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Scale-integrated spectral characterisation of mineralogical analogues to Mars at Rio Tinto

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Abstract

Iron-sulfur and phyllosilicate assemblages within the Rio Tinto basin of Huelva province in Spain show mineralogical similarities to sites on the surface of Mars as determined by orbital and lander datasets. Exploration of Mars surface environments is intermittent and resolution-limited, and additional layers of information available for terrestrial analogue sites may extend incomplete planetary datasets. Characterising mineralogy in satellite, field and laboratory reflectance spectra of Rio Tinto sites can determine how accurately Mars-relevant mineralogies are represented in orbital data. Comparisons with Mars datasets, such as OMEGA and CRISM, will provide insights into planetary surface conditions.

1. Introduction

Depositional environments of interest on the surface of Mars include the sulfate- and hematite-rich sedimentary deposits characterised by Opportunity at Meridiani Planum, and the extensive phyllosilicate deposits of the early Noachian detected by the OMEGA instrument onboard Mars Express. Partial environmental analogues to both mineralogies may be found within the Rio Tinto Basin in southwestern Spain [1, 2]. Carrying out a detailed spectral characterisation of the visible-near infrared (Vis-NIR) signatures of Rio Tinto minerals across varying scales will allow direct comparisons to be made between these terrestrial datasets and analogous Mars datasets provided by hyperspectral imagers including OMEGA and CRISM, which are currently providing information on Mars surface environments. The additional level of detail provided by laboratory analysis of hand samples, which provides ground truth for remotely sensed datasets in terrestrial environments, can also provide insights into Mars surface conditions for areas which have yet to be visited by lander.

2. Methods

Hyperspectral satellite coverage of sites within the Rio Tinto basin were acquired from the Hyperion instrument onboard Earth Observing 1 (EO-1). Vis-NIR field spectra of sites within the Rio Tinto basin were collected using an ASD field spectrometer, and laboratory-based measurements of returned samples were made in the same wavelength range. MIR, Raman and XRD of returned samples will provide additional mineralogical ground truth. The datasets generated can be utilized to characterise mineralogy from orbital to in situ scales to determine how accurately ground conditions are represented in orbital datasets.

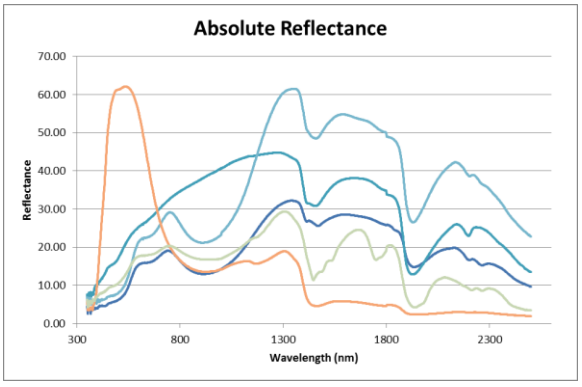

Figure 1. Preliminary Vis-NIR spectra of iron-sulfur field mixtures from sites within the Rio Tinto basin. At shorter wavelengths spectra are dominated by absorptions associated with electronic transitions of iron in hematite and goethite, while H_2O and OH vibrational bands in bound water within hydrated sulfates and hydrated oxyhydroxides dominate at longer wavelengths.

3. Discussion and Conclusions

Interaction between materials in field mixtures can lead to potential interferences between endmembers and/or offsets in spectral features, which can obscure or hinder the identification of certain minerals [e.g. 3]. Such interactions can be difficult to predict on the basis of library spectra collected using pure materials. Determination of which diagnostic spectral features can be identified in field mixtures is an advantage of collecting data in real world environments, and can be used to aid interpretation of planetary datasets.

This study will utilize the dynamic sulfur and iron deposits of Rio Tinto as an analogue of Mars sites such as Meridiani Planum, using the many scales of observation available for the terrestrial sites as a means of extending our view of Mars surface conditions from the orbital view to which we are frequently limited. The development of a scale-integrated (orbital to in-situ) approach to exobiological investigations and the design of effective surface science in planetary environments are facilitated by investigation of terrestrial analogues and biosignatures, which can inform our view of how microbiological activities are tied to macroscopic mineral deposits [4, 5].

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