Geophysical Research Abstracts
Vol. 14, EGU2012-1431, 2012
EGU General Assembly 2012

Tilting of post-glacial Fennoscandian shorelines requires a low-viscosity asthenosphere

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The Fennoscandian uplift has been intensely studied and discussed since the 18th century and it is now widely accepted to be an isostatic response to the recent deglaciation. Our knowledge of the fluid properties of the Earth comes largely from its uplift response to load redistributions that occurred over the last ice age. The elevation of past shorelines and the present rate of land uplift constrain the fluid properties of the mantle and the elastic rigidity of the lithosphere.

The post-glacial uplift in Fennoscandia has been mapped by the following means:

1. Shorelevel displacement curves, showing the vertical displacement at a certain location,
2. Shoreline diagrams, showing the displacement and tilting of palaeo shorelines,
3. Present-day uplift monitored by tide gauge, old water marks, GPS observations and by satellite missions.

We have now revisited the Fennoscandian uplift, and done high resolution (10 km spatial) modelling which includes glacial isostasy, hydro isostasy and sediment isostasy. The Earth's response to glaciers and sediments has been modeled by using a layered viscous model overlain by an elastic lithosphere. In the calculations we have used the tilting of the palaeo shorelines as to constrain the Earth rheology. Different kinds of data constrain different parameters. It has been shown that the tilting of paleoshorelines is very sensitive to the mantle viscosity and lithosphere rigidity.

Five sites along the Norwegian coast with observed paleoshoreline tilts have been selected for the present investigation; western Norway (Sotra Island and Sunnmøre), mid Norway (Trøndelag) and northern Norway (Lofoten and Finnmark). The observed tilts vary from 0.6 m/km (northern Norway) to 1.7 m/km (mid Norway). The theoretical palaeo shoreline tilts were calculated with different deglaciation models, and with a range of Earth rheology models. There are significantly variations in the calculated tilts, and the best fit with the observed tilts from Younger Dryas (last 12 000 years) was achieved with a low-viscosity asthenosphere of thickness less than 150 km and viscosity less than 7.0×10^{19} Pa s above a mantle of viscosity 10^{21} Pa s, and an effective elastic lithosphere thickness of 40 km (flexural rigidity 10^{24} Nm).