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Lithosphere thermal thickness and geothermal heat flux in Greenland from a new thermal isostasy method

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ABSTRACT

Lithosphere thermal structure in Greenland is poorly known and models based on seismic and magnetic data are inconsistent, while growing awareness in the fate of the ice sheet in Greenland requires reliable constraints on geothermal heat flux (GHF) from the Earth's interior in the region where conventional heat flux measurements are nearly absent. The lithosphere structure of Greenland remains controversial, while its geological evolution is constrained by direct observations in the narrow ice-free zone along the coasts. The effect of the Iceland hotspot on the lithosphere structure is also debated.

Here I describe a new thermal isostasy method which I use to calculate upper mantle temperature anomalies, lithosphere thickness, and GHF in Greenland from seismic data on the Moho depth, topography and ice thickness. To verify the model results, the predicted GHF values are compared to available measurements and show a good agreement. Thick (200–270 km) cratonic lithosphere of SW Greenland with GHF of ca. 40 mW/m^2 thins to 180–190 km towards central Greenland without a clear boundary between the Archean and Proterozoic blocks, and the deepest lithosphere keel is observed beneath the largest kimberlite province in West Greenland. The NW-SE belt with an anomalously thin (100–120 km) lithosphere and GHF of 60–70 mW/m^2 crosses north-central Greenland from coast to coast and it may mark the Iceland hotspot track. In East Greenland this anomalous belt merges with a strong GHF anomaly of > 100 mW/m^2 in the Fjordland region. The anomaly is associated with a strong lithosphere thinning, possibly to the Moho, that requires advective heat transfer such as above active magma chambers, which would accelerate ice basal melting. The anomaly may extend 500 km inland with possibly a significant contribution of ice melt to the ice-drainage system of Greenland.

The results are calculated for two models with the same density contrast across the Moho, but with a different Moho depth at zero topography:
Model 1 is based on the global continental average (41.1 km)
Model 2 - on the regional average Moho depth in Greenland (37.5 km).