SOLAR WIND AND COSMIC RADIATION HISTORY OF TAURUS LITTROW REGOLITH. P. Eberhardt, O. Eugster, J. Geiss, H. Graf, N. Grögler, S. Guggisberg, M. Jungck, P. Maurer, M. Mörgeli and A. Stettler, Physikalisches Institut, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland.

Trapped solar wind and cosmic ray produced noble gases and Ar^{39}-Ar^{40} ages in soils and rocks from the ALSEP site (station 0, deep drill core), the south rim of Shorty Crater (station 4), and rim of Camelot Crater were investigated. The most relevant results are given in Tables 1 and 2. Further measurements are in progress.

Deep drill core

The "exposure ages" calculated from the concentration of stable spallation isotopes are surprisingly uniform over the whole length of the core. The lunar material sampled over the whole length of the deep drill core has thus received the same dose of energetic particles with the exception of the top few tens of centimeters (samples 70008.192 and 70181.9). The exposure to cosmic radiation cannot have occurred in situ in an essentially static regolith as the cosmic ray intensity in 3 m depth is attenuated by at least a factor of 10. Other regolith models explaining the observed profile are:
(a) Mixed regolith. Mixing of the regolith over the whole depth of the drill core with a characteristic time constant of the order of 10^8 to 10^9 y would obliterate the original depth dependence of the concentration of cosmic ray-produced spallation isotopes and lead to an essentially depth independent exposure age. A total exposure time of 2×10^9 y with present day cosmic ray intensity is required to explain the total amounts of spallation products present in the core. The integrated amounts of trapped solar wind Xe in the core correspond in this model to a minimum exposure time of 3×10^9 y (assuming present day solar wind flux and no contribution from the lunar atmosphere). The lower exposure age of the top few tens of centimeters as well as the lower trapped solar wind concentration in 70008.192 can be explained by the recent ($< 10^8$ y) addition of unirradiated material to the surface layer. Camelot may be tentatively identified as the source of this fresh regolith component.
(b) Accumulating regolith. Continuous accumulation of preirradiated material also leads to an essentially depth independent exposure age profile for greater depth. Continuous accretion with a rate of 2.5 mm/10^6 y of preirradiated material (preirradiation of 200 to 400 m.y. duration, randomly variable with time) would reproduce the exposure age profile observed in the Apollo 17 deep drill core. This accretion rate corresponds to a cumulative regolith thickness of 10 m in 3.7×10^9 y (age of Apollo 17 basalts).

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Both models cannot account for all the observed regolith properties. It seems unlikely that well defined strata, as observed near Shorty Crater or in the deep drill core, could survive a thorough mixing. No obvious source for the preirradiated material in the accumulating regolith is evident. Material from the North and South massive might contribute to the valley regolith. However, because of the different chemistry, it could not be the dominant source. Most likely, no simple process alone is responsible for the evolution of the regolith, and continuous accretion, deposition of slabs of material as well as in situ mixing are all together important processes. The results of the neutron stratigraphy measurements will give additional important clues on the regolith dynamics at the Apollo 17 landing site.

Shorty Crater

Beds of orange and black soil occur at Shorty Crater and the regolith is certainly not well mixed at this site. This fact is also evident in the exposure ages and solar wind concentrations of the different soil types sampled at station 4. Both grey soils, collected adjacent to the orange soil band, have exposure ages and concentrations of trapped solar wind gases very similar to other Apollo 17 surface soils (2). The exposure age of the orange soil and the black soil from the bottom of the double drive tube are approximately a factor of 10 lower than the surface soil. These two soils were virtually not exposed to the solar wind, the trapped gas concentrations are only $\sim 10\%$ and $\sim 0.1\%$ respectively compared with the grey soil's. The exposure age of a basaltic rock from the rim of Shorty is essentially identical with the age of the orange soil. The following tentative sequence of events would be compatible with the noble gas data. After their formation, 3.6×10^9 y ago, the orange soil and the basalt 74275 were immediately ($< 10^7$ y) shielded from cosmic rays and solar wind. Only 20 to 30 m.y. ago, during the formation of Shorty Crater, rock 74275 was ejected and the orange and black soil layers lifted to their present position close to the surface. Somewhat puzzling, if substantiated by further measurements, is the apparent higher exposure age of the black soil relative to the orange soil. Sample 74001.15 was collected in a depth of 155 g cm^{-2} where the cosmic ray intensity is already reduced by approximately a factor of 2.5, whereas 74220 was collected close to the surface. Stronger preirradiation of 74001 shortly after its formation would be a possible explanation.

