COMPOSITION OF SOLAR FLARE ARGON DEDUCED FROM KAPOETA ETCHED MINERAL SEPARATES; M.N. Rao[1], D.H. Garrison[2], D.D. Bogard, NASA Johnson Space Center, Houston, TX 77058, A.V. Murali, and D.C. Black, Lunar & Planet. Inst., Houston, TX 77058, (also [1]P.R.L. Ahmedabad, India; [2]Lockheed-ESC)

Several recent investigations (1,2,3,4) have shown that the $^{20}Ne/^{22}Ne$ isotopic ratio in neon implanted by solar flares is 11.6 $\pm$0.2, which is ~15% smaller than this ratio in solar wind neon. The isotopic composition of solar flare (SF) neon is also considerably different from neon in the terrestrial atmosphere and neon trapped in carbonaceous chondrites (5 Fig.1). A $^{20}Ne/^{22}Ne$ ratio of 11.6 is, however, similar to a neon-C component derived from neon data for gas-rich meteorites and suggested to be from solar flares (6). It is pertinent to ask whether the isotopic composition of argon in solar flares differs from solar wind argon. The $^{36}Ar/^{38}Ar$ ratio, unlike the $^{20}Ne/^{22}Ne$ ratio (hereafter referred to as 36/38 and 20/22, respectively), shows little variation among various preserved gas components in the solar system. Furthermore, one of the isotopes of argon, ^{40}Ar, is almost entirely derived from the radioactive decay of ^{40}K during the solar system history. Consequently, examination of possible isotopic components on a three-isotope correlation plot is not possible for argon, as it is for neon. We have recently acquired data for SF Ne and Ar implanted in the Kapoeta howardite, which we believe shows a SF 36/38 ratio of 4.8 $\pm$0.2, significantly lower than the value of ~5.32 found in other argon reservoirs.

We have measured the isotopic compositions of Ne and Ar in three step-wise temperature releases of acid-etched samples of grain size separates prepared from pyroxene and feldspar mineral separates of both the dark (solar gas-rich) and light (solar gas-poor) phases of the Kapoeta howardite. These Ne data are presented in the companion abstract (5, Fig. 1). Independantly for the pyroxene and feldspar mineral separates, the Ne data define linear trends on a three-isotope correlation plot. The interception of these trends with a trend of probably trapped compositions defines the SF 20/22 ratio of 11.6 $\pm$0.2. Because we cannot use a 3-isotope correlation plot for Ar, we examined another method of treating the Ne isotopic data which would also indicate a SF 20/22 ratio of 11.6, and then applied this method to the argon data as well. The method of choice is the ordinate-intercept plot, where an isotopic ratio is plotted against the reciprocal concentration of one of these isotopes, i.e., 20/22 vs $1/[^{22}Ne]$ and 36/38 versus $1/[^{38}Ar]$. Mixtures of surface-and volume-correlated components should define a linear trend whose intercept at infinite gas concentration defines the isotopic ratio of the surface component, in this case the SF Ne and Ar composition (the solar wind component having been largely removed by etching the grains).

Fig. 1 shows the ordinate-intercept plot for the same Ne data for four Kapoeta dark pyroxenes as presented in a 3-isotope correlation plot in our companion paper. The 600°C extractions all have 20/22 ratios of ~11.6 (indicating that the surface solar wind component had been largely removed), and define a trend which yields a 20/22 intercept value of 11.5. The 1200°C extraction data also define an intercept of ~11.6. The 1600°C data are dominated by Ne produced by cosmic rays and thus plot much further from this intercept. Bulk analyses of grain size separates, rather than stepwise temperature releases of etched fractions, is the preferred way to use the ordinate-intercept plot. Therefore, the combined data for all extraction temperatures of each pyroxene separate are also plotted in Fig.1 and define an intercept of 11.67. Thus, the ordinate-intercept plot for the Ne data yield the same value for SF 20/22 as does the 3-isotope correlation plot, and we feel some confidence in now applying this technique to the Ar data. Although the Ar data sets exist for both pyroxenes and feldspars, only pyroxene data will be discussed because large amounts of cosmogenic Ar were released at all temperature extractions of feldspar, but cosmogenic Ar was released at only high temperature extractions for pyroxenes.

