New Mexico EARTH MATTERS

summer 2016

Gemstones of New Mexico

Pleasing colors, shapes, durability, and rarity are all characteristics of the minerals that we call gemstones. The quest for these stones has long allured people. Gemstones have been found in many archeological sites, attesting to a long fascination with beautiful objects from the earth. We continue to decorate ourselves with these objects as an expression of status, or simply to enjoy something beautiful. Many gemstones have a long and complicated path from where they are formed, in the earth, to finally becoming a necklace, ring, pin, or other type of adornment.

Gemstones are minerals that have clarity (containing little to no material interfering with the passage of light), color (a desirable hue, saturation, & tone), and a level of hardness that resists abrasion or chipping. When we think of gemstones, we typically think of diamond, emerald, ruby, or sapphire, which are cut (faceted) and placed in rings, pendants, pins, and earrings *(top photo)*. However, another class of gems, called gem materials, includes rocks or minerals that lack the clarity and sparkle of gemstones, but are used for adornment because of pleasing color or pattern. Turquoise, malachite, jasper, and other colored rocks and minerals represent gem materials, which are usually carved or "cabbed", worked into a disk or oblong smooth oval object called a cabochon *(bottom photo)*.

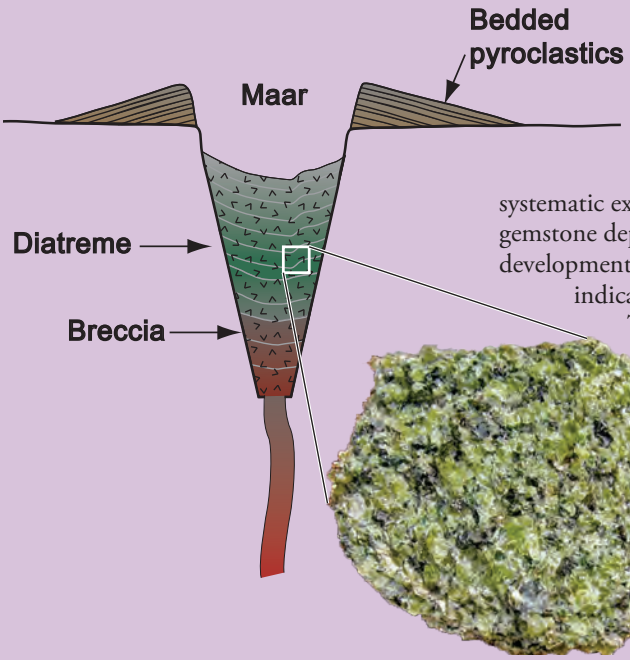
Introduction

New Mexico is blessed with a wide variety of gemstones and has a long history of gemstone use and production. Native people used a number of gem materials (turquoise, shell, and jet) in their ceremonial objects and gemstones, specifically pyrope garnet (red, magnesium-rich garnet) and peridot (pale green gem version of a mineral called olivine), which have been found in the ruins of their dwellings. Native American jewelry style is still based on the use of turquoise and other stones, often set in silver or strung in necklaces. However, the most well-known precious gems, diamond, emerald, ruby, and sapphire are poorly represented in the state. Semiprecious stones like quartz and its varieties (amethyst, citrine, smoky or rose), feldspar (the most common mineral in the earth's crust), peridot, and beryl (a beryllium-rich mineral) are more abundant. Turquoise is, by far, the most iconic New Mexico gemstone/gem material, as well as the classic, Kelly blue smithsonite *(bottom photo)*. A thorough discussion of these minerals is beyond the scope of this article, so we will focus on other gemstones and gem materials from the Land of Enchantment.

Top—Gemstones cut & polished for jewelry, from the Mineral Museum gemstone collection. Back row, left to right: amethyst, citrine, rose quartz, topaz; middle row, left to right: aquamarine, elbaite, chrysoberyl; front row, left to right: heliodor, rubellite, spessartine.
Bottom—Popular gem materials used in carvings, slabs, & cabochons, from the Mineral Museum gemstone & mineral collection. Back row, left to right: smithsonite sphere, calcite onyx slab; middle row, left to right: ricolite cabochon, Apache picture rhyolite slab, red agate cabochon; front row, left to right: turquoise cabochon, malachite/azurite cabochon, lepidolite teardrop cabochon. Photos by Virgil Lueth.

