DARK HALO CRATER STUDY TO INVESTIGATE LIGHT PLAIN RELATIONSHIP WITH BASIN FORMATION. B. Giuri[1], H. Hiesinger[1], N. Schmedemann[1], and C. H. van der Bogert[1], [1]Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany (gbarbara@uni-muenster.de).

Introduction: Light plains (LP) are flat, smooth terrains, with moderate to high albedo [1], widespread on both the near and far side of the Moon. Due to morphological similarities with lunar mare prior to the Apollo 16 mission, investigators supported a volcanic origin [2]. After Apollo 16 successfully returned samples from the Cayley Formation, however, these were found to be impact-generated breccias, thus the updated interpretation of light plains centered around two new hypothesis: 1) the emplacement of LP as primary ejecta from Imbrium and Orientale [3-7], or 2) a more diverse emplacement with some light plains being formed by volcanism, basin-related processes or local cratering [8]. However, due to the wide range in absolute model ages of light plains from 4.1 to 3.6 Ga [6,9], the hypothesis of LP formation from a single impact event is unlikely although a large number of LP appear to be related to the Orientale impact forming event up to a distance of 4 basin radii [1,6]. Nevertheless, the emplacement of LP from a variety of sources appears to be the most likely, although a volcanic origin cannot be excluded at least in some regions. In addition, one of the most favored hypotheses of emplacement for LPs appears to be ballistic sedimentation [10], where basin ejecta mixes with local material to form patches of smooth light plains beyond a basin's continuous ejecta blanket, with the proportions of primary to local material decreasing with distance from the basin [11], and covering pre-existing topography. In some cases, a relationship with cryptomaria is indicated by the presence of dark halo craters (DHC) that penetrated the light plains to expose dark underlying material of presumably volcanic origin. The study and search for DHCs not only is important for the identification of ancient mare deposits as a tool to understand the volcanic and thermal history of the Moon [12], but also to investigate further the relationship between light plain emplacement and basin formation.

In this study, we used the Kaguya TC map in combination with other data sets to search for signatures of DHCs superposed on light plain units. If we find a high number of dark halo craters, a closer relationship of LPs to volcanic units could be supported. If there are few to no occurrences of DHCs on LPs, then a volcanic origin for some LPs is less likely.

Data and Methods: For our investigation we used a near-global mosaic generated using data from SELenological and Engineering Explorer (SELENE) "Kaguya" Terrain Camera (TC) instrument to search for DHC albedo signatures together with available FeO maps and a composite M3 map to check the presence of high iron content. First, we mapped all known DHCs from the literature and geologic maps of the Moon. Second, we marked as verified and included or marked as unverified and excluded all DHCs that could or could not be confirmed using our data sets. Finally, we independently searched and mapped DHCs globally, and compared this map with maps of LPs.

Mapping and Classification: The purpose of this study is to search for DHC signatures overlying LP units. Thus, we collated and mapped known DHCs from the literature [13-17] and particularly focused on Type 2B DHCs, which are impact-related DHCs excavating buried mare (Fig.2) [18]. We also mapped DHCs identified on the Geologic Maps of the Moon [19-26] and divided them into groups: 1) standard – confirmed by our data sets, thus included in our map, 2) marked – endogenic in origin (Type 1, Fig.1), and 3) unverified – not confirmed by our data sets, thus excluded. DHCs in the latter group lack an iron anomaly around the crater rim and a dark halo. Furthermore, we independently searched for DHCs and divided them into two groups: a) certain – Type 2B, with a prominent low albedo dark halo over a high albedo plain, circular 10's of km wide and verified by all our data sets; and b) uncertain – these craters could have a strong or faint halo around the rim, but were not identified as DHCs on other maps. This group also included DHCs that formed on bright ray material and fresh crater ejecta, likely excavating underlying lower albedo material, rather than buried cryptomare, like those on the floor of Orientale basin and over the ejecta of Copernicus and Manilus crater and others.

Results: With our new map, we find that the global distribution of DHCs matches well with the known cryptomaria locations as shown in Whitten et al. 2015, but few standard and other DHCs overlay LPs. These few superposing DHCs occur on LPs of likely impact origin S-E of Orientale basin, an area of known cryptomaria [16]. The lack of DHCs occurrences over LP units anywhere else on the Moon might be indicative of either, 1) the thickness of the plains, where not even large crater are able to penetrate deep enough to excavate unknown buried mare deposits, or 2) the lack of widespread buried mare deposits. Consequently, we find most of the DHCs to be on the near side of the Moon, while others concentrate at the SPA and Orientale basin on the far side.

