DATING INDIVIDUAL SEVERAL-KM LUNAR IMPACT CRATERS FROM THE RIM ANNULUS IN REGION OF PLANNED CHANG'E-5 LANDING. G. G. Michael[1], Z. Yue[2], S. Gou[2], K. Di[2]. [1]Planetary Sciences and Remote Sensing, Institute of Geological Sciences, Freie Unversitaet Berlin, Malteser Strasse 74-100, Haus D, Berlin 12249, Germany. [2]State Key Laboratory of Remote Sensing Science, Institute of Remote Sensing and Digital Earth Chinese Academy of Sciences, Beijing, China 100101.

Introduction: The Chang'E-5 lunar sample return mission is planned to land in Oceanus Procellarum, north of Mons Rümker, within a zone of roughly 600 × 125 km [1] (Fig. 1). The spacecraft is designed to retrieve a drill core of up to 2m depth, making up a total soil sample of around 2 kg, and return it to Earth [2].

To anticipate components that may be found in the soil sample and dated in the laboratory, we attempt to estimate the ages of the largest craters in the vicinity, the ejecta of which may be distributed over the surface throughout the region and include a heated or melted fraction which could potentially be linked back to the source crater through radiometric measurements.

Dating surface features involves selecting an appropriate area that has been erased of its crater population by the process of formation, and measuring the subsequent accumulation of impact craters. Crater ejecta are sometimes taken as regions resurfaced by the impact process, but for several-km craters on the Moon, the transition from ejecta to the surrounding terrain is not well-defined because it occurs as a layer of continuously diminishing thickness. Outward from the crater rim, a pre-existing crater may remain observable, being merely draped by an ejecta layer of lesser thickness than its own relief. Such a crater may be indistinguishable from a more eroded crater superposing the ejecta layer when seen in images from orbit.

We consider, therefore, only craters superposed on or intersecting the uplifted rim: a zone which was unambiguously reformed in a pristine state by the impact process. This region has a rather small area, so we optimise the dating measurement using a Poisson statistical analysis [3] newly adapted for application to the buffered crater counting technique [4,5].

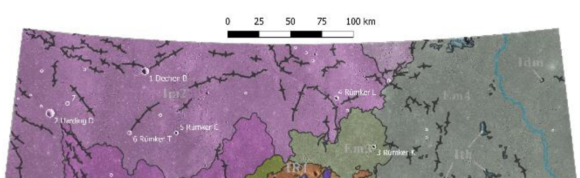

Figure 1. Chang'E-5 planned landing region with seven dated craters indicated, over geologic mapping from [6]. Im2 unit is coloured mid-purple.

Method: The seven largest impact craters, of size 3–6 km, in the planned CE-5 landing region (49–69W 41–45N) were selected for dating. For each crater, the LOLA-Kaguya 512 pix/degree (~60 m/pix) DEM was colourised such that the colour bar spans the height range from the local surrounding of the crater to the top of the crater rim. The area for crater counting was chosen as an annulus around the crater rim, its width being the limit of the area which is discernably uplifted by the crater formation. In this area we expect that pre-existing craters would be fully obliterated.

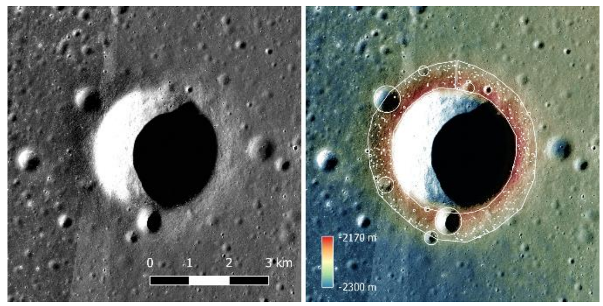

Figure 2. Crater 7 (unnamed) seen in a) CE-5 NAC mosaic, b) with added colourised LOLA-Kaguya surface elevation. White line denotes region of elevated rim material, and superposed craters marked.

Such annuli were constructed for each crater of interest, and smaller craters occurring within or intersecting the annulus were identified and measured in NAC images down to a completeness limit of about 20m diameter. Measurements were made using CraterTools [7] and overplotted on differential isochrons with Craterstats [8]. At the same time, the largest craters of the region were used to estimate the age of unit *Im2* (Fig. 1), on which most of the craters of interest occur, in the conventional manner.

Results: Over the diameter range of 20–80 m, all measured crater populations are consistent with an isochron of <50 Ma in the chronology system [9]. At the same time, the 14 largest craters (including 6 of those investigated) together suggest an age of $\mu 3.3^{+0.2}_{-0.4}$ Ga for the *Im2* unit [6], consistent with their finding of 3.39 Ga (μ is a function representing the uncertainty of calibration of the chronology model [3]).

