ION PROBE STUDIES OF INTERSTELLAR SIC IN ORDINARY CHONDRITES.

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SiC of probable interstellar origin, has been found in both CM carbonaceous[1,2] and some unequilibrated ordinary chondrites (UOCs)[3]. Yet SiC does not appear to be present in Allende (CV3), a meteorite generally considered to be more primitive than the UOC's. There is evidence for significant differences, on the average, between the isotopic compositions of SiC in the CMs and in UOCs[3,4] and even perhaps within the UOCs[4] themselves.

We are engaged in a survey of primitive classes of meteorite to investigate the nature of the differences both between and within them. In an attempt to simplify sample preparation procedures and to reduce to a minimum the size of sample required we have developed a method for analyzing SiC grains in the ion probe without the necessity of producing pure grain separates. By mapping for ^{12}C and ^{28}Si in the ion probe it is possible to locate and analyse even small (~1μm) SiC grains embedded in acid residue material. A major disadvantage, though, of not using pure separates is the ubiquitous carbonaceous material in residues. Even very small amounts of this material can compromise C isotopic measurements. Atomic oxygen plasma ashing has been used as a means of removing carbonaceous material in the past but has proved ineffective at removing Cδ, microcrystalline diamond. However, this component is effectively removed when a small sample (<0.1mg) of acid residue is dispersed on gold foil and then heated overnight in air at 500°C. It was found to be impractical to locate the SiC grains in the SEM prior to ion probe analysis so that we do not have grainsize or morphological information on the grains analysed.

Using this technique we have analysed some 40 SiC grains for C and Si isotopes (fig, 1a,b) in a 'standard' Murchison residue which has an enrichment factor of only 1200 (for acid residues enriched to this degree sample sizes of the order of only a gram are sufficient so that even the rarer meteorites may be analysed). These Murchison grains provide a standard with which to compare all other meteorites analysed. The range of Si and C isotopic compositions are almost identical to those previously reported for Murchison[2] using much purer residues. Even the apparent groupings in the Si isotopes (fig. 1a) are similar to those reported by Zinner *et al.* (1989) for single crystals and coarse aggregates. Most grains have C isotopic compositions between $\delta^{13}C$=0 and 1000‰ (fig. 1b). Three grains have $\delta^{13}C$ of between 3000 and 7000‰. However, we have not found any evidence for the grains whose C isotopic composition lie in the range $\delta^{13}C$ 1200-1700‰ and which dominate the fine-grained separates[2] and stepped combustion experiments[5]. Presumably these were too small to be detected. A remarkable feature of fig. 1a is that all the grains are arrayed along a line with a slope of 1.05. Despite intriguing parallels with the Allende O 'mixing line', which might result from mass independent fractionation[6], a nucleosynthetic origin for the Si isotopic compositions seems more likely at present.

To date residues from two UOCs, Krymka and Inman, have been analysed in the ion probe; SEM examination of residues from Tieschitz, Bishunpur and Semarkona indicate they also have sufficient SiC concentrations for ion probe analysis. As can be seen from fig. 2, the Si isotopic compositions of SiC grains in Krymka almost all cluster in the region of Murchison's group 1, with the remainder clustering near group 3. With three notable exceptions the C isotopic compositions of the Krymka SiC lie between 0‰ and 1000‰. Two of the exceptional grains are hugely enriched in ^{13}C with compositions of $\delta^{13}C$=27800‰ ($\delta^{29}Si$=68‰ and $\delta^{30}Si$=57‰) and $\delta^{13}C$ 32800‰ ($\delta^{29}Si$= 42‰ and $\delta^{30}Si$= 59‰). The third grain is depleted in ^{13}C with a composition of $\delta^{13}C$=-492‰ ($\delta^{29}Si$= -151‰ and $\delta^{30}Si$= -282‰).

In Inman, on the other hand, the majority of SiC grains fall in the region of Murchison's group 2 (fig. 3). Again the C isotopes of these grains typically fall between 0 and 1000‰. In Inman no grains with $\delta^{13}C$ greater than 1200‰ have been observed.

