October 2010 Mineraloid of the Month: Obsidian, variety "Apache Tears"

This month we are featuring the mineraloid obsidian from a classic source in Arizona. Our write-up explains obsidian's unusual volcanic origin, why it is not classified as a mineral, why its flaked edges are sharper than even those of surgical scalpels, the legend behind the name "Apache tears," and much more. We invite you to enjoy this fascinating information!

OVERVIEW

PHYSICAL PROPERTIES

Chemistry: Obsidian, which is not classified as a mineral, is a natural volcanic glass consisting of an indeterminate, noncrystalline mixture of silica with lesser amounts of feldspar minerals and ferromagnesian minerals.
Class: Mineraloids
Crystal System and Habits: None (amorphous)
Color: Usually black, greenish-black, or smoky; also gray, reddish-brown, mahogany, and dark green; occasionally yellow, golden, or iridescent. Mixed colors can produce a mottled or banded appearance.
Luster: Vitreous on fresh surfaces
Transparency: Translucent; sometimes subtransparent along thin edges; thick pieces or nodules (Apache tears) can appear opaque.
Streak: White
Refractive Index: 1.48-1.51
Cleavage: None
Fracture: Conchoidal
Hardness: 6.0-7.0
Specific Gravity: 2.3-2.6
Luminescence: None
Distinctive Features and Tests: Best field marks are occurrence in volcanic environments, especially rhyolitic lava flows or perlite (altered obsidian) formations; vitreous luster; and color banding. Sometimes confused with smoky quartz [silicon dioxide, SiO_2].
Dana Classification Number: None

NAME The name obsidian, pronounced Obb-SIH-dee-un, derives from the Latin *obsianus lapis*, literally "stone of Obsius," after a Roman explorer who discovered an obsidian deposit in Ethiopia. Obsidian is also known as "lava glass," "black lava glass," "volcanic glass," "mahogany glass," "Bergmahogany," and "xaga." The term "Apache tears" refers to rounded obsidian nodules. "Rainbow obsidian" is iridescent; "snowflake obsidian" contains included crystals of quartz or cristabolite (a tetragonal polymorph of quartz).

COMPOSITION: Because obsidian has neither a definite chemical composition nor a crystalline structure, it is classified not as a mineral, but as a mineraloid—a natural, noncrystalline, mineral-like material of indefinite composition. Obsidian is an extrusive (volcanic) igneous rock that formed from the solidification of rhyolitic (silica-rich) lava. It is a natural volcanic glass that consists primarily of silica with lesser amounts of feldspar and ferromagnesian minerals. The average composition of obsidian, expressed in oxide content, is 75 percent silica [quartz, silicon dioxide, SiO_2]; 14 percent alumina [aluminum oxide, Al_2O_3]; about 2.5 percent each of calcium oxide (CaO), sodium oxide (NaO), iron oxide (FeO), and magnesium oxide (MgO); and a small amount of water as vapor trapped within tiny bubbles. Obsidian forms when viscous, silica-rich, rhyolitic magma is extruded and solidifies immediately with no time for crystallization. Obsidian usually forms at the margins of rhyolitic lava flows or in lacustrine or marine environments where contact with water causes very rapid cooling. Obsidian's typical black, greenish-black, and smoky colors are due to the essential components iron and magnesium. An excess of iron produces reddish-brown to mahogany colors. Occasionally, the near-absence of iron and magnesium will create colorless obsidian. Light reflecting from inclusions can produce yellow or golden colors, as well as surface iridescence. In a slow weathering process, obsidian absorbs atmospheric water to become hydrated and alter into a glassy, gray, crumbly rock called perlite. Apache tears are unaltered remnants of perlite masses.

COLLECTING LOCALITIES: Obsidian is collected from rhyolitic lava flows in Pinal, Graham, Yuma, Greenlee, and Coconino counties in Arizona; and in Imperial, Inyo, Mono, and Napa counties in California. Other localities are in Colorado, Hawaii, Nevada, New Mexico, Oregon, Utah, and Wyoming. Notable foreign localities are found in Ethiopia, Peru, Greece, Hungary, Iceland, Italy, Japan, and Mexico.

