

Mineral of the Month June 2014

OPAL var. COMMON subvar. PINK

This month our featured “mineral”—beautiful, pink common opal from Peru—is actually a mineraloid. Our write-up discusses its opaline structure, the unusual cause of its striking pink color, and the differences between minerals and mineraloids.

OVERVIEW

PHYSICAL PROPERTIES

Chemistry: $\text{SiO}_2 \cdot n\text{H}_2\text{O}$ Hydrated Silicon Dioxide, containing varying amounts of Water, often with traces of iron and aluminum and rarely with traces of hydrocarbons.

Class: Silicates

Subclass: Tectosilicates (Framework Silicates)

Group: Opal (Hydrated Tectosilicates)

Subgroup: Common Opal

Crystal System: None

Crystal Habits: None; occurs as amorphous fillings in seams and cavities.

Color: Colorless and white, also yellow, red, pink, brown, green, gray, violet, and blue; common opal has a soft translucency and a wide range of colors; the precious or opalescent varieties exhibit an internal play of spectral colors.

Luster: Vitreous to dull

Transparency: Usually translucent or opaque; rarely transparent.

Streak: White

Cleavage: None

Fracture: Conchoidal, brittle.

Hardness: 5.5-6.5

Specific Gravity: Varies with water content, from 1.9-2.3; average 2.09.

Luminescence: Fluoresces greenish-yellow in shortwave, ultraviolet light and white in long-wave, ultraviolet light; also phosphorescent.

Refractive Index: 1.44-1.46

Distinctive Features and Tests: Substantial hardness, low density, fluorescence, conchoidal fracture, lack of crystal faces and cleavage surfaces, and opalescence in some varieties.

Dana Classification Number: 75.2.1.1

NAME: The word “opal,” pronounced “OH-pul,” comes from the Latin *opalus* or “opal,” which stems from the Sanskrit *upala*, meaning “stone” or “jewel.” Opal, also known as “opalite” and “gel-quartz,” appears in European mineralogical literature as *opolo* and *opale*. “Precious opal” exhibits a fiery play of light called “opalescence”; “common opal” is not opalescent, but softly translucent, and exhibits a wide range of colors. Opal has many variety names: “Black opal” is dark; “white opal” has a white or light body color; “honey opal” is yellow; “milk opal” is white; “porcelain opal” is white, but opaque; “prase opal” is green; “pink opal” is bright pink, and “blue opal” is bluish or bluish-green. Opalescent varieties include “precious opal,” “fire opal,” “flash

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opal,” “harlequin opal,” and “pinfire opal.” “Agate opal” has alternating layers of agate and opal; “wood opal” is opalized wood; “wax opal” is waxy and yellow-brown; “hydrophane” opal becomes translucent or transparent when immersed in water; and “hyalite” is colorless opal. Peruvian pink opal is also known as “Andean opal.”

COMPOSITION & STRUCTURE: As a mineraloid, opal is a naturally occurring substance that lacks the crystal structure and definite chemical composition necessary to classify it as a mineral. Opal is an amorphous, layered, solidified, colloidal silica gel consisting of randomly arranged, hydrated silica molecules interspersed with layers of microscopic silica spherules. The chemical formula $\text{SiO}_2 \cdot n\text{H}_2\text{O}$ identifies opal as a hydrous silicon dioxide containing the elements silicon, oxygen, and hydrogen. Opal always contains varying amounts of water attached as water of hydration. Unlike crystalline minerals that precipitate on a molecule-by-molecule basis, opal forms from silica gels that solidify or “freeze” into layers with a random molecular arrangement. As a low-temperature (epithermal) silicate, opal develops as amorphous fracture fillings and cavity fillings in both sedimentary and volcanic environments when silica gels slowly solidify under specific conditions of chemistry and temperature.

