HYPERSPECTRAL STUDY OF HYDROUS MAGNESIUM MINERALS (SERPENTINE) FROM ULTRAMAFIC ROCKS ALONG THE RIKHABHDEV LINEAMENT, RAJASTHAN, INDIA: AS AN ANALOGUE FOR HYDROUS MAGNESIUM MINERALS ON MARS. N. Jain, S. Bhattacharya, P. Chauhan, and Ajai. Planetary Sciences & Marine Optics Division, Marine, Geo and Planetary Sciences Group, Space Applications Centre (ISRO), Ahmedabad - 380 015, India (nirmala@sac.isro.gov.in, / Fax: +91-079-26915825).

Introduction: Earth can provide an excellent analog environment as it allows us to understand the geological processes that might have operated on Mars in its past. Serpentine has been reported from the Noachian crust of the Nili Fossae region of Mars by MRO-CRISM and Mars Express-OMEGA observations [1]. Aqueous alteration during the Noachian period suggests that liquid water might have been available in significant amount to alter the crust through hydrothermal activities. On the Earth, serpentine forms due to the aqueous alteration of dunites in the mid oceanic ridges and also in the obducted ophiolite suits associated with folded mountain belts. The objective of the present study is to characterise and interpret the diagnostic spectral features of terrestrial analogues to Mars, which in turn will help in remote exploration of Martian surface. Methane can form during serpentinisation process. The geologic settings of serpentine bearing deposits in and around Rikhabhdev lineament in the Aravalli Supergroup, found by FieldSpec3 spectrometer (0.3 µm-2.5µm) may help in the study of astrobiology and methane formation on the Mars.

Geology of study area: In and around study area, the hydrous magnesium mineral serpentine are occured in ultramafic rock types in the Aravalli Supergroup. The rocks are represented by serpentinite and its metamorphosed products namely talc-carbonate, talc-schist and dolomite. Here serpentinite is contain mainly antigorite with some amount of chrysotile. Antigorite is the major constituent in massive serpentinite and in altered varieties of serpentine, carbonate and talc are the dominant minerals with chlorite, tremolite etc. as minor constituents [2].

In the hydrous magnesium mineral (serpentine), chrysotiles are the silky and fibrous variety of serpentine, lizardites are Massive green serpentine and antigorites fibrous variety of serpentine [3]. Study area shows fine to medium grained serpentinites are hard, compact, and massive, jointed with colour in various shades of green and contain magnetite crystals. Ferruginus material were also found in the serpentine minerals [2].

Methodology: Reflectance spectra of hydrous magnesium minerals, serpentine (antigorite. chrysotile, lizardite) and other phyllosilicates (chlorite, talc, vermiculite, nontronite, kaosmectite, saponite) have been collected from Dungarpur area, Rajasthan, India using FieldSpec3 spectrometer (0.3 µm-2.5µm). Spectra of the minerals obtained from the study area have been compared with the USGS spectral library in order to identify the minerals present in the study area. Spectral Feature Fitting (SFF) and Spectral Angle Mapper (SAM) techniques have been utilized to carry out the similarity analysis between the unknown spectra from the field and the standard reference from the USGS spectral library.

Result: Here we present a comprehensive spectroscopic analysis of serpentines, as obtained from the Rikhabhdev ultramafic suite near Dungarpur, Rajasthan. Study area also contain carbonates and phyllosilicate minerals. In the present study, we have derived spectral band parameters, namely, band center, band depth and band width of hydrous magnesium minerals (serpentine) and other phyllosilicates (chlorite, talc, vermiculite, nontronite, kaosmectite etc.) from the Dungarpur, Rajasthan in order to identify the mineral phases present that may act as a clue to the understanding of the past climate.

Serpentines are trioctahedral phyllosilicates with the general formula $(Mg,Fe)3Si_2O_5(OH)_4$ and form during form during metamorphism, hydrothermal activity, or weathering of ultramafic rocks [4] and they forms under highly reducing environment and at high pH. As the serpentine minerals forms by the aqueous processes so their presence on the Mars gives the information about aqueous alteration processes which might be occured on the Mars.

The serpentines like antigorite (figure 1) shows the absorption feature at 1.39µm 2.11 µm and 2.32 µm which is the diagnostic absorptions of these minerals. Lizardite (figure 2) also shows the absorption at 2.32 µm and crysotile (figure 3) shows the absorption at1.39µm, 2.32 µm.