HISTORY, LORE, & USES: Because of its conchoidal fracture and noncrystalline structure, obsidian can be flaked into extraordinarily sharp points and edges and has been used in tools and weapons since earliest times. Researchers have recently learned that properly flaked obsidian edges are much sharper than surgical scalpels! Obsidian has also long served as a gemstone, achieving its greatest popularity during the Victorian era. Today, polished obsidian cabochons are set into rings, cuff links, earrings, brooches, and pendants. Apache tears (obsidian nodules) are tumble-polished and wrapped in silver wire for wear as pendants, or drilled as beads for stringing in bracelets and necklaces. Metaphysical practitioners believe that black or dark obsidian is a protective, grounding, and healing stone; rainbow obsidian enhances pleasure and enjoyment; and snowflake obsidian is a stone of serenity that provides balance in times of change and helps to deal with issues of love and anger. Apache tears are said to provide clear vision and the ability to deal with grief.

ABOUT OUR SPECIMENS: Our obsidian specimens were collected at Picketpost Mountain near Superior in Pinal County, Arizona. This area is 60 miles east of Phoenix and within the Superior Volcanic Field. This lava field, which covers 3,100 square miles of east-central Arizona, was extruded from five different eruptive centers between 18 and 21 million years ago. Some 20 million years ago, an eruption of particularly viscous, silica-rich rhyolite solidified into large obsidian flows. Over time, hydration and weathering altered much of this obsidian into perlite. Remnants of the original obsidian survived within the perlite masses as rounded nodules called Apache tears. In 1870, United States Army troops cornered a band of Apaches atop a volcanic ridge near present-day Superior. In the following battle, 75 Apaches were killed, many by riding their horses over cliffs rather than dying at the hands of the soldiers. Legend says that the families of the deceased warriors shed tears of sorrow that turned to stone upon touching the ground—the reason that obsidian nodules are known as "Apache tears" today.

10 YEARS AGO IN OUR CLUB: Hemimorphite, Potosi Mine, Santa Eulalia District, Chihuahua, Mexico. Our specimens, consisting mainly of bladed white crystals on an earthy brown matrix, were found at level 16 of the Potosi mine, 1600 meters (almost 1 mile) below the surface. A few clear hemimorphite crystals of exceptional beauty also came out at that time, along with outstanding specimens of water-clear calcite, gray crusts of willemite, and shiny black balls and freestanding dendrites of black chalcophanite! At that time, a flood of amazing mineral specimens was flowing from this remarkable district in Mexico, a flow that has now become barely a trickle. We had featured red calcite from the Santa Eulalia District in November 1996, when we had only a couple dozen members, and would feature its exceptional green smithsonite in April 2001–imagine what those latter specimens are worth now! Wish we still had some!

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COMPREHENSIVE WRITE-UP

COMPOSITION

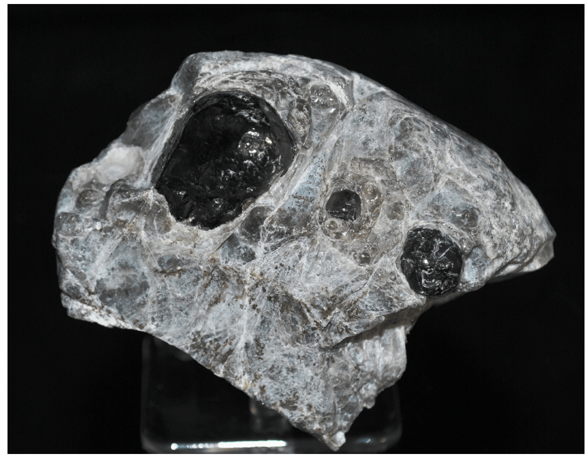

Figure 1. Apache Tears on perlite matrix.

By definition, a mineral is a naturally occurring, homogenous solid, usually of inorganic origin, with a definite chemical composition and an ordered crystalline structure. Because obsidian lacks these final two properties, it is not classified as a mineral, but as a mineraloid—a natural, noncrystalline, mineral-like material of indefinite composition. Examples of other mineraloids are Opal, a hydrated form of silica, which we featured in June 2005, from Opal Butte, Morrow County, Oregon; Jet, a compact form of coal, of which we have sold thousands of beads strands, spheres, and tumbled stones; and Tektites, pieces of natural glass of meteoric-impact origin–we featured Tektites from China in November 1999, and glassy-green Moldavite from the Czech Republic in December 2001. This is the first time we have featured obsidian.

