Rocks, Minerals, and Fossils of Kansas

Catherine S. Evans, Susan Stover, and Julie Tollefson

Rocks, Minerals, and Fossils of Kansas
A Companion Guide for the Rocks, Minerals, and Fossils of Kansas Box

Catherine S. Evans, Susan Stover, and Julie Tollefson

Educational Series 18
2018

Second printing: 2023

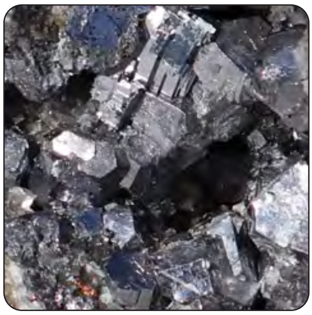
Kansas Geological Survey
1930 Constant Avenue
Lawrence, KS 66047-3724

785.864.3965
www.kgs.ku.edu

ISBN 978-1-58806-335-9

Acknowledgments
The authors are grateful to everyone who helped shape the contents of this book, including Rex Buchanan and Jon Smith for their thoughtful reviews of the manuscript; Bob Sawin and David Newell for providing information about geology and fossil sites; Pamela Griffin for maintaining and processing the KGS rock and mineral samples; and Pieter Berensen for assistance in obtaining samples. The Sternberg Museum allowed use of the "fish-within-a-fish" photograph on page 9, and several of the fossil illustrations originally appeared in *Windows to the Past: A Guidebook to Common Invertebrate Fossils of Kansas* by Liz Brosius.

KANSAS GEOLOGICAL SURVEY
The University of Kansas

Rocks, Minerals, and Fossils of Kansas

Kansas has an amazing history recorded in its rocks, minerals, and fossils. Each rock layer, mineral, and fossil provides clues to past environments—seas, swamps, forests, grasslands, and glaciers—that covered all or part of the state at one time or another. For example, coal developed from swamp slime, sandstone layers formed when sea or river sand was compressed into hard rock, and quartzite boulders were dragged in by massive ice sheets. The charts on pages 2 and 3 show how Kansas has changed over time.

To help understand the past and present environments in Kansas, the state has been divided into 11 physiographic regions (shown in the map on page 4). Those divisions are based on the rocks and natural features found on or near the surface. Physiography refers to surface features, including hills, plains, and rivers, and the natural forces that mold them over time.

Fossils of sea-dwelling brachiopods, soaring pterosaurs, elephant-like mammoths, moisture-loving sassafras trees, and other animals and plants are particularly helpful when identifying past environments. When seashell fossils are found in a rock layer, that shows the area was once underwater. Insects and fern fossils indicate a swampy and warm environment. Mammoth bones indicate dry land and a colder climate. If a rock layer containing mammoth bones, a layer with insects and ferns, and a layer with seashells were found stacked one on top of the other, that would reveal that the climate and environment changed drastically over time.

This guide was designed to accompany the Rocks, Minerals, and Fossils of Kansas box available from the Kansas Geological Survey (KGS). The box contains samples found throughout the state.

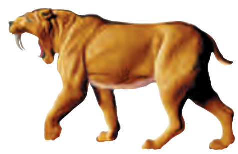
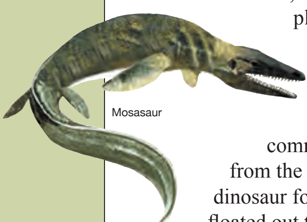
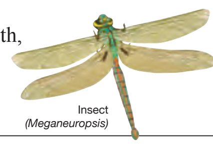
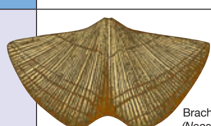
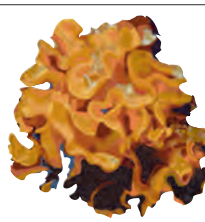
Geologic Time Scale for Kansas

