Dating prograde metamorphism by linking zircon recrystallization to fluid pulses

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During metamorphism, the formation or recrystallization of accessory phases is commonly triggered by fluid pulses, either from an external source, or liberated by dehydration reactions within the rock. We combined thermodynamic modelling, trace element analysis, zircon inclusion chemistry and U-Pb dating, to tie the dissolution-reprecipitation of zircon to prograde dehydration reactions in UHP rocks and to provide robust and precise ages for these reactions.

The Dora Maira whiteschists (Western Alps, Italy) are derived from an altered granite and were subducted to 40 kbar, 720°C to form phe-grt-ky-(qtz/coe) assemblages. Zircon rims and monazites yield Alpine ages of 34.5-34.9 Ma. In quartz-poor samples, zircons consist of a magmatic core surrounded by two metamorphic rims. Inner rims are HREE-rich, and thus crystallised when little garnet was present to fractionate REE. Outer zircon rims are depleted in HREE, indicating equilibrium with the garnet rims, and thus crystallised at near-peak conditions.

By modelling the prograde P-T path from 15 kbar, 600°C to 40 kbar, 720°C using Theriak, we show that the two rims correspond to different dehydration reactions. The first is the destabilisation of chlorite to produce biotite at 25 kbar, which produced 3.5 vol% H_2O. The second zircon growth is linked to the progressive disappearance of biotite from 30 kbar and talc at 40 kbar which liberated 2.5 vol% of H_2O. The $\delta^{18}O$ values of the two zircon rims are identical, supporting the conclusion that external fluids were not involved. The fluid liberated from the dehydration reactions led to the dissolution of the magmatic zircon cores and precipitation of prograde biotite and phengite inclusions whose Si p.f.u. match the compositions of 25 and 35 kbar experiments [1] respectively. Monazite recrystallised only with the second reaction. The dates obtained for these two events are identical within uncertainty at 34.5 Ma, which yield a maximum burial rate of ca. 2 cm/yr from 25 to 35 kbar. Combined, our U-Pb, REE, $\delta^{18}O$ and zircon inclusion data allow resolving the prograde P-T-time-fluid path of the Dora Maira UHP whiteschists.

[1] Hermann (2003), *Lithos* **70**, 163-182