Discussion and Conclusion: The identification of impact-related dark halo craters is not always straightforward. In addition to Type 2B exogenic DHCs described in the Mapping section and shown in Figure 2, other craters with dark halos around their rims have been shown to be impact melt deposits (exogenic Type 2A) [11,18], reflecting a highland composition contrary to a more mafic mare-like composition. However, despite having morphological characteristics of a typical simple bowl shaped impact crater, they are often confused with Type 1 DHCs. These are endogenic craters formed by pyroclastic activity around a volcanic vent, irregular in shape, aligned along fissures and rills [11,18] mostly found within fractured impact crater floors (Fig.1) and associated with the emplacement of Local Dark Mantle Deposits (LDMD) like for example within Alphonsus, Herschel, Atlas, and Franklin craters.

Consequently, for our study we focused on Type 2B DHCs to further investigate light plains origin.

Future work: We are currently investigating the south-eastern region of Orientale basin by applying crater size frequency distribution (CSFD) measurements on selected light plain units and together with the overlying DHCs, we hope to better understand the origin of LPs and their relationship with basin formation. In addition, we aim to study DHC diameters, and thus the thickness of the LP deposits, in relationship to their potential source basin/crater to test a basin related formation, or a more local/regional impact ejecta emplacement.

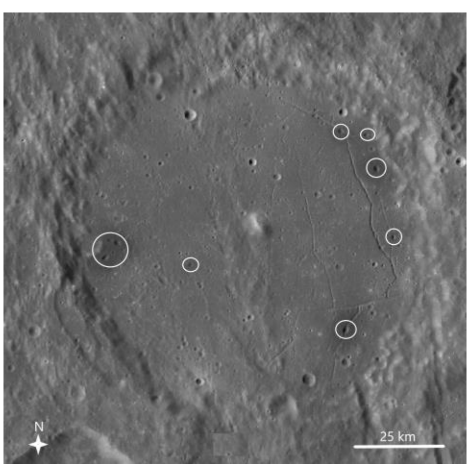

Figure 1: Alphonsus crater. White circles show known type 1 endogenic DHCs, irregular in shape and occurring along linear features within the crater.

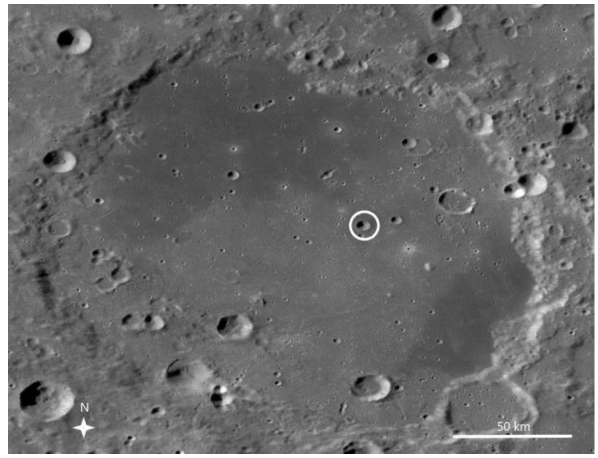

Figure 2: Schickard crater. White circle indicates Schickard R Type 2B exogenic bowl shape crater considered in this study.

References: [1] Meyer et al. (2020), JGRP, 125;. [2] Wilhelms (1965), Astr. Stud. Ann. Rep., v. 13, p. 28; [3] Wilhelms (1987), Geologic History of the Moon, USGS PP 1348; [4] Eggleton et al. (1972), Apollo 16 Prelim. Sci. Rep., 29-7 – 29-16; [5] Chao et al. (1973), LPSC 4, 127-128; [6] Meyer et al. (2016), Icarus, 273, 135-145; [7] Boyce et al. (1974), LSC, v. 5: Houston, Texas, 11-23; [8] Neukum (1977), The Moon, vol. 17, Dec. 1977, p. 383-393; [9] Hiesinger, H. et al. (2013), Lunar Planet. Sci. 44 #2827 (abstract); [10] Oberbeck, V. R. et al. (1974), PLPSC 5, 111-136 ; [11] Antonenko, I. et al. (1995), EMP 69, 141-172 ; [12] Antonenko, I. (1999), Thesis, Brown Univ. P. 309 ; [13] Gaddis, L. R. et al. (2003), Elsevier Sci. (USA), Icarus 161, 262-280; [14] Gustavson, J. O. et al. (2012), JGR Vol. 117, E00H25 ; [15] Jawin, E. R. et al. (2015), J. Geophys. Res. Planets, 120, 1310-1331 ; [16] Whitten, J., Head, J. (2015), PSS 106, 67-81; [17] Antonenko, I. (2013), LPSC 2607, (abstract); [18] Hawke, B. R. et al. (1985), LPI 16, 372H; [19] Carr, M. H. (1965; 1966; 1969); [20] Schmitt, H. H. et al. (1967); [21] McCauley, J.F. (1967); [22] Morris, E. C., Wilhelms, D. E. (1967); [23] Wilhelms, D. E. (1968); [24] Hackman, R. J. (1966); [25] Howard, K. A., Masursky, H. (1968); [26] Milton, D. (1968).