SiC AND Si_3N_4 IN QINGZHEN (EH3).

C. M. O'D. Alexander, C. A. Prombo, P. D. Swan and R. M. Walker. McDonnell Center for the Space Sciences, Washington University, St Louis, MO 63130, U.S.A.

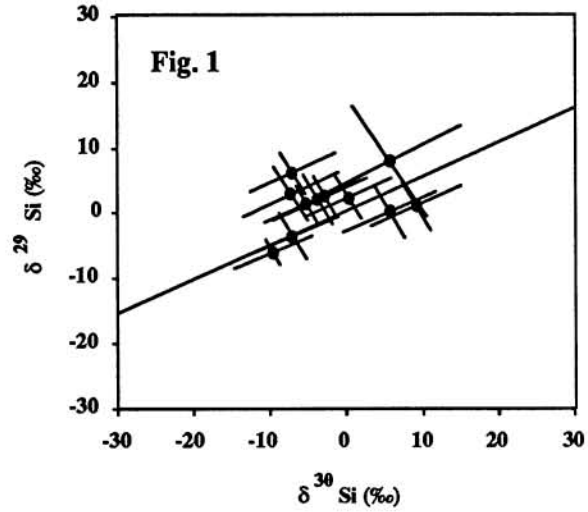
Isotopically anomalous SiC has now been found in almost all chondrite groups and is interstellar in origin (e.g. 1-3). Several meteorites also contain isotopically normal SiC (e.g. 2-3). While contamination cannot be ruled out, the presence of isotopically normal SiC in these chondrites has led to the suggestion that some SiC may have a solar system origin. Indeed, SiC has been predicted to be a condensate in the formation region of the enstatite chondrites (4). It might be anticipated, therefore, that if the isotopically normal SiC is not contamination it would be most abundant in enstatite chondrites. It is for this reason that we have initiated a search for SiC, both in acid residues and *in situ*, in Qingzhen (EH3).

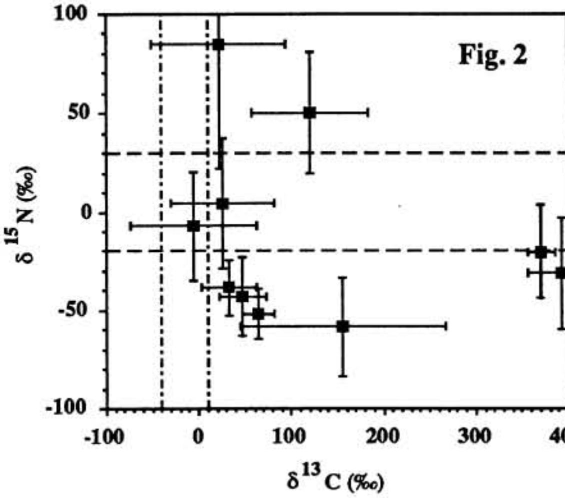
Contrary to our expectations the dominant Si bearing mineral in our acid residue is not SiC but a silicon nitride, probably Si_3N_4. The grains, which range from 0.1 to 10μm across, were identified as nitrides using a SEM equipped with an ultra thin window EDS detector. Silicon nitride has been previously reported (3) in another enstatite chondrite, Indarch (EH4). However, its predominance over SiC was unexpected; of 58 grains examined in the SEM, only one was SiC.

The possibility that silicon nitride in Qingzhen might be a new interstellar component, in addition to SiC, diamond and graphite, would seem to be ruled out by ion probe measurements of their isotopic compositions. The Si isotopic compositions of all the grains measured are within error of the terrestrial range (Fig. 1). The carbon and nitrogen isotopic compositions are more variable, but the errors are large. All but three grains have carbon and nitrogen isotopic compositions that fall within 2 sigma of the terrestrial ranges (fig. 2). However, there does appear to be a tendency for the carbon to be heavier and the nitrogen lighter than terrestrial carbon and nitrogen. Nitrogen released at high temperatures from enstatite chondrites during stepped combustion and pyrolysis falls in the range $\delta^{15}N = -20‰$ to $-50‰$ (5). Six of the ten grains fall in this range and two of others are within one sigma. The carbon in the silicon nitride, on the other hand, is generally heavier than that released from bulk samples which tend to be in the range $\delta^{13}C = -15‰$ to $+5‰$. The two grains with highly anomalous carbon isotopes may be presolar but an alternative explanation is that they had presolar SiC grains adhering to them. Indeed their C/Si ratios (0.2 and 0.8) are significantly higher than in the other grains (0.009-0.09). The one SiC identified in the SEM is anomalous with a Si isotopic composition of $\delta^{29}Si = 50\pm3$ ‰ and $\delta^{30}Si = 58\pm4$ ‰.

