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Reaction zone between pre-UHP titanite and host rock: insights into fluid-rock interaction and deformation mechanisms during exhumation of deeply subducted continental crust (Dabie Shan UHP unit, China)

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Exhumed crustal UHP rocks may occur as relict blocks in strongly metasomatized matrix rocks. Due to variations in competence between the mm to km sized blocks and their ductile matrix, the largely undeformed blocks may preserve the pre-subduction and the prograde history, whereas the matrix rocks have been ductilely deformed to high magnitudes and record successive stages of deformation. The reaction zones between blocks and matrix, however, provide insights into the fluid-rock interaction, deformation and the deformation mechanisms active during the exhumation of deeply subducted continental crust in the subduction channel.

We investigate a titanite megacryst (3 cm in diameter) in a calc-silicate marble from the UHP unit in the Dabie Shan, China. The core of the titanite megacryst grew prograde during subduction. Its U-Pb system remained closed and yields a maximum age for UHP metamorphism. Sr and Nd isotope compositions in the core demonstrate that the titanite megacryst precipitated from a homogeneous fluid source. During metamorphism in the subduction zone, infiltration of external fluids resulted first in Sr-loss from the marbles and then introduction of Sr with unusually low 87Sr/86S values (Romer et al., 2003), leading to the contrasting 87Sr/86Sr values in the titanite megacryst and the hosting UHP marbles (Wawrzenitz et al., 2006).

Related to deformation in the calc-silicate marble matrix, the rim of the titanite megacryst has been replaced during the following dissolution-precipitation reactions:

(i) Pseudomorphic replacement of the old titanite megacryst by coupled dissolution-reprecipitation. Fluid migrated into the old grain producing a sharp boundary of the replacement front.

(ii) New small titanite grains grew with their long axes parallel to the foliation of the marble matrix, reflecting the activation of dissolution precipitation creep. In the matrix, the foliation is defined by the orientation of the basal planes of phengitic white mica. The new titanite grains are patchy zoned and replace, along with rutile, calcite, quartz, and apatite, the old titanite megacryst. This reaction reflects the changing CO_2 versus fluorine activity in the available fluid phase, rather than changing P-T conditions. The Sr isotope composition of the phases formed by these fluid-mediated reactions is variable and depends on the reaction-history and origin of the fluids.

(iii) Brittle deformation of the titanite megacryst induced the formation of fractures, enhancing fluid transport and precipitation of new titanite, allanite, calcite $\pm$ rutile, and albite (locally anorthite), as well as Zn(Fe) - and Cu - sulphides along the vein walls.

Dislocation creep is indicated by subgrains in local zones of high differential stress within the rim of the titanite megacryst. However, dissolution precipitation creep has been much more effective in changing the (isotope)chemical composition of titanite compared to dislocation creep.

Romer, R.L., Wawrzenitz, N., Oberhänsli, R., 2003. Terra Nova 15, 5, 330-336.
Wawrzenitz, N., Romer, R.L., Oberhänsli, R., Dong, S., 2006. Lithos 89, 1-2, 174-201.