Analogous Mineralogical Study of Moon with respect to Earth

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Abstract

Geological and mineralogical studies of moon are significant to understand the evolution, origin and geological history of lunar surface materials. The advancements in imaging spectroscopy has made mapping of minerals an easier way than ever before. The availability of the unprecedented data for the study of the moon provided by Moon Mineralogy Mapping(M3) of Chandrayaan-1 which was India's first lunar probe orbiting around moon helped in mapping minerals and understanding their spectroscopy (Sivakumar et al. 2015). Lunar sample mineralogy can be broadly sub-divided into global and regional mineral mapping where the regional mapping concentrates on craters and highland regions. In the recent past researchers mapped different features existing on lunar surface and enumerated interesting facts related to the same. Few studies identified that among the mafic minerals, olivine and pyroxene are the most abundant and easily recognizable on lunar surface due to their diagnostic spectral absorption features (Adams, 1974; Cloutis, 1985; Kaur, 2013). Pyroxenes are Ferro magnesium silicates i.e., Silicon-Aluminum oxides of Calcium, Sodium, Iron, Magnesium, Zinc, Manganese, Lithium substituting for Silicon and Aluminum out of which Calcium, Iron, and Magnesium are predominant. It was found that most common pyroxenes are Wollastonite ($CaSiO_3$), Enstatite ($MgSiO_3$), Ferrosilite ($FeSiO_3$), etc. Referring to the previous studies, in the current study an attempt has been made to study the pyroxene absorption spectra of moon in the part of the Wegener crater using multiple mineral mapping techniques and select the effective methods based on image data (He et al. 2009) and compare with that of Earth pyroxene (taken from spectral library available on the world wide websites of USGS). Wegener crater is a wide impact crater of pre-Nactarian age having topographically rugged terrain located in the northern hemisphere of moon with the co-ordinates extending between 45.2°N and 113.3°W with a diameter 88km lies at approximate margin of Colomb- Sarton basin. The concept of this work dealing with analogue study of moon with respect to Earth was carried out using mineralogical data i.e., the spectral behavior of moon and terrestrial rocks. The reflectance spectra provided information about the presence of particular type of mineral (here pyroxene) at various locations of Wegener crater. ISRO Space Data Archive has provided visible- infrared spectral data (Hyper spectral Data of 64 bands) of lunar surface. Photometrically and thermally corrected Level-2 data has been taken from Lunar Orbital Data Explorer (http://ode.rsl.wustl.edu/Moon/). Band shaping methods have been used to identify pyroxene. It was found that Spectral Angle Mapping (SAM) and Spectral Feature Fitting (SFF) have shown varying success in identifying and mapping different minerals. Therefore these two methods have been adopted in this study. The spectral profile for the part of Wegener crater from identified areas was collected and worked using SFF and SAM techniques available within the SNAP/STEP tool and SAGA GIS. SFF was a rigorous method where continuum is removed separately

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from the image data and spectral library data. The continuum removed library spectrum is superimposed on to image spectrum using simple linear gain and offset adjustment whereas SAM the similarity is expressed in terms of average angle between two spectra where these spectra are treated as vectors in space. The spectra whose vectors are separated by small angles are considered as mutually similar. In comparison to SFF, SAM showed best performance in identifying pyroxene. This step aided in identifying the locations of pyroxene at different parts of crater. It was observed that this mineral was mostly found around the rim of sub craters i.e., along the perimeter of the sub craters. Now the sample points have been selected randomly from the locations where pyroxene was found and their absorption wavelengths and intensities are noted, and plotted. The plot between absorption and wavelength gave us the required spectra profile for all the sample points. The absorption feature of pyroxene that was obtained from the above was compared with that of Earth pyroxene. The study observed three different categories of pyroxene spectrum with different wavelength series. 1. Wavelength ranging 700- 750nm 2. 600- 700nm 3. 550- 600nm. These differences could be due to variations in the concentrations of Fe and Ca of pyroxene i.e., type of dominant pyroxene available at that particular place or due to percentage of pyroxene mineral in the rock. The results have shown no difference in the absorption dips of pyroxenes of Earth and Moon except at peak of the spectrum of Earth pyroxene which was expected because of the atmospheric interferences. This study was successful because of availability of correct spectral libraries of Earth pyroxene formation as well open lunar data. Similar studies can be carried out on any planet of solar system with respect to Earth, if data exists.

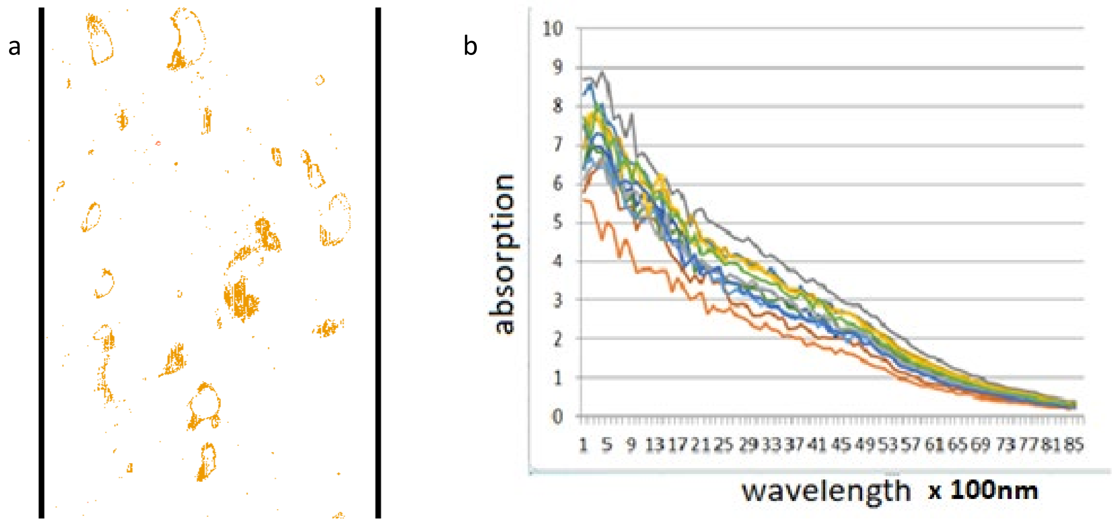

Fig. 1. (a) Locations of availability of pyroxene in the part of Wegener crater; (b) Spectral profile of pyroxene from various locations.

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