COMPREHENSIVE GEOLOGICAL MAPPING OF APOLLO 15 AND APOLLO17 LANDING SITES AND THEIR IMPLICATIONS.

W. Iqbal[1], H. Hiesinger[1], C. H. van der Bogert[1], and J. W. Head[2], [1]Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany, [2]Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI 02912 USA. (iqbalw@uni-muenster.de)

Introduction: The Apollo Landing sites data provided crucial knowledge for our understanding of geology of the Moon [1], whereas the data from recent missions [2-7] provided opportunities to reanalyze and enhance our knowledge furthermore. Here, we are representing detailed geological maps of Apollo 15 and 17 landing sites, which are prepared using the modern data set including high resolution images, digital elevation models (DEMs), and spectral data. The recent geological maps are being used to resolve various questions related to sources of samples [e.g., 8, 9], lunar geological processes [e.g., 10, 11,12], and secure ISRU [13].

Methods: Various data comprising Lunar Reconnaissance Orbiter Camera (LROC) Wide Angle (WAC; 100 m/pixel) and Narrow Angle (NAC; ~0.5-1.2 m/pixel) images [2], Selene/Kaguya images, LOLA/Kaguya digital elevation models (DEMs) and hillshades [3], NAC derived DEMs and related products [4], Clementine spectral data [5], Chandrayann-1 Moon Mineralogy Mapper (M3) data [6] and Kaguya Mineral imager (MI) data [7]. Therefore, the final maps are based on albedo, morphological and spectral differences observed in the data.

Wilhelms (1987) [1] stratigraphic scheme was used for the identification of the units. Federal Geographic Data Committee (2006) [14] standards are used for symbology and Gazetteer of Planetary Nomenclature (1999) [15] was concerned for the nomenclature.

Geological units: The geological maps are produced on two scales of 1:24,000 and 1:400, showing overview and local view respectively.

The highland units include Fra Mauro Formation Imbrium basin ejecta units: Ifm (Imbrian Fra Mauro formation) and Ifs (Imbrian Fra Mauro smooth plains); Ip (Imbrian plains); in addition to IpIt (Imbrian pre-Imbrian terrains) at Apollo 17 landing site; and Iap (Imbrian Apenninus material) and Ibm (Imbrian Basin material) at Apollo 15 landing site.

Mare units were mapped using same approach as [16] which involves hybrid mapping with albedo, spectral, and morphological differences. Crater size-frequency distribution measurements were used to identify the stratigraphic positions of the various mare units [e.g., 17,18].

Contributions: Geological maps produced before Apollo missions [e.g., 19, 20, 21] were vital to accomplish these missions. ALSEP (Apollo Lunar Surface Experiment Package) and the sample collection during the missions not only resolve many scientific questions, but also introduced new queries. Nevertheless, the provenance of these samples is still debatable. The updated geological maps are being used in various studies to find the origin of the important samples [e.g., 8,9]. The detailed geological map of the landing site also assists in resolving queries related to puzzling geological processes [10,11 12]. Subsequently Lunar In-situ resource utilization (ISRU) missions searching for safe and sufficient resources also requires more accurate up-to-date geological maps [13].

The maps define homogeneous geological units which are essential for accurate CSFD measurements. On basis of these maps and refined CSFD measurements the lunar cratering chronology [22] had been tested [23-29].

Acknowledgments: WI was funded by German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt) Grant #50OO2102. HH was funded by the German Research Foundation (Deutsche Forschungsgemein schaft SFB-TRR170, subproject A2) and CvdB was supported by EU H2020 project #776276, PLANMAP.

References: [1] Wilhelms, (1987) USGS Prof paper: 1348. [2] Robinson, et al (2010) Space Sci. Rev. 150, 81-124. [3] Barker, et al. (2016) Icarus 273, 346-355. [4] Henriksen, et al. (2017) Icarus 283, 122-137. [5] Pieters, et al. (1994) Science 266, 1844-1848. [6] Isaacson, et al. (2013). JGR Planets. 118, 369-381. [7] Ohtake, et al (2013) Icarus 226, 364- 374. [8] Iqbal, et al (2021) LPSC 52, # 1917. [9] Haber, et al (2018) AGU, P31G- 3785. [10] van der Bogert, et al. (2019) LPSC 50, #2132. [11] Borden, et al (2021) LPSC 52, # 2666. [12] Oliveira, et al (2021) LPSC 52 #2621. [13] van der Bogert, et al. (2020) LPSC 51, #1876. [14] FGDC (2006). FGDC-STD- 013-2016. [15] Blue, J. (1999) Gazette. of Planet. Nomen. USGS. [16] Hiesinger, et al. (2000) JGR 105, 29239-29275. [17] Iqbal, et al (2019) LPSC 50, 1005. [18] Iqbal, et al. (2020) LPSC 51, # 1073. [19] Scott D. H. and Carr M. H (1972) USGS Misc. Geol. Inv. Map I-800, sheet 1. [20] Lucchitta B. K. (1972) USGS Misc. Geol. Inv. Map I-800, sheet 2. [21]Carr M. H. and El-Baz F. (1971) Apollo 15, *USGS*, I-723, 1:250k. [22] Neukum, (1983) Habil. thesis, U. of Munich.[23] Iqbal, et al (2019) Icarus 333, 528-547. [24] Iqbal, et al (2020) Icarus 352, 113991. [25] Iqbal et al. (2019) LPSC 50, #1005. [26] Iqbal et al (2020) LPSC 51, #1073. [27] Borisov, et al (2019) LPSC 50, #2323. [28] Gebbing, et al (2019) LPSC 50, # 2337. [29] Hiesinger, et al. (2020) LPSC 51, # 2045