COLLECTING LOCALITIES: Common opal is collected in Peru, Brazil, Honduras, Mexico, Chile, Italy, Germany, Denmark, Indonesia, Japan, Slovakia, India, Madagascar, Namibia, New Zealand, Norway, Pakistan, Portugal, Romania, Russia, Spain, Switzerland, Turkey, Germany, Greece, Canada, and Australia. Localities in the United States are found in Alabama, Arkansas, Colorado, Maine, Nebraska, New Jersey, South Dakota, Utah, North Carolina, New Hampshire, Nevada, Idaho, Oregon, and California.

HISTORY, LORE & USES: Opal artifacts have been recovered from 6,000-year-old African tombs. Arab legends tell of precious opal falling from the heavens as flashes of lightning; the ancient Greeks believed that opal provided the powers of foresight and prophecy, while the ancient Romans valued opal as a symbol of hope and purity. Medieval physicians prescribed tonics of finely ground opal to aid in healing and prevent nightmares, and recommended prolonged gazing into opals to prevent eye disease. Medieval Scandinavian women believed that wearing opal would keep their blonde hair from fading. With its substantial hardness, soft translucency, and unusual colors, opal has served as a gemstone since antiquity. Peruvian pink opal, one of the finest gem subvarieties of common opal, is fashioned into cabochons that are mounted in silver. It is somewhat harder than precious opal, takes a superb polish, and has a soft translucency and an attractive, clean pink color that is rarely found in other gemstones. Metaphysical practitioners believe that opal wards off disease and enhances love between faithful lovers. Peruvian pink opal is specifically considered to be a stone of love and gentleness.

ABOUT OUR SPECIMENS: Our specimens of Peruvian ink opal were collected near the Acarí Mine in Caraveli Province, Arequipa Department, in southwestern Peru. The Acarí opal formed when silica-rich hydrothermal solutions circulated through fractured masses of diorite to fill fissures with a silica gel that solidified into solid masses of common opal. Peruvian pink opal consists of an indeterminate mixture of common opal, minor amounts of chalcedony, and substantial amounts of the silicate mineral palygorskite. The color of Peruvian pink opal is due to the presence of quinones, hydrocarbon compounds with reddish colors that originated from organic plant materials which are attached to palygorskite molecules. Pink common opal was

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first reported in Peru in the 1970s and has been mined commercially in small amounts since the early 1980s. Pink common opal associated with chalcedony occurs in veins up to two inches thick within a diorite host rock. After blasting the diorite, miners manually extract the opal using hammers and chisels. The rough pink opal is sent to a processing facility in the national capital of Lima, where craftsmen prepare specimens and cut and polish cabochons for jewelry use.

COMPREHENSIVE WRITE-UP

COMPOSITION & STRUCTURE

It is not often that we feature a Mineral of the Month that is not a mineral at all. This month's "mineral," opal, is technically a mineraloid—a naturally occurring material that, while having distinctive properties, fails to completely satisfy the requirements for classification as a mineral. Opal is an amorphous, layered, solidified, colloidal silica gel that consists of randomly arranged, hydrated silica molecules interspersed with layers of microscopic silica spherules. It is a mineraloid, not a mineral, because it has neither a definite chemical composition nor a crystal structure (see "Mineraloids").

The chemical formula $\text{SiO}_2 \cdot n\text{H}_2\text{O}$ identifies opal as hydrous silicon dioxide containing the elements silicon (Si), oxygen (O), and hydrogen (H). Opal's molecular weight varies with the proportions of its essential elemental components and the amount of water (H_2O) that is present. Opal can contain between 1 and 30 percent water. As an example, the molecular weight of an opal specimen with the empirical formula $\text{SiO}_2 \cdot 5\text{H}_2\text{O}$ contains 40.58 percent silicon, 57.98 percent oxygen, and 1.44 percent hydrogen. Expressed differently, this same opal specimen consists of 86.96 percent silica and 13.04 percent water. In the silica core of the opal molecule, the +4 charge of the silicon cation Si^{4+} balances the collective -4 charge of the oxygen anion 2O^{2-} .

