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GEMSTONE DEPOSITS OF THE FOUR CORNERS REGION, USA

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Abstract—Collecting of gem olivine (peridot), pyrope garnet, and chrome diopside has occurred in the four corners region prior to the arrival of Europeans and probably long before. These gemstones are derived from lower crustal and mantle xenoliths entrained in the volcanic necks and tuffs of the Navajo Volcanic Field. Subsequent weathering has liberated these minerals from their matrices leaving residual deposits of gemstones. Another concentration mechanism for these gems is reworking by ants and subsequent accumulations on their hills. Although these stones have been gathered, traded, or sold around the southwest for over 500 hundred years, perhaps longer, commerical mining is not likely given cultural prohibitions and low volume of commerical material.

INTRODUCTION

The pyrope, forsterite and (more rarely) chrome diopside deposits of the Four Corners Region are among the oldest known gem mineral occurrences in the United States having been exploited by Native Americans for hundreds if not a thousand or more years prior to the arrival of the Spanish (pers. commun., Bustard, 2009).

The deposits cover a wide area extending across the Arizona-New Mexico border from Fort Defiance on the southern extremity, northward through Buell Park, Green Knobs and Garnet Ridge to Moses Rock and Mule Ear just across the Utah border on the north (Fig. 1). Pyrope can be found at over 20 localities in the region, fewer for forsterite (Gregory, 1917), but only the more productive sites will be discussed. All the occurrences, it should be noted, are on Tribal Lands and collecting has been strictly limited to Native American residents since ca. 1960 (date uncertain). The indigenous collectors rarely disclose the site from which they collect their material and the exact locality is usually lost upon marketing.

Popularly called "garnet" and "peridot," the gemstones have acquired a number of other names over time. Most are terms invented for marketing the stones with little bearing on their actual mineralogy. Some of these terms assigned to the minerals include:

Pyrope Garnet: *American, Arizona, Colorado, Mountain, New Mexico, Rock, or Rocky Mountain "ruby," Arizona spinel, ant hill garnet" and "Oriental Ruby."*
Forsterite/Peridot: *"aqua-marine (sic)," "emerald," "beryl," "green garnet," and "Job's tears."*
Diopside, variety chromian: *"chrome pyroxene"*

The mineralogically "correct" names derive from a variety of sources. The term "garnet" itself is thought to derive from the Latin word "granatum" which refers to grain or seeds, the latter especially of the pomegranate. Pyrope is derived from the Greek "pyropos" or "fire-like," and refers to the beautiful red color of the species with the composition $Mg_3Al_2(SiO_4)_3$. Interestingly, pyropes with the characteristic garnet crystal shape are exceedingly rare and are more typically rounded and lack crystal faces. A number of chemical analyses of the pyropes reveal them to contain up to 2 wt. % CrO_3 in the darkest varieties and the more pale stones contain very little (O'Hara and Mercy, 1966).

"Peridot," the term assigned by gemologists to facet-grade green olivine comprised predominantly of the magnesian end member (Mg_2SiO_4), is formally known as the mineral forsterite (named for mineralogist, J. Forster). Compositions of olivine (reported in mol percent forsterite: Fo) from Buell Park and Green Knobs are reported to be between Fo 93 – 91 (Allan and

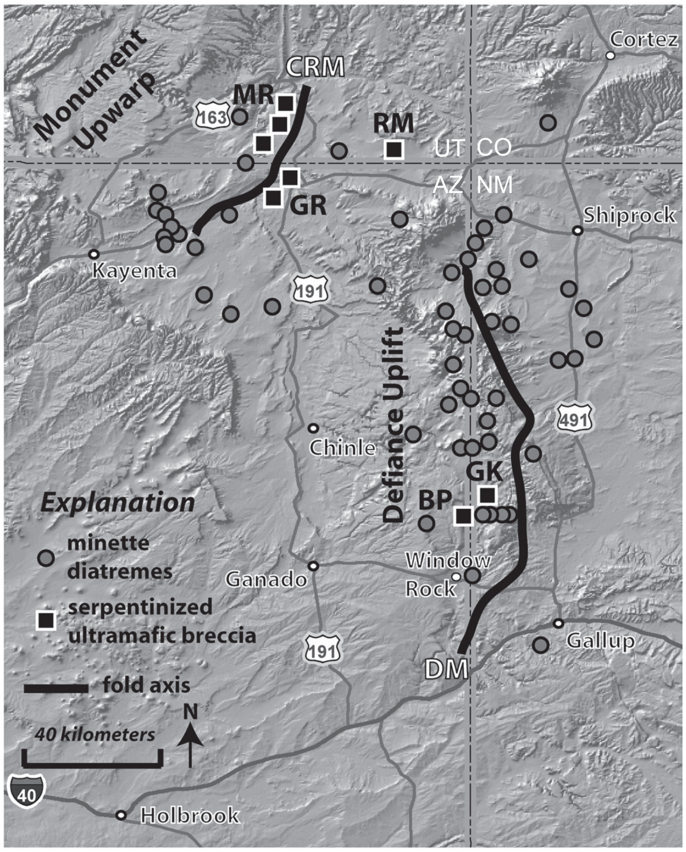

FIGURE 1. Location of the some of the diatremes in the Navajo Volcanic Field. The dominant pyrope and forsterite producing deposits are associated with the sepentinized ultramafic breccias at Buell Park (BP), Green Knobs (GK), Garnet Ridge (GR), Moses Rock (MR) and Red Mesa (RM). Monoclinal structures are identified as CRM - Comb Ridge Monocline and DM - Defiance Monocline.

