COMPARATIVE SPECTROSCOPIC STUDY OF PYROXENE AND HYDRATED MINERALS MIXTURES RELEVANT TO ZHURONG MarSCoDe SWIR DATA INTERPRETATION. Enming Ju[1], Changqing Liu[1], and Zongcheng Ling[1*] [1]Shandong Provincial Key Laboratory of Optical Astronomy and Solar-Terrestrial Environment, Institute of Space Sciences, Shandong University, Weihai, Shandong, 264209, China. (zcling@sdu.edu.cn)

Introduction: On May 15th 2021, China's Zhurong rover landed in southern Utopia Planitia on Mars. The Short-Wave Infrared Spectrometer (SWIR) on the MarSCoDe payload of Zhurong rover revealed the presence of hydrated minerals. Due to the existence of different matching results for SWIR spectral features, there are different interpretations for the identification of minerals, such as the possible presence of hydrated sillica, gypsum [1] or pyroxene, allophane, and imogolite [2]. In order to further constrain the mineral species and content, we synthesized allophone in the laboratory and mixed it with pyroxene in different ratios. The SWIR data from MarSCoDe were studied in comparison with laboratory spectra, leading to further use of SWIR data for mineral identification and quantitative analysis of mineral composition.

Data and method: The original radiance SWIR spectra were converted to absolute reflectance using calibration targets after wavelength calibration. Combined with Micro-Imaging Camera (MI) images, we selected 12 SWIR spectral data representing Martian soil for analysis. The selected spectra were averaged and smoothed to reduce the effect of noise (Fig. 1). The smoothed spectrum shows absorption features at ~0.935 μm and ~2.224 μm. The broad band at ~0.935 μm can be assigned to pyroxene. For the absorption band at ~2.224 μm, the features match better with allophane.

Table 1. Spectral ID for spectra as shown in this study.

Label in Figure	Composition 1	Composition 2
A:P=1.8:1.2	1.8 g Allophane	1.2 g Pyroxene
A:P=1.6:1.4	1.6 g Allophane	1.4 g Pyroxene
A:P=1.4:1.6	1.4 g Allophane	1.6 g Pyroxene
A:P=1.2:1.8	1.2 g Allophane	1.8 g Pyroxene
A:P=1.0:2.0	1 g Allophane	2 g Pyroxene
A:P=0.8:2.2	0.8 g Allophane	2.2 g Pyroxene
A:P=0.6:2.4	0.6 g Allophane	2.4 g Pyroxene
A:P=0.4:2.6	0.4 g Allophane	2.6 g Pyroxene
A:P=0.2:2.8	0.2 g Allophane	2.8 g Pyroxene
A:P=0:3		3 g Pyroxene
G:P=0.2:2.8	0.2 g Allophane	2.8 g Gypsum
EA-EAC-028-A	Montmorillonite	
ER-TGS-038	Montmorillonite	
JB-JLB-A33	Opal	

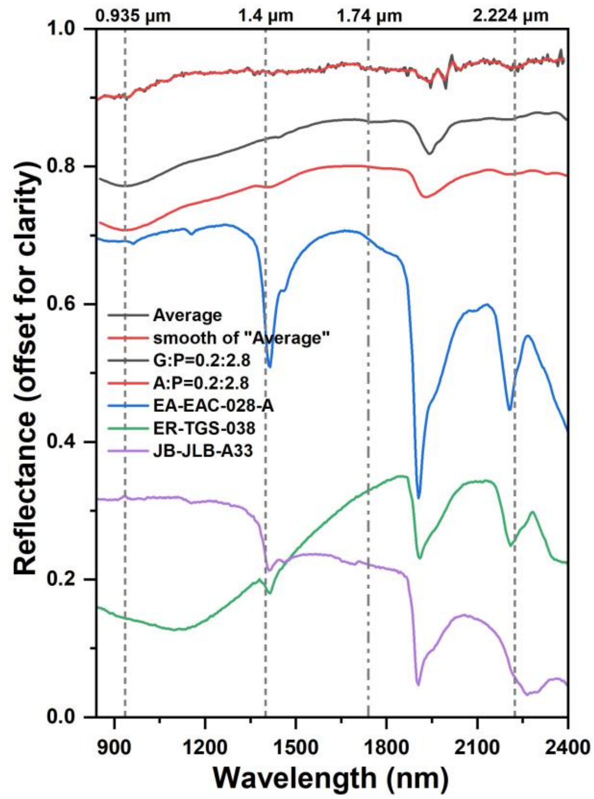

Figure 1. Comparison between MarSCoDe SWIR averaged spectrum and laboratory spectra. The top spectrum represents the processed SWIR spectra acquired by MarSCoDe. Black, red, blue, green, and purple lines represent laboratory spectra.

