ORGUEIL LOW-DENSITY PRESOLAR CARBON AIN'T GRAPHITE BUT GLASSY CARBON

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Presolar carbonaceous grains from Orgueil traditionally have been called "graphite" [1]. Graphite is a crystalline solid with a well defined 3-D structure. A recent Raman study [2] of grains from the Orgueil high-density fraction OR1f (2.02-2.04 g/cm^3) confirmed that the majority of them (86%) were indeed graphitic. However, this is not the case for grains from Orgueil's low-density separate OR1d (1.75-1.92 g/cm^3). The majority of low-density carbon grains (11 of 20) that were analyzed by Raman spectroscopy followed by NanoSIMS analysis [3] are not graphite, but rather glassy carbon, an amorphous solid. Only 3 of 20 grains were graphitic, and the remainder (6 of 20) had a "kerogen-type" Raman signature, i.e., they also were non-crystalline sp^2-bonded carbon. The physical properties of glassy carbon are well known to materials scientists. It has a unique structure with a random combination of small-sized (nanocrystalline) basal planes and edge planes with many large void spaces in between . The latter explains its low density (listed as 1.42 g/cm^3) compared to the one for graphite (listed as 2.09-2.23 g/cm^3).

Based on their 1st and 2nd -order Raman spectra, the sp^2-bonded carbon materials in Orgueil grains can be grouped into 3 different types [see also 2]. 1) Graphitic grains with more or less structural disorder have very narrow 1st- order peaks (D and G) and very strong 2nd- order peaks; their D/G intensity ratios can be used to infer the graphitic in-plane crystallite size; 2) Allende-type grains have wider 1st-order peaks than graphitic grains, but with a distinctive feature: their D band is more intense than their G band; in addition they have a very weak (or no) 2nd- order spectrum; and 3) kerogen-type grains have extremely wide 1st-order and no 2nd-order peaks. From the Raman spectroscopic perspective, only grains of type 1 deserve to be called "graphite", whereas grains of types 2 and 3 are amorphous. The very characteristic and unusual Raman signature of Allende-type grains is typical for glassy carbon and is not known to occur in any other form of sp^2-bonded carbon. Thus, we propose that the carbon in both Allende and the majority of the low-density presolar carbon grains in Orgueil are a form of glassy carbon, rather than crystalline graphite. This finding not only explains the low density of this so-called "graphite" separate, but it is also consistent with the hypothesis, based on isotopic data [4], that grains from the low- and high-density fractions come from different stellar sources. The presolar graphite probably comes from AGB stars (and dominates the high-density separate), whereas the presolar glassy carbon comes from supernovae (and dominates the low-density separate). Indeed, all grains with Allende-type (i.e., glassy carbon) spectra of this study have isotopic signatures (such as ^{14}N, ^{18}O, ^{28}Si excesses and high ^{26}Al/^{27}Al ratios) indicative of a supernovae origin [3]. One possible explanation for the presence of glass (rather than crystals) in carbon material from supernovae could be the relatively rapid cooling of their ejecta.

References: [1] Jadhav M. et al. (2006) *New Astron. Rev.* 50, 591-595. [2] Wopenka B. et al. (2011) *Lunar Planet Sci.* XLII, Abstract #1162. [3] Groopman E. et al., this conference. [4] Zinner E. et al. (2006), *Proc. of Science* PoS (NIC-IX) 019.