GARNET GROWTH IN THE NUFENEN PASS AREA (SWISS ALPS)

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Abstract

Textural division of a mineral in pyramids, with their apices located at the centre of the mineral and their bases corresponding to the mineral faces is called textural sector zoning. Textural sector zoning is observed in many metamorphic minerals like andalousite and garnet. Garnets found in the graphite rich black shales of the Mesozoic cover of the Gotthard Massif display textural sector zoning. The morphology of this sector zoning is not the same in different types of black shales observed in the Nufenen pass area. Garnets in foliated black shales display a well developed sector zoning while garnets found in cm-scale layered black shales display well developed sectors in the direction of the schistosity plane. This sector zoning is always associated with up to 30μm sized birefringent lamellae emanating radial from the sector boundaries. They alternate with isotrope lamellae.

The garnet forming reaction was determined using singular value decomposition approach and results compared to thermodynamic calculations. It is of the form chl + mu + cc + cld = bt + fds + ank + gt + czo and is similar in both layered and foliated black shales. The calculated X(O) is close to 0.36 and does not significantly vary during the metamorphic history of the rock. This corresponds to X_{CO2}, X_{CH4}, and X_{H2O}

BSE imaging of garnets on oriented-cuts revealed that the orientation of the lamellae found within the sectors is controlled by crystallography. BSE imaging and electron microprobe analysis revealed that these lamellae are calcium rich compared to the isotropic lamellae. The addition of Ca to an almandine rich garnet causes a small distortion of the X site and potentially, ordering. Ordered and disordered garnet might have very similar free energies for this composition. Hence, two garnets with different composition can be precipitated with minor overstepping of the reaction. It is enough that continued nucleation of a new garnet layer slightly prefers the same structure to assure a fiber-like growth of both garnet compositions side by side. This hypothesis is in agreement with the thermodynamic properties of the garnet solid solution described in the literature and could explain the textures observed in garnets with these compositions.

To understand the differences in sector zoning morphology, and crystal growth kinetics, crystal size distribution were determined in several samples using 2D spatial analysis of slab surfaces. The same nucleation rate law was chosen for all cases. Different growth rate law for non-layered black shales and layered black shales were used. Garnet in layered black shales grew according to a growth rate law of the form $R=kt^{1/2}$. The transport of nutrient is the limiting factor. Transport will occur preferentially on the schistosity planes. The shapes of the garnets in such rocks are therefore ovoid with the longest axis parallel to the schistosity planes. Sector zoning is less developed with sectors present only parallel to the schistosity planes. Garnet in non-layered blackshales grew according to a growth rate law of the form $R=kt$. The limiting factor is the attachment at the surface of the garnet. Garnets in these rocks will display a well developed sector zoning in all directions. The growth rate law is thus influenced by the texture of the rock. It favours or hinders the transport of nutrient to the mineral surface.