Microstructure, EBSD-Measured Texture and Seismic Properties of Mantle Eclogite FRB 1300 from the Premier Mine, Kaapvaal Craton, South Africa

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In the nodules that are brought to the surface by kimberlite eruptions in South Africa, there is a small population of clinopyroxene and garnet rocks of "eclogitic" composition (e.g., Schulze, 1989; Shirey et al., 2001). These "eclogitic" mantle xenoliths have a modal analysis similar to what would be expected in the transition zone (depth 410–670 km), where the percentage of clinopyroxene and garnet is predicted to be much higher than in the upper mantle. A knowledge of the deformation microstructure and texture of these rocks would help determine their deformation history, which may be different from peridotites, and provide some constraints the behaviour of similar assemblages in the higher temperature and pressure conditions of the mantle transition zone.

The nodule FRB1300 of mantle eclogite was collected from the Premier Mine of the Pretoria kimberlite group that is located in the one of the oldest Archean cratons (3.0–3.7 Ga) named Kaapvaal Craton. The sample is bimineralic with modal proportion of 44 % and 56 % for garnet and clinopyroxene, respectively and shows equilibrated coarse-grained fabric. It is crosscut by net of late fractures, along which chemical alteration of <100 microns thick took place, as well as along the majority of grain boundaries. Garnet grains of dark red colour are elongated with axial ratio of 2:1 and grain size between 1 and 5 mm, clearly defining foliation plane and also stretching lineation. Contacts at garnet-garnet grain boundaries are straight suggesting stability of original fresh grain boundaries. Clinopyroxene grains of pale green colour are less elongated and more variable in size than garnet (0.5–10 mm). Alteration at cpx-cpx grain boundaries has often lobbed shape with large radius of curvature. In the areas of lower garnet content, single cpx grain surrounds a garnet grain along significant part of its boundary. Signs of intragranular strain features, such as undulatory extinction or formation of subgrains were not observed in either the garnet or clinopyroxene.

Microprobe analysis across the garnet and clinopyroxene grains showed homogeneity of chemical composition in both minerals thus geothermometer based on Fe-Mg exchange between garnet and clinopyroxene after Ellis and Green (1979), Powell (1985) and Ai (1994) were applied. Data from seven grt-cpx couples have been used with geothermometeric equations to show small variation in temperature for individual geothermometers and given values of pressure. If the studied eclogites are chemically equilibrated at the same pressures as peridotitic nodules (4 GPa) sampled from the same kimberlite pipe (Ben Ismail, 1999), the calculated average temperature is 1050 °C. However, if PT data form the peridotite are not be taken into account, the microprobe data lie well into the range of 1100 °C and 4.7 GPa define by geothermometric equations in the X(Ca)-garnet versus lnKD space and these values are in good aggrement with PT values from eclogites nodules sampled in the Roberts Victor and Bellsbank pipes in the Kaapvaal craton (e.g. Carswell et al, 1981), i.e. deeper that the peridotite samples.

Clinopyroxene and garnet texture were determined from electron back-scattered diffraction (EBSD) technique by manual procedure, in order to do not exaggerate crystallographic orientation of single grain in resulting pole figure. Texture of clinopyroxene is similar to those measured from crustal eclogites (e.g., Bascou et al., 2001) and those modelled by visco-plastic self-consistent model in simple shear (Bascou et al., in press) concluding that [001]{110} and <110>{110} are the most active slip systems in clinopyroxene. In contrast to crustal eclogites, garnet shows texture with weak clustering of poles on {100}-, {111}-, and {110}-plane, and <100>{110} as the easiest slip system.

Qualitative microstructural analysis and texture analysis were used in order to characterise operative deformation mechanisms in both minerals at the calculated temperature. Clinopyroxene shows a tendency for boundary migration and growth at expense of another clinopyroxene grains, which is indicative for dislocation creep with high-temperature grain boundary migration mechanism. Garnet grains are clearly elongated without signs of intracrystalline strain features thus internal strain energy was insufficient for dislocation climb and formation of subgrains. It suggests that dislocation glide is dominant mechanism of deformation in garnet crystals.

