

**NOBLE GASES, C, N AND Si ISOTOPES IN INTERSTELLAR SiC FROM THE MURCHISON CARBONACEOUS CHONDRITE;** Tang Ming and Edward Anders, Enrico Fermi Institute and Department of Chemistry, University of Chicago, Chicago, IL 60637, USA, and Ernst Zinner, McDonnell Center for the Space Sciences and Physics Department, Washington University, St. Louis, MO 63130, USA.

Two Murray separates rich in Ne-E and Xe-S [1] were shown to contain interstellar SiC with extremely anomalous C, N and Si [1,2]. Since these residues still consisted mostly of Mg,Al- and Cr,Fe-spinels we processed a bulk sample of Murchison in order to obtain purer SiC samples. After treatment with HF-HCl,  $\text{Cr}_2\text{O}_7$ ,  $\text{HClO}_4$ , HF-HCl and sedimentation in  $\text{NH}_3\text{-H}_2\text{O}$ , three size fractions (0.03-0.2  $\mu\text{m}$ ; 0.2-2 $\mu\text{m}$ ; 2-10 $\mu\text{m}$ ) were subjected to  $\text{H}_3\text{PO}_4$  at 230°C to dissolve spinels and to  $\text{HClO}_4$  at 160°C to oxidize elemental carbon. The resulting residues HM (3.3 ppm), HN (3.6 ppm) and HO ( $\approx$  0.3 ppm) were analyzed by noble gas mass spectrometry (Ne, Xe), HM and HN also in the ion microprobe (C, N, Si) and SEM (EDX). Noble gas data are given in Table 1 together with the compositions of HM and HN obtained from SEM-EDX analysis and the Si/C ratios measured in the ion probe. All three separates are highly enriched in Ne-E, but the Xe-S concentration decreases sharply from HM to HO. While this is also the general trend in the corresponding Murray residues CF and CJ [1,3], there are important differences between Murchison HM and Murray CF, the two finer-grained separates that have relatively high Xe-S/Ne-E ratios. Not only is the Ne-E and Xe-S concentration per SiC content lower in Murchison but the Xe-S/Ne-E ratio in Murchison HM is only  $\sim 25\%$  of that in Murray CF. Physical loss cannot be excluded. Either the carriers of Ne-E(H) and especially Xe-S were partly lost in the Murchison separation or Murchison differs significantly from Murray.

