INVESTIGATING THE VOLCANIC OR/AND FLUVIOGLACIAL ORIGIN OF SURFICIAL DEPOSITS IN EASTERN ELYSIUM PLANITIA, MARS. J. Voigt[1] and C. W. Hamilton[1], [1] Lunar and Planetary Laboratory, University of Arizona, 1629 E. University Blvd., Tucson AZ 85721, USA (voigt@lpl.arizona.edu).

Introduction: In general, there are two main hypotheses for the deposition of the surficial material in Central Elysium Planitia: a volcanic origin [e.g., 1, 2, 3, 4] and a fluvioglacial genesis [e.g., 5]. Elysium Planitia is the youngest major volcanic province on Mars [1], with multiple phases of activity that have produced overlapping lava flow units [6, 7]. However, it is possible that these volcanic units have been subsequently modified by fluvioglacial processes [5].

Our study area is located in Eastern Elysium Planitia, including parts of the Cerberus Fossae, Rahway Valles, and Marte Vallis (Fig. 1). The work examines geologic features and facies relationships to test hypotheses regarding the origin of surficial deposits in this region by volcanic and/or fluvioglacial processes.

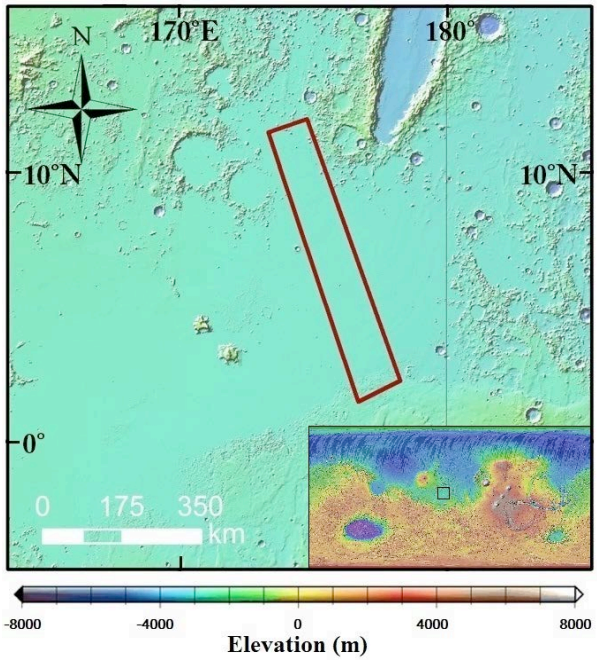

Figure 1: Mars Orbiter Laser Altimeter (MOLA) basemap outlining the location of the study area in red. The square box within the inset shows the general context of the study location within eastern Elysium Planitia.

Previous work: The surficial material in Rahway Valles and Marte Vallis is generally interpreted to be composed of young lava flows [1, 3, 4, 8] that include lobate scarps, sinuous troughs, ridges, and platy terrains [4]. However, Ramsdale et al. (2015) [5] investigated the Rahway Basin, which is located in the northern part of our area of interest, and concluded that the region has been modified by more recent cryolacustrine processes, mostly based on interpretations of morphological and structural features. The work also discussed the possibility of a volcanic origin for the surficial geologic unit, but favors the hypothesis that the Rahway Basin was rapidly filled with water, which subsequently underwent partial freezing and drainage.

Data and Methods: This study utilizes a regional mosaic of 526 images that were obtained by the Mars Reconnaissance Orbiter (MRO) Context (CTX) camera (6 m/pixel) [9], with supporting observations from the High Resolution Imaging Science Experiment (HiRISE) camera (0.3 m/pixel) [10], and topographic constraints from the Mars Global Surveyor (MGS) Mars Orbiter Laser Altimeter (MOLA). The CTX mosaic was generated using the United States Geological Survey (USGS)'s Projection On the Web (POW) tool, which allows us to perform accurate radiometric calibration and projection of the data prior to importing it into Environmental Systems Research Institute (ESRI) ArcGIS 10.3. Furthermore, we used the USGS software Raster Riser 1.0, Crater Helper Tools 1.1, and the software from Freie Universtität Berlin CraterTools, and Craterstats 2.0 to manage the data and estimate the crater retention ages of geological surface units.

