A REVIEW OF POTASSIUM - URANIUM SYSTEMATICS: GEOLOGIC IMPLICATIONS OF MOON - EARTH - METEORITE ORIGINS

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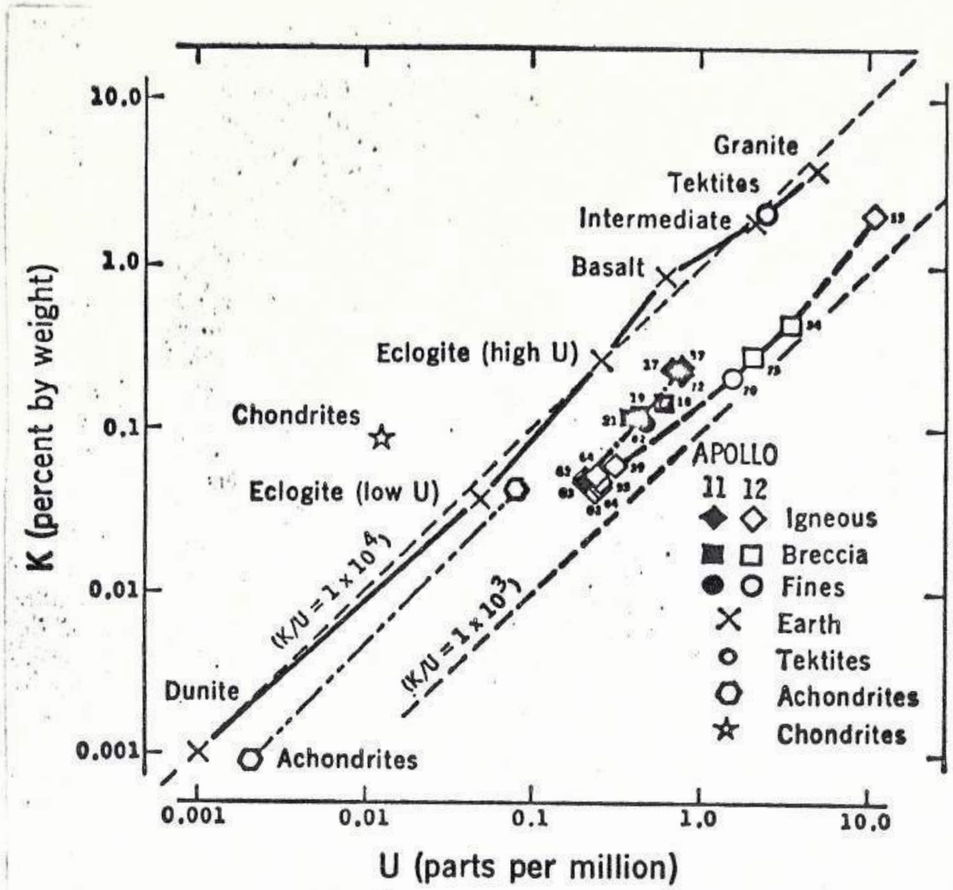
INTRODUCTION

The relative abundance of potassium, uranium (and thorium) is considered by a few workers in the field to be of significant value in assessing the early chemical fractionation histories of the moon and the earth. Since the Apollo program has now been completed, abundant data are now available on the K-U systematics for lunar material and new data are available for the earth. A review of this data together with an evaluation of previous interpretations is timely and could have considerable impact on the present knowledge of lunar-earth history. To this end, a compilation was made of all potassium and uranium analyses on lunar samples returned by the American Apollo and the Soviet Luna exploration programs. Thorium analyses were also included as an analytical check on the reliability of the uranium analyses.

DEVELOPMENT OF POTASSIUM - URANIUM SYSTEMATICS

Fanale and Nash (1971) first laid the foundation for later work by noting a significant difference in K-U abundances for Apollo 11 and 12 samples by graphically comparing the available lunar analyses and by comparing them with selected analyses of earth rocks and meteorites (Figure 1). They suggested that K/U ratios of igneous rocks on the earth are within 50 per cent of 1.0×10^4, despite the fact that magmatic

Figure 1



Comparative trends in potassium-uranium abundance for earth rocks, meteorites, and Apollo 11 and Apollo 12 moon rocks. (Fanale & Nash - 1971)

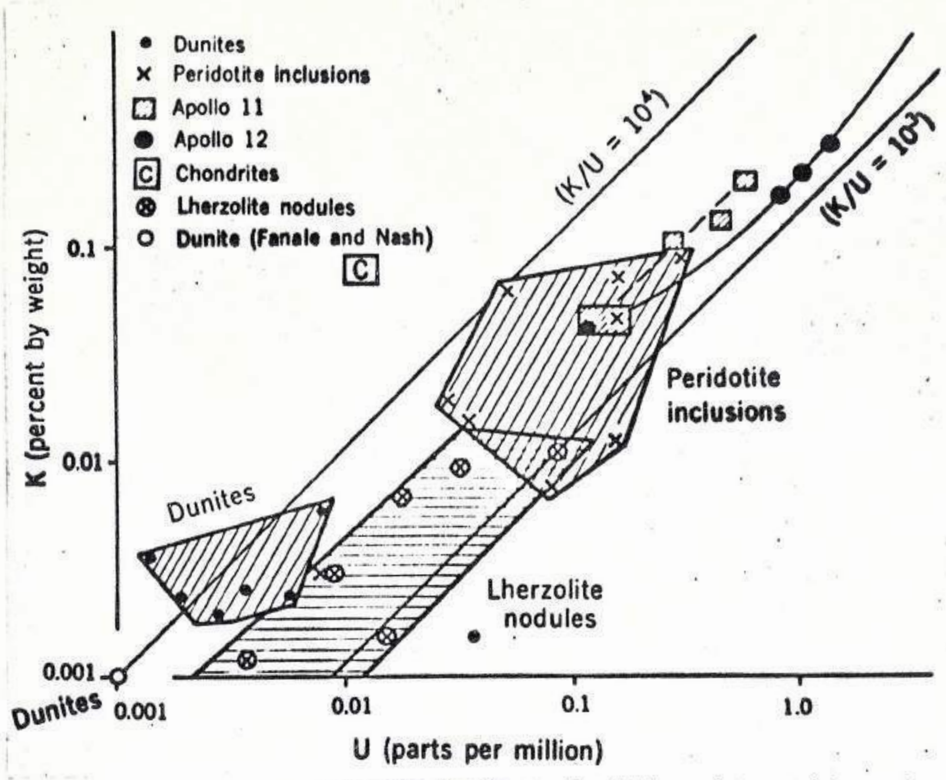
differentiation has produced rocks with a range of K and U concentrations covering 3½ orders of magnitude.

They concluded that: (1) at each Apollo site, the samples appear to be members of a single family defining their own trend line which represents the correlation between their K and U contents. Figure 1 shows that Apollo 11 and 12 samples exhibit different K-U correlation trends, which suggests that they are a result of differentiation; (2) breccias and fines appear to be members of the corresponding K-U trend lines and are defined by local igneous rocks and (3) their K-U systematics of Apollo 11 and 12 samples argues against moonwide transport and exchange of regolith materials subsequent to the formation of Oceanus Procellarum; (4) the two trends appear to diverge from a common cluster of points (Figure 1). They suggest that the two suites represent two separate differentiation sequences originating from materials of identical K and U content.

Their latter conclusion is of considerable importance since it would indicate that if the lunar highlands and mare material ~~is~~ are enriched in K and U, a depleted phase of ultramafic material at depth would be required. Furthermore, the samples of the depleted phase would be expected to produce trend lines that extend to the differentiation trend line of the earth at some material balance point, i.e. if the moon and the earth had a similar history of mantle development. However, Fisher (1971) suggests that the data along the terrestrial trend are overly simplified and that more recent K/U data for ultramafic rocks (which are regarded as the best earth mantle material obtained to date) show that lunar material is well within the range of terrestrial peridotite inclusions in basalt and kimberlite. (See Figure 2) He, therefore, discards the need for lunar subsurface depletion in K and U. Fanale and Nash counter this position on the basis that if the K/U is not depleted at depth then the moon should be molten throughout at the present time, material balance dictating such depletion.

Surkov, et al (1973) reviewed the K/U systematics and included data from the Soviet Luna 16 and 20 missions as well as data for Apollo 14 and 15. In addition to the data of Fanale and Nash (1971), Fisher (1971), Green, et al (1968), additional Soviet data is added on terrestrial

Figure 2

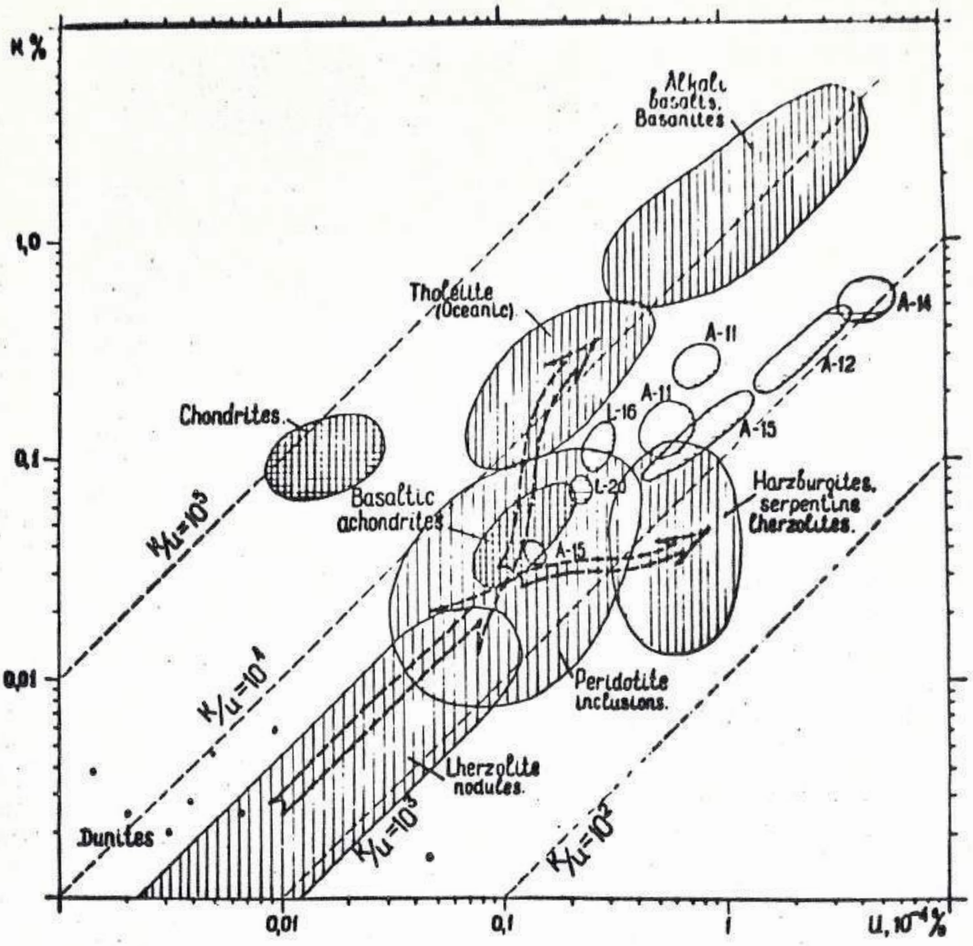


Potassium-uranium systematics for lunar, chondritic, and terrestrial samples.

