

EVIDENCE FOR AN INTERSTELLAR NITRIDE GRAIN WITH HIGHLY ANOMALOUS ISOTOPIC COMPOSITIONS OF C, N AND Si; P. Hoppe, R. Stöbel, and P. Eberhardt, Physikalisches Institut der Universität Bern, Sidlerstr.5, CH-3012 Bern, Switzerland; S. Amari, McDonnell Center for the Space Sciences and Physics Department, Washington University, St. Louis, MO 63130-4899, USA; R. S. Lewis, Enrico Fermi Institute, University of Chicago, Chicago, IL 60637-1433, USA.

We have analyzed the C-, N- and Si-isotopic compositions of 795 individual grains from the Murchison SiC separate KJE (average size 1.14 μm [1]) with the University of Bern ion microprobe. Results for a subset of these grains have been reported previously [2]. Subsequent analyses revealed one grain that contained only little carbon with an atomic abundance ratio of C/Si \sim 0.006. Its CN⁻/C⁻ ratio, a qualitative measure for the nitrogen content, is very high, \sim 30x higher than that of a typical SiC grain (cf. Fig. 4), suggesting that this grain is a refractory nitrogen-bearing mineral. The isotopic compositions of C, N and Si are highly anomalous and similar to those of the very rare SiC component grains X [3].

Silicon nitride (Si₃N₄) and silicon oxynitride (Si₂N₂O) are silicon- and nitrogen-rich minerals. Both minerals are known to occur in meteorites. Silicon nitride has been identified in ordinary as well as in enstatite chondrites [4, 5, 6], and silicon oxynitride has been found in enstatite chondrites [7, 8]. Since we do not have information on the detailed mineralogy of our silicon- and nitrogen-rich grain we measured the elemental ratios of C, N and Si in synthetic Si₃N₄ and synthetic Si₂N₂O that contained carbon in varying small amounts. As nitrogen is measured as CN⁻ the CN⁻/Si⁻ ratio strongly depends on the C⁻/Si⁻ ratio and on the mineralogy (Fig. 1). Unfortunately, the CN⁻/Si⁻ and C⁻/Si⁻ ratios of our silicon- and nitrogen-rich grain (KJE853) plot in a region where the correlation lines found for synthetic Si₃N₄ and Si₂N₂O do not allow a differentiation between these two minerals. However, regardless of the presence of oxygen, in grain KJE853 nitrogen is a major element and carbon is a minor constituent.

The isotopic properties of grain KJE853 are shown in Figs. 2 and 3. It is characterized by light C ($^{12}\text{C}/^{13}\text{C} = 157 \pm 33$), heavy N ($^{14}\text{N}/^{15}\text{N} = 18 \pm 1$) and light Si ($\delta^{29}\text{Si} = -43 \pm 56 \text{‰}$, $\delta^{30}\text{Si} = -271 \pm 50 \text{‰}$). Such an isotopic pattern is the signature of the rare SiC component called grains X [3]. As grain KJE853 is isotopically related to grains X the same type of stellar source, namely, type II supernovae is suggested. The formation of silicon nitride or silicon oxynitride requires a nitrogen-rich environment such as the H-burning shell of pre-supernova stars. While the ¹⁵N enrichment could originate from explosive nucleosynthesis in this layer, the isotopic signatures of C and more significantly Si require admixture of material from underlying layers, namely, the He-burning shell (rich in ¹²C) and the O-burning shell (rich in ²⁸Si).

Five of the SiC grains X found in separate KJE have a very high nitrogen content, \sim 5x higher than that of a typical SiC grain from KJE (Fig. 4). The fact that the Al-concentration of interstellar SiC roughly correlates with the N-concentration led Zinner et al. [9] to suggest that nitrogen is present as AlN. However, as grain KJE853 is isotopically related to grains X it appears not unrealistic that the very high nitrogen content of some grains X can be attributed to silicon nitride or silicon oxynitride that is present either as subgrains (such as TiC found within interstellar graphite grains [10]) or in solid solution with SiC.

While the Murchison grain KJE853 resembles isotopically the rare SiC grains X, it has a distinctive chemistry and is a further indication of the variety of stardust that can be found.

This work was supported by the Swiss National Science Foundation and by NASA.

INTERSTELLAR NITRIDE GRAIN: Hoppe P. et al.

