Anomalous birefringence in garnets from SW Sardinia

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The garnet supergroup includes 32 species, 30 of which are cubic, but in literature garnets with intermediate compositions which show anomalous birefringence are known.

Birefringent, euhedral, centimeter-sized garnet, commonly black but also dark-green or orange, has been found in few decameter-sized skarn lenses close to Villa San Pietro (SW Sardinia). These lenses are made up by a massive, fine-grained, black to greenish matrix, mainly consisting of garnet, epidote, amphibole, wollastonite, quartz, calcite and graphite.

In thin section garnets appear colorless or pale rose or green and not pleochroic; black garnets host graphite inclusions in the core, commonly arranged in a cross shape, whereas orange and green garnets are usually inclusion-free. In crossed polars all garnets are birefringent and clearly zoned. The core has high interference colors and is surrounded by two or three concentric rims with different optical features. The inner rim, when present, is thin and with second order interference colors. The medium rim, representing the major volume of the whole crystal, is characterized by low birefringence and a tartan-like extinction that resembles cross-hatched twinning of microcline. The outer rim is similar to the inner one for thickness and birefringence. The transition between the different zones is sharp and with parallel and well developed faces.

Powder XRD analyses, even if not decisive due to the similarity of the patterns of many garnet end-members, indicate for all analyzed crystals a mix of grossular, andradite and possible katoite.

Microanalyses performed by SEM show that chemical zonation exactly follows the optical zonation. From the core to the outer rim, Al_2O_3 decreases from 20-21 wt.% to 1-2 wt.% and FeO_{tot} increases from 3-5 wt.% to 25-27 wt.%. Within the iron-rich medium rim, as well as in the outer rim several micrometer-thick, concentric bands showing enrichment in Al_2O_3 and depletion of FeO_{tot} are commonly present. CaO and SiO_2 are constant in all layers (~33 wt.% and ~39 wt%, respectively), whereas MnO and MgO contents are negligible.

According to Shtukenberg et al. (2005) the possible mechanism leading to anisotropy in garnets is the loss of "long-range order" in the calcium series of garnet; Antao (2013) suggests that the birefringence is induced by the intergrowth and relative strain of two or more different cubic end-members, as andradite and grossular.

Further analyses such as HR-XRD, Rietveld refinement and chemical analyses that can measure the possible hydroxyl content are required in order to decipher the origin and the evolution of these garnets.

Shtukenberg, A.G., Popov, D.Y. & Punin, Y.O. (2005): Growth ordering and anomalous birefringence in ugrandite garnets. Min. Mag., 69, 537-550.

Antao, S.M. (2013): Three cubic phases intergrown in a birefringent andradite-grossular garnet and their implications. Phys. Chem. Min., 40, 705-716.