SOLAR WIND AND SPALLATION NEON IN SMALL DARK FRAGMENTS SEPARATED FROM THE KAPOETA HOWARDITE: EVIDENCE FOR EARLY GCR IRRADIATION? R. O. Pepin[1], R. L. Palma[2], P. E. Rider[3], D. J. Schlutter[1] and P. W. Weiblen[4], [1]School of Physics & Astronomy, University of Minnesota, 116 Church St. S. E., Minneapolis, MN 55455, USA; e-mail: pepin001@tc.umn.edu, [2]Department of Physics, Sam Houston State University, Huntsville, TX 77341, [3]Department of Physics, Grand View College, 1200 Grandview Ave., Des Moines, IA 50316, [4]Department of Geology & Geophysics, University of Minnesota, 310 Pillsbury Drive S. E., Minneapolis, MN 55455.

The Kapoeta howardite contains abundant noble gases in the dark phases of its brecciated structure, implanted during exposure of the parent body regolith to the solar wind [1-5]. These gases have been studied extensively over the years, most recently by the modern closed-system stepped etching technique [6,7], in efforts to determine the elemental and isotopic composition of the solar wind at the time of regolith exposure. Kapoeta is interesting as well for another aspect of its irradiation history: several investigations, most recently by Rao *et al.* [8], have shown that the dark, solar-wind-irradiated phases contain excesses of spallation-produced Ne above the levels expected to be generated by galactic cosmic rays (GCR) during the meteorite's space exposure age of ~3 Ma. These excesses have been attributed to production by GCR, and by a solar cosmic ray (SCR) flux substantially enhanced over current levels, during an early ~3-6 Ma irradiation of the parent-body regolith prior to compaction, burial, and ultimate ejection of the Kapoeta object to space [8].

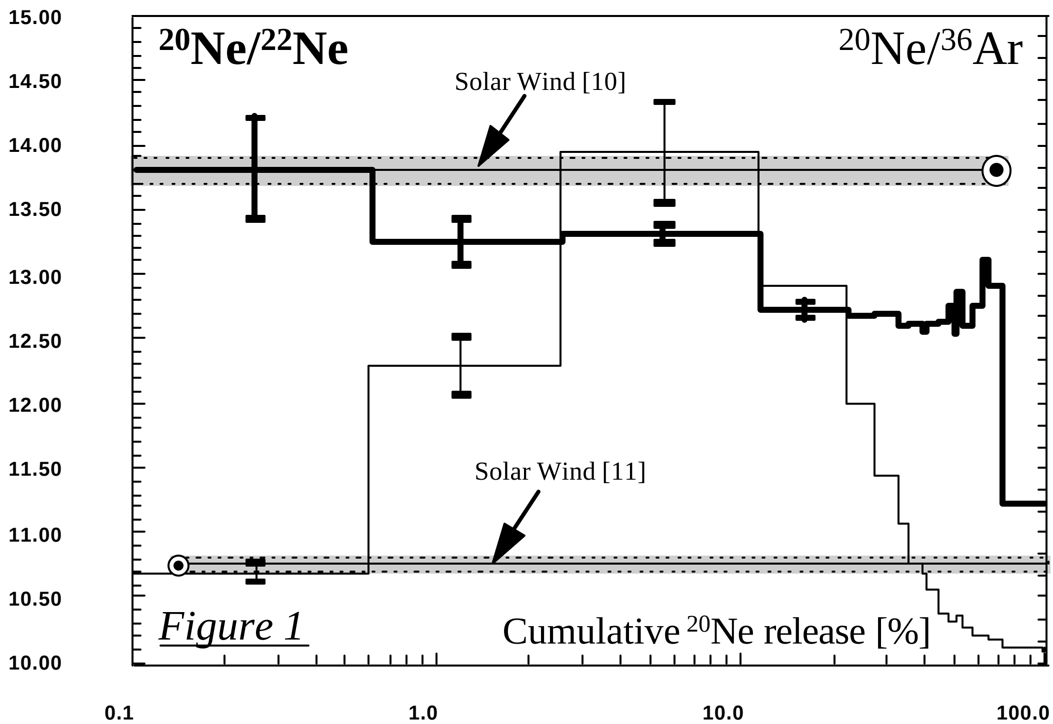
Results of the two recent acid-etch analyses of Kapoeta noble gases at Zürich [6] and Minnesota [7] agree closely, and are important data in estimating the isotopic composition of solar-wind Ne and Ar [9]. We decided to repeat this experiment using stepped pyrolytic extraction, in order to assess the extent of isotopic fractionation favoring lighter isotopes that might be expected to occur as a result of gas evolution by thermal mobilization rather than by room-temperature grain-surface etching. Because the supply of dark-phase material in our Kapoeta sample had been pretty much exhausted, for this analysis 18 small (~0.4 mm) dark fragments (~2 mg total) were hand-picked from a gently crushed sample of predominantly light-phase material, in the hope that these were dispersed pieces of the gas-rich solar-irradiated phase.