Eon	Era	Period	Epoch	Kansas Environment and Geology	
Phanerozoic Eon	Cenozoic	Quaternary	Holocene	Pleistocene glaciers reached northeast Kansas at least twice, leaving behind unsorted clay, sand, gravel, and quartzite boulders (still found on the surface) carried from Minnesota and other states. Cycles of incision and deposition by streams occurred. Wind deposited loess (fine silt). Volcanic ash blew in from the west. Forests decreased and grassland increased in the Holocene. Sand dunes formed by wind in western and central Kansas are now mostly inactive (covered with vegetation).	11,700 ya
			Pleistocene		2.6 mya
		Neogene	Pliocene	Silt, sand, and gravel eroded from the uplifting Rocky Mountains were carried by streams into western and central Kansas and formed the porous Ogallala Formation, a major source of groundwater. Volcanic ash was blown in from the west.	5.3 mya
			Miocene		23 mya
		Paleogene	Oligocene	Paleogene rocks have not been found in Kansas.	
			Eocene		
			Paleocene		66 mya
	Mesozoic	Cretaceous		Seas covered western and central Kansas late. Fossil-rich marine rocks at the surface include Greenhorn Limestone in central Kansas and Niobrara Chalk to the west. Dakota sandstone formed from delta-type deposits in central Kansas. Igneous kimberlite pipes erupted toward the surface in eastern Kansas. The Fence-post limestone bed (Greenhorn Limestone) was later used to build fences and buildings because wood was sparse.	145 mya
		Jurassic		Terrestrial shale and sandstone deposits are found in the western Kansas subsurface.	201 mya
		Triassic		Triassic rocks have not been found in Kansas.	252 mya
	Paleozoic	Permian		Cycles of shallow seas, tidal flats, and dry land resulted in deposits of limestone, shale, sandstone, dolomite, gypsum, and chert. Permian rocks are found at the surface in the Flint Hills and south-central Kansas Red Hills. Oil and gas are produced from Permian rocks. Salt left when seas dried is mined underground in central Kansas.	299 mya
		Carboniferous: Pennsylvanian Subperiod		Cycles of shallow seas, swamps, and river channels resulted in deposits of limestone, sandstone, shale, and coal found at the surface in eastern Kansas. Folding and faulting created the Central Kansas Uplift, a ridge now deeply buried. Oil, gas, and coal are produced from Pennsylvanian rock layers.	323 mya
		Carboniferous: Mississippian Subperiod		Cycles of shallow seas and dry land resulted in deposits of limestone, sandstone, shale, and chert. Mississippian rocks are found at the surface only in far southeast Kansas. Oil and gas are produced from Mississippian rocks. Lead and zinc were once mined in southeast Kansas.	359 mya
		Devonian		Seas covered Kansas during part of this period. Devonian limestone, shale, dolomite, sandstone, and chert are found in the subsurface. Oil and gas are produced from Devonian rock.	419 mya
		Silurian		Seas covered Kansas during part of this period. Silurian limestone, shale, dolomite, sandstone, and chert are found in the subsurface. Oil and gas are produced from Silurian rock.	443 mya
		Ordovician		Seas covered Kansas during part of this period. Dolomite, limestone, sandstone, shale, and chert from the period are found in the subsurface. Oil and gas are produced from Ordovician rock.	485 mya
		Cambrian		Early erosion was followed by shallow seas in Kansas. Cambrian dolomite, sandstone, limestone, and shale are found in the subsurface.	541 mya
Proterozoic Eon				This time is informally called the Precambrian. Proterozoic igneous and metamorphic rocks are found deep in the subsurface, but no Archean or Hadean rocks are known in Kansas. The Midcontinent Rift nearly split the North American plate apart about 1.1 bya but stopped short. A ridge created by the rift is underground in east-central Kansas.	2.5 bya
Archean Eon					4 bya
Hadean (informal)					4.6 bya

Reference: International Stratigraphic Chart, 2015, International Commission on Stratigraphy.

