AN ION MICROPROBE STUDY OF PLAGIOCLASE-RICH CLASTS IN THE NORTH HAIG POLYMICT UREILITE; Andrew M. Davis[1], Martin Prinz[2] and John R. Laughlin[3]. [1]James Franck Institute, [3]Department of Chemistry, University of Chicago, Chicago, IL 60637. [2]Department of Mineral Sciences, American Museum of Natural History, New York, NY 10024.

Ureilites are olivine, pigeonite-rich rocks with carbon-rich veins that appear to have formed as cumulates. They have very low concentrations of the rare earth elements (REE) and characteristic V-shaped REE patterns [1]. Siderophile element abundances suggest a relationship with C3V chondrites [2]. Their bulk oxygen isotopic compositions also suggest such a relationship, because they scatter along an ^{16}O-mixing line colinear with dark inclusions and refractory inclusions in C3V chondrites [3]. Among the models proposed for their origin are: compaction, recrystallization and removal of a Ca-Al-Fe-rich partial melt from a body having the composition of a carbonaceous chondrite [4]; a series of partial melting and cumulate formation episodes, each involving segregation of small fractions of material [5]; and separation of crystalline residues and liquids in a thermal gradient [6]. The polymict ureilites contain additional components that may provide new clues about the origin of the ureilites. In a study of Nilpena and North Haig, Prinz *et al.* [7] reported clasts similar to Angra dos Reis and monomineralic grains of clinopyroxene, enstatite, plagioclase (An_{0-100}), suessite, chromite and chloroapatite. Further study has revealed the presence of feldspathic clasts in North Haig, consisting of plagioclase with pyroxene and phosphates. We have begun an ion microprobe study of the chemical and isotopic compositions of these clasts to elucidate relationships between the clasts, ureilites and other meteorite groups.

Ureilites are believed to have formed early in the history of the solar system, but their precise age is not known. Most models for formation of ureilites require high temperatures. A possible early solar system heat source is ^{26}Al. If this radionuclide were present in the amounts found in Allende refractory inclusions, parent bodies as small as a few kilometers across could easily melt. Most ureilites contain no phases high in aluminum, but the polymict ureilites contain plagioclase ranging in composition from albite to anorthite. As a test for the possibility of heating of the ureilite parent body by ^{26}Al decay, we have measured the magnesium isotopic composition of several plagioclase grains in North Haig. The plagioclase with the highest $^{27}Al/^{24}Mg$ ratio measured to date, 400, has a $\delta^{26}Mg$ value of <2.3 ‰, corresponding to an initial $^{26}Al/^{27}Al$ ratio of $<1 \times 10^{-6}$. If ^{26}Al decay was the heat source for the igneous fractionations leading to the plagioclase in North Haig, the event must have been long enough in duration to permit the decay of ^{26}Al, at least 5 half-lives, or 3.5×10^6 years. While the measurement made here does not rule out the possibility of ^{26}Al as a heat source, it does place limits on the chronology of formation of components in North Haig, and presumably of other ureilites.

One of the clasts studied in North Haig closely resembles Angra dos Reis in its petrography and mineral chemistry [7]. As a test of the similarity of this clast to Angra dos Reis, we have measured the concentrations of REE in plagioclase, fassaite and olivine. The REE pattern of fassaite is similar in shape to that of Angra dos Reis pyroxene. C1 chondrite-normalized REE enrichment factors increase by a factor of 2 from La to Sm and are fairly constant from Sm through the heavy REE. The magnitudes of the enrichment factors in Angra dos Reis and the North Haig clast differ. In Angra dos Reis, pyroxene has C1 chondrite-normalized enrichment factors of 23 to 37 [8,9], while that in the North Haig clast has enrichments of only 4 to 10. If the clast is related to Angra dos Reis, the difference in REE levels in the pyroxene must be due to differences in crystallization history. Diffusive loss of REE to the ureilite matrix is unlikely, since olivine, which easily exchanges iron for magnesium, is zoned. Plagioclase (An_{98}) in the Angra dos Reis-like clast is enriched in Eu by a factor of 15 compared to C1 chondrites, but contains undetectable amounts of the other REE (<1 times C1 chondrites).