In the chemical formula $\text{SiO}_2 \cdot n\text{H}_2\text{O}$, the " $n\text{H}_2\text{O}$ " indicates the presence of a variable number of attached water molecules. These water molecules, called "water of hydration," consist of electrically neutral, integral water molecules that are attached by weak hydrogen bonding and do not affect the electrical balance of the parent molecule. In the water molecule H_2O , one oxygen ion O^{2-} shares electrons and covalently bonds to two hydrogen ions 2H^{1+} . Because the two small hydrogen ions group together on one side of the large oxygen ion, the water molecule is asymmetrical. The grouped hydrogen ions retain a small positive charge, while the opposite side of the water molecule retains a small negative charge. Hydrogen or polar bonding occurs when the faintly positive poles of water molecules are attracted to the negatively charged electrons of other atoms. In opal, the positively charged sides of water molecules are attracted to the negatively charged oxygen ions of silica tetrahedra.

Although opal is not a mineral, it is nevertheless a member of the silicate-mineral class because its basic building block is the silica tetrahedron (SiO_4)⁴⁻. Silica tetrahedra consist of single silicon atoms surrounded by four equally spaced oxygen ions positioned at the corners of a tetrahedron. Opal is subclassified as a tectosilicate or "framework" silicate, in which oxygen ions share electrons with the oxygen ions of adjacent tetrahedra to form repeating, rigid,

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compact, three-dimensional, framework-type structures. Tectosilicates include quartz [silicon dioxide, SiO₂], which is similar to opal only in that both contain silica tetrahedra. Unlike opal, however, quartz has an orderly, repeating atomic structure and a definite crystal form.

The physical properties of opal and quartz differ greatly. With its rigid crystal structure, tight atomic packing, and strong covalent bonding, quartz has a substantial Mohs hardness of 7.0. But with no rigid crystal structure, opal is considerably softer at Mohs 5.5-6.5 and is much more brittle. Attached water molecules also make opal much less dense (average specific gravity 2.09) than quartz (specific gravity 2.65).

As a low-temperature (epithermal) silicate, opal solidifies from silica gel as fracture-and-cavity fillings under specific conditions of chemistry and temperature. Unlike such crystalline minerals as quartz that precipitate on a molecule-by-molecule basis, opal forms from silica gels that solidify or “freeze” into layers with random molecular arrangements. Opal, which is relatively abundant and found worldwide, occurs in volcanic, sedimentary, and hydrothermal environments. Volcanic opal, which forms when silica solutions fill fissures and cavities in volcanic host rocks, has many occurrences. The much rarer sedimentary opal occurs mainly in Australia, Brazil, and Peru and forms when water circulates through sandstone to dissolve quantities of silica. These silica-rich solutions percolate downward until they become trapped by strata of impermeable rock, then move horizontally to fill fissures and cavities. In proper conditions of temperature and evaporation, these silica-rich solutions concentrate into gels that eventually solidify into opal. The also-rare hydrothermal opal, which includes our specimens of Peruvian pink opal, forms when silica-rich solutions fill crevices in igneous rock (see “About Our Specimens”).

Gemologically, opal is classified either as “precious” or “common.” Both are amorphous, layered, solidified, colloidal silica gel that consists of randomly arranged, hydrated silica molecules interspersed with layers of microscopic silica spherules. Precious opal exhibits opalescence, while common opal is characterized by a soft translucency. Opalescence refers to an iridescent, rainbow-like play of light called “fire,” which is caused by the interaction of light with layers of tiny silica spherules less than 1/1,000th of a millimeter in diameter. These spherules are composed of randomly arranged, hydrated silica tetrahedra and form three-dimensional structures with voids between adjacent spherules. Opalescence occurs when the spherule diameters approximate the wavelengths of visible light, thus enabling the spherule-void interfaces to function as diffraction gratings that diffract (separate) light into its red, orange, yellow, green, blue, and violet spectral components. Smaller silica spherules with diameters of roughly 140 nanometers (one nanometer equals one-billionth of a meter) diffract blue wavelengths; larger spherules with diameters of 240-300 nanometers diffract red wavelengths. Because diffraction angles vary with viewing angles, precious opal, when rotated, can sometimes display a full range of spectral colors. The complex structure of precious opal also reflects (mirrors) and refracts (bends) these diffracted spectral components. This creates light interference, in which various wavelengths of light reinforce each other to produce the brilliant spectral colors in the glittering “fire” of precious opal. Common or non-opalescent opal contains silica-spherule structures that are too large or too small to diffract light.

