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INVESTIGATION OF PERIDOT AND GREEN TOURMALINE IN TERMS OF CHEMICAL STRUCTURE AND IMPURITIES

Saeed SALAHI[1*], Sahar BAHARI JOKANDAN[2]

[1*] Geology, Islamic Azad University of Isfahan, Isfahan, Iran
[2] Geology, Islamic Azad University of Isfahan, Isfahan, Iran

*Corresponding Author
E-mail: Salahi.saeed1980@gmail.com

ABSTRACT

Tourmaline is a mineral shaped in nature that can have phenomena such as chatoyancy / aventu, which are often found in white, pinkish-white, greenish-yellow, green, purple-blue. In contrast, peridot is a subset of the olivine mineral that can have the phenomenon of chatoyancy/star 4 or 6 / aventu, which is often found in nature in greenish-yellow, green, yellow colors. Peridot mineral and tourmaline mineral are both found in green colors in nature and can have properties such as similar impurities, which makes it difficult to distinguish these two minerals from each other.
In addition to these, there are some features and differences with each other that cause the separation of the two, as well as some impurities specific to each mineral. Tourmaline contains amounts of aluminum, magnesium, sodium, lithium and copper. Tourmaline can be found in green, pink, black, etc. in nature. Its green color is very similar to Peridot. Peridot is an ideochromatic mineral, meaning that its coloring agent is part of the chemical formula of the rock, while tourmaline is not.

Keywords: *Tourmaline, Peridot, Chemical properties of peridot, Chemical properties of Tourmaline*

INTRODUCTION

Olivine is usually distinguished with glass polish, oyster fracture surface, green color, and grain nature. One of the oldest and most important peridot mines on the volcanic island of St. John's Island is the Red Sea. Other reserves of the mineral include Australia, Brazil, China, Kenya, Mexico, Norway, South Africa, Sri Lanka, Tanzania, and Saudi Arabia.
Tourmaline is a common and secondary mineral of igneous, sedimentary, and metamorphic rocks and is crystallized as a primary magmatic mineral in granite and pegmatite rocks. The chemical complexity of tourmaline, unlike most other minerals, can be due to the extensive substitutions that exist in this mineral and cause this mineral to have a very wide formation environment and to understand the lithogenesis and geological position of host rocks.

Differences in Chemical Composition and Crystallization System of Peridot and Tourmaline

Based on the definitions, the chemical formula of tourmaline is

$$Na\ Fe2 + 3(Al, Fe3 +)\ 6(OH)\ 4(Bo3)\ 3Si6O18 \quad (1)$$

Which includes compounds of boron, silicate, sodium, aluminum, calcium, lithium, iron, flora, and silicate. In rhombohedral systems, it is in the shape of the trigonal with long triangular crystals. In contrast, the peridot chemical formula is SiO4 (Mg, Fe) and crystallizes in orthorhombic systems.

Figure 1. Peridot appearance in terms of structure and impurities

Figure 2. Show the appearance of tourmaline in terms of structure and gas bubble inclusions

Tourmaline has a double chemical composition for hydrated silicate and can undergo various changes, especially for the cations in the formula Na Fe2 + 3 (Al, Fe3 +) 6 (OH) 4 (Bo3) 3Si6O18 (Adib, 2010). The crystalline system and the overall shape of the peridot are orthorhombic and are rarely found in the form of fine crystals, sometimes in the form of irregular masses or the form of pieces of crystal or circular rubble, thin prisms with lines. Vertical on them. Many gemstones may be mistaken for tourmaline. Stones such as Peridot and Brill, which are very similar to tourmaline (Ghorbani, 2003). The coloring metal in peridot is iron. Green tourmalines are rich in chromium metal (Adib, 2010).

Peridot Dye and Tourmaline

Peridot is found in greenish-yellow, olive green, and brown in nature. Tourmaline is found in nature in colorless, pink, red, yellow, brown, green colors (Ghorbani, 2003).

