NEW GEOLOGIC MAP OF THE APOLLO 16 LANDING SITE: IMPLICATIONS FOR THE LUNAR CHRONOLOGY. T. Gebbing[1], H. Hiesinger[1], W. Iqbal[1], and C. H. van der Bogert[1], [1]Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149, Münster, Germany, (thorsten.gebbing@uni-muenster.de).

Introduction: The Apollo 16 mission yielded a large amount of rock samples and much new information about the Moon, and many geological studies and crater size-frequency distribution measurements also yielded new insights [e.g. 1]. Using data from modern and advanced instruments, we created a geological map around the landing site, reexamined the CSFD measurements from [2], and made new measurements of the North Ray and South Ray craters. We compared our data with previous studies, sample analyses, CSFD measurements and ages [3,4]. Here we show the summary of our results from the reexamination of the landing site and the comparison with previous studies.

Apollo 16 Landing Site: The landing site is located on the Cayley Formation, in the Descartes Highlands, between North Ray and South Ray craters (8° 58'S, 15° 30' E). The calibration points yielded from the landing site are based on the Cayley formation, North Ray crater and South Ray crater. We reexamined these data points in our work with newly measured CSFDs using our geologic map for identifying homogeneous areas. In addition, the *N*(1) values were compared with previous data and ages of different samples.

Methods: The new geological map was created with Lunar Reconnaissance Orbiter (LRO) data - Wide-Angle Camara (WAC) and Narrow-Angle Camera (NAC) images, Selene/Kaguya data with different incidence angles and the LOLA / Selene merged digital elevation model. In addition, NAC digital terrain models (DTM) around the landing site and Clementine spectral data were used. The NAC data were processed with the Software for Imagers and Spectrometers (ISIS) [5] and all data sets were loaded into ArcGIS. The areas for the individual crater counts were created and carried out with CraterTools in ArcGIS [6]. Any secondary craters cluster and chains that were evident or became visible through randomness analysis were excluded [7]. The CSFDs were then plotted and fitted with Craterstats 2.0 [8,9] using the production and chronology functions of [10] to get the absolute model ages (AMAs).

Geological Units: According to the stratigraphy of [11], we mapped craters as Cc (Copernican craters), Ec (Eratosthenian craters), Ic (Imbrian craters) and pIc (pre-Imbrian craters). The Imbrium ejecta material is mapped as Ifm (Imbrian Fra Mauro Formation), highland material as Idh (Descartes Highland Material) and the smooth light plains as Ip (Imbrian Plains – Cayley Formation).

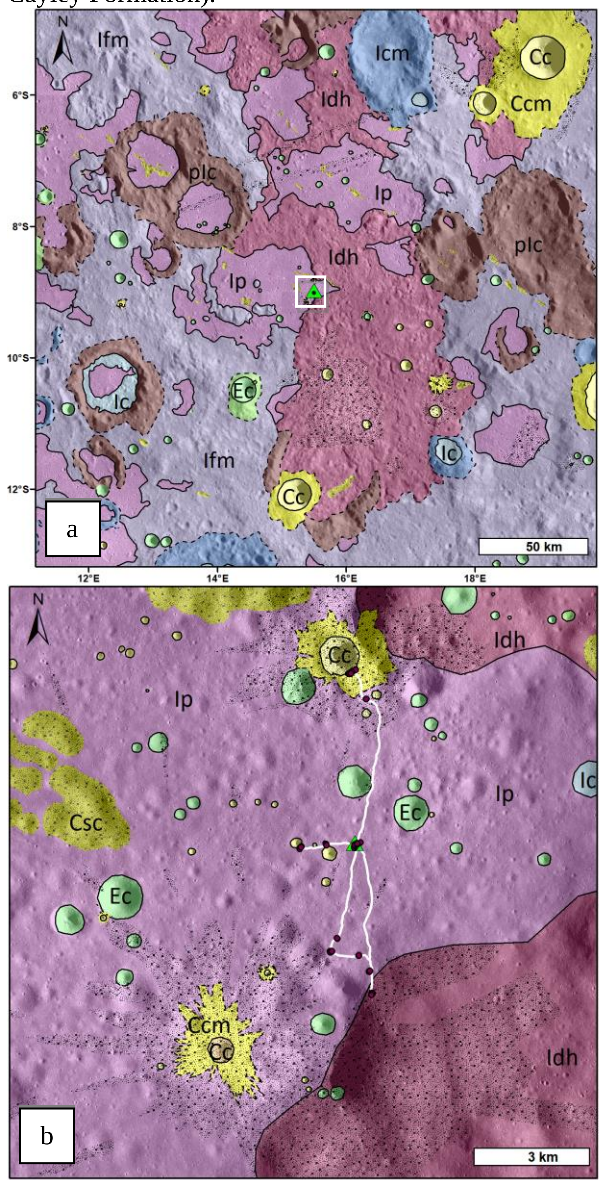

***Figure 1**. The overview map of the Apollo landing site extends between 4° 5'S, 11° E and 13° S, 19° 5' E; Imbrium Material: Descartes Highlands (Idh), Cayley Formation (Ip) and Imbrian Fra Mauro Formation (Ifm), various generations of craters and crater material as well as rays (a) and the detailed view of the landing site (b) with North Ray and South Ray craters and the traverse with sample locations.*

Table 1. *Comparison of the determined N(1)s and AMAs with measured crystallization and exposure ages.*