(Fisher, 1971)

lherzolites, dunites, tholeiitic basalts and basalts of other types (Dmitriev - 1972). Figure 3 summarizes this data and shows two branches of differentiation, one of tholeiitic basalt, the other of harzburgitic character. Of particular interest is the fact that the former branch is enriched in potassium and the latter is enriched in uranium. Surkov, et al suggest that this is a result of secondary uranium enrichment, which involves the incorporation of products of mantle degassing. They note that such enrichment cannot be associated with continental crust in oceanic rift regions and that variations in the K/U ratio can only be caused by differentiation in the mantle. Further, K/U ratios of terrestrial

Figure 3

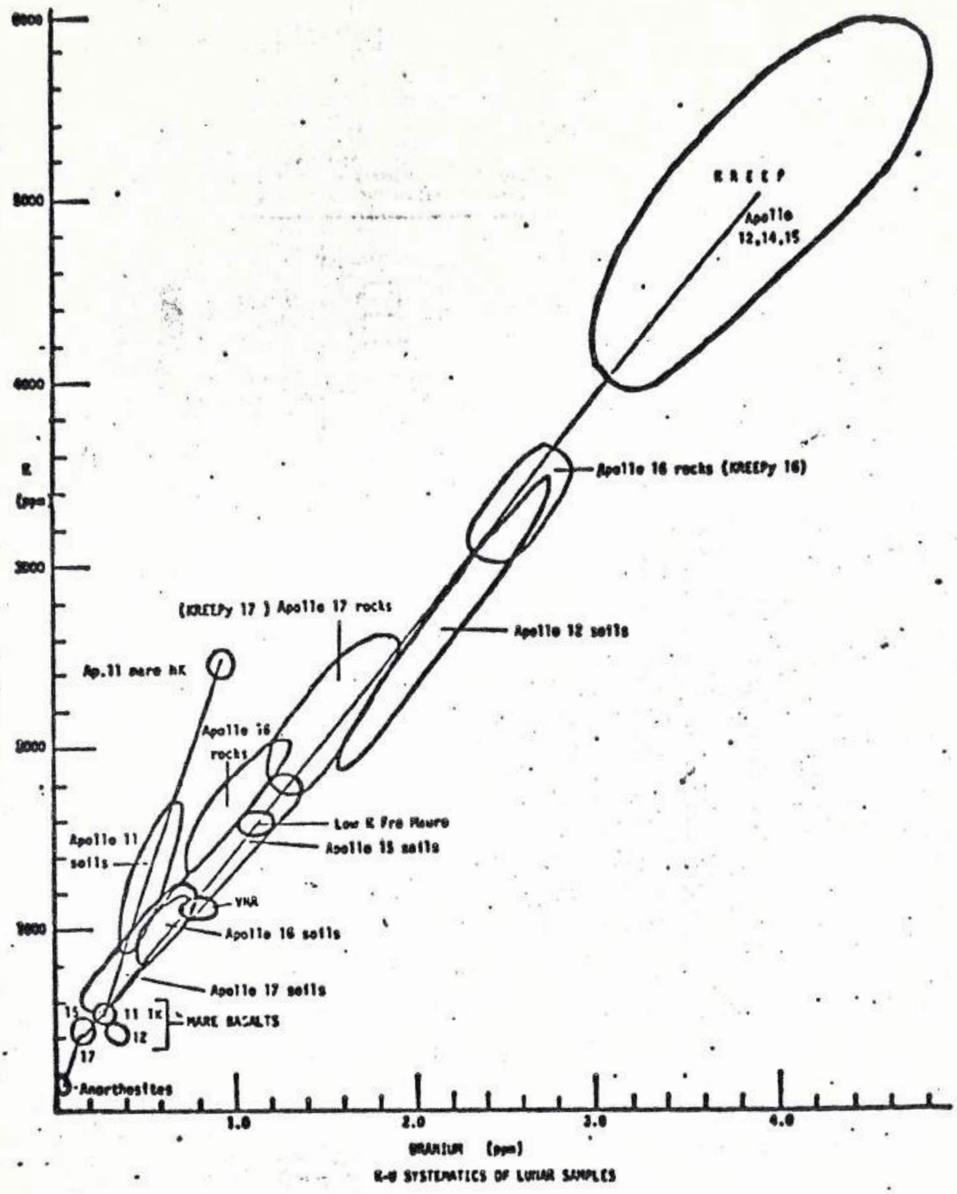


Potassium–uranium systematics for lunar, chondritic, achondritic, and terrestrial samples.

(Surkov, et al - 1973)

and lunar rocks suggest that the "lherzolite" zone being representative of the earth's mantle is also representative of primary lunar matter. They also note that since the lunar rocks are differentiated relative to the lunar mantle, the primary undifferentiated lunar material must then have lower K and U contents than surface materials. This supports Fanale and Nash. In addition, the Soviets note that K/U variations for lunar basalts and anorthosites are so small that their parent rocks should contain K/U ratios similar to them. They conclude that an achondritic composition of proto-planets of the solar system is likely.

Figure 4



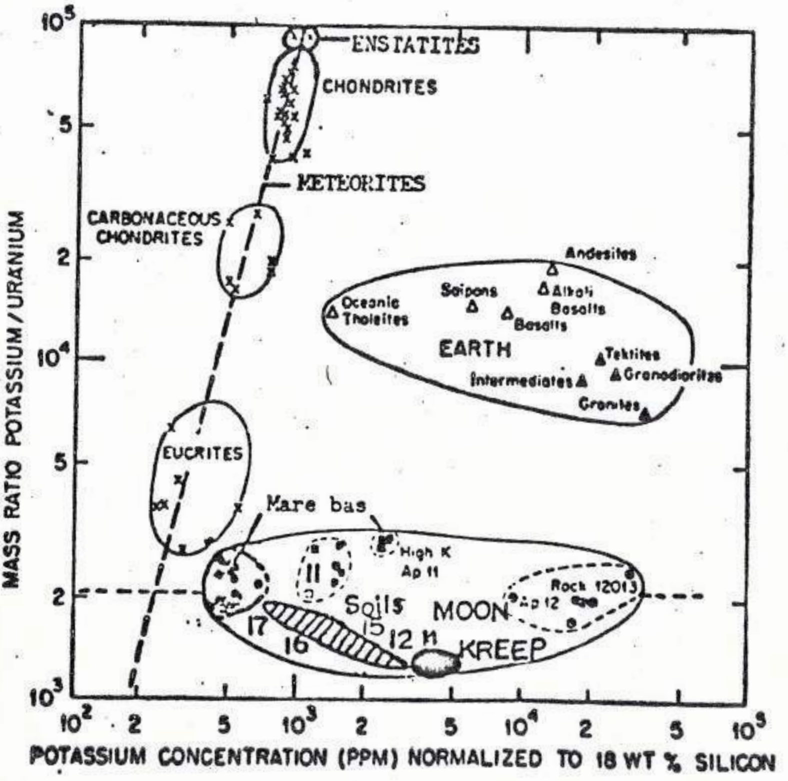
(Schonfeld - 1974)

With the completion of Apollo 16 and 17 missions, new K-U data became available. Schonfeld (1974) briefly reviewed the K/U systematics and observed that the majority of the soils and breccias follow a K/U trend line (on an arithmetic plot) between the mare basalts and the more differentiated material of the KREEP type. (See Figure 4) He concluded that this suggests simple mixing between those two components. This is contrary to Fanale and Nash (1971).

There are problems, he believes, with a number of new rock types (Apollo 16 and 17 samples) since they have K/U ratios similar to KREEP material, yet fall on his trend line. Therefore, based only on the K-U systematics, he feels that it is difficult to determine the component abundance in the lunar soils and that a multicomponent and multicomponent and multielement mixing model analysis is required. However, this does not negate the systematic trends thus far developed and Schonfeld did not confront the significance of these previously determined trends.

He does, however, consider K-U concentrations of value in considering the upper mantle of the moon. In Figure 5, Schonfeld suggests that the

Figure 5



(Schonfeld - 1974)

intersection of the meteoritic trend line and the "constant K/U line for the moon" indicates the K and U concentrations for the moon's upper mantle (in the areas of the moon where the lunar samples were derived). The uranium concentration agrees with U concentration estimated for the moon from heat flow experiments at Apollo 15 and 17 (Langseth, et al, 1973). The somewhat artificial uranium values derived do not seem applicable to the problem of K-U relationships along the lines of earlier work, as previously considered. Furthermore, a detailed compilation of available data and a graphical review has not been published. Since the approach has not been discredited, such an effort is attempted here.

SYNTHESIS OF POTASSIUM - URANIUM SYSTEMATICS

All available K-U data was collected for replotting the systematics. Of special interest was the lack of previous consideration of detailed trends from each Apollo and Luna site, especially with regard to rock-type and physical size of the samples analyzed (crystalline, breccia, fines, etc.)and their overall trend with respect to earth and meteoritic data. The data have been assembled in the Appendix; the source for each table has been appropriately cited for later review.

Sampling

Although mixing of the lunar regolith is probable, as a result of widespread impact phenomena, individual sample analysis of soils (fines) would nevertheless give an approximation of in situ K and U values from some location on the lunar surface. This, of course, suggests that horizontal layering of lunar dust at any one site may be generally representative of a rock type found somewhere on the lunar surface, and may not necessarily be representative of material found in subcrop at the sampling site.

Vertical variations, depending upon the sample location, would be expected since ejecta layering would represent materials of different composition as a result of scattering from different impact sites. Thickness of each ejecta layer would conceivably depend on the relative proximity to the impact point or points of the colliding body. Where single event layering of ejecta is thin, any subsequent addition of material from later blanketing may tend to produce diluted K and U values, assuming mixing of significant very fine meteoritic or other nonlunar material with previous ejecta.

Sample analyses of K and U have, in most cases, been reproduced within acceptable ranges, usually ± 1% (Reed and Jovanovich - 1971). The resultant data is therefore presumed to be reliable. Thorium analyses, also included in the Appendix, provided a check on the reliability of the uranium analyses (Clark and Keith, 1973, p. 210).

Figure 6 is a log-log plot (here) of all appropriate data in the Appendix. Each Apollo and Luna analysis is indicated according to the respective lunar mission during which the samples were obtained. (See Map Pocket)

The new Soviet data and data on other earth rocks have been included (Fisher, 1970; Green, et al (1968), etc.)

Five observations can be made with respect to Figure 6:

1) An apparent K-U lunar trend (or "corridor") with respect to the earth's basaltic trend.

2) An apparent K-U lunar trend toward an achondritic K-U composition and away from an earth-mantle K-U composition ("J trend").

3) An apparent K-U "threshold" at a uranium value of 0.1 ppm (K values range from ∼0.04% to 0.06%.)

4) An apparent "shift" of values in the lower K and U range (below 0.05% K and 0.1 U ppm).

5) An apparent overlap of the lunar K-U trend and the earth's "harzburgite trend".

Lunar K-U "Corridor"

The overall trend of lunar K-U analyses is parallel to earth rocks of basaltic and granitic K-U character, with only 4 lunar samples falling near the range of earth tholeiitic basalts.

