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Arctic and Antarctic Crustal Thickness and Continental Lithosphere Thinning from Gravity Inversion

Nick J. Kusznir (1), Andy Alvey (2), Alan P.M. Vaughan (3), Fausto Ferraccioli (3), Tom A.R.M. Jordan (3), and Alan M. Roberts (2)

(1) University of Liverpool, Department of Earth Sciences, Liverpool L69 3BX, United Kingdom , (2) Badley Geodynamics, Hundleby, Lincolnshire, PE23 5NB, United Kingdom , (3) British Antarctic Survey, Cambridge, CB3 0ET, United Kingdom

Mapping crustal thickness, continental lithosphere thinning and oceanic lithosphere distribution represents a substantial challenge for the Polar Regions. The Arctic region formed as a series of small distinct ocean basins leading to a complex distribution of oceanic crust, thinned continental crust and rifted continental margins. Antarctica, both peripherally and internally, experienced poly-phase rifting and continental breakup. We determine Moho depth, crustal basement thickness, continental lithosphere thinning and ocean–continent transition location for the Polar Regions using a gravity inversion method which incorporates a lithosphere thermal gravity anomaly correction. The method is carried out in the 3D spectral domain and predicts Moho depth and incorporates a lithosphere thermal gravity anomaly correction. Ice thickness is included in the gravity inversion, as is the contribution from sediments which assumes a compaction controlled sediment density increase with depth. A correction to the predicted continental lithospheric thinning derived from gravity inversion is made for volcanic material addition produced by decompression melting during continental rifting and seafloor spreading. For the Arctic, gravity data used is from the NGA (U) Arctic Gravity Project, bathymetry is from IBCAO and sediment thickness is from a new regional compilation. For Antarctica and the Southern Oceans, data used are elevation and bathymetry, free-air gravity anomaly, ice and sediment thickness from Smith and Sandwell (2008), Sandwell and Smith (2008) and Laske and Masters (1997) respectively, supplemented by Bedmap2 data south of 60 degrees south. Using gravity anomaly inversion, we have produced the first comprehensive maps of crustal thickness and oceanic lithosphere distribution for the Arctic, Antarctica and the Southern Ocean. 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. Moho depths predicted compare well with seismic estimates. Predicted very thin continental or oceanic crust under the North Chuchki Basin and Laptev Sea has major implications for understanding the plate tectonic history of the Amerasia Basin. Our gravity inversion study predicts thick crust (> 45 km) under interior East Antarctica. Thin crust is predicted under the West Antarctica Rift System and the Ross Sea. Continent scale rifts are also seen within East Antarctica. Intermediate crustal thickness with a pronounced rift fabric is predicted under Coates Land. An extensive region of either thick oceanic crust or highly thinned continental crust is predicted offshore Oates Land and north Victoria Land. Superposition of illuminated satellite gravity data onto crustal thickness maps from gravity inversion provides improved determination of rift orientation, pre-breakup rifted margin conjugacy and continental breakup trajectory (e.g. for the Southern Ocean). Gravity inversion predictions of crustal thickness, OCT location and oceanic lithosphere distribution may be used to test plate tectonic reconstructions. Using gravity anomaly inversion mapping of continental lithosphere thinning we have developed and applied a new technique to predict basement heat-flow, important for the prediction of ice-sheet stability, for the Polar Regions.