Geophysical Research Abstracts
Vol. 21, EGU2019-14824-1, 2019
EGU General Assembly 2019

New constraints on the timing of Alpine metamorphism in the eastern Central Alps from in situ U–Pb geochronology of low-U titanite and rutile

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Dating low-grade metamorphic events is notoriously challenging, as under these conditions many geochronometers are not reset (or only partially), and the assumption of isotopic equilibrium at the sample scale - which underpins methods such as Rb–Sr isochron dating – is increasingly difficult to justify. An appealing approach to date moderate-temperature metamorphism is to U–Pb date newly-formed minerals that grew below their closure temperature, but low U contents are a common challenge in this setting. We present an adapted technique to improve the precision and accuracy of sample U–Pb ages determined on young, low-U minerals, by using a two-dimensional U-Pb isochron determined on a conventional concordia instead of the Tera-Wasserburg concordia typically used for this type of regression. In young samples where low radiogenic Pb is the limiting factor analytically, this has the advantage of using the most precise input ratios (i.e. ^{207}Pb/^{235}U instead of ^{207}Pb/^{206}Pb). We show that this approach is mathematically justified, and yields improved data.

We present an example from the eastern Central Alps, where we dated titanite and rutile from the Ur Breccia, which occurs at the interface between stacked continental and oceanic units in southeast Switzerland. Alpine metamorphism of these units did not exceed 450–500 ºC, and the timing of Alpine metamorphism in this region is poorly constrained based on highly scattered data from moderate-temperature geochronometers. In the Ur Breccia samples, titanite rims rutile, and is aligned in the main foliation, indicating that it formed at the expense of rutile during Alpine metamorphism. Based on textural observations and the new geochronological data, rutile and titanite are both shown to be newly formed during Alpine metamorphism, with rutile growing close to Alpine peak pressures, and titanite crystallising during subsequent decompression. As peak Alpine temperatures did not exceed the closure temperature of Pb in either rutile or titanite, U–Pb geochronology of these minerals directly dates their growth during Alpine metamorphism. Rutile and titanite have low U contents, which in combination with their young ages result in very low concentrations of radiogenic Pb, and high and variable proportions of common Pb. Two-dimensional conventional concordia isochron ages reveal that rutile formed at 62 $\pm$ 7 Ma, while titanite grew at 54 $\pm$ 5 Ma. Our ages indicate that the Alpine pressure peak in the Malenco–Margna area occurred in the early Tertiary, significantly later than thought based on previous geochronology, and permit at most 20 Myr (and possibly much less) between the Alpine pressure maximum and subsequent decompression.