Upper Mantle Mylonites: Evidence for Hydrated Mantle Wedge Beneath the Eastern Transylvanian Basin

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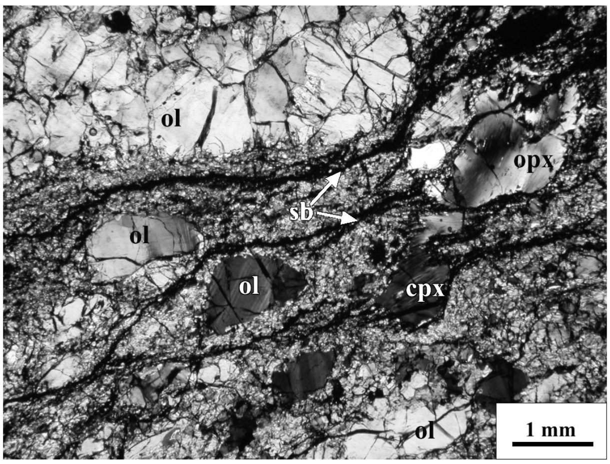
The severe effect of water on the deformation of the upper mantle (i.e. olvines) has only been recently recognized (e.g, Jung and Karato 2001, Katayama et al. 2004). The activation of slip systems (010)[001] ('b' slip) and (100)[001] ('c' slip) rather than the (010)[100] slip system ('a' slip) in H_2O-rich environments implies that hydrated upper mantle will have strongly distinctive texture from that deformed at H_2O deficient conditions (e.g., Jung and Karato 2001). Given that the development of the 'b' and 'c' type textures is extremely limited and at shallow mantle depth this texture only occurs within the mantle wedge in the presence of sufficient H_2O (> 500 ppm) and stress (> 100 MPa) (Kneller et al. 2005). Their recognition is a very strong evidence for identifying hydrated upper mantle developed in relation to subduction. Moreover, the occurrence of 'b' type textures in the hydrated mantle wedge explains arc-parallel fast shear waves observed in many supra subduction zone settings (e.g., Nakajima and Hasegawa 2004).

One of the best tools to directly study the deformation related textures in the upper mantle is from mantle xenoliths, hosted in deep-originated volcanic material, mostly alkali basalts. They are generally fresh and, in contrast to peridotite massifs and ophiolites, they have not experienced deformation during their emplacement to the crust. Moreover, they are relatively abundant in continental, back arc settings. The major disadvantage is that no direct tectonic implication can be derived from their textural analysis, because they cannot be directly fixed to any external reference frame. Instead, each xenolith must be fixed to its own reference frame (mostly foliation and lineation, if present), which is one of the major challenges, where texture analysis can go wrong.



■ **Fig. 1.** Anastomozing shear bands around strongly deformed porphyroclasts in a spinel lherzolite mylonite from the Eastern Transylvanian Basin (LGR03-01). Note extreme internal strain features in the porphyroclasts. ol – olivine; opx – orthopyroxene; cpx – clinopyroxene; sb – shear band. Cross-polarized light image.

In this study we represent 3 mantle xenoliths with mylonitic microstructures (Figure 1) from the Eastern Transylvanian Basin, which show the activation and dominance of (010)[001] and (100)[001] slip systems, indicating that they have been derived from the upper mantle which was deformed in an H_2O rich environment. This suggests that the subcontinental lithospheric mantle beneath the Eastern Transylvanian Basin represents a hydrated mantle wedge above the subducting European slab.

The mantle xenoliths are fertile, clinopyroxene rich peridotites. Clinopyroxenes show extremely primitive composition with high Al_2O_3 (4.5–5.3 wt%) and Na_2O (0.7–0.8 wt%) and low MgO (15.5–16.4 wt%) contents. Incompatible trace elements including Rb, Pb and U are depleted with respect to primitive mantle, whereas LREE is depleted with respect to MREE and HREE.

Our results strongly contradict recent models of delaminating continental crust (Knapp et al. 2005) and imply that the subduction beneath the Carpathian arc orogen, at least in part was 'normal' and involved the subduction of hydrated, most probably oceanic crust. We also confirm that the recent position of the slab is the consequence of rollback. Based on the presence of b-type olivine textures, we predicted an arc-parallel fast shear wave direction beneath the Eastern Transylvanian Basin. The observed chemical compositions disagrees with earlier results, which showed the enrichment of incompatible trace elements in the mantle wedge.

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Multicomponent Diffusion Modeling of Garnet: a Tool To Estimate Burial and Exhumation Rate of Metamorphic Complexes

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The occurrence of high-pressure rocks, mainly preservation and formation of concentration gradient within garnet or at its contact with other minerals provide evidence for the geodynamic processes of subduction and exhumation of crustal material within orogenic belts. With combination of the results from experimental data on diffusion coefficients and thermobarometric analyses from natural material, the measured concentration profiles in mineral can be used to estimate burial and exhumation rates of rock underwent high-pressure metamorphism. Diffusion modeling is based on definition of initial and boundary conditions, diffusion coefficients and the P-T-t history over which the diffusion takes place. During geological processes, diffusion in multicomponent minerals such as garnet results from simultaneous flow of more than two components. In garnet the diffusion of Mg, Fe, Mn and Ca are coupled to each other. The diffusion profiles measured in the microprobe can be modeled using the approach, proposed by Chakraborty and Ganguly (1991).

Starting with the initial profile shapes and calculated diffusion coefficients, a finite difference modeling scheme can be employed to calculate diffusion profiles. In this forward modeling approach, calculations are carried out until a good match is obtained with the observed, high resolution (points measured at l micron spacing) profile shapes near the interface of two minerals or two compositionally different garnets. It is here that a full multicomponent simulation is more useful than using effective binary diffusion coefficient – only for a rather limited range of time scales is possible to simultaneously reproduce the shapes of profiles for all elements. The time scale corresponding to the simulation that yields the best fit with the observed profiles is taken to be the one taken to traverse the P-T path being modeled. The method was used for burial and exhumation rate for two garnets of different composition, where the older garnet forms core and younger mantle. The simulation was don for a time scale estimated according to the P-T path. Diffusion coefficient was calculated for Mn, Mg and Fe, where Ca was treated as dependent component. The advantage of such simultaneous calculation is that it allows subtle details of variations in compositional profiles to be interpreted and considerably reduces the uncertainty in retrieved time scales that may be obtained from using only one profile. The modeling suggests that a minimum subduction / exhumation rate of ~ 4cm/a and heating / cooling rates on the order of 100–260 °C/Ma for a 60 °C subduction angel are required to preserve the observed compositional zoning overall while modifying the zoning at the interface between two garnets to the extent observed.

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