Mineral of the Month August 2014

GYPSUM
(variety SELENITE; subvariety DESERT ROSE)

This month our featured mineral is the selenite variety of gypsum in the form of desert roses from Mexico's Samalayuca Dune Fields. Our write-up discusses the mineralogy of gypsum, the origin of desert roses, and Mexico's emergence as a major source of mineral specimens.

OVERVIEW

PHYSICAL PROPERTIES

Chemistry: Hydrous Calcium Sulfate $CaSO_4 \cdot 2H_2O$
Class: Sulfates
Subclass: Hydrous Sulfates
Group: Gypsum
Crystal System: Monoclinic
Crystal Habits: Usually as bladed, rhombic crystals; occasionally as arrowhead-shaped twins with beveled edges. Thin crystals are slightly flexible and can be bent. Crystals are often heavily included. Also occurs in granular, fibrous, massive, and earthy forms, and as rosette-like, crystal clusters called "desert roses."
Color: Gypsum is usually colorless or white, but impurities can create pale shades of gray, yellow, red, tan, and brown. Desert roses take on the color of their included sand grains.
Luster: Vitreous to pearly; pearly on cleavage surfaces. Desert roses have a coarse surface texture and a dull luster.
Transparency: Desert roses are opaque, except for the translucent edges of thin crystals.
Streak: White
Cleavage: Perfect in one direction, distinct in two others.
Fracture: Conchoidal and splintery; brittle.
Hardness: Mohs 1.5-2.0
Specific Gravity: Usually 2.3-2.4; desert roses have a slightly greater density due to included quartz.
Refractive Index: 1.52-1.53
Luminescence: None
Distinctive Features and Tests: Gypsum can be recognized by its occurrence in sedimentary and evaporite-type deposits; the flexibility of its thin crystals; softness; and dominant, flat, bladed crystal habit. Desert roses have a distinctive "rose-petal"-like shape and are heavily included with sand grains.
Dana Classification Number: 29.6.3.1

NAME: The name "gypsum" is derived from the Greek *gypsos*, meaning "plaster" and alluding to an early gypsum product. The word "selenite" stems from the Greek *selēnitēs,* or "stone of the moon," referring to the pearly, moon-like luster of its cleavage surfaces. Gypsum's many alternative names include "gypsum rock," "gypsite," "alabaster," "satin spar," "lapis specularis," "oulopholita," "yeso," "gesso," "gypsta," "gypse," "aphroselenon," "acido vitriolo saturata," and "spectacle stone." Rosette-shaped clusters of sand-included selenite crystals are known as "desert roses," "sand roses," "rose rocks," "selenite roses," and "gypsum roses."

COMPOSITION & STRUCTURE: Gypsum, a hydrous calcium sulfate, consists of 23.28 percent calcium, 18.62 percent sulfur, 2.34 percent hydrogen, and 55.76 percent oxygen. It is the most abundant member of the sulfates, a class of nearly 200 minerals in which sulfur and oxygen, as the sulfate radical $(SO_4)^{2-}$, combine with one or more metals. The "$\cdot 2H_2O$" in the chemical formula $CaSO_4 \cdot 2H_2O$ indicates that gypsum is a hydrous (or hydrated) mineral with two molecules of water attached to each parent molecule of calcium sulfate. Selenite, the crystalline form of gypsum, occurs in hydrothermal replacement deposits, volcanic formations, and most commonly in evaporite deposits. Desert roses are cleavage-separated clusters of sand-included, blade-shaped gypsum crystals that form in evaporate deposits. The dominant mineral in desert roses is the selenite variety of gypsum, which imparts its shape as clusters of bladed crystals; the secondary mineral is included quartz [silicon dioxide, SiO_2] that imparts its color and a rough texture to the selenite crystals.

COLLECTING LOCALITIES: Gypsum desert roses are collected in Mexico, Morocco, Argentina, Chile, Tunisia, Namibia, Australia, Spain, Egypt, Libya, Mali, Mauritania, and Chad. In the United States, desert roses occur in Oklahoma and New Mexico.