ya = years ago
mya = million years ago
bya = billion years ago

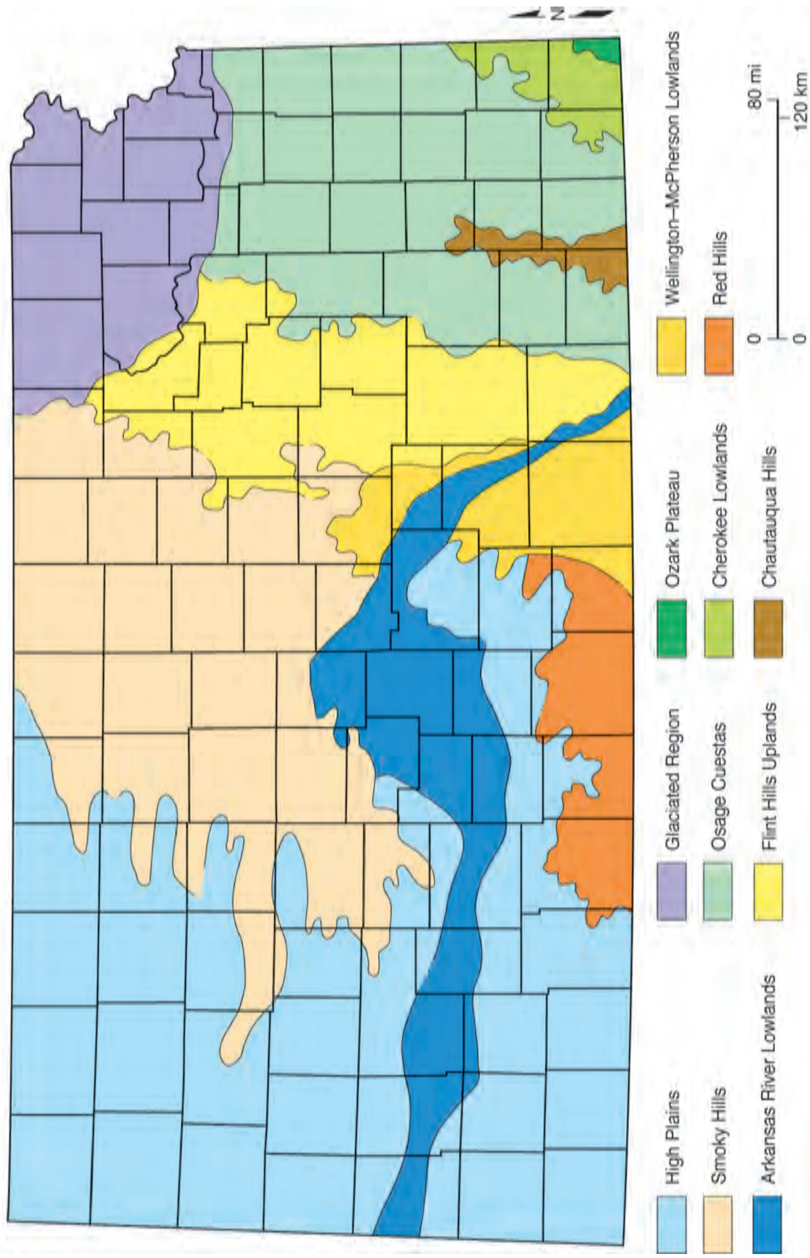
Common Fossils in Kansas

Eon	Era	Period	Epoch	Kansas Fossils	Age at base
Phanerozoic Eon	Cenozoic	Quaternary	Holocene	A variety of large mammals—including mammoths, camels, saber-tooth cats, and horses—lived in Kansas during the Pleistocene. Most died off during a mass extinction 9,000–12,000 years ago. Bison bones and human artifacts, dating back 11,000 years, have been found together. In the Holocene, grasslands became more prevalent and species found today began to dominate.  Saber-toothed cat *(Smilodon)*	11,700 ya
			Pleistocene		2.6 mya
		Neogene	Pliocene	Neogene animals and plants include rhinoceros, tapirs, horses, kangaroo rats, salamanders, elm trees, hackberry trees, and grasses. Trace fossils of animal burrows and ant nests have been found.	5.3 mya
			Miocene		23 mya
		Paleogene	Oligocene	Paleogene rocks have not been found in Kansas.	
			Eocene		
			Paleocene		66 mya
	Mesozoic	Cretaceous		Cretaceous marine animal fossils include squids, ammonoids, sharks, crinoids, and giant clams. World-class fossils of plesiosaurs and mosasaurs (large swimming reptiles) and pteranodons (large gliding reptiles) have been found in western Kansas. Leaf fossils have been found in the Dakota sandstone. In central Kansas, clam fossils are common in fences and building walls constructed from the Fence-post limestone bed. The few incomplete dinosaur fossils found are mostly from animals that died, floated out to sea, and sank. Mass extinction occurred at the end of this period.  Mosasaur	145 mya
		Jurassic		Jurassic and Triassic fossils have not been found in Kansas.	201 mya
		Triassic			252 mya
	Paleozoic	Permian  Amphibian tracks		Permian marine animal fossils include mollusks, brachiopods, bryozoans, crinoids, coral, sharks' teeth, and one-cell fusilinids. Terrestrial leaf and insect fossils have been found. Mass extinction occurred at the end of this period.  Insect *(Meganeuropsis)*	299 mya
		Carboniferous	 Pennsylvanian Subperiod	Pennsylvanian marine animal fossils include brachiopods, bryozoans, coral, crinoids, mollusks, and one-cell fusilinids. Terrestrial, or land, fossils include plants, amphibians, and early reptiles.	323 mya
			Mississippian Subperiod	 Brachiopod *(Neospirifer)* Mississippian marine fossils include crinoids, brachiopods, bryozoans, and mollusks.	359 mya
		Devonian		Microscopic fossils and some small marine fossils from the Cambrian through the Devonian periods have been found in rock cores that were brought up from the subsurface during drilling for oil and natural gas. No fossils from before the Cambrian Period have been found in Kansas.  Bryozoan	419 mya
		Silurian			443 mya
		Ordovician			485 mya
		Cambrian			541 mya
Proterozoic Eon					2.5 bya
Archean Eon					4 bya
Hadean (informal)					4.6 bya

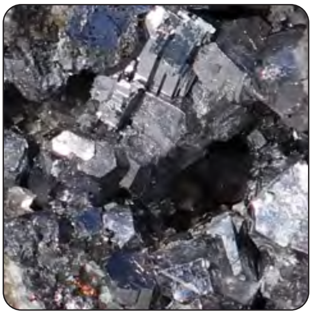
Reference: International Stratigraphic Chart, 2015, International Commission on Stratigraphy.

ya = years ago
mya = million years ago
bya = billion years ago

Generalized Physiographic Map of Kansas



The state is divided into 11 regions based on the rocks and land features found on or near the surface. The High Plains region in western Kansas, for example, is an area of vast flatlands and gently rolling plains. The Ozark Plateau in southeast Kansas, where the oldest rocks at the surface in Kansas are found, consists of steep slopes, rocky and thin soil, and hardwood forests.



What Are Minerals?

Minerals are natural (not human-made) solids. They typically form underground through processes involving water, cooling, heat, and pressure or at Earth's surface through evaporation of salty pools of water.

Minerals are crystals, meaning their atoms are arranged in regular, ordered, and repeated patterns. How a mineral's atoms are arranged determines that mineral's color, hardness, and other physical properties. When crystals have had enough time and space to grow large, you can see them without the aid of a magnifying glass or microscope. Often, however, crystals are microscopic because they compete for space with adjacent atoms and have very little room to grow.

Rocks are mainly made up of minerals. A few types of rock are composed of just one type of mineral. For example, calcite is the only mineral in pure marble. Most rocks, however, are a mix of minerals.

Minerals and chemical compounds

Elements are the basic building blocks of matter. Each element is made up entirely of one kind of atom. All of the atoms in the element oxygen, for example, have eight protons, eight neutrons, and eight electrons.

Chemical compounds are formed when two or more elements are chemically bonded together. Although a few minerals, such as gold, consist of just one element, most minerals are chemical compounds. For example, the chemical compound known as calcium carbonate is a combination of the elements calcium (Ca), carbon (C), and oxygen (O). The mineral calcite is a calcium carbonate.

Chemical formulas are symbols made up of letters and numbers that represent chemical compounds or single-element substances (such as gold). The chemical formula for calcium carbonate, for example, is $CaCO_3$. The "3" after the "O" means that for every atom of calcium (Ca) and carbon (C) in each mineral molecule, there are three atoms of oxygen (O). Molecules are the smallest possible units, or particles, within the mineral that have all the properties (such as color, luster, and hardness) of that mineral.

Every mineral has a fixed chemical formula. No matter where a mineral is found on Earth, it will have the same chemical formula. Two minerals can have the same chemical formula. For example, the chemical formula for both diamond and graphite is C because both diamonds and graphite consist exclusively of carbon molecules. Although they have the same formula, they are different minerals because they have different crystal structures. Diamonds are a 10 out of 10 on the hardness scale, and graphite—used as lead in pencils—has a hardness of 1 to 2. A mineral's crystal structure is determined by temperature, pressure, and other conditions that occur as the mineral is forming.