Balk, 1954). The iron end member of olivine, fayalite (Fe_2SiO_4), is named after its type locality on the island of Fayal in the Azores and is rarely used as a gemstone due to its dark brown color. Fayalite has not been reported in the four corners area.

The substitution of a small amount of chromium (1 – 2% Cr_2O_3) into the diopside structure results in a bright green variety known as "chrome diopside." The mineral is characteristic of rocks derived from mantle sources and is commonly associated with diamondiferous rocks.

GEOLOGY

The gemstones of the Four Corners area are associated with the often dramatic volcanic rocks of the Navajo Volcanic Field.(NVF) known to the Navajo people as "*tsézhinn 'íí 'ahí"* (black rocks protruding up). The field consists of approximately 100 diatreme pipes, dikes, and plugs that range in age from Oligocene to Miocene (Naeser, 1971; Roden et al., 1979; Laughlin et al., 1986; Gonzalez et al., 2010). The distribution of the volcanic features appears controlled by Laramide monoclinal structures (Delaney, 1987). An excellent overview of the features of the volcanic field can be found in Semken (2003) along with a discussion of the enthnogeology of the region.

Many of the eruptive volcanic centers are maar-diatreme volcanoes formed by explosive interaction between magmas and groundwater. The majority of gemstone occurrences are associated with tuffs at Garnet Ridge, Red Mesa, Green Knobs and Buell Park as part of the pyroclastic ejecta (Fig. 2). In many localities gemstones can be seen weathering out of the tuffs and collecting at the base of slopes. The aerial distribution of gem pyrope and olivine is greater than the distribution of the volcanic rocks suggesting the the gem-bearing tuffs were more extensive than are exposed. Allen and Balk (1954) suggested that dispersal of the gemstones could also have occurred during the explosive eruptions casting individual grains great distances from the edifice.

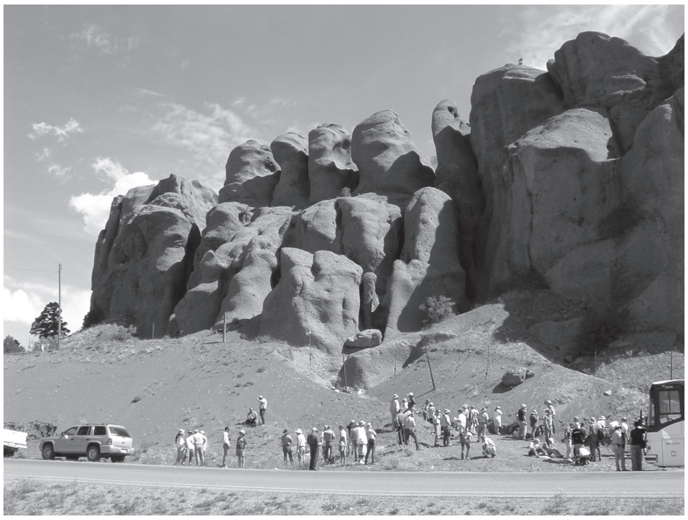

Figure 2 Photograph of Green Knobs during the 2003 field conference. Anthills covered in pyropes and olivines were observed along the road at this stop.

Minette constitutes the majority of the NVF ; a potassic mica bearing lamprophyre. The predominant mineralogy of the minette consists of an aphanitic groundmass of sanidine, diopside, phlogopite, and apatite, with phenocrysts of phlogopite, clinopyroxene and rarely olivine. Most minettes are relatively barren of both pyrope and olivine. A wide variety of mantle and crustal xenoliths are present that do contain olivine and garnet.

The other predominant rock type is serpentinized ultramafic microbreccia that was initially considered to be a carbonatite (Allen and Balk, 1954). These rocks are comprised of xenocrysts of olivine, enstatite, chrome diopside, chlorite, garnet, titano-clinohumite, oxides, and apatite in a matrix of serpentine, chlorite, clays, and talc (Semken, 2003). The microbreccias also contain a wide variety of mantle and crustal-derived xenoliths.

The wide variety of crustal and mantle xenoliths in the NVF has attracted a wide variety of studies (Semken, 2003). Mantle xenoliths are comprised of spinel peridotites and less common garnet peridotites (Smith et al., 1991). Lower crustal xenoliths consist of garnet and pyroxene granulite, gabbro, amphibolite, eclogite, and felisic gneiss. Phanerozic xenoliths of significant size, up to tens of meters, are also described. Most of the gem olivine, pyrope, and chrome diopside are derived from the mantle/lower crust xenolith suite.

