MOLYBDENUM ISOTOPIC COMPOSITION OF SINGLE SILICON CARBIDES FROM SUPERNOVAE*

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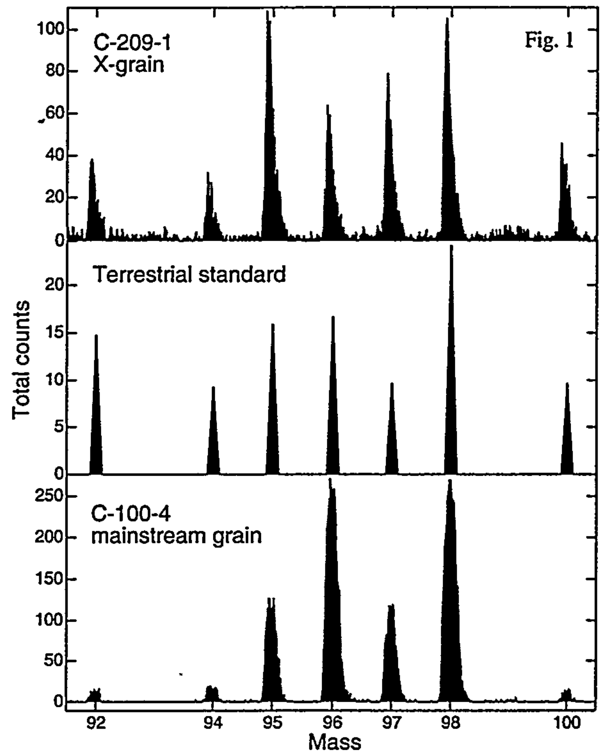
Introduction: Presolar silicon carbide grains form in a variety of types of stars, including asymptotic giant branch red giant stars and supernovae. The dominant mechanisms of heavy element nucleosynthesis, the *s*-process and *r*-process, are thought to occur in AGB stars and supernovae, respectively [1]. We have previously reported that mainstream SiC grains have strong enrichments in the *s*-process isotopes of Sr, Zr and Mo [2–5]. We report here the first measurements of Mo isotopes in X-type SiC grains, which have previously been identified as having formed from supernova ejecta.

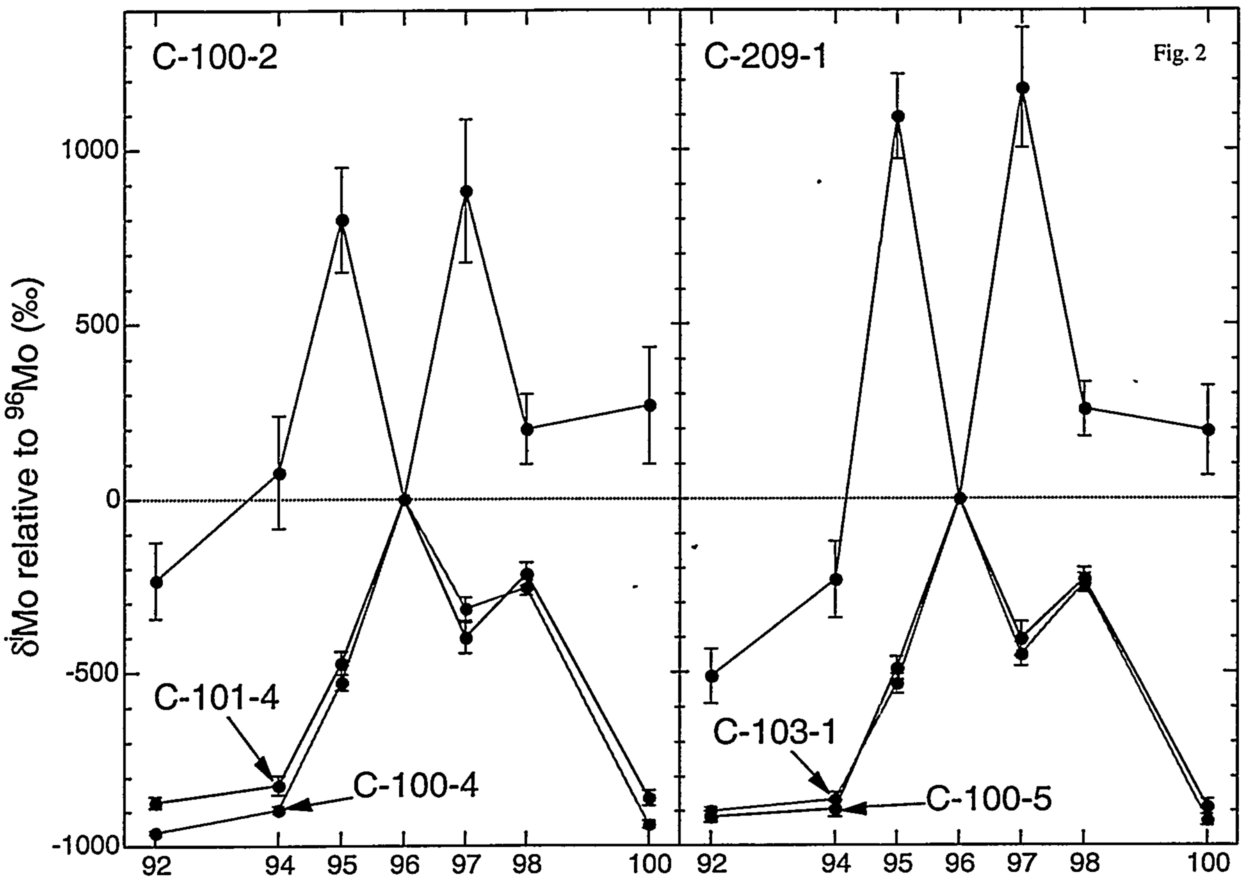
Experimental methods: Approximately 2000 grains of Murchison SiC grain size separate KJG [6] were dispersed onto a soft gold mount. A search for X-grains was made by ion imaging [7] with the Washington University ion microprobe. 11 X-grains were identified, along with 3 B-grains, one Z grain and a unique ^{29}Si, ^{30}Si-rich grain. These grains were analyzed for Si, C and N isotopic compositions, along with 56 of the mainstream grains. The mount was then carefully characterized by electron imaging and x-ray mapping with a scanning electron microscope at the University of Chicago, identifying all grains on the mount. High resolution images were made of all grains that had been analyzed by ion microprobe. The isotopic compositions of Mo in a number of grains were measured by laser ablation laser resonant ionization mass spectrometry using the CHARISMA instrument at Argonne National Laboratory. The analytical methods were similar to those used previously [3].

