IS CARBON IN THE ANCIENT SOLAR WIND ISOTOPICALLY LIGHT ? S.J. Norris, P.K. Swart, I.P. Wright and C.T. Pillinger. Department of Earth Sciences, University of Cambridge, Cambridge CB2 3EQ, U.K.

Lunar fines, breccias and rocks show a wide range in their carbon and nitrogen isotopic compositions. For carbon, values range from -20°/oo in coherent breccias to >+20°/oo in mature soils (1). Nitrogen, on the other hand, reveals a much larger range, approximately -200 to +120°/oo (2,3). The latter phenomenon has been explained (4) as a secular change in the solar wind composition from isotopically light to heavy brought about through one of the following (i) increase of ^{15}N at the solar surface by nuclear reaction (ii) accretion of ^{15}N-rich material (iii) temporary contamination of the sun by ^{14}N (4) change in solar wind dynamics. Alternatively, the same variation in nitrogen isotope compositions could be rationalised by the existence of two or more unrelated nitrogen containing components, one of which could be indigenous (light planetary nitrogen) and the other, solar wind.

We do not intend to examine the relative merits of these proposals; this has been well covered by Geiss and Bochsler (4). However, of interest to us is the apparent correlation between $\delta^{15}N$ and $\delta^{13}C$, pointed out by Becker (1) which suggests an ancient solar wind enriched in ^{12}C. The data base for this correlation was derived from numerous publications but there was some doubt as to the integrity of some measurements due to the problem of contamination. Unfortunately, low $\delta^{13}C$ values can either be real or the result of a terrestrial contribution. Thus, Becker and Epstein (5) examined three breccias known to have very low $\delta^{15}N$ values by a two step technique in which precombustion at 500°C was used to remove terrestrial carbon. Indigenous carbon was then extracted by pyrolysis at 800, 1000 and 1250°C. The summed carbon from these three steps seemed to have a consistently lower $\delta^{13}C$ value than carbon from soils of similar maturity and hence was taken to be further evidence of a secular change in the solar wind $^{13}C/^{12}C$ ratio.

The current study reports data obtained by high resolution (100°C intervals) stepped pyrolysis for nitrogen and combustion for carbon and both the pattern of release and total compositions are considered for correlation purposes. Like Becker and Epstein, we have concentrated on Apollo 11 samples because previous experience suggests they contain very light nitrogen. The Table gives N and C data for the organic reserve soil 10086, a breccia 10059 and pebble sized breccia recovered from 10086. All three samples, particularly the two breccias, show evidence for the suggested light nitrogen ($\delta^{15}N$ from +4 to -85°/oo), but in contrast, have high bulk $\delta^{13}C$ values in the range +12 to +14°/oo if contaminating species combusting below 500°C are ignored. More important, the lightest nitrogen released appears over the temperature range 800-1100°C and reaches a minimum of -145°/oo in the case of 10059 (see Fig.1). Carbon is isotopically heavy in the same temperature interval (Fig.2) up to a maximum of between +16 and +25°/oo. Even heavier carbon can be seen in the 1200°C fraction where it usually correlates with heavy nitrogen and can be ascribed to spallation reactions. For the purposes of comparison, we have examined one sample previously studied by Becker and Epstein. Breccia 79135 shows a stepped release of nitrogen which indicates a possible contaminant at low temperatures but above 600°C the profile corresponds almost exactly to those obtained for Apollo 11 samples with a $\delta^{15}N$ minimum of ca -133°/oo reached between 800-1100°C. The carbon isotopic composition over the same temperature range is isotopically heavy ($\delta^{13}C$ up to +9°/oo) although admittedly not as heavy as seen for the Apollo 11 samples.

All the specimens so far reported are characterised by a low bulk $\delta^{15}N$

value. We therefore examined a sample, 12023, which has a more positive $\delta^{15}N$ (+25.4°/oo) as well as heavy carbon (6). Stepped pyrolysis of 12023 reveals the presence of a light nitrogen component ($\delta^{15}N$ down to -60°/oo) in low abundance. However, again the heaviest carbon ($\delta^{13}C$=+13°/oo) corresponded to the lightest nitrogen.

