Chemistry and Ni-isotope composition of ureilites and their components

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Ureilites are olivine-pigeonite bearing achondrites with interstitial carbonaceous material and metal. The latter is present as <1 μm metal inclusions in reduced rims of silicate grains, 5-20 μm spherical inclusions in clear silicate grains, and in association with interstitial carbonaceous material.
We have studied the composition of metal and silicates in 9 ureilites with a fayalite content of Fa_2 to Fa_{21}. Vein metal contains 3.7 to 5.4 wt% Ni and 0.35 to 0.54 wt% Co. Cobalt and Ni contents in vein metal and fayalite in olivine do not correlate. Mass balance calculations assuming a chondritic parent body yield a metal core with 7 to 11 wt% Ni and 0.3 to 0.55 wt% Co. Thermodynamic calculations of Fe-Ni and Fe-Co exchange between olivine and vein metal show that vein metal cannot be in equilibrium with the olivine at any temperature. We conclude that the vein metal is genetically not linked to the ureilite olivine and may have been injected into the parent body by an impactor.
Recently published data show a deficit in ^{60}Ni of –0.24+/-0.02 ε-units for various achondrites including ureilites (Bizzarro et al., 2007). This has been interpreted as evidence for a late injection of ^{60}Fe after formation of these achondrites. However, our chemical data for vein metal, which is the dominant Ni host in ureilites, demonstrate that bulk Ni isotope data have little meaning with respect to the formation of ureilite silicates. In this work we present Ni isotope data for bulk samples but also vein material and the silicate phase of 4 ureilites (ALHA77257, EET87157, EET96041, Kenna). Bulk ureilites have a ε_{60} between –0.05+/-0.12 and 0.08+/-0.12; the vein metal gives ε_{60} = -0.05+/-0.13 to 0.11+/-0.16. No resolvable deficit in ε_{60} was found, in disagreement with results reported in Bizzarro et al. (2007). The vein material and the bulk samples have, within uncertainty, the same isotopic composition, confirming that the global Ni budget is controlled by the vein material. In ureilite silicates ε_{60} varies from –0.77+/-0.31 to –0.12+/-0.21. Due to the high Fe/Ni ratio of silicates, clear excesses of ^{60}Ni (at least several ε-units) are expected if they formed early in the solar system. This is not observed. There is thus no evidence for life ^{60}Fe in ureilites, which may be interpreted in different ways: either ^{60}Fe was injected at a later time into the protoplanetary disk as suggested by Bizzarro et al. (2007) (but this is difficult to reconcile with data obtained in other meteorites [e.g. Quitté et al. (2007)]), or several isotopically distinct reservoirs co-existed at the beginning of the solar system. The isotopic difference between vein material and silicates rather supports the second hypothesis, even if further studies are required to confirm it. It may also be that the Fe-Ni system has been disturbed at a later stage after formation of ureilites.

References

Bizzarro M. et al. 2007. Science 316 (5828), 1178-1181.

Quitté G. et al. 2007. LPSC 38, abstract #1900.

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