STUDY OF SPECTRAL CHARACTERISTICS OF THE CENTRAL PEAK REGION OF TYCHO CRATER USING THE SIR-2 DATA ON-BOARD CHANDRAYAAN-1. M. Bhatt[1], U. Mall[1] , R.Bugiolacchi[1] , and B. Lehmann[2], [1]Max Planck institute for Solar System Research, Max-Planck-Strasse 2, 37191 Katlenburg-Lindau, Germany, bhatt@mps.mpg.de, [2] Mineral Resources, Technical University of Clausthal, 38678 Clausthal-Zellerfeld, Germany.

Introduction: The Lunar Magma Ocean (LMO) hypothesis leads to the fundamental conclusion that Ca-plagioclase-rich rocks (anorthosites to norite) should be present globally in the upper lunar crust. However, impact activities and basin forming events in the early stages of the crust formation have modified the upper layer composition by mixing and redistributing sub-surface materials such as Mg-suite components. Impact activities on the Moon have given us a unique opportunity to investigate the lithology and mineralogy of freshly excavated materials from depth. Impact crater formation theory explains the central peak as the result of uplift of materials from the lower crust or even the upper mantle due to elastic rebound [1]. Surface areas on crater peaks which are often relatively fresh and have undergone less mixing and space weathering, provide, therefore, a good possibility to test the LMO hypothesis. The new instrumentation flown on the Chandrayaan-1 mission, the SELenological and ENgineering Explorer (SELENE) and on the Lunar Reconnaissance Orbiter (LRO) which now allows one to resolves the crater areas with much better spatial and spectral resolution, will foster significant progress in these studies.

We present here the results on spectral characteristics of the Tycho crater (43^0S, 349^0E, D=85 km) central peak using data acquired with the near-infrared spectrometer SIR-2 on Chandrayaan-1. The instrument covers a wavelength range between 0.93 to 2.41 µm with high spatial (~200 m) and spectral resolution (~6 nm) [2].

The study goal is the systematical investigation of the observable variations of the bidirectional reflectance within the central peak region.

Data and Methods: Tycho crater observations were taken during SIR-2 orbits 1085, 1086 and 1087 from an altitude of 100 km. Orbit 1086 crosses directly the central peak region of the crater. A total of 168 sampling points covered the crater interior of which 17 are within the central peak region (Figure 1). We used a SELENE image of the Tycho crater to show the SIR-2 tracks crossing the crater.

The SIR-2 raw data are converted into absolute reflectance values using a standard data reduction process. The photometric function proposed by Shkuratov [3] is used to convert reflectance data into the standard viewing geometry. The phase angle is $\sim 64^0$ for sampling points within the central peak region. The SIR-2 reflectance spectra are normalized to 1.0 at 1.50 µm. A standard continuum removal technique is used over the 2 µm absorption band region.

Analysis and Initial Results: The lunar surface is considered to be an intimate mixture of pure minerals of different grain sizes, containing pyroclastic materials and depositions of vaporized rocks. Space weathering and gardening processes continuously alter the surface materials and complicate lunar mineralogy analysis. Samples of laboratory spectra of major minerals present on the surface of the Moon are shown in Figure 2.

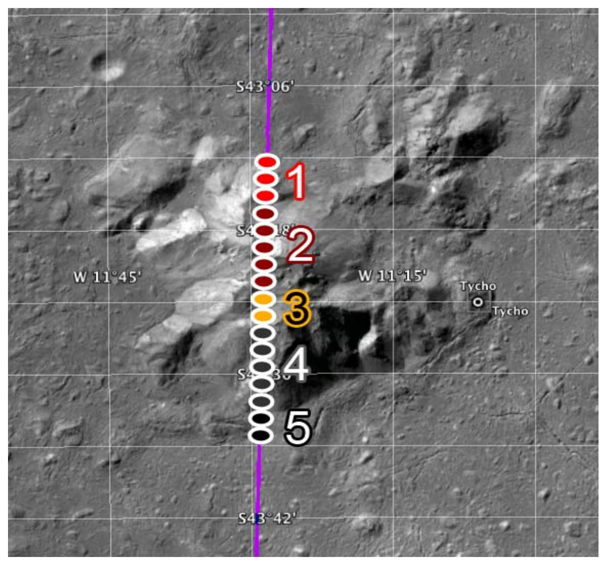

Figure 1: SIR-2 observations sampling the Tycho crater plotted on a SELENE image [10]. Orbit 1086 is crossing the central peak region. The ground spots which are observed by SIR-2 from this region are shown as ellipses.

