MINERALS SORTED BY MINERAL GROUP

Most minerals are chemically classified as native elements, sulfides, sulfates, oxides, silicates, carbonates, phosphates, halides, nitrates, tungstates, molybdates, arsenates, or vanadates. More information on and photographs of these minerals in Kentucky is available in the book "Rocks and Minerals of Kentucky" (Anderson, 1994).

NATIVE ELEMENTS (DIAMOND, SULFUR, GOLD)

Native elements are minerals composed of only one element, such as copper, sulfur, gold, silver, and diamond. They are not common in Kentucky, but are mentioned because of their appeal to collectors.

DIAMOND

Crystal system: isometric. Cleavage: perfect octahedral. Color: colorless, pale shades of yellow, orange, or blue. Hardness: 10. Specific gravity: 3.5. Uses: jewelry, saws, polishing equipment.

Diamond, the hardest of any naturally formed mineral, is also highly refractive, causing light to be split into a spectrum of colors commonly called play of colors. Because of its high specific gravity, it is easily concentrated in alluvial gravels, where it can be mined. This is one of the main mining methods used in South Africa, where most of the world's diamonds originate. The source rock of diamonds is the igneous rock kimberlite, also referred to as diamond pipe. A nongem variety of diamond is called bort.

Kentucky has kimberlites in Elliott County in eastern Kentucky and Crittenden and Livingston Counties in western Kentucky, but no diamonds have ever been discovered in or authenticated from these rocks. A diamond was found in Adair County, but it was determined to have been brought in from somewhere else.

SULFUR

Crystal system: orthorhombic. Fracture: uneven. Color: yellow. Hardness 1 to 2. Specific gravity: 2. Sulfur smells like rotten eggs and burns easily.

Sulfur crystals occur in geodes and nodules in the Borden–Fort Payne Formation in south-central Kentucky.

Although native sulfur is not common in Kentucky, sulfide and sulfate minerals, which are composed of sulfur and other elements, are common.

GOLD, SILVER, PLATINUM

Crystal system: isometric. Cleavage: octahedral. Color: brilliant yellow, paler if it has high silver content. Hardness: 2.5 to 3. Luster: metallic. Specific gravity: 19.3. Tenacity: malleable and ductile. Uses: jewelry, coins.

Gold is not common in Kentucky, but is included here because of its appeal. Gold has been of value to mankind for centuries because of its color, weight, and malleability.

Gold commonly occurs in microscopic amounts in the earth and in seawater, and is commonly found in metamorphic rocks and in quartz veins associated with igneous rocks. During weathering, gold can occur as placer deposits, where it accumulates in streams beds and soil horizons, including glacial outwash.

Silver (color: gray to silver white; hardness: 2.5 to 3; specific gravity: 10.5) and platinum (color: steel gray; hardness: 4; specific gravity: 21.5) do not have good cleavage and are not common in Kentucky, but are sometimes associated with gold.

SULFIDES (GALENA, PYRITE, MILLERITE, SPHALERITE)

Sulfide minerals, such as sphalerite, galena, pyrite, and millerite, are compounds of sulfur with another element.

GALENA

Crystal system: isometric. Cleavage: perfect cubic, although octahedrons are common as truncations to the cube. Color: silver to lead gray. Hardness: 2.5. Streak: grayish black. Luster: bright metallic. Specific gravity: 7.5. Tenacity: sectile. Uses: batteries, gasoline, type metal, solder, low-fusion alloys, telephone and telegraph cable coverings, protective shielding against radiation.

Galena is the chief ore of lead. It is recovered as a byproduct of fluorspar mining in western Kentucky. It has been recovered from the Columbia Mines in Crittenden County and Silver and Royal Mines in Livingston County. It also occurs to a limited extent in the central Kentucky vein system, where it used to be mined near Gratz in Owen County, and in vein deposits in Scott and Franklin Counties. In both of these areas, galena crystals can be found along with barite and sphalerite crystals. Galena also occurs with calcite, dolomite, fluorite, and pyrite.

PYRITE, CHALCOPYRITE, BORNITE, MARCASITE

Crystal system: isometric. Cleavage: when present, crystals are usually cube-shaped; crystal faces commonly marked by parallel lines called striations. Color: pale brass yellow to golden yellow. Hardness: 6.0 to 6.5. Streak: brown to black. Luster: metallic. Specific gravity: 5.0. Tenacity: very brittle. Uses: sulfuric acid.

When scratched or crushed, pyrite has a sulfurous smell.

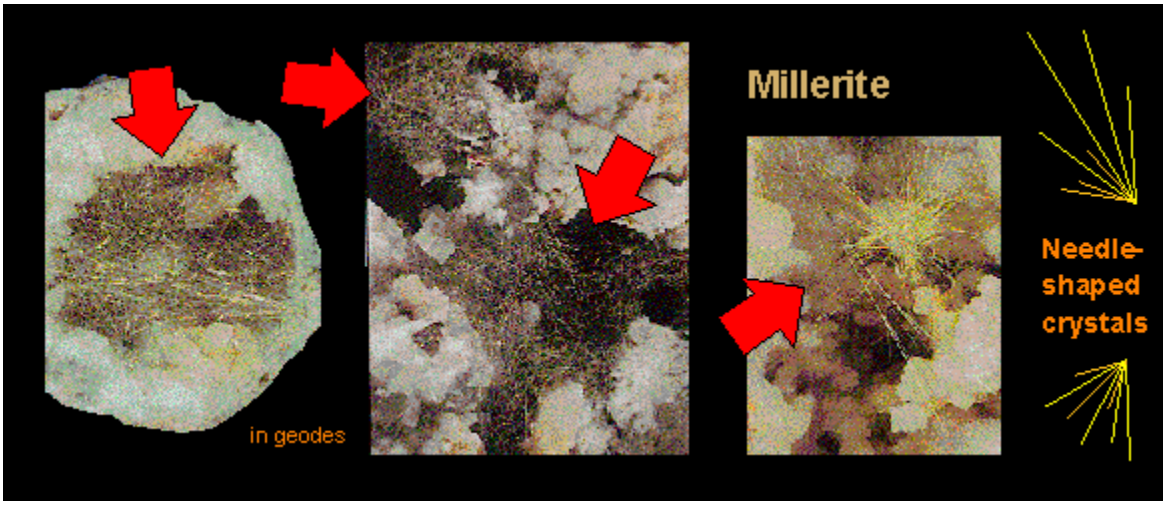
Pyrite has a brown to black streak (white unglazed tile is a streak plate).

Because of its brassy yellow color, pyrite is often mistaken for gold: hence its common name, fool's gold. In Kentucky, pyrite and marcasite are very common in several different rock types and in geodes, especially in strata associated with coal beds and in the Chattanooga Shale. Cubic pyrite and pyritohedrons can be collected from coal mines, and pyrite cubes occur with millerite at Halls Gap in Lincoln County. Pyrite can be massive with no crystals visible, or it can have euhedral cubic crystals. In some states pyrite can be mined, but there are no deposits large enough to be mined in Kentucky.

Pyrite occurs frequently with chalcopyrite, bornite, and marcasite. Chalcopyrite, also known as fool's gold, is commonly tarnished and iridescent. Bornite is known as peacock ore because it is iridescent and produces an array of colors.

Marcasite crystals have a pale-bronze color, hardness of 6.0 to 6.5, and a tabular cleavage that resembles cockscombs or spearheads. Marcasite, also called white iron pyrite, readily tarnishes yellow to brown and decomposes to a white powder. Immersion in epoxy will retard the decomposition process.