Obsidian is an extrusive (volcanic) igneous rock that formed from the solidification of rhyolitic (silica-rich) lava. It is a natural volcanic glass that consists primarily of silica with lesser amounts of feldspar and ferromagnesian minerals. The average composition of obsidian, expressed in oxide content, is 75 percent silica [quartz, silicon dioxide, SiO_2]; 14 percent alumina [aluminum oxide, Al_2O_3]; about 2.5 percent each of calcium oxide (CaO); sodium oxide (NaO); iron oxide (FeO); and magnesium oxide (MgO); and a small amount of water as vapor trapped within tiny bubbles.

Depending upon how quickly it cools and solidifies, rhyolitic magma can form any one of three different rock types having identical chemistries but radically different physical properties and appearances. When intruded into existing rocks where it cools very slowly, rhyolitic magma crystallizes on a mineral-by-mineral basis to form coarse-grained, crystalline granite. But when extruded as lava in a volcanic environment where it cools rapidly, crystal development is restricted and the lava solidifies into rhyolite, a very fine-grained, crystalline, extrusive (volcanic) rock. Finally, when rhyolitic magma is extruded in conditions that result in almost immediate cooling and solidification with no time for crystal development, the product is obsidian. Obsidian usually forms at the margins of rhyolitic lava flows or where lava extrudes into lacustrine or marine environments in which contact with water causes extremely rapid cooling.

While quartz (specific gravity 2.65) consists *entirely* of silica, obsidian (specific gravity 2.3-2.6) consists *primarily* of silica. Even though obsidian contains significant quantities of such relatively heavy elements as iron, magnesium, calcium, and aluminum, it is less dense than quartz. This is because quartz has an orderly crystalline structure with close atomic packing that maximizes density. Obsidian's random molecular arrangement has much looser atomic packing, which is inherently less dense. With its rigid crystalline structure and strong, covalent bonding, quartz (Mohs 7) is also harder than obsidian (Mohs 6-7). Nevertheless, obsidian is hard enough to scratch window glass. Both quartz and obsidian have no cleavage planes and exhibit a pronounced conchoidal fracture.

Obsidian's typical black, greenish-black, and smoky colors are due to its essential components iron and magnesium. An excess of iron produces reddish-brown to mahogany colors. Occasionally, unusually low amounts of iron and magnesium will create nearly colorless obsidian. Although homogenous, obsidian often contains inclusions of spherulites and lithophysae, groups of which can reflect light in a manner that produces yellow or golden colors, as well as surface iridescence. Spherulites are spherical, crystalline bodies of radiating crystal fibers. In obsidian, spherulites usually consist of feldspar fibers with interstitial crystalline quartz and cristabolite (a tetragonal polymorph of quartz), all of which crystallized immediately prior to, or during, the very rapid solidification of the obsidian matrix. Closely spaced spherulites create streaks or layers of color in obsidian that represent the flow-banding of the original lava. Reflection of light from spherulites creates the distinctive sheen in rainbow obsidian. Lithophysae are larger structures filled by concentric shells of such crystalline minerals as quartz, topaz [basic aluminum fluorosilicate, $Al_2SiO_4(F,OH)_2$], certain feldspar minerals (a group of complex aluminosilicates), and tourmaline minerals (a group of complex aluminum borosilicates). Lithophysal cavities form from gases escaping from the original lava flow, with the gases themselves supplying the constituents of the minerals that fill them. Lithophysae create the distinctive, white-in-black, "blotch" pattern of snowflake obsidian.

Apart from the minerals found within spherulites and lithophysae, obsidian is a poor environment for mineral development. Among the few other minerals that occur as crystalline inclusions within obsidian are fayalite [Fe_2SiO_4], tourmaline, topaz, and the garnet-group member spessartine [$Mn_3Al_2(SiO_4)_3$].

Newly formed obsidian contains about 0.2 percent water. Immediately after solidification, atmospheric water begins to slowly diffuse into obsidian through a maze of microscopic cracks that formed during the cooling process. This hydration process eventually alters obsidian into perlite, a rock with a similar chemistry but a higher water content of about 3.5 percent. Perlite is gray with a crumbly, glassy structure of tiny, shell-like, concentric flakes that eventually weather into the small, pearl-like spheres for which it is named. Geologists believe that all obsidian more than about 20 million years old has altered into perlite. Perlite is an important industrial mineral commodity. When heated to 1,600˚ F. (871˚ C.), its contained water changes to steam and expands each "pearl" into a bubble about 20 times its original volume. Expanded perlite is a very light, air-filled material used in insulation, roofing tiles, soil additives, and lightweight concrete.

