

INTEGRATED MODELING OF MAGMA  
OCEAN CRYSTALLIZATION John

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Although there have been several calculations of the lunar magma ocean's (LMO) chemical evolution, only a few have involved trace elements and major elements together (1). But these studies have calculated trace elements separately. However, it is now possible to calculate both types of elements simultaneously such that pressure, temperature, and composition parameters are continuously available to calculate partition coefficients from existing models (2).

Fig. 1 illustrates the evolution of a suite of select, generally incompatible, elements for which at least some P-T-X models exist. Fig. 1 illustrates the sequence of liquid compositions from 39 to 99.3 wt% crystallization of an initially 865 km-deep MO with composition similar to the Earth's

upper mantle (3) undergoing simple fractional crystallization from the bottom up. Lithophile incompatible elements are set at CI in the bulk composition. The KREEP composition of (4) is shown for reference. KREEP is widely believed to represent the last dregs of the LMO. Orthopyroxene appears at 39 wt% crystallization at a depth of 3880 km. Plagioclase appears at 79% at a depth of 115 km. And if no significant stable crust forms, then ilmenite appears at 97% at 13 km. At 99.3 % crystallization the residual liquid's composition has the general character of KREEP, but lacks the both the degree of enrichment and fractionation of KREEP.

Calculations of mixed cumulates from mineral compositions show many of the features of the mare basalt source, but are not completely faithful. Relative depletions of Th and U are too strong and suggest the need for a trapped liquid component.

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Fig. 1 Chemical Evolution of Lunar MO

