

Petrology, Mineral Chemistry and U-Pb Chronology of Lunar Feldspathic Meteorite Northwest Africa 11479

J. Chen¹, S. Li¹, W. Hsu², S. Liao¹ and M. Zhu¹, ¹State Key Laboratory of Lunar and Planetary Sciences, Macau University of Science and Technology, Macau, China (slli@must.edu.mo). ²CAS Center for Excellence in Comparative Planetology, Purple Mountain Observatory, Chinese Academy of Science, Nanjing.

Introduction: Lunar feldspathic meteorite is crucial for understanding the formation of lunar highland crust since the laden anorthositic lithologies are representative of the surface composition for Feldspathic Highland Terrain based on the global remoting data [1]. Especially, the widespread magnesian anorthositic rocks, including magnesian anorthosite and magnesian granulite, have been discovered in feldspathic meteorites, implying the lunar crust is more complicated than the simple anorthosite flotation scenario from the classical lunar magma ocean model [2,3,4]. Therefore, a detailed analysis of magnesian anorthositic rock and a better understanding of the origin of these mysterious magnesian materials is key to decoding the formation of the lunar crust. In this work, we investigated the mineral chemistry and *in situ* U-Pb isotope systematics of the magnesian anorthositic clasts in lunar feldspathic breccia NWA 11479.

Result and Discussion: NWA 11479 is a typical feldspathic meteorite with a depleted Th concentration of ~0.2 ppm [5]. Multiple highland lithologies are observed in our study, dominantly including anorthosites, granulites, and impact melt breccias. Most of the mafic minerals (Mg#: 65-82) and associated feldspar (An: 94-97) in these lithic clasts fall in the gap defined as the magnesian anorthosite (MAN) region [6]. REEs of plagioclase (~10 ×CI) in these magnesian clasts are within the range of that plagioclase in MAN [4]. The plagioclase in these magnesian clasts also overlaps with those of MAN and Mg-granulite on the Eu/Sm versus Sm plot, consistent with their coming from the same MAN source. This is further supported by major and trace elements of olivine and pyroxene in the magnesian anorthositic clasts.

Several apatite grains and one zircon in the matrix produced a weighted average ²⁰⁷Pb-²⁰⁶Pb age of 4326 ± 8 Ma, which equals their upper intercept age (4328 ± 9 Ma) in the U-Pb concordant diagram. The major and trace element composition of their coexisting silicates (including plagioclase and pyroxene) is in contrast to the apatite-rich and zircon-rich lunar lithologies, such as KREEPy basalt, alkali suite, and Mg-suite, but is similar to the dominant MAN lithologies in the meteorite, indicating they are derived from the same source. Although there are obvious shock imprints in NWA 11479, such as impact glass in the matrix, the presence of vacancy-rich clinopyroxene, which is a metastable high-pressure phase, indicates it did not experience prolonged annealing during the brecciation. As a result, the U-Pb system of apatite could possibly preserve their formation time. This is confirmed by the consistency between the apatite age (4305 ± 30 Ma) and the much more shock-resistant zircon age (4329 ± 5 Ma). Conclusively, we propose the weighted average ²⁰⁷Pb-²⁰⁶Pb age of 4326 ± 8 Ma represents the formation of these MAN in NWA 11479. In that case, the age of MAN is at best within the lower range of the age spectrum of Apollo FAN (4.29-4.57 Ga) [7], indicating that FAN and MAN formed contemporaneously. This temporal relationship between MAN and FAN provides clues to the genesis of MAN and the evolution of the lunar crust.

Reference: [1] Jolliff et al. (2000) *Journal of Geophysical Research: Planets* 105(E2):4197-4216. [2] Gross et al. (2014) *Earth and Planetary Science Letters* 388: 318-328. [3] Gross and Joy (2016) *Encyclopedia of lunar science*: 1-20. [4] Xu et al. (2020) *Earth and Planetary Science Letters* 53. [5] Korotev, R. L (2021) <https://meteorites.wustl.edu/lunar/>. [6] Takeda et al. (2006) *Earth and Planetary Science Letters* 247(3-4): 171-184. [7] Borg et al. (2015) *Meteoritics & Planetary Science* 50(4): 715-732