XENON ISOTOPIC ABUNDANCES IN THE SOLAR WIND

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Direct solar wind measurements of xenon may not be available for some time. However, the lunar regolith and gas-rich meteorite breccia are sources of solar wind implanted material. The Pesyanoe enstatite achondrite is a well-known gas-rich meteorite which has solar-type noble gas compositions. Since the identification of the solar-type Xe isotopic signature (1), our knowledge of solar Xe has been much improved, mainly owing to the moon missions. Lunar soil 12001 data (2) are generally used for recent solar wind records. A knowledge of the isotopic signature of solar Xe is essential for an understanding of solar system components. The sun is of course the major reservoir in our solar system. Here we report Xe and Ar data of Pesyanoe for the enstatite achondrite parent body, and compare the records to lunar data.

We studied the Pesyanoe Xe by stepwise pyrolysis, but added combustion steps at 400°C and 600°C to further concentrate the solar component by removing FVC-Xe (3). Also more temperature steps were used in order to get precise release patterns. We measured three grain sizes fractions, >350 µm (selected white enstatite crystals), 60 - 350 µm (grayish matrix) and $<$ 60 µm (fines). All fractions were prepared by gentle disaggregation, but optical inspection revealed that the fines fraction contained some fragmented particles. Samples were preheated at 200°C overnight, then the 400 and 600°C combustions were carried out after pyrolysis steps at these temperatures. Above 600°C only pyrolysis steps followed until the sample melted.

Fig. 1 shows the release curves for ^{36}Ar and ^{132}Xe of the 60 - 350 µm fraction and the ratio ^{36}Ar/^{132}Xe is compared to the solar value. The release pattern of Ar shows two peaks but only one broad Xe peak is observed. This confirms Zähringer's results (4) which showed two release peaks for Ne and Ar in Pesyanoe. Ar/Xe ratios for the first peak are close to the solar value, but the ratios above 800°C are lower by about one order of magnitude. Assuming that there is no significant elemental fractionation in the solar wind, it is clear that the implanted solar gas in Pesyanoe in the release above 800°C is strongly fractionated.

The results obtained from the combustion steps show that Pesyanoe has less FVC-type Xe than ordinary chondrites, even though it contains carbon, and the concentration is $\sim 4 \times 10^{-12}$ ccSTP/g ^{132}Xe. Fig.2 shows the isotopic signatures ^{132}Xe/^{136}Xe vs. ^{134}Xe/^{136}Xe. All data above 800°C are shifted away from "solar Xe" and plot between the mass fractionation line and the ^{244}Pu fission line. We note that no data is shifted towards the U-type Xe signature (5). If the observed shifts were due to the presence of Pu fission xenon, we would expect that the melting step would release more Xe_f. The ratios show that mass fractionation effects are present in the high temperature steps. Further evaluation of the signatures can be carried out using light Xe isotopes, after removing spallation effects, and this test shows that both fission and mass fractionation effects are responsible. For the Kr isotopes, Marti (6) has discussed possible fractionation mechanisms on the parent body and in the solar wind source region. Since there are two peaks in the release pattern and the gases released at low temperature are elementally unfractionated, we interpret the first peak as unfractionated solar wind (more recent) and second one as fractionated solar wind. The older implanted gases apparently were strongly fractionated

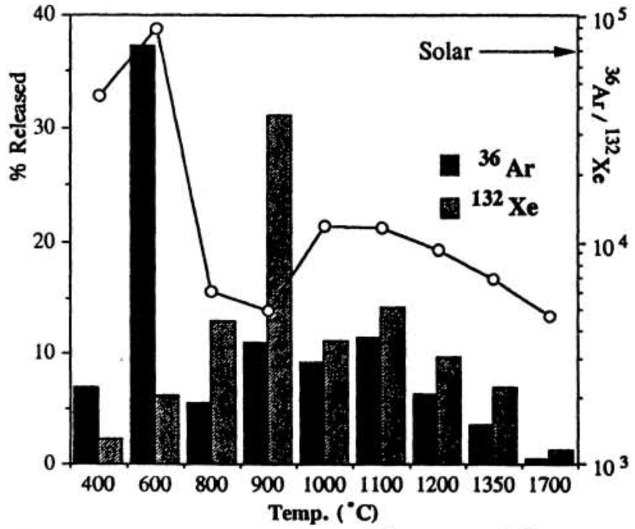

Fig. 1. Release patterns for ^{36}Ar and ^{132}Xe and $^{36}Ar/^{132}Xe$ ratios as a function of temperature step in Pesyanoe 60 - 350 μm matrix. Solar ratio from (7).

