Preliminary Geological Map of the Peace Vallis Fan Integrated with In Situ Mosaics From the Curiosity Rover, Gale Crater, Mars.

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Introduction: A geomorphically defined alluvial fan extends from Peace Vallis on the NW wall of Gale Crater, Mars [1,2] into the Mars Science Laboratory (MSL) Curiosity rover landing ellipse [3]. Prior to landing, the MSL team mapped the ellipse and surrounding areas, including the Peace Vallis fan. Map relationships suggest that bedded rocks east of the landing site are likely associated with the fan, which led to the decision to send Curiosity east (Fig. 1). Curiosity's mast camera (Mastcam) color images are being used to refine local map relationships. Results from regional mapping and the first 100 sols of the mission demonstrate that the area has a rich geological history. Understanding this history will be critical for assessing ancient habitability and potential organic matter preservation at Gale Crater.

Methods: Initial mapping of the Curiosity landing ellipse and surrounding areas was performed by >30 MSL team members using georeferenced HiRISE images and DEMs. Map units in HiRISE images were identified based on textural characteristics such as the presence of scarps consistent with bedding, surface roughness based on shadowing, apparent relative albedo, patterns in albedo variations such as those indicating fractures or mottling, cross cutting relationships, etc. The map was refined as individual contributions were compiled into a single GIS project and with ongoing remapping of units and boundaries [4,5].

In areas imaged by Curiosity, which extend 500 m east of Bradbury landing site (Fig. 2), Mastcam and navigation camera data were integrated into mapping efforts. Variations in rock characteristics were mapped on Mastcam images and these variations were translated onto HiRISE images and the map using: 1) comparisons of large features visible in both Mastcam and HiRISE images; 2) distance to features measured from NavCam DEMs where available; 3) azimuth and elevation of features relative to rover position; and 4) intersection of azimuths from two imaging locations if a feature is visible in both.

Peace Vallis Fan: Peace Vallis directed flow from a watershed within the rim of Gale Crater into the crater, resulting in deposition of an alluvial fan (Fig. 1) [1]. The upper fan consists of relatively smooth, mottled surfaces (MT), the lower portion of which contains localized downslope-trending linear ridges with a mean relief of 0.6-2.4 m [6]. Some ridges extend into a zone to the south with intermixed mottled (MT) and fractured surfaces that contain scarps consistent with m-scale bedding (BF). This intermixed zone has a higher thermal inertia than the upper fan [1,7]. Downslope and southward, fractured units with scarps consistent with m-scale bedding dominate outcrops (B, BF). The sizes of polygons defined by fractures do not appear to vary systematically with either distance downslope nor stratigraphic position. B, BF, and intermixed MT and BF share a sufficiently high thermal inertia to suggest that they consist of well-cemented or indurated bedrock. Map areas dominated by fractured, bedded units also include isolated smooth surfaces that have been separated into two map units: 1) smooth exposures that are flat and topographically below bedded units or are mounds that bedded units may embay (S1), and 2) smooth exposures that appear to drape neighboring units and topography (S2).

Interpretation. The geomorphology of the Peace Vallis fan supports its interpretation as an alluvial fan

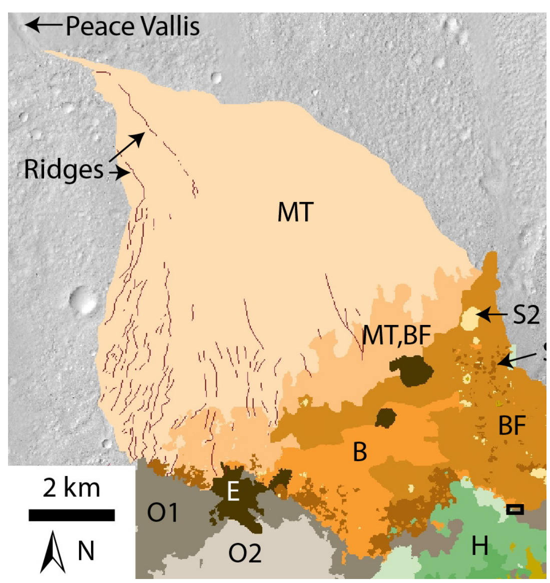

Fig. 1: Preliminary map of the Peace Vallis Fan; see text for MT, B, BF, S1, and S2. E, H, O1, 2, 3: geomorphic ejecta, hummocky and other terrains [4,5,9]. Box indicates location of Fig. 2.

[1,2,6]. The downslope trending, low-relief ridges are interpreted as channels inverted due to wind deflation. The presence of a few of these ridges crossing from the mottled to the intermixed mottled and fractured map unit ties the fractured lower fan to the upper fan. Thus, the downslope fractured, bedded units are interpreted as genetically associated with the Peace Vallis fan. The smooth unit that appears to drape other units is interpreted as younger than the fractured units. The flat and mounded smooth exposures that appear to be interbedded with or underlie the bedded units are interpreted as either interbeds of a different rock type or the surface overwhich the fan flows deposited sediment.

