Chapter 5: Mineral Resources of the South Central US

What is a mineral?
A mineral is a naturally occurring solid with a definite chemical composition and crystalline structure. Minerals provide the foundation of our everyday world. Not only do they make up the rocks we see around us in the South Central, they are also used in nearly every aspect of our lives. The minerals found in the rocks of the South Central are used in industry, construction, machinery, technology, food, makeup, jewelry, and even the paper on which these words are printed.

Minerals provide the building blocks for rocks. For example, granite, an igneous rock, is typically made up of crystals of the minerals feldspar, quartz, mica, and amphibole. In contrast, sandstone may be made of cemented grains of feldspar, quartz, and mica. The minerals and the bonds between the crystals define a rock’s color and resistance to weathering.
Several thousand minerals have been discovered and classified according to their chemical composition. Most of them are **silicates** (representing approximately a thousand different minerals, of which quartz and feldspar are two of the most common and familiar), which are made of silicon and oxygen combined with other elements (with the exception of quartz, SiO$_2$). **Carbonate rocks** are made of carbon and oxygen combined with a metallic element; **calcium carbonate** (CaCO$_3$) is the most common example, and most of it today originates as skeletal material precipitated by organisms. Other mineral categories include native elements (such as **gold**), oxides and **sulfur**-bearing minerals, and **salts**.

Metallic minerals are vital to the machinery and technology of modern civilization. However, many metals occur in the **crust** in amounts that can only be measured in parts per million (ppm) or parts per billion (ppb). A mineral is called an **ore** when one or more of its elements can be profitably removed, and it is almost always necessary to process ore minerals in order to isolate the useful element. For example, **chalcopyrite** (CuFeS$_2$), which contains **copper**, **iron**, and sulfur, is referred to as a copper ore when the copper can be profitably extracted from the iron and sulfur. Ores are not uniformly distributed in the crust of the Earth, but instead occur in localized areas where they are concentrated in amounts sufficient for being economically extracted by mining.

Non-metallic minerals do not have the flash of a metal, though they may have the brilliance of a **diamond** or the silky appearance of **gypsum** (CaSO$_4$·2H$_2$O). Generally much lighter in color than metals, non-metallic minerals can transmit light, at least along their edges or through small fragments.

**Mineral Identification**

Although defined by their chemical composition and crystal structure, minerals are identified based on their physical properties. A variety of properties must usually be determined when identifying a mineral, with each such property eliminating possible alternatives.
Hardness is a very useful property for identification, as a given mineral can only exhibit a narrow range of hardnesses, and since it is easily testable, this property can be used to quickly and simply minimize the number of possibilities. Hardness is important because it helps us understand why some rocks are more or less resistant to weathering and erosion. Quartz, with a rating of 7 on the Mohs scale, is a relatively hard mineral, but calcite (CaCO₃), rating 3 on the Mohs scale, is significantly softer. Therefore, it should be no surprise that quartz sandstone is much more resistant to erosion and weathering than is limestone, which is primarily made of the mineral calcite. Quartz is a very common mineral in the Earth’s crust, and it is quite resistant due to its hardness and relative insolubility. Thus, quartz grains are the dominant mineral type in nearly all types of sand.

Mohs Scale of Hardness

In 1824, the Austrian mineralogist Friedrich Mohs selected ten minerals to which all other minerals could be compared to determine their relative hardness. The scale became known as the Mohs scale of hardness, and it remains very useful as a means for identifying minerals or for quickly determining their hardness. Everyday items can be used to determine hardness if the minerals in the scale are not available. These include a streak plate or piece of unglazed porcelain (hardness 7), a piece of glass (5), a penny (3), and a fingernail (2).

