

FACIES AND STRATIGRAPHIC RELATIONSHIPS AT HIDDEN VALLEY, GALE CRATER, MARS.

R. M. E. Williams¹, M. C. Malin², K. M. Stack³, and E. Heydari⁴. ¹Planetary Science Institute, 1700 E. Fort Lowell, Suite 106, Tucson, AZ 85719, williams@psi.edu, ²Malin Space Science Systems, San Diego, CA. ⁴Jet Propulsion Laboratory, Caltech, Pasadena, CA, 91109. ⁴Jackson State University, Jackson, MS.

Introduction: Hidden Valley is the first location along *Curiosity's* traverse for imaging the topographic transition from Aeolis Palus to the base of Aeolis Mons [1]. Extensive vertical exposure around the canyon combined with a rare opportunity on the mission to survey outcrops from vantage points above and below provide insight into facies attributes and the three dimensional architecture. In this abstract, we present a stratigraphic framework for Hidden Valley based on the apparent correlation of similar facies succession in multiple wall exposures around the canyon.

Hidden Valley Imaging Campaign: Hidden Valley is a 3-walled canyon located along the edge of the Zabriskie Plateau (Fig. 1). The shallow canyon (relief ≤ 5.5 m) is defined by steep walls (~ 150 m x 30 m x 80 m in length) and opens to the southwest. Wall relief is ≤ 5.5 m, with the south wall ~ 2 m higher than the north wall). Mastcam images were acquired between sols 703 and 734. Canyon walls spanning nearly 330° in azimuth are visible from the farthest point the rover ventured onto the sand-covered valley floor on sol 709.

Background on Existing Geologic Models: Prior work [2] mapped Hidden Valley as a site with all three lithostratigraphic groups, as presently defined: Bradbury, Mt. Sharp and Siccac Point [1]. The Siccac Point group, which contains the aeolian Stimson formation, unconformably overlies the Mount Sharp group [1]. The elevation of the unconformity increases to the south, with local vertical variations ≤ 7 m reflecting paleotopography [3]. An interfingering relationship between fluvio-lacustrine units of the Bradbury group and lacustrine units of the Mt. Sharp group is inferred, with Hidden Valley identified as an example of where this relationship is present [1]. Based on orbital imaging mapping, [2] identified Hidden Valley caprocks as Bradbury group on the headwall and north wall, and Upper Stimson formation at top of the south wall.

Observations: Complications in Rock Attribute Assessment: Viewing conditions, such as geometry and illumination, can enhance or obscure sedimentary textures. Rock texture can be altered or covered by other confounding factors including dust cover, degree of erosion or diagenetic overprinting. For example, a split block illustrates laminated, pitted and massive textures on different faces (Fig. 2). This observation raises the possibility of the same rock being

misclassified as different facies depending upon viewing conditions. This risk is enhanced when there are only single observations.

Facies Descriptions: Facies attributes (numbered from base to top of section) and interpreted depositional environment are described in Table 1. The characteristics of facies 1 match the Murray formation mudstones documented in later detailed *in situ* analysis at the Pahrump Hills [1, 4, 5]. The dark-toned caprock (≤ 1 m thick) is comprised of two facies with a sharp contact in places. The Hidden Valley upper cross-stratified caprock has attributes consistent with the well documented aeolian sandstone of the Stimson formation [3,7,8]. Images of the plateau confirm the presence of in-place cross-stratified caprock (facies 4) around the perimeter of Hidden Valley, although it is not always visible in images taken from the valley floor. No examples of south-dipping bedding in either the upper or lower caprock are recognized.

Stratigraphic Sections: The walls of Hidden Valley display a consistent facies sequence, but with variations in stratigraphic thickness. Outcrop exposures range from 1-2 m in height, with lower surfaces covered in talus and sand bedforms. The upper section (facies 2 and caprock) is present in 5 measured sections that span all observed areas (Fig. 1), while the lower section (facies 1) has patchy exposure.

Discussion: We classify the Hidden Valley upper and lower caprock facies into the Siccac Point group based on similarities to other exposures. The lower caprock contact appears to follow paleotopography (Fig. 3C), consistent with the base Siccac Point unconformity [3]. At least two sub-units of the Siccac Point group have been identified at multiple locations in Gale crater [e.g., 2,8]. Furthermore, we note that a similar Siccac Point caprock with two facies was recently examined (sols 3312-3317) in blocks on the eastern side of the Greenheugh pediment: an upper cross-stratified facies in contact with a lower massive, vuggy facies [9].

We propose a stratigraphic interpretation of the Hidden Valley sequence: a lower lacustrine interval of the Mt. Sharp group (Murray formation), and a two facies (3 and 4) capstone of the Siccac Point group. This stratigraphic framework is consistent with the regional mapping based on extrapolated relationships from the Kylie and Kimberley area presented in [10, Fig. 28]. In that work the orbitally-defined rugged terrain geomorphic unit was re-classified from the

Bradbury to the Siccar Point group, which resulted in a uniform stratigraphic group for the Hidden Valley caprock. This matches our observations in Mastcam images that do not uniquely support differentiating the caprock into separate stratigraphic groups. This architecture is a revision to the interpretation in [1].

