CHARACTERISTICS OF MARE DEPOSITS ON THE EASTERN LIMB OF THE MOON: IMPLICATIONS FOR MAGMA TRANSPORT MECHANISMS. R. Aileen Yingst and James W. Head, Dept. Geological Sciences, Brown University, Providence, RI 02912 USA

Introduction: Lunar volcanic history has been examined in light of geomorphological and stratigraphic constraints placed upon the surface features [1,2]. Compositional and petrological analyses have provided models for the conditions of mare parent magma generation [3,4,5]. The connection between lunar magma source regions and volcanic surface features remains unclear, however, both conceptually and quantitatively with respect to our understanding of transport mechanisms. It has been suggested that mare emplacement was controlled by propagation of dikes driven by the overpressurization of diapir-like source regions stalled below the cooling lunar highland crust [6,7,8]. Recent analyses of the characteristics of lava ponds in the South Pole/Aitken and Orientale/Mendel-Rydberg basins based on Clementine [9], Lunar Orbiter and Zond data have provided evidence that supports this theory [10,11]. In this contribution we report on an analysis of the areas, volumes, modes of occurrence and crustal thicknesses for mare deposits in the Marginis and Smythii basins, and investigate implications for magma transport mechanisms.

Approach: The isolation and examination of the characteristics of single lunar eruptive events are complicated by multiple overlapping flows, burial of source vents by subsequent flows and the possibility of several associated source regions. To avoid these problems inherent to the large nearside maria, we limited our analysis to clusters of discrete mare deposits that occur in the adjacent highlands in order to more clearly determine basic commonalities for lunar eruptive events. Ponds were chosen as representative of single eruptive events based upon homogeneity in multi-spectral characteristics, albedo and crater density as well as their self-contained nature and lack of evidence for multiple eruptive events. Selection of lunar regions for this analysis centered on those areas displaying the presence of abundant isolated lava ponds so that statistics of individual occurrences might be significant. In order to test predictions about the role of crustal thickness in mare basalt transport and eruption [6,7,8], we chose regions that varied in crustal thickness with each other and with previously examined basins [e.g. 10,11]. This contribution analyzes Lunar Orbiter, Galileo and Apollo images, and utilizes Clementine crustal thickness estimates [9] and geologic maps [12] to examine the characteristics and crustal thickness relationships of mare deposits in the Marginis-Smythii basins.

Data and Results: Areas have been measured for 13 lava ponds (14 separate flow units) in the pre-Nectarian Marginis basin (580 km diameter defined by the largest extrapolated basin ring) [1,12], and 26 lava ponds (30 separate flow units) in the younger pre-Nectarian Smythii region (840 km diameter) [1]. Total mare deposit coverage of these ponds is approximately 110,000 km^2, less than 2% of the total surface area covered by lunar maria (figure 1). Of the total 39 mare deposits (44 separate flows) in this region, 95% have areas less than 10,000 km^2, while 82% have areas less than 2000 km^2. The majority of ponds (24, or about 62%) occur on crater floors, whether in the basin center (17 ponds, 44%) or in an outside ring (7 ponds, 18%). Another 12 ponds (31%) lie within intercrater regions, while one pond straddles a crater floor and an intercrater region. Two mare deposits (5%) are defined as maria proper. Distribution of ponds is highly concentrated in the southern quadrant in the case of the Marginis basin, while areal distribution in Smythii basin concentrates in the central region. The areal density of ponds for the region defined by the exterior rings of both basins [12] is estimated to be about 1 per 21,000 km^2.

Preliminary volumes for mare deposits in the Smythii-Marginis region were estimated by multiplying calculated areas for each eruptive event with an average thickness of 200 m [13] (figure 2). The total volume of mare deposits for this region is approximately 21,500 km^3. Individual volumes for these lava ponds were seen to be very large; the average volume for a single eruptive event for Marginis basin was 800 km^3, while for Smythii basin it was 350 km^3. For both of these basins combined, the average volume per eruptive event was approximately 500 km^3. For a terrestrial comparison, the Laki flow in Iceland was 12 km^3 [14], while the largest Grande Ronde

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flow in the Columbia River region was about 2000 km^3 [15]. These examples suggest that deep, rather than shallow source regions are prevalent in this region [8].

Crustal thickness (T_C) estimates derived from Clementine altimetry data [9] were compared to mare deposit volumes and frequency of occurrence. For Smythii basin, the number of ponds was observed to increase in areas of thinner crust, and the total volume of mare material increased as crustal thickness decreased. Thus, 73% of all eruptive events (22 separate flows) and 81% of the total mare volume in the basin occur where $T_C < 40$ km. For Marginis basin, the total mare deposit volume also increased with decreasing T_C; however, there were more pond occurrences at higher crustal thickness values. This result may be due to the generally low number of ponds in this region.

Conclusions: Crustal thickness is directly related to extrusion volume for each basin such that those areas with thinner crust show the highest volume of mare material and the highest volume for each individual eruptive event. This relationship has also been seen for South Pole/Aitken and Orientale/Mendel-Rydberg basins [10,11]. These conclusions suggest that we are observing a direct correlation between the efficiency of magma transport and the thickness of the overlying crust, such as is described by overpressurization and dike propagation [6], rather than a passive relationship, such as upwelling and hydrostatic fill. We interpret this to mean that the likelihood of extrusion is a function of the thickness of intervening crust through which a propagating dike must pass.

When the data for both basins are compared, however, it is seen that a greater total mare volume occurs in Marginis basin, a basin with thicker crust than that of Smythii, while a greater number of flows occurs in Smythii basin. This suggests that crustal thickness relationships are accurate in a general sense, but that the various characteristics of each locality may have differing effects on the exact number and volume of eruptive events in comparison to other basins. Because Smythii and Marginis are approximately contemporaneous [1], basin age does not seem to be a factor in likelihood of extrusion. Smythii is similar in size to the Orientale basin, but displays far fewer eruptive occurrences [10,11], so basin size appears not to be a key variable. Other possible explanations for local variations in total extrusion volume and frequency of eruptive events include basin location both globally and with respect to other basins, as well as degree of basin compensation and differences in thermal history. The amount of cryptomare in each basin is an unknown with potentially important consequences as well.

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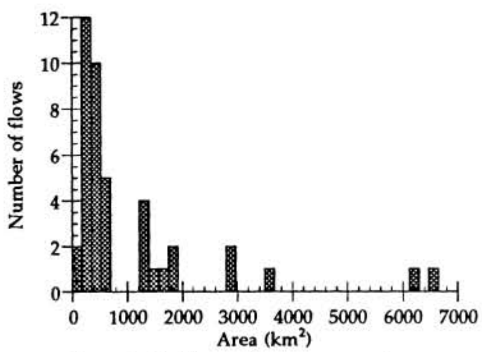

Figure 1. Single eruptive event areas for mare deposits in Smythii and Marginis basins

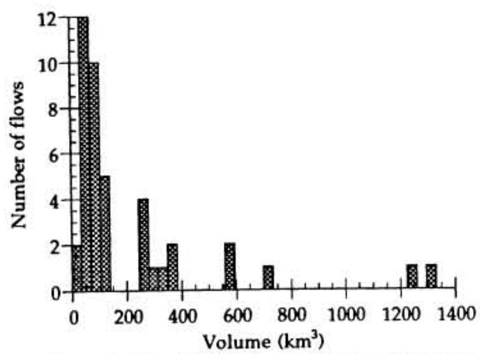

Figure 2. Estimated single eruptive event volumes for mare deposits in Smythii and Marginis basins