AN INTERDISCIPLINARY RE-INVESTIGATION OF THE APOLLO 14 LANDING SITE – PB-PB CHRONOLOGY OF THE IMPACT MELT ROCK 14310 AND NEW CRATER SIZE-FREQUENCY DISTRIBUTION MEASUREMENTS.

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Introduction: The dating of geological units and events on the Moon is achieved by two inherently different approaches: (1) radiogenic isotope chronology of lunar samples or meteorites and (2) model age determination from crater size-frequency distributions (CSFDs). The combination of results for Apollo and Luna landing sites from both approaches allowed the development of the lunar cratering chronology, which enables absolute model ages to be derived from CSFDs of unsampled regions on the Moon [1-4]. Since the initial development of the lunar cratering chronology, both radiometric and CSFD dating techniques have advanced, and recent orbital missions have collected new global datasets, which allow us to reevaluate and update the calibration points for the cratering chronology. Here, we combine bot techniques to re-investigate the Apollo 14 landing site.

Apollo 14 Landing Site: The Apollo 14 landing site is situated about 600-800 km south of the Imbrium basin within the Fra Mauro Formation (FMF), which has been interpreted to be Imbrium ejecta material (e.g., [5]). The landing site was originally chosen to sample ejecta blocks that were excavated by the very young and nearby Cone crater and interpreted to unambiguously represent the FMF [5]. Sampling the ca. 30 Ma Cone crater has also provided an important anchor point for young lunar surfaces [6, 7]. These two objectives make the Apollo 14 landing site especially worthy of re-investigation, as it can potentially constrain the lunar cratering chronology for both old and young ages.

Our Study: We use Pb-Pb chronology to date impact melt rock 14310, which was sampled during the Apollo 14 mission. This work will complement the recent chronological investigions by our group on sample 14310, which include ^{176}Lu-^{176}Hf, ^{87}Rb-^{87}Sr, and ^{147}Sm-^{143}Nd isochron dating [8]. We combine this laboratory investigation with the production of new geological maps of the Apollo 14 landing site at three different scales to define a representative crater count area for sample 14310 and determine an absolute model age based on CSFD measurements. The overall aim of our study is to constrain the position of the calibration point 'A14/Fra Mauro Formation' on the lunar cratering chronology curve [1-4].

Sample 14310 is a coherent impact melt rock, which according to a least-squares mixing model comprises about 65% KREEP, 25% anorthosite, 8% mare basalt, and 3% meteoritic material [9]. Reported Th concentrations of 8.6-13.7 ppm (e.g., [10, 11]) suggest that sample 14310 contains material from the Th-rich terrane in the Imbrium-Procellarum area (e.g., [12]). Sample 14310 could have formed during the deposition of Imbrium ejecta, i.e. the FMF, but it is more likely the result of a younger impact into the FMF that remelted local material (e.g., [13]). Whether the age of sample 14310 can be linked to the Imbrium basin formation event is an assumption we will investigate further in our study.

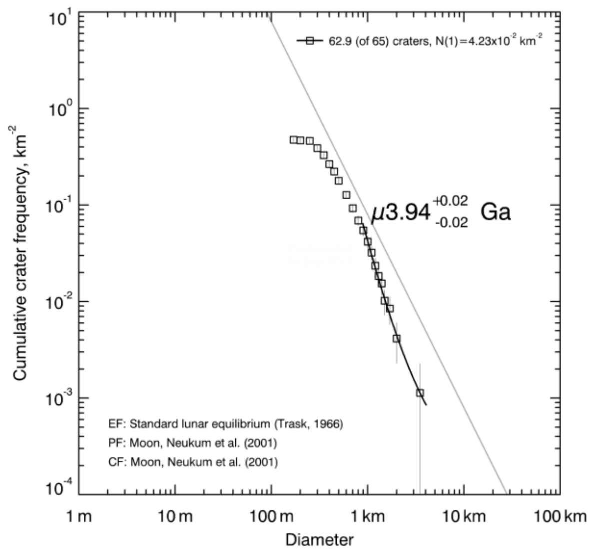

Fig. 1: Our updated cumulative size-frequency distribution for the original area selected by [1] for the calibration of the Fra Mauro Formation to the lunar cratering chronology gives an absolute model age within error of his original value.

Pb-Pb Dating: The pioneering U-Th-Pb studies of sample 14310 performed in the early 1970s yielded dates of ca. 3.9-3.8 Ga [14, 15], which were interpreted to represent the crystallization of this rock. We are carrying out Pb-Pb analyses of the same set of mineral concentrates used in our ongoing multi-system (Sm-Nd, Lu-Hf, Rb-Sr) chronological work on this sample [8], with the aim of testing for concordance among isotope systems and precisely constraining the crystallization age. For our Pb-Pb work, each mineral concentrate has been subjected to a 12-step washing and progressive digestion procedure based on [16-19] in an attempt to better separate radiogenic, initial, and contamination Pb components. The earlier U-Th-Pb studies [14, 15] did not do this, as it would have potentially fractionated these elements from each other. Our Pb-Pb results will be presented at the meeting. We can already note, however, that the application of an improved neutron capture model [20] lowers the ~4.0 Ga Lu-Hf date reported by [8] into concordance with the ~3.8 Ga Rb-Sr and Sm-Nd dates from the same study.

Geological Mapping and CSFD Measurements: We recounted the area originally chosen by [1] with the results shown in Figure 1. The originally reported *N*(1) value of $3.7 \pm 0.7 \times 10^{-2}$ yielded an estimated age of the FMF of 3.91 ± 0.1 Ga [1]. We used the global Wide Angle Camera (WAC) mosaic (100 m/pixel; incidence angle: 60°) to perform new CSFD measurements on the same counting area and report a *N*(1) value of 4.23×10^{-2}, which was fit with the lunar chronology function of [2], yielding an age of 3.94 ± 0.02 Ga. This result is within the uncertainty of [1] and agrees with recent Imbrium age estimations of about 3.91-3.94 Ga (e.g., [21]).

Outlook: We will perform additional CSFD measurements on counting areas for different geomorphological units surrounding the Apollo 14 landing site, as well as assess the age of sample 14310 using the Pb-Pb and three other independent isotopic chronometers. We will discuss whether sample 14310 can be considered representative of the FMF and how this can help to constrain the lunar cratering chronology.

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