Alien Sightings: Pallasite

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With some gemstones you might wonder if the price is down to earth, while one in particular may seem astronomical in cost.

Consider the beautiful gemstone peridot. While the attractive citrus-green shades of peridot have been a popular staple for more than just their role as a birthstone, larger peridot such as those from Myanmar and Pakistan have been steady sellers in the collector and high-end jewelry markets. Peridot is a gemstone that commonly wholesales for under $50 per carat in common ring sizes. While the finest large peridot can sell for up to $250 per carat, some exceptional rare collector specimens have been known to reach up to $500 per carat.

The quality and intensity of the color combined with rarity and different origin results in a different market structure. But when sub-carat sizes of this mineral variety command more than $1,000 per carat, what in heavens is going on? Have aliens landed?

Photo: Bear Williams.

Quite possibly so. Pallasites are a variety of meteorite that is composed mostly of iron, but some have transparent crystals of olivine within them. This olivine is referred to as "pallasitic peridot" and it is occasionally faceted as a gemstone. These olivine crystals are a type of peridot that is a very rare breed. Faceted pallasitic peridot over one carat is extremely scarce. For their size, few gemstones can compare in price; even fewer compare in provenance. In spite of recent reports of diamondiferous planets, there are very few known gems that form beyond Earth.

Typically light yellow-green in color due to their small size, pallasitic peridots have several telltale indicators of their other-worldly origin which can be detected by a fully equipped lab but are not apparent to an inexperienced eye. Such stones are frequently accompanied by documentation—or should be.

Location, Location

The formation environment often leaves clues as to the origin of a gem. Many terrestrial peridots are volcanic in origin and come forth through the earth's lithosphere; others are metamorphic. On the other hand, pallasites are known to have originated in the asteroid belt located between Jupiter and Mars, where they are thought to have existed in space's extremely dry and cold conditions since the early stages of the solar system. Further, they have entered the atmosphere at high speeds resulting in sudden heat and high-speed impact. With experience, one can learn to recognize some of the internal features of some pallasites,[1] but advanced testing with ED XRF and FTIR can readily identify important differences in trace chemistry and formation. This is important because many pallasitic peridots are too small and/or clean to show the telltale inclusions necessary to confirm their origin.

Besides having an extra-terrestrial origin, different pallasites are named according to the geographical region on Earth where they fell. Most facet-grade pallasitic peridot currently in the market is of the Jeppara variety, and most recent studies have focused on these. They tend to be cleaner and have a more pleasant green color. The Jeppara pallasite fell over Indonesia, but other pallasites fell in other places, such as Fukang (China), Brenham (USA), Esquel (Argentina), Imilac (Chile),

[1] *Gubelin, E.J., Koivula, J.I., 2005. Photoatlas of Inclusions in Gemstones, Vol.2, p.538*

and Brahin (Russia).[2,3] As the earth is mostly covered by water, there are an unknown number of pallasites lying beyond identification on the ocean floor; corrosion, weathering, and oxidation (rusting) along with the resulting disintegration also occur rapidly in land-fall meteorites, depending on environment.

A Brief History

Pallasites, named after the naturalist Peter Simon Pallas (1741-1811), are stony-iron meteorites. The olivine nodules embedded within the iron are currently referred to as pallasitic peridot. Pallas himself made "hints" of the gem-like appearance of the olivines.[4]

Interestingly, in the 1825 Philosophical Magazine and Journal,[5] an article entitled, "Researches on the Composition of Peridot," L.P. Walmstedt, outlines the rather destructive method of obtaining chemistry. A piece of rough was extracted from the host pallasite and thoroughly cleaned. What was left was a 1.5585 gram "pure" specimen. Depending on its shape, this large (7.79 carat) rough might have been cut into a record sized pallasitic peridot gem. Instead it was crushed, and subjected to caustic acids and alkali to determine its chemistry.

In the appendix of his findings, Walmstedt explains in "Professor Stromeyer [chemical] Analyses" regarding extraterrestrial peridot: *"Its composition is therefore wholly the same as that of olivine….and what is very remarkable, the oxide of nickel is wholly absent."* On the other hand, all of the peridot of earthly origin that Stromeyer measured had nickel. From recently published research we might get the impression that the terrestrial peridot having nickel, and the pallasitic peridot *not having* measurable nickel is a recent discovery. But as we can see, this fact was known almost 200 years ago.

Continuing Research

Fortunately, today there are non-destructive tests that can ascertain the chemistry of these extremely rare gems and destructive testing is no longer required. As reported in a recent study by the Gemological Institute Thailand in Bangkok,[2] using EDXRF, focus was given to the chemical differences between terrestrial peridot (having measurable Ni) and pallasitic peridot, which shows no nickel at detectable limits.