KANSAS OR MARS?

Rocks on Mars can look a lot like the sandstone and shale in the Red Hills of south-central Kansas. The mineral hematite, an iron oxide, makes the Red Hills red.

The Red Hills in Barber County, Kansas. ▶

Image taken by NASA's Mars Exploration Rover Spirit in 2007. NASA/JPL-Caltech/Cornell University. ▼

Physical Properties of Minerals

Minerals can be identified by physical properties, including the ones described below.

Color is always the same in a few minerals, such as gold, which is always yellow. Other minerals come in many different colors due to small variations in their chemistry. Quartz, for example, can be clear, white, pink, purple, yellow, or smoky brown.

Luster is how a mineral looks in reflected light. Some minerals are shiny while others are dull. Common mineral lusters are metallic, glassy, silky, pearly, and chalky.

Cleavage is the tendency of a mineral to break along flat surfaces. For example, mica breaks apart in thin sheets and halite (rock salt) breaks into cubes. Not all minerals have strong cleavage.

Hardness is determined by the resistance of a mineral to scratching. The Mohs Scale of Hardness—named after Friedrich Mohs, who established it—lists examples of minerals from 1 (softest) to 10 (hardest). Harder minerals always scratch softer minerals. Of those listed above, corundum scratches calcite, feldspar scratches fluorite, diamond scratches everything, and talc scratches nothing. You can test a mineral's hardness on other items, such as your fingernail (hardness = 2.0–2.5), a copper penny (hardness = 3), and a glass plate or steel knife (hardness = 5.5). Calcite, which has a hardness of 3, will scratch your fingernail but not a glass plate. Quartz, with a hardness of 7, will scratch both.

Mohs Scale of Hardness

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

Streak is the mark some minerals leave on an unglazed porcelain plate. The color of a mineral's streak may be different from the color of the mineral. Galena, which is lead gray, leaves a lead gray to black streak. Hematite, an iron-rich mineral that may look silver, leaves a reddish brown streak. Minerals harder than 7 will not streak, and some softer minerals do not leave a visible streak.

Specific gravity is a measure of the density (compactness) of a mineral. Denser minerals are generally heavier, so you can make a rough comparison of the specific gravity of two minerals by comparing how heavy they feel. For example, if you held a piece of quartz (specific gravity of 2.6) in one hand and a similar-sized piece of hematite (specific gravity of 5.0–5.3) in the other hand, the hematite would feel about twice as heavy as the quartz.

How Do Rocks Take Shape and Change?

Rocks are naturally occurring solids generally made up of one or more minerals. There are exceptions, though. Coal, for example, developed from compacted plant matter. The three basic rock types—based on how rocks are formed—are igneous, metamorphic, and sedimentary.

Igneous rocks form from magma—hot liquid, or molten, material that pushes up toward the surface from Earth's interior. As magma cools and hardens, minerals growing within it eventually build into rocks. If magma cools slowly as it works up through Earth's crust, it may harden underground and form crystals large enough to be seen easily, such as those in granite.

When magma reaches Earth's surface, it is called lava. Exposed to air and water, lava cools too quickly for crystals to grow much. Basalt is an example of a rock without visible crystals. Small amounts of kimberlite in Riley County and lamproite along the Woodson-Wilson county line are the only igneous rocks found at the surface in Kansas. Granite, basalt, and other igneous rocks are only found deep underground in the state.

Metamorphic rocks are created when existing rocks are altered, or metamorphosed, by extreme heat and pressure or through chemical processes. The rocks don't melt during the alteration process, but their minerals, shapes, and textures change. Under the right conditions, limestone will metamorphose to marble, shale will metamorphose to slate, and sandstone will metamorphose to quartzite. The only metamorphic rocks on the surface in Kansas are scattered quartzite boulders that did not actually form in the state. They were carried into northeast Kansas hundreds of thousands of years ago by glacial ice.

Sedimentary rocks form at Earth's surface when sand, gravel, and other sediment are compacted and cemented together into solid rock. The materials rocks are made of provide important insight into past life and environments. For example, sandstone is composed of sand that accumulated along seashores or rivers, and shale is compacted mud that was deposited in deeper or more still water. Unlike igneous and metamorphic rocks, sedimentary rocks often contain fossils.

Sedimentary rocks may form from grains eroded off other rocks or from the remains of plants, animals, and other organisms. They also may form from minerals that precipitate out of water. Precipitation occurs when dissolved minerals separate from the water and settle onto the bottom of an ocean, lake, or other body of water. That can happen as water evaporates or changes temperature.

Layers of sediment from various sources build up on Earth's surface, most often on the bottom of a sea or lake that eventually dries up. Over time, newer layers are deposited on top of older layers. As a layer that was once on the surface gets buried under the weight of younger, overlying layers, it becomes pressed and cemented together. Over millions of years, many distinct layers of rock form from different sediments, including gravel, sand, clay, and silt.

The vast majority of rocks on or near the surface in Kansas are sedimentary. Limestone, shale, and sandstone are the most common types in the state.

A FOSSILIZED FISH DINNER

Long ago in the Cretaceous sea that covered western Kansas, one fish ate another fish and then promptly died before digesting its dinner. More than 65 million years later, the two were found fossilized together in a layer of chalk in Gove County. The 6-foot-long victim, a type of fish known as *Gillicus,* was preserved within its attacker, a 14-foot-long *Xiphactinus.* This "fish-within-a-fish" can be seen at the Sternberg Museum in Hays. *(Photo courtesy of Sternberg Museum.)*

How Do Fossils Form?