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Color is helpful in identifying some minerals such as sulfur, but it is uninformative or even misleading in others such as garnet. Luster describes how light is reflected from a mineral's surface and it can range from adamantine, seen in diamonds, to dull or earthy (effectively no luster), such as in kaolinite. Crystal form, if visible, can also be diagnostic. For example, fluorite and calcite may appear superficially similar, but fluorite forms cubic crystals while calcite forms trigonal-rhombohedral crystals. Relatedly, crystals may have planes of weakness that cause them to break in characteristic ways, called cleavage. Or they may not, but instead display fracture when broken. Mica and graphite have very strong cleavage, allowing them to easily be broken into thin sheets, while quartz and glass (the latter not being a mineral) have no cleavage.
instead displaying a distinctive curved fracture form known as conchoidal. The density of a mineral may also aid in identifying it (e.g., metals tend to be very dense). Finding the exact density is straightforward, but it does require measuring the volume of the sample. Placing an unknown mineral in water (or other liquid) to find its volume by displacement can be a risky undertaking since several minerals react violently with water, and many more break down with exposure. A mineral’s streak is obtained by dragging it across a porcelain plate, effectively powdering it. The color of the powder eliminates conflating variables of external weathering, crystal habit, impurities, etc. Some minerals are magnetic (affected by magnetic fields), while a few are natural magnets (capable of producing a magnetic field).

Most minerals can be identified by process of elimination after examining a few of these properties and consulting a mineral identification guide. Mineral testing kits often include several common objects used to test hardness: a porcelain streak plate, a magnet, and a magnifying glass. Some minerals have rare properties, which may be more difficult to test. For example, there are minerals that exhibit luminescence of all types, giving off light due to a particular stimulus. Some minerals are radioactive, usually due to the inclusion of significant amounts of uranium, thorium, or potassium in their structure. Carbonate minerals will effervesce when exposed to hydrochloric acid. Double refraction describes the result of light passing through a material that splits it into two polarized sets of rays, doubling images viewed through that material. For example, a single line on a sheet of paper will appear as two parallel lines when viewed through a clear calcite crystal.

What Are Minerals Used For?
Mineral resources fall into many different categories, including industrial minerals, construction materials, gemstones, and metallic and non-metallic ores. Some minerals and rocks are abundant and are used in the construction industry or in the manufacturing of many of the products we commonly find in stores. Construction materials include dimension stone (e.g., sandstone, limestone, and granite), which is used for the exterior or interior of structures.

Minerals used in manufacturing include kaolinite for ceramics, gypsum for wallboard, fluorite for the fluoride in toothpaste, and halite for common table and rock salt. We also seek out specific rock types and sediment to use in the construction of buildings, highways, and bridges. Many of the statues in museums are commonly made of marble, jade, or soapstone. Granite, travertine, and other decorative stones are increasingly used to beautify our home interiors and to make art, in addition to being used in public buildings.

There are many more interesting and distinguishing properties that minerals may possess, and there are many more elaborate and precise means for identifying them. The branch of geology that studies the chemical and physical properties and formation of minerals is called mineralogy.
Mineral Resources

What distinguishes a regular mineral from a gem?

Minerals are assigned to the category of gemstones based primarily on our interpretation of what has value. Typically, the beauty, durability, and rarity of a mineral qualify it as a gemstone. Beauty refers to the luster, color, transparency, and brilliance of the mineral, though to some degree it is dependent on the skillfulness of the cut. Not all gems are prized for these reasons; for example, scarcity may be artificially inflated, or a mineral may be valued for its unusual color.

Gemstones can be further categorized as precious or semi-precious stones. Precious stones, including diamond, topaz, and sapphire, are rare and translucent to light. They are more durable because they are hard, making them scratch resistant. On the Mohs scale of hardness, the majority of precious gemstones have values greater than 7. Semi-precious stones are generally softer, with hardness scale values between 5 and 7. The minerals, peridot, jade, garnet, amethyst, citrine, rose quartz, tourmaline, and turquoise are examples of semi-precious stones that can be cut and used in jewelry.

Gems may have common names that differ from their geological ones, and these names may be dependent on mineral color. For example, the mineral beryl is also referred to as emerald, aquamarine, or morganite depending on its color. Corundum can also be called sapphire or ruby, and peridot is another name for olivine.

Some minerals are considered to be precious or semi-precious and are used in jewelry, including diamond and some crystalline forms of quartz.

