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Evolution of the lithosphere-asthenosphere system in the Carpathian-Pannonian region following the Miocene extension: as viewed in petrology, geochemistry, deformation pattern of mantle xenoliths and geophysical observations

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Detailed geochemical and deformation analysis of numerous of mantle xenoliths from the Carpathian-Pannonian region revealed that the present lithosphere, which suffered significant thinning in the Miocene, may be divided into two major layers based on the equilibrium temperatures as indicators for the depth of origin. The shallower layer, from the MOHO to ∼40 km depth, is characterized mostly by fine grained, equigranular to porphyroclastic xenoliths, generally displays an 'axial [010]' deformation pattern typical for transpressional deformation regime. Mineral constituents from this shallower layer show high Mg#, low H_2O content in nominally anhydrous minerals (NAMs) and depleted in basaltic major elements implying that this layer may have undergone considerable depletion. Trace element patterns, however, show enrichment most probably due to subsequent metasomatic enrichment episodes.

The deeper layer is below ∼40 km and above the present lithosphere-asthenosphere boundary. The xenoliths show mainly coarse grained, protogranular texture with 'A-type' deformation pattern typical for asthenospheric flow. Minerals usually have lower Mg# and richer in basaltic major elements. The NAMs from this layer show higher H_2O content than those in the shallow layer. Trace element patterns, on the other hand, do not refer to later refertilization episodes by showing dominantly depleted pattern.

There is also a special group of tabular equigranular xenoliths, which may represent a domain separating these shallower and deeper layers of the present day lithosphere. This group shows geochemical and deformation properties resembling more the shallower layer, however, the H_2O content of NAMs is the highest among all studied samples. Xenoliths, nevertheless, displaying transitional character among these major groups also occur indicating the complex history of the upper mantle.

We suggest that the deeper, more H_2O rich and less-depleted layer of the present day lithosphere is a juvenile one, which may have added to the lithosphere following the Miocene extension (∼10 Ma) in the thermal relaxation stage. The shallower layer, in contrast, may have undergone several episodes of depletion, deformation and refertilization prior to and during the Miocene extension.

This layering may also be seen as seismic reflectors at ∼40 km depth in the present lithospheric mantle beneath the region, and, in addition, the anomalous seismic anisotropy pattern beneath the CPR may also be explained by the deeper, juvenile layer.