

XENON ISOTOPES IN ALUMINUM SOLAR WIND COLLECTORS FROM GENESIS MISSION.

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Samples containing solar wind (SW) particles captured by Genesis Discovery Mission [1] became available for laboratory analyses in early 2005. But it took more than 5 years to achieve the analytical capabilities allowing for accurate isotopic analyses of all heavy noble gases in the solar wind [2]. The small solar abundances of Kr and Xe required development of a new multi-collector mass-spectrometer and an intricate low-blank laser extraction system capable of handling large amounts of H, the dominant SW component.

A unique 8-multiplier mass spectrometer Noblesse, developed in conjunction with Nu-instrument, with an electrostatic zoom lens and a bright ion source (~ 60% transmission) was used for simultaneous analyses of all Kr and Xe isotopes. The measured Kr/Xe ratio, which is different from terrestrial contamination and the SW, was used for internal blank correction.

A laser ablation system utilizing both UV and IR wavelengths was developed for extraction of SW noble gases. One extraction mode was a stepped laser power ablation technique which allows depth profiling of the implanted SW He, Ne and Ar but, for the extraction of Kr and Xe, only 3 steps were utilized: 1st – to degas the very surface, 2nd – most of the solar wind, and the 3rd – to check the completeness of the SW extraction.

Besides the low abundance of SW Xe (~ 10,000 atoms/mm² accumulated during the 2.3 year collection), there was one isotopically specific problem, the isobaric interference of C₃F₅ with ¹³¹Xe, which cannot be fully resolved by Noblesse. This fluorocarbon, apparently coming from the surface of plastic bags, and not removable by traditional cleaning fluids: acetone, methanol and de-ionized water, is present at very low levels in most modern mass-spectrometers. To address this problem an additional cleaning step was added to the sample purification line. It consists of a W-filament held at >1500°C, which cracks large molecules into simpler compounds, and an associated Ti-sublimation pump in the same ~ 150 cm³ housing. This combination reduces C₃F₅⁺ peak by a factor ~10. The rest was taken care off by modifying the field the of electrostatic zoom lens in such a way that the ¹³¹Xe was measured slightly off-center to the low-mass side where the heavier fluorocarbon contribution is negligible. This adjustment does not affect the ¹²⁹Xe peak, the second isotope measured at this setting of the bending magnet.

AoS (Aluminum on Sapphire) SW-collectors were analyzed using three laser extraction cells having different angles between laser beam and the surface of AoS (to minimize Al-deposition on the viewport). Nineteen individual areas (from 0.3 to 3.8 cm²) of AoS were analyses over the course of several months.

All 19 analyses and 4 averaged blanks are shown in Figure 1.

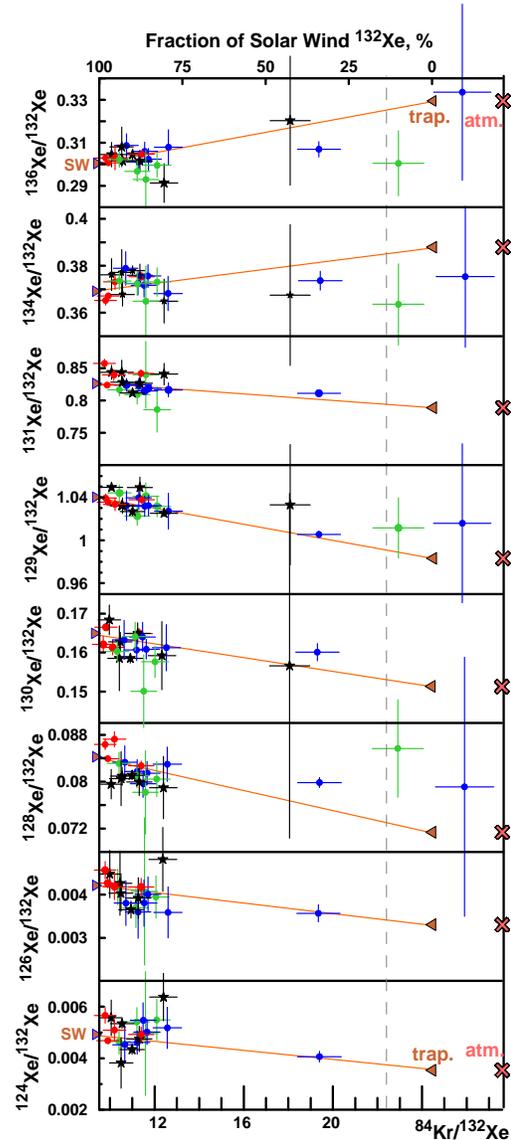


Fig. 1. Xe in Genesis AloS collectors. Points nearer atmospheric with the large error bars are the averaged blanks, although not all of them are shown because errors are too large. The fit lines are forced through the estimated trapped component with $^{84}\text{Kr}/^{132}\text{Xe} = 24.4$ [2]. The ordinate intercepts, at SW $^{84}\text{Kr}/^{132}\text{Xe} = 9.55$ [3], give the isotopic composition of SW Xe. The different colors correspond to different experiments run several months apart under different conditions.

