PATTERNS OF U-Th-Pb DISTRIBUTIONS AND ISOTOPE RELATIONS IN APOLLO 17 SOILS. Leon T. Silver, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, California 91109. Contribution No. 2446

Thirteen surface soils collected at the major features visited in Taurus Littrow valley were surveyed for their U-Th-Pb abundances and isotopic systematics. Nine aliquots from throughout the Apollo 17 deep drill core were analyzed similarly. Volatile lead components in six samples have been isolated and evaluated including "orange" and "gray" soils at station 4. Data for the bulk soils are shown in table 1.

Average uranium and thorium levels in the surface soils of the valley floor are 0.344 ppm and 1.09 ppm, respectively. Similar levels are observed in the deep drill core. It is noteworthy that these are the lowest average values observed at any Apollo mare site. The Th/U ratios in the valley soils, averaging 3.14, are distinguishably lower from all other mission sites except Apollo 16. There appears to be a significant increase in radioactivity in the lower 160 cm of the deep drill core. This correlates with other evidence for a discontinuity in the drill core stratigraphy. Values of U and Th concentrations rise progressively in suites collected from the bases of the Sculptured Hills, North Massif and South Massif. Th/U ratios show comparable increases. The serial variation appears to reflect the degrees of mixing between valley floor and massif components. The South Massif soils, the most radioactive observed here, are comparable in level to those observed in the Descartes region and much less radioactive than "highland" soils from Apollo 14 and 15.

The lead concentrations throughout the valley range from 1-2 ppm, generally correlating with the associated uranium and thorium. Conspicuous exceptions are the soils from station 4, "Shorty" crater rim, which are at the 3 ppm level, reflecting the anomalous volatile element content of these soils reported by Tatsumoto et al.[1], Reed et al.[2], and many other workers. Lead in the deep drill core is generally similar to other values observed on the valley floor. Both concentration and composition data indicate that the 1-15 ppm levels of terrestrial lead contamination observed in Apollo 15 and 16 deep drills [3], [4] are not present in this core. Estimated upper limits for possible contamination are shown in table 1, and are all less than 0.2 μg/g except for 70006,7 which appears to have a possible 0.4 μg/g contamination. Whether this is derived from the drill or from subsequent sample processing has not been determined. This improvement of lead background by 1-2 orders of magnitude is a significant achievement by NASA.

The isotopic composition of leads in all samples (corrected for blanks of less than 3% of the sample lead except in the cores) is shown. The leads are typically less radiogenic than those observed from other mission sites. They reflect the lower radioactivity levels found at Taurus Littrow and the presence of widely dispersed trace to significant contributions from the anomalous leads associated with the soils from station 4. These soils, particularly 74220, are 4-10 times richer in ^{204}Pb and have the lowest $^{206}Pb/^{204}Pb$ ratios observed in the lunar collections from all missions[1]. They are characterized by $^{207}Pb/^{206}Pb$ ratios which are much higher than those of any other leads at this site

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and their presence as a component in the soils can be easily recognized. Valley floor and drill core samples are estimated to derive from 5 to 50% of their lead from components similar to the leads at "Shorty" crater. $^{238}U/^{204}Pb$ ratios range from 50 to 100 in valley surface soils and are as low as 30 in drill stem unit 70008. In contrast soils from the massifs have much lower ^{204}Pb concentrations, with $^{238}U/^{204}Pb$ values from 100 to 250. Other contributions to the lead isotopic compositions in the valley floor soils can be identified in the local basalts, debris from the adjacent highlands, and from variable amounts of volatile radiogenic lead.

Some very distinct and unusual patterns emerge from this data. The U-Th-Pb systems of the valley floor generally show excess leads and reverse discordant older model ages in the vicinity of 4750-5000 million years. In contrast, the rake soil 72500 from the toe of the South Massif shows nearly concordant model ages at 4440-4530 m.y. Sample 73221 from the light mantle slide apparently derived from the South Massif shows slightly older ages at 4650-4750 m.y., as do the two soil samples from the North Massif. Samples from the Sculptured Hills are nearly identical with the valley floor systems. Thus, a reversal of the hitherto consistently observed relation of older model ages in highlands compared to mare surfaces apparently has been introduced by the presence of the "orange" soil and its kindred on the valley floor. This must reflect, also, a paucity of ^{207}Pb-rich systems in the breccias which comprise the massifs.

Studies of volatile leads in massif soils indicate another important anomaly. The rake soil from station 2 contains almost none of the ancient, low-temperature volatile lead characteristic of most highland soils. Very little is indicated in the other three massif soils. It is difficult to understand how these massif slopes which have existed since before Serenitatis volcanism, and show no great colluvial accumulations at their base, have failed to accumulate such a component. Has mass-wasting been more active over the long history of the valley than has been previously recognized?