Two opposing interpretations seem possible. The first is that the lunar samples represent a typically lunar differentiation trend as opposed to that of an earth differentiation trend or model.

The second interpretation requires that the lunar surface material has been subjected to some "diagenetic" differentiation or other process that systematically removes or alters potassium and adds uranium, together resulting in a depressed K-U trend. Cosmic particle bombardment may be able to alter or destroy potassium but it is doubtful if the bombardment could add uranium. The former interpretation is favored.

Individual Apollo sites produce K-U trends that are generally unique. Apollo 16, for example, shows a trend with a character considerably different than that of Apollo 11. This, plus the other Apollo trend variations, probably reflect subtle differences in differentiation at various locations on the moon, which would be expected.

Lunar K-U "J Trend", K-U "Threshold" and K-U "Shift"

The lunar "corridor" trend changes slope near the lower end (in the 0.2 - 0.3 ppm uranium region), and terminates abruptly at the 0.1 ppm uranium (0.04 to 0.06% K region).

The "J" trend is toward the calcium-rich achondrite's upper limit. It also trends away from the lherzolite field of earth rocks. One interpretation of the "J" trend is that the moon had a very different differentiation history than the earth, beginning with achondritic material. This is supported in part by the interpretation preferred for the K-U "corridor". If it were similar to the earth, the "J" trend would be expected to be toward the lherzolite field.

However, the K-U "threshold" at the 0.1 uranium level combined with the abrupt shift of K-U values below the 0.1 uranium level suggests the possibility of partial melting of lherzolite-peridotite-type material at depth with a delay of the differentiation process of the lunar mantle relative to the earth for an unknown period of time, after which lunar differentiation progressed although along a trend parallel to that of the earth. Apollo 16 illustrates this trend with some clarity.

There is also some evidence that lunar differentiation, after once begun, was rapid relative to the earth because of total volume differences between the two bodies. Only a few Apollo samples show characteristics similar to granitic material. This conclusion is, however, highly speculative since sampling of the moon is presently far from representative of the lunar surface and subsurface.

A similar shift through a peridotite field, although over a wider range than the lunar range, can be demonstrated for the earth materials shown in Figure 6, also at about the 0.1 uranium level, i.e. lherzolite-peridotite to tholeiitic basalt. The harzburgite field is considered a differentiation product of the lherzolite field, also showing some delay of differentiation relative to tholeiitic basalts. The possibility also arises by extrapolating from apparent lunar processes that the alkali basalt field may be a partial-melting product of the harzburgite field as well as a differentiation product of the tholeiitic basalt field, although intermediate rocks are presently unknown for the former.

Lunar-Earth Upper Mantles

If the partial-melting phenomenon postulated for the lunar "K-U Threshold" and the "K-U Shift" is essentially correct, an achondritic original lunar mantle material is not possible, nor is chondritic material. A proto-lunar body originating with considerably less than 0.001 ppm uranium but slightly less than 0.1% potassium is indicated from the K-U data. Therefore, the K-U values to the left of the K-U "threshold" (Figure 6) may in fact represent original undifferentiated lunar material. The K-U values for the earth in the lherzolite and dunite fields appear to represent an already partially differentiated body, a product of an undifferentiated body with an original compositional make-up of very different character than that of the moon.

However, since the number of samples in the lower K value area is less than that desired for a firm conclusion, a second interpretation of the area may be made with only somewhat less confidence that held for the first interpretation. This alternative appears to fit better with prevailing interpretations on a simultaneous lunar - earth origin.

The question arises: What is the significance of the lunar sample - earth lherzolite field overlap? Assuming the trend of lunar analyses in the 0.01 K range is fortuitous (interpreted above as a significant trend), except for the overlap in or near the lherzolite field, the possibility arises that lunar and earth mantle material are indeed similar and both mantles underwent partial melting at about the same stage in their development but that the lunar mantle did not begin to differentiate for some period after the earth's upper mantle began to differentiate along the tholeiitic basalt and harzburgite trends. It also appears that partial melting of the lunar mantle may have begun earlier than the earth as indicated by the 0.1 uranium lunar "threshold" and the higher, though less apparent, uranium value for the lherzolite-tholeiitic basalt "shift". Sampling inadequacies, however, require that this conclusion be very tentative, until additional samples of the lherzolite field have been obtained.

Chondrites and Achondrites

The origins of chondrites and achondrites have been considered along many avenues of approach. The use of K-U systematics apparently has not previously shown any direct line toward an acceptable hypothesis or theory.

However, assuming the previously developed partial melting and differentiation models are appropriate, K-U systematics may now also shed some light on the histories of chondrites and achondrites.

First, Figure 6 shows that the partial-melting phenomenon postulated for the lherzolite field - tholeiitic basalt field transition incorporates a one order of magnitude shift upward in potassium values; the same magnitude is indicated for the harzburgite field - alkali basalt shift (assuming this indeed is real). Secondly, the lunar shift is not quite an order of magnitude. However, since the lunar mantle did not apparently begin to differentiate for some period after its shift, it is assumed that some restraint or limiting phenomenon prevented the full order of magnitude shift to a "normal" earth trend and would have otherwise made the shift.

By applying this same approach to the chondrites, K-U values also demonstrate a one order of magnitude shift from the dunite field to the chondrite field. In this case, complete differentiation of the available material may have taken place almost immediately, a process expected when a large planetary body, having earth-type ("normal") mantle material (dunitic and other material), either explodes or collides with another body of sufficient size to cause total break-up of that body. Therefore, a partially differentiated dunitic material that undergoes instantaneous break-up, may partially melt to form chondritic material which instantly thereafter then undergoes complete differentiation or is the end product of a unique type of instaneous partial melting of dunitic material.

In considering achondrites along this same line of approach, their K-U trend is conspiculously along that of the earth's differentiation trend, also conspicuously paralleling that of the lherzolite differentiation trend and ending very near the lherzolite-tholeiitic basalt transition shift. The possibility then arises as to whether lherzolite-type material, having been subjected to a break-up history similar to dunitic material, undergoes partial-melting under similarly unique conditions to form achondritic type material. The K-U compositional limits of a lherzolite-type field may limit the K-U compositional limits of achondritic material. Therefore, the achondritic material may represent partial-melting products of a differentiating lherzolite-type body, any one point on the achondritic trend is the end product of partial melting of lherzolite-type material, the former not having the geochemical character of basaltic material until the lherzolite-type material reaches a differentiation stage chemically compatible with the shift to definative basaltic composition. conveniently at about the previously mentioned 0.1 uranium stage. However, earth mantle material would not be expected to contain achondritic material nor chondritic material, unless the earth were to break-up, thereby instantaneously creating achondritic material from the lherzolites (and chondrites from the earth's dunites). The implications of the proximity of the achondrite trend's upper termination, with respect to the lunar "threshold," may therefore be fortuitous.

In the above considerations it was assumed that the period during which the meteoritic material was formed was at the time of break-up. However, this is not necessary and somewhat difficult to establish. Another possibility arises if it is assumed that meteors are earth-type planetary fragments of dunitic and lherzolitic (perhaps granitic) material before reaching the earth's atmosphere and which undergo partial-melting as they travel at increasingly refractory speeds through the atmosphere or impacting the earth. A similar history for other more differentiated materials is considered feasible although data were not available for plotting during this investigation. Tektites may, however, represent originally basaltic material on the basis of their common occurrence and the relative abundance of basalt-type material over granitic material in the earth's crust.

Dunite-Lherzolite Transition

Based on K-U data, dunite does not appear to differentiate to other products in any manner similar to other earth trends, although it does occupy an isolated position along the lower end of the "normal" earth trend, slightly overlapping the lherzolite field. The process involved in the postulated partial-melting to chondrites is the only phenomenon indicated from K-U data for such transition, and that is accomplished under unique extraterrestrial physio-chemical conditions, although other transitions must be possible in the earth.

One interpretation, although without significant supporting data, is that dunites and lherzolites are coexisting mineralogical phases in the upper mantle of the earth. Dunites may only be transitional to lherzolites up to a specific stage (e.g. 0.01 K - 0.01 U level), after which dunite becomes a subordinate phase in the lherzolite field, controlled by even very minor concentrations of excess silica according to the well known phase relationships. It would be surmised that given adequate data, lherzolites would show increasing silica with increasing potassium and uranium along the trend of the lherzolite field. The two may also represent two zones (perhaps overlapping) below ridge areas of oceanic plates, with the lherzolites overlying the dunites. This is inferred from the Figure 6 K-U data, i.e. dunite as a less differentiated phase than the lherzolites.

Tholeiitic Basalt - Alkali Basalt Transition

By extending the postulated "shift" phenomenon to the earth's basaltic trend, it seems possible that the tholeiitic basalts do not differentiate to alkali basalts on a large scale but may instead, via partial-melting, produce granitic material in a 6% K - o.6 U field, while the alkali basalts, being essentially partial-melt products of the harzburgite field, may differentiate to syenitic material. The two granitoid fields, however, would be expected to be rather diffuse since degassing, pegmatitic injections, metamorphism, etc., may considerably alter K-U systematics. Further work along these lines appears fruitful.

Future Research

Considerable emphasis should now be placed on the lunar samples plotting near the K-U "threshold", both in the range between 0.1 and below. The relative ages of these samples may show a rather wide gap since the pre-"threshold" samples should be appreciably older than post-"threshold" samples. Ages of the 0.1 to 0.4 ppm uranium range should also show a significant age difference, although perhaps not within present age dating resolution limits.

Other elemental systematics should be considered in view of the interpretations generated from K-U systematics.

Additional work is also needed on the K-U systematics in context with plate tectonics, since the dunite and lherzolite fields are of considerable significance in lunar-earth investigations on their origins.

