MINERALOGIC STRATIGRAPHY AND DEPOSITIONAL ENVIRONMENT IN MIYAMOTO CRATER, MARS.

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Introduction: Miyamoto Crater is a 160-km impact crater located in Terra Meridiani to the southwest of the MER Opportunity rover landing site [1]. Miyamoto Crater was among the top 6 MSL candidate landing sites considered at the 3rd MSL Landing Site Workshop largely due to the presence of remotely sensed phyllosilicates, an inverted channel, and a possible mechanism for preserving organic material in cemented channels [2]. However, Miyamoto Crater did not advance as a final candidate site partly because its stratigraphy and geologic context was not as well constrained as other sites.

Since then, several studies have further examined the complex geomorphology of the area, and have hypothesized that the hydrated sulfates and phyllosilicates detected appear to have been precipitated during separate episodes [1-3]. However, another hypothesis claims that co-existing sulfate and phyllosilicates deposits like those found in Miyamoto could have formed simultaneously, through a combination of processes like those observed in certain ephemeral acid saline lakes in Australia [4]. Thus, some locations on Mars where sulfates and phyllosilicates co-exist may not necessarily indicate different climates at different times, but rather reflect a more complicated hydrological history of the planet.

Background: The Planetary Sciences Decadal Survey ranks study of the aqueous environmental history of Mars and thus its habitability as among the top 10 priorities for the field [5]. Meridiani has been a popular site for NASA exploration due to the fluvial geomorphology of the region and clear spectral evidence of phyllosilicate and hydrated sulfate minerals. Some Martian global climate history models separate the precipitation of these aqueous minerals into distinct time periods. For example, clays could have formed first during the Noachian period, followed by a period of surface volcanism and global climate change, before sulfates were formed in the Hesperian era [6].

Meridiani has been analyzed in great detail from orbital remote sensing images and spectra. One study [7] concluded that several wetting events and depositional episodes had occurred in Meridiani, but that the overall classic model of phyllosilicates predating sulfates is still consistent with the available observations. Another study [4] suggested that the complex coexistence of phyllosilicates and hydrated sulfates in Miyamoto Crater and other Martian sites could be analogous to the aqueous mineralogy observed in Western Australia, where acid lake evaporation cycles create both of these mineral types concurrently. The Australian lake analog sites provide evidence for a terrestrial environment where a large-scale change in climate or properties (*e.g.,* pH) is not necessarily required to explain the observed geochemical variations. Perhaps, then, a global-scale change from Noachian to Hesperian Mars [6] is not required to explain the coexistence of clays and sulfates in Meridiani.

A plausible geologic history of Miyamoto Crater could consist of 4 stages [8]. First, impact structures shaped the early Martian crust. Then, a fluvial episode eroded major channels and formed channel complex deposits near the western rim (where the proposed MSL landing site was located). Third, Meridiani Planum materials were buried. And finally, exhumation and erosion formed inverted channel deposits and revealed the basal phyllosilicates-bearing deposits [8].

Methods: Mars Reconnaissance Orbiter Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) Full-Resolution Targeted (FRT) sequences were processed in ENVI with the CRISM Analysis Tools software. A corrective processing workflow procedure [9] was followed to correct calibrated radiances for solar incidence angle and to correct the spectrum for atmospheric CO_2 absorptions. For each scene, CRISM parameters BD2100 (band depth at 2100 nm, diagnostic of monohydrated minerals) and D2300 (depth of the 2300 nm phyllosilicate feature) were map projected [9,10]. The ENVI Region of Interest (ROI) tool was used to collect pixels from high signal locations in these parameter maps, then reflectance spectra of the different regions were examined to confirm the characteristic Mars I/F spectra with an absorption band at 2300 nm and shoulder at 2100 nm for phyllosilicates and hydrated sulfates, respectively. For example, CRISM parameter maps for sequence FRT0000AE19 of infrared albedo, olivine, and hydrated sulfates were combined into an RGB composite image (Fig. 2) to show geographic relationships between materials.

To assess the stratigraphic relationships between the phyllosilicate and hydrated sulfate deposits in Miyamoto crater, we also created a Digital Terrain Model (DTM) of the crater using Mars Express High Resolution Stereo Color Imager (HRSC) topography.

