SHOCKED PLAGIOCLASE AND IRON OXIDE GLASS FROM LONAR IMPACT CRATER (MAHARASHTRA, INDIA) R. Basu[1], S. Das[2], B. K. Mukherjee[3] and S. Bose[4], [1]Department of Geology, Asutosh College, 92 S.P. Mukherjee Road, Kolkata 700026, West Bengal, India, ***rwiti.basu06@gmail.com***; [2]Department of Earth & Environmental Sciences, 107 Geosciences Building, University of Texas at Arlington,Arlington, Texas 76019, *souvikdasgeology@gmail.com*; [3]Wadia Institute of Himalayan Geology, 33, GMS Road, Dehra Dun 248 001, India; [4]Department of Geology, University of Calcutta, 35 Ballygunge Circular Road, Kolkata 700019, West Bengal, India.

Introduction: Lonar crater (19°58′ N, 76°31′ E), in the Deccan flood basalt province, Indiais one of the youngest meterorite impact craters in the world. Having formed in basaltic rocks, it becomes an important analog for simple lunar and Martian craters. It is a simple, bowl shaped crater, ~1.8 km in diameter. It is ~135 m deep, with the crater rim rising about 30 m from the ground level. The crater cavity is filled by breccia overlain by unconsolidated sediments. [1]. A continuous blanket of ejecta materials extend outwards from the crater to a distance of ~1350 m [2], containing basalt fragments of various shapes and sizes. The basaltic flows of the region are horizontal to subhorizontal in nature with an average dip of 5º-10º [1], but are much steeper (30º-60º) in the crater walls. Exposures in the crater are limited to a 30 m horizon within the inner wall, a few meters beneath the crater rim.

Lonar crater having been formed in basalt, quartz is not readily present in the system, except as rare secondary mineral fillings in the vesicles. Thus, shocked quartz grains which are generally used for characterising the degree of shock metamorphism cannot be used in such a setting. Therefore, in the present study, we have emphasised on the characterisation of the shock metamorphic effects in feldspar. Along with this, we have also attempted to delineate other indicators of shock metamorphism as evidenced by petrographic study and Raman spectroscopic analysis of the deformed rocks.

Petrographic study: The Lonar basalt rocks are mainly composed of plagioclase, clinopyroxene, opaque minerals and altered glass (Boelingite, Iddingsite) in decreasing order of abundance [3]. In some places, calcite grains have also been documented. The grain size distribution in the rocks is bimodal in majority of thin sections. Large laths of plagioclase form the phenocryst, while smaller laths of plagioclase and clinopyroxene form the ground mass of the rock gives rise to porphyritic texture The pyroxene grains present in Lonar basalt are extremely fine-grained; hence these grains are not feasible for petrographic study. The larger phenocrysts of plagioclase are thus used for micro textural analysis.

Shock effects in plagioclase: Planar deformation feature (PDF) is documented in some plagioclase grain. In some grains PDFs of multiple orientation are present (Fig. 1.a). The PDFs are not present throughout the grains; instead they are restricted to sub grains within the phenocryst of plagioclase. Deformation twins are a fairly common occurrence within the shocked Lonar basalts. Microstructural studies reveal that the twin lamellae are sometimes dislocated (Fig. 1.b). Such dislocation planes are recorded both within the phenocrysts and groundmass grains of plagioclase.

In a few places, feldspar grains were seen to be encrusted with a glassy red rim (Fig. 2.c). A dark vein crosscutting the basalt is also encountered hosting numerous microcrystals within a glassy material (Fig. 2.a & b). The implications of these findings as characterized by Laser Raman Spectroscopy are discussed in the next section.

Raman spectra study: The Laser Raman spectroscopy was performed on thin sections of Lonar crater rocks using a Lab RAM HR - Horiba Jovin Yuvon Instrument at the Wadia Institute of Himalayan Geology, Dehra Dun (India). Spectra were generated at room temperature with the 514.5 nm green Ar Laser. The laser spot on the surface had a diameter of approximately 2 - 4 μm and a power of 25 - 33 mW. Exposure times for minor mineral phases were 1 - 40 sec with accumulation number 1- 10. The Raman was calibrated with synthetic Si standard at 520.5 cm^{-1}. The estimated spectral resolution at the time of analyses was < 1 cm^{-1}.

Findings: Raman spectra of the relatively unshocked plagioclase show distinctive characteristic peaks of plagioclase feldspar ranging in composition from labradorite to anorthite. Raman spectra of the deformed part and relatively unshocked part of plagioclase are compared (Fig. 1.b1 & b2). An additional major peak is seen to appear around 548.6 cm^{-1} (Fig. 1.b2) in the deformation twin lamellae. This evidence strongly suggests that the deformation twins represent localized zones of structural disorder within the host plagioclase grains. An additional peak at 342 cm^{-1} is also seen to appear in these spectra. This could also be deformation induced.