The distribution of the ^{204}Pb-rich component on the valley floor is so widespread as to indicate that the orange soil kindred may exist at the top of the basalt flow system over a broad region of the valley. In the upper 60 cm of the drill core, in a zone characterized by abundant basaltic fragmental debris, orange glass is conspicuous and the soil yields the highest model ages encountered. This is 4 km east of "Shorty". This zone appears to be part of a young ejecta blanket from a relatively large crater such as nearby Camelot, or from the secondary crater cluster which lies to the east of the LM, which penetrated into the basaltic sub-regolith.

Volatilization studies of the station 4 soils have revealed that 60 to 80% of the total lead and even more of the ^{204}Pb is released below 600°C. The isotopic composition of 74220 low temperature lead is the most primitive observed in lunar materials and is clearly the end member toward which Tatsumoto et al.(1) were moving with their acid-washing experiments. The residual lead is a relatively young radiogenic component. The 2 gray soils, 74240 and 74260, also contain large quantities of low temperature volatile leads rich in ^{204}Pb, but they differ systematically from 74220 in an enrichment in a second very ancient radiogenic component. A multi-component solution suggests directly,

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Table 1. Apollo 17 Soils

Sample	Station; Depth (cm)	Pb Isotope Composition[2] 206/204	207/204	208/204	Concentrations (ppm)[3] Total Pb	Contam. Pb[4]	U	Th	Th/U
South Massif									
72500,8	Sta. 2	221.18	133.67	225.38	2.062		0.889	3.106	3.49
73321,14[1]	Sta. 3	195.66	126.98	-	1.91		0.733	2.714	3.70
North Massif									
76240,14	Sta. 6	121.14	82.58	131.97	1.736		0.637	2.164	3.40
76260,8	Sta. 6	119.90	81.00	129.73	1.570		0.540	2.038	3.77
Sculptured Hills									
78420,3	Sta. 8	93.28	68.17	105.40	1.325		0.447	1.520	3.40
78480,5	Sta. 8	118.71	85.72	129.55	1.219		0.432	1.518	3.51
78500,6	Sta. 8	74.24	56.15	88.24	1.310		0.406	1.337	3.30
Dark Surface Soils - Valley Floor									
70180,5	ALSEP	77.91	61.26	70.79	1.134		0.316	1.046	3.31
70181,22	ALSEP	83.59	64.85	95.30	1.134		0.331	1.049	3.17
72160,2[1]	LRV-3	70.35	55.05	-	1.723		0.459	1.518	3.31
75080,9	Sta. 5	73.19	53.99	85.93	0.935		0.291	0.901	3.12
74220,28	Sta. 4	22.84	24.40	40.72	3.008		0.231	0.643	2.78
74260,11	Sta. 4	54.19	55.61	67.99	3.038		0.434	1.365	3.14
Drill Core	ALSEP								
70001,7	290 cm	67.17	53.39	83.56	1.750	<0.2	0.458	1.458	3.18
70002,7	256	92.91	68.38	105.10	1.800	<0.1	0.742	2.814	3.79
70003,7	215	75.55	59.92	89.92	1.817	<0.2	0.478	1.623	3.40
70004,7	174	78.62	61.29	92.14	1.627	<0.2	0.422	1.462	3.47
70005,7	133	95.59	72.95	107.42	1.384	<0.1	0.450	1.535	3.41
70006,7	93	36.19	28.95	54.14	1.920	0.4?	0.345	1.086	3.15
70008,181	63	66.97	59.69	80.26	1.640	<0.1	0.324	1.090	3.36
70008,240[1]	28	58.88	52.41	-	1.64	<0.2	0.305	1.154	3.78
70008,187	26	65.08	58.61	79.83	1.191	<0.1	0.233	0.766	3.29

[1] Preliminary lead data - spiked with ^{208}Pb-rich spike. [2] Corrected for blanks of 10-20 ng. [3] Concentrations have precisions of ± 1 %; minor corrections may be expected when spiked-only samples are completed. [4] Estimated by comparisons with surface soils.

for the first time, the presence of original primordial lead in the moon, and the existence of lunar interior regions with $^{238}U/^{204}Pb$ ratios similar to the earth, relatively undepleted in volatiles. These unusual leads are found with, but not in, the orange glass.

REF: (1) Tatsumoto, M. and others, EOS 54, 614 (1973). (2) Reed, G. and others, Oral presentation, 4th Lunar Science Conference (1973). (3) Silver, L. T., The Apollo 15 Lunar Samples, 388, LSI (1972). (4) Silver, L.T., Lunar Science IV, 674, LSI (1973).