INTRODUCTION: Presolar SiC grains of type X have large $^3$He excesses, indicative of an origin in Type II supernovae [e.g., 1, 2] since SNe produce Si with large $^{26}$Si excesses in the innermost zones [e.g., 3]. A SN origin is confirmed by evidence for radiogenic $^{44}$Ca from the decay of $^{44}$Ti in some X grains [4, 5]. Many X grains also exhibit large $^{49}$Ti excesses, which Hoppe and Besmehn [6] attributed to the decay of short-lived $^{49}$V. $^{44}$Ti and $^{48}$V are both found in the $^{28}$Si-rich Si/S zone [3]. Motivated by Ca and Ti isotopic measurements in X grains from the Qingzheng meteorite [7], we are revisiting $^{44}$Ti and $^{49}$V and ask whether there are differences between two sub-classes of X grains, X1 and X2. Type X1 grains have Si isotopic ratios that plot along a line of slope $-0.65$ in a $\delta$-value Si 3-isotope plot, whereas X2 grains plot below this line [8]. In our comparison of the X grain data we do not limit ourselves to the Qingzheng grains but consider all available X grain data [9].

DISCUSSION: Figure 1 shows Si, Ti and V isotopic ratios in the inner zones of the 25M$\odot$ SN model by Rauscher et al. [3]. These are the zones that contain the short-lived nuclides $^{44}$Ti and $^{49}$V. Ratios of stable isotopes are normalized to their solar ratios. The $^{26}$Si excesses in X grains require contributions from these zones. The C and N isotopic ratios in the grains, on the other hand, require material from the He/N and He/C zones. Here we try to explain the Si, Ti, and V isotopic ratios of X grains by mixing of material from these different zones.

First, we investigate whether $^{49}$Ti excesses can be explained by the decay of $^{49}$V. In Fig. 2a we show a plot of inferred $^{49}$V/$^{51}$V versus inferred $^{44}$Ti/$^{48}$Ti ratios under the assumption that all $^{49}$Ti excess originates from $^{49}$V decay and compare these ratios with theoretical predictions. The diamonds are the ratios for the layers between 2.05 and 3M$\odot$ interior mass of the 25M$\odot$ SN model of [3]. The lines show compositions for mixtures with C$>$O, required for SiC condensation, between various inner layers and a H/N-He/C mixture that gives $^{12}$C/$^{13}$C=100. As can be seen, most of the grain data plot above compositions that can be obtained by the mixtures, indicating that not all the $^{49}$Ti excesses in X grains are due to $^{49}$V decay. As a matter of fact, the H/N-He/C mix we used for the mixing curves has a $\delta^{48}$Ti/$^{46}$Ti value of 522‰ due to neutron capture in the He/C zone [3].

In Fig. 2b we plot the $\delta^{48}$Ti/$^{46}$Ti values of X grains against their inferred $^{44}$Ti/$^{48}$Ti ratios together with mixing curves obtained in the same way as in Fig. 2a. The plot shows that the $^{49}$Ti excesses of almost half of the grains can be accounted for by n-capture in the He/C zone and no contributions from $^{49}$V decay are required. Our assumed He/N-He/C mix has $^{12}$C/$^{13}$C=100. However, many grains have larger ratios (numbers next to the data symbols in Fig. 2b), implying higher $^{48}$Ti/$^{46}$Ti ratios because of a larger fraction of He/C material in the He/N-He/C mix. Thus it seems that most of the $^{49}$Ti excesses can be explained by n-capture in the He/C zone and $^{49}$V decay is needed only for a few grains.

In Fig. 2c and d we plot also $^{46}$Ti/$^{48}$Ti ratios. Plot d contains more data points than plot c because $^{44}$Ti/$^{48}$Ti data are limited. We note that several grains have large $^{46}$Ti deficits and even $^{49}$Ti deficits. $^{46}$Ti deficits can be explained by admixture from the inner Si/S zone (Fig. 1), but $^{49}$Ti deficits are more difficult to explain. From Figs. 2c and d it is apparent that any contributions from layers $\geq$2.4M$\odot$ in interior mass would result in a large $^{46}$Ti excess, which is seen in only one grain. This indicates only small contributions from the outer Si/S and inner O/Si zone, a conclusions also reached from the lack of large $^{54}$Fe excesses in X grains [10].

Fig. 3 shows that X2 grains have higher inferred $^{44}$Ti/$^{46}$Ti ratios than X1 grains. Although a correlation between $^{44}$Ti/$^{46}$Ti ratios and Si isotopic ratios is expected since the zones containing $^{44}$Ti are rich in $^{26}$Si, such a correlation is observed only for the $^{26}$Si/$^{28}$Si ratio (Fig. 3a). In Fig. 3, we also show (only for C$>$O) curves obtained by mixing a He/N-He/C mix having $^{12}$C/$^{13}$C=390, $^{34}$N/$^{35}$N=100, $\delta^{28}$Si/$^{29}$Si=800‰, and $\delta^{30}$Si/$^{28}$Si=1,100‰ with material from different layers of the Ni, Si/S, and O/Si zones. Only the ratios in X1 grains can be reproduced in this way; most X2 grains plot above the mixing curves. Their $^{44}$Ti/$^{46}$Ti ratios can be reached by mixing with the layer at 2.4M$\odot$ interior
mass, where this ratio is highest (Fig. 1); however the corresponding Si isotopic ratios are much smaller than those in the grains. The layer at 2.05M⊙ interior mass does not have a 28Si excess (Fig. 1) but has very little Si. Since it contains a lot of 44Ti, we can achieve the high 44Ti/48Ti ratios and the Si isotopic ratios observed in most X2 grains by combining contributions from this layer and from 28Si-rich layers in the Si/S zone. For example, the curves labeled “2.05+2.2M⊙” in Fig. 3 are obtained by mixing 10% from the 2.05M⊙ and 0.6 to 3% from the 2.2M⊙ layer with the remaining fraction from the He/N-He/C mixture previously described. This confirms the conclusion [2] that contributions from the Ni core are needed in order to account for the high 44Ti/48Ti ratios of some X grains, particularly those of type X2.