HELIUM AND NEON IN “BLANK” STARDUST AEROGEL SAMPLES.

R. L. Palma[1,2], R. O. Pepin[2], A. Westphal[3], D. Schlutter[2] and Z. Gainsforth[3]. [1]Minnesota State University, Mankato, USA. russell.palma@mnsu.edu [2]University of Minnesota, Minneapolis, USA. [3]University of California, Berkeley, USA.

Introduction: We measured the concentrations and isotopic compositions of He and Ne by stepwise pyrolysis in Stardust cell 2044 “blank” aerogel samples adjacent to track 41. These samples appeared distinctly separated from track 41 material and did not contain visible particle fragments. Analyses were previously reported on five 200μm thick blank aerogel wafers from this cell [1]. Three of those samples released sufficient He and Ne for multiple stepwise heating analyses, with integrated isotopic compositions of $^{3}He/^{4}He$ = (3.4–3.7) x 10^{-4}, $^{20}Ne/^{22}Ne$ = 10.6–13.2 and $^{21}Ne/^{22}Ne$ = 0.021–0.034. A fourth sample (“X”) released extremely high abundances of He and Ne between 800 and 900°C, accompanied by large amounts of water and hydrocarbons. Mass spectrometer memory effects allowed only limits to be placed on the measured isotopic compositions of “X”; nonetheless, these limits, $^{3}He/^{4}He < 2.27 \times 10^{-4}$ and $^{20}Ne/^{22}Ne > 18.0$, were intriguing in light of elevated $^{20}Ne/^{22}Ne$ ratios also observed in IDPs that may have originated in neon novae and incorporated into comets 26P/Grigg-Skjellerup and 55P/Tempel-Tuttle [2]. In light of the surprising gas release from the blank aerogel wafer samples, a survey of He and Ne in 49 smaller blank samples was undertaken. This work extends and better constrains data reported earlier in a progress report on this project [3].

Samples: Sample set 1 (designated St44-1Bx,y) was prepared from a 1.5mm-thick, ~10mm tall slice of aerogel cut parallel to track 41 and ~2mm away from it (Fig. 1). This slice was subdivided into 6 columns (x, 1-6), with each column further divided into 9 smaller samples (y, 1-9, with 1 at the surface). The slice thus produced 54 ~(1.5mm)^3 samples, of which 29 were individually wrapped in Pt foil at UC Berkeley, ready for attachment to electrical leads in the UM multiple sample furnace. Sample set 2 (designated St44-2Bx,y) was prepared from the remaining block of material from which sample set 1 derived. These samples were made somewhat larger, ~(2.5mm)^3, with the x,y designations having similar meanings as in sample set 1. Of the 23 set 2 samples prepared at UC Berkeley, 20 were sent and analyzed at UM. Blank Pt foil packets were also loaded for blank procedure background analyses. System bakeout took place at ~150°C for 3 days after sample loading, and all sample and blank foils were heated and analyzed by the same procedures, similar to those described in [4]. Two heating steps (<200°C) were first done to remove any surface sited contamination. Except in one case where significant He evolved at <200°C (sample St44-1B2,8; see below), He and Ne released in these steps equaled that measured in both cold procedural and hot blank foil runs. Seven sequential pyrolysis steps were carried out (maximum T ~1400°C), with the total gas released then analyzed for He and Ne concentrations and isotopic compositions.

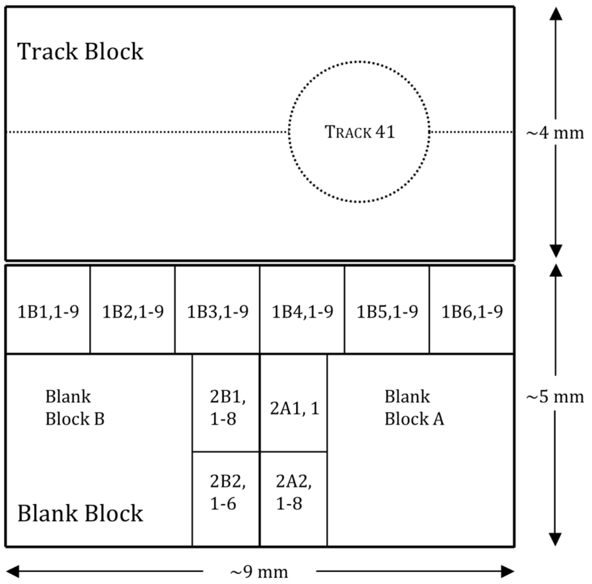

Fig. 1. Top view of the aerogel blocks containing Track 41 (Track Block) and the locations of the blank aerogel samples analyzed in this study (Blank Block). The two blocks have a depth of ~10mm, with two 200μm thick slices from the exposed surface having already been removed.

Results: Of the 49 samples analyzed, 13 had either He or Ne, or both, concentrations above blank uncertainties (Table 1). Of these 13 samples, five (1B1,1; 1B6,8; 1B6,9; 2B1,2; 2B2,5) had minor Ne gas abundances of isotopic composition consistent with a trace atmospheric contamination contribution, and three (1B1,3; 1B3,3; 2B1,3) had minor He gas abundances of isotopic composition consistent with a trace solar wind contribution. Although there may be ample opportunity for a trace atmospheric contamination component to be introduced to the samples, it is more difficult to see how a solar wind component could be incorporated into samples of blank aerogel a minimum of 3mm below the surface of the aerogel block. The remaining 5 samples each have significant gas abundances and interesting isotopic signatures. The data from these samples is in bold in Table 1 and discussed individually below.

