NEW EVIDENCE THAT THE VALLES MARINERIS INTERIOR LAYERED DEPOSITS FORMED IN STANDING BODIES OF WATER. C. M. Weitz[1] and T. J. Parker[2], [1]NASA Headquarters, Code SR, 300 E Street, SW, Washington, DC, 20546 (cweitz@hq.nasa.gov), [2]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109 (timothy.j.parker@jpl.nasa.gov).

Introduction: The interior layered deposits (ILDs) of Valles Marineris have previously been proposed as sedimentary deposits formed in lakes [1,2, 3]. Proposed origins include: mass wasted material from the walls [2, 4]; carbonate deposits [5,6]; aeolian deposits [2,7]; and volcanic deposits [4,7,8,9]. The ILDs appear to span several ages from Hesperian to Amazonian although most of the deposition is thought to be concurrent with formation of the troughs [8]. Later episodes of tectonism and erosion caused the ILDs to remain as mesas inside the troughs, though in some locations, such as Ophir, the ILDs abut and are superimposed on the remnant wall rock. *Lucchitta* [8] has also reported three younger units of light-colored ILDs that may be Amazonian in age. The deposits in each chasmata have distinct morphologies suggesting different depositional histories [3]. There is still no consensus about the formation of the ILDs because none of these ideas can explain all the features seen in the deposits, such as their varying thicknesses, diverse albedos, erosional patterns, separation from the canyon wall rock, and spectral signatures. For this research, we have used Viking, MOC, and MOLA data to investigate the geology of the ILDs in Hebes, Candor, Ophir, and Melas. The MOC and MOLA data used in this study are from the aerobraking and SPO periods.

General Observations about the ILDs: The ILDs tend to be concentrated in the southern parts of each of the canyons where the topography is much higher than to the north. For example, MOLA track 10379 (Figure 1), which transects the central portion of eastern Candor Chasma, indicates that the northern floor is at an elevation of –5 km compared to 0.5 km for the southern floor. The concentration of the ILDs in the southern portions of the canyons where the topography is higher suggests that either the canyons have enlarged primarily to the north after the ILDs formed or that the ILDs were preferentially deposited in the southern portions of the canyons.

Another interesting observation is that each canyon floor has pockets of topographic lows. Although both the floors of central Candor and Melas are at an elevation of –4.0 km, there is a 1.5 km topographic sill between them. This sill would have prevented all water within northern Valles Marineris from draining into Melas and eventually to the east along Coprates. As reported by [9], the bottom of Candor Chasmata is approximately 1 km below that of the eastern outflow channels, similarly indicating that not all of the water could have flowed out into the northern plains.

In a few cases, the MOLA profiles are very close to MOC images. MOC image 8204 is located slightly to the west of MOLA profile 10917 (Figure 2). Both data sets cover the northeastern portion of the Ophir ILDs. The channels in the MOC image along the northern edge of the ILD (Figure 2) are seen in the MOLA profile as well (Figure 3), with the deepest channel about 170 m deep.

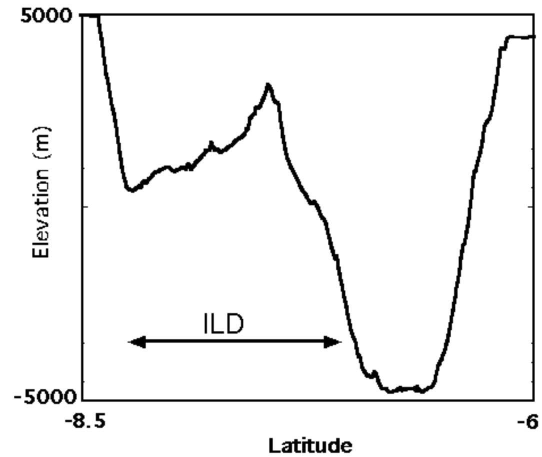

Figure 1. MOLA track 10379 across eastern Candor Chasma. Notice how much lower in elevation the northern floor is compared to the south and the concentration of the ILDs in the south.

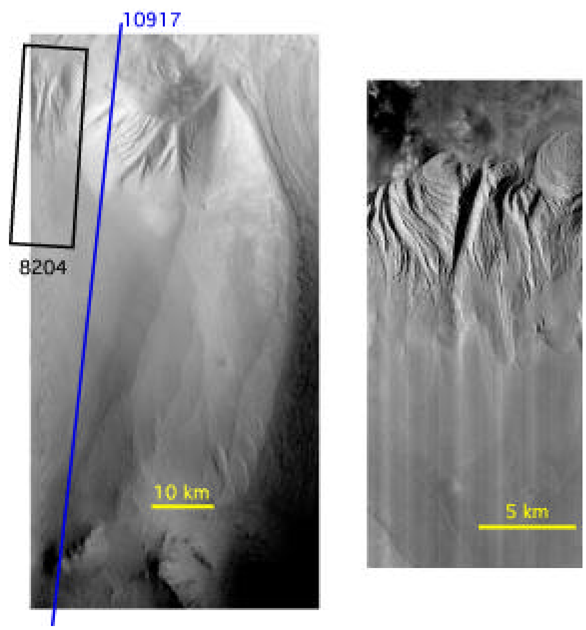

Figure 2. Left image is Viking 913a12 of northeastern Ophir ILD showing the location of MOC image 8204 and the approximate location of MOLA profile 10917. Right image is MOC 8204. Notice the channels in the north edge of the Ophir ILDs.