The results described above demonstrate that there are indeed differences in the compositions of SiC grains from meteorite to meteorite. These differences are probably the result of variations in the relative proportions of several groups of SiC grains. A fundamental question is whether these differences resulted from fractionation from an initially uniform population in the nebula. Size sorting is unlikely, unless some grains were part of larger objects, as all the measured grains have similar size ranges. Alternatively, these differences could reflect differing sources of SiC grains becoming available during accretion of the respective parent bodies. *The authors wish to thank K. Levsky and U. Ott for generously providing the sample of Krymka acid residue analysed.* (1) Bernatowitz *et al.* (1987) Nature 330, 728-730; (2) Zinner *et al.* (1989) G.C.A. 53, 1235-1244; (3) Alexander *et al.* (1989) Meteoritics, in press; (4) Alexander *et al.* (1990) E.P.S.L., in press; (5) Tang *et al.* (1988) G.C.A. 52, 1221-1234; (6) Thiemens and Hiedenreich (1983) Science 219, 1073-1075.

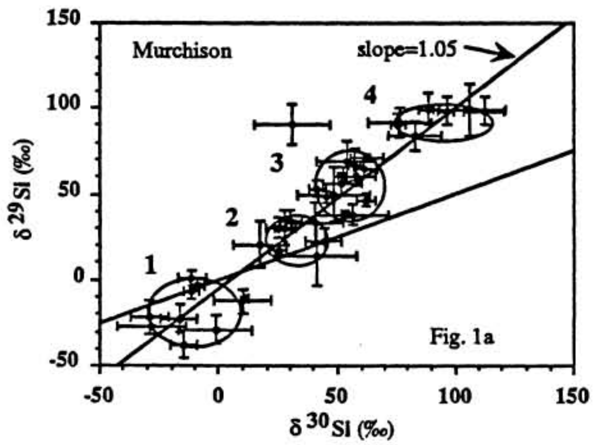

Fig. 1a

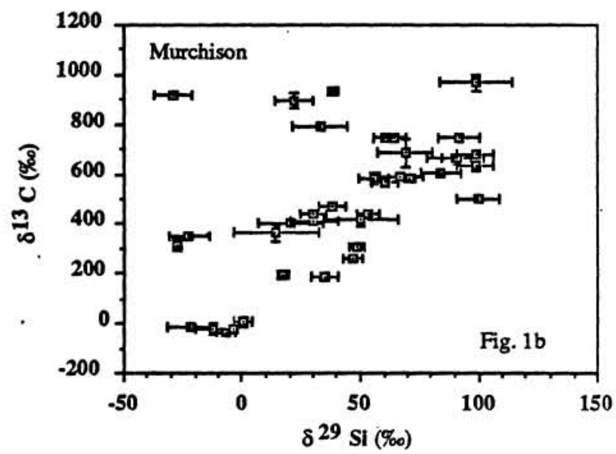

Fig. 1b

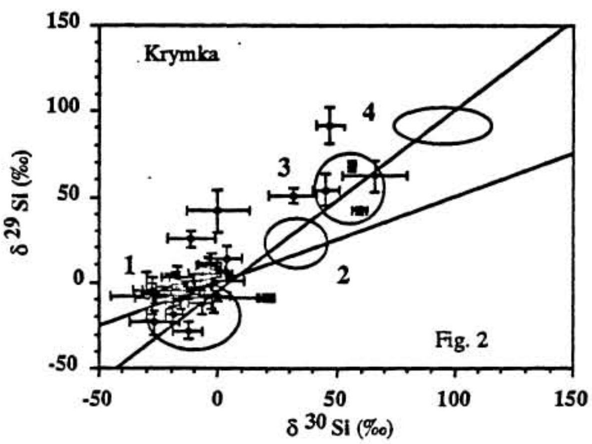

Fig. 2

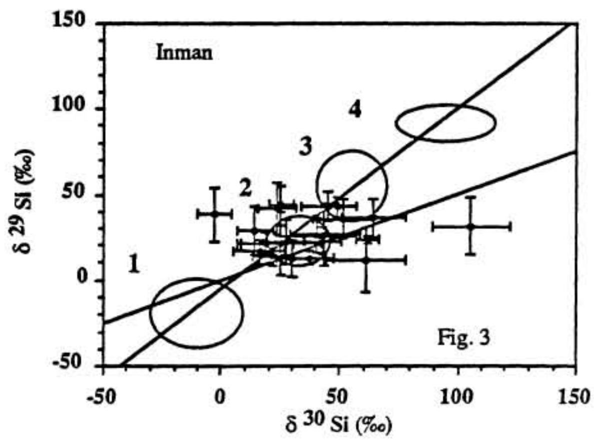

Fig. 3