THE BULK COMPOSITION OF THE MOON

Stuart Ross Taylor
Department of Nuclear Physics, Research School of Physical Sciences,
Australian National University, Canberra, Australia, 0200

The bulk composition of the Moon is of crucial importance in deciding between theories of lunar origin. If the Moon is derived largely from the mantle of the Earth, then some recognisable signature of our planet should identifiable in the lunar composition. On the contrary, if it can be demonstrated that the Moon is distinct in composition from that of the terrestrial mantle, then a separate origin is called for[1].

The Apollo and Luna sample returns established that the Moon is bone-dry and is depleted in the very volatile elements (e.g., Bi, Tl) relative to abundances in the solar nebula. Trace siderophile elements are depleted in order of their metal-silicate partition coefficients, consistent with their removal into a small metallic lunar core.

Data from the Clementine Mission established the alumina-rich composition of the highland crust, requiring that relative to the Earth, there is an enrichment of refractory elements (e.g., Ca, Al, Ti, REE, U, Th) in the Moon [e.g., 2]. Those elements with condensation temperatures above 1100-1200K are present in the Moon in their solar nebular ratios, so that material subjected to extreme temperatures apparently was not incorporated in the Moon. Recent interpretation of the seismic data [3] suggest significantly higher concentrations of FeO and the refractory elements (Ca, Al) in the lunar mantle compared to the composition of the Earth's mantle. The FeO content of 13% in the bulk Moon is intermediate between that of Mars with 18% and the terrestrial mantle with 8% FeO. The high bulk FeO content of the Moon rules out the derivation of the proto-lunar material from any but a small fraction of the terrestrial mantle.The alkali elements are depleted relative both to the Earth and the solar nebula. The low value of LUNI (= BABI) argues for very early loss of volatile Rb relative to refractory Sr and is consistent with an early depletion of volatile elements in the solar nebula. Fractionation effects in the potassium isotopes due to Raleigh-type distillation processes between the Earth and the Moon are not observed [4]. Models that account for the low alkali content of the Moon by evaporative loss from the terrestrial mantle are thus ruled out. In summary, the bulk composition of the Moon differs significantly from that of the terrestrial mantle.

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