HELIUM AND NEON IN 15 INDIVIDUAL PRESOLAR SILICON CARBIDE GRAINS OF TYPE AB.
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Introduction: About 90% of all presolar silicon carbide (SiC) grains in meteorites belong to the "mainstream" group deriving from asymptotic giant branch (AGB) stars. A few percent of the presolar SiC grains are of the type AB. They are defined by low $^{12}C/^{13}C$-ratios (<10). Their $^{14}N/^{15}N$ ratios vary from ~40 to ~10000 and they have Si-isotopic compositions as observed for SiC mainstream grains [1]. About two thirds of all A+B grains show an enrichment in s-process elements (3-5 times) relative to solar (e.g., in Zr or Mo), while the rest show a solar-like composition of s-process elements [2]. The C-isotopic composition observed in A+B grains does not fit the model predictions for AGB stars, and supernovae are unlikely sources for AB grains [3]. Low $^{12}C/^{13}C$ ratios, in combination with no enrichments in s-process elements relative to solar, point to J-type carbon stars as possible sources. For AB grains with s-process enrichments, an origin in "born again" AGB stars (like Sakurai's Object, V4334 Sgr) has been proposed [3]. The database for noble gas measurements of individual AB grains is small [4-6]. Here we present new results of He and Ne isotope analysis of 15 individual AB grains.

Methods: We used the Cameca NanoSIMS 50 at MPI Mainz to measure the C- and N-isotopic compositions of ~1000 presolar SiC grains from the meteorite Murchison. The grains had been previously deposited on a Au foil. The measurements were done by fully automated ion imaging with a Cs^+ primary ion beam in multicollection mode ($^{12}C^-$, $^{13}C^-$, $^{12}C^{14}N^-$, $^{12}C^{15}N^-$, $^{28}Si^-$). 36 grains (~4%) had low (<15) $^{12}C/^{13}C$ ratios. Because of potential C contamination we consider grains with $^{12}C/^{13}C$ < 15 as AB grains. Two of them, with a very low $^{14}N/^{15}N$ ratio (<40), have been identified as possible nova grains, resulting in 34 grains classified as AB grains. As the spot diameter of the laser beam used for the noble gas analysis work is much larger (~100 µm) than the average grain spacing on the sample-holder (~2-20 µm), the interesting grains had to be transferred to a separate sample-holder using a piezoelectric-driven micro-manipulator in a focused ion beam workstation (FIB). Four grains were transferred in a FIB (FEI Strata DB235) at Saarland University, Germany. Eleven additional AB grains were transferred in a FIB (Zeiss LEO 1540XB) at the Argonne National Laboratory, USA. The new sample holder was then imaged with an SEM at the MPI for Chemistry before the grains were brought to ETH Zurich for He, Ne analysis. This was done with a custom-built mass spectrometer that uses a molecular drag pump to concentrate the sample gas almost quantitatively into the ion source, thereby achieving a two-orders-of-magnitude increase in sensitivity [7]. In addition, we used a low-blank extraction line, including three liquid-nitrogen-cooled charcoals and two hot-metal getters. Beside the noble gas species $^3He^+$, $^4He^+$, $^{20}Ne^+$, $^{21}Ne^+$ and $^{22}Ne^+$, we measured $(H_2O)^+$, $^{40}Ar^+$ and $(CO_2)^+$, to correct for possible interferences on masses 20 ($(H_2{}^{18}O)^+$, $^{40}Ar^{++}$) and 22 ($^{44}(CO_2)^{++}$). To establish our detection limit, a total of 16 cold blanks and 4 hot blanks (where the laser is aimed on an empty spot of the Au foil) were measured. Before extraction, we measured all interesting species for four cycles in peak-jumping mode. The grains were then extracted using a Nd:YAG laser (λ=1024 nm), operated for ~30-60 seconds on each grain, and all isotopes were measured for another seven cycles. Any release of sample gas will lead to a difference between the forward-extrapolation of the first four measurements and the backward-extrapolation of the seven following ones (Fig 1). For blanks, any difference between the two extrapolated signals will scatter around zero, and two standard-deviations of this blank-scatter define our detection limit [6]. The grains were measured in two separate noble gas runs, one encompassing the first 4 grains transferred and 5 cold blanks, while the other 11 grains, together with 11 cold blanks

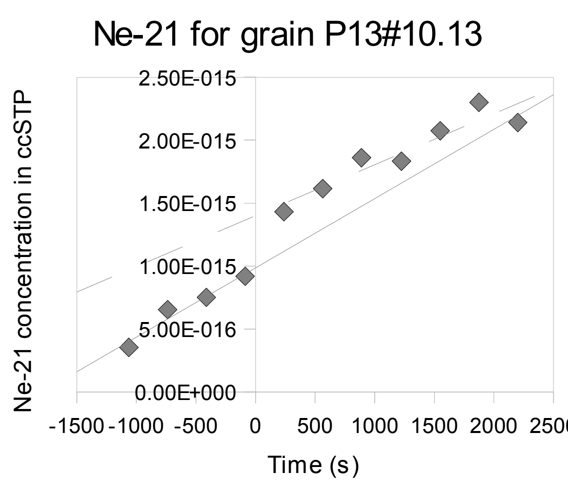

*Figure 1: Ne-21 concentration measured for grain P13#10.13 against time. Note the sudden increase of ~0.4*10^{-15} ccSTP at the moment of gas extraction.*

and 4 hot blanks, were measured in the second run. We calculate different detection limits for the two runs.

