Mineral of the Month Club June 2017

OPAL subvar. FIRE

This month our featured mineral is the fire subvariety of common opal from Mexico. Our write-up discusses the mineralogy of fire opal, the origin of its yellow-orange-red coloration, and its classification as a mineraloid.

OVERVIEW

PHYSICAL PROPERTIES

Chemistry: $SiO_2 \cdot nH_20$ Hydrous Silicon Dioxide, containing varying amounts of water. The fire subvariety of common opal contains traces of hematite and hydrous iron oxides.
Class: Silicates
Subclass: Tectosilicates (Framework Silicates)
Group: Hydrated Tectosilicates
Subgroup: Opal
Crystal System: None; opal has a noncrystalline structure.
Crystal Habits: None; occurs as amorphous fillings or botryoidal coatings in vugs and fissures.
Color: Fire opal is always a shade of yellow, orange, or red, or a mix of these colors; color intensity varies from pale to saturated; color zoning and multicoloration is common. Fire opal occasionally exhibits an internal play of green color.
Luster: Vitreous to dull
Transparency: Transparent to translucent
Streak: White
Cleavage: None
Fracture/Tenacity: Conchoidal; tough. Brittleness increases with level of hydration.
Hardness: 5.5-6.0
Specific Gravity: Varies with water content from 1.9 to 2.3; the average specific gravity of all opal varieties is 2.09. The specific gravity of fire opal is about 2.2.
Luminescence: Most opal fluoresces pale greenish-yellow in shortwave ultraviolet light and white in long-wave ultraviolet light.
Refractive Index: 1.44-1.46
Distinctive Features and Tests: The best field identification marks for fire opal are low density; conchoidal fracture; lack of crystal faces and cleavage planes; yellow-orange-red coloration; and occurrence in rhyolite formations.
Dana Mineral-Classification Number: 75.2.1.1

NAME: The word "opal," pronounced OH-pul, comes from the Latin *opalus*, which, in turn, 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*. Opal's two varieties are "precious" and "common." Precious opal, which exhibits an internal play of light called "opalescence," is also known as "flash opal," "harlequin opal," and "pinfire opal."

Common opal is not opalescent. Fire opal is a yellow-orange-red subvariety of common opal. In the term "fire opal," the word "fire" refers not to opalescence, but to its fire-like body colors. Other names for fire opal are "orange opal," "cherry opal," "lemon opal," "sun opal," and "girasol."

COMPOSITION & STRUCTURE: Opal is not technically a mineral, but a mineraloid, which is a natural, mineral-like material that lacks the crystal structure and definite chemical composition necessary for classification as a mineral. Opal is an amorphous, layered, solidified, colloidal silica gel that contains varying amounts of water attached as water of hydration. The general chemical formula $SiO_2 \cdot nH_20$ identifies opal as hydrous silicon dioxide containing the elements silicon, oxygen, and hydrogen. Precious opal consists of randomly arranged, hydrated silica molecules interspersed with internal layers of microscopic silica spherules that diffract light as opalescent colors; common opal lacks opalescence and occurs in a wide range of base colors. Unlike crystalline minerals that precipitate on a molecule-by-molecule basis, opal forms when silica gels solidify or "freeze" into layered masses. Opal is a low-temperature (epithermal) silicate that develops as amorphous fracture and cavity fillings in sedimentary and volcanic environments. Fire opal's diagnostic yellow-orange-red colors are due to inclusions of microscopic or submicroscopic particles of hematite and basic iron oxides.

COLLECTING LOCALITIES: Notable sources of fire opal are found in Mexico, Brazil, Argentina, Canada, Madagascar, Slovakia, Turkey, Austria, Hungary, Australia, and England. In the United States, fire opal occurs in Colorado, California, Idaho, Oregon, Arizona, and Nevada.

HISTORY, LORE & USES: Because of the opalescence of its precious variety and the attractive, translucent colors of its common variety, opal has served as a gemstone since antiquity. Opal is the birthstone for 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. The fire variety of common opal was first known as *girasole*, the Italian word for "sunflower," in allusion to its bright, sun-like colors. Girasole appeared in the English language in 1516 and remains an alternative name for fire opal today. The term "fire opal" was first used in 1816. Mexico's fire opal deposits were first developed commercially in the late 1830s and are still mined today. Mexico is the world's leading source of fire opal and produces the best stones. Metaphysical practitioners believe that fire opal bestows courage, stamina, determination and energy upon those who wear it. Fire opal's yellow-orange-red colors are thought to impart an inner sense of warmth, peace, and harmony.

