CRISM-DERIVED MODAL MINERALOGY AND THERMAL INERTIA FOR OXIA PLANUM.

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Introduction: Oxia Planum was chosen as the landing site for the ExoMars Rosalind Franklin rover on the basis of having extensive, Noachian-aged clay-bearing deposits [1-3]. These deposits extend roughly west-northwest across more than 100 km, originating from the overlying deltaic deposits of the Cogoon Vallis system in Arabia Terra. The clay-bearing deposits have a mineral component that closely matches Fe/Mg phyllosilicates like vermiculite or saponite, rather than more Al/Fe-rich phyllosilicates like nontronite, based on absorption band comparisons of Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité (OMEGA) and Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) orbiter data with library reflectance spectra [2, 4]. Meanwhile, the delta deposits lack the strong clay signature, but appear to be composed of Fe-rich olivine, pyroxene, and hydrated silica [2-5]. In addition, the clay-bearing deposits and delta have been further discriminated based on overall albedo, texture, and thermal inertia using Context Camera (CTX), High Resolution Imaging Science Experiment (HiRISE), and Thermal Emission Imaging System (THEMIS) orbiter data, respectively [6].

Here, we present initial results including: (1) a surface kinetic temperature map and (2) mineral endmember abundances for a deposit with a particularly strong clay signature, both derived from a targeted CRISM scene covering part of the Oxia delta (Fig. 1). The temperature map will eventually be used as an input to a thermal inertia model, allowing for the retrieval of thermal inertia values at a spatial resolution of 40 m/pixel or better [7]. Both high-resolution thermal inertia studies and modal mineralogy will be useful in strategic path planning and determining potential science targets in time for the rover's arrival in 2023.

General Methods: We use our Washington University in St. Louis pipeline [8] to derive single-scattering albedo (SSA) spectra and surface kinetic temperatures at each pixel in CRISM scene ATU00038B10 (L_s = 57.11, local solar time = 14.93). Our pipeline involves using DISORT to model atmospheric gases and aerosols, the Hapke function to model surface reflection, and a neural network to produce the temperature map. The SSA data are denoised using a maximum likelihood method and map-projected. Finally, the S and L data cubes are coregistered separately to a CTX basemap using manual tie points and ENVI triangulation warping.

Using the same scene, we create a region of interest (ROI) of the strongest clay detections based on the D2300 spectral parameter (Fig. 1) [9]. Finally, we take the average SSA spectrum of this ROI (Fig. 2), and run iterative spectral unmixing models using a Markov chain Monte Carlo (MCMC) method to determine mineral abundances [10]. The details are given below.

Spectral Modeling: The MCMC method is a probabilistic formulation of the Hapke function, taking into account the tradeoffs between mineral endmember abundance and grain size in spectral modeling [10]. This method also takes advantage of the fact that SSAs add together linearly in the visible and near-infrared spectral range [11]. Using our aforementioned clay-bearing ROI mixed spectrum, we run MCMC models for ~3500 different combinations of endmembers in the spectral range of 0.75 to 2.5 µm, iterating over different olivine and pyroxene solid solutions, and three different clays (vermiculite, saponite, and nontronite). We also include labradorite and a weaker clay-bearing endmember from the CRISM scene (Fig. 2), to help account for most of the spectral shape and uncertainties in precisely modeling this unit.

Initial Results: The surface kinetic temperature map is shown in Fig. 1, with the delta deposits an average of 5 K warmer than the underlying clay-bearing unit. The warmest temperatures within the delta are associated with higher elevations, slopes, and albedos.

The spectral modeling results are shown in Fig. 2. Models including vermiculite provide the best fit to the clay bands from 2.3 to 2.5 µm, which is consistent with previous work [2, 4]. However, in the absence of more rigorous modeling efforts, we cannot rule out the possibility of other clays providing the same or better fits. Also, olivine is a significant component of the mixture, and the presence of high-calcium pyroxene is favored over low-calcium pyroxene.

Future Work: Using the surface kinetic temperature map, we plan to derive thermal inertias at the spatial resolution of CRISM. We will continue to refine our spectral mixing models, testing additional clay minerals and other endmembers. Finally, we plan to build mineral abundance maps using MCMC, for additional CRISM and OMEGA observations that cover Oxia Planum.

