INTERSTELLAR SiC OF TYPE X: HOW MANY DISTINCT STELLAR SOURCES?

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We have analyzed ~ 3200 individual SiC grains from Murchison separates KJD (average size 0.81 µm) and KJE (average size 1.14 µm) [1] by ion imaging with the University of Bern ion microprobe. We were mainly searching for X grains which constitute ~ 1% of the interstellar SiC grains [2] in order to significantly broaden the data base of this rare exotic component of interstellar matter. Together with our data previously obtained for separate KJE [3,4,5] we now have data on the C-, N- and Si-isotopic compositions of 39 X grains. Based on their Si-isotopic compositions we distinguish between three subtypes of X grains. Furthermore, there exist interelemental correlations between the isotopic compositions of C, N and Si. The previously postulated type II supernova origin of the X grains [2] is qualitatively supported by our new data. The Si-isotopic pattern of the X grains suggests that at least three different stellar sources contributed material to this exotic family of interstellar grains.

X grains are characterized by unusual isotopic compositions, namely, strong depletions of the heavy Si isotopes, strong enrichments in ^{15}N and mostly also in ^{12}C and high inferred ^{26}Al/^{27}Al ratios [2]. We have analyzed C in all of our 39 X grains, N in 35 grains, and Si in 29 grains. Figure 1 shows the Si-isotopic data for SiC grains from separates KJD and KJE. The X grains are clearly separated from the majority of the SiC grains which are mostly enriched in the heavy Si isotopes. The X grains of our study have δ^{29}Si values between -100 and -660‰ and δ^{30}Si values between -220 and -770‰. Previous analyses made on larger X grains from Murchison separates KJG and KJH (average size 3.02 and 4.57 µm, respectively) have shown that most of these grains fall along a line with slope ~ 0.66 (going through the point of solar Si) whereas a few grains (3 out of 14) form a tight cluster with δ^{29}Si ~ δ^{30}Si ~ -500‰ close to the line with slope 1 that connects solar Si with a component consisting of pure ^{28}Si [2,6]. Most of our X grains (19 out of 29) plot along the slope 0.66 line and we have named them X-A (Fig. 2; two grains with large errors are not plotted). Nine grains plot roughly along the slope 1 line and these grains are referred to as X-B. In comparison to the X-A grains their ^{28}Si enrichments extend to clearly higher values. One grain can not be related to one of these two groups and it thus seems to represent a third, distinct type (X-C). The C- and N-isotopic data of our X grains are shown in Fig. 3. ^{12}C/^{13}C ratios vary between 18 and 6800 and ^{14}N/^{15}N ratios range from 13 to 180. As indicated by the question mark in Fig. 3 no N data were obtained for the grain with the lowest ^{12}C/^{13}C ratio. Except one grain (X23), the C- and N-isotopic compositions seem to be roughly correlated, grains with high ^{12}C/^{13}C ratios tend to have low ^{14}N/^{15}N ratios. Among the 5 grains that have the highest ^{12}C enrichments are 3 X-B grains, the only X-C grain and a grain not considered in our classification scheme (no Si data), but no X-A grain. Disregarding the KJD grains X31, X33 and X34 a weak correlation seems to exist also between the Si- and N-isotopic compositions in that grains with low ^{14}N/^{15}N ratios tend to have stronger excesses in ^{28}Si (Fig. 4). Grains X31 and X34 are very N-rich (~ 6x more N than typical X-B grains) and it appears possible that their N is dominated by contaminating terrestrial N which would have shifted the measured ^{14}N/^{15}N ratios to higher values.

Type II supernovae have been invoked as the most likely stellar source of the X grains [2]. Taking the model calculations of Meyer et al. [7] for a 25M⊙ supernova, the apparent correlations between the isotopic compositions of C, N and Si can be qualitatively explained by mixing different proportions of material that experienced partial He-burning (high ^{12}C/^{13}C, low ^{14}N/^{15}N, ^{29}Si and ^{30}Si excesses) with material from the overlaying zone where H-burning by the CNO cycle has gone to completion (low ^{12}C/^{13}C, high ^{14}N/^{15}N) and with material processed through advanced burning stages, namely, Ne- and O-burning as these processes produce large amounts of ^{28}Si. The presence of 3 subtypes A, B, and C of X grains points to the possibility that different supernovae contributed to the population of the X grains. As

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we do not know whether subtypes X-A and X-B are subdivided any further, at least 3 distinct stellar sources are suggested.

Because the grains of our study are small, only a limited number of elements could be analyzed simultaneously. In order to get additional information on the fascinating class of the X grains we plan to determine the MgAl- and Si-isotopic compositions of submicrometer-sized X grains in the near future.

