OBSERVATIONS OF FLOW LOBES IN THE PHASE I LAVAS, MARE IMBRIUM, THE MOON. W. B. Garry[1], M. S. Robinson[2], and the LROC Team, [1]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, MRC 315, PO Box 37012, Washington DC 20013, garryw@si.edu, [2]School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85281.

Introduction: Lava flow margins on the Moon are scarce [1,2], and the best preserved examples are observed in Mare Imbrium [3,4]. This flow field was erupted in three phases (I-III) from 3.0±0.4 to 2.5±0.3 Ga with flow lengths of 300 km, 600 km, and 1200 km [4] (Fig. 1a). Lava flow margins, 10 to 63 m thick, are observed in the younger Phase II and III lavas, while the older Phase I lavas are primarily defined by a color and albedo boundary with the surrounding mare [4-6] (Fig. 1b). No flow lobes or margins related to the Phase I flows have been identified in previous data sets. Using Lunar Reconnaissance Orbiter Camera (LROC) images we address the following questions: 1) Are flow lobes/margins preserved in the Phase I lava flows in Mare Imbrium? 2) If they are observed, what are the thicknesses of the lobes/margins in the Phase I lavas? 3) What can we infer about the emplacement process based on the observed morphology of the flow lobes (channeled, non-channeled, inflated)? 4) Can emplacement parameters (e.g. underlying slope, eruption temperature) of the Phase I lavas be constrained from lobe thicknesses?

We have identified potential flow lobes within several Narrow Angle Camera (NAC) pairs from LROC [7] that cover the Phase I lavas (e.g. M102314335, M102321461, M102299877). Here, we focus on three well-defined flow lobes in NAC pair M102271324 (1.61 m/pixel, incidence angle: 80.5°) (Fig. 2).

Data: The NAC pair was processed, calibrated, and map projected (orthographic) using ISIS 3. Topographic profiles across the lobes were derived from photoclinometry. Errors in height measurements derived from the profiles can be attributed to the assumed D_N value that represents a flat surface in the image, variations in the topography from impact craters along or at the base of the lobes, non-lambertian behavior, and albedo variations. These are preliminary results using basic photoclinometric methods, therefore, we expect errors in our thickness values, but maintain the shape of the profile is representative of the lobe morphology.

Discussion: *Flow Path.* The Phase I lavas are interpreted to have flowed around the eastern side of crater Le Verreir [4] (Fig. 1a), but Clementine UVVIS and color-ratio maps [8] show a narrow band of older mare material across this inferred flow path [6] (Fig. 1b). The LROC NAC pair crosses this color boundary, which is subtle, but noticeable within the images. The lobes identified in the NAC pair are observed within the lower albedo material of the Phase I lavas and do not occur within the higher albedo stripe of the older mare material, where the flows have been inferred to flowed through. Therefore, we interpret that the Phase I lavas flowed between craters Le Verrier and Helicon and west of Helicon based on this observation. The characteristics and coverage of the Phase I lavas will need to be remapped with new available data sets.

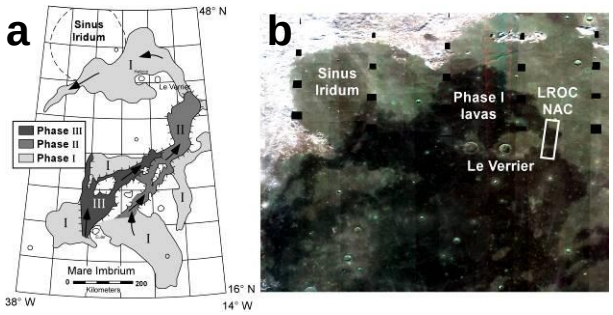

Figure 1. (a) Flow morphology map of the Mare Imbrium lava flows [4]. (b) Clementine NIR map of the Phase I flows from 30° to 50° N. Box shows coverage by LROC NAC pair M102271324.

Lobe Morphology. The identified lobes (Fig. 2) are found towards the interior of the flow, although there are possible lobes adjacent to the inferred flow margin. The perimeter of the lobes can be traced for ~2 to 6 km, but are not as extensive as margins observed in Phase II and III lavas which can be traced for hundreds of kilometers. Orientation of the lobes is consistent with overall flow direction of the Phase I lavas and they do not exhibit any apparent structural control. A tectonic origin for the lobes cannot be ruled out. However, the tongue-like, lobate scarps and elongate platform morphologies resemble previously identified flow margins on the Moon [1, 2]; therefore we infer a volcanic origin.

Lobe Thickness. Topographic profiles derived from photoclinometry indicate these lobes are ~40 to 65 meters thick (Fig. 2). These measurements are consistent with flow thicknesses in the Phase II and III lavas [4] and with other lunar flow margins [2]. The tops of the lobes are relatively flat with changes in height of meters to ~10 meters across the platforms. Smaller, superposed impact craters can cause local variations in topography across the flows; however the topographic high along the east side of lobe 'a' (Fig. 2a) appears to be related to a narrow ridge at the top of the scarp and not a crater rim.

