U-Pb rutile and zircon dating of eclogite-facies quartz-rich veins and layers from the Münchberg Massif (Germany)

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Dating of accessory minerals in heterogeneous samples like vein-bearing eclogites provides not only the ages of key events, but it can also test the plausibility of proposed petrogenetic processes. Here, we present U-Pb data of rutile (analyzed by LA-ICP-MS) and zircon (analyzed by SIMS) from quartz-rich layers and their host eclogites from the Variscan Münchberg Massif, which experienced P-T conditions of ~700°C and at least ~30 kbar.

Rutile from a quartz-rutile vein (a 1 cm long phenocryst), its host eclogite, and two other eclogites from the same unit yield concordant dates around 390 Ma, with very low common Pb contents. These dates agree with published ages of peak metamorphism (380-400 Ma) despite peak temperatures close to the Pb closure temperature. Oxygen isotope data indicate disequilibrium between vein and host rock rutile, which may reflect either retrograde oxygen diffusion, or an external fluid origin. In any case, vein rutile of this size indicates growth from a fluid phase, and the rutile ages suggest vein formation during, or shortly after high-pressure metamorphism.

At another locality of the same major unit, a partly retrogressed kyanite-bearing eclogite derived from a plagioclase-rich cumulate gabbro (35 ppm Zr) contains several quartz-garnet (+Zo, Ky, Ph, Rt) layers (574 ppm Zr) that are subparallel to each other and to the eclogite foliation. Major and trace element, and oxygen isotope compositions of whole rocks and minerals are reconcilable with an internal origin of these quartz-garnet layers by dehydration or partial melting of the eclogite. The quartz-garnet layers host subhedral zircon crystals up to 200 µm long with a rim that is much brighter in cathodoluminescence images than the cores. The $^{206}Pb/^{238}U$ age of the zircon cores is around 500 Ma, thus coeval with the known eclogite protolith age of the Münchberg Massif. Zircon rims in the same sample yield dates that are scattered (probably due to variable Pb loss) around 360–400 Ma, consistent with their metamorphic growth.

It is intriguing that the quartz-garnet layers are enriched in relic magmatic zircon relative to the host eclogite. If these layers were formed by dehydration or partial melting of the host eclogite, as textures and chemical data may suggest, this would mean that the zircon crystals were inherited from the host eclogite protolith and mechanically concentrated in the vein/layer, followed by metamorphic rim growth. Alternatively, the quartz-garnet layers may reflect a different protolith, such as aplite dikelets that intruded the original gabbro and experienced the same subduction-exhumation cycle.