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Epidote U–Pb ages vs. fluid–mineral interaction

Veronica Peverelli¹, Alfons Berger¹, Pierre Lanari¹, Martin Wille¹, Igor Maria Villa^{1,2}, Daniela Rubatto^{1,3}, Thomas Pettke¹, and Marco Herwegh¹

¹University of Bern, Institute of Geological Sciences, Bern, Switzerland (veronica.peverelli@geo.unibe.ch)

²Università degli Studi di Milano-Bicocca, DISAT, Milano, Italy

³University of Lausanne, Institut des Sciences de la Terre, Lausanne, Switzerland

Recently, the application of LA–ICP–MS has enabled U–Pb dating of epidote minerals within the epidote–clinozoisite solid solution series (Peverelli et al., 2020). Epidote crystallization ages can provide an absolute time frame of deformation sequences when combined with detailed microstructural and metamorphic P–T analysis. Epidote deformation occurs in a brittle manner over a wide range of conditions below its closure temperature for Pb diffusion (685–750 °C; Dahl, 1997); hence, such deformation will not affect its formation U–Pb age. Nevertheless, the possibility of isotopically resetting epidote via fluid–mineral interaction has to be taken into account even at low deformation temperatures.

We investigated the geochemical and Sr–Pb isotopic characteristics of epidote in one hydrothermal vein in the Aar Massif (central Swiss Alps). The vein is associated with an Alpine shear zone and it is composed of aggregates of 0.1–1 mm anhedral to subhedral epidote grains (epidote-A) + green biotite within a quartz matrix. This quartz dynamically recrystallized by subgrain rotation at temperatures above 400 °C (Stipp et al., 2002) along with crystallization of a second epidote generation (epidote-B) made of tiny (< 0.1 mm) anhedral epidote grains in part mantling epidote-A and defining a fold. We address whether interaction with the fluid that precipitated epidote-B chemically affected epidote-A, i.e. whether the U–Pb age measured by LA–ICP–MS in epidote-A still dates its crystallization upon vein formation or displays age disturbance.

LA–ICP–MS Sr and Pb concentration data overlap between epidote-A and epidote-B, as do their REE patterns, with (La/Yb)_N ratios of 0.03–0.92. Lead and Sr isotopic signatures were measured respectively by solution MC–ICP–MS and by TIMS in epidote-A and in separates mixing different proportions of epidote-A and -B (no pure mechanical separates of epidote-B possible), and they are different. This requires open-system conditions during deformation, i.e., introduction of an external fluid with higher ⁸⁷Sr/⁸⁶Sr and ²⁰⁸Pb/²⁰⁶Pb ratios during crystallization of epidote-B. Despite the presence of an external fluid and the incorporation of external Sr and Pb in epidote-B, LA–ICP–MS U–Pb isotopic data for epidote-A define a regression in a Tera–Wasserburg plot indicating an age of 19.2 ± 4.3 Ma, consistent with epidote-A crystallization during original vein opening. The preservation of the crystallization age in epidote-A indicates that interaction with the fluid that formed epidote-B did not geochemically and isotopically affect epidote-A. The

consistency in trace element contents between epidote-A and -B hints that the epidote-forming cations were inherited by the fluid from epidote-A, and thus suggests dissolution-precipitation as the formation process for epidote-B.

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