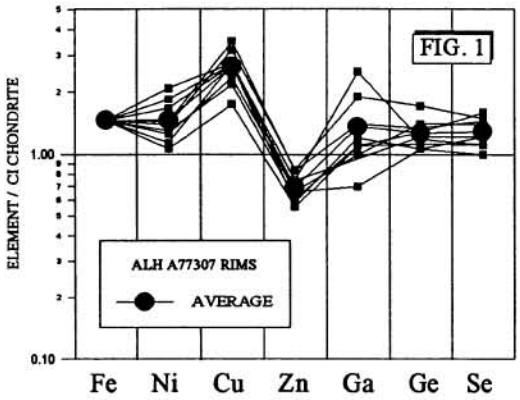
SXRF DETERMINATION OF TRACE ELEMENTS IN CHONDRULE RIMS IN THE UNEQUILIBRATED CO3 CHONDRITE, ALH A77307. Adrian J. Brearley[1], Saša Bajt[2,3], and Steve R. Sutton[2,3] [1]Institute of Meteoritics, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131. [2]Dept. of Applied Sciences, Brookhaven National Laboratory, Upton, NY 11973. [3]Dept. of Geophysical Sciences, University of Chicago, Chicago, IL 60637.

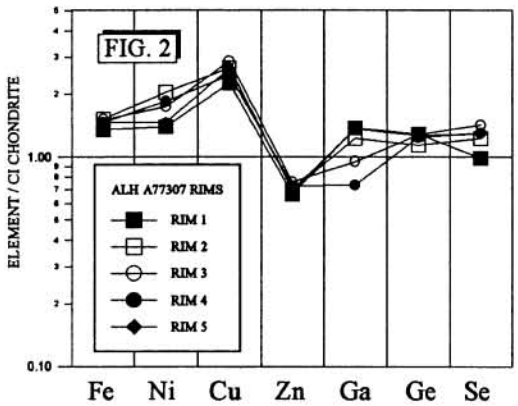
We have determined the concentrations of Ni, Cu, Zn, Ga, Ge and Se in five chondrule rims in the CO3 chondrite ALH A77307 (3.0) using the synchrotron X-ray fluorescence (SXRF) microprobe at Brookhaven National Laboratory. The data show that the trace element chemistry of rims on different chondrules is remarkably similar, consistent with data obtained for the major elements by electron microprobe. These results support the idea that rims are not genetically related to individual chondrules, but all sampled the same reservoir of homogeneously mixed dust. Of the trace elements analysed Zn and Ga show depletions relative to CI chondrite values, but in comparison with bulk CO chondrites all the elements are enriched by ~1.5 to 3.5 x CO. The high concentrations of the highly volatile elements Se and Ga and moderately volatile Zn (1.5 to 2 x CO) in rims show that matrix is the major reservoir of volatile elements in ALH A77307.

Introduction. Allan Hills A77307 is the most unequilibrated of the CO3 carbonaceous chondrites [1]. Such unequilibrated chondrites represent some of the least processed samples of meteoritic material available for study. They may preserve, to varying degrees, evidence of processes which took place during the earliest stages of the formation of our solar system. One of the major components of the CO3 chondrites is a dark, fine-grained matrix which occurs interstitially to chondrules. The origin of this material and matrix materials in other chondrites has long been a question of considerable controversy e.g. [2,3,4]. In order to address the origin of matrix it is important to characterize these materials as fully as possible. Although mineralogical and major element compositions have become more widely available as a result of detailed transmission electron microscope (TEM) and electron microprobe studies, trace element compositions of matrix are extremely rare. Because the trace element geochemistry of matrix can provide important geochemical constraints on the origin of matrix, we have commenced a study of the trace element compositions of fine-grained matrix in the CO3 chondrites, using the SXRF microprobe at Brookhaven National Laboratory.

