Chemistry of Earth's Putative Steam Atmosphere

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The concept of a steam atmosphere generated by impact devolatilization of planetesimals accreted during Earth's formation is over 20 years old (Matsui and Abe, 1986; Lange and Ahrens, 1982). Surprisingly, with the possible exception of a few qualitative remarks, no one has critically assessed this scenario. We use thermochemical equilibrium and, where relevant, thermochemical kinetic calculations to model the chemistry of the "steam" atmosphere produced by impact volatilization of different types of accreting material. We present results for our nominal conditions (1500 K, total P = 100 bar). We also studied the effects of variable temperature and total pressure. The composition of the accreting material is modeled using average compositions of the Orgueil CI chondrite, the Murchison CM2 chondrite, the Allende CV3 chondrite, average ordinary (H, L, LL) chondrites, and average enstatite (EH, EL) chondrites. The major gases released from CI and CM chondritic material are H_2O, CO_2, H_2, H_2S, CO, CH_4, and SO_2 in decreasing order of abundance. About 10% of the atmosphere is CO_2. The major gases released from CV chondritic material are CO_2, H_2O, CO, H_2, and SO_2 in decreasing order of abundance.

About 20% of the total atmosphere is steam. The major gases released from average ordinary chondritic material are H_2, CO, H_2O, CO_2, CH_4, H_2S, and N_2 in decreasing order of abundance. The “steam” atmosphere is predominantly H_2 + CO with steam being about 10% of the total atmosphere. The major gases released from EH chondritic material are H_2, CO, H_2O, CO_2, N_2, and CH_4 in decreasing order of abundance. The “steam” atmosphere is predominantly H_2 + CO with about 10% of the total atmosphere as steam.

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