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Origin and Distribution of Water Amongst the Inner Planets

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Abstract. A new model for the origin and bulk chemical composition of the inner planets, especially for their water content, is reported.

There is a growing body of evidence that the planets of the inner Solar system condensed within narrow, compositionally-distinct annuli, close to their present orbital radii (Drake & Righter 2002). Such a picture is consistent with the Laplacian nebular hypothesis, namely that the planetary system had formed from a concentric family of gas rings. Such rings were shed by the contracting proto-solar cloud [hereafter PSC] as a means for disposing of excess spin angular momentum (Prentice 1978). A new model for the PSC has been constructed. It consists of an adiabatic convective core surrounded by a super-adiabatic envelope of negative polytropic index. This structure is suggested by numerical simulations of supersonic thermal convection in a model atmospheric layer (Prentice & Dyt 2003). The cloud possesses a radial turbulent stress whose ratio to the gas pressure achieves a maximum value ~ 15 at the core/envelope boundary. If the controlling parameters stay constant, the PSC contracts homologously and sheds gas rings whose mean orbital radii $R_n (n = 0, 1, 2, \cdots)$ are nearly geometrically spaced. The ring mean temperatures T_n vary with R_n as $T_n \simeq A/R_n^{0.9}$, where A is a constant (Prentice 2001a). Choosing iron-rich Mercury to calibrate A (Prentice 2001b), Venus forms at 917 K and is totally anhydrous. The initial Earth (678 K) has 0.0023, by mass fraction, of water tied up in tremolite. Mars (460 K) contains an H_2O mass fraction of 0.00295 in tremolite and 0.0027 in (Na,K)OH. The asteroids (275 K) contain 0.0027 of H_2O in (Na,K)OH. Mars is thus the most water-rich of all the inner planets. Other predicted bulk constituents of Mars are: $MgAl_2O_4$ (0.0324), $MgSiO_3$-Mg_2SiO_4 (0.3677), Fe_2SiO_4 (0.1796), Fe-Ni-Cr (0.0533), (Fe-Ni)S (0.2042), MnS & ZnS (0.0050), NaCl (0.0016), Cr_2O_3 & $FeTiO_3$ (0.0065) and P_2O_5 (0.0031).

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