Apatite: a nanoscale story-teller of lunar geological history

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The field of planetary mineralogy has greatly benefited from recent studies of accessory minerals, facilitated by advancements in µm- and nm-scale analytical techniques such as EBSD, APT, TEM, and SIMS. Two phosphate minerals, apatite and merrillite, have been of particular interest in this regard, as they record vital information on the volatile content, U-Pb ages and trace-element composition of various planetary materials. Here we report on severely deformed phosphate minerals from a highly-shocked norite collected during Apollo 17 mission. Our study has revealed intriguing nm-scale compositional variations and U-Pb ages of the phosphates.

SIMS U-Pb analysis on phosphates reveals a discordia line with an upper intercept of ~4.2 Ga and a lower intercept of ~0.5 Ga. The lower intercept could not correspond to U-Pb resetting induced by a major impact event, responsible for the high shock-deformation of these rocks, as such an event would have caused partial to complete resetting of all other geochronometers, primarily Ar-Ar. However, no such resetting has ever been observed. Thus, a minor thermal event must have reactivated existing nm-scale grain boundaries, observed by APT, to allow for Pb-loss at ~0.5 Ga. Potential small craters located near the Apollo 17 landing site are currently being investigated as possible sources. Interestingly, the younger event is concordant with the apatite age in some ordinary chondrites, interpreted to reflect the catastrophic disruption of the L chondrite parent body. Regardless of the extent of the younger impact, an older ~4.2 Ga, the large impact must have been responsible for the highest-grade (S5-S6) whole rock and phosphate deformation. This particular observation takes us on a journey of revisiting the timing of one of the largest basin-forming impacts in the lunar geological history.