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Pure opal, regardless of variety, has no base color at all. Common opal is therefore allochromatic (other-colored), meaning that its broad range of colors is due to traces of nonessential chromophoric (color-causing) elements such as iron and, in the case of Peruvian pink opal, hydrocarbon compounds of organic origin (see “About Our Specimens”).

Based upon structure and composition, opal is divided into four categories: opal-C, opal-CT, opal-A_N, and opal A_G.

Opal-C is a form of common opal consisting of cristobalite spheres interspersed with molecules of attached water. Cristobalite is a quartz polymorph that crystallizes in the tetragonal system. Although cristobalite itself has a crystalline structure, the attached water molecules prevent the formation of a unified crystal lattice.

Opal-CT is another form of common opal that is similar to Opal-C. Opal-CT contains spheres of cristobalite and tridymite (a quartz polymorph crystallizing in the triclinic system), along with various silicates. Our specimens of Peruvian pink opal are classified as opal-CT.

Opal-A_N is the most abundant form of common opal. The “A” signifies “amorphous,” while the “_n” denotes a structure similar to that of volcanic glass.

Opal-A_G includes most forms of precious opal. The “A” signifies “amorphous,” while the “_G” signifies a gel-like structure in which attached water molecules surround layers of silica spheres in a manner that diffracts light to create opalescence.

Because opal, which is a mineraloid, was historically thought to be a mineral, it is assigned the Dana mineral-classification number 75.2.1.1. This number first identifies opal as a tectosilicate (75); the subclassification (2) defines it as a tectosilicate containing water or such organic components as carbon (C) and methane (CH₄). Opal is then assigned to the opal group (1) as the first and only member (1).

COLLECTING LOCALITIES

Opal has many occurrences, but few yield gem-quality material. Our specimens of pink common opal were collected near the Acarí Mine in Caraveli Province, Arequipa Department, Peru. Other Peruvian sources of common opal are the Monte Rosa Mine at Ica, Ica Province, Ica Department; and the El Sol 3 deposit at Cajamarca in Cajamarca Department. Brazilian sources include the Amazon Opal Mine at Porto Velho, Rondônia; the Bodó Mine at Lajes Pintadas in the Borborema Mineral Province, Rio Grande do Norte; the Boi Morto Mine at Pedro II, Piauí; the Manoel Ambrósio Ranch at São Geraldo do Araguaia, Pará; and the Proberil Mine at Galiléia in the Doce Valley, Minas Gerais. Honduran opal is collected at the Gracias and Erandique deposits near Gracias in Lempira Department. In Mexico, common opal occurs at the Cerro de Mercado Mine near Durango and the Barranca Mine at Coneto de Comonfort, both in Durango; the Lomo Deltoro Mine at Zimapán, Hidalgo; the Buena Vista Mine at La Yesca, Nayarit; the San Simón, Chela, Mara, Única, and Tepucanapa mines near Magdalena, Jalisco; the Santín Mine on Cerro de las Fajas, Santa Catarina, Guanajuato; Mapimí, Durango; Mexquitic, San Luis Potosí; the Colón Mine at Colón, Querétaro; and the Candelaria mine at Moctezuma, Sonora.

