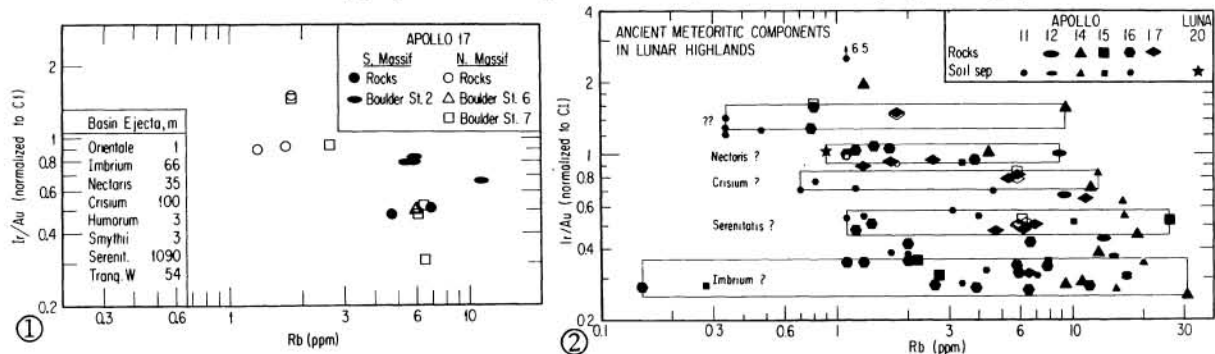


❁ LUNAR BASINS: TENTATIVE CHARACTERIZATION OF PROJECTILES,  
FROM METEORITIC ELEMENTS IN APOLLO 17 BOULDERS ❁

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Ancient Meteoritic Components. Like other highland breccias, Apollo 17 rocks seem to contain debris of basin-forming objects, as manifested by  $10^2$ - $10^3$ -fold enrichments in Ir, Re, Au, Ni, and Ge over indigenous levels. Several discrete components can be recognized on the basis of Ir/Au, Re/Ir, and Ge/Au ratios (1). Some tentative assignments can be made by comparing the relative frequency of these components at different landing sites with calculations of ejecta thicknesses by McGetchin *et al.* (2). We shall use Ir/Au as the diagnostic ratio (corrected for the indigenous contribution and normalized to C1 chondrites). In order to spread out the points and to reveal any correlations with rock type, we have plotted Ir/Au vs. Rb (Figs. 1,2).



The components of  $\text{Ir/Au} \approx 1.0$  and  $0.8$  probably represent Nectaris and Crisium. At Apollo 16, they are found in dark-matrix breccias from Stations 11 and 13 (3) which underlie the cataclastic anorthosites identified as deep ejecta from Nectaris. We favor a Nectaris origin for the 1.0 component, because of its greater abundance at Apollo 16 and its presence at Luna 20. By analogy to the stratigraphy of Apollo 16, as revealed at N. Ray Crater (3), all but the bottom portion of the thick Crisium blanket at Luna 20 should consist of deep ejecta, uncontaminated by projectile debris. It will be overlain by a thin blanket of meteorite-bearing Nectaris material. The source crater of Luna 20 soil, Apollonius C, should have ejected mainly Nectaris material.

Thus we assign a Crisium origin to the component of  $\text{Ir/Au} \approx 0.8$ , found in boulder 72255-72275. This is consistent with the high stratigraphic position of this boulder, and the rarity of this component at other sites.

The most prominent grouping at Apollo 17 ( $\text{Ir/Au} \approx 0.5$ ) is assigned to Serenitatis. This leaves one group unassigned, at  $\text{Ir/Au} \approx 1.5$ . It may be related to Tranquillitatis, if this basin was excavated by one large rather

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than two small projectiles, or to the cryptic basin at 10°N, 16°W (4).

Boulders, Igneous Rocks. From our limited sampling, it seems that the blue-gray breccias have the least variable composition, with respect to both meteoritic and non-meteoritic elements. Clast and matrix from Phinney's boulder 76315 look nearly identical (Table 1). Both plot in the Serenitatis cluster (Fig. 1), along with two samples from S. Massif (73235 and 73275; the former has unusually high Br, Zn, and Cd contents, however).