Metallic minerals have many applications and are used to manufacture many of the items we see and use every day. For example, iron comes from hematite and magnetite, and from it we make steel. Lead, from the mineral galena, is used in the manufacture of batteries and in the solder found in electronic devices. Titanium, from the mineral ilmenite, is used in airplanes, spacecraft, and even white nail polish. Aluminum comes from bauxite and is known for being both lightweight and strong—many of the parts that make up today’s automobiles are made of this metal. Copper comes from a variety of copper-bearing minerals, including chalcopyrite, and is used to make electrical wire, tubing, and pipe.
Mineral Formation

Economically recoverable mineral deposits are formed by geologic processes that can selectively concentrate desirable elements in a relatively small area. These processes may be physical or chemical, and they fall into four categories:

Magmatic processes separate minor elements of magma from the major elements and concentrate them in a small volume of rock. This may involve the early crystallization of ore minerals from the magma while most other components remain molten, or late crystallization after most other components have crystallized. Magmatic processes responsible for the formation of mineral deposits are usually associated with igneous intrusions (formed during mountain building events, rifting, and volcanic activity), which can range in composition from granite (felsic) to gabbro (mafic). Metamorphism may also cause recrystallization of minerals and concentration of rare elements. Under conditions of extreme high-temperature metamorphism, minerals with the lowest melting temperatures in the crust may melt to form small quantities of pegmatite magmas.

Hydrothermal processes involve hydrothermal solutions that dissolve minor elements dispersed through large volumes of rock, transport them to a new location, and precipitate them in a small area at a much higher concentration. Hydrothermal solutions are commonly salty, acidic, and range in temperature from over 600°C (~1100°F) to less than 60°C (140°F). Some of these fluids may travel very long distances through permeable sedimentary rock. Eventually, the hydrothermal fluids precipitate their highly dissolved load of elements, creating concentrated deposits.

Sedimentary processes gather elements dispersed through large volumes of water and precipitate them in a sedimentary environment, such as in sedimentary layers on the ocean floor or on lakebeds. Sedimentary mineral deposits form by direct precipitation from the water.

Weathering and erosion break down large volumes of rock by physical and chemical means and gather previously dispersed elements or minerals into highly concentrated deposits. Residual weathering deposits are mineral deposits formed through the concentration of a weather-resistant mineral, as a result of surrounding minerals being eroded and dissolved. In contrast, mineral deposits formed by the concentration of minerals in moving waters are called placer deposits.

A mineral is not necessarily restricted to one method of concentration or environment of formation. For example, economically important deposits of gypsum may form as a precipitate from evaporating water. However, gypsum formation may also be associated with volcanic regions where limestone and sulfur gases from the volcano have interacted, or from other areas as a product of the chemical weathering of pyrite.
What are hydrothermal solutions?

Hot water enriched in salts such as sodium chloride (NaCl), potassium chloride (KCl), and calcium chloride (CaCl₂) is called a hydrothermal solution, or simply “brine.” Brine is as salty or even saltier than seawater, and may contain minute bits of dissolved minerals such as gold, lead, copper, and zinc. The presence of salt in the water stops the metallic minerals from precipitating out of the brine because the chlorides in the salt preferentially bond with the metals. Additionally, because the brine is hot, the minerals are more easily dissolved, just as hot tea dissolves sugar more easily than cold tea does.

Hot water brines can have varying origins. Most bodies of magma contain mineral-enriched, superheated water, which is released into the surrounding rock as the magma cools. Rainwater can become a hydrothermal solution as it filters through rocks and picks up soluble materials along its path. Seawater, which is already enriched in salt, often becomes a hydrothermal solution in the vicinity of volcanic activity on the ocean floor where tectonic plates are pulling apart.

