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Lunar Time Travels – Introduction to a Revised Cratering Chronology Model

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Lunar cratering-chronology models are to provide temporal constraints globally by linking crater densities with isotope geochemistry. Such a chrono-stratigraphy uses crater statistics by deriving size-resolved and area-normalised crater frequencies, and it is one of the few tools to globally assess times and rates of the geological evolution of the respective planetary body. Since the Apollo and Luna missions, plenty of new information has arisen: global spectral mapping, improvement in dating of samples and mapping of geological units as well as crater statistics. Recently, the sample return of the Chang'E 5 mission added a new calibration point. Therefore, the existing lunar cratering-chronology models need revision to account for these developments.

Here, we present a self-consistent, revised, lunar cratering-chronology model that accounts for the above updates. Unprecedentedly, we use the spectral information at the actual landing sites and the spectral and mineral data of the samples to define the outline of the counting units. Thus, we uniquely describe count areas that concomitantly define the samples selectable for the calibration age. The calibration of the impactor flux before 3.9 Ga remains challenging. The heterogeneous nature of breccia samples challenges the definition of homogeneous units and suitable reference samples to establish appropriate sample-unit links. The 'Late Heavy Bombardment' concept captures rather the last large basin formation event, Orientale, as a marker horizon, instead of the subsequent formation of several basins in a short time period. Compared to previous models, the new calibration pairs (frequency vs. age) suggest a monotonically decaying and, more importantly, lower throughout projectile flux. This lower flux is NOT the result of a systematic shift related to the derivation of the crater frequencies, but relates to different outlines of counting units and modern sample ages. Applying the new model to crater counts across the Moon suggests much older surfaces (by at least by 200 million years) than any of the current cratering-chronology models. Transferring this model to other solid-surface planetary bodies implies the ageing of these surfaces, too.