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Arctic Regional Heat-flow Prediction from Mapping of Crustal Thickness and Continental Lithosphere Thinning using Gravity Inversion

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The ocean basins of the Arctic formed during the Late Jurassic, Cretaceous and Tertiary as a series of small distinct ocean basins leading to a complex distribution of oceanic crust, thinned continental crust, rifted continental margins, micro-continents and ridges. The distribution of continental lithosphere thinning and oceanic lithosphere exerts an important control on top-basement heat-flow and the predicted response of ice-sheets and perma-frost to climate change. Using gravity anomaly inversion, we have produced the first comprehensive regional maps of Moho depth, crustal thickness, continental lithosphere thinning and oceanic lithosphere distribution for the Arctic region and its periphery. Continental lithosphere thinning has been used to predict the preservation of continental crustal radiogenic heat productivity and the transient lithosphere heat-flow contribution for thermally equilibrating oceanic and thinned continental lithosphere. The resulting crustal radiogenic productivity and lithosphere transient heat flow components, together with base lithosphere background heat-flow, are used to produce regional maps of present-day Arctic top-basement heat-flow. We determine crustal thickness, continental lithosphere thinning factors and ocean-continent transition location for the Arctic using a new gravity inversion method which incorporates a lithosphere thermal gravity anomaly correction (Greenhalgh & Kusznir, 2007; Chappell & Kusznir, 2008). NGA (U) Arctic Gravity Project and IBCAO bathymetry data are used in the gravity inversion. Moho depths predicted by gravity inversion compare well with estimates from the TransArctica-Arctica seismic profiles for the Podvodnikov and Makarov Basins, and the Lomonosov Ridge. Our gravity inversion predicts thin crust and high continental lithosphere thinning factors in the Makarov, Podvodnikov, Nautilus and Canada Basins consistent with these basins being oceanic or highly thinned continental crust. Larger crustal thicknesses, in the range 20 – 30 km, are predicted for the Lomonosov, Alpha and Mendeleev Ridges. Outside the main oceanic Amerasia and Eurasia Basins, locally thinner crust is predicted in the Laptev Sea and North Chuchki Basins. Thinner crust is also predicted in the region of the East Siberian Sea Basin and separated from the Podvodnikov Basin by thick crust under the De Long Massif. The sensitivity of present-day heat-flow to initial continental radiogenic heat productivity, continental breakup age and oceanic lithosphere age has been examined. The technique described above is also applicable to the Antarctic polar region.