

Zn stable isotope contribution to constraint ureilite formation process

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Ureilites are ultramafic achondrites. They are usually considered to be derived from a single parent body (UPB) now-disrupted. They are mainly composed of olivine and pigeonite. This is already demonstrated that ureilites are mantle restites. But, this hypothesis is not consistent to explained preservation of the primitive characteristics such as the O heterogeneity in ureilites [1] and confirmed by the new $\Delta^{17}\text{O}$ data in our samples. In this study, we report new Zn stable isotopic composition and also ^{26}Al - ^{26}Mg systematic for seven monomict ureilites Yamato (Y) 790981, Y 791538, Y 981750, Y 981810, Asuka (A) 881931, Allan Hills (ALH) 81101 and ALH 84136 to constraint the ureilite formation by smelting process.

Zn isotope analysis of our seven samples yielded non-chondritic and heterogeneous composition in $\delta^{66}\text{Zn}$ signatures ranging $+0.61 \pm 0.01\%$ to $+2.68 \pm 0.11\%$. This heterogeneity in Zn can reflected the isotopic signature of the precursor(s). In opposition, Zn is a moderately volatile element, and alternative explanation already mentioned by previous studies suggested this heavy isotope enrichment may reflect volatilization process following major impact [2]. This explanation is generally supported by the correlation between the $\delta^{66}\text{Zn}$ and the Zn abundance in ureilites. However, this hypothesis is not well supported by the shock degrees. In our study, we evaluated the possibility that $\delta^{66}\text{Zn}$ signature could be produced by smelting process during ureilites genesis like already suggested by [3-4]. To evaluate the effects of such a volatilization process during smelting, we modeled the Zn isotope fractionation in ureilites on the basis of the Rayleigh distillation equation, according to [5] when Zn isotope fractionation was explored during the smelting process in the metallurgic industry. In this model, we made the assumption that UPB precursor had an initial composition in Zn content and $\delta^{66}\text{Zn}$ signature similar to a CI type chondrite. The smelting degrees of our samples were evaluated based on their Zn content. Based on this assumption, we show that the observed $\delta^{66}\text{Zn}$ variability in our ureilites match the data obtained using the smelting process model.

On the other hand, smelting process can occur only if the UPB precursor starts to melt. During this step, the ureilite witch is the residues should be depleted in incompatible elements like suggested by the REE pattern in ureilites [6]. Based on the new REE data [6] and our data, we evidenced correlation between $(\text{Dy/Lu})_n$ ratios and the degrees of smelting modeled. This observation suggests that smelting degrees increased with the degrees of melting (F).

Finally, based on ^{26}Al - ^{26}Mg isotopic system, no isochron has been obtained with the $\delta^{26}\text{Mg}^*$ and $^{27}\text{Al}/^{24}\text{Mg}$ data analyzed in our samples. If all these samples crystallized at the same time, the $\delta^{26}\text{Mg}^*$ data suggest our samples could come from different parent bodies. However, our data set could also reflect different crystallization ages from a single parent body. Considering the smelting process for ureilites formation, this hypothesis could be considered since smelting was a local process. Assuming all the ureilites originated from a single parent body with a chondritic composition, a model age can be determined. This model age reflects the time when the ureilite common source differentiated from a chondritic reservoir. This differentiation can be modeled at 1.09 ± 0.75 Ma after the CAI formation. [1] Clayton R. & Mayeda T. (1988) GCA, 52, 1313-1318. [2] Moynier F. et al. (2010) Chem. Geol., 276, 374-379. [3] Singletary S. & Grove T. (2003) Meteorit. Planet. Sci., 38, 95-108. [4] Goodrich C.A. et al. (2007) GCA, 71, 2876-2895. [5] Mattielli N. et al. (2009) Atmos. Environ., 43, 1265-1272. [6] Barrat J.-A. et al. (2016), GCA, 194, 163-178

