December 2010 Mineraloid of the Month: Boulder Opal

"There is in them a softer fire than in the carbunkle, there is the brilliant purple of the amethyst; there is the sea-green of the emerald–all shining together in incredible union. Some by their refulgent splendor rival the colors of the painters, others the flame of burning sulphur or of fire quickened by oil."–Pliny the Elder, circa 79 AD. Our write-up explains the unusual geologic origin of precious opal, the cause of its colorful opalescence, its gemological history, and the importance of opal in the culture and economy of Australia.

OVERVIEW

PHYSICAL PROPERTIES

Chemistry: $SiO_2 \cdot nH_20$ Hydrous Silicon Dioxide, always containing varying amounts of water; often with traces of iron and aluminum.
Class: Silicates
Subclass: Tectosilicates (Framework Silicates)
Group: Opal (Hydrated Tectosilicates)
Crystal System: None
Crystal Habits: None; usually occurs as amorphous fillings in seams and cavities.
Color: Colorless and white to yellow, red, pink, brown, green, gray, violet, and blue; opalescent varieties exhibit a rich, internal play of varied colors that can represent the entire spectral range.
Luster: Vitreous to dull
Transparency: Usually translucent, occasionally transparent or opaque
Streak: White
Cleavage: None
Fracture: Conchoidal, brittle
Hardness: 5.5-6.0
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: Low density, fluorescence, conchoidal fracture, lack of crystal faces and cleavage surfaces, and opalescence in many varieties.
Dana Classification Number: 75.2.1.1

NAME The word "opal," pronounced "OH-pul," stems from the Latin *opalus* or "opal," which derives 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. The term "boulder opal" refers to a type of Australian precious opal that forms within sandstone concretions. Because of its 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 translucent white; "porcelain opal" is opaque white; "prase opal" is green; and "blue opal" has a blue or blue-green body color. Opalescent varieties are known as "precious opal," "fire opal," "flash opal," "harlequin opal," and "pinfire opal." "Agate opal" consists of 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.

COMPOSITION: For the second time in three months we are featuring a natural wonder that is classified by scientists as a mineraloid rather than as a mineral. (Obsidian was the other, in October.) As a mineraloid, opal is classified a naturally occurring substance that lacks the crystal structure and definite chemical composition necessary for classification 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 $SiO_2 \cdot nH_20$ 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 and cavity fillings in both sedimentary and volcanic environments when silica gels slowly solidify under specific conditions of chemistry and temperature

COLLECTING LOCALITIES: Most precious-opal comes from Australia, where important localities include the Queensland opal fields in Queensland; the Wyoming, Lightning Ridge, Glengarry Coocoran, Grawin, Cumborah, New Coocoran, Muttabun, K.K., and Mehi opal fields in New South Wales; and the Stuart Creek, Andamooka, Coober Pedy, and Mintabie opal fields in South Australia. Opal is also found in Brazil, Mexico, Honduras, Italy, Slovakia, and Japan. In the United States, precious opal is collected in Nevada, Oregon, and Idaho. A new find of opal of very high quality from Ethiopia, Africa, has recently reached gem and mineral shows in the U.S.--perhaps we will feature Ethiopian opal in the future!

HISTORY, LORE, & GEMSTONE/TECHNOLOGICAL USES: Although precious opal has only moderate hardness of Mohs 5.5-6.0, its brilliant opalescence or "fire" has made it a coveted gemstone since antiquity. Opal is usually cut into cabochons to best display its opalescent colors. Until the discovery of large Australian deposits in the 1880s, precious opal was quite rare. In recent decades, jewelers have compensated for the scarcity of rough precious opal of sufficient thickness to cut into cabochons by fabricating composite gems called "doublets" and "triplets." In doublets, thin sections of precious opal are cemented to colored backing material of common opal or obsidian to enhance both structural strength and opalescent color. Triplets have hard, durable, clear quartz cabochons cemented atop doublets to protect the underlying opal. Opal is the birthstone for the month of October. It is also Australia's national gemstone and one of Nevada's two state gemstones. Modern metaphysical practitioners believe that opal enhances love between faithful lovers, and that because opal intensifies all thoughts and actions, including those that are negative, it must be worn judiciously.