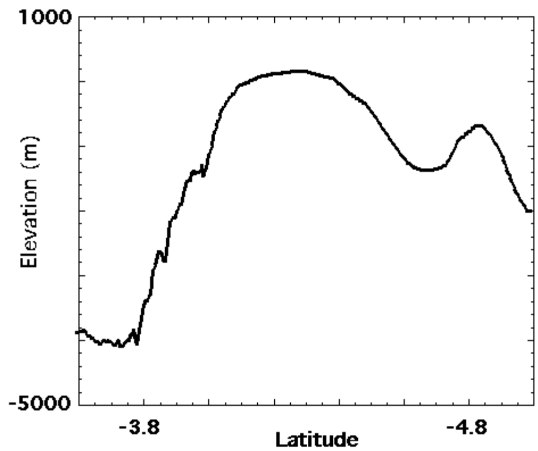

Figure 3. MOLA track 10917 across Ophir ILD (see Figure 2 for approximate location of this profile)

Evidence for water in Valles Marineris: Several investigators have proposed that the ILDs could have formed in standing bodies of water. *McCauley* [1] proposed that the layering and lateral continuity of the deposits could best be explained by deposition within lakes. The large outflow channels emanating from the troughs also supports the suggestion that water must have once existed in the canyons. *Nedell et al*. [2] investigated how aeolian debris could accumulate on ice-covered lakes in the troughs and then by Rayleigh-Taylor instability falter through the ice to form the ILDs. Precipitation of atmospheric CO_2 as carbonates has also been proposed as a possible origin for the ILDs [11]. However, spectral data from Viking images and TES spectra reveal no carbonate signatures for the deposits.

Komatsu et al. [3] proposed that the source of water for the lakes could be the chaotic terrain identified in several of the canyons. A problem with this interpretation is that some of the ILDs are superimposed on top of the chaotic terrain, which would require a younger post-lake formation of these deposits. Alternatively, the source of the water for the lakes may have been the high-standing water table in the southern highlands [12]. Additionally, the volcanism and uplift associated with Tharsis may have caused subsurface flow of water from Tharsis to Valles Marineris where it ponded in the canyons.

We believe that the channels seen along the flanks of many of the ILDs (eg. Figure 2) formed by water rather than wind. The channels can either form by strong slope winds or by water flowing downhill. We support a water origin for the channels because of their curvature downslope. Other fluting features on the top of the ILDs in the same MOC images have a well-organized and finer scale direction, some of which transect across eroded impact craters and fractures, suggesting yardangs formed by wind.

Lack of large boulders along the floor of the Valles Marineris system relative to other canyon systems might indicate that the wall material is disintegrating. Just to the south of the ILDs in Ophir, one can see in MOC image 4206 chaotic-like terrain where the floor is cracked and has collapsed. Both these observations support water in the canyons.

Source of the Interior Layered Deposits: Most of the ILDs have visible layering but only certain deposits show distinct light-dark banding. The most prominent banding is seen in western Candor Chasma. MOC image 23304 exhibits several kms of alternating light-dark banding at the meter-scale. MOLA profiles in western Candor across Candor Mensa show no topographic features associated with the light-dark banding seen at the scale of the Viking images, supporting that the layers represent albedo differences.

Based upon individual MOLA profiles, we can estimate the approximate thickness of the ILDs and how far they are below the canyon wall. Hebes ILD is 6.1 km thick, about 0.5 km below the top of the canyon wall. Ophir ILD has a maximum thickness of 5.8 km and reaches 0.9 km below the northern wall. East Candor is 1.7 km below the southern wall and is 8.0 km thick at its maximum. Candor Mensa in western Candor Chasma is 5.4 km thick and 1.2 km below the northern wall while further to the west the ILD has a maximum thickness of 5.7 km. Finally, the Melas ILD has several peaks that are approximately 3.5 km thick and reach 3.5 km below the top of the southern canyon wall.

A constant influx of water into the canyons is required to offset evaporation and sublimation off the top of the lake (even if lake is ice-covered). To build the deposits almost as high as the canyon wall, new water is needed to carry in sediments and evaporites [e.g., 12]. High-resolution spectral data is required to precisely determine the composition of the ILDs.

Where did the water go?: The majority of the water in Valles Marineris would have flowed out through eastern Coprates and then into Chryse Planitia. However, MOLA data show that some water must have remained ponded in portions of the canyons. In the case of Hebes, the canyon is completely enclosed; hence, all water must have sublimated and/or drained below.

Conclusions: Our results indicate that the best explanation for the origin and current morphology of the ILDs is by deposition of sediments, including chemical precipitates, in standing bodies of water. We find no evidence for volcanic features associated with the ILDs, such as vents or lava flows, which would support that the ILDs formed from either effusive or explosive volcanic activity.

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