To further enable spectral matching and soil composition content inversion, we prepared 10 sets of mixtures of pyroxene and allophane with different mass ratios (Table 1 and Fig. 2). The visible and near-infrared (VNIR) spectra of mixtures were obtained using a FiledSpec4 Hi-Res VNIR spectrometer. The VNIR spectra were further resampled into SWIR using ENVI software.

The absorption depth of the SWIR spectrum is positively correlated with the composition content, so we choose the absorption features of ~0.935 μm and ~2.224 μm as a characterization of the presence of pyroxene and allophane (or hydrated minerals). Integrated band depth (IBD) parameter technique [3] to evaluate the content of pyroxene and allophane. We use the IBD ratio to characterize the content of allophane, and the meaning of the IBD ratio is as follows:

$$IBD\ ratio = \frac{IBD_{Allophane}}{IBD_{Allophane} + IBD_{Pyroxene}} \times 100\%$$

$IBD_{Allophane}$ and $IBD_{Pyroxene}$ represent the IBD values of ~2.224 μm and ~0.935 μm absorption features, respectively. The IBD ratio was used to establish a correspondence model with the Allophane content. Leave-one-out validation was used to evaluate the performance of the IBD ratio model.

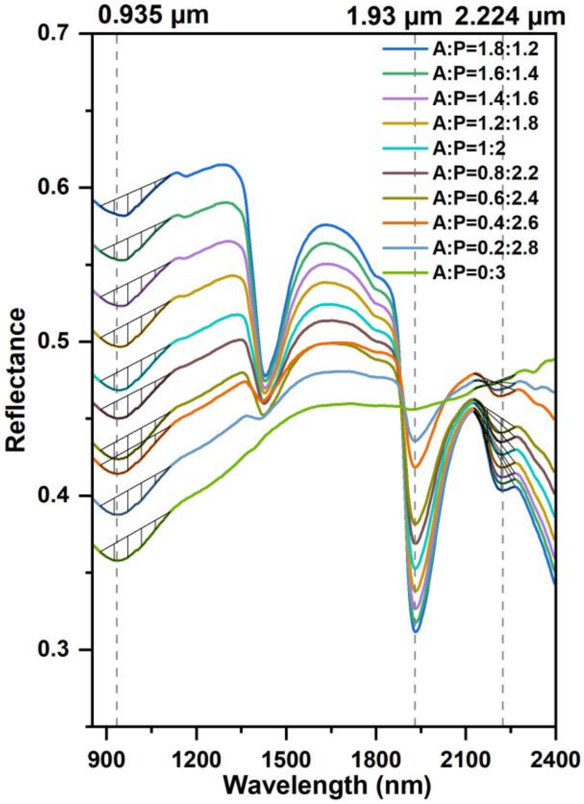

Figure 2. SWIR spectra of pyroxene and allophane mixtures. There were 10 sets of mixed samples, each with a total mass of 3 g. The allophane mass varied from 0 to 1.8 g with a mass gradient of 0.2 g.

Results: The IBD ratio model was applied to SWIR data to assess the content of allophane in Martian soils and rocks (Fig .3). We only considered the simplest case of binary mixture when building the IBD ratio model. Therefore, the model is only able to reflect the relative content of minerals with absorption features at ~0.935 μm and ~2.224 μm. With the preliminary predictions of the model, the allophane content in Martian soils and rocks at Zhurong's landing site varies widely. Considering the relatively small signal-to-noise ratio of the SWIR data itself, the noise may lead to some inaccuracy in the results of allophane. The IBD values for the absorption features of pyroxene at ~0.935 μm may be small due to the effect of noise, while the allophone content is relatively amplified, and the results for allophane content of ~80% may be due to this reason.

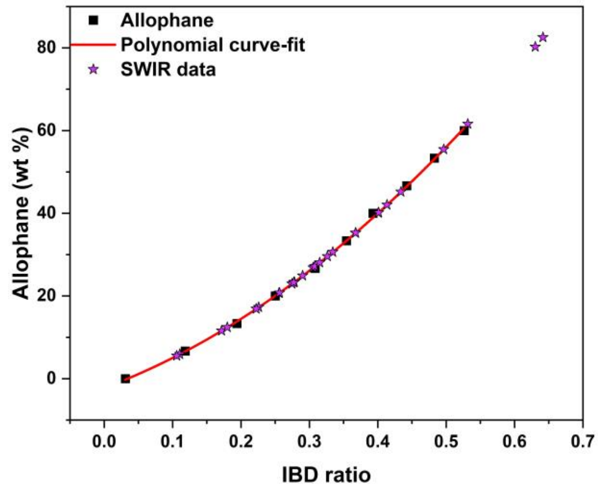

Figure 3. Results of the IBD ratio model applied to SWIR data.

In summary, the content of allophone or hydrated minerals in Martian soils and rocks is more concentrated in the range of ~20% to ~30%, representing to some extent the degree of weathering. To further constrain the degree of weathering and the content of pyroxene and allophone or hydrated minerals in the Tianwen-1 landing site, noise and atmospheric influences will be further eliminated in future work.

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