

U-Th-Pb SYSTEMATICS OF SOME APOLLO 17 SAMPLES. P. D. Nunes,
M. Tatsumoto, and D. M. Unruh, U. S. Geological Survey, Denver, Colo. 80225

Apollo 17 mare basalts 75055, 75035, and 74275 have U, Th, and Pb contents (Table 1) like those of Apollo 11 low-K basalts. Highland gabbro 77017 has somewhat higher U, Th, and Pb concentrations similar to highland basalt 68415.

Mare basalts 75055 and 75035 plot within error of concordia at 4.49 and 4.50 b.y., respectively (Fig. 1), extremely close to where Apollo 16 highland basalt 68415 plotted (4.47 b.y.) (1). Highland anorthositic gabbro 77017 plots slightly below but within error of concordia and has a $^{207}\text{Pb}/^{206}\text{Pb}$ age of 4.45 b.y. The clustering of these data in the 4.45- to 4.50-b.y. region of concordia is perhaps more than coincidence and may well reflect a major period of lunar differentiation at that time. The ~4.5-b.y.-old refractory phase, inferred from Pb data volatilized at 1350°C, in Apollo 12 and 14 soils (2) may well be reflecting this same event. Although the Apollo 17 mare basalts crystallized ~3.8 b.y. ago as evidenced by Rb-Sr internal isochrons (3, 4) and ^{39}Ar - ^{40}Ar gas retention ages (5, 6, 7), we believe that the whole-rock U-Th-Pb systems were little affected and continued to reflect early differentiation of the source rocks. A very old (~4.42 b.y.) whole-rock Rb-Sr isochron age of Apollo 16 KREEP rocks (8) was recently emphasized as likely reflecting early lunar differentiation. The sparsely cited whole-rock Rb-Sr isochron ages of Apollo 11 mare basalts (4.42 ± 0.12 b.y.) (9), and Apollo 11, 12, and 15 mare basalts (4.56 ± 0.34 b.y.) (10) now take on new significance. We believe that U-Th-Pb and Rb-Sr whole-rock data of all types of igneous lunar rocks (KREEP, highland gabbros and basalts, and mare basalts) reflect at least one pre-"Imbrian" (i.e., pre-~4.0 b.y.) event--the oldest being 4.4 to 4.5 b.y. old. Apollo 17 mare basalt sample 74275 with a $^{207}\text{Pb}/^{206}\text{Pb}$ age of ~4.24 b.y. may or may not reflect a distinct event at about this time as suggested by whole-rock Rb-Sr data (8).

Breccia 78155 and "gabbro" 79155 both contain excess Pb relative to U and may have suffered complex histories. In any case, the excess Pb in "gabbro" 79155 and the slightly higher U and Th contents as compared to Apollo 17 mare basalts (Table 1) suggest to us that this rock incorporated a significant portion of regolith during crystallization.

Except for soil 72701, all Apollo 17 soils analyzed by us contain excess Pb relative to U. The scatter in these analyses is outside of analytical error and may well reflect mixing of three or more different components (Fig. 2).

Of particular interest is orange soil sample 74220, which consists mostly of glass spherules. U and Th contents of the soil (about 0.16 and 0.56 ppm, respectively) are quite similar to those of Apollo 17 mare basalts (Table 1). The Pb isotopic composition of the orange soil is remarkably non-radiogenic relative to all other lunar leads so far analyzed (4). We have analyzed water and acid leaches, the resulting residue (4), and various size fractions of the orange soil for U, Th, and Pb. Pb in this soil was not easily leachable with water, indicating that the Pb is not a surface coating of an easily soluble compound such as PbCl_2 or PbBr_2 on the glass spherules. However, the Pb was

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easily leached with dilute acids and the Pb isotopic compositions in the H₂O, 1.5N HCl and concentrated HNO₃ leaches are very similar (Fig. 3), suggesting a rather homogeneous, relatively non-radiogenic lead was incorporated in the glass spherules. The residual lead from the leach experiment is far more radiogenic than the leach leads but not quite as radiogenic as Apollo 17 basalt leads.