Results: We report here the isotopic compositions of two X-grains and compare them with several mainstream grains measured in the same mount. Mass spectra of a terrestrial standard, an X-grain and a mainstream grain are compared in Fig. 1. It is immediately apparent that all three patterns are quite different. The mainstream grain is most enriched in ^{96}Mo and ^{98}Mo, whereas the X-grain is most enriched in ^{95}Mo and ^{98}Mo. Following our previous practice, we have normalized the data to ^{96}Mo and to the terrestrial standard and calculated delta values. Two X-grains are compared with 4 mainstream grains in Fig. 2. The two kinds of SiC have very different patterns. Mainstream grains are strongly depleted in *p*-process ^{92}Mo and ^{94}Mo and *r*-process ^{100}Mo, somewhat depleted in mixed *r*- and *s*-process ^{95}Mo, ^{97}Mo and ^{98}Mo. In contrast, the X-grains have large positive δ^{95}Mo and δ^{97}Mo values.

Discussion: Among the huge range of isotopic compositions of presolar SiC, X-grains have been distinguished by their high $^{12}C/^{13}C$, low $^{14}N/^{15}N$ and low δ^{29}Si and δ^{30}Si values. These isotopic compositions strongly suggest nucleosynthesis in supernovae [8] and the discovery of excess ^{44}Ca from the in situ decay of ^{44}Ti ($T_{1/2}$=48y) [9,10] confirmed this idea. The question of whether X-grains come from Type Ia [11] or Type II [12] supernovae is unresolved. The *r*-process most likely occurs in Type II supernovae, although the details remain unclear. The presence of *r*-process enrichments in X-grains would argue strongly that these grains formed in Type II supernovae.



Molybdenum has seven stable isotopes: ^{92}Mo and ^{94}Mo are pure *p*-process isotopes; ^{96}Mo is a pure *s*-process isotope, shielded from the *r*-process by ^{96}Zr; ^{100}Mo is a pure r-process isotope; and ^{95}Mo, ^{97}Mo and ^{98}Mo can be produced by both the *r*- and *s*-processes. We had expected that if X-grains were enhanced in *r*-process Mo, the largest excesses would be in the pure



r-process isotope, ^{100}Mo. This is clearly not the case in the two X-grains analyzed so far. The largest enrichments (compared to solar system Mo) are in ^{95}Mo and ^{97}Mo and there are smaller enrichments in ^{98}Mo and ^{100}Mo. All of these isotopes can be produced by the *r*-process. Thus, the X-grains do appear to have an *r*-process signature and thus they likely came from Type II supernovae. The Mo isotopic signature in the X-grains is quite different from one as the one responsible for the solar system *r*-process isotopes. This is easily noted by the observation that the mainstream grains, which have an *s*-process signature, are not complementary to the X-grain patterns. *r*-Process nucleosynthesis calculations are very sensitive to the parameters chosen. The *r*-process responsible for the X-grains is an unusual one, as it produced significantly more ^{95}Mo than ^{100}Mo. One possibility is that the source experienced sort of a weak *r*-process with only a small neutron burst that acted on seeds in the Se-Br-Kr-Rb-Sr region and only neutron-captured out to mass 95 to 98 rather than to mass 100 and beyond. Detailed calculations will be necessary to test this possibility.

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