Fossils, most often found in sedimentary rocks, are evidence of past life. To become fossilized, an animal, plant, or other organism (such as algae) must be buried and preserved before it rots, gets eaten, or is washed away. Most fossils in Kansas are the remains of animals that were buried in fine sand or mud in shallow seas.

Hard animal parts—such as shells, bones, and teeth—are more likely to be preserved than skin, feathers, and other soft parts or plants. Although rarely fossilized because they disintegrate quickly, soft body parts and plants may be preserved under the right environmental conditions. Mammoths have been found with their fur and muscle still intact after being frozen in ice for thousands of years in Siberia and other cold places. Fossil leaf imprints, wood, and insects have been found in Kansas.

The two main types of fossils are body fossils and trace fossils. Body fossils are the preserved remains of plants, animals, and other organisms. Often, mineral matter carried by water fills in the pores of plants, bones, shells, teeth, and other body parts in a process called permineralization. In some cases, the original materials are completely replaced, commonly by calcite or silica. The fossil, then, retains the shape of the animal or plant even though it is now made of a different material. Most fossils are only pieces and parts because organisms are often damaged before and during fossilization. Fossils also get worn down or broken through erosion and other geologic processes. Sometimes DNA can be extracted from body fossils, although that is rare.

Trace fossils are indirect evidence of animal activity and include burrows, snail trails, tracks, and footprints preserved in rock. They can be especially helpful in determining how animals lived.

Mineral Samples

Calcite

Calcite is the primary mineral in limestone and seashells. Because limestone is common in Kansas, calcite is one of the most common minerals in the state. It is also often a cementing material in sandstone. Calcite crystals are most often rhombohedrons, which are six-sided shapes that, unlike cubes, do not have square faces with right-angled corners. Individual crystals in limestone are usually very small and rarely visible.

Chemical compound: calcium carbonate
Chemical formula: $CaCO_3$
Color: usually white or colorless, but may be tinted red, gray, blue, or green
Luster: glassy to earthy
Hardness: 3
Streak: white
Specific gravity: 2.71

Halite (salt)

Halite, commonly known as table salt, dissolves rapidly in water. Salt beds don't appear at the surface because rain and streams wash them away. Underground in Kansas, salt deposits are often 250 feet thick and more. Salt is mined underground near Hutchinson, Lyons, and Kanopolis. Most Kansas salt is used to de-ice roads in the winter and for other non-edible purposes because much of it contains too many impurities to be used as table salt. Halite has a cube-shaped crystal.

Chemical compound: sodium calcite
Chemical formula: $NaCl$
Color: usually colorless or white when pure
Luster: glassy
Hardness: 2.5
Streak: white
Specific gravity: 2.16

Key to elements listed in the chemical formulas of minerals:

C = Carbon	H = Hydrogen	Pb = Lead
Ca = Calcium	Na = Sodium	S = Sulfur
Cl = Chlorine	O = Oxygen	

Galena

Galena is an ore—a mineral of economic value—found in the far southeast corner of Kansas. That area is part of a mining region that extends into Missouri and Oklahoma. It was once the most important lead and zinc mining area in the world. The metal lead was extracted from galena and the metal zinc was extracted from another mineral, sphalerite. After the bulk of the two minerals had been removed in southeast Kansas, all the mines there closed. Galena has a cube-shaped crystal.

Chemical compound: lead sulfide
Chemical formula: PbS
Color: metallic to lead gray
Luster: often metallic
Hardness: 2.5
Streak: gray-black
Specific gravity: 7.5

Rock Gypsum

Rock gypsum, one of three types of gypsum found in Kansas, is granular. The other varieties are selenite (described below) and satin spar, which is white or pink and fibrous with a satin sheen. Rock gypsum is mined in Barber County in south-central Kansas and Marshall County in northeast Kansas. It is used in cement, plasters, sheet rock, and as a fertilizer. The Red Hills in Barber and surrounding counties are also known as the Gyp Hills, short for gypsum.

Chemical compound: calcium sulfate containing water
Chemical formula: $CaSO_4 \bullet 2H_2O$
Color: white or gray
Luster: glassy to pearly
Hardness: 2
Streak: white
Specific gravity: 2.32

Selenite

Selenite is a variety of gypsum. It is transparent with flat, diamond-shaped crystals. Because it has strong cleavage in one direction, it can be split into thin sheets. Selenite is common in the dark, Cretaceous-age shales in western Kansas and shale slopes at Kanopolis State Park in central Kansas. Fresh, clear selenite crystals can be found by digging into weathered shale on hillsides.

Chemical compound: calcium sulfate containing water
Chemical formula: $CaSO_4 \bullet 2H_2O$
Color: colorless or lightly colored
Luster: glassy to pearly
Hardness: 2
Streak: white
Specific gravity: 2.32

Rock Samples

Quartzite

Quartzite is a metamorphic rock altered from sandstone. The sand grains in quartzite are fused and cemented together. Red quartzite boulders and cobbles found in northeast Kansas did not form in the state. They eroded off outcrops about 200 miles to the north where Nebraska, Iowa, and Minnesota meet and were transported by glaciers. This metamorphic quartzite is often referred to as Sioux quartzite.

Strongly cemented sandstones with high quartz content are sometimes referred to as sedimentary quartzite, which is not a true quartzite but is similar in appearance. Locations for sedimentary quartzite include Lincoln and Graham counties, erosion-resistant ledges in eastern McPherson County, and Kearny County west of Lakin.

Kimberlite

Kimberlite is an igneous rock that forms in subsurface volcanic pipes created by magma that explodes deep in the Earth and rushes toward the surface at about 1,200 feet per second, or 818 miles per hour. Kimberlite contains the mineral olivine, which gives it a green or brown color. Other minerals in kimberlite include mica, serpentine, and calcite. Kimberlite is found only in small areas of Riley and Marshall counties, where it either just reached the surface or was exposed by erosion. Diamonds are associated with kimberlite pipes in other parts of the world but none have been found in Kansas.