Gemstones appear to be most commonly associated with the serpentinized ultramafic breccias. This is probably due the greater variety of xenoliths, especially eclogite and garnet granulite that contain pyrope and olivine. The brecciated nature of the host rock also enhances the susceptibility of weathering that releases the individual grains making them easier to collect.

HISTORY AND FOLKLORE – PREHISTORY TO PRESENT

Native Americans of the southwestern US proved to be some of the best "prospectors' the world has ever known. Prior to the Spanish *entrada,* the only means of transportation was on foot and in this manner the Indians closely scrutinized every square foot of ground of their homelands. Nearly every occurrence of turquoise was known to them but any stone or rock of unusual color commanded their attention and was discovered early on, the garnets and peridots among them. Then as now the larger stones were prized possessions, used for adornment purposes and possibly even as a talisman to ward off bad omens. A roughly spherical pyrope measuring 0.7 x 0.8 mm was recovered from an archaeological site in Chaco Canyon (Fig. 3) and is preserved in the Chaco Culture National Historical Park Museum Collection (pers. commun., Wendy Bustard, 2009). The age of the site is tentatively assigned to the Archaic period (roughly 5500BC to 1 AD) but it is also possible the stone was dropped there at a later date, perhaps as recently as AD 690 or even later. An unsuccessful attempt was made to drill the stone for use as a bead or pendant but it proved to be too hard for the primitive techniques employed and the effort was abandoned (pers. commun., F. Joan Mathien, 2010).

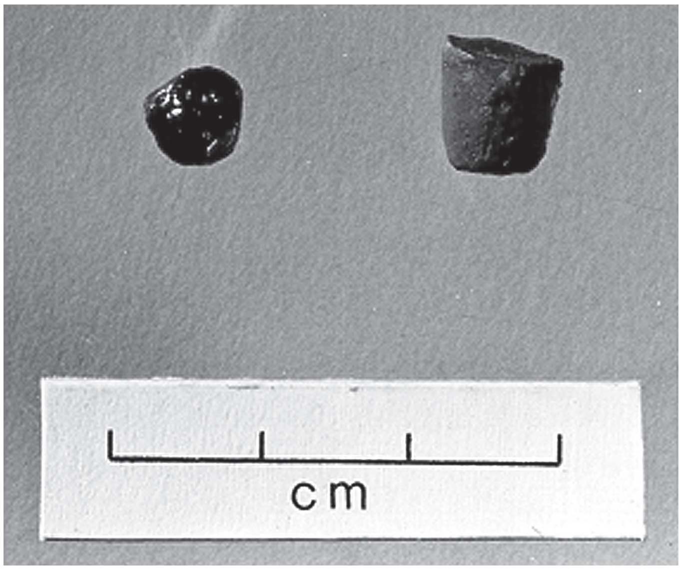

FIGURE 3. Pyrope garnet, specimen No. CHCU 18488 (upper left) recovered from archaeological site 29SJ116 in Chaco Canyon. Photo courtesy of National Park Service, Chaco Culture National Historical Park Museum Collection.

A second garnet was found during the excavation of nearby Pueblo Bonito. This stone (U. S. N. M. No. 336036), recovered from room 330, was described as "rather sizable and unworked." Tree-ring dating techniques indicated a date range of AD 919 to 1130 (Judd, 1954).

A recurring "legend" suggests that the Indians of the past century or two used the rounded ant-hill garnets for bullets because they believed the blood-red stones were capable of inflicting a more fatal wound. However, due to adverse physical characteristics of the projectile itself (low density and excessive hardness), coupled with the absence of contemporary accounts, we remain skeptical.

Exactly when the Indians first became aware of and began to utilize the deposits is uncertain but there is no doubt the stones were widely distributed throughout the various New Mexico Pueblos by the mid-16th century when the Spanish arrived. Spanish explorers such as Marcos de Niza, Cabeza de Vaca, and Melchior Diaz described turquoises, emeralds, and gem stones from the Cibola area in the 1536-39 period (Riley, 1982). When Captain-General Francisco Vazquez de Coronado reached Cibola on July 7, 1540, he reported finding turquoise, garnet, and emerald. Northrop was convinced that the "emeralds were peridots and that both the peridots and garnets came from the vicinity of Fort Defiance" (Northrop, 1959). He further observed "it is probable that ants have been mining pyrope garnets and peridots for millions of years on the Navajo Reservation along the Arizona-New Mexico line…northwest of Gallup (New Mexico). Much later, when man appeared on the scene, he proceeded to exploit the "stock piles" accumulated by the ants…some of the gravel composing the mound is collected by the ants from the surface but some of it is [also] brought up from the underground galleries" (Northrop, 1959). We speculate that some of the so-called "emeralds" may have been chrome diopsides, the latter which possess a deep emerald hue whereas the peridots are quite pale in comparison.

