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Using vein fabric and fluid inclusion characteristics as an integrated proxy to constrain the relative timing of non cross-cutting, syn- to late-orogenic quartz vein generations

Dominique Jacques, Philippe Muchez, and Manuel Sintubin
KU Leuven, Department of Earth and Environmental Sciences, Leuven, Belgium (dominique.jacques@ees.kuleuven.be)

Research on ancient fluid systems mainly focuses on veins, because they offer the opportunity to combine macro- and microstructural data with geochemical data to gain insight into the P-T-X conditions present during veining. By applying such an integrated petrographic and microthermometric methodology to syn- to late-orogenic quartz veins in the Palaeozoic High-Ardenne slate belt (Belgium), we were able to define the relative timing and related P-T-X conditions of different quartz vein generations, despite of the absence of any mutual cross-cutting relationships in the field (Jacques et al., 2014).

The different quartz vein generations represent the meso-scale brittle accommodation during fold initiation, amplification and locking. The presence of free polycrystal growth in cavities at a midcrustal depth, and fluid-assisted brecciation indicate that veining occurred under overpressured fluid conditions during the orogeny. Significant differences in crystal-plastic deformation microstructures and P-T trapping conditions indicate that the different processes accommodating folding occurred in a progressive manner along a retrograde deformation path. While vein quartz in an extrados vein and in the peripheral part of a lenticular, fault-accommodating vein shows moderate crystal-plastic deformation (e.g. bulging recrystallisation, deformation lamellae, shear bands), crystal-plastic deformation is relatively absent in the vein quartz of a saddle reef and the core of the lenticular vein (i.e. no to minor undulose extinction).

Successive veining occurred from peak metamorphic conditions (ca. 300 ˚C and 190 MPa), measured in the extrados vein, to lower P-T conditions in the periphery of the lenticular vein (ca. 275 ˚C and 180 MPa), the late-orogenic saddle reef (ca. 245 ˚C and 160 MPa) and the core of the lenticular vein (ca. 220 ˚C and 150 MPa). The relative timing and accompanying decrease in P-T conditions of the different quartz vein generations reflect the gradual exhumation of the slate belt from ca. 7.5 to 6 km depth along a retrograde deformation path.

A comparison of these results with a former study of syn- to late-orogenic calcite veins at the Variscan front zone (Kenis et al., 2000), indicates that exhumation processes throughout the Rhenohercynian fold-and-thrust belt were diachronous. While exhumation and related quartz veining in the High-Ardenne slate belt occurred during the Sudetic stage of the Variscan orogeny (ca. 325-310 Ma), the exhumation and related calcite veining at the Variscan front zone occurred during the Asturian stage of the Variscan orogeny (ca. 300 Ma).

With this study we demonstrate that a relative timing for different vein generations, lacking any cross-cutting relationship, can still be attained through an integration of petrographic and microthermometric arguments. Moreover, this particular approach, enables to further delineate the P-T history of an orogenic system from its pre-, to its syn-, late- and finally postkinematic stages.

References

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