May 10, 2021

Olivine

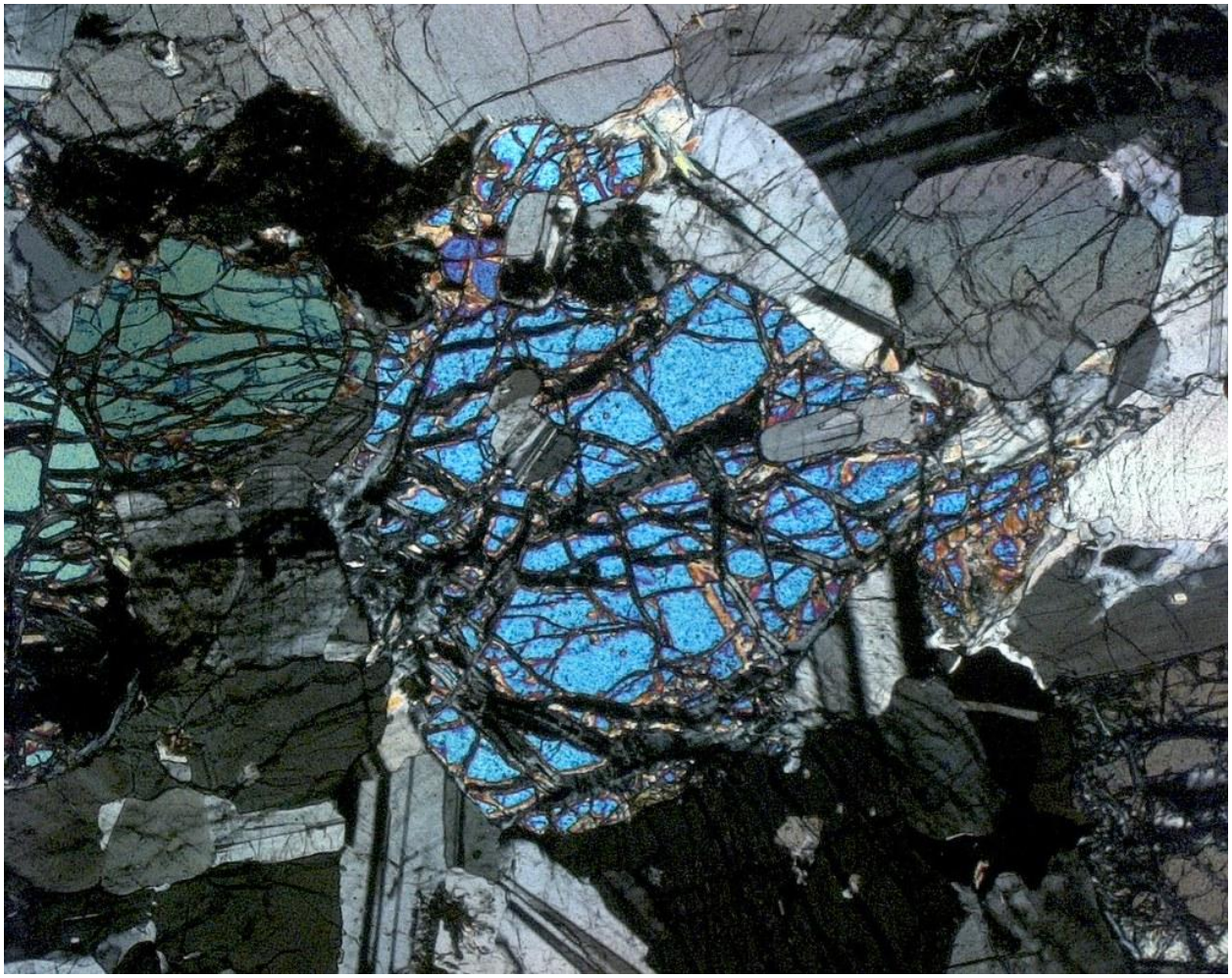

Figure 1 - Olivine in Thin Section

Olivine is an important rock forming mineral. It is also interesting in its own right. The Olivine Group includes the Fayalite-Forsterite Series, Monticellite, Kirschsteinite, Tephroite, and Knebelite. The most common examples of olivine are found in the Fayalite-Forsterite Series, a solid solution series of iron-magnesium silicates. Replacing the iron and magnesium cations in the atomic matrix with calcium or manganese will make the other olivine minerals.