The gemstones were "discovered" by Americans within a few years of signing the Treaty of Guadalupe-Hidalgo. Soon after Col. Sumner established Fort Defiance in the Navajo Country in 1851, soldiers stationed there reported "precious stones, as emeralds, rubies, garnets, etc…were abundant in the neighborhood" (New York Times, March 9, 1852, p. 1). Col. Kit Carson confirmed their existence as a result of his campaign against the Navajo in 1864 (New York Times, Aug. 1, 1872, p. 1; Quilibet, 1872). C. O. Brown of Tucson, well-known throughout New Mexico at that time, reported "when the soldiers from Defiance (and later Wingate) go out on a scout they pick up their pockets full of theses stones…" He further observed "that emeralds and topazes are also found by the Navajo Indians"…and that they "place a high valuation on the emeralds and will not part with them" (Santa Fe New Mexican, Sept. 13, 1872)

The garnets are occasionally closely associated with diopside: Sterrett (1908) noted "among the minerals found associated with the garnets is emerald-green diopside, and in one specimen of garnet which had been split, a small diopside crystal of pin-head size was found in the center. In another specimen a tiny garnet was found attached to a larger diopside crystal."

John Dunn (of Taos, NM, fame) stopped by a newspaper office in Silver City on a return trip from Fort Defiance and displayed "a large lot of fine stones consisting of garnets, emeralds, aquamarines (sic), smoky topaz, with a few small Oriental Rubies of probably five to eight carats (Santa Fe New Mexican, June, 7,1873). Diamonds were often mentioned in these contemporary accounts and more will be said about them later.

GEM PRODUCTION AND THE ROLE OF NATURE'S SECOND-BUSIEST MINERS

"Go to the ant, thou sluggard; consider her ways and be wise" (Proverbs 6:6-8). Thus did King Solomon admonish the ne'er do wells among his people to be more industrious. There is no question that the ants are, second only to man, the most active miners on the planet. The size of some colonies is astounding: For example a nest of the leafcutter ant, *Atta sexdens*, was excavated in Brazil: "the loose soil that had been brought out and piled on the ground by the ants, when shoveled off and measured, occupied 22.7 cubic meters (800 cubic feet and weighed approximately 40,000 kilograms (44 tons). The construction is easily the equivalent, in human terms, of building the Great Wall of China. It requires roughly a billion ant loads, each weighing as much as four or five times as much as a worker. Each load was hauled straight up from the depths in the soil equivalent, again in human terms, to as much as a kilometer (Holldobler and Wilson,1994).

The somewhat less-zealous harvester ant of the western United States, the genus *Pogonomyrmex* as well as several genera of *Formica*, are known to clear the surface to about 15 feet (more rarely up to 30 feet) in diameter. "The mounds generally average a foot in height and 3 feet or so in diameter at the base. The activity extends commonly as much as 6 feet below the surface and in places as much as 10 feet. As much as 50 cubic feet of soil below the surface may be modified by a complex system of rooms and galleries" (Northrop, 1949; Scott, 1951).

Over a century of observations by both Native Americans and more recently Europeans suggest that the above species of ant select and transport from below the surface and the area surrounding their mounds small crystals and fragments of pyrope and peridot and scatter them on the mounds. When this phenomenon was first presented to the world there was, as to be expected, much skepticism:

> *"During the Arizona diamond fever no story was so absurd but it found believers. The editor of the Cape of Good Hope newspaper makes a pretty exhibition of his credulousness. He wrote: 'In the narratives of the exploration of the Arizona diamond mines it is stated that one of the party, an intelligent young Englishman, stepped upon an ant hill. His attention was called to the appearance of the broken surface and to his astonishment he found that the whole was a mass of…precious stones too numerous to particularize.' The editor hereupon innocently puts the question, 'Can Mr. Trimen* (Roland Trimen was a noted late 19th century entomologist) *or any other entomologist, inform us whether the habit of collecting precious stones is peculiar to Arizona ants, or may it possibly be shared by the South African?'"(Youmans, 1873).*

The answer to the editor's question (above) is, yes, the habit seems to be peculiar to the southwestern harvester ant but may be due to the fact they inhabit an area in which a significant portion of the groundmass is made up of garnet and other gem fragments (Fig. 4).

Douglass B. Sterrett, speaking primarily of peridot, appears to stand alone in his conclusion that the stones collected came from the surface and "not brought from the ground underneath the hills as thought by some persons…the ants use no selective method, but take the most available grains" (1908, p 834). The stones, however, appear to be truly "concentrated" in and on the ant mounds which suggest forces at work beyond wind and rain. All other observers, including the Indians, tend to disagree as several accounts dating back at least as far as 1872 attest and some observers such as Oscar Loew (1875), the mineralogist and chemist who accompanied the Wheeler Survey, suggested the ants intentionally select the most colorful ones:

> *"Over large areas, some ten to fifteen miles east of Fort Defiance, we find these beautiful gems scattered in the loose sand…It is worthy of mention that among the pebbles composing the ant-hills, it is usual to find the finest colors of garnets, which leads to the supposition that bright colors have a peculiar attraction for these ants."*

C. O. Brown stated "the garnets and other stones are picked up by Indians on ant beds, the ants bringing them to the surface. Thousands of small garnets, and sometimes a few larger ones, are found in a single ant bed…The post trader at Fort Wingate has over four hundred pounds of the garnets in hand, which he has bought from the Navajo Indians for a trifle "(Grey River Argus, Nov. 4, 1872, p. 4).

