STABILITY OF METALLIC Si-, Fe-RICH ALLOYS, SiC AND GRAPHITE IN MIXED SUPERNOVA EJECTA.

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Introduction: Low-density, presolar graphite grains from the Murchison chondrite contain inclusions of TiC and Si-rich metal alloys but, in most cases, no SiC [1], while all three phases are found as inclusions in many of those from Orgueil [2, 3]. Fedkin and Grossman [4] found that a specific mixture of 5 layers computed by [5] in a model of a 21 solar mass Type II supernova has the same C, N and O isotopic compositions, $^{48}Ti/^{44}Ti$ and inferred initial $^{26}Al/^{27}Al$ as are found in the Murchison graphite, and a bulk chemical composition that allows equilibrium condensation of TiC, SiC and a Si-rich metal alloy at a higher temperature than graphite when the expanding gas has a total pressure, P^{tot}, $=10^{-4}$ bar at 2000K. Here we investigate condensation details to see why SiC is found as inclusions in some supernova graphite grains but not in others.

Elemental Abundances: The mixture preferred in [4] has an exotic chemical composition compared to solar gas or any individual SN layer. H is a trace element, and atomic C/O=3.5. In declining order of abundance and after radioactive decay, atom fractions are: He-0.630; Fe-0.187; Si-0.0741; S-0.0537; Ca-0.0131; Ni-0.0121; Co-0.0103; C-1.17×10^{-3}. Most of the condensates of interest, TiC, SiC and graphite, are compounds of carbon, one of the least abundant condensable elements in this mix. This makes the condensation sequence particularly interesting, as C speciation is controlled by chemical reactions among most of the other condensables.

Results: At $P^{tot}=10^{-4}$ bar and 2000K, TiC is the only condensate, containing ~85% of the Ti and ~28% of the C. As T and P^{tot} decline at the "clumpy ejecta" rates in [4], SiC condenses at 1875K, consuming ~0.6% and ~37% of the Si and C, resp. by 1690K. (Fe,Ni)Si begins to form at 1820K, and accounts for ~11% of the Fe and ~25% of the Si before beginning to dissolve into a metallic Fe-, Si-rich alloy at 1690K. At 1660K, SiC decomposes into metallic Si, which dissolves into the alloy, and graphite, which gradually reacts with $SiS_{(g)}$ to form more metallic Si and $CS_{(g)}$. Graphite nearly disappears by 1555K, but at this point, $Ca_{(g)}$ begins to react with $CS_{(g)}$ and $SiS_{(g)}$ to form oldhamite (CaS), more metallic Si and graphite. The amount of graphite increases, reaching a maximum of 35% of the carbon by 1165K before beginning to react with $SiS_{(g)}$ to form metallic Si and $CS_{2(g)}$. If P^{tot} is 8x larger at each T, *i.e*, 8×10^{-4} bar at 2000K, metal containing 47% Si forms at a very high T, 2255K. Only TiC condenses at a higher T. The great stability of the metal phase precludes formation of SiC at such pressures. If $P^{tot}<5\times10^{-6}$ bar at 2000K, the metal phase forms below the incoming T of graphite.

Conclusions: Absence of SiC inclusions in supernova graphite may indicate formation in expanding gases whose $P^{tot}\geq8\times10^{-4}$ bar at 2000K, while the presence of inclusions of SiC and Si-rich metal may indicate formation at $5\times10^{-6}<P^{tot}<8\times10^{-4}$ bar at 2000K. Alternatively, in the latter P^{tot} range, absence of SiC could be due to total reaction to form graphite and metallic Si.

References: [1] Croat T. K. et al. 2003. *GCA* 67:4705-4725. [2] Croat T. K. et al. 2009. Abstract #2175. 40th LPSC. [3] Croat T. K. et al. 2011. Abstract #1533. 42nd LPSC. [4] Fedkin A. V. and Grossman L. 2010. *GCA* 74:3642-3658. [5] Rauscher T. et al. 2002. *Ap. J.* 576:323-348.