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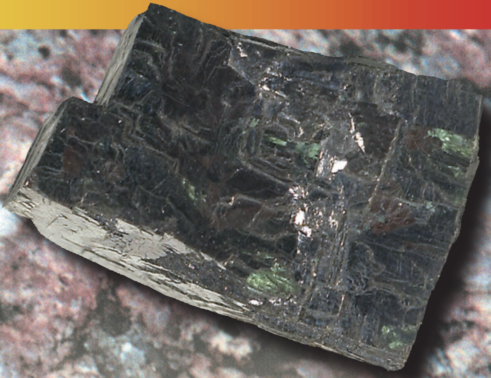

Guide to Rocks and Minerals of Illinois

Wayne Frankie

Illinois State Geological Survey

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ILLINOIS DEPARTMENT OF NATURAL RESOURCES

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Guide to Rocks and Minerals

Wayne Frankie

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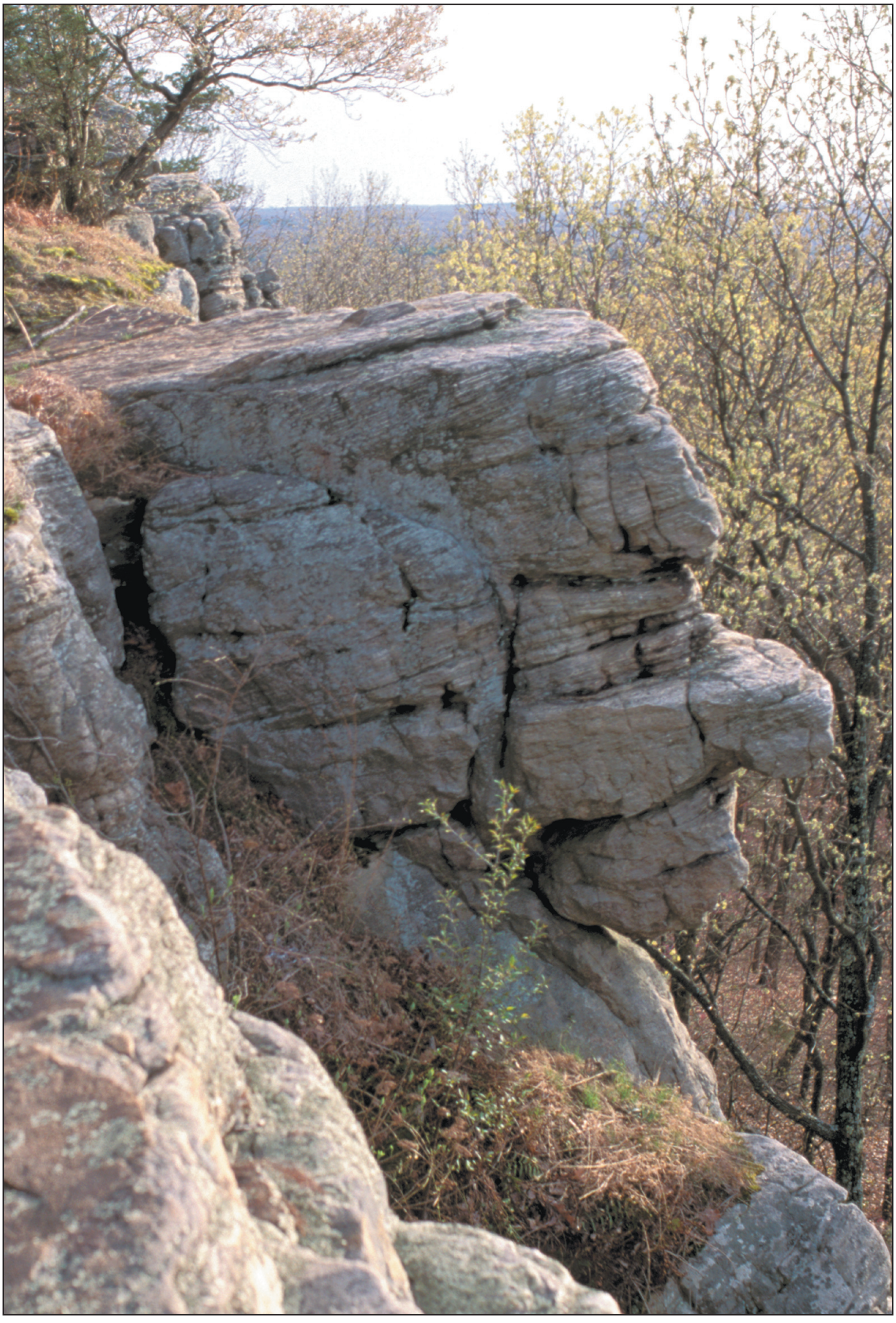
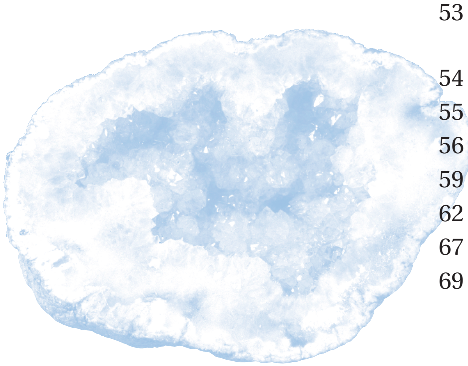
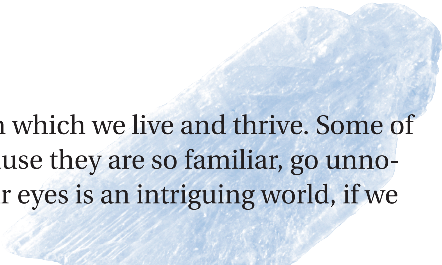


Old Stoneface, Shawnee National Forest, Saline County.

CONTENTS





Introduction

Most of us know little about the Earth on which we live and thrive. Some of nature's most remarkable wonders, because they are so familiar, go unnoticed. Yet beneath our feet and before our eyes is an intriguing world, if we will just pause to examine it.

At first glance, Illinois, "The Prairie State," may appear to be an unlikely place in which to collect rock and mineral specimens. But Illinois is surprisingly rich in rock and mineral resources, thanks to the great diversity and wealth of materials beneath its land surface. The state contains some of the most interesting mineral and rock specimens in the world.

The fertile prairies that gave the state its nickname are themselves derived from ancient rocks, which have been changed by millions of years of weathering and erosion by ice, water, wind, plants, and animals. Beneath the cityscapes, open fields, hills, and valleys lie layered sedimentary rocks that, in some parts of the state, are exposed in outcrops, canyons, and river valleys. Boulders and gravel, brought in from the north by the glaciers thousands of years ago, are strewn across most of the state.

Why Are Rocks and Minerals Important?

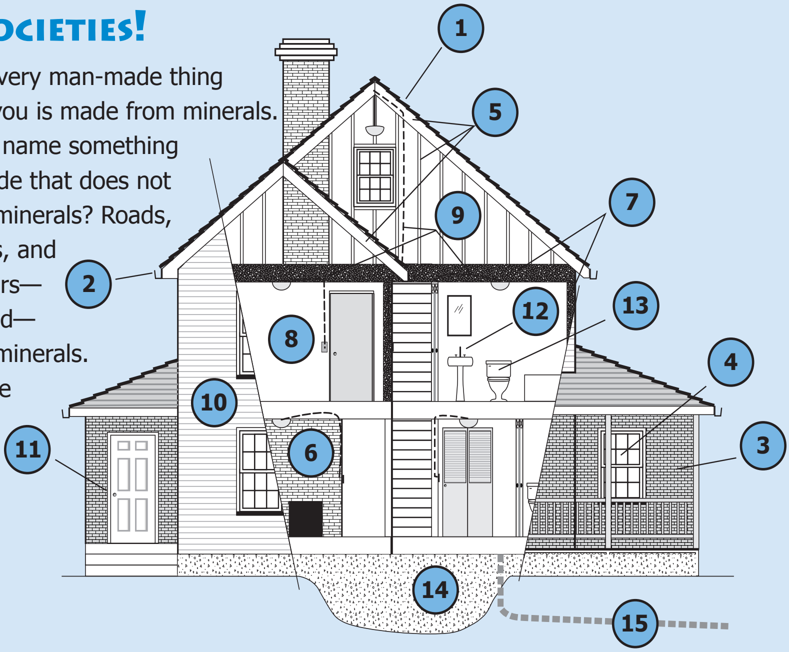
The geologic materials—from soils, to sands and gravels, to rocks and minerals, to petroleum resources—form the basis of our modern society. These resources are important to all of the state's industries, including agriculture, construction, manufacturing, energy production, information delivery, or transportation. Every county in Illinois possesses rocks and minerals that are being used or have potential future value.

The Complexity of Illinois Geology

The majority of the Illinois landscape appears relatively flat and featureless. Hidden beneath this unassuming surface are numerous layers of soils, clay, silt, and sand and gravel that bury the bedrock that lies below them. In Illinois, economic minerals are present deep underground in many places; for example, coal is mined to a depth of 1,000 feet, and oil is produced from porous rock layers, called pay zones, at depths of several thousand feet.

Minerals Are the Foundation of Societies!

Nearly every man-made thing around you is made from minerals. Can you name something man-made that does not contain minerals? Roads, buildings, and computers—even food—contain minerals. There are minerals in this paper.



The majority of the raw material used in building your home was furnished by the mining industry.

1. If the **roof** is covered with asphalt shingles, the filler in the shingles is made from a variety of colored silicate minerals.
2. **Gutters** are galvanized steel (iron ore and zinc) or aluminum (bauxite).
3. **Exterior walls** may be made of brick (clay) or stone (dimension stone).
4. **Windows** are made of glass (trona, silica, sand, and feldspar).
5. Lumber in the structure will be fastened with **nails** and **screws** (iron ore and zinc).
6. The **fireplace** is probably made of brick or stone, lined with a steel box (iron ore).
7. The **insulation** in the walls may be glass wool (silica, feldspar, and trona) or expanded vermiculite.
8. Interior walls are usually **wall board** (gypsum), commonly called sheet rock.
9. **Electrical wiring** is made of copper or aluminum (bauxite).
10. **Paint** is manufactured with mineral fillers and pigments.
11. **Door knobs**, **locks**, and **hinges** are made of brass or steel (copper, zinc, and iron ore).
12. **Plumbing fixtures** are made of brass (copper and zinc), or stainless steel (nickel, chrome, and iron).
13. **Sanitary facilities** are made of porcelain (clay).
14. The **foundation** is probably concrete (limestone, clay, shale, gypsum, and aggregate).
15. The **sewer pipe** is made of clay or iron.
16. Many of the materials used in your home may be **plastic** (petroleum by-products).
17. And finally, your mortgage is written on **paper** made from wood or cloth fibers but filled with clay.

Lead and zinc ores, fluorspar, silica sand, limestone, sand, gravel, clay, and shale are all found at shallower depths. Most people, though, are aware of only those rocks and minerals found at or near the surface.

Geologists gather some information about the state's subsurface directly by looking at and taking samples from outcrops, quarries, and mines. But, for most of the state, geology is "seen" and understood mainly from descriptions (logs) and samples (cores) of the sediments and rocks penetrated during shallow and deep drilling. Other instruments that provide information are geophysical logs, seismic reflection, and electrical resistivity surveys. All of these help geologists interpret subsurface materials.

Understanding a bit of Illinois' geologic history helps us understand how the state's rock and mineral deposits came into being.

Building the Bedrock

Through several billion years of geologic time, the geology of the region that includes what is now called Illinois underwent many changes (see figure 1). The oldest rocks in the state belong to the Precambrian basement complex. Little is known about these rocks because they are not exposed at the surface anywhere in Illinois and can't be seen directly. Only a few drill holes have reached deep enough to sample these igneous and metamorphic rocks.

These rocks were once exposed at the land surface, from about 1 billion to 0.6 billion years ago. From the time of their formation through the middle Cambrian Period, they were deeply weathered and eroded. During this time, tectonic forces in the midcontinent region began to rip apart the North American continent, forming rifts—long, narrow, continental troughs.

From about 543 to 323 million years ago, during the Cambrian through Mississippian Periods, the rifting stopped, and the region's landscape began to sink slowly, allowing the invasion of a shallow, tropical ocean from the south and southwest. Illinois was immersed in this shallow sea. The sands deposited in those oceans became sandstone, and the formation of carbonate mud and the deposition of billions of marine organisms, such as shells, algae, and corals, formed limestone. The extensive beds of the Mississippian Period are more than 3,000 feet thick in some parts of Illinois and contain limestone deposits that hold large amounts of oil and fluorspar.

Era		Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks
CENOZOIC "Recent Life"	Age of Mammals	Quaternary 0–500′	Holocene	10,000	Recent; alluvium in river valleys
			Pleistocene Glacial Age	1.8 m	Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt; wind deposits of loess and sand dunes. Deposits cover nearly all of state except the northwest corner and southern tip
		Tertiary 0–500′	Pliocene	[5.3 m 33.7 m]	Chert gravel, present in northern, southern, and western Illinois
			Eocene	54.8 m	Mostly micaceous sand with some silt and clay; present only in southern Illinois
			Paleocene	65 m	Mostly clay, little sand; present only in southern Illinois
MESOZOIC "Middle Life"	Age of Reptiles	Cretaceous 0–300′		[144 m 290 m]	Mostly sand, some thin beds of clay, and, locally, gravel; present only in southern and western Illinois
PALEOZOIC "Ancient Life"	Age of Amphibians and Early Plants	Pennsylvanian 0–3,000′ ("Coal Measures")		323 m	Largely shale and sandstone with beds of coal, limestone, and clay
		Mississippian 0–3,500′		354 m	Black and gray shale at base; middle zone of thick limestone that grades to siltstone, chert, and shale; upper zone of interbedded sandstone, shale, and limestone
	Age of Fishes	Devonian 0–1,500′		417 m	Thick limestone, minor sandstones, and shales; largely chert and cherty limestone in southern Illinois; black shale at top
	Age of Invertebrates	Silurian 0–1,000′		443 m	Principally dolomite and limestone
		Ordovician 500–2,000′		490 m	Largely dolomite and limestone but contains sandstone, shale, and siltstone formations
		Cambrian 1,500–3,000′		543 m	Chiefly sandstones with some dolomite and shale; exposed only in small areas in north-central Illinois
		Precambrian			Igneous and metamorphic rocks; known in Illinois only from deep wells

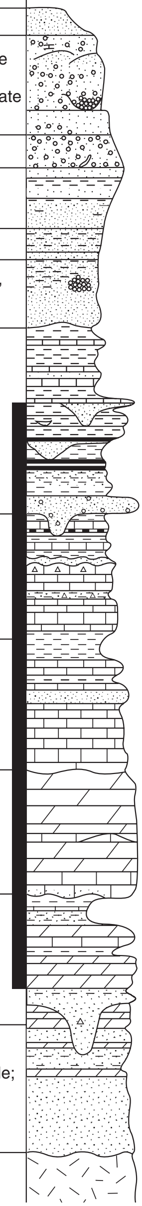


FIGURE 1 Generalized geologic column showing the succession of rocks in Illinois (thick black line indicates rocks with known oil reserves).

From about 323 to 290 million years ago, during the Pennsylvanian Period, the oceans advanced and retreated many times. During retreats, large river systems buried the shallow ocean bed under a series of deltas. Vast swamps grew on the ancient deltas and formed thick deposits of peat. Eventually these peat deposits were buried and compressed over millions of years to form the coal beds found in the Pennsylvanian rocks. All of the coal in Illinois comes from this time period. The Pennsylvanian rock, which is widespread in Illinois, also contains important deposits of limestone, shale, clay, sandstone, and some oil and gas.

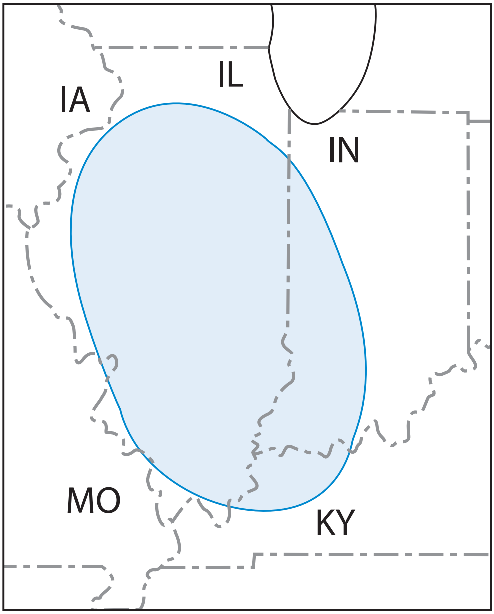


FIGURE 2 Location of the Illinois Basin.

The deltas of the Pennsylvanian Period later covered the entire state, building up great thicknesses of sediment as the land underneath gradually subsided over millions of years. These sediments compacted to form layers of rock that are over 2,000 feet thick in southern Illinois. During this time of oceans and deltas, as tectonic forces gently folded the bedrock of Illinois, a large basin was formed centered in the southeastern part of the state. This basin is known today as the Illinois Basin. Because of the basin shape, the Paleozoic Era rocks are much thicker in southern than in northern Illinois (figures 2 and 3).

During the last part of the Paleozoic Era (Permian Period, 290 to 248 million years ago), throughout the Mesozoic Era (248 to 65 million years ago), and through most of the Cenozoic Era (65 to 1.8 million years ago), Illinois had a rolling topography. With time, water carved valleys into the exposed and weathered rocks of the ancient ocean and deltas, and great rivers flowed through Illinois removing sediment, much like today. The combination of flowing waters, blowing wind, and the freeze-thaw cycles eroded the bedrock and transported the sediments, thus creating an eroded land surface.

