Lunar constraints on core formation: a new model with many implications

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The widely accepted iron-cores-by-percolation model is invalidated in two ways. The mantle has preserved, at least since 3.8Ga, a nearly chondritic Ni:Co (~20) despite Ni's tenfold higher liquid Fe/silicate partition coefficient. Although the coefficients do even up at mid-mantle pressure, most melting and segregation would have been at low pressure. Secondly, its essential corollary, the provision of a siderophile- and water-rich 'late veneer' after core completion (set at ~4.45Ga by the ending of mantle Pb depletion, if attributed to Fe percolation), is denied by the Moon, which never underwent a late veneer (Taylor & Esat 1996, *AGU Monogr 95*) and was in Earth orbit by 4.50Ga (Lee & Halliday 1998, *AGU Spring*).

The new core genesis model must work at least all the way from Mercury to Jupiter's Io, Ganymede and watery-surfaced Europa. In the presence of a dense and high-opacity radiatively cooled nebular disc the growing protoplanets would have acquired an accretion-rate controlled temperature and internal convection, largely independent of orbit radius. Erupted magmatic FeO was reduced to Fe by the nebular atmosphere and 'subducted'. The dense Fe-loading of the downwelling limb ensured its deep penetration, with the Fe dropping off at the bottom, thus accelerating convection and core formation. Transfer to the core of mantle chalcophiles and siderophiles took place across the CMB but was delayed by the expulsion of silicate dross from the core. The CMB was sealed at ~4.45Ga by the build-up of subducted primitive crust to start forming D", leaving a time-window for transfer, evident in the Hf-W data for Earth and Mars (Lee & Halliday 1998*, ibid.).* This function of D" denies that mantle plumes can start at the CMB.

Planetary core formation was terminated (= 'age of the Earth') by nebula departure (4561Ma?), with comets and the Great Planets incorporating some of the potentially 1000 Earth-ocean volumes of total reaction water expelled with it. The model makes C and S the preferred core dilutants. Entry of U and Th is possible. Much water entered the early-Earth mantle, as seen in komatiites (e.g. -Nb anomalies), ensuring their high-melting magmagenesis without a need for plumes.

Early acquisition of the Moon, its distinct siderophile composition and the dynamics of the Earth-Moon system suggest tidal-drag capture by a hot low-viscosity Earth, rather than by impact. The predominance of prograde satellites preserved in the Solar System implies a similar mechanism for their capture (Counselman 1973*, Ap.J.),* the retrograde ones (bar Triton) having been ‘wound in’ to coalescence. So most non-gas planetary growth was completed in nebula-present conditions. Thus their growth would have been much faster than by impact alone because nebular-atmospheric drag combined with their accretion-generated partially melted state provided a much bigger (tidal) capture cross-section for planetesimals.

The extent to which asteroids possess cores is put in doubt. Small bodies would cease convecting and resurfacing themselves very soon after nebular departure, leaving iron and lavas on their surfaces as sources for iron and eucrite meteorites.

References in full (not given in published version due to format limitation)

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