Smelting process evidenced by $\delta^{66}Zn$

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Ureilites are highly fractionated ultramafic achondrites that also have some primitive characteristic, such as heterogeneous $\Delta^{17}O$ values. They are usually considered to be derived from a single parent body (UPB). The chemical composition and texture of ureilites indicate that they could be mantle residues after ~15-30% basaltic melt extraction during UPB mantle melting [1]. However, such high degrees of partial melting would not preserve the $\Delta^{17}O$ heterogeneity of ureilites, as documented in the literature [2].

In this study, we report new oxygen and zinc stable isotopic compositions for five monomict ureilites Yamato (Y) 790981, Y 791538, Y 981750, Y 981810 and Asuka (A) 881931. Our new $\Delta^{17}O$ values range from -0.493 ± 0.001‰ to -1.887 ± 0.023‰, indicating poor homogenization. In order to reconcile evidence of partial melting with poor homogenization, we propose that the smelting process might explain ureilite formation [3]. Smelting might occur at low degrees of partial melting, with melt extraction taking place too rapidly to homogenize the $\Delta^{17}O$ signature [4].

Zn isotope analysis of the five ureilites yielded heterogeneous $\delta^{66}Zn$ values ranging from +0.61 ± 0.01‰ to +1.06 ± 0.02‰. This heavy isotope enrichment may reflect volatilization processes associated with the smelting process during ureilite genesis [5]. To evaluate the effects of such a volatilization process, we modeled the Zn isotope fractionation in ureilites on the basis of the Rayleigh distillation equation, according to [6] when Zn isotope fractionation was explored during the smelting process in the metallurgic industry. A CI type initial composition was considered for the UPB precursor. Based on this assumption, we show that the observed $\delta^{66}Zn$ variability in our ureilites match the data obtained using the smelting process model.

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