TRACE-ELEMENT ABUNDANCES IN SEVERAL NEW UREILITES

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Summary: Four new ureilites are analyzed for trace-element abundances. Frontier Mountain (FRO) 90054 is an augite-rich ureilite and has high REE abundances with a pattern expected of augite. FRO 90036 and Acfer 277 have REE patterns similar to the V-shape pattern of other ureilites. Nuevo Mercurio (b) has very high REE abundances, but they look like they are due to terrestrial alteration. The siderophile-element pattern of these ureilites are similar to those of known ureilites.

Introduction: Ureilites are a group of enigmatic meteorites whose origin is unknown [1]. There appears to be a consensus that they have undergone igneous processing, but beyond that there is little agreement on the petrology of ureilites. Suggestions have been made that they formed by Ostwald ripening [2], as a residue from partial melting [3], as a cumulate [4], or by a three-stage [5] or a four-stage [6] igneous fractionation process. Their petrogenesis has been reviewed recently by Spitz [7].

Samples: In this work we have analyzed three new ureilites (FRM 90036 and FRO 90054, from Antarctica, and Acfer 277, from the Sahara) as part of a consortium effort lead by Robert Hutchison of the British Museum (Natural History), and a fourth meteorite Nuevo Mercurio (b) found in Zacatecas Mexico and supplied by Ron Farrell of Bethany Sciences. The consortium samples are described as heavily shocked (FRO 90036), lightly shocked and augite rich (FRO 90054), and moderately shocked (Acfer 277) [8]. Nuevo Mercurio (b) has been described by Treiman and Berkley [9]. It is a Group 1 ureilite (Kenna-like) and is altered from terrestrial exposure, containing calcite and silica in cracks and up to 1% nickel oxide in grain boundary alterations.

Experimental: So far the samples have been analyzed only via INAA using the U of A low-flux Triga reactor. Ureilites are known to have low REE abundances that require radiochemical separations to properly determine the shape of the REE pattern. We expect to have RNAA results for the REE at the conference.

Results: The siderophile-element abundances are plotted in Fig. 1a; literature data are shown in Fig 1b for comparison. The refractory, incompatible siderophiles (Re, Os, W, Ir) are correlated with each other and are more abundant than the volatile, compatible elements. At this time, only Ir could be determined among the former group in Nuevo Mercurio (b) as its abundance is low and the others are below detection limits. This incomplete siderophile-element pattern is consistent with this ureilite having abundances like that of Alan Hills (ALH) A81101, the only other ureilite with refractory siderophiles as low as the volatile siderophiles. Because of the formation of NiO in this meteorite due to alteration, the significance of this result cannot yet be determined. The W data in the two Frontier Mountain samples seem high. Contamination may well be responsible for this result, but at this time we do not fully understand the collection and curation processes and thus cannot say whether this hypothesis is likely.

The REE are plotted in Fig 2a, and literature data are shown in Fig 2b. The pattern of Nuevo Mercurio (b) is unlike that of any other ureilite and may well be a weathering artifact. Sample FRO 90054 has the highest REE of any known ureilite. The pattern is similar to that expected of an augite, and the data suggests that augite probably dominates the REE abundances. Unless augite is particularly coarse grained and heterogeneous, this result is not likely to be simply a sampling artifact, as we analyzed three splits totaling 460 mg, and each split showed a similar result. Without the RNAA data, it is difficult to say much about the REE in the other new ureilites except to say that they appear to have a normal V-shape pattern.

Discussion: At this early stage in our study, these new data provide little additional insight into the petrology of ureilites. Clearly no new arguments can be made to choose between the various hypotheses that have been offered. Nevertheless, the presence of FRO 900054, which
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may be an end member in the igneous fractionation process, may be able to contribute to our understanding once the consortium can combine the constraints provided by the different investigations.

Figure 1. Siderophile-element data in ureilites; this work (a) and literature data from [1] (b). The new ureilites show the same type of pattern with the incompatible siderophiles (Re, Os, W, Ir) enriched by constant amounts relative to the compatible siderophile elements (Ni, Co, Au, Ga).

Figure 2. Rare-earth-element data in ureilites; this work (a) and literature data from [1] (b). Frontier Mountain 90054 has higher REE abundances than any known ureilite. The pattern is not the typical V-shape pattern or linear pattern found in other ureilites. It is similar to that expected of augite. The pattern of Nuevo Mercurio (b) may be due to terrestrial alteration.