

Multi-parameter approach to constrain projectile types and origins in impactites: relation between the Ordovician impact spike and the L-chondrite parent body (LCPB) breakup

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Identifying meteoritic components within terrestrial impact structures remains challenging due to impactor vaporization, complex mixing with target rocks, and post-impact alteration. A multi-parameter approach enhances our ability to constrain projectile types and origins, ultimately leading to a better understanding of asteroid delivery towards Earth.

Identifying crater clusters in the terrestrial record relies on precise age constraints, while projectile components preserved in the associated impact structures should not exceed more than two meteorite types. For the first time, this study systematically investigates geochemical signatures preserved in impact melt rocks from multiple structures to explore their link with L-chondrite parent body (LCPB) breakup within the asteroid belt (~465.8 Ma) and the Mid-to-Late Ordovician impact spike (~465–440 Ma). We focus on five post-LCPB impact structures in Canada and Sweden: Brent, Charlevoix, Clearwater East, Lac La Moinerie, and Lockne. Except for Charlevoix, all are dated to an uncertainty <5 Ma.

Projectile contribution is initially assessed through Cr, Co, and Ni abundances relative to target rocks. Samples are prepared and digested relying on nickel sulfide fire assay or acid dissolution combined with isotope dilution, and analyzed for their platinum group element (PGE) abundances through ICP-MS analysis. The PGE signatures of Lockne (~1 ppb Ir), Brent (up to ~19 ppb Ir), and Clearwater East (up to ~30 ppb Ir) strongly support meteoritic contributions (average continental crust: 0.02 ppb), while the signal is more diluted for Charlevoix (<0.1 ppb Ir) and Lac Moinerie (<1 ppb Ir). Further constraints rely on inter-element ratios (e.g., Ru/Rh, Pt/Ir).

Finally, the novel Ru isotopic methodology, along with Os and Cr isotopic compositions, are measured using high-precision

thermal ionization mass spectrometry (TIMS) or multicollector ICP-MS, to quantify the amount of meteoritic contamination and refine the projectile type. The data compiled on Brent and East Clearwater indicates that the impactors were likely ordinary chondrite bodies originating from the inner Solar System, pointing towards the LCPB as the impactor source.

This work highlights the necessity of combining elemental and isotopic tracers for impactor identification. We advocate for a routine multi-parameter approach to refine our understanding of meteoritic contributions in Earth's impact record.