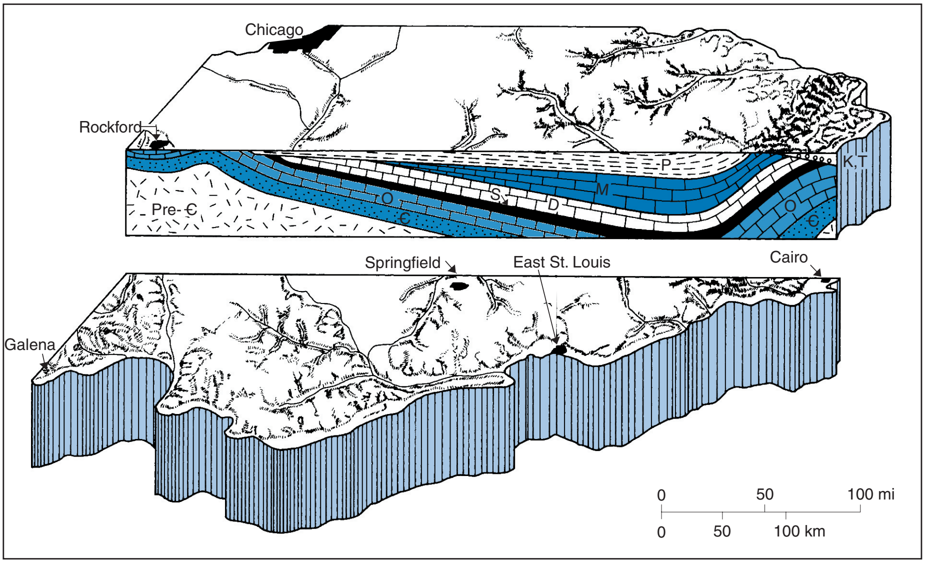


FIGURE 3 Stylized north-south cross section shows the structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated, and younger, glacial deposits have been eliminated. The oldest rocks are Precambrian (Pre-€) granites. They form a depression filled with layers of sedimentary rocks of various ages, primarily Cambrian (€), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). Scale is approximate.

Glaciers Smooth the Surface

Late in the Cenozoic Era, the world cooled down. From about 2 million years to about 10,000 years ago, glaciers of the Pleistocene Epoch —or "Ice Age"—profoundly affected the topography of Illinois (figures 4 and 5). The modern Illinois landscape is a result of bedrock carving and associated sediments deposited during the episodes of glaciation that occurred during this time. The network of deeply eroded valleys in the bedrock surface that formed in preglacial times was filled with glacial deposits that covered most of the state. Much of the present land surface of the glaciated areas of Illinois does not reflect the underlying bedrock surface.

How did this happen? What forces filled valleys, diverted rivers, and smoothed the landscape? During the Pleistocene Epoch, much of North America was covered repeatedly by huge glaciers. These continent-size ice masses formed in eastern and central Canada and advanced southward.

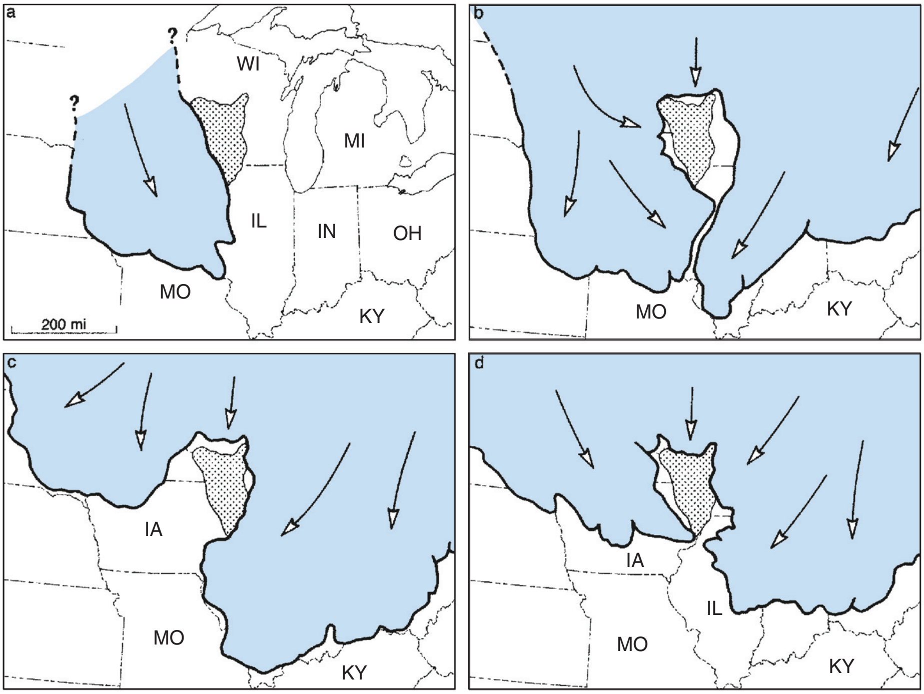


FIGURE 4 Maximum extent of (a) early Pre-Ilinois glacial episode (1,000.000±years age); Driftless Area shown by stippled pattern; arrow indicates direction of ice movement; (b) late Pre-Illinois glacial episode (600,000±years ago); (c) Illinois Glacial Episode (250,000±years age): (d) late Wisconsin Glacial Episode (22,000 years age).

As the glaciers flowed, they eroded rock along their path and carried this debris into Illinois; these materials were dropped out from the glaciers as the ice melted. Because the identification of the early glacial episodes in Illinois is obscured by reworking and burial during later glacial advances, they are collectively known simply as the pre-Illinois glacial episodes. These episodes ended about 425,000 years ago and were followed by a long warm interval between glaciations (the Yarmouth) that lasted about 125,000 years. A deep weathered zone, the Yarmouth Geosol, formed during that time.

Approximately 300,000 years ago, the Illinois Episode of glaciation began. During the 175,000 years of this episode, the ice advanced three times out of the northeastern center of accumulation. During the Illinois Episode, North American continental glaciers reached their southernmost position, located just north of the Shawnee Hills in southern Illinois (see figure 4c). During the first of these advances, ice of this episode reached westward across

Years before present	Interglacial and glacial episodes	Sediment record	Dominant climate conditions and land-forming and soil-forming events
HOLOCENE	interglacial episode	River, lake, wind, and slope deposits. **7**	Warm; stable landscape conditions. Formation of modern soil; running water, lake, wind, and slope processes.
10,000	WISCONSIN (late) glacial episode; glacial ice	Till and ice-marginal deposits; outwash and glacial lake deposits; loess. **6**	Cold; unstable landscape conditions. Glacial deposition, erosion, and land-forming processes (e.g., formation of end moraines, outwash plains, valley trains, proglacial lakes, kettles), plus running water, lake, wind, and slope processes.
25,000	WISCONSIN (early and middle) glacial margin north of Illinois	Loess; river, lake, and slope deposits. **5**	Cool; stable. Weathering, soil formation (Farmdale Soil and minor soils); wind and running water processes.
75,000	SANGAMON interglacial episode	River, lake, wind, and slope deposits. **4**	Warm; stable. Weathering, soil formation (Sangamon Geosol); running water, lake, wind, and slope processes.
125,000	ILLINOIS glacial episode	Till and ice-marginal deposits; outwash and glacial lake deposits; loess. **3**	Cold; unstable. Glacial deposition, erosion, and land-forming processes, plus proglacial running water, lake, wind, and slope processes; possible minor soil formation.
300,000	YARMOUTH interglacial episode	River, lake, wind, and slope deposits. **2**	Warm; stable. Long weathering interval with deep soil formation (Yarmouth Geosol); running water, lake, wind, and slope processes.
425,000 – 1,600,000 and older	? PRE-ILLINOIS glacial and ? interglacial episodes	Till and ice-marginal deposits; outwash and glacial lake deposits; loess plus nonglacial river, lake, wind, and slope deposits. **1**	Alternating stable and unstable intervals of uncertain duration. Glacial deposition, erosion, and land-forming processes, plus proglacial and interglacial running water, lake, wind, and slope processes; interglacial weathering and soil formation.

PLEISTOCENE EPOCH (not to scale)

FIGURE 5 Timetable illustrating the glacial and interglacial events, sediment record, and dominant climate conditions of the Ice Age in Illinois (from *Illinois' Ice Age Legacy*).

Thick loess deposit in southwestern Illinois.

Illinois and into Iowa. After the Illinois Episode, during the Sangamon interglacial interval, another major soil, the Sangamon Geosol, developed.

Next came the Wisconsin Episode of glaciation, which created the landscape we see today. The Wisconsin glaciers advanced into Illinois about 25,000 years ago. Although late Wisconsin glaciers advanced across northeastern Illinois, they did not reach southern or western Illinois (see figure 4d). As the glaciers advanced, earth materials from previous times were buried, transported, or otherwise rearranged. As the Wisconsin ice retreated, large ridges of deposited earth materials—called moraines—were formed. The Illinois Episode left few moraines, and all are markedly smaller in size than the later Wisconsin moraines. Illinois moraines are only preserved south of the limits of the younger Wisconsin age glacier.

The glacial deposits of Illinois consist primarily of (1) till—pebbly clay, silt, and sand, deposited directly from melting glaciers; (2) outwash—mostly sand and gravel, deposited by the rapidly flowing meltwater rivers; (3) lacustrine deposits—silt and clay that settled out in the clear, quiet water of glacial lakes and sand and gravel that waves concentrated at or near shorelines; and (4) sand dunes and loess (windblown silt). During the major glacial advances, outwash deposits of silt, sand, and gravel were dumped along the

Mississippi and Illinois River valleys. When these deposits dried out during the winters, strong prevailing winds from the west (the westerlies) winnowed out the finer materials, such as fine sand and silt, and carried them eastward across most of the state.

Scattered along the Mississippi and Illinois River floodplains are several areas of sand dunes. These dune areas generally contain a random arrangement of small hills, mounds, or elongated ridges that are almost entirely made of sand. Dunes are formed by the piling up of sand by the wind and can develop in any region with a readily available source of sand and occasional strong winds.

The loess that mantles most of the state of Illinois was laid down by the wind during the Illinois and Wisconsin Glacial Episodes. In general, the thickness of the loess deposits is greater along the eastern boundaries of the Mississippi and Illinois Rivers, and the thickness decreases to the east. The loess deposits are up to 25 feet thick along the Illinois River valley and more than 50 feet thick, in some localities, along the east edge of the Mississippi River valley. Illinois is the only state with an almost complete blanket of loess, because of the westerly winds crossing the combined Mississippi and Illinois River valley outwash plains, which extend the full length of the western edge of the state. These loess deposits form the parent materials for a large majority our modern soils.

The glaciers also brought in large boulders of igneous and metamorphic rock that geologists call erratics. These large erratic boulders were plucked from bedrock in Michigan, Wisconsin, and Canada and now are scattered throughout Illinois. Often, these erratics can be seen along country fence rows where farmers have cleared them from their fields.

Although the glaciers left Illinois about 13,500 years ago, they left behind many kinds of erratics, including quartzite, schist, granite, and gabbro.

Description of Minerals and Rocks

The terms mineral and rock are often confused. They are frequently used together, and the materials they describe are closely related. In general, a mineral is a naturally occurring, inorganic, chemical element or a group of elements (a compound). A mineral has a crystalline structure and a unique chemical composition. A rock is a mixture of particles or grains of one or more minerals.

When we refer to mineral resources or industrial minerals, however, we generally include materials that are technically rocks—such as limestone, dolomite, and shale. We also include coal and oil, which are in fact organic substances. Conversely, we include in the rock category high-purity sandstone, which is composed almost entirely of quartz, and high-purity limestone, which is composed largely of the mineral calcite.

Mineral Groups

A few minerals are composed of only one element, such as diamond (carbon), native copper, and sulfur, but most minerals are chemical compounds that contain several elements (table 1). Only about 100 of the more than 2,000 identified minerals are considered to be common minerals. Of those 100, fewer than 20 are found everywhere in the Earth's crust. Scientists group minerals according to their chemical composition and crystal structure. The main mineral groups, their composition, and examples of each are shown in table 1.

TABLE 1 Main mineral groups, their composition, and examples of each.

Group	Composition	Examples
Elements	Pure elements	Copper, gold, sulfur
Silicates	Metals, silicon, oxygen	Quartz, feldspar, mica, garnet, beryl, talc
Carbonates	Metals, carbon, oxygen	Calcite, dolomite, siderite
Oxides	Metals, oxygen	Hematite, bauxite
Sulfides	Sulfur, metals	Galena, pyrite, chalcopyrite
Sulfates	Metals, sulfur, oxygen	Gypsum, barite, anhydrite
Halides	Metals, chlorine, fluorine, iodine, bromine	Halite, fluorite

Rock Types

Rocks, because they are mixtures of minerals, are more complex and are classified according to how they formed. The broadest grouping of rocks is based on the origin of the rock rather than on the minerals that compose it. In this scheme, all rocks are divided into three general groups: igneous, sedimentary, and metamorphic rocks (figure 6).

Igneous Rocks Igneous rocks can be categorized based on their texture and composition. Igneous rocks are produced directly from hot molten rock, called magma, that comes from deep within the Earth. As magma cools, the elements that form individual minerals come together and crystallize, as water crystallizes into ice on a winter day.

Different minerals crystallize at different temperatures, which causes differences in grain size, or texture. If the magma cools slowly, some individual mineral grains have the opportunity to grow larger than others. If the magma cools quickly, as lava or basalt does, the separate mineral grains are small. Igneous rocks are classified on the basis of the size and arrangement of the individual crystals and the kinds of minerals present (table 2).

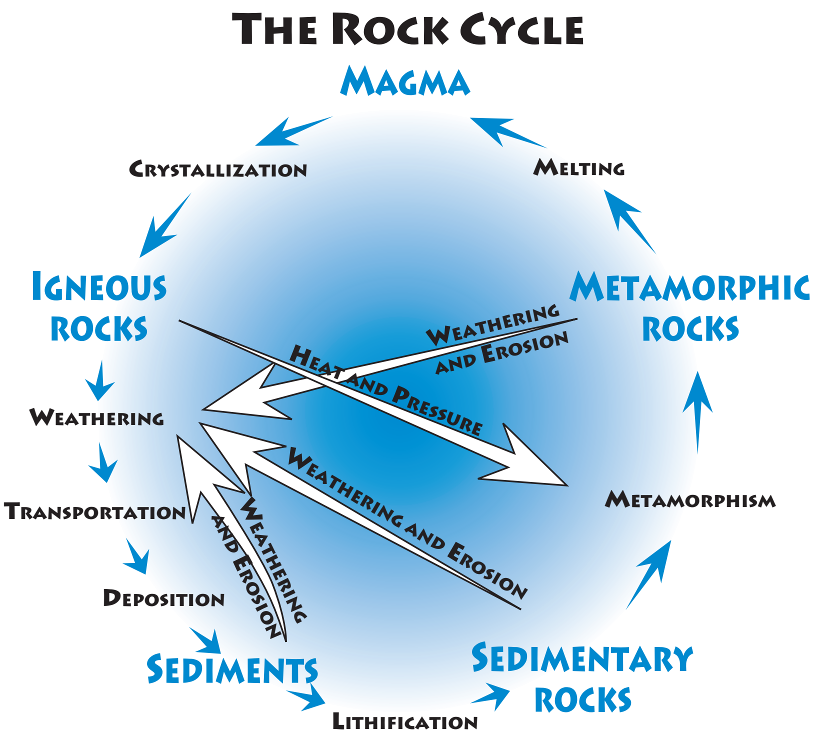


FIGURE 6 The three main groups of rocks and the processes that create them are shown. Each rock group may be derived from the other two by these processes. The white arrows indicate alternative paths within the rock cycle.

When magma reaches the Earth's surface, cooling occurs quickly, and small crystals form. These igneous rocks are called extrusive rocks because they are extruded onto the exterior of the Earth. When magma remains inside the Earth, cooling occurs more slowly, and large crystals form. Such igneous rocks are called intrusive rocks because they form in the Earth's interior. Porphyritic rocks are igneous rocks that have large crystals, called phenocrysts, within a small crystal ground mass. The magma that produced these rocks began to form larger crystals within the Earth, followed by rapid cooling as the magma moved upward or extruded onto the surface, forming the fine-grained surrounding rock.

TABLE 2 Examples of intrusive (formed within the Earth) and extrusive (formed on the Earth's surface) igneous rocks.

Color	Intrusive (coarse-grained, large crystals)	Extrusive (fine-grained, small crystals)
Light	Granite Diorite	Rhyolite Andesite Pumice
Dark	Gabbro Peridotite	Basalt Obsidian

Igneous rocks can also be classified by composition into felsic and mafic rocks. Felsic igneous rocks are made up primarily of feldspar and quartz (silica). Mafic igneous rocks are made up primarily of minerals rich in iron and magnesium. Felsic rocks are usually light to intermediate in color, and mafic igneous rocks are usually dark.

Sedimentary Rocks Most of the rocks native to Illinois are sedimentary rocks. Some are made of small pieces of shells, plant and animal remains, and weathered fragments of other rocks (sediments) that have been moved by rivers, waves, winds, or ice (glaciers). These sediments have been deposited and later compacted or cemented by the mineral matter that precipitated out of the water moving through the voids between the sediment particles. Pores are voids in the sedimentary rocks that were not filled with material. Such sedimentary rocks are called clastic (meaning broken pieces) rocks. Other sedimentary rocks may be formed by chemical precipitation from water (chemical) or consist of fossil remains (organic).

Clastic sedimentary rocks are classified by (1) their grain size or texture (examples include gravel, sand, silt, and clay) and (2) their mineral composition (table 3). Rocks such as gypsum and some limestones were formed by chemical precipitation from sea water. Organic rocks such as limestone come from animal remains and chemical precipitation; coal comes from plant remains.