This work has implications for understanding the extent of diagenetic fluid flow along the base Siccar Point unconformity [e.g. 8] as well as re-assessment of regional correlations to and relative age relationships of the Hidden Valley strata. For example, the Hidden Valley sequence appears similar to that seen east of

Pahrump Hills with the most conspicuous commonalities being the distinctive thickly laminated interval, and the thinly-laminated, south-dipping beds.

References: [1] Grotzinger J.P. et al. (2014) *Science*, 350. [2] Stack, K.M. et al., (2017) *LPSC*. Abstract #1889. [3] Banham, S. et al., (2022, *in review*). [4] Schieber, J., et al. (2022) *LPSC LIII*. [5] Stack, K.M. et al., (2019) *Sedimentology*, 66. [6] Banham, S. et al., (2018) *Sedimentology*, 65, 95-1042. [7] Banham, S. et al., (2021) *JGR*, 126. [8] Kronyak , R.,E. et al., (2019) *JGR*, 124. [9] Dietrich, W.E. et al. (2022) *LPSC LIII*. [10] Williams, R.M.E. et al., (2018) *Icarus*, 309.

Table 1: Hidden Valley Sedimentary Facies

Facies	Description	Interpretation
4	Dark-toned cross-stratified caprock with beds up to 2 m thick	Aeolian deposits
3	Dark-toned massive caprock; variably smooth, pitted or bulbous in texture; pinches out laterally; heavily fractured	Uncertain; possibly altered/coated facies 4
2	Thickly laminated facies; 5 mm mean laminae thickness; beds 0.5-2 cm thick	Lacustrine varves [1]
1	Light-toned, thinly (<0.3 cm) laminated facies; traced laterally >1 m; 1A: parallel laminations, 1B: inclined beds with apparent S/SW dip (~10°)	Lacustrine deposits

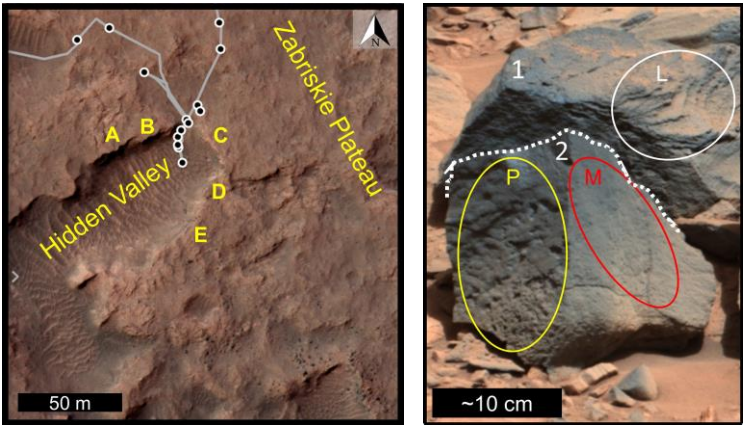


Fig 1 (far left). Study site with rover traverse (white), stops (dots) and stratigraphic section locations (letters) marked.

Fig 2 (at right). Example of textural differences on two blocks (numbered) inferred to be pieces of a former coherent rock that has split (dotted line): L = Laminated, P = Pitted, and M = Massive. Sol 721 MR_mcam003086.

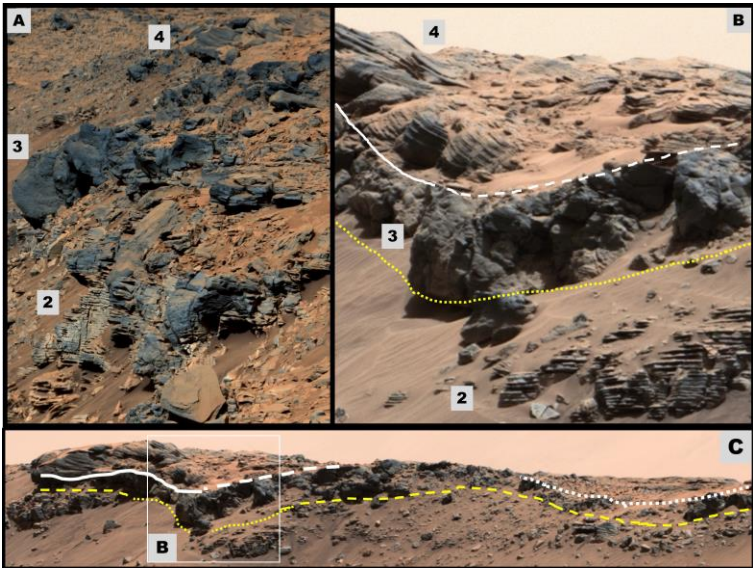


Fig 3. Examples of upper succession from north wall. Facies are numbered (see Table 1 for facies description) and contacts are drawn (solid line where observed, dashed for partially covered, dotted for inferred). A) Oblique along-wall view. Sol 726 MR_mcam003100. B) & C) View to west. Sol 710 MR_mcam003015.