Pb-Pb ages and Pb initial isotopic composition of lunar meteorites: new constrains on the timing of lunar magmatism and its mantle sources

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Constraining the duration of magmatic activity on the Moon is essential to understand how the lunar mantle evolved chemically through time. Determining age and initial isotopic compositions of mafic lunar meteorites is a critical step in defining the periods of magmatic activity that occurred during the history of the Moon and to constrain the chemical characteristics of mantle components involved in the sources of the magmas.

We have used the in-situ Pb–Pb SIMS technique to investigate lunar gabbros and basalts, including meteorites from the Northwest Africa (NWA) 773 clan (NWA 2727, NWA 3333, NWA 2977, NWA 773 and NWA 3170), LAP 02224, NWA 4734 and Dhofar 287A. These samples have been selected as they all belong to the dominant chemical group of low-titanium mare basalts and there is no clear agreement on their age. We have obtained ages of 2978 ± 13 Ma for LAP02224, 2981 ± 12 Ma for NWA 4734 and 3208 ± 22 Ma for Dhofar 287. For the NWA 773 clan, four samples (NWA 2727, NWA 773, NWA 2977, NWA 3170) yielded isochron-calculated ages that are identical within uncertainties with an average age of 3086.1 ± 4.8 Ma. The gabbroic sample NWA 3333 yielded an age of 3038 ± 20 Ma suggesting that two distinct magmatic events are recorded in the meteorites of the NWA 773 clan.

The entire age dataset from lunar mafic meteorites was screened to identify data that are problematic from an analytical viewpoint and/or show evidence of resetting and terrestrial contamination. This refined dataset combines the ages of mafic lunar meteorites and Apollo samples and suggests pulses in magmatic activity, with two main phases between 3350 and 3100 Ma and between 3900 and 3550 Ma followed by a minor phase at ~3000 Ma.

The evolution of the Pb initial ratios of the low-Ti mare basalts between 3400 Ma and 3100 Ma suggests that these rocks were progressively contaminated by a KREEP-like component. Nevertheless, the ~3000 Ma mafic rocks (NWA4734 and LAP02224) show significant differences in terms of initial $^{204}\text{Pb}/^{206}\text{Pb}$ ratios that illustrates that the lunar mantle is probably more
heterogeneous than has previously been assumed.