A feldspathic clast containing feldspar (An_{15}), chloroapatite and augite was found. The REE patterns of chloroapatite and augite in this clast are shown in the figure. Plagioclase is enriched in Eu by 8 times C1 chondrites and has undetectable levels of the other REE. The REE pattern of chloroapatite is quite typical, but that of the augite is quite steeply fractionated. The steep fractionation could occur if the augite/chloroapatite ratio of the bulk clast were low. REE appear to have equilibrated among the phases of the clast.

Two isolated plagioclase grains of An_{74} and An_{48} were also analyzed for REE. Only Eu was detected and the C1 chondrite-normalized enrichments in both were ~22.

It is clear from this study that the polymict ureilite North Haig contains components that have much higher enrichments in incompatible elements than bulk ureilites. If these components originated on the same parent body, they must differ by several generations of igneous fractionation events. It seems unlikely that components as distantly related by igneous fractionation processes as the clasts are from one another and from the ureilite host could come from the same parent body and end up in one meteorite. It seems more likely that they came together from separate parent bodies in an impact event. It is hoped that further study of the feldspathic components in polymict ureilites will reveal some systematics in trace element abundances.

REFERENCES: [1] Boynton W. V. *et al.* (1976) *GCA* **40**, 1579. [2] Janssens M.-J. *et al.* (1987) *GCA* **51**, 2275. [3] Clayton R. N. and Mayeda T. K. (1988) *LPS XIX*, this volume. [4] Takeda H. (1987) *EPSL* **81**, 358. [5] Goodrich C. A. *et al.* (1987) *GCA* **51**, 2255. [6] Walker D. and Agee C. B. (1988) *Meteoritics* **23**, in press. [7] Prinz M. *et al.* (1986) *LPS XVII*, 681-682. [8] Ma M.-S. *et al.* (1977) *Earth Planet. Sci. Lett.* **35**, 331-346. [9] Zinner E. and Crozaz G. (1986) In *Secondary Ion Mass Spectrometry (SIMS V)* (eds. Benninghoven A. *et al.*), pp. 444-446, Springer-Verlag.

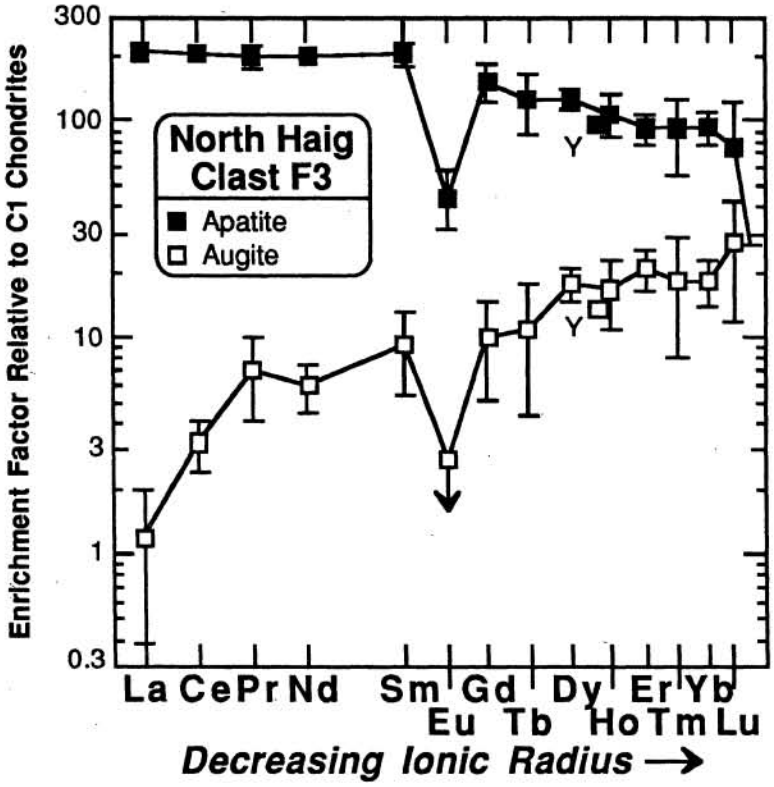

Figure. REE in apatite and augite in North Haig feldspathic clast F3, determined by ion microprobe. The uncertainties shown are $\pm 2\sigma$, based on counting statistics. The arrow gives a 2σ upper limit.