Although the nitrogen and carbon are extracted by slightly different procedures, we believe a direct comparison of the pyrolysis and combustion release patterns is allowable because of the nature of carbon in lunar samples (implanted atoms). Indeed, application of a stepwise combustion technique to release nitrogen from 10086 produced only very minor changes in the yield profile. The minimum $\delta^{15}N$ (-181°/oo) was detected sharply in the 800-900°C fraction and there was some evidence of a slightly earlier evolution of spallogenic N_2.

From this study, we can see no evidence to support a correlation between light nitrogen and light carbon and hence no indication of an ancient solar wind of low $^{13}C/^{12}C$ ratio.

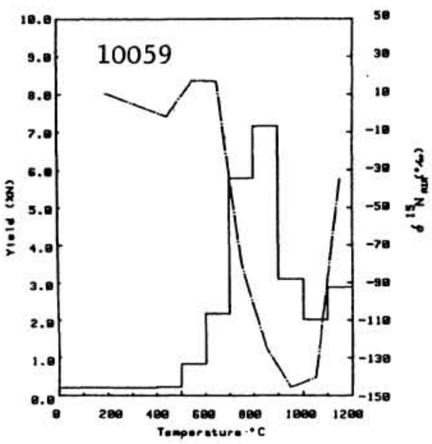

Fig. 1

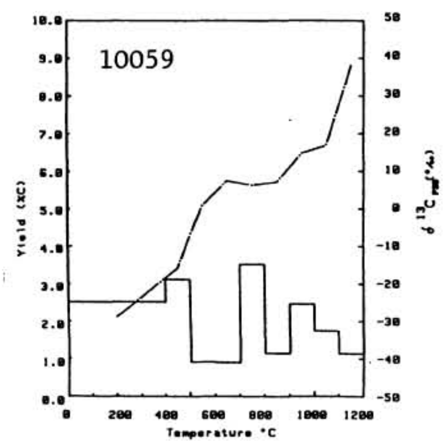

Fig. 2

SAMPLE	TEMPERATURE STEP	C μg g^{-1}	$\delta^{13}C$ °/oo	N μg g^{-1}	$\delta^{15}N$ °/oo
	500	7.74	+16.0	0.92	-24.7
	600	9.91	+23.7	4.58	+23.9
	700	17.50	+15.0	8.61	+8.8
10086	800	29.91	+8.7	20.81	-79.3
Breccia	900	35.56	+19.0	26.10	-126.8
	1000	12.69	+20.7	9.89	-136.3
	1100	23.15	+26.5	6.76	-146.3
	1200	10.56	+36.1	10.84	-44.0
	500	34.17	-14.7	18.37	+24.7
	600	29.08	-11.3	3.40	+32.7
	700	10.86	+15.4	4.98	+57.4
10086	800	14.35	+10.9	13.19	+17.9
Soil	900	19.16	+18.5	21.96	-27.2
	1000	12.65	+17.4	1.80	-53.4
	1100	13.50	+25.1	1.01	-37.2
	1200	21.52	+25.0	17.01	0.0
	500	46.69	-15.8	1.04	-1.6
	600	13.55	+0.9	3.79	+17.4
	700	13.35	+7.5	9.94	+16.9
10059	800	52.71	+6.3	26.40	-79.9
	900	16.97	+7.1	32.68	-124.6
	1000	36.94	+14.7	14.14	-145.6
	1100	26.10	+16.8	9.20	-140.3
	1200	16.97	+38.2	13.15	-34.7

References

1. Becker EPSL 50, 189-196 (1980) and refs cited therein.
2. Thiemans & Clayton EPSL 47, 34-42 (1980)
3. Kerridge et al. GCA 39, 137-162 (1975)
4. Geiss & Bochsler GCA 46, 529-548 (1982)
5. Becker & Epstein PLPSC-12, 289-293 (1981)
6. Kerridge et al. GCA 42, 391-402 (1978)