MILLERITE, HONESSITE



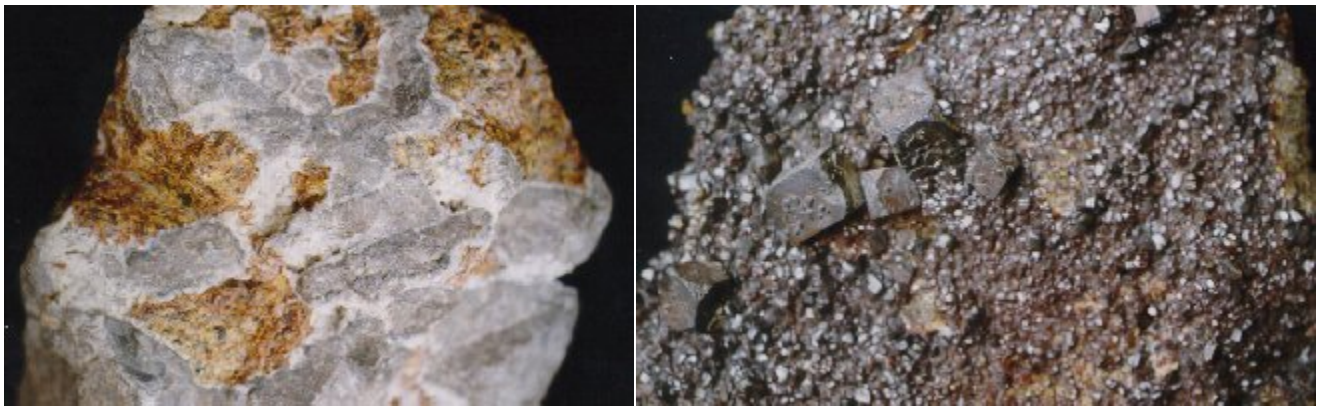
Crystal system: hexagonal; individual crystals can be twisted, spiraled, or offset along the crystal axis. Cleavage: usually does not occur in cleavable masses. Color: brass yellow. Hardness: 3.5. Luster: metallic. Specific gravity: 5.5.

Millerite is an acicular (needle-like) mineral that occurs in interwoven groups of radiating crystals, usually in geodes and cavities. Millerite hydrates (water is incorporated into its chemical composition) to honessite ($NiS \cdot H_2O$), which has the same mode of occurrence as millerite, but is commonly green to brown and acicular. Capillary pyrite has also been associated with millerite.

Since the early 1960s, millerite from Halls Gap near Stanford in Lincoln County has been a prized collector's item. Most mineral books have pictures of millerite, honessite, and capillary pyrite collected from the Halls Gap locality. Millerite and honessite occur in the Wildie Member of the Borden Formation. Most millerite geodes are small, but some are as big as softballs. Pyrite cubes and calcite crystals have also been observed attached to millerite hairs, and a pyrite ring was observed in one geode (Anderson, 1994).

SPHALERITE, GREENOCKITE

Crystal system: isometric. Color: yellowish brown to black. Hardness: 3.5 to 4.0. Streak: pale yellowish brown. Luster: resinous to adamantine. Specific gravity: 4.0. Tenacity: brittle. Uses: galvanizing iron, brass, die castings; associated cadmium used for batteries and in the electronics industry. Associated minerals: germanium and gallium are used to produce transistors, diodes, and rectifiers.



Sphalerite is also called zincblende or blackjack and is a common vein-forming mineral in numerous mines in central, southern (above left), and western Kentucky, where it has been mined. It is predominantly associated with galena (above right), but also occurs with barite, fluorite, calcite, pyrite, and chalcopyrite.

Sphalerite has been mined from the Hutson Mine in Livingston County, and the Lexington Quarry Co. has mined sphalerite from a vein deposit in Jessamine County for several years, producing very fine, dark brown to black, tetrahedral crystals. There is a large unmined zinc deposit in southern Kentucky (Anderson and Price, 1991). The sphalerite there is associated with calcite, barite, and gypsum.

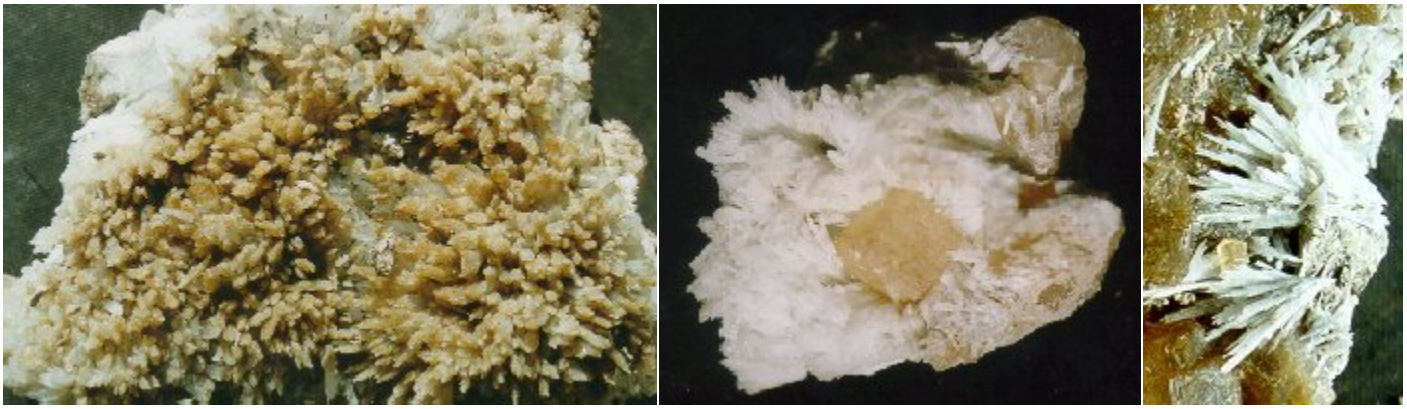
Cadmium, a trace element commonly found in sphalerite, forms the mineral greenockite. Greenockite occurs as orange or yellow crystals or coatings associated with sphalerite. Germanium and gallium, also trace elements in sphalerite, are produced as byproducts of sphalerite in the fluorspar area in western Kentucky.

SULFATES (BARITE, CELESTITE, GYPSUM, SECONDARY SULFATES)

Sulfates are compounds combined with both sulfur and oxygen, such as gypsum, barite, and anglesite.

BARITE

Crystal system: orthorhombic. Cleavage: often in groups of platy or tabular crystals. Color: usually white, but may be light shades of blue, brown, yellow, or red. Hardness: 3.0 to 3.5. Streak: white. Luster: vitreous to pearly. Specific gravity: 4.5. Tenacity: brittle. Uses: in heavy muds in oil-well drilling, to increase brilliance in the glass-making industry, as filler for paper, cosmetics, textiles, linoleum, rubber goods, paints.



Barite generally occurs in a white massive variety (often appearing earthy when weathered), although some clear to bluish, bladed barite crystals have been observed in several vein deposits in central Kentucky, and commonly occurs as a solid solution series with celestite where barium and strontium can substitute for each other. Various nodular zones have been observed in Silurian–Devonian rocks in east-central Kentucky. Rosettes are common in many Kentucky mineral veins. Feathery barite is also known in Kentucky.

Barite is extremely insoluble in acid and water and is therefore chemically inert. It is the principal source of the element barium. Barite is the most abundant of the semi-commercial vein-forming minerals in central Kentucky. Until World War I, barite was mined along with fluorite and sphalerite in Jessamine, Woodford, and Fayette Counties. Limited barite mining was attempted during the 1960s in Lincoln and Boyle Counties. Commercial barite was recovered as a byproduct of fluorspar production in western Kentucky during World War II and the 1960s.