ABOUT OUR SPECIMENS: Our specimens of fire opal are from the fire opal fields of central Mexico in the states of Querétaro, Hidalgo, Jalisco, and Aguascalientes, all of which are located north or west of Mexico City. Mexico's fire opal occurs as vug and fissure fillings in formations of rhyolite within the Mexican Trans-Volcanic Belt, a geological zone of volcanic activity that trends east-west for 600 miles across central Mexico from the state of Jalisco on the Pacific to the state of Veracruz-Llave on the Gulf of Mexico. During the 1300s and 1400s A.D., the Aztecs used fire opal from these sources in ceremonial rites and as inlay pieces in mosaics and murals. Central Mexico's fire opal deposits were rediscovered in the late 1830s by a Querétaro landowner. Thanks to the output of dozens of Querétaro mines, Mexican fire opal began attracting international attention in the 1870s. Mexican fire opal was exhibited at world's fairs and major trade expositions in the United States and Europe in the 1880s and 1890s. Modern interest in Mexican fire opal began in the 1950s, when new deposits were discovered near the town of Magdalena in the state of Jalisco. Several hundred mines produce fire opal today in the states of Querétaro, Hidalgo, Jalisco, and Aguascalientes. The few larger mines break the rhyolite with dynamite and pneumatic rock drills; the many smaller operations rely on manual labor, hammers, and hand steels.

COMPREHENSIVE WRITE-UP

COMPOSITION & STRUCTURE

Opal is technically classified as a mineraloid (see "The Mineral-Like Mineraloids"), which is a natural, mineral-like material that has distinctive properties, yet lacks the definite chemical composition and crystal structure necessary for classification as a mineral. Opal is defined an amorphous, layered, solidified, colloidal silica gel consisting of randomly arranged, hydrated silica molecules interspersed with internal layers of microscopic silica spherules. Because it was originally considered a mineral, the International Mineralogical Association retains opal's Dana mineral-classification number 75.2.1.1. This number identifies opal as a tectosilicate (75); the subclassification (2) defines it as a tectosilicate containing water or such organic components as carbon (C) or methane (CH_4). Opal is then assigned to the opal group (1) as the first (1) and only member.

As shown by its chemical formula $SiO_2 \cdot nH_20$, opal is hydrous silicon dioxide containing the elements silicon (Si), oxygen (O), and hydrogen (H). Opal's molecular weight and the proportions of its elemental components vary with the amount of water (H_2O) present, which ranges between 1 percent and 30 percent. As an example, opal with the empirical formula $SiO_2 \cdot H_2O$ contains about 36 percent silicon, 62 percent oxygen, and 2 percent hydrogen with water accounting for 22 percent of its molecular weight.

In opal's general chemical formula $SiO_2 \cdot nH_20$, the "$\cdot nH_2O$" indicates a variable number of attached water molecules. These water molecules, called "water of hydration," are attached by weak hydrogen bonding. Because they are electrically neutral, they do not affect the electrical balance of the parent molecule. In the water molecule H_2O, one oxygen ion O^{2-} shares electrons with, and is covalently bonded to, two hydrogen ions $2H^{1-}$. Because the two small hydrogen ions are grouped together, the water molecule is asymmetrical. The two hydrogen ions retain a small positive charge, while the opposite side of the molecule, dominated by the large, negatively charged oxygen ion, retains a residual negative charge. Hydrogen or polar bonding occurs when the faintly positive poles of water molecules are attracted to the negatively charged electrons of other ions. In opal, the positively charged sides of water molecules are attracted to the negatively charged oxygen ions within the silica tetrahedra. The fire subvariety of common opal is heavily hydrated and often contains as much as 20 percent water, meaning that one water molecule is present for every five silica molecules.

Opal's basic building block is the silica tetrahedron $(SiO_4)^{4-}$, which consists of a silicon ion surrounded by four equally spaced oxygen ions positioned at the corners of a tetrahedron. Opal is a tectosilicate or "framework" silicate, in which oxygen ions share electrons with the oxygen ions of adjacent tetrahedra to form rigid, repeating, compact, three-dimensional, framework-type structures. The tectosilicates include quartz [silicon dioxide, SiO_2], which is similar to opal only in that it contains silica tetrahedra. Unlike quartz, opal has no orderly, repeating atomic structure and thus no crystal form. Opal and quartz also differ in their physical properties. With its rigid crystal structure, tight atomic packing, and strong covalent bonding, quartz has a substantial Mohs hardness of 7.0. But because opal lacks a rigid crystal structure and has weaker atomic bonding, it is considerably softer at Mohs 5.5-6.0 and more brittle. Opal is also much less dense (average specific gravity 2.09) than quartz (specific gravity 2.65).

