GEOLOGIC STUDIES OF VOLCANIC CONSTRUCTS IN EASTERN MARE FRIGORIS

T.A. Giguere1,2, B. Ray Hawke1, L.R. Gaddis3, J.O. Gustafson4, S.J. Lawrence3, J.D. Stopar5, S. Mattson6, M.S. Robinson5, & LROC Science Team.
1Hawaii Institute of Geophysics and Planetology, University of Hawaii, Honolulu, HI 96822, 2Intergraph Corporation, P.O. Box 75330, Kapolei, HI 96707, 3U.S. Geological Survey, Astrogeology Science Center, Flagstaff, AZ 86001, 4Dept. Earth & Atmospheric Sciences, Cornell University, Ithaca, NY 14853, 5School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85281, 6Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721.

Introduction:
A number of interesting geologic features can be seen in the easternmost portion of Mare Frigoris. The features include cryptomaria, light plains deposits, dark mare units, crater rays, volcanic constructs, and a variety of tectonic structures [1,2] (Figure 1). The region of interest is centered at the easternmost edge of Mare Frigoris at 31°28’N, 39°4’W. We have used a variety of spacecraft imagery and remote sensing data to investigate the morphology, composition, and origin of geologic units in the eastern Frigoris region. Particular emphasis was placed on the volcanic constructs and the surrounding dark unit (Figures 1, 2, 4a).

Volcanic Constructs originally mapped as domes by Lucchitta [1] are visible in the center of the eastern Frigoris region (Figure 1). These constructs are mapped as small domes by Lucchitta [1], the features do not seem to fall into any of the dome classes defined by Head & Gifford [9]. The volcanic constructs originally mapped as domes by Lucchitta [1] are visible in the center of the eastern Frigoris region (Figure 1).

Conclusions:
The consistent dome dimensions, heights, and slopes suggest a common origin for all of the volcanic constructs. In total, the morphologic and compositional data suggest that the volcanic constructs may be low, steep-sided cones of spatter as has been postulated at other locations [15]. The mare built up on a plains during the eruptions that emplaced the surrounding dark mare unit.

Data and Methods:
LROC WAC and NAC images were utilized in this investigation [3]. The high resolution (0.3 m/pixel) provided by the NAC images was critical for the study of the smallest volcanic features. Regional topographic data were provided by the LROC GLOD100 [4]. A high resolution (7 m/pixel) DTM was produced [5] using NAC images M101227431LR and M101304877LR. The U.S.G.S. Astrogeology Program published on CD-ROM a Clementine five-color UV-VIS digital image model (DIM) for the Moon [e.g., 6]. This DIM was used to produce an image cube centered on the study area. The calibrated image cube served as the basis for the production of a number of other data products, including optical maturity (OMAT) images and FeO and TiO2 maps [7, 8]. Five-point spectra were extracted from the calibrated and registered Clementine UV-VIS image cube.

Results and Discussion:
Volcanic constructs originally mapped as domes by Lucchitta [1] are visible in the center of the eastern Frigoris region (Figure 1). These constructs are mapped as small domes by Lucchitta [1], the features do not seem to fall into any of the dome classes defined by Head & Gifford [9]. The volcanic constructs originally mapped as domes by Lucchitta [1] are visible in the center of the eastern Frigoris region (Figure 1).

Morphology. The four volcanic constructs, lettered A through D in figure 3a, are oriented linearly in a roughly east-west direction spanning 5 km from end to end. They are irregularly shaped and tend to be elongated in the east-west direction. Each construct is about a kilometer wide as measured in the north-south direction (A: 0.8 km, B: 1.0 km, C: 0.7 km, D: 1.2 km). The volcanic constructs average about 70 m in height above the surrounding plains (A: 64 m, B: 66 m, C: 73 m, D: 67 m) (Figure 5a). Construct slopes are steeper than typical mare domes [9] which suggests an alternative origin (Figure 5b). A also has the steepest average slopes at ~5°, and D the least at ~11°. Each construct has material surrounding the base which has a gentle slope of ~5° which is probably either early flow material from the cone breaches or less likely material eroded off of the steeper parts of the feature. Although, four volcanic constructs are described, the morphology is slightly more complicated. Construct A is separate from the others, but constructs B, C, and D are joined by a low ridge, which is 25–35 m below the top of the constructs. The summit of each feature is smooth and black in color, with occasional small impact craters. The steep sides of the constructs have scattered clusters of light plains deposits, dark mare units, crater rays, volcanic constructs, and a variety of tectonic structures.

Lunar features that have a volcanic origin will often have a vent or summit crater associated with the feature [10, 11]. We investigated the region and two possible breached summit craters were identified (Figure 3b). Although these craters were mapped as small domes by Lucchitta [1], the features do not seem to fall into any of the dome classes defined by Head & Gifford [9]. The dark plains surrounding the volcanic constructs measures 13 by 15 km (Figures 2, 4a). Lucchitta describes this type unit (CEG) as having very low albedo and a smooth velvetlike surface [1]. The low albedo plains transition gradually to a higher albedo to the east and west, is bordered to the south by the ejecta blanket of a 1.8 km fresh crater, and terminates at the edge of the lobate scar at the north. The geometric composition of the plains is the same as the constructs, as mentioned above (Figures 4b, 4c). Other regional features include a 2 km hummock 19 km to the northwest, and a 1.6 km hummock 23 km to the southwest. These hummocks, which are outside of the dark plains, are morphologically different from the subject volcanic constructs. The FeO values for these hummocks, <6 wt. % for the NW hummock and <8 wt. % for the SW hummock, are much lower than the volcanic constructs, thus they are more likely to be just eroded highlands material which are not volcanic. Because of the morphologic (Figures 1-3, 5) and compositional (Figure 6) differences these hummocks are not related to the volcanic constructs.