

**THERMAL ALTERATION OF DECCAN PALEOSOLS, INDIA: A CORRELATION WITH MARTIAN PHYLLOSILICATES USING FOURIER TRANSFORM INFRARED SPECTROSCOPY.** A. Elsenousy<sup>1</sup>, P. Gavin<sup>1</sup>, V. Chevier<sup>1</sup>, M.R.G. Sayyed<sup>2</sup>, R. Islam<sup>3</sup>. <sup>1</sup>Arkansas Center for Space and Planetary Sciences, 202 Old Museum Building, University of Arkansas, Fayetteville, AR, USA, 72701. <sup>2</sup>Department of Geology, Poona College, Camp, Pune 411 001, India, <sup>3</sup>Wadia Institute of Himalayan Geology, 33 General Mahadeo Rd, Dehradun, 248 001, India. [amira@uark.edu](mailto:amira@uark.edu).

### Introduction:

Mars's surface has been identified by large Phyllosilicates deposits that linked with Noachian terrains [1]. It has been suggested that this Phyllosilicates formed by activity of water on Mars's surface long time ago [2]. Additional possible methods were suggested about formation of Phyllosilicates deposits on Mars's surface. It has been suggested that the Phyllosilicates might be formed by the hydrothermal processes caused by meteoritic impacts [3]. For complete identification of how Phyllosilicates formed on Mars, we compare it with earth's Phyllosilicates from the Deccan Paleosols, India. Indeed, Martian phyllosilicates have probably been affected by thermal alteration due to volcanism and/or meteoritic impacts [6].

Deccan paleosols formed between 61.5 and 64.4 million years ago by weathering of basalt and volcanic ash in western India [4]. Then, they have been buried under later volcanic flows after their formation and it has been suggested that they experienced significant thermal alteration [5].

The purpose of this study is to heat the Deccan soils under atmospheric conditions similar to early Mars in an attempt to determine the paleotemperature at which the soils were affected by the volcanic flows. This will bring information on possible thermal processes on early Mars.

### Experimental Methods and Equipment:

The experimental work was performed at the wet laboratory, University of Arkansas following the same method reported in our previous study [6]. The experimental process is carried out by heating each sample by steps of 100°C and measuring its reflectance spectra. Primarily 0.25 gram of each sample were weighted and then placed in the center of ceramic heating tube and after that placed in a Lindberg high-temperature tube oven. The samples were heated to temperatures ranging from 300°C to 600°C for durations about 24 hours in air. Some samples were also heated for 24 hours under a steady flow of CO<sub>2</sub> to more closely simulate the early Martian atmosphere. After heating, the samples were allowed to cool overnight and then were removed and weighed again. Samples that had been heated under CO<sub>2</sub> remained under the gas flow until they had totally cooled. After

weighing, the samples were placed into small plastic tubes until they were analyzed using Fourier transform infrared (FT-IR).

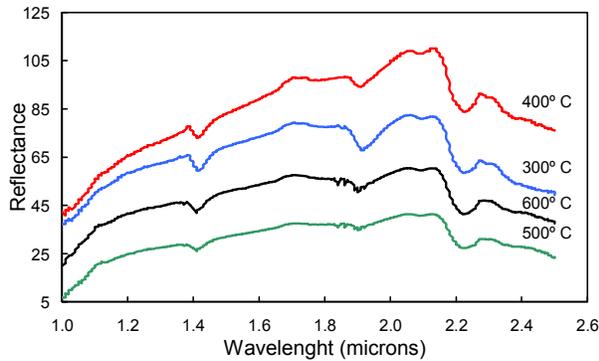
Near-infrared (NIR) spectra were recorded for each sample with using attached optical probe. Before each spectrum the samples were heated under flow of N<sub>2</sub> purge gas for about 2h on a hotplate at 150°C to get rid of atmospheric gases like H<sub>2</sub>O and CO<sub>2</sub>. NIR spectra were recorded in reflectance mode in the range of 4000–10,000 cm<sup>-1</sup> using a CaF<sub>2</sub> beam splitter and a TECP detector. Mid-infrared (MIR) spectra were recorded in the range 350–7350 cm<sup>-1</sup> using an IR source, and a KBr beam splitter and a DTGS detector.

### Results:

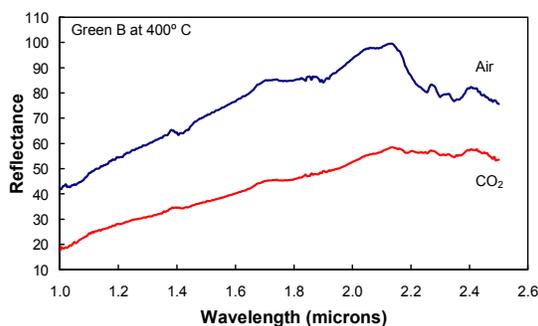
Samples of this study were classified based on their difference in color. There are 11 samples: (A, C, E, F, G and HR) are red, (B, D) are green, and (HG, EG) are yellow, suggesting differences in mineralogy and/or heating conditions, possibly related to oxydoreduction conditions. The mass of every sample was measured before and after heating for each temperature to record if there was any change in the volatile contents (mostly water) (Table 1).

