SHOCK BAROMETRIC CALIBRATIONS FROM IMPACTITES OF DHALA (MOHAR) IMPACT CRATER, INDIA.

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Introduction: The near circular structure (diameter ~ 11 km) at Dhala (Mohar) in the western part of Bundelkhand Gneissic Complex (BGC), is marked by a prominent table-top like geomorphic high rise (outlier) of Vindhyan Supergroup having Meso-to Neo-Paleoproterozoic age and surrounded by granitoid breccias and basement rocks of Archean age (2.5 Ga) [1, 2, 3, 4, 5]. The tentative timing of impact event can be poorly constrained in between 2.1 Ga to 1.7 Ga [1, 5]. This strcture had been interpreted as a volcanic eruption related "cauldron structure" [6, 7] and meteoritic "impact crater" by several workers [1, 2, 3, 4], mostly on the basis of absence or presence of shock features in the clasts of granitoid breccia. The presence of impact melt breccias and pseudotachylite melt veins with diagnostic shock metamorphic features [1, 2, 3, 8, 9, 10] and rhyolite-like felsic melt breccia derived by the impact melting of the basement granitoids [4, 11 and 12] were reported by earlier workers. This study negates the presence of any melt generation due to impact and shock barometric calibrations were established from shock features / high pressure mineral phases within the cataclasite veins.

Methodology: Raman spectra were accquired by using Renishaw In-Via Reflex Micro-Raman instrument at GSI, Kolkata. The signals were obtained through 514 nm edge Ar+ laser (gratings: 2400 lines/mm) and 785 nm edge diode laser (gratings: 1200 lines/mm), having ~ 0.84 – 1.2 µm spot beam diameter and focus energy varies from 15 – 18 mW to acquire the Raman signal attached with an automated confocal microscope (Leica made). Accumulations time of Raman spectra have lasted for 10 – 100s. The spectral resolution for each Raman vibrational mode is on the order of ± 1-2 cm^{-1}. Scaning Electron Microscope (SEM) studies were carried out at GSI, Kolkata by using Carl-Zeiss Oxford Instruments (Model No. EVO - 40) having SEM HV (Heat Voltage) ~ 20 kV, beam intensity ~ 15 – 20 and beam spot size ~ 0.3 – 1 µm. In the following section several shock features of impact granitoid breccia will be discussed based on their petrography (aided by BSE – SEM studies) and characteristics Raman microspectroscopy with Raster mapping and/or imaging.

Results: The Dhala/Mohar impact crater is characterized by a near circular breccia zone (having average width of ~ 2 Km) and dominantly contains angular to sub-angular, rectangular and rarely subrounded clasts/fragments of K-feldspar rich coarse grained granite, granite gneiss, fine grained pink granite (likely to be part of BGC), with subordinate mafic rock and vein quartz. These clasts/fragments (clast size ~ ≤ 1 mm to a few meter) are randomly distributed/oriented and commonly embedded within a extremely fine grained granitic matrix. This granitic matrix is chocolate brown colored, occasionally occurs as multiple crisscross veins and/or patches and contains numerous clasts of various sizes, mostly formed by intense fracturing and comminution due to impact (Figure 1).

Figure 1: Cataclasite vein within granitoid breccia.

These cataclasite veins have various orientations, e.g. N40-60E, N15E, N25W, N70W etc. with average width of ~ 4 – 16 cm. At places the granitic groundmass is deformed/sheared and a crude foliation has developed on local scale. Interestingly the granitoid clasts/fragments observed within this breccia zone have a close resemblance with the surrounding country rock (parts of BGC), for both proximal and distal zones. Field evidences support in-situ brecciation and cataclasite development of the country rock, without any aerial transportation. Thus the Dhala (Mohar) structure represents an eroded remnant of a Palaeoproterozoic impact structure where the brecciated country rock is exposed at present day erosion level. These granitoid breccias are essentially composed of K-feldspar + quartz + plagioclase (Kfs > Qtz > Pl) + biotite + amphibole + chlorite + magnetite ± zircon ± monazite ± allanite ± apatite. Rock fragments/clasts are observed within the very fine grained cataclasite matrix. K-feldspar composition varies from sanidine to orthoclase, where as most of the plagioclase are albitic to

oligoclase. Perthitic rock fragments are common. Several impact induced shock features like Planar Fractures (PFs) and Planar Deformation Features (PDFs) in feldspar and quartz (Figure 2), kink bending of plagioclase lamellae and grain welding, toasted feldspar grains, ballen quartz and cataclasite veins are observed in granitoid breccia.

