Dynamics and evolution of the Earth's core and lowermost mantle

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Transport properties control many processes in the deep Earth. For example, the geodynamo is crucially dependent on electrical conductivity in the core. A typical estimate at relevant pressure and temperature is $5x10^5$ S m^{-1}, although this value is probably uncertain by a factor of two. At first glance a higher electrical conductivity might be expected to enhance the geodynamo. However, a higher electrical conductivity also implies a higher thermal conductivity, which suppresses the geodynamo. According to the Wiedemann-Franz law, an electrical conductivity of $5x10^5$ S m^{-1} corresponds to a thermal conductivity of 50 W K^{-1} m^{-1} at 4000 K. Approximately 8 TW of heat is carried by conduction toward the core-mantle boundary when the core is well mixed (i.e. adiabatic). This conductive transport represents a large fraction of the total core heat flow, suggesting that the transport due to convection is relatively small. Even modest changes in thermal conductivity can substantially alter the vigor of thermal convection. Present uncertainties in thermal conductivity permit widely varying estimates for the power available to drive the geodynamo.

Mass transport across the core-mantle boundary can also affect the dynamics and evolution of the core. Chemical disequilibrium between the core and mantle inevitably drives a flux of mass across the boundary, but the rate of transfer is limited by diffusion. Recent suggestions that the core is undersaturated in O and/or Si implies a flux of light elements into the core. Downward diffusion through the liquid core can produce a stratified layer 50 to 70 km thick if the flux of light elements from the mantle is sufficiently large. Dynamical arguments suggest that the residence time of material at the base of the mantle is 40 to 80 Ma. Steep chemical gradients in the mantle can drive a large mass flux, especially in the presence of partial melt or an interconnected ferropericlase phase. Local depletion of Si by transfer to the core would likely promote interconnection as the volume fraction of ferropericlase increases. Alternatively, a randomly oriented post-perovskite phase could permit a large flux. On the other hand, a large volume fraction of silicate perovskite at the boundary would likely suppress mass transfer. Differences in the mineralogy could have important implications for both the composition and dynamics of the core.

Net redistribution of ^{137}Cs over Australia

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Cesium-137 (^{137}Cs), a radionuclide by-product of atomic testing, is a stratigraphic marker specific to the period of above-ground nuclear tests (1950s-70s), used to trace the movement of surficial material in terrestrial landscapes [1]. Its half-life is short (30.2 y) and its utility as a tracer will be of limited duration. We show here that its geographic pattern can shed valuable insight into contemporary geomorphic processes. We use geostatistics and estimates of net ^{137}Cs redistribution relative to a baseline reference fallout level to quantify and map topsoil erosion over Australia between 1950 and 1990. We show that net soil loss occurs in the main cultivated areas along the coastal regions of Western Australia, South Australia, Victoria, New South Wales, and Queensland. The most eroded area is in the Pilbara region of Western Australia, with median erosion rates > 6 t ha^{-1} yr^{-1}. The coincidence of net gain areas with eolian deposition in southeastern Australia suggests that the map is identifying wind-borne transport patterns. Eolian deposition in the Wet Tropics World Heritage Area supports the theory that dust is a major source of nutrients on ancient highly weathered soils where rainforests grow [2]. The potential for eolian deposition over the Wet Tropics is evident from an animation of MODIS imagery from the late September 2009 dust storm across Australia. However this is the first time that dust deposition over NE Australia has been substantiated.

[1] Zapata (2002) *Handbook for the assessment of soil erosion and sedimentation using environmental radionuclides*. Kluwer Academic Publishers, 219 pp. [2] Chadwick *et al.* (1999) *Nature* **397**, 491-497.