Al AND Ti ISOTOPIC RATIOS OF PRESOLAR SiC GRAINS OF TYPE Z.

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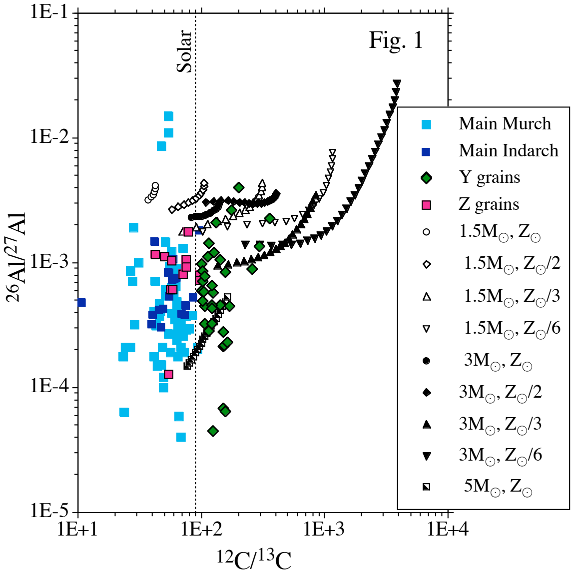
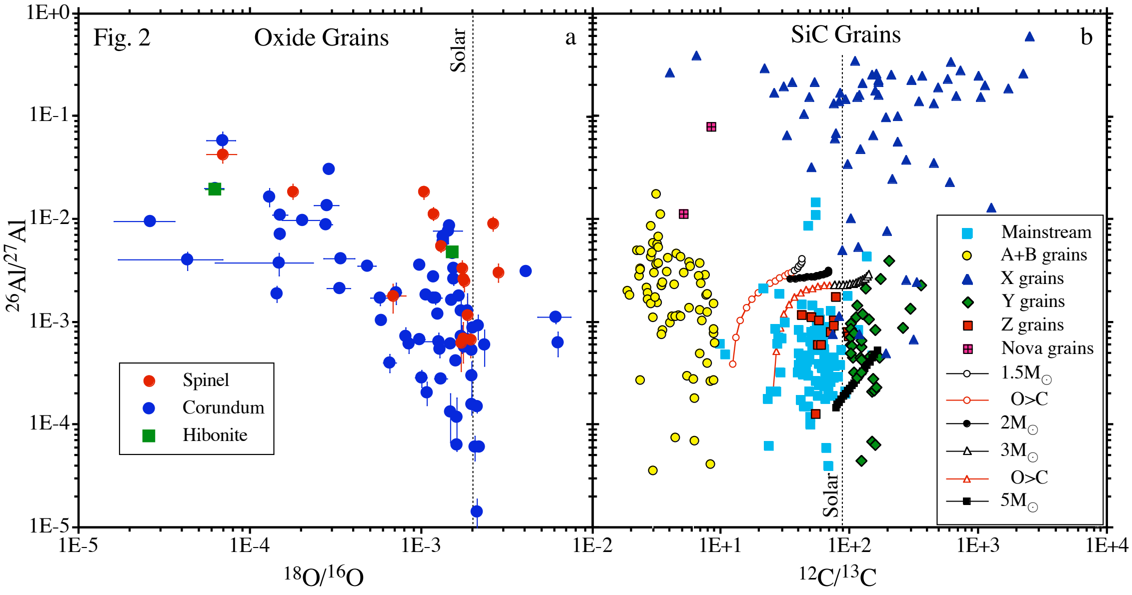
Introduction: Presolar SiC grains of type Z are a minor population of all presolar SiC grains [1]. Their Si isotopic compositions, characterized by negative δ^{29}Si values and ^{30}Si excesses relative to the mainstream correlation line, have been explained by low-metallicity parent stars of these grains [2]; the C isotopic ratios, which have the same range as those of mainstream grains, have been explained by invoking cool bottom processing (CBP) [2-4]. Because Z grains larger than 1-2 µm are rare (~1%), only a couple of Al and Ti isotopic measurements have been reported [5, 6]. However, abundances of Z grains are much higher in submicron SiC grains [7]. Here we report measurements of Al and Ti isotopes in small (average size 0.4 µm) Z grains from the EH4 Indarch chondrite and in larger Z grains from Murchison.