CELESTITE

Crystal system: orthorhombic. Cleavage: tabular or prismatic. Color: generally white, but may be tinted blue or pink. Hardness: 3.0 to 3.5. Streak: white. Luster: glassy to pearly. Specific gravity: 3.9. Tenacity: brittle. Uses: fireworks, flares, tracer bullets, refining sugar beets, ceramic and glass industries, caustic soda solutions.

Celestite is the principal ore of strontium and occurs as a solid-solution series with barite where strontium and barium can replace each other. It is not common in Kentucky, but is sometimes found in vein deposits and lining cavities in limestones. Good celestite crystals have been found in nodules and geodes in Ordovician rocks in Woodford and Jessamine Counties, in Silurian rocks in Montgomery County, and in Mississippian rocks in Rockcastle and Lincoln Counties. The geodes are generally composed of an outer shell of siliceous material, such as chalcedony, and inner parts of celestite and associated minerals such as calcite, fluorite, barite, gypsum, and quartz.

GYPSUM, ANHYDRITE

Crystal system: monoclinic. Color: colorless when pure, but often stained gray to yellow. Hardness: 2.0. Streak: white. Luster: glassy. Specific gravity: 2.32. Uses: plaster, wallboard, pottery molds, orthopedic and dental plasters, portland cement.


Gypsum usually occurs as a massive variety, although crystals are common. A fibrous variety is called satin spar; it has a silky luster and is found as vein fillings and as thin layers in shales and limestones. Selenite is a transparent crystalline variety. Excellent selenite specimens and curved gypsum have been collected from the Lexington Quarry Co., where foot-long crystals have been discovered and are on display in the foyer of the Mining and Mineral Resources Building on the UK campus. The New Providence Formation in northwestern Marion County also has good gypsum crystals. The gypsum occurs as diamond-shaped crystals that often grow together to form "swallowtail twins." Numerous "gypsum flowers" adorn the walls of many caves in Kentucky.




From a commercial standpoint, rock gypsum is the most important variety. It is an aggregate of crystals that range from less than 0.1 millimeter to more than 2.0 millimeters in diameter. Bedded rock-gypsum deposits associated with

anhydrite occur deep underground in the St. Louis Limestone in northwestern Kentucky and at moderate depths southwest of Louisville.

Anhydrite (crystal system: orthorhombic; color: white, gray, or bluish; hardness: 3.5; streak: white; luster: vitreous; specific gravity: 3.0) usually hydrates to gypsum. Anhydrite crystals have been found in well cuttings of deep oil wells, in nodules in Wayne County, and in some vein deposits.

SECONDARY SULFATES

Many other sulfates occur in lesser amounts in various parts of Kentucky. They are fragile, fibrous, granular, or powdery, clear to white masses (except for copiapite). These minerals occur in coal beds, coal mines, and the black shale. Most of these minerals are difficult for the experienced collector to distinguish, and some may require analysis for correct identification. These minerals are humidity-sensitive and their chemistry may change when they are dehydrated. Epsomite is white and occurs as delicate encrustations. Melanterite is a white powdery mineral with glassy luster. Alunite is white and massive, and is distinguished from limestone and dolomite by not effervescing in an acid test. Copiapite occurs as a loose crust with a distinctive yellow color. Mirabilite forms white, massive crusts. Haliotrichite and pickeringite are massive and white, with silky luster and astringent taste.

Goslarite is a rare secondary zinc mineral that has been reported in the Western Kentucky Fluorspar District. It may be white to reddish, with good cleavage, and forms in acicular, orthorhombic crystals. Anglesite is white and soft, has a hardness of 3, and heavy specific gravity of 6.4. It is also rare but can be found in oxidized lead deposits.

OXIDES (GOETHITE, HEMATITE, ILMENITE, LIMONITE, PYROLUSITE, RUTILE, URANIUM MINERALS)

Oxides are elements combined with oxygen. Oxide minerals are iron oxides, titanium oxides, manganese oxides, and uranium oxides, and oxygen can form with carbon or silica to form carbonates and silicates.

GOETHITE

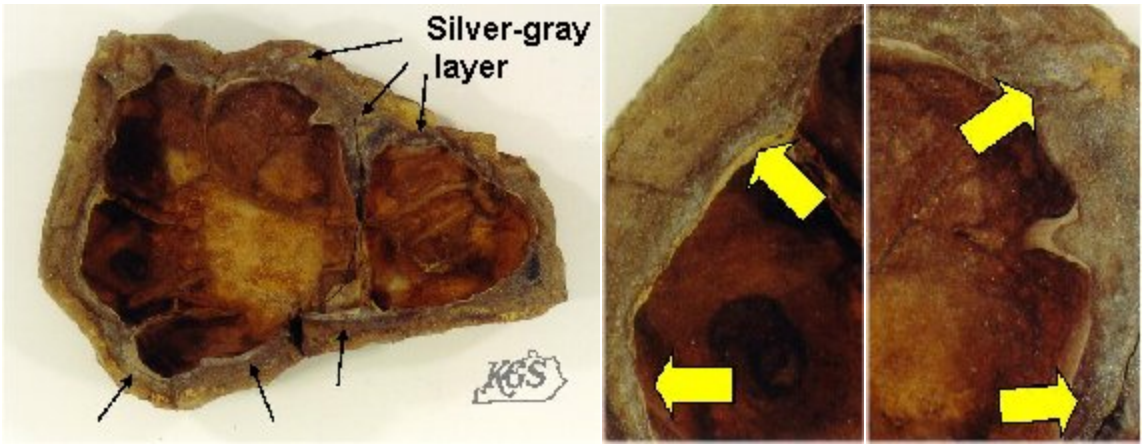
Crystal system: orthorhombic. Color: yellowish brown to dark brown. Hardness: 5.0 to 5.5. Streak: brownish-yellow. Luster: dull to adamantine. Specific gravity: 4.37.

Goethite usually occurs in massive, stalactitic, fibrous, or botryoidal (grape-like) forms, and exhibits radial growth. Goethite weathers from preexisting iron minerals. In western Kentucky, goethite is associated with limonite in porous earthy masses called bog iron ore. Goethite is mined as an ore of iron in some areas, but is noncommercial in Kentucky.

HEMATITE

Crystal system: hexagonal. Cleavage: indistinct. Color: brownish red, steel gray, or black. Hardness: 5.5 to 6.0. Streak: cherry red. Luster: dull to metallic, opaque. Specific gravity: 5.2.

Hematite occurs in platy, compact, granular, or earthy masses. When individual grains are red and about the size and roundness of fish eggs, the mineral is called oolitic hematite; when it occurs in plates or scales as mica does and is steel gray, it is called micaceous or specular hematite; and when it occurs as a fine powder that can be mixed with oil and used as a paint pigment, it is called red ocher. Hematite is often the red cementing material in sandstones, and is found to a lesser extent in red clays and shales. It is readily distinguished from all other minerals by its cherry red streak.



Specular hematite is the sparkling silver-gray band (arrows) in this limonite concretion.

Hematite is the most important ore of iron, and also the most important metallic mineral in the world. The value of the pig iron and steel manufactured from it every year exceeds the value of any other metal.

During the late 19th century, oolitic hematite was mined in Bath County in northeastern Kentucky. In this area, hematite is found in the Brassfield Dolomite of Silurian age and the Boyle Limestone of Devonian age. The average thickness of the iron-bearing beds is 3 feet, and the higher grade ore ranges in iron content from 46 to 57 percent. Iron ore of this type occurs in Silurian rocks from New York to Alabama. Because of its limited thickness in Kentucky, and because of vast supplies of hematite ore in the Great Lakes region, mining in Kentucky became unprofitable.