Unit	***N(1) (km^{-2})***	***AMA (Ga)***	***Sample***	***Exposure Age (Ma)***	***Absolute Age (Ga)***
Neukum areas (recounted) [3]	*1.84×10^{-2}*	*3.80±0.02*	*60016*		*~3.9* [12]
edited Neukum area [3]	*1.88×10^{-2}*	*3.81±0.02*			
Kaguya [3]	*1.87×10^{-2}*	*3.81±0.02*			
			Feldspathic basalt		*3.74±0.05* [13]
		AMA (Ma)			
North Ray [4]	*4.26×10^{-5}*	*50.8±2.5*	*67015*	*51.1[14]* *50.2[15]*	
			60025	*2.1 ± 0.3[16]*	
South Ray [4]	*8.95×10^{-7}*	*1.07±0.26*		*1.13 ± 0.06[16]*	
			66095	*1.4 ± 0.3[17]*	

Results: The light plains on WAC with the same areas as [2] have a $N(1)$ value of 1.84×10^{-2} km^{-2} and 1.88×10^{-2} km^{-2} for the areas with improved geological and topographical boundaries. For the CSFD measurement on Kaguya data the $N(1)$ value is 1.87×10^{-2} km^{-2} in comparison to the $3.4\pm0.7\times10^{-2}$ km^{-2} from [2]. For North Ray crater the determined $N(1)$ value is 4.26×10^{-5} km^{-2} and for South Ray it is 8.95×10^{-7} km^{-2} (*Tab. 1*, *Fig. 2*) [4]. Applying the production and chronology function of [10], our newly determined AMAs are 50.8±2.5 Ma and 1.07±0.26 Ma, respectively (*Tab. 1*).

Discussion: The new geological map allows us to determine CSFD measurements on more homogenous areas and we get a better understanding of the local geology. The new $N(1)$ values can be used in conjunction with the sample ages to test the lunar cratering chronology. Our $N(1)$ values and AMAs show good agreement in comparison with other studies between different sample sites. Accordingly, the choice of samples is not easy and in cooperative studies with LRO team [18] detailed sample mapping and correlation will be studied.

Further Work: As this work is part of our series of Apollo landing sites studies [e.g. 3,4,19], we will further study the correlation of sample ages with the newly derived $N(1)$ to test and possibly improve the lunar chronology.

References: [1] Ullrich et al. (1981) *USGS Prof Paper* 104. [2] Neukum (1983) *Habil. Thesis*, U. of Munich. [3] Gebbing et al. (2019) *LPSC 50*, #2337. [4] Gebbing et al. (2020) *LPSC 50*, #1871. [5] Anderson et al. (2004) *LPSC 35*, #2039. [6] Kneissl et al. (2011) *PSS 59*, 1243-1254. [7] Michael et al. (2012) *Icarus 218*, 169-177. [8] Michael et al. (2016) *Icarus 277*, 279-285. [9] Michael et al. (2010) *EPSL 294*, 223-229. [10] Neukum et al. (2001) *Space Sci. Reviews 96*, 55-86. [11] Wilhelms (1987) *USGS Prof paper 1348*. [12] Niihara et al. (2019) *MAPS 54*, 675-698. [13] Stoeffler et al. (2006) *Reviews in Mineral. & Geochem. 60*, 519-596. [14] Marti et al. (1973) *Proc Lunar Sci Conf 4*, 2037-2048. [15] Drozd et al. (1974) *Geochim Cosmochim Acta 38*, 1625-1642. [16] Fernandes et al. (2013) *MAPS 48*, 241-269. [17] Fruchter et al. (1978) *LPSC 9*, 2019-2032. [18] Gonzales et al (2020) *LPSC 51*, #1578. [19] Iqbal et al. (2020) *LPSC 51*, #1860.

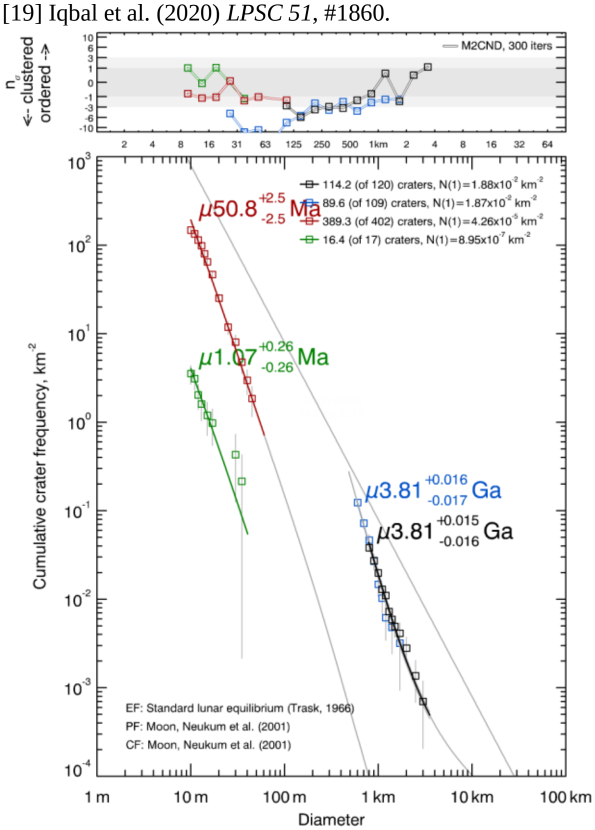

Figure 2. *CSFD measurements gained at the Apollo 16 landing site area in a cumulative fit with determined AMAs: reexamined area using WAC data [2] (black), and Kaguya data [4] (blue). NAC data was used for North Ray crater [4] (red) and South Ray Crater [4] (green); the randomness analysis for the different areas is shown above.*