ABOUT OUR SPECIMENS: Our specimens of boulder opal were collected at Woodstock Downs Station, a sheep station not far from the Middleton road stop west of Winton in west-central Queensland, Australia. This site is about 700 miles northwest of the coastal city of Brisbane and at the northern limit of the Queensland opal fields, a large area in which opal occurs as intermittent deposits of boulder opal—opal emplaced within cracks and seams in concretions or boulders of iron-rich sandstone. Our specimens consist of fragments of ironstone concretions in which precious opal fills seams and cracks. Using both surface and underground mining methods, opal miners excavate weathered sandstone to recover opal-bearing concretions, which are then split to reveal seams of gem-quality, precious opal. Because boulder-opal seams are typically thin, gem cutters usually retain a section of ironstone as a natural backing material. The Queensland opal fields have excellent potential for future opal discoveries.

10 YEARS AGO IN OUR CLUB: Celestite, Sakoany Mines, Madagascar. We closed out the twentieth century by sending Club members exceptional pieces of this marvelous mineral! Though originally discovered at Bellwood, Blair County, Pennsylvania in the late 1700s, celestite from Madagascar dominates the market today. The official name is of course "celestine" rather than "celestite," but few in the U.S. seem to care about using the correct nomenclature. The breathtaking beauty and translucence of the finest blue celestite crystals from Madagascar appeals to collectors everywhere, and was the subject of a recent article in the *Mineralogical Record* a couple of months ago, with glorious photos of the finest crystals! Though still abundant, few pieces have the breathtaking blue color of the best celestite crystals.

December 2010 Mineraloid of the Month: Boulder Opal

COMPREHENSIVE WRITE-UP

COMPOSITION

This is the second time we have featured opal in our Club, the first being the exceptional opal found at Opal Butte, Morrow County, Oregon, in June 2005. You can probably imagine our keen interest in featuring Australian opal, and our frustration in not being able to obtain sufficient specimens. What prevented us is what prevents us from featuring other traditional gem materials such as Lapis Lazuli and turquoise–virtually all the material goes directly to the jewelry market! So it has been a challenge to find a source of specimens like we have this month, but our persistence has paid off!

Opal, this month's "mineral," is actually classified as a mineraloid–a naturally occurring substance with distinctive properties that does not meet the full requirements for classification as a mineral. Opal is properly defined as an amorphous, layered, solidified, colloidal silica gel consisting of randomly arranged, hydrated silica molecules interspersed with layers of microscopic silica spherules. It is not classified as a mineral because it has neither a definite chemical composition nor a crystal structure. Nevertheless, because opal 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 (CH_4). Opal is then assigned to the opal group (1) as the first and only member (1).

The chemical formula $SiO_2 \cdot nH_20$ identifies opal as 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. Opal can contain between 1 and 30 percent water. The molecular weight of an opal specimen with the empirical formula $SiO_2 \cdot 5H_2O$, for example, contains 40.58 percent silicon, 57.98 percent oxygen, and 1.44 percent hydrogen. Expressed differently, this same opal specimen would consist 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 $2O^{2-}$.

As a silicate, the basic building block of opal is the silica tetrahedron $(SiO_4)^{4-}$. A silica tetrahedron consists of a silicon atom surrounded by four equally spaced oxygen atoms positioned at the corners of a tetrahedron. Opal is sub-classified as a tectosilicate or "framework" silicate, in which oxygen ions share electrons with oxygen ions of adjacent tetrahedra to form repeating, rigid, compact, three-dimensional, framework-type structures. Tectosilicates include quartz [silicon dioxide, SiO_2], which is similar to opal only in that both contain silica tetrahedra. Unlike quartz, opal has no orderly, repeating atomic structure, and thus no definite crystal form. Opal and quartz also have greatly different physical properties. 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 5.5-6.0 and much more brittle. Attached water molecules also make opal much less dense (average specific gravity 2.09) than quartz (specific gravity 2.65).

In opal's chemical formula $SiO_2 \cdot nH_20$, the "$n \cdot H_2O$" indicates 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. Furthermore, the grouped hydrogen ions retain a small positive charge, while the opposite side of the 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.

As a low-temperature (epithermal) silicate, opal solidifies from silica gel as fracture and cavity fillings under specific conditions of chemistry and temperature. Unlike crystalline minerals 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 both volcanic and sedimentary environments. Volcanic opal, which forms when silica solutions fill fissures and cavities in volcanic host rocks, has many occurrences. Sedimentary opal, which is much rarer, occurs mainly in Australia and Brazil 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. Australian boulder opal, as represented by our specimens, forms only within iron-rich sandstone concretions (see "About Our Specimens").

