COMPARISON OF SIMULATED CRISM OBSERVATIONS USING AIRBORNE HYPERSPECTRAL IMAGES WITH GROUND TRUTH: IMPLICATIONS FOR MARS.

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Introduction: Hyperspectral data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) on the Mars Reconnaissance Orbiter (MRO) has provided invaluable information for understanding current and past environments on Mars [1-2]. However, natural surfaces can be complex, with coatings or rinds of a few microns masking the underlying rocks, mixing of materials, and other surface complexities potentially leading to incorrect interpretations of the geology. Therefore, verfication in the field is recognized as a fundamental component for most terrestrial remote sensing campaigns, a luxury only possible for Mars at the lander and rover sites, for which in situ analytical capabilities are limited. As part of a study of terrestrial analogs of Martian habitable environments [3-6], we have generated synthetic CRISM spectral summary parameter maps of the analog study sites using converted airborne hyperspectral data. These have been used to make surface composition predictions which were then verified through field study and sample analysis. We show that the pseudo CRISM parameter maps identify geologic boundaries and approximate mineralogy, with mineral mixing complicating interpretations. Our results have implications for interpreting similar data for Mars.

Background: The presence of phyllosilicates overlain by sulfates on Mars, originally found by the OMEGA (Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité) spectrometer [7] and subsequently verified and mapped in greater detail by CRISM [8], forms the basis of the hypothesis of global-scale changes from alkaline to acidic conditions in the presence of water, followed by the dry environment that exists up to the present day [7]. An alternative proposal is that the apparent stratification is caused by chemical gradients, not temporal boundaries [5], similar to those found in modern acid-saline lakes in Australia [9-11]. As part of a broader effort investigating terrestrial analogs to habitable environments, we have obtained airborne hyperspectral data over two lake regions in southern Western Australia, the Brown-Campion-Chandler system (henceforth referred to as the Lake Brown region) and Lake Gilmore. These locations are applicable to Mars, as they contain a suite of clays, sulfates, and salts formed under variable pH and salinity - mineralogies similar to those observed in Noachian and Hesperian terrain. Visible and near infrared hyperspectral data for these sites were obtained from HyMap, an airborne imaging spectrometer built by Integrated Spectronics Inc., Sydney, Australia. HyMap has a similar spectral range and resolution to CRISM, OMEGA, and the ASD field spectrometer (Table 1). The bandpasses within the spectral range are also similar, except that The CRISM team uses spectral summary parameters and mapping browse products (parameter composites) to investigate the presence and distribution of minerals and amorphous phases [12]. Of relevance to this investigation are the IR_PHY and IR_HYD products, which parameterize spectral structure consistent with phyllosilicates and sulfates, respectively. Each product uses three different detection parameters, mapping them into the red, green, and blue channels.

Table 1. Comparison of HyMap, CRISM, OMEGA and ASD Spectrometer

	HyMAP	CRISM	OMEGA	ASD
Wavelength Range (μm)	0.45 to 2.5	0.36 to 3.92	0.5 to 5.2	0.35 to 2.5
Spatial Resolution	3 to 10 m/pixel	18 to 200 m/pixel	300 m to 4.8 km per pixel	25 degree FOV
Spectral Resolution	~15 nm/ channel*	6.55 nm/ channel	14 nm/ channel	3 to 10 nm/ channel**
Number of Bands	126	544	352	2151

*15-16 nm from 0.45-1.8 and 18-20 nm from 1.95 to 2.48
**3 nm at 700 nm and 10 nm at 1400 nm and 2100 nm

Methods: The HyMap data were acquired on Nov. 28, 2008 for the Lake Brown region and on Dec. 6, 2008 for Lake Gilmore. These were accomplished using nine ~1.8 x 32 km and eight ~1.8 x 17 km flightlines, respectively. Atmospherically-corrected reflectance data at ~ 3 m/pixel were provided by HyVista Corporation. These data were then resampled to the wavelengths and full width-half maximum of the CRISM 73 bandpasses used in multispectral mapping mode, except for gaps in HyMap spectral coverage corresponding to atmospheric water absorption bands. Ten relevant bands were extracted from available bandpasses and used to make simulated IR_PHY and IR_HYD maps (Fig. 1, Table 2). These maps differed from the CRISM products in not mapping the band depth at 1.9 μm (BD1900) into the blue channel, as HyMap has no spectral coverage in this region because of atmospheric water bands. Instead, reflectance at 1.6 μm was used. Similarly, the reflectance at 1.93 μm used in the CRISM 2.1 μm band depth (BD2100) parameter could not be used for HyMap. Instead reflectance at 1.9742 μm was used.