Metamorphic Rocks Metamorphic rocks literally mean rocks that have changed form (table 4). This change can be caused by heat and pressure that occur below the surface of the Earth or by heat from upward-moving hot magma or melted rocks. Chemical reactions can also change rock form. Metamorphic rocks are found in Illinois as boulders and pebbles in the glacial drift. Foliated metamorphic rocks contain minerals that occur in layers; unfoliated rocks are massive.

TABLE 3 Some common sedimentary rocks classified by texture and composition.

Rock	Texture	Composition
Clastic		
Conglomerate	Round pebbles	Pebbles, cobbles, boulders
Breccia	Angular fragments	Cemented by sand and clay
Sandstone	Sand-sized grains	Mostly quartz, feldspar, some mica
Siltstone	Very fine grains	Mostly quartz, feldspar, some clay
Shale	Microscopic grains	Mostly clay, some mica flakes
Organic		
Limestone	Microscopic to coarse crystals	Calcite from shells or shell fragments (animal remains)
Chalk	Very fine-grained	Calcite from microscopic animal remains
Coal	Microscopic	Carbon from plant remains
Chemical		
Rock salt	Cubic crystals	Halite
Gypsum	Microscopic to coarse crystals	Gypsum
Limestone	Microscopic to coarse crystals	Calcite precipitated from seawater

TABLE 4 Some examples of metamorphic rocks and their texture and origin.

Rock	Texture	Original Rock Type	Original Rock Group
Foliated			
Slate	Fine (microscopic)	Shale	Sedimentary
Schist	Medium to coarse	Slate Basalt Granite	Metamorphic Igneous Igneous
Gneiss	Coarse	Granite	Igneous
Unfoliated			
Quartzite	Medium	Sandstone	Sedimentary
Marble	Coarse	Limestone	Sedimentary

Using Characteristics of Minerals to Identify Them

Most minerals can be characterized and classified by their unique physical properties: hardness, luster, color, streak, specific gravity, cleavage, fracture, and tenacity.

Hardness The ability to resist being scratched—or hardness—is one of the most useful properties for identifying minerals. Hardness is determined by the ability of one mineral to scratch another. Federick Mohs, a German mineralogist, produced a hardness scale (table 5) using a set of ten standard minerals. The scale arranges the minerals in order of increasing hardness. Each higher-numbered (harder) mineral will scratch any mineral with a lower number (softer).

A rough measure of mineral hardness can be made by assembling a kit of handy objects (table 6). A fingernail has a hardness ranging from 2 to 2.5, a penny is a little harder than 3, window glass ranges from 5.5 to approximately 6 in hardness, and a knife blade is generally in the range of 5 to 6.5.

Luster Luster is how a mineral reflects light. The terms metallic and nonmetallic describe the basic types of luster. Table 7 lists the most common terms used to describe luster and an example of a corresponding mineral. Some minerals that don't exhibit luster are referred to as "earthy," "chalky," or "dull."

TABLE 5 Mohs hardness scale and common field tests for hardness.

Hardness	Mineral	Common field test
1	Talc	Easily scratched with a fingernail
2	Gypsum	Scratched by a fingernail (2.5)
3	Calcite	Scratched by a penny (3)
4	Fluorite	Difficult to scratch by a nail (4); scratched easily by a knife (>5);
5	Apatite	Difficult to scratch with a knife (>5); barely scratches glass (5.5)
6	Feldspar	Scratched by a steel file (6.5); easily scratches glass
7	Quartz	Scratches a steel file and glass
8	Topaz	Difficult to test in the field
9	Corundum	Difficult to test in the field
10	Diamond	Difficult to test in the field

Creating a Mineral Hardness Test Kit

A mineral hardness test kit can be easily created from common household or hardware items (table 6). Parents should help children make the kit. Wear safety glasses and gloves when cutting glass. All pieces in the hardness test kit should be compared to one another and specific minerals with a known hardness.

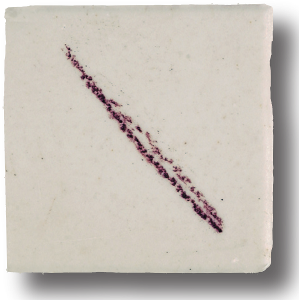
TABLE 6 Determining approximate mineral hardness using common items to scratch them.

Approximate hardness	Item
1	Blackboard chalk
2.5	Fingernail
3	Copper penny
4	Common nail
5–6.5	Pocket knife
5.5	Window glass (2 inches square; use caution making this scratch plate. Tape the edges of the glass with duct tape. You may be able to get this cut at a local hardware store.)
6.5	Steel file or tempered steel. Try to find an old broken or worn flat file.

TABLE 7 Types of luster and examples.

Luster	Example
Metallic	Galena/pyrite
Nonmetallic	
Adamantine (brilliant)	Diamond
Vitreous (glassy)	Quartz
Pearly	Talc
Resinous	Sphalerite
Silky	Asbestos/fibrous gypsum
Greasy	Graphite
No luster	
Dull or earthy	Limonite
Chalky	Chalk

Color One of the most obvious properties of a mineral is color. Color should be considered when identifying a mineral, but should never be used as the major identifying characteristic.



Streak Streak is the color of the powdered mineral, which is usually more useful for identification than the color of the whole mineral sample. Rubbing the mineral on a streak plate will produce a streak. A streak plate can be made from the unglazed back side of a white porcelain bathroom or kitchen tile. Some minerals won't streak because they are harder than the streak plate.

Specific Gravity Specific gravity is the ratio between the mass (weight) of a mineral and the mass (weight) of an equal volume of water. A mineral's specific gravity (SG) can be determined by dividing its weight in air by the weight of an equal volume of water. For instance, quartz with a density of 2.65 is 2.65 times as heavy as the same volume of water.

$$SG = \frac{\text{mineral mass}}{\text{water mass}}$$

Cleavage The way in which a mineral breaks along smooth flat planes is called cleavage. These breaks occur along planes of weakness in the mineral's structure. However, if a mineral breaks along an irregular surface, it does not have cleavage.

Fracture When a mineral breaks irregularly, the breaks are called fractures. The breaks can be described as grainy, hackly (jagged), conchoidal (curved), or splintery.

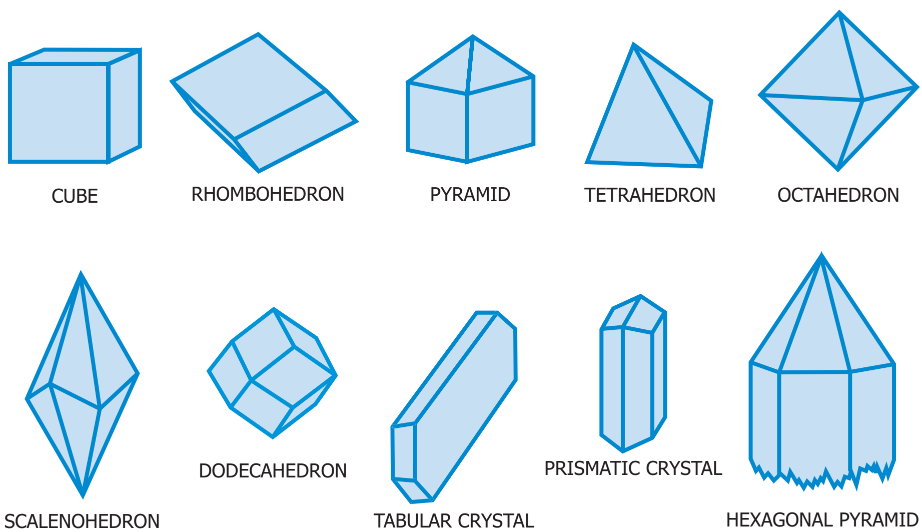
Tenacity How well a mineral resists breakage is known as tenacity. Tenacity is described using these terms:

- Brittle - Mineral crushes to angular fragments (quartz).
- Malleable - Mineral can be modified in shape without breaking and can be flattened to a thin sheet (copper, gold).
- Sectile - Mineral can be cut with a knife into thin shavings (talc).

- Flexible - Mineral bends but doesn't regain its shape once released (selenite, gypsum).
- Elastic - Mineral bends and regains its original shape when released (muscovite and biotite mica).

Other Diagnostic Characteristics Other characteristics may be useful in identifying some minerals:

- Transparency - Objects are visible when viewed through a mineral.
- Translucency - Light, but not an image, is transmitted through a mineral.
- Opaqueness - No light is transmitted, even on the thinnest edges.
- Taste - Taste can be used to help identify some minerals, such as halite (salt).
- Acid reaction - Object reacts to hydrochloric acid. The most distinguishing characteristic of calcite is that it effervesces when hydrochloric acid is applied. Dolomite shows a reaction on a freshly broken or powdered surface. Testing for calcite, limestone, or dolomite calls for 10% hydrochloric acid, but strong white vinegar can be substituted for the acid.
- Magnetism - Magnetism is a distinguishing characteristic of magnetite.
- Crystal shape - Cubic, rhombohedral (tilted cube), hexagonal (six-sided), etc. Some crystal shapes are illustrated below.



Rock and Mineral Collections

Keeping good records is an important part of building a rock and mineral collection. All specimens should be labeled with basic descriptive information. As your collection grows, you may want to consider setting up a system of cataloging:

- List each specimen within your collection and assign each a unique number. For example,

X-1	Minerals
S-1	Sedimentary rocks
I-1	Igneous rocks
M-1	Metamorphic rocks
F-1	Fossils

- Create an index card for each specimen, listing where the specimen was collected. You may also want to record specific information about each specimen, such as physical properties, uses, and date collected.
- Label specimens using white enamel paint (model paint) and a fine-tipped permanent marker. Paint a small area on the bottom side of the specimen, let it dry, and then write your specific file number on the white space.

Equipment for Collecting

1. Hammer (bricklayer's) with one chisel or pick head. (Chisel end works best for sedimentary rocks.)
2. Cold chisel about 6 inches long and an edge about 0.5 inches wide.
3. Dilute hydrochloric (muriatic) acid (10% solution) in a dropper bottle for testing the presence of carbonate minerals. Mark the bottle POISON. If acid is spilled on skin or clothing, wipe immediately and, if possible, rinse with water. (Note: Strong white vinegar can be substituted for acid.)
4. A small water bottle, with water.
5. Magnifying glass or hand lens; 10× power is probably the most useful.
6. Hardness testers: penny, window glass square, pocket knife, nail.
7. Streak plate or a piece of unglazed white porcelain such as the back of a tile.
8. Notebook and pencil or pen for keeping records of the locality and bed from which specimens are collected. A topographic map may be useful.
9. Collecting bags or backpack of strong material to carry your equipment and specimens.
10. Heavy gloves and goggles to protect hands and eyes.
11. Labels and wrappings. Field identification of specimens may be written on adhesive tape and attached to the specimen or on a slip of paper enclosed in the wrapping. Newspaper, brown paper, or paper bags can be used for wrapping specimens to protect them from damage by other specimens. Label the outside of the wrapped specimen, too.

Descriptions of Illinois Minerals

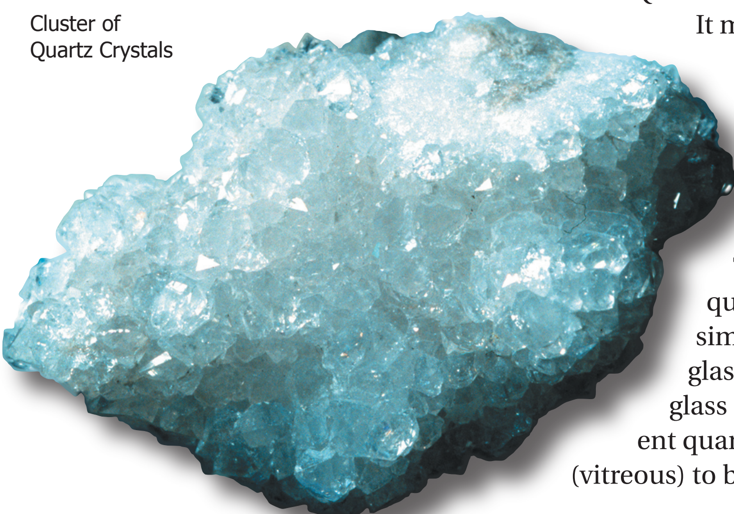
The most common Illinois rocks and minerals are described in this publication, but many other rocks and minerals can be collected in the state. For that reason, keys for identifying other Illinois minerals and rocks are included beginning on page 54. Those keys include specific hardness values and chemical composition as well as other identifying characteristics.

Quartz Quartz (SiO_2) is the most common of all minerals, making up 12% of the Earth's crust. There are two main types of quartz: (1) crystalline quartz and (2) dense, microcrystalline to cryptocrystalline (microscopic to submicroscopic) quartz. Many dense varieties occur in Illinois; the most common is chert.

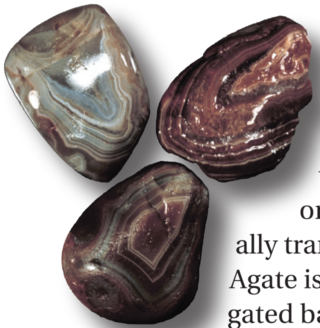
Hexagonal Pyramidal End of Single Quartz Crystal

Well-formed, prismatic crystals of quartz are typically six-sided and elongated with sharply pointed pyramid-like ends. Quartz crystals are apt to grow together, in clusters. Good, large crystals are rare in Illinois. However, good, well-formed crystals occur within some geodes (see page 51) and within certain openings (vugs) in some limestone layers.

Cluster of Quartz Crystals



Quartz is brittle and hard. It may be colorless or tinted, transparent or translucent; more commonly, it is white and nearly opaque. Transparent quartz appears similar to ordinary glass, but scratches glass easily. Transparent quartz has a glassy (vitreous) to brilliant luster and

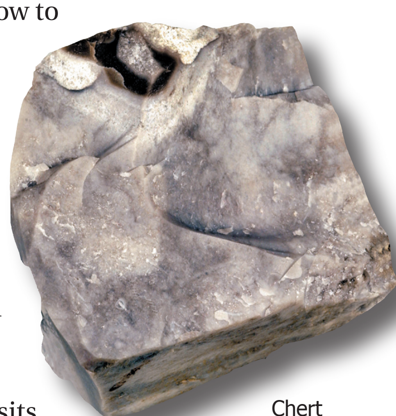


Lake Superior Agates

breaks irregularly or with a good curved (conchoidal) fracture. Specific gravity is 2.65.

Some varieties of cryptocrystalline quartz that are used for semiprecious gems are chalcedony, agate, onyx, and jasper. Chalcedony is waxy, smooth, generally translucent, and white to gray, blue, brown, or black. Agate is a form of chalcedony that has a mottled or variegated banded appearance and may be yellow, green, red, brown, blue, gray, or black. Onyx is agate with parallel bands that as a rule are brown and white or black and white. Jasper, an impure opaque chert, generally is red or yellow-brown.

Quartz occurs as rock crystal (colorless, transparent), milky quartz (white, nearly opaque), and smoky quartz (smoky yellow to gray or brown) in geodes from the Warsaw and Keokuk Limestones of the Nauvoo-Hamilton-Warsaw area. Quartz also occurs as vein and cavity fillings associated locally with fluorite, sphalerite, and galena in extreme southern Illinois. It also occurs as vug (cavity) fillings in limestones and sandstones.



Chert

Chert Chert, one of the main forms of silicon dioxide, is cryptocrystalline (microscopic) quartz. Most of the chert in Illinois is white, gray, or black, but impurities stain many deposits yellow, brown, or even pink. Chert is so hard that it can scratch glass and ordinary steel. It is fairly lightweight, opaque, dull, and brittle. Specific gravity is about 2.6 to 2.64.

Arrowheads

Flint, a variety of chert, is generally dark colored, is more dense, may have a glassy luster, and may be translucent in thin flakes. Both chert and flint have a smooth, curved (conchoidal) fracture, but flint tends to break with thinner, sharper edges. Native Americans used flint and chert to make arrow points and spearheads. Archeologists reserve the term flint for the dark varieties of chert from the Old World and use the term chert for the New World varieties.

Chert occurs as rounded masses (nodules and concretions) or as irregular layers in limestones and dolomites throughout Illinois. Because chert is hard and more resistant to weathering than limestone or dolomite, it often remains after the rest of the rock has weathered away. Chert also is abundant in many glacial deposits because it is hard and resistant to erosion. Streams that flow through cherty bedrock or glacial deposits carry pebbles along and concentrate them as gravel in stream channels. Cherty stream gravels are especially abundant in western and southern Illinois.

Ancient brown chert gravels in the southern part of the state are used for road gravel. Other deposits in extreme southern Illinois, consisting of angular fragments of chert and a small amount of clay (known locally as novaculite gravel), also are used for road surfacing, but chert reacts adversely with cement and cannot be present in aggregate used for roads or foundations.

White and gray chert occurs as thick lenses within massive bedrock deposits several hundred feet thick in Union and Alexander Counties.

Feldspar Feldspar is the name applied to a group of minerals that is the second most common of all the minerals. All feldspars are composed of aluminum, silicon, and oxygen combined with varying amounts of one or more metals, particularly potassium, sodium, and calcium.

Feldspar

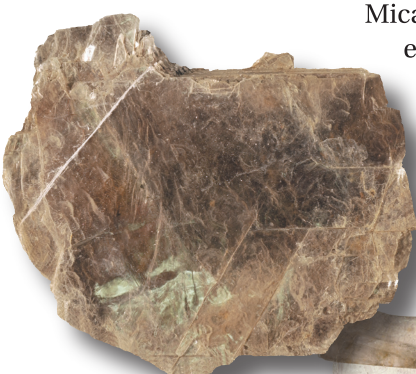
Feldspars have a hardness of 6, have a smooth, glassy or pearly luster, and show good cleavages along two planes at nearly right angles to each other. Specific gravity is about 2.6. The streak is white, but the color of the mineral is highly variable. Potassium feldspars (or K-feldspars) contain potassium, and color is commonly pink to reddish, but otherwise white, gray, yellowish, or pale green (amazonite variety).