Other sources are the El Toto geothermal field, El Loa Province, Antofagasto Region, Chile; the Brasso Mine at Ivrea, Torino, Piemonte, Italy; the Leisnig Mine at Döbein, Saxony, Germany;

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the Skarrhage Moler Quarry at Thy, Viborg, Denmark; Kali Maya in Banten Province, Java, Indonesia; the Kawazu and Rendaizi mines at Shimoda, Shizuoka Prefecture, Honshu Island, Japan; the Čevenica mines in the Northern Slanské Mountains, Prešov Region, Slovakia; Mahadari, Nashik District, Maharashtra, India; the Faratsiho opal locality at Faratsiho, Vakinankaratra Region, Antananarivo Province, Madagascar; the Aris quarries at Aris, Windhoek District, Khamau Region, Namibia; the Tekopia geothermal region at Bay of Plenty, North Island, New Zealand; the A/S granite quarry, Stavern, Vestfold, Norway; Stak Nala, Haramash Mountains, Skardu District, Baltistan, Gilgit-Baltistan (Northern Areas), Pakistan; the Espadanal Mine, Rio Maior, Satarem District, Portugal; Surdești and Danești, Șișești Commune, Maramures County, Romania; the Sinancha tin deposit, Dal'ganorsk, Primorskiy Kray, Far-Eastern Region, Russia; the Campo de Calatrava volcanic region, Ciudad Real, Castile-La Mancha, Spain; the Gilschi Glacier in the Kriegalp Valley, Binn Valley, Valais, Switzerland; the Potatli Basin, Ankara Province, Central Anatolia Region, Turkey; Todtnau and Schörnau, Black Forest area, Baden-Württemberg, Germany; Kimolos Island, Cyclades Islands, Aegean Islands Department, Greece; and the Souris quarries at Souris, Manitoba, and the Beryl Pit in Lyndoch Township, Renfrew County, Ontario, both in Canada.

Australia is the world's largest supplier of precious opal from localities in Queensland, New South Wales, and South Australia. Common opal is found in Western Australia, notably in the shires of Coolgardie, East Pilbara, Gingin, Goomaling, Meekathana, Murchison, Northam, and Upper Gascoyne.

In the United States, common opal occurs at Alabaster, Shelby County, Alabama; Crater of Diamonds State Park at Murfreesboro, Pike County, Arkansas; the Creede Formation outcrops on the Rio Grande at Creede, Mineral County, Colorado; the Oxford County pegmatites in Maine; Arnold, Custer County, Nebraska; Sterling Hill at Ogdensburg, Franklin Mining District, Sussex County, New Jersey; the Helen Beryl Mine at Fourmile, Custer County, South Dakota; the Gold Hill Mines in the Gold Hill District, Tooele County, Utah; the Carter Mine at Maro Hill, Madison County, North Carolina; and the pegmatites of Carroll County, New Hampshire. Nevada localities include the Ivanhoe, Delano, and Rock Creek districts in Elko County; the Fish Lake Valley and Tonopah districts in Esmeralda County; numerous mines in the Opalite, Virgin Valley, and Donnelly districts in Humboldt County; and the Lucky Chief Mine in the Chief district of Lincoln County. In Idaho, common opal is collected at the Moscow Opal Mine near Moscow in Latah County; the Idaho Blue Mine at Salmon in Lemhi County; and the Opal Mountain Mine at Spencer in Clark County. Oregon localities include the Durkee Opal Mine at Swayze Creek in Baker County; the Juniper Ridge Opal Mine at Hart Mountain in Lake County; and the Opal Butte mines near Heppner in Morrow County. In California, common opal is collected at the Barnett Opal Mine in the El Paso Mountains of Kern County; the Opal Hill Mine in the Mule Mountains of Riverside County; and the Opal Mountains agate field in the Opal Mountains of San Bernadino County.

JEWELRY & DECORATIVE USES

With its substantial hardness, along with the pleasing, soft translucency of the common variety and the fiery opalescence of the precious variety, opal has been valued as a gemstone since

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antiquity. Both varieties of opal are cut into cabochons to display opalescence, color, and translucency. Exceptional, transparent specimens of common opal are occasionally faceted. Opal gems usually weigh at least 3 carats, and stones of 10 to 20 carats are not unusual.

