SOLAR WIND- AND INDIGENOUS NITROGEN IN APOLLO 17 LUNAR SAMPLES.

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We report on chemically bound nitrogen concentrations in various Apollo 17 lunar samples from the Taurus Littrow landing site. This work continues our earlier investigations of bound nitrogen in lunar material with the Kjeldahl method by Müller (1,2). This technique detects nitrogen only in a bound state and discriminates against molecular nitrogen N_2 which may be derived from atmospheric contamination. We have analyzed eight Apollo 17 bulk fines of grain size <1mm from different stations. Two of them have been separated into several grain size fractions to study the grain size dependence of nitrogen implanted by the solar wind. These are fines 74241,11, a gray soil beside orange soil, sampled at the rim of Shorty Crater, and fines 78501,26 collected from mountain slopes at the base of Sculptured Hills. Three rock samples, a crushed anorthositic gabbro, a homogeneous gabbro and a fine-grained basalt, have been analyzed to determine bound nitrogen indigenous to Apollo 17 rocks. Furthermore, the light and dark, noble gas-rich portions of the achondrite Kapoeta have been investigated to study possible contribution of solar wind nitrogen in the dark portion.

The results are compiled in Table 1. Bulk fines of the Apollo 17 sampling areas range in bound nitrogen contents from 23 to 73 ppm N. The fines 71501, 74241 and 75061 from the valley floor have nitrogen contents of 51,23 and 42 ppm N, respectively, and are distinctly lower in nitrogen than those from the mountain slopes (range 63 to 73 ppm N). Valley floor soil 70011, sampled at the Lunar Module, has 73 ppm N and is possibly exhaust contaminated. The seven Apollo 16 bulk fines, previously analyzed, vary in nitrogen from 70 to 124 ppm N, the Apollo 11 through Apollo 15 fines from 80 to 113 ppm N (1,2). The Apollo 17 bulk fines, especially the valley floor soils, contain the lowest amounts of bound nitrogen among all Apollo fines analyzed so far. It is unlikely that the duration of solar wind irradiation, being the main source for nitrogen in lunar fines, was rather different for valley floor and mountain slope soils. According to trapped noble gas contents, the Apollo 17 fines are saturated with solar wind (Hübner and Kirsten, and Hübner et al. (3,4). Correlation of nitrogen with trapped noble gases in fines will be discussed in the forthcoming paper. The low nitrogen contents of valley floor soils may be a function of agglutinate content and grain size distribution. Agglutinates are present in nearly all of the Apollo 17 soils, although in smaller proportions than in soils from the other mare sites. In fact, soil 74241 having the lowest nitrogen content is also very low in agglutinates. Moreover, the median grain size of valley floor soils 74241 and 75061 is around 110 µm, respectively, whereas that of mountain slope soils 76501 and 78501 is 53 and 38 µm, respectively, causing different shielding of fine grains to the solar wind.

In Fig. 1 the results of the grain size fraction analyses of Apollo 17 fines 74241 and 78501 are illustrated. Our previous data on Apollo 14, 15 and 16 fines are included for comparison (1,2). The nitrogen concentrations of sieve fractions are plotted versus the mean grain diameter. As approximate mean grain diameter of the fractions in µm 3-12, <24, 12-24, 24-48, 48-60, 60-109 and 109-272 we have used 6, 8, 16, 32, 53, 79 and 164 µm, respectively, in this plot. The data of fines 74241 sampled beside the orange soil at the rim of Shorty Crater show as in our previous studies a distinct increase of nitrogen with decreasing grain size. It is now commonly accepted that the surface-correlated nitrogen in lunar fines is mainly derived from the solar wind. The grain size fraction curve for 74241 is distinctly different from those of other lunar fines shown in Fig. 1. The slope at small grain sizes is rather steep. With increasing grain size the nitrogen curve turns rather sharply and becomes nearly horizontal. Two features are remarkable: the nitrogen content at a very small grain size is with about 140 ppm relatively low, and likewise the concentrations of the larger grain size fractions, 13 to 19 ppm N. The grain size dependence of bound nitrogen for fines 78501 from the base of Sculptured Hills is also rather unique. The slope at smaller grain sizes is distinctly smoother than that of other fines, and the nitrogen content at a very small grain size is with about 120 ppm the lowest measured so far by us.

To learn more about bound nitrogen indigenous to lunar rocks we have analyzed rocks 77017, 79155 and 70215. They contain only less than 8 ppm N, respectively (Table 1). Their nitrogen contents are similar to those of igneous rocks 12063, 12075 and 15556, previously analyzed (1). The low nitrogen contents of igneous lunar rocks suggest that indigenous nitrogen was low in abundance at the time of mineral formation billions years ago and demonstrates once more the severe loss of volatile elements in the early history of the moon.

The nitrogen results of the light and dark, gas-rich portion of the achondrite Kapoeta show that there was no significant contribution of solar wind-derived nitrogen to the dark portion. This result is surprising, because besides the trapped noble gases carbon is enriched in the dark portion by a factor of almost two relative to the light portion, Müller and Zähringer (5).

