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Upper mantle P-wave velocity structure beneath southern Scandinavia

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This study images upper mantle structure beneath different tectonic and geomorphological provinces in southern Scandinavia by P-wave travel time tomography based on teleseismic events. We present integrated results using data from several projects (CALAS, MAGNUS, SCANLIPS, CENMOVE and Tor) with a total of 202 temporary seismological stations deployed in southern Norway, southern Sweden, Denmark and the northernmost part of Germany. These stations, together with 18 permanent stations, yield a high density data coverage enabling presentation of the first high resolution 3D seismic P-wave velocity model for the upper mantle for this region, which includes areas of Baltic Shield, Scandinavian Caledonides, the entire northern part of the prominent Tornquist Zone and the Southern Scandes Mountains.

P-wave arrival time residuals of up to ± 1 s are observed reflecting large seismic velocity contrasts at depths. Relative regional as well as absolute global tomographic inversion is carried out and consistently show upper mantle velocity variations relative to the ak135 reference model of up to $\pm$ 2-3 % corresponding to P-wave velocity differences of about 0.4 km/s from depths of about 100 km to more than 300 km.

High upper mantle velocities are observed to great depth to the east in Baltic Shield areas of southwestern Sweden. Lower velocities are found to the west and southwest beneath the Danish and North German sedimentary basins and in most of southern Norway. A well-defined, generally narrow deep boundary is observed between areas of contrasting upper mantle seismic velocity. In basin areas, low upper mantle velocities are associated with thinned lithosphere and velocity contrasts are interpreted to represent differences between deep shield lithosphere and shallow basin asthenosphere with a deep lithospheric boundary running close to the Sorgenfrei-Tornquist Zone. Differences in P-wave velocity are here likely to arise mainly from temperature differences.

To the north, the boundary crosses various tectonic and geomorphologic units including shield units, the Caledonides as well as areas of high topography, and a structural and geodynamic interpretation is more complex. Reduced upper mantle velocities below southern Norway also appear to be associated with a thinner lithosphere compared to shield areas to the east. Velocity contrasts may be explained to a higher degree by both compositional and temperature differences and a geodynamic origin including both Proterozoic and Phanerozoic events. Below southern Norway, a regional contribution to buoyancy from reduced density in the upper mantle is likely to exist, but we observe no clear correlation between reduced upper mantle seismic velocity and high topography of the southern Scandes Mountains.