SPECTRAL RESULTS FROM MID-IR DRIFT ANALYSIS OF LONAR IMPACT BASALTS, INDIA.

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Introduction: Spectral signatures are important diagnostic tool to decipher mineralogy and impact cratering phenomenon occurring on Earth and Planetary Surfaces. Fortuitously, Lonar Impact Crater in India is the only well-preserved terrestrial crater excavated completely within Deccan trap flod basalts and serves as an "excellent analogue" to craters on Mars and Moon[1]. Here we report on laboratory results of spectral studies on fine-grained (<45 µm) basaltic rock powers using Mid-IR (1400–400 cm^{-1}) Diffuse Reflectance Infrared Fourier Transform (DRIFT) spectroscopy.

Infrared spectra of rock powders of relatively unshocked and shocked basalts are obtained to document the mineral and hence spectral variations with the direction of impact.The results clearly show relative loss of spectral features in western sector compared to eastern sector(direction of impact) as a result of increased shock wave and subsequent disordering of primary mineralogy.Again, mineral distribution maps reveal distribution of primary and secondary minerals around the Lonar crater.

Sample Acquisition and Recording: Most basalt samples were collected from all the sections of the crater, the upper most crater rim, ejecta and distant locations, often as impact basalts,which later subdivided into sector-wise samples to carry out a systematic study of spectral properties of impacted basalts. All spectra were recorded on Nicolet 6700 spectrometer with DTGS detector and KBr window at IIG, Mumbai.

Results: All feldspar dominant rock powder varieties shown here display a continuous sequence of shock effects with increasing pressure. From east (direction of impact) to western sector, spectral features of all samples change systematically. These observed changes are (i) line shift, more pronounced in western sector than in eastern sector (ii) systematic weakening in intensity and strength of absorption bands results in only few absorption bands in high pressure western sector. Our results for powders show that Si-O antisymmetric stretching bands between 1200-900 cm^{-1} get weakened, slightly broadened and the resulting broad absorption band is slightly shifted toward higher wavenumbers in western sector relative to eastern sector. SiO_6 octahedral stretching vibrations between 750-850 cm^{-1} and TF near 825-833 cm^{-1} is associated with feldspar in spectra of powders. Our spectra of the shocked powders show that Si-Si stretching bands between 800 and 700 cm^{-1} also weakened, merge and the resulting absorption band is shifted towards smaller wavenumbers. Again, curve at ~630 cm-1 decrease in intensity, strength and the resulting absorption band is shifted toward higher wavenumbers prominently in west.

Most importantly, ~590 cm^{-1} band decrease in strength & intensity drastically which is very sensitive to structural changes induced by shock pressure in feldspars dominant rocks [2]. This band becomes shallower and gets shifted slightly towards smaller wavenumbers .All feldspar dominant samples display a similar curve of decreasing intensity of ~590 cm^{-1} absorption band. Between 400 and 550 cm^{-1}, bending vibrations in the Si-O-Al planar ring structures in tectosilicates and diaplectic glasses occur. It is observed that there is decrease in strength of ~540 cm^{-1} band & is shifted towards higher wavenumbers. Also observed that all samples, irrespective of direction of impactor, show spectral slope towards higher wave number and for biconical reflectance spectra of powders, CF position is not observed in the powdered sample spectra consistent with previous results [3].

