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Comparative chronology of Apollo 16 impactites and implications for the landing site stratigraphy

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The surface of the Moon provides a unique record of the impact history of the inner Solar System, yet there is no consensus on the impactor flux and the ages of the largest lunar basins. To obtain a better understanding of ages from lunar impactites and their relations to ejecta deposits and basin forming impacts, we studied impactites from the Apollo 16 landing site.

Ancient basin-forming events are mostly preserved in complex, polymict impactites or in large rock clasts that stem from nearly pristine Mg suite rocks. Multiple events can sometimes be resolved within a single sample. For instance, recent studies of Apollo 15–17 impactites revealed complex age distributions: Different mineral isochrons yielded ~4.2 Ga (A16, A17), whereas U-Pb ages of zircon and baddeleyite (re-)crystallized by impact-induced processes yielded ages ≥4.2 Ga (A15, A16). Both these geochronometers contrast with the Ar-Ar dates, which make up the ~3.9 Ga impactite age peak reflecting resetting by the Imbrium impact (3922 ± 12 Ma). To avoid geochronological bias it is, therefore, essential to perform comparative dating using multiple chronometers. We performed a comparative analysis of A16 impact breccias: 67955 and 67935 by mineral isochron dating, and 67935, 60035 and 67415 by in situ U-Pb dating of accessory minerals. Complex Apollo 16 breccias rich in highland material have been studied to evaluate the age record in the Cayley Plains (60035) and Descartes (67955, 67935, and 67415) formations.

Analyses of 60035 revealed dominant pre-Imbrium material in all accessory phases (~4.2 Ga) and even older in some phosphates (~4.37 Ga), with minor heating by Imbrium ejecta recorded by phosphates and previously by Ar-Ar data. Similarly, 67955, 67935, and 67415 show Imbrium ages recorded by phosphates and previously by Ar-Ar, but also 4.2 Ga ages, recorded by zircon, zirconolite, Sm-Nd isochrons (this work, Norman & Nemchin, 2014; Norman et al., 2016), and baddeleyite (67415). The data show that both geological units at the Apollo 16 landing site comprise older minerals and rock fragments that were variably overprinted by heating processes related to the Imbrium impact, but also retain a record of ~4.2 Ga impacts.