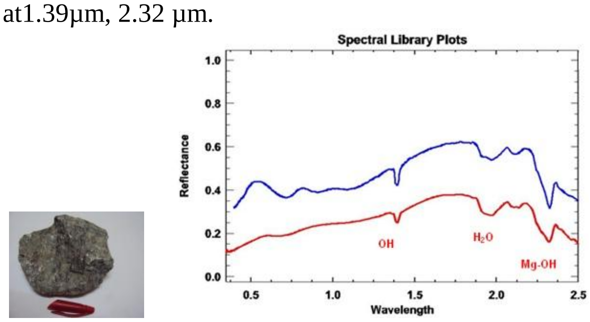

Figure 1. Reflectance spectra of Antigorite from dungarpur area (Red) and pure antigorite spectra from USGS spectral library (blue). The spectra of the sample shows absorption feature at 0.7, 0.9, 1.39, 1.97, 2.11, 2.32 µm.

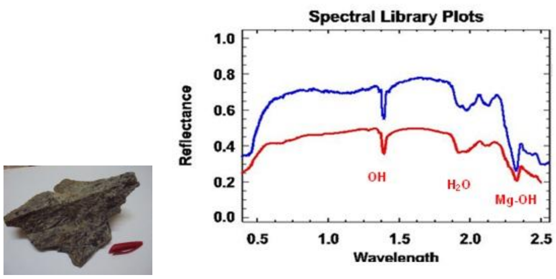

Figure 2. Reflectance spectra of Lizardite from dungarpur area (Red) and pure lizardite spectra from USGS spectral library (blue). The spectra of the sample shows absorption feature at 0.7, 1.4, 1.95, 2.12, 2.32, 2.46 µm.

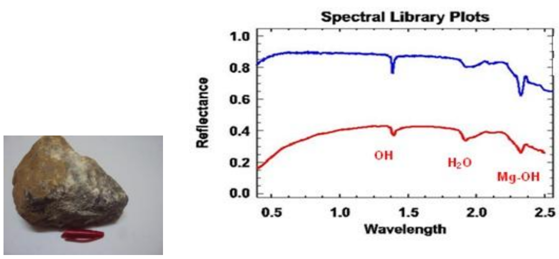

Figure 3. Reflectance spectra of Chrysotile from dungarpur area (Red) and pure chrysotile spectra from USGS spectral library (blue). The spectra of the sample shows absorption feature at 1.39, 1.9, 2.0, 2.32, 2.37, 2.42, 2.45 µm.

The strongest absorption is centered at 2.32 µm for Mg-OH in all magnesium serpentines. Serpentines have an OH stretching overtone located at 1.39 µm for Mg serpentines that shifts to somewhat longer wavelengths (1.40–1.41 µm) for Fe-rich serpentines. Mg serpentines also have a diagnostic band at 2.10–2.12 µm. There is a 1.9 µm band indicating the presence of H_2O. This study will help in the study of Mg serpentine formation occurs in Nili Fossae region on the Mars. Spectra of serpentine (figure 4) also shows the presence of Mg-OH and OH stretching overtone at 2.32 µm and 1.39 µm respectively.

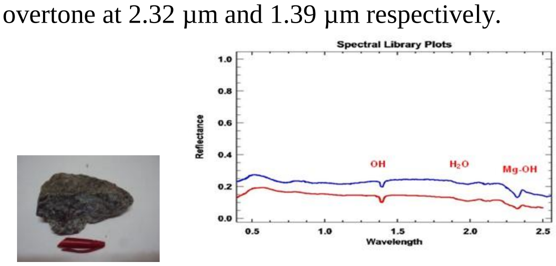

Figure 4. Reflectance spectra of Serpentine from dungarpur area (Red) and pure serpentine spectra from USGS spectral library (blue). The spectra of the sample shows absorption feature at 0.69, 1.39, 1.85, 1.95, 2.32, 2.38, 2.46 µm.

A comparative analysis of these spectral features with USGS mineral spectra has also been carried for identifying the specific mineral in field area.

Conclusion: Reflectance spectroscopy has been extensively used as a tool for remote compositional assessment of planetary bodies including the Mars. Spectroscopic and geochemical (e.g., XRD, XRF and SEM) techniques are useful for the study of spectral and geochemical signatures of Martian analogues. A detailed and combined geochemical and spectroscopic analysis of minerals in the analogue sites will help in better understanding the fluid-rock interactions and aqueous alteration processes on Mars. Serpentines, associated with phyllosilicates as obtained from the Rikhabhdev ultramafic suite near Dungarpur, Rajasthan act as a potential analogue for the mars as the similar mineralogy has been observed in the Nili Fossae region on the Mars.

References:

[1] J. F. Mustard. et al. (2007), [2] Shri Benudhar Behera, Geological Survey of India. Journal Of Geophysical Research, Vol. 112, E08S03. [3] G. W. Brindley . et al. (1957), The American Mineralogist, Vol 42. [4] Bethany L. et al. (2007), Journal Of Geophysical Research, Vol. 114, E00D08.