BONANZA, A HUGE PRESOLAR SIC GRAIN OF TYPE X. E. Zinner[1], M. Jadhav[1,2], F. Gyngard[3], and L. R. Nittler[3], [1]Laboratory of Space Sciences and the Physics Department, Washington University in St. Louis, One Brookings Dr., St. Louis, MO 63130, USA, [2]Present address: Institute of Geophysics and Planetology, University of Hawaii, Honolulu, HI 96822, USA, [3]Department of Terrestrial Magnetism, Carnegie Institution, Washington, DC 20015, USA. ekz@wustl.edu .

Introduction: During Raman and isotopic studies of presolar SiC grains from size fractions LS+LU of the Murchison L separation series [1, 2], we discovered a huge (30 μm, Fig. 2d) SiC grains of type X [3].

The C, N and Si isotopic ratios of this grain named Bonanza ($^{12}C/^{13}C$=190; $^{14}N/^{15}N$=28; $\delta^{29}Si/^{28}Si$=–282‰, $\delta^{29}Si/^{28}Si$=–442‰) clearly identify this grain as an X grain. The extremely large size of this grain, greatly exceeding those of previously analyzed X grains, poses the problem of how such a grain can condense in SN ejecta. Furthermore, the grain seems to be an aggregate of smaller grains (see Fig. 2d). How were these subgrains joined together and did they all form in the same place? The grain's large size offers the opportunity to analyze its elemental and isotopic composition as well as its internal structure in great detail.

Last year, we reported the spatial distribution of the C and Si isotopic ratios in the Bonanza grain by isotopic imaging in the NanoSIMS [3]. Variations in these ratios were observed but could be explained by contamination with small mainstream SiC grains. Here we report Al-Mg, Ca, Ti, Fe and Ni isotopic ratios.

Results: We obtained isotopic images of ^{24,25,26}Mg, ^{27}Al, ^{28}Si, ^{40,43,44}Ca, and ^{48}Ti with the Washington University NanoSIMS and images of ^{46,47,48,49,50}Ti, ^{52}Cr, ^{54,56,57}Fe, and ^{58,60,61,62}Ni with the Carnegie NanoSIMS, with positive secondary ions.

The Mg-Al isotopic images of Bonanza are shown in Fig. 1. Al is heterogeneously distributed in the grain (c). Mg is completely dominated by radiogenic ^{26}Mg from the decay of ^{26}Al (averaged over the whole image $^{26}Mg/^{24}Mg$ =97, in some areas the ratios is as high as 700; the normal ratio is 0.139). The distribution of the inferred $^{26}Al/^{27}Al$ ratio is shown in Fig. 1d. The ratio is inhomogeneous and ranges from 0.4 to 0.9, the highest ratio ever observed in a presolar grain. In order to investigate whether contamination with Al could account for the apparent heterogeneity in $^{26}Al/^{27}Al$, we assume that the intrinisic ratio is homogeneous and has the highest observed value of 0.9. Figs. 1e and 1f show the distributions of the inferred intrinsic ^{27}Al in the grain and of contamination whose addition would result in smaller $^{26}Al/^{27}Al$ ratios. As can be seen, the contamination is mostly present at the periphery of the grain. Because we cannot exclude possible contamination, we cannot claim $^{26}Al/^{27}Al$ heterogeneity for Bonanza.

The $^{26}Al/^{27}Al$ ratio of 0.9 in Bonanza is higher by at least a factor of three than the highest ratio predicted in any SN model [4-6]. In SN models, the highest ratios are obtained in the He/N zone. However, since the C and N isotopic ratios of X grains make contributions from the He/C zone, where $^{26}Al/^{27}Al$ is very low, necessary, the discrepancy in $^{26}Al/^{27}Al$ between the models and Bonanza is at least an order of magnitude.

Contamination is also a problem for other elemental and isotopic systems. Figure 2 shows isotopic images of ^{40,42,44}Ca and ^{48}Ti and an SEM image (d). Ca is largely isotopically normal and is probably contamination. An exception is a small region that shows an excess in the $^{44}Ca/^{40}Ca$ ratio (Fig. 2f). This is the region with a Ti subgrain (Fig. 2e), leaving little doubt that the ^{44}Ca excess is due to the decay of short-lived ($T_{1/2}$=60yr) ^{44}Ti. This provides additional evidence for a SN origin of Bonanza. The inferred $^{44}Ti/^{48}Ti$ is 0.005 and lies within the $^{44}Ti/^{48}Ti$ vs $^{29}Si/^{28}Si$ trend shown by other X grains [7].

