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Reconciling Geochemical and Geophysical Evidence for Supercontinent Insulation

Mark Hoggard, Oliver Shorttle, Fred Richards, John Maclennan, and Nicky White
University of Cambridge, Bullard Labs, Department of Earth Sciences, Cambridge, United Kingdom (mjh217@cam.ac.uk)

A plethora of theoretical studies have suggested that the insulatory effects of supercontinent assemblies should have a dramatic impact upon the thermal structure of the upper mantle. For example, build up of sub-plate heat beneath Pangea has been linked to hotspot locations, the geoid high, polar wander, the Central Atlantic Magmatic Province and mass extinction of life at the Triassic-Jurassic boundary. Numerical experiments have investigated a range of behaviours, including thermal erosion of the lithosphere, surface uplift, continental rifting and rapid propulsion of continental rafts away from break-up sites.

Modelling has indicated a great diversity of possible effects that insulation by supercontinents may have on mantle dynamics and Earth's surface environment. In this contribution, we provide additional insight into this phenomenon by placing tighter observational constraints on the magnitude and duration of post-breakup thermal anomalies within the mantle. Sub-plate temperatures have a primary impact on the geochemistry and melt productivity of mid-oceanic spreading centres. We therefore interrogate a new global compilation of oceanic crustal thickness measurements for signals associated with continental insulation. Our results suggest that excess temperatures of $\sim 50°C$ are recorded within the Atlantic and Indian Oceans that decay away over 50 Myr timescales. No such variation is observed in crustal thickness patterns in the Pacific Ocean, which has not formed by rifting of a supercontinent.

These results are combined with analysis of the geochemical composition of mid-ocean ridge basalts. Variations in sodium oxide content as a function of mantle potential temperature are calibrated using dredged samples and crustal thicknesses from active spreading ridges. Application of this relationship to boreholes drilled into Mesozoic and Cenozoic basement in the Atlantic Ocean confirms the presence of $\sim 50°C$ excess temperatures following rifting, that steadily decay towards the present-day.