Historical Accounts of Gems in New Mexico

When the Spanish conquistadors explored New Mexico, they were seeking gold, silver, and gemstones. A number of their reports mention the presence of gemstones, usually highlighting their abundance (showing that exaggeration is not something invented by modern advertisers!). One of the first accounts was by Cabeza de Vaca,



Schematic diagram of a funnel-shaped diatreme at depth and a broad shallow crater, or maar, at the surface. Shiprock represents an exposed portion of a diatreme, while Kilbourne Hole is an excellent example of a maar. Photo shows xenocrysts of light green olivine (peridot) and dark green chrome diopside that were carried from the mantle to the surface during an explosive eruption. Specimen is 8 cm across. Photo by Shari Kelley.

describing emeralds shaped like arrow points. Quartz crystals known as "Pecos Valley diamonds" were first described by Don Antonio de Espejo in 1583. Carrera reported the presence of "lapis lazuli" in the Organ Mountains that turned out to be another blue mineral, lazulite. Reports of emeralds, rubies, and diamonds, all misidentified, persisted through the Mexican period and into statehood.

The first gem minerals advertised from New Mexico, in early mineralogical magazines, were peridot and pyrope. An article published in *The Mineral Collector* in 1895 titled, "American Jewel Mines" touts New Mexico gem occurrences: "…The fine aquamarine beryl has also come quite extensively from Stoneham, Maine. This gem, or rather mineral, abounds in New Mexico and Arizona where it was mined by the early Aztecs, and later by the Spaniards and Pueblo Indians. The demand for it is good and the supply never keeps pace with the sales. The finest garnets in the world come from these latter Territories. Peridots are mined there, or rather taken from ant hills and scorpion nests by the Indians and soldiers." Once again it appears exaggeration transcends reality concerning New Mexico gemstones.

Large-scale production of gemstones and gem material has been attempted in New Mexico, particularly for turquoise. There has been a general lack of systematic exploration for other types of gemstone deposits because the costs of development usually are greater than any indicated profit from production. The small size of the deposits, capricious distribution and quality of stones, and market demands conspire to make New Mexican gem mining only a small scale affair. Most deposits in our state are found and developed by mineral collectors or weekend gem hunters.

Gemstone Deposits of New Mexico

Gemstones form in a wide variety of environments, from the earth's partially molten mantle, to the earth's surface, through alteration of volcanic rocks. The unique environments that allow gemstones to form in the earth's crust and mantle result in their rarity. A multitude of physical processes and conditions (e.g. temperature & pressure regime, presence or absence of fluids, trace elements, etc.) must combine in particular ways in order to produce a beautiful gemstone. Gemstones can be grouped, or classified, based on their environment of formation. Several such environments, which will be defined and discussed below, include—volcanic-related, pegmatitic, hydrothermal, metamorphic, and sedimentary. In the following sections, locations of gemstones marked with an asterick can be found on the map.

Volcanic-Related

Most volcanic-related gemstones originate deep in the earth's mantle. These crystals, called xenocrysts (foreign crystals), form at great depth 150–650 kilometers (93–403 miles), and are carried to the surface rapidly during very explosive volcanic eruptions that form features called diatremes and maars. Diatremes are funnel-shaped volcanic throats, or conduits, filled with fragmented (brecciated) volcanic rocks, as well as xenocrysts derived from the mantle and/or rocks from the crust through which the magma erupted *(diagram above)*. Maars are shallow craters found above diatreme vents. Erosion following the eruption can expose the diatreme as a high-standing landform, a well-known example in New Mexico being Shiprock. Peridot, red pyrope garnet, and bright green chrome diopside are the most common examples of diatreme-related gems in New Mexico. The Navajo Volcanic Field on the Navajo Nation* has numerous occurrences of these gems. Peridot, pyrope, and chrome diopside weather from the host rock, called peridotite, and accumulate on the surface or are concentrated on ant hills by the industrious insects. The gems can be easily collected, and are packaged and sold in local trading posts. At these gift shops, the gems are often given fanciful names like, "emerald, beryl, green garnet or Job's tears" for peridot, and "Arizona, Rocky Mountain, or New Mexico rubies" for pyrope.

Another famous peridot locality is Kilbourne Hole, a maar crater in the Potrillo Volcanic Field of Doña Ana County*. At Kilbourne Hole, fragments of volcanic rocks, called bombs, that were ejected from the vent during a very energetic and explosive eruption, can include peridot xenocrysts *(diagram upper left)*. These bombs are scattered about the crater and have been collected for over 100 years.

A rather unique occurrence of volcanic-related gemstones can be found at Pueblo Park in Catron County*. Hosted in a basalt lava flow are large, clear, yellow crystals of calcium-rich plagioclase feldspar that grew in the magma chamber from which the basalt was erupted. These stones, formally known as labradorite, have been collected and faceted by gem hunters only fairly recently (probably only since the 1960s), and were hence not mentioned in the first two editions of *Minerals of New Mexico*. These gems are a pleasing honey-yellow color, and a few rare stones display a copper color similar to sunstones found in Oregon.

