ON THE NUCLEOSYNTHESIS OF ^{48}Ca AND ^{50}Ti B. S. Meyer[1], L.-S. The[1], and M. F. El Eid[2]. [1]Department of Physics and Astronomy, Clemson University, Clemson, SC 29634-1911. [2]Department of Physics, American University of Beirut, Beirut, Lebanon.

Endemic isotopic anomalies of ^{50}Ti exist in all carbonaceous (CI, CM, CO, and CV) meteorites [1]. These anomalies occur in all phases of the meteorites and apparently call for small, refractory Ti-containing precursor grains. Within the refractory mineralized inclusions in these meteorites, ^{48}Ca anomalies accompany the ^{50}Ti anomalies [e.g. 2]. These anomalies are roughly correlated in the sense that excess ^{48}Ca associates with excess ^{50}Ti and deficient ^{48}Ca associates with deficient ^{50}Ti, but not is a strictly proportional way. These anomalies hold important clues, and deciphering these clues will provide important information about the formation of solid bodies in the solar system.

Unraveling the message of the ^{48}Ca and ^{50}Ti anomalies will be greatly aided if we have a clear picture of the nucleosynthesis of these isotopes. Meteoriticists have long worked under the assumption that these isotopes were produced in neutron-rich matter ejected in Type II (core-collapse) supernovae [3]. Nucleosynthesis theory no longer holds this to be true. It is the purpose of this brief paper to present some current ideas on how and were ^{48}Ca and ^{50}Ti were produced and some speculations on what their carriers were.

^{48}Ca is made in freezeouts of neutron-rich, low-entropy matter. ^{48}Ca does not survive in freezeouts of high-entropy material due to a shifting quasi-equilibrium during the expansion [4]. Since Type II supernova core material has high entropy, ^{48}Ca production is impossible there. Type Ia supernovae, that is, detonations or deflagrations of C/O or O/Ne/Mg white dwarf stars, do yield low-entropy matter. If the Type Ia core is dense enough, then enough electron capture can occur to produce ^{48}Ca. Only a *rare* class of Type Ia events will be dense enough at ignition to become neutron-rich enough to make ^{48}Ca. Indeed, it is estimated that such events comprise less than 10% of all Type Ia events [5]. They thus occur on timescales greater than $\sim$ 1000 years, which is infrequent compared to the $\sim$ 30 years timescale for Type II supernovae and the $\sim$ 100 year timescale for typical Type Ia events.

^{50}Ti production will naturally accompany the ^{48}Ca production in these rare Type Ia supernovae. This is not the sole production of ^{50}Ti, however. He, C, and Ne burning in massive stars also synthesizes considerable amounts of ^{50}Ti, which are then ejected in the Type II supernova that ends the star's life. To study this, we evolved a 20 $M_\odot$ stellar model (with initial solar abundances [6]) to the end of core Ne burning. In figure 1 we present overproductions ($X_i/X_\odot$) for ^{12}C, ^{16}O, ^{48}Ca, and ^{50}Ti as a function of interior mass in the star (the outer layers of the star are not shown since the overproductions do not vary with interior mass there). The overproduction is the ratio of the mass fraction of a species at some point relative to its solar system mass fraction. Because we began the model with solar abundances, an overproduction greater than unity means the isotope has been produced in the star, and, conversely, an overproduction less than unity means the isotope has been destroyed. As is apparent, ^{50}Ti is quite overproduced (at a level of $\sim$50) in matter that has completed core C burning (the inner $\sim$ 3.5 $M_\odot$ of the star). This is due to s-processing during He and C burning. ^{48}Ca, on the other hand, is destroyed in these zones. ^{48}Ca, unlike ^{50}Ti, does not lie on the dominant s-process path, so any neutron exposure tends simply to deplete the initial ^{48}Ca. Note that the outer layers of the star will simply return their initial ^{48}Ca. Clearly massive stars produce ^{50}Ti but destroy ^{48}Ca.

What is the deconvolution of the nucleosynthetic spectrum of ^{48}Ca and ^{50}Ti? The ejected ^{50}Ti overproduction in Type II supernovae is ~ 5 [7]. Since Type II supernovae are the dominant producers of ^{16}O, with a typical overproduction of 15, we expect the supernovae to have made $\sim 1/3$ of the solar system's ^{50}Ti. The other $\sim 2/3$ of the ^{50}Ti and all of the ^{48}Ca likely came from the rare Type Ia events.

These results have interesting implications for the carriers of ^{48}Ca and ^{50}Ti. About 1/3 of the solar system's ^{50}Ti likely condensed in the ^{16}O-rich ejecta of a Type II event. We thus might expect an oxide carrier. On the other hand, about 2/3 of the ^{50}Ti and all of the ^{48}Ca were likely ejected in anion-depleted matter from the Type Ia event. The nuclei may have condensed in metal droplets or remained in the gaseous phase to plate out later on small, pre-existing interstellar grains.

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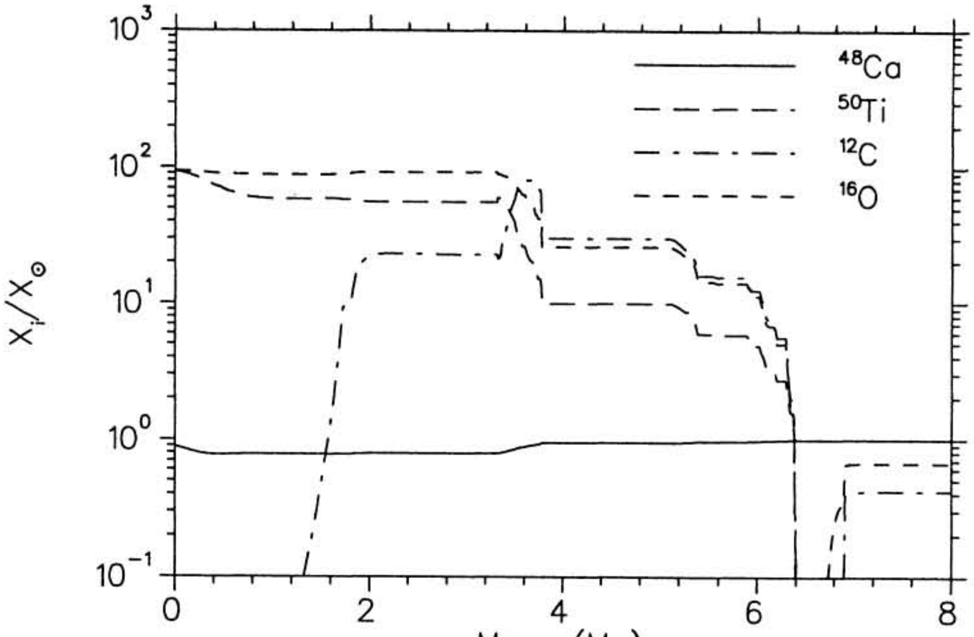

Figure 1.