IS THE AGE OF THE MOON'S SOUTH POLE AITKEN BASIN PRESERVED IN LUNAR METEORITE NORTHWEST AFRICA 2995?

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Introduction: Samples from the 2500 km diameter lunar farside South Pole Aitken (SPA) basin would be significant as they are expected to hold clues to several key lunar science questions [1-2] including: (i) what is the age of the SPA basin, which will help to anchor the early Earth-Moon impact flux chronology; (ii) what is the nature of igneous rock samples from the lunar farside, and what do these tell us about asymmetries in lunar dif-ferentiation (i.e., urKREEP presence or absence); (iii) how do large impact melt sheets differentiate; (iv) what is the composition and timing of farside mare volcanism and magmatism; and (v) did the SPA basin excavate lunar mantle material [3]?

Sample availability: The Chang'e-4 mission analysed in situ the mineral compositions of SPA soils and rocks [4-5], however, to date we do not have samples from the SPA basin itself that have been directly collected by missions. Despite this, we do have the possibility that some Apollo rocks [6] and some samples in the lunar me-teorite collection ([7] and refs. therein) may have originated from within the SPA basin. We focus here on the geochemistry, mineralogy, and chronology records preserved in lunar meteorite Northwest Africa (NWA) 2995, which has been proposed through its pairing with NWA 2996, to be a candidate SPA-derived meteorite [8].

Methods: A 1×0.7 cm thick section of NWA 2995 was polished, carbon coated, and analysed using Scanning Electron Microscopy (SEM) at the University of Manchester to derive whole sample qualitative energy disper-sive spectroscopy X-ray element distribution maps and a backscattered electron (BSE) image. Mineral phases of interest were imaged at high spatial resolution using BSE and cathodoluminescence imaging (CL) at the Universi-ty of Manchester. Some zircon grains were examined by electron backscatter diffraction (EBSD) at the Universi-ty of Portsmouth. The chemical compositions of silicate mineral phases and apatite were analysed at the Institute of Tibetan Plateau Research, Chinese Academy of Sciences, with a JEOL JXA-8230 Electron Probe Micro Ana-lyzer. The sample was also gold coated and analysed at the Institute of Geology and Geophysics, Chinese Acad-emy of Sciences, for U-Pb-isotope dating of zircon and apatite phases using secondary ion mass spectrometry (SIMS) on a Cameca 1280HR instrument.

Results and Conclusions: Our section of NWA 2995 is a fragmental breccia with a dark grey matrix, enclos-ing white, brown, and grey clasts (up to 1.5 mm). Mercer et al. [8] report a glass bead in NWA 2996, suggesting that the sample is a regolith breccia representing a fused lunar soil. Clasts consist of a range of impact melt brec-cias with different textures, including clast-bearing and dendritic crystalline types, granulitic breccias, quartz monzogabbros (QMG) and gabbro clasts, and Si-K-rich granophyres. Chi squared test analysis comparing the meteorite's bulk rock composition – including SiO2, Al2O3, MgO, FeO, TiO2, CaO, Th, K, and U abundances [7] – with the Lunar Prospector gamma ray lunar surface composition dataset shows that the meteorite is composition-ally similar to regolith (soil) within the SPA Basin (see also [8]). Zircon and apatite grains within the matrix and QMG clasts yielded U-Pb dates of 4.32-4.33 Ga, which is consistent with the crater count model age range pro-posed for the formation of the SPA basin (from 4.26 to >4.33 Ga [9]).

We propose that these U-Pb dates in NWA 2995 correspond to zircon and apatite resetting ages associated with the excavation of various lithologies during the SPA basin forming event, indicating that formation of SPA is at least 4.32 Ga old. This age, which is at the upper end of previous estimates for the age of the basin [9], has important implications for the early bombardment history of the Moon [2]. Our results also indicate that quartz monzogabbro lithologies could be an important component of the lower crust on the farside of the Moon, where they are likely lithological carriers of the small Th-bearing chemistry signature seen from orbit within the SPA basin floor. These findings should be testable in coming years, when the Chang'e-6 mission returns with samples collected from the floor of the SPA basin in ~2023 [10].

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