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# Timeline and composition of lunar impactors

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The Moon's impact bombardment history is fraught with discrepancies. Experimental results analysing the relative abundances and isotopes of highly-siderophile elements (HSEs) in lunar samples reach divergent conclusions: the impactors are either akin to non-carbonaceous (NC) materials[1,2], or may be sourced heterogeneously containing carbonaceous materials (CC)[3,4]. Similarly, the impact timeline of the Moon derived from crater chronology or dynamical modelling has been expressed with various parametric fits[5,6,7,8] that are mostly inconsistent with each other for ages >3.5 Ga. Its crater population is a superposition of impactors left over from terrestrial planet formation, the main asteroid belt, and the hypothesised E-belt[9].

We ran new dynamical simulations combining all three sources, varying the mass in leftovers only. Our main results are:

- the impact probability with the Moon depends logarithmically on the leftover planetesimal mass;
- impacts are dominated by the leftovers in the first ~300 Myr
- impactor composition is expected to be NC since they form the source material of the terrestrial planets[10];
- the size frequency distribution for large impactors (D>100 km) is steep;
- the lunar HSEs were preserved after 4.35 Ga;
- the lunar highlands are about 4.35 Ga.

A predominantly CC impactor flux represents a paradox that is difficult to solve dynamically unless the projectiles mostly came from the main asteroid belt. An episode of giant planet migration coincident with, or shortly after, lunar formation may supply these projectiles[11].

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