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REFERENCES: [1] Amari S. et al. (1994) *Geochim. Cosmochim. Acta* **58**, 459-470. [2] Amari S. et al. (1992) *Astrophys. J.* **394**, L43-L46. [3] Hoppe P. et al. (1993) *Meteoritics* **28**, 363-364. [4] Hoppe P. et al. (1994) *Lunar Planet. Sci.* **XXV**, 563-564. [5] Hoppe P. et al. (1994) *Meteoritcs* **29**, 474-475. [6] Nittler L. et al. (1993) *Meteoritics* **28**, 413. [7] Meyer B. et al. (1994) *Meteoritics*, submitted.

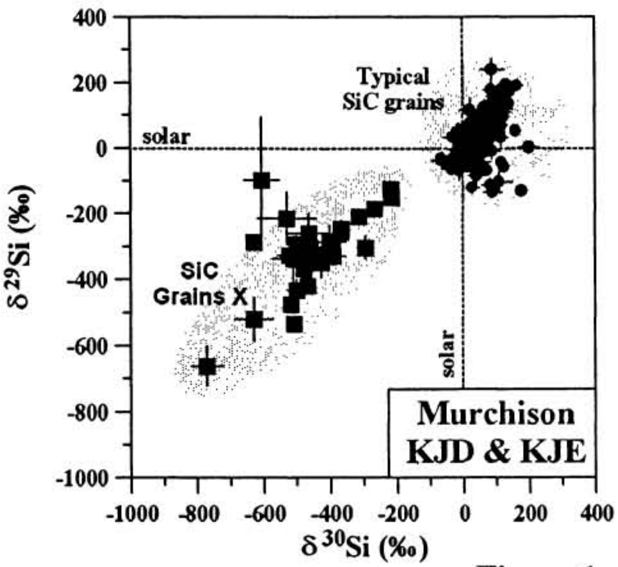

Figure 1

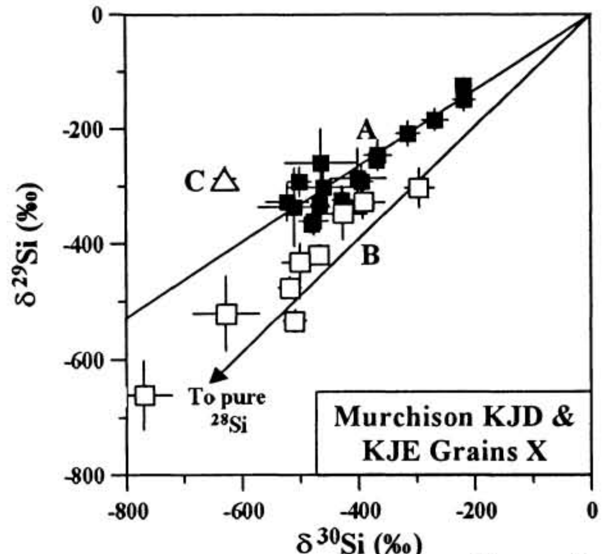

Figure 2

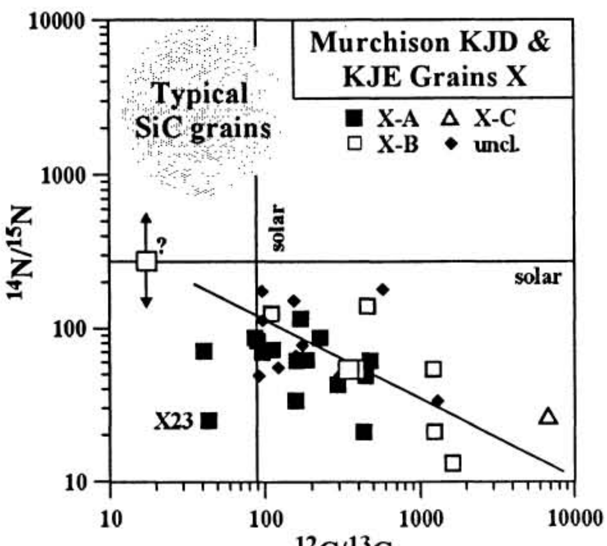

Figure 3

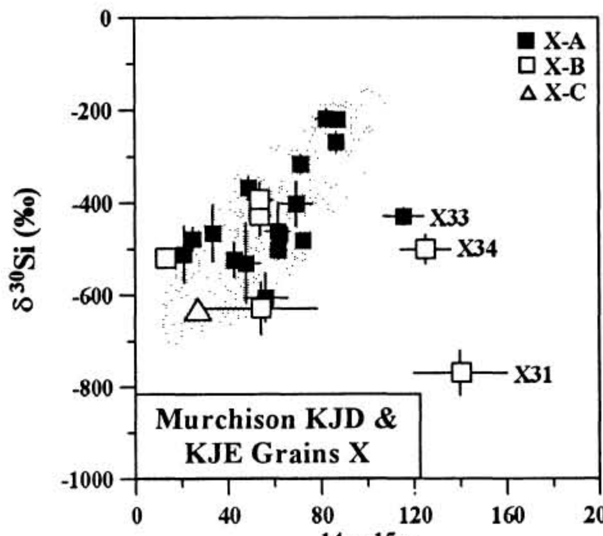

Figure 4