The obsidian nodules known as "Apache tears" are remnants of the hydration process that alters obsidian into perlite. This hydration process begins on the surface of obsidian and progresses slowly into its interior until all that remains is a small core of obsidian embedded within a mass of perlite. As this hydration process continues, the remnant obsidian core deteriorates into small, rounded obsidian nodules. Apache tears are found within perlite masses or, after weathering free of the perlite, loose in gravels.

COLLECTING LOCALITIES

Our Apache tear obsidian specimens were collected at Picketpost Mountain near Superior in Pinal County, Arizona. Other Arizona sources are the nearby Obsidian Group claims in the Pioneer district, also in Pinal County; several sites in the greater San Francisco Volcanic Field near Flagstaff in Coconino County; the Tank Mountains obsidian occurrence in the Tank Mountains, Yuma County; the Triangle claims in the Black Mountains, Graham County; and the San Francisco River near Clifton in the Shannon Mountains, Greenlee County.

California's sources include Obsidian Butte near Niland, Imperial County; the Sugarloaf Mountain lava flow at Coso Hot Springs, Inyo County; Panum Crater near Mono Lake, Mono County; and the Glass Mountain deposit at Angwin, Napa County. Other sources in western volcanic areas are Ruby Mountain at Nathrop, Chaffee County, Colorado; Puu Waawaa Dome at Hualalai Volcano on Hawaii Island, Hawaii; the Black

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Devil Mine in the Wild Horse District, Lander County, Nevada; Valle Grande in the Jemez Mountains, Sandoval County, New Mexico; Obsidian Buttes in Lake County, Oregon; the Snowflake Queen and Black Butte mines in the Black Rock Desert, Millard County, Utah; and Obsidian Cliff in Yellowstone National Park, Park County, Wyoming.

Notable foreign sources are the Chabbi Volcano at Awassa, Sidamo-Borana Province, Ethiopia; the Miraflores volcanic formation in Potosí Department, Peru; Nisyros Island in the Dodekánisos Islands, Dodekánisos Prefecture, South Aegean Department, Greece; the Tolcsva volcanic area in the Zempléni Mountains, Hungary; the Hrafntinnuhruggur volcanic area at Myvatn, Iceland; Lipapri Island in the Aeolian Islands, Messina Province, Italy; Iwo Jima in the Volcano Islands, Tokyo Prefecture, Japan; and the Querétaro volcanic area in Hidalgo, Mexico.

JEWELRY & DECORATIVE USES

Obsidian has served as a gemstone since antiquity, reaching its height of popularity in jewelry during the Victorian era. Today, polished obsidian cabochons are set into rings, cuff links, earrings, brooches, and pendants. Large cabochons of snowflake and rainbow obsidian are especially popular as pendants. Apache tears (obsidian nodules) are tumble-polished and wrapped in silver wire for wear as pendants, or drilled for stringing into bracelets and necklaces. Obsidian is also fashioned into figurines and other decorative objects, notably flaked knife blades for display purposes.

In recent years, glass imitations of obsidian have appeared in gem and specimen markets. Most of these fragments and tumbled nodules of dark, artificial glass with obsidian-like coloration and banding are made in Indonesia and China and passed off as natural obsidian to unsuspecting buyers. Sad to say, the advice "Buyer Beware" applies even to abundant, inexpensive stones!

HISTORY & LORE

Obsidian has acquired a rich history, thanks to its vitreous, mirror-like luster and its ability to flake into extraordinarily sharp points and edges (see "Technological Uses"). Obsidian has been used since earliest times in tools and weapons–flaked obsidian tools from African cultural sites being among the oldest, while a saw with a blade of obsidian was discovered at Ur of the Chaldeans, in Mesopotamia. An unexpected early use of flaked obsidian was as scalpels for trephination, the surgical removal of pieces of the human skull to relieve brain pressure or, from a superstitious shamanistic perspective, to allow the escape or entrance of spirits. Trephination was most often performed on adult males whose skulls had been fractured by heavy blows, probably received in battle. Only obsidian blades were sharp enough to cut bone so precisely that skull sections could be replaced. Trephination surgery seems to have had surprising recovery rates, with two-thirds of all recovered trepanned skulls exhibiting varying degrees of healing.

