ARE THE VALLES MARINERIS GIANT VOLCANO-TECTONIC DEPRESSIONS? B. K. Lucchitta and M. G. Chapman, U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001. blucchitta@usgs.gov.

Introduction: The origin of the layered deposits in the Valles Marineris has been controversial ever since they were discovered. Because of their perceived horizontality and great lateral extent the hypothesis of lacustrine origin has prevailed [1,2]. Recent comparison with similarly layered, presumably lacustrine deposits inside craters [3] apparently supported this idea. However, the notion that the deposits are of volcanic origin [4,5] has never been disproved. Recent investigations of the troughs with MOC images strengthened the hypothesis of a volcanic origin, as shown by Chapman and Tanaka [6]. This study, based on the investigation of hundreds of MOC images, supports that the interior layered deposits are volcanic. Thus, the interior mesas may be edifices over eruptive centers, and the troughs may be giant volcano-tectonic collapse structures.

Observations: Evidence comes mainly from the detection of flow lobes on the plateau and within the troughs, the recognition that the beds are not flat lying but dipping outward on many of the interior mesas, and the existence of numerous possible vents.

*Flow lobe on plateau***.** The plateaus surrounding the Valles Marineris troughs are locally covered with light, friable layers interpreted to be diagenetic material by Treiman [7]. However, one image on the south side of Coprates Chasma clearly shows that the material in this area is volcanic (Fig. 1). The picture shows a flow emerging from a small vent located at the convergence of two faults. The flow is light colored, but has a medium dark, soft-looking, undulating surface and shows few craters. Where the flow is truncated by the trough wall, it exposes the light layers. The plateau material, on which the flow rests, is heavily cratered and rugged. The flow apparently consists of material that is composed of weaker, less resistant material than the lava plateau. The dark surface color may come from a weathering rind or from atmospheric fallout. It is not clear whether the flow spilled over the edge or was truncated by faulting or erosional retreat on the walls. The flow is about 8 km long from the vent to the farthest visible edge, and at least 3 km wide. A MOLA traverse shows that it is about 50 m thick at the front. Inside Capri/Eos Chasmata, the presence of a similar-looking dark-covered, light-colored layer supports the idea that such layers are part of the interior deposits. This layer appears to be relatively young, judging by its stratigraphic position on the trough floor (not within a mesa sequence). The recognition of the flow lobe on the plateau and a similar layer inside the troughs strongly suggests that at least some of the interior layered deposits are of volcanic origin.

Flow lobes inside troughs. Flow lobes also occur inside the troughs. On the floor of Ius Chasma, near the Melas Chasma reentrant, a large lobe and some smaller ones consist of platy material [8]. In west Candor Chasma, similar platy flows emerge from the top of Ceti Mensa and flow toward the adjacent lowlands, dropping several kilometers. These flows are either a late phase of activity in the stack that forms the mesas, or they are a later eruptive or remobilization phase [8]. Both in Ius Chasma and in west Candor Chasma, the flows embay or overlap landslides off the trough walls, attesting to a relatively young age.

In Hebes Chasma, Viking images showed several spurs of light material jutting out from the apparently flat-lying beds of the central mesa. One MOC image shows the nature of one of these spurs: it is composed of light material that originates at a layer near the top of the mesa and forms several thick ropy lobes. No scar or reentrant is left where the flow emerges, making it unlikely that the material is a mass wasting lobe. The characteristics support a volcanic origin, making it plausible that the other beds in the mesa are also volcanic.

Dipping mesa layers. The interior mesas were thought to be underlain by massive and by thinly bedded materials [9,2]. MOC images now show that most of the so-called massive materials are really composed of fine, evenly bedded layers of the same color. These layers dip in the direction of the slope, so that they are not readily identified. Characteristic are triangular facets, due to wind erosion, that either point uphill or downhill. Where they point uphill, the layers dip more steeply than the hill slope, where they point downhill, the layers dip more gently. Once this observation is realized, it becomes apparent that many of the mesas of layered deposits are in fact edifices with flat-lying tops and sloping sides, underlain by layers dipping outward in several directions [6]. This configuration is difficult to reconcile with a lacustrine origin of the beds, nor a structural origin of the dips. However it is readily explained if the edifices are extrusive complexes: the sloping sides may be volcanic deltas in sub-ice/water volcanoes, as proposed by Chapman and Tanaka [6], or they may be subaerial deposits on the flanks of volcanic stacks.