Hematite crystals have been observed lining the cavities of geodes from Estill County. These crystals are dark brown, bladed, and visible to the naked eye.

Hematite can also occur in association with fossils in eastern Kentucky. The productid brachiopods pictured above were replaced by siderite, which oxidized to hematite, giving the brachiopods a silver-gray color. The yellow mineral on the right brachiopod is the mineral limonite, another iron oxide.

ILMENITE

Crystal system: hexagonal. Color: black to brownish black. Hardness: 5.0 to 6.0. Streak: black to brownish red. Specific gravity: 4.3 to 5.5. Magnetism: slightly magnetic; more magnetic when heated. Uses: pigment for white paints.

Ilmenite is considered a heavy mineral and commonly occurs with rutile in the McNairy Sands in western Kentucky and in peridotite dikes in eastern and western Kentucky. It was mostly deposited in ancient, near-shore sandstone environments. Although the mineral is very noticeable in beach sands as black specks, it is used as a pigment for white paints; the refining process removes traces of iron and other deleterious materials to create a white refined product.

PYROLUSITE

Crystal system: tetragonal. Color: black. Hardness: 2 to 6.

Pyrolusite is commonly found as a secondary mineral and forms in a black, dendritic pattern in sedimentary rocks. It is commonly called wad. The black, soft, sooty mineral is associated with hematite, siderite, and limonite, and is found in the Givens vein in the Western Kentucky Fluorspar District and in sandstones in eastern Kentucky.

RUTILE

Crystal system: tetragonal. Color: red to black. Hardness: 6. Streak: yellow or brown. Specific gravity: 4.3. Uses: source of titanium.

Rutile generally occurs with ilmenite and has been noted in the peridotite dikes of eastern and western Kentucky. Rutile also occurs in the McNairy Sands in the Jackson Purchase Region and has been mined in Tennessee, Florida, and parts of the East Coast.

URANIUM MINERALS, URANINITE

Crystal system: isometric. Color: black to dark gray. Hardness: 5 to 6. Specific gravity: 9 to 10.

Some radioactive minerals have been reported in the black shale that crops out around the Bluegrass Region. Other occurrences of uranium minerals have been reported in eastern Kentucky, including one at Bell Falls in Menifee County. These radioactive minerals are detected by Geiger counter or scintillometer, since the minerals themselves are usually too small to see with the naked eye. Uraninite generally occurs as massive, botryoidal (grape-like), or banded coatings. The microcrystalline variety of uraninite is called pitchblende. Because of rapid oxidation, the radioactive decay process, and numerous hydrous phases, uraninite can have many chemical variations.

SILICATES (CALAMINE-HEMIMORPHITE, FELDSPARS, GARNETS, MICAS, OLIVINE, PEROVSKITE, QUARTZ, SERPENTINE, CLAY MINERALS)

Silicates are arrangements of the elements silicon and oxygen with a wide variety of other elements. The most common silicates are quartz and feldspars. Quartz is abundant in Kentucky, and some of the feldspars occur as very fine grains in sandstones in Kentucky.

CALAMINE-HEMIMORPHITE

Crystal system: orthorhombic. Cleavage: tabular. Color: clear to white, with yellow or red iron-staining common. Hardness: 4.5 to 5. Luster: vitreous. Specific gravity: 3.4.

Calamine is an older name for the rare mineral hemimorphite. It forms in oxidized zinc deposits. Hemimorphite is commonly associated with smithsonite and cerussite, and occurs in clusters of radiating, acicular crystals. A massive variety contains worm-like shapes. Hemimorphite occurs in zinc-bearing vein deposits in the Western Kentucky Fluorspar District in Crittenden and Livingston Counties.

FELDSPAR GROUP (DIVERSE SILICATES)

Crystal system: monoclinic and triclinic. Cleavage: good at 90 degree angle. Hardness: 6.

The feldspars are an important rock-forming group of minerals, but their occurrence in Kentucky is limited to very small detrital fragments of sandstones and cement that are only visible with microscopes.

GARNET (DIVERSE SILICATES)

Crystal system: isometric. Color: various. Hardness: 6.5 to 7.5. Luster: vitreous. Specific gravity: 3.5 to 4.3. Uses: semi-precious stone, industrial abrasive saws, polishing tools.

The garnet group of silicates has a diverse chemical composition consisting of calcium, aluminum, magnesium, and chromium silicates. Some minerals included in the garnet class are pyrope (red to black), almandine (red), grossularite (green yellow), and uvarovite (green). It is translucent to transparent. Pyrope and almandine are abundant in ultramafic dikes in Elliott County, and many can be obtained by panning in the alluvial sediments near the dikes. An unusual garnet, schorlomite has been detected in igneous dikes in western Kentucky. Garnets can also be found in some glacial erratics in northern Kentucky and in metamorphic rocks in the Appalachian Mountains in Virginia and North Carolina.

MICA GROUP (BIOTITE, MUSCOVITE, PHLOGOPITE)

Crystal system: monoclinic. Cleavage: cleaves into sheets; flexible when bent. Color: dark gray to black (biotite), white to light brown (muscovite). Hardness: 2.5 (biotite) to 3.0 (muscovite). Specific gravity: 2.7 (muscovite) to 3.0 (biotite).

Muscovite and biotite generally occur in igneous and metamorphic rocks, but in Kentucky they are commonly found as detrital sediment in sandstones, shales, and clays. Mica minerals are commonly mistaken for gold because of their golden color and cleavage, which causes light to be reflected easily. The magnesium-rich phlogopite has similar physical characteristics as biotite and muscovite, and is found in kimberlite dikes in Elliott County and in western Kentucky.

OLIVINE

Crystal system: orthorhombic. Fracture: conchoidal. Color: green. Hardness: 6.5 to 7. Luster: glassy. Specific gravity: 3.3 to 4.3.

Olivine is a common igneous rock-forming mineral and occurs in both basaltic rocks and the kimberlite dike in Elliott County. Transparent gem-quality varieties are known as peridot. Olivine alters readily to serpentine.

PEROVSKITE

Fracture: uneven. Color: black to dark brown. Hardness: 5.5. Luster: metallic. Specific gravity: 4.

Perovskite can occur as cubic crystals and massive or reniform (kidney-shaped) masses. It is found in ultramafic rocks and in the peridotite dikes in eastern and western Kentucky.

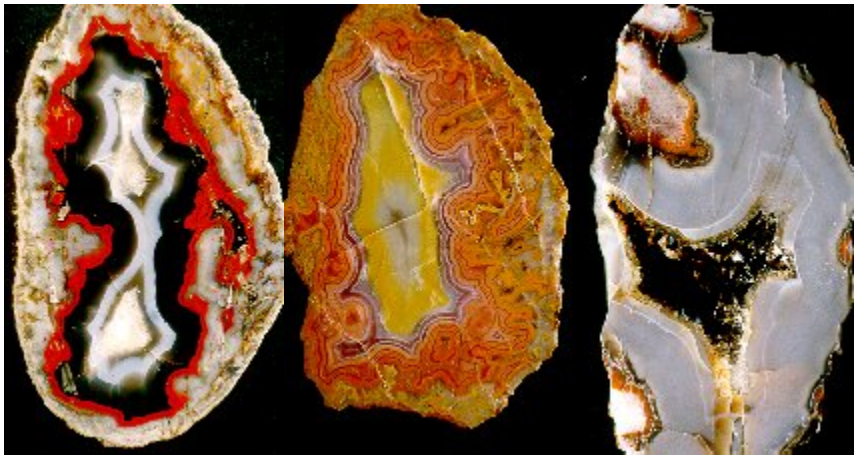
QUARTZ (INCLUDING AGATE, CHERT, FLINT, AND JASPER)

Crystal system: hexagonal. Fracture: conchoidal. Color: colorless or white, but may be tinted various colors (for example, amethyst is purple). Hardness: 7.0. Streak: colorless. Luster: glassy. Specific gravity: 2.65. Uses: jewelry, prehistoric arrowheads, knives (flint), gravel (chert).