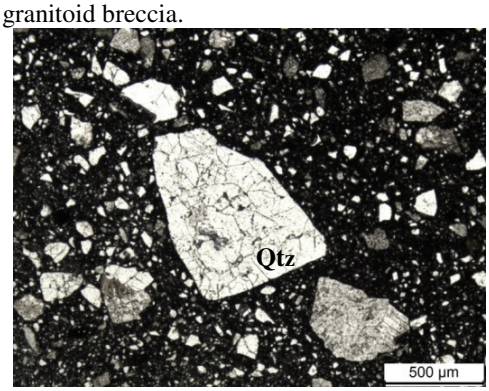

Figure 2: PF in quartz grain from cataclasite vein.

Cataclasite veins, patches and pockets contain angular/sub angular clasts of quartz and K-feldspar (± plagioclase) within a dark colored fine grained matrix composed of quartz + K-feldspar + Fe-oxides/hydroxides (magnetite and goethite) ± plagioclase. Very high resolution SEM images of cataclasite veins show evidences of intense brecciation and granulation of granitoid matrix upto micron to sub-micron level, without any frictional or impact melting, contradicting to the observations made by earlier workers [1, 2 and 4] (Figure 3; studied from outcrop samples only).

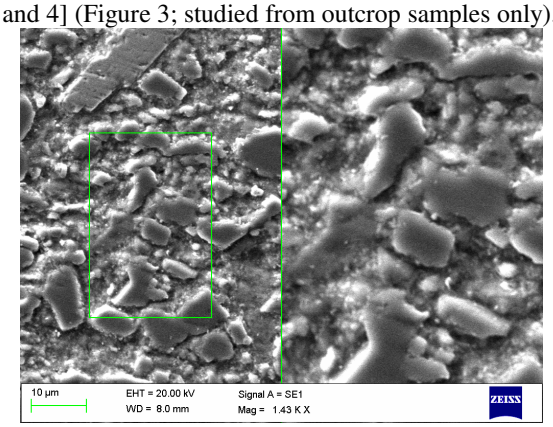

Figure 3: SEM images of cataclasite vein showing brecciation and granulation.

Feldspars normally preserve a progression of textures related to the pressure changes experienced due to impact. Shocked quartz grains show characteristic Raman peaks at 463 and 520 cm^{-1} suggests presence of coesite as revealed by Raman mapping (Figure 4). Raman imaging of shocked feldspar grains shows characteristic Raman peaks at 476, 510, 609, 765, 818, 1240, 1614, 2320, 2468 cm^{-1}, and 640, 749 cm^{-1} (relatively weaker Raman bands), which probably suggest a structural similarity with maskelynite (isotropized feldspar) and diaplectic glass [13]. The presence of coesite, maskelynite and diaplectic glass from the cataclasites and impact granitoid breccias of Dhala (Mohar) crater as determined by Raman mapping suggests escalation of shock pressures at ~ 5 – 40 GPa [14] which was not reported earlier.

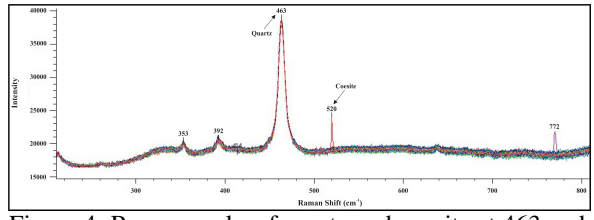

Figure 4: Raman peaks of quartz and coesite at 463 and 520 cm^{-1} respectively.

Conclusions: The present study emphasises on in-situ brecciation and extensive cataclasite development of country rock (parts of BGC) without any melting by impact. These cataclasites apparently show aphanitic mosaic texture in mesoscopic scale, though high resolution SEM – BSE images exhibit intense brecciation upto sub-micron level testifying absence of melting. Optically the presence of coesite and maskelynite in impactites of Dhala (Mohar) impact crater was reported earlier [1 and 4]. The systematic Raman mapping of quartz and feldspar grains from cataclasites and granitoid breccias provides fingureprint signatures of shock metamorphic pressures at ~ 5 – 40 GPa [14], which can broadly be correlated with the S4 – S5 shock stages [15].

References:

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