Tourmaline-Like Stones

Many gemstones may be mistaken for tourmaline. Stones such as Peridot and Brill, which are very similar to tourmaline (Adib, 2010).

Appearance

Peridot is one of the rare gemstones available in only one color: olive green. Though, the intensity and color of green depend on the percentage of iron in the crystal structure, so the color of each

of the peridot gems can vary from yellow, olive green, to brownish-green. In rare cases, peridot may be pure green, dark, with no secondary yellow or brown (Adib, 2010).
Two types of green tourmaline can be very close to emerald: one of these chromium-rich tourmalines is found in Tanzania, which looks red in a Chelsea filter study, and the other is dark green tourmaline, which is mined in Namibia. In addition, when heated, its color turns emerald green (Moin Vaziri, 2004).
Lithium impurities in tourmaline make any color such as blue, green, red, yellow, and pink.
Rare peridot green tourmaline is painted with chromium (Adib, 2010).

Occurrence in Peridot

Peridots can be distinguished from tourmaline in size and composition. Peridot formed because of volcanic activity tends to contain higher concentrations of lithium, nickel, and zinc than those found in meteorites (Bayani, 2011).
Peridot crystals have been collected from some pallasite meteorites. The most studied Pallasite Peridot belongs to the Indonesian Jeppara meteorite, but there are others such as the Brenham, Esquel, Fukang, and Imilac meteorites (Bayani, 2011).

Peridot Impurities

Peridots found on St. John's Island often contain Ludwigite and vonsenite inclusions, which look like black lines on a rock. Another type of inclusion is water-lily leaves, which may be detected in peridots due to the recrystallization of fluid trapped in the cavities. Some other peridots have a solid crystal-shaped halo inclusion at their center. Others have circular apatite crystals.
Crystal components are commonly found in peridot, but the variety of crystals depends on where peridot is found. The stones imported from Pakistan include silk and rod-like components as well as black and white chromite crystal components that look like fingerprints. Brown mica shells are more prominent in Arizona gemstones (Bayani, 2011).
Internal features such as "vonsenite-Ludwigite" (with negative crystals or chromite grains), chromite crystal or green diopside, and somewhat improved fractures have been observed in peridots of various origins. Some peridots have the inclusion of a Lily pad or lotus and can only be seen in this rock. This inclusion is seen in the form of a thin disk, sometimes with lines (Bayani, 2011).

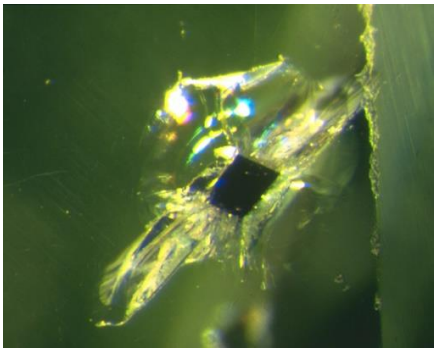

Figure 3. If black mineral crystals in peridot are visible to the eye, they lower the stone's value.

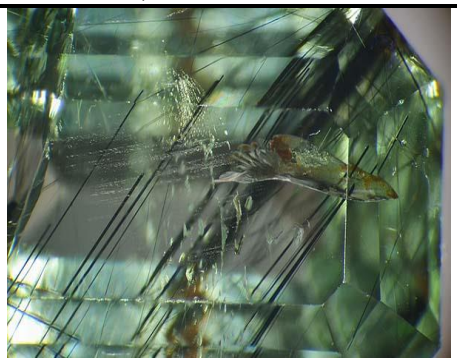

Figure 4. Ludwigite-vonsenite needles typical for peridot from Pakistan, Which is easily visible at 80x zoom

Types of Tourmaline Colors

Tourmaline is boron silicate, which contains amounts of aluminum, iron, magnesium, sodium, lithium, copper, and potassium. Tourmaline can be found in different colors from colorless to black. Tourmaline crystals that show green on one side and pink to red on the other with white in the middle are called watermelon tourmaline. Tourmaline has a strong multicolor phenomenon, which means that its crystals show different colors depending on your viewing angle.