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APPENDIX

Supporting Bibliography

and

K-U Data

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Table 7-2. Minor and Trace Elements in Apollo 11 Crystalline Rocks, Showing Quantization between Fine-grained (A) and Medium-grained (B) Types

Rock Number	K	Rb	Zr	Ba	Ce	Th	U	Type
17	2610	5.6	476	308	77	3.4	0.85	A
22	2290	5.6	450	277	75	—	0.80	A
24	2400	6.0	375	310	108	4.1	—	B
49	2730	6.2	—	338	84	—	0.74	A
57	2100	5.2	635	280	75	3.4	0.87	A
69	2300	5.6	566	300	65	—	0.78	A
71	2770	5.9	644	327	84	3.4	0.87	A
72	2300	5.7	497	300	80	3.3	0.88	A
03	470	0.5	340	108	45	1.0	0.27	B
20	490	0.6	360	80	26	0.7	0.20	A
44	820	1.2	280	95	42	1.0	0.33	B
45	420	0.6	194	90	23	0.9	0.26	B
47	900	1.2	334	88	48	0.6	0.26	B
50	530	0.7	—	60	34	0.5	0.16	B
58	880	1.0	380	120	40	1.1	0.20	B
62	630	0.9	319	80	43	0.9	0.27	B

(Mason and Melson, 1970)

Table 3. Minor and trace elements in igneous rocks (ppm)

	"Basalts"					"Microgabbros"				Range in error esti-mates
	10022	10069	10024	10071	10003	10047	10058	10062	10050	
Na	3550	3650	3620	3640	2700	3490	3020	3140	2630	50–70
Ba	220	250	170	450	220	—	140	230	—	50–80
La	25·9	23·7	23·0	25·8	13·5	11·3	11·8	13·1	7·2	0·3–0·5
Ce	81	65	76	84	37	46	39	38	34	2–3
Sm	20·3	18·0	19·2	20·0	13·0	18·9	14·0	11·9	11·8	0·2–0·3
Eu	2·15	2·04	—	2·12	1·84	2·71	2·14	2·07	2·0	0·08–0·2
Tb	5·7	4·8	—	5·7	3·5	4·1	3·5	3·3	2·1	0·2–0·6
Ho	8·2	6·9	8·1	9·2	4·0	7·9	5·5	4·4	4·6	0·4–0·9
Yb	21	20·8	19·6	20·8	15·3	18·2	14·0	13·5	11·1	0·5–3
Lu	2·69	2·67	3·20	3·08	2·62	2·88	1·94	1·94	1·96	0·05–0·12
U	0·67	0·78	0·67	0·69	0·31	0·16	0·18	0·27	0·21	0·04–0·10
Zr	130	520	650	210	560	—	190	290	—	80–160
Hf	19·6	17·8	20·0	19·1	11·6	13·2	11·2	11·8	8·6	0·3–1·0
Ta	1·8	2·7	2·4	2·0	—	2·6	1·6	1·0	2·2	0·3–0·5
Mn	1770	1600	1640	1650	1740	2100	1870	1790	1990	100–120
Cu	—	12	—	11	—	—	—	—	—	2
Co	29·8	26·0	28·4	27·1	14·1	12·2	14·4	13·8	13·6	0·4–0·7
Sc	76·6	72·4	76·2	73·2	74·0	92·0	80·8	74·7	88·9	0·8–1·1
V	89	87	84	92	63	63	78	75	117	6–10
Cr	2250	2130	2290	2170	1390	1250	1800	1540	2120	30–100

(Goles, et al, 1970)

Table 4. Minor and trace elements in breccias (ppm)

	10018	10019	10021	10048	10056	10059	10060	10061	10063	10064	10065	10066	10067	10068	10070	10073	10074	10075	Range in error estimates
Na	3720	3530	3430	3490	3370	3590	3630	3550	3380	3650	3600	3420	3590	3280	3740	3220	3750	3350	60–180
Ba	280	—	350	200	240	—	—	260	—	290	220	—	—	150	310	—	280	430	50–100
La	16·9	15·5	17·5	17·3	11·0	18·1	17·7	16·8	16·7	19·6	17·8	17·4	20·1	16·4	17·3	12·8	13·8	14·9	0·3–0·4
Ce	64	54	61	38·1	34	59	61	48·6	—	59	63	62	68	60	56	48	55	50	1·7–5
Sm	14·6	12·7	15·0	13·2	17·8	15·1	15·4	13·2	12·9	15·5	14·6	15·1	16·7	14·4	13·1	11·5	11·5	11·5	0·2–0·3
Eu	1·82	1·78	1·80	1·91	2·63	1·78	1·84	1·78	1·83	1·77	1·73	1·70	2·4	1·80	1·74	1·60	1·73	1·62	0·07–0·2
Tb	3·6	—	4·2	3·8	5·0	3·7	3·7	3·4	—	3·7	4·0	2·8	3·1	3·6	3·1	—	2·8	3·1	0·3–0·5
Ho	5·3	5·0	6·9	4·6	6·5	5·5	5·3	3·7	4·7	5·5	6·7	6·5	7·5	6·6	5·8	5·0	5·0	5·4	0·4–0·8
Yb	15·2	11·7	14·5	15·2	18·0	12·5	13·2	13·1	11·0	14·8	14·5	11·8	13·8	12·2	14	7·2	12	11·2	0·4–1·5
Lu	2·14	1·84	2·25	1·90	2·5	1·97	2·30	1·94	1·76	2·46	2·01	1·90	2·20	2·6	1·80	1·76	1·7	1·89	0·06–0·15
U	0·60	0·49	0·56	0·69	0·18	0·52	0·51	0·59	0·51	0·65	0·54	0·56	0·54	0·61	0·62	0·45	0·49	0·52	0·05–0·08
Zr	340	580	250	240	340	—	770	240	490	520	—	—	—	700	360	—	500	390	70–180
Hf	12·9	10·8	12·2	14·5	13·8	11·5	12·1	13·1	13·1	13·9	12·1	10·6	15·4	11·0	12·8	8·9	11·9	8·8	0·3–0·5
Ta	1·4	1·7	1·6	1·9	1·6	1·6	2·1	—	—	1·7	2·1	2·1	2·1	1·8	1·0	1·6	1·0	1·4	0·3–0·4
Mn	1590	1510	1560	1560	1970	1440	1650	1450	1620	1600	1540	1590	1820	1470	1520	1580	1420	1540	80–110
Cu	—	—	—	—	—	—	—	—	16	—	—	—	—	15	12	14	10	10	2
Co	32·7	34·5	30·7	32·2	11·9	34·0	31·6	33·7	35·2	29·0	31·6	33·8	35·9	31·7	37·3	31·1	30·9	28·7	0·4–0·9
Sc	60·3	60·9	61·8	62·7	91·6	61·1	64·0	59·6	62·2	60·5	62·6	60·3	66·0	60·9	57·4	62·0	53·7	56·8	0·6–1·6
V	67	63	73	67	47	64	58	80	90	73	84	59	71	46	82	82	78	85	6–17
Cr	1880	1870	1950	1950	1280	1900	1880	1930	1940	1850	1890	1910	2040	1890	1860	1900	1770	1790	50–80

(Goles, et al, 1970)

TABLE 5–VI. *Summary of gamma-ray analyses of lunar samples*[a]

	10057	10072	10003	10017	10018	10019	10021	10002
Weight, g	897	[b]399	[b]213	971	[b]213	[b]245	[b]216	302
Classification	A	A	B	B	C	C	C	D
Potassium,[c] weight percent	0.242±0.036	0.232±0.035	0.050±0.008	0.227±0.0034	0.144±0.022	0.12±0.02	0.120±0.018	0.11±0.02
Thorium, ppm	3.4±0.7	2.9±0.4	0.95±0.14	2.9±0.4	2.3±0.3	1.9±0.3	1.8±0.3	1.6±0.3
Uranium, ppm	0.78±0.16	0.75±0.11	0.20±0.03	0.70±0.10	0.60±0.09	0.43±0.06	0.39±0.06	0.46±0.10
^{26}Al, dpm/kg	77±16	70±15	69±14	66±13	100±20	98±20	81±16	97±19
^{22}Na, dpm/kg	44±9	42±9	41±8	34±7	55±11	47±10	41±8	±9
^{44}Ti, dpm/kg	[d]TI	TI	—	—	—	—	—	TI
^{46}Sc, dpm/kg	10±3	13±4	13±3	11±3	13±4	10±4	10±4	9±3
^{48}V, dpm/kg	—	—	[d]TI	[d]TI	—	—	—	—
^{52}Mn, dpm/kg	—	—	39±18	—	—	—	36±20	—
^{54}Mn, dpm/kg	40±13	20±8	28±5	38±13	28±14	27±10	15±7	28±9
^{56}Co, dpm/kg	30±12	30±10	38±6	18±6	33±11	35±11	38±13	27±10
^{7}Be, dpm/kg	TI	—	TI	TI	—	—	—	TI

[a] Values for short-lived nuclides have been corrected for decay to 00:00 hr c.d.t., July 21, 1969.

[b] Weight uncertain; see text.

[c] Potassium determined by assaying ^{40}K and assuming terrestrial isotopic ratios for potassium.

[d] Tentatively identified.

(LSPET, 1969)

Table 1. Abundances of major and trace elements in lunar fines 10084,141 and mineral fractions. Comparison with the reported values (in ppm except for those noted by %)

Element	10084,141	feldspar	ilmenite (?)	clinopyroxene	glass red brown	glass green	fraction			Reported values (10084)
							11.7	11.8	11.9	
Na (%)	0.28	0.55	0.31	0.11	0.38	0.23	0.30	0.37	0.33	0.33[a]
Mg (%)	5.4	2.5	4.3	6.7	5.6	3.9	4.2	5.7	5.5	4.73[a]
Al (%)	7.5	17.2	4.6	2.4	11.2	9.3	7.5	8.3	6.6	7.13[a]
Si (%)	(23)	(24)	(28)	(37)		(19)	(20)	(16)	(20)	19.53[a]
K (%)	0.11	< 0.06		0.07			0.14	0.13	0.14	0.1107[a]
Ca (%)	7.8	11.7	7.3	8.3		10.5	8.0	8.3	8.0	8.40[a]
Sc	60	10.1	123	133	90	67	63	63	74	61.4[a]
Ti (%)	4.6 4.2*	0.5	9.6	2.6	5.8	3.8	4.4	4.4	5.4	4.36[a]
V	77	18	107	97	154	86	74	78	86	63[b]
Cr (%)	0.18	0.044	0.27	0.27	0.33	0.18	0.22	0.21	0.27	0.2005[a]
Mn (%)	0.16	0.046	0.21	0.23	0.18	0.15	0.16	0.16	0.19	0.1603[a]
Fe (%)	11.2 10.9*	2.8	16.8	14.5	15.0	12.7	11.7	12.1	12.7	12.34[a]
Co	28	8.5	24	22	115	32	35	32	23.4	29.2[a]
Ni	200							< 250	250	229[a]
Sr	230*						< 380	< 300	< 250	162[a]
Y	85*									96[b]
Zr	340 340*			400			190	380	410	380[c]
Cs	< 0.2			< 1			< 0.3	< 0.3	< 0.3	0.122[a]
Ba	160	210		230		180	350	220	180	167[a]
La	20.4	16.4	15.7	12.2	78	113	21	21	20	17.2[a]
Ce	53	47		30		47	51	52	53	49.4[a]
Nd	48	45								40.5[a]
Sm	12.1	7.1	19.5	11.2	19.2	11.1	11.9	13.4	13.9	13.5[a]
Eu	1.8	1.8	2.3	1.2	2.2	2.7	1.7	1.9	1.7	1.84[a]
Gd	18						17	17	17	17.6[a]
Tb	2.9	1.4	11.8	3.3		2.4	3.1	3.5	3.4	3.14[a]
Dy	22	9	28	20	27	18	19	18.5	21.3	20.1[a]
Ho	4.3	2.1	5.0	3.3		4.6	3.5	5.5	3.8	5.03[a]
Tm	1.9	1.3	9.3	4.6			2.9	2.2	2.3	1.8[b]
Yb	10.1	5.0	18.3	11.2		8.2	12.9	12.0	12.8	10.9[a]
Lu	1.44	0.56	2.2	1.65		1.05	1.4	1.6	1.5	1.49[a]
Hf	9.2	5.0	11.0	5.5		6.5	7.9	9.3	10.2	10.0[a]
Ta	1.16			1.25			1.3	1.3	1.2	1.40[a]
W	< 2	< 6	< 10	27.5		24	< 4	< 1.6	< 1.4	0.235[a]
Ir	0.0045							< 0.03	< 0.02	0.00688[d]
Au	< 0.02	< 0.04	< 0.08	0.25		0.65	0.3	< 0.02	< 0.02	0.00275[a]
Th	1.9	1.7		< 1.5			1.2	2.0	1.7	2.35[a]
U							1.4	1.5	2.1	0.37[a]
Weight of sample milligram	1.490 98.762†	1.216	0.108	0.279	0.015	0.153	3.326	7.797	15.072	

The values in parentheses are semiquantitative only.

