

SOLAR WIND GASES IN A METAL SEPARATE FROM LUNAR SOIL 68501; R.  
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In the interest of determining the best set of values for solar wind elemental and isotopic ratios for the noble gases and nitrogen, a number of different materials have been examined, and by several techniques (1-3). One which seemed promising was oxidation of metal particles. There was reason to believe, based on the degassing of spallation-produced noble gases from the iron meteorite Carbo (4), that noble gases in metal would be resistant to diffusive loss, unlike the case for silicates, and that any diffusion that did occur might not fractionate the noble gases. Preliminary data on solar wind in metal from the gas-rich meteorite Weston seemed to confirm this belief (5), although the gas content of the metal was too low to permit measurement of the heavy noble gases or nitrogen. Metal from a lunar soil seemed to offer the best hope of obtaining the desired data, because the longer exposure times and higher fluxes to which lunar grains have been exposed suggested the possibility of getting adequate yields of implanted ions even for the heavy gases. We therefore undertook the preparation and analysis of a metal separate from lunar sample 68501.

Soil 68501 was chosen because it had been previously reported to contain free metal particles (6), because the relatively low iron content of highland materials would reduce the contributions from magnetic agglutinates, and because there was a sufficient amount of the soil available to allow separation of the quantity of metal required. From an initial sample of 30 grams of this soil, about 240 mg of strongly magnetic material was extracted. This material was sieved to remove particles smaller than 38  $\mu\text{m}$  and then put through a heavy liquid separation ( $\rho = 3.3 \text{ g/cm}^3$ ). Finally, the denser fraction was hand-picked, separating it into particles that were primarily silicate, those that appeared to be pure metal, and a residual which was mainly metal but with obvious small particles of silicates attached or imbedded. Roughly 40 mg each of metal and the residual "dirty" metal were obtained.

The analytical procedure involved a combination of pyrolysis and combustion steps. The intent was to empty sites in the silicate contaminant susceptible to diffusion at relatively low temperatures by performing a pyrolysis at moderate temperature, and to follow that with combustion steps at the lower temperatures which should release gases only from the metal grains. This procedure was reasonably successful in the analysis of Weston metal grains (5). It was decided to analyze the dirty metal sample from 68501 initially, to get some idea of the gas amounts involved and to test the analytical procedure for possible modifications. At present, only preliminary data from this 41 mg sample (designated M1) are available.

Total noble gas yields from 68501 M1, in ccSTP/g, are as follows:  ${}^4\text{He} = 8.13 \times 10^{-2}$ ,  ${}^{22}\text{Ne} = 1.27 \times 10^{-5}$ ,  ${}^{36}\text{Ar} = 2.28 \times 10^{-5}$ ,  ${}^{84}\text{Kr} = 1.55 \times 10^{-8}$ , and  ${}^{132}\text{Xe} = 1.96 \times 10^{-9}$ . Total nitrogen is 9.9 ppm. Compared to reported bulk 68501 yields (7), nitrogen and the heavier noble gases are all down by roughly an order of magnitude, whereas Ne is only a factor of 4 lower and He only a factor of 2. These results are consistent with previous observations that mineral separates, as opposed to agglutinates, show lower yields than bulk soils, and with the expected better retentivity for He and Ne of metal as compared to silicates. The  ${}^{40}\text{Ar}/{}^{36}\text{Ar}$  ratio of 1.36 is close to the previously reported value, and the nitrogen isotopic ratio obtained, of about +65 per mil, is somewhat higher than the bulk soil value, but in the range of Apollo 16 soils (8). Xenon isotopic ratios are influenced somewhat by spallation and possibly by fission-produced Xe, but appear as if they will correct to values very near those seen in the low-temperature data for Pesyanoe (9).

More interesting than the total sample results are those seen in the temperature steps. The initial pyrolysis step, at 430°C, yielded a  $\delta^{15}\text{N}$  value of +235 per mil, with several subsequent combustion steps in the range of +250 to +300 per mil. These early steps released argon with  $^{40}\text{Ar}/^{36}\text{Ar}$  ratios as low as 0.27, with this ratio rising in later steps to values between 1 and 2 while the nitrogen isotopic ratio decreased towards the bulk value. The preliminary interpretation would be that we are seeing evidence of a very recent exposure to solar wind of some grain surfaces in the early steps, and that later steps include solar wind species which have become trapped within grains or at interfaces between silicate and metal splashed onto the surfaces of silicate grains. These trapped species were implanted at earlier times characterized by higher  $^{40}\text{Ar}/^{36}\text{Ar}$  ratios and lower nitrogen isotopic ratios. Exactly what the implanted solar nitrogen isotopic ratio is at present is hard to determine, because it is not known to what degree fractionation effects might be represented in the early steps, but a value of at least 200 per mil might be a conservative choice.

Another interesting, and somewhat puzzling result, is the observed elemental ratios. The bulk elemental ratios are not unlike those of the ilmenite reported in (2). In the individual steps, He:Ne:Ar ratios at low temperatures are close to solar, as was observed in the ilmenite as well. However, even though 85-90% of the Kr and Xe are released at 1050°C or upon melting, they are still enhanced relative to Ar in the lower temperature steps ( $\text{Ar/Kr/Xe} = 1.0/1.8/3.0$ , normalized to solar ratios, in steps up to about 600°C). The overall impression is that there is a flat solar pattern superimposed over a fractionated one at low temperatures. This is in contrast to the observation for the ilmenite (2). One possible explanation is that the minor silicate component of the sample contains the bulk of the solar wind gases, and that the metal contains unfractionated gases which are being overprinted by the fractionated silicate pattern. More likely, however, is that the metal itself contains both the unfractionated and fractionated gases, and that unlike the suggested situation for ilmenite (2) the fractionated component in the metal has not diffused far enough inward to avoid significant release in low temperature combustion steps. Analysis of the purer metal sample will help distinguish between these alternatives.

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