Most red, pink, brown, and yellow in tourmaline are dyed with manganese, while iron and titanium can cause green to bluish-black colors.

Differences Between Tourmaline and Peridot in Terms of Mining

Peridot mainly in poor igneous rocks can be found in Silica, Australia, Brazil, Burma (Mogok), China, Egypt (St. John's Peridot Island in the Red Sea), Mexico, Norway, Pakistan, Sri Lanka, USA (Arizona, New Mexico, Hawaii) Vietnam (Hosseini, 2011). Tourmaline is typically found in the mines of Afghanistan, Australia, Brazil, Burma, Kenya, Namibia, Madagascar, Russia, Sri Lanka, Tanzania, USA (California and Maine).

The most common and valuable source of tourmalines is granite pegmatites and their surrounding rocks. In some occlusions, tourmaline is more than 6 cm long (Malai, 2006).

Tourmaline is found in the United States, mines in California, Maine, and New Hampshire in South Africa, East Africa, Brazil, and many other places. Tourmalines found in California mines are usually yellow and green.

Tourmaline Processing

Heat treatment causes dark blue and green tourmalines to turn lighter blue/green or yellow/green. Some blue/green jewels from Namibia turn into medium emerald green. All obtained colors are stable. Peridot is not usually heat-treated (Etredi, 2006).

Absorption Spectra

The absorption spectrum of green tourmaline is 4150 – 4970 (Majidi, 2012).

The absorption spectrum of Peridot 5430-5290 is very strong, in a blue bar with three lines due to the presence of iron in it (Loghmani, 2014).

Differences between peridot and tourmaline impurities by gemological microscope

One of the peridot impurities caused by metamorphism, which is partially drawn and has liquid residues in it, is usually called Burmese peridot (Tahmasebi *et al.*, 2009). One of the impurities of green tourmaline with thin filaments in the form of hair is seen in the hydrothermal liquid phase, whose mines are in South Africa (Bayani, 2009). Peridot is an idiochromatic mineral, i.e. the coloring agent is part of the chemical formula, and tourmaline is allochromatic, which is a coloring agent separate from the chemical formula of the mineral (Bayani, 2009).

