REFINED COMPOSITION OF SOLAR WIND XENON DELIVERED BY GENESIS: IMPLICATION FOR PRIMITIVE TERRESTRIAL XENON.

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Introduction: For all major isotopes the composition of Solar Wind (SW) noble gases is now measured with the precision required by the Genesis Mission objectives [1]. Heavy SW-Xe isotopes (A ≥ 128) have been determined with the $1 - 4$ ‰ precision, but light, least abundant ^{124}Xe and ^{126}Xe are only known to ~2%. Meanwhile, these two isotopes are important for estimating the extent and linearity of mass fractionation. Genesis SW-collectors contain < 4000 atoms/cm^2 of ^{124}Xe and ^{126}Xe. To improve counting statistics we have to analyze large areas of a SW-collector, which dictates the choice of AloS (Aluminum on Sapphire), the most abundant, though not the cleanest SW-collector flown on Genesis. However, there were two problems making laser ablation of large areas of AloS impractical. The first one was the sputtering of Al during the ablation. The sputtered Al covered the vacuum viewport, obscuring delivery of the laser beam to the target. This problem has been solved by redesigning the laser extraction cell [1]. The second problem was caused by the long time required for ablation of large areas. Even with 30Hz repetition rate of the Q-switched IR-laser and fast Newport stage, it took almost an hour to ablate a cm–sized area. During this time, procedural Xe blank was accumulating increasingly fast. This work presents a solution for this problem and the first set of improved analyses of SW-Xe in AloS #60559b/c flown on Genesis.

Experimental: Traditionally for laser ablation of Genesis SW collectors, the laser beam is focused to a $<$ 100 μm dia spot by the laser objective, often consisting of a simple plano-convex lens. We replaced this spherical lens with an IR-coated cylindrical lens which focuses the laser beam only in one axis, producing a line. The expanded to ~ 6 mm dia laser output beam was trimmed to 4 mm in order to homogenize the power along the line. This new cylindrical objective dramatically reduced ablation time, removing the last obstacle in analyzing large areas of Genesis SW-collectors. Now SW noble gases can be easily extracted from cm-size areas in just a few minutes.

Mass spectrometry: We continue to use the 8-multiplier Noblesse instrument dedicated to Genesis analyses and so far exposed only to atmospheric and SW noble gases. This is important because we use "internal" blank correction based on the difference of Kr/Xe ratios in the SW and the trapped atmospheric

value. Unfortunately the ion transmission of Noblesse is only ~ 65%, implying that every third ion is wasted. The useful counting time is only ~17 min. In order to use this time efficiently, in this work most of the time we counted only even Xe isotopes and very briefly Kr isotopes. Odd Xe isotopes (A=131, 129) were not analyzed since we already know them with sufficient precision [1]. The results are shown in the Figure 1.
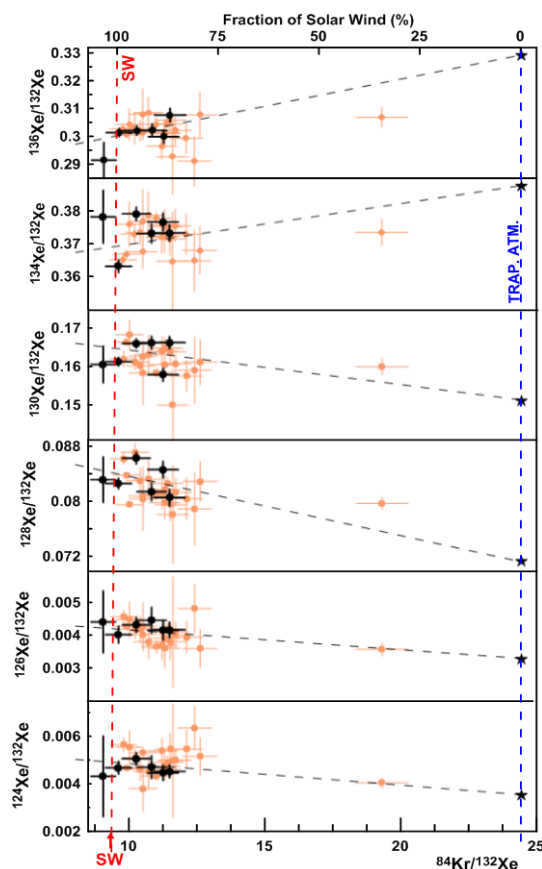

Fig. 1. New Solar Wind analyses of even Xe isotopes (black symbols) compared with our old results (orange, [1]). Vertical lines represent Kr/Xe values in Solar Wind and Trapped Xe (stars). The intercept of the error weighted fit (dashed line) forced through the trapped Xe correspond to Solar Wind isotope ratios.

Results: We completed the first set of the refined analyses of AloS SW-collector to improve the precision of low abundant Xe isotopes. Present results agree with published data and allow us to further reduce uncertainties on general weighted average (Table 1).

Table 1. Solar Wind Xe before and after this work.

