LIGHT PLAIN ABSOLUTE MODEL AGES IN THE ORIENTALE REGION, MOON. 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: Globally distributed on both the near and far side of the Moon, light plains (LP) are flat, smooth terrains, similar in morphology to mare basalts, but with moderate to high albedo, occupying about 9.5% of the surface [1]. Their smooth appearance and low crater density led many authors to support a volcanic origin [2,15-17]. However, after the Apollo 16 mission successfully returned samples from the Cayley Formation, these were found to be impact breccias and consequently, the origin of LP was re-interpreted to be related to the largest young basin impact events, i.e., Orientale and Imbrium [2-7]. Neukum [8] however argued that the origin of the LP might be more diverse with some LP being formed by volcanism, basin-related processes, or local cratering. Despite the numerous studies investigating LP, their mode of emplacement, ages and origin remain highly debated. In this study, we used new high-resolution images of the Lunar Reconnaissance Orbiter Camera (LROC), in combination with other modern data sets, to study LP in unprecedented detail in order to decipher their potential origin. Thus, we present a new independent global map of LP and preliminary absolute model ages (AMA) of 15 previously undated LP with crater size-frequency distribution (CSFD) measurements in the Orientale region on the far side of the Moon.

Data and Methods: In this study, for the mapping of LP we used (1) the LRO WAC monochrome global mosaic, 100m basemap, (2) the LRO LOLA Shaded Relief 237m v4, (3) the FeO map from Lucey et al. [9], (4) the Kaguya Lunar Multiband Imager Derived FeO wt.%, 50N50S 50 mpp, and (5) ArcGIS 10.5 to manually map all LP. Pre-existing LP maps [1,6,10] were also consulted for comparison. For the dating of selected LP, we performed CSFD measurements within ArcGIS using CraterTools [11] to perform the counts. The count areas define individual homogeneous LP units. The CSFDs were then plotted using CraterStats [12] with the production function and lunar chronology function of Neukum et al. (2001).

Mapping approach: The initial mapping was solely based on a visual identification of smooth, flat and moderate- to high-albedo plains with respect to the surrounding terrains. The global map was later refined using the available FeO maps listed in the Data and Methods section, to better constrain LP around mare regions.

Results: From the LP global map we find: on the nearside, LP appear denser around mare regions where high FeO mare units grade into intermediate-low FeO light plain units. North of Imbrium, light plains are large and have high albedo, hence they are distinguishable from the maria south of them. To the South, Orientale's ray-like patterns of LP extend to Tycho crater and become more sparse and patchy with increasing distance from the basin. To the East, LP delineate Mare Marginis, Crisium and south of Mare Smythii with large areas where LP were not identified. In this region we find LP of a more intermediate albedo, flat but not necessarily smooth.

The far side instead, appears significantly affected by the Orientale basin-forming impact. We find ray-like patterns of LP converging towards Orientale basin up to a distance of 4 radii. The origin of these plains is likely impact-related, thus in agreement with the work of [1,6], while plains appear to be more evenly distributed to the north. These plains are located within and around craters and might have been formed by local cratering processes, volcanism, or both. Although no morphological evidence such as vents were observed in this region, we do not exclude a volcanic origin. Plains that do not appear to be related to a specific basin may be more likely due to local and/or regional impact cratering and/or volcanism. With increasing distance from Orientale, plains occur mainly within and around craters, they appear mature and of lower albedo, almost undistinguishable from surrounding terrains, rendering their identification challenging.

Finally, to further investigate their relationship with basin formation, we dated 15 occurrences of light plains in the Orientale region. Our preliminary measurements yield AMAs of 3.64 to 3.81 Ga (Fig.1), thus in agreement with the work of [6] for eleven areas NW of Orientale and closer to the lower limit with the work of [14] for sixteen areas in the SPA region. The areas chosen to perform our CSFD measurements are selected based on homogeneity and as little secondary crater contamination as possible. As we proceed with our investigation we hope to provide further support for our preliminary findings and to expand our data set of AMAs globally.

Discussion: While our new and independent map of LP shows similarities with prior maps, differences arise in the mapping methodology adopted. We based our identification of LP exclusively on their flat and smooth appearance, bright albedo and FeO content, whereas [1] used additional data sets such as slope maps, and [10] applied an automated LP identification technique on the basis of a slope analysis from the LROC WAC topography and Clementine FeO maps – which appears to be less suitable for differentiating between plains especially around mare regions. In these areas, we only mapped the smooth parts of these plains for consistency with our morphological definition of LP and with an upper limit FeO content between 6 and 11 wt.%. We believe while most LP have FeO contents < 4 wt.% [6,9], those around mare region represent mixed deposits with underlying or adjacent mare. Similarly, light plains on the far side beyond Orientale's 4 crater radii, have a lower albedo than the average highland LP and low FeO content, perhaps indicative of maturity. It is clear that not all LPs have the same morphology, albedo, and composition globally.

Investigating the relative and absolute ages of LP provides another way to gain insight into their origin. Of the 15 occurrences we dated in the Orientale region (Fig.1), we find that areas closest to the basin on the western side range in age between 3.79 and 3.81 Ga consistent with Orientale's ejecta emplacement age [14]. Areas to the north of Orientale, beyond the Hevilius, date between 3.68 to 3.71 Ga likely the result of more local cratering events with some Orientale contribution. Finally, those areas closest to the basin but on the eastern side, range between 3.64 to 3.78 Ga. It is yet unclear the significance of such young ages close to the basin rim. Hence, this region is currently under further investigation.

Conclusion and Future work: In this study we present a new and independent global map of light plains on the Moon. Despite the patchier appearance and mismatches in some areas, our map is largely consistent with previous maps, thus appearing to represent a reliable depiction of the distribution of LPs. However, given the Imbrium and Orientale basin ages and the wide ranges in AMAs from various studies in different areas of the Moon, we find that our preliminary absolute model ages for selected LP occurrences require additional studies to investigate different potential origins. For this reason, we aim to date at least 50 plains distributed globally to better constrain LP ages and their relationship with basin formation.

Light Plains	Preliminary AMAs	Error
Mach	3.79	+0.014/-0.015
Fizeau	3.81	+0.049/-0.058
N of Blackett	3.81	+0.02/-0.023
W of Stromgren	3.80	+0.008/-0.0084
Carnot	3.71	+0.017/-0.011
Coulomb	3.75	+0.0098/-0.01
Rontgen	3.70	+0.0057/-0.0059
Volts	3.79	+0.04/-0.045
W of Lorentz	3.68	+0.0058/-0.0061
N of Vasco da Gama A	3.78	+0.018/-0.02
Rocca W	3.64	+0.011/-0.011
W of Lagrange L	3.71	+0.025/-0.03
N of Fourier N	3.68	+0.012/-0.013
Wargentin	3.71	+0.011/-0.012
E of Piazzi G	3.71	+0.023/-0.027

Fig. 1: Preliminary AMAs of LP investigated so far.

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] Lucey et al. (2000), Geophys. Res. 105 (E8), 20297-20305; [10] Boyd, Mahanti, et al. (2012), Presented at the EPSC; [11] Kneissl et al. (2011), PSS 59, 1243-1254; [12] Michael and Neukum (2010), EPSL 294, 223; [13] Neukum et al. (2001), Space Sci. Rev. 96, 55-86; [14] Hiesinger et al. (2013), LPSC, #2827 (abstract); [15] Wilhelms and McCauley (1971), USGS I-703; [16] Trask and McCauley (1972), EPSL 14, 201-206; [17] Hodges (1972), U.S. Geol. Survey Misc. Goel. Inv., I-748.