For ion probe analysis HM was divided into an optically light and an optically dark portion. In addition, fractions of HM and HN were oxidized in an oxygen plasma discharge (asher). The analysis techniques for the isotopic measurements of C, N and Si have been described previously by [3,4]. Measurements were made on agglomerates of varying sizes with a  $\text{Cs}^+$  beam of 3-5 $\mu\text{m}$  in diameter. During each analysis many grains were consumed, typically tens for the coarser and hundreds to thousands for the finer fraction. Results on different fractions of HM and HN are presented in Figures 1-3. The Si isotopic compositions measured in different agglomerates are highly anomalous (Fig. 1). Within the errors all except one fall within the boundaries (triangle) spanned by the data points previously measured in the Murray residues CF and CJ which are also shown (without errors) in Fig. 1. One point from HN falls significantly below the terrestrial fractionation line thereby extending the range of anomalous Si compositions in SiC (dotted extension to triangle). Since each single analysis still measures many grains, the true end components (of which at least three must be present) must be substantially outside the region populated by the data. The larger spread in the HN data is probably the consequence of the larger grain size of SiC and thus the smaller number of individual grains (probably still on the order of 10-50) consumed during an analysis. The C isotopic data (Fig. 2) show mixing between an isotopically normal C phase, probably  $\text{C}\theta$  [5], mostly present in the dark fraction, and isotopically heavy SiC that has a range of  $\delta^{13}\text{C}$  values. As for Si, the coarser fraction HN shows larger variability with four data points in the inset ranging up to  $\delta^{13}\text{C} = 7300 \pm 250\%$ . In HN the C isotopic ratios were measured from  $\text{C}^-$  and  $\text{C}^{14}\text{N}^-$ . While in most cases the  $\delta^{13}\text{C}$  values are comparable, in a few cases the C in the  $\text{CN}^-$  is much heavier than that in  $\text{C}^-$  ( $\delta^{13}\text{C}$  values of 14250 $\%$  versus 7300 $\%$  in the most extreme case) indicating an isotopically extremely heavy C component associated with N. It is hoped that single grain measurements which seem feasible for the coarser ( $\sim 1 \mu\text{m}$ ) grains in HN will give information on the original carbon isotopic components present in meteoritic SiC. The N isotopic data (Fig. 3) show a complex mixture of several components. The  $\delta^{15}\text{N}$  values for HM dark are only slightly negative which suggests that the pure carbon phase in this fraction is  $\text{C}\theta$  whose N is close to normal [7] rather than  $\text{C}\delta$  whose  $\delta^{15}\text{N}$  is  $-375\%$  [6]. The SiC in both HM and HN shows evidence for light and heavy N, with the HN data again displaying larger variability ranging from  $\delta^{15}\text{N} = -856$  to  $+3200\%$ . Although the SiC with the isotopically heaviest C shows normal or moderately heavy N, the heaviest N is found in samples having  $\delta^{13}\text{C}$  values within the range shown by most other agglomerates. There is no simple correlation between  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ , at least three different components must be present. Unfortunately, because of the low N concentration, the required high mass resolving power and the low  $^{15}\text{N}$  abundance even in terrestrial N, it is doubtful that single grain analysis of N isotopes will be possible.

In summary, the isotopic diversity of interstellar SiC suggests that several stellar sources contributed this material to the forming solar system. Formation of SiC requires  $\text{C/O} > 1$  (carbon stars), and the variety of the Si isotopic compositions requires at least three different stars. The light N points to red giants, whereas the heavy N and Ne-H suggests a nova [8].

REFERENCES: [1] Tang and Anders (1988), GCA, submitted; [2] Bernatowicz *et al.* (1987), Nature 330, 738; [3] Zinner *et al.* (1987), Nature 330, 730; [4] McKeegan *et al.* (1985) GCA 49, 1971; [5] Tang *et al.* (1988), GCA, in press; [6] Ash *et al.* (1987) Meteoritics 22, (in press). [7] Zinner (1987) unpublished data; [8] Clayton and Hoyle (1976), Ap.J. 203, 490.

