Geophysical Research Abstracts
Vol. 20, EGU2018-10856-1, 2018
EGU General Assembly 2018

Topography and Thickness of the Mantle Transition Zone Beneath Scandinavia

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Processes responsible for high topography and the present high uplift rates – up to 8 mm/year in Scandinavia – have been explained by multiple types of surficial and tectonic processes, but no clear consensus has emerged yet. In addition, little is known about mantle structure. Here we investigate the mantle transition zone (the MTZ) in order to investigate if active processes provide a support for the high topography areas in Scandinavia.

We use continuous records from 259 recording stations of multiple seismic arrays deployed in Scandinavia since 1998, including the recent temporary experiment ScanArray that consists of 83 new seismic stations deployed across Norway and Sweden during the 2012-2016 period.

We apply the teleseismic P-wave receiver function method and build two-dimensional long-range seismic images of the mantle structure. We further reconstruct the three-dimensional topographic variations of major phase boundaries near 410 and 660 km depth accompanied with uncertainty.

We find an uplift of the 410-km discontinuity in the central part of Scandinavia beneath the Gulf of Bothnia to 390 $\pm$ 5 km (calculated using IASP91 velocity model), while the depth is close to 410 km along the Norwegian margin and Swedish south-eastern margin. According to the current results topography of the 660-km discontinuity is uplifted with a maximum elevation of 640 $\pm$ 15 km beneath Southern Scandes, in the central west coast of the Gulf of Bothnia and in the northern Finland. Apart from these elevations the depth of the 660-km discontinuity is around 650 km.

Due to the depth-velocity trade-off, the MTZ thickness is a more reliable proxy for temperature than the absolute topography. The most prominent feature is the thinning of the MTZ ($\sim$230 km instead of normal, 250 km) along the Norwegian margin, beneath the Scandes Mountains. While the ScanArray data coverage allow us to interpret only the northern part of the Norwegian margin (65N-70N), the inclusion of the additional datasets allow to widen the area of interpretation.

The apparent thinning of the MTZ can be explained by the following reasons: 1) The depressed 410- and the uplifted 660-km discontinuities are due to the effect of high temperatures on the mineral phase transitions with opposite Clayperon slopes in the olivine mantle system. 2) The presence of a high velocity anomaly within the MTZ gives an apparent uplift of the 660-km discontinuity, while the 410-km discontinuity remains at the standard depth.

We discuss our results relative to several tomography models available for the region. The potential presence of high mantle temperatures raises a question about possible influence of the upper mantle and the MTZ structures on the high topography areas in Scandinavia.