Quartz is the hardest, most resistant mineral found in abundance in Kentucky. It is the main constituent in sandstones and geodes, and also occurs as vein quartz. Crystals usually consist of six-sided hexagonal prisms capped by pyramids on one or both ends. Quartz crystals are found in geodes that occur in several different rock types, particularly

limestone. In south-central Kentucky, valleys and stream beds downslope from the Warsaw-Salem Formation are filled with geodes, some containing amethyst.

Several cryptocrystalline (microscopic crystals) varieties of quartz occur in Kentucky. They are commonly recognized on the basis of their fibrous texture and granularity. The fibrous varieties include chalcedony, agate, onyx, and jasper, and granular varieties include chert and flint.



Kentucky agate.

Agate has delicate and varying shades of color arranged in layers. In the typical occurrence, the bands are irregular, curved, or in concentric patterns. Agate is used as an ornamental material or in semi-precious jewelry. The color banding is usually related to chemical impurities; for example, iron gives a red or orange color and manganese or calcium give black or blue colors.

For the past decade, beautiful specimens of red, black, yellow, and gray banded agate have been discovered in Estill, Jackson, Powell, Madison, and Rockcastle Counties. These Kentucky agates are derived from the Renfro-Borden Formation of Early Mississippian age and can be collected along some river drainages where the Borden is exposed to weathering. Many of these agates are displayed at local rock shows. More pictures of Kentucky agates can be seen in the Kentucky Agate section of this website and in the book, "Kentucky Agate: State Rock and Mineral Treasure of the Commonwealth" (McIntosh and Anderson, 2013).

Flint is dark brown to black and breaks with a conchoidal fracture into fragments with sharp cutting edges. It is found in limestones or in soils derived from limestones.

Chert and jasper.

Chert and flint are cryptocrystalline varieties of quartz. Chert is usually gray to white; flint is dark brown to black. Chert and flint are very hard and break with a splintery fracture. Chert is usually associated with dolostone and limestone and occurs as lenses, irregular layers, and nodules, but some rock units are composed almost entirely of chert. Chert abounds in the upper St. Louis Limestone in south-central Kentucky between Glasgow and Somerset. The Boyle Dolomite of Silurian age also contains abundant gray, blue, and black chert. Any roadcuts or active or abandoned quarries in this region in the St. Louis Limestone or Boyle Dolomite would contain numerous chert nodules. Chert and flint were the most common silicate minerals used by early Native Americans for making arrowheads. Because chert and flint have a conchoidal fracture, they are easily shaped into arrowheads.

Jasper is an impure variety of quartz that has been colored some shade of red by iron oxide inclusions. The name jasper may also be used for some siliceous agate material that has replaced organic material in petrified wood. It is used as an ornamental stone and in jewelry.

Opal is an amorphous, massive silicate that exhibits a conchoidal fracture and has a characteristic play of colors caused by its water content. Opal is not common in Kentucky, but may occur in some siliceous fossils, particularly in the black shale, and in microscopic amounts in cherts and chalcedony. Opal is not a stable mineral, and in geologic time alters to other silicate minerals.

Many fossils found in Kentucky are silicified. This means the original material of the fossil has been replaced with quartz. The small brachiopod fossils pictured above are from Lexington and are silicified. Click on the image to see the quartz inside. When the brachiopods are broken open you can see the white to clear quartz inside. In some cases the quartz is massive; in others, crystalline.

SERPENTINE

Crystal system: monoclinic. Color: green. Hardness: 3 to 5. Luster: greasy, wax-like. Specific gravity: 2.5. Uses: asbestos.

Serpentine occurs in both a platy and a fibrous variety. The most common variety is chrysotile, which is the chief source of asbestos. In Kentucky, serpentine occurs in peridotite dikes.

CLAY MINERALS

Clay minerals are a subgroup of silicates that comprise the various claystones, such as ball clay, flint clay, and fuller's earth.

Illite

Illite is the constituent of many shales and is an intermediate clay between montmorillonite and muscovite. It has more potassium than montmorillonite, but is not expandable or absorptive. It is structurally similar to chlorite, but chemically different.

Glauconite

Crystal system: amorphous. Color: green. Streak: colorless or greenish, but lighter than the grains themselves. Luster: earthy to dull. Specific gravity: 2.3. Tenacity: brittle. Uses: fertilizer, soil conditioner.

Glauconite, a variety of illite, occurs disseminated in shales, sandstones, and limestones, and is commonly associated with phosphate pebbles and iron sulfides. The Floyds Knob Bed of the Borden Formation (Mississippian) is a glauconitic siltstone that crops out in a semicircle around the Outer Bluegrass.

Kaolinite

Crystal system: monoclinic. Hardness: 2 to 2.5. Luster: earthy. Specific gravity: 2.6.

Kaolinite is the chief component of ball clay and flint clay. It has a sheet structure, and is therefore not as absorbent as montmorillonite.

Halloysite is a hydrated variety of kaolinite (crystal system: amorphous; fracture: conchoidal; color: white, yellowish white, gray, green; hardness: 1.5; streak: white; luster: earthy to pearly; specific gravity: 2.1; tenacity: brittle) with little or no plasticity. Halloysite has a distinctive tube-like structural appearance.

Montmorillonite

Crystal system: monoclinic. Hardness: 1 to 1.5. Specific gravity: 2.5.

Montmorillonite is very fine grained, and visible only with powerful microscopes. It is the main mineral in bentonite and fuller's earth. Montmorillonite is called an expanding clay because the arrangement of its crystal lattice allows frequent and extensive substitution of additional minerals; actual composition may vary depending on iron, magnesium, zinc, aluminum, and silicate ratios.

Vermiculite is a related montmorillonite clay mineral that has the absorbent characteristics, but not the expandable characteristics, of typical montmorillonite.

CARBONATES (CALCITE, DOLOMITE, CERRUSITE, OTHER IRON-CARBONATES)

Carbonates are minerals combined with carbon and oxygen, including calcite, dolomite, smithsonite, malachite, and cerrusite.

CALCITE, ARAGONITE, TRAVERTINE

Crystal system: hexagonal. Cleavage: three-directional in rhombohedron-shaped fragments. Color: usually white, but may be tinted various colors by impurities. Hardness: 3.0. Luster: glassy. Specific gravity: 2.71. Acid test: effervesces

strongly when treated with dilute hydrochloric acid. Uses: in the form of limestone, as aggregate for road surfacing and concrete, agricultural lime, flux, building stone, sulfur sorbents, and in cement; in the form of Iceland spar in optical instruments to polarize light.