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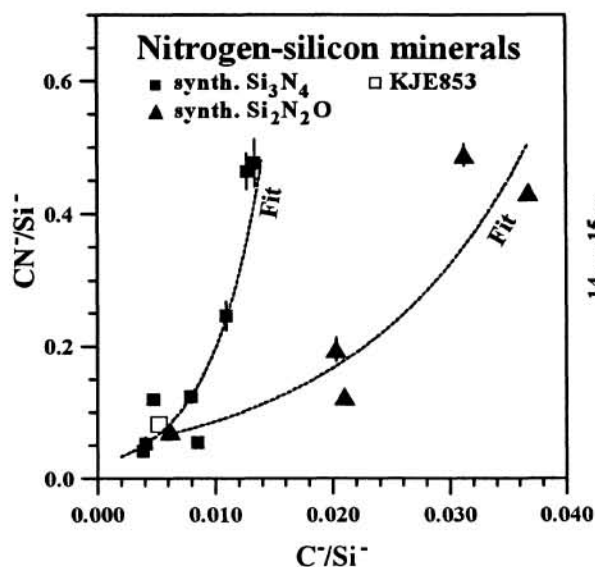


Figure 1

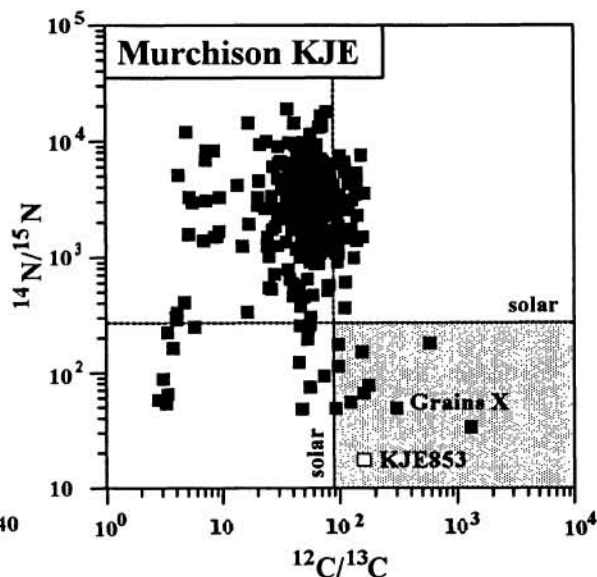


Figure 2

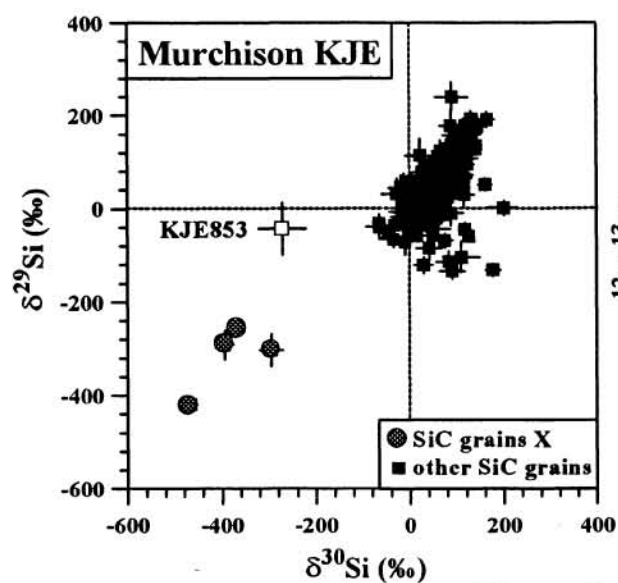


Figure 3

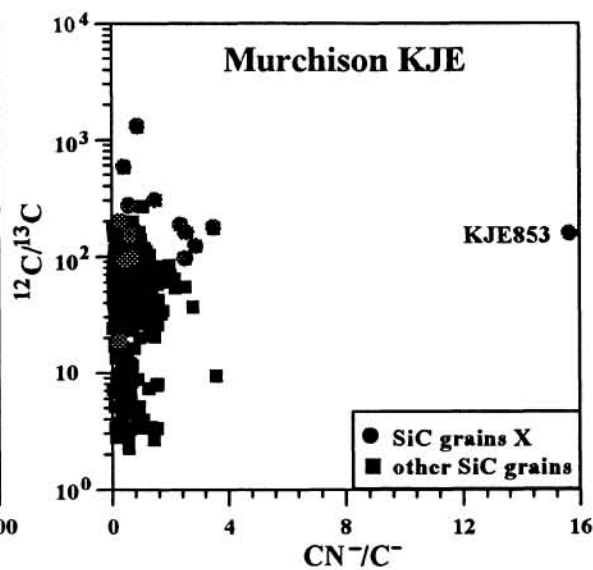


Figure 4