Investigating the Response of Carbonates to Hypervelocity Impact

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How carbonates respond to hypervelocity impact is poorly understood, yet whether they melt or decompose, liberating CO_2 gas, has implications for impact-associated environmental effects. Study of impactites from sedimentary targets can yield insight into this debated topic. We investigate polymict breccias from the crater fill deposits of the 25-km diameter Steen River impact structure, Canada. The target stratigraphy comprised ~1.28 km of Devonian evaporites, carbonates and shales. Previous study of calcite in these breccias point to several generations distinguished by texture and major element composition including lithic limestone clasts, impact melt, thermally decomposed and / or recrystallized calcite and calcite associated with a post-impact hydrothermal system.

Here, electron backscatter diffraction (EBSD) was employed to quantify calcite textures. These crystallographically mapped areas were then sampled using a micromill for stable isotope and trace element analyses. Calcite in recrystallized limestone rims are isotopically light, from δ^{13}C -69.63 ‰ and δ^{18}O = -14.69 ‰ to δ^{13}C -21.69 ‰ and δ^{18}O = -16.05 ‰ (all values σ=0.01 ‰). These values contrast with those of calcite extracted from the centre of cm-size limestone clasts (δ^{13}C -3.74 ‰ and δ^{18}O = -12.85 ‰). Critically, thermal decarbonation cannot explain such light values [1], which suggest instead oxidation of methane.

Trace element geochemistry of calcite may be grouped by signatures that generally align with their inferred mode of formation, deduced by textural characterization. For example, calcite in the centre of limestone clasts within the breccia show anomalies inherited from seawater, athough the slope of the REEs is reversed compared to normal sedimentary signatures, implying significant REE mobilization. Several samples show REE abundances that are enriched up to four times crustal values. Although interpretation of these data remains ongoing, they represent important steps in characterizing calcite from complex hypervelocity impact-affected systems.

[1] Sharp et al. 2003. The effect of thermal decarbonation on stable isotope compositions of carbonates. *Am. Min.* 88, 87-92.