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# Lithospheric Convergence Preceded Extension in the Pannonian-Carpathian System

Gregory Houseman (1), Graham Stuart (1), Ben Dando (1), Gyorgy Hetenyi (2), Piroska Lorinczi (1), Endre Hegedus (3), and Ewald Brueckl (4)

(1) University of Leeds, School of Earth and Environment, Leeds, United Kingdom (greg@earth.leeds.ac.uk, +44 113 343 5259), (2) Department of Earth Sciences, ETH, Zurich, Switzerland, (3) Eotvos Lorand Geophysical Institute, Budapest, Hungary, (4) Technical University of Vienna, Austria

The continuing collision of the Adriatic block with European continental lithosphere has its clearest expression now in the Alpine collision zone. Recent tomographic images of the upper mantle beneath the eastern Alps and western Pannonian Basin support the interpretation that in the Early Miocene the collision zone extended further east: a steeply dipping seismically fast structure stretches downward beneath the Eastern Alps reaching to the base of the transition zone, consistent with the long history of convergence in this region. This high velocity structure also extends eastward beneath the extensional Pannonian Basin. The high velocity anomaly beneath the Basin is strongly developed in transition zone depths (410 to 660 km) but the anomaly weakens upward. High velocities beneath the center of the extensional basin are unexpected because there is substantive evidence that the onset of extension in the Pannonian domain at around 17 Ma produced rapid extension of the lithosphere and replacement of the lower part of the lithosphere by hot asthenosphere. These deeper structures, however, must be explained by the long history of convergence that preceded the extension of the basin. Further evidence of a history of sustained convergence in the present Pannonian region is found in the depression of the 660 km seismic discontinuity beneath the Alps (Lombardi et al., EPSL, 2009) and also beneath the Pannonian Basin (Hetenyi et al., GRL, 2009). The 660 km discontinuity in both places is depressed by as much as 40 km, whereas the 410 km discontinuity is at approximately nominal depths. Evidently in both regions relatively dense material derived from the mid-Miocene collision sits stagnant on top of the 660 km discontinuity, where further descent is obstructed by the negative Clapeyron slope of the spinel-to-perovskite phase transition and/or the high viscosity of the lower mantle. The rapid extension of the Intra-Carpathian Basins in the Mid-Miocene (between about 17 and 12 Ma) thus seems to have locally decoupled the Pannonian lithosphere from the upper mantle circulation while convergence persisted in the Alps. The descending flow that apparently produced the cold material at the base of the Pannonian upper mantle was presumably detached (possibly by a type of slab break-off mechanism) from the Pannonian lithosphere when extension occurred. Whether extension of the Pannonian lithosphere was driven by subduction at the Carpathians or by gravitational spreading of a crust thickened in the preceding convergent phase we might have expected to identify local downwelling that occurred in association with Carpathian convergence. The apparent lack of any fast material between the present Carpathian lithosphere and the cold material in the mantle transition zone is therefore puzzling unless it too has undergone a form of slab break-off.