Diamonds may be found in diatremes, having been transported to the surface in a similar way to the gemstones described above. Diamonds are typically associated with a rock type called kimberlite (a potassic igneous rock), thought to erupt from great depths extremely rapidly, possibly because the magma contained high concentrations of CO_2, driving the explosive eruption. Some magma compositions found in the Navajo Volcanic Field rocks are similar to kimberlites, but no substantiated occurrence of diamond has ever been documented in New Mexico.

However, one of the first great gem hoaxes of the west had a New Mexico connection, the Ralston diamond hoax (for more information, please see the links provided at the end of this article).

Pegmatites

These rocks are very coarse-grained and form during the last stages of magmatic crystallization or from high-grade metamorphism. As magma crystallizes, some less abundant (trace) elements (boron, beryllium, fluorine, phosphate, zirconium) are excluded from the crystal structures of common minerals. As crystallization continues, they concentrate in the residual (left over) magma. When concentrations become great enough, unusual minerals characteristic of pegmatites begin to form and can grow quite large from 2.5 centimeters to over 10 meters (about one inch to over 32 feet)! These include tourmaline, beryl, topaz, apatite, and zircon. New Mexico has abundant pegmatites, many of which have produced small amounts of gemstones and gem material. Quartz crystals can also grow to large sizes in these settings and impurities within the crystal give rise to the different varieties of smoky, amethyst and clear rock crystal quartz. New Mexico pegmatites are typically Proterozoic (around 1 billion years old) or Tertiary (around 30 million years old), and their distinct mineralogies described below have produced different suites of gemstones.

Northern New Mexico Proterozoic pegmatites have been mined and studied the most, but pegmatites occur in igneous and metamorphic rocks throughout the state. Beryl is the main gemstone produced and runs the gamut of varieties; pink (morganite), clear (goshenite), blue (aquamarine), and green (emerald). Gem-quality beryl from this state is actually quite rare. Most beryls are cloudy and pale, probably because they crystallized too deep in the crust and too slowly to generate good clarity. Good gem beryl (mainly morganite) has been produced from the Harding Pegmatite*, as well as some aquamarine from the Petaca and Las Vegas (Elk Mountain) areas. Emerald was found recently in the Picuris Range* although the crystals are cloudy. Gem-quality quartz can also be found, the most famous from the Petaca District*. No gem-quality tourmalines have been found, even though the correct chemical variety (elbaite) has recently been documented from the Rociada area. Like the other gemstone occurrences, apatite, topaz, and zircon are also cloudy and not suitable as gems.

Map of New Mexico gemstone localities. NOTE: Photos by Virgil Lueth.

Other gem material from the northern New Mexico pegmatites is the rose-colored mica lepidolite, which in some deposits forms dense masses and is used in carvings and cabochons *(gem group at bottom on first page)*. Spodumene, another lithium-bearing mineral, is found in some deposits usually as flesh-colored blades. When clear and colored pink or green, this mineral is known by the gem names kunzite and hiddenite, respectively. Some New Mexico spodumene has a pink color, but remains cloudy. No known stones of kunzite exist, but the potential remains for their discovery.

The Tertiary age pegmatites have produced much better gem quality material, although the gems are the more common varieties of quartz, feldspar, and apatite. These magmas crystallized much faster and closer to the surface than the older pegmatites, forming better gemstones. The finest smoky quartz in New Mexico comes from miarolitic (giant gas bubbles in granite) deposits of Sierra Blanca*. Occasionally,

Gemstones of Raab Canyon pegmatites. Blue to silver-white moonstones. Photo by Virgil Lueth.

yellow to purple crystals of apatite in miarolitic cavities from the Organ Mountains* attain a size and clarity that allow them to be faceted into gems.

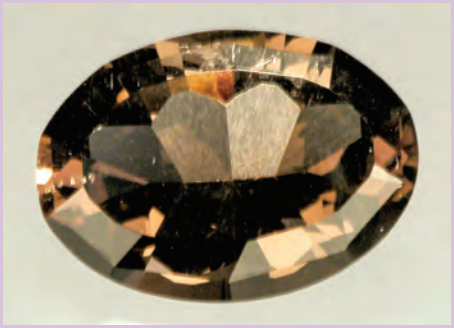
A unique pegmatite body at Rabb Canyon in Grant County produces gem sanidine (a high temperature potassium feldspar) known as moonstone*. Microscopic lamellae (thin layers) of sanidine and albite (sodium feldspar) create a grating effect that generates the "glow" of moonstone when held at certain orientations in the light. The color of moonstone at this locality ranges from blue to silver-white (*above*). The Rabb Canyon pegmatite also produces a fine smoky amethyst that may be found as rough masses and then faceted into purplish-black gemstones (*right*).

