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Garnet cannibalism provides clues to extensive hydration of lower crustal fragments in a subduction channel (Sesia Zone, Northwestern Alps)

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The extent to which granulites are transformed to eclogites is thought to impose critical limits on the subduction of continental lower crust. Although it is seldom possible to document such densification processes in detail, the transformation is believed to depend on fluid access and deformation.
Remarkably complex garnet porphyroblasts are widespread in eclogite facies micaschists in central parts of the Sesia Zone (Western Italian Alps). They occur in polydeformed samples in assemblages involving phengite+quartz+rutile ±paragonite, Na-amphibole, Na-pyroxene, chloritoid. Detailed study of textural and compositional types reveals a rich inventory of growth and partial resorption zones in garnet. These reflect several stages of the polycyclic metamorphic evolution. A most critical observation is that the relict garnet cores indicate growth at 900 °C and 0.9 GPa. This part of the Eclogitic Micaschist Complex thus derived from granulite facies metapelites of Permian age. These dry rocks must have been extensively hydrated during Cretaceous subduction, and garnet records the conditions of these processes.
Garnet from micaschist containing rutile, epidote, paragonite and phengite were investigated in detail. Two types of garnet crystals are found in many thin sections: mm-size porphyroclasts and smaller atoll garnets, some 100 μm in diameter. X-ray maps of the porphyroclasts show complex zoning in garnet: a late Paleozoic HT-LP porphyroclastic core is overgrown by several layers of HP-LT Alpine garnet, these show evidence of growth at the expense of earlier garnet generations. Textures indicate 1-2 stages of resorption, with garnet cores that were fractured and then sealed by garnet veins, rimmed by multiple Alpine overgrowth rims with lobate edges.
Garnet rim 1 forms peninsula and embayment structures at the expense of the core. Rim 2 surrounds rim 1, both internally and externally, and seems to have grown mainly at the expense of the core. Rim 3 grew mainly at the expense of earlier Alpine rims. In the same samples that show porphyroclastic garnet, atoll garnet occurs, filled with quartz, and the same Alpine overgrowth zones are observed in both types of garnet. Similar features of garnet zoning are present in various lithotypes, allowing the evolution of this continental domain during subduction to be traced.
Modeling the different garnet growth zones is challenging, each growth step demanding an estimate the effective bulk composition. According to the XRF analyses of the bulk sample, the core is found to have formed at 900°C, 0.9 GPa. Based on effective bulk compositions, the successive Alpine rims are found to reflect an increase from 600°C, 1.55-1.60 GPa for rim 1 to 630-640°C, 1.9-2.0 GPa for rim 2. Allanite crystals contain inclusions of Alpine garnet; in situ geochronology (U-Th-Pb by LA-ICP-MS) on allanite yields a (minimum) age of ∼69 Ma for the main growth of garnet.
In summary, the textures and mineral compositions clearly reflect reactive interaction of major amounts of hydrous fluids with dry protoliths. The source of these fluids responsible for converting granulites back to micaschists at eclogite facies conditions within the Sesia subduction channel is being investigated.