Data of size fractions of orange soil 74220 are also plotted in Figure 3 ($^{206}\text{Pb}/^{204}\text{Pb}$ vs. $^{207}\text{Pb}/^{204}\text{Pb}$). The finest fraction (acetone float) contains 8.6 ppm Pb and the least radiogenic lead ($^{206}\text{Pb}/^{204}\text{Pb} = 20.53$; $^{207}\text{Pb}/^{206}\text{Pb} = 23.93$; $^{208}\text{Pb}/^{206}\text{Pb} = 38.62$), whereas the >150 μm fraction of glass spherules contains only 0.54 ppm Pb and the lead is more radiogenic ($^{206}\text{Pb}/^{204}\text{Pb} = 38.43$; $^{207}\text{Pb}/^{204}\text{Pb} = 29.25$; and $^{208}\text{Pb}/^{206}\text{Pb} = 55.06$). Pb concentrations and isotopic compositions in the other fractions progressively change between these two end members, but the U and Th concentrations in all fractions are similar. These results indicate that one kind of lead (and other volatiles?) was incorporated into the spherules after their formation. The excess lead should have evolved in a μ_1 ($^{238}\text{U}/^{204}\text{Pb}$, normalized to today's value) of about 35 (assuming a two-stage, U-Pb evolution history starting at ~4.65 b.y. ago), which is significantly lower than μ 's for the source of lunar basalts ($\mu = 150\text{--}300$) and KREEP-type rocks (600–1,000). Thus the excess Pb of the orange soil evolved in a U-poor environment compared to other lunar rock leads, although the origin of the Pb (lunar or extralunar) is as debatable as the origin of the glass spherules (4, 11, 12, 13). The trend line defined by the size fractions is slightly lower than the leach trend line, but the two lines are parallel within error. The reason for the relative displacement of these lines is not clear at present, but it might be due to contamination during the size fraction separations. Soil 74240 from the same station contains relatively less-radiogenic lead compared to other lunar rocks, but the lead is more radiogenic than that of orange soil, indicating that the soil 74240 contains some orange soil component.

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Table 1. U-Th-Pb analyses of Apollo 17 rocks and soils. All whole rock or whole soil analyses.

Sample no.	Description	P/C	Weight (mg)	Concentration (ppm)	U	Th	Pb	Atom ratios corrected for analytical blank*						
								$\frac{^{238}\text{U}}{^{235}\text{U}}$	$\frac{^{238}\text{U}}{^{206}\text{Pb}}$	$\frac{^{238}\text{U}}{^{207}\text{Pb}}$	$\frac{^{235}\text{U}}{^{206}\text{Pb}}$	$\frac{^{235}\text{U}}{^{207}\text{Pb}}$	$\frac{^{238}\text{U}}{^{206}\text{Pb}}$	$\frac{^{238}\text{U}}{^{207}\text{Pb}}$
75055	mare basalt	P	621.4											
		C	533.8	0.136	0.447	0.311	3.40	250.4	260.1	150.0	--	0.5888	0.9725	
75035	mare basalt	P	120.7											
		C	209.4	0.151	0.488	0.326	3.35	507.4	579.2	341.0	520.5	0.9888	0.8967	
74275	mare basalt	P	105.1											
		C	181.0	0.136	0.465	0.265	3.54	430.4	449.9	222.6	418.3	0.4947	0.9298	
77017	anorthositic gabbro	P	103.5											
		C	94.7	0.270	1.025	0.573	3.92	653.2	582.0	337.0	553.0	0.5790	0.9502	
78155	anorthositic breccia	P	113.4											
		C	112.1	0.269	0.935	0.851	3.60	164.9	263.0	212.4	256.0	0.8076	0.9734	
79155	"gabbro"	P	92.0											
		C	152.6	0.220	0.793	0.652	3.73	138.2	168.9	121.9	172.3	0.7217	1.0201	
72701	soil	P	111.3											
		C	141.8	0.808	2.962	1.781	3.79	394.7	507.3	309.7	492.3	0.6104	0.9705	
76501	soil	P	107.8											
		C	87.4	0.405	1.484	1.183	3.78	182.6	291.7	234.5	--	0.5987	--	
75120	soil	P	99.4											
		C	170.1	0.334	1.216	1.094	3.76	106.8	248.5	170.4	245.2	0.6859	0.9866	
79241	soil	P	108.3											
		C	213.9	0.325	1.163	1.234	3.70	95.9	226.7	165.5	--	0.7299	--	
79261	soil	P	97.4											
		C	144.9	0.322	1.165	1.115	3.74	101.4	141.1	111.4	147.0	0.7893	1.042	
79227	soil	P	117.3											
		C	205.3	0.313	1.134	1.255	3.75	78.4	137.2	109.5	144.2	0.7981	1.051	
74001.B	from drive tube	P	48.4											
		C	37.8	0.139	0.466	1.080	3.47	10.47	147.1	118.6	--	0.8062	--	
74240	soil	P	93.6											
		C	208.2	0.314	1.136	1.983	3.74	38.9	160.5	122.5	162.8	0.7632	1.014	
									144.9	114.1	--	0.7871	--	
									123.0	103.1	130.6	0.8367	1.063	
									125.4	104.7	--	0.8351	--	
									25.49	24.60	43.18	0.9654	1.695	
									25.46	24.56	--	0.9649	--	
									87.29	89.52	96.84	1.0256	1.109	
									90.79	92.18	--	1.0153	--	