Trapped $^{84}\text{Kr}/^{132}\text{Xe} = 24.4$ [2] is only $\sim 12\%$ lower than the atmospheric value, implying that the isotopic compositions of trapped Xe have not been significantly altered by diffusive losses. All measured Xe compositions can be treated as mixtures of two end members: $(^{84}\text{Kr}/^{132}\text{Xe})_{\text{TRAP.}} = 24.4$ and $(^{84}\text{Kr}/^{132}\text{Xe})_{\text{SW}} = 9.55$ [3].

The general weighted average of our 19 analyses compared with weighted average of two independent SW-Xe analyses of Si SW collectors by RELAX [4] are shown in the following table:

Xe ratios $^{132}\text{Xe}=1$	AloS (this work)	Si [4] wtd. ave.	best current estimate
^{136}Xe	.3003 (6)	.3006 (20)	.3003 (6)
^{134}Xe	.3692 (7)	.3712 (19)	.3694 (7)
^{131}Xe	.8263 (13)	.8163 (28)	.8245 (12)
^{130}Xe	.1649 (4)	.1662 (11)	.1651 (4)
^{129}Xe	1.0401 (10)	1.042 (4)	1.0401(10)
^{128}Xe	.0842 (3)	.0818 (49)	.0842 (3)
^{126}Xe	.00422 (9)	-	.00422 (9)
^{124}Xe	.00492 (7)	.00456(31)	.00490 (7)

The weighted average of AloS and Si results (right column) is considered to be the current best estimate of Xe composition in the present solar wind. This composition is very close to SW-Xe derived from analyses of the lunar regolith [5], and allows us to put a strict upper limit of $\sim 10\%$ on any temporal variations of SW-Xe (Figure 2). To push this limit further, we will now need to improve the precision of the lunar-derived SW data, since the Genesis Xe isotopic analyses are presently the more accurate.

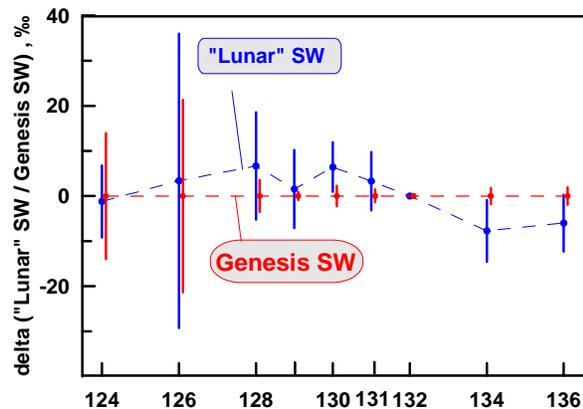


Fig. 2. “Current best estimate” of modern SW (Genesis) and SW-Xe in lunar regolith [5] accumulated for millions of years agree with each other within experimental errors. For comparison of the precisions the errors are not propagated to the delta values.

The higher precision of SW-Xe measured in the Genesis collectors now open up opportunities for find-

ing relationships between the original solar nebular Xe (represented by SW-Xe) and other major reservoirs in the Solar System, such as Q-Xe, the major “planetary” component, and perhaps eventually atmospheric Xe.

Using the χ^2 criterion, we found that we can make Xe-Q by fractionating Genesis SW-Xe by 8 ‰/amu and adding 1.5% of unfractionated Xe-HL (found in nanodiamonds) with the touch of .003% Xe-S (located in silicon carbide), as demonstrated in Figure 3.

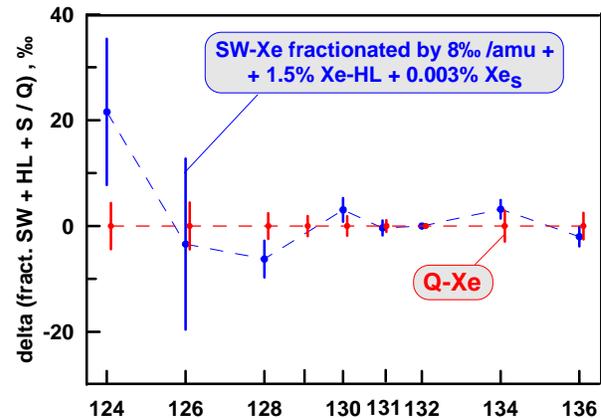


Fig. 3. 98.5% of SW (current best estimate) fractionated by 8 ‰/amu with 1.5% addition of Xe-HL and .003% of Xe-S provides the best fit for Q-Xe. Errors are not propagated to delta values. ^{129}Xe is excluded because of ^{129}I decay.

Although the association of Xe-HL with Q-Xe has been noted previously [6, 7, 8], this is the first indication that contributions of these Xe components is needed. This is very interesting since the phase-Q, the proposed carrier of Q-Xe, is seen as a 2D surface layer and seems to be associated with nano-diamond, the carrier of Xe-HL and SiC, the carrier of Xe-S.

The next step is to understand the mechanism of how the Q-Xe was formed. As indicated above, pre-solar nanodiamond and SiC, refractory presolar grains, may be key players as substrates and anomalous adsorption [9] may be a key player as a process.

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