Obsidian was especially prized by pre-Columbian cultures in the Americas, most notably the Aztecs of what is now southern Mexico. The Aztecs knew obsidian as *teoteti* ("divine stone") and considered it sacred, using it for mosaic inlays, weapons, ceremonial blades for human sacrifice, and mirrors. The Aztec creation myth involved the use of an obsidian knife, and they believed that one of their demon gods lived within obsidian and revealed his image in reflections from smooth, mirror-like obsidian surfaces. Only obsidian knives were sharp enough to cut out human hearts for their barbaric sacrifices! And flaked obsidian blades are so sharp that the Aztecs may not have felt a high degree of pain when performing their ritualistic self-mutilation. The Aztec *macuahuitl*, a sturdy wooden staff inset with large blades of flaked obsidian, was arguably the most deadly of all ancient weapons.

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English mathematician and alchemist Dr. John Dee (1527-ca. 1608) introduced the Aztec obsidian mirror to Queen Elizabeth I (1533-1603) as means of "seeing the future." The "John Dee mirror" is among the most famous of Elizabethan artifacts and is now displayed at the British museum in London.

In the American West, obsidian, along with turquoise [$CuAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$], abalone shell, and white shell, is one of the four sacred "stones" of the Navajos. Obsidian, often translated as "black jet," is part of the Navajo creation legends in which First Man had feet and ankles of earth, legs of lightning, and a heart of obsidian. A more recent southwestern legend tells how obsidian nodules became known as "Apache Tears" (see "About Our Specimens.")

Obsidian is named for Obsius, a Roman legionnaire and explorer who discovered an obsidian deposit in Ethiopia. In documenting Obsius' discovery, the Roman scholar Pliny the Elder (Gaius Plinius Secundus, A.D. 23-79) referred to the stone as *obsianus lapis*, literally "stone of Obsius." (No doubt this is one of the oldest known stones named in honor of its discoverer!) Over the centuries, this phrase was erroneously transcribed as "*obsidianus lapis*"—the basis of the modern word "obsidian," which entered the English language in the 1790s. At that time, obsidian was still being confused with quartz. Finally in 1920, X-ray diffraction analysis showed that obsidian lacked a crystalline structure and thus could not be classified as a mineral.

A cabochon of black obsidian appeared on the Indonesian 2000-rupiah postage stamp of 2000. Modern metaphysical practitioners believe that each obsidian variety has unique qualities. Black or dark obsidian is considered a protective, grounding, and healing stone. Rainbow obsidian is believed to enhance pleasure and enjoyment, while snowflake obsidian is a stone of serenity and purity that provides balance in times of change and helps to deal with issues of love and anger. Apache tears are said to provide clear vision and the ability to deal with grief.

TECHNOLOGICAL USES

Obsidian has been flaked into tools and weapons since early Paleolithic time. Because of its noncrystalline structure and pronounced conchoidal fracture, properly flaked obsidian produces the sharpest cutting edges of any natural material. The degree of sharpness of properly flaked obsidian was not appreciated until 1974 when the ancient technique of obsidian flaking was rediscovered (see "Master Flint-knappers": Ishi and Dr. Don Crabtree). At the time, stainless-steel surgical scalpels were thought to have the sharpest known cutting edges. But under the 10,000-x magnification of an electron microscope, the cutting edges of surgical scalpels actually appeared square. The same magnification revealed that flaked-obsidian cutting edges were much sharper. Researchers explained that the stainless-steel scalpel edges, because of their crystalline structure, retained a three-dimensional, blocky shape that limited their degree of sharpness. But obsidian, which lacks a crystalline structure, can be flaked into edges of nearly molecular thinness. For this same reason, properly-flaked obsidian edges are also much sharper than similar edges of flaked, microcrystalline quartz. Clinical tests have shown that incisions made with obsidian scalpels, compared to those made with stainless-steel scalpels, produce less scar and granulation tissue, heal faster, and inflame fewer cells. One professor of archaeology said "the sharper the blade, the less damage to tissue. These cut so sharp they even cut between blood vessels, making a cleaner, less easily infected and faster-healing incision with less scar tissue." Obsidian scalpels are now finding growing use in specialized procedures, mainly in eye surgery and neurosurgery.

