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Re-examining Age-Depth Cooling Using High Accuracy Oceanic Basement Depths

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The dominant control on Earth's bathymetry is the progressive subsidence of the seafloor with age resulting from conductive cooling of oceanic lithosphere. Starting with analytical half-space cooling models in the 1960s, a series of increasingly complex numerical models have been proposed to describe this thermal evolution. During this same period, vast quantities of high-quality seismic reflection data have been gathered by the oil gas industry throughout the world's ocean basins. We have collated this global database to create a new, high-accuracy compilation of oceanic basement depths, corrected for sediment and crustal thickness variations.

We subsequently develop a new thermal model that yields an excellent fit to both this updated subsidence dataset and existing oceanic heat flow measurements, whilst simultaneously honouring geochemical constraints on mantle potential temperature derived from basalt geochemistry. It is essential to include the experimentally-determined temperature and pressure dependence of mantle and crustal thermal parameters in order to uniquely determine plate thickness, ridge depth and potential temperature. The model yielding the best fit has a potential temperature of 1317^{-57}_{+62} °C, a plate thickness of 135^{-16}_{+29} km and an initial ridge depth of $2.60^{-0.24}_{+0.28}$ km. The resulting thermal structure is in good agreement with independent constraints on earthquake depth and seismological observations of the velocity structure of oceanic plates and the depth to the lithosphere-asthenosphere boundary.

The gravity contribution of this plate model is consistent with observations in the Atlantic, Indian and Pacific Oceans. We believe that residual gravity anomalies have the potential to isolate contributions from deep mantle processes, as well as short-wavelength thermal and compositional heterogeneity in the oceanic lithosphere.