This research was supported by the Swiss National Science Foundation.

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Table 1. Results of noble gas analyses. All data obtained on bulk material. Preliminary data. Kr- and Xe-isotopic abundance ratios not given here are identical with BEOC 12001 (1) to within 5%.

		He^4	Ne^{20}	Ar^{36}	Kr^{86}	Xe^{132}	He^4/He^3	Ne^{20}/Ne^{22}	Ne^{22}/Ne^{21}	Ar^{40}/Ar^{36}	Ar^{36}/Ar^{38}	Kr^{78}/Kr^{86}	Kr^{80}/Kr^{86}	Xe^{124}/Xe^{132}	Xe^{126}/Xe^{132}	Xe^{128}/Xe^{132}
		[10^{-4} cm^3 STP/g]			[10^{-8} cm^3 STP/g]							x 100				
A. ALSEP-area																
Deep drill core (depth)																
70001.13	(290 cm)	1460	19.6	3.35	5.3	2.2	2650	12.6	28.8	1.24	5.30	2.20	13.8	.63	.72	8.77
70002.13	(253 cm)	1260	18.9	2.95	5.6	2.5	2660	12.5	28.0	1.48	5.23	2.24	13.7	.67	.80	8.90
70003.13	(213 cm)	1460	21.5	3.50	5.5	3.1	2720	12.5	28.4	1.71	5.25	2.24	13.9	.63	.74	8.80
70004.13	(173 cm)	1220	16.3	2.36	5.9	2.4	2640	12.4	28.6	1.16	5.24	2.18	13.6	.64	.75	8.76
70005.13	(133 cm)	1020	14.6	2.79	4.4	1.8	2570	12.4	28.4	1.08	5.28	2.28	13.7	.68	.82	8.90
70006.13	(93 cm)	940	13.5	1.99	3.8	1.7	2540	12.4	26.6	1.32	5.20	2.29	13.8	.75	.92	9.10
70008.186	(62 cm)	1070	16.4	2.08	4.1	1.9	2730	12.4	28.2	2.36	5.22	2.29	14.0	.63	.72	8.74
70008.192	(26 cm)	505	7.6	.80	1.4	.7	2630	12.3	26.7	3.36	5.21	2.45	14.6	.69	.82	8.98
Top reference																
70181.9	(0-5 cm)	1550	20.0	3.31	5.4	2.0	2470	12.8	30.5	.92	5.26	2.14	13.2	.59	.60	8.56
B. Shorty Crater-area																
Orange soil																
74220.15	(5-8 cm)	125	1.4	.16	.29	.12	2760	12.5	28.8	6.15	5.22	2.24	13.8	.69	.81	8.94
Ref. to orange soil																
74241.23	(top)	1370	13.9	1.56	1.7	.78	2930	12.3	30.0	7.44	5.30	2.24	13.8	.62	.69	8.76
74261.5	(top)	1340	15.0	1.5	2.1	.92	2800	12.4	30.7	6.9	5.4	2.24	13.8	.64	.73	8.82
Black soil	(drive tube, depth 71.5 cm)															
74001.15		1.9	.019	.005			880	8.3	3.3	130	3.8					

Table 2. Cosmic ray exposure ages of Apollo 17 samples. Surface production rate used for exposure age calculation.

Sample	Description	Depth [cm]	Area	my		Exposure age based on
70001.13	deep drill core fines	290	ALSEP area	490	average 550 ± 60	Ne^{21} Kr^{78} Xe^{126}
70002.13		253		550		
70003.13		213		610		
70004.13		173		530		
70005.13		133		490		
70006.13		93		610		
70008.186		62		560		Ne^{21}, Kr^{78}
70008.192		26		330		
70181.9	top surface fines 3 m from deep drill core	0 - 5	ALSEP area	360		Kr^{78}, Xe^{126}
70035.6 (1)	basaltic rock	-	ALSEP area	100		Ar^{37}/Ar^{38}
70035.6 (2)				95		
74220.15	orange soil	5 - 8	south rim of Shorty Crater	30		Ar^{37}/Ar^{38}
74241.23	grey soil, on both sides of orange soil band	0		230		Ne^{21}, Kr^{78}, Xe^{126}
74261.5	grey soil, on both sides of orange soil band	0		240		
74001.15	drive tube at orange soil band	71.5		45		Ne^{21}, Ar^{38}
74275.24	basaltic rock	-		25		Ar^{37}/Ar^{38}
75083.4	5 coarse fine fragments	0	south rim of Camelot Crater	290, 145, 140, 110, 380		Ar^{37}/Ar^{38}