Gem quality beryls, albeit small, were uncovered during the mining of molybdenum at the Questa Mine in northern New Mexico. These gemstones occurred in the pegmatite-like ore bodies associated with the Tertiary igneous intrusions at the mine. Microscopic grains of green emerald and blue aquamarine are clear and would be considered gems if they attained a sufficient size. Now that the mine is closed, the potential for finding quality stones has disappeared.

Hydrothermal

Hot water derived from crystallizing magma and/or deeply circulated and heated water, scavenges elements from the rocks it flows through and produces most ore deposits of gold, silver, and base metals. Occasionally, gemstones are created as part of the mineralizing process, mainly comprising the quartz varieties smoky and amethyst. Some of the finest amethyst gems have been produced from veins associated with fluorite in the Ladron Mountains near Socorro*. Similar, but less spectacular, amethyst and smoky quartz has been found from deposits near Bingham. Banded white and purple quartz gem material has been cabbed from deposits near Silver City and in the Black Range.

When hydrothermal waters react with impure limestones, a unique metamorphic rock called skarn can be formed. These rock bodies may contain large masses of garnets, ranging from grossular (aluminium rich) to andradite (iron and calcium rich) in composition. A rare clear garnet, called demantoid, produces a gemstone with a dispersion characteristic (a measure of splitting white light into its spectral colors) greater than diamond. Demantoid-like stones have been produced from the



Smoky amethyst. Photo by Virgil Lueth.

Apache Hills near Hatchita. Occasionally, complex intergrowths of andradite, grossular, and calcite create an iridescent garnet that is highly sought after. Garnet Ridge, near San Pedro*, is famous for producing this type of stone that may be fashioned into cabochons or directly polished, and can yield a "cat's eye" effect.

Hydrothermal fluids moving through volcanic rocks, mainly rhyolite, can produce gemstone deposits of red beryl and topaz. These deposits have been famously developed in Utah but remain to be discovered in New Mexico. Small red beryls and topaz are found in the Black Range of Sierra County associated with tin deposits. So far, the stones have proven too small to be fashioned into gems but the potential exists for more significant deposits. Similarly, the rhyolites at East Grants Ridge in Cibola County, contain beautiful crystals of topaz, aquamarine, and spessartine (manganese-bearing) garnet that are collected for micromineral specimens, but remain too small to fashion into gemstones.

Metamorphic

Under extreme heat and pressure rocks are metamorphosed (meaning "to change form"). Minerals transform in response to these changing conditions and occasionally form gemstones and gem materials. The heating and squeezing of mud-rich sedimentary rocks typically results in the formation of alumino-silicate minerals, specifically andalusite, kyanite, and sillimanite, which all may qualify as gemstones or gem materials. Most metamorphic-derived gemstones of New Mexico are associated with the formation of Proterozoic pegmatites. The most well-known of these is viridine (green andalusite) in the Pilar and Petaca areas. Crystals of kyanite are found in places, but are not clear enough to constitute gem-quality kyanite. Fibrous sillimanite of varying color produces the gem material fibrolite, known to gem cutters for over 100 years, and has come from the Truchas area. Likewise, near-gem-quality andradite, almandine (iron-bearing), and spessartine garnets have been collected from the northern mountains*, but remain disappointingly cloudy despite their beautiful root beer-red to orange-yellow colors.

Perhaps New Mexico's most famous metamorphic gem materials are the staurolites of Hondo Canyon, near Taos*.

Minerals commonly not used as gemstones due to softness, inclusions, and/or structural defects. From left to right: barite, fluorite, and dolomite. Photo by Virgil Lueth.

The most prized specimens are red-brown "fairy crosses," interpenetrating twins that resemble a cross. These are often mounted in necklaces and sold around the Taos area. They are never clear and may be coated with mica, which requires abrasive cleaning to make them presentable. Both staurolite and metamorphic-derived garnets are typically cloudy due to mineral inclusions, which are present because these minerals envelop other mineral grains during their formation.