Obsidian's unique weathering properties are the basis for a geochemical technique that can establish the age of obsidian artifacts. Known as obsidian-hydration dating, this technique presupposes that a fresh surface is created when an obsidian tool is flaked. As obsidian slowly hydrates and begins to alter into perlite (see "Composition"), it forms a thin, water-rich, hydration "rind." Rind thickness can be optically measured because the precise boundary between the hydrated and unhydrated obsidian is marked by an abrupt change in refractive index. Because hydration-rind thickness is a function of time, it is possible to determine when an obsidian surface was exposed, whether by the natural cracking or glacial abrasion of an obsidian flow, or by the manual flaking of an obsidian artifact.

Variations in trace-metal content of obsidian also enable geochemists to determine the original source of obsidian artifacts. These unique chemical "fingerprints" can be accurately quantified by X-ray-fluorescence analysis. Using this technique, geochemists and archaeologists have determined that much of the obsidian in artifacts used by Native American cultures in southern Arizona actually originated in lava flows nearly 1,000 miles to the south in Jalisco, Mexico. Artifacts fashioned from obsidian from Yellowstone National Park's famed Obsidian Cliff have been found in cultural sites 400 miles distant. This ability to chemically "source" obsidian is helping anthropologists to reconstruct the production, distribution, and trade systems of ancient cultures.

MASTER FLINT-KNAPPERS: ISHI AND DR. DON CRABTREE

Obsidian is often considered the ultimate material for flint-knapping, the ancient art (some say science) of shaping obsidian and microcrystalline quartz into utilitarian objects by systematically breaking off or "knapping" conchoidal flakes. In recent times, the art of flaking obsidian has been dominated by two individuals with very diverse backgrounds. Ishi, a California Yahi Indian and the last of his culture, carried on the ancient tradition of flaking obsidian to create utilitarian blades and points in order to survive. Don Crabtree, an amateur archaeologist and master flint-knapper, rediscovered the ancient art of flaking obsidian, achieving degrees of proficiency that astounded modern scientists.

In the years immediately following the California Gold Rush, only 400 Yahi Indians were known to exist. By the early 20th century, only a few members of the tribe still existed. Among them was Ishi (ca. 1862-1916), who wandered the rugged, still-unsettled foothills north of the Sacramento Valley. He survived by hunting and gathering in true early-man fashion. But in 1911, after the Oro Power & Light Company sent surveyors into this area to map a route for an electrical-transmission line, Ishi was forced to flee the cave where he lived, leaving the surveyors to collect his bows, arrows, stone points, and stone knives as "souvenirs." Later that year, Ishi, emaciated and starving, wandered into a stockyard corral near Oroville. Ishi's appearance created such excitement among the local citizens that the Oroville sheriff kept him in jail for five days for his own protection.

News of the "last wild Indian" appeared in the San Francisco Examiner, drawing the attention of anthropology professors from the University of California at Berkeley. These professors traveled to Oroville, befriended Ishi, took him back to the university, and learned that he spoke a language that was thought to be extinct. The professors taught him rudimentary English, while Ishi imparted to them the basics of the Yahi language. Ishi then worked at the university as both as janitor and a teacher of his culture. In Ishi's first six months at the university, an estimated 24,000 people came to see his demonstrations of flint-knapping and fire-making. Intrigued by Ishi's extraordinary skill in flaking obsidian, the professors recorded his techniques in great detail and built a collection of his elaborately notched, razor-sharp, obsidian hunting points. When Ishi died of advanced pulmonary tuberculosis in March 1916, his friends at the university placed in his coffin as a tribute one of his own bows, his shell bead money, a purse of tobacco, and pieces of flaked obsidian.

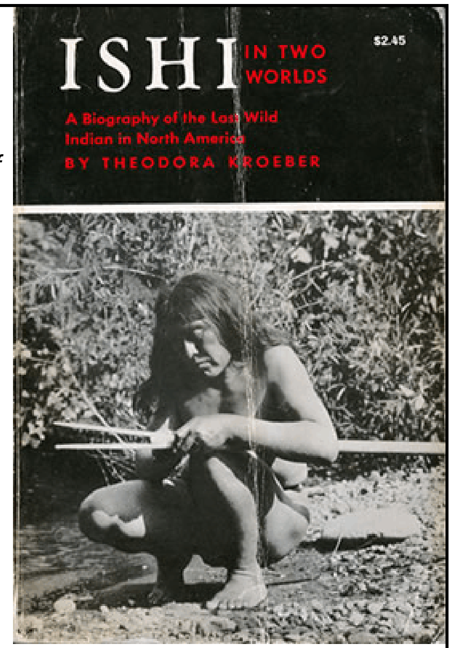

Figure 2. Theodora Kroeber's biography of Ishi sold more than one million copies after its release in 1961.