Analytical techniques. Polished thin sections of ALH A77307 were prepared on Suprasil glass slides. Several chondrules with well-developed fine-grained rims were selected for study and their major element compositions were determined by electron microprobe for 6-10 spots on each rim using a 10 μm beam. Trace element concentrations were determined by SXRF microprobe at the same locations on the sample used to acquire the electron microprobe analyses. Between 6 to 10 analyses were carried out on each chondrule rim using a beam size of 8 x 10 μm. Because of the intense Fe peak a 170 μm thick Al filter was used on the fluorescent beam. Concentrations of Ni, Cu, Zn, Ga, Ge and Se were determined.

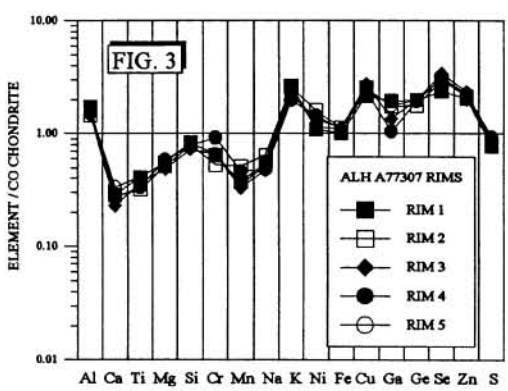
Trace element chemistry. The results of several analyses in different positions on one rim are reported in Fig.1 normalised to CI abundances. The plot shows that there is some variation from point to point for all the elements analysed, especially Ga. This spread in Ga values is due to the relatively large uncertainty resulting from its low concentration levels. However, overall the data for Ni, Cu, Zn, Ge and Se are relatively closely clustered. Some of the variation in the data can be attributed to localized variations in the matrix composition on the scale of 10 μm which have also been observed in electron microprobe analyses [3]. It is notable that the relative enrichments and depletions for each analytical spot are essentially identical. The average trace element compositions from the five different rims, normalised to CI chondrite values, are also shown in Fig. 2. This plot clearly shows that the trace element compositions of individual rims are essentially identical, with Ni, Cu, Ge and Se all showing enrichments relative to CI





abundances. Zn is consistently depleted, but Ga shows variable behavior, presumably due to the errors noted above. Overall it appears to be enriched relative to CI abundances. In Figure 3 the trace element data, combined with major element data for the same rims, are plotted, normalised to CO chondrites. There is a remarkable compositional homogeneity of individual rims in ALH A77307. Relative to bulk CO all the trace elements are enriched, particularly Se which shows enrichments of up to 3.5 x CO values.

Discussion. The trace element data clearly demonstrate the remarkable compositional homogeneity of rims on different chondrules, which has previously been reported for major elements in ALH A77307 [3]. These results support the idea that this fine-grained material represents a single reservoir of dust which was sampled by chondrules. Mineralogically, rim material has been shown to consist of an ultrafine-grained, highly unequilibrated assemblage of amorphous material, silicates, oxides and sulfides, which was clearly mixed extremely thoroughly on a fine scale. The absence of any variation in the mean trace element abundances from rim to rim is strong evidence to support the arguments presented elsewhere [3] that rim materials in ALH A77307 are not related to chondrules. One of the major observations from this study is that the highly volatile elements Se and Zn are significantly enriched (2 to 3.5 x CO) in rims as is the moderately volatile element Ga relative to bulk CO chondrite values. Se and Ga also show modest enrichments relative to CI chondrite values illustrating that matrix is indeed the major reservoir for these elements in ALH A77307. The only other analysis of CO3 matrix [5] was carried out by neutron activation analysis from a matrix fragment in Ornans. These data show evidence for lower enrichments for the volatile elements Se, Zn and Ga (~1.5 x CO) than our SXRF analyses, but differ in other important respects in having higher refractory abundances in comparison with the microprobe data as noted by [5]. Fig. 3 illustrates that ALH A77307 matrix has suffered extremely complex fractionations, consistent with the presence of a number of different matrix components with different origins [3]. Overall, matrix appears to be depleted in refractory elements, but is enriched in the moderately volatile siderophile and chalcophile elements, consistent with the view that matrix did not suffer extensive high temperature processing prior to accretion. The high volatile contents also argue strongly against a chondrule origin for rim materials.



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