AN EXPERIMENTAL APPROACH TO EFFECTIVELY SEPARATE A PROJECTILE COMPONENT FROM IMPACTITES

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Introduction: Anomalous abundances of iridium (Ir) and other highly siderophile elements (HSE; e.g., Ru, Os, Pt, and Pd) in impactites are generally considered as chemical traces of extraterrestrial projectiles [1-3]. However, these elements are generally observed in very low concentrations (e.g., Ir ≥1-2 ppb; Ru >4 ppb; Os ≥1-2 ppb; Pt >4-5 ppb and Pd >2 ppb) in impactites [4], and the relative projectile contribution to impactite is typically <1 wt% [2-3]. Analysis for possible projectile contributions is often done with bulk samples of milligram sizes. Attempts to geochemically ascertain the presence of a projectile component in impactites have not always been successful: of the ca. 200 impact structures recognized, only some 50 have confirmed presence of impactor traces in impactite. Here, an experimental method is proposed for effective separation of the impactor component from impactites under highly reducing conditions above their liquidus temperatures. We are reporting successful application of this method to various impactite samples from the Lonar and Dhala structures, India, that have 0.03 to 0.3 wt% of reported projectile contributions [5-6].

Material and methods: Eight relatively fresh impact melt breccia samples from the Lonar (2) and Dhala (6) structures were powderized in an agate mortar. These homogenized starting materials were weighed into graphite cylinders (Length: 12 mm, inner diameter: 3 mm, and outer diameter: 5 mm). These cylinders were placed into snugly-fitting larger graphite cylinders (Length: 44 mm, inner diameter: 6 mm, and outer diameter: 10 mm; Fig. 1A), whereby the open space between the graphite walls, if any, was filled with graphite powder. This sample assembly is then fired in a molybdenum disilicide furnace at 1400°C under 1 atm pressure for run durations of 30 to 180 min. Each capsule assembly was then quenched with a jet of cool pressurized air. The run products were analyzed using a petrographic microscope and an electron probe microanalyser (EPMA) at the National Centre of Experimental Mineralogy and Petrology, University of Allahabad.

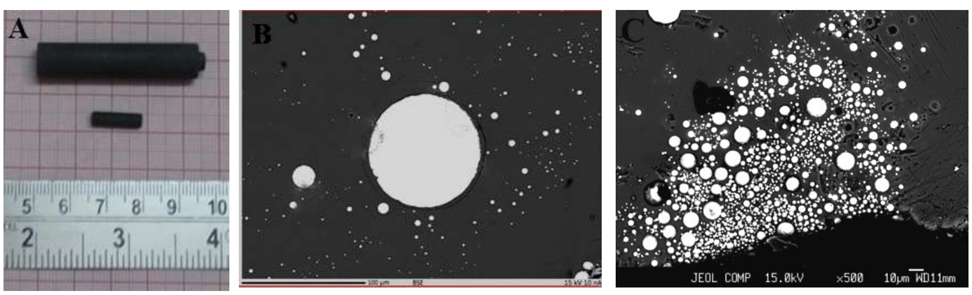

Figure 1: (A) Two graphite capsules of different sizes. The smaller one contains the starting material. (B) and (C). Back-scattered electron (BSE) images of metal spherules of different sizes in groundmass of melt from Lonar and Dhala, respectively. The diameter of the largest spherule in (B) is ~90µm.

Results and Discussion: All experimental runs showed the presence of metallic spherules of varied diameters (Fig. 1B-C). EPMA showed significant enrichment of Ni and Cr (for Lonar, Fe 93.40-99.20 wt%; Ni upto 0.26 wt%; Cr upto 0.20 wt%, and for Dhala, Fe 89.56-99.34 wt%; Ni upto 3.68 wt%; and Cr upto 0.47 wt%). The Ni/Cr ratios in experimentally produced iron-rich spherules from Lonar samples (0.10-16.88) are extremely high compared to target basalt (0.54-1.67), impact melt breccia (1.42-2.65) and impact spherules (0.75-1.91). Similarly, the Ni/Cr contents in Dhala target granitoids (0.51-1.88) and impact melt breccia (0.24-1.99) are insignificant in comparison to the values (0.65-11.13) in experimentally formed metallic spherules from the Dhala impact melt breccia samples. The siderophile elements including PGEs tend to partition into the Fe-metal phase due to silicate-metal liquid immiscibility at high temperature under controlled Iron-Wüstite (IW) buffer condition [4, 7]. Therefore, instead of using bulk sample compositions of the impactites, the geochemical analyses (e.g., LA-ICP-MS, INAA) of these Fe-rich metal spherules shall yield diagnostic chemical imprints of the projectile component. This technique shall improve the chemical detection of the extraterrestrial component in impactites, especially in cases of felsic impact melt rocks having very low concentrations of siderophile component. This experimental approach shall further help in the future discovery and confirmation of terrestrial impact structures where the unequivocal shock-metamorphic features are still not discovered and chemical imprints of the impactor component have remained elusive.

References: [1] Claeys P. et al. 2002. *Geological Society of America Special Paper* 356:55-68. [2] Tagle R. and Hetch L. (2006) *Meteoritics & Planetary Science* 41:1721-1735. [3] McDonald I. et al. 2007. *Meteoritics & Planetary Science* 42:743-753. [4] Koeberl C. (2014) In *Treatise on Geochemistry (Second Edition)* 2:73-118. [5] Schulz et al. 2016. *Meteoritics & Planetary Science* 51:1323-1339. [6] Pati et al. 2017. *Meteoritics & Planetary Science* 52:722-736. [7] Day et al. 2016. *Reviews in Mineralogy and Geochemistry* 81:161-238.