GEOLOGICAL MAP OF THE VON KÁRMÁN CRATER: CONTEXT FOR THE CHANG'E-4 LANDER.

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Introduction: Located near the center of the South Pole-Aitken basin (SPA) the Von Kármán crater is the Chang'e 4 landing site. The ongoing Chinese Chang'e 4 mission is unique in being the first rover mission on the lunar farside and is giving unique insights on the crater surface properties [1-4].

To assist ground truth data from such missions a detailed understanding of the local geology is necessary. Here, we provide a detailed map of the Von Kármán crater as part of our large geological map of the whole SPA basin [5].

Methods: For mapping the geological units we used the Lunar Reconnaissance Orbiter (LRO) Wide-Angle Camera (WAC) (100 m/pixel), Narrow-Angle Camera (NAC) (0.5 m/pixel) images [6], and Kaguya Terrain Camera mosaics (10 m/pixel) with different incidence angels. We also used using Clementine [7], M3 [8], and Kaguya MI data for spectral unit definition. Lunar Orbiter Laser Altimeter (LOLA) Digital elevation models and the LOLA/Kaguya merged digital elevation model (DEM, 59 m/pixel) [9] were also used to aid in defining geological boundaries. Our maps conform to the mapping standards of the PLANMAP project [10], which are an extension of the USGS mapping standards [11].

In addition to stratigraphically establishing the relative ages of the geologic units, we determined absolute model ages (AMAs) for specific units by performing crater size-frequency distribution (CSFD) measurements and using the production and chronology functions of [12]. We use CraterTools [13] in ArcGis for CSFD measurements and Craterstats to determine the corresponding AMAs [14]. Detailed descriptions of the technique are given by [12, 15, 16].

Results: The Von Kármán crater is a pre-Nectarian impact crater which superposes the northern part of Von Kármán M crater. In turn, the younger Leibnitz crater obscures the northern half of Von Kármán crater rim. Von Kármán crater itself is filled with dark plains. Near the center of the crater, the embayed central peak is still visible. The dark plains exhibit a dome-like structure in the southwest part of the crater. Finsen crater ejecta covers most of the NE part of the Von Kármán crater.

We identified several generations of secondary crater chains in the region. The most prominent are those belonging to Finsen crater and are mapped as discontinuous Finsen ejecta (Fig. 2). In the southern part of Von Kármán crater are several crater chains with a S to SW orientation. To the NW of the Von Kármán crater a NW/SE trending crater population can be observed.

One of the youngest and most prominent craters in the area is Zhinyu, which is S of the Von Kármán central peak. Its morphological appearance qualifies it as a Copernican crater. Its dark ejecta likely represent excavated mare basalt.

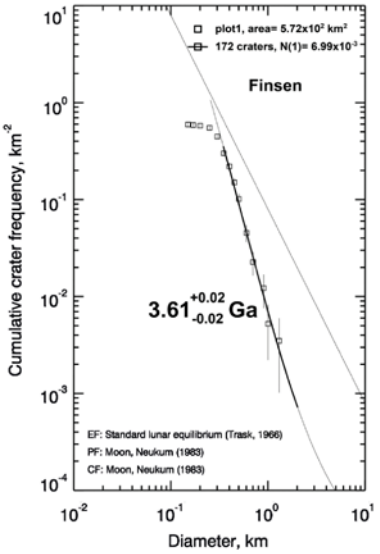

Figure 1. *Absolute model age of Finsen crater determined by CSFD measurement [17].*

Discussion: Most of the mare units in Von Kármán are mantled by Finsen crater ejecta. All of the mare units are heavily affected by secondary cratering. We identified at least four distinct secondary crater populations. Only one of these secondary crater populations can be directly linked to their source crater, which is Finsen crater. A weak connection can be drawn for the secondary craters in the NW part of Von Kármán which trend NW/SE, to a Copernican crater E of Leibnitz S as a potential source crater. For the prominent crater chains trending N/S and SW/NE, no direct source could be identified. Previous studies proposed these secondaries originate from Von Kármán L [2]. However, the direction of the crater chains strikes to the west of the center Von Kármán L thus making it an unlikely source crater.