The distinguishing characteristics of olivine is its olive green colour, its orthorhombic crystal shape and moderate to imperfect cleavage.

Olivine minerals are typically found in dunite, peridotite, gabbro, dolerite, basalt and syenite, but can also be found in sediments that have been thermally metamorphosed through contact with

an igneous intrusion. It is when rocks have been thermally metamorphosed that the iron and magnesium in Fayalite-Forsterite olivine can be replaced with calcium or manganese. Figure 2, below, graphically shows how thermally metamorphosis works.

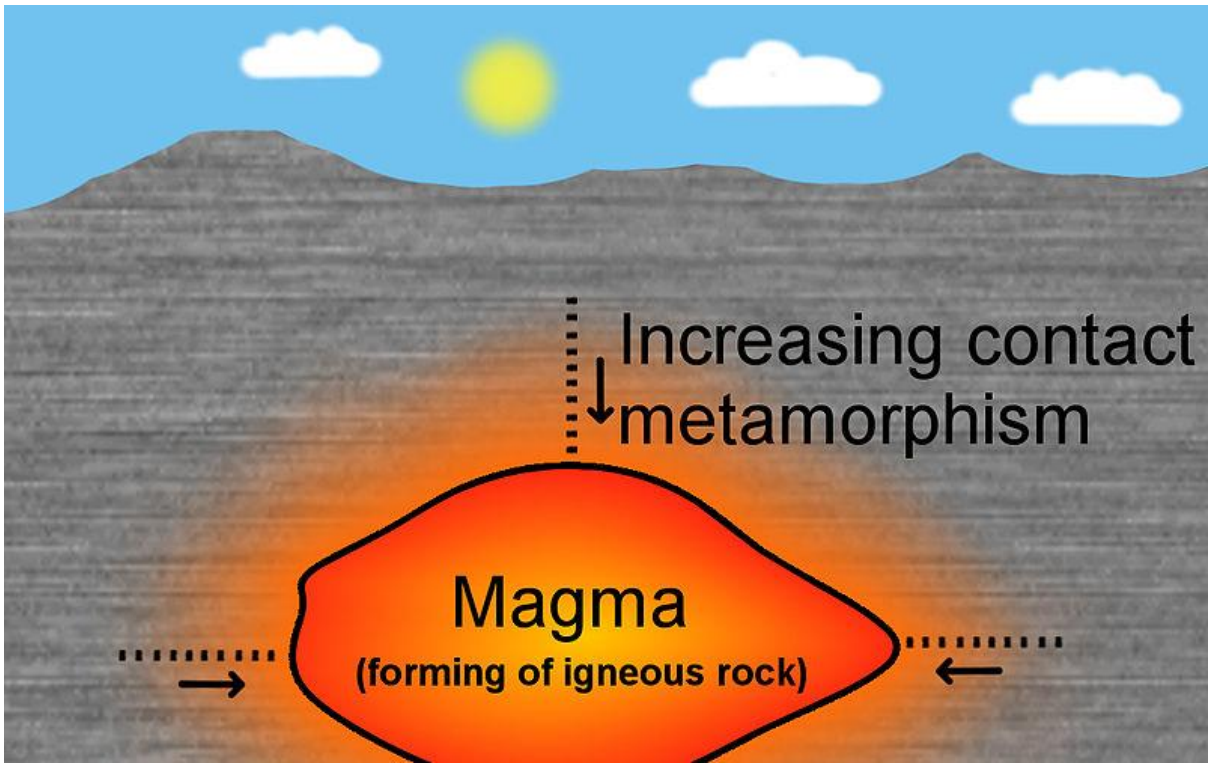

Figure 2 - Thermal Metamorphosis

Much of the Earth's mantle is made up of olivine and olivine is also found in some meteorites. Researchers Michael J. Russell and Adrian Ponce listed olivine as one of the "Six 'Must-Have' Minerals for Life's Emergence".