Because of the scarcity of gem-quality precious opal with sufficient thickness to fashion into traditional cabochons, cutters have developed composite gems of precious-opal called “doublets” and “triplets,” which consist of thin sections of precious opal cemented to colored backing material and protective surface layers. Opal was first synthesized in laboratories in 1900. Introduced in commercial quantities in the 1960s, synthetic gem opal is now mass-manufactured.

Peruvian pink opal is one of the finest gem subvarieties of common opal. It is somewhat harder than precious opal, takes a superb polish, and has a soft translucency and a delightful, clean pink color that is found in few other minerals. Peruvian pink opal and other types of distinctively colored, common opal are faceted into cabochons and mounted in silver settings. Unlike composite gems of precious opal, gems of common opal are single pieces that have only been shaped and polished. Dyed, translucent chalcedony is sometimes used to imitate common opal.

Rough specimens of Peruvian pink opal are collected for striking pink color and association with chalcedony.

HISTORY & LORE

Opal artifacts have been recovered from 6,000-year-old African tombs. Arab legends tell of precious opal falling from the heavens as flashes of lightning; the ancient Greeks believed that opal granted powers of foresight and prophecy, while the ancient Romans valued opal as a symbol of hope and purity. Medieval physicians prescribed tonics containing finely ground opal to aid in healing and prevent nightmares, and recommended prolonged gazing into opals to prevent eye disease. Scandinavian women of the medieval era believed that wearing opal would keep their blonde hair from fading.

Because it occurs in all gemstone colors, many cultures assumed that opal had unusually broad powers. To English dramatist and poet William Shakespeare (1564-1616), opal's fiery, shifting colors symbolized unpredictability. In *Twelfth Night; Or, What You Will*, Shakespeare likened opal's play of color to the changeability of the human mind, when the jester said to the mercurial Duke of Orsino, “Now the melancholy God protect thee, and the Tailor make thy garments of changeable taffeta, for thy mind is opal.” In the novel *Anne of Geierstein*, by Scottish novelist and poet Sir Walter Scott (1771-1832), the main character wore a dazzling opal gem. But her existence became entwined with the opal's beauty and as its fire faded, so, too, did her life—convincing many Europeans that opal was unlucky. Opal's popularity plummeted in Europe in the early 1800s after the sudden appearance of inferior Russian opal. Until the discovery in the late 1800s of large Australian opal deposits, along with smaller deposits in Brazil, Mexico, and the western United States, opal was quite rare. But the subsequent increase in availability and affordability soon restored its popularity.

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Opal has been featured on the Australian eight-cent and nine-cent stamps of 1973 and 1974, the \$1.20 stamp of 1995, the \$2.50 stamp of 1998, and the 600-franc stamp of Central Africa of 1998. Opal is the birthstone for the month of October. It is also Australia's national gemstone and one of Nevada's two state gemstones.

Metaphysical practitioners believe that opal wards off disease and enhances love between faithful lovers. However, because opal intensifies all thoughts and actions, including those that are negative, it must be worn judiciously. Pink common opal is assigned specific metaphysical properties as a stone of gentleness that increases the energy that can be committed to love and kindness.

MINERALOIDS

Although such natural materials as opal, obsidian, and amber are often thought of as minerals, they are correctly classified as mineraloids, which are defined as natural, mineral-like materials that, for reasons of origin, lack of crystal structure, or indeterminate chemical composition, fail to meet the criteria of a mineral. Minerals are naturally occurring, homogenous solids of inorganic origin with definite chemical compositions (within established limits) and ordered crystalline structures.

A classic example of a mineraloid is our Mineral of the Month—opal. As explained in “Composition & Structure,” opal is a solidified, colloidal silica gel. It has an amorphous, layered structure that consists of randomly arranged, hydrated silica molecules interspersed with layers of microscopic silica spherules. Opal is not a mineral because it lacks both a definite chemical composition and a crystal structure. Nevertheless, because it was historically considered a mineral, it is assigned the Dana mineral-classification number 75.2.1.1. Opal is also assigned a chemical formula of $\text{SiO}_2 \cdot n\text{H}_2\text{O}$, in which “*n*” refers to an indefinite number of attached water molecules.

