Complex, contrasting behavior of chromium during late-stage processes in ureilites

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Introduction Ureilites are ultramafic asteroidal mantle samples with remarkably high proportions of graphite (or, more commonly, amorphous carbon and diamonds that may originally have been graphite). At a late stage in their evolution, a sudden change in intensive or extensive parameters (possibly a sudden drop in pressure, leading to destabilization of graphite in favor of CO_x gas) triggered an abortive redox process that partially converted their olivines into "reduced rims" consisting mainly of extremely high-*mg* olivine and tiny blebs of Fe-metal [1,2,3].

There is some controversy about the degree to which the olivines were also reduced by earlier, slow and gradual "smelting" during the development of the ureilites as mantle restites [e.g., 4]. One obvious problem with such a model, at least in a too extreme form, is that slow cooking within a still deep and well-insulated mantle restite can hardly be expected to leave the sorts of highly zoned olivines that we so typically observe in ureilites.

In a few of the most ferroan ureilites, such as LEW88774 [3] and NWA766 [5,6], even more extraordinary late-stage processes occurred. These ferroan ureilites are unusual in containing small proportions of Cr-spinel. Near the widely scattered Cr-spinels in NWA766, a phase originally identified as a Cr-rich, shock-produced garnet [5,6] formed narrow, arcing rim-bands; by one interpretation [6], this "knorringite-uvavorite garnet" has at least locally decomposed into an extremely fine-grained symplectite. It now appears doubtful whether this phase was ever a garnet of any kind. The hypothesis that these materials are (or formerly were) garnets fails the test of charge balance. (I am indebted to Craig Manning for originally suggesting this test to me.)

A clue to the nature and causative mechanism of the late-stage processing of the ureilites might be derived from study of the distribution of Cr within their mafic silicates, particularly olivine. This project is at an early stage, but interesting results have already emerged.

In most ureilites, it seems that the formation of the reduction rims was accompanied by little change in the olivine Cr contents. Even this null result is slightly puzzling, because reduction of the Fa component of the olivine might be expected, by very simple mass balance, to leave the residual olivine enriched in Cr. However, in some ureilites, the reduced rim olivines even show marked Cr depletions. For example, Fig. 1 shows new data for HaH 126 and NWA1241. Berkley et al. [1] also found that the reduced olivine rims in Kenna feature Cr depletions.

NWA766 is again exceptional. Near (within ~ 50 µm of) its Cr-spinels, the olivine rims typically show highly enriched Cr (Fig. 1). The fact that these enrichments are found only in proximity to Cr-spinels suggest that the mobility of Cr was limited, by either too-slow diffusion or too short a duration of the *T,P* conditions that were (briefly) conducive to Cr diffusion.

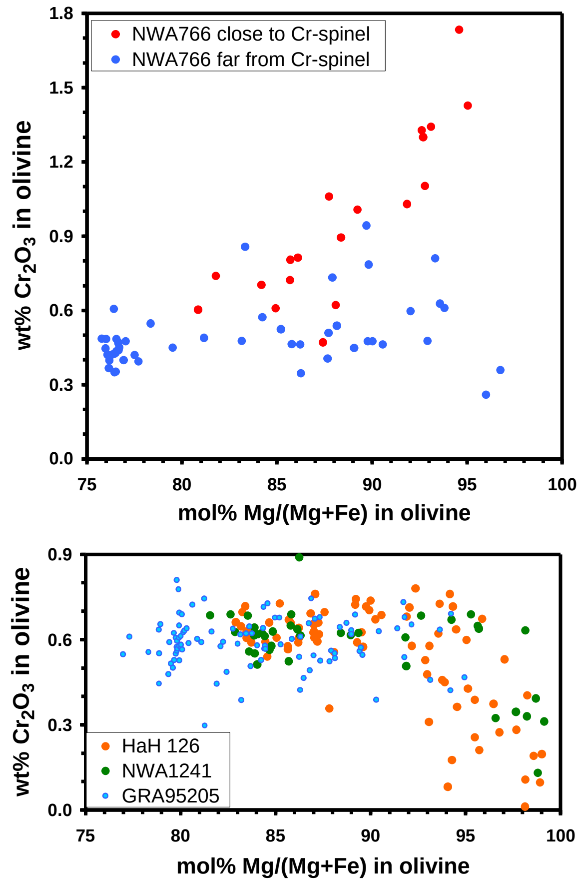

Fig. 1. Mg/(Mg+Fe) zonation trends in several relatively ferroan ureilites.

Conclusions: The behavior of Cr during the late stages of ureilite formation may provide important clues to the processes involved, and to the general issue of the "smelting" of ureilites.

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