Silicon nitride grains have also been found *in situ* using the SEM technique previously developed for the location of SiC (6). These *in situ* observations of the silicon nitride appear to confirm their solar system origin. All nine of the grains found to date, which range from 0.3-2.5μm across, are inclusions within metal and phosphide (Fig. 3). The silicon nitride concentration in Qingzhen, estimated from the areal fraction, is approximately 40ppm. Thus, nitrogen in silicon nitride comprises only about 17ppm of the meteorite; this is only 2-10% of the total nitrogen typically found in enstatite chondrites (e.g. 5). No sinoite was found in Qingzhen. Therefore, most of the nitrogen must be dissolved in the metal, substituting for O in silicates or in other nitrides such as osbornite. No SiC has yet been found *in situ*. Consequently, the concentration of SiC greater than 0.3μm across in Qingzhen cannot be much higher than 1ppm, which is consistent with the concentration estimated from noble gas measurements (7).

Possible origins for the silicon nitride are: nebular condensates or by exsolution either as their host phases cooled shortly after formation or during metamorphic reheating. A condensate origin seems unlikely since the silicon nitride has been found only in metal and phosphide and not in other phases or the matrix. At present there is no evidence to favour either of the latter two possibilities. The absence of measurable concentrations of isotopically normal SiC in Qingzhen suggests SiC was not a condensation product in the enstatite chondrite forming region. This would seem to strengthen the case for the isotopically normal SiC found in other meteorites being contamination. However, the growth of silicon nitride in metal grains suggests a possible mechanism for producing the isotopically normal SiC. Inorganic nitrogen is not as abundant in other meteorites as it is in the enstatite chondrites but both Si and C (e.g. 8) do appear to be present in the metal of most of the least metamorphosed chondrites. It is possible, therefore, that in some meteorites the conditions may have allowed for the formation of SiC in the metal rather than silicon nitride as in the enstatite chondrites. (1) Zinner et al., (1989) *G.C.A.* 53, 1235-1244. (2) Alexander *et al.* (1990) *LPSC XXI*, 9-10. (3) Stone *et al.* (1990) *LPSC XXI*, 1212-1213. (4) Larimer and Bartholomay (1979) *G.C.A.* 43, 1455-1466. (5) Grady *et al.*, (1986) *G.C.A.* 50, 2799-2813. (6) Alexander *et al.* (1990) *Nature*, 715-717. (7) Huss (1990) *Nature* 347, 159-162. (8) Rambaldi and Wasson (1981) G.C.A. 45, 1001-1015.





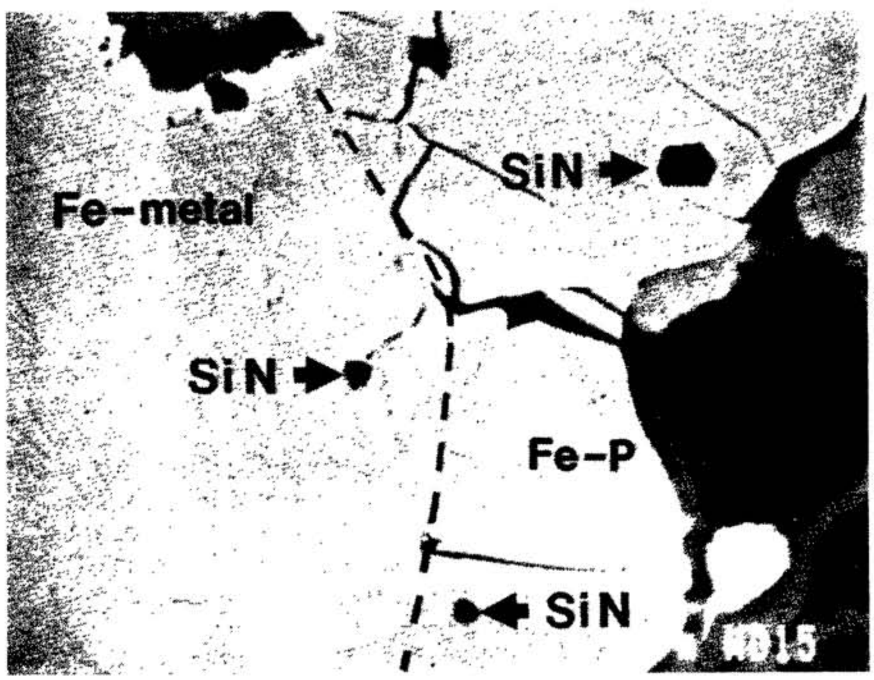


Fig. 3 Three silicon nitride grains (labeled SiN) in Qingzhen. The host phases are kamacite (Fe-metal) and schreibersite (Fe-P).