Hydrothermal solutions move away from their source of heating through cracks, faults, and solution channels into the adjacent cooler rocks. While the water moves quickly through fractures and openings in the rock (where it experiences changes in pressure or composition and dilution with groundwater), it can cool rapidly. This rapid cooling over short distances allows concentrations of minerals to be deposited. When a hydrothermal solution cools sufficiently, the dissolved salts form a precipitate, leaving behind minerals in a vein or strata-bound deposit.
Minerals in the South Central

Throughout the South Central, the deposition of sediment has left behind an abundance of deposits useful for construction materials. River systems and glaciers deposited sand and gravel, while ancient seas that spread across the area also left behind thick deposits of halite and gypsum. The advance of inland seas and the subsequent deposition of marine detritus also made possible the widespread existence of energy resources (fossil fuels) throughout the area, most notably oil, natural gas, and coal. Some of the natural gas produced in the South Central also contains helium in sufficient concentrations to be profitably extracted—it originates from the decay of radioactive elements in the source rocks of accumulated natural gas.

Periods of igneous activity commonly produce metals. However, some sources of metals in sedimentary rocks resulted not from igneous activity, but rather from chemical reactions that took place within rocks either as they formed or at some time after their formation—the hydrothermal precipitation of minerals is one such example. Igneous activity also contributes to the occurrence of non-metallic minerals and gemstones. For example, diamonds form near the Earth’s mantle, but are often carried toward the surface by explosive volcanic eruptions.

Mineral Resources of the Central Lowland

Mineral resources in the Central Lowland have accumulated primarily due to the deposition of sediment (Figure 5.2). The region’s surface rocks are sedimentary strata from the Pennsylvanian and Permian, covered by glacial, river, and wind-blown deposits from the Quaternary and Holocene. Sources of non-organic sediment (sand and finer-grained materials) are derived from erosion, while organic carbonate sediment accumulated in shallow seas to form limestone. Ancient forests produced layers of organic debris that eventually formed coal. All of these depositional patterns have also been influenced by cyclical fluctuations in sea level, producing cyclothems: repeated sequences of terrestrial shale, sandstone, and coal layered with marine shale and limestone (Figure 5.3). Episodes of Quaternary glaciation and erosion in northeast Kansas and northern Missouri left behind discontinuous patches of glacial deposits consisting of till interspersed with sand and gravel outwash. As a result of all these processes, sand, gravel, stone, limestone, and clay occur abundantly throughout the Central Lowland, and all are quarried for use in construction. Industrial sand is mined at several locations in Oklahoma and Texas, primarily for use in glassmaking.
Mining is a profit-focused undertaking. The profitability of mining minerals or rocks depends on a number of factors, including the concentrations of recoverable elements or material contained in the deposit; the anticipated amount of the deposit that can be mined; its accessibility using current mining methods and technologies; its marketability; and lastly the cost of returning the site to its original state once the extraction phase of mining has ended (reclamation). All these factors determine the choice of mining method. Types of mining include underground (tunnel or shaft), surface (open pit or quarry), hydraulic operations (placer), solution using hot water, and seawater evaporation ponds. Once a mineral resource has been removed from the ground, the next step is to process it in order to recover its useful elements or to transform it so that it can be used in manufacturing or other industrial processes.

Modern mining is accomplished in three phases: exploration, extraction, and reclamation. Exploration is performed to determine the extent of the mineral resource and usually involves extensive use of drilling and geophysical techniques to determine the shape, size, and quality of the resource. Extraction involves removing the mineral resource from the ground. Reclamation is done when mining ceases and is designed to restore the land to a condition where it can be used for other purposes. This last phase usually involves removing sources of contamination, which can be considerable depending on the scope of the mining activity. A good example of the need for an extensive and expensive cleanup of past activity is in the Tri-State mining district in southeast Kansas, northeast Oklahoma, and southwest Missouri, where lead and zinc deposits were actively mined for many decades in the late 19th and early 20th centuries.
Pangaea • supercontinent, meaning “all Earth,” which formed over 250 million years ago and lasted for almost 100 million years.

Carboniferous • a geologic time period that extends from 359 to 299 million years ago.

climate • a description of the average temperature, range of temperature, humidity, precipitation, and other atmospheric/hydrospheric conditions a region experiences over a period of many years (usually more than 30).
During and after the formation of Pangaea, the humid and tropical Carboniferous environment transitioned to the hot and arid climate of the Permian. These arid conditions led to the formation of hypersaline, shallow seas with restricted circulation, and layers of evaporite minerals were deposited as these seas evaporated. Today, Permian evaporite beds in Kansas, Oklahoma, and Texas are mined for halite and gypsum.