Opal forms from the solidification of silica gel. Relatively abundant and widely distributed, opal occurs in both volcanic and sedimentary environments. Volcanic opal forms when groundwater dissolves silica from such rocks as rhyolite and basalt, then forms silica gels that fill fissures and cavities and eventually solidify into opal. The rarer sedimentary opal forms by a similar process within sandstone.

Gemologically, opal is classified into two varieties: precious and common. Precious opal exhibits opalescence; common opal does not. Opalescence refers to an iridescent, rainbow-like play of multicolored light caused by the interaction of white light with internal layers of tiny silica spherules that are less than 1/1,000th of a millimeter in diameter. Common (non-opalescent) opal, which includes fire opal, either lacks these silica-spherule structures or contains spherules that are too large or too small to diffract light.

Opal has four structural groups:

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

Opal-CT is common opal similar to Opal-C, but which contains spherules of both cristobalite and tridymite (a triclinic quartz polymorph);

Opal-A_N is the most abundant type of common opal and includes the fire subvariety of common opal. "A" signifies "amorphous"; "$_N$" denotes a structure similar to that of volcanic glass;

Opal-A_G is precious opal. "A" signifies "amorphous"; "$_G$" signifies a gel-like structure with attached water molecules surrounding internal layers of silica spherules that diffract light to create opalescence.

Pure opal, regardless of variety, has no base color. Precious opal exhibits both allochromatic (other-colored) and idiochromatic (self-colored) properties; its body color, which is usually white or gray, is allochromatic, while its opalescent colors are idiochromatic and result from light reflecting from its internal structure. Common opal is entirely allochromatic, meaning that its colors are due to traces of nonessential, chromophoric (color-causing) elements. Fire opal's diagnostic yellow-orange-red base colors are caused by light reflecting from inclusions of microscopic or submicroscopic particles of hematite [iron oxide, Fe_2O_3] and basic iron oxides.

Fire opal occasionally exhibits an internal play of opalescent green color, which is caused by diffracted light reflecting from partially formed layers of silica spherules.

COLLECTING LOCALITIES

The world's greatest sources of fire opal are the Mexican states of Querétaro, Hidalgo, Jalisco, and Aguascalientes. Lesser deposits of fire opal are also found in the Mexican states of Chihuahua, San Luis Potosí, Guerrero, Michoacán, and Baja California Norte. Fire opal is collected in Brazil at the Manoel Abrósio Ranch at Saõ Geraldo do Araguaia, Para; Compos Borges, Rio Grande do Sul; and the Amazon Opal Mine at Porto Velho, Rondónia. Other sources include El Mirador, Cushamen Department, Chubut, Argentina; and the Eagle Mine at Burns Lake, Omenica Mining Division, British Columbia, Canada.

Fire opal occurs at Bemia, Befotaka Sud District, Atsimo-Atsaninana Region, Fianarantsoa Province, Madagascar; Povrazník and Streiníky in Banska Bystrika Region and the Jozef Adit at Libanka in Preŝov Region, both in Slovakia; the Şaphane Dagi fire opal deposit, Pizaria, Kütahya Province, Aegean Region, Turkey; the Schlarbaum Quarry and Traus Pit at Bad Gleichenberg, Styria, Austria; and Hosszú Hill at Megyaszó in the Tokaj Mouintains, Borsod-Abaúj-Zemplén County, Hungary. Australia's sources include Lightning Ridge in New South Wales; the Mintabi opal field at Mintabi, South Australia; and White Cliffs at Laverton Shire, Western Australia. In England, fire opal occurs in Cornwall at the Botallak Mine at Botallak in the St. Just District; and in the Wheal Gorland and Wheal Gerry mines, Camborne-Redruth-St. Day District.