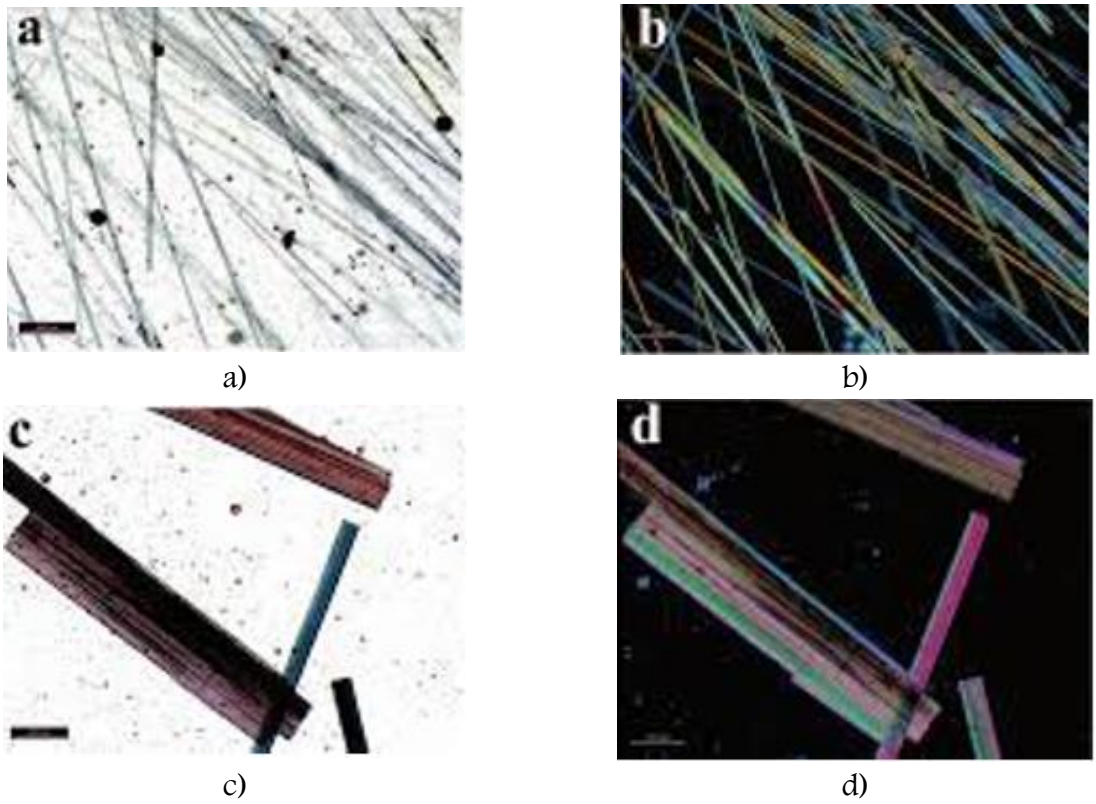

Figure 5. You can see the needle impurities in tourmaline that have grown. This impurity is made of crystal.

Tourmaline is crystallized from a geometric crystallographic point of view in a 3m class hexagonal system. Its physical properties include hardness of 7 to 7.5, the density of 3 to 3.25, glass to gum polish, and shell fracture. Optical properties of tourmaline also include direct blackout, high protrusion, and inverse polychromatism (Bayani, 2009). Tourmaline is shaped with hydrothermal origin called post-magmatic (delayed) tourmalines, in the final stages of magma crystallization and due to the reaction of boron-rich fluid with the host rock and alteration. These tourmalines often have a clear halo that is caused by the reaction of a portable fluid with a host rock (Wise, 2016). The source of this mineral is pegmatites, granites, and aplites that cut granite masses. Tourmaline is also found subdivided in metamorphic and sedimentary rocks.

The nominal similarity of tourmaline is derived from the word tourmali meaning ash adsorbent because this mineral with piezoelectric properties absorbs ash due to heat (Shen *et al.*, 2011).

One of the processes of tourmaline formation in igneous rocks is the effect of hot gases containing boron in the pneumatic stage and alteration of igneous rocks and finally their conversion to tourmaline. In other words, this mineral is formed by the reaction of magmatic-hydrothermal fluids rich in boron in granitic environments with the host rock (Leelawatanasuk *et al.*, 2014).

In metamorphic rocks, the term tourmalinite is used for tourmaline. This mineral is stable in all degrees of metamorphism and the boron element is considered as a mobile element during metamorphic phenomena that can be released from its parent rock due to dewatering and dehydration phenomena with increasing degree of metamorphism (Koivrzla & Fryer, 1986).

The greener the peridot, the juicier and smoother they are and the sooner they break down (Li, 1993). It is one of the few rocks that have a color factor in its chemical composition and has been formed because of interactions within molten materials. Against chemical agents, sulfuric acid and hydrochloric acid are more or less corroded. What helps identify peridot is the presence of a strong double fracture and the dual appearance of impurities on the sides (Le Fort, 1991).

By 10x magnification in peridot rock, one can see a special impurity called lily pad, which is an impurity of liquid and gas and due to the crystallization of the liquid inside the cavities in the stone, it is seen in the form of dark brown octagonal crystals (Nagatani, 1988).

All these aspects make the boron isotope system useful in the study of deposits because in most cases the host is predominantly boron and allows it to maintain its isotopic ratio in terms of chemical, thermal, and mechanical stability.

