

MAY Eric (2016) : Origin and Growth of Alpine fissure minerals in the western swiss Alps : recording fluid flow during exhumation

Abstract

Post peak-metamorphic retrograde extensional veins are formed during uplift of a rock pile in response to crustal thickening during the Neoalpine phase. The veins record a contrasted response to the general SE-NW shortening. In the lower tectonic units (Mont Blanc and Aiguilles Rouges massifs) they are constrained by steeply dipping retrograde shear-zones affecting crustal rocks and recording vertical extension. In the cover rocks they recorded orogen-perpendicular extension. Veins formed in the Mont Chemin area appear to record dextral transpressive displacement along the Rhône-Simplon fault line, which does not affect the Penninic domain though. Textural and mineralogical observations on the studied Alpine fissures support an initial slow opening rate and a quartz supersaturated fluid of local origin. Progressive cooling and increasingly brittle behaviour facilitates advection of fluids of external origin, which have less fluid-rock interactions and a lower quartz concentration. Tectonic control on fluid flow is evidenced by the presence of multiple generations of quartz and the presence of low-temperature minerals such as zeolites close to shear-zones. Those crustal discontinuities acted as conduits and remained tectonically active for an extended period of time. Stable isotope analyses of whole rocks, host-rock quartz and the different minerals in vein indicate that mineralizing fluids evolved from rock-buffered fluids to fluids in isotopic disequilibrium with host-rock. Those fluids coincide with the precipitation of amethyst, clay minerals, calcite and zeolites in the veins. Apparent equilibrium temperatures range from circa 390°C down to 100°C. Quartz-hematite, quartz-adularia and quartz-albite pairs record the highest apparent equilibrium temperatures. Chemical thermometry on chlorite indicate formation temperatures between 370 and 250°C. It is deduced that they do not form only due to a temperature decrease but most probably appear when quartz starts to be less saturated in the fluid. Apparent temperatures of quartz-carbonates assemblages in crustal rocks indicate that carbonates are not in equilibrium with other vein minerals and their isotopic composition advocates that they precipitate from an externally derived fluid or from fluid mixing. Isotopic zonation in calcite recorded several pulses of fluids with contrasted isotopic compositions. In-situ stable isotope measurements in quartz do not indicate sector zoning but recorded fluids that were not in equilibrium with host-rock during the last stages of growth. However, trace element growth and sector zoning in quartz suggest a control of relative concentration by differential sector growth rates. Despite relatively constant oxygen isotope compositions, indicating isotopic equilibrium with the host-rock, trace element variations of up to three orders of magnitude are recorded in crystals. These variations were not controlled by fluid composition or temperature variations and therefore are attributed to fluid pressure variations, which can be large in the brittle domain and influence pH and precipitation rates. Sector and growth zoning of titanium concentrations was measured and cannot be attributed to temperature variations in a generally cooling system, therefore, absolute and relative growth rate of the different crystallographic domains must be considered. This has an implication on titanium-in-quartz thermometry accuracy.