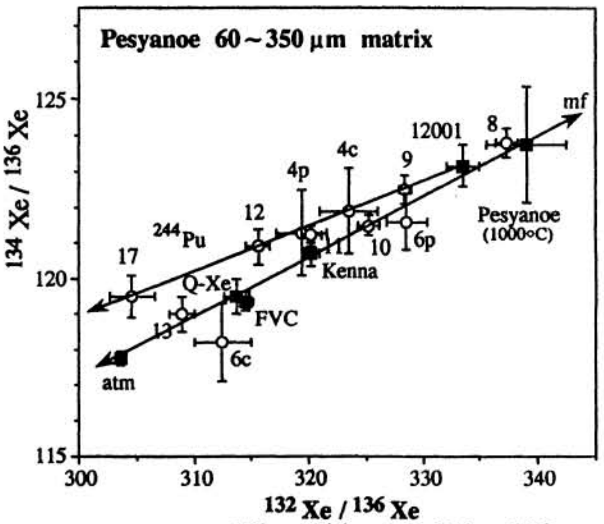

Fig. 2. The ratios $^{132}Xe/^{136}Xe$ and $^{134}Xe/^{136}Xe$ as observed in temperature fractions of Pesyanoe matrix (1σ uncertainties are shown). Temperatures are indicated in hundreds of degrees. [Pesyanoe(1000°C) from (1), FVC from (3) and Q-Xe from (8)]

before a later implantation. The Pesyanoe parent body regolith was either exposed to solar wind before and after heat pulse(s) or mixtures of regolith materials of distinct thermal history.

For the above reasons, we calculate the solar wind Xe isotopic signature only from low temperature pyrolysis steps. We compute averages of (air corrected) 600°C pyrolysis and measured 800°C steps from two different fractions (< 60 μm and 60 - 350 μm) and obtain the following "solar" composition (uncertainties represent 95% C.L.) :

^{124}Xe :	^{126}Xe :	^{128}Xe :	^{129}Xe :	^{130}Xe :	^{131}Xe :	^{132}Xe :	^{134}Xe :	^{136}Xe
3.04	3.05	50.95	634.4	=100.	497.9	609.3	223.3	180.5
±.14	.09	.43	3.8		2.4	3.6	1.0	.8

These ratios agree with the solar wind composition obtained from lunar soil 12001 (2) within error limits except for ^{126}Xe. The ^{126}Xe ratio indicates the presence of a minor spallation component in the Pesyanoe data. The ^{136}Xe ratio may hint at the existence of a residual very minor fission component in the 12001 data. The good agreement of the Xe isotopic composition as measured on two different solar system bodies implies that the solar wind Xe signature was the same at the respective times of implantation. There is no evidence for an evolution of the solar Xe isotopic signature.

References: (1) Marti, K. (1969) Science 166, 1263-1265. (2) Eberhardt, P. et al. (1972) Proc. Lunar Sci. Conf. 3rd, 1821-1856. (3) Lavielle, B. and Marti K. (1988) Lunar and planetary Science XIX, 667-668. (4) Zähringer, J. (1962) GCA 26, 665-680. (5) Pepin, R. O. and Phinney, D. (1978) Components of Xenon in the Solar System. Preprint, Univ. of Minnesota Space Science Center. (6) Marti, K. (1980) Proc. Conf. Ancient Sun, 423-429. (7) Anders, E. and Grevesse, N. (1989) GCA 53, 197-214. (8) Wieler, R. et al. (1991) Noble Gases in "Phase Q": Closed System Etching of an Allende Residue, GCA (in press).