LIMESTONE: ROADS AND RAILROADS, COURTHOUSES AND CONCRETE

Limestone quarried in Kansas is chopped into blocks for buildings, crushed into roadbed—the foundation of roads and railroads—or pulverized as a component of cement.

The Chase County Courthouse in Cottonwood Falls is made from Cottonwood Limestone. ▶

Shale
Shale is a sedimentary rock that forms when mud consisting primarily of clay and silt-sized mineral particles is compacted. The color varies from black and gray to red and variegated red to green, depending on the environment in which the mud was deposited. All of these colors are found in Kansas. Shale is common in eastern and central Kansas. It is especially visible in the Flint Hills, Smoky Hills, and Red Hills, where it has weathered away to form the slopes of hillsides under less-easily eroded limestone and sandstone that form the ledges and hilltops.

Sandstone (tan)
Sandstone is a sedimentary rock composed mainly of cemented sand-sized quartz, feldspar, and other minerals. The sandstone layers in Kansas were formed after sand deposited on or near a seashore or in a riverbed was buried and compressed together over thousands, even millions, of years. The color of sandstone often reflects the environment in which the sand was deposited. Like sand, sandstone can be a variety of colors from white to red to black. Just as tan sand is common, so is tan sandstone.

Sandstone (red)
Sandstone cemented by iron oxide (rust) ranges from a bright red to a dark-purplish-red color. Giant concretions at Rock City near Minneapolis, Kansas, and Mushroom Rock State Park north of Kanopolis Lake are composed of the red Dakota sandstone commonly seen in the eastern Smoky Hills. The Dakota sandstone was formed from sand deposits near the shore of a Cretaceous sea about 80 million years ago. The concretions were left standing on the surface when the less-durable sandstone around them eroded away. Other red sandstones occur in the Red Hills and at Point of Rocks, a high bluff in far southwestern Kansas. These older sandstones formed from deposits in a Permian sea about 260 million years ago.

Limestone
Limestone is a sedimentary rock formed primarily from the mineral calcite. Pure limestone is white or almost white, but impurities such as clay, sand, and iron oxide can make limestone a variety of colors, including tan, red, and gray. Limestone usually forms from sediment deposited in an ocean. Much of the sediment was produced by algae and from fecal pellets (the waste) of small marine animals. Fossil shells and shell fragments also are part of many limestones. Limestone is common in Kansas, particularly in eastern Kansas, the Flint Hills, and the central portion of the Smoky Hill region.

◀ *Quartzite boulder at Kill Creek Park in Johnson County.*

Layers of limestone and shale in a Geary County roadcut. Yellow arrows mark the top and bottom of shale, which is sandwiched between limestone ledges above and below. ▼

▲ *Tan sandstone at Echo Cliff in Wabaunsee County was formed from sand deposited in ancient riverbeds.*

Rock City in Ottawa County features red sandstone concretions left behind when the sandstone around them eroded. ▼

Chalk

A sedimentary rock, chalk is a type of limestone. It is composed of the skeletons of microscopic ocean-dwelling animals and plants as well as calcium carbonate chemically precipitated from seawater. The precipitation occurred when dissolved minerals separated from the water and settled onto the sea floor. Pure chalk is white but is easily colored with impurities and often appears tan or gray.

The thick Cretaceous-age chalk beds in western Kansas were built up slowly over millions of years. Castle Rock and Monument Rocks in Gove County are the two best-known examples of chalk formations in the state. Now surrounded by plains, they remained standing after the less-durable chalk around them was eroded away by wind and water.

▲ *The chalk pillars at Monument Rocks in Gove County were left standing when chalk around them eroded.*

Coal

Coal is a sedimentary rock formed from plant remains compressed and transformed by the weight and heat of overlying, younger sediments. Coal beds are found mainly in the eastern half of Kansas. Coal was once mined in eastern and southeastern Kansas, particularly in Crawford and Cherokee counties. Most of the coal mined in Kansas formed from deposits of decaying plants in large swamps about 300 million years ago. Kansas's mid-grade coal has more impurities than a high-grade coal, which burns cleaner and creates less pollution.

Volcanic Ash

Volcanic ash is a fine-grained material composed of rock, mineral, and glass fragments thrown out during a volcanic eruption. Igneous in origin, the ash can be gritty like sand or powdery. It is often carried hundreds of miles by the wind. When Mount St. Helen's erupted in the state of Washington in 1980, the ash was detected in the atmosphere around the globe. Traces of wind-blown ash were seen in Kansas, about 1,500 miles from the volcano.

Thousands, even millions, of years ago, ash was carried into the state from volcanic eruptions in Wyoming, New Mexico, and California. Deposits ranging in thickness from a few inches to 30 feet are found below the surface throughout central and western Kansas. Still mined commercially in Kansas, volcanic ash is used as an abrasive in soap, an ingredient in ceramic glazes, and an additive in cement.

Alluvium

Alluvium consists of sand, gravel, silt, and clay—and often bits of plant material—carried by water and deposited in the streambeds and adjacent floodplains of rivers and creeks. Eroded off larger rocks, the particles of sand an
broken down by rushing water and other processes. Alluviu
or unconsolidated, although the particles sometimes become

DID YOU KNOW?

Kansas has two official state fossils. Tylosaurus—a gian
mosasaur, an extinct reptile that swam in oceans coveri
Kansas 85 million years ago—is the Kansas marine foss
Pteranodon, a winged pterosaur that soared above the Cretaceous ocean, is the Kansas flight fossil.