HISTORY, LORE & GEMSTONE/TECHNOLOGICAL USES: Gypsum was used in crude plasters in the Middle East as early as 6000 B.C., and later in the construction of Egypt's pyramids. The ancient Greeks and Romans made stucco from powdered gypsum. Today, gypsum is used in ceramic casts, surgical splints, soil conditioners, smelting fluxes, and drywall. It also serves as a filler material in papers and paints, and as a setting retardant in cement. Because of their rarity, desert roses are not a commercial source of gypsum. But they are a source of colorful lore. Some cultures believed that desert roses were flowers that had turned to stone. Others considered them a warning to travelers of impending bad fortune. Still others saw them as a good omen that indicated the nearby presence of water. According to modern metaphysical beliefs, desert roses have a gentle energy that increases mental clarity; creates an awareness of self and the environment; enables one to see inner truths; promotes protection, prosperity, and purification; and helps recall past lives and see into the future. Collectors value desert roses for their rarity, unusual occurrence, and wide range of colors, shapes, and sizes.

ABOUT OUR SPECIMENS: Our desert-rose specimens were collected at the Samalayuca Dune Fields near Ahumada in Chihuahua, Mexico. The Mexican state of Chihuahua is bordered on the north by the American states of Texas and New Mexico. Much of northern Chihuahua is part of the Chihuahuan Desert, the world's seventh largest desert area. The Samalayuca Dune Fields, known locally as "*Los Médanos*" ("the dunes"), is an area of large, separated fields of sand dunes roughly 50 miles south of El Paso, Texas. The dune fields, also called the "Samalayuca Desert," cover about 700 square miles and lie along Mexico's Federal Highway 45. The Samalayuca Dune Fields have a recent geological origin and are thought to be only about 100,000 years old. The dune sand originated when silica-rich rocks weathered into sand particles that accumulated in a broad, dry lake bed. Prevailing winds then carried the sand particles and deposited them at the northwest base of Cerro de Samalayuca (Samalayuca Mountain) where they accumulated into dunes. This process of erosion, airborne transport, and deposition continues today. Desert roses probably formed only about 10,000 to 20,000 years ago when groundwater rich in dissolved gypsum rose into the subterranean sand strata beneath the dunes. As erosion reduced the surface, the water table dropped, causing the saturated, aqueous gypsum solutions to precipitate selenite. As the selenite crystals grew, included sand distorted the crystal lattices along the one-directional planes of perfect cleavage, causing them to separate into clusters of flat, bladed crystals that resemble rose petals. Wind-driven dune movement now periodically uncovers these desert roses, which are collected commercially.

COMPREHENSIVE WRITE-UP

COMPOSITION & STRUCTURE

Desert roses are actually composite specimens that consist primarily of the selenite variety of gypsum with secondary amounts of quartz sand. The bladed selenite crystals determine the physical shape of desert roses, while the included sand particles impart color and a rough texture to the crystal clusters.

Gypsum, chemical formula $CaSO_4 \cdot 2H_2O$, is a hydrous calcium sulfate containing the elements calcium (Ca), sulfur (S), hydrogen (H), and oxygen (O). The molecular weight of gypsum is made up of 23.28 percent calcium, 18.62 percent sulfur, 2.34 percent hydrogen, and 55.76 percent oxygen. Like all molecules, those of gypsum are composed of positively charged cations and negatively charged anions. Gypsum's simple cation is the calcium ion Ca^{2+} with its +2 charge. Its anion is a radical, a group of ions of different atoms that behave as entities in chemical reactions. The gypsum anion is the sulfate radical $(SO_4)^{2-}$, in which four oxygen ions positioned at the corners of a tetrahedron surround a single sulfur ion. In the sulfate radical, the sulfur ion S^{6+} carries a +6 electrical charge. The four oxygen ions $4O^{2-}$ each have a -2 electrical charge, and thus a collective -8 charge. This leaves the sulfate radical $(SO_4)^{2-}$ with a total -2 anionic charge which balances the +2 cationic charge, thus providing the gypsum molecule with electrical stability.

