PRESOLAR SIC TYPE C GRAIN M7-D: ISOTOPIC FINGERPRINTS FROM EXPLOSIVE HE-BURNING.

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Introduction: A rare subgroup of presolar grains are SiC grains from supernovae (SNe) [1]. A few % of them are the so-called C grains. Important characteristics of C grains are strong enrichments in the heavy Si isotopes and in ^{32}S. The latter signature is most likely the result of decay of radioactive ^{32}Si (half life 153 y), predicted to be produced in significant amounts by explosive He burning in core-collapse SNe [2].

Here, we focus on C grain M7-D from the Murchison meteorite. Previous isotope studies on this grain [3] were complemented by measurements of N. In order to identify the most likely formation site in the SN ejecta and to provide nucleosynthetic constraints on SN models we will compare the isotope data of M7-D with the predictions of the SN model by [2,4].

Experimental Methods: The experimental details of the C, Si, S, Mg-Al, and Ca-Ti isotope measurements are given in [3]. Nitrogen isotope compositions were measured with the NanoSIMS at MPI for Chemistry by employing a ~1 pA primary Cs^+ ion beam and recording negative secondary ions of $^{12}C^{14}N$ and $^{12}C^{15}N$ (together with ^{12}C, ^{13}C, and ^{28}Si).

Results and Discussion: The isotope data of M7-D are summarized in the Table. An attractive feature of the 15 $M_\odot$ SN model m15_exp_r by [2,4] is that it predicts a C- and Si-rich zone from explosive He burning at about 2.95 $M_\odot$, which makes ad-hoc mixing of matter from inner and outer SN zones dispensable. For grain M7-D the inferred abundances of ^{32}Si and ^{44}Ti as well as the enrichments in ^{29}Si and ^{30}Si suggest formation from matter from a layer between 2.82 and 2.95 $M_\odot$ ("zone A"), i.e., slightly below the C/Si zone defined by [2,4]. This layer has a C/O ratio close to unity and mass fractions of C and Si in the % range. It was argued by [4] that mixing of He by rotation or convective boundary mixing into the underlying O/C zone might expand the C/Si zone which would lift the C/O ratio in zone A above unity. Overall, given the uncertainties in nuclear reaction rates and SN physics, the agreement of the N and Si isotope data, and inferred abundances of ^{32}Si, ^{26}Al, and ^{44}Ti of M7-D with the model predictions for zone A (cf. Table) can be considered satisfactory. On the other hand, the $^{12}C/^{13}C$ ratio and low N abundance in zone A (>1000x lower than in M7-D) pose serious problems. Extending the upper limit of zone A to 4.9 $M_\odot$ ("zone B") resolves the N problem completely, but $^{12}C/^{13}C$ is still 100x too high (cf. Table). To pursue this issue further we plan to explore explosive He burning in detail, considering uncertainties in SN physics and progenitor structure, and with the data of SN grains as observational guidance.

Object	$^{12}C/^{13}C$	$^{14}N/^{15}N$	$\delta^{29}Si$ (‰)	$\delta^{30}Si$ (‰)	$^{32}Si/^{28}Si$ (10^{-3})	$^{26}Al/^{27}Al$ (10^{-1})	$^{44}Ti/^{48}Ti$ (10^{-2})
M7-D	109±2	147±10	1082±12	1207±16	1.2±0.2	1.2±0.1	7.7±0.2
Zone A	~10^7	238	6000	9300	0.84	0.37	6.8
Zone B	~10^4	157	2600	4200	11.0	0.17	3.5

References: [1] Zinner E. (2014) In *Meteorites and Cosmochemical Proc.*, Chap. 1.4 (ed. A. Davis), pp. 181. [2] Pignatari M. et al. (2013) *ApJ*, 771, L7. [3] Hoppe P. et al. (2012) *ApJ*, 745, L26. [4] Pignatari M. et al. (2013) *ApJ*, 767, L22.