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U–Pb geochronology and isotopic signatures of epidote in hydrothermal veins: evidence for Eo-Alpine fluid circulation in the Albula area (eastern Swiss Alps)

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Fluids play a fundamental role in many geochemical and petrological processes. One way to unravel the interplay between deformation and fluid dynamics is to determine the age and isotopic signature of suitable minerals in veins (i.e. fluid-dominated systems). For this purpose, we investigated epidote in hydrothermal veins crosscutting the Albula Granite (Err nappe, eastern Swiss Alps). This pluton intruded the basement of the Err nappe (Lower Austroalpine) in Variscan to post-Variscan times and was mainly affected by the Jurassic extensional and Cretaceous compressional tectonics, with only a minor Cenozoic overprint.

Two successive veining events have been identified by epidote U–Pb geochronology by LA-ICP-MS [1]: (1) Epi-1 at ca. 90 Ma with an initial $^{207}Pb/^{206}Pb$ ratio of 0.7951 and (2) Epi-2 at ca. 60 Ma with initial $^{207}Pb/^{206}Pb$ ratios of 0.8232–0.8334. The bimodal distribution of certain trace element ratios and strontium isotopes (measured respectively by LA-ICP-MS and TIMS) confirm distinct geochemical characteristics between the two epidote-forming fluids, lending support to the vein-forming fluids having equilibrated in contact with different lithologies: (1) more radiogenic ones (i.e. high initial Rb/Sr and U/Pb ratios) for Epi-1 veins and (2) less radiogenic ones (i.e. low initial Rb/Sr and U/Pb ratios) for Epi-2 veins. Tentatively, Epi-1 fluids could have equilibrated with granitoid rocks (e.g., the host Albula Granite), whereas Epi-2 ones with carbonatic sediments in the surroundings of the veining area. Oxygen isotopes also suggest equilibration along different fluid pathways, both connected to the Eo-Alpine deformation history of the region. The age of Epi-1 veins is consistent with the inversion of the passive continental margin, while Epi-2 veining occurred during uplift of the Lower Austroalpine on the retrograde path or shortly after – respectively D1 and D2 of Alpine orogeny [2]. The distinct trace element and isotopic characteristics preserved in Epi-1 and Epi-2 veins attest to complex fluid dynamics in a relatively small area (ca. 20×400 m) during the Alpine orogeny.

[1] Peverelli, Ewing, Rubatto, Wille, Berger, Villa, Lanari, Pettke & Herwegh (2020), Geochronology Discuss. [preprint]

[2] Handy, Herwegh, Kamber, Tietz & Villa (1996), Schweiz. Mineral. Petrol. Mitt. 76, 453-474.