The "$\cdot 2H_2O$" in the chemical formula $CaSO_4 \cdot 2H_2O$ identifies gypsum as a hydrous (or hydrated) mineral with two molecules of water ($2H_2O$) attached to each parent calcium-sulfate molecule. The chemical formulas of all hydrous minerals end with "$\cdot H_2O$." By convention, these formulas employ the "chemical period" (·) to separate the attached water molecules from the parent molecule. Attached water molecules, which are called "water of hydration," are electrically neutral molecules that do not affect the electrical balance of the parent molecule. In water molecules, two hydrogen ions group together on one side of a large oxygen ion. These hydrogen ions retain a small positive charge, while the opposite side of the molecule, dominated by the large oxygen ion, retains a small negative charge. The resulting polarity enables water molecules to act as tiny dipole magnets that attach themselves to other molecules by the weak attraction of "hydrogen bonding." In gypsum, the positive poles of the water molecules bond to the slight negative charge of the oxygen ions in the sulfate anions. Water of hydration accounts for 20.93 percent of the weight of the gypsum molecule.

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Gypsum is the most abundant of the sulfates, a class of nearly 200 minerals in which sulfur and oxygen, as the sulfate radical $(SO_4)^{2-}$, combine with one or more metals. Because the sulfate radical's two excess negative charges are distributed evenly across its oxygen ions, it can readily bond with one or more metal cations. Although gypsum is a simple sulfate with a single metal cation and a single sulfate radical, its lattice has three different types of atomic bonding. Strong covalent bonds with shared electrons join the four oxygen ions to the single sulfur ion within the sulfate radical. The negatively charged sulfate radicals then bond ionically with the positively charged calcium ions, while the water of hydration is attached by hydrogen bonding.

Because hydrogen bonding is strongest at cold temperatures, gypsum is unstable when heated. When gypsum is calcined or heated to sub-fusing temperatures to drive off volatile materials, the hydrogen bonds part to release some of the water of hydration. The result is "calcined gypsum," a hemihydrated powder with the chemical formula $CaSO_4 \cdot ½H_2O$. In calcium sulfate hemihydrate, one water molecule is attached to every two calcium-sulfate molecules. The structures of calcined gypsum and natural gypsum are the same, except that half the lattice sites previously occupied by water in natural gypsum are vacant in calcined gypsum. When water contacts calcined gypsum, it immediately reoccupies these vacant sites, establishes hydrogen bonds, and reassumes the rigid, crystalline structure of natural gypsum. This ability to lose and quickly regain water of hydration gives gypsum many important uses, most notably as a fast-setting plaster.

The gypsum crystal lattice consists of repeating, ionically bound calcium and sulfate ions, with four oxygen ions surrounding each sulfur ion. The calcium-sulfate molecules form layers which "sandwich" the weakly bound water molecules, an arrangement that explains gypsum's perfect, one-directional cleavage. Weak hydrogen and weak ionic bonding account for gypsum's softness (Mohs 1.5-2.0) and moderate solubility in water, along with the flexibility of its thin crystals.

The Dana classification number 29.6.3.1 first identifies gypsum as a hydrated sulfate (29). It is subclassified (6) by the general formula $AXO_4 \cdot nH_2O$, in which "A" is calcium, "X" is sulfur, and "n" is a quantifier. Gypsum is then assigned to the gypsum group (3) as the first (1) and only member.

Gypsum forms in many mineralogical environments, but occurs primarily in sedimentary rocks of chemical origin, sometimes in massive strata more than 30 feet thick. Gypsum frequently forms in marine evaporite deposits as stratigraphic beds that alternate with strata of shale, sandstone, limestone, or rock salt [halite, NaCl]. Most gypsum occurs as gypsum rock or gypsite. These earthy, impure, massive forms are gypsum ores. Gypsum is also found in association with dolomite [calcium magnesium carbonate, $CaMg(CO_3)_2$] and barite [barium sulfate, $BaSO_4$] in hydrothermal replacement deposits and in volcanic formations through the action of sulfuric acid (H_2SO_4) on calcium-containing minerals. Gypsum is a component of many clays, forming from the reaction of sulfuric acid with limestone, a rock consisting primarily of calcium carbonate ($CaCO_3$).