Pasckert et al. (2018)[18] dated the mare unit or upper Imbrian dark plains unit within Von Kármán and determined an age of 3.15 Ga, with an older resolvable

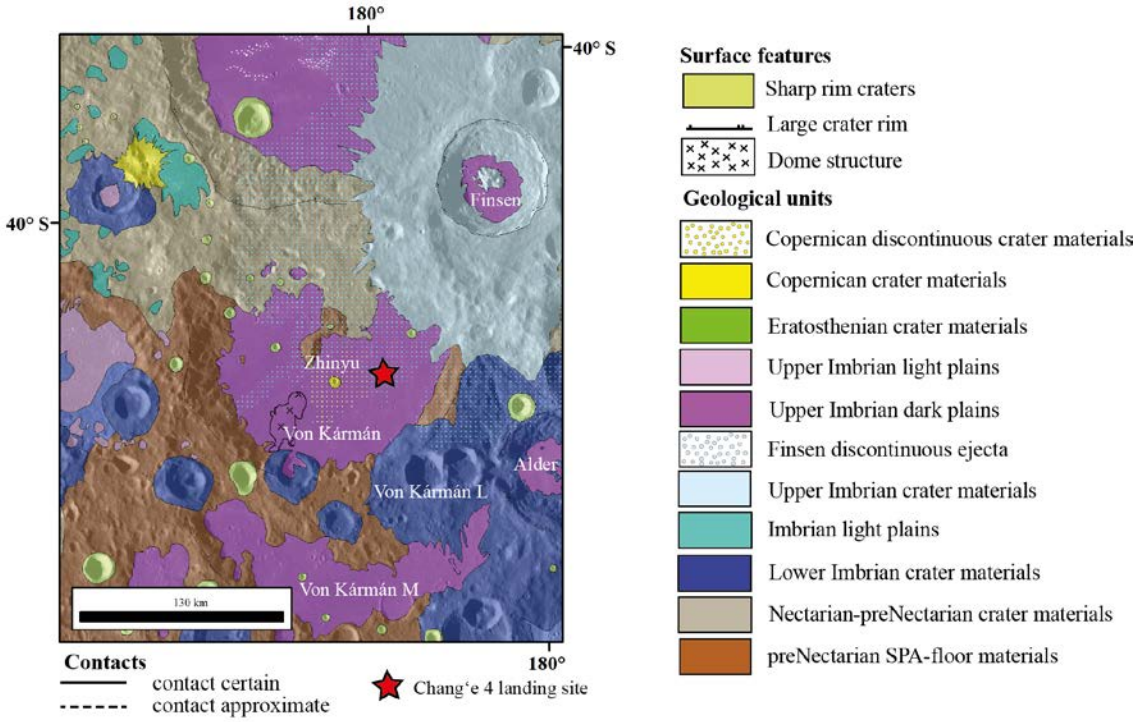

Figure 2. *Geological map of the Von Kármán crater region. Lambert projection centered at -157,5°S and 53°E.*

age of 3.75 Ga. Haruyama et al. (2009)[19] determined an age of 3.35 Ga for these dark plains. Ivanov et al. [17] proposed an AMAs for Finsen of 3.61 Ga. However, morphological evidence such as cross-cutting relationships, suggests Finsen to be younger than the plains within Von Kármán. This clear disagreement of AMAs and morphological evidence cannot be resolved yet and will be part on ongoing studies.

Stratigraphically, Von Kármán M formed first. Von Kármán crater formed in the pre-Nectarian obscuring-most of Von Kármán M. The formation of Leibnitz crater obscured the N rim of Von Kármán crater and covered part of its northern interior. Volcanism in the lower Imbrian started to fill Von Kármán, Von Kármán M (3.38-3.52 Ga [18]), Leibnitz (3.37-3.68 Ga [18]), and several other surrounding craters and low-lying areas. This volcanism started at least by 3.75 Ga [18], but its onset could be earlier if older flows were buried under those visible at the surface. In the meantime, Alder crater formed and got filled with dark plains. The two smaller craters Von Kármán L and one E of it also formed. The youngest basalt flows covered the Von Kármán floor. The dome-like structure in the SW might be the origin of these flows. Finsen crater formed at 3.61 Ga and its ejecta and materials cover most of Von Kármán floor.

We expect most of the material around the Chang'e 4 landing site to be related to Finsen crater, including mare basalt fragments entrained during the deposition of the Finsen ejecta and secondary craters. The best chance of probing fresh mare material would be close to Zhinyu crater, where dark material was excavated.

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