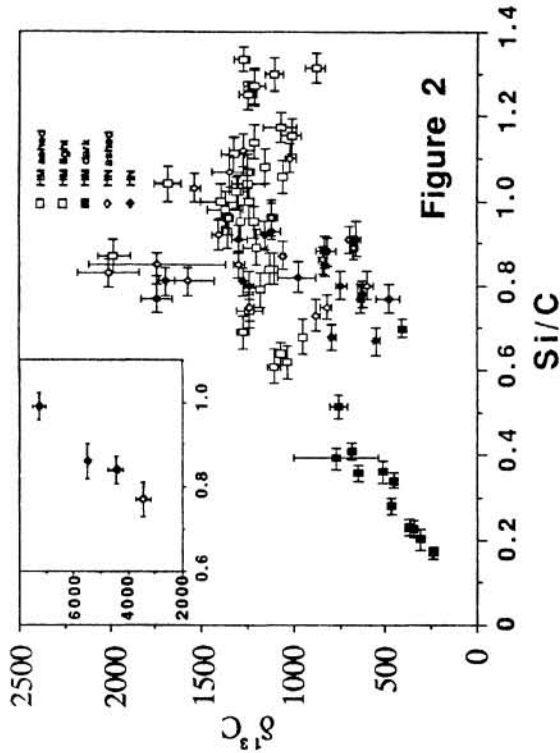


Figure 2

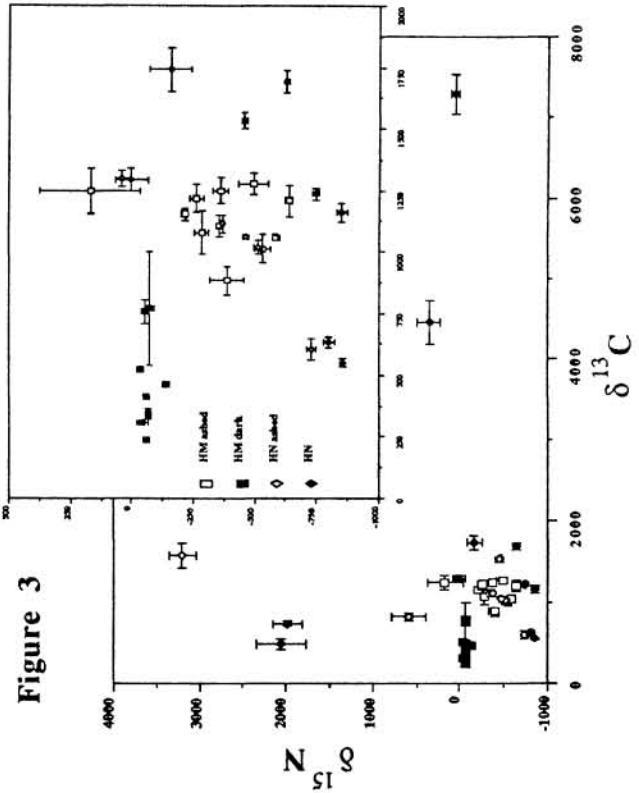


Figure 3

Table 1  
Mineral and noble gas composition  
of Murchison HM, HN and HO

	HM	HN	HO
SiC (%)	76	94	-
Carbon (%)	23	5	-
Spinel (%)	~1	-0.5	-
<sup>22</sup> Ne-E (10 <sup>-8</sup> cc/g)	1953	3780	2232
<sup>130</sup> Xe-S (10 <sup>-10</sup> cc/g)	194	43.4	2.0
<sup>136</sup> Xe-HL (10 <sup>-10</sup> cc/g)	219	37.1	21.7

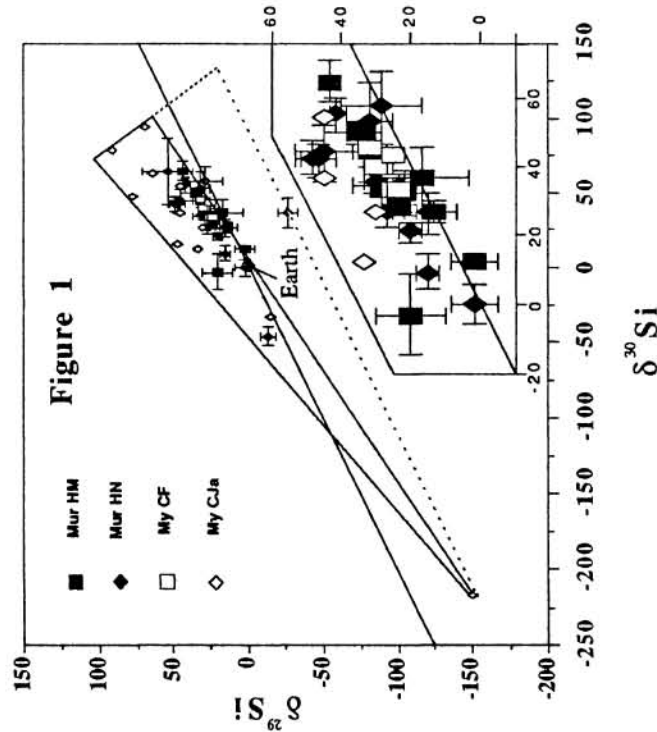


Figure 1