

Lacus Mortis: Age, Composition, and Origins. T.A. Giguere¹, J.M. Boyce¹, J.J. Gillis-Davis², and J.D. Stopar³. ¹Hawaii Institute of Geophysics and Planetology, Univ. of Hawaii, Honolulu, HI 96822, ²Washington University, Department of Physics, One Brookings Drive, St. Louis, MO 63130. ³Lunar and Planetary Institute, USRA, Houston, TX 77058. (giguere@hawaii.edu).

Introduction: Our research provides an understanding of the age, composition, and origin of lava flows in Lacus Mortis (45.13° N, 27.32° E), a small mare (diameter 158.78 km; ~19,200 sq km) located on the north-eastern lunar nearside. The mare is north of Lacus Somniorum and Mare Serenitatis and south of the eastern portion of Mare Frigoris. Determining the model age of the basalts will serve to place this mare in age sequence with the neighboring maria and further our understanding of the thermal history of the Moon. This region, part of a larger study, provides an opportunity to cross-calibrate crater counting procedures between researchers, which is in need of refinement [1].

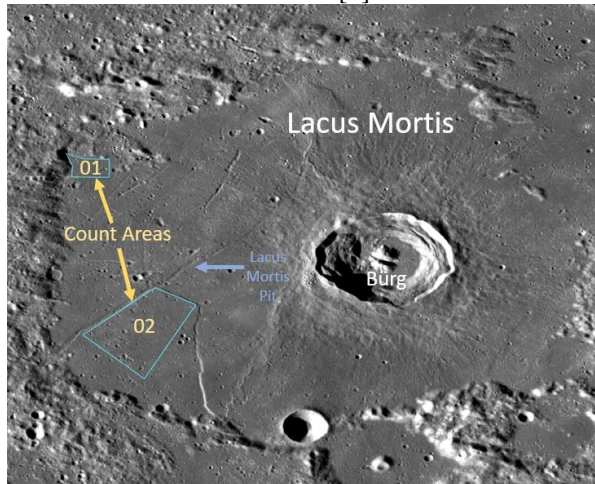


Figure 1. Lacus Mortis, located in the northeast quadrant of the lunar nearside, north of Mare Serenitatis and south of the eastern portion of Mare Frigoris. North is up in this WAC Global Morphologic base map.

Despite the small size, this mare exhibits characteristics that are noteworthy. Most major mare along with many minor ones have been age dated in lunarwide studies [2,3]; However, Lacus Mortis has been largely overlooked. One recent study provides basalt model ages of 3.3, 3.5, and 3.8 billion years ago for the areas around the Lacus Mortis pit [4]. We provide model ages for two additional areas within this mare to further refine our understanding of eruptions in this area.

Telescopic spectral analysis classifies this mare as “LBG-“; low TiO₂ [5]. Clementine geochemistry analyses have shown that the mare has both low FeO and TiO₂ (FeO 12-15 wt%, TiO₂ 0-3 wt%, [6]; Unit “EF1”, FeO 14 wt%, TiO₂ 1.5-2 wt% [7]).

Crater Bürg has been identified as a radar dark halo crater with relatively few blocks in the ejecta [8]. Low CPR values acquired with radar (P-band, 70 cm; Mini-RF Arecibo bistatic) also indicate a lack of boulders

from the area around Atlas crater to eastern Lacus Mortis [9].

A lunar pit was identified previously in the western portion of the mare [4,10], and lies between our count areas. This general area is the planned landing location of the Astrobotics Peregrine Mission One (M1); one of the first missions of the NASA Commercial Lunar Payload Services (CLPS) program [11]. Our updated model ages, geochemistry, and interpretations will help us to understand the eruptive history of this part of the Moon, as well as provide context for the ~14 instrument packages on the Astrobotics CLPS mission.

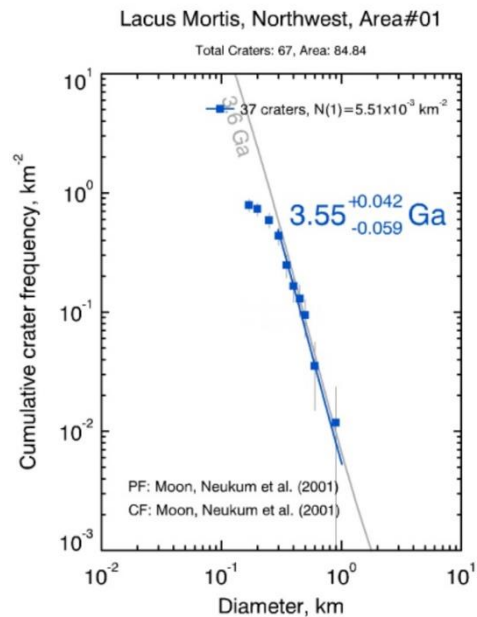


Figure 2. Count area #01, located in northwest Lacus Mortis, yields an absolute model age of $3.6 \pm 0.04/-0.06$ Ga.