We have divided 17 sampling points into 5 representative groups of spectra based on its spectral signature (Figure 3). The representative spectra are the average spectrum of SIR-2 sampling points falling within that group. We observe a systematic change in spectral signature as we move downward from spectrum no. 1 to spectrum no. 17 (Figure 1). Groups 1 and 2 show a high-Ca pyroxene absorption band with the band center between 2.00 to 2.07 µm. This finding is consistent with previous published results [4], [5] and [6]. In groups 2 and 3, the 2-µm absorption feature is broader and shallower than that of group 1 and also the absolute reflectance is weaker than group 1. The higher absorption band depth for group 1 spectra indicates exposure of fresh materials in the area corresponding to the group 1 footprints. Groups 2 and 3 are possibly a mixture of high- and low-Ca pyroxenes. The shallower and broader absorption features could be attributed to both maturity and grain size. The higher the maturity and coarser the grain size, the shallower and broader the absorption feature will be. A prominent absorption feature around 1.25μm has been observed in the spectra belonging to group 4 which indicates the probable presence of iron bearing crystalline plagioclase. This group also shows a very broad and shallow 2 μm absorption band which could be due to low-Ca pyroxene. Featureless spectra of group 5 represent mature soil materials.

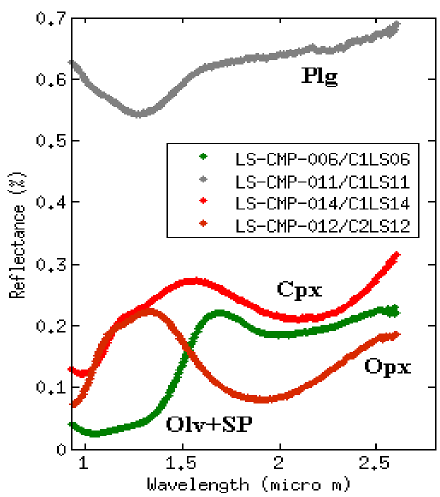

Figure 2: Reflectance spectra of major lunar rock forming minerals.

Our analysis shows similar results with previous work [4], [5] and [6]. Additionally, we see the signature of low-Ca pyroxene for a small area of the central peak. Our present analysis hints towards the probable anorthositic and noritic compositions for the Tycho central peak. Detection of crystalline plagioclase in the central peak also supports the LMO hypothesis; nevertheless, we have not detected the pure anorthosites signature described by [7].

Future Study: The absorption band center is a key parameter for identifying the chemistry of the minerals presence in reflectance spectra. Our understanding about lunar mineralogy is based on the laboratory analysis of returned lunar samples. SIR-2 has great potential of identifying and mapping the major lunar minerals based on the absorption features and spectral band parameters. The global distribution of mafic and felsic minerals can help us to better understand the overall lunar crustal evolutionary process and can probably answer the questions related to: the age range of ferron anorthosites present in the crust, the volume percentage of mafic minerals on central peaks, and the stratigraphic and selenographic distribution of pristine rocks in the lunar crust.

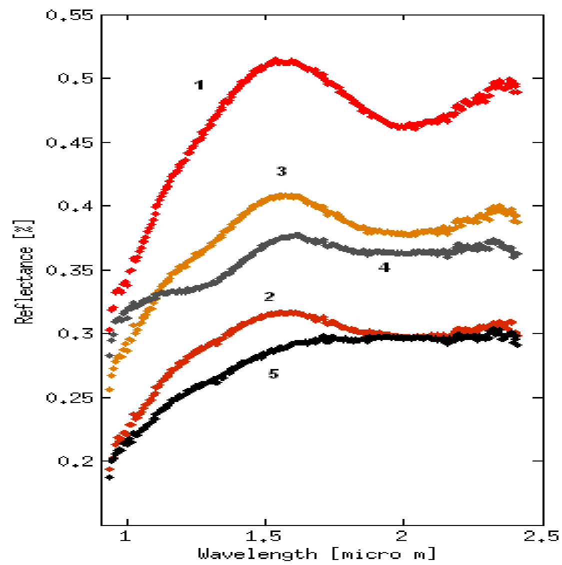

Figure 3: Representative SIR-2 spectra from the central peak region. Grouping is based on spectral variations of 17 sampling points. The group colors correspond to the SIR-2 footprint colors in Figure 1.

A relationship between the absorption band center and molar Ca/Fe content can be derived by empirical calibration correlations obtained by laboratory studies of returned lunar samples [8], [9] and [10]. We can find an empirical calibration correlation using a 2 μm absorption band depth to produce a global distribution map of major mafic minerals present on the lunar surface.

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