Halite is mined in two ways. When deposited in thick beds, salt can be excavated by mechanically carving and blasting it out. This method, called “room and pillar” mining, usually requires that pillars of salt be left at regular intervals to prevent the mine from collapsing (Figure 5.4). Another method, called solution mining, involves drilling a well into a layer of salt. In some cases, the salt exists as part of a brine that can then be pumped to the surface and the water then removed, leaving the salt behind. In others, fresh water is pumped down to dissolve the salt, and the solution is brought back to the surface where the salt is removed (Figure 5.5).

Selenite, a variety of gypsum, is commonly found where Permian rocks appear at the surface, most notably in the Salt Plains of Oklahoma. In many locations, crystals of selenite are impregnated with sand and clay and are often referred to as “sand crystals.” In Salt Plains National Wildlife Refuge, groundwater seeping through salt- and gypsum-saturated sand becomes concentrated with these minerals, spurring the formation of selenite crystals with a distinctive hourglass-shaped sand inclusion (Figure 5.6). The Salt Plains are the only place in the world where this phenomenon occurs. Barite roses can also be found at the surface in central Oklahoma (Figure 5.7). Due to their attractive form, sand crystals and barite roses are often sought after as collectibles.
Figure 5.5: An example of solution mining that involves the pumping of fresh water through a borehole drilled into a subterranean salt deposit.

Figure 5.6: A selenite crystal from Salt Plains National Wildlife Refuge, Oklahoma with distinctive hourglass-shaped sand inclusion. Individual crystals up to 18 centimeters (7 inches) long have been found at this locality.
Igneous activity has also contributed to the formation of minerals found in the Central Lowland. During the late Cretaceous, eastern Kansas experienced episodes of volcanism. Some magma solidified in the necks of erupting volcanoes, eventually becoming kimberlite. These deposits, exposed by erosion at several locations in northeastern Kansas, yield small garnets. In southeastern Kansas, igneous intrusions led to the formation of lamproite sills and pipes. The lamproite contains shiny flakes of mica (Figure 5.8), which, when first observed in the 1870s, led to reports of silver and the formation of a mining town called Silver City. Although the lamproite does not actually contain silver, it is still mined today for its mica (used in polymers, coatings, and construction). In addition, the lamproite itself is ground and used as a mineral supplement in cattle feed.

Ancient sedimentation patterns and tectonic activity have favored the placement of widespread fossil fuel resources in the Central Lowland. Processing plants in Texas and Kansas recover commercial quantities of helium gas, an important byproduct of natural gas extraction. Non-commercial deposits of asphalt, formed by the breakdown of petroleum in the underlying rock, are also common in eastern Oklahoma.

The Central Lowland does not contain economically viable metal deposits. However, copper-bearing minerals can be found in the Permian rocks of southern Kansas, parts of Oklahoma, and north-central Texas.
Mineral Resources of the Interior Highlands Region 2

The Interior Highlands region consists of two areas of uplifted rock—the Ozark Uplift and the Ouachita Mountains—which have existed since the formation of Pangaea. Thick sequences of Paleozoic limestone and dolomite, with lesser thicknesses of sandstone and shale, underlie the area occupied by the Ozarks, except in the St. Francois Mountains (where erosion has stripped away the sedimentary cover and exposed Precambrian granite). Nodules of chert are present and often abundant in most of the limestone and dolomite. The weathering and erosion of these rocks has produced the chert gravels that mantle much of the Ozark Uplift.

See Chapter 4: Topography to learn more about the Ozark Uplift and Ouachita Mountains.
The Interior Highlands is a source of several industrial minerals, primarily from sedimentary rocks. Episodes of marine transgression have left behind considerable resources for construction materials, including clay, limestone, sandstone, and granite (Figure 5.9). Deposits of tripoli (porous, weathered limestone mixed with silica) and novaculite (a form of chert) are mined in Missouri, Arkansas, and Oklahoma for use as abrasives. Tripoli is also used as filler in plastics, rubber, paint, and even toothpaste! Novaculite has been mined since prehistoric times; Native Americans used it to make arrow and spear points (Figure 5.10), and it has been quarried for use as whetstones since the 1800s.

