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Anomalous subglacial heat flow in central Greenland induced by the Iceland plume.

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3000 m of ice sheet thickness has ensured that central Greenland has kept it geothermal heat flow (GHF) distribution enigmatic. Some few direct ice temperature measurements from deep ice cores reveal a GHF of 50 to 60 mW/m^2 in the Summit region and this is noticeably above what would be expected for the underlying Early Proterozoic lithosphere. In addition, indirect estimates from zones of rapid basal melting suggest extreme anomalies 15 to 30 times continental background. Subglacial topography indicates caldera like topographic features in the zones hinting at possible volcanic activity in the past [1], and all of these observations combined hint at an anomalous lithospheric structure. Further supporting this comes from new high-resolution P-wave tomography, which shows a strong thermal anomaly in the lithosphere crossing Greenland from east to west [2]. Rock outcrops at the eastern and western end of this zone indicate significant former magmatic activity, older in the east and younger in the west. Additionally, plate modelling studies suggest that the Greenland plate passed over the mantle plume that is currently under Iceland from late Cretaceous to Neogene times, consistent with the evidence from age of magmatism. Evidence of rapid basal melt revealed by ice penetrating radar along the hypocentre of the putative plume track indicates that it continues to affect the Greenland continental geotherm today. We analyse plume-induced thermal disturbance of the present-day lithosphere and their effects on the central Greenland ice sheet by using a novel evolutionary model of the climate-ice-lithosphere-upper mantle system. Our results indicate that mantle plume-induced erosion of the lithosphere has occurred, explaining caldera-type volcanic structures, the GHF anomaly, and requiring dyke intrusion into the crust during the early Cenozoic. The residual thermo-mechanical effect of the mantle plume has raised deep-sourced heat flow by over 25 mW/m^2 since 60 Ma and explains the high basal melting rates of the Greenland ice sheet observed in the study area.

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[2] Jakovlev, A.V., Bushenkova, N.A., Koulakov, I.Y., Dobretsov, N.L., 2012. Structure of the upper mantle in the Circum-Arctic region from regional seismic tomography. Russian Geology and Geophysics. 53, 963–971.