Opal is classified gemologically as precious opal or common opal. Precious opal exhibits opalescence; common opal does not. 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 unusually brilliant, pure spectral colors characteristic of the glittering "fire" in precious opal.

Common (non-opalescent) opal either lacks these silica-spherule structures or contains spherules that are too large or too small to diffract light. Pure opal, regardless of variety, has no base color at all. Common opal is therefore allochromatic (other-colored), meaning its broad range of colors and degrees of transparency or translucency are due to traces of nonessential chromophoric (color-causing) elements such as iron and aluminum. Precious opal, however, exhibits both allochromatic and idiochromatic (self-colored) properties; its body color is allochromatic, while its opalescence colors, which are caused by the manner in which its structure interacts with light, are idiochromatic.

Structurally, opal is divided into four categories: opal-C, opal-CT, opal-A_N, and opal A_G, as described:

Opal-C is a form of common opal consisting of cristobalite spheres interspaced 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 a form of common opal similar to Opal-C that contains spheres of both cristobalite and tridymite (a quartz polymorph crystallizing in the triclinic system).

December 2010 Mineraloid of the Month: Boulder Opal

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.

COLLECTING LOCALITIES

Sources of common opal are relatively abundant, but those of precious opal are rare. The following list of collecting localities includes only those that yield gem-quality or otherwise notable opal specimens. Our boulder opal specimens were collected at Woodstock Downs Station, a sheep station not far from the Middleton road stop west of Winton in west-central Queensland, Australia. Other Queensland sources are the Eromanga Opal Field near Quilpie, Quilpie Shire; the Barcoo River in Barcoo Shire; the Alladin Mine at Listowel Downs in Bulloo Shire; the Nicholson River at Burketown in Burke Shire; Point Danger at Coolangatta in Gold Coast City Shire; the Yowah Opal Field in Paroo Shire; and Squaretop Mountain and Black Top Hill at Kaimkillenbun in the Western Downs Region. Other notable Australian localities are Finch County in New South Wales, where sources include the Wyoming Opal Field at Wyoming Station; the Glengarry Coocoran Opal Field at Lightning Ridge; the Grawin Opal Field at Grawin; the Cumborah Opal Field at Cumborah; the Collarenebri Opal Field at Collarenebri; and the New Coocoran, Muttabun, and K.K. opal fields at Coocoran. Also in New South Wales is the Mehi Opal Field near Mehi in Murchison County. In South Australia, opal is collected at the Stuart Creek diggings at Stuart Creek and in the Andamooka Opal Field near Lake Torrens in the Andamooka Ranges; the Coober Pedy and Eight-Mile opal fields at Coober Pedy in the Everand Range; the Mintabie Opal Field at Mintabie; and the O’Donahue Castle and Mount Painter mines in the North Finders Ranges.

Among Brazil’s opal sources are the Amazon Opal Mine at Porto Velho in Rondônia state; the Bodó Mine at Lajes Pintadas in the Borborema Mineral Province, Río Grande do Norte state; the Boi Morto Mine at Pedro II in Piauí state; and the Manoel Ambrósio Ranch at Sâo Geraldo do Araguaia in Pará state. Mexico’s localities include the Cerro de Mercado Mine near Durango and the Barranca Mine at Coneto de Comonfort, Durango; the Lomo Deltoro Mine in Zimapán, Hidalgo; the Buena Vista Mine at La Yesca, Nayarit; the San Simón, Chela, Mara, Unica, and Tepucanapa mines near Magdalena, Jalisco; and the Santín Mine on Cerro de las Fajas, Santa Catarina, Guanajuato. In Honduras, opal is found at the Gracias and Erandique deposits near Gracias in Lempira Department. Other notable localities include the Brasso Mine at Ivrea, Torino, Piemonte, Italy; the Leisnig Mine at Döbein, Saxony, Germany; 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; and the historic Čevenica mines in the Northern Slanské Mountains, Prešov Region, Slovakia. Recent finds of opal with exceptional fire have been made in Ethiopia.

In the United States, precious opal is found in Nevada in 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. Oregon’s 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, the source of the specimens we sent Club members in June 2005. Idaho’s sources are the Moscow Opal Mine near Moscow in Latah County and the Idaho Blue Mine at Salmon in Lemhi County.