Results and Discussion: We performed crater counts and produced Cumulative size-frequency distribution curves (CSFDs) to determine model ages in two areas on the western side of the mare (Fig. 1). The Lunar Reconnaissance Orbiter (LRO) Wide Angle Camera (WAC) and Narrow Angle Camera (NAC) images were used for this task [12,13]. Crater size count data provide a means of determining relative age, and a means of estimating absolute (model) age (here after simply called “age”) [14]. CSFD curves were constructed from the crater count data, with ages calculated from these data using the Craterstats2 program [14], and the lunar production function of Neukum et al. [15] to estimate the age for these curves. Count areas were selected to exclude crater rays and secondary craters [16,17], alt-

though this task was especially challenging as Copernican crater B rg (45.0 N 28.2 E) impacted near the center of Lacus Mortis and along with its continuous ejecta blanket obscures at least 20% of the surrounding mare. Every effort was made to avoid the discontinuous ejecta blanket, which also obscures the mare, when defining each count area and during the crater selection process.

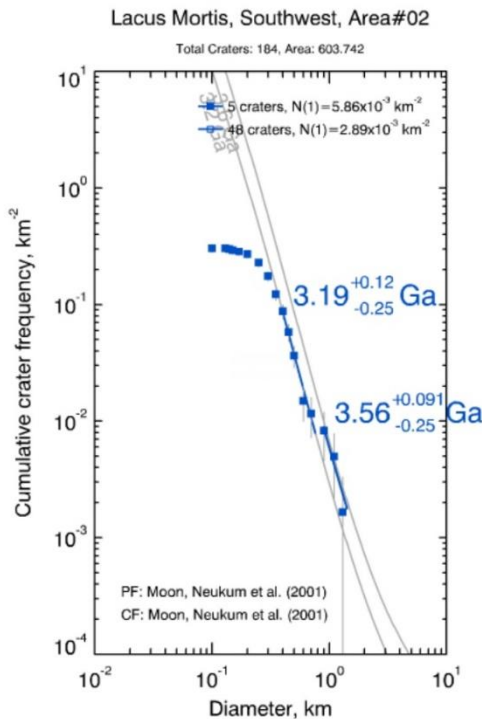


Figure 3. Count area #02, located in southwest Lacus Mortis, yields two absolute model ages of $3.2 \pm 0.1 \pm 0.3$ and $3.6 \pm 0.09 \pm 0.3$ Ga, which suggest that the count area has been re-surfaced.

Crater model ages were determined for two locations in the western portion of the mare as far from crater B rg as possible. Count area #01 has a model age of $3.55 \pm 0.04 \pm 0.06$ Ga (Fig. 2). Count area #02 exhibits a "knee" in the curve suggesting two model ages; $3.19 \pm 0.1 \pm 0.3$ and $3.56 \pm 0.09 \pm 0.3$ Ga (Fig. 3). The knee in the CSFD curve of Area #2, along with the subdued appearance of craters suggests that the small crater population (<600 m) is more sparsely distributed compared with the larger craters. This characteristic is generally regarded as evidence of the partial resurfacing of a mare area where a thin young lava flow superposes an older cratered surface, however, in this unusual mare the most likely scenario is obscuration by distal B rg impact ejecta [18]. The ejecta would have the same affect as a lava flow, namely reducing the number of craters visible. When the number of craters of a given size is reduced in a fixed area; the absolute model age becomes younger.

Image data from the SELENE (Kaguya) Multiband Imager (MI) [19] visible and near-infrared multispectral

camera were used for detailed geochemical analysis. The average FeO abundance for the mare is ~ 12.5 wt% in an overall range of 8-14 wt%. While the TiO₂ abundance for the mare is ~ 1.0 wt% in a range of 0-2 wt% [20]. On the northern portion of count area #02 we observe lower FeO and TiO₂ values that correspond to elevated terrain in the WAC/NAC digital terrain models (DTM). Secondary crater chains are associated with this area, which suggests that this area was covered by B rg ejecta, which has lower FeO and TiO₂ values than the mare.

Summary and Next Steps: The basalts in Lacus Mortis with a ~ 3.6 Ga model age (count area #01; partial count area #02), may have been emplaced as part of the same eruptive sequence as eastern Mare Frigoris (age units: F13 3.56/3.64 Ga; F14 3.56 Ga) [3], Lacus Spei (~ 3.56 Ga) [21], and slightly earlier than the basalts in northern Mare Serenitatis (age units: S13 3.49 Ga; S17 3.43 Ga) [3]. Preliminary analysis shows that the remotely acquired geochemistry between these mare basalts are similar (e.g. Mare Frigoris unit "EF2" [7]). Furthermore, these basalts are geochemically anomalous (low FeO) compared to those samples in the Apollo/Luna sample collection. e.g., Assessing the composition and age of Lacus Mortis addresses the SCEM report science goal [22], 3b) "Inventory the variety, age, distribution, and origin of lunar rock types." Our analyses aims to provide new insights into planetary differentiation, thermal evolution, and volcanism; the diversity of mantle processes and magmatism, including the generation of low-FeO melts in an otherwise high-FeO basaltic environment.

As fundamental issues have been identified with the determination of absolute model ages for mare surfaces [1], additional calibration continues in order to assure accurate absolute model ages for Lacus Mortis and other mare locations.

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