EARLY HiRISE IMAGING OF VOLCANIC TERRAINS. L. Keszthelyi[1], W. L. Jaeger[1], A. McEwen[2], C. Dundas[2] and the HiRISE Team. [1]U.S. Geological Survey, Astrogeology Team, 2255 N. Gemini Dr., Flagstaff, AZ 86001 [2]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721.

Introduction: Mars is a volcanic world with most of the surface consisting of primary or only moderately modified igneous rocks. The High Resolution Imaging Science Experiment (HiRISE) camera onboard the Mars Reconnaissance Orbiter (MRO) spacecraft is providing unprecedented new views of Mars, including many diverse volcanic terrains.

Early Observation Strategy: For the first three months, the objective has been to collect images from a wide range of volcanic terrains of different ages. This was particularly important for determining what imaging mode (e.g., level of image binning) is most appropriate for specific types of investigations. To conduct this sampling in an orderly manner, 40 targets in the HiRISE catalog of suggested images were given the highest priorities. As of this writing, 28 images with “Volcanic Processes” as the primary science theme have been acquired, including 14 of the highest priority images. Therefore, the sampling of volcanic terrains is not complete, but we do have a substantial early data set. We have subdivided the volcanic terrains into the following subcategories: Shield Volcanoes, Flood Lavas, Vent Processes, Pyroclastic Deposits, and Hydrovolcanic Structures.

Shield Volcanoes: As already indicated by MOC images, the main shield volcanoes are largely mantled by a thick deposit of unconsolidated, fine-grained material (which we colloquially referred to as “dust”) [1]. HiRISE shows that this dust is locally several tens of meters thick and evenly drapes the underlying topography (Fig 1). This is consistent with airfall (either from dust storms or volcanic eruptions) rather than recent pyroclastic flows. Ripples and other eolian features can be found down to the limit of HiRISE resolution, suggesting that the wind continues to modify the dust. The dust also largely obscures any underlying meter scale features, except the occasional boulder. In fact, most of the primary volcanic features that can be seen in the HiRISE images are also well-resolved in the ~6 m/pixel CTX or even 18 m/pixel THEMIS Vis images. The HiRISE images do support earlier interpretations of a wide variety of lava flow features on the shield volcanoes, including leveed lava channels, collapsed lava tubes, and small satellite shields.

In order to examine the lava flows at the sub-meter scale that HiRISE can provide, it is necessary to find outcrops that are not covered with dust. Therefore, we are concentrating on topographic scarps, such as the walls of calderas, collapse pits, and impact craters. To date, we have not yet found the kinds of exposures that would reveal new details of the tops and bottoms of lava flows. The thicknesses and lateral extents of the moderately to poorly exposed lava layers we have observed are, unsurprisingly, consistent with the sizes of lava flows seen on the surface of the shield volcanoes. We hope future images of cuts into these volcanoes will reveal if the nature of the eruptive activity at the shields varied substantially during their construction.

Flood Lavas: Because they are so areally extensive, a large number of images have been acquired of flood lavas. These lavas are dominated by platy-ridged surfaces indicative of a mobile crust rafted on a broad sheet flow. In general, features on the flood lavas (e.g., plates, pressure ridges, polygonal intraplate terrain, lobate margins, wakes, shear zones) are large enough to be well resolved in MOC images [1-3]. The rough texture of the flows often traps eolian materials, hiding features at the sub-meter scale.

One surprise was provided by PSP_001420_2045, which shows a partially-roofed lava channel within a flood-lava flow (Fig. 2). Flood lavas are usually assumed to have broad insulated sheets as the internal lava conduits [4]. However, in this case, the flow was confined by pre-existing topography. Within the narrowest part of the flow, the lava formed a channel that at least partially roofed over. This is the first documented lava tube within a Martian flood-lava flow.

The most pristine flood lavas, which flowed through Athabasca Valles, into Cerberus Palus and across much of Elysium Planitia, are discussed in more detail by [5]. We note that the highly fluid nature of those lavas is consistent with the composition of the lavas in the nearby Gusev Crater [6]. Further research is needed to reconcile these observations suggesting an extremely low-viscosity lava with the more viscous rheology preferred by earlier lava flow modeling [3].

