

SMECTITES ON CAPE YORK, MATIJEVIC HILL, MARS, AS OBSERVED AND CHARACTERIZED BY CRISM AND OPPORTUNITY.

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Introduction: Opportunity has conducted an extensive “walk-about” and set of in-situ measurements on strata exposed on the inboard side of Cape York, a segment of the dissected rim of the Noachian-age ~22 km wide Endeavour crater [1] (Fig. 1). The specific region for the observations (Matijevec Hill) was chosen based on along track oversampled (ATO) CRISM hyperspectral observations (processed to 5 m/pixel) that showed the presence of exposures of Fe/Mg smectite phyllosilicates. We describe the first ground-based observations of phyllosilicates on Mars and discuss implications based on the combined CRISM and Opportunity measurements.

CRISM Data: CRISM is a hyperspectral imager on the Mars Reconnaissance Orbiter, operating from 0.41 to 3.92 μm and using a gimbaled optical system to acquire standard full resolution targeted mode (FRT) data with 18 m/pixel resolution [2]. By special gimbal commanding, data have also been acquired in an ATO mode with pixel spacing as small as 1 m projected onto the surface. We focus on an ATO (FRT0001D86B) centered over Cape York, processed to 5 m/pixel using Tikhonov damped least squares regularization [3]. Single scattering albedos (SSA) were retrieved using DISORT to model aerosols, gases, and Hapke function surface scattering [4]. Results were also constrained by the emission phase function portions of the observation. The relatively warm detector temperature (-146° C) necessitated specialized filtering to suppress noise.

Wray et al. [5] reported the presence of an extensive exposure of Fe/Mg smectites on Cape Tribulation and a hint of exposures on Cape York, although column-dependent noise characteristic of an early version of CRISM's calibration, plus the small areal extent of the occurrence on Cape York, made definitive identification difficult. We searched our 5 m/pixel SSA cube for the diagnostic Fe/Mg smectite features at ~1.4, 1.9, 2.2, 2.3, and 2.4 μm , together with the presence of any iron transition features at shorter wavelengths. Results showed the presence of the two longer wavelength bands (metal-OH combination bands) for the locations mapped in Fig. 2, with the spectral mean for the region of interest shown in Fig. 3. The spectra do not show evidence for hydration, i.e., interlayer H₂O combination bands at 1.4 or 1.9 μm . This is consistent with laboratory dehydration experiments of smectites in

which the H₂O bands disappear but the longer wavelength metal-OH features are retained [6]. Opportunity was commanded to explore Matijevec Hill based on the locations with this unique spectral signature.

Opportunity Data: The “walk-about” Pancam and Navcam data show Matijevec Hill exposes a set of strata that includes a relatively bright, recessive deposit termed Whitewater Lake (Fig. 4). Microscopic imager observations show that this unit is very fine-grained, with a relatively small component of irregularly shaped sand grains and occasional ~1 to 2 mm diameter spherules. Coatings and bright veins are evident throughout the deposits. The Whitewater Lake outcrops map one to one with where CRISM data indicate the presence of smectite exposures.

APXS data were acquired for a number of Whitewater Lake targets, including natural, brushed, and ratted outcrop and coatings (Fig. 5). Correspondence analysis (CA) is a dimensional reduction procedure that solves for the directions in both variable and sample space that explain the highest fractional variances of a multi-dimensional data set [4]. CA results applied to all APXS rock measurements in Cape York indicate that the Whitewater Lake deposits and related strata (Kirkwood, Onaping, Vermilion Cliffs) are compositionally distinct from the Shoemaker formation rocks (located uphill from Matijevec Hill) and that the Whitewater Lake outcrops represent an endmember enriched in SiO₂, Al₂O₃, and Na₂O relative to other Cape York rocks. The data also indicate the presence of coatings with distinctly different compositions relative to the bedrock. APXS data do not show excess light elements for these outcrops, consistent with the dehydrated nature of the CRISM spectra.

Synthesis: The Whitewater Lake stratum is part of a series of Noachian rocks that are either part of or predate the Endeavour event. The enhancement in SiO₂, Al₂O₃, and Na₂O suggests aqueous alteration of olivine and pyroxene (and formation of smectite) relative to more insoluble feldspars [7]. Alteration may have occurred during or shortly after emplacement or when exposed to the surface. Veins speak to aqueous fluids emplaced after deposition, and coatings imply a unique ability to form surface deposits after emplacement, perhaps enabled by surface water as small amounts of frost or snow melt. The strata explored on

Matijevec Hill may have been emplaced as impactites or by a number of other processes [1]. Synthesis of the measurements being acquired by Opportunity will allow narrowing of these hypotheses and an understanding of the geologic setting for alteration of Whitewater Lake outcrops.

References: [1] Squyres S. et al. (2013) *LPS XLIV*. [2] Murchie S. et al. (2007) *JGR*, doi:200710.1029/2006JE002682. [3] Fraeman A. *Geology*, submitted. [4] Arvidson R. et al. (2011) *JGR*, doi:10.1029/2010JE003746. [5] Wray J. J. et al. (2009) *GRL*, doi:10.1029/2009GL040734. [6] Morris R. V. et al. (2011) *LPS XLII*, Abstract #2757. [7] Brantley S. et al. (2008), *Kinetics of Water-Rock Interaction*, Springer, 833p.

