NOBLE GASES IN APOLLO 17 BOULDERS AND SOILS. D.D. Bogard and L.E. Nyquist, NASA Johnson Space Center, Houston, TX 77058 and W.C. Hirsch, Northrop Services, Inc., Houston, TX 77058.

The isotopic abundances of He, Ne, Ar, Kr and Xe have been measured in samples of the station 6 large boulders and eight Apollo 17 soils. Grain size separates of a surface soil (76501) and a soil (76321) scooped from the sloping side of one of the large boulders were also analyzed. A stepwise heating analysis was performed on matrix material of 76315. Noble gases in station 6 samples ought to yield valuable information about sample history and large scale erosional processes on this slope of North Massif. Earlier analyses of survey chips (1) taken from the surface of boulder rocks 76315, 76255, and 76295 indicated the presence of trapped solar noble gases. However, analyses of documented samples from 76315 (two clasts and the matrix) show trapped solar gas concentrations to be at least 10^3-10^4 lower than lunar soils. The radiogenic ^{40}Ar concentration of 76315 matrix is 12.5×10^{-5} cm^3/g, which combined with the K abundance of 2240 ppm (3) yields a whole rock K-Ar age of 4.0×10^9 yr.

The presence of fission Xe in 76315 is shown by a Xe isotope correlation plot (Fig. 1). These Xe isotopes are predominantly a mixture of fission Xe and the atmospheric system blank, with small amounts of cosmogenic ^{132}Xe and possibly of trapped solar Xe in the 700°C extraction. The sum of the fission ^{136}Xe in the higher temperature extractions is $6 \times 10^{-12} cm^3/g$, and for a 4×10^9 yr gas retention age, this amount corresponds to a uranium content of 3.5-4.5 ppm, depending on the spontaneous fission half-life of ^{238}U assumed. This U concentration is only slightly higher than those measured for 76315, and indicates that excess fission Xe from ^{244}Pu is not present. The concentrations of cosmic ray-produced gases in 76315 matrix are (units 10^{-8} cm^3 STP/g) $^{21}Ne=1.5$, $^{38}Ar=0.9$, and $^{126}Xe=0.0006$. Slightly different concentrations in the two clasts probably reflect variations in target element abundances. Chemistry-corrected production rates (2), an assumed 2π irradiation geometry, and chemistry reported by PET (3), yield ^{21}Ne and ^{38}Ar exposure ages of approximately 11 and 13×10^6 yrs, respectively. Assuming a ^{126}Xe production rate of 0.13x 10^{-8} cm^3/g Ba-10^6 yrs, gives a ^{126}Xe exposure age of 13×10^6 yrs. These ages are probably low (by up to a factor of two) due to self-shielding effects of the boulder, and will be refined as more chemical analyses of the boulder rock samples become available. Except for rocks ejected by Apollo 16 South Ray Crater, these boulder samples rank among the lowest cosmic ray exposure ages measured for lunar rocks.

Neon isotopic data for two clasts and a stepwise temperature extraction of the matrix of 76315 is shown in Figure 2. The two clasts and the 500°C extraction show small amounts of solar neon, but the higher temperature extractions are consistent with a two component mixture of cosmogenic neon and the atmospheric system blank. Assuming extreme variations in cosmogenic $^{20}Ne/^{22}Ne$ of 1.0-0.7 defines the cosmogenic $^{22}Ne/^{21}Ne$ as 1.22-1.18, higher than commonly found in lunar rocks or meteorites. High $^{22}Ne/^{21}Ne$ generally indicates cosmic ray irradiation under conditions of low shielding. The subsurface depths of our samples were $\sim$1 cm for the clasts and $\sim$3 cm for the matrix material. Low shielding irradiation is also indicated by the cosmo-

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genic $^{131}Xe/^{128}Xe$ value of 1.83 (Fig. 3). This value is the lowest that we have measured for any lunar rock and is similar to values measured for meteorites (4). As the higher $^{131}Xe/^{128}Xe$ values typical of lunar rocks are attributable to neutron capture by ^{130}Ba to yield ^{131}Xe (5), sample 76315 has apparently experienced an unusually low neutron flux, which is consistent with an irradiation under conditions of low shielding.

The young exposure age and the evidence for low shielding suggest a simple cosmic ray exposure history for that side of the station 6 boulders from which the rock samples were taken. This portion of the boulders apparently was deeply buried in its original position higher on the slopes of North Massif. Approximately 12-24 x 10^6 yrs ago the mass broke loose and rolled to its present location, initiating cosmic ray exposure of the collected samples. This would indicate that the track associated with this particular boulder was formed approximately 12-24x10^6 yrs ago, and that soil 76320 collected on the boulder was emplaced since that time. No samples were collected from the opposite side of the boulder, and this side may have a longer exposure time reflecting prior irradiation in the original position higher on North Massif. Possibly breccia sample 76055, which was collected from the regolith near the boulders and which has a reported exposure age of 120x10^6 yrs (6), is representative of the exposure time of that side of the boulders not sampled.