The green-gray breccias, judging from Chao's boulder 77135-77075, are more heterogeneous. Matrix and black dike material are nearly identical, as is the poorly characterized 77135,10 (though it has a different, Imbrian meteoritic component). However, troctolitic clasts 1 and 2 are lower in alkalis and U and have distinctly different meteoritic components (Nectaris and unassigned; the latter is also represented by 78155). Our interpretation requires that the green-gray breccia comprises Serenitatis ejecta, which became remobilized at some later time and incorporated clasts from younger basins.

Wood's gray boulder 72255-72275 is also heterogeneous. The two matrices and clast 2 are almost identical, but the black rim of clast 1 is richer in Rb, Cs, U and shows a somewhat different meteoritic pattern. The rim may represent ejecta plastered on in flight (5). The black-and-white basaltic clasts are not perceptibly enriched in meteoritic elements and thus represent uncontaminated igneous rocks. The basalt is nearly two orders of magnitude richer in Ge than other lunar igneous rocks; this lessens the reliability of Ge as a meteoritic indicator element. Troctolite 76535 is exceedingly low in nearly all elements measured by us; this is consistent with a deep-seated origin as proposed by Gooley et al. (6).

Volatile Enrichment. In contrast to Apollo 16, only one anorthosite, 78155, shows the enrichment in Tl, Cd, and Sb which we attributed to fumarolic volcanism. The orange soil 74220 is enriched in Ag, Br, Zn, Cd, and Tl, compared to ordinary lunar rocks or soils, but is quite low in siderophile meteoritic elements. An indigenous source seems to be required for the volatiles. Judging from our data on soil separates, much of the enrichment seems to reside in the orange glass fraction. We see no significant enrichment of volatiles in the two shadowed soils 72321 and 76241.

(1) GANAPATHY R. et al. (1973) GCA Suppl.4, 1239. (2) MC GETCHIN T.R., SETTLE M., and HEAD J.W. (1973) EPSL, 20, 226. (3) GANAPATHY R. and ANDERS E. (1974) Lunar Sci. V. (4) WILHELMS D.E. and MC CAULEY J.F. (1971) Geologic Map of the Near Side of the Moon. (5) WOOD J.A. et al. (1974) Lunar Sci. V. (6) GOOLEY R., BRETT R., WARNER J., and SMYTH J.R. (1974) GCA, in press.



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Table 1. Trace Elements in Apollo 17 Rocks and Soils (ppb, except Ni, Rb, Zn, ppm)