COLLECTING LOCALITIES

The few collecting localities for gypsum desert roses are in regions with arid climates and an abundance of quartz sand. Because desert roses are often found over broad areas, many localities are not point-specific. Our desert-rose specimens were collected in the Samalayuca Dune Fields near Ahumada in Chihuahua, Mexico. Other Western Hemisphere sources are Arroyo Saladillo de Garcia, Bahia Blanca District, Buenos Aires Province, Argentina; and the Atacama Desert in northern Chile. In the United States, desert roses are collected near White Sands National Monument at Alamogordo, Otero County, New Mexico; and on the Great Salt Plains near Jet in Alfalfa County, Oklahoma.

Other localities include Erg Chebbi near Erfoud, Errachidia Province, Meknès-Tafilalet Region, Morocco; the Grand Erg Occidental region in Ouargla Province, Algeria; the Grand Erg Oriental region near Douz, Tunisia; and the Namibian Desert near Swakopmund, Erongo Region, Namibia. The intermittent saline lakes at Bolton, Victoria, Australia, also yield desert roses. Localities in Spain include Pájara in Las Palmas Province, Canary Islands; La Almarcha near Cuenca, Castile-La Mancha; and Canet de Marat near Barcelona, Catalonia. Desert roses are also collected at poorly documented localities in Egypt, Libya, Mali, Mauritania, and Chad.

JEWELRY & DECORATIVE USES

Desert roses are collected for their rarity and distinctive, rose-petal-like shapes. A number of museums and many private collectors maintain large collections of desert roses that include specimens from different sources, all varying considerably in color, texture, size, and degree of crystal development. Desert roses are popular display items.

HISTORY & LORE

Gypsum was used in crude plasters in the Middle East as early as 6000 B.C. By 3700 B.C., the Egyptians were using gypsum-based mortars in pyramids and as wall plaster. The ancient Greeks and Romans used stucco, a fine-grained mix of powdered gypsum and marble dust, as plaster and as a medium for sculpting and casting. Renaissance artists painted frescoes on gypsum-based plaster substrates. White stucco was molded into church-wall decorations, especially statuettes of angels, while colored, architectural stucco friezes were popular in plazas, gardens, and pavilions. Stuccowork reached its peak in the 17th and 18th centuries, when many European Baroque and rococo-style palaces were decorated with elaborately sculpted, polychrome stucco statues. By 1800, “plaster of paris,” named for the huge gypsum beds in France’s Paris Basin, had become Europe’s standard household wall covering. In 1888, gypsum became the primary component of drywall panels for residential and industrial construction—its greatest use ever.

Many early cultures thought that gypsum desert roses were flowers that had turned to stone. To some Saharan tribes, desert roses were a warning to travelers that bad fortune awaited them, and that they would perish and turn to stone; other tribes saw desert roses as good omens that indicated the presence of water and living flowers in a nearby oasis. Still others believed that desert roses were a reminder of a time when the desert bloomed before their ancestors' sins took away the water. According to modern metaphysical practitioners, desert roses emit a gentle energy that increases mental clarity; creates awareness of self and the environment; reveals inner truths; promotes protection, prosperity, and purification; and helps recall past lives and to see into the future. Desert roses have appeared on Algeria's 70-centime stamp of 1983, Namibia's one-cent stamp of 1991, and Tunisia's 250-millimes stamp of 1997. Desert roses are collected in all of these nations.

THE MINES AND MINERALS OF MEXICO

Most mineral specimens on today's international markets come from six nations: Brazil, Pakistan, Peru, China, India, and Mexico. Brazil and Pakistan owe their positions as leading specimen sources to a wealth of granite pegmatites, India to crystal-filled vugs in vast basalt formations, and China, Peru, and Mexico to rich mineral deposits that were emplaced within crustal fractures. Of the more than 220 Minerals of the Month we have featured since the Club was founded in 1996, our current Mineral of the Month marks the 18^{th} time that we are featuring a mineral from Mexico.

The many mineral deposits within Mexico's uplifted and thoroughly fractured crust have supported a vibrant mining industry for more than 400 years. Rich mineralization and a large mining industry alone would be enough to make Mexico a major source of mineral specimens. But Mexico also enjoys a geographic advantage because it shares a common border with the United States, the world's greatest mineral-specimen market. Tucson, Arizona, which annually hosts the world's biggest gem-and-mineral show, is only 65 miles north of the Mexican border. American mineral dealers, specimen miners, and mineralogists have easy access to Mexican mines, mineral localities, and specimen markets, while Mexican mineral dealers have equally easy access to American specimen markets and gem-and-mineral shows. Of all foreign minerals specimens, those from Mexico have the shortest, most direct route to American mineral markets, which substantially reduces shipping costs and the involvement of middlemen.