The renowned gemologist of the late 19th century George F. Kunz indicated that the stones were found not only on ant-hills but "near the excavations made by scorpions, having been taken therefrom by the busy occupants as obstructions to the erection of their galleries and chambers" (Kunz, 1887; New York Times, June 30, 1889, p. 16.). The latter could account for some of the larger stones – those in excess of ~3mm.

A superb anecdotal story regarding the Navajos gathering ant-hill garnets (Fig 5) was preserved in the eastern press: "You've seen these ant hills that are common all along in New Mexico and Arizona? Well, in travelling you will often see an Indian standing alongside of one, just as if he was saying his prayers. I went up to one once and asked him what he was doing. In answer he held out a handful of stones – bits of garnet, a little ruby, and a lot more small stones, and would you believe it, that [fellow] was

FIGURE 4. Ant moving a pyrope garnet <www.gemscape.com/facets/garnet1.htm.> See Plate 17, p. 89, for a color version of this image.

FIGURE 5. Navajo gathering garnets from a New Mexico ant hill. Sketch originally from the Albuquerque Tribune, June 15, 1943, Stuart Northrop papers, Socorro.

making those ants work for him. They were toting up those stones from somewhere below, and he was scooping them up in a little bag. When he got enough he said he sent them up to Santa Fe and the jewelers bought them. That was going to the ant thou sluggard and make no mistake. You see these ant holes, or nests, were right in what they call a good garnet country, and in sinking their shafts the little fellows naturally brought up small stones which the Indian sorted over" (New York Times, June 6, 1887).

Some observers believe that the ants' efforts in removing the stones from their galleries and scattering them on their mounds are indicative of an additional phenomenon: that of "thermoregulation." Detailed investigation and research into the natural sciences usually discloses that no action or behavioral pattern on the part of Nature's animal kingdom is done either randomly or without specific purpose. According to Holldobler and Wilson (1994), "in cool habitats ants seek heat for the rearing of their larvae." The *Pogonomyrmex* harvester ants of the western deserts "decorate the surface of their mounds variously with small pebbles…pieces of charcoal, etc. These dry materials heat rapidly in the sun and serve as solar energy traps." W. S. Burke (1896) deduced the ant's efforts were two-fold:

> *"The garnet miner is a species of mound building ant who gathers these jewels and scatters them over the sunny side of his mound, where after they are heated by the sun, they are removed and placed among the ant eggs that their heat may aid in hatching them."*

Intrigued by this concept, Dr. Stuart Northrop (1959) stated "this is a fascinating bit of natural history, if true." Yet others, some of whom may suffer from over-active imaginations, have speculated whether the ants could possibly derive not only heat but, if their visual range extends into the infrared, illumination as well. Alas, as so vividly stated by Grizmek (1977), "we will never know how an insect sees its environment…in all known cases the spectral sensitivity of insects goes far into the ultraviolet range, up to approximately 300 nm…[but]…is shorter for the visual spectrum in the area of red, terminating above 600nm." Unlike humans who are "superb in the auditory and visual channels upon which we built our civilizations…ants did not venture into the world we occupy… have followed another evolutionary course…[and] have accomplished relatively little with sound and virtually nothing with sight" (Holldobler and Wilson, 1994). Similarly the question of whether the ants actually do engage in selectively "mining" and bringing the stones to the surface where they are dumped on their mounds, etc., is yet to be subjected to scientific investigation (Fig. 6)

LOCALITIES

Pyrope and forsterite deposits are widespread throughout the region but the most productive sites appear to be those in the Fort Defiance-Buell Park-Green Knobs area and at Garnet Ridge near Kayenta in Apache County. Garnets are also found at Moses Rock and the Mule Ear deposits near the AZ/UT border but are considered small as compared to the others (Fig. 1).

FIGURE 6 – An "anthill" assortment of gemstones consisting of peridot (transparent), pyrope (dark), and two chrome diopsides (Cr). The elongated chrome diopside (lower left center) is 1.1 cm long. Gift of Debra Davies, NMBGMR Collection. See Plate 17, p. 89, for a color version of this image.