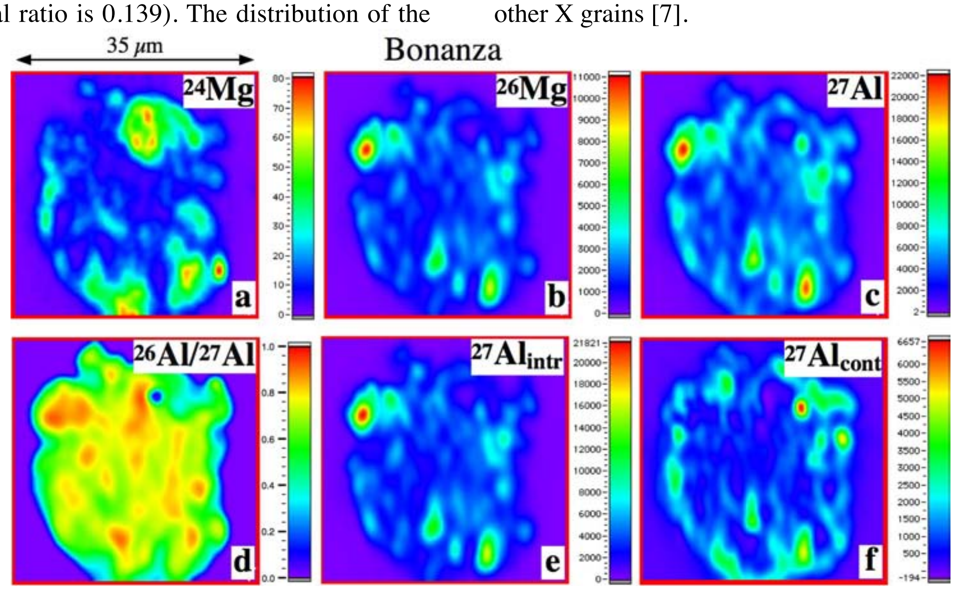

Figure 1

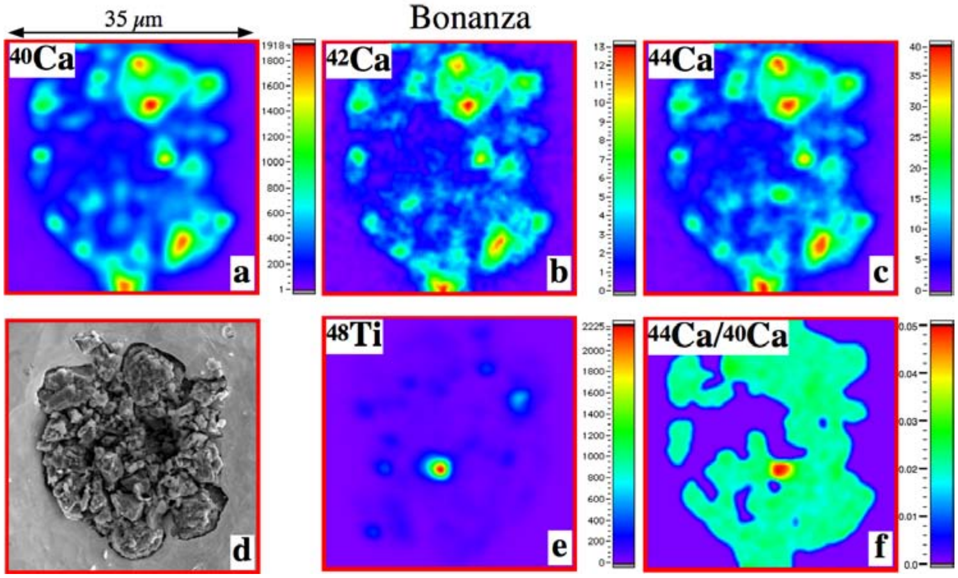

Figure 2

As the primary ion beam sputtered away material, more Ti-rich subgrains were exposed. The Ti isotopic analysis from the Ti isotopic images revealed normal $^{46}Ti/^{48}Ti$, a small deficit in ^{47}Ti, a large excess in ^{49}Ti, and a smaller excess in ^{50}Ti (Fig. 3). No statistically significant isotopic variations among different subgrains were observed. The Ti pattern is typical for X grains [7] and can be well reproduced by mixing between the He/C and He/N zone (Fig. 3), without the need for ^{49}V contributions [7].