Mexico's topography is dominated by three major mountain systems—the Sierra Madre Occidental in the northwest, the Sierra Madre Oriental in the northeast, and the Sierra Madre Sur in the south. The nation's mineral wealth is concentrated in an area 900 miles long and 150 miles wide that follows the northwest-southeast-trending Sierra Madre Occidental and extends from the American border south to Mexico City. Most of Mexico's mines and mineral-specimen localities are within this geologically complex region.

The origin of Mexico's rich mineralization can be traced to its position near the common junction of the North American, Caribbean, Cocos, and Pacific tectonic plates. The collision and subduction of these four plates generated the enormous stresses that weakened, faulted, uplifted, and folded the crust over much of what is now Mexico, leaving it vulnerable to magmatic intrusion and volcanism. The original basement rock consisted largely of marine sediments laid down between 150 and 70 million years ago that lithified into limestone and dolomite. The Sierra Madre Occidental, Mexico's major western mountain range, formed about 65 million years ago when the Laramide Orogeny, a major mountain-building episode, uplifted huge blocks of basement rock. The Laramide Orogeny, which impacted all of western North America, also uplifted the Rocky Mountains in the United States and Canada. The Sierra Madre Occidental is actually a southern extension of the greater Rocky Mountains.

Some 30 million years after the uplifting of the Sierra Madre Occidental, huge volumes of magma surged into the fractured crust to form intrusive bodies of granitic rocks and extrusive formations of rhyolitic and dacitic (quartz-rich) volcanic rock. This volcanism created the Trans-Mexican Volcanic Belt, a range of volcanic mountains that extends from the central Sierra Madre Occidental southeast toward Mexico City. It was accompanied by surges of mineralized hydrothermal solutions that emplaced many rich deposits of lead, zinc, copper, and silver in the present-day states of Sonora, Chihuahua, Durango, Guerrero, Zacatecas, San Luis Potosí, Guanajuato, Jalisco, and Querétaro.

Spanish prospectors first discovered silver in 1534 at Taxco, Guerrero; subsequent finds soon extended northward for 600 miles. The Spanish initially worked these shallow, oxidized deposits from open pits, then later sank shafts into deeper, silver-lead sulfide deposits. The huge output of these rich mines enabled Spain's viceroyalty of Mexico to lead the world in silver production for the next three centuries. After Mexico won its independence in 1821, mine production declined, but later recovered with the influx of European and American development capital in the 1880s. By 1900, Mexico had regained its position as a major producer not only of silver, but also of lead, zinc, and copper. Remarkably, Mexico has yielded about one-third of all the silver ever mined throughout history. In 2012, Mexico again led the world in silver production with an output of 100 million troy ounces (3,085 metric tons). Mexico also ranks second in output of bismuth; third in fluorspar; fifth in cadmium, molybdenum, and lead; seventh in zinc and gypsum; and tenth in copper and gold.

Two of Mexico's best-known mines are the Ojuela Mine at Mapimí, Durango; and the Naica Mine at Naica, Chihuahua. Spanish prospectors discovered the Ojuela deposit in 1598. By 1640, Ojuela had become a major source of silver. Over its long life, Ojuela has produced more than seven million tons of ore that contained on average 15 troy ounces of silver, 15 percent lead, 12 percent zinc, 0.1 troy ounce gold, and small amounts of copper. Regular ore production did not end until after World War II. Total production at Ojuela amounts to more than 100 million troy ounces of silver, 700,000 troy ounces of gold, and roughly 200,000 tons of lead and zinc. Although Ojuela has not produced ore in decades, it remains an important source of mineral specimens and may reopen for production mining in the future.

