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New insights into the Pb isotope systematics of Apollo anorthosites

JOSHUA F. SNAPE[1], KATHERINE H. JOY[1], ROMAIN TARTÈSE[1], JOHN F. PERNET-FISHER[1] AND MARTIN J. WHITEHOUSE[2]

[1]University of Manchester
[2]Swedish Museum of Natural History

The Pb isotope system provides unique chronologic and geochemical fingerprints for planetary samples, which can be used to better constrain magmatic evolution of terrestrial planets. In the past decade significant advancements have been made in Pb isotope analysis of lunar basaltic samples using Secondary Ion Mass Spectrometry (SIMS) [1,2]. These results have enabled the development of new models for the Pb isotope evolution of the Moon [1].

In contrast, lunar anorthosites are more challenging to analyse, typically having no trace element-bearing accessory phases and being extensively modified by impact brecciation and shock metamorphism. Research into Pb systematics of lunar anorthosites has not progressed significantly since 1999 [3]. It was observed that Apollo anorthosites are often characterised by high $^{207}Pb/^{206}Pb$ ratios, consistent with Pb derived from a source with a high U/Pb ratio (μ-value) of >1000 [3]. Such high μ-values are more typical of evolved lunar lithologies, but not primitive lunar crustal rocks comprising mostly anorthitic plagioclase, in which Pb is significantly more compatible. This high-μ signature has been interpreted as representing overprinting of the anorthosite signature by Pb mobilised during impact bombardment, particularly on the lunar nearside [3,4]. Hints of less radiogenic Pb potentially representing an original lower-μ anorthosite source have been identified in a few samples, notably 60025 [3,5].

Here we present new in situ SIMS analyses of Pb isotope systematics in ten Apollo 15 and 16 anorthosites. As with earlier work, our data are dominated by a radiogenic Pb signature consistent with derivation from a source(s) with a μ-value >1000. In many cases this can be modelled as having been introduced to the rocks ~3.9 billion years ago (Ga). However, two samples show evidence of older Pb signatures: 15415 at ~4.1-4.2 Ga and 62236 at ~4.3 Ga. Meanwhile, a much younger modelled date of ~3.0 Ga is derived from 60025 data.

References: [1] Snape J. F. et al. (2016) *EPSL* 451:149–158. [2] Che et al. (2021) Science 374:887–890. [3] W. R. Premo et al. (1999) *Int. Geol. Rev.* 41:95–128. [4] Tera et al. (1974) *EPSL* 22:1-21. [5] Borg L. E. et al. (2011) *Nature* 477:70-72.