LAVA FLOWS IN NORTHEASTERN OCEANUS PROCELLARUM: MORPHOLOGY, COMPOSITION AND AGES. T.A. Giguere[1], J.M. Boyce[1], J.J. Gillis-Davis[2], and J.D. Stopar[3]. [1]Hawaii Institute of Geophysics and Planetology, Univ. of Hawaii, Honolulu, HI 96822, [2]Washington University, Department of Physics, One Brookings Drive, St. Louis, MO 63130. [3]Lunar and Planetary Institute, USRA, Houston, TX 77058. (giguere@hawaii.edu).

Introduction: Volcanism on the Moon was active for an extended period of time (~1.1-4.0 Ga), with the major activity occurring between 3.4 and 3.7 Ga [1-3]. Based on impact crater size-frequency density-based techniques, mare volcanism in Oceanus Procellarum ranged (Figure 1 inset) from ~1.2 to 3.93 Ga [2,3]. The lower end of the range represents some of the youngest mare surfaces on the Moon, with the possible exception of irregular mare patches [4]. Determining eruption ages specifically eruption ages for northeastern (NE) Oceanus Procellarum (Figure 1), establishes the timing of mare basalt emplacement and may provide insight into the thermal and eruptive history of this interesting area. While this broad expanse of mare basalt, with minimal topographic surface variations, is similar to other mare-filled impact basins, there are other aspects of interest that set it apart from other locations. Mons Rumker, located to the west, is a ~4000 km^2, 1300 m high basaltic dome [5,6] or shield volcano [7].

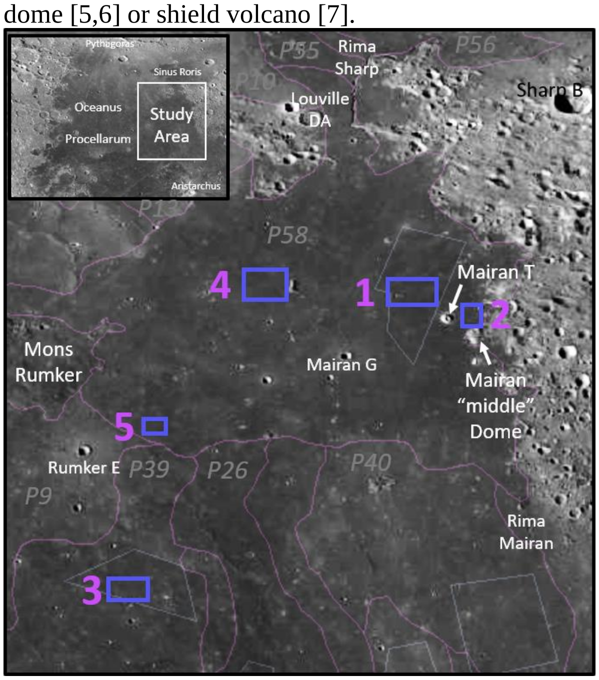

Figure 1. Northeastern (NE) Oceanus Procellarum overview (inset) and detail view. Count locations (this study) - bold numbered blue boxes. Mare crater count areas (white shapes) and mare age units (pink outlines) used in previous studies [2,3]. Image width 320 km (center). WAC Global Morphologic basemap (July 2013). North is up.

The shield has 20+ smaller domes on its surface that range in age from absolute model ages ~3.5 to 3.7 Ga. Buttressing this area to the east are the four Mairan domes (Northwest, Mairan T Dome, Mairan "Middle", Mairan "South"), which Glotch et al. [8], determined were formed as the result of silicic volcanism. Oceanus Procellarum lies within the high thorium (Th) Procellarum KREEP Terrane (PKT) [9].

Determining of surface absolute ages has evolved over time by both researcher and technique [2,10-14]. Surface age may also vary with distance as resurfacing flows are encountered. Stadermann et al. [15] demonstrated that ages within a spectrally defined compositional unit may contain multiple flows with unique ages. We, along with other workers [16], leverage this observation to target individual flows in NE Oceanus Procellarum. Morphology (flow fronts/margins, embayments, boulders), geochemistry (FeO, TiO_2), and topographic data aid our flow identification. Our objectives for NE Oceanus Procellarum include: 1) determine the absolute model ages of the mare surface and compare with past results, 2) identify spatial variations in the absolute model ages for the mare surface, 3) characterize the chemical composition and stratigraphy of mare basalts, which provides insight into the compositional evolution of erupted material over time, 4) describe flow morphology, 5) leverage topographic data to determine flow direction and the location of vents. The individual results of this research, when combined, yield an understanding of the most recent volcanic processes that occurred in NE Oceanus Procellarum.

