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Tectonic history of continental crustal wedge constrained by EBSD measurements of garnet inclusion trails and thermodynamic modeling

E. Skrzypek (1), K. Schulmann (1), O. Lexa (2), and J. Haloda (3)

(1) Université de Strasbourg, EOST, UMR 7516 - 7517, 1 Rue Blessig, Strasbourg 67 084, France (etienne.skrzypek@eost.u-strasbg.fr), (2) Institute of Petrology and Structural geology, Charles University, Albertov 6, 128 43, Prague, Czech Republic, (3) Czech Geological Survey, Klárov 3, 118 21 Prague 1, Czech Republic

Inclusion trails in garnets represent an important but underused tool of structural geology to examine non-coaxial or polyphase coaxial deformation histories of orogens. Garnet growth with respect to deformation during prograde and retrograde orogenic evolution of a continental crustal wedge was constrained by EBSD measurements of internal garnet fabrics and petrological record from mid-crustal rocks of the Śnieżnik Massif (Western Sudetes). Textural position of metamorphic minerals and thermodynamic modeling document three main stages in the tectonic evolution. Few garnet cores show prograde MnO zoning and growth coeval with the formation of the earliest metamorphic foliation which is only rarely observed in the field. The major garnet growth occurs synchronously with the second steep S2 fabric under still prograde conditions as shown by garnet zoning and appearance of staurolite and kyanite (peak at 6,5kbar/600°C). Oppositely, garnet retrogression associated to the development of sillimanite and later andalusite indicates pressure decrease of ca. 3 kbar for the late flat and pervasive S3 fabric associated with macroscopic recumbent folding of steep S2 foliation. Electron back-scatter diffraction measurements on ilmenites platelets included in garnets help determining their crystallographic preferred orientation. Ilmenites a[100] axes define planar structures that are interpreted as included foliations. Consequently, microscopic observations and foliation intersection axes (FIA) allow to distinguish between two different records. Only few (prograde) garnet cores yield information on the orientation of the presumed first metamorphic fabric whereas most of the internal garnet foliations are straight, steep and correspond to relics of originally steep S2 fabric. Importantly, this steep attitude of internal garnet foliations is persistent in both F3 fold hinge and limb zones as well as in zones of complete transposition of S2 into flat S3.

Therefore, these microstructural and petrological records bring new insights on the mechanical behaviour of this Variscan continental crustal wedge. Burial was initiated during the formation of the first flat metamorphic foliation and continued during the formation of a steep fabric while a major phase of garnet growth entrapped the orientation of this structure. This metamorphic and structural evolution is interpreted as a result of crustal thickening due to subhorizontal material influx followed by large-scale vertical folding. The following tectonic phase produces a flat fabric without any reorientation of the garnet porphyroblasts as exemplified by strong orientation consistency and good compatibility between internal records (foliations, FIA) and field data (measured or reconstructed positions of S2, F3 fold axes). Thus, the vertical D3 shortening looks like it was controlled by passive amplification of folded S2 surfaces and coaxial (non-rotational) flow in weak micaceous matrix. The homogeneous pure shear vertical shortening could be responsible for crustal thinning corresponding to the 3-4 kbar difference between peak assemblage and mineral association of horizontal S3 fabric. The latter fabric is interpreted as a result of horizontal flow related to ductile thinning of the thickened crustal wedge.