Specifically, the data were used to develop 1:200,000-scale maps of the major geological units in the study area (examined at a digitizing scale of 1:50,000) and subdivided, on the basis of morphology, into facies. This facies-based approach enables variations within a single geologic unit to be distinguished and compared to expected patterns and associations within volcanic and fluvioglacial units.

Results: The study area covers 56,000 km^2 and includes three main geologic units: the Noachian age Nepenthes Mensae unit, the Hesperian age Medusae Fossae Formation, and a younger Amazonian age unit that infills Rahway Valles and Marte Vallis. For the Amazonian age unit, we also estimated its crater retention age and determined that the southern part of this unit is ~12 Ma (6–24 Ma), based on the size frequency relationships of 768 craters, and the northern part of the unit has an age of ~23 Ma (11.5–46 Ma) based on 838 craters. These ages are based on the Hartmann (2004) crater production function and have an uncertainty within a factor of approximately ± 2 [11].

To explore the characteristics of the younger Amazonian age unit, we also created a facies map for the inset region shown in Figure 1. This facies map consists of eight different units (Fig. 2), which include: (a) a unit with lobate margins, (b) a smooth surfaced unit with pits, (c) narrow positive relief features, (d) wide

positive relief features, (e) negative relief features, (f) a terraced margin unit, (g) a platy surfaced unit, and (h) elliptical islands.

Interpretation: Our geological mapping results show that Rahway Valles and Marte Vallis are infilled by a material of Late Amazonian age, rather than composed of two units of significantly different ages (i.e., Middle to Late Amazonian), as previous studies have suggested (e.g., [1, 6, 7]). However, to assess if this young geologic unit is composed of one or more flows of comparable age we rely on more detailed facies maps and stratigraphic relationships.

In our facies maps, the lobate margin unit (a) and smooth surfaced unit with pits (b) are interpreted as the exterior and interior, respectively, of an inflated pāhoehoe-like lava flow that includes lava-rise pits [12]. The narrow positive relief features (c), wide positive relief features (d), and (e) negative relief features, are interpreted to represent stages the development of fractures though a lava crust that exposed upwellings of viscous lava that are analogues to the plates and spreading zones observed within the 1959 Kilauea Iki lava lake [13]. The terraced margins (f) include tilted slabs of material and "bathtub rings" that are attached to high standing obstacles, which we interpret as lava crust that has been stranded during a major drainage event. The platy surface unit (g) is interpreted to be a disrupted lava flow, analogous to the December 1974 flow on Kilauea Volcano, where disrupted crust separates to expose smooth lava surfaces within the fractures. The elliptical islands (h) are interpreted to have formed were disrupted lava encountered highstanding knolls associated with the Nepenthese Mensae unit, many of which are now buried by the lava.

Discussion and Conclusion: In contrast to previous studies, which concluded that Rahway Vallis and Marte Valles includes two geologic units with Middle and Late Amazonian ages [1, 6, 7], our results show that the region has been resurfaced by a unit of much younger (~12–23 Ma) age. This unit is interpreted to be flood lava that infilled Rahway Vallis before partially draining and disrupting into plates with smooth upwelling zones exposed in between. However, it is possible that the unit includes two or more flows. These flows may represent different stages of a single eruption, or be the products of distinct eruptions separated in time by millions of years. Nevertheless, it is clear that Rahway Valles does not include outcrops of the older Cerberus Fossae 2 unit and therefore the surficial material should be reassigned to the Ceberus Fossae 3 unit. Our observations favor a volcanic origin for young material within the study area and we have not found evidence in support a fluvioglacial activity. However, future work will expand our investigation to more rigorously test these hypotheses.