JEWELRY & DECORATIVE USES

Although precious opal has only a moderate hardness of Mohs 5.5-6.0, its brilliant opalescence, called "fire," has it made it a coveted gemstone since antiquity. Opal is usually cut into cabochons to best display its opalescent play of color. Occasionally, exceptional specimens of transparent common and fire opal are faceted. Most opal gems weigh at least 3 carats, and stones of 10 to 20 carats are not unusual. Opal gems are delicate, brittle, and subject to dehydration. Dehydration can shrink the physical size of an opal, causing it to loosen in its setting, and also to "craze" or develop an internal network of fine cracks. This problem can be prevented in dry climates by storing opal in water or in moist cotton within sealed containers. Because high water content also makes opal vulnerable to thermal shock, rapid, extreme temperature changes (such as sudden hot-water immersion) should be avoided.

In recent decades, the depletion of many opal mines has sharply reduced the availability of top-quality rough of sufficient thickness to fashion into traditional cabochons. Accordingly, cutters have developed composite opal gems called "doublets" and "triplets." In doublets, thin sections of precious opal are cemented to colored backing material of common opal or obsidian to enhance structural strength and intensify the opalescent color. In triplets, clear quartz cabochons are cemented atop doublets to make durable ring stones because of the protective hardness of the top quartz layer. Virtually all mass-produced opal jewelry now consists of doublets or triplets. Because of rarity and demand, fine, natural (non-composite) precious-opal gems can cost as much as one thousand dollars per carat.

Precious opal is often treated to enhance color and brilliance. To darken the color to resemble valuable black opal, light-colored opals are soaked in sugar solutions, then immersed in acids that carbonize the absorbed sugar to a black color. Opal is also chemically dyed, impregnated with artificial resins to seal in the water of hydration, and cemented to glittery, artificial backings to create the illusion of opalescence. Opal was first synthesized in laboratories in 1900. Synthetic gem opal was introduced in commercial quantities in the 1960s and is now mass-manufactured into doublets and triplets.

HISTORY & LORE

Archaeologists have recovered opal artifacts from African cultural sites dating to approximately 4000 B.C. Arabian folktales tell how precious opal fell from the heavens as flashes of lightning; ancient Greeks believed that opal bestowed the power of foresight and prophecy upon its owner. Romans valued opal as a symbol of hope and purity. Roman opals were mined at the present-day site of Čevenica, Slovakia. For hundreds of years, miners protected their interests by misrepresenting this source to the Romans as being located in "India." The Roman scholar Pliny the Elder (Gaius Plinius Secundus, A.D. 23-79) described 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.' (The full quote is found in the beginning of the write-up.) In medieval times, physicians administered tonics containing finely ground opal to aid 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 opal exhibits all gemstone colors, many cultures believed it possessed unusually 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 opal's play of color 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." But opal's favor would itself prove mercurial when its popularity suddenly plummeted in Europe in the early 1800s. One reason was the sudden appearance of a large supply of inferior Russian opal that soon cracked and faded. Another was the novel *Anne of Geierstein,* by Scottish author and poet Sir Walter Scott (1771-1832), in which 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. Until the discovery in the late 1800s of large Australian opal deposits, along with smaller deposits in Brazil, Mexico, and the western United States, precious opal was quite rare. But increased availability and affordability quickly restored its popularity. British Queen Victoria (Alexandrina Victoria, 1819-1901) also focused attention on opal by using it extensively in her personal jewelry and giving opal gems as wedding gifts.

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 also 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. Modern metaphysical practitioners believe that opal enhances love between faithful lovers; but, because opal intensifies all thoughts and actions, including those that are negative, they recommend wearing opal judiciously.

TECHNOLOGICAL USES

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

AUSTRALIA'S LEGACY OF OPAL

Since 1910, Australia has supplied most of the world's fine opal. Australia's numerous opal deposits originated during the Cretaceous Period some 100 million years ago when the Great Inland Sea covered much of what is now eastern Australia, depositing thick formations of sandstone atop older layers of impervious sediments. Long after the sea had receded, circulating groundwater within the sandstone dissolved huge quantities of silica. These silica-rich solutions percolated downward to "pool" atop the impervious sediments and filled cracks and fissures in the overlying sandstone. As water content was gradually reduced, these solutions formed silica gels which eventually solidified into intermittent deposits of opal. Australian precious opal forms as either "seam" opal and "boulder" opal. Seam opal, which forms seams and fracture fillings within sandstone, occurs in northwestern New South Wales and northeastern South Australia. Boulder opal occurs only within sandstone concretions (boulders) and is found in west-central and southwestern Queensland. Subsequent surface erosion exposed certain deposits, leaving opal scattered about the surface. Ancient Aborigines explained its origin in legends that tell of "great wheels of fire" that fell from the sky to cover the ground with glittering, vividly colored stones.

