Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.20353

A Lu-Hf isotope study of igneous clasts in the martian breccia meteorite NWA 7533 indicating ancient formation ages by re-melting of the primordial crust

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The martian breccia Northwest Africa 7533 and paired meteorites provide a unique opportunity to investigate the timing and processes of crust formation on Mars. Bulk breccia ^{147}Sm-^{143}Nd isochron work suggests an ancient formation age (>4.4 Ga) for the majority of the breccia components [1] implying that the igneous clasts formed very early. However, geochronological studies of individual igneous clasts are challenging (due to their small sizes) and crystallisation ages are typically inferred from in situ zircon U/Pb dating which return ancient formation ages [*e.g.*, 2] in consistence with the prediction in Nyquist et al. [1]. Costa et al. [3] obtained nearly concordant U/Pb ages for a zircon from the basaltic clast C27 defining a ^{207}Pb/^{206}Pb date of 4443.7 ± 1.2 Myr, suggesting an ancient formation age for the clast assuming that the zircon is autocrystic in origin. However, due to the chemical and mechanical resistance of zircon, it should be explored whether these zircons could be xenocrystic (inherited) in origin and, thus, would be dating an event prior to the crystallisation of the host rock. We present bulk Lu-Hf isotope data for individual igneous clasts that provide evidence that they are ancient and experienced limited Lu-Hf isotope disturbance since the time of formation. In detail, the present-day εHf values and ^{176}Lu/^{177}Hf ratios in the clasts range from -51 to -73 and 0.0102 to 0.0176, respectively. The backprojected Hf isotope compositions of the clasts intersect the ancient Black Beauty zircon array [3], indicating that they formed contemporaneously with these zircons by re-melting of a pre-existing crust. Moreover, the backprojected composition measured for the basaltic clast C27 intersects the initial Hf isotope composition in a zircon separated from the same clast [3] further confirming an autocrystic origin for the zircons present in the igneous clasts and, by extension, that the clasts represent pieces of the ancient crust on Mars.

[1] Nyquist, L. E. *et al.* (2016) *Meteorit. Planet. Sci.* **51**, 483-498. [2] Humayun, M. *et al.* (2013) *Nature* **503**, 513-516. [3] Costa, M. M. *et al.* (2020) *PNAS* **117**, 30973-30979.