Another familiar mineraloid is obsidian, an extrusive (volcanic) igneous rock that forms from the very rapid solidification of rhyolitic (silica-rich) lava. It is a natural, volcanic glass that consists primarily of silica with lesser, varying amounts of feldspar and ferromagnesian minerals. Like opal, obsidian lacks both a crystal structure and a definite chemical composition. Tektites are very similar to obsidian in that they, too, consist of natural glass and have neither a crystal structure nor a definite chemical composition. Tektites, however, form from the very rapid solidification of silica material that was instantaneously melted in meteoric impacts.

Amber is another material that is sometimes classified as a mineraloid, specifically as an “organic non-mineral”—a natural substance of organic origin that satisfies neither the definition of a mineral nor that of a mineraloid, as it is not particularly “mineral-like.” Amber is a noncrystalline, oxygenated hydrocarbon of widely variable composition that consists primarily of carbon, oxygen, and hydrogen. Amber can be considered a fossil only if the usual definition of the term is expanded. While most fossils are created through mineral replacement or molded impressions, amber forms through the chemical process of molecular polymerization and thus is an altered tree resin.

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Yet another mineraloid is jet, a compact form of coal and minor gemstone that forms from the high-pressure decomposition of wood in marine-burial environments. Although jet consists almost entirely of carbon and is chemically homogeneous, it lacks the crystal structure necessary to qualify as mineral.

Native mercury, which often occurs as tiny, bright, silvery globules on cinnabar [mercury sulfide, HgS], is also a mineraloid—sometimes. While cinnabar clearly qualifies as a mineral, mercury falls into the no-man's-land between minerals and mineraloids. At ambient temperatures, mercury lacks a crystal structure. Nevertheless, because it was historically considered a mineral, mercury is assigned a Dana mineral-classification number. And mercury technically does become a mineral at -40° F. (-40° C.), the temperature at which it crystallizes in the hexagonal (trigonal) system.

A similar relationship exists between water, which is a mineraloid, and ice, which is a mineral. Both share the same definite chemical composition. But while water lacks the crystal structure necessary to qualify as a mineral, ice is a mineral because, at temperatures below 32° F. (0° C.), it crystallizes in the hexagonal system, as is evident in the symmetrical, six-fold shapes of snowflakes.

Another interesting mineraloid is whewellite [hydrous calcium oxalate, $\text{Ca}(\text{C}_2\text{O}_4)\cdot\text{H}_2\text{O}$], which forms in methane-rich environments in coal seams as a salt of organic acids. Although it crystallizes in the monoclinic system and is assigned a Dana mineral-classification number, it is not technically a mineral because of its organic origin. Although whewellite is somewhat rare and certainly not a collectible mineraloid like opal, it is nevertheless sometimes closer than we might think: It is the primary component of kidney stones.

TECHNOLOGICAL USES

Opal has served as the model for its own laboratory synthesis.

ABOUT OUR SPECIMENS

Our specimens of Peruvian pink opal were collected near the Acarí Mine in Caraveli Province, Arequipa Department, Peru. Arequipa, one of Peru's 21 departments (political divisions comparable to American states), is located in southwestern Peru along the Pacific coast, with its interior regions extending eastward into the high Andes. One of Arequipa's eight provinces (the equivalent of American counties), Caraveli Province is in far northwestern Arequipa. It covers 5,000 square miles, but has only 40,000 residents. The coastal region of Caraveli has an agricultural economy; inland sections rise quickly into the Andean foothills, where the economy is based on herding and mining. The Acarí Mine, in northern Caraveli Province, is 30 miles from the Pacific coast and the same distance southeast of Nazca in neighboring Ica Department. This region lies at an elevation of 3,500 feet in the rugged Andean foothills and is 250 miles southeast of the national capital of Lima.