Peridot at Buell Park was once abundant near the southern rim of the Park on a narrow curving feature called "Peridot Ridge." Peridots and garnets also appeared to be concentrated in a small hill on the floor near the center of the Park. Most of the stones are small, 0.6 cm or less, but larger peridots to 2.5 cm have been found in the past though usually not of facet grade. The pyropes are smaller occurring in sizes ranging from mere granules up to 0.6 cm, more rarely to 1.3 cm, in angular or rounded masses. Crystal faces have yet to be observed but some very interesting nodules, or "clusters," of intergrown pyropes up to 3.2 cm have been recovered (Larry Caviggia, pers. commun., 2010; Sinkankas, 1959). At the nearby Green Knobs locality peridot seems to dominate over pyrope but the opposite is true at Garnet Ridge near Kayenta about five miles west of Mexican Water in northern Apache County, AZ., where garnet dominates over peridot and is widely distributed in the soils around four intrusive pipes varying in size from 800 ft in dia. to 1200 by 3000 ft. "The great quantity of garnets and the ease with which they may be obtained give this area first rank as a collecting field. In selected localities five minutes is sufficient time for gathering from a natural riffle a quart of material of which fully one half is garnets" (Gregory, 1916).

The rarest constituent of the deposits is the emerald green chrome diopside, the color of which is so deep as to be confused by the casual observer with true emerald. Few collections, discussed in more detail later, include even a single sample of this species though it is known to occur at several localities.

At Buell Park excellent examples of all three species were found in the low outcrops 1000 feet east-southeast of the hill. Balk and Bureau mineralogist Ming-Shan Sun listed them as follows: "forsterite ("olivine"): 11mm; pyrope, 7mm; and chrome diopside, 14mm," the latter remarkably large. Another unusual feature at this locality is the cleavage noted in forsterite. Generally difficult to detect the more typically observed fracture surface is conchoidal but larger flat chips at this site "showed good cleavage parallel to (010) and parting parallel to (100)" (Sinkankas, 1959; Allen and Balk, 1954).

QUALITY, COLOR AND SIZE

Gemologists have been fascinated by the quality and color of the Four Corners gemstones for well over a century. George F. Kunz (1887) was much impressed especially with the garnets:

> *"The finest garnets in the world are those found near Gallup, New Mexico, Fort Defiance, Arizona, and Helena, Montana. They are often associated with the oily green and olive green peridots called "Job's tears" on the surface of ant hills where they have been carried not only by the ants but also by scorpions. They are there called rubies. Although the garnets found in the diamond mines at the Cape of Good Hope (the so-called "Cape Rubies") are larger in size than these, and perhaps by daylight equal to them, there are undoubtedly no garnets found that appear better in the evening and by artificial light than those from the United States. The dark color of the Cape garnets remains in artificial light, whereas the American garnets show only the clear blood-red hues. The color of these is usually a rich red, but very often purple or almandine, and sometime approaching the tint of honey. Many thousand dollar's worth of these garnets have been disposed of. They are rarely larger than three carats each."*

A group of 160 pyropes examined by Sinkankas (1959) revealed that most contained inclusions and the dark red color prevailed. Fifteen of the stones "were decidedly orange to orange-brown in color, one specimen being so pale that it could easily be mistaken for orange spessartite. Of the remaining 145 stones, about 45 were a vivid shade of purplish-red and the remainders were dark red, some inclining slightly toward purple and some toward brown. Very few…were pale red, the majority were quite dark and some appeared almost black." Garnets in the Gallup, New Mexico area (i.e. Buell Park-Fort Defiance) were said to be "from 1-1/2 to 2 degrees harder than the celebrated German stones and in luster and brilliancy exceed them in the same degree" (Burke, 1896). How Burke decided the pyropes of the Four Corners were harder than German stones is unknown.

Pyropes in the Garnet Ridge-Agathla Needle area "range in size from small grains to over 3 cm in diameter. The larger ones are not perfect, being badly flawed or cracked. They often have a brownish-red color and rarely contain gem material. The best gem garnets are not often over a centimeter or 12 millimeters in diameter and the greatest yield of gems is in garnets of less than 8mm in diameter." Internal imperfections in the garnets range from microscopic mineral grains or needles, possibly rutile, to fluid inclusions or gas-filled voids. The peridots, however, are usually clear and free from imperfections. When the latter are observed they "appear as minute hexagonal plates with a dirty brown color" [probably hematite]…and more rarely "a few blades of an emerald-green mineral (probably diopside)…" (Sinkankas, 1959; Sterrett, 1908).

Most of the so-called "tourist-grade" stones sold in small glass or plastic vials at the various trading posts are of the inferior variety, dark red to almost black and generally small (3-5mm/½ - 1-1/2 cts). Some of the stones described by Sterrett might seem excessively large by today's standards but accounts in nineteenth century press indicate that gems in the 5-8 ct. range and larger were once more abundant (Santa Fe New Mexican, 6/5/1873). Top-end facet-grade stones up to 1 cm may still be obtained, if one is willing to search for them (Fig 7).