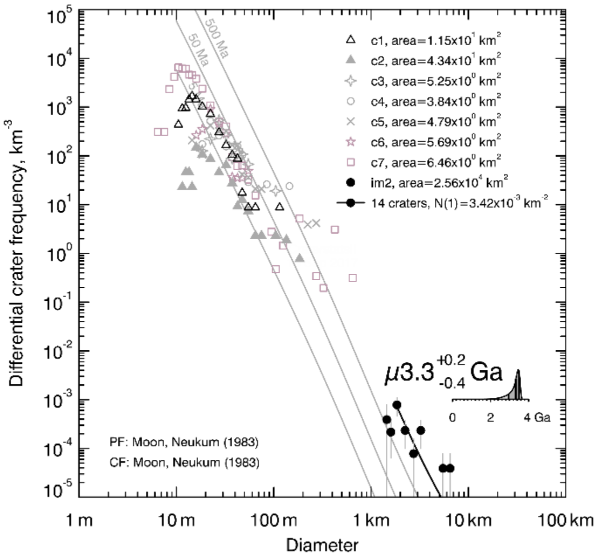

Figure 3. Crater populations from annuli around seven largest craters in planned CE-5 landing region. Six of these and several smaller craters are used to estimate the age of the Im2 unit [6] at $\mu 3.3^{+0.2}_{-0.4}$ Ga. μ is a function representing the uncertainty of calibration of the chronology model [3].

It follows that the annulus ages for superposed craters of 20–80 m do not represent the crater formation times, but more likely represent the lifetime of the surface structure of the regolith to the depth of the superposed craters. From the largest of the size range, 80m, we could estimate this depth to be around 20m [10]. It is expected that rim slopes could be problematic for crater counting because of mass-wasting processes. The rim heights of the studied craters range from 80–320m above the plateau, so a loss of structure in the upper 20m may not be surprising.

Several annuli show superposed craters larger than 80m. Their scatter with respect to the 3.3 Ga isochron suggests they could represent the accumulation population from formation.

Poisson calculation for a buffered area: We extend the Poisson statistics approach [3] to consider a buffered crater count [7] over the annulus. The essential change is that each present crater size, d_i, requires reference to a different area, calculated as:

$$A_i = A + \frac{d_i\, L}{2} + \frac{\pi {d_i}^2}{4}$$

where A is the annulus area, and L is the annulus polygon circumference (inner plus outer). The expression holds for other convex or mildly concave polygon counting regions, but not tightly concave ones.

Figure 4 shows how the superposed craters larger than 250 m constrain the annulus formation times, with the result expressed as a likelihood function. Crater 7 (Fig. 2) is the oldest, at $\mu 2.9^{+0.5}_{-0.8}$

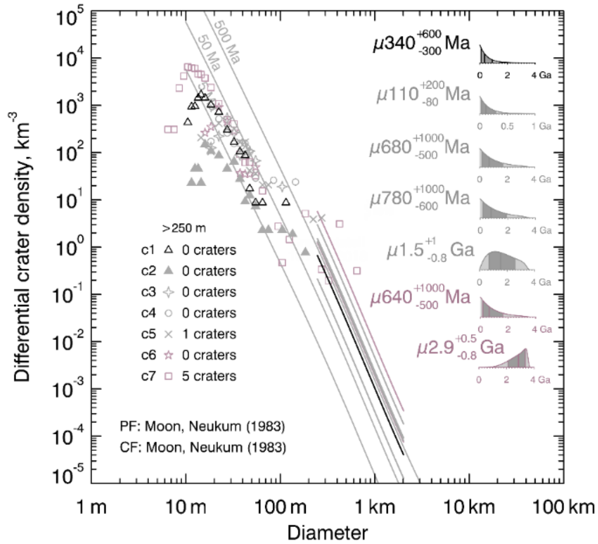

Figure 4. Buffered Poisson calculation for craters 1 (upper inset plot) to 7 (lower). Inset plots show relative likelihood that crater has indicated age given observed superposed crater population. The 50 (median) and 50±34 (1-sigma for a Gaussian distribution) percentiles are shown and used to represent the model age and uncertainty numerically.

Conclusion: We are able to constrain the ages of individual craters at 3–6 km scale using the annulus method using superposed craters >250m diameter. If the Chang'E-5 soil samples contain an impact melt component, the enumerated craters in this work are likely source candidates.

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