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3 stages of Earth evolution - core formation, ocean emergence and the 2.3 Ga rise of atmospheric oxygen: How are they linked?

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Recognized nearly a century ago [1], the mean specific angular momentum (a.m.) of SS planetary materials is >10^5 times the Sun's, so it is an important constraint upon how the planets were built. Nebula is the only conceivable agent for this partition. And it must do this for both the protoplanet and all of its feedstock, so planetary growth must be essentially complete before it departs (<5 Ma?). This rules out the post-nebula growth in cores-by-Fe-percolation models, for which isotopic (Hf-W, etc) data have been interpreted as needing upwards of 30 Ma for completion, though these data may actually relate to post-core-completion exchange at the CMB..

Those models also do nothing for the origin of SS water. Ringwood's model (1960-1978) invokes a cool nebula, acheivable with other advantages [2], to give high-*f*O2 accretion. It then uses the nebula to reduce hot erupted FeO at the protoplanet's surface; the Fe then being 'subducted' to form the core. Nebular departure halted this, leaving some FeO in the mantle. Incorporation into its mineral structure of a few of the >400 Earth-ocean volumes of reaction water thus generated greatly water-weakened it, facilitating convective loss of early heating.

But at ~2.49Ga, ocean production caused parts of the upper mantle to reach a critical loss of water-weakening in the presence of interstitial melt [3], halting convective motion for ~270Ma [4,5]. MOR collapse lowered sea-level by >3km, exposing cratons to erosion, unroofing TTG, lowering atmospheric CO2 and causing Huronian glaciation (2.4 Ga). During this hiatus, oxygenic life, previously confined to the top 200m of oceans, won its battle against MOR effusions, depositing BIF and initiating our oxygen-bearing atmosphere, which is why we are here [3,5]. The restart after 2.22Ga left cratons with the deep-keeled tectospheres of stiffened mantle, manifest in plate dynamics behaviour for at least the past 90Ma [6].

[1] Jeans J. H. (1919) Problems of cosmogony and stellar dynamics. Adams Prize Essay, Oxford, Clarendon Press. 293 pp.

[2] Osmaston (2006) *GCA* **70** (18S) A465; A new scenario for forming the Sun's planetary system (and others?): dynamics, cores and chemistry (pt 2).

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[3] Hirth & Kohlstedt (1996) *EPSL* **144**, 93-108. Water in the oceanic upper mantle: implication for rheology, melt extraction, and the evolution of the lithosphere.

[4] Osmaston (2001) *J.Conf Abstr* **6** (1) 417. Two-layer convection of the mantle. How is it possible? When did it change? What are its geochemical and plate tectonic implications?

[5] Condie, O'Neill & Aster (2008) *GCA* **72** (12S) A175. Did plate tectonics shut down for 200 to 300 My during the Early Proterozoic?

[6] Osmaston (2009) *Geophys.Res.Abstr*. **11**, EGU2009-6359. (Solicited) Deep cratonic keels and a 2-layer mantle? Tectonic basis for some far-reaching new insights on the dynamical properties of the Earth's mantle: example motions from Mediterranean, Atlantic-Arctic and India.