The spatial distributions of Fe and Ni in Bonanza are similar. Fe has a small ^{54}Fe deficit and large ^{57}Fe excess (Fig. 4), similar to other X grains [8]. Again, the Fe isotopic pattern can be well fitted by mixing between the He/C and He/N zone (Fig. 4). The Ni isotopic pattern shows a large ^{61}Ni excess and smaller ^{60}Ni and ^{62}Ni excesses (Fig. 5). For the ^{58}Fe correction on ^{58}Ni we assumed the $^{58}Fe/^{56}Fe$ ratios predicted for the He/C-He/N mix that best fits the Fe isotopic pattern [8] (Fig. 4). As for Ti and Fe, the Ni pattern is well fitted by He/C-He/N mixing (Fig. 5).

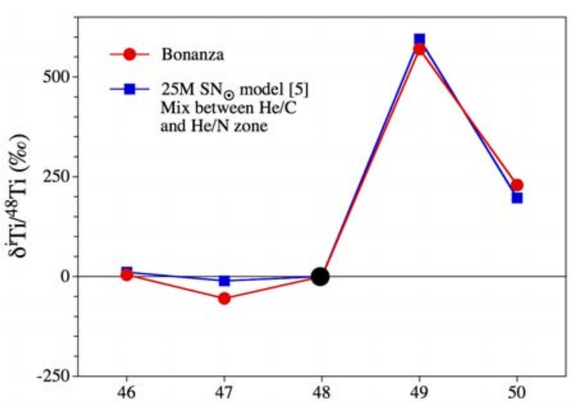

Figure 3

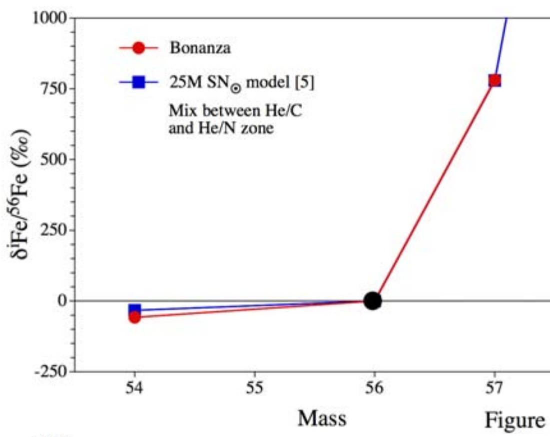

Figure 4

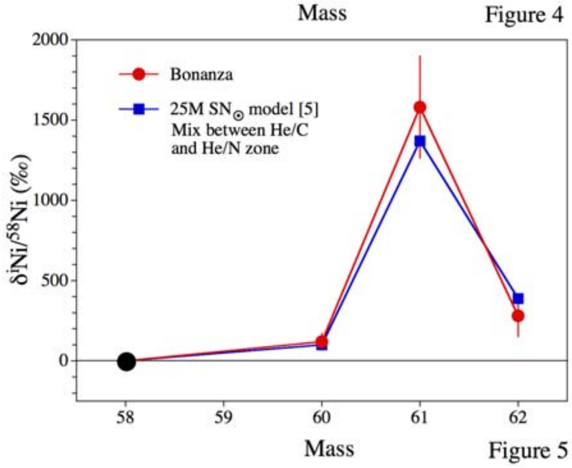

Figure 5

References: [1] Amari S. et al. (1994) *GCA* 58, 459-470. [2] Virag A. et al. (1992) *GCA* 56, 1715-1733. [3] Wopenka B. et al. (2010) *LPS* XLI, Abstract #1390. [4] Limongi M. and Chieffi A. (2003) *ApJ* 592, 404-433. [5] Rauscher T. et al. (2002) *ApJ* 576, 323-348. [6] Woosley S. E. and Weaver T. A. (1995) *ApJS* 101, 181-235. [7] Lin Y. et al. (2010) *ApJ* 709, 1157-1173. [8] Marhas K. K. et al. (2008) *ApJ* 689, 622-645.