Discussion of Spectra: Diffuse (Biconical) Reflectance spectra of the shocked and relatively less shocked basalt powders shown in Fig.1 demonstrate variety of features that change with increasing shock pressure indicative of lattice disorders and hence changing mineralogy. Entire sample on crater rim and close to it were subjected to nearly same shock pressures. Moreover, most important shock features in feldspar dominant rock powder are found to change drastically in the western sector. These distinctive spectral changes are caused by pressure-induced structural distortions in the bending and stretching motions of Si and Al tetrahedra dominantly within plagioclase feldspars rich basalts [2,4].Previous study show that high shock pressures cause structural disorder in mineral lattice of feldspars resulting in change in position and strength of spectral properties in feldspar dominant spectra whereas pyroxene and olivine dominant spectra are relatively more resilient even at high pressure [5]. And,the precise peak shock pressures at which structural disorder and chang in mineralogy occur vary among different mineral compositions. The IR patterns in relatively high pressure west sector are interpreted as a mixture of decreasing amounts of TS, IS and increasing amounts of PS. Thus, in shocked samples,crystalline and amorphous phases are likely coexist as intimate mixtures with the proportion of primary mineralogy decreases with increasing shock pressure resulting in the gradual disappearance of absorption bands in mid-infrared spectra. Ex. small bands <500 cm^{-1} fade away, shift position & strength at higher pressures. It is well known that the Deccan basalt comprising mainly Labradorite (50%), Augite (31%), Pigeonite (7%) & small amounts of Sulfides + oxides (8%). At the relatively lower shock pressure in east, it is observed that absorptions in the less shocked samples near 1010, 833, 630, 590, 541, and 460 cm^{-1} resulting from plagioclase feldspars with some contributions from pyroxene and olivine. With increasing pressure, the progressive structural disorder caused the Si-O absorption bands in feldspars to shift, weaken and merge such that the highest shock pressure result in suppressed spectra with only few notable bands. In less shocked Deccan basalts, features at ~1010 and ~540 cm^{-1} attributed to slightly more Labradorite (50%) in Deccan basalt flows in the Lonar region. Spectral features attributed to plagioclase feldspar seen in almost all basalt spectrum in east but these features get suppressed in the spectra of more shocked samples in west as the feldspar/tectosilicate has been converted to ionosiliocates & phyllosilicates. The main difference between the two sectors is the abundance of TS, IS and PS. At shorter wavenumbers(<500 cm^{-1}) other absorption bands disappeared and the spectral slopes related to such bands flattened. This is attributable to lower abundance of olivine and pyroxene(IS) relative to TS minerals.Again spectral features apparent in the relatively less shocked powder spectra that diminished in spectrum of more shocked basalt include the position of a Si-O stretching vibrations in region 1010–1008 cm^{-1} region, and Si-O bending vibrations at 590, 541, and 470–460 cm^{-1} band, agreeing with previous reported work [6].Also,known that majority of clinopyroxene in Deccan basalt are Augites (31%) whereas Pigeonite is rarer (~5–8%). In contrast to the multiple features in feldspar dominant spectra that provide sensitive barometers to shock pressure, the pyroxene dominant samples shows little changes in spectral properties with increasing pressure. This is consistent with previous observations of shocked pyroxenes that demonstrated their resiliency to high pressures & also consistent with results obtained from early transmission study of shocked pyroxenes. As suggested previously,absorption band at ~590 cm^{-1} is very sensitive to the structural changes induced by shock. This band appears to represent a measure of the crystallinity and mineralogy of the sample. Previously it is observed that at shock pressure of >18 GPa the intensity of this absorption band decreases drastically in all samples. Our all samples display a similar curve of decreasing intensity of 590 cm^{-1} absorption band. This behavior is similar to that observed in absorption spectra of experimentally shocked feldspars [2]. **Mineral Abundances Maps:** Mineral abundances maps shown here in Fig. 2 are valuable to determine the uniqueness of the shocked feldspar dominant spectra relative to combinations of common minerals. These shocked powder spectra can be used to detect and map shocked materials located in impact ejecta at Lonar to provide an additional means of interpreting the geology and mineralogy of impact materials.

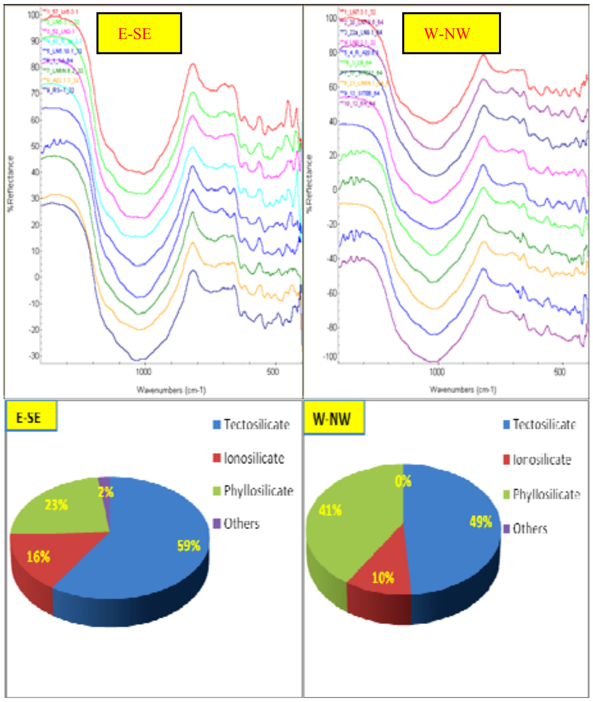

Fig.1:Spectral results from different sectors and mineral distribution maps showing abundance of minerals.

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