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FIRST CONTACT WITH A ROCK AVALANCHE DEPOSIT ON MARS. W. E. Dietrich¹, A. B. Bryk¹, A. Cowart², C. Fedo³, A. Fau⁴, O. Gasnault⁴, E. Kite⁵, S. A. Wilson⁶, J. M. Davis⁷, R. M. E. Williams², L. M. Thompson⁸, A. R. Vasavada⁹. ¹Depart. Earth & Planetary Science, Univ. Cal. Berkeley, ²Planetary Science Institute, ³U. Tennessee, ⁴IRAP, Université de Toulouse, ⁵Univ. Chicago, ⁶Center for Earth & Planetary Studies, Smithsonian National Air & Space Museum, ⁷Imperial College London, ⁸Univ. New Brunswick, ⁹Jet Propulsion Laboratory

Introduction: The progressive erosion of Mt. Sharp, a 5 km peak in the center of Gale Crater, has led to a basal footslope of planar topography (pediment [1]), followed (upslope) by isolated rounded buttes on a stepped surface, and broad, shallow flat-floored canyons that terminate in a deeply etched yardang unit (Fig. 1a). That unit is cut by a narrow canyon that drains a catchment of about 127 km² and leads to a 900 m wide, 120 m deep canyon (Gediz Vallis) that curves and terminates abruptly on the stepped surface (Fig. 1a). Three distinct strongly eroded deposits over a distance of about 4 km are found in and that emanated from Gediz Vallis (GV) (Fig. 1a). Gediz Vallis ridge (GVR) is about 1.7 km long, consisting of an upslope onlapping sequence of 4 distinct units consisting of varying amounts of likely debris flow and fluvial deposits [1]. The fourth unit onlaps the upper Gediz Vallis (uGVR) deposit which is a slightly sinuous narrow ridge that extends upslope about 1.2 km. GVR and uGVR are likely remnants of a large fan [1]. The uGVR deposit once lay on the fan floor, possibly in a channel, and is now resting on a narrow ridge, and likely consists of debris flow dominated deposits [2]. Upslope of uGVR is a chain of deposits extending ~1060 m up the floor of Gediz Vallis (Fig. 1a). The lower portion lies in a bedrock channel canyon cut into the floor of Gediz Vallis. Further upslope the massive deposits locally rise well above the floor (e.g. Milestone Peak, Fig 1b, [3])

We propose that Fascination Turret (Fig. 1b) is a rock avalanche deposit that buried a channel-cut bedrock canyon. Rock avalanche deposits are widespread across Mars [4]. This is the first close contact on the ground with one.

Observations: The wind scoured, light toned, ridged Fascination Turret (FT) is about 120 m long and 85 m wide (Fig. 1c). The surface slope is about 14%. Between the two dashed lines in Fig. 1c, isolated broken blocks of dark-toned, wind resistant rock lie on the surface, locally in some cases forming a slight pedestal around them. In the northern part of Fig. 1c, the yellow dashed line shows the contact between the uGVR and Fascination Turret (seen from the rover), and to the south the dashed yellow line is inferred to continue the contact. The uGVR visibly onlaps FT. To the right of the orange dashed line, the dark blocks are nearly absent and scoured light toned deposits are prominent.

Fig. 2 shows examples of outcrop exposure (arrow in Fig. 1 shows location) from lowest to top of the

deposit (~4 m ascent). There may be systematic stratigraphic variation. Limited exposure in the trough floor (position 0 in Fig. 2.0) indicates avalanche deposits. Fig. 2.1 is a basal exposure of intensively fractured darker bedrock with isolated light tone blocks. In Fig. 2.2 large angular dissimilar blocks are resting in close contact. In the massive outcrop in Fig. 2.3 the stones are so densely packed and broken that boundaries are difficult to distinguish. Figure 2.4 shows the large broken dark-toned cap blocks, and how they have both protected the underlying bedrock against wind erosion and shed broken stones. This boulder bearing top layer is about 1.6 m thick

The FT deposit presently is ~ 100,000 m³ but the deposit may have continued to Pinnacle Ridge and beyond, and also extended further downslope.

Interpretation: The densely packed, angular, locally jigsaw broken rocks are signatures of rock avalanches which typically travel as granular flow causing continuous fragmentation of the entrained bedrock (e.g. [5],[6]). The basal, intensely fragmented layer may represent a shear zone, common to rock avalanches while the large broken clasts scattered across the top of FT are characteristic of the so-called carapace of rock avalanches [7,8]. The small size of the eroded FT is still large enough to be considered able to mobilize fully as a rock avalanche [5]. Relative to correlations on terrestrial rock avalanches, FT slope is very low for the present volume of deposit. This may indicate significant post-depositional erosion and that the rock avalanche extended much further upslope. The FT deposit was at least partially confined by a bedrock canyon, which would have deepened the flow and increased its mobility (e.g. [5]). The stratigraphic relationships suggest that the sediment that was delivered to uGVR and GVR fan, exited GV while crossing the rock avalanche deposit. Perhaps the relatively modest topographic slopes and densely packed bedrock significantly reduced erosion rates. The ridge or striated topography of FT may be primarily due to strongly oriented wind scour, but such striations are common in rock avalanches on both Mars [4]) and Earth [7]. Over 28 each of LD RMI and M100 are in review.

