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Construction and differing evolutionary outcomes of the terrestrial planets; insights provided by the 2-stage scenario for constructing planetary systems

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Note. The presence of iron cores in three of the Galilean satellites is taken here to justify extending the ‘terrestrial’ appellation to relevant Jovian matters.

Two of the most explicit, but hitherto unresolved, problems of the solar planetary system have been (a) the huge (x 137,000) mean specific angular momentum (a.m.) of the planet material relative to the Sun’s [1] and (b) the origin of its water, not readily provided within the hot contracting solar nebula picture. It is suggested [2-5 and during this Congress] that a 2-stage scenario offers hope of resolving these issues in a well-integrated manner. In this scenario the protoSun is formed as a star in one nebular dust cloud, subsequently traversing a second, from which it acquires an external addition of fresh material and establishes a disk in which the planets are formed.

New physical reasoning [3-5] shows that the second-cloud material will converge upon the solar poles, passing to low latitude where it will form a dense and powerful outward-propelled Protoplanetary Disk Wind (PDW). Crucial properties of this material would have been (i) its high dust-opacity, and (ii) its low temperature, the source cloud being typically at 10K or even lower. Consequently only that part of the flow very close to the solar surface would get heated enough to generate CAIs, the outer part staying cool enough to preserve CI composition. Planets would nucleate, successively, in the root of the disk, very close to the Sun (where opacity shielded them from the Sun) and be pushed outward in the PDW, fed by smaller material passing them. The asteroids are likely representative of that smaller material, so were not a ‘failed planet’.

The radial displacements due to PDW action offer the growth of a.m. that we seek. So the high a.m. requirement of individual planets can only be met if both protoplanet and its feedstock had reached that radial position by PDW action, so post-nebula accretion is largely ruled out. Moreover the low temperature of the disk (<600K) would have meant that construction was of oxidized, not reduced, materials. This reinstates the rapid core-formation process long favoured by A.E. Ringwood. FeO erupted by the growing protoplanet would get reduced to Fe by its nebular atmosphere, and then ‘subducted’, thus also generating the solar system water (totalling about 1000 Earth-ocean volumes for the 4 terrestrial planets). The process would cease at the moment of nebular departure. Disk opacity rendered solar distance unimportant, each body needing to raise its own temperature (accretion, gravitation, radiogenic heat) for convective overturn to begin, so the distance of the Galilean cores is no problem. But the size of Europa may be near the lower limit for overturn, implying that meteoritic irons come from ‘unsubducted’ positions on asteroids, not from cores.

We will show that the resulting early wetness of the mantles of the terrestrial planets has proved central to their individual evolution. But all the greatly excess water, as dense hydrous atmospheres, was apparently stripped off the inner planets by the final outward clearance of the PDW as the Sun emerged from the second cloud, much of it being captured by the Gas-Giant Planets and some by their satellites.

The complicated effects of water upon mantle rheology have been too little appreciated. If the water content is fairly low, the still-appreciable water-weakening of the mineral structure may be virtually removed by partitioning into a small degree of interstitial melt [6]. But at higher water content such a melt becomes saturated and major water-weakening remains. The early/Archaean Earth shows abundant signs both of a wet mantle and of rapid convective plate motions. By 2.5 Ga, evolution of the ocean volume from the mantle appears to have precipitated a rheological stiffening and a changeover to a 2-layer mantle convective layout, during which oxygenic life was able to bring about the primary rise in atmospheric oxygen which distinguishes us from the other terrestrial planets [7].

Venus, closer to the Sun and hotter, seems to have lost its magmatically evolved water by photolysis, with no magnetosheath to inhibit that. So its mantle became too stiff for convective overturn to continue, and release of heat build-up by a plume-type mechanism has become necessary.

In Mars, much smaller than Earth, core formation would have proceeded more slowly, leaving more FeO in its mantle composition and a proportionately smaller core volume. Much lower levels of magmagenesis, over its lifetime, will have left much more water in its mantle, suggested by its andesitic volcanics, and a low-viscosity mantle. So mantle convection must be bringing heat to shallow levels; heat which, if juxtaposed with the crustal ice by tectonic rupturing, might have produced the evident floodings.

Compositionally, the new scenario does provide for varying input as the ProtoSun moved through the cloud. But this would only affect individual planetary nuclei at the close-in point of their successive origin. Thereafter the outward relative movement of feedstock would distribute the current growth composition across the entire system then in being. Distinct isotopic compositions speak of selective processing (e.g. diffusion during magmagenetic processes) over the lifetime of the planet, not of distinct manufacture.

[1] Jeans, JH (1919), Problems of cosmogony and stellar dynamics, Adams Prize Essay, Univ. Oxford, Clarendon Press, 293 p.

[2] Osmaston, MF (2000). A new scenario for formation of the solar planetary system; dynamics, cores and chemistry. Goldschmidt 2000, Oxford, UK. *J. Conf. Abstr.* **5** (2) 762

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

[4] Osmaston, MF (2009) A new, mainly dynamical, two-stage scenario for forming the Sun’s planetary system and its relation to exoplanet findings. *Geophys. Res. Abstr.* **11**, EGU2009-12204-2.

[5] Osmaston, MF (in press) Continuum Theory: what can CT do that GR cannot? Fundamental illumination of the dynamical construction and evolution of well-observed spiral galaxies and planetary systems. *In*: Proc. 11th Int. Conf. on Physical Interpretations of Relativity Theory (PIRT XI), Imperial College, London, Sept. 2008, PD Publications, Liverpool.

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

[7] Osmaston, MF (2009) 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. *Geophys. Res. Abstr.* **11**, EGU2009-6359-6.