In the United States, fire opal is collected in Colorado at the Good Hope Mine, Vulcan district, Gunnison County; and at Green Mountain and North and South Table mountains at Golden in Jefferson County. California localities include the Weise clay pit at Glen Ellen in Sonoma County; Dunsmiur and Mount Bradley in the Klamath Mountains in Siskiyou County; and the Barnett, Last Chance, and Cowden opal mines in the El Paso Mountains district in Kern County. Sources in Idaho are Moore Creek at Idaho City in Boise County; Lewiston in Nez Perce County; and the Bruneau Jasper and Opaline claims in Owyhee County. Oregon's localities include Opal Butte in Morrow County; the Hart and Juniper Ridge opal mines in Lake County; and the Durkee Fire Opal Mine at Durkee in Baker County. Other sources are the Oatman district in the Black Mountains, Mohave County, Arizona; and the Royal Peacock Opal Mine in the Virgin Valley, Humboldt County, Nevada.

JEWELRY & DECORATIVE USES

With its substantial hardness, range of pleasing colors, varying degrees of transparency or translucency, and opalescence (in the precious variety), opal has been valued as a gemstone since antiquity. It is traditionally cut into cabochons to display its colors and opalescence. Opal gems usually weigh at least 3 carats and as many as 20 carats. Because of the scarcity of gem-quality precious opal with sufficient thickness to fashion into traditional cabochons, cutters have developed composite gems 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; synthetic opal was introduced commercially in the 1960s and is now mass-manufactured.

The fire variety of common opal has been popular as a gemstone only since the mid-1800s. Its yellow-orange-red base colors are unlike those of any other opal or, for that matter, any other gemstone, with the possible exception of orange spessartine [garnet group, manganese aluminum silicate, $Mn_3Al_2Si_3O_{12}$]. Fire opal's color ranges from light yellow through orange to red; color-zoning and multicoloration is common. The orange and orange-red colors are the most desirable. While all other forms of opal are traditionally cut into cabochons, fire opal, because of its unusual degree of transparency, is often faceted to add "sparkle" to the finished gems.

Because fire opal has a high water content, it is sometimes subject to "crazing" or dehydration cracking. Certain forms of opal, including fire opal, begin to dehydrate immediately after mining. This loss of water can cause slight shrinkage in volume and "crazing," the development of an intricate network of fine cracks that can compromise appearance and, most importantly, stability of the stone. Such weakened stones tend to chip or fracture when cut or polished. Newly mined fire opal that will be faceted is always "screened," or gently heated to a temperature of about 80° F. for several weeks. Stones that do not exhibit crazing after screening can usually withstand the stresses of cutting and polishing.

Faceted fire opal is mounted in all types of jewelry in silver, white and yellow gold, and platinum settings. Top-quality, faceted fire opal gems with good transparency and rich orange colors in sizes of two or three carats cost about $100 to $200 per carat. In sizes of six carats or more, faceted fire opal gems can cost as much as $300 per carat. Natural fire opal that is bright and colorful, but too thin to shape or cut, is often polished in free form in its rhyolite matrix and worn in pendants.

Gemologists have recently developed a new type of synthetic fire opal called "Mexifire." Mexifire has a silica-like composition that is physically and chemically similar to natural fire opal. It has a high degree of transparency, bright and uniform coloration, and does not dehydrate or craze. Synthetic Mexifire opal can be differentiated from natural fire opal by its lesser density.

HISTORY & LORE

Artifacts of both precious and common opal have been recovered from 6,000-year-old cultural sites in Africa. Arabian folktales tell of precious opal falling from the heavens as flashes of lightning. The ancient Greeks believed that opal bestowed the power of foresight and prophecy upon its owner, while the Romans valued opal as a symbol of hope and purity. The Roman scholar Pliny the Elder (Gaius Plinius Secundus, A.D. 23-79) described precious opal as having "the living fire of the ruby, the glorious purple of the amethyst, the sea-green of the emerald, all glittering together in a wonderful play of light." Medieval physicians administered tonics of finely ground opal to aid healing and prevent nightmares, and recommended prolonged gazing into opals to prevent eye disease. Also during the medieval era, Scandinavian women believed that wearing opal would keep their blonde hair from fading.

Many cultures believed that precious opal possessed broad powers. To English dramatist and poet William Shakespeare (1564-1616), opal's shifting, fiery colors symbolized unpredictability. In *Twelfth Night; Or, What You Will,* Shakespeare likened this opalescence to the changeability of the human mind, when the jester says to the mercurial Duke Orsino, "Now the melancholy God protect thee, and the Tailor make thy garments of changeable taffeta, for thy mind is opal." Opal's popularity in Europe plummeted suddenly during the early 1800s with the appearance of large quantities of inferior Russian opal, the color of which soon faded. Opal also figures prominently in the novel *Anne of Geierstein,* by Scottish author and poet Sir Walter Scott (1771-1832). In this novel, the main character wears a dazzling opal gem. But her existence becomes entwined with the opal's beauty and as its fire fades, so, too, does her life—convincing many European readers that opal was unlucky. Until the discovery in the late 1800s of large Australian deposits, precious opal was quite rare and very costly. But the subsequent increased availability and affordability quickly restored its popularity. British Queen Victoria (Alexandrina Victoria, 1819-1901) often wore opal jewelry to further its popularity.