Sample 1B2,8 is the only sample that released gas above blank levels in the initial two <200°C heating steps. In both the low and high T steps, enough He was released to accurately determine the isotopic composition, and although the overall ^{3}He/^{4}He ratio appears similar to that of the solar wind, the low T ratio is distinctly less than that of the high T ratio.

Sample 1B4,7 released the second highest abundance of Ne, although He was not detected. Within the uncertainty of the value for ^{20}Ne/^{22}Ne, the isotopic composition of this sample is consistent with a solar wind origin. However, in this case the sample comes from a location a minimum of 7mm below the surface of the aerogel block, requiring some mechanism of incorporating material that had solar wind exposure. It may be significant that this sample comes from an aerogel column closest to Track 41, and its depth is roughly consistent with secondary tracks radiating from the Track 41 impact bulb. This would require a sample travelling roughly 2-3mm from the center line of Track 41.

Sample 1B5,6 released the most He of any sample, along with a minor amount of Ne (too little to determine its isotopic composition). The ^{3}He/^{4}He ratio of 3.13×10^{-4} is intermediate of values for Jupiter and the solar wind, and both its value and the ^{4}He/^{20}Ne ratio are similar to that observed in typical IDPs [2].

Sample ID	**^{3}He/^{4}He** (E-4)	**^{4}He** (E-10 cc STP)	**^{20}Ne/^{22}Ne**	**^{21}Ne/^{22}Ne**	**^{20}Ne** (E-12 cc STP)	**^{4}He/^{20}Ne**	potential gas source
1B1,1		n.d.	8.8 (11)	0.039 (22)	2.46 (13)		atm
1B1,3	4.4 (14)	0.125 (10)			n.d.		SW
1B3,3	6.3 (18)	0.0692 (48)			n.d.		SW
1B2,8	2.74 (77) 4.92 (69)	0.0716 (47) 0.0910 (36)			n.d. n.d.		
total	**4.3 (13)**	**0.1626 (59)**			**n.d.**		**SW**
1B4,7		**n.d.**	**12.9 (13)**	**^{21}Ne n.d.**	**4.58 (23)**		**SW**
1B6,8		n.d.		0.171 (77)	0.53 (10)		atm
1B6,9		n.d.	9.1 (14)	^{21}Ne n.d.	0.751 (79)		atm
1B5,6	**3.13 (21)**	**0.512 (17)**	**^{22}Ne n.d.**	**^{21}Ne n.d.**	**0.542 (73)**	**94 (12)**	**?**
2B1,3	^{3}He n.d.	0.015 (10)			n.d.		SW
1B6,4	**^{3}He n.d.**	**0.192 (05)**	**16.21 (83)**	**0.0427 (70)**	**22.9 (04)**	**0.838 (76)**	**?**
2B1,2	^{3}He n.d.	0.022 (09)	11.0 (43)	0.033 (24)	2.09 (26)	1.05 (45)	atm
2B2,5		n.d.	12.2 (77)	0.064 (44)	1.48 (19)		atm
2A2,4	**>150**	**<0.013**	**8.9 (80)**	**^{21}Ne n.d.**	**0.727 (43)**	**<1.8**	**?**
blank		0.050 (12)			0.664 (97)		

The two most startling samples are 1B6,4 and 2A2,4. Sample 1B6,4 has remarkably similar elemental and isotopic light noble gas ratios to the values reported for IDPs containing debris potentially originating in neon (ONe) novae [2]. This sample released the second greatest abundance of ^{4}He, but despite that, ^{3}He was not detected. Given the amount of ^{4}He and the detection limits for ^{3}He, this suggests that the ^{3}He/^{4}He value is $<1.0 \times 10^{-4}$. The ^{20}Ne abundance was more than 34 times the blank value, and approximately 5 times the amount released by the second highest sample, 1B4,7. The high abundance of Ne allowed its isotopic composition to be accurately determined. Besides the ^{3}He/^{4}He value, the values of ^{20}Ne/^{22}Ne = 16.21 ± 0.83, ^{21}Ne/^{22}Ne = 0.0427 ± 0.0070 and ^{4}He/^{20}Ne = 0.838 ± 0.076 all fit within the results expected from the ejecta of an ONe novae.

Sample 2A2,4 is perhaps the most intriguing sample of the 49 analyzed. There is a very minor Ne component whose very imprecisely determined ^{20}Ne/^{22}Ne ratio is consistent with the terrestrial value. The ^{4}He value was consistent with that of the blank value, so only a upper limit is reported. However, the ^{3}He release was more than 4 times that of the blank, by far the greatest abundance of ^{3}He measured for any sample and yielding a lower limit of 1.5×10^{-2} for ^{3}He/^{4}He ratio. This is among the highest values for this ratio ever reported, similar to ratios measured by [5] in IDPs. As in that report, the absence of appreciable ^{21}Ne would appear to rule out the high ^{3}He abundance as the result of spallation.

Discussion: The origin of significant light noble gases in at least 5 samples of "blank" aerogel that are a minimum of several mm from Track 41 and the surface of Stardust Tile C2044 is a challenge. More puzzling yet is the wide array of isotopic compositions observed. Even if some mechanism can be invoked to provide the transfer of unobserved fragments from the Track 41 impactor to the aerogel samples analyzed, the ultimate origin of gases with such wide compositional differences within a single impactor suggests a complicated parent particle indeed.

References: [1] Palma R. et al. (2009) *Met. Planet. Sci.* 44, A164. [2] Pepin R. O. et al. (2011) *Ap.J.,* 742, 86, 1-15. [3] Palma R. et al. (2010) *Met. Planet. Sci.* 45, A160. [4] Marty B. et al. (2008) *Science* 319, 75-78. [5] Neir A. and Schlutter D. (1993) *Meteoritics* 28, 675-681.