* Values obtained by the nondispersive X-ray fluorescence analysis.

† For 20 hours irradiation only.

[a] WÄNKE *et al.* (1970).

[b] WAKITA *et al.* (1970).

[c] TUREKIAN and KHARKAR (1970).

[d] KEAYS *et al.* (1970).

(Vobecky, et al, 1971)

Table 5. Gamma-ray analyses of lunar samples.

Sample	Weight (g)	K (wt %)	Th (ppm)	U (ppm)	^{26}Al (dpm/kg)	^{22}Na (dpm/kg)	Other radionuclides detected	Remarks
12002	1530	0.044 ± 0.004	0.96 ± 0.1	0.24 ± 0.033	72 ± 14	53 ± 10	^{54}Mn, ^{52}Mn, ^{56}Co, ^{46}Sc, ^{48}V	Crystalline rock
12004	502	0.048 ± 0.004	0.88 ± 0.09	0.25 ± 0.033	112 ± 22	65 ± 13	^{54}Mn, ^{56}Co, ^{46}Sc, ^{48}V	Crystalline rock
12039	255	0.060 ± 0.005	1.20 ± 0.12	0.31 ± 0.040	80 ± 16	45 ± 9	^{56}Co, ^{54}Mn	Crystalline rock
12053	879	0.051 ± 0.004	0.89 ± 0.09	0.25 ± 0.033	85 ± 17	42 ± 9	^{56}Co, ^{48}V, ^{46}Sc, ^{54}Mn	Crystalline rock
12054	687	0.052 ± 0.004	0.77 ± 0.08	0.21 ± 0.030	50 ± 11	42 ± 9	^{48}V, ^{56}Co, ^{54}Mn, ^{46}Sc	Crystalline rock
12062	730	0.052 ± 0.004	0.81 ± 0.08	0.21 ± 0.030	65 ± 13	34 ± 7	^{48}V, ^{56}Co, ^{54}Mn, ^{46}Sc	Crystalline rock
12064	1205	0.053 ± 0.004	0.88 ± 0.09	0.24 ± 0.035	58 ± 12	44 ± 9	^{56}Co, ^{46}Sc, ^{48}V, ^{54}Mn	Crystalline rock
				Miscellaneous samples				
12034	154	0.44 ± 0.035	13.2 ± 1.3	3.4 ± 0.4	58 ± 12	27 ± 6	^{54}Mn	Breccia
12073	405	0.278 ± 0.022	8.2 ± 0.8	2.0 ± 0.3	125 ± 25	60 ± 12	^{56}Co, ^{54}Mn, ^{46}Sc	Breccia
12070	354	0.206 ± 0.016	6.0 ± 0.6	1.5 ± 0.2	140 ± 25	65 ± 13	^{56}Co, ^{48}V, ^{46}Sc, ^{54}Mn	Fines
12013	80	2.02 ± 0.016	34.3 ± 3.4	10.7 ± 1.6				Feldspathic differentiate

(LSPET, 1970)

Table 2. Abundances of major and trace elements in lunar fines 12070,83 mineral and glass fractions (in ppm except for those noted by %).

				glass particles					fractions						
Element	12070,83	olivine (?)	pyroxene	dark violet	black opaque	green	dark brown	black opaque (slag)	12-8	12-5	12-6	12-7	12-13	12-14	Element
Na (%)	0.29	0.41	0.10	0.09	0.30		0.19	0.25		0.34	0.40	0.29	0.35	0.32	Na (%)
Mg (%)	6.6	7.4	6.4	7.0	5.6	6.7	5.1	6.2	<3	5.2	5.6	6.2	7.0	7.0	Mg (%)
Al (%)	7.1	6.1	2.1	6.6	6.6	13.8	8.3	5.9	9.2	7.2	7.6	7.2	6.9	6.9	Al (%)
Si (%)	(19)	(28)	(21)		(38)		(27)	(37)		(21)	(29)	(25)	(23)	(22)	Si (%)
K (%)	0.20	1.65	0.06	0.05	0.23		0.42	0.28	<2	0.22	0.27	0.53	0.24	0.21	K (%)
Ca (%)	6.8	4.5	6.2	7.3	4.2		8.5			6.9	6.9	3.0	6.8	7.1	Ca (%)
Sc	43	24	70	47	45	25	48	34	<40	38	38	41	44	48	Sc
Ti (%)	1.74 1.7*	0.5	1.5	2.5	1.8		1.0	1.8	1.5	1.8	1.8	1.6	1.6	1.6	Ti (%)
V	129	72	220	140	120	100	115	130	74		112	150	130	135	V
Cr (%)	0.27	0.16	0.32	0.24	0.31	0.20	0.35	0.24	0.16	0.32	0.24	0.27	0.26	0.29	Cr (%)
Mn (%)	0.18	0.13	0.22	0.18	0.14	0.06	0.08	0.15	0.12	0.17	0.16	0.18	0.19	0.18	Mn (%)
Fe (%)	13.4 13.6*	9.5	14.6	13.3	12.9		12.8	11.5	<10	12.1	11.4	12.6	12.2	13.5	Fe (%)
Co	46	39	35	62	53	<100	80	39		57	41	134	35	52	Co
Ni	200	<400								<300	340		<200	<200	Ni
Sr	170*	<500								<430	<200	<470	<200	<200	Sr
Y	97*														
Zr	680 605*	<300								460	740	530	740	590	Zr
Cs		2.2								<0.4	<0.6	<0.6	<0.2	(0.25)	Cs
Ba	390	1000		1000	6200		1000	700	5000	410	650	490	400	370	Ba
La	45	50	28	32	36		70	32	210	45	45	21	49	43	La
Ce	103	112		93	94		172	67		109	114	85	111	93	Ce
Nd	60	<40								<60	80	40			Nd
Sm	13.9	11.0	9.2	16.7	18.4		30	14.3	42	19.4	19.7	14.8	18.1	15.8	Sm
Eu	1.9	1.2	0.8	2.1	2.2		2.8	1.7	14	1.8	2.2	1.6	1.5	1.7	Eu
Gd	23	17								22	19		24	26	Gd
Tb	3.6	3.9		5.5			12.1	4.6		4.6	4.4	3.4	4.4	3.7	Tb
Dy	22.5	21.4	13.4	27	22.0	8.0	35	27	96	28	25	23.7	26	21.3	Dy
Ho	4.4	5.2	11.9	4.9	5.5		4.3	3.8	23	5.3	5.9	4.7		3.8	Ho
Tm	2.7	5.2						9.0		3.1	3.2	2.6	2.9	2.6	Tm
Yb	12.9	25	8.8	13.1	13.2	6	23	16	140	14.3	14.0	11.4	15.8	13.0	Yb
Lu	1.7	3.4	1.1	2.1	1.9	0.7	2.5	1.1	7.3	2.0	1.8	1.6	1.8	1.8	Lu
Hf	12.7	11.7	6.8	11.6	13.3		13.8	10.8		13.1	13.6	12.1	14.6	14.3	Hf
Ta	1.4	5.0								1.3	1.9	1.1	1.6	1.8	Ta
W		<2	<2	<5	<5		<6	<5		3.9	<6	<3	<4	4.2	W
Ir										<0.04		<0.04	<0.01	<0.01	Ir
Au	0.016	<0.01	<0.03	<0.04	<0.07		<0.07	<0.07		<0.04	<0.07	<0.04	<0.02	0.06	Au
Th	5.9	33		5.3	4.6		10.6	9.3		5.6	6.2	5.5	6.3	5.4	Th
U	2.3	9.0	0.7		3.2		4.6			2.4	2.6	2.5		2.8	U
Weight of sample milligram	7.614 100.315†	2.431	1.296	0.050	0.090	0.008	0.041	0.074	0.014	1.793	1.526	1.089	52.968	18.251	Weight of sample milligram

The values in parentheses are semiquantitative only.
*. Values obtained by the nondispersive X-ray fluorescence analysis.

† For 20 hours irradiation only.

(Vobecky, 1971)

Table. 1. Concentrations of primordial radionuclides in lunar samples*

Sample	Weight (g)	K (ppm)	Th (ppm)	U (ppm)	K/U Mass ratio	Th/U Mass ratio
Crystalline rocks						
12002,0	1529	450 ± 20	0.89 ± 0.06	0.23 ± 0.02	1960 ± 192	3.87 ± 0.42
12002,20	260	425 ± 21	0.73 ± 0.04	0.21 ± 0.02	2020 ± 216	3.50 ± 0.39
12002,30	46	440 ± 20	0.86 ± 0.06	0.22 ± 0.02	2000 ± 212	3.91 ± 0.45
12004,1	502	469 ± 33	0.92 ± 0.09	0.24 ± 0.03	1960 ± 282	3.83 ± 0.61
12021,0	1877	500 ± 50	0.98 ± 0.10	0.26 ± 0.03	1920 ± 292	3.77 ± 0.53
12039,0	255	673 ± 40	1.20 ± 0.06	0.31 ± 0.03	2170 ± 246	3.87 ± 0.42
12051,0	1660	530 ± 50	1.00 ± 0.10	0.26 ± 0.03	2040 ± 304	3.85 ± 0.59
12052,1	201	540 ± 20	1.03 ± 0.06	0.27 ± 0.02	2000 ± 166	3.82 ± 0.36
12053,0	879	535 ± 40	1.06 ± 0.11	0.28 ± 0.03	1910 ± 244	3.79 ± 0.57
12054,0	687	530 ± 35	0.79 ± 0.08	0.22 ± 0.03	2410 ± 365	3.59 ± 0.61
12062,0	739	510 ± 35	0.83 ± 0.09	0.22 ± 0.03	2320 ± 354	3.78 ± 0.66
12064,0	1214	520 ± 35	0.87 ± 0.09	0.23 ± 0.02	2260 ± 248	3.78 ± 0.51
12065,0	2109	510 ± 50	1.06 ± 0.11	0.27 ± 0.03	1890 ± 280	3.92 ± 0.54
Average, crystalline rocks					2066	3.79 ± 0.14
Breccia						
12034,0	155	4560 ± 130	13.1 ± 0.3	3.4 ± 0.2	1341 ± 88	3.85 ± 0.24
12073,0	405	2960 ± 90	8.45 ± 0.10	2.19 ± 0.08	1352 ± 68	3.86 ± 0.15
Fines						
12032,16	89.6	3100 ± 100	8.8 ± 0.2	2.35 ± 0.07	1320 ± 58	3.75 ± 0.14
12070,0	354	2030 ± 120	6.25 ± 0.50	1.65 ± 0.16	1230 ± 140	3.79 ± 0.48
Average, fines and breccia					1311	3.81 ± 0.14

* Standardization for assay of K, Th, and U assumed terrestrial isotopic abundances and equilibrium of Th and U decay series.