The Naica multi-metal deposit was first mined in 1794 for silver. Naica has operated more-or-less steadily for 220 years and now produces lead, zinc, and smaller amounts of silver, copper, and gold. Its historic production exceeds 40 million tons of ore. Naica is Mexico's oldest producing mine and currently its leading source of lead. Naica gained fame in the 1970s for its mineral specimens, initially fluorite [calcium fluoride, CaF_2] and pyrite [iron disulfide, FeS_2]. In 1981, Naica became a classic locality for anhydrite [anhydrous calcium sulfate, $CaSO_4$] specimens. In 2000, Naica miners discovered a natural geodic (geode-like) cave now known as *La Cueva de los Cristales Gigantes* (the Cave of the Giant Crystals). This horseshoe-shaped cave is 100 feet long and 35 feet wide, and is filled with huge crystals of the selenite variety of gypsum. The most spectacular of these crystals is 36 feet long, 4 feet thick, and weighs an estimated 55 tons. It is the largest freestanding crystals ever found.

Mexican mineral specimens first received attention when European and American geologists began surveying regional mines in the late 1800s. But American mineralogists did not fully realize the astounding diversity of Mexico's minerals or the quality of its specimens until the 1920s. Specimens finally began reaching collectors' markets in the late 1940s, when specimen-savvy, retired Americans living in the region brought them to dealers in the United States. As demand increased among American collectors, Mexican miners started supplementing their incomes by collecting and selling specimens. By the 1970s, when mineral collecting was becoming big business in the United States and Europe, Mexico was already well-established as a major source of fine specimens. Today, most Mexican mineral specimens are collected by miners working in lead, silver, zinc, copper, and fluorite mines, who have become skilled at extracting intact specimens. The remainder of the Mexican specimen supply is gathered by commercial collectors from both the United States and Mexico who contract for permission to collect on mining-company properties.

Mexico has more than 60 type localities where mineral species were first discovered, along with a dozen classic localities that provide superb specimens. Mexico is best-known for specimens of creedite [basic hydrous calcium aluminum fluorosulfate, $Ca_3Al_2(SO_4)(OH)_2F_8\cdot 2H_2O$] from the Navidad Mine near El Rodeo, Durango; native silver [element, Ag] from Batopilas, Chihuahua; the amethyst variety of quartz [silicon dioxide, SiO_2] from Las Vigas de Ramírez, Veracruz-Llave; calcite [calcium carbonate, $CaCO_3$] and smithsonite [zinc carbonate, $ZnCO_3$] from Santa Eulalia, Chihuahua; and anhydrite from the Naica Mine in Chihuahua. Ojuela specimens include hemimorphite [basic hydrous zinc silicate, $Zn_4Si_2O_7(OH)_2\cdot H_2O$], adamite [basic zinc arsenate, $Zn_2(AsO_4)(OH)$], wulfenite [lead molybdate, $PbMoO_4$], legrandite [basic hydrous zinc arsenate, $Zn_2(AsO_4)(OH)\cdot H_2O$], mapimite [basic hydrous zinc iron arsenate, $Zn_2Fe_3(AsO_4)_3(OH)_4\cdot 10H_2O$], vanadinite [lead chlorovanadate, $Pb_5(VO_4)_3Cl$], malachite [basic copper carbonate, $Cu_2(CO_3)(OH)_2$], rosasite [basic copper zinc carbonate, $(Cu,Zn)_2(CO_3)(OH)_2$], aurichalcite [basic zinc copper carbonate, $(Zn,Cu)_5(CO_3)_2(OH)_6$], köttigite [hydrous zinc arsenate, $Zn_3(AsO_4)_2\cdot 8H_2O$], and conichalcite [basic calcium copper carbonate, $CaCu(AsO_4)(OH)$]. Mexico also provides fine specimens of fluorite [calcium fluoride, CaF_2], danburite [calcium borosilicate, $CaB_2(SiO_4)_2$], and grossular [calcium aluminum silicate, $Ca_3Al_2(SiO_4)_3$].

TECHNOLOGICAL USES

Gypsum is a major industrial mineral. Gypsum mining and the manufacturing of gypsum products are multi-billion-dollar global industries. Massive gypsum ores are surface-mined from large evaporite deposits. After mining, gypsum ore, called "crude gypsum," is coarsely crushed. Because gypsum (specific gravity 2.3-2.4) is considerably lighter than such quartz-based gangue materials as common sand (mainly quartz, specific gravity 2.65), it is easily and inexpensively concentrated by hydraulic washing. Concentrates are dried in gas-fired ovens to produce an intermediate product called "land plaster," which is ground to a powder and calcined in rotating, gas-fired kilns. The final product is "stucco," an industrial term for dry, white, hemihydrate calcium sulfate ($CaSO_4 \cdot ½H_2O$) that is the basic material for the manufacture of plaster of paris and wallboard.