Efforts to trace and document the largest and/or finest are often difficult but digital communication has somewhat simplified this task. An early-day "notable" was the so-called "Stanton Ruby," the name derived from its owner at the time Charles P. Stanton. This stone generated a tremendous amount of excitement in the gemological world of the early 1870s and it was declared to be a genuine ruby by people who should have known better. The specimen in the rough weighed 28 carats and when cut yielded a 12-1/2 ct. stone valued at the astronomical figure of $250,000 – until Prof Schirmer, a "qualified lapidary" of the San Francisco mint demonstrated that it was easily scratched with a corundum and thus too soft to be a ruby. The value of the Stanton "Ruby" – now thoroughly demoted to a garnet - plummeted to a mere $100 (New York Times, Dec. 6, 1872, p. 1; March, 15, 1873, p. 5). Considering this equates to about $2,000 in terms of today's dollars this was still a remarkable specimen. We were unable to trace its current location.

Kunz (1893) tends to corroborate the above price, in part: "a few remarkably fines ones have brought from $50 to over $100

FIGURE 7. Two lots of "Ant-Hill" garnets: "tourist-grade" pyropes (right) have been sold in small glass (and more recently plastic) vials at the various trading posts for a century or more . The stones are generally small in size and inferior in quality. Top of the line stones (left) selected for best color can, with effort, be had at a premium. The faceted stone immediately left of the bottle weighs 3.3 ct, is 9mm in diameter, and has a retail value of $695.00. Rough on left courtesy Larry Caviggia. All others NMBG&MR collection. See Plate 17, p. 89, for a color version of this image.

each, though others equally good have been sold for much less. Fine stones of 1 carat bring from $1 to $3 each, and exceptional ones even $5" (again, keeping in mind the current value of late 19th century dollars).

The top specimens and gems from any locality tend to migrate toward those who can best afford them and in that regard the name of J. Pierpont Morgan, the great 19th century financier, immediately comes to mind. In 1892 Mr. Morgan purchased and gifted the Tiffany Collection of Gems to the American Museum of Natural History, a collection that George Kunz described at the time as the finest known (New York Times, Feb. 14, 1892, p. 8). Within the Tiffany-Morgan collection, as it is known today, reside some of the finest surviving examples of New Mexico-Arizona garnets and peridots.

Stuart Northrop at one time had three excellent Buell Park stones in his collection. One was a pyrope measuring 11x5x3mm and the other two were forsterites measuring 12x12x5mm and 13x8x5mm respectively (Northrop, 1959). Current locations of the Northrop and the Balk-Sun specimens, previously mentioned, are unknown. Three chrome diopside specimens in public collections have been traced by us: two are in the Bureau's collection (11x4x2mm and 7x4x4mm) (Fig. 6) and the other ("about 12mm in length," pers. commun., Gary Smith, 2010) in the University of New Mexico collection. The largest known collection of these stones is in the private collection of Larry Caviggia (Fig. 8).

DIATREMES AND DIAMOND POTENTIAL

Diamond is one of the few mineral substances beyond gold that is capable of generating enough excitement to cause a "rush" and the gem fields along the New Mexico-Arizona border did not escape from the promotion and the hype due in part to the notoriety bestowed by the infamous Ralston Diamond Hoax (below). The alleged existence of diamonds in the Buell Park, etc, diatremes has, in fact, been a topic of discussion dating at least to the 1850s and those who thought they found diamonds were quite adamant about it. The mid to late 19th century press offered several accounts, some of them convincing to the gullible. C. O. Brown stated "A soldier in the United States Army found [a diamond] near old Fort Defiance in 1858 which was sold for seven thousand dollars" (Grey River Argus, Nov. 4, 1872, p. 4). Elias Brevoort (1874), quoting from the 1872 report of the U. S. Surveyor General for New Mexico stated that "well authenticated and thoroughly tested rough diamonds" were present in a collection of garnets and other precious stones" which originated in the so-called "diamond region" of New Mexico and Arizona (Northrop, 1959). Territorial Socorro's own Ben Leggett "secured a fine diamond…in a spring of water in southeastern Arizona, not far from the New Mexico line…" The stone was ultimately sold in San Francisco "for $5000 but our old and honest friend Ben was defrauded of its value" (Bullion, March, 15, 1892, p.8).

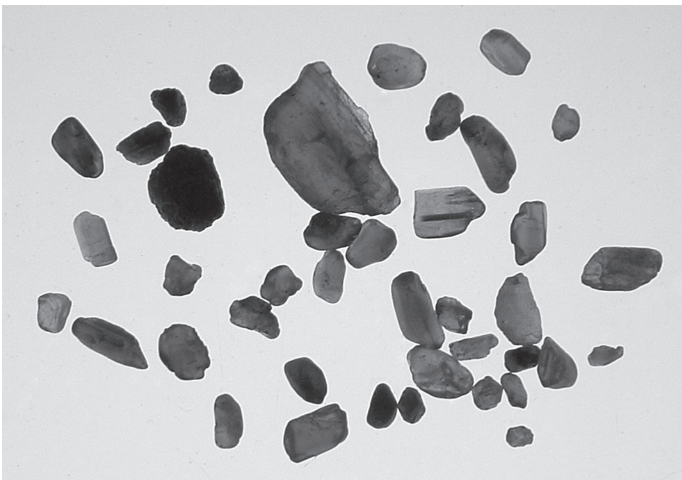

FIGURE 8. Chrome diopside grains from the Larry Caviggia collection. Largest grain is 1.0 cm in the longest direction. See Plate 17, p. 89, for a color version of this image.