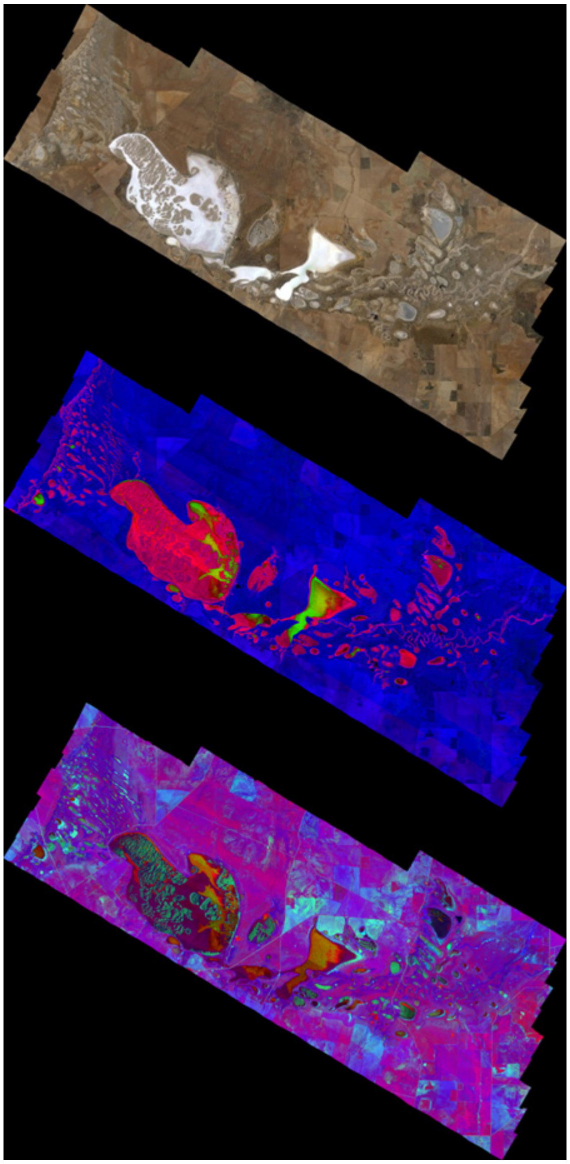

Figure 1. HyMap data of the Brown-Campion-Chandler system. Visible color using HyMap bands (R=R705, G=R589, B= R499) is at top, simulated CRISM IR_PHY product is in middle, and IR_HYD at bottom (with 1.6 μm albedo mapped to blue). Each strip is ~1.8 km wide.

Table 2: Simulated CRISM Spectral Parameters Used in Map

	Red	Green	Blue
IR_PHY	D2300	BD2210	R1600*
IR_HYD	SINDEX	BD2100	R1600*

*CRISM BD1900 replaced with R1600 due to atmospheric H_2O

Three principal morphologic/geologic units types were identified: Lunnettes, inter-lunette surfaces, and playa surfaces. Coverage also included nearby farms and forests, which were not relevant to this study. Regions of interest in both the IR_PHY and IR_HYD parameter maps were correlated and identified for field investigation. Once at the sites, the units were located with GPS, photographed, and analyzed with a field spectrometer. Collected samples were then analyzed in the laboratory using an ASD spectrometer and XRD.

Results: *Lunnetes*: The IR_PHY/IR_HYD maps indicate a sulfate-dominated surface. In the field, these crescent-shaped duneforms are composed of gypsum-rich lake sediment and are commonly anchored by plants, consistent with the prediction. *Playa Surfaces*: 1) The maps predict a phyllosilicate-dominated surface with some sulfates. Field investigation shows these surfaces as crystal-free clay overlain by gypsum crytals. 2) Other playa surfaces, although having a similar gypsum cover, were predicted to have mixed (Fe/Mg + Al) phyllosilicates in addition to sulfates. The observations are consistent with laboratory spectral and XRD analyses of samples, which showed mixing of clay-rich soils with sulfates. These complexities may reflect mixing of clay-rich soil and mud with gypsum at the surface.

Discussion and Summary: Results show that HyMap hyperspectral data could be used to simulate CRISM data and derived spectral parameter maps. Despite atmospheric water hindering the use of the CRISM BD1900 spectral parameter, sufficient spectral information was still obtained for CRISM IR_HYD and IR_PHY products. The simulated CRISM parameter maps show their use in identifying geologic units and their component materials, with some caveats. While sulfate-rich surfaces correlate to predictions in the IR_HYD map, the IR_PHY map exhibits variable responses, even for apparently similar conditions seen in the field. This may result from mixing of low albedo clay-rich materials in variable amounts with high albedo sulfates. This suggests caution in cases on Mars where surfaces are mixed.

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