Plagioclase feldspars contain varying amounts of calcium and/or sodium, and color is commonly white or gray. A diagnostic feature is fine lines or striations seen with a hand lens on cleavage faces.

Feldspar is used as flux for glass and ceramic manufacture, abrasives, and fillers in paint and plastics.

Feldspars are essential minerals in most crystalline igneous rocks. Their decomposition products are clay minerals that are present in most soils. In Illinois, relatively small feldspar crystals can be found associated with quartz and other minerals in granite and gneiss boulders, and larger crystals occur in some pebbles in glacial drift.

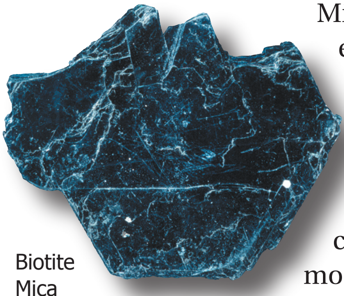
Mica Mica is the name of a family of complex aluminum silicate minerals that can be split easily into paper-thin, flexible sheets. If broken across the grain at right angles to the flat, smooth surface, they fracture raggedly. In a single mica crystal, the sheets range from more or less transparent to translucent and are arranged one on top of another like a deck of cards.



Muscovite Mica

Transparent Sheet of Mica

Micas are tough and somewhat elastic, soft enough to be split and scratched by a fingernail, and lightweight. They have a nonmetallic, glassy to silky or pearly luster, although yellow mica may appear to be metallic. Color and streak depend upon the chemical composition of the mineral. Muscovite, or white mica $(KAl_2AlSi_3)O_{10}(OH)_2$), contains potassium and is colorless and transparent in thin sheets. In thick sheets, muscovite varies in color from light yellow to light brown, green, and red and is translucent. It makes a colorless or white streak. Muscovite is named for a region in Russia where large muscovite sheets are used as window panes (muscovy glass). Biotite, also called black mica ($K(Mg,Fe)_3(AlSi_3)O_{10}(OH)_2$), contains iron and magnesium and is commonly dark green or brown to black, although it may be shades of yellow or brown; its streak is colorless. Thin sheets generally have a smoky color.



Biotite Mica

Mica is used in electronics, insulators, filler and extender in plasterboard, cement, paint, and drilling mud.

Mica can be abundant as tiny, shimmering flakes in Illinois sands, sandstones, and shales (which are then said to be micaceous). It also is common in many varieties of igneous and metamorphic rocks. White or yellow flakes may show a brilliant luster and may be mistaken for silver, platinum, or gold, but those minerals are heavy and malleable.

Object Viewed through "Iceland Spar" Calcite Rhomb

Calcite Calcite ($CaCO_3$), a common rock-forming mineral, consists of calcium carbonate. Calcite is the principal mineral in limestones, and crystals occur as a component in many concretions. Calcite is white or colorless, but impurities may tint it shades of yellow or gray. Transparent calcite is rarer than the tinted varieties. Transparent calcite (known as "Iceland Spar") possesses the property of double refraction; an image appears double when viewed through a calcite cleavage block.

Cleaved Calcite

Calcite has a glassy luster; its streak is white or colorless. The mineral is of medium hardness and can be scratched by a penny but not by a fingernail. Specific gravity is 2.71. Calcite effervesces freely in cold dilute hydrochloric acid or full-strength vinegar.

Calcite has a variety of crystal forms but, in Illinois, most commonly contains flattened, block-shaped (rhombohedron) crystals and elongate crystals with tapering points (scalenohedron) known as "dogtooth spar". When broken along its three cleavage planes, calcite forms six-sided blocks called rhombs.

Crystals of calcite are found in Illinois as linings in geodes, especially in the Nauvoo-Hamilton-Warsaw area. Thin calcite veins occur along joints in coal beds and as crystalline masses in vugs within limestone and dolomite. Small amounts of clear crystalline calcite are associated with various ores in northwestern and extreme southern Illinois.

"Dogtooth Spar" Calcite

Fluorite Fluorite (CaF_2), or fluorspar, is made up of the elements calcium and fluorine. The mineral is easily identified by its perfect cleavage, color, and hardness.

Cubic Fluorite Crystals

Fluorite occurs in cubic crystals that may be twinned. Most often, fluorite occurs as irregular masses in which individual crystals cannot be distinguished. Fluorite can be split along its four cleavage planes into diamond-shaped, eight-sided forms (octahedrons). Fluorite is commonly gray, white, or colorless, but it may also be green, blue, purple, pink, or yellow. The streak is colorless and the luster glassy. Fluorite can be scratched by a knife or a piece of window glass, is fairly lightweight (specific gravity ranges from 3 to 3.3), and is transparent to translucent.

Cleaved Octohedrons of Fluorite

Extensive deposits of fluorite, once one of Illinois' important commercial minerals, occur in Hardin and Pope Counties in extreme southern Illinois, where fluorite is associated with galena, sphalerite, calcite, barite, and other less abundant minerals.

Fluorite is used to make hydrofluoric acid. It is used to form a slag in the production of iron and steel. Fluorite is used also in toothpaste and in many chemical products and to make colored glass, enamels, and glazes in the ceramics industry. Fluorite—the state mineral—is no longer mined in Illinois, the last mine closing in 1997.

Gypsum Gypsum ($CaSO_4 \cdot 2H_2O$), hydrous calcium sulfate, is a colorless, transparent to translucent mineral when pure, but it is often stained yellow by impurities. It has a white streak, is soft enough to be scratched by a fingernail, and is lightweight.

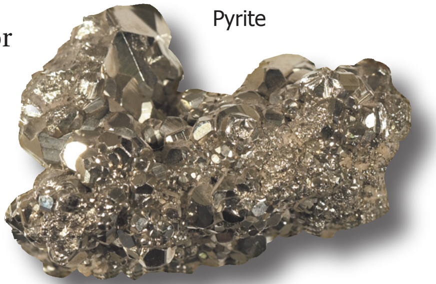
Selenite Gypsum Crystal with "Fishtail Twin"

Gypsum occurs in several forms. Selenite is a coarsely crystalline, transparent to translucent variety, composed of flat, nearly diamond-shaped crystals that can be split easily into thin sheets, have a glassy luster, and often grow together to form "fishtail twins." Crystals of selenite occur in shales of the Pennsylvanian Period of southern, north-central, and western Illinois and can be picked up at the surface. Satin spar gypsum has crystals resembling silky threads closely packed together, splits parallel to the fibers, and is found as fillings in cracks within rocks and as thin layers in shales. Massive microcrystalline gypsum is granular.

Gypsum deposits occur deep underground in Illinois, but thus far have not been mined.

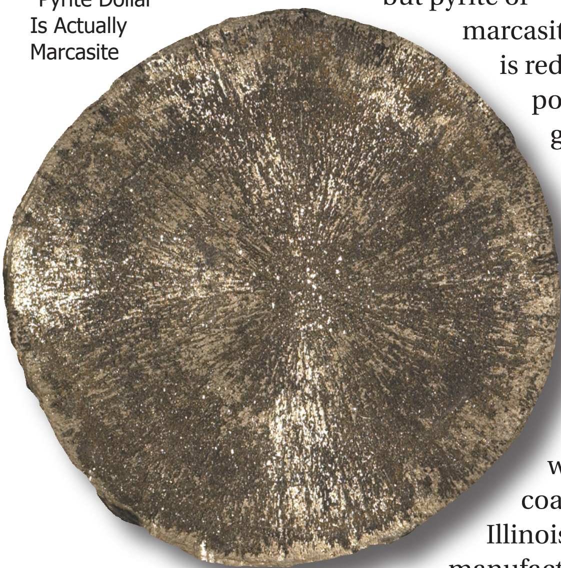
Pyrite and Marcasite Pyrite and marcasite (FeS_2) are iron disulfide compounds. They look similar but have different crystal forms. Both are brittle, hard, brassy yellow with metallic luster, and opaque. Their crystal shape is the most distinguishing feature. The pyrite crystals are cubes, but the marcasite crystals are blade- or needle-shaped.

Pyrite



Pyrite and marcasite have been mistaken for gold because they are yellow and metallic. They are commonly known as "fool's gold." These rocks are much harder than gold, tarnish, and leave a dark streak; gold is soft, very heavy, does not tarnish, and leaves a yellow streak. Gold is malleable, but pyrite or marcasite is reduced to powder if pounded and gives off a noticeable odor of sulfur dioxide gas if heated or cooked.

"Pyrite Dollar" Is Actually Marcasite



Pyrite Cube

Both pyrite and marcasite are common as surface coatings, veins, and concretions in coal and in dark shales associated with coal. They are referred to as "coal brasses" or "sulfur" when found as impurities in coal. Coal brasses recovered from Illinois coal have been used in the manufacture of sulfuric acid for industrial use.

Limonite Limonite ($FeO(OH)\cdot H_2O$) is an iron oxide that may contain adsorbed water. Limonite has a complex chemical composition. The limonite found in Illinois may be yellow, orange, red, brown, or black, but its streak is always yellowish brown. This medium-weight mineral may have a glassy or an earthy luster. It may be too hard to be scratched by a knife.

Limonite is common and occurs within concretions and cavity fillings in sedimentary rocks and as coatings on the rocks, especially sandstone. It also occurs as iron rust and accumulates around rootlets in soils. Small amounts of limonite discolor limestone, dolomite, clay, shale, sandstone, and gravel. Some sands are firmly cemented by brown or black limonite and look much like iron ore. Clays containing a high percentage of limonite are called ocher.

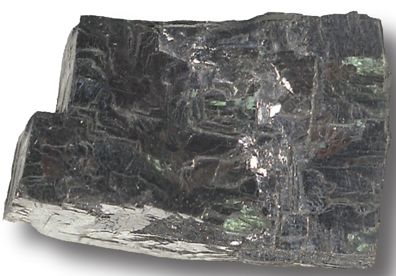
In some states, limonite is mined as an iron ore. In the middle 1800s, limonite was mined in Hardin County in Illinois, but deposits are not large enough to be mined economically.

Sphalerite

Sphalerite Sphalerite (ZnS), zinc sulfide, is a major zinc ore. Sphalerite has a resinous luster and a white to yellow and brown streak. Illinois sphalerite is generally yellow, yellowish brown, reddish brown, or brownish black. It is of medium weight (specific gravity is 3.9 to 4.1) and is brittle; it can scratch a penny but not a piece of window glass. Sphalerite is commonly opaque but may be translucent on thin edges.

Sphalerite was mined with galena in northwestern Illinois and in extreme southern Illinois with galena and fluorite. Small crystals occasionally are found in limestones, within geodes, and as crystalline masses in clay-ironstone concretions.

Galena Galena (PbS) is lead sulfide, the principal ore of lead. It is steel gray, heavy (specific gravity is 7.4 to 7.6), and opaque and has a bright metallic silver-colored luster, although the shiny surface may be dulled by a coating of lead carbonate. Galena has a gray or black streak; it is soft enough to mark paper and can be scratched by a penny. The cube-shaped crystals readily break into cubic, right-angled cleavage fragments. Probably the most obvious features of the mineral are its bright metallic luster on fresh surfaces, high specific gravity, and cubic cleavage.



Galena

Galena was an important mineral resource in Illinois during the nineteenth century and during the first half of the twentieth century. It was mined in northwestern and extreme southern Illinois. Galena can be found in small voids within limestones and dolomites and as crystals in geodes. Galena is often associated with fluorite and sphalerite deposits.

Igneous Rocks


Granite

Granite Granite is one of the most widespread intrusive (originating deep within the Earth) igneous rocks. Granite consists chiefly of feldspar and quartz with small amounts of biotite, muscovite, or hornblende. Most granite is light-colored, but it can be white, gray, yellow, pink, or deep red. The texture ranges from medium-grained to coarse-grained.

Granite pebbles or boulders are the most common igneous rocks found in glacial deposits in Illinois. These pebbles and boulders are not native to the state but were brought here by the glacial ice sheets that advanced southward across Canada to cover much of the northern United States during Pleistocene time.

Granite is used extensively as building stone. Native Precambrian granitic rock lies at great depths beneath the state and has been recovered from oil test drillings along the western, northern, and southern margins of Illinois.

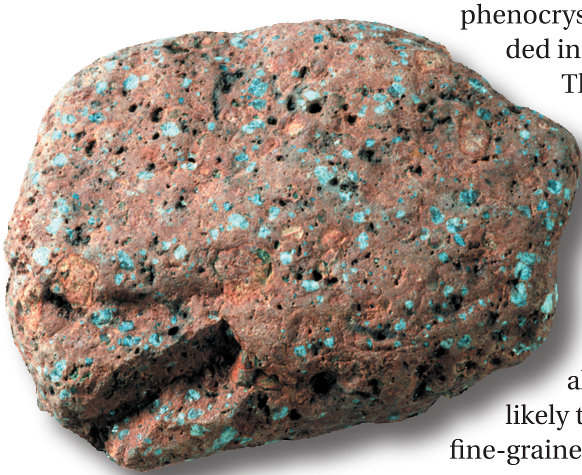
Gabbro Gabbro is another intrusive igneous rock, but it is heavier and darker than granite. Gabbro is composed mainly of feldspar and dark iron-bearing minerals such as amphibole or pyroxene that give the rock a dark color. It is coarse-grained and contains very little or no quartz.


Gabbro

Mineral crystals in gabbro are especially tightly interlocked, making the rock very difficult to break. Weathered gabbro is a rusty color on the surface, because the iron minerals in gabbro weather in the same way that a piece of metallic iron becomes coated with rust when left outdoors.

Like other igneous rocks found near the surface in Illinois, gabbro was carried into Illinois by the glaciers and deposited as glacial debris.

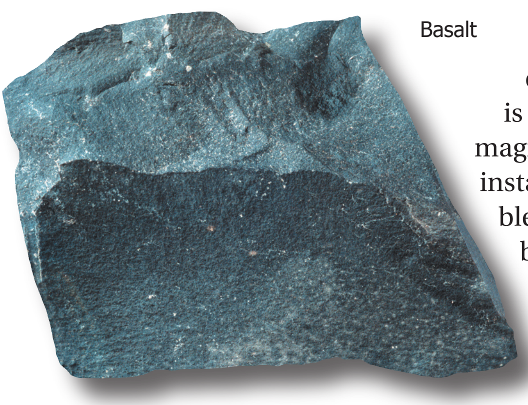
Porphyry Porphyry is an igneous rock identified by its texture rather than its mineral content, which is variable. Large, distinct crystals—called phenocrysts—of minerals are embedded in a matrix of fine-grained rock. The phenocrysts, commonly feldspar, formed before the main molten mass of the rock crystalized.



Rhyolite Porphyry

Any igneous rock may have a porphyritic variety, such as granite porphyry, rhyolite porphyry, or basalt porphyry although porphyries are most likely to form in association with fine-grained igneous rocks.

Porphyry is found in Illinois only in glacial drift.

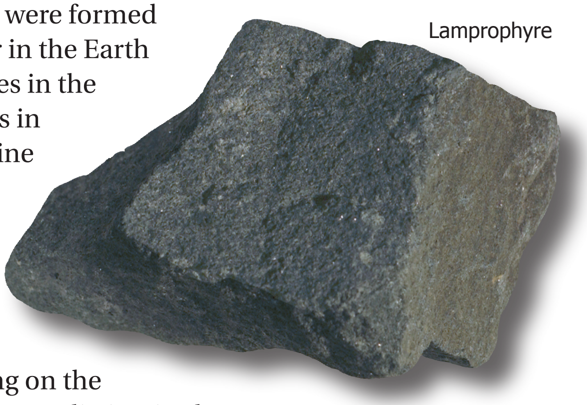


Basalt

Basalt Worldwide, basalt is one of the most widely distributed extrusive volcanic rocks. This rock is composed of pyroxene, feldspar, magnetite (an iron ore), and in some instances olivine, biotite, and hornblende. The dark green, gray, or black color is due to the dark minerals that make up much of the rock. The minerals in basalt are fine-grained and closely packed together. Phenocrysts of olivine, pyroxene, and hornblende may be present. Basalt is easily identified by its dark color and fine-grained texture.

The glaciers brought basalt into Illinois along with other igneous rocks.

Lamprophyre Lamprophyre is the only igneous rock native to Illinois that crops out at the surface. It is found as dikes (irregular veins) or sills (thin roughly horizontal sheets) that were formed when molten rock from deeper in the Earth intruded into cracks and fissures in the bedrock of southeastern Illinois in Hardin, Pope, Gallatin, and Saline Counties.


Lamprophyre

Lamprophyre ranges from very fine-grained to medium-grained rock and has an even texture. It is dark gray to greenish gray, depending on the minerals present, and weathers to a distinctive brown to tan color. In general, lamprophyre is composed of biotite, hornblende, and pyroxene; little or no feldspar or quartz is present.

Metamorphic Rocks

Gneiss and Schist Gneiss is a metamorphic rock composed of roughly parallel bands of different minerals. It is medium- to coarse-grained and is generally light in color. The names given to gneiss emphasize a distinctive texture or indicate a dominant mineral composition. For example, biotite gneiss emphasizes a mineral, and granite gneiss indicates the rock's composition.


Gneiss

Schist

Schist is much like gneiss, but schist is fine-grained and has a thinly layered, micaceous structure that commonly makes the rock break with a wavy, shiny surface. Some common types of schistose rocks are talc schist, chlorite schist, and hornblende schist. As the names indicate, they are characterized by their dominant mineral. Mica schist may be formed by the metamorphism of either sedimentary or igneous rocks.