Changing conditions during the formation of tourmaline crystals often lead to the formation of single crystals that contain two or more dissimilar colors in the rock. The premature color usually grows by the next color. These two-color crystals are known as "zoned crystals."

Inspection of tourmaline with radiation can make many light-colored stones clearer. If the stones are heated, the results are often reversed. In addition, with exposure to intense light, the results may be reversed over time.

The distribution of tourmaline in metasomatized, secondary halo, and flow sediments is usually much larger than the appropriate size of ore bodies. This fact indicates that it could be useful for geochemical exploration. The reddish-purple to orange-red color spectrum is called Rubellite. This type of color has a color similar to ruby or pink sapphire. The reason for this red color is the element manganese, and sometimes the pink type has the element titanium. The presence of iron creates a range from very strong blue and bluish-green to yellowish-green in the rock.

Peridot with the quality of precious stones has been reported in various sources, including Zabrgad Island (Webster, 1983).

Common Lathes in Peridots

One of the best methods of lathing in peridots is step cutting. This very simple lathe consists of plates parallel to the edges of the jewel, which is cut from the ring of the belt up and down with a steeper slope, and the lower part of the jewel often has more levels than the upper part. Other lathes include oval, circular, flat, and composite lathes.

In composite lathing, the upper part of the crystal has a flat and large plate and the lower part has several plates that have fixed angles concerning the edges of the gem (Harlbut & Kammerling, 1991).

This mineral has incomplete cleavage parallel to the vertical crystal axis. Its crystallization system is orthorhombic, which has short and thick prisms with longitudinal lines on the crystal. Peridot has a glassy or oily sheen and decomposes under the action of sulfuric acid. It is not resistant to high pressure and is often covered with a thin metal coating to protect it from impact. The phenomenon of strong double failure in this mineral is a good characteristic for its detection. These crystals form when hot water and steam evaporate the elements needed to form the rock into cavities and fractures, which provide open space for the crystals to grow. The size of tourmaline crystals formed in these cavities ranges from tiny millimeter crystals to massive prisms weighing more than 100 kg.

Minerals Similar to Peridot

The oil gloss profile and strong peridot dual fracture help to differentiate these stones from similar types. Peridot has historically been mistaken for other gems, including the emerald. Many royal emeralds are similar to peridots, although peridot has distinctly different shades of green. Emerald is dark green in contrast to yellowish-green and always has inclusion (such as three-phase inclusions, internal growth pattern, etc.). Other green gems that may be mistaken for peridot include green and moldavite garnets (no double fracture), apatite (much softer), green tourmaline, and green sinhalite (both strong multicolors), and green zircon (specifically heavier). All of these jewels rarely have a yellow component with their green color, while most peridots have this property.

Miners find peridot in some lava flows in the United States, China, and Vietnam in the form of rugged clumps (round boulders with peridot crystals inside) and very rarely, in the form of large crystals in certain types of solidified molten rock. Peridot sources in countries include Finland, Pakistan, Myanmar, and Zabargad Island.

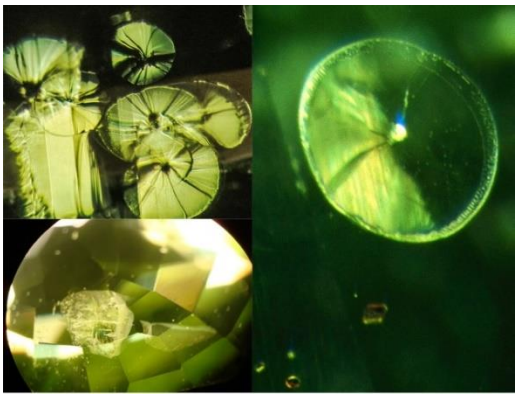

Figure 6. Lily Pad impurities in peridot, These disk-like fracture inclusions in peridot are descriptively called lily pads.

Peridot is effortlessly hydrothermally decomposed and, on the other hand, is easily affected by low-grade metamorphic phenomena and atmospheric factors.