The authors confirmed these nickel readings (Figure 1) on their laboratory's ED-XRF but continued with further research. This resulted in finding another possible means of confirming origin using FTIR spectroscopy (Figure 2). Because of the extreme age and the scarcity of water in space, pallasitic peridot contains no measurable amount of water (H2O) or hydroxyls (O-H). In comparison, terrestrial peridots, particularly those formed in steamy volcanic conditions; all contain comparatively significant water in their crystal lattice. For this study, only Jeppara pallasitic peridots were tested.

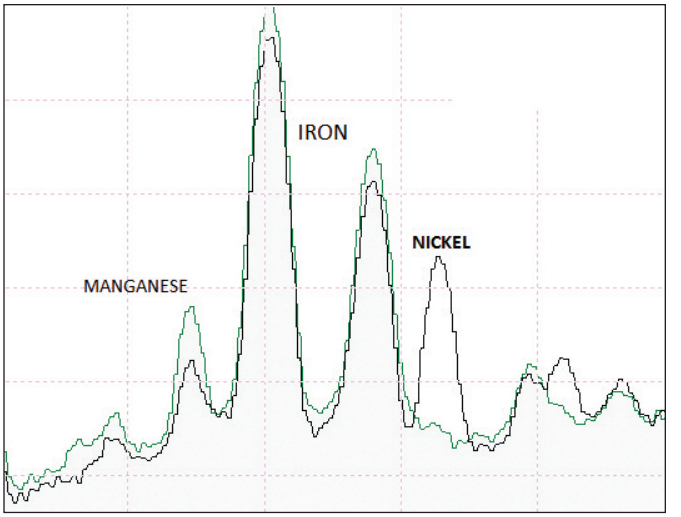

Figure 1. Chemical tests on XRF show the lack of nickel in the extraterrestrial pallasitic peridot and significant quantities in the terrestrial peridots.

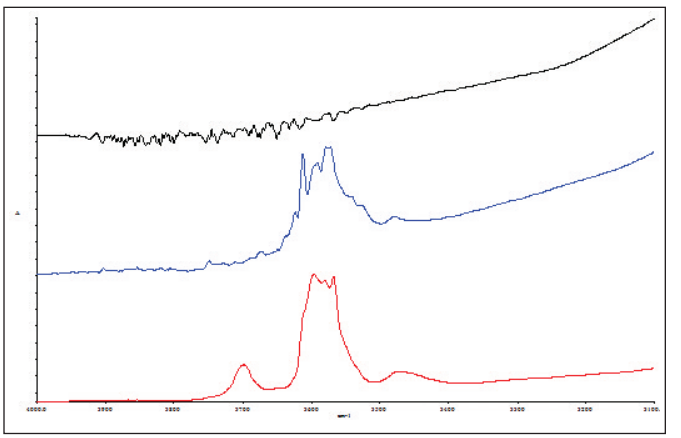

Figure 2. Mid infrared spectra (FTIR) The ET peridot (black trace) shows little action in the H2O and O-H regions, as compared to plenty in the Myanmar (blue), and Pakistani (red) peridot.

[2] *Leelawatanasuk, T., Atichat, W., Sutthirat C., Wathanakul P., Sriprasert B., Naruedeesombat N., Srithunayothin P., Davies S. Pallasitic peridot: The gemstone from outer space. Proceedings of the 32nd International Gemmological Conference, Interlaken, Switzerland, 13-17 July 2011, pp. 110–113.*

[3] *Pearson, G., 2009. Meteorites: Origins, Properties and Gemmological Significance. Australian Gemmologist, vol.23, no.10, pp. 457-472*

[4] *Sinkansas, J., Koivula, J., and Becker, G. 1992. Peridot as an Interplanetary Gemstone. Gems and Gemology, vol.28, no.1, pp. 43-51*

[5] *Walmstedt, L.P., 1825 Researches on the Composition of Peridot. Philosophical Magazine and Journal, vol.66, p.357*

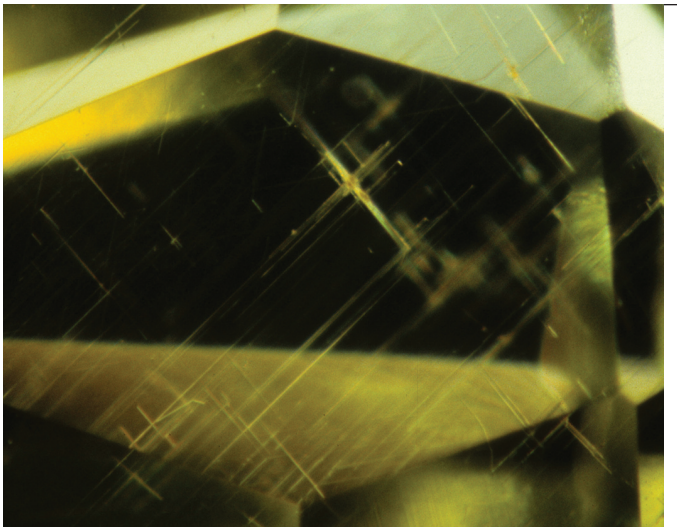

Figure 3. Cruciform acicular dislocations. These internal features are not seen in terrestrial peridot.
Photo Courtesy of John Koivula.