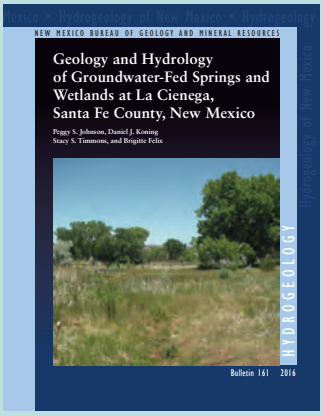
Sedimentary

The low temperature and pressure environments of sedimentary rocks precludes the formation (contintued on page 6)

BUREAU NEWS

Bureau Bulletin 161 Awarded Frye Memorial Award

The recently published New Mexico Bureau of Geology and Mineral Resources Bulletin 161, "Geology and Hydrology of Groundwater-Fed Springs and Wetlands at La Cienega, Santa Fe County, New Mexico" **http://geoinfo.nmt.edu/publications/monographs/bulletins/161/**, has received the Johnathan C. Frye Memorial Award from The Geological Society of America and the American Association of State Geologists. The Frye Award is presented annually for the best publication in the field of environmental geology



published by a state geological survey or by GSA during the past three years. The award will be presented to the authors of the study, Peggy Johnson, Daniel Koning, Stacy Timmons, and Brigitte Felix, all of the New Mexico Bureau of Geology and Mineral Resources, at the GSA annual meeting in September 2016.

Bulletin 161 focuses on the geology and hydrology of the La Cienega wetlands, located near Santa Fe, New Mexico. La Cienega's springs and wetlands are important hydrologic, ecologic and cultural resources, and provide many beneficial water-related functions.

Findings from this investigation emphasize possible solutions that may allow hydrologic resilience and successful preservation of the important wetland resources at La Cienega. These solutions focus on reducing groundwater depletions in the Ancha Formation and supporting a positive wetland water balance. Possible remedies include managing groundwater withdrawals, managing unwanted invasive vegetation, and developing effective aquifer storage projects.

Taos County Honors Peggy Johnson with Community Service Award

Taos county commissioners honored Peggy Johnson with a Community Service Award for her 20 years of water-science work in Taos County. She has worked on about a dozen major hydrogeology studies for the county over the years.

Rockin' Around New Mexico, Las Vegas, New Mexico

Rockin' Around New Mexico, a geology workshop for teachers, was held in Las Vegas on July 6–8, 2016. The 27 teachers who participated gained field geology experience at locations near Las Vegas, where they learned about the uplift process that created Hermit Peak, and Montezuma Hot Springs. Other field trip stops included a recent landslide and a spectacular exposure of the Great Unconformity.

In the classroom, Next Generation Science Standards were introduced. Teachers worked with several seismic models to explore faults and structural stability in buildings. After a presentation on seismic hazards and safety, and an update on the 2011 Christ Church, NZ earthquake recovery efforts, teachers practiced the Drop, Cover, and Hold On! earthquake safety drill. This workshop was sponsored by New Mexico Bureau of Geology, New Mexico Department of Homeland Security Emergency Management, and New Mexico Mining Association.

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GEMSTONES OF NEW MEXICO *(continued)*

of many gemstones. This environment does produce some gem materials, mostly colored silica materials (chert, jasper, and agate), and variably-colored sandstones that may be fashioned into cabochons (bottom gem group page 1). Occasionally, facetors will practice their skills and fashion beautiful, but fragile gemstones from calcite, dolomite, barite and fluorite (see photo of three gems page 4).

Future of Gemstone Exploration in New Mexico

Although New Mexico has many gemstone localities, these have never proven to be a major source of revenue. New finds may still be discovered by collectors and prospectors, but probably never on a scale large enough to support significant mining operations. Most likely, as has been the case in the past, specimens will be sold at mineral shows to collectors of New Mexico material. Nevertheless, small-scale collecting and faceting of gemstones and gemstone materials is a hobby that brings pleasure to many of the state's residents and visitors.

—Kelsey McNamara and Virgil Lueth

Kelsey McNamara is the new curator at the New Mexico Bureau of Geology Mineral Museum. Prior to joining the bureau she worked as a hydrogeological field technician, a geology field camp instructor, and a freelance geologist.

Virgil Lueth is the director of the New Mexico Mineral Museum as well as Senior Mineralogist/Economic Geologist at the bureau.

Links of Interest

Ralston Diamond Hoax articles:

http://www.smithsonianmag.com/history/the-great-diamond-hoax-of-1872-2630188/?no-ist

http://www.history.com/this-day-in-history/the-great-diamond-hoax-is-exposed

Correction: *In the Winter 2016 issue of Earth Matters, we highlighted a book published by Dana Ulmer-Scholle and Peter Scholle. In that writeup, we suggested that the book had won an award, which was incorrect.*

For more information about the bureau and our publications:

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