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Arctic and N Atlantic Crustal Thickness and Oceanic Lithosphere Distribution from Gravity Inversion

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The ocean basins of the Arctic and N. Atlantic formed during the Mesozoic and Cenozoic as a series of distinct ocean basins, both small and large, leading to a complex distribution of oceanic crust, thinned continental crust and rifted continental margins. The plate tectonic framework of this region was demonstrated by the pioneering work of Peter Ziegler in AAPG Memoir 43 “ Evolution of the Arctic-North Atlantic and the Western Tethys” published in 1988. The spatial evolution of Arctic Ocean and N Atlantic ocean basin geometry and bathymetry are critical not only for hydrocarbon exploration but also for understanding regional palaeo-oceanography and ocean gateway connectivity, and its influence on global climate. Mapping crustal thickness and oceanic lithosphere distribution represents a substantial challenge for the Polar Regions. Using gravity anomaly inversion we have produced comprehensive maps of crustal thickness and oceanic lithosphere distribution for the Arctic and N Atlantic region, We determine Moho depth, crustal basement thickness, continental lithosphere thinning and ocean-continent transition location using a 3D spectral domain gravity inversion method, which incorporates a lithosphere thermal gravity anomaly correction (Chappell & Kusznir 2008). Gravity anomaly and bathymetry data used in the gravity inversion are from the NGA (U) Arctic Gravity Project and IBCAO respectively; sediment thickness is from a new regional compilation. The resulting maps of crustal thickness and continental lithosphere thinning factor are used to determine continent-ocean boundary location and the distribution of oceanic lithosphere. Crustal cross-sections using Moho depth from the gravity inversion allow continent-ocean transition structure to be determined and magmatic type (magma poor, “normal” or magma rich). Our gravity inversion predicts thin crust and high continental lithosphere thinning factors in the Eurasia, Canada, Makarov, Podvodnikov and Baffin Basins consistent with these basins being oceanic. Larger crustal thicknesses, in the range 20 – 30 km, are predicted for the Lomonosov, Alpha and Mendeleev Ridges. Crustal basement thicknesses of 10-15 km are predicted under the Laptev Sea which is interpreted as highly thinned continental crust formed at the eastward continuation of Eurasia Basin sea-floor spreading. Thin continental or oceanic crust of thickness 7 km or less is predicted under the North Chukchi Basin and has major implications for understanding the Mesozoic and Cenozoic plate tectonic history of the Siberian and Chukchi Amerasia Basin margins. Restoration of crustal thickness and continent-ocean boundary location from gravity inversion may be used to test and refine plate tectonic reconstructions. Using crustal thickness and continental lithosphere thinning factor maps with superimposed shaded-relief free-air gravity anomaly, we improve the determination of pre-breakup rifted margin conjugacy and sea-floor spreading trajectory within the Arctic and N Atlantic basins. By restoring crustal thickness & continental lithosphere thinning maps of the Eurasia Basin & NE Atlantic to their initial post-breakup configuration we 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. We interpret gravity inversion crustal thicknesses underneath Morris Jessop Rise & Yermak Plateau as continental crust which provided a barrier to the tectonic and palaeo-oceanic linkage between the Arctic & North Atlantic until the Oligocene. Before this time, we link the seafloor spreading within the Eurasia Basin to that in Baffin Bay.