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Constraints on Alpine hydrothermal activity and deformation from U-Th-Pb dating of cleft monazite and xenotime (Western Alps)

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In this large-scale regional study, age of hydrothermal monazite (and xenotime) precipitation has been investigated through in-situ U-Th-Pb dating of crystals collected in 11 clefts (veins) taken in the internal and external massifs (Western Alps). The investigated clefts are composed of quartz, chlorite (± epidote), albite and millimetric accessory minerals (monazite, apatite, xenotime, anatase, rutile). Prior to dating, cleft monazite composition was thoroughly studied to reveal potential zoning.

In-situ dating through different compositional domains of single monazite crystal yields well-resolved Th-Pb ages (typically with 0.1-0.3 Ma resolution) indicating for growth episodes with short duration. Comparison of U-Pb and Th-Pb dating indicates that the U-Pb systematics appears successful to date cleft monazite with low Th/U ratio (typically <30). In one cleft, in which monazite and xenotime coexist, xenotime was dated using the monazite analytical protocol. Hydrothermal xenotime has remarkably high Th/U ratio and U-Pb dating shows evidence of 206Pb excess. In comparison, Th-Pb dating gives robust ages (35.2 ± 0.8 Ma) that are close but higher than the monazite date obtained in the same cleft (32.3 ± 0.3 Ma).

Brief episodic monazite crystallization is likely attributed to enhanced hydrothermal activity during periods of higher tectonic activity. Correlation with other geochronological data suggests that it occurs in a host-rock that already cooled down at temperature close or below to the zircon fission track. In the Belledonne massif, the new monazite ages confirm for two periods of hydrothermal activity at around 11-13 Ma and 8-6 Ma, respectively. Only one vertical cleft monazite was investigated in the Mont-Blanc massif but it gives an age that is similar to the early population of the Belledonne massif (11.1 ± 0.2 Ma). Monazite dating therefore suggests for similar late-stage tectonic activity from Belledonne up to the Aar massifs, likely due to dextral movements along major strike slip faults. On the other hand, monazite dating in the Argentera (20.6 ± 0.3 Ma) confirms for the regional diachronism observed from South to the North of the ECM in the Western Alps. First ages were here obtained for the hydrothermal activity of the internal massifs of the Western Alps. As expected from other (thermo)chronometers, hydrothermal activity in the Internal Alpine domains (Briançonnais) is older than in the ECM. In the Briançonnais zone, monazite age at 32.1 ± 0.2 Ma coincides with the exhumation along the penninic front. In the second cleft, monazite age at 23.3 ± 0.2 Ma is more complex to attribute to a specific deformation stage.