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Detachment of mantle downwelling beneath the Pannonian Basin caused lithospheric extension?

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The Pannonian Basin of central Europe formed by extension of the continental lithosphere in the Miocene. This phase of extension followed a period of convergence driven by the collision of Adria and Europe. A widely held view is that the extension of this region was enabled, if not actively driven, by the north-eastward retreat of a subduction system that was briefly active beneath the East Carpathian mountain range. This episode of lithospheric extension had a profound effect on the entire upper mantle in this region. Previous regional tomography studies showed an anomalously fast transition zone (410-660 km depth) and anomalously slow mantle above 410 km beneath the basin, implying that possibly the entire upper mantle in this region had undergone recent and rapid mantle overturn, presumably on the same time scale as the lithospheric extension (approximately 17 to 12 Ma). Based on the results of an international seismic tomography experiment (the Carpathian Basins Project, CBP) which used a temporary deployment of 57 broadband seismographs across the Vienna and Pannonian Basins in the period 2005-2007, together with data from permanent national networks, we describe here an alternative interpretation of the tectonic events that resulted in Pannonian Basin extension. Contrary to expectation, tomographic images of the upper mantle beneath the basin show a relatively fast structure which stretches out across the basin below 300 km depth, generally aligned along strike with a cold upper mantle structure beneath the Eastern Alps. We interpret this feature as the remnant signature of mantle downwelling beneath a collision zone comparable to the present-day Alps, which occupied the present location of the central Pannonian Basin. This collision zone might be regarded as an eastward extension of the Alpine chain or as a precursor for the Carpathian system. Above 300 km depth, however, the fast structure is absent. We interpret that this structure represents cold mantle that detached from the lithosphere at the time when the Pannonian region abruptly changed from convergence to extension; this cold mantle then simply sank down into the transition zone and spread horizontally. The lateral spreading suggests that the cold material has not penetrated the phase change at 660 km; in fact deep receiver functions reveal that the 660 km transition is depressed by as much as 40 km beneath the Pannonian Basin. This fast material is presumably cold and relatively dense compared to ordinary transition zone and has not yet undergone the phase change which would allow the 660 km boundary to re-equilibrate. The tomographic images are consistent with the idea that this descending cold material has spread outwards from the centre of the Pannonian Basin; in the 500 km depth slice a relatively sharp transition from fast material beneath the basin to slow material outside is apparent. While this transition is located approximately beneath the Carpathian perimeter of the basin, we do not see evidence of direct vertical continuity between fast material at 500 km depth and the Carpathian lithosphere above, except in a localised area near the SE Carpathians. We suggest instead that the ridge of fast material which crosses the centre of the basin below 300 km depth is the source of most of the fast material in the transition zone, and that its detachment from beneath the convergent orogen was closely associated with (if not the causal mechanism for) the transition from convergence to extension in the pre-Pannonian orogen. This new interpretation, however, generates new questions: if these events imply that lithosphere was spreading outward from the centre of the basin synchronously with cold material in the transition zone spreading outward from beneath the centre of the basin, then an abrupt reversal of flow direction in the mantle above the detached slab is implied.

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