Volatility-related element loss during large impact events: new Pb and Zn insight from the Sudbury basin

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The Earth is depleted in volatile and moderately volatile elements compared to CI chondrites and other meteorites. All differentiated rocky bodies in the inner Solar System have undergone impact erosion, likely having contributed to the non-chondritic patterns of volatile elements but empirical observations supporting the impact erosion process are rare.

Evidence of preferential loss of the volatile metals Pb and Zn is found on the Earth's Moon whose mantle is depleted in Pb by as much as 90% relative to the silicate Earth. Lunar basalts are enriched in heavy Zn isotopes substantiating the notion of volatile loss during or after the giant impact.

Earth is less depleted in volatile elements but impact-derived glass beads (tektites) reveal diffusion-limited evaporative loss of Zn and concomitant isotope fractionation [1] in the context of impact melting. Here we report on a study from the 1.85 Ga Sudbury impact basin where we have recently discovered strong Pb-depletion in the lower basin fill [2]. The new data confirm that the meltsheet was depleted in Pb by a factor of ca. 3 relative to upper continental crust, that the Pb in the lower basin fill is highly radiogenic, that original Pb depletion of the impact breccia was >95% and that a melt coating of a target clast is depleted in many volatile metals, including Pb and Zn.

We also present the first high-precision stable Zn isotope investigation of the Sudbury crater fill (Onaping Formation). In one traverse across 1 km of the Onaping Formation, 19 of 20 samples yield a Zn concentration of 37±15 ppm ranging in $\delta^{66}Zn_{JMCLyon}$ from +0.39 to +0.59 ‰. The stratigraphically highest sample has high Zn content (163 ppm) and crustal $\delta^{66}Zn_{JMCLyon}$ of +0.31 ‰. In a second traverse across 300 m of the lower basin fill, Zn concentration was lower (22±7 ppm) and Zn isotope composition generally heavier, $\delta^{66}Zn_{JMCLyon}$ ranging up to +1.05 ‰. The consistent Zn depletion and deficit in light isotopes supports the idea that at least in subaqueous large impacts, volatile elements are being lost.

[1] Moynier et al. (2009) *EPSL* 277, 482-489.
[2] O'Sullivan et al. (2016) *GCA* 183, 198-233.