AN UNUSUAL LOW-DENSITY SUPERNOVA GRAPHITE GRAIN WITH A NANOCRYSTALLINE CORE. E. Groopman, T. Bernatowicz, and E. Zinner. Laboratory for Space Sciences and Dept. of Physics, Washington University, St. Louis, MO 63130, USA. eegroopm@wustl.edu.

Introduction: A small fraction of presolar graphite grains consist of nanocrystalline cores surrounded by mantles of well-ordered graphite [1,2]. Nearly all of these are high-density (HD) graphite grains with Asymptotic Giant Branch star (AGB) origins (~30% of HD grains from Murchison [3]), although a few with morphological similarities to low-density (LD) graphite grains also contain small nanocrystalline centers [4]. Such cores consist of randomly-oriented 3-4nm sheets of graphene, interspersed with smaller particles potentially of polycyclic aromatic hydrocarbons (PAHs, <1nm) [5]. These grains exhibit a sharp transition between the nanocrystalline and well-graphitized regimes, indicative of changing stellar atmospheric conditions during grain growth [1].

Results: From the OR1d size/density (>1µm, ρ=1.75-1.92 g·cm^{-3}) fraction of the Orgueil CI chondrite we have discovered a LD presolar graphite grain, OR1d6m-6 (6.5µm, hereafter G6), containing a nanocrystalline core (1.5 µm). G6 exhibits clear supernova (SN) nucleosynthetic signatures, excesses in ^{12}C, ^{15}N, ^{18}O, and ^{28}Si, and a high inferred initial ^{26}Al/^{27}Al ratio.

As seen in TEM images of microtome slices, G6 is composed of a turbostratic graphite (see [6]) mantle surrounding its nanocrystalline core, with a smooth transition between the two regimes, differing from HD graphite grains. G6's core consists of graphene sheets ~3-4nm in size inferred from electron diffraction studies, consistent with [1]. We found relatively weak (002) diffraction peaks, corresponding to planar stacking of graphene sheets, though with spacings considerably larger than for pure graphite (3.35Å). The (002) diffraction peaks become more intense during the transition from nanocrystalline to turbostratic morphology. G6 also contains numerous subgrains of TiC (up to 265nm), and Fe-Ni (up to 75nm), and one SiC (70nm) near its surface. The subgrains lack overabundances of heavy elements such as Mo and Ru, consistent with a SN origin [6]. The largest TiC subgrain is located at the edge of the nanocrystalline core, while others are located at larger distances from the center. No subgrains are observed within the core itself.

Discussion: The morphological structure of G6 implies that the grain formed under monotonically changing conditions in SN ejeta, consistent with isotopic data from other SN graphite grains [7]. The subgrains must have formed prior to, or concurrently, with the turbostratic graphite mantle; the lack of subgrains within the nanocrystalline core indicates that the conditions responsible for their formation were unfavorable for subgrain formation. At high C/O ratios (>1.5) graphite condenses prior to TiC at realistic pressures [1]. Turbostratic graphite likely forms at C/O ratios closer to 1 where TiC can form before graphite [6]. A growing nanocrystalline grain could begin to develop turbostratic layering and to capture subgrains if it were moving through a gas with decreasing C/O ratio. The formation of nanocrystalline graphene cores is discussed in [1], however the presence of coherent stacking of graphenes has previously not been observed.

References: [1] Bernatowicz, T. et al. (1996) *ApJ*, 472: 760 [2] Croat, T. K. et al. (2005) *ApJ*, 631:976 [3] Croat, T. K. et al. (2008) *Meteorit. Planet. Sci.*, 43, 1497 [4] Croat, T. K. (unpublished, private communication) [5] Messenger, S. et al. (1998) *ApJ*, 502:284 [6] Croat, T. K. et al. (2003) *Geochim. Cosmochim. Ac.*, Vol. 67:4705 [7] Groopman, E. et al. (2012) *ApJ Let.*, 754:L8