Gneiss and schist are not native to Illinois but are found in the glacial drift.

Quartzite Quartzite is a metamorphic rock that originally was quartz sandstone. Quartzites are produced by intense heat and/or pressure, probably aided by hot silica-bearing solutions. The quartz grains may be so closely interlocked that individual grains are no longer recognizable. The rock fractures conchoidally (with a curved surface) through both the grains and cement, so the broken surface, unlike that of sandstone, is smooth and may even exhibit a glassy luster like quartz.

Quartzite

Color depends upon the amount and kind of impurities that are present. An all-quartz quartzite is white or gray, but iron or other elements may change the quartzite's color to shades of purple, yellow, brown, or red. Quartzite is a very resistant, hard rock and cannot be scratched by a knife.

Quartzite is abundant as boulders and pebbles in the glacial drift of Illinois, having been brought into the state during the Ice Age.

Glacial Erratics

A variety of rock types occur within the glacial deposits in Illinois. Some of the most distinctive include the igneous and metamorphic rocks known as erratics that originate only from specific regions to the north. For example, Lake Superior agates from the Lake Superior region of northern Michigan (see page 23) and, rarely, native copper from the upper Keweenaw Peninsula of Michigan have been found in Illinois.

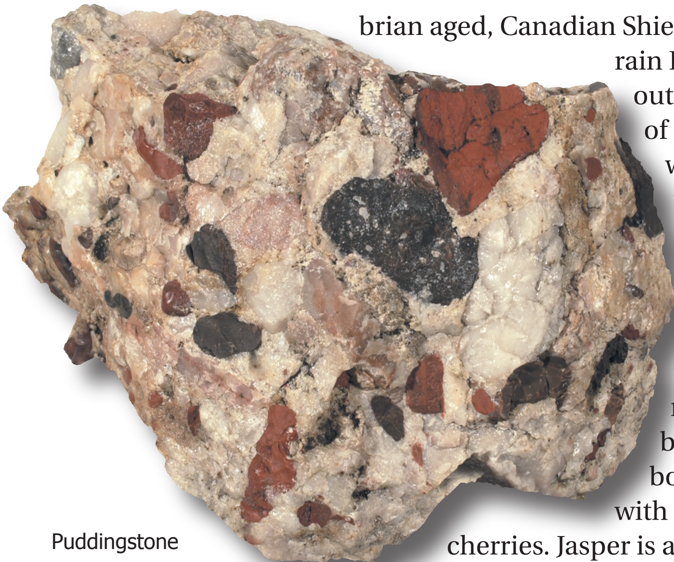
Within the glacial deposits of Illinois are several unique and distinctive glacial erratics that indicate the specific areas where they originated. Knowing the source areas for specific types of rocks found within Illinois glacial deposits provides evidence for the flow paths (or directions) that the various continental glacial lobes traveled on their journey to Illinois, during the Pleistocene Ice Age.

Unique Glacial Erratics

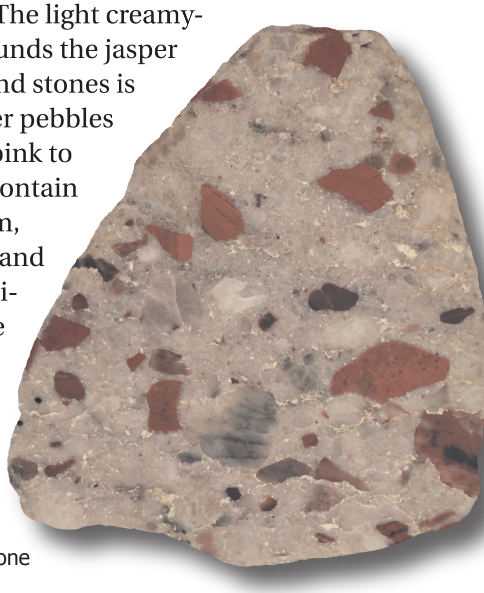
Omars

Omars A distinctive type of glacial erratic called an omar has been collected from glacial deposits in Illinois. Omars refer specifically to a dark gray to black, metamorphosed, tough, fine-grained sandstone (a graywacke). Omars are characterized by the occurrence of white to cream-colored, usually spherical, calcareous concretions that commonly weather out, leaving rounded depressions (pits) in the rock. The source rock for omars is the Precambrian age, Omarolluk Formation of the Belcher Group, which is exposed in the Belcher Islands on the southeastern side of Hudson Bay in the Northwest Territories of Canada. The occurrence of omars in Illinois indicates a flow path from Hudson Bay, south across Ontario, into the Lake Michigan basin, and south into Illinois.

Jasper Conglomerates A second, more distinctive and unusual type of glacial erratic found in Illinois is the jasper conglomerate, also called puddingstone. These conglomerates were transported from the Precam-


Puddingstone

brian aged, Canadian Shield rocks of the Lorrain Formation. They crop out north and northwest of Bruce Mines village, which is located along the far northwestern shore of Lake Huron in Ontario. In the early 1800s, English settlers there gave the stone its unusual name “puddingstone” because it looked like boiled suet pudding with currants and red cherries. Jasper is a fine-grained, red to brown, iron-bearing chert, and the jasper conglomerate is considered to be a transitional rock—from sedimentary to metamorphic. The jasper conglomerates were originally sandstone conglomerates containing white quartz sand and clasts of red jasper. The original sediments were eroded from older rocks and deposited by flowing water in streams and rivers. The material was buried and, with time, formed a sedimentary rock. Heat and pressure (metamorphism) transformed them into a low-grade metamorphic rock. The light creamy-white, fine-grained matrix that surrounds the jasper pebbles and other types of pebbles and stones is primarily a white quartzite. The jasper pebbles vary in color from red to brown and pink to purple. Some jasper conglomerates contain minerals such as chromite, corundum, platinum, diamonds, gold, sapphire, and zircon. Although somewhat rare in Illinois, jasper conglomerate erratics are found in northeastern-source glacial deposits. These tightly cemented conglomerates make a good ornamental stone when cut and polished.


Slice of Puddingstone

Tillites Tillite is defined as a sedimentary conglomerate formed by the consolidation or lithification (cementation) of glacial tills from an ancient glacial deposit.

Tillite

Fairly common in the glacial deposits of Illinois, these tillites were derived from the Precambrian age, Canadian Shield rocks of the Bruce, Gowganda, and Lorrain Formations of Ontario. Tillite (also called diamictite and mixtite) is made up of sediment that was carried or deposited by glaciers and later cemented to form rock. In general, tillites consist of a fairly fine-grained matix that contains pebbles and larger size pieces of distinctive rock types. Most tillite erratics have a dark green, gray, or grayish brown matrix that contains lighter-colored, fairly angular igneous or metamorphic pebbles. The Ontario source area for tillites is larger than that for the jasper conglomerate, which probably accounts for the greater abundance of Precambrian age tillite erratics in Illinois glacial deposits of Pleistocene age.

Sedimentary Rocks

Conglomerate Conglomerate is a sedimentary rock made up of pebbles or other rock fragments (sand and gravel) cemented together by a matrix of finer material, generally silica, calcium carbonate, clay, iron oxide, or a mixture of these substances. The rounded rock fragments have been worn by being rolled in streams or by waves along beaches.

If the pebbles embedded in the matrix are sharp and angular, freshly broken, and not worn, the rock is called breccia; breccia is generally found

Conglomerate

close to the place where the fragments originated. Conglomerate or breccia may be made up of any type of rock or mineral, but most commonly a durable material such as chert, quartz, quartzite, granite, and gneiss.

In Illinois, conglomerates commonly are found at the base of sandstone formations and as beds in the lower Pennsylvanian aged rocks. They are also found in some gravel deposits.

Sandstone Sandstone is a clastic sedimentary rock consisting of sand-sized grains (0.0025 to 0.08 inch or 0.064 to 2.032 mm in diameter) held together by a cementing material. In general, the individual grains in sandstone are visible to the unaided eye. As sandstones become more finely grained, they grade into siltstones; as they become more coarsely grained, they grade into conglomerates. The shape of sand grains in sandstones ranges from rounded to angular.

Quartz is the dominant mineral in sandstone, but other rock grains and mineral grains (especially, feldspar, muscovite, hornblende, magnetite, or garnet) generally are present. Sandstones are commonly cemented by carbonates, silica, iron oxides, or clays. Most sandstones are a shade of gray or brown, but the color may vary from gray or white to yellow, brown, or red. The color largely depends on the type of cement, the amount of organic material present, and the amount and degree of oxidation of iron in the rock.

The durability of sandstones depends largely on the character of the cement. Some sandstones crumble easily, but others, especially those cemented by iron oxides or silica, are tough and durable. In contrast to their metamorphic equivalents, quartzites, which break across their individual grains, sandstones break around the grains, giving the broken surface a granular appearance.

Pennsylvanian age Pounds Sandstone Member at Camel Rock, Garden of the Gods Recreation Area, within the Shawnee National Forest, Saline County.

Sandstone crops out in many places throughout the state. In Ogle and La Salle Counties, for example, many tons of almost pure quartz sand are mined from the St. Peter Sandstone and are sold for a variety of uses, including abrasive sand, molding sand, and sand for making glass. In extreme southern Illinois, attractively colored sandstones have been quarried for building stone.

A specially prepared St. Peter sand, known throughout the world as Standard Ottawa Testing Sand, is used to test the strength of cements and as a laboratory standard in physical tests of other sands.

Siltstone Siltstone is a clastic sedimentary rock consisting of silt-sized grains (0.00016 to 0.0025 inch or 0.0041 to 0.064 mm) held together by a cementing material; some siltstones are well cemented, and some are weakly cemented and disintegrate readily. This consolidated rock is intermediate in grain size between sandstone and shale. The composition is predominantly quartz and clay minerals; mica flakes may be present. In general, the individual grains in a siltstone are visible using a 10× magnification. If the individual grains are not distinguishable, then the fine-grained sedimentary rock is classified as a shale. Siltstones are most common in Illinois among rocks of the Pennsylvanian and in some rocks of the Mississippian Period. Siltstones generally do not have commercial value, although some occasionally have been used locally for building stone walls and similar projects.

Shale Shale is a common sedimentary rock composed primarily of lithified clay or mud. It is so fine-grained that the minerals forming it generally cannot be identified without the aid of x-ray diffraction or scanning electron microscopy. The particles of most clay minerals are thin and flat and overlap each other. These flat, overlapping clay minerals permit the shale to weather or be split into very thin layers that are approximately parallel to bedding. Shales that exhibit this characteristic are said to be fissile. This property of splitting into layers is called fissility and is a characteristic of shales and slates.

Shales are composed mainly of clay minerals but, like other sedimentary rocks, generally include other minerals. Shales containing calcium carbonate are called calcareous shales. Most shales contain some silt or sand particles; if silt or sand is present in large quantities, the rock is called silty shale or sandy shale. If mica minerals are present in quantity in a shale, it is called micaceous shale. Mudstone is a general term used to describe rocks with the composition of shale but lacking the fissility.

Shales have a wide range of colors, but most Illinois shales are gray or black. The black color is caused by organic matter in the shale; red, brown, yellow, or green colors are caused by iron compounds.

Crushed shale is used as a source for the clay used in the manufacture of bricks, drain tile, and building tile and can also be used as a lightweight aggregate.

Shale is widely distributed in Illinois, especially in Pennsylvanian age rocks.

Clay Clay is an unconsolidated rock made up of a group of hydrous aluminum silicate minerals, of which chlorite, montmorillonite, kaolinite, and illite are the most abundant. These minerals are formed by the weathering or alteration of other rocks and minerals. If clay is well consolidated, the result is called claystone. If clay is lithified, it is called shale or mudstone.

Clays are very fine-grained, and their minerals have tiny, flat crystals that can be distinguished from one another only by laboratory methods. Although clays may appear to be similar, their compositions and properties vary greatly.

Some clays are white, but most are colored by iron compounds and organic matter. Wet clays have an earthy odor and generally are slick and plastic, but dry clays are relatively hard and are greasy to the touch.

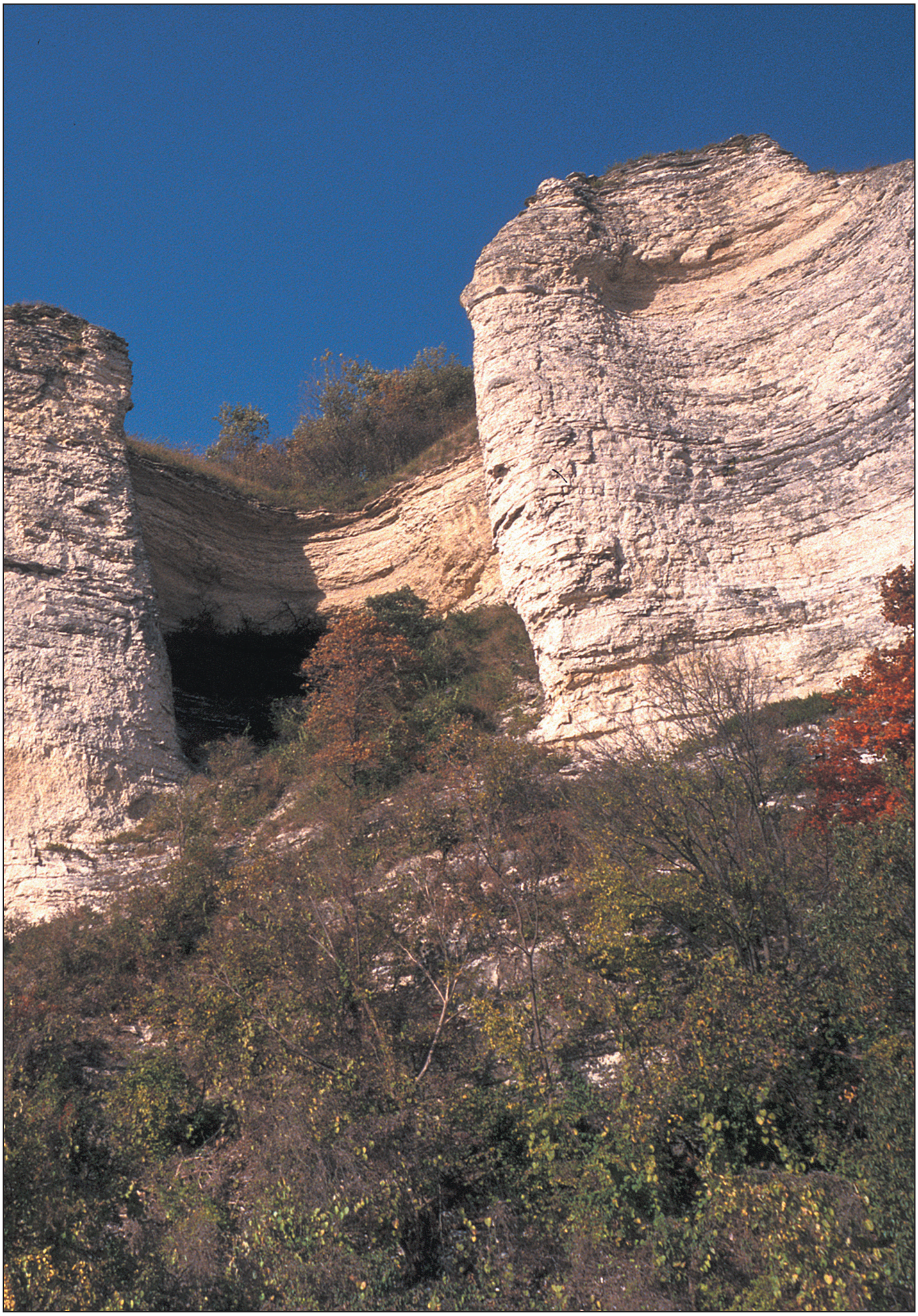
Clays are abundant in Illinois, especially in soils, in shales, and as clay deposits. In Illinois, the underclays that occur beneath coal beds are particularly well suited to the manufacture of bricks, pottery, stoneware, drain tile, paint, rubber, and drilling mud.

Fuller's Earth Fuller's earth is a very fine-grained earthy material composed of clay-sized or silty clay-sized material that is chiefly made up of the clay mineral montmorillonite. Fuller's earth is soft, nonplastic, and opaque; has a greasy feel when wet; and does not readily break up in water. Its color varies from blue-gray to yellow or buff.

Fuller's earth is valuable for its unique property of absorbing and decolorizing substances. The material was first used to "full" or remove grease from woolen cloth; hence, its name. Fuller's earth also has been used to filter and bleach mineral and vegetable oils by absorbing dark organic matter.

In Pulaski County in extreme southern Illinois, the Porter's Creek Formation contains deposits of clay that were at one time the source of fuller's earth and that still afford a clay with absorbent properties that make it useful as cat litter and as an absorbent cleaning compound for oil spills.

Limestone and Dolomite Limestone is a sedimentary rock composed of particles of calcite (calcium carbonate) or calcitic fragments of shelly organisms. The crystals may range from fine to coarse. Many limestones contain other minerals, such as chert, clay, or sand, and, in some places, limestones grade into dolomite (calcium-magnesium carbonate).



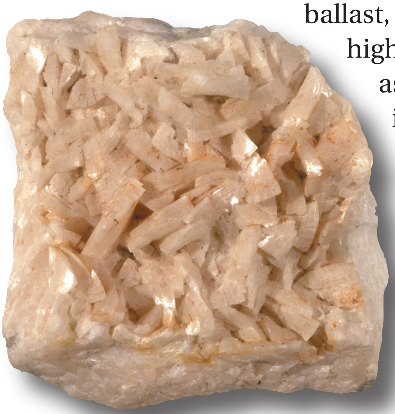
Limestone palisades, Madison County.