The most shared materials for peridot decomposition are serpentine, iddingsite, bolengite, chlorite, amphibole, talc, carbonates, and iron oxides. These materials may be in the form of tiny granules.

Origin of Peridot Formation

Magmatic - Basal pegmatites - Adjacent metamorphism - Alluvium - Meteorites

Peridot can rarely have an extraterrestrial source, such as in meteorites that have fallen to Earth. The color range of peridot is limited, from a brown-green, yellowish green to pure green, yellowish-green is the most common peridot color found in jewelry.

Peridot stone is slightly brittle and cracks in the face of severe impact, and does not last in acidic environments. The peridot olive color is due to the element iron in this stone. Peridot is also available in yellow-olive or brownish-yellow colors, but its grass green color is very popular.

Peridots are found all over the world. One of the oldest and most important peridot mines on the volcanic island of St. John. John's Island is the Red Sea.

Figure 7. Zabargad Island has been a source of gem peridot since the time of Greco-Roman rule in Egypt. Archaeological excavations have revealed interesting information about the commercial exploitation of these resources, and geological investigations have provided important knowledge about the formation of the Red Sea and upper mantle conditions.

DISCUSSION

Peridot is a transparent gemstone from the olivine family with a hardness of 6.5 to 7, which forms a group of iron-magnesium-rich silicate minerals. Amethyst is one of the rare gems that is

characterized by a monochromatic olive green color. This gem has incomplete cleavage, glass polish and light refraction of 1.690 to 1.654. Olivine, of which peridot is one of its types, is a common mineral of mafic and ultramafic rocks and is often found in lavas and alien peridotitic rocks of the earth's mantle that reach the surface of the earth through lavas; But it is found only in small parts of the mentioned areas.

Peridot does not have the Florence phenomenon. Its crystal form is orthorhombic and it is usually cut as faceted (mixed and step-cut), cabochon and beads. Gemologists are usually surprised to see the large variety of this gem because it usually exists in small form. One of the rare types of this mineral is cat's eye and star Peridot.

The trigonal tourmaline crystal system consists of hexagonal or three-cornered prisms and some circular ones. In fact, this is a piezoelectric and hemimorphic mineral whose two crystal heads have different end plates. In nature, tourmaline stone has the most variety of colors among jewelry minerals, and usually iron, manganese, chromium, copper and vanadium elements are the coloring agents in this family. Red, orange, blue, pink, yellow, green, blue, purple, purple, colorless and black are among the colors that this gem can have. In Brazil, almost every type of this gem can be found.

CONCLUSION

In nature, tourmaline and peridot are both found in green, which must be separated under a microscope to examine the types of impurities that distinguish them from each other. Green tourmalines are commonly found in Brazil and Africa, and their coloring agents are chromium and vanadium. It has the radiance of tourmaline, green, and peridot polish. Two types of tourmaline found in green in Tanzania and Namibia, which can be very similar to Peridot, which one can view using a Chelsea filter (a device that displays the specific light properties of each gem) and distinguish them from each other according to their optical properties.

Green tourmalines are found in the mines of Namibia and green peridot is found in the mines of Pakistan, Sri Lanka, South Africa, etc. Again, due to the differences seen in their mines, their types of impurities can be different from each other. Another way to identify and distinguish peridot from tourmaline is to find their hardness. The hardness of peridot is 6.5 to 7 and the hardness of tourmaline is 7 to 7.5 that if we can identify it, these two minerals can be distinguished from each other. Gemologists can see the green color clearly by placing the peridot under a microscope, which is very light. In contrast, tourmaline green is slightly darker if you look closely, and differs in transparency, although peridot in dark green is also found in nature. The phenomenon of strong double fracture in peridot minerals is a good characteristic for distinguishing it from tourmaline. Peridots often contain needle-shaped impurities of the minerals ludwigite and vonsenite. Lily Pad or lotus impurity is an impurity found in peridot and can be distinguished from tourmaline by observing it under a peridot microscope.

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