Historical accounts of Australian opal date to 1840, when German-born geologist Johannes Menge (1788-1852) discovered common opal north of Adelaide, South Australia. In 1868, precious boulder opal was discovered at Listowel Downs in southwestern Queensland. The remoteness of this site discouraged immediate mining, but subsequent finds in the late 1880s renewed interest. Among those investigating the new discoveries was Tully Cornthwaite Wollaston (1863-1931). From his home in Adelaide, Wollaston trekked 700 miles to southwestern Queensland to acquire mining interests and purchase opal from local miners. Wollaston then brought this opal to London where jewelers, suspecting that their brilliant opalescence was not natural, initially refused to carry the stones. But Wollaston finally persuaded the London-based Hasluck Brothers jewelry firm to test-market the gems. The response was overwhelming and Wollaston soon had contracts with such prestigious jewelry firms as Tiffany and Cartier. Returning to Australia in 1902, he promoted opal mining and expanded the international markets for opal. Recognized as the "father of Australian opal," Wollaston died a wealthy man in 1931.

December 2010 Mineraloid of the Month: Boulder Opal

In 1889, a stockman named Jack Murray discovered bits of precious black opal near White Cliffs in New South Wales. Two years later, two local stockmen hired a geologist to assess the area's opal potential. When the geologist reported that opal might be found through underground mining, the hapless stockmen rejected the idea. But Jack Murray returned in 1900 to dig a 15-foot-deep shaft into rich seams of precious black opal. Miners flocked to White Cliffs, which soon had a population of 3,000. In 1905, kangaroo hunters discovered opal at nearby, aptly named Lightning Ridge, where a violent electrical storm a decade earlier had taken the lives of a shepherd, his dog, and 600 sheep. As the White Cliffs mines played out in the 1930s, Lightning Ridge continued to grow until its name had become synonymous with fine black opal. When Lightning Ridge reached the peak of its production in the 1980s, its population topped 8,000.

In 1915, gold prospectors came across South Australia's Coober Pedy Opal Field. The discoverer was 14-year-old Willie Hutchinson who, disobeying orders not to leave camp, had gone off searching for water, of which his group was in short supply. Young Hutchinson returned the next morning to report a source of water, along with a surface deposit of precious white opal. The town grew rapidly and in 1920 was named "Coober Pedy," an Aboriginal phrase that loosely translates as "white men in holes in the ground." In 1945, as the original deposits were depleting, an Aboriginal woman, Toddy Bryant, discovered the nearby Eight-Mile Opal Field that brought new life to Coober Pedy, which reached its peak in the 1970s with 10,000 residents. South Australia also hosted two other major discoveries, the Mintabie Opal Field in 1921 and the Andamooka Opal Field in 1930.

After World War II, Australian opal gained international recognition as the world's finest. As opal mining boomed in the 1950s, more than a dozen remote, outback towns owed their existence primarily to opal mining and trading. Meanwhile, Australian researchers in Sydney were working to determine the true nature of opalescence, which was initially thought to be caused by simple refraction (bending) of light within thin opal layers. In the 1960s, five Australian mineralogists from the Commonwealth Scientific and Industrial Research Organization (the Australian federal research agency) used 20,000-power electron microscopes to reveal that opalescence was really due to layers of tiny silica spherules that acted as diffraction gratings to separate (diffract) light into its spectral components (see "Composition"). On July 28, 1994, in recognition of the economic and cultural importance of opal mining and the role of opal in attracting attention to Australia, an Act of Parliament established opal as the national gemstone.

