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Evolution of anisotropy in the upper mantle of a tectonically inverted extensional basin: A joint study of xenoliths and shear-wave splitting from the Carpathian-Pannonian region

NORA LIPTAI[1,2], ZOLTÁN GRÁCZER[2], GYÖNGYVÉR SZANYI[2], SIERD A. P. L. CLOETINGH[1,3], BÁLINT SÜLE[1,2], LÁSZLÓ ELÅ'D ARADI[2,4], GYÖRGY FALUS[5], GÖTZ BOKELMANN[6], MÁTÉ TIMKÓ[1,2], GÁBOR TIMÁR[7], CSABA SZABÓ[8,9] AND ISTVÁN JÁNOS KOVÁCS[1,2]

[1]Institute of Earth Physics and Space Science
[2]MTA FI Lendület Pannon LitH2Oscope Research Group
[3]Tectonics Group, Department of Earth Sciences, Faculty of Geosciences, Utrecht University
[4]Eötvös Loránd University
[5]Supervisory Authority of Regulatory Affairs
[6]Department of Meteorology and Geophysics, University of Vienna
[7]Department of Geophysics and Space Science, Institute of Geography and Earth Sciences, Eötvös Loránd University
[8]Lithosphere Fluid Research Lab, Eötvös University
[9]Institute of Earth Physics and Space Sciences

Presenting Author: n.liptai.elte@gmail.com

Development of anisotropic structures in the mantle during tectonic processes is generally addressed through large-scale geophysical measurements or the direct study of lattice preferred orientation of rock-forming silicates in mantle xenoliths. The former can provide regional data from a large depth range, whereas the latter can reveal more detailed structural information locally on a small scale. So far, these two approaches have rarely been applied simultaneously in geodynamic studies.

In this study we present the nature of seismic anisotropy of the upper mantle in the western Carpathian-Pannonian region, an area which was subjected to extension during the Miocene followed by tectonic inversion up to recent times. Shear wave splitting analyses were compared with seismic properties obtained from lattice preferred orientation of olivine in mantle xenoliths to characterize the depth, thickness, and regional differences of the anisotropic layer in the mantle. Regional differences occur between the northern and the central/southern part of the studied area. Beneath the Western Carpathians, the lack of azimuthal dependence of the fast split S-wave indicates a single anisotropic layer, which agrees with xenolith data from the Nógrád-Gömör volcanic field. In the central Pannonian Basin, multiple anisotropic layers are suggested by data from several seismological stations, which may be explained by two xenolith subgroups described in the Bakony-Balaton Highland, differing from each other petrographically and in their deformation patterns. The thickness of the anisotropic layer may be estimated based on the depth of the maximum anisotropy which is considered the centre of the layer. This was put at ~140-150 km beneath the Western Carpathians using spatial coherency analysis assuming single anisotropy. Thickness calculated from seismic properties of the xenoliths resulted in lower values on average. This may be explained by: (1) the xenoliths are sampling a heterogeneous part of the upper mantle and do not accurately represent the whole anisotropic layer, or (2) foliation is not perfectly vertical in the mantle, as it would be expected in a compressional stress field resulting from tectonic inversion.