More than 150 million metric tons of crude gypsum are mined each year, one-third of it in China. Iran, Spain, and Thailand are also important sources. The United States ranks fifth in gypsum production, mining 9.9 million metric tons of crude gypsum annually with a value of $70 million. Most American crude gypsum is mined in Oklahoma, Texas, Iowa, and Nevada. The United States also imports an additional 16 million metric tons of crude gypsum to meet demand. Crude gypsum now sells for $7 per metric ton, calcined gypsum for $28 per metric ton.

The biggest single use of gypsum is the manufacture of 60 billion square feet (more than 2,000 square miles) of wallboard each year. Gypsum-based plaster of paris is used extensively in ceramic and metal molds, and in surgical casts. Granulated natural gypsum is used as a conditioner for arid, alkaline soils; a bedding material for pouring and polishing plate glass; a filler material for paints and papers; and a flux for certain reduction-smelting processes. Gypsum is also the setting retardant for portland cement, enabling it to be premixed at central plants, then transported elsewhere for use.

ABOUT OUR SPECIMENS

Our desert-rose specimens were collected in the Samalayuca Dune Fields near Ahumada in northern Chihuahua, Mexico. Chihuahua, one of the northernmost of the Mexican states, covers 245,000 square miles, an area nearly as large as that of the American state of Texas. Chihuahua is bordered on the west by the Mexican states of Sonora and Sinaloa, on the south by Durango, on the east by Coahuila, and on the north by the American states of Texas and New Mexico. Chihuahua has 3.2 million residents, one-quarter of whom live in the capital city of Chihuahua. Much of northern Chihuahua is covered by the Chihuahuan Desert, the world's seventh largest desert area. The Samalayuca Dune Fields, known locally as "Los Médanos" ("the dunes"), is an area of large, separated fields of sand dunes roughly 50 miles south of El Paso, Texas, and 150 miles north of the city of Chihuahua. The dune fields, also called the "Samalayuca Desert," cover about 700 square miles. The dunes are just north of Ahumada, population 8,500, along Federal Highway 45, the main route connecting El Paso, Texas, and Ciudad Juárez, Mexico, with the city of Chihuahua. This region is covered with sparse desert vegetation and has an elevation of about 3,700 feet.

Geologists believe that the Samalayuca Dune Fields are only about 100,000 years old. The sand there originated with the weathering of silica-rich rocks to the northwest. The extreme daily and seasonal thermal changes common in the Chihuahuan Desert caused rock surfaces to crack and fragment into rock particles that filled the vast, dry lake bed of Laguna Guzman. Winds then swept across the lake bed, picking up and carrying the nodular and spherical-shaped grains southeast to Cerro de Samalayuca (Samalayuca Mountain), which rises 1,200 feet above the surrounding plateau. This topographical barrier slowed the winds, causing them to drop the sand grains into a broad, shallow depression at the base of the northwest side of the mountain. The accumulation of these grains eventually created the Samalayuca Dune Fields. This slow, steady process of weathering, erosion, airborne transport, and deposition continues today.

The biggest dunes in the Samalayuca Dune Fields are almost 200 feet high, devoid of vegetation, and occur in two distinct types. Barchan dunes, named from the Arabic word for “rams’ horns,” are created in areas of strong winds. These are the highest dunes and form U-shaped crescents with “horns” that point downwind. Star dunes are somewhat lower and have four or five long, continuous ridges culminating at a common crest. Both barchan and star dunes can move as much as 30 feet per year. The sand in the Samalayuca Dune Fields is fine-grained, with a light-tan to gray-brown color. It is also unusually pure, consisting of 90-95 percent quartz and only 5-10 percent feldspar-group and mica-group minerals.

The Samalayuca Dune Fields are directly on the historic Chihuahua Trail that once connected the city of Chihuahua with Paso del Norte (the “pass of the north”—now El Paso, Texas). Travel across the dunes during the Spanish colonial period was very difficult and dangerous. No reliable source of drinking water existed. Shifting dunes quickly covered trails, while the soft sand mired the Spaniards’ *carretos* (two-wheeled carts) and made walking exhausting for both humans and animals.

