Forum

Stratigraphic architectures spotted in southern Melas Chasma, Valles Marineris, Mars: COMMENT

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Dromart et al. (2007) describe a spectacular stratigraphic complex within southern Melas Chasma, Vallis Marineris, Mars. Following a rigorous stratigraphic description of the complex, they proceed to interpret the responsible depositional processes as analogous to subaqueous channel-levee processes on Earth. The observed stratigraphy, however, can be explained as large-scale cross-bedding typical of eolian bed forms.

Large-scale cross-bedding in the Jurassic Navajo Sandstone of the Colorado Plateau region, United States (Rubin, 1987), has also been the subject of debate regarding its subaerial versus subaqueous origin (Picard, 1977, and subsequent discussions). Traditionally interpreted as eolian, a subaqueous tidal bedform interpretation for cross-bedding in the Navajo Sandstone was suggested (Freeman and Visher, 1975) based partly on the discovery via seismic sounding of large-scale tidal bedforms in estuaries and in the North Sea (Houbolt, 1968). However, these large subaqueous bedforms did not have angle-of-repose cross-bedding, although in vertically exaggerated images, it appeared they did. In addition, Freeman and Visher (1975) invoked deformed bedding in the Navajo Sandstone as indicative of a subaqueous environment. However, an eolian interpretation for the Navajo and similar formations is now very well accepted (Kocurek, 1991; Rubin, 1987).

Dromart et al. (2007, p. 364) propose a "channel-levee system" (CLS) as the most likely explanation for the stratigraphic complex seen in Melas Chasma. They correctly point out that their CLS interpretation is challenged by the observed Martian "levee" slope of 25°–30°, versus a maximum of 9° observed in the subaqueous Rhône delta in Lake Leman. Furthermore, the slope of the buried Oligocene CLS they present, revealed from seismic stratigraphy, has a levee slope of 2°, an order of magnitude less than observed on Mars. Coarseness of the Mars Orbiter Laser Altimeter data at the scale of the complex makes it difficult to measure slopes of the bedding accurately, but 25°–30° is certainly more consistent with the angle of repose of sand for Mars (~34°) (Matijevic et al., 1997), than with a subaqueous CLS.

Dromart et al. dismiss the eolian hypothesis based on scale, but whereas the height of subaqueous bedforms is depth-limited, eolian bedforms are only limited by sediment supply. Indeed, the largest-scale dunes and associated cross-bedding on Earth are eolian in origin. Very large cross-sets can attend Gilbert deltas, which have flat subaerial tops and subaqueous avalanche foresets, but the geometry of the Martian case does not fit this model. As such, we feel it is premature to dismiss the subaerial hypothesis in favor of the subaqueous one based solely on a scale argument.

Indeed, the morphology of the levee and channel bed can be obtained from bedform migration alone. We modeled bed morphology and internal structure (Rubin, 1987; Rubin and Carter, 2005) of a deposit caused by spurs oscillating back and forth but with a net migration direction, normal to a migrating bedform, and produced a similar morphology (Fig. 1). While we do not claim this result as being the correct one, we feel it is sufficiently compelling to stress the importance of not dismissing the eolian bedform hypothesis prematurely.

Another important point to address is the relationship of the stratigraphic complex with the history of Valles Marineris. Dromart et al. suggest that the subaqueous environment occured following the formation of Valles Marineris under a "thick ice sheet" (Dromart et al., 2007, p. 365), thus allowing significant water discharge to form the complex fairly recently in Martian history. We find little evidence to support the ice-sheet claim.

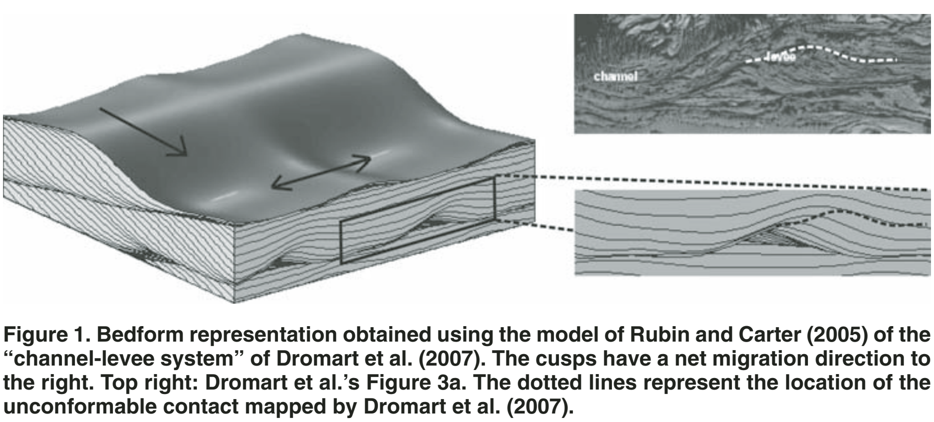

Figure 1. Bedform representation obtained using the model of Rubin and Carter (2005) of the "channel-levee system" of Dromart et al. (2007). The cusps have a net migration direction to the right. Top right: Dromart et al.'s Figure 3a. The dotted lines represent the location of the unconformable contact mapped by Dromart et al. (2007).

In contrast, a more likely hypothesis is that the complex was deposited prior to the opening of Valles Marineris, and was exposed during formation of the canyon. Indeed, other layered outcrops in and around Valles Marineris have been studied by different workers and found to have been exhumed, rather than deposited (Catling et al., 2006; Malin and Edgett, 2000; Montgomery and Gillespie, 2005). In this interpretation, the stratigraphic complex is evidence that the early periods of sedimentation (whether aqueous or eolian) on Mars are now buried under several kilometers of volcanic rock at the Tharsis locale (Clifford and Parker, 2001), except where exhumed by the formation of Valles Marineris.

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