Table 1. Model ages of unit P58 in Figure 1[a]

Study	Age[b]	Count Location[c]
Boyce[17]	3.2	East
Hiesinger, et al.[2,3]	1.33	East (white outline)
Morota, et al.[14], Model A	1.91, 3.46	Central
Morota, et al.[14], Model B	2.20, 3.46	Central
Giguere, et al.[This Study]	3.33	East

[a]*Model ages from this study and previous studies.*
[b]*Ages (Ga) are for unit P58[2]*
[c]*Count Location within mare surface unit P58*

Data and Methods: Both Lunar Reconaissance Orbiter (LRO) Wide Angle Camera (WAC) (high and low incidence) and Narrow Angle Camera (NAC) images were used in this study [18,19]. High resolution lunar topography were obtained from the SLDEM2015 [20] and the JAXA SELENE "Kaguya" monochromatic Terrain Camera [21,22]. Crater count data provide a means of determining relative age, and with assumptions, a means of estimating absolute (model) age [23]. LROC NAC images were used for crater counts and crater diameter measurements. Cumulative size-frequency distribution (CSFD) curves were constructed from the crater count data collected for each area, while excluding secondary craters. Crater model ages were calculated based on the CSFD curve using the Craterstats2 program [23]. The statistical error was calculated for the craters in each diameter bin (N) based on a Poisson distribution and is represented as error bars on the CSFD. The lunar production function and lunar chronology of Neukum et al. [24] was used to estimate model crater age for the CSFD curves . Image data from the SELENE "Kaguya" monochromatic Terrain Camera (TC) [23] and the Multiband Imager (MI) [25] visible and near-infrared multispectral camera were used for detailed surface and geochemical analysis.

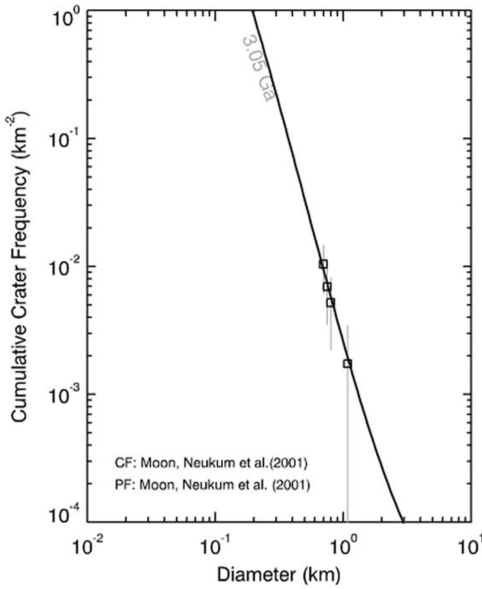

Figure 2. *Crater count data (CSFD) for count area 1, method of [23]. Area is 570.55 km^2.*

Results and Discussion: Our initial focus is on the absolute model age of the mare surfaces both inside and outside of existing mare crater count areas [2], which in turn are used to determine ages of the surrounding mare age units. We defined five count areas within two mare age units (P39, P58), blue outline in Figure 1. These widely spaced areas were selected to minimize secondary craters. Count area 1, northwest of the Mairan T dome and east of Rima Sharp, shows variations in FeO (<2.5 wt. %) across the area. This count area and in turn the larger original count area [12] likely crosses flow boundaries and has a model age of 3.05 Ga (Figure 2), older than the published age of 1.33 Ga [2]. Count area 2, east of the Mairan T dome, is outside of the defined mare crater count area [2], while remaining inside the mare age unit P58. Similar to the first count area, the FeO surface values range from 16-19 wt. % [25]. The absolute model age determined is 3.33 Ga (Figure 3). This age is between the ages determined in previous studies [14,17], which had different count locations. We see two issues that affect absolute model age determination. First, count areas are a small percentage of the over age unit, thus not representative. The count area for P58 is ~6% of the ascribed mare unit. Second, compositionally uniform units may actually be more complex and have differing ages revealed with higher resolution data [16]. The accuracy of absolute model ages may be improved by counting larger areas composed of multiple discrete areas and by using current datasets. Further count area improvements are available from a new approach [15,16] that separates compositional units (FeO, TiO_2) into smaller distinctive units, which allows lava flows to be mapped.

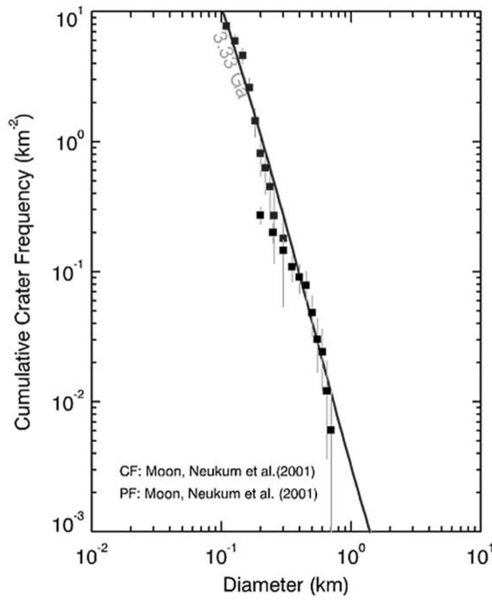

Figure 3. *Crater count data (CSFD) for count area 2, method of [23]. Area is 174.92 km^2.*

Summary: Absolute model ages have been determined for small portions of NE Oceanus Procellarum. Work to construct the stratigraphic history of NE Oceanus Procellarum continues. Our aim is to locate where the most recent lava flows occur — which may help with targeting future sample return missions — and to determine their age, which is critical for establishing the the end of volcanism in this region.

References:

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