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Arctic Crustal Thickness, Oceanic Lithosphere Distribution, and Ocean-Continent Transition Structure From Gravity Inversion

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ABSTRACT

The ocean basins of the Arctic formed during the Mesozoic and Cenozoic as a series of small distinct ocean basins leading to a complex distribution of oceanic crust, rifted continental margins, micro-continents and volcanic ridges. The determination of the distribution of oceanic lithosphere, ocean-continent transition (OCT) structure and continent-ocean boundary (COB) location presents a substantial scientific and technical challenge common to all frontier deep-water hydrocarbon exploration. Using gravity anomaly inversion, we have produced comprehensive regional maps of Moho depth, crustal thickness, continental lithosphere thinning and oceanic lithosphere distribution for the Arctic. We use a gravity inversion method which incorporates a lithosphere thermal gravity anomaly correction (Alvey et al. 2008; Chappell & Kusznir 2008). Public domain free-air gravity anomaly, bathymetry and sediment thickness data are used in the gravity inversion. Results from gravity inversion provide estimates of OCT structure and COB location which are independent of magnetic isochrons. Crustal cross-sections using Moho depth from our gravity inversion allow continent-ocean transition structure to be determined (e.g. narrow versus wide) and also provide constraints on their magmatic type (magma poor, “normal” or magma rich). Superposition of illuminated satellite gravity data onto crustal thickness maps from gravity inversion provides improved determination of pre-breakup conjugacy and post-breakup trajectory of the Arctic and North Atlantic margins. By restoring crustal thickness & continental lithosphere thinning maps of the Eurasia Basin & North Atlantic to their initial post-breakup configuration we can show the geometry and segmentation of the rifted continental margins at their time of breakup, together with the location of highly-stretched failed breakup basins and rifted micro-continents. Continental lithosphere thinning and post-breakup residual thicknesses of continental crust determined from gravity inversion have been used to predict the preservation of continental crustal radiogenic heat productivity and the transient lithosphere heat-flow contribution within thermally equilibrating rifted continental margin and oceanic 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.