LACK OF STABLE ISOTOPE FRACTIONATION DURING HIGH TEMPERATURE VOLATILIZATION

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Introduction: Because of its high volatility, if is often considered that Zn isotopes can be fractionated during impact because of the related heating and vaporization of the target and the preferential loss of light isotopes over heavy isotopes [1]. This could explain the depletion in Zn light isotopes in lunar samples [2] or in some achondrites, for example the ureilites [3]. However, because the meteoritic sampling is quite limited, it is difficult to have a full insight into processes of elemental loss and isotopic fractionation, since the initial composition of the impacted parent body is systematically missing. Testing this hypothesis on Earth may also be difficult because of the few impact craters existing, and because they often show a complex history of mixing between the impactor and the impacted terrestrial rocks [4]. Recently, it has been proposed that trinitite, green glass resulting from nuclear tests in the Trinity test site, New Mexico, USA, shows Zn isotopes fractionation resulting from partial evaporation during the explosion, hence corroborating the Zn depletion of the Moon in light isotopes [5]. However, the temperature reached by the explosions is estimated to be around 1663K [5], much lower than what could be expected during large impacts, up to 8000 K [6]. Here, we have measured Zn, Cu and Fe isotope on basaltic fulgurites from the Nagpur Area, India, i.e. basalt that has been impacted by lightning. In this case, we can have access to both the protolith and the residue after heating. Even if fulgurites differ from impact melt by the lower pressure reached, the > 2000 K temperature they experienced [7] can be quite similar to the ones modelled during large impact [8].

Results: 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 [9], while Fe, a major element, does not record elemental loss. On the other hand, δ^{68}Zn, δ^{65}Cu and δ^{56}Fe do not show any isotope fractionation despite an obvious elemental vaporization of Zn and Cu. This is at odds with what has been proposed for the Moon after the giant impact [2]. Different mechanisms will be investigated, possibly related to the high temperature reached during lightning. As major impacts also reach very high temperature, the results found here could also have implications for stable isotope fractionation during impact volatilization. Other processes at lower temperature, such as recondensation after impact or evaporation from a magma ocean, as proposed for the Moon [10], should be considered.

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