The written details of Ishi's obsidian-flaking techniques were forgotten until Don E. Crabtree (1912-1980) arrived at the University of California at Berkeley in the 1930s. A native of Heyburn, Idaho, Crabtree was deeply interested in paleontology, archaeology, and flint-knapping. Although he had intended to become a paleontologist, he dropped out of college to begin a program of self-education. After working in several paleontological laboratories in the 1930s, Crabtree became a preparator at the vertebrate-paleontology laboratory of the University of California at Berkeley. During this time, he often demonstrated his flint-knapping skills for faculty, students, and visiting scholars. He also became intrigued with the university's detailed, written accounts of Ishi's obsidian-flaking techniques.

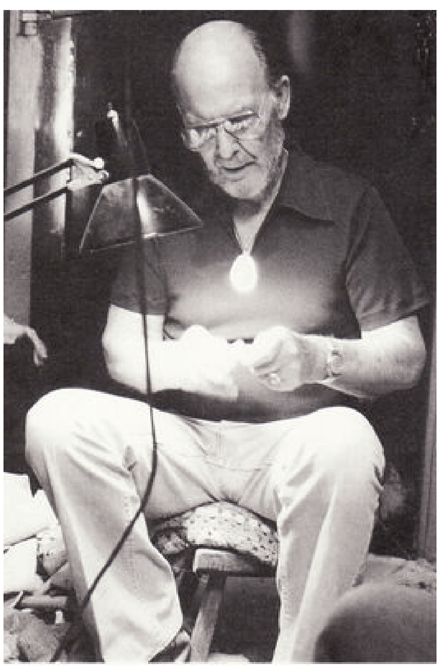

Figure 3. Don Crabtree.

Moving back to Idaho after World War II, Crabtree improved his flint-knapping skills and attempted to replicate Ishi's obsidian-flaking techniques. He worked with lithic-technology programs at Ohio State University and Idaho State College (now Idaho State University) and continued to improve his already remarkable flint-knapping skills. After being appointed Research Associate at the Pocotello (Idaho) Museum, the National Science Foundation awarded him a grant to further his lithic-technology studies. In 1969, New York City's American Museum of Natural History featured a special exhibit of Crabtree's finest flint-knapping work. Finally, in the early 1970s, Crabtree succeeded in replicating Ishi's obsidian-flaking techniques by preshaping "cores," thick, cylindrical pieces of obsidian, then knapping them in a manner that produced inch-long "microblades," each being a single, extraordinarily sharp, conchoidal flake. In 1974,

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Crabtree brought his obsidian microblades to the attention of medical researchers. After extensive testing, they confirmed that these obsidian microblades were indeed much sharper than the best stainless-steel surgical scalpels (see "Technological Uses") then in use.

For advancing the understanding of ancient lithic technologies and especially for replicating the obsidian-flaking techniques of Ishi, Crabtree received an honorary doctoral degree in archaeology from Idaho State University. Nor has Ishi been forgotten. As the last of his culture, Ishi has been memorialized with a stone monument in Oroville, California, and two made-for-television movies filmed in 1978 and 1992 that depict his life. The second movie, "The Last of His Tribe," produced by River City Productions and starring Jon Voight, David Ogden Stiers, and Graeham Greene as Ishi is available in DVD format.

ABOUT OUR SPECIMENS

Our obsidian specimens were collected at Picketpost Mountain near Superior, Pinal County, Arizona. Superior is 60 miles east of Phoenix on U.S. Highway 60, where the regional topography is dominated by the low hills and ridges of the western Pinal Mountains. At an elevation of 2,500 feet, this area is an ecological transition zone between the lower Sonoran Desert and the higher scrub woodlands of juniper and piñon. Superior was once an important source of copper. After copper-silver mineralization was discovered nearby in 1874, a mining district survived on small-scale silver mining. But by 1901, when silver prices had collapsed and copper prices were increasing rapidly, miners had turned their attention to copper and founded the town of Superior. Superior's Magma Copper Mine went on to become Arizona's deepest mine with eight shafts and 36 levels, some as deep as 4,800 feet. Copper production ended there in 1995, although exploration is continuing today.