Results: The 10x10 km CRISM image analyzed had a nearly identical spatial distribution of the OLINDEX (olivine) and D2300 (phyllosilicate) parameters. Thus, Fig. 2 also shows that the phyllosilicates are concentrated near what appear by visual inspection to be higher, rougher terrain (green) around peaks in the northwest of the image, but also along the base of what appear to be fluvial channels. The wide-ranging apparent spatial distribution of phyllosilicates is interesting to consider, especially because there are hydrated sulfates and olivine signatures at the same nearby locations and elevations. Based on the roughly symmetrical exposures of phyllosilicates along the tops of ridges, flat lying beds of these materials are inferred. However, their exposure at the top most layer of an inverted channel and at the base of a nearby normal (not inverted) channel is puzzling. We note that hydrated sulfates (blue, Fig. 2) do not compose the missing layer between phyllosilicate groups, but rather are restricted more by proximal location to the phyllosilicates and are not dependent on elevation.

HiRISE and CTX images of this location show dunes, boulders, hills, and plains at the smallest scale, and ridges, inverted channels, mesas, landslides, and craters at scales larger than 1 km. The occurrence of hydrated sulfate deposits in this region does not appear to be specifically correlated with any of these morphologic features. This could imply that a favorable environment for widespread hydrated sulfate deposition was present at the same time as nearby phyllosilicate deposition, or that multiple wetting, evaporation, and precipitation cycles occurred over shorter timescales.

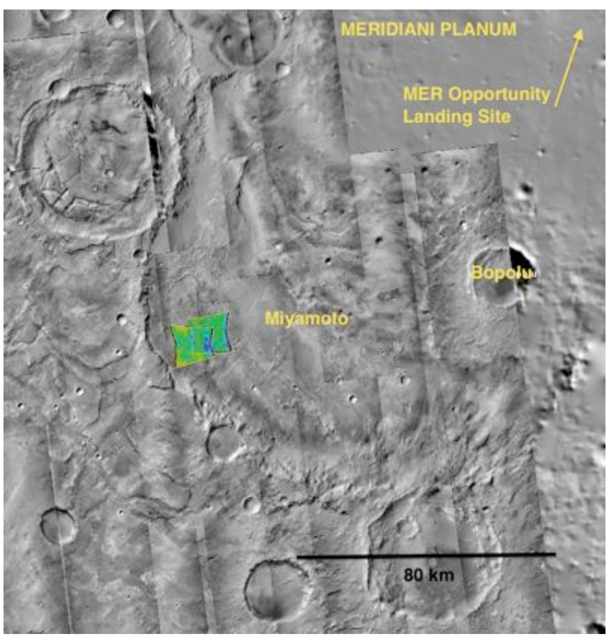

Fig 1. CRISM footprints near proposed MSL landing site in western Miyamoto Crater. FRT00007B8B and FRT0000AE19 CRISM footprints with Monohydrated Sulfate Color Index are shown above CTX and MOLA imagery in JMARS. Yellow values are higher in monohydrated minerals, blue values are lower.

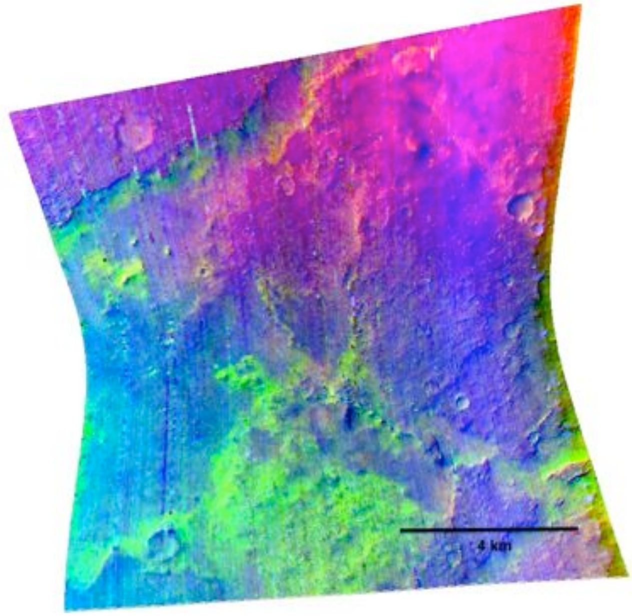

Fig 2. RGB Composite of FRT0000AE19 CRISM footprint. Red: IRA (IR Albedo) Green: OLINDEX Blue: BD2100.

Future Work: We are generating an annotated geologic map of the entire crater, including cross sections, to identify and characterize features like dune fields, inverted and non-inverted channels, craters, fans, and ridges from HiRISE and CTX images. A 10x vertically exaggerated HRSC mosaic DTM of the entire crater is being created to display the topographic relationships between hydrated materials. Future work includes mapping the spectral parameters from FRT0000AE19 and other CRISM sequences onto this Miyamoto Crater DTM, so add quantitative aspects of the regional context and stratigraphy to our analysis.

References:

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