References: [1] Vaucher, J. et al. (2009), *Icarus 204*. [2] Jaeger, W. L. et al. (2010), *Icarus 205*. [3] Keszthelyi, L. et al. (2004), *Geochem. Geophys. Geosyst. 5*. [4] Tanaka, K. et al. (2014), *pamphlet 43 p*. [5] Ramsdale, J. D. et al. (2015), *Icarus 253*. [6] Morgan, G. A. (2013), *Science 340*. [7] Morgan, G. A. (2015), *Geophys. Res. Letter 42*. [8] Fuller, E. R. et al. (2002), *J. Geophys. Res. Vol. 107*. [9] Malin, M. C. et al. (2007), *J. Geophys. Res. Planets 112*. [10] McEwen, A. S. et al. (2007), *J. Geophys. Res. Planets 112*. [11] Hartmann, W. K. (2005), *Icarus. Vol. 174*. [12] Walker, G. P. L., (1991), *Bull. Volcanol., 53*. [13] Stovall, W. K. (2009), *Bull. Volcanol., 318*.

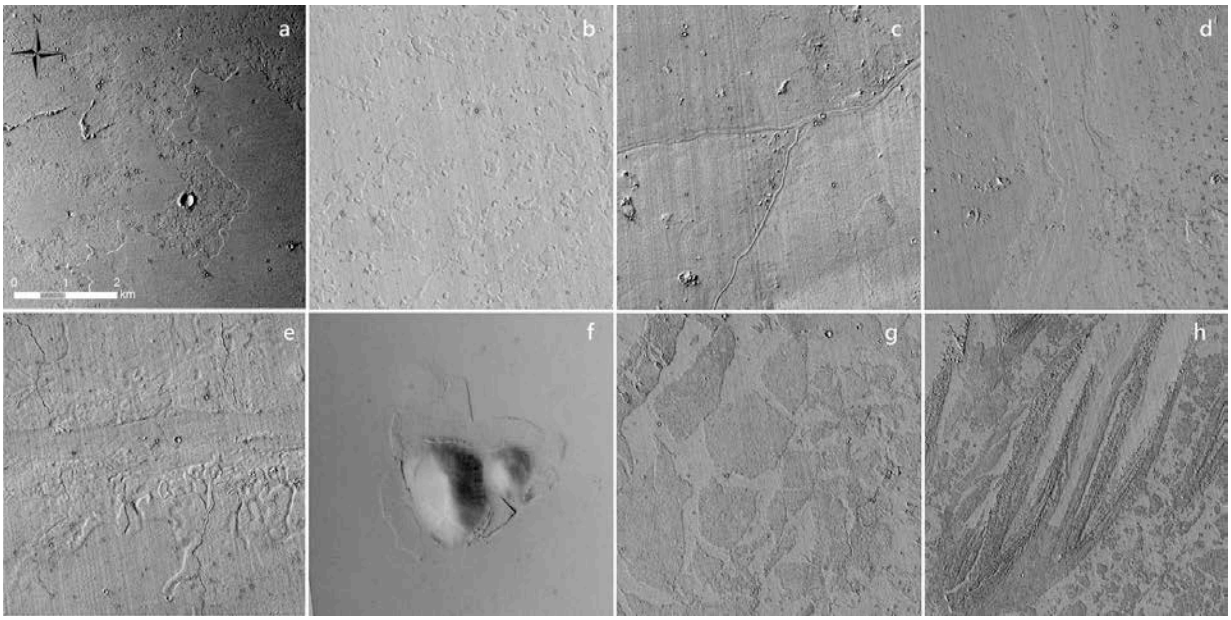

Figure 2: Examples for the eight facies within the Amazonian age geologic unit. All of the CTX images are presented at the same scale of 1:50,000: (a) lobate margins, (b) smooth surfaced unit with pits, (c) narrow positive relief features, (d) wide positive relief features, (e) negative relief features, (f) terraced margins, (g) platy reassigned surfaces, and (h) elliptical islands.