In Table 2 total carbon and bound nitrogen data, and the C/N atomic ratios in Apollo 17 fines are presented. Carbon data from (6). The ratios of six fines range from 1.68 to 2.80, and are in the average distinctly higher than those previously calculated for Apollo 14, 15 and 16 fines (2). The high C/N values of Apollo 17 soils approach those determined in the solar photosphere by analysis of atomic and molecular spectra (C/N=3 to 4).

Fines <1 mm	71501	72501	72701	74240+) 74241	76501	78501
C(10^{18}at./g)	3.7	6.3	7.0	2.8	6.0	8.5
N(10^{18}at./g)	2.2	3.0	3.1	1.0	2.7	3.1
C/N(at./at.)	1.68	2.10	2.26	2.80	2.22	2.74

Table 2.: Total carbon and chemically bound nitrogen data and C/N atomic ratios in Apollo 17 lunar fines. Carbon data: Gibson et al. (6). $^{+)}$unsieved.

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(6) Gibson E.K., Moore C.B. and Lewis C.F.(1973) Apollo 17 Lunar Sample Information Catalog, LRL, NASA-MSC 03211, p. 56.

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Sample No. Apollo 17	Station and Landmark	Sample Type	Chem. Bound N (ppm)
70011,18	LM, ALSEP Valley floor	fines < 1 mm SESC	73
71501,23	Sta. 1a Valley floor	fines < 1 mm rake soil	51
72501,27	Sta.2,Mountain slopes South Massif	fines < 1 mm rake soil	70
72701,27	Sta.2,Mountain slopes Upslope from the valley at Nansen Crater	fines < 1 mm rake soil	73
74241,11	Sta.4,Valley floor Near Shorty Crater	fines < 1 mm gray soil beside orange soil	23
Grain size fractions (µm)		3 - 12 µm	117
		12 - 24	82
		24 - 48	19
		48 - 60	19
		60 -109	13
75061,23	Sta.5,Valley floor Near Camelot Crater	fines < 1 mm Skim-top of flat boulder	42
76501,44	Sta.6,Mountain slopes,North Massif	fines < 1 mm rake soil	63
78501,26	Sta.8,Mountain slopes Base of Sculptured Hills	fines < 1 mm rake soil	73
Grain size fractions (µm)		3 - 12 µm	107
		< 24	109
		12 - 24	91
		24 - 48	68
		48 - 60	48
		60 -109	42
		109 -272	40
77017,32	Sta. 7 North Massif	Crushed anorthositic gabbro,brecciated and invaded by glass	< 8
79155,24	Sta.9,Rim of Van Serg Crater	Homogeneous gabbro, partially coated with glass	< 8
70215,21	near LM	Fine-grained basalt	< 8
Kapoeta	light portion	Achondrite	86
Kapoeta (MPI No.137)	dark,gas-rich portion	(Howardite)	82

Table 1.: Chemically bound nitrogen concentrations in Apollo 17 bulk fines and grain size fractions, in three Apollo 17 rocks, and in the light and dark portion of the achondrite Kapoeta. Nitrogen determinations as ammonia by the Kjeldahl method and Nessler's reagent. Error: ± 5 ppm. (SESC= Special Environment Sample Container).

Acknowledgment.
Valuable discussions with Prof. W. Gentner, Dr.P. Horn, W.Hübner and Dr.T. Kirsten are appreciated. The skillful assistance of D. Kaether is gratefully acknowledged. I thank R. Schwan for making the grain size fractions and for sample preparation, and Miss H. Urmitzer for her assistance.

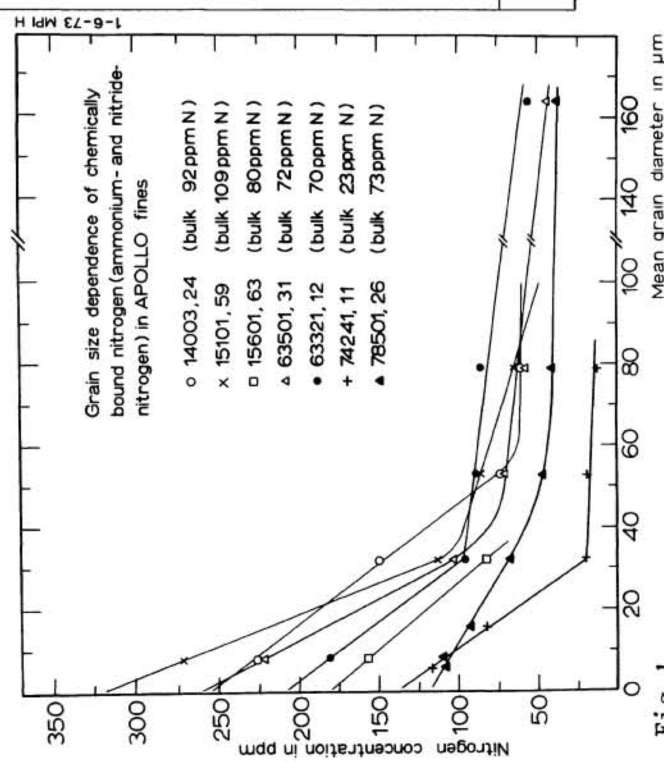

Fig.1