Results & Discussion: Of the 15 grains analyzed, only three showed He or Ne amounts above the detection limit. In two cases, the released gases are likely due to terrestrial contamination: During extraction of grain P11#14.42, the laser beam defocused during operation, forcing us to repeat the extraction, leading to a total operation time of 60 sec instead of the usual 30 sec. A hot blank (on an empty spot of the Au foil) with the laser shot during 60 sec done after extraction of this grain yielded a larger crater than usual and a ^{4}He amount of 3700±900 * 10^{-15} ccSTP (1 ccSTP = 2.687 * 10^{19} atoms), much higher than the standard ^{4}He detection limit of ~1000 * 10^{-15} ccSTP. Therefore, we attribute the measured ^{4}He amount of grain P11#14.42 to the gold foil. A second grain, P13#2.3, released measurable amounts of ^{20}Ne, ^{21}Ne and ^{22}Ne, but with nearly atmospheric isotopic composition (^{20}Ne/^{22}Ne = 9.5±2.5, ^{21}Ne/^{22}Ne = 0.04±0.01). We suspect some terrestrial contamination (e.g., adsorbed to the grains, or on the sample-holder surface) as the source of the Ne measured in this grain.

We are left with a single grain (P13#10.13) with a measurable ^{21}Ne content. While this is a first for SiC AB grains, we have not found a single grain with measureable ^{22}Ne, similar to [4], but in contrast to [6], who found 3 out of 5 AB grains to be gas rich, and [5], where all 4 AB grains contained presolar He and Ne. This difference is likely due to the small amounts of gas released by the small grains analyzed here. The lower limit to the ^{21}Ne/^{22}Ne-ratio in grain P13#10.13 is clearly higher than atmospheric (0.07 vs. 0.029). This grain also released some ^{20}Ne just above the detection limit. A purely interstellar cosmogenic origin for ^{21}Ne is excluded, as the concentration of 3.8 * 10^{-3} ccSTP/g, combined with an interstellar production rate of 5.6*10^{-9} ccSTP/g/Myr [5] yields a nominal interstellar cosmic ray exposure age of 690 Gyrs. The most probable explanation is a nucleosynthetic origin. A high ^{21}Ne/^{22}Ne-ratio is not expected from AGB models [9], confirming that grains of type AB are derived from a different source. So far there are no detailed nucleosynthetic model predictions for either J-type carbon stars or born-again AGB stars. The ^{17}O(α,γ)^{21}Ne reaction has been proposed to play an important role in the s-process [10], as it competes with the reaction ^{17}O(α,n)^{20}Ne that re-releases neutrons absorbed by the neutron-poison reaction ^{16}O(n,γ)^{17}O. In a ^{21}Ne-rich environment, the ^{17}O(α,γ)^{21}Ne reaction is probably more important than the ^{17}O(α,n)^{20}Ne reaction. This yields less neutrons, thereby inhibiting the s-process and indicating an s-process-poor nucleosynthetic environment (like J-type carbon stars) as possible source.

Conclusions: A He and Ne analysis of 15 SiC AB yielded one grain with ^{21}Ne (and possibly ^{20}Ne) of probable nucleosynthetic origin. The high ^{21}Ne/^{22}Ne-ratio could be explained by ^{21}Ne production by ^{17}O(α,γ)^{21}Ne. Whether this is consistent with the nucleosynthesis in J-type carbon stars remains to be seen.

Table 1. All measured grains. DL: Detection limits. All noble gas amounts in 10^{-15} ccSTP. Errors are 1σ.

Grain #	ϕ µm	^{12}C/^{13}C	^{14}N/^{15}N	He, Ne
Run 1 (grains transferred at Saarland University) DL: ^{3}He: 0.61 ^{4}He: 1400 ^{20}Ne: 30 ^{21}Ne: 0.76 ^{22}Ne: 13				
P8.2#2.16	-	12.2±0.1	1230±250	<DL
P9#4.3	-	5.5±0.1	229±15	<DL
P9#16.25	-	11.3±0.3	349±46	<DL
P10#7.8	-	2.3±0.1	102±7	<DL
Run 2 (grains transferred at Argonne National Laboratory) DL: ^{3}He: 0.37 ^{4}He: 3800 ^{20}Ne: 12 ^{21}Ne: 0.25 ^{22}Ne: 5.7				
P13#10.5	0.4	14.3±0.2	2050±500	<DL
P10#7.5	0.5	8.8±0.1	546±59	<DL
P11#13.11	0.8	5.3±0.1	651±154	<DL
P11#14.42	0.6	9.0±0.1	293±29	^{4}He: 4630±750
P13#9.7	0.5	10.4±0.1	478±68	<DL
P13#15.9	0.4	9.7±0.1	364±28	<DL
P14#13.7	0.8	8.9±0.1	1300±94	<DL
P11#10.12	0.4	6.1±0.1	848±150	<DL
P13#2.3	0.5	9.7±0.20	607±132	^{20}Ne: 74±15 ^{21}Ne: 0.32±0.08 ^{22}Ne: 7.7±1.2
P13#10.13	0.4	12.9±0.2	575±154	^{20}Ne: 14±13 ^{21}Ne: 0.41±0.11
P13#18.21	0.9	9.4±0.1	1320±220	<DL

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