Many limestones are very light gray or gray. Yellow or brown shades are caused by iron oxide impurities, and dark gray to black colors are from organic matter. Limestones form in various ways. Some are deposited when calcium carbonate precipitates from solution; others are formed when the shells or skeletons of organisms such as brachiopods, clams, and corals accumulate on a sea floor. If such fossils are very abundant, the rock is called fossiliferous limestone. Limestone composed of rounded, sand-size grains is called oolite or oolitic limestone.

Fossiliferous Limestone with Bryozoans

Limestone effervesces freely in dilute hydrochloric acid or full-strength vinegar, but dolomite must be powdered before it effervesces. In nature, limestones may be dissolved by percolating groundwater containing weak acid (such as carbonic acid, composed of water and carbon dioxide). In many places, such solution of limestones has produced sinkholes, caves, and caverns, especially in the well-known Illinois karst terrain of southwestern Illinois in St. Clair, Monroe, and Randolph Counties.

Limestone has many uses: building stone, road surfacing, railroad ballast, portland cement manufacture, and, if of high purity, for making lime and chemicals and as a flux in smelting metals. Limestone also is added at coal-burning plants to curtail acid emissions—an important consideration when using Illinois coal. Agricultural limestone is used to add calcium to the soil, which reduces the soil acidity.



Dolomite Crystals

Limestone outcrops are abundant in Illinois, especially along the bluffs of the Mississippi, Ohio, and Illinois Rivers. Quarries that mine limestone or dolomite are scattered throughout Illinois.

Ordovician age dolomite, Savanna Blacktop Quarry, Carroll County.

Tripoli quarry, Alexander County, in southern Illinois.

Tripoli Tripoli, called amorphous silica in southern Illinois, is a white or light brown powdery substance that rubs off on the hands like chalk. It consists mostly of very small particles of quartz that result from the weathering of calcareous chert or highly siliceous limestone.

Tripoli is finely ground and used as "white rouge" for polishing optical lenses, as a filler in paints, in making ceramic products, as a component of buffing compounds, and as a fine abrasive.

Tripoli occurs in Alexander and Union Counties.

Tripoli with Brachiopod Shell Mold

Natural Mineral Products

Peat Peat is produced by the partial decomposition of plants that accumulate, with varying amounts of mineral matter, in wetlands, swamps, ponds, and lakes and in abandoned river channels in valley bottoms along many rivers and streams. Peat is an early stage in the formation of coal.

Peat ranges from light to dark brown. The color and compaction increase as depth of the deposit increases. Some of the plant remains are clearly distinguishable and appear as fibrous fragments held together by the fine peat particles. The type of peat common in Illinois has a high water content. Before peat is dried, it is soft and spongy to the touch; upon drying, it loses moisture and becomes harder.

Peat is used as a fuel in some parts of the world, but its heating value is much lower than coal. Peat burns with a long flame and leaves a great amount of ash because of the silt and sand that were deposited and buried along with the vegetation. Peat and peat moss are used chiefly as an absorbent, as stable bedding, as insulating and packing material, and by gardeners to increase the water-holding capacity of soils.

Peat is found in many places in Illinois, but the largest deposits are found in northeastern Illinois.

Bituminous Coal

Coal Coal, an organic stratified rock, is formed from accumulated plant material and partially decayed plants (peat) that were buried during the Pennsylvanian Period in Illinois more than 200 million years ago. Sediments deposited over the peat buried and compacted it. Chemical changes gradually took place and resulted in the loss of water and gases, leaving a higher percentage of carbon than the original material contained. This process is called coalification.

The amount of such change that has taken place determines the rank of the coal. The lowest rank is called lignite, the intermediate is called bituminous (soft) coal, and coals of the highest rank and the highest carbon content are called anthracite (hard) coal. Mineral matter, such as shale, clay, or pyrite, generally is present in the coal and becomes ash when the coal is burned.

All of the coal mined in Illinois is bituminous coal. It is black, brittle, and breaks into angular blocks; has a shiny luster; and generally shows a banded structure.

Coal mining is an important industry in Illinois, and the state contains the largest known reserves of bituminous coal in the United States. Minable coal beds underlie about two-thirds of the state. As many as twenty different coal beds have been mined in Illinois, the most important being the Herrin (No. 6) and the Springfield (No. 5) Coals. The coal in most mining areas averages 5 to 7 feet thick and in places may attain a thickness of 15 feet.

In underground mines, the coal is approached by vertical or inclined shafts. In surface mines, all of the overlying material (overburden) is removed, leaving the coal exposed. After mining, coal companies must restore surface-mined land. Coal beds that occur as much as 100 feet deep are now being surface mined in Illinois.

Illinois coal is used mainly for generating electric power, for industrial purposes, and for heating. In industry, coal is used extensively for power and heating; for firing clay products such as brick, tile, pottery, porcelain, and china; and for making coke.

When mixed with coal from the eastern United States, certain Illinois coals produce metallurgical coke for making steel. Gases, oils, and tars derived in processing coal for coke have been used for making many chemical products, including dyes, perfumes, explosives, medicines, insecticides, plastics, and road tar.

Petroleum Petroleum (crude oil) is classified as a mineral resource even though it is a liquid hydrocarbon and not technically a mineral or rock. Petroleum, however, is found in the pores and fractures of rocks. The color of crude oil ranges from yellow through green and brown to black.

Petroleum had its origin in the organic portions of marine plants and animals buried in ancient sediments. The organic matter changed slowly into the complex mixture of hydrogen and carbon compounds that constitute petroleum. Because gas is lighter than oil, and oil in turn is lighter than

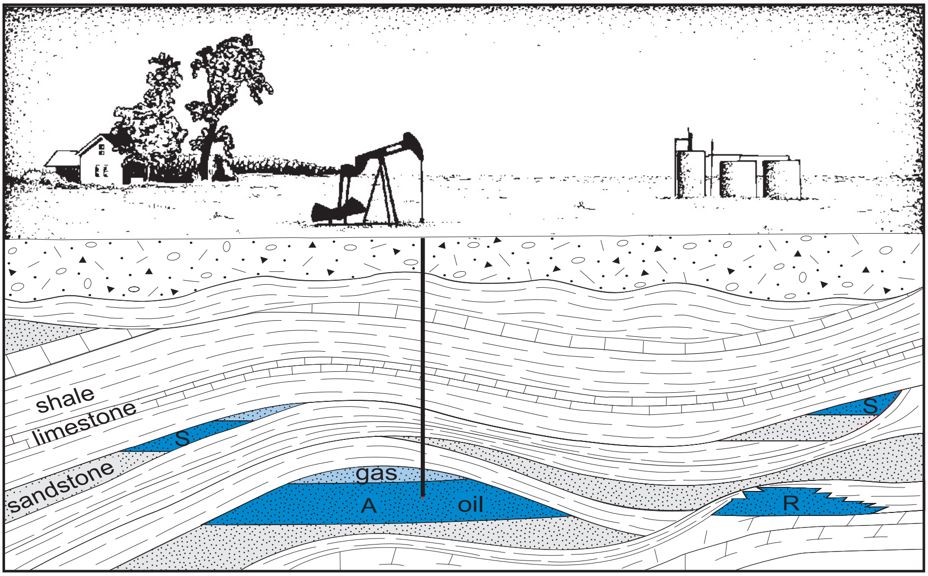


FIGURE 7 Impervious rocks such as shale trap oil and gas in crests or upwarps of rock layers. A = anticline trap, R = reef trap, S = stratigraphic trap.

water, gas and oil move upward in a porous rock containing all three. Gas moves to the highest position with oil next and water in the lowest part of the rock (figure 7). Oil pools exist where geologic barriers (called seals) have stopped the movement of gas and oil. Arches (upward folds or anticlines), breaks (faults), and lateral changes from porous to nonporous rock are geologic features that serve to trap oil pools within the reservoir rock.

Petroleum is obtained by drilling wells into the reservoir rock. Gas that is free or dissolved in the petroleum expands as pressure is released when the well is pumped and drives the oil to the well. Water in the reservoir rock also acts as a driving force. When this natural pressure is no longer effective, other methods (secondary recovery) are used to recover the oil remaining in the reservoir.

Porous sandstones and limestones are the main oil-bearing rocks. Illinois also has deposits of oil shale from which petroleum may be produced in the future. Most Illinois oil fields are located in central and southern Illinois.

Thousands of products are derived from petroleum, including gasoline, kerosene, naphtha, lubricating oils and waxes, medicinal oils, salves, heavy fuels, road oils, tar, and asphalt, and a wide variety of plastics and synthetic rubber.

Subsidiary Rock Forms

Glaciated Rock

Glaciated Pebbles Glaciated pebbles are small stones, the shapes of which have been altered by the grinding action of a glacier. Such pebbles commonly have at least one flattened side that shows scratches called striae. The striae were produced when the pebbles were pushed over bedrock or ground against other pieces of rock while being transported by glaciers.

Glaciers tore fragments from the bedrock over which they moved, and the fragments accumulated in, on, and under the mass of ice. The rock fragments were transported, some of them far from their source, and were deposited as the glacier moved along or when the ice melted. “Soft” rocks such as limestone and dolomite are easily scratched; “hard” igneous and metamorphic rocks are not as easily scratched. Therefore, soft rocks tend to have more striae.

Glaciated pebbles can be found in deposits in many parts of the state, especially in northeastern and east-central Illinois. However, many deposits near the surface have been weathered, and striae have been destroyed. Especially good places to look for striated pebbles are in the glacial drift overburden piles that have been removed at quarries and surface mines. Pebbles found in such deposits show good striae because they are only slightly weathered.

Concretions Concretions are concentrations of minerals within other sediments. Minerals that commonly form concretions are silica (in the form of opal, chert, chalcedony, and quartz), calcite, siderite, pyrite, marcasite, and limonite.

Concretions may form as the sediment around them is being deposited or later, after the sediment has hardened. They may be formed when water containing dissolved minerals seeps through the sediment or rock and leaves a concentration of mineral matter in a cavity or around a central particle (nucleus) such as the remains of a plant or animal. Portions of rock may also become firmly cemented by such mineral matter.

Loess Kindchen

Concretions range in size from minute particles to objects several feet in diameter. Shapes range from spheres to tubes. Many are globular or lumpy-surfaced; some are smooth. Because concretions generally are harder than the surrounding rock in which they have formed, they may remain after the surrounding material has been eroded.

Concretions of calcite are found in loess deposits. They may look like bizarre, knobby figurines, and the Germans called them loess kindchen (little children of the loess).

Ironstone concretions, which are especially common in many Illinois shales, are formed by a local concentration of the mineral siderite (iron carbonate) in the rock. The concretions found in weathered outcrops commonly are partly or entirely weathered to limonite. Some ironstone concretions grow together into odd shapes. Mazon Creek ironstone concretions of northeastern Illinois, world famous for their fossils, are sideritic. The concretions are commonly covered with limonite, the result of oxidation.

Siderite Concretion

Limonite concretions, generally with a high content of clay, silt, or sand, occur in loess, shale, and sandstone.

Concretions of chert and other forms of silica are common in limestones. In many places, because of their greater resistance to weathering, lenses and nodules of chert protrude from the beds.

Pyrite or marcasite occurs as concretions or concretion-like masses in some coal beds and in the black shales, sometimes popularly called "slates," above coal beds. Some other Pennsylvanian clays and shales also contain concretions or coarsely crystalline aggregates of these minerals.

Geodes Geodes are roughly spherical, hollow bodies that may be filled with layers of minerals, lined with crystals, or both. As a rule, the outer layer of geodes found in Illinois is composed of chalcedony, a form of fine microcrystalline silica. Geodes are commonly associated with limestone and dolomite or, at some places, with shale. Quartz is the most common mineral deposited in geodes, but calcite, aragonite, dolomite, siderite, pyrite, galena, fluorite, and sphalerite also are found.

Geodes differ from concretions in that geodes grow inward from the outer shell, but concretions develop outward from a center. Even if geodes have been completely filled by mineral matter, their inward-projecting crystals prove that they formed within a cavity. In a partly filled cavity, crystals generally are well formed because they grew without being crowded. Some of the best mineral specimens known in Illinois are found as crystal linings in geodes. Hollow geodes are the most desirable because they have better crystals. They can be distinguished from solid ones by their comparative lightness.

Geodes ranging in size from less than one inch to a foot or more in diameter can be gathered from streams where they have accumulated as residual boulders after the rock in which they were enclosed has been eroded.

In Illinois, geodes can be found most easily in the Warsaw Formation in the area of Nauvoo, Hamilton, and Warsaw, but they also occur in other areas and in other formations.

Geodes

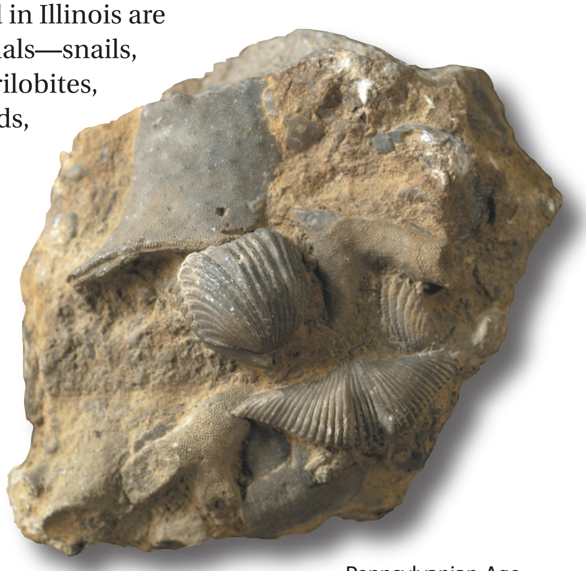
Animal Fossils Prehistoric animals lived in water, on land, and in the air, and these animals left both direct and indirect evidence of their existence—evidence we now call fossils.

Most ancient animals died without leaving a trace, but some, especially those that had hard parts such as shells, bones, or teeth, may be found preserved in rocks much as they were when buried beneath sediments on the floor of an ancient sea. Sometimes only imprints of the outside (molds) or fillings of the inside of the shells (casts) remain, the original material having been completely dissolved. Footprints of land or amphibious animals, burrows made by clams, or holes made by worms are called trace fossils.

The animals whose remains are fossilized lived and died while the sediments that contained them were being deposited. Fossils provide clues to the variety of life and climate that existed in the past. Fossils of animals characteristic of a certain geological time period are an index to the age of formations where they occur. For example, if a certain trilobite is known to have lived only during a definite time, then all rocks in which the trilobite is found are the same age.

Some of the oldest fossils found in Illinois are shells of Paleozoic marine animals—snails, corals, crinoids, brachiopods, trilobites, pelecypods (clams), cephalopods, bryozoa, arthropods, fish, and others. The youngest fossils are the teeth and bones of prehistoric bison, giant beavers, deer, mammoths and mastodons of the Ice Age, and snails found in loess deposits.

Fossils of animals that lived in the ancient seas are found in carbonate rocks in many parts of Illinois, especially in quarries, river bluffs, and road cuts.



Pennsylvanian Age Brachiopods and Bryozoa from Will County

Plant Fossils Plant fossils are the remains of prehistoric plants. Woody structures of plants aid preservation just as hard parts of animals do. Leaves and plants without much woody material generally are well preserved only if they were buried quickly in fine, soft sediment.

The most famous Illinois plant fossils are those from the Mazon Creek area in Grundy and Will Counties in northeastern Illinois. There the plant material acted as a nucleus around which iron minerals accumulated to form concretions. Many good fossils—of trunks, branches, leaves, and seeds—are found in coals and in shale directly overlying coals. Descendants of Pennsylvanian plants, such as ferns, mosses, and rushes, are still living today, but they no longer thrive as they did in the warm, moist climate of the Pennsylvanian age forests.

Some plants of Pennsylvanian age are petrified, and occasionally such trees or stumps are found. Petrified trees are found also in the upper Mesozoic deposits of southern Illinois. Fossils of Ice Age plants closely related to forms living at the present time are occasionally found in peat bogs or scattered throughout glacial deposits.

Plant Fossil
from Mazon Creek

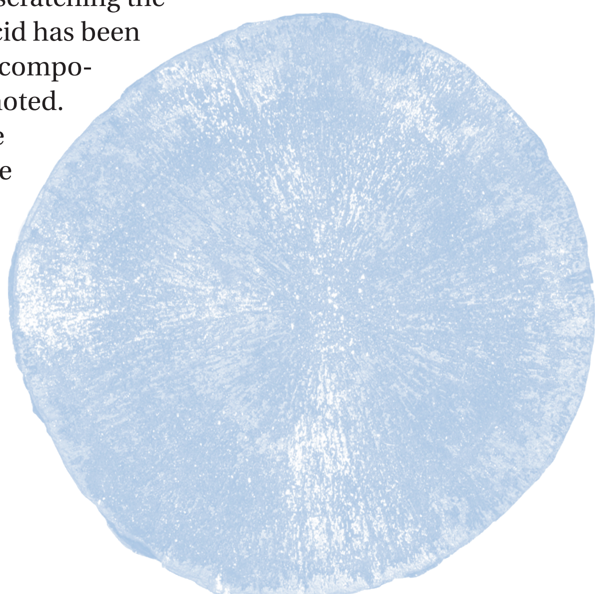
Keys for Identification of Common Illinois Rocks and Minerals

Two keys, one for rocks and one for minerals, present clues that may aid the collector in identifying rocks and minerals found in Illinois. In outline form, the keys are a guide to some of the easily observable properties that various rocks and minerals display.