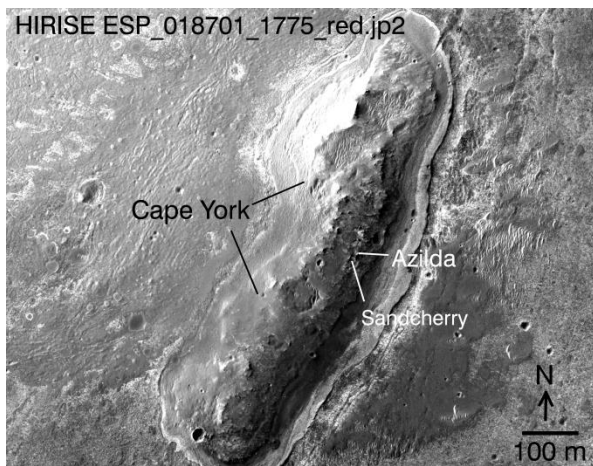


Fig. 1 – HiRISE view of Cape York, an isolated Endeavour crater rim segment. Sandcherry and Azilda are in-situ targets that are part of the Matijevec Hill portion of Cape York examined during Opportunity’s “walk about”.

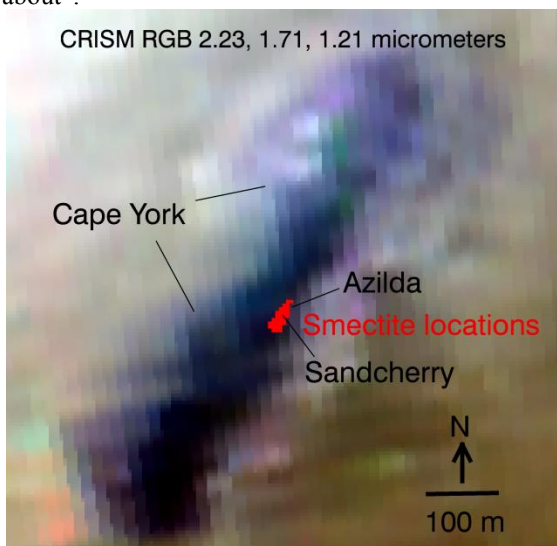


Fig. 2 – CRISM view of Cape York with Azilda and

Sandcherry in-situ targets labeled. The red area with the smectite signature corresponds to Whitewater Lake outcrops.

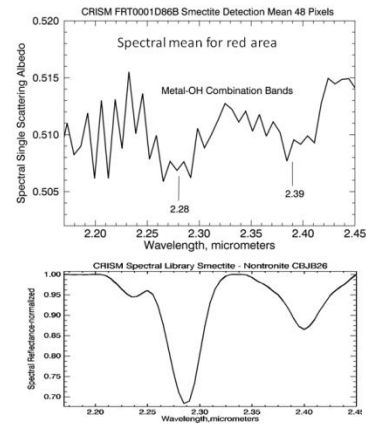


Fig. 3 – CRISM SSA spectrum for area shown in red in Fig. 2 compared to lab-based smectite spectrum.

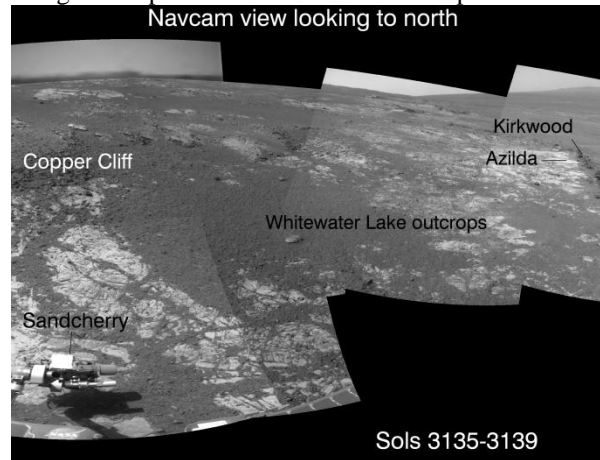


Fig. 4 – Navcam view looking north at Whitewater Lake outcrops, which are the bright recessive deposits that carry the smectite signature seen from CRISM.

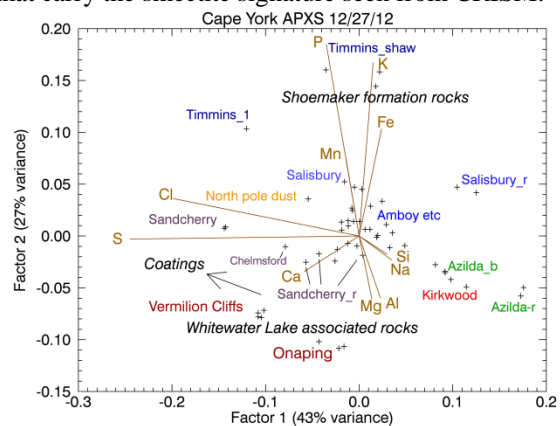


Fig. 5 – CA for Cape York rocks, where b=brushed and r=ratted. The Azilda series are for Whitewater Lake outcrops whereas Sandcherry and Chelmsford are for overlying coatings (arrow shows coatings trend).