Response of Shock-Deformed Zircons and Their Transformation to Reidite and Baddeleyite in Impactites from Dhala Impact Structure, Madhya Pradesh, India.

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Introduction: The Dhala impact structure [1,2], is a near circular remnant of a Proterozoic [3] simple crater in Madhya Pradesh, India. Formed over the Bundelkhand Gneissic Complex (BGC), the impactites include lithic breccia, suevite breccia, impact melt breccia, impact melt rocks and pseudotachylitic veins.

In a comparative study between the target rocks and the impactites from Dhala, it is observed that zircon occurs as a well preserved accessory mineral in both the rock types. Zircon being known to withstand shock deformation and subsequent extreme temperature conditions for a long period [4] a detailed study of the grains of zircon from the impactites has been carried out to note their response to the impact event. The observations are further utilized to categorize the response of zircon grains to progressive stages of shock metamorphism, in correlation with the established shock metamorphic effects observed in quartz, feldspars and biotite grains within sections of impactites from Dhala structure.

Methodology: Sections of impactites have been studied in transmitted and reflected light under petrographic microscopes, followed up by detailed study under high contrast back scattered electron (BSE) mode of Scanning Electron Microscope (SEM) and Electron Probe Micro Analyzer (EPMA) at GSI, Kolkata to identify the zircon grains. EPMA was further used to acquire mineral chemical data using an accelerating voltage of 15-20 kV and beam current of 12-15 nA. Raman spectroscopic studies were also carried out on few sections, using 785 nm edge diode laser having ~ 0.84 – 1.2 µm spot beam diameter to understand any crystal-structural deviation within the zircon grains.

Discussion and Results: Zircons, as discussed earlier, are found to be evenly distributed in almost all the impactites, as an accessory mineral. They preserve a sequence of subhedral to strongly 'digested' (Fig 1) to granular textured grains of zircons (Fig 3), showing a variation in the crystal habit and the grain sizes in the different units of lithic breecia, suevite breecia and impact melt rocks.

Within the lithic breccia of shock stage F-S2 [5] characterized by highly fractured and strained grains of quartz, feldspar, kinked biotite, the zircons are mostly fractured and appear bit opaque.

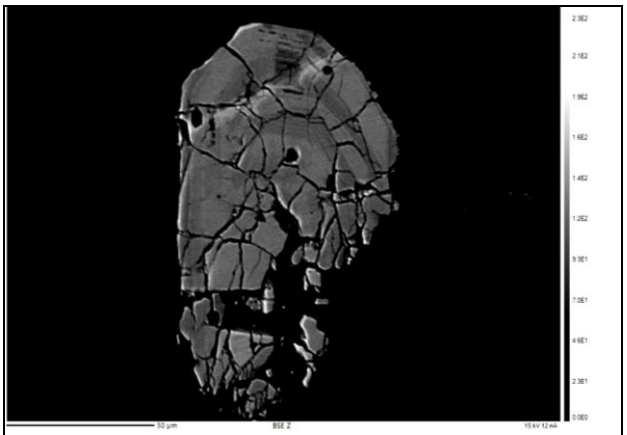

Fig 1: BSE image of compositionally zoned and highly fractured zircon grain from suevite breccia. Note that the near subhedral grain is 'digested' in the lower right corner.

The fractures observed in these zircon grains are usually linear to sub-linear. Whereas in zircons from the suevite breccia and impact melt breccias of shock stage F-S4 to F-S6/7 [5], the linearity is conspicuously diminished.

In the suevite breccia and impact melt breccia units, granular texture of zircon is more common. The grains are seen to co-exist with the shocked grains of quartz and feldspar with PDFs and with ballen quartz, in sections from suevites.

Presence of Reidite, the high pressure polymorph of zircon has been determined from a section of impact melt breccia, within a ballen structured quartz, with the help of characteristic Raman Spectroscopic spectra (Fig 2). Raman peaks at 287, 323, 392, 462, 557, 591, 608, 638, 820, 915, 965, 1067, 1114, 1190 cm^{-1} are attributed to reidite [6].

Within the same unit, occurrence of baddeleyite, the high temperature break-down product of zircon has been confirmed through electron microprobe and SEM (Fig 3). Common in most impact structures, baddeleyite is being reported for the first time from Dhala structure.

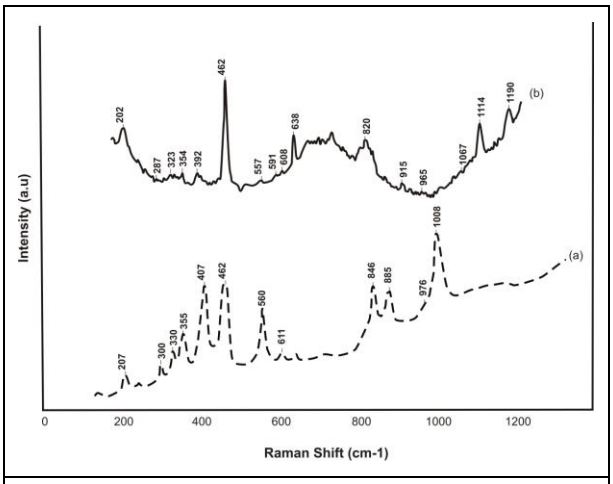

Fig 2. Raman spectra of reidite bearing zircon from Dhala structure (b) within a grain of ballen quartz. The data is compared with that of reidite bearing Zircon from Xiuyan crater [6]. Raman peaks at 287, 323, 392, 462, 557, 591, 608, 638, 820, 915, 965, 1067, 1114, 1190 cm^{-1} are attributed to reidite (b).

Overall, as evident from the fractured grains of the lithic breccia with kinked bands in biotite to the whole rock melt of the, the shock effects observed in the impactites of Dhala impact structure is inferred to vary from shock stage F-S2 to F-S6/7 [5].

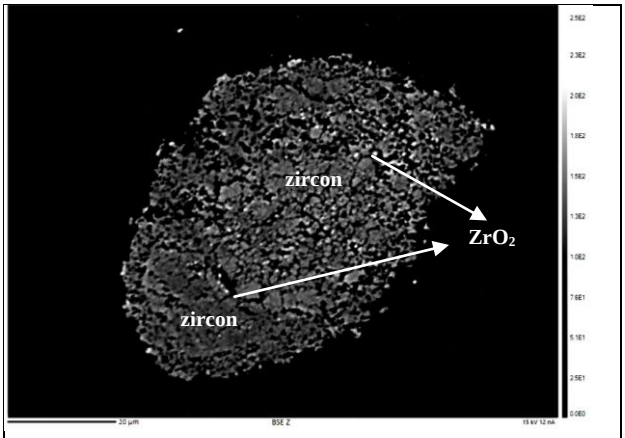

Fig 3: BSE image of Granular textured zircon with µm sized granules of ZrO2 within impact melt breccia.

With the gradation of the shock metamorphic effect, the zircon grains are also observed to respond differently in the studied sections of impactites from Dhala. They are found to have a distinct gradation from subhedral, linearly fractured grains in the lithic breccia to decomposed grains of zircon into baddeleyite and silica in the impact melt breccia of higher shock stages. The presence of both high pressure zircon polymorph reidite and high temperature zircon breakdown product baddeleyite, along with other shock metamorphic evidences have helped to determine the upper limits of pressure and temperature during the Dhala Impact event, and thereby classify to the present shock stages, discussed above.

References:

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