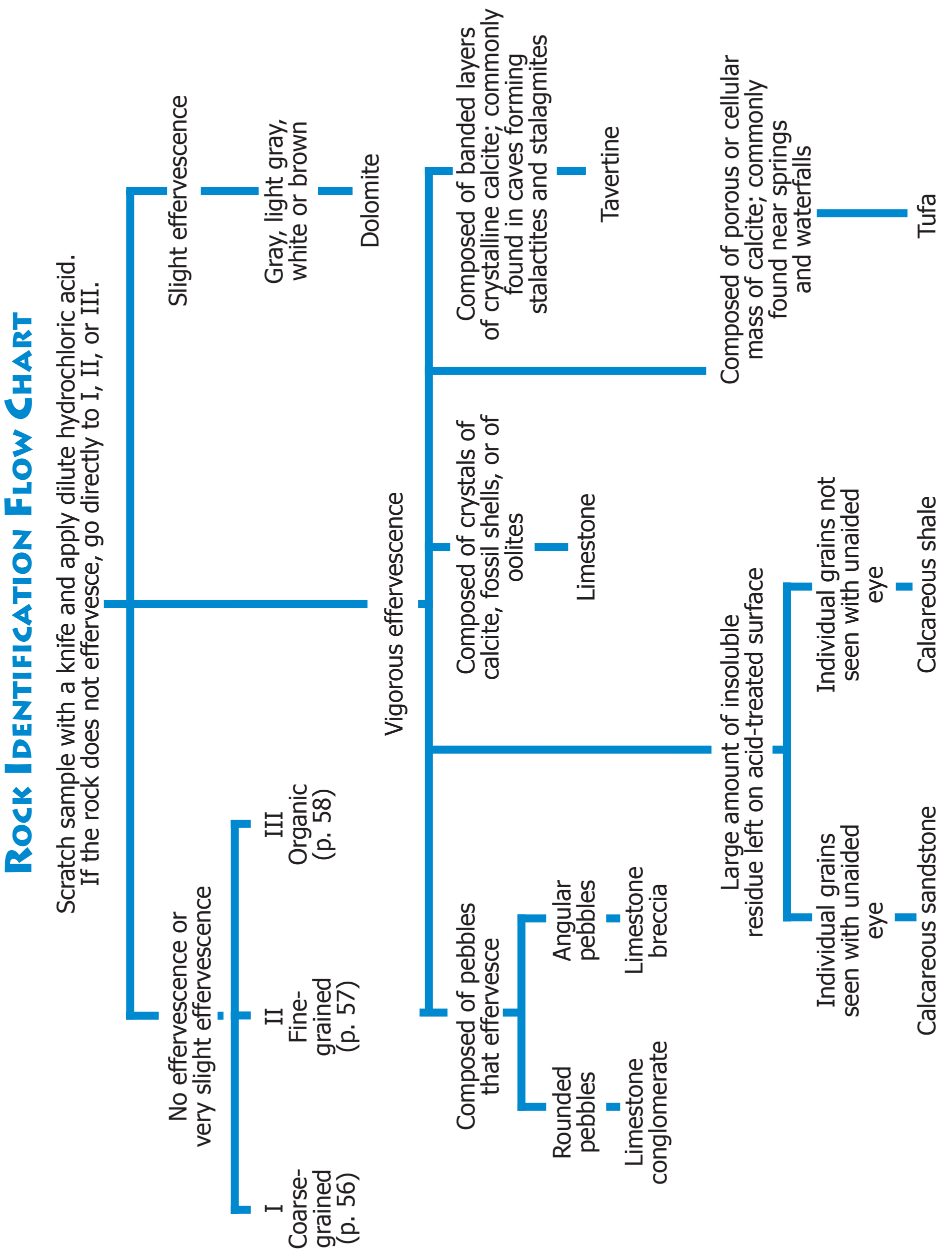
The key includes all rocks and minerals in the ISGS school set, *Typical Rocks and Minerals of Illinois,* plus other relatively common rocks and minerals that can be found in Illinois. Because of the great diversity of rocks and minerals in this state, the keys are not conclusive. Other, more complete guides (such as that in the *Manual of Mineralogy*) should be consulted when identifying rocks and minerals that are from other states or Illinois specimens that are difficult to identify.

The minerals are arranged in two groups: (1) those with metallic luster and (2) those with nonmetallic luster. Each group is arranged according to increasing hardness. Other characteristics such as color, streak, cleavage, fracture, and composition are listed.

The rocks are arranged according to their reaction to dilute hydrochloric acid applied to a scratched surface. (The acid reacts more readily to powdered material produced by scratching the rock.) After the reaction to acid has been determined, the texture and components of the rock should be noted. Because rocks grade into one another, clear distinctions are not always possible.



Rock Identification Flow Chart



Rock Identification Key

I. Coarse-grained rocks

A. Rock consists of interlocking grains or crystals, easily seen; too hard to scratch with a knife.

1. Crystals aligned in one direction.

a. Crystals in parallel bands with layers of quartz and feldspar separated by mica and other minerals.	Gneiss
b. Crystals in thin parallel bands; tends to split into thin sheets parallel to banding; some varieties may be scratched with a knife.	Schist

2. Crystals not aligned in any particular direction.

a. Light gray, pink, red, or tan with only a few dark minerals; feldspar and quartz principal minerals.	Granite
b. Dark to medium gray; composed of feldspar and dark minerals with little quartz.	Gabbro
c. Dark green to black; essentially dark minerals, may have some feldspar; quartz generally lacking.	Lamprophyre
d. Light color; similar to granite in texture but lacks quartz; composed of feldspar and some dark minerals.	Syenite
e. Large, easily seen crystals set in a fine-grained to extremely fine-grained background; any color.	Porphyry
f. Essentially quartz; grains may be identifiable; specimens break through rather than around grains.	Quartzite

B. Rock composed of individual rock particles or fragments, non-interlocking crystals, cemented or not cemented together; may or may not be scratched with a knife.

1. Particles or fragments not uniform in size; a mixture of pebbles, sand, and smaller materials.

a. Solid rock consisting of large rounded particles or fragments cemented together or in a sand matrix.	Conglomerate

b. Solid rock consisting of large angular particles or fragments cemented together.	Breccia
c. Fragments ranging in size from clay to large boulders; may be compacted, but not cemented; much clay generally present; may effervesce when 10% hydrochloric acid is applied.	Glacial till (diamicton)
d. Loose particles of many sizes, not cemented together; some particles may effervesce.	Gravel
2. Rock particles or fragments, about the size of sugar grains.	
a. Loose particles consisting largely of quartz.	Sand
b. Solid rock consisting largely of individual grains of quartz; granular; breaks around rather than through grains.	Sandstone

II. Fine-grained rocks

A. Cannot be scratched easily with a knife; crystals or particles not easily seen with the unaided eye; very hard; difficult to break; may contain a few crystals or particles large enough to see; granular.

1. Dense; brittle; splintery or conchoidal fracture; sharp edges and corners when broken; often associated with limestone; usually white or gray; very dense; dark varieties called flint.	Chert
2. Light gray, pink, red, or tan varieties common; boulders or fragments in the glacial drift.	Felsite
3. Dark gray, greenish, black, or maroon varieties common; may have small mineral-filled cavities; occurs as boulders or fragments in the glacial drift.	Basalt
4. Essentially quartz; grains may be identifiable; specimens break through rather than around grains.	Quartzite

B. May or may not be scratched with a knife; fairly uniformly fine-grained.

1. Soft; feels slippery or soapy when wet; may disintegrate in water; gives off an earth odor when breathed upon. Comes in many colors.	Clay/claystone

2. Loose; gritty; particles smaller than table salt; commonly gray.	Silt
3. Solid rock; often in thin beds or sheets; separates into silt; mica flakes may be present; may contain fossils; may effervesce slightly.	Siltstone
4. Solid rock; breaks into thin platy sheets; may feel slippery when wet; black to gray; may contain fossils; shows thin laminations or may effervesce.	Shale
5. Solid rock; does not break into thin platy fragments; may effervesce slightly.	Mudstone
6. Solid rock; usually gray or black; splits into platy sheets or slabs; harder than shale; occurs in glacial deposits.	Slate
7. Powdery; white or light brown; commonly associated with chert and limestone from which it forms; may contain fossils.	Tripoli

III. Organic rocks (dark colored)

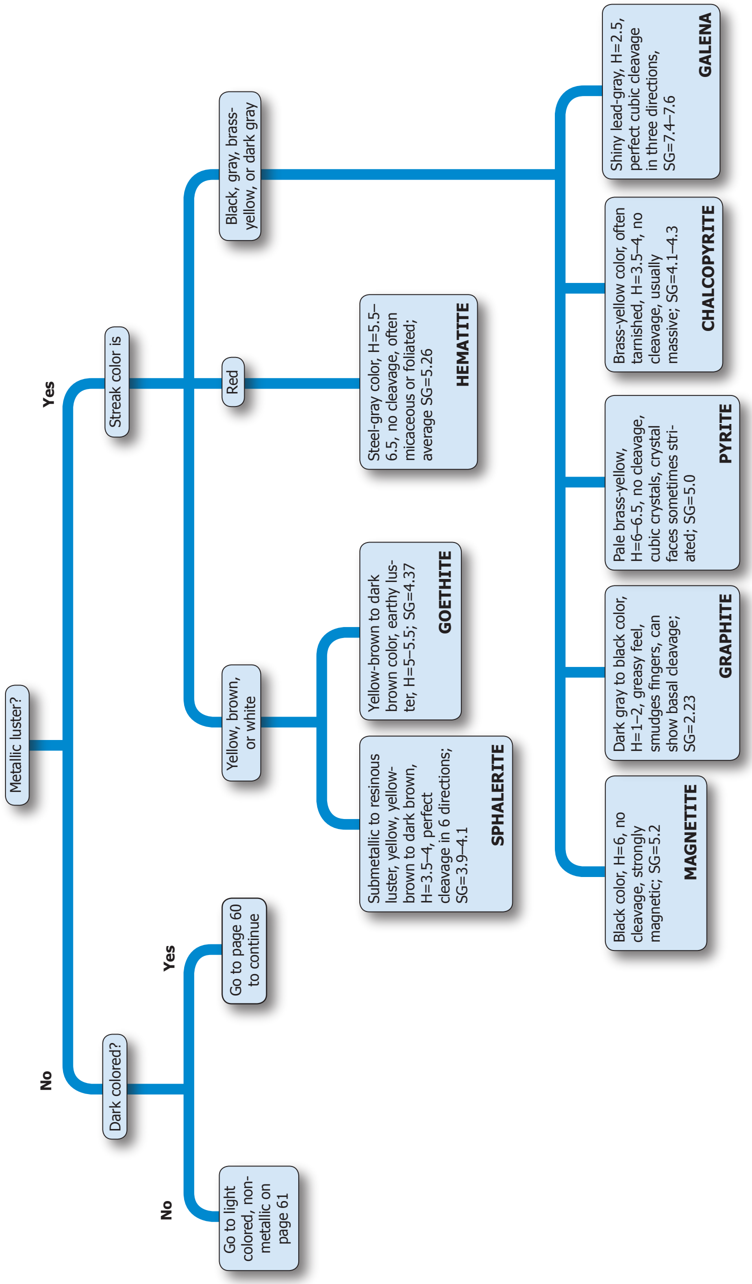
A. Soft; spongy when wet; very lightweight when dry; forms in swampy places.

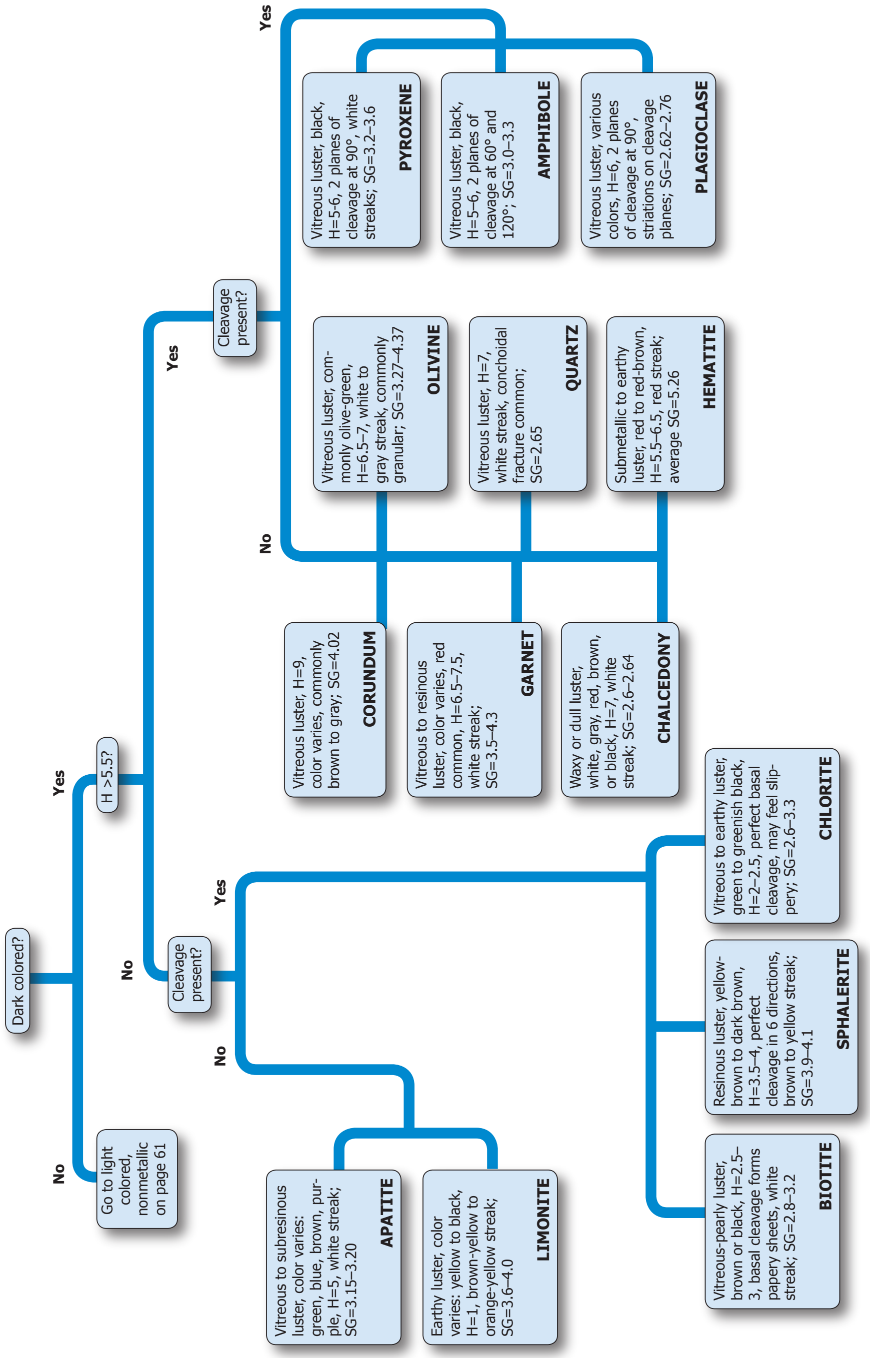
1. Fine mass with coarse plant fragments; dark gray to black.	Peat
2. Plant fragments small and not easily recognized; fine-grained; black to dark gray; earthy.	Muck

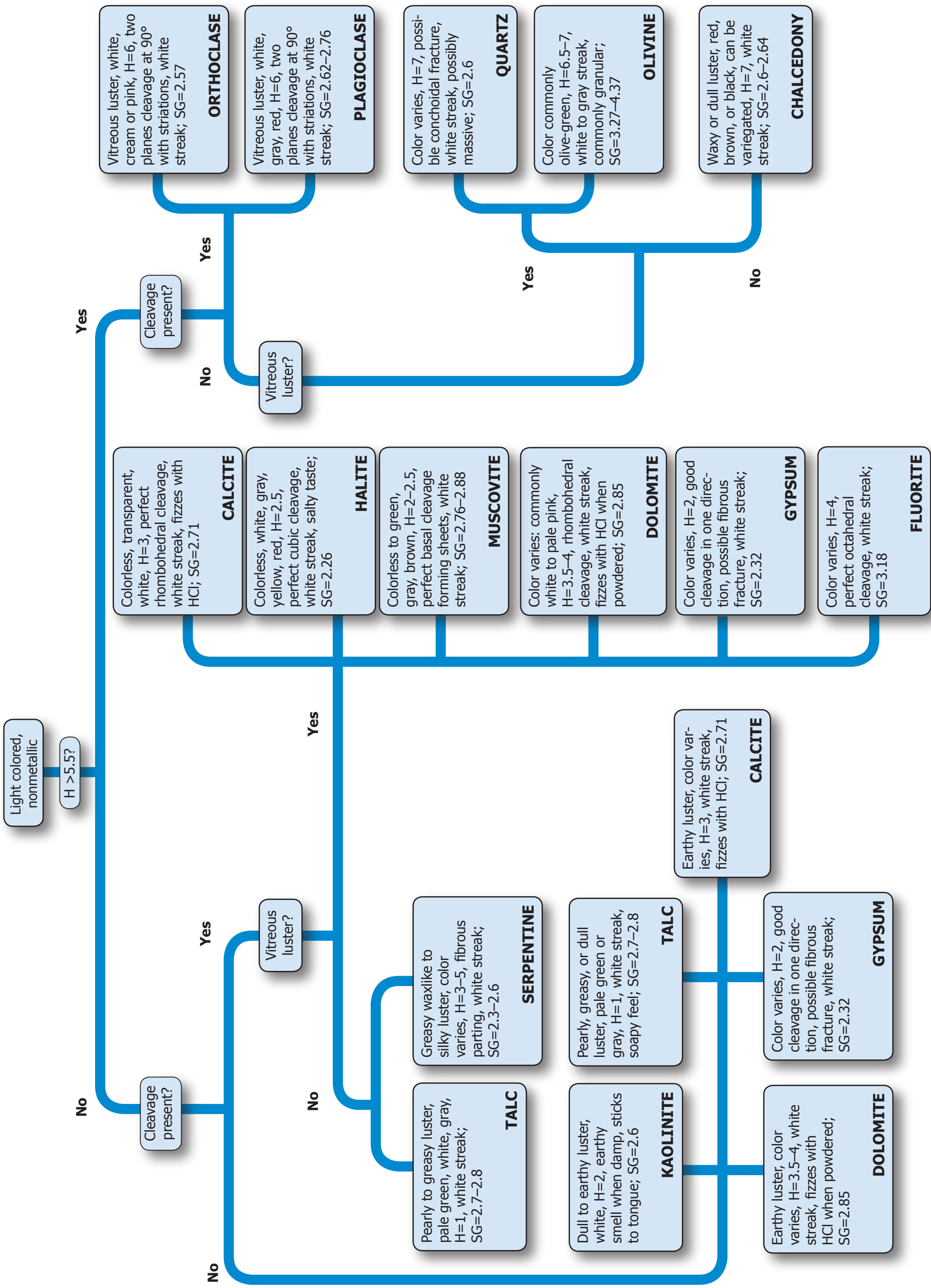
B. Hard but can be scratched with a knife.