(O'Kelley, et al, 1971)

Table 2. Concentrations of K, Th, and U in lunar rock 12013.

Sample	Weight (g)	K (ppm)	Th (ppm)	U (ppm)	K/U Mass ratio	Th/U Mass ratio
12013,0*	80.0	20,400 ± 600	34.2 ± 0.8	10.3 ± 0.5	1980 ± 112	3.32 ± 0.18
12013,11*	66.2	21,100 ± 600	32.2 ± 1.4	9.8 ± 1.0	2160 ± 228	3.29 ± 0.36
12013,10 (dark)	—	~6500†		~5.7‡	~1100	3.7‡
12013,10 (light)	—	25,500§		~13.0‖	~2000	(2.3-3.2)‖

* Standardization for assay of K, Th, and U assumed terrestrial isotopic abundances and equilibrium of Th and U decay series.

† Average of analyses by Schnetzler *et al.* (1970), Hubbard *et al.* (1970) and Turner (1970).

‡ Estimated from Tatsumoto (1970).

§ Average of analyses by Alexander (1970), Schnetzler *et al.* (1970), Hubbard *et al.* (1970), Turner (1970), and Wakita and Schmitt (1970).

‖ Wakita and Schmitt (1970).

(O'Kelley, et al, 1971)

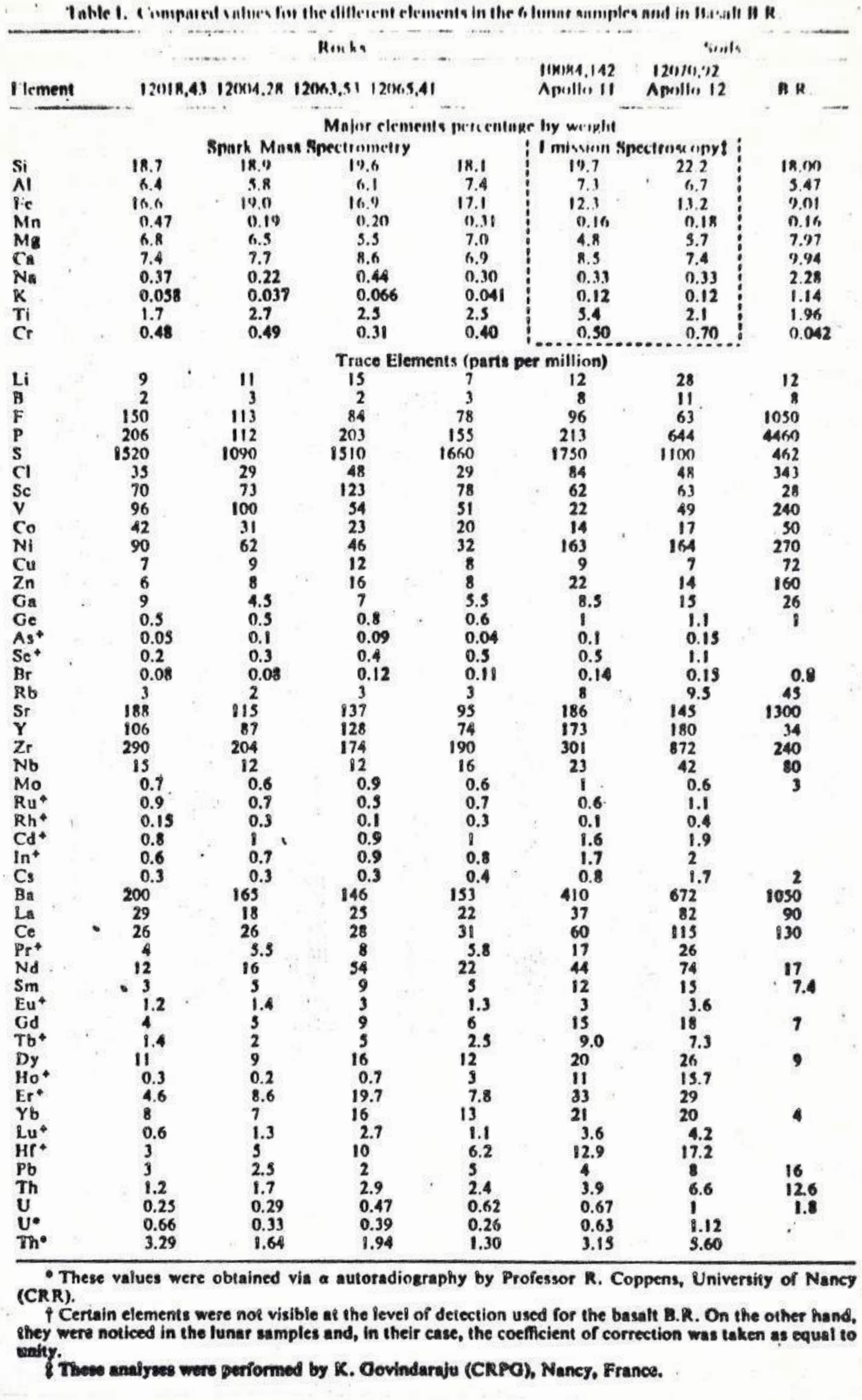


Table I. Compared values for the different elements in the 6 lunar samples and in Basalt B.R.

	Rocks				Soils		
Element	12018,43	12004,28	12063,51	12065,41	10084,142 Apollo 11	12070,92 Apollo 12	B.R.
			Major elements percentage by weight				
		Spark Mass Spectrometry			Emission Spectroscopy§		
Si	18.7	18.9	19.6	18.1	19.7	22.2	18.00
Al	6.4	5.8	6.1	7.4	7.3	6.7	5.47
Fe	16.6	19.0	16.9	17.1	12.3	13.2	9.01
Mn	0.47	0.19	0.20	0.31	0.16	0.18	0.16
Mg	6.8	6.5	5.5	7.0	4.8	5.7	7.97
Ca	7.4	7.7	8.6	6.9	8.5	7.4	9.94
Na	0.37	0.22	0.44	0.30	0.33	0.33	2.28
K	0.058	0.037	0.066	0.041	0.12	0.12	1.14
Ti	1.7	2.7	2.5	2.5	5.4	2.1	1.96
Cr	0.48	0.49	0.31	0.40	0.50	0.70	0.042
			Trace Elements (parts per million)				
Li	9	11	15	7	12	28	12
B	2	3	2	3	8	11	8
F	150	113	84	78	96	63	1050
P	206	112	203	155	213	644	4460
S	1520	1090	1510	1660	1750	1100	462
Cl	35	29	48	29	84	48	343
Sc	70	73	123	78	62	63	28
V	96	100	54	51	22	49	240
Co	42	31	23	20	14	17	50
Ni	90	62	46	32	163	164	270
Cu	7	9	12	8	9	7	72
Zn	6	8	16	8	22	14	160
Ga	9	4.5	7	5.5	8.5	15	26
Ge	0.5	0.5	0.8	0.6	1	1.1	1
As†	0.05	0.1	0.09	0.04	0.1	0.15	
Se†	0.2	0.3	0.4	0.5	0.5	1.1	
Br	0.08	0.08	0.12	0.11	0.14	0.15	0.8
Rb	3	2	3	3	8	9.5	45
Sr	188	115	137	95	186	145	1300
Y	106	87	128	74	173	180	34
Zr	290	204	174	190	301	872	240
Nb	15	12	12	16	23	42	80
Mo	0.7	0.6	0.9	0.6	1	0.6	3
Ru†	0.9	0.7	0.5	0.7	0.6	1.1	
Rh†	0.15	0.3	0.1	0.3	0.1	0.4	
Cd†	0.8	1	0.9	1	1.6	1.9	
In†	0.6	0.7	0.9	0.8	1.7	2	
Cs	0.3	0.3	0.3	0.4	0.8	1.7	2
Ba	200	165	146	153	410	672	1050
La	29	18	25	22	37	82	90
Ce	26	26	28	31	60	115	130
Pr†	4	5.5	8	5.8	17	26	
Nd	12	16	54	22	44	74	17
Sm	3	5	9	5	12	15	7.4
Eu†	1.2	1.4	3	1.3	3	3.6	
Gd	4	5	9	6	15	18	7
Tb†	1.4	2	5	2.5	9.0	7.3	
Dy	11	9	16	12	20	26	9
Ho†	0.3	0.2	0.7	3	11	15.7	
Er†	4.6	8.6	19.7	7.8	33	29	
Yb	8	7	16	13	21	20	4
Lu†	0.6	1.3	2.7	1.1	3.6	4.2	
Hf†	3	5	10	6.2	12.9	17.2	
Pb	3	2.5	2	5	4	8	16
Th	1.2	1.7	2.9	2.4	3.9	6.6	12.6
U	0.25	0.29	0.47	0.62	0.67	1	1.8
U*	0.66	0.33	0.39	0.26	0.63	1.12	
Th*	3.29	1.64	1.94	1.30	3.15	5.60	

* These values were obtained via α autoradiography by Professor R. Coppens, University of Nancy (CRR).

† Certain elements were not visible at the level of detection used for the basalt B.R. On the other hand, they were noticed in the lunar samples and, in their case, the coefficient of correction was taken as equal to unity.

§ These analyses were performed by K. Govindaraju (CRPG), Nancy, France.

(Bouchet, et al, 1971)

Table I. Elemental abundances determined by neutron activation in Apollo 12 lunar samples