Chemistry and Structure

The general chemical formula for olivine is

$$A_2SiO_4$$

Where **A** is a cation such as iron (Fe^{2+}), magnesium (Mg^{2+}) calcium (Ca) or Manganese (Mn) and SiO_4^{4-} is the silicate anion.

The general description of the structure of olivine is orthosilicate. The silicate anion forms a tetrahedron that is not directly linked to other silicate tetrahedrons. Rather, the tetrahedrons are linked by the cations, as in Figure 3.

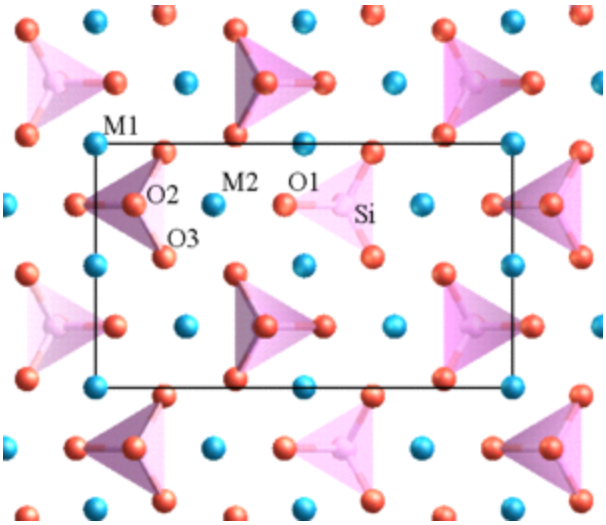

Figure 3 - Atomic Structure of Olivine
Credit: andreww , Public Domain

Olivine Minerals

Fayalite-Forsterite Series

Figure 4 - Olivine
Credit: Aram Dulyan, Public Domain

The classic olivine minerals are those that are part of the Fayalite-Forsterite Series. Fayalite, Fe_2SiO_4, and forsterite, Mg_2SiO_4, form a solid solution series. Figure 5, below, shows a phase diagram for the Fayalite-Forsterite Series.

