TRAPPED SOLAR FLARE NE IN LUNAR SOIL PLAGIOCLASES: SECULAR DECREASE OF THE SOLAR FLARE/SOLAR WIND FLUX RATIO. R. Wieler, Ph. Etique, and P. Signer
Swiss Federal Institute of Technology ETH, Sonneggstrasse 5, CH-8092 Zürich, Switzerland

The goal of this investigation is to test whether the mean Ne flux in solar flares (SF) relative to that in the solar wind (SW) has changed with time. An indication for a higher SF/SW ratio some 500 My ago was reported on the basis of a high value of the track density/36-Ar concentration in plagioclases of an Apollo-15 drill core soil (1). Furthermore, implanted noble gases of solar flare origin were identified in lunar samples by several groups: An investigation of He and Ne in the outermost millimeters of a lunar rock lead to the detection of solar flare implanted He (2). SF-implanted Ne with a 20-Ne/22-Ne ratio <11.3 was found in plagioclase soil grains of various sizes and etched to various depths (3). Ne data obtained from heating experiments of etched plagioclase separates from various soils were interpreted as evidence for implanted solar flare Ne (4).

In the light of these reports, we examine here all plagioclase separates from lunar soils which were measured in our laboratory for evidence of SF-Ne contributions. Even unetched plagioclases appear suitable for this purpose, because their low retentivity for SW-Ne (<5%) causes a natural depletion of this gas with respect to SF-Ne. Due to the larger implantation depth of SF-Ne, this component is likely to be retained more efficiently than SW-Ne. Furthermore, SF-Ne has a lower 20-Ne/22-Ne ratio than the retained SW-Ne (~11.3 and 12.5±3, respectively). Thus, a SF contribution would show up in a lowering of 20-Ne/22-Ne of the solar Ne component, as well as in an increased Ne/Ar ratio. A possible secular variation of the mean ratio of SF-Ne/SW-Ne fluxes may be detected by comparing the 20-Ne/22-Ne ratios of solar-type Ne in plagioclases separated from recently exposed soils with those ratios in antique samples. Concerning the recording time of minerals, it was shown that 150-200 μm minerals acquire their SW-gases over some 10'000 y of integrated exposure time (1). The individual exposure episodes are spread over an interval of 10 to 100 My. The 20-Ne/22-Ne ratios of the solar Ne retained in the plagioclases (denominated (20-Ne/22-Ne)sol), were calculated by assuming the isotopic composition of spallogenic Ne according to Lugmair et al. (5).

This method is clearly not as direct as the investigation by Etique et al. (3). It has, however, the advantage to be also applicable...
to drill core samples where material limitation precludes preparation of grain-size suites.

Fig. 1 shows the data of all 150-200 μm plagioclase separates in an "Ar-Ne 3 isotope correlation plot". Mare- as well as highland samples show a trend to higher (22-Ne/20-Ne)\textsubscript{sol} values with lower Ar/Ne ratios. This trend can be explained by an increasing contribution of SF-Ne. The straight lines indicate mixtures of SW- and SF-gases with the following elemental and isotopic compositions: in solar flares:

- 20-Ne/22-Ne = 11.3 and 20-Ne/36-Ar = 30; in retained solar wind:
- 20-Ne/22-Ne = 13 and 20-Ne/36-Ar in highland- and mare soils 1 and 2, respectively. The explanation of the trend in Fig. 1 is supported by the Ne data of 7 plagioclase separates from the deep drill core section 60002, the sample with the highest (22-Ne/20-Ne)\textsubscript{sol}. These data are presented in Fig. 2, together with those of 6 plagioclases of the upperlying core section 60003. The data sets of both sections define each a straight line with correlation coefficients >0.99. The 20-Ne/22-Ne ratios of the solar component extrapolated for the two sets of plagioclase samples are indicated in the upper left hand corner. The value for 60002 is lower than for 60003. In contrast, the pyroxenes, which are about 5 times more retentive for SW-Ne than the plagioclases, do not indicate such a difference. Therefore, the data are best accounted for by postulating a larger SF-Ne contribution in section 60002. This is further supported by the higher mean 20-Ne/36-Ar ratios of the plagioclases in section 60002 (1.9 ± 0.2 versus 1.3 ± 0.1 in 60003). In contrast, the SW-retentive pyroxenes have similar Ne/Ar ratios in both sections. High Ne/Ar ratios in bulk soils from core section 60002 were already noted earlier (6), and were attributed to a higher Ne/Ar ratio in the solar wind some 500-1500 My ago. However, in our view, the Ne excess of about 40 % in the 60002 plagioclases as well as their low (20-Ne/22-Ne)\textsubscript{sol} are due to an additional SF-Ne contribution with a 20-Ne/22-Ne ratio around 11.2. This value is in good agreement with that given by Etique et al. (3).

A secular change of the mean flux ratio of SF- and SW-Ne would have to cause a systematic variation of the (20-Ne/22-Ne)\textsubscript{sol} in plagioclases with their "antiquity (7)". As measure of antiquity, the 40-Ar/36-Ar ratio of surface correlated Ar has been proposed (8). In Fig. 3 the (20-Ne/22-Ne)\textsubscript{sol} in plagioclases is plotted against the 40-Ar/36-Ar ratios in olivines or pyroxenes for all soils where also mafic minerals were measured. In mafic minerals, the measured 40-Ar/36-Ar ratios are a fair approximation for the 40-Ar/36-Ar of the surface correlated Ar component, because these minerals contain little in-situ produced radiogenic 40-Ar. The trend in Fig. 3 indeed indicates an increase of the (20-Ne/22-Ne)\textsubscript{sol} towards recent time, i.e. low 40-Ar/36-Ar values.

In conclusion, we postulate that the averaged SF/SW particle flux ratio was indeed higher in the past than it is now. This postulate rests primarily on noble gas data from plagioclase separates. More track determinations and etching experiments on minerals with high noble gas retentivity and low inward diffusion of surficially implanted SW-gases must be carried out to confirm this postulate. Such experiments should also reveal the flux ratio of the individual gas species.

This work is supported by the Swiss National Science Foundation, Grant No. 2.480-0.79.

REFERENCES