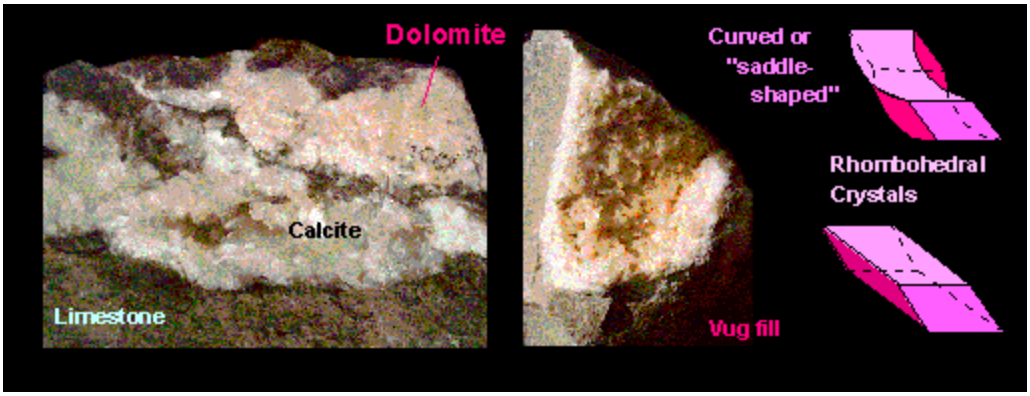
Calcite is one of the most abundant and widespread minerals in Kentucky. It may occur in a multitude of crystal forms, of which scalenohedrons and rhombohedrons are the most common; it may also be granular, massive, earthy, or fibrous. Calcite is the chief mineral in limestone, where it is generally in the form of small, broken fragments of fossil shells. Large, well-developed crystals are generally found in veins, commonly associated with faults. Numerous quarries throughout the state contain various nodules and geodes with calcite crystals. Numerous scalenohedral calcite crystals have been discovered along veins in quarries owned by the Lexington Quarry Co. in Nicholasville and the Caldwell Stone Co. in Danville and some are on display in the Kentucky Geological Survey mineral collection in the Mining and Mineral Resources Building on the UK campus. Vein calcite is usually associated with fluorite, barite, galena, and sphalerite. Calcite often appears as twinned crystals.

Iceland spar, a clear, pure, colorless variety of calcite, has been found at the Twin Chimneys Mine in Mercer County; other localities near Mundys Landing and the Chinn Mine might contain optical calcite as well.

Aragonite is a polymorph of calcite and is distinguished from calcite by a higher specific gravity (2.95) and hardness (3.5 to 4), and a lack of rhombohedral cleavage. Aragonite usually occurs as radiating crystals and is commonly found in reniform, columnar, and stalactitic forms.

Travertine, often called cave onyx, has properties similar to those of calcite. It is usually a shade of yellow or brown, and exhibits banding because of intermittent deposition and iron oxide impurities. Travertine is redeposited calcium carbonate. The best known deposits in Kentucky are in caves in the Mammoth Cave region. It also occurs as a surface deposit associated with groundwater seeps and springs, and may be collected around crevices in most limestone quarries. An attractive deposit of travertine may be seen at Elk Lick Falls in Fayette County, where it forms the impressive Petrified Falls. Travertine may be found in stalactitic, stalagmitic, columnar, nodular, encrusting, and many other forms. Travertine is the chief scenic attraction of caves and should not be destroyed, because it grows very slowly.

DOLOMITE, ANKERITE, BARYTOCALCITE



Crystal system: hexagonal. Cleavage: rhombohedral with curved or saddle-shaped faces. Color: white or pink, rarely gray, green, yellow, or black. Hardness: 3.5 to 4.0. Streak: colorless. Luster: glassy or pearly. Specific gravity: 2.85. Acid test: effervesces slowly in cold dilute hydrochloric acid.

Dolomite is the chief mineral in dolostone. It is also associated with calcite, galena, sphalerite, barite, and fluorite. Dolomite is found in nodules or geodes in some limestone quarries and in some of the vein deposits in the state.

Iron substitutes for magnesium to form ankerite (cleavage: rhombohedral; color: yellowish brown; hardness: 3.5; specific gravity: 2.9), and barium substitutes for magnesium to form barytocalcite (crystal system: monoclinic; color: white to greenish; hardness: 4; specific gravity: 3.67). Barytocalcite is a polymorph of alstonite and may fluoresce under ultraviolet light. Its high specific gravity makes it feel heavy, and it may resemble heavy calcite. Barytocalcite has been observed in some mineral veins in Cumberland County.

CERUSSITE

Crystal system: orthorhombic. Cleavage: orthorhombic crystals are commonly tabular, prismatic, and pyramids; good cleavage in four directions. Color: white when pure, but often gray to very pale blue. Hardness: 3.25. Streak: white. Luster: resinous to adamantine. Specific gravity: 6.5. Tenacity: brittle. Acid test: effervesces in nitric acid. Uses: mined as a lead ore.

Cerussite is distinguished from other carbonates by its high specific gravity; it is distinguished from anglesite ($PbSO_4$) by effervescing in nitric acid and by its crystal form. It also occurs in fibrous, granular, and earthy forms. It forms by the reaction of carbonated water on galena. It occurs in noncommercial quantities near the Big Four Mines and Dike Eaton area in the Western Kentucky Fluorspar District. Cerussite has also been observed in vein deposits in north-central Kentucky. It is associated with galena, sphalerite, anglesite, limonite, and smithsonite.

MALACHITE, AZURITE

Crystal system: monoclinic. Cleavage: perfect, but commonly massive. Color: green (malachite), blue (azurite). Hardness: 3.5 to 4.

Malachite is rare in Kentucky, but does occur as microscopic grains or green coatings as a weathering/oxidation product of chalcopyrite in some vein deposits in central and western Kentucky. Azurite is extremely rare in Kentucky, although it could have the same mode of occurrence as malachite.

Aurichalcite, a zinc-copper carbonate associated with smithsonite, also occurs in oxidized zinc/copper deposits with malachite and azurite. It is distinct because of its acicular blue crystals. The only known occurrence of aurichalcite is in a deep well in western Kentucky. It was formed from the oxidation of oil-field tubular goods and drill steel and found in cuttings from the well.