Emplacement. The observed morphologies observed in the Phase I lavas support a non-channeled, compound flow field, with inflated lobes [11]. The identified lobes may represent inflated sections within thinner (<40m), non-inflated surrounding flows, therefore, they are our best constraint on flow thickness for the Phase I lavas, so far. Parameters for the emplacement of the Phase I lavas have been calculated in numerical models and were interpreted to be turbulent flows fed by high effusion rates [4,9,10]. Our initial thickness profiles agree with the calculated flow heights (41.7 to 55.6 m) necessary to obtain a 1200 km long flow on a slope of 0.001° with minimum initial temperatures of 1250 to 1300 °C, whereas if we assume the flows were initially thinner, they agree with calculated values (19.3 to 25.8 m) for a surface slope of 0.01° [see 4, Table 3]. Continued morphologic analysis of flow lobes will provide more insight into the complex history and emplacement parameters of the Phase I lavas in Mare Imbrium.

References: [1] Schaber G.G. et al. (1976) *Proc Lunar Sci Conf 7th*:2783-2800. [2] Gifford A.W. and El Baz F. (1981) *The Moon and the Planets* 24:391-398. [3] Fielder G. and Fielder J. (1968) *Boeing Science Research Laboratory Document* D1-82-0749:1-36. [4] Schaber G.G. (1973) *Proc Lunar Sci Conf 4th*, 73-92. [5] Schaber G.G. et al. (1975) *The Moon* 13:395-423. [6] Bugiolacchi R. and Guest J.E. (2008) *Icarus*, 197, 1-18. [7] Robinson M.S. et al. (2005) LPSC XXXVI, Abs. 1576. [8] Eliason E. et al. (1999) The Clementine UVVIS Global Lunar Mosaic. [9] Hulme G. and Fielder G. (1977) *Phil Trans R Soc Lond A* 285:227-234. [10] Wilson L. and Head. JW. (2008) *LPSC XXXIX*, Abs. 1104. [11] Walker G.P.L. (1991) *Bull. Volcanol.*, 53, 546-558.

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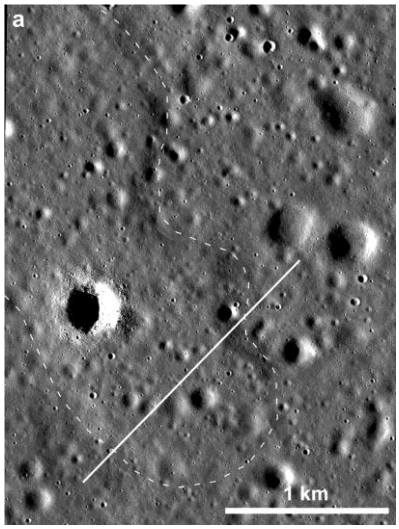

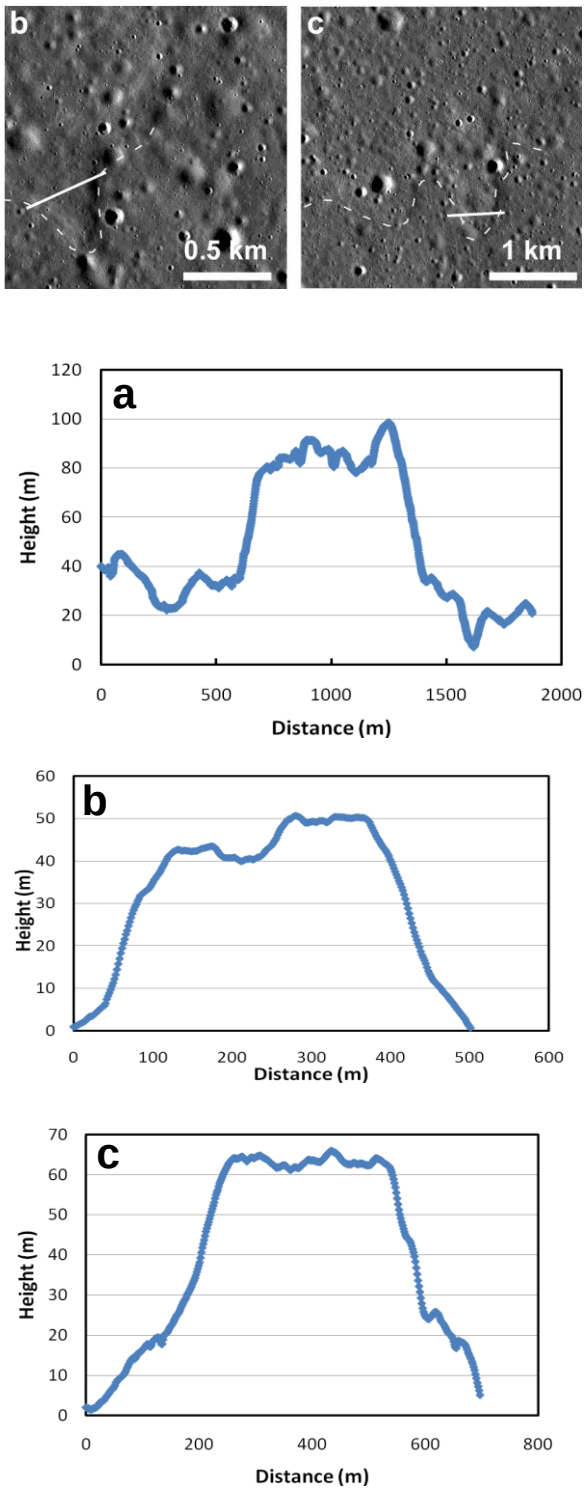

Figure 2: (a-c) Lobes located in the Phase I lavas of Mare Imbrium (LROC NAC M102271324, 1.61 m/pixel) and corresponding topographic profiles. Lobe margins marked by dashed line. Location of profile indicated by solid line. North is up in each image.