Seismic properties of the studied sample were calculated by combining the measured texture and the single crystal elastic constants of omphacite and garnet using the Voigt average. The fast P-wave velocity shows 8.8 km/s and its propagation direction is close to lineation. The P-wave anisotropy shows very weak value of 2.1 %. The S-wave anisotropy is also very weak showing complex pattern and Vs maximum anisotropy value of 2.6 %. Generally, seismic property data shows very similar results as those calculated from the crustal eclogites, thus eclogite/peridotite interface in the upper mantle would be hardly detectable (Bascou et al., 2001).

Presented petrophysical study of the first mantle eclogite show that plasticity of garnet becomes usual feature at natural strain rates above approximately 1000 °C and 4 GPa as it was proposed by experimental studies (Wang and Ji, 1999). As the mantle eclogites are hardly detectable it is difficult to estimate their abundance in the stable lithosphere of Kaapvaal craton. Nevertheless, it is possible to speculate that higher abundance of such eclogites in the base of the craton might significantly increase viscosity of the base and then protects rest of the stable root for the significant period of time (3Ga).

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Emplacement of Syenite Intrusion into Transtensional Pull--Apart Domain: Structural Evidences and Magnetic Fabric of the Jihlava Pluton, Moldanubian Zone (Bohemian Massif)

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The Jihlava pluton crops out as NW-SE elongated Variscan intrusion in the high grade gneisses of the Monotonous and Gfohl Units of the Moldanubian Zone. It is composed of high K melasyenitoids comprising two main textural varieties: equigranular medium grained melasyenites and very fine grained syenitoid. Moldanubian country rocks, adjacent to the intrusion, are represented by biotite-sillimanite paragneisses. Further to the E, migmatized paragneiss occurs with small bodies of amphibolite, quartzitic and locally graphite gneiss. The boundary between Monotonous and Gfohl Units, delineated by numerous lenses of eclogites and interpreted as a deep-level thrust, is not clearly exposed in the study area. The main migmatite body is intruded by numerous small syntectonic bodies of leucocratic granitoids. The thermal aureole of the intrusion is patchily developed and marked by extensive melting of host gneisses and cordierite bearing nebulites. The syenite intrusion contains stoped blocks of host rocks predominantly composed of migmatised paragneisses up to 300 m in size.

In this study, we present structural and AMS data in order to asses structural evolution of the country rock – intrusion system and to interpret the possible emplacement mechanism of the Jihlava pluton. Structures of the pluton are characterised by the transition from magmatic to subsolidus fabric developed along intrusion margins. In general, the magmatic fabric is weak and its intensity varies across the pluton, from very weak in the central part to more intensely developed along intrusion margins. Magmatic foliation pattern is different in southern and northern parts of intrusion. In the southern part the magmatic foliations dip SE at steep angles, whereas in the north they dip NW. Magmatic foliation trajectories show sigmoidal geometry being locally sub-parallel to the margins of large stoped blocks. Other primary magmatic structures are rare, scarses chlieren layering, where preserved, is mostly parallel to the magmatic foliation.

Structures in Moldanubian country rocks are dominated by pervasive development of S2 regional metamorphic foliation with relics of isoclinaly folded earlier S1 foliation. The S2 foliation is dipping steeply NE and it bears sub-horizontal mineral lineations trending SE and NW-SE. Regional metamorphic fabric is affected by 2–5 km wide steep greenschist facies mylonitic shear zone (the Přibyslav mylonite zone). Mylonitic deformation reactivates or cross cuts the regional S2 fabric in anastomose manner. New mylonitic foliation generally dips steeply towards the N, NE, E and SE and bears sub-horizontal stretching lineation. S3-S2 foliation trajectories form sigmoidal pattern which is consistent with overall dextral kinematics of the shear zone, as indicated by numerous sense-of-shear criteria.

Magnetic fabric was investigated along two E-W oriented transects across the pluton and roughly corresponds to the orientation of observed mesoscopic magmatic fabric. Magnetic foliations are dipping at moderate angles to the SE, S and SW in the northern part of intrusion with magnetic lineations plunging at moderate angles to the SW. To the S, magnetic foliations are dipping to the NE, N and NW, magnetic lineations plunge moderately to the NW. Degree of anisotropy is very low throughout the intrusion suggesting magmatic origin of the AMS fabric. Magnetic ellipsoids are mostly oblate in the northern part,