The origin of the Moon revisited

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"There is nothing permanent except change (Heraclitus of Ephesus ca 500 BCE)
'When the facts change, I change my mind" J. M. Keynes, economist 1940

The origin of the Moon, after having been settled for a generation, is once again in a state of flux, with new geochemical data and geophysical models varying between large [1] and small [2] impactors.

The following geochemical facts about the Moon appear reasonably solid:

a. The Moon as an isotopic composition similar to the silicate mantle of the Earth for O [3] Cr [4] Mg [5] Ti [6] and Si [7].
b. It is depleted in volatile elements [8]
c. It is very dry although not totally so [9]
d. The heavy isotopes of Zn are enriched [10]
e. It appears to have little trace of the impacting body.

While the Moon thus may be distal ejecta from the Earth, many problems remain. So what happened to the lunar-forming impacting body and its possible core? Was it larger [1] or smaller [2] than the canonical Mars-sized body. What happened to it? Was it incorporated into the Earth and homogenized or lost (vaporized?). Models have always suggested that a putative impactor core was incorporated in order to account for the low density of the Moon compared to the Earth.

The Earth was assembled, in the planetesimal hypothesis, from a wide variety of bodies, which may have been differentiated into cores and mantles. Was the Earth homogenized before the Moon-forming event or by that event?

Lunar basalts have high FeO contents analogous to those from Vesta and Mars. The FeO content of the lunar mantle is often thought to be 13 wt% compared to 8 wt% for the Earth. Was the impactor responsible for the possible higher FeO content of the lunar mantle compared to the Earth or were the lunar basalts derived from Fe-rich cumulates and so are not representative of the bulk lunar mantle?

The lunar data bear a curious parallel to the formation of tektites. Tektites are mm to cm sized objects produced by the impact of asteroids under some specific conditions onto the crust of the Earth [11-15]. They are characterized by

a. Similarity in composition to the upper continental crust for the refractory elements [11-15]
b. Depletion in elements more volatile than potassium [11, 12, 15]
c. They are very dry with water contents around 80 ppm [16]
d, They are enriched in their heavy isotopes of volatile elements (e.g., Cu, Cd and Zn [17,18]). Evaporation during impact has not altered the abundance or isotopes for elements less volatile than K [19,20]
e. They contain negligible [21] and debatable [22] traces of the impacting body.

This curious similarity in composition suggests that the formation of the Moon was somewhat analogous to the formation of high-temperature distal impact ejecta [23]. Naturally, we do not propose that the Moon is something like a giant tektite, as the Moon formed during a giant collision many orders of magnitude greater than tektite-forming impacts and this event occurred very early in Earth history. However, the processes that occur during large-scale impact events can provide guidance in understanding certain aspects of the composition of the Moon.

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