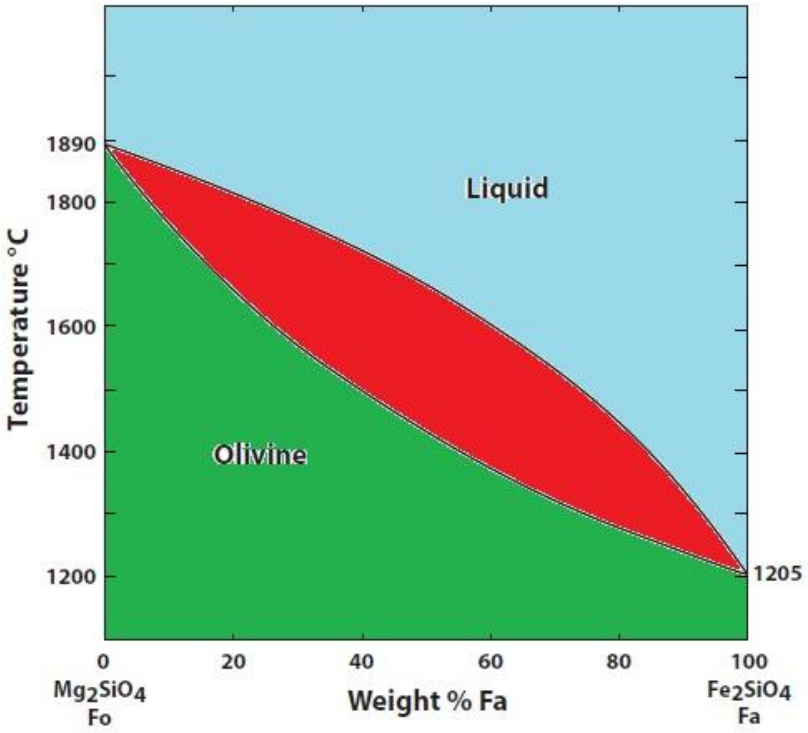

Figure 5 - Forsterite-Fayalite Series
Modified from Binary Phase Diagrams

Pure examples of forsterite are rare in nature, almost always there is a mixture or iron and magnesium in the crystal matrix. This is usually expressed as the forsterite percentage: the abbreviation Fo_{75} means that the olivine is 75% forsterite. Olivine that leans toward the forsterite composition, Fo_{92} and Fo_{88}, is found in dunite and peridotite. Gabbro, dolerite, basalt, and trachyte often contain olivine in the Fo_{85} to Fo_{40} range.

Iron rich olivine and relatively pure fayalite are found in dolerite , ferrogabbro, granophyre and syenite rocks. Fayalite also occurs in iron rich sediments that have been thermally metamorphosed.

Fayalite is named after the Island of Faial in the Azores. Forsterite is named after Johann R. Forster, a German scientist and explorer.

Monticellite

Figure 6 - Monticellite Crystals on Brown Vesuvianite

Credit: Robert M. Lavinsky, iRocks.com – CC-BY-SA-3.0

Named after the Italian geologist Teodoro Monticelli, Monticellite, $CaMgSiO_4$, is a gray to colourless mineral. It is most commonly found in thermally metamorphosed rocks at the contacts between volcanic rocks and siliceous dolomitic limestone.

Kirschsteinite

Figure 7 - Kirschsteinite

Credit: Leon Hupperichs, Creative Commons Attribution-Share Alike 3.0 Unported

Kirschsteinite, $CaFe^{2+}SiO_4$, is a greenish grey olivine mineral where calcium has been incorporated into the crystal matrix. It is typically found in calcareous skarn, another thermally metamorphosed rock formed in the contact between intrusive volcanic rock and limestone sedimentary rock. Kirschsteinite was named after the German geologist Dr. Egon Baron von Kirschstein, best known for a disastrous 1908 expedition to Mount Karisimbi on the border between Rwanda and the Democratic Republic of the Congo.

Tephroite and Knebelite

Figure 8 - Tephroite

Varying in colour from grey, to olive-green, to flesh red or reddish-brown, to dark brown and black, Tephroite, Mn_2SiO_4, and closely related Knebelite, $(Mn\ Fe)_2SiO_4$, are formed where manganese is incorporated into fayalite. These two minerals are also found skarns formed in the contact between intrusive volcanic rock and iron-manganese ores.

Tephroite was named by Johann Friedrich August Breithaupt for its colour, from the Greek τεφροζ "tephros" = ash-coloured. Knebelite was named after a German poet and translator, Karl Ludwig von Knebel.

Olivine as Jewelry

Figure 9 - Swarovski Tennis Bracelet in Olivine
Credit: Mannia&Titta licensed under CC BY-ND 2.0

Olivine is best known as the jewel Peridot. Peridot serves as a birthstone for the month of August. The most valuable Peridot crystals are dark green or lime green and are relatively clear. Gem quality olivine tends to be on the Forsterite end of the Forsterite-Fayalite Series.

Standard Caveat

The purpose of my weblog postings is to spark people's curiosity in geology. Don't entirely believe me until you've done your own research and checked the evidence. If I have sparked your curiosity in the subject of this posting, follow up with some of the links provided here. If you want to, go out into the field and examine some rocks on your own with the help of a good field guide. Follow the evidence and make up your own mind.

In science, the only authority is the evidence.