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, 46Ti/44Ti and inferred initial 26Al/27Al 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} \approx 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-1.17x10^{-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 ~15% 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_{tot} to form more metallic Si and CS_{tot}. Graphite nearly disappears by 1555K, but at this point, CaS_{tot} begins to react with CS_{tot} and SiS_{tot} to form olivine (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_{tot} to form metallic Si and CS_{tot}. If P_{tot} is 8x larger at each T, i.e., 8x10^{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}<5x10^{4} 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} \geq 8x10^{4} bar at 2000K, while the presence of inclusions of SiC and Si-rich metal may indicate formation at 5x10^{4}<P_{tot}<8x10^{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.