

Implications of a non-chondritic Earth for terrestrial heat production and geodynamics

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Previous geochemical estimates of terrestrial radiogenic heat production were based on the assumption that refractory lithophile elements, such as the REE, U, and Th are present in the Earth in chondritic relative proportions (the “modified chondritic Earth’ model). However, $^{142}\text{Nd}/^{144}\text{Nd}$ ratios in modern terrestrial materials imply that the Sm/Nd ratio in the Earth, or at least the observable part of it, that is about 6% higher than chondritic, and hence the Earth is non-chondritic, even for ratios of refractory lithophile elements. The most likely explanation is that a low Sm/Nd igneous protocrust that formed as the Earth accreted was lost through collisional erosion. A protocrust 6% enriched in Nd relative to Sm would have been more strongly enriched in the more highly incompatible elements K, U, and Th. Calculations based on a model of protocrust formation and collisional erosion that satisfy both Sm-Nd and Lu-Hf isotopic constraints imply U and Th concentrations in the bulk silicate Earth (BSE) about 40% lower than in the ‘modified chondritic Earth’ model. Assuming a $\text{K}/\text{U} = 13800$ for the BSE, the K concentration is 30% lower than previously believed. This corresponds to a terrestrial heat production of 11.9 TW, compared to estimates ranging from 16 to 20 TW based on ‘modified chondritic Earth’ model. Of this, some 5 to 10 TW of heat production is in the continental crust, leaving <6 TW of heat production in the mantle. For comparison, recent estimates of U, Th, and K in the depleted mantle imply heat production in the range of 0.6–1.0 $\mu\text{W}/\text{kg}$; if the depleted mantle occupies the entire mantle, this translates into mantle heat production of 3–4 TW. Mantle heat losses are roughly 33 TW, hence the mantle Urey ratio (ratio of heat production to heat loss) is in the range of 0.09 to 0.19. At present, heat generated by viscous dissipation of the gravitational energy released by sinking slabs is 12 to 15 TW, and <5 TW is released by the cooling core. Of this energy, only a fraction, 3.8 to 4.8 TW can produce new gravitational power to drive convection and plate tectonics. Thus gravitational energy is being consumed at a much higher rate than it is being regenerated. This is a clear indication that the present rate of slab subduction is not sustainable and that the mantle is in a phase of faster than normal slab subduction and plate spreading.

Hygroscopic and CCN properties of marine aerosol

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The impact of marine aerosols on cloud properties is the subject of active research due to the high level of uncertainty associated with their effect on the climate. In order to quantify these effects more accurately, it is important to measure and understand aerosol water uptake, which can vary greatly with particle size and composition. The tools available for this task include the Hygroscopicity Tandem Differential Mobility Analyser (HTDMA) and the Cloud Condensation Nuclei counter (CCNc), however consistency between the aerosol water uptake derived with these instruments can be affected by the composition in particular due to the presence of organic components [1].

Both instruments were operated at Mace Head, during winter 2010 and summer 2011. The site’s location on the west coast of Ireland makes it ideal for sampling air masses from over the North Atlantic without significant local anthropogenic influence. During the winter, the aerosol particles in the clean marine air at this location consist largely of inorganic components, so it is expected that reconciliation between the hygroscopic and CCN properties of the aerosols will be straightforward. Owing to hotly-debated impacts of the contribution of organic aerosol components to droplet activation and to the expected higher summertime contribution to primary marine particulate of biogenically derived organic matter [2], reconciliation of aerosol water uptake derived with each instrument presents additional challenges. This can be examined with reference to aerosol composition data from an Aerosol Mass Spectrometer (AMS) simultaneously operating at the same location.

Recent progress with the analysis and comparison of the winter and summertime data will be presented and discussed in the context of previous marine experiments.

[1] Good *et al.* (2010) *Atmos. Chem. Phys.* **10**, 3189–3203. [2] Yoon *et al.* (2007) *J. Geophys. Res.* **112**, doi:10.1029/2005JD007044.