Xe isotope	Published results [1] (before this work)	Including results of this work
^{136}Xe	.3001 ± .0006	.3003 ± .0005
^{134}Xe	.3691 ± .0007	.3698 ± .0006
^{132}Xe	≡ 1	≡ 1
^{131}Xe	.8256 ± .0012	not changed
^{130}Xe	.1650 ± .0004	.1648 ± .0003
^{129}Xe	1.0405 ± .00010	not changed
^{128}Xe	.0842 ± .0003	.0842 ± .0002
^{126}Xe	.00416 ± .00009	.00420 ± .00007
^{124}Xe	.00491 ± .00007	.00489 ± .00006

Implications: Terrestrial atmospheric Xe is deplet-ed in ^{134}Xe and ^{136}Xe relative to mass fractionated SW-Xe, and this depletion cannot be explained by addition of fissiogenic Xe from ^{244}Pu and/or ^{238}U. To solve this puzzle Takaoka [2] and Pepin&Phinney [3], using 2-D and 7-D correlation analyses and a somewhat different meteoritic database, derived primitive terrestrial Xe, distinct from the rest of the Solar System. This hypo-thetical precursor called U-Xe (unrelated to Uranium) apparently resolved the puzzle of ^{134}Xe and ^{136}Xe defi-cit in terrestrial Xe which now can be precisely derived from mass-fractionated U-Xe with addition of fission Xe from ^{244}Pu. Later Igarashi [4] deduced another "Primitive Earth" Xe component which was similar to Xe-U. But in contrast to [2, 3] he employed Principal Component Analysis which did not requite the assump-tion of fission spectra. In this approach the fission spectrum was a free parameter. The resulting composi-tion of fission Xe in the atmosphere turned out to be different from both ^{244}Pu and ^{238}U fission spectra [4].
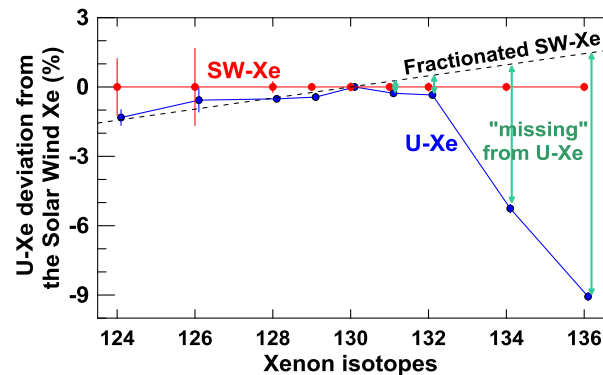
Fig. 2. New SW-Xe composition (red) suggests that U-Xe (blue) is a fractionated SW-Xe (black dashed line) depleted not only in ^{136}Xe and ^{134}Xe, but also in ^{132}Xe and ^{131}Xe, although the latter two are less prominent.

Interestingly, U-Xe was derived mathematically from meteoritic data without any reference to SW-Xe composition. Yet it turned out to be almost identical to SW-Xe with the exception of ^{134}Xe and ^{136}Xe. How-ever, our present results suggest that all non fissiogenic

isotopes ($^{124-130}$Xe) lie on the same fractionating line, thus U-Xe is depleted not only in ^{134}Xe and ^{136}Xe but also in ^{132}Xe and ^{131}Xe (green arrows, Figure 2). Since never reproducibly observed, U-Xe is likely not a real component. We believe that it is actually not U-Xe that is depleted in $^{131-136}$Xe isotopes, but rather these isotopes are being lost from the primitive terrestrial atmosphere. Indeed, the isotopic pattern of the appar-ently "missing" from U-Xe isotopes (green arrows, Fig. 2) (^{136}Xe/^{134}Xe/^{132}Xe/^{131}Xe = 1/0.714/0.126/0.083) is complimentary to the Igarashi's terrestrial fission Xe [4] (Figure 3).
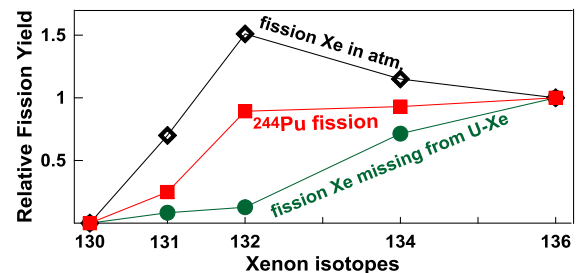
Fig.3. Fission Xe in terrestrial atmosphere (black, [4]) and Xe "missing" from U-Xe (green) are clearly complimentary components. Combined together they form Xe from spontaneous fission of ^{244}Pu (red).

Apparently Xe from ^{244}Pu in the early atmosphere was depleted in $^{131-134}$Xe, making it compositionally similar to Xe "missing" from U-Xe. Most likely that was a result of modification of fission yields in open systems due to "chemical separation" of Xe β-active precursors [5]. After the partial loss of primary atmos-phere, the remaining terrestrial fission Xe became en-riched in $^{131-134}$Xe, just like Igarashi's fission Xe. This isotopic signature is still observed in well gases [6, 7] and some ancient rocks [*i.e.* 8].

Conclusion: Refined composition of SW-Xe opens an opportunity to reexamine the origin of terrestrial Xe. Fractionated Solar Xe seems to be the starting point. After the Earth accretion "chemically" modified ^{244}Pu fission Xe enriched mainly in $^{136, 134}$Xe began to accu-mulate in the earlier atmosphere which later has been lost leaving behind fission Xe complimentary depleted in the lost isotopes.

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