THE AGE OF VOLCANISM NORTH AND EAST OF THE ARISTARCHUS CRATER. M. Madrid¹ and J. Stopar², ¹Calvin College, 3201 Burton St. SE, Grand Rapids, MI 49546, (maiamadrid822@gmail.com), ²Lunar and Planetary Institute, 3600 Bay Area Blvd, Houston TX 77058

Introduction: The study area of this investigation lies in Oceanus Procellarum, to the north and east of Aristarchus crater and Aristarchus Plateau (Fig. 1). Our study area includes the northeast portion of the P60 unit, one of the basaltic units determined and dated by Hiesinger et al. [1, 2], who derived an absolute model age (AMA) of 1.20 +0.32/-0.35 Ga for this unit. This age was based on a small part of the P60 unit west of the plateau [1,2]. The maria south and east of Aristarchus crater have also been previously dated to ~3.1 to 3.5 Ga using crater degradation methods [4, 5]. Stadermann et al.’s more recent analysis examined variations in crater density across the P60 unit and found areas of the P60 unit with ages ranging from 1.03 +/- 0.16 Ga to 2.81 +/-0.04/-0.06 Ga [3]. Their crater size-frequency distributions (CSFD) indicate an east-to-west trend of increasingly younger volcanism across the P60 [3]. Our study area focuses on a portion of the P60 and nearby deposits that were not included in Stadermann et al.’s work [3].

Fig. 1: Current study area outlined in orange; P60, P4, and P7 units of [1,2] outlined in cyan; yellow starburst indicates location of IMP; green starburst indicates location of small volcanic vent identified. LROC WAC mosaic

The objectives of this investigation are to differentiate and map maria units and to establish CSFD-derived ages for the inter-ray maria regions, which should lead to an improved understanding of the stratigraphy and timeline of events in this area.

Nearby P4 and P7 mare units have reported ages of 3.48/3.74 +0.07/-0.10 Ga and 3.48 +0.07/-0.14 Ga, respectively [1, 2]. Ejecta and secondaries from Aristarchus crater (~280 Ma [6]), as well as from the more distant Kepler and Copernicus craters (to the southeast), have been emplaced on top of the P60 unit [3] and our study area. The study area also contains a small Irregular Mare Patch (IMP), which has been proposed to be a young volcanic vent [7] (Fig. 1). The stratigraphic emplacement of the IMP on top of the continuous Aristarchus ejecta blanket, along with previously determined superposed crater densities, supports an age between ~110 Ma and 18 Ma for the IMP’s volcanic activity [7]. The seemingly extensive history of volcanism in our study region (ranging from ~3.7 Ga to potentially 18 Ma) could provide further insight into the timing, and evolution of volcanism on the Moon in the Aristarchus-Rimae Prinz regions.

Methods: This investigation utilized Lunar Reconnaissance Orbiter Camera (LROC) data, both 100 m/pixel Wide Angle Camera (WAC) and high-resolution Narrow Angle Camera (NAC) images [8], as well as Clementine UVVIS 100 m/pixel albedo data and 200 m/pixel derived TiO₂ and FeO abundance maps [9].

A geologic sketch of the study area (Fig. 2) was developed using Clementine UVVIS albedo, FeO and TiO₂ data [9], as well as the publicly available WAC morphology base map and WAC GLD100 topography map. Mapping units were defined based on morphology, topography, albedo, and composition. For each mare unit, average and standard deviations were determined from the FeO and TiO₂ data sets for 15 random samples within the unit. Units in topographically contained and morphologically similar areas with similar albedos and FeO, TiO₂ contents (within a standard deviation) were grouped together to create mare groups A, B, C, D, and E (Fig. 3).

WAC base maps were used to map all visible craters within the study region larger than 400m in diameter, which is the minimum limit of crater determination using this data. CSFDs and AMAs were determined for the inter-ray portions of the five mare groups using standardized procedures [3, 10]. Crater chains, crater clusters, and herringbone-shaped craters were mapped as secondary craters and excluded from the final CSFD, while all other craters were considered primary and included.

AMAs were calculated with the chronology and production functions from Neukum et. al., 2001 [11]. The methods used in this study were validated by also determining ages from several areas studied by Stadermann et al. [3]; we reproduced their reported ages within the uncertainties, lending confidence to our abilities in both identifying inter-ray mare and excluding most secondary craters from final age determinations.
Results: Two distinct mare varieties were determined during mapping (Fig. 2): 1) a relatively low TiO$_2$ mare, defined as having between 1.8-4.0 wt% and 2) a higher TiO$_2$ mare, defined as having 4.0-6.5 wt% TiO$_2$. Significant craters and ejecta that were large enough to affect local albedo and composition of the mare units were mapped separately (Fig. 2).

The ejecta from Aristarchus crater was divided into two morphological units, with the continuous ejecta blanket defined as hummocky ejecta with few to no inter-ray areas, and the discontinuous ejecta defined as rays of higher-albedo, low TiO$_2$ ejecta materials and extensive secondary craters. A small portion of the Aristarchus Plateau intersects the northwest corner of the study area, and includes volcanic and pyroclastic deposits mapped by McBride et al. [12]. A non-mare massif was also identified in the central part of the study area.

CSFDs yield ages for the five maria groups ranging from 3.11 ±0.05/0.07 Ga to 3.60 ±0.03/0.4 Ga (Fig. 3). The oldest unit (E) is located in the north-central part of the study area. Fits using only craters greater than 800 m in diameter did not yield significantly different ages for the maria groups, but did result in less robust statistics because of the limited number of craters present in that size range.

Discussion: Extensive secondary cratering, impact ejecta, and crater rays covering much of the surface indicate substantial modification of the surface by the Aristarchus impact (~280 Ma [6]). However, it is reasonable to assume that such modification would preferentially erase the smaller craters, leaving the larger ones still visible, particularly at greater distances from the crater. Even so, it is possible that our CSFDs include some hard-to-identify secondary craters that could affect the derived ages. Nonetheless, our crater mapping suggests that the inter-ray maria within our study area are significantly older than the rest of the P60 unit (~1.0 to 2.9 Ga [3]).

Conclusion: The ~3.1 to ~3.6 Ga ages of the mare groups in our study area are inconsistent with the young ages proposed by previous studies for the P60 unit [1-3], suggesting that the units within our study area are not genetically related to the young flows of the P60. Young volcanic flows (~1.0 – 2.8 Ga [3]) in the Aristarchus region are focused to the west and south of the Plateau [1-3]; the area to the north and east of the Plateau, however, did not experience this resurfacing by mare flow emplacement. Stadermann et al. [3] proposed the presence of an older basaltic substrate, with ages ranging from ~3.2 to ~3.6 Ga, beneath the younger flows of the P60 based on ghost craters larger than ~2 km in diameter. These ages are more in line with the ages of the flows in our study area, as well as those of the Rimae Prinz region.

The IMP near Aristarchus crater, based on its geographic occurrence and stratigraphy, is also unlikely to be related to the young mare volcanism that occurred in the P60 unit, and instead represents a highly localized geologic process.