Metals have also generated a historically important mining industry in the Interior Highlands. Lead, zinc, copper, and silver are all found in significant quantities.
quantities, and are thought to have precipitated from hydrothermal solutions during the Carboniferous and Permian. Lead mining first began in southeastern Missouri around 1720, and it has continued into the present. There are three mining districts in the Missouri portion of the Ozark Uplift: the Southeast Lead District, the Tri-State, and the Central (Figure 5.11). The Southeast Lead District includes the Old Lead Belt on the eastern side of the St. Francois Mountains and the New Lead Belt on the western side. Smaller, localized deposits of lead ores are located in northern Arkansas and southeastern Oklahoma. The Southeast Lead District contains the highest known concentration of galena, a lead-bearing ore, in the world (Figure 5.12). More than 17 million tons of lead have been produced in Missouri since mining began there, valued at more than 5 billion dollars. The Southeast Lead District produces about 70% of the US lead supply, most of which is used in the manufacture of batteries and ammunition.

Of Missouri’s three mining districts, perhaps the most famous is the Tri-State, which includes southwest Missouri around Joplin, and adjacent areas in southeast Kansas and northeast Oklahoma (Figure 5.13). The discovery of
ore in Joplin occurred in 1838, and mining reached full swing by the beginning of the Civil War. Both sides fought over the mines, each trying to secure a source of lead for the war effort. This conflict resulted in the suspension of most mining operations until after the war’s end. Lead mining resumed after the war, and zinc production began in the early 1870s. In the western part of the Tri-State District, the ore bodies are deeper, and mining was conducted underground, but in the east the ore bodies are shallower and were mined using pits. Production of metals from the district fluctuated with the economic fortunes of the country and the need for wartime supplies. Production began dropping after World War II, and the last mine closed in 1970. During the district’s life, 4000 mines produced 23 million tons of zinc concentrates and 4 million tons of lead concentrates, accounting for 50% of the zinc and 10% of the lead used in the US. Today, some of the Tri-State’s mines have become Superfund sites due to the quantities of toxic waste left behind after the closure of the mines. The Tar Creek Superfund site, located near the towns of Picher and Cardin in Oklahoma, was originally a major lead-zinc mining area. After its closure, the mine left behind about 75 million tons of chat, or lead-contaminated dust.

A Superfund site is a heavily polluted location, designated by the government to receive a long-term clean-up response in order to remove environmental hazards and contamination.
Waste materials, acids, and heavy metals have seeped into the groundwater, contaminating local aquifers and other freshwater sources. The severe environmental and health impacts of Tar Creek’s mining waste have lead the EPA to declare Picher, Oklahoma as one of the most toxic places in the US.

In addition to lead and zinc, mines in the Interior Highlands have also produced significant quantities of silver and copper. Other metallic elements are also present, including cadmium, nickel, and cobalt. Pyrite, calcite, dolomite, and quartz specimens from the region are highly prized by collectors.

Mining for iron ore began in Missouri in the mid-19th century, and has been intermittent since 2000. The ores precipitated from hydrothermal solutions, filling sinkholes and fractures in limestone, dolomite, and the Precambrian rocks of the St. Francois Mountains. The Interior Highlands’ iron mines produce hematite and magnetite, unique among the iron ores for its magnetic properties.
Mineral Resources of the Coastal Plain Region 3

The Coastal Plain is underlain by thousands of feet of sedimentary rock and sediments that were deposited in both marine and terrestrial environments. Strata underlying this region consist of limestones, shales, and sandstones that were deposited in river valleys as well as in shallow seas, deltas, bays, and beaches. Cycles of deposition, erosion, and stability are tied to changes in sea level, which in turn have been influenced by Quaternary glacial and interglacial periods. Throughout the Cenozoic, the Mississippi River has continually deposited sediment in its alluvial plain, contributing to its evolving delta system. Offshore, Louisiana and Texas continue to experience the deposition of sediment from rivers emptying into the Gulf of Mexico.

