Morpho-Stratigraphy of Sakarya Vallis, Gale Crater, Mars: A Virtual Outcrop Study

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Sakarya Vallis is a 26-km-long, up to 3.5-km-wide, and up to 450-m-deep feature that cross-cuts the northwest of Mount Sharp in Gale crater, Mars. The center of the canyon is ~30 km from and 700 m higher in elevation than the approximate location of the Mars Science Laboratory (MSL) and exposes the upper Lower mound formation of the Mount Sharp group. Analysis of this immense outcrop can provide insight into the extents and geometries of these rock layers, contribute to understanding of the stratigraphy of Gale crater, and help to inform depositional models of these strata and the formation of Mount Sharp.

We present morpho-stratigraphic interpretations from a 3D HiRISE scene visualized and analyzed as a 400-m-thick, 15-km-long digital outcrop in the 3D visualization environment PRo3D. Seven primary units (packages 1–7) were identified from the exposed stratigraphy based on their visible morphologies, such as bedding styles, key features, sub-packages, and bounding surfaces. Stratigraphic logs and cross-sections were constructed at eleven sites throughout the canyon, derived from topographic profiles and measured layer thicknesses and dips and dip directions (e.g., Fig. 1). Finally, these interpretations were extrapolated over a basemap of the northwest Mt. Sharp, and compared with units identified in other works alongside insight from CRISM.

Four packages exhibit morphologies and bedding geometries that may indicate aqueous deposition or otherwise problematize a layer-cake model for the Lower mound formation: a progradational sequence; cyclic bedding; an unconformity; and a lens feature. The package bounding surfaces overwhelmingly dip to the west and northwest, consistent with other works, while internal layers vary. Initial CRISM analysis reveals monohydrated and polyhydrated sulfates, along with low-Ca pyroxene dust, exposed in Sakarya Vallis, while Package 3 is likely a mix of sulphates and other hydrated mineralogy.

We also present a commentary on both automated and manual image processing techniques and how they affect digital outcrop measurements, with relevance to future 3D studies in this field. It is observed that at changes in slope, slight shifts between the overlying imagery and the terrain data can generate uncertainty in layer boundaries, and this will affect dip/dip-direction measurements.

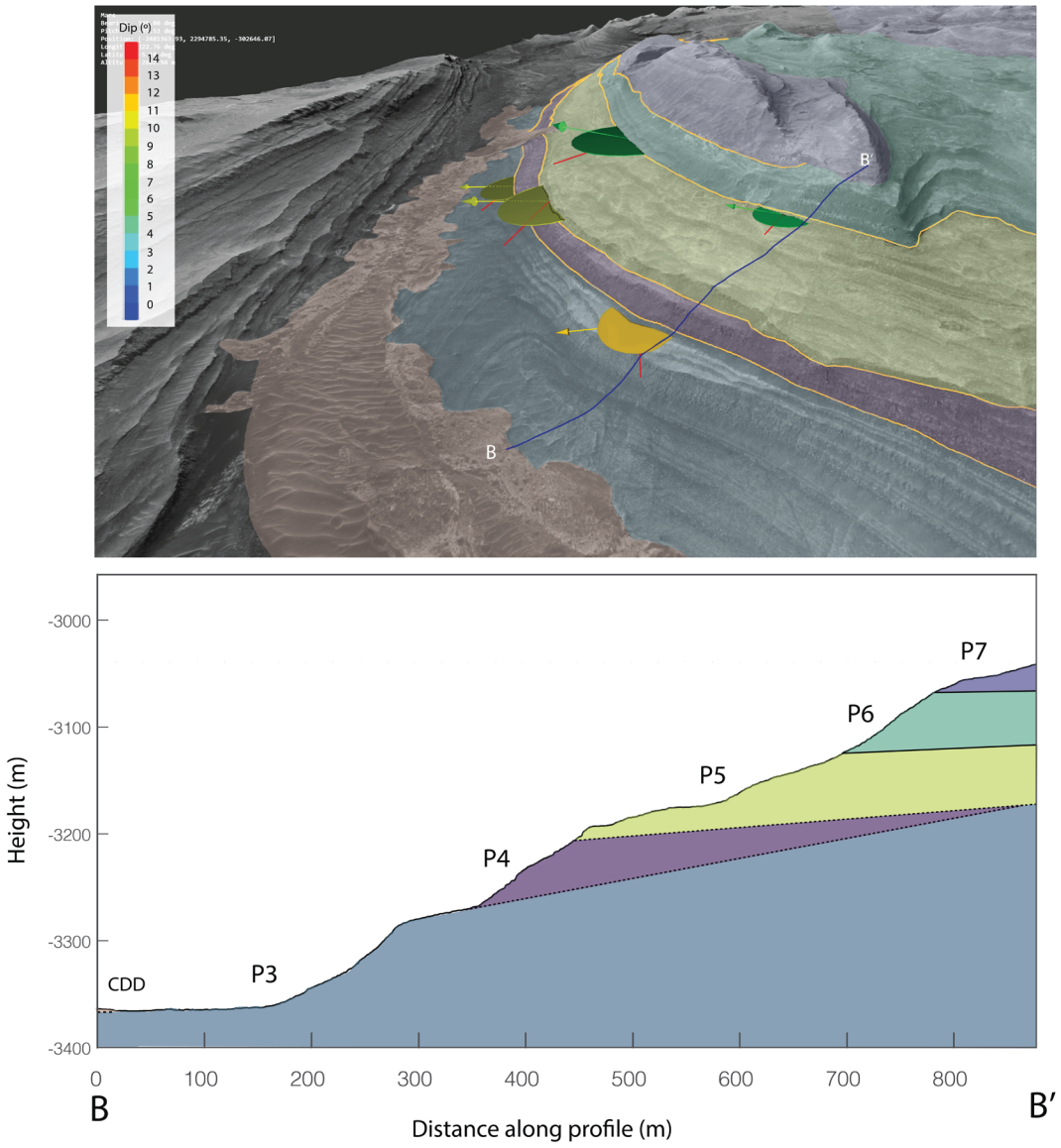

Figure 1. (a) Profile B – B′ in PRo3D, overlaid with the package interpretations. (b) Cross-section B – B′, showing packages P3–P7.