Fossil Samples

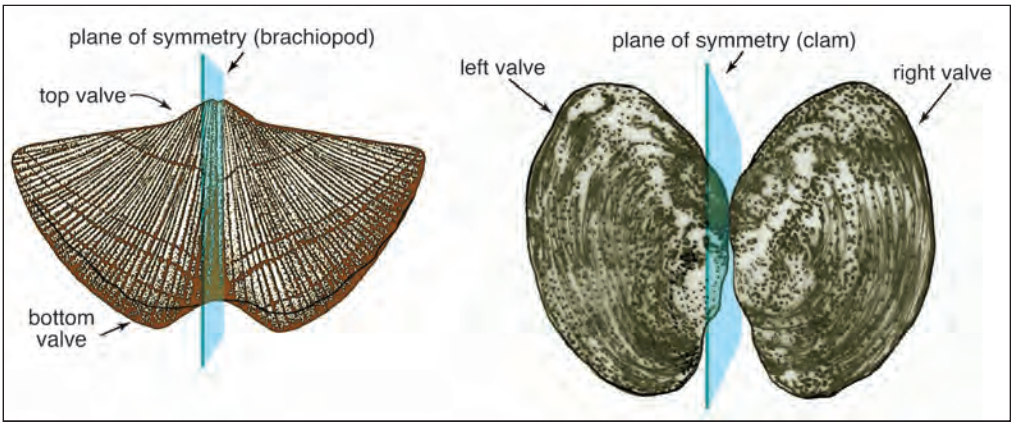
Brachiopod

Brachiopods are shelled marine animals that were abundant in the Paleozoic Era. Only a few varieties exist today. The shell of a brachiopod consists of two valves (each a half shell) hinged together. Other two-valve animals common in today's oceans—including clams, oysters, and mussels—are known as bivalves.

Although brachiopods have two valves, they are not called bivalves. There are several differences between brachiopods and bivalves, but the most obvious one has to do with symmetry. The two valves (half shells) of bivalves are mirror images of each other. In contrast, brachiopod valves are not mirror images of each other, but each valve on its own is symmetrical. If you look straight at the top valve of a brachiopod, the left half is the mirror image of the right half. Flip the brachiopod over, and the same is true on the other side. Brachiopods, which come in many shapes and sizes, are common in Pennsylvanian- and Permian-age limestones in eastern Kansas.

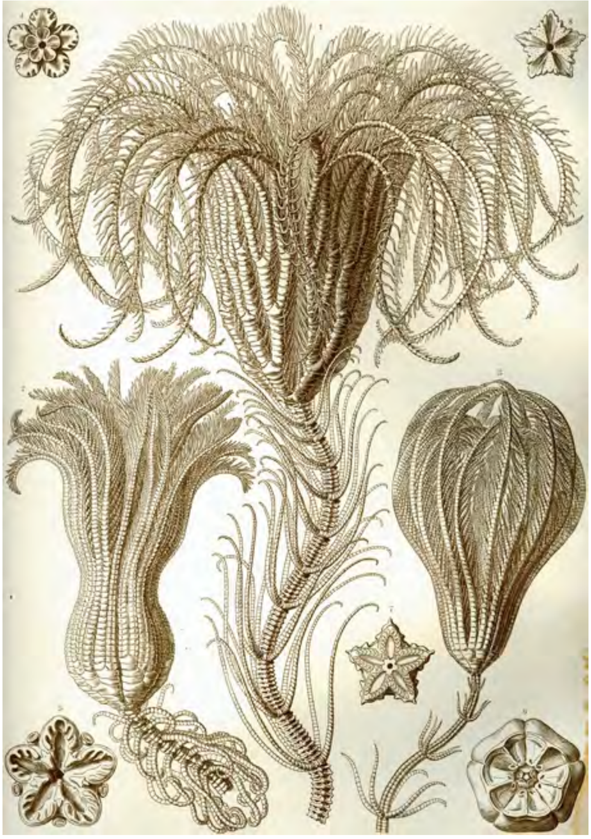
Some types of brachiopods found in Kansas. ▶

Differences in symmetry between a brachiopod and a clam, which is a bivalve. ▼



Crinoid

Crinoids are marine animals that most often have long stems like a plant, a cuplike body called a calyx, and feathery arms that filter food out of seawater. They attach themselves to the sea floor and look enough like flowers to also be called sea lilies. While hundreds of crinoid species are still around today, they were much more common and varied in the past. Fossil crinoid stems are common in Pennsylvanian- and Permian-age limestones and shales in eastern Kansas. The stems break into small pieces that look like small O-shaped cereal. A single piece or a short stack of pieces are easy to recognize. Although crinoid calyxes and arms are much harder to find, beautiful specimens have been found in the chalk beds of western Kansas.



◀ *Drawing of crinoids by Ernst Haeckel in* Kunstformen der Natur *(1904).*

Segments of crinoid stems are common in some Kansas rock layers. ▶

Bryozoan

Bryozoans are tiny aquatic animals that live in colonies. When you find a bryozoan fossil, it is actually a colony formed by a handful to millions of individual bryozoans. Each individual averages less than 0.04 inches (1 mm) in length. Different types of bryozoans build different-shaped colonies. Some colonies look like sticks or antlers. Others look like fans. They can appear as fine mesh, net, or lace encrusted on rocks or the shells of other marine animals.

Today, there are still thousands of types of living bryozoans, although not nearly as many as there were hundreds of millions of years ago. In Kansas, bryozoans are most common in the Pennsylvanian-age and Permian-age rocks in the eastern third of the state. They are sometimes confused with corals, which also build colonies. Unlike corals, bryozoans do not build reefs.

