

SIMS PB-PB DATING OF PHOSPHATES IN THE LUNAR METEORITE NORTHWEST AFRICA 4734.

Y. Wang¹ and W. Hsu², ¹Purple Mountain Observatory, Nanjing 210008, China (y_wang@pmo.ac.cn),
²Space Science Institute, Macau University of Science and Technology, Macau.

Introduction: Impact between celestial bodies is one of the most important processes in the history of solar system. Chronological studies on returned lunar samples and meteorites inferred that intensive impact events had caused the global isotopic resetting in the lunar crust during a so-called “late heavy bombardment (LHB)”^[1] period at ~3.9 Ga, probably due to the orbital migration of giant planets. Most lunar rocks have impact ages around ~3.4-4.2 Ga^[2]. However, the lunar bombardment history after the LHB period is poorly constrained due to the scarcity of relatively young lunar samples. Several mare basalt meteorites with crystallization ages of ~3.0 Gyr have been recovered recently. Northwest Africa (NWA) 4734 is one of them. NWA 4734 had experienced extensive shock metamorphism, with an Ar-Ar age of ~2.7 Gyr^[3-4]. This work aims to determine the impact age of NWA 4734 by in situ U-Pb dating on apatite and merrillite grains. Due to their relatively low closure temperature (~500 °C), the U-Pb systems of the phosphates are readily disturbed or reset by shock-induced heating.

Experimental: SIMS U-Pb dating of phosphates was conducted using the Cameca SIMS 1280 HR at the Institute of Geology and Geophysics in Beijing. Analytical conditions are similar to those in our previous work^[5].

Results and Discussion: Phosphates are minor phases (<1 vol%) in NWA 4734 whereas apatite is more abundant than merrillite. Phosphate grains in NWA 4734 can be grouped into three petrographic categories: (i) relatively large isolated crystals (~50 μm) dispersed among phenocrysts of pyroxene, maskelynite, olivine, and silica; (ii) small crystals (5-15 μm) interstitially set in mesostasis with late-formed phases or forming “swiss-cheese” intergrowths with Si,K-rich glass; (iii) relict grains in shock-melt veins or partially melted plastic structures in and near melt veins. Apatite is usually F-rich (3.2-5.3 wt%) with minor FeO (1.3-2.4 wt%) and SiO₂ (1.0-1.8 wt%). Merrillite has high contents of FeO (6.1-6.9 wt%) and SiO₂ (0.3-1.5 wt%). Raman spectra of merrillite exhibit characteristic bands of clinopyroxene at 660 and 1006 cm⁻¹ in addition to the merrillite band at 970 cm⁻¹. Sub-micron pyroxene inclusions could be present within merrillite grains.

Ten categories (i) and (ii) phosphate grains located away from shock-melt regions were analyzed and yielded ²⁰⁷Pb/²⁰⁶Pb ages from 3101.2 ± 13.2 Ma (1σ) to 3155.8 ± 8.7 Ma, with a weighted mean of 3129 ± 16 Ma (2σ) (Fig. 1). The scattering of data points could reflect different degree of isotopic disturbance. Previous studies gave slightly different crystallization ages of NWA 4734, from 3024 ± 27 Ma (Sm-Nd) to 3073 ± 15 Ma (Pb-Pb), and to 3083 ± 42 Ma (Rb-Sr)^[6-7]. The in situ phosphate Pb-Pb ages of NWA 4734 are consistent with the relatively old Rb-Sr age within uncertainty.

Our results show that the Pb-Pb isotopic systems of the phosphates in the host of NWA 4734 had not been significantly reset by impact. Due to the heterogeneous distribution of shock-induced high pressure and temperature in the rock^[3], phosphate grains within and nearby the shock-melt regions should be more susceptible to isotopic disturbances than those in the host. U-Pb dating on the category (ii) phosphates is in the process, which might shed some lights on the late impact history of the Moon.

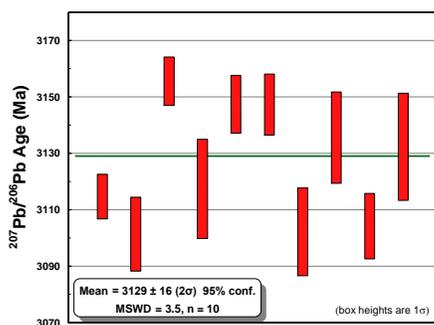


Fig.1 Weighted mean ²⁰⁷Pb/²⁰⁶Pb ages of apatite and merrillite in NWA 4734.

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