A POSSIBLE 4.1-4.2 Ga IMPACT EVENT RECORDED IN LUNAR METEORITE NORTHWEST AFRICA 5000

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Introduction: Northwest Africa (NWA) 5000, a large lunar meteorite (~11 kg), was recovered in Morocco in 2007 [1]. It is a feldspathic, gabbroic, polymict breccia composed of mostly plagioclase, pyroxene and lesser olivine, with kamacite (Fe-Ni alloy), merrillite, ilmenite, chromite, baddeleyite, troilite and K-feldspar as accessory minerals [1]. Previous petrographic observations of NWA 5000 show evidence of impact melt: most of the coarse-grained gabbroic anorthosite clasts as well as the less abundant black vitreous clasts contain metal grains (up to 4 mm) whereas other clasts are injected with shock veins composed of glass, troilite and mineral fragments [1]. Its gabbroic mineralogy is unlike most of the feldspathic Apollo samples, which commonly have a noritic composition, and indicates that NWA 5000 likely originates from a region not sampled by the Apollo missions. Siderophile element compositions of the larger metal grains indicate meteoritic contamination and suggest that the gabbroic anorthosite lithology is an impact melt rock [2]. Ar-Ar dating on bulk fraction gives a minimum age of 3.2 Ga [3].

Our initial study [4] presented major and trace element results on plagioclase and pyroxene fractions from this sample. These results indicate that NWA 5000 likely crystallized from a melt slightly enriched in REE but not as much as might be expected for a source within the Procellarum-KREEP terrane and may suggest a source terrane more akin to the Feldspathic Highlands Terrane [5-6]. This abstract presents new Sr and Nd isotopic data for plagioclase separates in order to constrain the isotope characteristics of the source of this breccia and to estimate the crystallization age of the coarse-grained, gabbroic anorthosite clast.

Analytical Techniques: Initial crushing and magnetic separation were prepared by Amy Gaffney and Lars Borg and consist in magnetic fractions of 100-200 and 200-325 mesh size for an overall ~1 g of meteorite. Six fractions of plagioclase separates were handpicked from the 100-200 mesh (~75-150 µm), 1.2A non-magnetic fraction. They were optically evaluated as relatively pure plagioclase. Sample weights ranged from 12-20 mg. Prior to dissolution, the mineral fractions were mildly leached in HCl in order to removed impurities and potential terrestrial contamination. Rb, Sr, Sm and Nd were separated in the ANU SPIDE^{2}R clean laboratory, following procedures described by [7]. Samples were analyzed on a Thermo Triton Thermal Ionisation Mass Spectrometer at the Research School of Earth Sciences, Australian National University.

Results: The six fractions of plagioclase produced consistent results. Strontium concentrations are between 181 and 201 ppm and are in good agreement with LA-ICPMS data (195-206 ppm). Isotopic measurements give $^{87}Sr/^{86}Sr$ between 0.699501 and 0.699513, with an average of 0.699506 ± 0.000005 (1SD). Neodymium and Samarium concentrations obtained by TIMS are between 1.33 and 1.47 ppm, and 0.30 and 0.33 ppm, respectively. Both are consistent with data obtained by LA-ICPMS (average of 1.25 ppm and 0.29 ppm, respectively). $^{143}Nd/^{144}Nd$ isotopic compositions range from 0.510948 to 0.510957, with an average of 0.510951 ± 0.000004 (1SD).

Discussion: Sr and Nd model ages [8] can be calculated from these results. Using a present value of $^{143}Nd/^{144}Nd$ for the Chondritic Uniform Reservoir (CHUR) of 0.512638, a $^{147}Sm/^{144}Nd$ for CHUR of 0.1966, and the average $^{147}Sm/^{144}Nd$ measured in our sample (0.1351 ± 0.0008), the T_{CHUR} Nd model age of the plagioclase is 4140 ± 65 Ma. A similar approach can be applied to the Sr data, with considerably larger uncertainties. Assuming an initial lunar composition with $^{87}Sr/^{86}Sr$ of 0.69906 ± 0.00002 at 4515 ± 10 Ma, a corresponding $^{87}Rb/^{86}Sr$ of 0.01734 deduced from the bulk Moon Rb/Sr of 0.006 ± 0.001 [9], and using the $^{87}Rb/^{86}Sr$ for our sample estimated from the LA-ICPMS data (0.0033), we obtain a T_{Sr} model age of 3400^{+305}_{-460} Ma. Agreement of the Sr model age with the Nd model age would require a Rb/Sr of the source reservoir of 0.0155, which could be consistent with a small contribution from an ITE-enriched component as also suggested by our trace elements data [4].

As the whole rock REE composition of NWA 5000 has approximately chondritic Sm/Nd [10], the Nd model age of 4.1-4.2 Ga for the plagioclase may approximate the crystallization age of the gabbroic anorthosite, and therefore the timing of the impact event that created this melt rock, although additional measurements are needed. If confirmed, this may have significant implications for the early impact history of the Moon and the Terminal Cataclysm hypothesis.

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