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Upper mantle structures beneath the Carpathian-Pannonian region: Implications for the geodynamics of continental collision

Y. Ren (1), G. W. Stuart (1), G. A. Houseman (1), B. Dando (2), C. Ionescu (3), E. Hegedus (4), S. Radovanovic (5), and South Carpathian Project Working Group ()

(1) University of Leeds, United Kingdom (earyr@leeds.ac.uk), (2) International Seismological Center, Thatcham, United Kingdom, (3) National Institute of Earth Physics, Bucharest, Romania, (4) Eotvos Lorand Geophysical Institute, Budapest, Hungary, (5) Seismological Survey of Serbia, Belgrade, Sebia

The Carpathian-Pannonian system of Eastern and Central Europe represents a unique opportunity to study the interaction between surface tectonic processes involving convergence and extension and convective processes in the upper mantle. Here, we present high-resolution images of upper mantle structure beneath the region obtained using P- and S-wave finite-frequency teleseismic tomography to help constrain the geodynamical interpretation of the region. We have selected earthquakes with magnitude greater than 5.5 in the distance range 30°-95°, which occurred between 2006 and 2011. The data were recorded on 54 temporary stations deployed in the South Carpathian Project (2009-2011), 56 temporary stations deployed in the Carpathian Basins Project (2005-2007), and 131 permanent broadband stations of national networks. The relative arrival times are measured in high, intermediate and low frequency bands (0.5-2.0 Hz, 0.1-0.5 Hz and 0.03-0.1 Hz for both P-waves, 0.1-0.5 Hz, 0.05-0.1 Hz and 0.02-0.05 Hz for S-waves), and are inverted using a 3-D finite-frequency formulation to produce P- and S-wave velocity maps at depths between 75 and 600 km in the mantle. Our images show a sub-vertical slab of fast material beneath the eastern Alps which extends eastward across the Pannonian basin at depths below $\sim$300 km. The fast material extends down into the mantle transition zone (MTZ), where it spreads out beneath the entire basin. Above $\sim$300 km, the upper mantle below the Pannonian basin is dominated by relatively slow velocities, the most dominant of which extends down to nearly 200 km and underlies the >7km thick sediments of the Mako-Békés rift basins. We suggest that cold mantle lithospheric downwelling occurred below the Pannonian Basin before detaching in the mid-Miocene. In the Vrancea Zone, intermediate depth seismicity occurs at the NE end of a tabular upper mantle high velocity structure that trends SW along the southern edge of the South Carpathians and extends to depths of $\sim$400 km. This sub-vertical high-velocity body is bounded by slow anomalies to the NW and SE, which extend down to the top of the MTZ. The slow anomalies correlate with outcrops of Neogene-Quaternary volcanic activities in the East Carpathians and Apuseni Mountains. No clear evidence of residual slabs is observed in the mid upper mantle beneath Eastern Carpathians; the eastern Carpathians are underlain by slow velocities everywhere above the transition zone. These observations suggest that intermediate depth seismicity in the Vrancea Zone is unlikely to be due to slab tearing, but rather could be explained by either gravitational instability or delamination of mantle lithosphere.