Today, Australia supplies about 95 percent of the world's precious opal. The overall economic impact of Australian opal mining amounts to more than $200 million per year. Opal mining in the remote, arid Australian outback is a true test of human endurance and determination, as mining, either surface or underground, depends heavily on chance. Thin seams of precious opal can easily be overlooked in the mining process, and core-drilling and geophysical prospecting techniques cannot accurately delineate the extent and richness of opal deposits. According to an outback saying, the three things needed to succeed in opal mining are a strong back, eternal optimism, and a bit of luck. Although many of Australia's greatest opal deposits are now largely depleted, vast areas remain to be prospected. Among the most promising are the Queensland opal fields, the source of our specimens. Australia has provided virtually all the world's great opal specimens, among them:

The ***Flame Queen Opal,*** *a black opal that flashes red and gold in a blue-green background and measures 2.75x2.50x0.5 inches. It was mined in 1914 at Lightning Ridge at a depth of 35 feet.*

The ***Halley's Comet Opal,*** *the world's largest uncut opal. Mined at Lightning Ridge in 1986, it weighs 1,982 carats, is the size of a man's fist, flashes brilliant green and orange, and is valued at $1.5 million.*

Mineral of the Month Club 1770 Orville Avenue Cambria, CA 93428
1-800-941-5594 www.mineralofthemonthclub.org

December 2010 Mineraloid of the Month: Boulder Opal

*The **Andamooka Opal** is cut to a weight of 203 carats and flashes a magnificent array of reds, blues, and greens. Set with diamonds in a platinum necklace, it was presented to Queen Elizabeth II on her first visit to Australia in 1954.*

*The **Olympic Australis** was mined in 1956 from the Eight-Mile Opal Field at Coober Pedy. Weighing 17,000 carats and measuring 11 inches long and 4.5 inches wide and thick, it is valued at $3 million.*

ABOUT OUR SPECIMENS

Our boulder-opal specimens were collected at Woodstock Downs Station, a sheep station not far from the Middleton road stop west of Winton in west-central Queensland, Australia. Winton, population 970, is located in west-central Queensland about 700 miles northwest of the coastal city and state capital of Brisbane. This region is typical of the Australian outback, being extremely arid, thinly vegetated, and very sparsely populated. The average January (summer) high temperature exceeds 100˚ F. (37˚ C.), while the average July high temperature is a pleasant 68˚ F. (20˚ C.). The basically flat topography is broken only by occasional low hills and intermittent river channels. Winton lies within the Great Artesian Basin, a geological remnant of an ancient interior sea. The town's water supply comes from sulfur-tainted artesian waters that bubble to the surface at 181˚ F. (83˚ C.) and are channeled into cooling ponds before use.

Settled by Europeans in the 1860s, Winton became a town in 1879 to serve sheep stations scattered over 10,000 square miles (an area larger than the state of Vermont). The railroad reached Winton in 1899, and telephone service arrived in 1909. By then, boulder opal was already a factor in Winton's economy. Organized mining of the regional opal deposits that had been discovered in 1888 was well underway. Winton had also achieved a measure of fame as the place where "Waltzing Matilda," Australia's unofficial national anthem, was written and first performed in 1895 by Australian attorney and "bush poet" Andrew Barton "Banjo" Patterson (ca. 1864-1941). Additional attention came in 1922 when Winton hosted the first board meeting of a new outback air service—Queensland and Northern Territory Aerial Services (now the major international carrier QANTAS). Today, Winton is the trading center for widely scattered stock stations, opal mines, and oil-and gas-drilling sites. Middleton, 90 miles west of Winton on an unpaved track or bush road, was founded in the 1880s as a hub for regional sheep stations. Today, all that remains are 20 residents, several houses, and the Middleton Hotel, which is famed as Queensland's "most isolated pub." Middleton is surrounded by a dozen sheep stations, including the Chiltern Hills, Franklin, Brighton, and Woodstock Downs stations, the latter the source of our boulder-opal specimens.

Winton and Middleton are located at the northern limit of the Queensland Opal Fields, a huge area that extends from the border of New South Wales north for 600 miles to beyond Winton. These opal fields, which cover 100,000 square miles (the size of the state of Colorado), contain scattered zones of intermittent opalization and are the world's only source of boulder opal. This region was once covered by the Great Inland Sea, a shallow Cretaceous sea (see "Australia's Legacy of Opal") that deposited the Winton Formation sandstone. The Winton Formation overlies an older, impervious layer of iron-rich sandstone called "ironstone." Some 30 million years ago, warm, circulating groundwater dissolved silica from the Winton sandstone, then percolated downward to become trapped atop the impermeable ironstone where it turned to a thick silica gel and eventually solidified into opal.

For reasons not fully understood, Queensland opal formed only within ironstone concretions or "boulders." Concretions are volumes of sedimentary rock in which mineral precipitates displace surrounding sediments or fill the pores between sediment grains. In the Queensland opal fields, these ovoidal, flattened, "pancake" concretions range in diameter from several inches to a few feet. They formed soon after sediment deposition when minerals precipitated around a nucleus, usually a bit of organic matter.

