massive” is rarely used in reference to size

Matrix: The rock in which a mineral forms; see host

Metamorphic rock: Rock derived from the alteration of existing igneous or sedimentary rock through the forces of heat and pressure

Metamorphosed: A rock or mineral that has already undergone metamorphosis

Mica: A large group of minerals that occur as thin flakes arranged into layered aggregates resembling a book

Microcrystalline: Crystal structure too small to see with the naked eye

Mine dump: Piles of waste rock left behind at mine sites. This rock was produced when mine shafts were dug to access valuable ores and may or may not contain collectible minerals.

Mineral: A naturally occurring inorganic chemical compound or native element that solidifies with a definite internal crystal structure

Native element: An element found naturally uncombined with any other elements (e.g. copper)

Nodule: A rounded mass consisting of a mineral, generally formed within a vesicle or other cavity; a mineral specimen formed in this way is said to be nodular

Octahedral: A structure with eight faces, resembling two pyramids placed base-to-base

Opaque: Material that lets no light through

Ore: Rocks or minerals from which metals can be extracted

Oxidation: The process of a metal or mineral losing electrons to another element or material, often when combining with oxygen, which can produce new colors or minerals

Pearly: A mineral with reflectivity resembling that of a pearl

Placer: Deposit of sand containing dense, heavy mineral grains at the bottom of a river or a lake

Pyroxene: A group of hard, dark, rock-building minerals that make up many dark-colored rocks like basalt or gabbro

Radiating: Crystal aggregates growing outward from a central point, often resembling the shape of a paper fan

Rhombohedron: A six-sided shape resembling a leaning or skewed cube

Rock: A massive aggregate of mineral grains

Rock-builder: Refers to a mineral important in rock formation, usually in reference it igneous rocks

Schiller: A mineral that exhibits internal reflections or "flashes" from within its structure when rotated in bright light, often showing an interplay of white, yellow, or blue

Schist: A rock (usually sedimentary) that has been metamorphosed so that most of its minerals have been concentrated and arranged into parallel layers

Sediment: Fine particles of rocks, minerals, or organic matter deposited by water or wind (e.g. sand)

Sedimentary rock: Rock derived from sediment being cemented together

Silica: Silicon dioxide; pure silica crystallizes to form quartz; silica contributes to the makeup of thousands of minerals

Slag: Waste material produced in the processing of ores; often with a rocky, glassy, or "bubbly" texture and sometimes with a nearly metallic luster

Species: A mineral distinguished from others by its unique chemical and physical properties.

Specific gravity: The ratio of the density of a given solid or liquid to the density of water when the same amount of each is used (e.g. the specific gravity of copper is approximately 8.9, meaning that a sample of copper is about 8.9 times heavier than the same amount of water)

Specimen: A sample of a rock or mineral

Stalactite: A cone-shaped mineral deposit grown downward from the roof of a cavity; sometimes described as icicle-shaped. Formations in this shape are said to be stalactitic

Striated: Parallel grooves in the surface of a mineral

Tabular: A crystal structure in which one dimension is notably shorter than the others, resulting in flat, plate-like shapes

Tarnish: A thin coating on the surface of a metal, often differently colored than the metal itself (see oxidation)

Tectonic plate: The enormous sheets of rock that make up the earth's crust and upon which the continents and oceans reside. Tectonic plates move slowly as a result of the extreme heat below them, causing earthquakes and volcanoes, and forming mountains and oceans

Translucent: A material that lets some light through

Transparent: A material that lets enough light through so one can see what lies on the other side

Vein: A mineral that has filled a crack or similar narrow opening in a host rock or mineral

Vesicle: A cavity created in an igneous rock by a gas bubble trapped when the rock solidified; a rock containing vesicles is said to be vesicular

Volcano: An opening, or vent, in the earth's surface that allows volcanic material such as lava and ash to erupt

Vug: A small cavity within a rock or mineral that can become lined with different mineral crystals

Waxy: A mineral with a reflectivity resembling that of wax

Weathering: The process of rocks and minerals being worn down by exposure to the elements, such as wind, rain, waves, ice, glaciers, and naturally occurring chemicals

Zeolite: A group of similar minerals with very complex chemical structures that include elements such as sodium, calcium, and aluminum combined with silica and water and that typically form within cavities in basalt as it is affected by mineral-bearing alkaline groundwater

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BIBLIOGRAPHY AND RECOMMENDED READING

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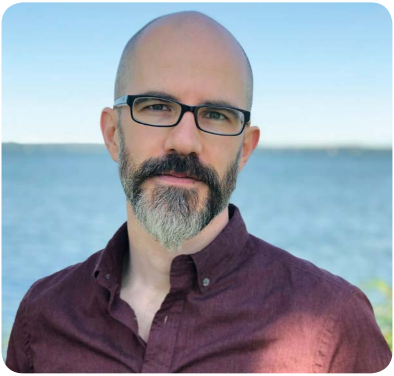
ABOUT THE AUTHORS



Dan R. Lynch has a degree in graphic design with an emphasis in photography from the University of Minnesota Duluth. But before his love of art and writing came a passion for nature. His interest in rocks and minerals was cultivated growing up in his parents' rock shop near Lake Superior's shore, learning rock and mineral identification first-hand. Initially working with his father, Bob Lynch, Dan has since written more than 20 books about rocks and enjoys educating his readers in a straight-forward, easy-to-understand manner. Dan's photography complements his books and he takes special care to ensure that his photographs always honestly represent the specimens pictured. By introducing a complex subject like geology in a clear, concise way, and by starting at the beginning, he hopes to excite readers and spark a lifelong interest in the amazing science underfoot. He lives in Madison, Wisconsin, with his wife, Julie, where he works as a classical numismatist and a writer.

ABOUT THE AUTHORS *(continued)*

Bob Lynch is a jeweler and lapidary living and working in Two Harbors, Minnesota. His experience in cutting and polishing rocks and minerals began in 1973, when he desired more variation and control over which gemstones he could use in his jewelry. After years of working with turquoise and malachite, he moved from Douglas, Arizona, to Two Harbors in 1982, and his eyes were opened to Lake Superior's entirely new world of minerals—especially agates. In 1992, Bob and his wife, Nancy, whom he taught the art of jewelry making, acquired Agate City Rock Shop, a family business founded by Nancy's grandfather, Art Rafn, in 1962. Since the shop's revitalization, Bob has made a name for himself as a highly acclaimed agate polisher and as an expert resource for curious collectors seeking advice. Today, the semi-retired jewelers still own and operate Agate City, open throughout the summer months and most weekends year-round. When he's not creating jewelry, Bob enjoys trap shooting and visiting his sons.

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Learn to Identify Lake Superior's Rocks & Minerals

Full-color photos and the information you need for identifying and collecting

- **incredible, sharp, full-color photos:** the authors took their own photographs to depict the detail needed for identification
- **comprehensive entries:** photos of over 100 rocks and minerals means you're more likely to know what you've found
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This area indicates the Lake Superior region addressed in this book, but rock hounds will find the guide useful throughout Minnesota, Michigan, Wisconsin, and Ontario.

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