IRON AND OTHER CARBONATES

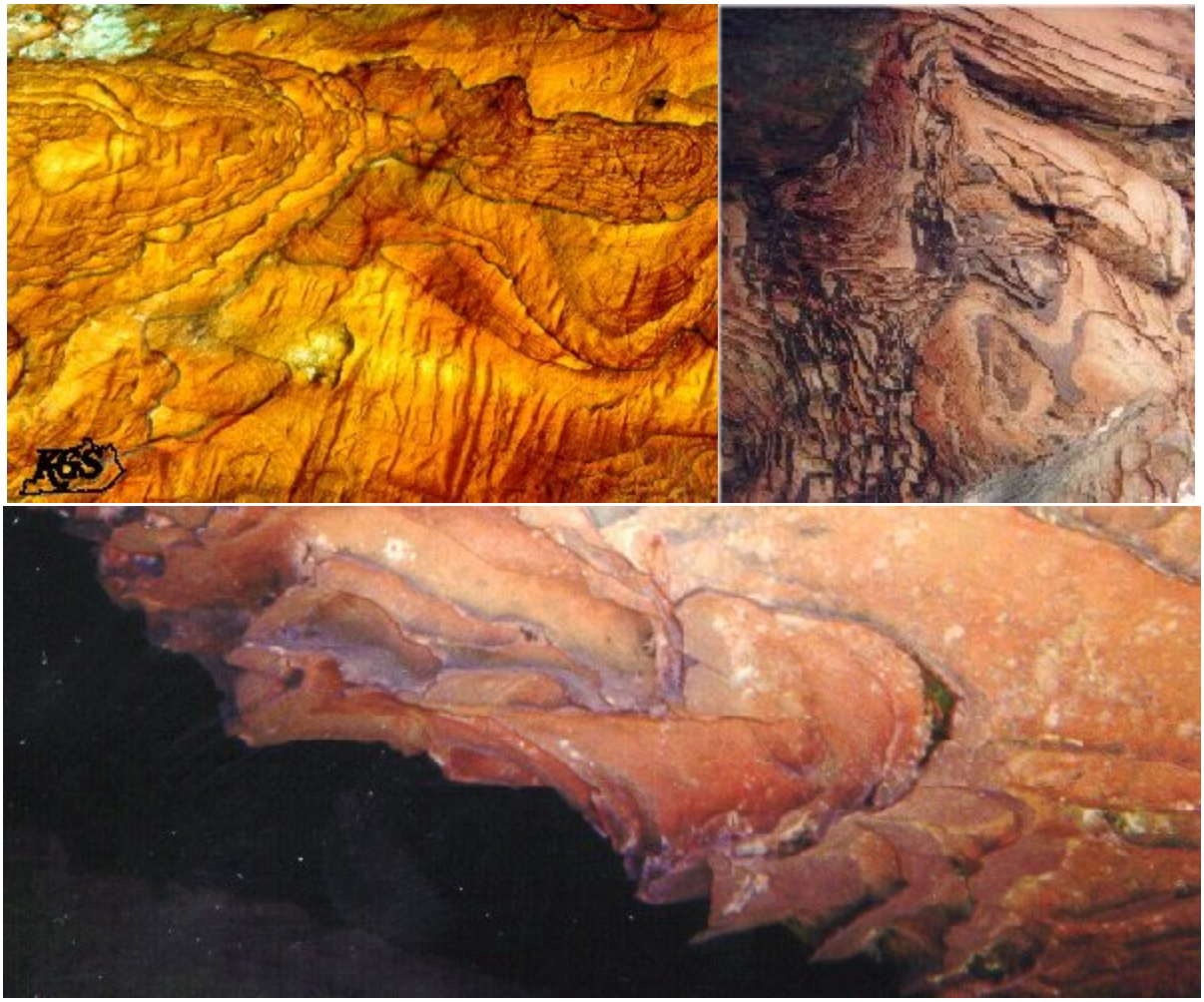
Siderite

Crystal system: hexagonal. Cleavage: frequently rhombohedral crystals with curved faces, similar to dolomite. Color: light to dark brown. Hardness: 3.5 to 4. Luster: vitreous. Specific gravity: 3.96. Acid test: soluble in hot hydrochloric acid.

Siderite is a common mineral associated with geodes, nodules, and ironstone banding. Siderite is very common in the coal fields, where it occurs as a reddish-brown mineral in shale layers, nodules, concretions, and fossil burrows. Commonly, a siderite nodule will have a nucleus of another mineral such as pyrite, sphalerite, or chert. Siderite also occurs in geodes with dolomite and calcite. Siderite becomes magnetic on heating, and alters readily to limonite and goethite.

Siderite and associated iron minerals form curved bands common in sandstones in Kentucky. These bands are called Liesegang bands.

Liesegang Bands



The curved to irregular bands seen in these pictures are deposits of iron minerals and are called Liesegang bands. These bands are reddish brown to yellow and are common in cliff-forming sandstones, such as those in the Red River Gorge, Cumberland Falls, Natural Bridge, and Cumberland Gap areas. Much of the red iron mineralization in these bands are hematite, goethite, and limonite. The source of the iron is the carbonate mineral siderite. But when siderite weathers, it oxidizes, forming the yellow-brown mineral limonite as well as hematite and goethite.

Siderite nodules occur in the Mazon Creek area of Illinois, and look similar to siderite nodules found in the coal fields of Kentucky. Siderite nodules from Mazon Creek are world famous for the fossils they sometimes contain. Fossils of plants are the most famous. Some brachiopod and clam fossils have been found in siderite nodules in Kentucky, but no fossils of soft-bodied organisms have been found.

Smithsonite, Hydrozincite

Crystal system: hexagonal. Cleavage: perfect. Fracture: uneven. Color: white to greenish brown. Hardness: 5.0. Streak: white. Luster: glassy. Specific gravity: 4.37. Acid test: effervesces rapidly in dilute hydrochloric acid.

Smithsonite occurs usually in reniform, botryoidal, and stalactitic forms and as crystalline encrustations. It is formed by the reaction of carbonated water on sphalerite, and occurs in calcareous rocks associated with galena, sphalerite, cerussite, limonite, fluorite, and calcite. It is distinguished from most other carbonates by its greater hardness and weight (it is distinctly harder than cerussite, but lighter in weight).

Another zinc carbonate, hydrozincite (crystal system: monoclinic; color: white to gray; hardness: 2.5; specific gravity: 3.5), is a massive mineral that forms as earthy, compact crusts in oxidized zinc deposits. It commonly will luminesce blue under ultraviolet light.

One of the better occurrences of smithsonite and hydrozincite is at the Old Jim Mine in Crittenden County, where the deposit is associated with an igneous intrusive dike. Smithsonite can be found at numerous mines in western Kentucky and has been observed at the Shrylock Ferry vein in Woodford County in central Kentucky.

Strontianite

Crystal system: orthorhombic. Cleavage: good. Color: white to gray to green. Hardness: 3.5. Luster: vitreous. Specific gravity: 3.7. Acid test: effervesces in dilute hydrochloric acid. Uses: fireworks, flares, rockets.

Strontianite generally occurs as tufts and radiating acicular crystals. It also occurs as columnar or fibrous crystals. It gives off a crimson flame on ignition, and occurs in hydrothermal veins with barite and celestite. It is found in the north-central part of the Central Kentucky Mineral District in Franklin and Scott Counties. Strontianite balls have been observed in the Caldwell Stone Co. Quarry.

Witherite

Crystal system: orthorhombic. Cleavage: indistinct. Fracture: uneven. Color: white to pale yellow. Hardness: 3.5. Streak: white. Luster: glassy. Specific gravity: 4.3. Tenacity: brittle. Acid test: effervesces rapidly in dilute hydrochloric acid.

Witherite is a relatively rare mineral, but is found in central and western Kentucky, where it occurs in veins associated with barite and galena. Elsewhere a minor source of barium, it is noncommercial in Kentucky.

PHOSPHATES (APATITE, VIVIANITE, PYROMORPHITE)

Phosphates are minerals that are combined with phosphorus and oxygen. Apatite is common in various places in Kentucky and phosphates were once mined in Woodford County in central Kentucky.

APATITE

Crystal system: hexagonal. Fracture: conchoidal. Color: red, brown, white. Hardness: 5.0. Luster: opaque or semitransparent. Specific gravity: 3.1.

Apatite, also called collophane, occurs in peridotites in eastern and western Kentucky. A microcrystalline variety of collophane found in northern Woodford County is dark reddish brown, porous, and occurs in phosphatic beds, lenses, and nodules in the Tanglewood Member of the Lexington Limestone. Some fossils in the Tanglewood Member are coated with phosphate. Beds are generally very thin, but occasionally several feet thick. The Woodford County phosphate beds were mined during the early 1900s near Wallace, Ky.

VIVIANITE

Crystal system: monoclinic. Color: blue. Hardness: 2. Specific gravity: 2.68. Vivianite commonly occurs in radiating small aggregates or earthy masses. It is rare, though reported in Floyd County. It is possible that this mineral could occur in geodes, nodules, or fossil cavities in the phosphate beds of central Kentucky.

PYROMORPHITE

Crystal system: hexagonal. Cleavage: occurs in rounded or barrel-shaped crystals. Color: light green to brown. Hardness: 4. Specific gravity: 7.0.

Pyromorphite is a rare lead phosphate that can occur in oxidized lead deposits and has been reported at the Big Four Mines and Dike Eaton areas in the Western Kentucky Fluorspar District.