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Although the source of our Peruvian pink opal is near the Acarí Mine, an underground gold mine, it is not part of the mine workings or the gold-ore deposit. Nevertheless, the Acarí geology is similar to that of the nearby opal occurrence. The Andes were uplifted during the Andean Orogeny (mountain-building episode) some 60 million years ago. This uplifting of massive amounts of dioritic basement rock was accompanied by extensive volcanic activity and the emplacement of necks and plugs of such low-silica, volcanic rocks as andesite and dacite. Associated mineral-rich, hydrothermal solutions then surged through the fractured dioritic and granitic emplacements, where they precipitated an array of metallic and semimetallic minerals in erratic vein systems.

The Acarí opal occurrence formed when silica-rich, hydrothermal solutions circulated through fractured masses of dioritic country rock to fill fissures with a silica gel that later solidified into solid masses of common opal. This opal is closely associated with a grayish, translucent chalcedony, the microcrystalline form of quartz [silicon dioxide, SiO_2]. The direct contact of opal and chalcedony infer a two-phase emplacement. The chalcedony formed first through a process of slow precipitation and crystallization. After the original silica solutions withdrew, new silica solutions containing different chromophoric contents refilled the remaining spaces, this time solidifying very quickly into masses of pink common opal.

Peruvian pink opal is classified as opal-CT (see “Composition & Structure”) and consists of an indeterminate mixture of opal, minor amounts of chalcedony, and substantial amounts of palygorskite [basic hydrous magnesium aluminum silicate, $(\text{Mg,Al})_2\text{Si}_4\text{O}_{10}(\text{OH})\cdot 4\text{H}_2\text{O}$]. Palygorskite is a phyllosilicate that crystallizes in the monoclinic system, often as fibrous crystals that have an affinity for organic or hydrocarbon molecules, which attach by hydrogen bonding. Peruvian pink opal contains between 10 and 40 percent palygorskite. While palygorskite does not directly cause the pink coloration of the opal, it does play an indirect role in creating this color.

The color of Peruvian pink opal is due to the presence of quinones, hydrocarbon compounds with reddish colors that are derived from organic plant materials. At Acarí, these quinones were present in a buried, fossil lake within a basaltic environment. Because of the magnesium-rich, basaltic environment, palygorskite would have been one of the silicates present in the silica-rich groundwater. This palygorskite, together with the attached, reddish-colored quinones—was present in the silica gels that formed the opal and created the pink coloration.

Pink common opal is rare and has very few occurrences. The main source is Peru, where it was first reported in the 1970s. It has been mined commercially in small amounts since the early 1980s. Near the Acarí Mine, pink opal and associated chalcedony occur in veins up to two inches thick within diorite host rock. The dioritic rock must first be blasted; the opal is then manually recovered with the use of hammers and chisels. The rough pink opal is sent to a processing facility in the national capital of Lima, where craftsmen clean and prepare specimens and cut and polish cabochons for jewelry use.

Two other types of common opal are also mined in Peru. The Acarí opal source yields a translucent, white “milk opal” that takes an attractive, pearl-like polish. The Monte Rosa Mine

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(see “Collecting Localities”) yields a blue opal that is colored by tiny inclusions of chrysocolla [basic hydrous copper aluminum acid silicate, $(\text{Cu,Al})_2\text{H}_2\text{Si}_2\text{O}_5(\text{OH})_4 \cdot n\text{H}_2\text{O}$]. The same commercial-collecting organization that provided our pink-opal specimens mines all three types of Peruvian common opal.

As you examine your specimen of Peruvian pink opal, note first its soft translucency and clean, pink color, the latter a hue that is not found in any other type of common opal. The colorless-to-grayish, translucent matrix material is chalcedony. The slight color zoning of light and darker pink results from the incomplete mixing of the opal and palygorskite components within the original silica gel prior to solidification. Your specimen of Peruvian pink opal is a very unusual type of common opal that exhibits, in the view of some gemologists, the most delightful pink color of any gemstone.

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