CM2-TYPE MICROMETEORITIC LUNAR "WINDS" DURING THE LATE HEAVY BOMBARDMENT.

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Two conjunctures for the "late heavy bombardment". Both conjunctures are reported as variations of the relative lunar cratering rates with time —they are discussed in Ref. 1, and both represented in fig. 6.6 of Hartmann [2]. For Hartmann, an exponentially decreasing flux of impactors was striking the Moon —this conjuncture is coined here after as the ***LHBomb***. In the other alternative of the lunar terminal cataclysm (***LTC***), there is a spectacular burst of impacts, spreading over a narrow time interval of ~150 Myr centred around 3.9 Gyr ago [3].

The accretion formula. One of us (M.M.) relied on the works of Ahrens [4] and Canup and Asphaug [5], to derive a simple "accretion" formula, yielding the total amount, M_A, of a given volatile species, ***A*** (e.g., Ne, N_2, H_2O, CO_2), released during the aerodynamical braking of micrometeorites in the terrestrial atmosphere, since the formation of the Moon —Ahrens deduced that the giant Moon forming impact blew off the pre-lunar complex atmosphere of the early Earth, and Canup and Asphaug gave a credible timing of this impact.

It reads as $M_A \sim A(\%) \times \Phi(Earth)$, where $A(\%)$ is the wt% content of a volatile, ***A***, in Antarctic micrometeorites (AMMs), and $\Phi(Earth)$, the integrated micrometeorites mass flux accreted by the whole Earth since the formation of the Moon [6]. The value of $\Phi(Earth)$ was first estimated from the total amounts of either neon or nitrogen in the Earth's atmosphere, and the concentrations of these two elements in AMMs, which differ by a factor of ~100,000. We got values of about 4×10^{24} g and 7×10^{24} g, respectively. Next, the variation of relative lunar cratering rates with time conjectured by Hartmann was assumed to scale to the micrometeorite flux. The integration of this curve yielded a value $\Phi(Earth)$ ~5.6×10^{24} g [7]. With the same assumptions, the burst of impactors of the ***LTC***. (see Fig. 6.6 in reference [1]), gave a value ~200 times smaller.

Only, the ***LHBomb*** yielded the high M_A values that well fit the observed amounts of Ne, N_2, H_2O and CO_2 (see Table 1 in Ref. 6). This was astonishing because Hartmann warns that prior to ~3.9 Gyr the lunar cratering rates are known only within a factor 10, and Tolstikhin and Marty [8] even quote a factor of ~100!

An unexpected validation of EMMA on the Moon. Meanwhile, the ***LTC*** was gaining popularity, in particular because it well explains the late formation of large lunar basins [1]. It was even claimed that the iridium content of lunar samples invalidates the high fluences of impactors predicted by the ***LHBomb***, and consequently our scenario. While scrutinizing these criticisms, we noted some confusion in the arguments —e.g., the total mass of impactors *incident* on the lunar surface can be misleadingly assimilated to that *retained* in the lunar crust after the impact. And the confusion gets even worst when considering the contributions of micrometeorites.

Let us compare the integrated mass flux of micrometeorites, Φ (*Moon*), striking the lunar surface since the formation of the lunar crust, to the total amount of extra-lunar material accreted by the Moon, and deduced from the Ir contents of lunar samples. The value of $\Phi(Moon)$ ~ 4.6×10^{23} g is obtained multiplying $\Phi(Earth)$ by the ratio of the cross sections of the Moon and the Earth (0.077).

Levinson et al [9] carefully reviewed estimates of a parameter coined as *the mass fraction, f, of the lunar crust that is of "meteoritic" origin* —they implicitly assumed that this material was deposited by the crater forming impactors. This value, which ranges from about 2% to 0.3%, was inferred from the Ir contents of lunar samples. They also quoted estimates of the thickness of the lunar crust contaminated by this material, Δ *(crust)*, which is bracketed between 35 km and 15 km. One ends up with a total mass of "meteoritic" material dispersed in the lunar crust ranging from 8×10^{22} g to 5×10^{21} g. As these values are much smaller than $\Phi(Moon)$, it could be argued that the ***LHBomb*** overestimates the amount of material deposited on the Moon by a factor ~ 6 to ~100.

But this deduction is incorrect, because iridium found in the crust was delivered by the fraction of the impactor mass, η, retained after the