1. Black; contains bands of shiny and dull material; burns well.	Coal
2. Dark gray to black; does not contain shiny bands; splits into thin sheets; burns poorly or not at all.	Bituminous shale

Mineral Identification Flow Chart




Dark colored?
No
Yes
Go to light colored, nonmetallic on page 61
H >5.5?
No
Yes
Cleavage present?
Yes
No
Vitreous to subresinous luster, color varies: green, blue, brown, purple, H=5, white streak; SG=3.15–3.20
APATITE
Earthy luster, color varies: yellow to black, H=1, brown-yellow to orange-yellow streak; SG=3.6–4.0
LIMONITE
Vitreous to earthy luster, green to greenish black, H=2–2.5, perfect basal cleavage, may feel slippery; SG=2.6–3.3
CHLORITE
Resinous luster, yellow-brown to dark brown, H=3.5–4, perfect cleavage in 6 directions, brown to yellow streak; SG=3.9–4.1
SPHALERITE
Vitreous-pearly luster, brown or black, H=2.5–3, basal cleavage forms papery sheets, white streak; SG=2.8–3.2
BIOTITE
Cleavage present?
Yes
No
Vitreous luster, black, H=5-6, 2 planes of cleavage at 90°, white streaks; SG=3.2–3.6
PYROXENE
Vitreous luster, black, H=5–6, 2 planes of cleavage at 60° and 120°; SG=3.0–3.3
AMPHIBOLE
Vitreous luster, various colors, H=6, 2 planes of cleavage at 90°, striations on cleavage planes; SG=2.62–2.76
PLAGIOCLASE
Vitreous luster, commonly olive-green, H=6.5–7, white to gray streak, commonly granular; SG=3.27–4.37
OLIVINE
Vitreous luster, H=7, white streak, conchoidal fracture common; SG=2.65
QUARTZ
Submetallic to earthy luster, red to red-brown, H=5.5–6.5, red streak; average SG=5.26
HEMATITE
Vitreous luster, H=9, color varies, commonly brown to gray; SG=4.02
CORUNDUM
Vitreous to resinous luster, color varies, red common, H=6.5–7.5, white streak; SG=3.5–4.3
GARNET
Waxy or dull luster, white, gray, red, brown, or black, H=7, white streak; SG=2.6–2.64
CHALCEDONY


Light colored, nonmetallic
H >5.5?
Yes
Cleavage present?
Yes
Vitreous luster, white, cream or pink, H=6, two planes cleavage at 90° with striations, white streak; SG=2.57
ORTHOCLASE
Vitreous luster, white, gray, red, H=6, two planes cleavage at 90° with striations, white streak; SG=2.62–2.76
PLAGIOCLASE
No
Vitreous luster?
Yes
Color varies, H=7, possible conchoidal fracture, white streak, possibly massive; SG=2.6
QUARTZ
Color commonly olive-green, H=6.5–7, white to gray streak, commonly granular; SG=3.27–4.37
OLIVINE
No
Waxy or dull luster, red, brown, or black, can be variegated, H=7, white streak; SG=2.6–2.64
CHALCEDONY
No
Cleavage present?
Yes
Vitreous luster?
Yes
Colorless, transparent, white, H=3, perfect rhombohedral cleavage, white streak, fizzes with HCl; SG=2.71
CALCITE
Colorless, white, gray, yellow, red, H=2.5, perfect cubic cleavage, white streak, salty taste; SG=2.26
HALITE
Colorless to green, gray, brown, H=2–2.5, perfect basal cleavage forming sheets, white streak; SG=2.76–2.88
MUSCOVITE
Color varies: commonly white to pale pink, H=3.5–4, rhombohedral cleavage, white streak, fizzes with HCl when powdered; SG=2.85
DOLOMITE
Color varies, H=2, good cleavage in one direction, possible fibrous fracture, white streak; SG=2.32
GYPSUM
Color varies, H=4, perfect octahedral cleavage, white streak; SG=3.18
FLUORITE
No
Pearly to greasy luster, pale green, white, gray, H=1, white streak; SG=2.7–2.8
TALC
Greasy waxlike to silky luster, color varies, H=3–5, fibrous parting, white streak; SG=2.3–2.6
SERPENTINE
No
Dull to earthy luster, white, H=2, earthy smell when damp, sticks to tongue; SG=2.6
KAOLINITE
Pearly, greasy, or dull luster, pale green or gray, H=1, white streak, soapy feel; SG=2.7–2.8
TALC
Earthy luster, color varies, H=3, white streak, fizzes with HCl; SG=2.71
CALCITE
Earthy luster, color varies, H=3.5–4, white streak, fizzes with HCl when powdered; SG=2.85
DOLOMITE
Color varies, H=2, good cleavage in one direction, possible fibrous fracture, white streak; SG=2.32
GYPSUM

Mineral Identification Key

Color	Streak	Hardness	Cleavage	Fracture	Remarks	Name and composition	Specific gravity
Metallic luster, streak colored, with a hardness of ≥2.5							
Lead gray	Black	2.5	Cubic; perfect in 3 directions	Subconchoidal or even	Very heavy; occurs as crystals, grains, or masses; easily identified by color and cleavage.	Galena PbS	7.4–7.6
Copper red	Metallic, shiny	2.5	None	Jagged	Very heavy; apt to have green coating; distorted or wirelike forms; malleable.	Native copper Cu	8.9
Metallic luster, streak colored, with a hardness >2 but ≤6.5							
Brassy yellow	Greenish black	6	Poor	Conchoidal to uneven	As compact masses, grains, cubes, and in 8- and 12-sided crystals; commonly associated with coal and with lead-zinc ores of northwestern Illinois.	Pyrite FeS_2	5.0
Pale brassy yellow to silver-white	Greenish gray	6	Poor	Uneven	As fibrous, radiating, tabular, and cockscomb crystals or compact masses; usually lighter colored than pyrite, but difficult to distinguish from pyrite; associated with coal and with lead-zinc ores of northwestern Illinois.	Marcasite FeS_2	4.89
Nonmetallic luster, streak colored, with a hardness >2 but ≤6.5							
Yellow-brown to black	Yellow-brown	5.5 (may be as low as 1)	None	Uneven	In earthy masses; coloring material in many sandstones, conglomerates, and soils; often mixed with and difficult to distinguish from goethite and other iron minerals.	Limonite $FeO(OH)\cdot H_2O$	3.6–4.0

Color	Streak	Hardness	Cleavage	Fracture	Remarks	Name and composition	Specific gravity
Nonmetallic luster, streak white, with a hardness ≤2 (can be scratched by a fingernail)							
Usually white, but may be almost any color	-	2	Perfect in one direction, less perfect in two others	-	Commonly found in Illinois as twinned or needle-shaped crystals in weathered shales containing pyrite and calcium carbonate.	Gypsum $CaSO_4 \cdot 2H_2O$	2.32
White or a shade of green	-	2	-	-	As needle-shaped crystals or powdery coating on pyrite or marcasite.	Melanterite $FeSO_4 \cdot 7H_2O$	1.9
Nonmetallic luster, streak white, with a hardness >2 but ≤3 (can be scratched by a penny)							
Colorless, silver-white, gray, brown	-	2–2.5	Perfect in one direction	-	As scales or "books"; splits into thin sheets; common in sandstones, shales, and igneous and metamorphic rocks, such as schist.	Muscovite (white mica) $KAl_2(Si_3Al)O_{10}(OH)_2$	2.76–2.88
Brown or black	-	2.5–3	Perfect in one direction	-	As scales or "books"; splits into thin sheets; common in igneous and metamorphic rocks such as granite or gneiss, but not in sedimentary rocks.	Biotite (black mica) $K(Mg, Fe)_3(Si_3Al)O_{10}(OH)_2$	2.8–3.2
Colorless, white, gray, and various tints	-	3	Perfect in three directions, not at right angles (rhombohedral)	-	Common mineral; effervesces vigorously in cold acid; occurs in many crystal forms and as fibrous, banded, and compact masses; chief mineral in limestones.	Calcite $CaCO_3$	2.71
White, gray, red, or almost any color	-	3	Perfect in one direction, less perfect in two other directions	-	Very heavy; commonly in tabular crystals united in diverging groups, as laminated or granular masses; associated with fluorite in southern Illinois.	Barite $BaSO_4$	4.5

Color	Streak	Hardness	Cleavage	Fracture	Remarks	Name and composition	Specific gravity
Nonmetalic luster, streak white, with a hardness >3 but ≤5 (cannot be scratched by a penny; can be scratched by a knife)							
White, gray, light yellow	-	3.5	In one direction	Uneven	Relatively heavy; effervesces in acid; associated with fluorite and barite in southern Illinois, but is not abundant.	Witherite $BaCO_3$	4.3
White, pink, gray, or light brown	-	3.5	Perfect in three directions; not at right angles (rhombohedral)	-	In grains, rhombohedral crystals and cleavable or granular masses; effervesces slowly in cold acid when powdered, more vigorously in warm acid; principal mineral in rock called dolomite; crystals found in vugs.	Dolomite $CaMg(CO_3)_2$	2.85
Colorless, white, gray, grayish black	-	3–3.5	-	-	In fibrous or compact masses or may be in orthorhombic crystals as a coating on galena; very heavy; formed by alteration of galena.	Cerussite $PbCO_3$	6.55
Brown to gray	Usually white, but may tend toward brown when weathered	3.5–4	In three directions; not at right angles (rhombohedral) slightly curved surfaces	-	In fibrous or botryoidal masses or rhombohedral crystals; effervesces in hot acid.	Siderite $FeCO_3$	3.96
Yellow, yellow-brown to almost black	Light yellow to brown	3.5–4	Parallel to dodecahedral faces; in six directions	-	In crystals, in fibrous or layered masses; associated with galena in northwestern Illinois and with fluorite and galena in southern Illinois.	Sphalerite ZnS	3.9–4.1
Colorless, white, yellow, purple, green, blue	-	4	Perfect, parallel to octahedral faces; in four directions	-	In cubes and cleavable masses; many colors; mined in Hardin and Pope Counties.	Fluorite (fluorspar) CaF_2	3.18

Color	Streak	Hardness	Cleavage	Fracture	Remarks	Name and composition	Specific gravity
White, tinted yellow, blue, or green	-	4-4.5	-	-	As crystalline incrustations or in earthy or compact masses; associated with fluorite-sphalerite ores in southern Illinois and with galena and sphalerite in northwestern Illinois.	Smithsonite $ZnCO_3$	4.3–4.45
Nonmetallic luster, streak white, with a hardness >5 but ≤7							
White, green, brown, black	-	5–6	In two directions intersecting at about 60 and 120 degrees	-	In long, slender six-sided crystals; cleavage angle important in differentiating from pyroxenes; common in metamorphic and some igneous rocks.	Amphibole Group $(Mg, Fe, Ca)_7 Si_8O_{22}(OH)_2$ May also contain Na or Al	3.0–3.3
Gray, dark green, black, dark brown, bronze	-	5–6	In two directions intersecting at about 90 degrees	-	Crystals short, stout, and eight-sided; cleavage angle important in differentiating from amphiboles; common in igneous and some metamorphic rocks.	Pyroxene Group $(Mg, Ca, Fe)_2 Si_2O_6$	3.2–3.6
White, gray, pink, light blue, green		6	In two directions; nearly at right angles	-	As crystals, cleavable masses, and grains; common in igneous and metamorphic rocks, also found in river sands and gravels; many varieties.	Feldspar Group (K, Na, Ca) $(Al, Si)_4O_8$	2.57–2.76
White when pure; may be colored by impurities	-	7	None	Conchoidal	Finely crystalline variety of quartz; botryoidal or concretionary masses; lining in geodes; forms agates.	Chalcedony SiO_2	2.6–2.64
Colorless, white, or almost any color	-	7	-	Conchoidal	Most abundant mineral; occurs in six-sided crystals capped by pyramids in geodes. In grains or masses; principal mineral in sandstone, also abundant in igneous and metamorphic rocks.	Quartz SiO_2	2.6

Color	Streak	Hardness	Cleavage	Fracture	Remarks	Name and composition	Specific gravity
Red	-	7	-	Conchoidal	A variety of quartz usually colored red by hematite inclusions; common in glacial and river sand and gravel found along Lake Michigan shores and in the Mississippi River.	Jasper SiO_2	2.6–2.64
Many; arranged in bands	-	7	-	Conchoidal	Cloudy banded variety of silica; widely used as semi-precious stones. Silicified wood is a form of agate; found in glacial gravels and upper Mesozoic sediments in southern Illinois.	Agate SiO_2	2.6–2.64
Nonmetallic luster, streak white, with a hardness >7 (cannot be scratched by quartz)							
Red, brown, yellow, green, black, white	-	7.5	Poor	Even	Irregular grains or masses; sometimes as 12-, 24-, and 36-sided crystals; abundant in glacial sands and Lake Michigan beach sands; common in metamorphic rocks.	Garnet Group $(Ca, Mn, Fe, Mg)_3 (Al, Cr)_2 (SiO_4)_3$	3.5–4.3

Selected Readings

Bradbury, J.C., G.C. Finger, and R.L. Major, 1968, Fluorspar in Illinois: Illinois State Geological Survey, Circular 420, 64 p.

Learn more about the official state mineral—its geology, mining history, and uses. Although no longer mined in Illinois, the state was once the leading U.S. producer of fluorspar.

Collinson, C., 2002, Guide for Beginning Fossil Hunters: Illinois State Geological Survey, Geoscience Education Series 15, 48 p.

This update of an ISGS classic publication features twenty-two full-page plates of fossil drawings and eight color plates of fossil photographs. Tips on collecting fossils and descriptions of basic fossil types make this publication an excellent source of information for beginning collectors ages 8 to adult.

Johnsen, O., 2002, Minerals of the World, Princeton Field Guides: Princeton, New Jersey, Princeton University Press, 440 p. ISBN: 069109537X.

A well-illustrated and informative book covering more than 500 minerals. Over 600 color photographs and crystallographic diagrams located next to the text descriptions help with identification.

Killey, M.M., 1998, Illinois' Ice Age Legacy: Illinois State Geological Survey, Educational Series 14, 66 p.

This book introduces the legacy of the glaciers that advanced and retreated across Illinois in the last 1.8 million years. Described are the history of the glaciers that covered Illinois, the deposits they left behind, and how geologists study and learn about them.

Klein, C., 2001, Manual of Mineralogy (after James D. Dana): John Wiley and Sons, New York, 656 p. ISBN: 0471251771.

This standard college text for mineralogy is a great reference for the advanced collector.

Pough, F.H., and R.T. Peterson,1998, Field Guide to Rocks and Minerals, The Peterson Field Guide Series: Boston, Houghton Mifflin Co., 542 p. ISBN: 039591096X.

A standard reference for many years and still a great field guide.

Symes, R.F., 2000, Rocks and Minerals; Eyewitness Books: New York, DK Publishing Inc., 64 p. ISBN: 0789458047.

Beautifully illustrated and a great resource for generating interests in early collectors.

Symes, R.F., and R.R. Harding, 2000, Crystal and Gem; Eyewitness Books: New York, DK Publishing Inc., 64 p. ISBN: 0789457644.

Part of the same Eyewitness Books series as *Rocks and Minerals,* this volume also is a well-illustrated, great resource for beginning collectors.

Zim, H.S., and P.R. Shaffer, 1970, Rocks and Minerals, Golden Nature Guide: New York, Golden Press, 160 p. ISBN: 0307244997.

Without a doubt, one of the most popular books for beginners, well illustrated with drawings.

Mineral Identification Worksheet

Mineral #__________________ Hardness____________________

Streak______________________ Luster_______________________

Color_______________________ Specific Gravity_______________

Cleavage____________________ Fracture_____________________

Special Properties____

____

____

Mineral Name____

The Geoscience Outreach program of the Illinois State Geological Survey uses many channels to inform the public about the geology and mineral resources of the state and the results of the Survey's research projects. The Survey distributes nontechnical publications, offers sets of rock and mineral specimens to Illinois schools and educational groups, presents lectures and exhibits, responds to inquiries, conducts workshops for teachers, and leads field trips. The Survey's full-day field trips, conducted in widely separated areas of the state, offer teachers, students, and the general public the opportunity to learn about the geologic processes that shaped the land and formed the rocks and glacial deposits.

The Geoscience Outreach program is specifically designed to assist in the teaching of earth sciences and to help citizens understand how the research programs of the Illinois State Geological Survey help to protect the environment and strengthen the economy of Illinois.