Carbonate-silicate melt immiscibility in impact melt breccia from Mohar, Shivpuri district, Madhya Pradesh, India.

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Introduction: The Mohar (Dhala) circular structure, Shivpuri dist., M.P, India, is an established impact structure in a granitic terrane, which forms a part of the Bundelkhand massif of Central India. The rock types around Mohar comprise Archean to Paleoproterozoic rocks dominated by Bundelkhand Granitoids with enclaves of older metasedimentary-metavolcanic supracrustals, unconformably overlain by the sediments of Meso- to Neo-Proterozoic Vindhyan Supergroup. The model of meteoritic impact as a cause for the formation of this megastructure, was founded on the basis of presence of diagnostic shock metamorphic features in the clasts of melt breccia that crops out sparsely in the north western part [1,2] and extensively in subsurface [3]. The present work reports, petrological evidences of rare carbonate-silicate melt immiscibility in a largely felsic melt breccia derived by the impact melting of the target granite. This feature is observed in subsurface samples from boreholes, located near the south eastern flank of the structure.

Methodology: The methodology involves detailed petrological study of polished thin sections of surface and subsurface samples drawn from 76 boreholes. This is followed by Micro-Raman Spectroscopy using STR-300 Micro-Raman spectrometer (SEKI Technotron, Japan at Wadia Institute of Himalayan Geology, Dehradun, India) and Horiba JY HR Lab Ram laser Micro Raman spectrometer (at BARC, Mumbai), on thin sections (without cover slip) and Scanning Electron Microscopy (Zeiss Auriga FE SEM) and X-ray imaging (EDS-Oxford Instrument X-Max^N).

Results: It has been petrologically observed that a minor phase of carbonate melt co-exists with the dominant felsic phase, in the melt breccia, that contains telltale signatures of shock metamorphism, viz., Ballen quartz, Planar Deformation Features (PDF) in quartz, toasted, diaplectic and ladder textured feldspar and kink-banded biotite/chlorite. The minor carbonate melt is in the form of oval to ameboid, often bulbous to ‘budding-out’ globules (which appear to float, squeeze and align along the flow of the glassy to microcrystalline felsic groundmass (Fig.1). They vary in size from <50 µm to approximately 500 µm across. The globules contain crystalline/sparry grains of carbonate that under the microscope appear colorless, exhibit twinkling effect and characteristic cleavage under one Nicol condition and high order interference color with faint traces of twin planes under crossed Nicol condition. At places, the carbonate shows fluidal texture under high magnification, entraining microvesicles within it. The meniscus of the carbonate globules against the red felsic groundmass, is sharp, indicating contrast in composition and suggesting primary growth as droplets in a molten state.

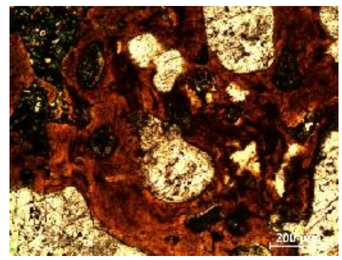

Fig.1. Immiscible carbonate melt globules (white) within red felsic groundmass. Trans. Light, 1N, air, bar=200 µm

The carbonate globule and the red felsic groundmass have been subjected to Micro-Raman Spectroscopy. The obtained Raman spectra of the carbonate globule matches with standard carbonate with peaks on the lesser side of 300 cm^{-1}, 1100 cm^{-1} and slightly >700 cm^{-1}. The spectra obtained for the felsic groundmass (Fig.2) shows distinct peaks at around 289cm^{-1}, 407cm^{-1} and 511cm^{-1}, with additional peaks at around 1319cm^{-1} and 1567 cm^{-1} and several minor peaks occur at around 223 cm^{-1}, 243 cm^{-1}, 480 cm^{-1}, 540 cm^{-1} and 605cm^{-1}, implying aberration from the characteristic peaks of standard K-feldspar in all the three Regions described by [4].

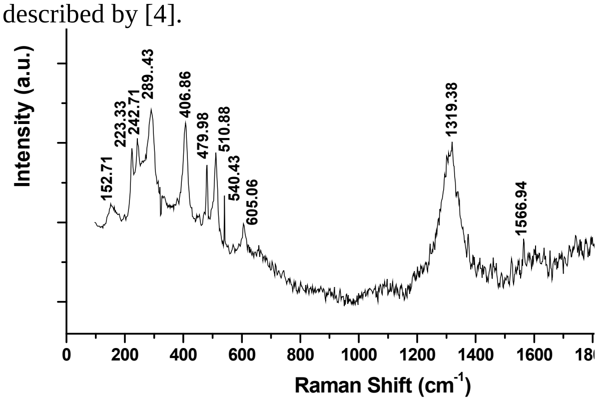

Fig.2. Raman spectra of feldspathic groundmass

SEM image documents the primary immiscible texture of carbonate-silicate melt and capture the globulelike once-dynamic melt droplets within a fine, felsic groundmass (Fig.3). X-ray imaging was carried out for selected major (Si, Al, Mg, Fe, Ca, K) and trace elements (Rb, Ba, Sr), which established the composition of majority of the carbonate globules as Ca-rich and Mg- Fe- and Sr poor (calcitic), with a few globules being rich in Mg, Fe and deficient in Ca, Sr (dolomitic). The composition of the felsic groundmass is K-, Si-, Al-, Rb-, Sr-rich and Ba-poor, which qualitatively indicates co-presence of K-feldspathic composition. The carbonate-silicate contact is often marked by some changes in oxygen content (Fig.4).

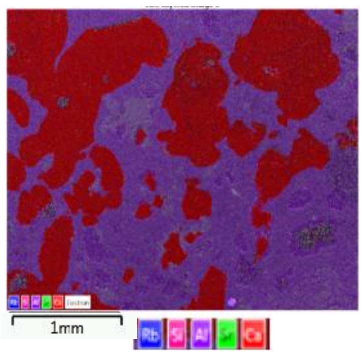

Fig.3. EDS layered image showing carbonate melt globules (red) within felsic groundmass (purple). Bar=1mm

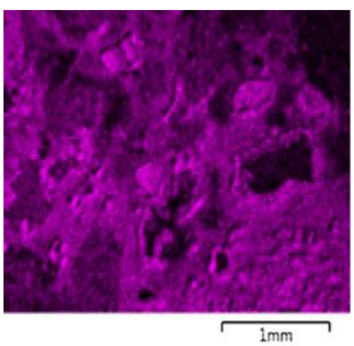

Fig.4. X-ray image showing oxygen (bright) distribution (O Kα1) around melt globules.

Conclusion: Ca-rich carbonatitic melt is extremely uncommon in near-surface condition and is generally considered to be mantle derived. It is now recognized to form in near-surface condition by impact melting at >40GPa where it occurs as immiscible phases intermingled with silicate melt in Ries crater, Germany, Chixulub crater, Mexico, Azuara impact structure, Spain, Martian meteorite ALH84001, Haughton structure, Canada [5,6,7,8]. In a target terrane dominated by granite crystalline that contributed to a large amount of granite melt, the small portion of carbonate melt is possibly derived by the melting of precursor calcsilicate supracrustals occurring as mappable enclaves and relicts within the granite in the western part of the structure. In perspective of this, and also the fact that caught-up fragments of carbonate are observed in subsurface melt rock samples from neighbouring boreholes, it appears that concomitant impact melting of both granite and minor calcsilicate supracrustal enclaves took place at Mohar, producing a miniscule amount of calcium-rich (with minor Mg-rich) insitu carbonate melt in near-surface condition, corroborating the processs of impact.

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