Experimental: Among 541 SiC grains from the SiC-rich Indarch separate IH6 (diameter 0.25–0.65 µm) [7], analyzed for their C and Si isotopic ratios in the NanoSIMS, we identified 36 Z grains. Of these we measured Al-Mg isotopes in 16 and Ti isotopes in 5 grains. Ti isotopes were also measured in 4 larger Z grains from a Murchison separate [8, 9]. We analyzed Al and the Mg isotopes, together with ^{28}Si using multidetection in the NanoSIMS, the Ti isotopes in a combination of multidetection and peak jumping, with the even Ti isotopes, ^{28}Si and ^{52}Cr detected in one magnetic field step and the odd isotopes in a second step.

Results and Discussion: Al and C isotopic ratios of the 19 Indarch grains and 2 Murchison grains reported by [6] are plotted in Fig. 1 together with mainstream and Y grains, also believed to come from C-rich AGB stars. Also plotted are theoretical predictions for AGB stars of different masses and metallicities for C>O in the envelope. These models do not include CBP, which might result in even higher ^{26}Al/^{27}Al ratios [4]. While ^{26}Al/^{27}Al ratios in Y grains, believed to have an origin in AGB stars with metallicity $Z_\odot/2$ [10], agree with predictions, Z grains, whose Si isotopic ratios require metallicities as low as $Z_\odot/6$ [3, 11], have ^{26}Al/^{27}Al ratios that are much lower than predicted for such parent stars. This discrepancy might be even larger if we consider CBP, invoked to explain the low ^{12}C/^{13}C ratios in Z grains.





Another puzzle posed by the ^{26}Al/^{27}Al ratios in presolar grains is the fact that ratios in presolar oxide grains [12-16] reach higher values than those measured in mainstream, Y, and Z grains (Fig. 2). AGB models predict the opposite. In Fig. 2b the red tracks are theoretical predictions for O-rich stars from which oxide grains are expected to condense. Because of the dredge-up of C during the thermally-pulsing AGB phase these stars will turn into C-stars from which SiC grains can condense. Thus one would expect SiC grains from AGB stars to have, on average, higher ^{26}Al/^{27}Al ratios than oxide grains. A possible explanation is that the parent stars of oxide grains suffered CBP, which increased ^{26}Al production. However, CBP is also invoked to explain the low ^{12}C/^{13}C ratios in Z grains but ^{26}Al/^{27}Al ratios in Z grains are an order of magnitude smaller than those in some oxide grains.

Figure 3 shows the Ti isotopic ratios of the 9 Z grains of this study together with two previously measured Z grains from Murchison [5]. Also plotted are Ti ratios of mainstream, A+B, and Y grains. The blue lines are best-fit lines through the mainstream grains. As can be seen, the Z-grain data points for ^{46}Ti/^{48}Ti, ^{47}Ti/^{48}Ti, and ^{49}Ti/^{48}Ti extend the mainstream correlation to lower δ-values. The general correlation between these Ti isotopic ratios and the ^{29}Si/^{28}Si ratio also still holds (Fig. 4).