Mineral resources in the Coastal Plain have accumulated primarily as a result of sedimentary processes (Figure 5.15). Sand and gravel, limestone for cement, crushed stone, and clay are mined throughout the region. Halite, gypsum, and industrial sand are produced in Texas and Louisiana, and bromine is extracted from brine wells located in Arkansas and Texas. Sulfur is produced from sources associated with salt domes in the Texas coastal plain, and as a byproduct from the processing of oil and gas. Zeolites—porous alumino-silicate minerals with cation-exchange properties that can transform hard water into soft water—are mined in south-central Texas.

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**Figure 5.14**: Residential area in Ottawa County, Oklahoma near the Tar Creek site. Note the proximity of several large lead-contaminated chat piles.

**See Chapter 4: Topography for more about the Mississippi River Delta.**
Although the Coastal Plain is primarily made up of sedimentary strata, small areas of Cretaceous igneous intrusions are located in southwestern Arkansas. Deposits of diamonds and other gemstones do not appear here in commercially viable quantities, but individuals may prospect for and freely remove diamonds and other gemstones they find from the Crater of Diamonds State Park in Pike County, Arkansas. These minerals are found in an ancient volcanic pipe or conduit—the volcano was so explosive that it brought minerals like diamonds, clays, and others.

Coastal Plain clays include fire clay, ball clay, kaolin, and bentonite. Fire clay is used in the production of refractory brick, and ball clay is used to produce ceramic products. Kaolin is used in ceramics, as well as a stabilizing agent or filler in many products. Bentonite is used in drilling muds and can be used as a sealant in instances where it is important to provide a barrier for water flow through rock or sediment.
Mineral Resources

olivine, and garnet, all of which are formed at great depths, up toward the surface. When the ancient vent exploded, it left behind a crater filled with volcanic material. Today, minerals can be collected from within the weathered crater. Over 75,000 white, brown, and yellow diamonds have been found in the park, including “Uncle Sam,” the largest diamond ever found in the United States, and the Strawn-Wagner Diamond, the world’s only “perfect” diamond (Figure 5.16). Other gems and minerals found in the park include amethyst, banded agate, jasper, peridot, garnet, quartz, calcite, barite, and hematite.

Metals are not currently mined for commercial purposes in the Coastal Plain. While some deposits of metal-bearing minerals do occur in Texas and Arkansas, most of these deposits are either too small or low grade to be profitably mined.

Figure 5.16: The Strawn-Wagner Diamond, found at Crater of Diamonds state Park in 1990, was cut to 1.09 carats and graded “perfect” by the American Gem Society and Gemological Institute of America. It is the only diamond in the world to receive such a grading. Crater of Diamonds State Park purchased the diamond for $34,700, and it is currently on exhibit there.
Mineral Resources of the Great Plains Region 4

The near-surface geology and mineral resources of the Great Plains region result from a complex suite of factors (Figure 5.17). Marine and terrestrial Cretaceous deposits indicate that several periods of sea level rise and fall were associated with the expansion and contraction of the Western Interior Seaway, which extended from what is now western Illinois to central Utah. Deposition ended with the final retreat of the sea and the uplift of the Rocky Mountains. Uplift in Colorado and New Mexico was renewed in the Miocene and Pliocene, gently tilting the underlying strata eastward. This tilting is more pronounced in the Texas panhandle than it is in western Kansas. Mountain streams transported and deposited large volumes of eroded sediment onto the plains, resulting in a thick blanket of sand, gravel, silt, and clay on top of eroded Mesozoic and Permian strata throughout the region. The sands and gravels here are rich in quartz and feldspar from the weathering and erosion of igneous and metamorphic rocks in the Rocky Mountains to the west. Sand, gravel, limestone, and other construction materials are mined throughout the Great Plains, and building stone is quarried from rocks near the Llano Uplift in central Texas.