Element	BCR-1	12070		12002				12018		12021		12038		Analytical method
		79		132	133	134	135	42		77		59		
Na %	2.42	0.319,	0.326		0.153	0.160	0.158	0.151,	0.152	0.188,	0.182	0.466,	0.471	B
Al %	7.40	6.64,	6.74		4.72	4.28	4.49	4.59,	4.37	5.97,	5.53	6.67	6.65	A
Cl ppm	54	21,	27				17	5.1,	5.2	10.5,	12.5	4.7,	8.5	E†
K ppm	13300	1970,	1890		438	398	420	404,	395	486,	490	531,	500	A
Sc ppm	30.7	39.3,	38.3	41.7	45.0	42.1	43.9	39.4,	40.2	54.6,	52.5	44.6,	42.7	D
Ti %	1.29	1.67,	1.75		1.57	1.50	1.65	1.58,	1.64	1.93,	1.93	1.91,	2.04	A
V ppm	476	143,	142,		223	212	227	191,	200	192,	217	154,	144	A
Cr ppm	—	2570,	2620		6780	5650	5450	3720,	3940	2570,	2650	2040,	2010	D†
Mn ppm	1419	1730,	1750		2090	2150	2080	2070,	2050	2090,	2090	1870,	1900	B
Fe %	9.37	12.5,	12.1	16.5	17.1	16.5	16.0	16.1,	16.2	14.9,	15.3	14.1,	13.8	C
Co ppm	36.2	41.3,	40.2	58.7	59.8	58.3	58.1	54.2,	55.0	31.7,	31.2	28.4,	28.0	F
Cu ppm	15.7	6.7,	6.7		5.9	6.5	5.3	5.0,	4.4	8.1,	8.3	16.6,	10.3	F
Zn ppm	127.4	7.1,	7.6		3.4	2.9	7.2	2.6,	1.9	1.2,	1.2	6.1,	3.2	F
Ga ppm	22.2	4.1,	4.0		3.1	2.9	2.6	2.6,	2.8	3.7,	3.5	5.1,	5.5	F
As ppm	0.60	0.57,	0.58		← <0.05 →			<0.05		0.09,	0.18	0.15,	0.10	F
Se ppb	116	239,	253		← 172 →			181,	177	226,	221	182,	174	G†
Rb ppm	50	8.3,	8.1		← 1.14 →			1.42		1.19,	1.30,	0.43	0.44	G†
Sr ppm	312	<100		<100	← <100 →			79,	77	137		137,	152	C
Ag ppm	0.031	0.14,	0.29		← 0.03 →			0.01,	0.01	0.10,	0.13	0.08,	0.06	G†
In ppb	103	360,	880		—	—	24	2.6,	<3.3	640,	470	171,	149	E†
Sb ppm	0.60	0.05,	0.03		← 0.07 →			0.21,	0.05	0.04,	0.04	0.01,	0.02	G†
Cs ppm	0.97	0.29,	0.31		← 0.075 →			0.047,	0.035	0.062,	0.073	0.014,	0.021	G†
Ba ppm	580	321,	304	66	58	65	48	65,	61	46,	42	91,	89	C
La ppm	23.7	33.2,	33.7		5.8	5.6	5.1	5.8		5.9,	6.7	11.6,	11.5	D
Ce ppm	53	84,	90		22	21	19	12,	18	24,	17	24,	30	D
Sm ppm	6.52	16.1,	15.8		4.38	5.50	4.32	3.90,	3.90	5.32,	5.55	6.93,	6.87	C
Eu ppm	1.94	1.77,	1.84		0.91	0.82	0.86	0.76,	0.76	1.05,	1.04	2.04,	2.05	D
Tb ppm	0.96	3.22		0.84	0.93	1.22	0.79	0.76,	0.74	1.28,	1.21	1.19,	1.19	C
Dy ppm	5.65	22.7,	24.1		7.5	10.6	6.0	5.6,	5.3	9.1,	9.5	8.8,	8.0	E
Ho ppm	1.20	4.3,	5.2		—	—	—	1.33		2.32,	2.22	1.48,	1.48	E†
Er ppm	4.5	13.1,	14.2		—	—	—	3.2		7.9*,	8.0*	5.0,	4.9	E
Yb ppm	3.21	12.9,	12.6		7.0*	12.8*	5.9*	3.5,	3.7	10.2*,	9.4*	4.9,	4.5	D
Lu ppm	0.535	1.90,	1.90		1.11*	2.07*	0.86*	0.61,	0.56	1.65*,	1.48*	0.75,	0.76	D
Hf ppm	4.72	13.4,	11.6	2.9	3.3	3.1	3.1	3.0,	2.8	3.8,	3.3	5.0,	4.8	C
Ta ppm	0.74	1.53,	1.30		0.35	0.37	0.37	0.36,	0.37	0.43,	0.41	0.59,	0.63	C
W ppm	0.38	0.64,	0.64		0.14	0.29	0.20	0.115,	0.092	0.26,	0.21	0.108,	0.106	F
Ir ppb	<0.1	4.36,	4.33		← <0.1 →			<0.1		<0.1		<0.1		G†
Au ppb	0.75	4.5,	5.4		← 11 →			1.9,	1.7	2.1,	2.2	42,	3.5	G†
Th ppm	4.98	4.6,	4.2	0.60	2.5*	9.3*	2.3*	0.48,	0.44	5.2*,	3.8*,	0.29,	0.18	C
U ppm	1.68	1.5,	1.6	0.19	2.1*	8.5*	1.7*	0.22,	0.17	3.3*,	3.4*	0.14,	0.10	F

* These samples were apparently contaminated with U, Th, and heavy REE during grinding in agate mortars in our laboratory.

† For these elements separate standards were used; for all the other elements the results are relative to BCR-1, using the values listed in the table.

(Brunfelt, et al, 1971)

Table 3. Abundances of major and trace elements in lunar rock fragment 12063,73 and mineral fractions separated from it (in ppm except for those noted by %).

Element	12063,73	Ilmenite(?)	pyroxene	feldspar	olivine
Na (%)	0.19	0.13	0.08	0.64	0.056
Mg (%)		2.4	7.5	1.8	15
Al (%)		3.5	2.3	15.3	1.0
Si (%)		(17)	(26)	(27)	(23)
K (%)	0.056	0.053	0.052	<0.1	<0.1
Ca (%)		4.6	6.9	10.8	1.5
Sc	61	38	98	97	17.2
Ti (%)		14.0	1.9	0.56	0.77
V		133	277	26	109
Cr (%)	0.29	0.19	0.43	0.38	0.25
Mn (%)		0.24	0.27	0.05	0.23
Fe (%)	15.1 17.1*	18.2	17.9	2.8	16.2
Co	44	29	45	6.4	70
Ni	<100	<160	<500	<90	<250
Sr		<200	<300	<200	
Y	400*				
Zr	250*	400			
Cs	<0.2	<0.2	<1	<0.1	<0.3
La	7.1	11.2	6.5	1.5	0.9
Ce	19.2	32	21	5.6	<4
Nd	16.5	36	<90	<30	<60
Sm	5.1	9.1	5.9	1.3	0.9
Eu	1.17	1.3	0.85	1.9	0.2
Gd	<6	16	7.0		<4
Tb	1.5	2.2	1.6	0.42	<0.1
Dy		19.6	10.0	9.0	2.2
Ho	1.3	2.9	2.4	0.5	<0.4
Tm	1.1	2.0	1.7	0.54	<0.3
Yb	5.5	8.4	6.6	1.05	1.0
Lu	0.7	1.3	0.86	0.1	0.15
Hf	3.9	8.2	3.9	0.9	0.7
Ta	0.5	1.3	<0.8	<0.4	<0.1
W		<3	<2	<2	<0.7
Ir	<0.004	<0.01	<0.01		
Au	<0.008	<0.02	<0.03	<0.01	<0.01
Th	0.66	1.5	1.0	0.3	0.4
U		1.1		<0.85	3.3
Weight of sample milligram	101.007†	1.559	1.921	2.856	2.066

The values in parentheses are semiquantitative only.

* Values obtained by the nondispersive X-ray fluorescence analysis.

† For 20 hours irradiation only.

(Vobecky, et al, 1971)

Table 3. Concentrations and residuals for lunar soils 10084, 12070, and 12032.

		Soil 10084			Soil 12070			Soil 12032		
Elements	Units	Concentration	Res Obs-cal σ	Obs-cal Obs × 100	Concentration	Res Obs-cal σ	Obs-cal Obs × 100	Concentration	Res Obs-cal σ	Obs-cal Obs × 100
Si	%	19.7	0.07	0.2	21.6	0.4	0.9	21.75	0.1	0.2
Ti	%	4.69	−0.2	−0.9	1.72	1.0	5.8	1.53	0.6	3.9
Al	%	7.25	0.1	0.3	6.72	−0.8	−2.4	7.62	−1.1	−3.2
Ca	%	8.58	−0.5	−1.1	7.50	0.5	1.3	7.69	0.6	1.7
Fe	%	12.23	−0.4	−0.6	12.80	−1.7	−2.7	11.74	−0.5	−0.9
Mg	%	4.76	0.3	1.3	5.8	1.4	4.8	5.81	1.1	3.8
P_2O_5	%	0.13	−0.3	−11	0.32	−0.4	−6.2	0.29	−0.8	−13
Cr	ppm	1870	1.0	5.4	2850	1.3	6.8	2350	0.1	0.6
Mn	ppm	1630	−1.1	−7	1710	−0.8	−4.7	1630	−0.2	−1.6
Na	ppm	3190	0.5	1.6	3210	−0.4	−1.7	4267	1.0	3.3
K	ppm	1100	−1.3	−4.7	2030	−0.8	−3.9	3030	0.9	3.0
Rb	ppm	2.77	0.3	1.1	6.41	0.2	0.6	9.21	0.8	1.8
Ba	ppm	172.6	−0.2	−0.6	390	0.1	0.3	529	−1.8	−0.34
U	ppm	0.54	−0.1	−0.6	1.65	0.3	1.8	2.35	0.1	3.0
Th	ppm	2.09	0.35	1.7	6.30	0.5	2.3	8.72	0.3	1.4
La	ppm	16.6	−0.3	−2.0	30	−1.1	−6.5	47	0.6	2.3
Ce	ppm	46.6	−0.4	−2.9	90	−0.2	−1.4	117	−0.9	−4.6
Sm	ppm	13.7	0.4	2.8	16.4	0.2	2.2	20.7	−0.4	−3.4
Eu	ppm	1.82	0.3	1.6	1.73	0.1	1.0	2.12	0.5	4.2
Sr	ppm	166.4	0.6	1.1	142.5	1.0	2.1	157	0.7	0.6
Yb	ppm	11.05	−1.1	−4.9	12.5	0.2	1.4	15.2	−0.7	−4.1
Y	ppm	99	0.1	0.5	130	1.0	6.1	175	2.1	8.0
Sc	ppm	65	1.3	6.4	42	1.2	7.1	36	−0.1	−1.0
V	ppm	70	−0.25	−2.9	110	−0.6	−5.4	110	0.1	0.9
Zr	ppm	320	−0.9	−5.6	510	0.1	0.8	680	−0.1	−0.6
Nb	ppm	20	−0.1	−2	30	−0.3	−4.0	45	0.4	3
Co	ppm	29	0.7	6	40	0.1	0.8	39	−0.5	−1.9
Ni	ppm	185	0.1	0.5	200	0.1	0.5	117	0.1	0.9
Li	ppm	12.5	0.4	6	18	−0.4	−5.2	23.4	−0.4	−5.1
Au	ppb	2.7	0.2	2.9	24	−0.5	−10	1.4	0.4	14
Ir	ppb	7.4	−0.4	−3.2	8.5	1.5	9	4.0	1.0	12

(Schonfeld and Meyer, 1974)

Table 1. Major and trace elements in lunar fines, breccias, and igneous rocks.

