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Tracing the influence of the Trans-European Suture Zone into the mantle transition zone

Brigitte Knapmeyer-Endrun (1), Frank Krüger (1), Cedric P. Legendre (2), Wolfram H. Geissler (3), and the PASSEQ Working Group Team

(1) University Potsdam, Institute of Earth and Environmental Sciences, Karl-Liebknecht-Str. 24-25, 14476 Potsdam, Germany (brigitte.endrun@geo.uni-potsdam.de), (2) Institute of Earth Sciences, Academia Sinica, 128, Sec. 2, Academia Road, Nangang, Taipei 11529, Taiwan, (3) Alfred Wegener Institute for Polar and Marine Research, Am Alten Hafen 26, 27568 Bremerhaven, Germany

Cratons with their thick lithospheric roots can influence the thermal structure, and thus the convective flow, in the surrounding mantle. As mantle temperatures are hard to measure directly, depth variations in the mantle transition zone (MTZ) discontinuities are often employed as a proxy. Here, we use a large new data set of P-receiver functions to map the 410 km and 660 km discontinuities beneath the western edge of the East European Craton and adjacent Phanerozoic Europe across the most fundamental lithospheric boundary in Europe, the Trans-European Suture Zone (TESZ).

We observe significantly shorter travel times for conversions from both MTZ discontinuities within the craton, caused by the high velocities of the cratonic root. By contrast, the differential travel time across the MTZ is normal to only slightly raised. This implies that any insulating effect of the cratonic keel does not reach the MTZ. In contrast to earlier observations in Siberia, we do not find any trace of a discontinuity at 520 km depth, which indicates a rather dry MTZ beneath the western edge of the craton. Within most of covered Phanerozoic Europe, the MTZ differential travel time is remarkably uniform and in agreement with standard Earth models. No widespread thermal effects of the various episodes of Caledonian and Variscan subduction that took place during the amalgamation of the continent remain. Only more recent tectonic events, related to Alpine subduction and Quarternary volcanism in the Eifel area, can be traced.

While the East European craton shows no distinct imprint into the MTZ, we discover the signature of the TESZ in the MTZ in the form of a linear region of about 350 km width with a 1.5 s increase in differential travel time, which could either be caused by high water content or decreased temperature. Taking into account results of recent S-wave tomographies, raised water content in the MTZ cannot be the main cause for this observation. Accordingly, we explain the increase, equivalent to a 15 km thicker MTZ, by a temperature decrease of about 80 K. We discuss two alternative models for this temperature reduction, either a remnant of subduction or an indication of downwelling due to small-scale, edge-driven convection caused by the contrast in lithospheric thickness across the TESZ. We consider an explanation by an ancient subducted slab in the MTZ more unlikely, though, as Eurasia has moved significantly northward since the Variscan orogeny, the last major episode of subduction in the area.