**Table 1:** Conditions and masses of heated samples of Deccan soils.

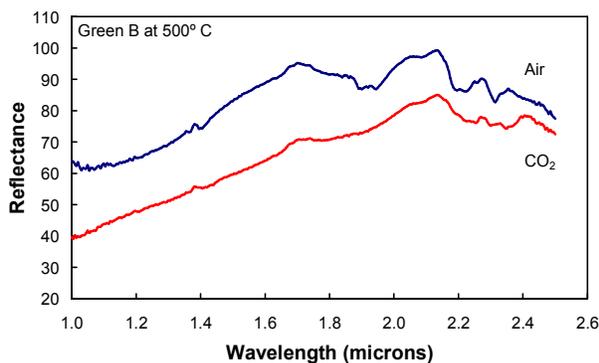
Sample	Color	T (°C)	Atmosphere	Mass before	Mass after
A	Red	300	air	0.24g	0.21g
		400	air	0.19g	0.18g
		500	air	0.13g	0.11g
		600	air	0.1g	0.09g
B	Green	300	air	0.24 g	0.24 g
		400	air	0.21 g	0.17 g
		500	air	0.16 g	0.14 g
		600	air	0.10 g	0.10 g
B	Green	300	CO <sub>2</sub>	0.26 g	0.26 g
		400	CO <sub>2</sub>	0.25g	0.23g
		500	CO <sub>2</sub>	0.19g	0.15g
		600	CO <sub>2</sub>	0.14g	0.14g



**Figure 1:** NIR reflectance spectra of Samples A (red), at different temperatures from 300°C to 600 °C.



**Figure 2:** NIR reflectance spectra of Sample B (green) in Air and in CO<sub>2</sub> at 400°C



**Figure 3:** NIR reflectance spectra of Sample B (green) in Air and CO<sub>2</sub> at 500°C

NIR spectra of red samples were characterized by specific absorption bands. Figure 1 shows the NIR spectra of red sample (A) at different temperatures ranging from 300 to 600°C. The NIR spectrum of red sample is characterized by 1.4 and 1.9  $\mu\text{m}$  hydrated bands decreases as the temperature increases (Fig. 1). No significant changes have been noticed for the metal-OH band at 2.2-2.4  $\mu\text{m}$  section. Figure 2 and 3 show the NIR spectra of green sample (B) at 400 °C

and 500°C under two different atmospheric conditions (air and CO<sub>2</sub>). Treating the samples under two different atmospheric conditions can be clearly observed through the NIR spectrum. The NIR spectrum of green sample at 400°C and 500°C in air is characterized by 2.35-2.37  $\mu\text{m}$  absorption bands, which indicate the presence of Fe<sup>2+</sup> [7]. A 2.29  $\mu\text{m}$  absorption band is obviously observed, which indicates presence of Fe<sup>3+</sup>. In contrast, at the 2.35-2.37  $\mu\text{m}$  and 2.29  $\mu\text{m}$  regions, no absorption bands have been observed.

#### Discussion:

Spectral properties in the NIR spectrum of Sample A (red) (Figure. 1) starts to change at temperature of 500°C. The intensity of 1.4 and 1.9  $\mu\text{m}$  hydrated bands decreases as the temperature increases. We assume that the temperature at which the spectral properties would start to change would indicate the temperature at which the soil was heated by the volcanic flow. The only other thing that could affect the spectra would be the atmosphere as shown by sample B (green) (Figure 2 and 3). The 2.35-2.37 $\mu\text{m}$  and 2.29  $\mu\text{m}$  absorption bands is obviously observed at figure 2 at 400°C , which indicate presence of Fe<sup>2+</sup> and Fe<sup>3+</sup>. Heating sample B at higher temperature (500°C) shows decreases in 2.35-2.37 $\mu\text{m}$  absorption band and increases in 2.29  $\mu\text{m}$  absorption band. This change is due to oxidation of Fe<sup>2+</sup> when heated under atmospheric air. Heating sample B under CO<sub>2</sub> atmosphere shows no change in 2.35-2.37 $\mu\text{m}$  absorption band, due to absence of atmospheric oxygen.

#### Conclusion:

From all data analysis with NIR and MIR, it has been found that both increasing the temperature and changing the atmosphere could change the spectral properties of Deccan soils. In addition, this data confirmed that the Deccan paleosols are a candidate material to study and understand the early thermal processes on the early Mars.

#### References:

- [1] Poulet, F., et al., (2005) *Nature* 481, 623-627. [2] Chevrier, V., et al., (2007) *Nature* 448, 60-63. [3] Fairen, A., et al., (2010) *PNAS* doi: 10.1073/pnas.1002889107. [4] Wilkins, A., et al., (1994) *Wiley Eastern Ltd, New Delhi*, 217-232. [5] Roy, A., et al., (2001) *Geol. Surv. Ind. Spl. Pub. No.* 64, 543-551. [6] Gavin, P., and Chevrier, V., (2010) *Icarus*, 208, 721-734. [7] Bishop, J., et al., (2008) *Clay Minerals* 43, 35-54.