Solar-wind (SW) Ne. Results for spallation-corrected $^{20}Ne/^{22}Ne$ ratios vs. cumulative ^{20}Ne release in the 21-step thermal extraction between 470 and 1050•C are shown in Fig. 1. The dark fragments, while clearly containing a SW component, turned out in fact to be rather gas-poor, and so uncertainties in measured isotope ratios are relatively large. But the nominal $^{20}Ne/^{22}Ne$ ratio (Fig. 1, left scale) in first release matches the current best estimate for the solar wind [10,9], as does the elemental $^{20}Ne/^{36}Ar$ ratio [11] (right scale). There is no obvious evidence for thermal release fractionation in these data, a conclusion reinforced by the fact that in the early steps the $^{36}Ar/^{38}Ar$ ratio agrees with that measured in acid-etching (see [9]), and the $^{4}He/^{3}He$ ratio is close to solar.

Spallation Ne. Ne data are plotted on a 3-isotope diagram in Fig. 2. After trending downward from early-release mixtures of solar wind and spallogenic Ne, they define a precise 15-point correlation (line 1 in Fig 2) between a SW-SEP [10] mixture with $^{20}Ne/^{22}Ne \cong 12.7$ and a spallogenic $[^{21}Ne/^{22}Ne]_c$ endpoint ratio of 0.81, within error of the value for GCR production in Kapoeta feldspar [8]. Calculated cosmogenic ^{21}Ne content $[^{21}Ne]_c$ of these 15 fractions is ~2.6 x 10^{-8} ccSTP/g. The final three fractions, evolved at T = 1045-1050•C, define a distinctly different correlation (line 2) between pure SEP-Ne [10] and $[^{21}Ne/^{22}Ne]_c \cong 0.91$. This ratio, although higher than the value of 0.85 adopted by [8], is suggestive of GCR production in pyroxene. The real surprise is the large $[^{21}Ne]_c$ content of these fractions, ~1.7 x 10^{-7} ccSTP/g.

A detailed comparison of the chemical composition and mineralogy of these small fragments with Kapoeta feldspars and pyroxenes, discussed in a companion abstract [12], revealed nothing chemically unusual; on average they are consistent with a ~1:3 feldspar:pyroxene mixture, and for all major oxides fall well within the compositional range given by Mason [13] for the pyroxene-plagioclase achondrites. If correlations 1 and 2 in Fig. 2 are really due to degassing from feldspar and pyroxene separately (note that our only evidence for this is the $[^{21}Ne/^{22}Ne]_c$ ratios), and if the ~1:3 mineral ratio is roughly right, then the actual $[^{21}Ne]_c$ abundances are ~1.0 and 2.3 x 10^{-7} ccSTP/g in feldspar and pyroxene respectively. These imply excesses ~10x larger than those found by [8] in mineral separates from Kapoeta dark, and GCR exposure ages, using 2π production rates from [8], of ♠100-170 Ma. There is no hint in the $[^{21}Ne/^{22}Ne]_c$ values for significant production by an enhanced SCR flux. It is clear from previous work ([8] and referenced therein) that most of the regolith materials now in Kapoeta could not have been exposed to the GCR for anything like this length of time. The regolith irradiation history of these fragments is, for the moment, an intriguing mystery.