Opal has been featured on the Australian eight-cent and nine-cent stamps of 1973 and 1974, the $1.20 stamp of 1995, and the $2.50 stamp of 1998. It has appeared on the 600-franc stamp of Central Africa in 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.

Like other forms of opal, fire opal has been collected since antiquity. It was first known as *girasole,* the Italian word for "sunflower," in reference to its bright, sun-like colors. Girasole entered the English language in 1516 and remains an alternative name for fire opal today. The term "fire opal" was first used in 1816. The Aztecs used fire opal mined from sources to the north and west of what is now Mexico City in ceremonial rites and as inlay pieces in mosaics and murals. Mexico's fire opal deposits were rediscovered in the late 1830s and have been mined ever since (see "About Our Specimens"). Today, Mexico is the leading source of fire opal in both quantity and quality.

According to metaphysical lore, opal of all kinds 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. Metaphysical practitioners believe that fire opal specifically bestows courage, stamina, determination and energy upon those who wear it. For many wearers, its yellow-orange-red colors impart an inner sense of warmth, peace, and harmony.

THE MINERAL-LIKE MINERALOIDS

Although often thought of as a mineral, opal is actually a mineraloid. Mineraloids are natural, mineral-like materials that, because of origin, lack of crystal structure, or indeterminate chemical composition, do not meet the criteria of a mineral. Minerals are naturally occurring, homogenous solids of inorganic origin with definite chemical compositions (within limits) and ordered crystalline structures.

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. But because it was historically considered a mineral, it retains its original Dana mineral-classification number (75.2.1.1). Opal is also assigned the chemical formula $SiO_2 \cdot nH_2O$, in which "*n*" refers to an indefinite number of attached water molecules.

Another 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 varying amounts of feldspar and ferromagnesian minerals. Like opal, obsidian lacks both a crystal structure and a definite chemical composition. Tektites, which consist of natural glass with neither a crystal structure nor a definite chemical composition, are similar to obsidian. Tektites form from very rapid solidification of silica material that was instantaneously melted in meteoric impacts.

Amber is another material that is often classified as a mineraloid. Amber is specifically considered an "organic non-mineral"—a natural substance of organic origin that satisfies neither the definition of a mineral nor that of a mineraloid, the latter because it is not particularly "mineral-like." Amber is a noncrystalline, oxygenated hydrocarbon of 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. Most fossils are created through mineral replacement or molded impressions, but amber forms through the chemical process of molecular polymerization and is correctly described as an altered tree resin.

Yet another mineraloid is jet, a compact form of coal and a 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 a mineral.

Elemental 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 a vague area between minerals and mineraloids. At ambient temperatures, mercury is a liquid and lacks a crystal structure. Nevertheless, because it was historically considered to be a mineral, mercury retains its original Dana mineral-classification number 1.1.7.1. Mercury technically becomes a mineral at -40° F. (-40° C.), the temperature at which it freezes and crystallizes in the hexagonal (trigonal) system.

A similar relationship exists between water, a mineraloid, and ice, a mineral. Both share the same definite chemical composition. Water lacks the crystal structure necessary to qualify as a mineral; ice, however, is a mineral because it crystallizes in the hexagonal system, as is evident in the symmetrical, six-fold, crystalline shapes of snowflakes.

TECHNOLOGICAL USES

Apart from serving as the model for its own laboratory synthesis, opal has no technological uses.

ABOUT OUR SPECIMENS

Our specimens of fire opal are from central Mexico. Fire opal is found in 9 of Mexico's 31 federal states—Querétaro, Hidalgo, Jalisco, Aguascalientes, Chihuahua, San Luis Potosí, Guerrero, Michoacán, and Baja California Norte. Most fire-opal occurrences and mines are in Querétaro, Hidalgo, Jalisco, and Aguascalientes, which are located in central Mexico to the north and west of Mexico City.