The hills and ridges near Superior are part of the Superior Volcanic Field, an area of Miocene Epoch lava flows that covers 3,100 square miles of east-central Arizona. This lava was extruded from five different eruptive centers between 18 and 21 million years ago. About 20 million years ago, one particular eruption extruded particularly viscous, glassy, silica-rich lavas that solidified into large obsidian flows. Over time, subsequent hydration and weathering altered most of this obsidian into perlite (see "Composition"), leaving large numbers of small, rounded nodules of obsidian—Apache tears—within the perlite masses.

This profusion of nodules was known in earliest times as a source of obsidian to make flaked points and blades. The term "Apache tears" stems from an event in 1870, when the United States Army was attempting to suppress the Apaches in Arizona Territory. Heading this military effort was Lieutenant Colonel George Stoneman, Jr. (1822-1894), a former union cavalry general in the Civil War, who commanded the First Military District of the Department of Arizona. In July 1870, Stoneman established Picket Post, a small outpost just west of present-day Superior. That winter, Stoneman and his troops pursued a large band of raiding Apaches, cornering them atop Big Picacho, a steep volcanic ridge. In the following battle, 75 Apaches were killed, many by riding their horses over cliffs rather than dying at the hands of the soldiers. Shortly afterwards, Lieutenant Colonel Stoneman was relieved of his command for his controversial methods of suppressing the Apaches.

This battle, which is historical fact, has since been overshadowed by a poignant legend that tells how families of the deceased warriors, upon hearing of the tragedy, shed tears that touched the ground and

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turned to stone—hence the name "Apache tears" for the local obsidian nodules. Apache tears are thought by some to be good-luck charms, and that those who carry them will never cry, because Apache families have already shed their tears for them. These legends were furthered ingrained into local lore when the name of the volcanic ridge where the Apaches died, Big Picacho, was later renamed "Apache Leap." Some collectors maintain that specimens from other localities are simply obsidian nodules, and that only those from Superior can rightfully be called "Apache tears."

The widespread popularity of Apache tears had its start with perlite mining, an industry that was born in Superior, Arizona. In 1928, researchers discovered that when heated, perlite expands into a lightweight, air-filled material with many industrial applications (see "Composition"). The first field tests to mine and expand perlite took place at Superior near the base of Apache Leap in 1946. Commercial mining and milling began soon afterwards to supply perlite for the nation's post-World War II building boom. During crushing and screening operations at several Superior perlite mines, quantities of Apache tears were discarded onto the mine dumps. By the 1950s, collectors had gathered large numbers of Apache tears, which began appearing in rock shops. Although the perlite mines at Superior are no longer active, the popularity of Apache tears among collectors—and as Arizona souvenirs—has never diminished. Today, Superior, considered the classic source of the Apache tear variety of obsidian, attracts many field collectors. The World's Smallest Museum, located on U.S. Highway 60 in Superior, displays what it claims to be the world's largest Apache tear, about six inches in diameter.

If you have a matrix specimen, note first the gray matrix of perlite with its structure of glassy, shell-like, concentric flakes. When this specimen solidified from rhyolitic lava some 20 million years ago, it consisted entirely of obsidian. But since then, the process of hydration has altered most of the obsidian to perlite. The Apache tear in your specimen is an unaltered remnant of the original obsidian. Lines of small, reddish-brown crystals that may be visible in the perlite matrix consist of the garnet-group mineral spessartine [manganese aluminum silicate, $Mn_3Al_2(SiO_4)_3$], which is often present in rhyolite as an accessory mineral. These spessartine crystals are clustered in lines that represent the flow pattern of the original lava! The absence of any crystal faces on the Apache tear reflects obsidian's amorphous structure. Although your Apache tear may appear opaque, backlighting from an intense light source will reveal its translucency. We have enough of the Silver-level "Apache Tears" sans matrix that we can supply one to any Gold or Platinum level members who would like to examine one.

We hope you found this month's write-up is unique at this month's stone! Though not classified as a true mineral, obsidian is certainly a fascinating and valuable stone and worthy of inclusion in our collections!

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