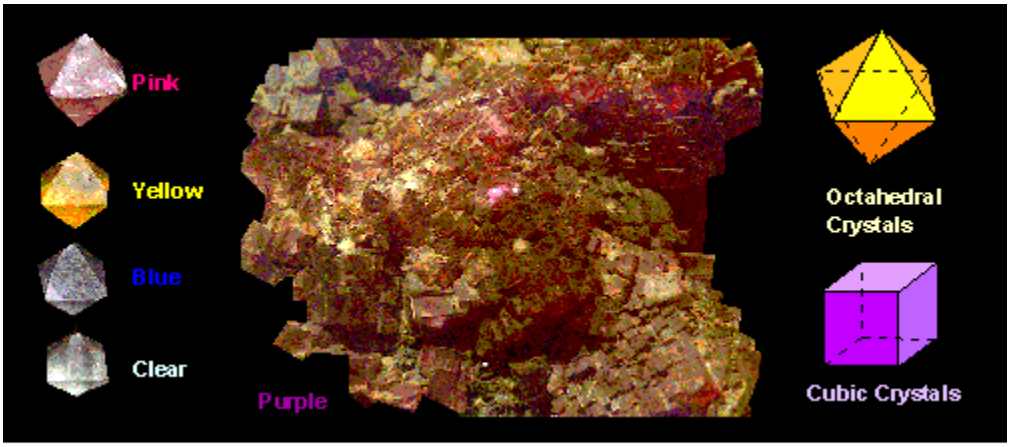
TUNGSTATES AND MOLYBDATES

Although no tungstate occurs in Kentucky, molybdenite was found in a dike in western Kentucky, and some molybdenum salts have been noted in Menifee County. Chemical analysis shows some trace of molybdenum in deep oil wells in western Kentucky.

HALIDES (FLUORITE, HALITE)

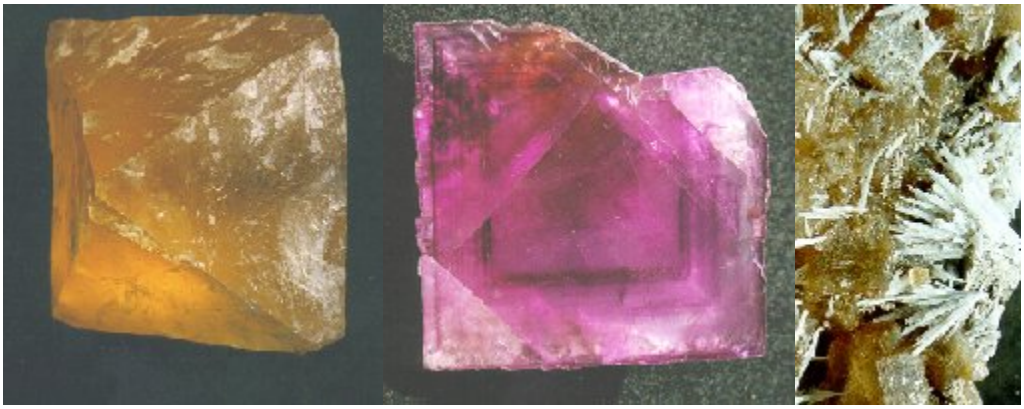
Halides, nitrates, and borates are minerals that combine with the halogen elements, nitrogen, and boron. Examples include halite (salt), sylvite, fluorite, niter (saltpeter), borax, and kernite. Fluorite is very common in central and western Kentucky, whereas the borate minerals are not common in Kentucky.

FLUORITE OR FLUORSPAR



Crystal system: isometric with cubic crystals, more often massive. Cleavage: excellent octahedral cleavage; may be broken into triangular-faced fragments. Color: white, purple, green, yellow, brown. Hardness: 4.0. Streak: colorless. Luster: glassy. Specific gravity: 3.18. Uses: flux, hydrofluoric acid, enamel and glass industries, refrigerating fluids, portland cement, insecticides, to retard tooth decay.

Fluorite is often called spar or fluorspar. Massive fluorite may resemble calcite, but it is heavier and does not effervesce when treated with hydrochloric acid. It is distinguished from gypsum and quartz by its hardness. The Kentucky-Illinois Fluorspar District once was ranked first in the United States in the production of fluorite. In Kentucky, commercial deposits occur in Caldwell, Crittenden, and Livingston Counties. A small amount of noncommercial fluorite occurs in veins in the Central Kentucky Mineral District. Numerous mines and mine dumps along the Tabb and Commodore Faults in western Kentucky contain fluorite, and several mines near Mundys Landing in southern Woodford and northern Mercer County have produced nice fluorite specimens. There are many old uncovered shafts in the vicinity of old mines, so use caution when collecting near these areas. Most of these mines are now closed, and the best place to examine fluorite specimens is in museums.



One of the most outstanding collections of fluorite is the Clement collection, in Marion, Ky. This collection displays various specimens of fluorite collected by Ben Clement while he worked in the fluorspar district. Another collection and a small exhibit of the Clement museum specimens are on display at the Kentucky Geological Survey in Lexington.

HALITE

Crystal system: isometric. Cleavage: commonly in cubes. Color: white. Hardness: 2.5. Streak: white. Luster: vitreous. Specific gravity: 2.25.

Halite, also known as common table salt, has a strong salty taste, which is the most diagnostic tool for identification. Although not common in Kentucky, it does occur in brine waters, salt springs, and salt licks. It can be formed as encrustations and small crystals at salt licks. Prehistoric animals walked miles to salt springs and licks to obtain this chemical. Pleistocene mammals have been preserved, trapped in mud, at a salt lick at Big Bone Lick in Boone County, northern Kentucky. Salt was obtained by early pioneers by boiling down water from salt springs, and it was a major item of trade for Native Americans and pioneers. The locations of salt springs were considered of strategic importance.

NITRATES (SODA NITER, NITER)

Nitrates usually occur as massive but delicate crusts on walls, roofs, and floors in caves, although some fine acicular crystals forms may also be found. These minerals are biogenic deposits. Nitrates were used as explosives, and several caves in Kentucky were mined for their saltpeter compound during the Civil War.

SODA NITER

Crystal system: crystals rare, but may be found in hexagonal form. Color: colorless to white, gray, or reddish brown. Hardness: 1 to 2.

Soda niter is very soluble in water. Because it is so soluble, when taken out of a cave environment it may decompose (deliquesce) upon exposure to humidity in the atmosphere.

NITER

Color: white. Hardness: 2.

Niter, commonly called saltpeter, is a massive, encrusting mineral found on the surfaces and floors of caves. Like soda niter, niter is very soluble in water. Tufts of acicular crystals, similar to aragonite, may be found, and niter will not deliquesce (become liquid).

MINOR MINERALS

Numerous minerals occur in Kentucky rocks in small quantities or to a limited extent, or can only be observed under a microscope. Among these minerals are albite, orthoclase feldspar, zircon, and epidote, which are some of the small constituents of sandstones in eastern Kentucky. Pyroxene (diopside), hornblende, ilmenite, rutile, enstatite, and chromite are a few additional microscopic minerals that have been noted in the igneous dikes of Kentucky.

REFERENCES

Anderson, W.H., 1994, Rocks and minerals of Kentucky: Kentucky Geological Survey, ser. 11, Special Publication 20, 82 p.

Anderson, W.H., and Price, P., 1991, Mineralization and hydrocarbon emplacement in the Cambrian-Ordovician Mascot Dolomite of the Knox Group in south-central Kentucky: Kentucky Geological Survey, ser. 11, Report of Investigations 4, 31 p.

McIntosh, R.L., and Anderson, W.H., 2013, Kentucky agate: State rock and mineral treasure of the commonwealth: Lexington, University Press of Kentucky, 216 p.