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On the use of SEM techniques to determine clockwise or counterclockwise P-T paths: insights from metapelites (Yunquera Unit, Betic Cordilleras)

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Garnet porphyroblast textures and compositions, coupled to those of accompanying phases, are one of the most useful tools to determine the change of P-T conditions during metamorphism. This is currently done quantitatively through the use of conventional thermobarometry and pseudosection analysis, whose validity is conditioned by assumptions on the chemical mineral equilibrium (e.g. Spear, 1993). In the case of metapelites, the classic approach involves the use of core to rim compositions in zoned garnets and coexisting phases by electron microprobe analysis. Nonetheless, it is a high time consuming technique. As an alternative, we test the use of back-scattered electron (BSE) images and semi-quantitative energy-dispersive X-ray spectroscopy profiles obtained by scanning eletron microscope (SEM-EDX) to distinguish between clockwise and counterclockwise P-T paths. We applied these SEM techniques in samples of micaschist from the Yunquera Unit (Internal Zone, Betic Cordilleras, Spain) (Dürr, 1969).

BSE images were obtained on selected areas covering the texturally and mineralogically most significant garnet-bearing portions, whereas semiquantitative profiles for Ca, Fe, Mg and Mn were obtained by means of EDX counting. Different types of chemical profiles were observed: (a) normal (growth) continuous zoning, (b) discontinuous, and (c) reverse continuous zoning. The patterns of chemical profiles are in agreement with changes in internal microstructures and density of inclusion. Two types of continuous growth zoning were identified in subspherical garnets bearing internal foliations. XMn and XFe ratios show the classical bell-shaped geometry while XCa increases in some cases and decreases in others towards rims. Discontinuous garnet profiles are typical of multistage garnet growth, which is outlined by the occurrence of alternating low- and high-inclusion density areas. Garnets with low-inclusion density cores show homogeneous core composition with an abrupt change towards the rims marked by a rapid increase in XCa and decrease in XFe and XMg ratios. Garnets with high-density inclusion cores depict XCa ratios at core similar to the previous ones and a sudden decrease towards the rims, whereas XFe and XMg continuously increase from core to rim. Reverse continuous profiles are typical of small idiomorphic garnets either enclosed or surrounding large muscovite porphyroblasts. These garnets show an increase in XMn and a decrease in XFe and XMg ratios from core to rim with minor variations in Ca.

Taken as a whole, the chemical profiles reveal a generalized increase in Fe# [Fe/(Fe+Mg)] towards the rims that would attest to a temperature increase during the growth of the garnets. In addition, continuous and discontinuous variations in XCa ratios in large garnets suggest prograde garnet growth following a clockwise P-T path evolution, that is, a pressure increase followed by decrease under continuously increasing T conditions.

As a conclusion, it is suggested that a method based mainly on the acquisition of BSE images and semiquantitative chemical profiles on selected minerals, and their interpretation using conventional thermo-barometric reasoning would be useful in the establishment of relative P-T paths that might help to save time and better identify the areas of interest for later detailed electron microprobe studies.

References:

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