Geochmical tracers linking impacts to target rocks in the Precambrian

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Meteorite impacts in the Archean and early Proterozoic are preserved as spherule deposits without identified source craters. High field strength elements (HFSE) and other immobile elements can be used to track target rock compositions. Bulk and spot analyses of Nb, Ta, Zr, Hf, Ti, Al, Sc, Cr and Ir within spherule beds and single spherules are compared to known bulk rock spidergram patterns from a variety of crustal and mantle compositions. Mixing models are used to identify likely target components. The 3.24 Ga S3 layer from South Africa has a trace element pattern consistent with a mantle and MORB-type basalt target, and the 2.47 Ga Paraburdoo spherule layer in W. Australia has a trace element pattern consistent with a continental crust and OIB target without mantle. Spidergrams of the K/Pg spherule bed layer, where impact spherules can be tied to known targets, mimics those of the source rocks indicating conservation of the interelement ratios through the impact process.

Bulk and spot analyses indicate overall homogeneity in the HFSE ratios between different spherule types within a single deposit and between spherules from separate sampling sites that have significantly different diagenetic histories. In particular, Nb/Ta and Zr/Hf ratios are highly consistent between sampled spherules and between bulk sampled sublayers. These ratios are also distinct from overlying and underlying rock units. This may therefore allow for identification of target rocks in layers were fall deposits are not present or preservation is poor.

Rare earth elements (REE) cannot be used to track target compositions due to diagenetic effects. REE patterns are highly variable within the spherule bed and within individual spherules. Bulk REE analyses from the top of the spherule beds more closely resemble the overlying rock composition, and Ce anomalies are consistently similar to the overlying layer, indicating that this is a strong alteration effect.

This has important implications for our understanding of Archean crustal composition, as well as understanding the scaling properties of impacts. With increasing size of impact, we see a greater proportion of target component within the vaporized material. In the largest impacts, we also see excavation of mantle material, with implications for Precambrian climate condidtions as well as sterilization effects.