Ar isotopic data for the four size separates of dark pyroxenes are presented in Fig.2. Again the 600°C extractions all give 36/38 ratios less than typical solar wind values of ~5.35 and define a trend with a 36/38 intercept of 4.7. The 1200°C data cluster may define a somewhat higher intercept, but measured values are all still less than 4.8. The combined data for each size separate define a linear trend intercepting at 36/38 =4.90. The observed 36/38 intercept values of 4.7-4.9 and the absence of measured 36/38 values greater than 4.9, even in the 600°C extractions of the most lightly etched samples, suggest that the solar flare Ar composition lies in this range.

An additional test that can be used to compare correlations between specific Ne and Ar components is to plot 20/22 ratios against 36/38 ratios for stepwise temperature release data of the four pyroxene size separates from the dark material (Fig.3). The 600°C and 1200°C data cluster on one side of the plot, and the

SOLAR FLARE ARGON Rao M.N. et al.

1600°C data, which account for only ~10% of the released argon in the lightly etched samples, plot closer to the expected glactic cosmic ray (GCR) composition. The 20/22 value of 11.6 ±0.2 derived from a 3-isotope correlation plot (5), intercepts a two-component mixing line drawn through the mean of most of the data points and the GCR composition (Fig.3) at 36/38 = 4.8 ±0.2. A line fitted to all Kapoeta data and not constrained to pass through the GCR composition would give a slightly lower 36/38. Even with some variance in the slope of the fit line, the 36/38 ratio, defined by the SF 20/22 intercept point, will not rise above a value of 5.0.

Thus, from the 36/38 value of ~4.7-4.9 derived from Figs. 2 and 3, and from analogy of the Ar data with the Ne data, we suggest that long-term solar flare Ar implanted in Kapoeta has a 36/38 ratio of 4.8 ±0.2, which is significantly lower than most other Ar reservoirs (except, of course, those made by nuclear reactions). It may be pointed out that (1) observed a similar 36/38 ratio of 4.9±0.2 in the 600°C release of etched pyroxene grain-sized fraction from lunar fines 14148. Based on studies of gas-rich meteorites, (6) proposed a SF-Ar value of 4.1 ±0.8. It is also interesting to speculate on whether this relatively low SF 36/38 ratio has any relation to the low values of 3.9 to 4.3 found in a few temperature releases of the EET-79001 shergottite meteorite and suggested by (7) to possibly represent one Ar component of Mars.

In our companion abstract [5], we calculated abundances of SCR-produced neon and apparent SCR 21Ne exposure "ages" using SCR 21Ne production rates of [8]. These SCR 21Ne ages were ~1790My for pyroxene and ~2400My for feldspar. We concluded that these high apparent ages were, in fact, due to an enhanced SCR flux in the early solar system which was ~600-800 times the long-term SCR flux. Applying the same calculation methods to our argon data, we find apparent SCR 38Ar exposure ages of ~2110My for the two feldspar samples and ~1830My for the four pyroxene samples, in relatively good agreement with calculated SCR 21Ne ages. Clearly additional studies of SF Ar are needed.

(1) Nautiyal et al. Ap.J. 301, 465-470 (1986); (2) Wieler et al. G.C.A. 50, 1997-2017 (1986); (3) Padia & Rao, G.C.A. 53, 1461-1467 (1989); (4) Wieler et al., G.C.A. 53, 1441-1448 (1989); (5) Rao et al., L.P.S.C. XXI (1990); (6) Black, G.C.A. 36, 347-375 (1972); (7) Wiens et al., E.P.S.L. 77, 149-158 (1986); (8) Hohenberg et al, Proc. LPSC, 2311 (1978).