*Analytical total Pb blanks ranged from 0.67 ng to 1.6 ng for all samples, except 75055 composition (2.9 ng) and concentration (1.9 ng) runs.

*Concentration and composition portions were divided from solution. For all other analyses, division was from crushed rock or soil splits (i.e., concentration runs were "total spiked").

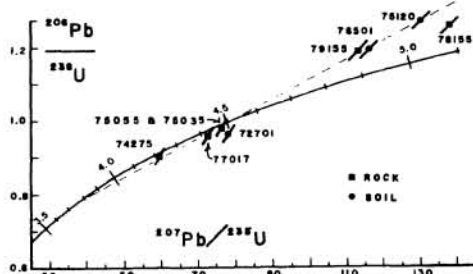


Fig. 1. Apollo 17 rocks and soils. Numbers on concordia are in b.y. Data corrected for blank and primordial Pb.

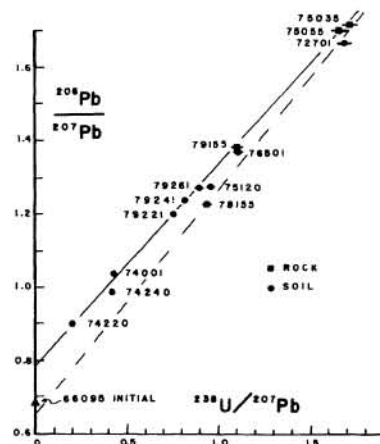


Fig. 2. Apollo 17 rocks and soils. Breccia 66095 initial Pb ratio (14) plotted for comparison. U/Pb errors estimated at ± 2 percent. Data corrected for blanks only.

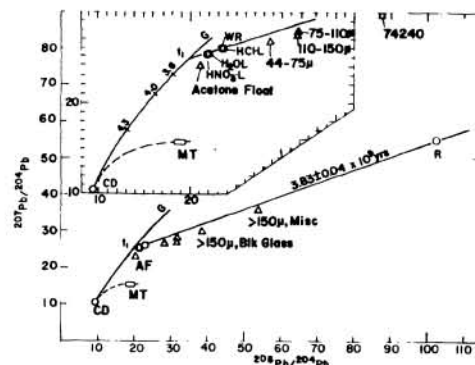


Fig. 3. Leaches, residue, and size fraction data of orange soil 74220.