December 2010 Mineraloid of the Month: Boulder Opal

The Winton Formation concretions, which developed from the precipitation of silica and iron oxides, are harder, more durable, and darker in color than the host sandstone. They have a characteristic structure of concentric layers and are concentrated in the lower Winton Formation sandstone near the stratigraphic contact with underlying ironstone. After these concretions developed, silica gels permeated cracks and seams between the concentric layers to form precious opal.

Over millions of years, surface erosion exposed some of these opalized ironstone boulders which prospectors discovered in the 1880s (see "Australia's Legacy of Opal"). Surface and underground opal mining near Winton and Middleton began in the early 1900s. Today, opal miners sublease ground from large sheep stations, which are in turn leased from the state of Queensland. The larger Middleton opal mines are mostly open-cut mines which use mechanized equipment to trench the weathered sandstone to depths of 10 or 15 feet. Miners blade away the weathered sandstone as coarse gravel, then set aside the durable boulders to inspect for signs of opalization. Promising boulders are then broken, either manually with hammers or with hydraulic splitters, to expose any seams of gem-quality, precious opal. To follow concentrations of boulders at depth, miners sometimes use shaft-boring machines designed for operation in "soft" rock, mechanically driving narrow, circular shafts as deep as 40 feet. At predetermined depths, they adjust these borers to drive narrow, horizontal drifts following the layers of concentrated boulders. Miners sell their opal to dealers in Winton, which is the opal-trading center for the northern section of the Queensland opal fields.

When examining your boulder-opal specimen, first observe the ironstone host rock. This is a fragment of an iron-rich, sandstone concretion or boulder. Most specimens exhibit prominent, irregular, concentric layers of alternating light and dark sandstone. Opal can be seen filling seams between these concentric layers. In some specimens, the opal may fill radial fractures that are perpendicular to the concentric layers. Notice that these seams are generally thin—the reason that boulder opal is usually cut to retain a section of ironstone as a natural backing material. Most of our pieces contain opal in shades of blue, but you may see other colors as well. Be sure to examine and rotate your specimen under an intense light source or in daylight (preferably with a 10x loupe or other strong magnification) to fully take in the wonderful color of the opal. You may even see some fire!

As mentioned previously, we have been wanting to feature Australian opal for years! You might say that we "rescued" these pieces from the hands of the jewelry cutters, who eagerly grab up all the opal they can. We were happy to connect with an Australian opal digger who spent a season specifically collecting these specimens with us in mind–normally they would go straight to the jewelry market. We were able to obtain a smattering of specimens with the brilliant opalescence or "fire" that so attracts opal lovers worldwide. These were made available to our Platinum-level members and to anyone who wished to consider upgrading this month. No doubt, we will have a few left over, so feel free to contact us if you would like to obtain one of these unique pieces for your collection. Your specimen of boulder opal is a natural form of one of the world's oldest gemstones and a unique souvenir of the vast Australian outback. As you consider your piece, think of the processes that brought about its formation, its rich history, and the tremendous effort involved in collecting it--but most of all, enjoy its amazing color!

References: *Dana's New Mineralogy*, Eighth Edition; *Encyclopedia of Minerals,* Second Edition, Roberts, et al, Van Nostrand Reinhold Company; *2008 Fleischer's Glossary of Mineral Species*, J. A. Mandarino; *Mineralogy*, John Sinkankas, Van Nostrand Reinhold Company; *Manual of Mineralogy*, 21st Edition, Cornelia Klein and Cornelius S. Hurlbut, Jr., John Wiley & Sons; *Color Encyclopedia of Gemstones*, Joel E. Arem, Van Nostrand Reinhold Company; *Gemstones of the World*, Walter Schumann, Sterling Publishing Company; *Gems and Jewelry*, Joel E. Arem, Geoscience Press; *The World of Opals*, Allan W. Eckert, John Wiley & Sons, 1997; *The Curious Lore of Precious Stones*, George Frederick Kunz, Newcastle Publishing Company (reprint); "Opal," Bob Jones, *Rock & Gem*, March-April 1971; "The Microstructure of Precious Opal," J. V. Sanders and P. J. Darraugh, *The Mineralogical Record*, November-December 1971; "Precious Opal," Bob Jones, *Rock & Gem*, October 2004.