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The impact history of the Moon: implications of new high-resolution U-Pb analyses of Apollo impact breccias

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Constraining the impact history of the Moon is a key priority, both for lunar science [1] and also for our understanding of how this fundamental geologic processes [2] has affected the evolution of planets in the inner solar system. The Apollo impact breccia samples provide the most direct way of dating impact events on the Moon. Numerous studies have dated samples from the Apollo landing sites by multiple different methods with varying degrees of precision [3]. This has led to an ongoing debates regarding the presence of a period of intense meteoritic bombardment (e.g. [4-8]). In this study we present high precision U-Pb analyses of Ca-phosphates in a variety of Apollo impact breccias. These data allow us to resolve the signatures of multiple different impact events in samples collected by the Apollo 12, 14 and 17 missions. In particular, the potential identification of three significant impact events between the period of ∼3915-3940 Ma, is indicative of a high rate of meteorite impacts at this point in lunar history.

A more fundamental problem with interpretations of Apollo breccia ages is that the samples originate from the lunar regolith and do not represent samples of actual bedrock exposures. As such, although improvements in analytical precision may allow us to continue identifying new impact signatures, the proposed links between these signatures and particular impact features remain highly speculative. This is a problem that will only be truly addressed with a more focused campaign of lunar exploration. Most importantly, this would include the acquisition of samples from below the lunar regolith, which could be confidently attributed to particular bedrock formations and provide a degree of geologic context that has been largely absent from studies of lunar geology to date.

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