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Structure and composition of the Earth

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The bulk silicate Earth's (BSE) composition is the product of planetary accretion, core differentiation, and Moon formation. Given the BSE's composition one can determine the composition of the bulk Earth and by subtraction calculate the core's composition. The BSE represents the bulk Earth minus the core, which in today's terms equals the modern mantle, the continental crust, and the hydrosphere-atmosphere systems. The modern mantle can be framed in terms of two compositionally distinct components, an enriched and a depleted mantle, with the latter as sampled by MORB (mid-ocean ridge basalts) and the former as sampled by OIBs (ocean island basalt).

The Earth's surface heat flux is 46±3 TW (terrawatts, 1012 watts). Some fraction of this flux (~40% or ~20 TW) is derived from radioactive heat produced by the decay of U, Th, and K. Some 40% of the Earth's budget of these elements is stored in the continental crust (~7.5 TW) and does not contribute to mantle heating. The remaining energy is primordial derived from accretion and core separation. The heat flux through the mantle also includes a core contribution (~10±5 TW; i.e., bottom heating of the mantle).

The rich record of seismic tomography documents ocean tectonic plates entering the mantle at oceanic trenches, plunging deep into the mantle, stagnating at the base of the Mantle Transition Zone (410-660 km depth), while others stagnating at ~1000 km depth, and others still plunge directly into the deep mantle. Collectively, these images reveal mass exchange between the upper and lower mantle and are consistent with whole mantle convection. The Mantle Transition Zone (MTZ) plays a major role in the differentiation of mantle. Mantle dynamics is controlled by its viscosity, which in turn is controlled by its water content and temperature. Evidence for core-mantle exchange remains elusive. Water is transported between the surface and interior, however, we are challenged to document if the net flux to the surface is positive or negative with time.

The Earth's metallic core at ½ a radius and 1/3 of its mass, separated from the silicate Earth during planetary formation over a few 107 years, as documented by 182Hf-182W isotope system (t1/2 ~9 Ma). The core's composition was established during this period and remained in isolation, because there is negligible evidence for any significant core-mantle mass exchange through time. The core is dominantly an FeNi alloy with about 10% of a light element component based on its density, as compared with an alloy at these PT conditions. The nature of this light element component is considerably discussed in the literature and not resolved. There is negligible evidence in support of radioactive elements in and heating the core.

Moon (1022 kg) formation happened anywhere between 50 Ma and 150 Ma after solar system initiation due to one or more impact events of Mars (1023 kg) sized impactors. The Moon's chemistry indicates that the bulk of its composition is derived from the Earth's mantle (1024 kg) and was unlikely to have involved core materials from either colliding body.

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Classification de Session: Overview - neutrinos and geoscience