Late mafic deposits. Windblown mafic [11] deposits on the trough floors are common throughout the troughs. As shown by Lucchitta [12], the dark materials are associated with possible vents, suggesting that the material may be due to local volcanic activity. If volcanism was abundant late in the history of the Valles Marineris, it becomes plausible that it also occurred in earlier times, when the layered deposits were emplaced.

Composition: The layered deposits are generally light in color. Their characteristics suggest that they may be mostly volcanic ash. They are locally topped by a dark, mafic [11] cap. The light color may be from palagonites [13] that formed when the magma interacted explosively with ground ice or water/ice in lakes. The dark cap could have formed in the subaerial phase of tuyas [6]. The latest stage of volcanic activity resulted in dark, mafic material, after the ground became desiccated or the lakes evaporated or spilled. Of course, it is also possible that early felsic volcanic activity was followed by more mafic eruptions after the depletion of a stratified magma chamber.

History: The following scenario is compatible with the observations. Rising magma at the site of the current Valles Marineris caused eruption of pyroclastic material due to interaction with ground ice. The increased heatflow also melted this ice, and both the withdrawal of magma and ice caused major collapse forming ancestral enclosed troughs harboring lakes. Volcanic edifices formed inside the troughs from the erupted magma, probably as tuyas [6] within the lakes. The first stage of collapse was followed by later tectonic subsidence related to the Tharsis stress field. This graben-forming event caused straight fault scarps, most notable in the Ius/Coprates system [14]. The later grabens cut the earlier troughs, spilling water that had not yet evaporated. By that time, volcanism had waned and ground ice was mostly depleted. This supposition is supported by the observation that only few low mesas of light layered deposits are found in the Ius/Coprates system, and that the late, dark mafic volcanism produced only thin deposits.

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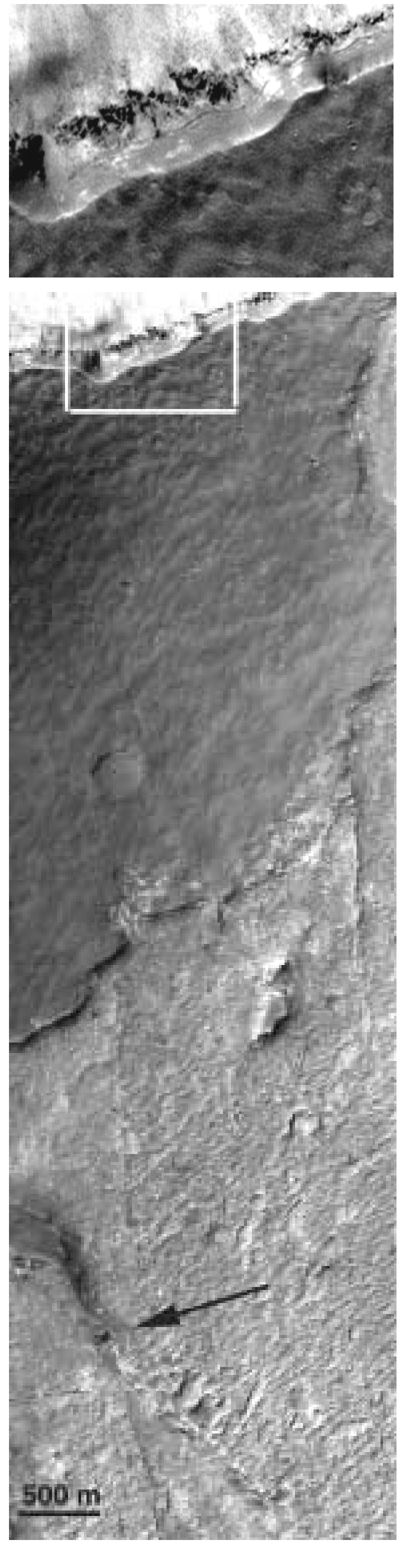

Fig. 1. Dark, undulating material is light flow with dark surface, on top of plateau next to SE Coprates Chasma. White box delineates enlarged picture (above main image). Flow emerges from vent hole located at convergence of two fault scarps (arrow near bottom). Flow leaves picture on left, but reenters it about 1 km farther north. Near top of image, flow is cut by Coprates wall. Enlarged image shows cut exposing wall rock toward top of picture, diagonal dark, rugged cliff line composed of plateau lava, and overlying light layers with dark surface cover toward bottom of picture. Image shows that light layers on top of plateau are volcanic. MOC image 1801178.