Class.*	Ir	Re	Au	Ni	Sb	Ge	Se	Te	Ag	Br	Bi	Zn	Cd	Tl	Rb	Cs	U
<u>Rocks</u>																	
70215,64 Mare Basalt	0.003	0.0015	0.026	1	0.18	1.66	176	2.1	1.1	8.1	0.099	2.1	1.8	0.16	0.36	15	118
72255,42 GB B&W Ct	0.0040	0.0068	0.008	4	0.26	61	280	14.3	0.76	15.3	0.30	4.5	5.8	0.30	1.27	67	240
72255,52 GB Mx	5.28	0.498	2.00	227	0.77	174	77	5.2	0.57	101	0.21	2.8	8.1	1.18	5.8	240	1790
72275,57 GB Mx	2.26	0.225	0.82	97	1.17	406	34	4.4	0.74	48	0.11	2.7	13	0.71	5.9	260	1500
72275,80 GB Ctl bl rim	2.54	0.233	1.16	122	0.94	137	63	3.6	0.93	290	0.14	2.8	15	0.71	11.3	480	3100
72275,83 GB Ct2 G Aph	3.44	0.334	1.30	147	1.06	178	52	3.7	0.56	95	0.12	2.4	26	0.62	5.4	260	1840
72275,91 GB Ct5 Basalt	0.023	0.0066	0.045	43	2.87	1290	230	7.3	0.58	44	0.14	2.7	8.3	0.58	8.0	360	1500
73235,45 BGB	3.71	0.385	2.31	144	1.14	230	53	4.3	1.0	90	0.69	9.4	27	2.1	4.7	198	1060
73275,23 Breccia	5.71	0.494	3.34	182	1.19	265	92	5.5	0.74	73	0.16	2.5	4.1	1.60	6.9	270	1360
75035,35 Mare Basalt	≤0.0007	0.0007	0.0084	1	0.04	1.27	156	1.5	0.62	8.0	0.043	2.3	1.1	0.29	0.79	29	153
76315,73 BGB Mx	5.42	0.507	3.21	256	1.49	346	100	3.6	0.84	48	0.098	3.1	5.0	0.31	5.91	250	1540
76315,74 BGB Ct3	5.97	0.575	3.48	260	1.54	354	107	5.1	0.88	44	0.28	3.4	6.4	0.34	5.9	250	1490
76535,20 Troctolite	0.0054	0.0012	0.0025	44	0.014	1.70	4.1	0.28	0.12	3.2	0.037	1.2	0.60	0.012	0.20	14	19.4
77017,48 An Ol Gabbro	17.0	1.73	5.65	443	0.72	110	68	1.9	0.87	35	0.22	2.5	9.0	0.77	1.34	61	137
77075,19 GGB bl dike	8.89	0.781	5.09	286	1.92	532	112	6.3	1.2	81	0.34	2.8	7.5	2.4	6.4	270	1450
77135,10 GGB Ctl/Mx?	3.78	0.485	3.57	205	1.21	295	137	3.6	1.1	47	0.18	2.9	10.5	2.6	6.5	270	1390
77135,50 GGB Ct2:Troct	7.20	0.662	1.46	174	0.58	50	11.3	2.6	0.38	11.6	0.17	2.6	6.8	0.48	1.80	74	260
77135,62 GGB Ctl:OlPlB	15.1	1.42	4.74	412	0.47	78	33	1.1	0.58	17.6	0.14	2.4	3.7	0.58	2.6	73	450
77135,69 GGB Nonves Mx	10.5	1.06	6.45	438	2.16	618	144	9.3	1.2	45	0.23	3.3	3.5	2.3	6.1	250	1380
78155,30 Catacl An	3.32	0.278	0.66	68	20.4	27	49	3.2	1.0	65	0.29	2.3	63	5.9	1.76	84	250
79035,19 Friable B	7.50	0.629	2.39	162	0.89	278	300	18.6	19	117	0.70	40	71	2.2	1.69	72	310
<u>Soil Separates, &lt;1 mm</u>																	
74220,54,1 Dark Glass	0.114	0.0135	0.23	70	1.00	41	129	10.0	320	15	0.50	45	92	1.60	0.66	30	130
74220,54,2 Orange Glass	0.214	0.0553	1.07	72	25.3	191	460	49	75	88	1.53	141	260	9.9	0.77	44	115
<u>Soils, &lt;1 mm</u>																	
72321,1 Shadowed	8.87	1.07	6.03	550	1.81	625	240	24	6.5	78	0.65	18	37	1.51	4.1	170	900
74001,5 Below Orange	0.021	0.213	0.705	68	1.16	105	350	38	72	210	0.67	148	25	4.0	0.76	37	141
74220,54 Orange	0.411	0.052	0.99	67	0.65	250	640	62	111	520	1.43	230	320	20	0.95	55	168
74241,30 Above Orange	2.78	0.296	1.01	64	0.55	155	340	24	25	610	0.75	86	210	9.1	2.3	107	330
75081,33 Nr Camelot	5.36	0.470	1.70	113	0.67	190	250	10	9.9	100	0.54	27	32	1.3	1.2	47	240
76241,12 Shadowed	8.57	0.820	3.81	220	1.34	420	240	17.0	9.4	88	0.67	25	82	1.95	2.8	133	550
76261,13 Control	6.46	0.671	2.52	160	1.06	300	210	13.6	7.9	65	0.59	23	39	1.59	2.7	115	490

\* An = anorthite, anorthosite

B = breccia

bl = black

G = gray

Mx = matrix

Pl = plagioclase

Aph = aphanitic

BG = blue gray

Ct = clast

GG = green gray

Ol = olivine