MULTIPLE NITROGEN COMPONENTS IN LUNAR SOIL SAMPLE 12023. D.R. Brilliant, I.A. Franchi and C.T. Pillinger, Planetary Sciences Unit, The Open University, Milton Keynes MK7 6AA.

Nitrogen is one of the enigmatic elements in lunar soils and breccias. The large range in $\delta^{15}N$ values found within lunar soils was initially attributed to a secular increase in the $^{15}N/^{14}N$ ratio of 50% within the solar corona, and hence in the implanted nitrogen within the lunar regolith (1). However, more recent explanations have proposed a two (or many) component mixing model of solar wind nitrogen with some hypothetical non-solar components (2,3). Such components could include indigenous lunar nitrogen (4), nitrogen contained in interstellar grains in primitive meteorites (5,6) and magnetospheric nitrogen from the terrestrial atmosphere (7).

To understand the makeup of multi-component mixtures it is advantageous to have carbon and noble gas data measured simultaneously, particularly in the case of lunar soils, where the solar wind is a likely fundamental contributor of nitrogen. To this end, a new nitrogen instrument has been adapted to give some of the desired data in parallel. Here we report conjoint measurements of N abundance and $\delta^{15}N$, together with N/$^{36}Ar$ and $^{36}Ar/^{38}Ar$ ratios obtained during a stepped combustion of lunar soil 12023. The results are preliminary to a much more comprehensive investigation of well characterised fractions of the sample which we still have available from a previous study (8). Stepped combustion of a sample of 12023.7 yielded 94 ppm nitrogen with a $\delta^{15}N = +22.2\%_o$, as well as the characteristic heavy-light-heavy pattern observed for lunar samples (4). The low temperature maximum was +75.1%o at 550°C, the minimum at 800°C with $\delta^{15}N = -16.7\%_o$ and the high temperature $\delta^{15}N$ peak is +90.6%o at 1250°C. The major releases of nitrogen occurred between 650°C - 800°C in the form of a double peak; a third, substantial release occurred at 1150°C yielding 14.2 ppm of nitrogen coinciding with a small but recognisable drop in $\delta^{15}N$ against a regularly increasing trend.

The $^{36}Ar$ and $^{38}Ar$ release profiles at face value resemble those of nitrogen but whilst N/$^{36}Ar$ varies by nearly a factor of three (Fig. 1) with quite clearly defined mixing trends between different components, the $^{36}Ar/^{38}Ar$ remains virtually constant between about 5.9 and 6.3 (N.B. no effort has been made to calibrate the mass spectrometer absolutely for argon or correct for mass fractionation effects; these are considered to be constant and raw data without blank subtraction are used throughout). If the consistency of the $^{36}Ar/^{38}Ar$ is accepted as a measure of the solar wind contribution then the variation of N/$^{36}Ar$ is interpreted as recognising input of nitrogen from different non-solar wind sources. The alternative, that N/$^{36}Ar$ is being fractionated by a factor of 3 by some diffusive process between different minerals or phases seems highly unlikely but clearly will be explored by the analysis of physical separates. On the basis of the total dataset, there is evidence of a component of nitrogen liberated at low temperature <600°C enriched in $^{15}N$. A major contributor to the nitrogen from the contemporary solar wind (possibly 50% of the total) comes off between 700°C and 1000°C when the N/$^{36}Ar$ is about 10. The true $\delta^{15}N$ of this component is difficult to discern but may be $\approx +10\%_o$. The problem of establishing its $\delta^{15}N$ value is related to the fact that a smaller, isotopically lighter ($\approx -16\%_o$) fraction is liberated in the temperature range 760°C to 900°C during which the N/$^{36}Ar$ ratio changes to at least 13. Whether this
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is the so called ancient lunar nitrogen is open to question; if it ultimately has a $\delta^{15}N < -200\%$ it is of low relative abundance in 12023. From the data here however we can say that the light nitrogen is not found in the interior of complex particles. The "ancient surfaces" component can be directly equated with the major release at 1100 to 1150°C coinciding with the anticipated melting temperature of the soil. This relatively large amount of gas must have an isotopic composition close to the 10% suggested for the major component discussed earlier to account for the dip of only 5% in the overall upward $\delta^{15}N$ trend. There is no possibility that this pulse of nitrogen can be a spallogenic component because (i) the amounts observed are totally unreasonable (ii) if spallogenic gas was released in amounts of this magnitude the $\delta^{15}N$ would go off-scale (spallogenic nitrogen has a $^{14}N/^{15}N$ ratio ca. 1) and (iii) the $^{36}Ar/^{38}Ar$ ratio shows no increase of cosmogenic $^{38}Ar$. However since the $\delta^{15}N$ is increasing regularly all across the high temperature extraction region, a small amount of spallogenic nitrogen is being released at least up to 1250°C. The $N/^{36}Ar$ ratio of what we believe to be ancient particles is slightly higher than that proposed for contemporary surfaces but this might be a genuine fractionation effect.

At a conservative estimate we can see four different nitrogen components in 12023. The major solar wind contributed gas is sited in two locations which can readily be discerned. Further analyses of physically separated particles, and higher resolution heating programmes, with conjoint data gathering to include carbon measurements, and use of pyrolysis to supplement combustion extraction techniques, can be expected to shed more light on problems concerning the nitrogen budget of the lunar soil which are long overdue for solution.

References: