Lack of stable isotope fractionation during high temperature volatilization

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Because of their low volatility, if is often considered that non-traditional stable isotopes such as Zn can be fractionated during planetary impact because of the related heating and vaporization of the target [1]. However, because the meteoritic sampling is quite limited, it is difficult to have a full insight on the elemental loss and isotopic fractionation, since either the initial or the impacted rock is systematically missing. Testing this hypothesis on Earth may also be difficult because of the few impact craters existing that often show a complex history of mixing between the impactor and the impacted terrestrial rocks. Here, we have realized Zn, Cu and Fe isotope measurements on basaltic fulgurites, i.e. basalt that has been impacted by lightning. In this case, we can have access to both the protolith and the heated rock composition. Even if fulgurites differ from impact melt by the lower pressure reached, the temperature they experienced of > 2000 K [2] can be quite similar to the ones modelled during large impact [3].

When comparing the composition before and after lightning, a dramatic loss in volatile element budget is observed, for example the H_2O loss is 85-97 %. Concerning Zn and Cu, the respective loss after lightning is 85-91% and 21-38%, in agreement with their respective volatility [4], while Fe, a major element, does not record elemental loss. On the other hand, δ^{68}Zn, δ^{65}Cu and δ^{57}Fe do not show any isotope fractionation despite an obvious elemental vaporization of Zn and Cu. This is at odd with what has been proposed for the Moon after the giant impact [1]. Such an absence of fractionation can be explained by the high temperature reached during lightning. As major impacts also reach very high temperature, they are actually unlikely to fractionate stable isotopes. Other processes at lower temperature, such as re-condensation after impact or evaporation from a magma ocean, as proposed for the Moon [5], should be considered.

[1] Paniello et al. (2012) *Nature 490* 376-379. [2] Essene and Fisher (1986) *Science 234* 189-193. [3] Pahlevan and Stevenson (2007) *Earth Planet. Sci. Lett. 262* 438-449. [4] Lodders (2003) *Astrophys. J. 591* 1220-1247. [5] Day and Moynier (2014) *Phil. Trans. R. Soc. A 372*.