Vent Processes: HiRISE has imaged several locations inferred to be lava vents. These include three small shields with fissures on or near the Tharsis Rise and two images of the Cerberus Fossae. Some parts of Cerberus Fossae do appear to have fed large fluid lava flows [5], but other sections are devoid of volcanic emanations. Whereas a dike that did not reach the surface could cause the extension in those areas, it also allows the possibility that the fissures are primarily tectonic in origin with local exploitation by opportunistic magma.

The vents on/around Tharsis have extensive dust coverage, but they do not show evidence of substantial vent constructs (e.g., cinder cones or spatter ramparts) (PSP_001695_2080 is the best current example). This, and the very fluid appearance of the channels that lead away from the vents, suggests that there was little local accumulation of pyroclastics. There are two scenarios that fit this observation: (a) the eruptions were almost entirely effusive or (b) the pyroclastic materials were too easily dispersed to accumulate in the near vent region. We tentatively favor the latter explanation.

Pyroclastic Deposits: To date, we have not found any unequivocal primary pyroclastic deposits. The difficulty lies in morphologically distinguishing between "dust" carried by the wind and a volcanic airfall deposit. Detailed study of the lateral variations in the thickness of the mantling deposit may provide important constraints in the future. Investigation of the Medusae Fossae Formation, which has been hypothesized to be an extensive pyroclastic deposit, is discussed in [7,8].

Hydrovolcanic Structures: Evidence for interaction between hot lava or magma and water on Mars is of special interest. Larger cones in Acidalia Planitia and along the Hephaestus Fossae are described by [9]. At this point in time, mud and silicate volcanism appear to be plausible formation mechanisms for these features. Cones and mounds in Athabasca Valles have been central to the debate about recent ice/permafrost activity near the equator. New HiRISE images show that these are hydrovolcanic cones built atop a voluminous, low-visocosity lava sheet flow than thinly drapes the underlying flood-carved topography [5,10].

Conclusions: We have found it challenging to locate outcrops where we can take full advantage of the capabilities of HiRISE (both spatial resolution and color). As such, sampling of different terrains will continue to be an important part of the HiRISE observation strategy. However, the initial results lead us to focus on inherently younger volcanic terrains and places where recent scarps have been cut into the volcanic stratigraphy. High-resolution topographic data from key areas has also proven to be invaluable.

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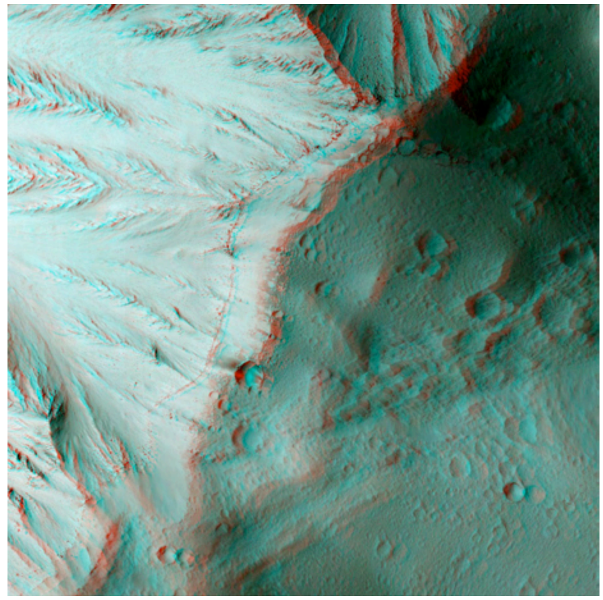

Figure 1. Anaglyph of the rim of the Olympus Mons basal scarp, combining PSP_001432_2015 and PSP_001630_2015. Note that the dust layer has a relatively uniform thickness over the rugged topography. Anaglyph covers 2x2 km, north is to the top.

Figure 2. Portion of PSP_001420_2045 in the Tartarus Colles. Note the roofed portion of the channel, which indicates that at least parts of the lava conduit was a lava tube. Figure covers 462 x 578 meters, north is up.