References. [1] J. Zähringer & W. Gentner, *Z. Naturforsch.* **15a**, 600 (1960). [2] T. Kirsten *et al.*, *GCA* **27**, 13 (1963). [3] P. Signer & H. E. Suess, Earth Science & Meteoritics (North-Holland, Amsterdam), p. 241 (1963). [4] H. Hintenberger *et al.*, *Z. Naturforsch.* **19a**, 327 (1964). [5] D. C. Black, *GCA* **36**, 347 (1972). [6] A. Pedroni, PhD Thesis, ETH Zürich (1989). [7] R. H. Becker *et al.*, *Meteorit. Planet. Sci.*, in press (1998). [8] M. N. Rao *et al.*, *Meteorit. Planet. Sci.* **32**, 531 (1997). [9] R. O. Pepin, *LPS* **XXIX,** this volume (1998). [10] J-P. Benkert *et al.*, *JGR* **98**, 13147 (1993). [11] C. A. Murer *et al.*, *GCA* **61,** 1303 (1997). [12] P. W. Weiblen & D. J. Schlutter, *LPS* **XXIX,** this volume (1998). [13] B. Mason, Meteorites (Wiley, New York), p. 113 (1962).



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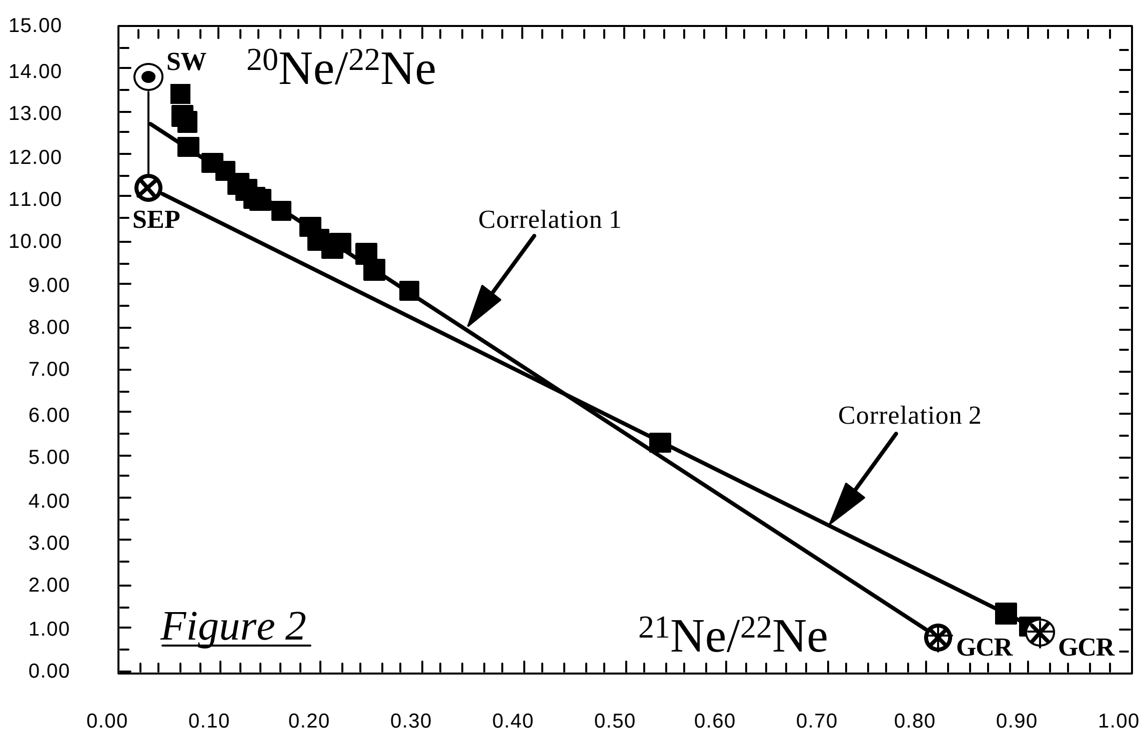
^{20}Ne/^{36}Ar
Solar Wind [10]
Solar Wind [11]
Figure 1
Cumulative ^{20}Ne release [%]



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SW
SEP
^{20}Ne/^{22}Ne
Correlation 1
Correlation 2
Figure 2
^{21}Ne/^{22}Ne
GCR
GCR