An equal if not greater number of accounts refute their existence: "Notwithstanding the reports of wonderful diamond and ruby discoveries in Arizona and New Mexico are generally ridiculed here, still a man named Savage, now in this city, claims that he has prospected the locality and that he brought specimens of stones to Salt Lake City six months ago. In proof he refers to several jewelers to whom he sold the stones, not knowing their true value. Nearly all the stones were rubies and sapphires but there were no diamonds" (New York Times, Aug. 3, 1872, p. 1). The "rubies" and "sapphires" were, of course, pyropes of various shades.

"A Colorado party which prospected Arizona pretty thoroughly on both the thirty-second and thirty-fifth parallels, found an abundance of rubies, almandines, chalcedony, and brilliant crystals resembling diamonds, but they are believed not to be such" (New York Times, Aug. 20,1872, p 1). And lastly, "A former resident of Arizona, who is thoroughly familiar with the so-called diamond regions, asserts that Arizona diamonds are nothing more than peculiarly brilliant quartz crystals. Of these he has repeatedly collected large quantities, for the amusement of the little ones of his acquaintance, among whom he has lavished incalculable wealth – provided [that] quartz crystals and diamonds are synonymous" (New York Times, Aug. 27, 1872, p.4).

Considering that the deposits played a peripheral role in the infamous Ralston Diamond Hoax there is little doubt some of the fever can be ascribed to it. One of the perpetrators of that "Great Swindle," J. B. Cooper, related how he accompanied Philip Arnold and John Slack to the New Mexico gem fields in 1871 and collected quite a number of rubies, etc. Later Arnold went "to Arizona where he bought a large quantity of rubies, garnets, and sapphires" In this manner the bona-fide pyropes and other stones from New Mexico and Arizona became a part of the "salt" that was "scattered with reckless profusion" at the site the dubious scammers selected in NW Colorado (New York Times Dec. 8, 1872, p. 1).

If not diamonds, what were these stones that appear to have confused early-day prospectors? We scrutinized inventories of some of the largest repositories of gemstones in the United States and have found not a single diamond ascribed to Arizona or New Mexico. Mineral collectors and rockhounds, convinced they found diamonds, have brought to Bureau scientists for identification purposes numerous water-clear crystals or crystal fragments. At first glance the stones bear a remarkable superficial resemblance: they are often psuedo-cubic and possess exceptional brilliance. But they lack the requisite hardness and density in addition to other critical physical characteristics (refractive index, symmetry, etc). They are, in the final analysis, “beta” quartz and, as correctly indicated by the unnamed former resident of Arizona (above), “nothing more than peculiarly brilliant quartz crystals.”

Several observers have noted that the lapilli tuffs in Buell Park and other nearby areas bear a strong resemblance to kimberlite which is the host rock for the African diamond deposits (Williams, 1936; Allen and Balk, 1954). Even if the tuffs are kimberlitic in nature that does not infer they are diamondiferous. Consider that only about 10% of the African kimberlite pipes are worthy of exploitation and just 3% account for most of the production. Ultimately, the recognition that the rocks initially identified as kimberlite are actually microbreccias (Smith and Levy, 1976; Roden, 1981) also reduces the potential for diamonds. The inescapable truth is that no known and/or verifiable diamonds have been found to date.

THE FUTURE OF THE DEPOSITS

The pyrope and forsterite deposits as described above are distributed over a wide geographic area. The rocks in which the gems are found are presumed to have originated deep within the earth and brought to the surface by eruptive activity. A bore hole said to have been drilled to a depth of 115 feet remained in the gem-bearing rocks (Sinkankas, 1959) and the inference is they extend to thousands, not mere hundreds, of feet.

Two natural processes have been described in which the gems are concentrated: erosion by wind and water and harvesting by ants. Douglass Sterrett, as discussed above, stood alone in his belief that ants played no role in raising the gems to the surface but that “the garnets may be uncovered by a wind from one direction and then covered up by that from another…the shifting of the sand uncovers garnets at one time and covers them up at others and therefore renders the possibilities of new finds attractive. The garnets are scattered throughout the drift…and are carried down with it to the mesa country below during erosion. It seems the garnets undergo a partial concentration on the mesas during the breaking down and washing away of its loose matrix” (Sterrett, 1908). Otherwise the role of the garnet-mining ant seems firmly established and there are photographs posted on the internet of the critters engaging in this very activity (Fig.4). The ants have likely been mining garnets and peridots since they moved into the arid desert southwest and there is no reason to assume they won’t continue this activity as long as they remain a part of the ecosystem.

The deposits have never been exploited on a commercial basis and likely never will be. We thus conclude that the supply of New Mexico-Arizona forsterites and pyropes, though never abundant, will be available in quantities sufficient to satisfy current demand long into the future.

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