EGU23-732, updated on 26 Apr 2024
https://doi.org/10.5194/egusphere-egu23-732
EGU General Assembly 2023

Complementing the hydration history of an inverted passive continental margin using epidote U–Pb geochronology and isotope geochemistry

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Crustal rocks involved in orogenic processes frequently bear evidence for widespread fluid circulation. The hydration history of the granitic continental crust in inverted passive continental margins is of particular interest, as granitoids experience rheological weakening by fluid-rock interaction processes. Regrettably, it is often unclear if hydration occurs during rifting or during tectonic inversion. Hence, it is difficult to appreciate the interplay of pre- and syn-orogenic fluids inside continental crustal segments of rifted margins. The geochemical fingerprint of ancient hydration events is stored in hydrous minerals that crystallized directly from circulating paleo-fluids. Thus, such minerals can shed light on the nature of these ancient fluids, as well as provide temporal constraints if they can be dated. Hence, advances in geochronological methods applied to hydrous minerals may prove pivotal in untangling the history of fluid circulation in the granitic continental crust in orogens.

We applied U–Pb geochronology of epidote [i.e., $Ca_2Al_2(Al,Fe^{3+})Si_3O_{12}(OH)$] in hydrothermal veins hosted by a late Carboniferous/early Permian calc-alkaline granodiorite in the inverted Adriatic passive continental margin (hereafter “Err nappe”), both located in the eastern Swiss Alps. During Jurassic rifting leading to the break-up of Pangea, the continental crust in the Err nappe was hydrated, as seawater-derived fluids percolated along syn-rift faults. However, geochronological data of epidote reveal that the hydration of the granitic continental crust in the Err nappe occurred also later during inversion. Epidote U–Pb geochronology returned two age clusters: (1) 85.2 ± 9.7 Ma, related to Late Cretaceous compression; and (2) 59.9 ± 2.7 Ma, related to subsequent Paleocene extension. These age clusters unveil two distict events of fluid circulation, which are consistent with the timing of tectonic inversion and deformation proposed in the literature. As confirmed by Pb–Sr–O–H isotope geochemistry of epidote, Late Cretaceous fluid circulation was likely mediated by fluids released by underlying units undergoing metamorphism during Eo-Alpine compression. Notably, the Paleocene fluids circulating during extension were most likely surficial

in origin (i.e., meteoric water and/or modified/connate seawater), and they percolated into the granitic continental crust by exploiting extensional faults.

In the context of existing data, our results show that the hydration of the granitic continental crust of the Adriatic passive continental margin was mediated by a repeated series of fluid circulation events. Our work advocates that the use of a multi-methodological approach, combining new geochemical and geochronological, tools provides unprecedented insight into complex processes of fluid circulation in the continental crust, and beyond.