

Impact triggered mantle melting? New data from the Sudbury Basin

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The Hf-isotope record of Hadean and Archaean zircon supports the view that the Hadean protocrust was relatively long lived (several 100 Ma) but was then apparently destroyed quite rapidly between 4.0 and 3.85 Ga. One possibility is that a high giant impactor flux was responsible for the destruction of the Hadean crust, perhaps aided by basaltic resurfacing in response to decompression melting of the mantle. However, until now, there has been no direct terrestrial evidence to back up this proposal.

Here we present new field, petrological and geochemical data from the 1.85 Ga Sudbury impact crater. We report a systematic stratigraphic succession of volcanic shards in the crater fill. The lower portion of the fill (breccias) is dominated by blocky shards that have the same chemistry as the underlying meltsheet. The first appearance of a different shard type, often lenticular (chlorite-dominated; previously termed 'green shards'), occurs at the top of the breccia and becomes the dominant shard type of the overlying tuff. These lenticular shards, characterised with in situ analysis (SEM EDS and LA-ICP-MS), yielded many juvenile features, in particular REE patterns identical to modern N-MORB. In addition, we present high-precision major and trace element data for carefully hand-picked ash matrix. This shows that the ash experienced limited chemical alteration and also that there is an upwards trend towards more juvenile magma.

This new evidence suggests that phreato-magmatic reworking of the crustal melt sheet was followed temporally by a separate episode of emplacement of juvenile mantle-derived magmas. We propose that the juvenile magma was not generated by melting target rocks during the impact itself but may have been caused by mantle upwelling/heating after cavity collapse. The first occurrence of juvenile shards coincides with strong reorganisation of the crater floor along major faults, an observation compatible with material flow below. Our new evidence suggests that even >150 km terrestrial impact basins could have become resurfaced with basalt. Therefore, cratering by giant (>1000 km) impacts and concomitant reworking are a likely viable mechanism for destroying the Hadean protocrust.