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Tracing lithospheric mantle variations underneath Norway and Sweden - An integrated modelling approach with LitMod3D

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The Scandinavian Mountain Chain (the Scandes) exhibits characteristics that are unusual for an old, Palaeozoic mountain belt. These include the lack of an isostatically compensating shape of the Moho and renewed Neogene uplift in a passive margin setting. Several mantle processes have been invoked to explain a post-rift uplift of the Scandes, and their respective durations and wavelengths are strongly controlled by the rheology and thermal structure of the lithosphere. We investigate the potential influence of current mantle structures on the topography of the Scandes and on the processes that may have influenced it.
Recent seismological studies show evidence for a strong transition from seismically slower lithospheric mantle underneath southern Norway to seismically faster lithospheric mantle underneath southern Sweden. Additionally, the presence of a high-density lower crustal body (LCB), which extends west of the Scandes into the Fennoscandian shield, has been inferred from gravity models and is locally supported by seismic data. We use an integrated 3D model of the lithospheric subsurface and the available geophysical data sets in order to better characterise the transition zone of the lithospheric mantle (its thermal, compositional and geometric nature). This approach allows us to trace the mantle transition zone, which has only been mapped in southern Norway and Sweden farther to the north, and to investigate its connection to the structure of the LCB.
LitMod3D is an interactive modelling program that performs combined geophysical-petrological forward modelling of the lithosphere and sublithospheric upper mantle. All relevant properties are functions of temperature, pressure and composition. The models are therefore self-consistent and can be used to simultaneously fit available geophysical and petrological observables.
A 3D subsurface model of Norway and Sweden is built from the most recent geophysical data sets for the crustal architecture, lithosphere geometry, density distributions and thermal properties. Density and geometry of the LCB are only poorly defined but are constrained through the condition of an isostatically compensated topography.
The increase in seismic mantle velocities from Norway towards Sweden reflects a transition towards a much thicker and colder mantle. Differences in mineral composition (owing to stronger depletion) may enhance the velocity contrast. Values for the density and thickness of the LCB attain values suitable to those obtained from gravity and seismic studies. The strong differences in thickness and composition of the sub-continental lithospheric mantle in western Scandinavia indicate major differences in the evolutionary history prior to the Paleozoic Caledonian orogeny. However, these differences have not been linked to proposed post-rift mechanisms such as mantle delamination or underplating. Furthermore, no other support for the occurrence of such processes appears evident from the current mantle structures.