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Mechanical Collapse of Vertically Extruded Orogenic Root System: SW Moldanubian Zone

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We investigated the structure and PT evolution of two contrasting crustal levels within the internal part of the Moldanubian orogenic root which are separated by the N-dipping normal fault. The E-W cross-section S of the Kravsko fault comprises from the W to the E: middle – crustal rocks of the Monotonous group, the lower -crustal Gföhl and Raabs units, the Drosendorf window (composed of the middle-crustal Varied unit, paragneisses and amphibolite complex in the E) and the lower -crustal granulitic complex adjacent to the Moravian zone. The cross-section N of the Kravsko fault is traced from the Monotonous unit through the Raabs unit containing eclogites and granulites to the Gföhl unit.

The oldest high-grade fabric in the studied area is best preserved in the southern cross-section. This fabric is represented by a N-S trending subvertical syn – metamorphic foliation S_1, fairly well preserved in schists of the Monotonous group, dominant in the Gföhl gneiss and granulites and well-developed in the Varied group. In the eastern lower crustal segment, the S_1 fabric becomes shallower and dips under medium angles to the W-NW. The S_1 foliation is progressively folded by open to isoclinal folds F_2 with subhorizontal axial planes parallel to the metamorphic foliation S_2. In the Monotonous group, the S_2 foliation is heterogeneous and dips to the SE, in the Gföhl gneiss is missing, in the Raabs unit is subhorizontal and pervasive. The S_2 foliation is flat in the Varied group whereas in migmatites of the eastern lower – crustal segment dips to the NW and exhibits kinematic criteria indicating normal shearing. In all units except the Varied group the, D_2 fabrics are characterized by conditions of partial melting. The S_2 flat-lying foliation is in the Varied group folded by steep folds which is later refolded by subhorizontal folds. Towards the N, this structural pattern is complicated by S-dipping shear-zone with an intense N-S stretching lineation which is developed in both the Monotonous and Varied groups. This structure is contemporaneous with the S_2 foliation in other areas. Further to the E, the shear zone geometrically coincides with the Kravsko fault. N of this prominent fault, the flat S_2 fabric in granulites and amphibolites of the Raabs unit is dominant, locally preserving relics of S_1 foliation. The S_2 fabric is affected by numerous extensional structures such as shear bands, asymmetrical pull-apart boudinage and extensional gashes filled by melts. The Gföhl unit shows similar structural pattern which is locally overprinted by brittle-ductile extensional N-dipping shear zones in the vicinity of the Kravsko fault.

It is important to understand at what depth and thermal conditions the transition from vertical to horizontal fabrics takes place. Therefore, we studied lenses of crustal eclogites and granulites in the Raabs unit and adjacent middle crustal units (Monotonous group and Drosendorf window). The omphacite relics in the eclogites and the relict ky-grt-rt assemblage in granulites testify the HP stage. During the M_2 metamorphism (consistent with flat S_2 fabric) an amp-grt-pl-qtz assemblage in the eclogites has developed, which is equivalent to association found in amphibolites. For the granulites and paragneisses characteristic the M_2 assemblage sil-grt-bt-qtz-pl is characteristic. The conditions of M_2 metamorphism were in all the lithologies calculated at 700–850 °C / 9–13 kbar. In the Monotonous, group the sil-grt-pl-qtz-bt-kfs in paragneisses and the cpx-amp-pl assemblages in amphibolites give evidence of the HT stage. Near the contact with the Moldanubian pluton, the sillimanite becomes unstable and cordierite originates through a reaction sil + bt = crd + ms which is a result of decompression under 6 kbar at T > 650 °C. In the Drosendorf window, the sil-grt-pl-qtz-bt assemblage is stable in paragneisses and amp-grt-pl in the amphibolites yielding the PT conditions of ~700–800 °C / 8–10 kbar.

The distribution of the lower and middle crustal complexes and steep S_1 fabrics S of the Kravsko fault are interpreted in terms of successive extrusion of the lower crust over the basement to the E and over the middle crust in the central part of the root. The E-W shortening of the root produced vertical N-S trending fabrics in all structural levels (lower granulitic crust and middle crust) producing a positive flower structure within the Gföhl unit which extruded symmetrically over the western Montonous unit and the easterly-lying Varied unit. The second extrusion occurred at along the boundary of the Moravian complex where the root was thrust over the Moravian basement. This extrusion brings to middle crustal levels rocks from the base of the orogenic root (16–18 kbar / 800 °C, O Brien 2000) through relatively narrow vertical channels. The S_2 fabrics represent a mechanical collapse of vertical fabrics of the extruded lower and middle crustal material. The highest extruded and rheologically weakest lower crustal rocks of the Raabs and Gföhl complexes show almost entire flat reworking. The PT conditions of the horizontal flow in the extruded lower-crustal rocks correspond to 9–10 kbar / ~800 °C. The underlying middle crustal rocks show similar pressure range and temperatures between 700–800 °C. However, these rocks show evidence of only partial vertical shortening and reworking. We suggest that the collapse of vertical "syn-extrusion" fabrics should not be exclusively gravitational but may be associated with a subhorizontal shearing due to lateral flow of the weak crustal material.