Figure 5.17: Principal mineral resources of the Great Plains.
Mineral Resources

Cyclical changes in climate during the Quaternary and Holocene initiated episodes of stream erosion, uncovering underlying Permian rocks containing layers of halite and gypsum. In and near river valleys, the movement of groundwater dissolved these soluble minerals, further accelerating the pace of erosion. Sediments were carried and deposited by the wind during drought periods and by streams during wet periods, leading to the development of soil horizons rich in deposits of caliche (Figure 5.18). Caliche forms when water infiltrates the soil, dissolves soluble material, and evaporates, leaving behind precipitated minerals in the pore space between soil grains. A zone of cemented material forms within the soil if this happens repeatedly. Layers of caliche accumulate to tens of feet in some locations, and multiple layers are commonly found throughout the Great Plains. Caliche is commonly collected for use as an additive in cement.

Beginning in the Miocene, episodes of volcanism in the Western and Southwestern US produced widespread ashfalls that covered much of the Great Plains. Deposits of silicate volcanic ash, as well as sands and gravels derived from the erosion of basaltic lavas, are present in the sediments at many locations in the Great Plains, such as the Pearlette Ash Bed in Kansas (Figure 5.19). This volcanic ash was mined between the 1930s and 1950s for use in concrete, abrasives, and as a cleaning material.

Figure 5.18: A shelf of caliche in central Texas.

See Chapter 8: Soils to learn more about caliche and other soils of the Great Plains.
Widespread fossil fuel resources in the Great Plains have led to the recovery of several associated elements that are often found alongside gas and oil. Oklahoma is the nation’s sole producer of iodine, extracted from deeply buried gas brines that occur in the Woodward Trench in northwest Oklahoma. Helium and sulfur are recovered from the Hugoton Gas Field in southwestern Kansas and the panhandles of Oklahoma and Texas. This area contains the largest reserve of helium in the United States; helium collected here is piped to the National Helium Reserve in Amarillo, Texas, for safekeeping and storage (Figure 5.20).

Potash is mined commercially from Permian deposits in west Texas. Potash is a name used for a variety of salts containing potassium, with mined potash being primarily potassium chloride. The majority of potash is used as fertilizer, but an increasing amount is being used in a variety of other ways: water softening, snow melting, a variety of industrial processes, as a medicine, and to produce potassium carbonate.
Mineral Resources of the Basin and Range
Region 5

The Basin and Range province of west Texas is underlain by sedimentary, igneous, and metamorphic rocks ranging in age from Precambrian to Neogene. These are exposed in north-south oriented, fault-bounded mountain ranges, with considerable amounts of eroded sediment filling the valleys in between ranges (Figure 5.21). Taken together, these peaks and valleys (also called horst and graben landscapes) produce basin and range topography, formed as a result of stretching and thinning of the lithosphere during the Paleogene, when crustal extension and faulting led to the formation of almost 400 separate mountain blocks.

The mineral resources that are mined commercially in the Basin and Range are limited to talc and bentonite, industrial minerals used in manufacturing (Figure 5.22). Crushed stone, sand, and gravel are quarried as construction materials, and sulfur is extracted from oil at a plant in El Paso County. Deposits of barite and fluorite have been found in this region, but they are of no commercial value and are not currently mined. Sources of metals (including uranium, tungsten, zinc, tin, iron, manganese, lead, silver, molybdenum, and mercury) have also been discovered in El Paso County, but these are typically too small to be of commercial value.

See Chapter 4: Topography for more details about the formation of the Basin and Range.

Paleogene • the geologic time period extending from 66 to 23 million years ago.

Talc • hydrated magnesium silicate, formed during hydrothermal alteration accompanying metamorphism.

Bentonite • a clay, formed from decomposed volcanic ash, with a high content of the mineral montmorillonite.

Manganese • a metallic chemical element (Mn).

Molybdenum • a metallic chemical element (Mo) which has the sixth-highest melting point of any element.
Figure 5.21: An example of basin fill in the Basin and Range.

Figure 5.22: Principal mineral resources of the Basin and Range.
Resources

Books


State-based Resources


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