Journal of Geochemical Exploration 101 (2009) 106

Contents lists available at ScienceDirect

Journal of Geochemical Exploration

journal homepage: www.elsevier.com/locate/jgeoexp

Evidence of pressure fluctuations recorded in crack-seal veins in low-grade metamorphic siliciclastic metasediments, Late Palaeozoic Rhenohercynian fold-and-thrust belt (Germany)

Koen Van Noten *, Isaac Berwouts, Philippe Muchez, Manuel Sintubin

Geodynamics and Geofluids Research Group, Department of Earth and Environmental Sciences, Katholieke Universiteit Leuven, Celestijnenlaan 200E, 3001 Leuven, Belgium

Crack-seal quartz veins have often been described in low-grade metamorphic terrains. Fluid-inclusion trails are abundantly present in such extension veins and their orientation is often used as a kinematic marker to unravel rock deformation history. Quartz veining in the High-Ardenne slate belt (Belgium, Germany) occurred at low-grade metamorphic conditions and is related to the latest stages of the Rhenohercynian basin development, i.e. predating the Late Palaeozoic main Variscan fold-and-cleavage development. Earlier structural, mineralogical and fluid-inclusion studies on quartz veins in the epizone of the slate belt evidenced that overpressured fluids caused a hydraulic fracturing event under low differential stresses. This study concentrates on crack-seal quartz veins in the anchizone of the slate belt and aims at constraining pressure–temperature conditions of early veining, to be able to find out whether early veining occurred at a constant or at fluctuating fluid pressures. The veins studied are restricted to competent psammitic units and display parallel arrays across the whole study area, demonstrating the presence of a regional consistent stress field during vein formation. Quartz commonly occurs as elongated-blocky ataxial crystals (sub)perpendicular to both vein walls. They have straight to saw-tooth crystal boundaries. Primary inclusions are absent. Solid inclusion bands and pseudosecondary inclusion trails are oriented perpendicular to the crystal elongation. The latter correspond to intracrystal healed microcracks reflecting the incremental crack-seal. Secondary inclusion trails, parallel to the vein walls but not necessarily perpendicular to crystal elongation, correspond to transcrystal microcracks. Although they have a secondary origin, their orientation evidences that microcracks still developed during the opening of veins and demonstrably under similar conditions as the pseudosecondary inclusion trails.

Microthermometry reveals that both pseudosecondary and secondary trails contain aqueous (H_2O–NaCl) inclusions with low salinities (2–6 eq.wt.% NaCl), which homogenise at temperatures ranging mainly from 140 °C to 200 °C. Veining occurred in equilibrium with the host rock, which is affected by low-grade peak metamorphism, prekinematic to the Variscan deformation. Undulose extinction and deformation lamellae are observed in the quartz crystals, inferring that limited deformation of the host crystals has taken place and that burial metamorphic conditions are not exceeded during subsequent Variscan deformation. Trapping temperature of the fluid inclusions can therefore be determined using published vitrinite reflectance data (at about 4.5–5.5% R_{max}) of the metapelite layers alternating with the vein-hosting psammite layers. By using this vitrinite reflectance range and taking a common effective heating time of 20 Ma into account, we deduce a maximum burial temperature of 250 °C. This offers us an independent temperature for pressure correction of the trapped inclusions. The variation of homogenisation temperatures can fully be explained by fluid pressures fluctuating between suprahydrostatic and lithostatic. Crack-sealing thus occurred at fluctuating fluid pressures, taking place in a regional consistent stress field controlling the quartz-vein alignment.

* Corrresponding author.
E-mail address: koen.vannoten@ees.kuleuven.be (K. Van Noten).

doi:10.1016/j.gexplo.2008.11.040