THE CLAY-BEARING UNIT IN GALE CRATER II: PLANS FOR THE INVESTIGATION OF THE CLAY-BEARING UNIT BY THE CURIOSITY ROVER

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Introduction: The Mars Science Laboratory (MSL) rover (Curiosity) is located in Gale crater, a ~150 km diameter impact crater that hosts a sedimentary central mound (Mt. Sharp). Mt. Sharp exhibits a layered stratigraphy that preserves a record of environmental conditions in the Early Hesperian [i.e. 1-3]. Clay minerals were identified from orbit near the base of Mt. Sharp and sulfates were identified at a slightly higher elevation in the lower part of the mound, which suggests a transition from wetter to drier conditions [1-3]. Curiosity has been driving up Mt. Sharp through the Murray formation, which was found to contain clay-bearing mudstones interpreted to have been deposited in a lake [4, 5]. The rover is currently on Vera Rubin Ridge (VRR), a hematite-enriched topographically high feature [3], and is expected to descend off of the ridge and arrive at the clay-bearing unit mapped from orbit in 2018. Here we discuss the strategic plan that is being developed for the investigation.

The Clay-Bearing Unit: The clay-bearing unit (see Figure 1 for context) was originally identified on the basis of metal-OH absorptions in CRISM near-infrared spectra [1]. The region that exhibits smectite signatures in CRISM contains two morphologies: a smooth, ridged morphology and a rough, polygonally fractured, morphology. Although the stratigraphy of the clay-bearing unit is not well constrained, there is some evidence that these two sub-units are interbedded [6]. For a more complete overview of previous orbital investigations of the clay-bearing unit, please refer to "The Clay-Bearing Unit in Gale Crater I" (Fox et al., this conference).

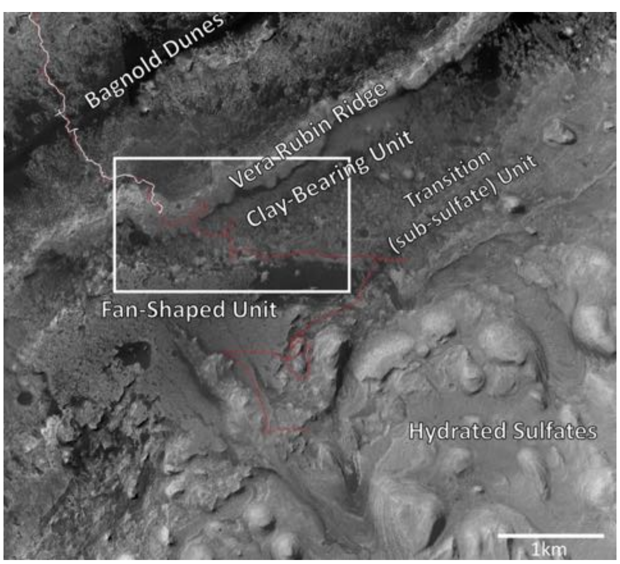

Figure 1: HiRISE basemap of the MSL traverse area [16]. The red line shows the planned Mount Sharp Ascent Route and the white line shows the actual rover traverse up to sol 1867. The white box shows the location of Figure 2.

Rover Capabilities: The MSL payload includes cameras (Mastcam [7], Navcam [8], ChemCam remote microimager (RMI) [9]) that take images at varying resolutions and spectral ranges. ChemCam LIBS (laser-induced breakdown spectroscopy) remotely measures elemental chemistry [10]. On the rover arm, the Mars Hand Lens Imager (MAHLI) can take images down to ~15 microns per pixel [11] and the Alpha Particle X-ray Spectrometer (APXS) provides in situ elemental abundance [12]. The Dynamic Albedo of Neutrons (DAN) detects the presence of hydrogen in the subsurface to depths of ~60 cm [13]. The Sample Analysis at Mars (SAM) [14] and Chemistry and Mineralogy (CheMin) [15] instruments yield elemental/isotopic measurements and detailed mineralogy of soil and rock samples. The full suite of rover instruments will be used to investigate the clay-bearing unit and understand the geologic context of the area, but the SAM and CheMin instruments will be the primary tools to identify and characterize phyllosilicates.

Science Goals and Objectives: MSL activities at the clay-bearing unit will address three mission science goals: (1) Understand the geologic context of Gale crater and Mt. Sharp, (2) Constrain the habitability of ancient Mars and understand the preservation potential for organic molecules, and (3) Understand the evolution of the atmosphere and climate. To address these science goals, we have developed questions and hypotheses to test:

What is the stratigraphic context of the clay-bearing unit? By understanding how the clay-bearing unit relates to the surrounding units (hematite-enriched VRR, the fan shaped unit, and the transitional unit/sulfate unit), we will determine how the clay-bearing unit fits into the stratigraphy and what this implies for the geological evolution of Mt. Sharp.