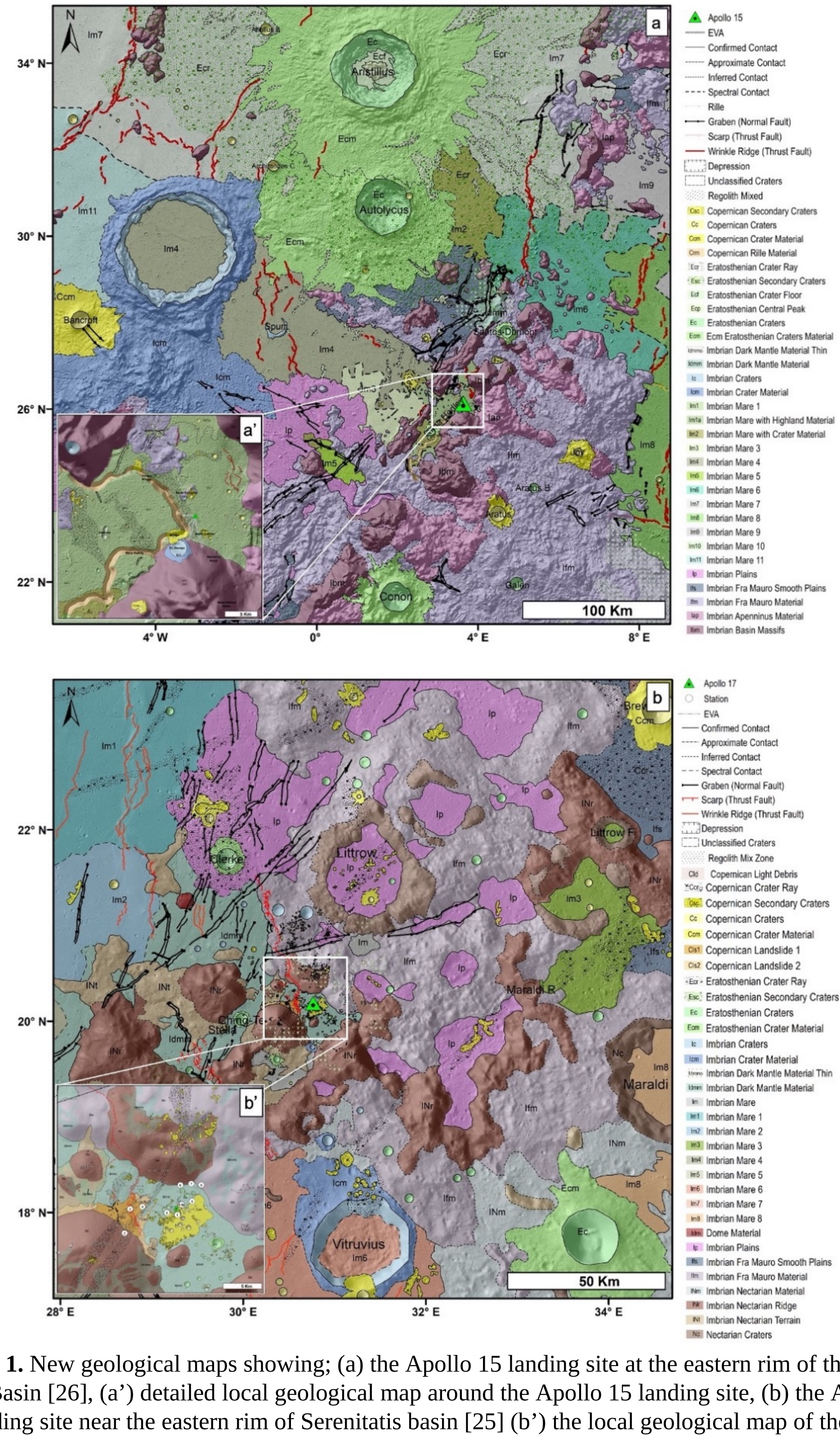

Figure 1. New geological maps showing; (a) the Apollo 15 landing site at the eastern rim of the Imbrian Basin [26], (a') detailed local geological map around the Apollo 15 landing site, (b) the Apollo 17 landing site near the eastern rim of Serenitatis basin [25] (b') the local geological map of the Taurus Littrow valley around the Apollo 17 landing site. The green triangle shows the locations of the landing sites.