# Geochemical constraints and dynamic simulation of the origin of the Earth-Moon system

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Some geochemical characteristics of the Moon are difficult to reconcile with its origin from the Earth mantle. Here we suggest a concept, which is alternative to the currently accepted giant impact hypothesis.

Evaporation is believed to be ruled out as a viable mechanism of the observed depletion of the Moon in volatiles because of unavoidable isotope fractionation. However the isotope fractionation may be absent or negligible if evaporation occurs reversibly. Such conditions are implemented in a cloud of heated dispersed particles.

We showed by use of a modified method of particle dynamics that evolution of a cloud of evaporating particles can result in formation of two body systems, which might have been embryos of the Earth and Moon. The dynamic simulation (computer animation will be presented) shows that for the chondrule-like particles evaporation intensity of the order $10^{-12}$ to $10^{-13}$ $kg/m^2s$ is sufficient to generate repulsive force preventing immediate collapse. This corresponds to 40% decrease of the initial particle mass during $2.10^4$ to $6.10^4$ years. After 40% evaporation of chondritic material the composition of the residue almost coincides with the composition of the Moon, including its present iron content.

| Component | Initial melt composition | Composition of residual melt after 40% evaporat. | Moon |
|---|---|---|---|
| MgO | 23.4 | 31.9 | 32.0 |
| $SiO_2$ | 35.0 | 42.9 | 43.4 |
| FeO | 36.9 | 15.8 | 13.8 |
| Al+Ca | 4.6 | 9.4 | 10.8 |

The computer modeling shows that of two bodies the higher-mass one grows faster. Therefore embryo of the Moon kept relatively low content of iron, while the body that became an embryo of the Earth eventually accumulated the rest of the cloud and acquired its full iron content.

The suggested model is consistent with the elevated concentration of the refractory elements, including Al, Ca, Ti in the Moon compared to the Earth and loss of volatiles without isotope fractionation. Distribution of siderophile elements in the Moon as well as the interpretation of Hf-W systematic can be reconciled with formation of the Moon from the primitive material of chondritic origin. If the suggested model is valid, a necessity arises of a revision of the current concept of planet-satellite formation.

# The characterization of Martian meteorite ALH84001 using focused ion beam specimen preparation and transmission electron microscopy

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Focused ion beam (FIB) in-situ lift-out techniques were used to prepare a specimen from Martian Meteorite ALH84001 for subsequent transmission electron microscopy (TEM). A site specific specimen was prepared from the magnetite rich double black rimmed region surrounding a carbonate globule within an orthopyroxene matrix. TEM results show that the black-rimmed region consists primarily of a two-phase region consisting of carbonate and a dense distribution of nanocrystalline magnetite grains that are < 100 nm. The dense population and grain overlap of the magnetite made it extremely difficult to assess the crystallographic faceting geometry and purity of individual magnetite particles (see bright field TEM image below). X-ray energy dispersive spectrometer of the two-phase region shows the presence of Fe, O, Mg, Si, Ca, and small amounts of S, the ratios of which depend on the location within the two-phase region. The orthopyroxene is Si-rich with smaller amounts of Fe and Mg present.

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