Bradbury Landing Site to Glenelg: The Bradbury landing site was mapped as a smooth-textured hummocky geomorphic unit prior to landing (H; Fig. 1). Mastcam images reveal small outcrops of pebble conglomerates close to the landing site [8]. Farther east and downslope, the surface was mapped as two units prior to landing, but has been divided into 6 units based on Mastcam images (Fig. 2, 3). The lowest unit (Unit 1), consists of fractured bedrock. It is separated from Unit 2 by regionally continuous, decimeter-thick beds. Unit 2 displays fewer fractures and includes decimeter-thick interbeds with variable resistance to weathering. Unit 3 abruptly overlies Unit 2. Unit 3 has a blocky weathering style, often ropey texture, and vuggy porosity. It is overlain by Unit 4, which is mostly covered in scree. The overlying Unit 5 is more finely laminated and commonly contains mm-cm sized open fractures. The upper contact of Unit 5 is not defined. The sixth unit (platy unit) consists of cm-thick, finely laminated beds with abundant cross stratification. This unit is only locally exposed (Fig. 2) and may either be stratigraphically equivalent to Unit 4 or may be younger. Units 1-5 show fairly consistent stratigraphic relationships, although units 3 and 4 may be partially intermixed [9].

Interpretation. Due to its regional distribution and bedding relationships, Unit 1 is interpreted as part of the bedded units that extend northward to the toe of the Peace Vallis Fan. Unit 2 may be similarly associated with this regional unit, although its distribution is still poorly constrained. Units 3 and 4 are less well bedded and form part of a unit that was mapped as locally distributed prior to landing. They may or may not be genetically associated with Unit 1. The platy unit cross stratification indicates deposition from turbulent flows, although whether they were fluvial, eolian or base surge/pyroclasics is not constrained from data obtained prior to sol 100. It is interpreted as the same age as or younger than unit 4. The relative ages of units 1-5, rocks forming Bradbury Rise, and the pebble conglomerates are poorly constrained [9].

Summary: These maps provide regional context for observations obtained with Curiosity. In turn, observations are being used to refine geological and geomorphic maps. These complementary efforts will guide data collection using Curiosity and facilitate extension of results to regional interpretations.

References: [1] Anderson and Bell (2010) *Mars, 5*, 76-128, [2] Milliken, et al. (2010) *GRL*, 37, L04201, [3] Golumbek, et al., (2012) *Space Sci. Rev.* 170, 641-737, [4] Calef, et al. (2013) *LPS XXXIV,* [5] Rice, et al. (2013) *LPS XXXIV,* [6] Palucis, et al. (2013) *LPS XXXIV,* [7] Fergason, et al. (2012) *Space Science Reviews, 170*, 739-773, [8] Williams, et al. (2013) *LPS XXXIV,* [9] Stack, et al. (2013) *LPS XXXIV.*

Acknowledgements: This research was carried out in part by JPL, Caltech, in addition to many other universities and organizations, under contract with NASA. Orbital data acknowledgements: HiRISE, CTX, HRSC, MOLA, MRO, MGS, ASU, UA, LPI, ESA, JPL, NASA. Government sponsorship acknowledged.

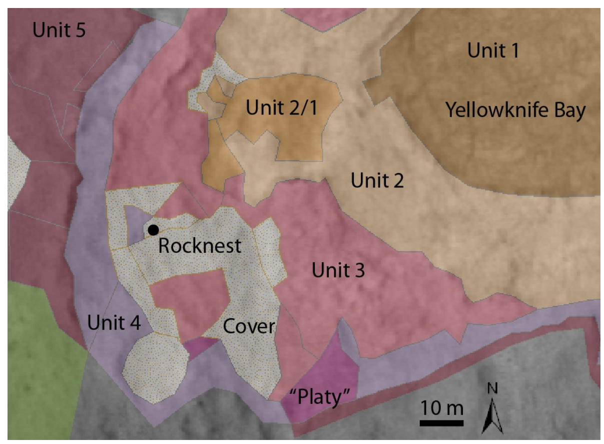

Fig. 2 Preliminary map of the Rocknest-Yellowknife Bay area based on combined data from HiRISE, Mastcam and NavCam images. See text for unit descriptions. Area labeled Unit 2/1 is a near bedding parallel outcrop very near the contact between units 1 and 2.

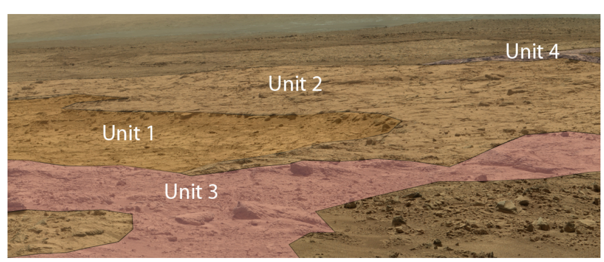

Fig. 3 Mastcam image mosaic taken from Rocknest (Fig. 2) showing map units. Note the distinctive topographic break between units 1 and 2.