PB-PB CHRONOMETRY OF IMPACT MELTS FROM LUNAR METEORITE OUED AWLITIS 001

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Introduction: Oued Awlitis (OA) 001 meteorite was classified as a lunar clast-rich melt rock [1]. It was proposed to have been launched from the Pierazzo crater (9.3 km diameter) that resides on the ejecta blanket of Orientale basin, based on its petrography and remote-sensing data [2]. In this case, OA 001 would have formed during the Orientale-basin-forming event and its formation age may then be used to constrain the age of this basin. The only age reported so far for OA 001 is an Ar-Ar age earlier than 3555 ± 34 Ma [3]. Here we present Pb-Pb isotopic analyses of a fragment of crystallized impact melt from OA 001 that places further constraints on the Orientale-basin-formation age.

Sample: OA 001 contains 89 vol% of plagioclase ($An_{88–97}Ab_{3–12}Or_{0–0.3}$), and other mineral phases are olivine ($Fa_{30–44}$), pigeonite ($En_{48–59}Fs_{26–40}Wo_{6–19}$), and augite ($En_{64–70}Fs_{20–24}Wo_{25–34}$) [2]. The oikocrystic olivine and pyroxene are within a phenocrystic plagioclase groundmass [2]. It has minor phases like troilite, ilmenite, and spinel [2], and we also identified apatites. The plagioclase has strong undulose extinction, planar deformation features, and is partially transformed to diapletic glass. The shock stage of OA 001 was estimated to be S4 (20–24 GPa) [3]. The selected chip was documented using back-scattered electron microscopy and did not contain any clasts.

Methods: About 125 mg of the impact melt-rich chip from OA 001 was ground to fine powder in an agate mortar. The powder was leached sequentially as follows: ultrasonicated for 15 min each in 0.5 M HBr (acid wash named W1), H_2O (W2), and 0.5 M HNO_3 (W3); in 6 M HCl (W4), 7 M HNO_3 (W5) and 7 M HNO_3 (W6) at 120°C for one hour each; then ultrasonicated for 1 hour in 1 M HF (W7) and fluxed at 90°C for 12 hours in 1M HF (W8). For sample digestion, we used a 29 M HF and 16 M HNO_3 mixture (at 120°C for 48 hours); the sample and all leachates were then treated with 16 M HNO_3 (at 120°C), and 6 M HCl (at 120°C); finally, all the samples were dissolved in 1.5 M HBr (at 120°C). For Pb chromatography, we followed the HBr-HNO_3 method [4]. The procedural blank (included leaching, digesting, and column passing) was on average 1.4 ± 0.3 pg. A Thermo-Finnigan Neptune Plus MC-ICPMS was used to analyze Pb isotope ratios at UCA. Tl-doping and standard (NBS 981) bracketing methods were used to correct for instrumental mass bias [5], and NBS 983 was used as a secondary isotopic standard.

Results and Discussion: In total, we analyzed 8 leachates and 1 residue of an impact melt-rich chip from OA 001. Only the most radiogenic leachates (W4, W6–8) were used to calculate the Pb-Pb age. An isochron age of 3902.2 ± 4.8 Ma (MSWD=2.0) was defined by these 4 leachates (Fig. 1) using $^{238}U/^{235}U=137.79$.

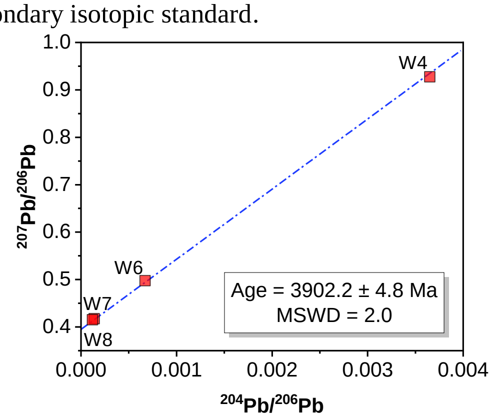

Figure 1. Pb-Pb isochron age of OA 001

If OA 001 was launched 0.3 My ago from the Pierazzo crater located on the ejecta blanket of the Orientale basin [2], the crystallization age of OA 001 impact melt would point to the age of the Orientale-basin-forming event. The Orientale event has been previously proposed to have an age of 3.72–3.85 Ga based on crater counting in [6]. This period is significantly later than the Pb-Pb age reported here; as such, OA 001 would not be related to the Orientale ejecta blanket. However, using new crater imagery from the Lunar Reconnaissance Orbiter Camera, the Orientale formation age is defined at $3.89^{+0.06}_{-0.1}$ Ga [7], which is in very good agreement with our Pb-Pb age. This suggests that the formation age of the OA 001 impact melt constrains the Orientale event more precisely at 3902.2 ± 4.8 Ma. Regardless of the potential connection between OA 001 impact melt and the formation of the Orientale basin, our data suggest that an impact melt-forming impact event may have occurred on the lunar far side [2] at ~3.9 Ga, slightly later than near-side basin-formation events such as Imbrium (proposed at 3.92–3.94 Ga) [8].

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