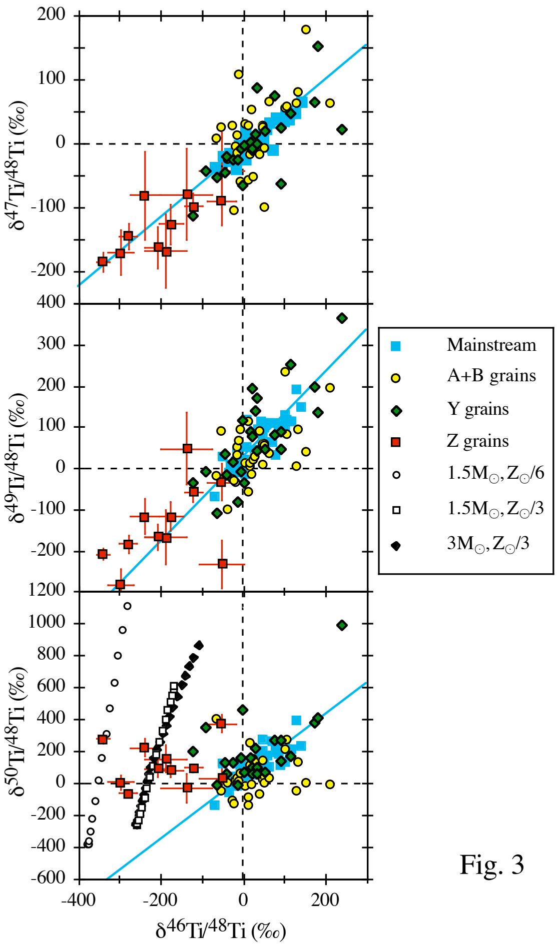


Fig. 3

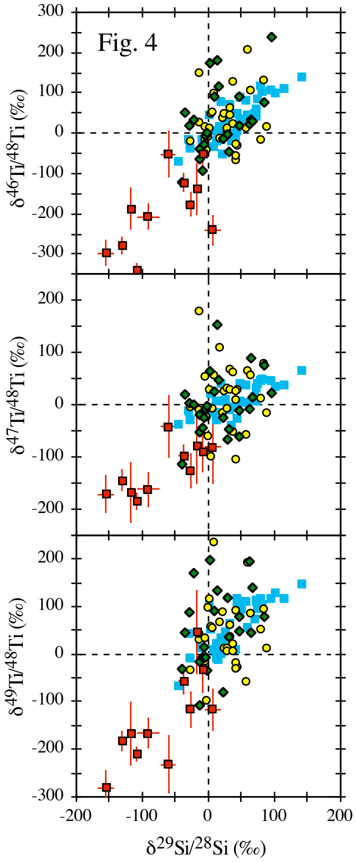


Fig. 4

This result confirms the interpretation that Z grains come from low-metallicity parent stars and indicates that, as for the Si isotopic ratios, the Ti isotopic ratios relative to ^{48}Ti increase with increasing metallicity during Galactic chemical evolution. The fact that the Z-grain data points lie close to the correlation line through the mainstream grains indicates that even for low-metallicity parent stars AGB nucleosynthesis does not affect the ^{46,47,49}Ti isotopes very much, similar to ^{29}Si. The situation is different for ^{50}Ti whose δ-values clearly lie above the mainstream correlation line (Fig. 3), indicating large excesses in low-metallicity AGB stars. Theoretical models indeed predict the largest excesses for this Ti isotope. Predictions for three models are plotted along with the grain data in Fig. 3. These models are for the standard ^{13}C pocket and finetuning could possibly achieve better agreement with the data.

References: [1] Hoppe P. and Ott U. (1997) in: *Astrophysical Implications of the Laboratory Study of Presolar Materials*, (eds. T. J. Bernatowicz and E. Zinner), pp. 27-58, AIP, New York. [2] Hoppe P. et al. (1997) *ApJ 487*, L101-L104. [3] Nittler L. R. and Alexander C. M. O'D. (2003) *GCA 67*, 4961-4980. [4] Nollett K. M. et al. (2003) *ApJ 582*, 1036-1058. [5] Amari S. et al. (2003) *MAPS 38*, A66. [6] Hoppe P. et al. (2004) *LPS XXXV*, Abstract #1302. [7] Zinner E. et al. (2003) *MAPS 38*, A60. [8] Nittler L. R. and Hoppe P. (2004) *LPS XXXV*, Abstract #1598. [9] Besmehn A. and Hoppe P. (2003) *GCA 67*, 4693-4703. [10] Amari S. et al. (2001) *ApJ 546*, 248-266. [11] Nittler L. R. et al. (2004) in: *Nuclei in the Cosmos VIII*, 54. [12] Nittler L. R. et al. (1997) *ApJ 483*, 475-495. [13] Choi B.-G. et al. (1998) *Science 282*, 1284-1289. [14] Choi B.-G. et al. (1999) *ApJ* 522, L133-L136. [15] Zinner E. et al. (2004) *LPS XXXV*, Abstract #1337. [16] Nittler L. R. et al. (2005) *LPSC XXXVI*.