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Investigations on alpine-type albite-quartz veins of the Western Swiss Alps

Eric May (1) and Torsten Vennemann (2)

(1) Institute of Earth Sciences, University of Lausanne, 1015 Lausanne, Switzerland (eric.may@unil.ch), (2) Institute of Earth Sciences, University of Lausanne, 1015 Lausanne, Switzerland (torsten.vennemann@unil.ch)

Fluids and fluid-rock interactions are common and indeed important for the transfer of mass and heat during different tectonic stages of orogenic systems. Mineralized veins provide important information about the P-T-X conditions, the fluid chemistry and fluid-rock interactions as well as the sources of the fluids. Stable isotope analyses have proven valuable to help constrain these aspects.

Oxygen and carbon isotopic compositions of cogenetic minerals from veins and adjacent whole rocks were investigated to characterize the fluid-rock interaction and the origin of the fluid as well as the growth conditions of these minerals. In this study, extensive albite-quartz veins were sampled in Triassic olistoliths from the tectonic mélange of the Pierre-Avoi unit in the Sion-Courmayeur zone, Lower Penninic domain of the Western Swiss Alps. Such veins offer gem quality crystals of pure, large low-albite crystals ($>$ 99 mol% Ab), associated with quartz and carbonates (calcite, dolomite). Structural analyses of the veins indicate that the fissures were formed by mode I opening during a generally compressive Alpine event.

Carbon and oxygen isotopic measurements of the different minerals as well as on the adjacent rocks support an isotopic disequilibrium between veins and host rocks. δ^{18}O values for albite and quartz vary between 14.9 and 16.9 ‰ (± 0.1; VSMOW) and between 17.8 and 20.6 ‰ (±0.1), respectively. These compositions are systematically lower than those from the adjacent rocks suggesting that the vein minerals precipitated from external fluids. The same trend is observed for δ^{13}C values. Indeed, euhedral calcite and dolomite crystals have systematically negative δ^{13}C values between –2.9 and –0.2 ‰ (± 0.1; PDB), while host sediments have positive values. This difference indicates the presence of organic-derived carbon in fluids present during calcite crystallisation, probably derived from organic-rich black shales surrounding the olistoliths. Finally, some isotopic profiles within the wall rocks suggest a partial buffering of the fluids by the host rocks.

Isotopic thermometry of cogenetic albite-quartz pairs from these extensional veins gives temperatures of between 270 and 320 °C (depending on the calibration) for the formation of these veins. The oxygen isotope compositions of mineralizing fluid were calculated using these temperatures and isotopic composition of the minerals. The calculated δ^{18}O values range from 11.2 to 11.5 ‰ suggesting externally derived metamorphic fluids. Fluid inclusions studied on quartz, coeval with albite, consist of two-phase, saline fluids containing between 6 and 8 % NaCl equivalent without the presence of CO_2 or methane.

Two simple oxygen isotope profiles in albite crystals show similar features with up to 1‰ difference with values increasing from the core towards the rims. Additional studies on growth and sector zoning of the isotopic compositions in the vein minerals are in progress and will be based on ion-probe measurements.

This study shows that a combined approach of mineralogical and geochemical study of extensional veins containing co-existing minerals can be of interest to characterize the P-T-X conditions of rocks during late retrograde Alpine metamorphism.