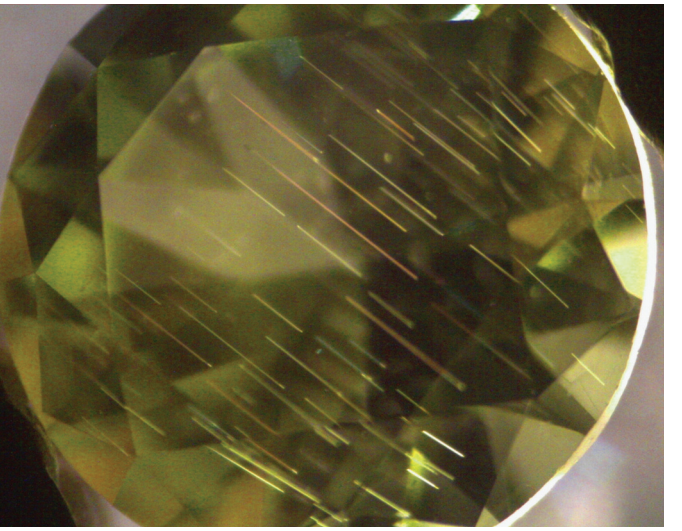

Figure 4. Irridescent quality of the parallel tubular inclusions as seen in Jeppara (and other pallasitic peridot.)
Photo: Bear Williams.

Further research will continue to compare hydroxyl results with other pallasitic peridot of various origins.

A 2011 study by the GIA[6] using LA-ICP-MS also showed certain light and trace elements provided positive results in separations between the pallasitic and terrestrial origins.

Identification

All pallasitic peridot is not the same. The different pallasites that have landed in different parts of the world have properties that vary but also overlap, not just with other pallasitic peridot but with terrestrial peridot as well.[4] Standard, measurable properties such as refractive index and specific gravity vary with too much overlap to rely on such methods to identify the pallasitic variety. Color ranges from a golden brown to mossy green to a clear citrus green. However, certain visual features are seen in pallasitic peridot that can aid in its identification. With experience, one may identify them by observing certain unique inclusions, such as cruciform acicular dislocations[1] (Figure 3), but when there is a lack of indicators, advanced lab testing equipment is required. In addition to the cruciform inclusions, which Koivula states are, "not seen in any terrestrial peridot," other inclusions seen in the material studied were iridescent needlelike inclusions. These curious tubular inclusions are described by Stevens and Busek[7] as occurring in parallel sets that are crystallographically oriented (Figure 4). They are seen in pallasites of various sources such as Fukang and Jeppara.

It is thought that such inclusions occurred as a result of a "shock event," such as entering the Earth's atmosphere or the final impact. One might expect that a meteorite impact at speeds well of over ten kilometers per second might cause such dislocations, but more recent thought hypothesizes that these inclusions nucleated during heating following dislocation formation in an earlier shock event concurrent with that proposed to have disrupted the pallasite parent body and sent it on an eventual path towards Earth.[7]

Respect for our Rare Elders

How rare are they? Grant Pearson states, *"It has been estimated that more gold is mined annually than the total weight of all meteorites ever found of which metal meteorites then comprise only a small proportion of the total. Stony meteorites such as mesosiderites and pallasites are much rarer still."*[3] Another specialist in pallasitic peridot stated, "Less than 15 of the 61 pallasitic meteorites are known to contain olivine which is large and clean enough to facet." One might imagine that one-day's worth of mining terrestrial peridot might equal more than all the pallasitic peridot ever found. Meteorites are studied for clues to the early formation of our solar system. This makes pallasitic peridot older than any gem on earth, including diamonds. A truly forever gem and those who have an August birth date can claim to have a birthstone that is from out of this world. ◆

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6 *Shen, A., Koivula, J., and Shigley, J. 2011. Identification of Extraterrestrial Peridot by Trace Elements. Gems and Gemology, vol.47, no.3, pp. 208-213*

7 *Stevens,M.R., Bell, D.R., Buseck, P.R., 2010. Tubular Symplectic Inclusions in Olivine from the Fukang Pallasite. Meteoritics & Planetary Science, vol.45, no.5, pp. 899-910*

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