Apollo 17 fines contain noble gas concentrations (Table 1) similar to fines from previous missions. The trapped solar $^{20}Ne/^{22}Ne$ (∿12.85) and $^{36}Ar/^{38}Ar$ (∿5.39) are slightly higher than typical for bulk analyses, and analyses of grain size separates indicate that this effect is largely produced by the <20 micron grain sizes. Cosmogenic ^{21}Ne ranges from ∿18x10^{-8} cm^3/g in two soils at station 2, to ∿30-35x10^{-8} cm^3/g in soils at stations 5 and 6. ^4He concentrations, $^4He/^{22}Ne$ ratios, and cosmogenic ^{21}Ne contents of the bulk fines tend to show a positive correlation with the fractional ilmenite content. Ratios of $^{84}Kr/^{36}Ar$ and $^{132}Xe/^{36}Ar$ show much smaller variations. Only minor differences exist in the noble gas compositions of four soils collected at station 6 (Table 1), including soils collected between the large boulders and on the sloping side of one of the boulders (76321). In particular, the composition of trapped solar wind gases, the $^{40}Ar/^{36}Ar$ ratio, and the concentrations of cosmogenic noble gases determined in grain size separates of 76501 and 76321 are essentially identical. The cosmic ray exposure ages of these soils, including the 0.25-1.0 mm size fractions, are at least an order of magnitude greater than those measured on the station 6 boulders. Therefore, 76321 appears to have been thrown onto the boulder by local impacts, rather than being significantly derived by erosion of the boulder surface.

References:
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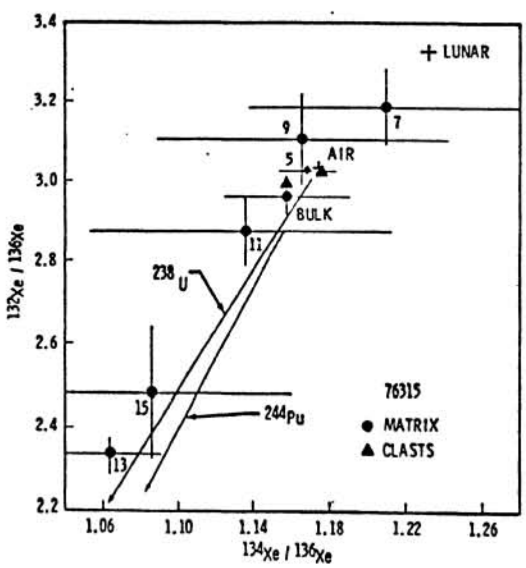
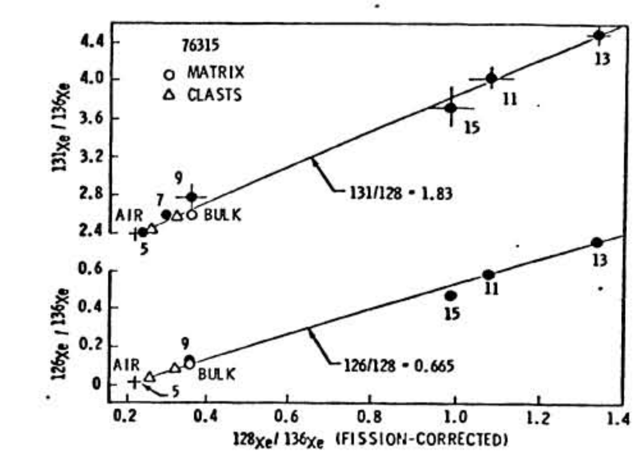
Noble Gas Concentrations and Isotopic Ratios of Apollo 17 Fines (cm^3 STP/g).

Sample	wt. (mg)	^{4}He 10^{-2}	4/3	^{22}Ne 10^{-6}	$\frac{20}{22}$	$\frac{21}{22}$	^{36}Ar 10^{-6}	$\frac{40}{36}$	$\frac{36}{38}$	^{84}Kr 10^{-9}	^{132}Xe 10^{-9}
72501,14	5.87	7.78	2700	119	12.84	29.65	292	1.11	5.40	184	26.1
72701,14	4.57	7.30	2720	111	12.88	29.45	323	1.06	5.40	192	26.6
75081,32	5.59	16.2	2820	139	12.92	28.79	268	0.79	5.38	148	22.7
76501,12	6.21	10.0	2715	127	12.84	28.92	371	0.90	5.39	196	27.5
76261,23	7.05	8.99	2730	103	12.91	28.64	307	0.98	5.39	164	22.7
76321,2	5.77	12.5	2710	146	12.85	29.30	351	0.95	5.38	211	30.7
76281,2	6.14	9.87	2760	107	12.87	28.66	286	1.13	5.39	148	22.2
70051,17	6.24	15.1	2870	182	12.81	28.62	352	1.43	5.36	185	31.1





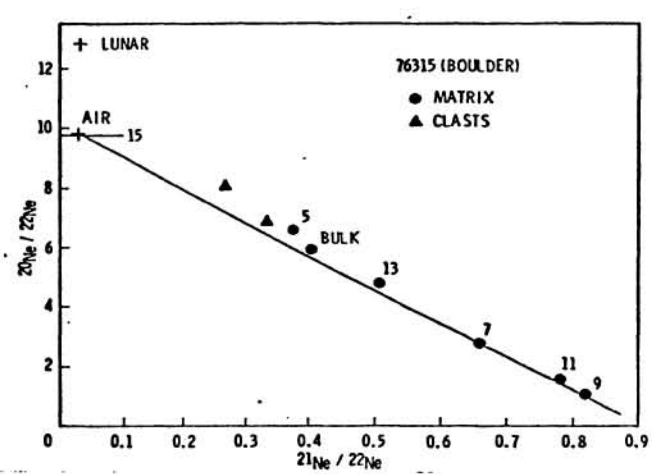


Fig.1 (above) $^{132}Xe/^{136}Xe$, $^{134}Xe/^{136}Xe$ correlation diagram. Matrix extration temperatures are in hundred C°. Trend lines show effect of fission Xe from U-238 and Pu-244.

Fig.2 (right) $^{20}Ne/^{22}Ne$, $^{21}Ne/^{22}Ne$ correlation diagram. Trend line is between atmospheric blank and cosmogenic neon.

Fig.3 (upper right) Xe isotope correlation diagrams showing two component mixtures of air blank and cosmogenic Xe. The 900°-1500° data have been corrected for fission Xe.