What is the origin of the phyllosilicates? Are they authigenic or detrital? By constraining the composition of the phyllosilicate-bearing rocks and understanding their geologic context we can infer whether the clay minerals are authigenic or detrital, although some ambiguity will remain due to our instrument set.

For example, results earlier in the mission at Yellowknife Bay indicated that the phyllosilicates formed in a closed weathering system, which suggests that they are authigenic.

What geologic environment(s) does the clay-bearing unit represent? We will test hypotheses that the clay-bearing unit represents an ancient lacustrine environment (similar to the Murray formation) or some other environment (fluvial, volcanic tephra, eolian dust, eolian traction deposits, etc.). We will also aim to constrain the primary geochemical processes involved in the deposition of the clay-bearing unit and distinguish these from the effects of secondary overprinting.

What are the implications for habitability and the preservation of organic molecules, particularly within iron-bearing clay mineralogies? Mudstones and phyllosilicates both have a high potential to preserve organics [17]. We will use SAM and CheMin to test the hypotheses that the clay-bearing unit contains detectable organic molecules, organic carbon, and/or inorganic sulfides that may have aided in organic preservation.

Overview of Planned Campaign: There are limited paths that Curiosity can take to leave the VRR and enter the clay-bearing unit due to the topography of the ridge. Figure 2 shows the location of the planned ridge descent route that follows areas of low slopes. We will conduct several long-distance imaging observations of the clay-bearing unit while Curiosity is still above it. However, the topography of the VRR does not provide many locations from which the clay-bearing unit is visible. For this reason, the majority of the long-distance imaging of the clay-bearing unit will take place during the descent from the VRR. The long-distance imaging campaign will include ChemCam RMIs, ChemCam passive observations, Mastcam color images, and Mastcam multispectral observations. These observations will yield the first ground based observations of the clay-bearing unit that will provide context for narrowing down potential waypoints to visit.

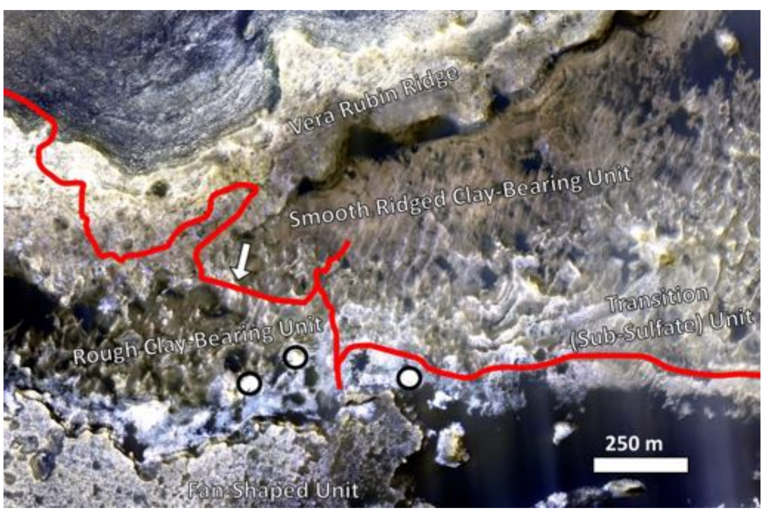

Figure 2: Color HiRISE of the clay-bearing unit along the MSL traverse. Several units of interest are labeled. The red line is the proposed Mount Sharp Ascent Route. The white arrow shows the location where the rover is planned to descend from Vera Rubin Ridge into the clay-bearing unit. The black circles show the location of several light toned mounds.

Once Curiosity arrives at the clay-bearing unit, we will document the region through a variety of remote sensing and contact science. Understanding potential contacts between units is of particular interest, and both sides of potential contacts will be targeted. Ideally, Curiosity would use its drill to obtain at least one sample at each unit (clay-bearing unit, transition/sub-sulfate unit, sulfate unit), but the number of drill sites could increase or decrease depending on the status of the drill. In addition to regular EGA and GCMS measurements, the SAM-TMAH-GCMS experiment, optimized for fatty acid detection, is planned to occur using a sample from the clay-bearing unit [17]. The clay-bearing unit is the ideal location for this, as clays have the potential to preserve organics [18].

Several locations within this area have been identified from orbit as potential targets along Curiosity's traverse (Figure 2): the morphologic subunits of the clay-bearing unit (smooth vs. rough), the contact between the base of VRR and the clay-bearing unit, a location with very high phyllosilicate signatures (as seen from orbit), light toned mounds, and the edge of the fan-shaped unit.

After traversing through the clay-bearing unit, the rover will continue driving up Mt. Sharp to investigate how the clay-bearing unit is related to the transition (sub-sulfate) unit and the sulfate unit.

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