Implications: These observations suggest that the GV valley form was well-established before the succession of landscape erosion and sediment transport that led to the Gediz Vallis deposits and fan construction. A bedrock canyon incision by fluvial or

debris flow erosion that cut through a wind scoured Gediz Vallis floor first developed. A rock avalanche (perhaps multiple events) then swept downslope and infilled the canyon. The local canyon walls may have been much higher and the valley adjacent walls of the Gediz Vallis may have been closer. Then came the hydrologic conditions that mobilized and swept sediment as debris flows and fluvial transport. The densely packed rock avalanche deposit preserved the bedrock canyon and defined the upslope apex of the Gediz Vallis fan. The subsequent likely billion years of wind erosion nearly eliminated the fan deposit, but left a remnant of the rock avalanche. Erosion removed any trace of a landslide scar source area. The dark stones, for which we have no identified source, occurs in the carapace, but become interspersed with the fan deposits.

References: [1] Bryk, A.B. et al. (2024), *LPSC 1770*, [2] Wilson, S.A. et al. (2024) *LPSC 2224*, [3] Hughes, M.N. et al. (2022) *JGR Planets*, [4] Crosta, G.B. et al. (2018) *Earth Space Sci*, [5] Hermanns, et al. (2022) *Treatise on Geomorphology*, [6] Davies, T. (2018) <https://doi.org/10.1093/acrefore/9780199389407.013.326>, [7] Wang, Y. et al. (2023) https://doi.org/10.1007/978-3-031-44296-4_2, [8] Dufresne, A. et al. (2016) *Earth-Sci Rev*

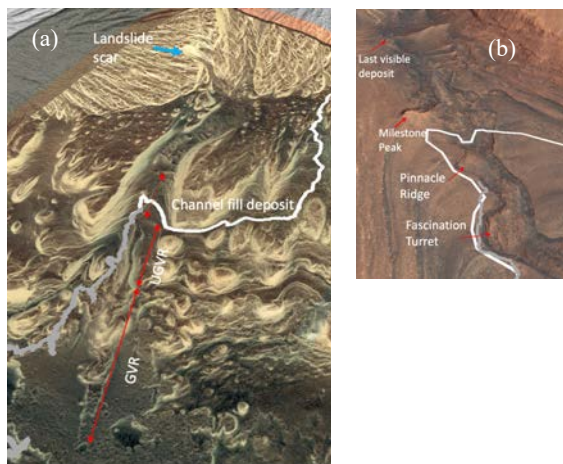


Figure 1. (a) Mt. Sharp footslope (yellow areas are steep slopes). Three depositional units GVR, uGVR and Channel fill deposits marked by red arrows. MSAR past (grey) and future (white) shown. (b) Channel fill deposit reach. (c) FT shows the bounds of deposits and Fig 2 location.

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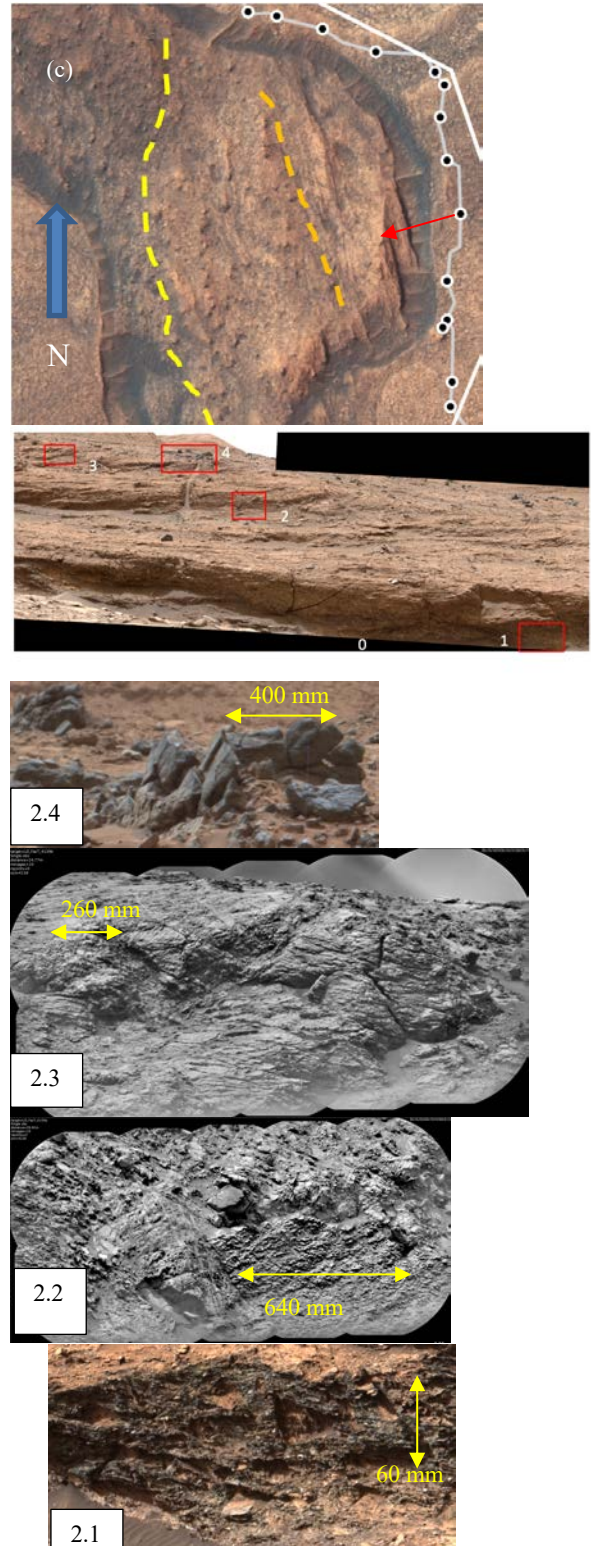


Figure 2. Profile across Fascination Turret.
2.1: shattered, possibly sheared bedrock
2.2: angular blocks in close contact
2.3: densely packed, broken blocks
2.4 broken dark toned blocks of the carapace