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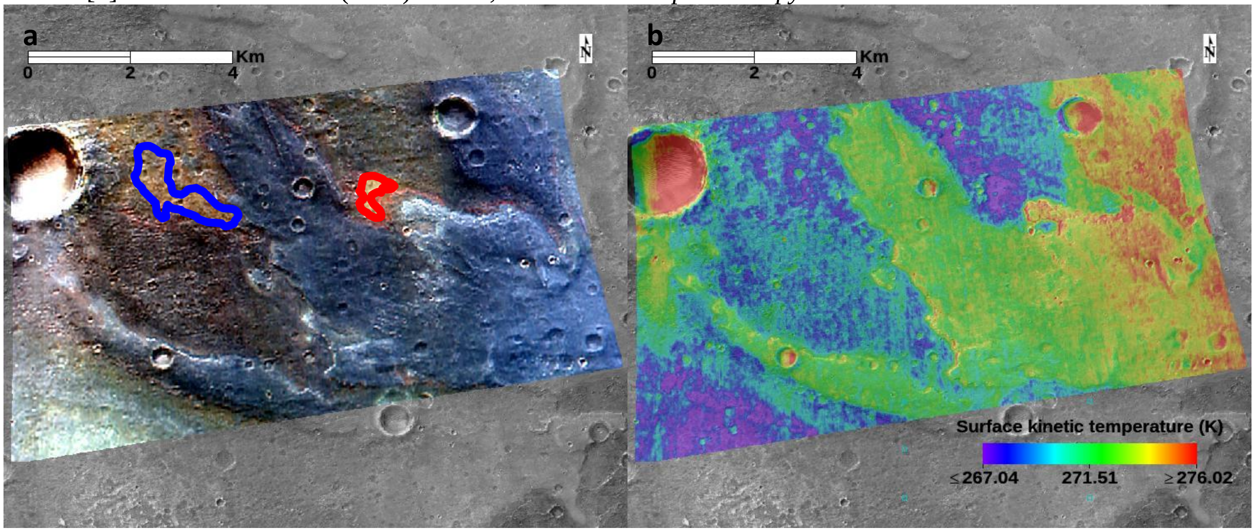

Figure 1. (a) CRISM scene ATU00038B10, processed to SSA using the WUSTL pipeline (R: 2.53 µm, G: 1.51 µm, B: 1.06 µm). The delta has a blue-gray color, and the clay-bearing deposits appear more yellow. The red and blue outlines are ROIs representing strong and weaker clay detections, respectively. Spectra for these ROIs are shown in Fig. 2. (b) Surface kinetic temperature map for the same scene. The basemap is a CTX mosaic of Oxia Planum.

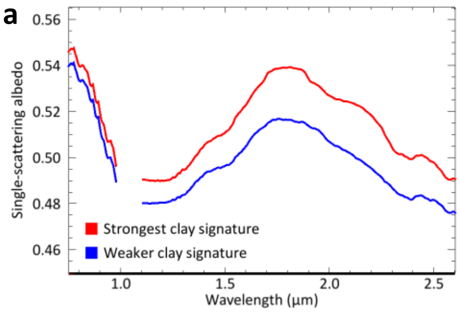

Figure 2. (a) Spectra for each of the ROIs shown in Fig. 1. The red spectrum is the data to be unmixed, and the blue spectrum is a weaker clay-bearing endmember used in the modeling. (b-d) Best fit MCMC models for vermiculite (RELAB CAVE01), saponite (RELAB C1SA53), and nontronite (R. V. Morris, personal communication). Gray spectra are all other fits, and bad bands are excluded. Abundances are: (b) 8.87% labradorite, 31.46% vermiculite, 44.16% clay-bearing endmember, 8.05% Fo 10 olivine, 3.68% Fo 40 olivine, 3.78% diopside; (c) 1.39% labradorite, 20.5% saponite, 50.49% clay-bearing endmember, 17.83% Fo 20 olivine, 8.97% diopside, 0.83% ferrosilite; (d) 12.29% labradorite, 23.66% nontronite, 42.79% clay-bearing endmember, 15.65% Fo 0 olivine, 1.78% Fo 60 olivine, 3.83% augite.