Mexico's fire agate occurs as vug and fissure fillings in formations of rhyolite, a high-silica, extrusive, igneous rock common to many volcanic regions. The most productive fire opal deposits are in the rhyolite formations of the western part of the Mexican Trans-Volcanic Belt, a volcanic zone of plateaus, peaks, ridges, and active volcanoes that trends west-east for 600 miles across central Mexico from the state of Jalisco on the Pacific to the state of Veracruz-Llave on the Gulf of Mexico. The Mexican Trans-Volcanic Belt was emplaced in three eruptive phases that occurred between 20 million and 7 million years ago. The final eruptive phase occurred in the late Miocene Epoch some eight million years ago and extruded masses of rhyolitic lava that form bedrock across much of the Belt today.

Fire opal occurs in vugs and fissures within rhyolite formations. When rhyolite solidifies from magma, it often contains gas cavities. Over time, mineral-laden ground water filled these empty vugs and precipitated quartz and calcite [calcium carbonate, $CaCO_3$]. But with the right conditions of chemistry, temperature, and pressure, silica-rich groundwater sometimes converted to thick silica gels that later solidified into opal. Because this solidification process was too rapid to enable the tiny silica spherules within the gels to align in layers that would diffract light, the opal that formed was of the common, non-opalescent variety. This opal also contained traces of particulate hematite [iron oxide, Fe_2O_3] and basic iron oxides that produce the distinctive yellow-orange-red coloration of fire opal.

During the 14th and 15th centuries A.D., the Aztecs of central Mexico collected this fire opal for use in ceremonies and as inlay pieces for murals and mosaics. The Aztecs knew fire opal as *vitztziltecpa*, or "hummingbird stone," alluding to the similarity of its colors to the iridescent colors of hummingbirds. In 1521, Spanish conquistadores described a mosaic image of Quetzalcoatl, the Aztec god of wind and wisdom, wearing a headdress in which inlaid fire opal depicted tongues of flame. But following the Aztec conquest, the Spanish, apparently obsessed only with finding gold and silver, took no interest in fire opal.

Mexican fire opal was rediscovered in the late 1830s by Don José María Siurab, a wealthy Querétaro landowner, who began mining the gemstones on his hacienda. By the 1870s, thanks to the output of dozens of Querétaro mines, Mexican fire opal had attracted international attention. During the 1880s and 1890s, specimens and gems of Mexican fire opal were often exhibited at world's fairs and trade expositions in the United States and Europe. One superb specimen, exhibited at the Universal Exposition of 1889 in Paris, France, and described as "nodular, large as a hen's egg, the color of a reddish sun, and set in rhyolite," is now in the collection of the Harvard Mineralogical Museum in Cambridge, Massachusetts.

Interest in Mexican fire opal then waned until the 1950s, when new deposits were discovered near the town Magdalena in the state of Jalisco. The unusually high quality of this fire opal attracted much attention in the gem markets of the United States, Europe, and Japan. Thousands of opal miners flocked to Magdalena where, by the mid-1960s, some 300 mines, mostly small, family-operated, surface excavations, were turning out record amounts of fire opal. American gem buyers who visited Magdalena during these years told how miners gathered in the town plaza in the evenings to sell top-quality fire opal literally by the sack full. During this period, Mexico established itself as the world's leading source of fine fire opal.

Several hundred small mines, almost all open pits, in the states of Querétaro, Hidalgo, Jalisco, and Aguascalientes continue to produce fire opal today. The few large mines are operated by crews of 10 or more workers who break the rhyolite with dynamite and pneumatic rock drills. Some larger mines have exposed rhyolite cliffs nearly 200 feet high. The many smaller operations are labor-intensive and rely upon sledge hammers and hand steels to break the tough rhyolite. Because fire opal occurs erratically in the rhyolite, finding it is largely a matter of luck. All rhyolite pieces more than four inches in size must be further broken with hammers to expose possible vugs of fire opal. Hundreds of *opaleros*, or "opal scavengers," many of whom are children, gather at the mines to search the heaps of waste rock for overlooked pieces of fire opal.

The color of your specimen of Mexican fire opal is a rich, clean orange, which is the most desirable hue for gem use. Notice that your specimen feels light in the hand. This reflects opal's low specific gravity of 1.9-2.3, which makes it roughly 25 percent less dense than quartz. View your specimen with backlighting to fully appreciate its high degree of transparency and unusual orange color. Conchoidal fractures are evident on broken surfaces. In some specimens, backlighting may reveal crazing, which appears as a network of fine cracks caused by natural dehydration after mining. Some specimens may also show remnants of the tan-colored, rhyolite host rock. Your specimen of Mexican fire opal, one of the few orange-colored gemstones, represents the most valuable form of common opal.

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