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Regional Heat-flow Prediction for Antarctica using Gravity Inversion Mapping of Crustal Thickness and Lithosphere Thinning

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Top-basement heat-flow is important for the prediction of ice-sheet stability and its response to climate change. The prediction of heat flow for Antarctica and its regional variations presents a substantial scientific and technical challenge. Antarctica, both peripherally and internally, experienced poly-phase rifting and continental breakup during the Jurassic, Cretaceous and Tertiary, which exerts an important control on top-basement heat-flow. Using gravity anomaly inversion mapping of crustal thickness and continental lithosphere thinning we have developed and applied a new technique to predict basement heat-flow for Antarctica. We determine Moho depth, crustal basement thickness, continental lithosphere thinning (1-1/β) and ocean–continent transition location for Antarctica and the Southern Ocean using a gravity inversion method which incorporates a lithosphere thermal gravity anomaly correction. Data used in the gravity inversion are elevation and bathymetry, free-air gravity anomaly, ice thickness 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. The gravity inversion method, which is carried out in the 3D spectral domain and predicts Moho depth, incorporates a lithosphere thermal gravity anomaly correction. Lithosphere thermal model re-equilibration (cooling) times, used to calculate the lithosphere thermal gravity anomaly correction, are conditioned by ocean isochron information (Mueller et al. 2008), and continental rifting and breakup ages. Ice thickness is included in the gravity inversion, as is the gravity anomaly 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 the addition of volcanic material produced by decompression melting during continental rifting, breakup lithosphere thinning and seafloor spreading. Superposition of illuminated free air gravity anomaly onto crustal thickness maps derived from gravity inversion provides improved determination of rift orientation and Southern Ocean continental breakup trajectory. Our gravity inversion study predicts thick crust (> 45 km) under interior East Antarctica. Thinner crust is predicted under the West Antarctica Rift System and the Ross Sea. 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. Continental lithosphere thinning from gravity inversion 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 convective heat-flux, are used to produce regional maps of present-day Antarctic top-basement heat-flow. The sensitivity of predicted present-day regional variations in Antarctic top-basement heat-flow to initial continental radiogenic heat productivity, rift age and continental breakup age are examined.