Raman spectroscopy of the opaque minerals was also conducted, and the spectral trends thus obtained showed the minerals to be of α-Fe_2O_3 variety [4].The dark glassy part of the veins discussed eariler show distorted bands of α-Fe_2O_3 but with similar trend (Fig. 2.b1). Interestingly, the tiny crystals show a shift to the lower values of bands (209, 265.2 and 1293.9 cm^{-1}) with respect to the Fe-oxide glass. Their imperfect crystal structure could be the probable reason for the downshifting of bands (Fig. 2.b2).

The Raman spectra of the red rim around plagioclase mentioned earlier are also obtained (Fig. 2.c3). The 210.1, 268.2 & 1298.3 cm^{-1} peaks confirm the phase as α - Fe_2O_3 [4].

Discussion: The presence of PDFs, deformation twinning and dislocation planes within plagioclase are strong indicators of impact. Impact effects are also evident from the distortion in the plagioclase crystal structure. The present study also reports unusual Fe-oxide glass in an impactite vein crosscutting the host basalt. Within the impactite vein numerous tiny α – Fe_2O_3 or hematite crystals are seen with strong orientations. These micro crystals suggest high nucleation rate due to rapid cooling of Fe-oxide liquid. This Fe-oxide glass is also seen to encrust some plagioclase grains. This mode of occurrences of the Fe-oxide glass indicates that it was formed by a post magmatic extraordinary secondary process which is likely to be the impact event.

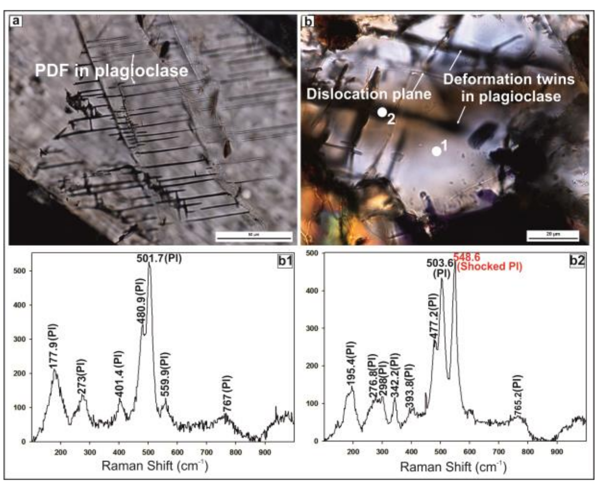

Fig.1. PDFs(a) and deformation twins(b) in plagioclase. Raman spectra analysis shows characteristic peaks to be shifted (b1) and additional peaks appear in the deformation twin lamellae(b2).

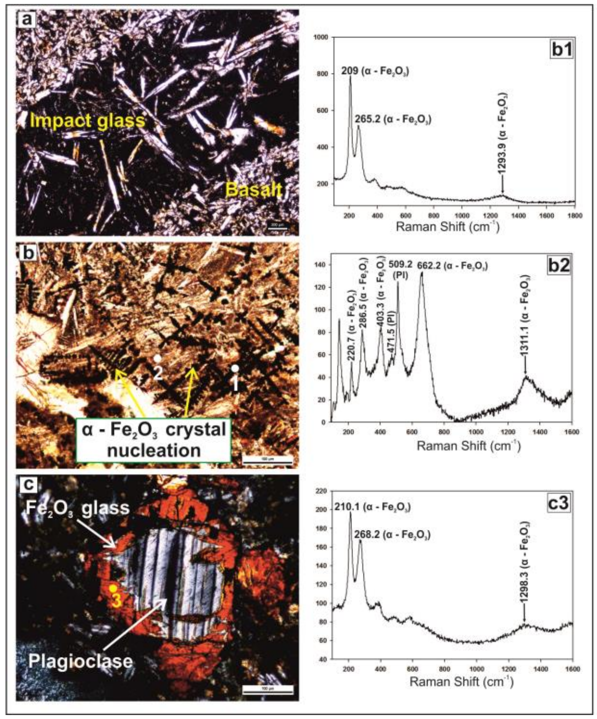

Fig. 2. Glassy vein (a) with α-Fe_2O_3 nucleation as evidenced by Raman spectra analysis (b1 & b2) in Lonar basalt. Plagioclase encrusted with a glassy red rim (c) showing characteristic α-Fe_2O_3 peaks (c3).

References:

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