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May eclogite dehydration cause slab fracturation ?

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Petrological and geophysical evidences strongly indicate that fluids releases play a fundamental role in subduction zones as in subduction-related seismicity and arc magmatism. It is thus important to assess quantitatively their origin and to try to quantify the amount of such fluids. In HP metamorphism, it is well known that pressure-dependent dehydration reactions occur during the prograde path. Many geophysical models show that the variations in slab physical properties along depth could be linked to these fluid occurrences. However it remains tricky to test such models on natural sample, as it is difficult to assess or model the water content evolution in HP metamorphic rocks. This difficulty is bound to the fact that these rocks are generally heterogeneous, with zoned minerals and preservation of different paragenesis reflecting changing P-T conditions. To decipher the P-T-X(H_2O) path of such heterogeneous rocks the concept of local effective bulk (LEB) composition is essential. Here we show how standardized X-ray maps can be used to constrain the scale of the equilibration volume of a garnet porphyroblast and to measure its composition. The composition of this equilibrium volume may be seen as the proportion of the rock likely to react at a given time to reach a thermodynamic equilibrium with the growing garnet.

The studied sample is an eclogite coming from the carboniferous South-Tianshan suture (Central Asia) (Loury et al. in press). Compositional maps of a garnet and its surrounding matrix were obtained from standardized X-ray maps processed with the program XMapTools (Lanari et al, 2014). The initial equilibration volume was modeled using LEB compositions combined together with Gibbs free energy minimization. P-T sections were calculated for the next stages of garnet growth taking into account the fractionation of the composition at each stage of garnet growth. The modeled P-T-X(H_2O) path indicates that the rock progressively dehydrates during the prograde path, leading to a complete dehydration at the pressure peak conditions, (25 kbar and 510°C). The amount of water released during this stage is about 20 g/dm3. In this example, no hydration event is recorded during the exhumation, explaining the good preservation of the anhydrous eclogite.

This study shows that garnet thermobarometry in eclogite may be used as a proxy for progressive oceanic crust dehydration as suggested by the models of Baxter & Caddick (2014). In contrast to such models, the estimations proposed in the present study are based on the measured composition of local domains in rock-samples and not on average bulk rock compositions. Complete dehydration of eclogites around 75 km corresponds to the maximum depth of most exhumed oceanic eclogites except for a few special cases. Moreover the distribution of seismicity along the slab shows that only few earthquakes do occur in the crust beyond this limit as compared to the seismicity above it. Consequently this example from a natural sample strongly suggests that the eclogite dehydration at this depth can cause slab fracturation and consequently enhance eclogite exhumation.

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