Chemistry of the protolunar disk and volatile depletion in the Moon

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In the giant impact theory for lunar origin, the Moon forms from a circumterrestrial disk of silicate debris produced by the collision of a planetary-sized impactor with the early Earth [1]. Recent accretion models [2] suggest that the final 10-60% of the lunar mass may be provided by the accretion of melt material spreading outward from the inner (Roche-interior) disk over the first ~10^2 years following the giant impact. The chemical and thermal evolution of the inner disk material is thus expected to strongly influence the bulk chemical composition of the Moon.

In a previous study [3] we explored the chemistry of the melt+vapor protolunar disk in order to examine the vapor pressure of the silicate magma and the chemistry of the protolunar disk atmosphere. Here we combine a chemical model for the disk with lunar accretion simulations [2] and a thermal evolution model [4] in order to explore the chemistry of the accreting lunar material and implications for the bulk lunar composition. A chemical equilibrium code [3] [5] [6] is used to determine the partial pressure of each species in equilibrium with a BSE-composition melt. These vapor pressure results, along with the bulk elemental inventory of the disk, are used to estimate the relative fraction of each element in the melt vs. vapor phase as a function of the mass surface density and temperature of the disk.

The coupled chemistry + lunar accretion + thermal model suggests that the temperature of the melt in the inner disk remains above estimated 50% condensation temperatures for the volatile elements Zn, Na, and K until the Moon has nearly completed its accretion [7]. We thus expect the portion of the lunar material derived from the inner disk to be depleted in these and similarly volatile elements, even in the absence of thermal escape.

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