◀ *Bryozoan colonies vary in shape.*

For more about the state's geology and natural resources, visit GeoKansas at http://geokansas.ku.edu.

Other publications about rocks, minerals, and fossils available from the Kansas Geological Survey

Books

Kansas Rocks and Minerals
Revised by Rex Buchanan; by Laura Lu Toldsted and Ada Swineford

Packed with information about common and not-so-common rocks and minerals found in Kansas, this book describes the geology of the state, from limestone and galena to oil and fossilized raindrops.

Ancient Life Found in Kansas Rock
by Roger B. Williams

This introduction to common fossils of Kansas focuses on invertebrate fossils but also features a vertebrate land tortoise, teeth of sharks and other fish, and molars from elephant-like mastodons and woolly mammoths.

Windows to the Past: A Guidebook to Common Invertebrate Fossils of Kansas
by Liz Brosius

Windows to the Past explores invertebrate fossils of Kansas—brachiopods, clams, corals, crinoids, trilobites, snails, insects, echinoids—and related topics.

Public Information Circulars

Public Information Circulars (including *Invertebrate Fossils of Kansas,* described below) are short publications that cover dozens of topics related to Kansas natural resources, including meteorites, kimberlites, glaciers, earthquakes, and landslides. Available online or in print.

Invertebrate Fossils of Kansas
by Liz Brosius

This circular features full-color photos and information about ammonoids, brachiopods, clams, corals, crinoids, fusulinids, trilobites, and snails and other gastropods.

For more information about these and other KGS publications, contact:

Kansas Geological Survey
Publication Sales
1930 Constant Ave.
Lawrence KS 66047-3724
785.864.3965
kgs-publications@ku.edu

Online Resources
from the Kansas Geological Survey
http://www.kgs.ku.edu

GeoKansas: A Place to Learn About Kansas Geology
http://geokansas.ku.edu

Besides rocks, minerals, and fossils, GeoKansas allows you to explore many topics related to the state's geology, including where to find popular and off-the-beaten-path sites to visit and information about earthquakes and other environmental hazards, water and natural resources, geologic time, and the maps, tools, and techniques developed and used by the KGS.

The Kansas Geological Survey Photo Library
http://www.kgs.ku.edu/Images/DB/index.html

Our online photo library holds thousands of photographs of the state, free for you to use.

Interactive Geologic Map of Kansas
http://maps.kgs.ku.edu/state_geology

This multilayered map lets you learn about geologic units, rivers and lakes, county boundaries, roads, and towns of Kansas. Activate shading for a three-dimensional look, and click on geologic units to see pop-up descriptions.

Find us

Facebook
http://facebook.com/KansasGeologicalSurvey

Twitter
http://twitter.com/ksgeology

Instagram
http://instagram.com/ksgeology

Contents of the Rocks, Minerals, and Fossils of Kansas box

Calcite $CaCO_3$ Primary mineral in limestone and seashells. Often a cementing material in sandstone. Usually white or colorless but may be tinted.	**Halite** NaCl Dissolves rapidly in water so doesn't appear at the surface. Mined under-ground from salt beds up to 250 feet thick in central Kansas.	**Galena** PbS Formerly mined for its lead content in Cherokee County in the Tri-State mining district that extends into Missouri and Oklahoma.	**Rock Gypsum** $CaSO_4 \cdot 2H_2O$ Commonly found in the Red Hills of south-central Kansas. Mined in Barber County in the Red Hills and Marshall County in northeast Kansas.	**Selenite** $CaSO_4 \cdot 2H_2O$ A type of gypsum that is transparent and can be split into thin sheets. Found in some western and central Kansas shales.	**Volcanic ash** Fine-grained rock, mineral, and glass fragments erupted from volcanoes and carried by wind. Found in central and western Kansas subsurface. - - - - - - - **Alluvium** Mass quantities of loose particles—mainly sand, gravel, silt, and clay—found in streambeds and floodplains. Occasionally cemented together.
Quartzite metamorphic Altered from sandstone. Quartzite boulders found in northeast Kansas were carried in by glaciers about 700,000 years ago.	**Kimberlite** igneous Contains the mineral olivine, which gives it a green or brown color. Found only in small areas of Riley and Marshall counties.	**Shale** sedimentary Formed from compacted clay and mineral particles. Color varies (black, gray, red, green). Found in eastern and central Kansas hills.	**Sandstone (tan)** sedimentary Mainly cemented sand-sized particles of quartz, feldspar, and other minerals. Formed in shallow marine or river environments.	**Sandstone (red)** sedimentary Mineral particles cemented by iron oxide (rust). Bright red to dark purplish-red. Common in Red Hills and eastern Smoky Hills.	
Limestone sedimentary Primarily formed from calcite. White, tan, red, or gray. Common in eastern Kansas, Flint Hills, and central Smoky Hills.	**Chalk** sedimentary Type of limestone composed mainly of microscopic organisms. White, tan, or gray. Cretaceous chalk beds found in western Kansas.	**Coal** sedimentary Formed from deposits of decaying plants in large swamps. Once mined in eastern Kansas, mainly in Crawford and Cherokee counties.	**Brachiopods** Shelled marine animals with two symmetrical valves (half shells) hinged together. Common in some eastern Kansas limestones.	**Crinoids** Marine animals with plant-like stems and feathery arms. Stem segments are common in some eastern Kansas limestones and shales.	**Bryozoan** Colonies of tiny aquatic animals that may look like sticks, antlers, fans, lace, or mesh. Most common in the eastern third of Kansas.

mineral | rock | fossil

KANSAS GEOLOGICAL SURVEY

The University of Kansas

ISBN 978-1-58806-335-9