Because the Samalayuca Dune Fields fit the popular image of a sandy desert, the area has served an outdoor motion-picture set for a number of movies, mainly Hollywood B-westerns, but also for such major productions as *Dune* (1984) and *Conan the Destroyer* (1984). Because of the high purity of the quartz sand, the dunes also recently attracted the interest of mining companies hoping to “mine” the high-quality silica sand and ship it to glass and ceramic manufacturers. But the dunes may never be mined. In 2009, the Mexican government established a 250-square-mile protected area to preserve much of the natural dune environment. The Samalayuca Dune Fields is now known for tourism and recreation. Hiking the dunes is increasingly popular, and local guides also offer all-terrain-vehicle excursions and rental equipment for sand-boarding.

Geologists believe that the gypsum desert roses found in the Samalayuca Dune Fields are only about 20,000 years old. They formed when groundwater rich in dissolved gypsum rose into the subterranean sand strata beneath the dunes. As erosion reduced the surface, the water table dropped, causing the saturated, aqueous gypsum solutions to precipitate selenite as tiny “seed” crystals. With further precipitation, clusters of selenite crystals grew around each seed crystal, encapsulating surrounding grains of sand. As the selenite crystals grew, the included sand distorted the crystal lattices along the one-directional planes of perfect cleavage, causing them to separate and form clusters of flat, bladed crystals that resemble rose petals. Continued surface erosion and dune movements now periodically expose the strata containing these desert roses.

Local residents collect desert roses uncovered by the wind and sell them to tourists or commercial dealers. The desert roses range in size from single “flowers” less than an inch in diameter to massive clusters weighing 20 or 30 pounds. Most desert roses are heat-treated to enhance their appearance. Brief exposure to propane-torch flames dehydrates the gypsum at the “petal” edges, converting it to bright-white, hemihydrated gypsum ($CaSO_4 \cdot \frac{1}{2}H_2O$) that accents the floral shape of the desert roses.

Your desert-rose specimen consists of the selenite variety of gypsum that is heavily included with grains of quartz sand. Its light-tan to gray-brown color, caused by the included sand, is the same color as the Samalayuca dunes. While desert roses appear generally opaque, strong backlighting will reveal translucency at the edge of the "petals." Specimens have also been heat-treated to accent the edges of the numerous, delicate petals. Your desert-rose specimen is a souvenir of Mexico's largest dune field and a reminder that the common mineral gypsum occurs in many unusual forms.

References: *Dana's New Mineralogy*, Eighth Edition; *Encyclopedia of Minerals*, Second Edition, Roberts, et al, Van Nostrand Reinhold Company; *2008 Glossary of Mineralogical Species*, Malcolm E. Back and Joseph A. Mandarino, The Mineralogical Record, Inc.; *Mineralogy*, John Sinkankas, Van Nostrand Reinhold Company; *Gemstone and Mineral Data Book*, John Sinkankas, Geoscience Press; *Cement, Lime, and Gypsum*, American Society for Testing and Materials, 2002; "Naica's Glittering New Crystal Cave, Chihuahua, Mexico," Carlos Sabagún and James Winchell, *Rocks & Minerals*, September-October 2001; "Selenite," Bob Jones, *Rock & Gem*, September 1989; "Gypsum: From Selenite to Drywall," Steve Voynick, *Rock & Gem*, October 1999; "Gypsum," *2012 Mineral Commodity Summaries*, United States Geological Survey; "The Mineral Industry of Mexico," Alberto Alexander Perez, *2012 Minerals Yearbook*, United States Geological Survey; *Geology of Mexico*, Susana Alaníz-Alvaréz and Ángel Nieto-Samaniego (editors), Geological Society of America Special Paper 422, 2007; "Tales from Mexico (Parts I and II)," B. Smith and C. Smith, editors, *Rocks & Minerals*, January-February and March-April 1999.

The locality for our Desert Rose specimens are the Samalayuca Dune Fields which is located in the northern part of the state of Chihuahua. You will see Chihuahua towards the top left of the above map of Mexico.