		Apollo 12	Fines		Apollo 11 Breccia							Apollo 12 Rocks				accuracy
		12001,114	12037,26	12070,74	12073,31	10049	12002,120	12004,33	12018,41	12020,37	12052,94	12053,20	12063,69	12064,15	12065,29	%
O	%	42.6	42.4	42.6	43.3	41.0	41.7	41.9	42.0	42.0	42.2	42.1	41.4	–	41.4	1
Mg	%	5.92	6.99	5.84	5.58	4.4	8.90	7.49	8.69	9.44	5.10	4.86	5.05	—	5.12	4
Al	%	6.65	5.90	6.72	7.37	4.5	4.13	4.62	4.22	3.81	5.35	5.39	4.94	—	5.47	2
Si	%	21.6	21.6	21.5	22.1	20.0	20.8	21.5	21.1	20.5	22.1	22.1	20.9	—	21.9	1
Ca	%	6.1	7.4	7.6	8.0	6.3	—	5.9	4.4	5.8	8.5	6.7	9.3	10.2	7.7	10
Ti	%	1.6	1.5	1.6	1.3	4.8	—	1.53	1.59	1.58	1.5	2.2	2.8	2.6	2.1	10
Fe	%	13.1	14.3	12.7	11.4	14.1	17.2	16.4	16.5	16.4	15.2	15.6	16.7	15.1	15.4	3
B	ppm			2.3		—	—	0.8	0.9		1.1	1.4	5.2	—		20
Li	ppm			12.0		—	—	11.0	4.5		4.7	4.8	5.9	—		20
Na	ppm	3200	2760	3090	4460	3600	1560	1470	1430	1290	1760	1960	2150	1980	1800	5
Cl	ppm			24.4		—	—	31.5	17.8		28.0	27.0	17.2	—		20
K	ppm	2100	1700	1900	3300	2280	450	410	410	380	560	500	630	670	660	5
Sc	ppm	38.1	39.0	37.3	36.2	80.9	42.6	43.8	41.7	45.4	50.6	56.4	62.9	63.1	56.5	5
Cr	ppm	2430	3230	2270	2260	1960	6570	4100	3730	4560	3490	3480	2580	2160	3560	5
Mn	ppm	1710	1910	1590	1590	1600	2230	1990	1980	2170	2180	2220	2200	2280	2290	5
Co	ppm	38.3	47.1	41.5	38.2	24.0	68.7	47.9	51.6	61.0	38.4	39.1	39.1	27.2	38.8	5
Ni	ppm	310	180	200	230	—	150	80	100		39	28	49	—		20
Cu	ppm	7.2	4.5	7.2	5.7	—	5.5	6.9	5.5	6.9	39	7.1	12.9	6.6	7.8	10
Ga	ppm	4.2	4.4	3.3	5.1	4.3		3.8	3.2		3.9	4.1	5.3	—		10
Ge	ppb	200	—	210	110	≤1		100	100		60	100	100	—		30
As	ppb	27	—	22	26	—		4	10		6	10	53	—		15
Rb	ppm	23	6.1	8.7	11.3	—		0.9	1.5		—	1.7	1.1	—		20
Sr	ppm	130	90	140	190	180		72	96		110	140	130	—		10
Pd	ppb	9.0	13.5	6.5	10.2	—		≤1	3		≤1	≤1	≤1	—		30
In	ppb	92	109	486	12.5	16		10.4	1.9		7.8	0.86	2.3	—		10
Cs	ppb	530	310	390	500	—		90	90			100	80	—		20
Ba	ppm	460	190	390	390	202		79	84		70	120	140—			15
La	ppm	32.4	24.5	33.0	49.8	27.4	5.65	5.43	5.68	4.82	6.52	7.07	6.88	6.33	6.68	5
Ce	ppm	87	—	86	131	118	—	15	21	—	21	30	19	20	24	15
Pr	ppm	10.8	9.1	10.6	—	—	—	1.9	1.75	—	—	2.8	3.1	—	—	10
Nd	ppm	72	—	—	—	59.1	—	12.9	14.7	—	—	—	—	—	24	30
Sm	ppm	15.0		14.7	21.4	12.8	3.3	3.2	3.8	3.4	4.5	4.7	6.6	5.5	4.5	10
Eu	ppm	1.80	1.57	1.80	2.44	2.11	0.96	0.82	0.84	0.82	1.08	1.34	1.62	1.30	1.06	5
Gd	ppm	19.4	16.0	15.7	—	—	—	4.7	4.7	—	—	7.6	11.0	—	—	10
Tb	ppm	3.78	3.22	4.0	6.2	5.46	1.10	0.97	1.0	0.91	1.35	1.73	2.65	1.75	1.58	10
Dy	ppm	22.6	17.8	20.2	31.0	—	5.8	5.5	5.8	5.68	7.44	6.53	10.3	9.48	7.64	5
Ho	ppm	5.0	4.13	5.2	7.58	—	—	1.40	1.11	1.07	1.34	1.49	2.46	1.87	1.11	10
Er	ppm	14.5	12.7	15.8	—	—	—	3.84	4.2	—	—	5.4	7.35	—	—	10
Yb	ppm	11.0	8.9	10.6	16.0	16.4	3.33	3.17	3.45	2.91	3.70	3.92	5.71	5.25	3.78	5
Lu	ppm	1.56	1.35	1.52	2.17	2.45	0.55	0.44	0.40	0.42	0.58	0.62	0.84	0.67	0.59	10
Hf	ppm	13.3	10.9	15.6	21.7	—	3.6	5.1	3.4	3.8	3.8	4.0	6.3	3.9	3.9	10
Ta	ppm	1.4	1.04	1.46	2.1	2.0	0.54	0.33	0.36	0.45	0.44	0.45	0.47	0.33	0.51	15
W	ppm	0.63	0.45	0.74	1.21	—	—	0.14	0.15		0.15	0.12	0.14	—		10
Ir	ppb	11	5	7.5	8.8	—		(33)	(0.5)		(3.6)	(0.24)	(1.3)	—		20
Au	ppb	2.6	1.5	1.8	2.7	(1.1)		(4.0)	(3.6)		(0.9)	(2.2)	(2.9)	—		15
Th	ppm	5.50	3.52	5.52	8.17	4.03		0.82	0.85	0.71	1.28	0.87	0.82	—		10
U	ppm	1.67	0.72	1.69	2.32	0.814		0.238	0.252		0.356	0.242	0.236	—		10
	%	98.31	100.95	99.35	100.01	—	—	100.14	98.76	100.37	100.75	99.77	102.05	—	99.82	

Samples 12002, 12020, 12064, and 12065 are exchange samples from H. HINTENBERGER. These samples were analyzed in order to obtain data on the K content; the data for the other elements listed were obtained as byproducts. For the Ir and Au values in brackets we suspect contamination before we received the samples. Accuracy of the Ca values for samples 12001 and 12063 is 20%.

(Wanke, et al, 1971)

Abundances (in ppm unless otherwise indicated) of the Elements in Apollo 11 Materials and in Apollo 12 Fines Compared to Terrestrial Basaltic Rock W-1, Eucrites, and Type I Carbonaceous Chondrites. **(If no mean is given for the Apollo 11 materials, the data are inadequate for this purpose)**

	Apollo 11		Apollo 12			Carbonaceous
Element	Range	Mean	fines	W-1	Eucrites	chondrites
Li	9–23	12	11	12	8	1.3
Be	1–6	2	—	0.8	0.1	0.04
B	1–4	2	—	15	0.8	5
C	64–230	140	110	—	700	3.5%
N	30–150	100	—	14	30	2600
O	37.6%–43.4%	40.0%	—	44.6%	42.7%	45.3%
F	30–340	140	—	250	60	190
Na	2600–4000	3300	3000	1.6%	3000	5500
Mg	3.4%–5.1%	4.5%	7.2%	4.0%	4.3%	9.6%
Al	3.7%–7.8%	5.6%	7.4%	7.9%	6.5%	8500
Si	17.7%–20.6%	19.2%	19.6%	24.9%	22.8%	10.3%
P	200–900	500	—	610	400	1400
S	1200–2400	1700	—	130	900	6.2%
Cl	3–30	14	—	200	20	260
K	400–2800	1400	1500	5300	400	1400
Ca	7.2%–9.0%	8.0%	7.1%	7.8%	7.7%	1.1%
Sc	60–100	75	47	34	35	5
Ti	4.3%–7.4%	5.9%	1.9%	6400	4600	420
V	20–100	50	64	240	75	57
Cr	1300–2800	2100	2800	120	2100	2200
Mn	1500–2400	1900	1900	1300	3900	1700
Fe	11.8%–15.6%	14.3%	13.2%	7.7%	14.5%	18.4%
Co	11–35	25	42	50	4	480

(Continued)

	Apollo 11		Apollo 12			Carbonaceous
Element	Range	Mean	fines	W-1	Eucrites	chondrites
Ni	3–280	—	200	78	13	1.0%
Cu	4–25	11	—	110	7	140
Zn	2–40	15	5.4	82	2	320
Ga	3–6	4.5	4.9	16	2	10
Ge	<0.1–0.4	—	—	1.7	0.1	34
As	0.01–0.09	0.05	—	2.4	0.05	2.0
Se	0.4–1.6	0.8	0.24	0.11	0.002	27
Br	0.01–0.4	0.1	0.13	0.4	0.4	5
Rb	0.5–6	3.4	8.7	22	0.35	2.3
Sr	110–220	170	170	180	85	8
Y	70–170	120	130	25	23	1.6
Zr	180–660	370	670	100	46	9
Nb	14–31	21	—	10	—	0.5
Mo	0.4–0.7	0.5	—	0.5	—	1.6
Ru	—	—	—	<0.4	—	0.7
Rh	—	—	—	<0.005	—	0.2
Pd	0.001–0.013	0.006	—	0.01	—	0.6
Ag	0.001–0.024	0.008	0.005	0.05	—	0.4
Cd	0.003–0.11	0.004	0.05	0.3	0.04	1.0
In	0.003–0.05	0.003	0.009	0.07	0.001	0.09
Sn	0.3–1.2	0.6	—	3	—	1.6
Sb	0.005–0.01	0.007	—	1.1	0.01	0.15
Te	0.008–0.073	0.02	0.075	<0.2	0.0002	3.3
I	0.006–1.4	—	—	<0.05	0.2	0.3
Cs	0.02–0.17	0.10	0.32	1.0	0.01	0.19
Ba	70–340	200	420	180	35	4
La	7–29	18	—	12	3.7	0.19

(Mason and Melson, 1970)

(Continued)

Element	Apollo 11 Range	Apollo 11 Mean	Apollo 12 fines	W-1	Eucrites	Carbonaceous chondrites
Ce	23–83	54	—	23	9.7	0.63
Pr	5–16	11	—	4	1.4	0.09
Nd	21–69	46	—	17	6.9	0.42
Sm	8–23	15	—	4	2.3	0.13
Eu	1.5–2.7	1.9	—	1.1	0.72	0.05
Gd	12–29	20	—	4	2.9	0.24
Tb	2.1–5.0	3.6	—	0.8	0.57	0.04
Dy	14–36	25	—	4	3.8	0.22
Ho	2.2–8.7	4.9	—	1	0.80	0.06
Er	9–21	14	—	3	2.3	0.14
Tm	1.2–2.8	1.9	—	0.35	0.38	0.02
Yb	8–20	13	—	2.2	1.9	0.13
Lu	1.2–2.9	1.9	—	0.35	0.38	0.02
Hf	7–18	13	—	2	0.8	0.32
Ta	1.0–2.7	1.7	—	0.7	0.1	0.02
W	0.1–0.4	0.3	—	0.45	—	0.14
Re	0.01	—	—	0.0003	0.00005	0.04
Os	0.0003	—	—	0.0003	0.0005	0.45
Ir	0.00001–0.01	0.00007	0.009	0.0003	0.0002	0.40
Pt	—	—	—	0.02	—	0.90
Au	0.00002–0.004	0.00004	0.002	0.005	0.001	0.18
Hg	0.0006–0.013	—	—	0.1	—	17
Tl	0.0003–0.003	0.0006	0.002	0.13	0.0007	0.14
Pb	0.3–1.8	1.2	—	8	0.5	2.9
Bi	0.0001–0.003	0.0003	0.002	—	—	0.13
Th	0.5–3.4	2.0	6.0	2.4	0.4	0.04
U	0.16–0.9	0.5	1.5	0.5	0.1	0.01

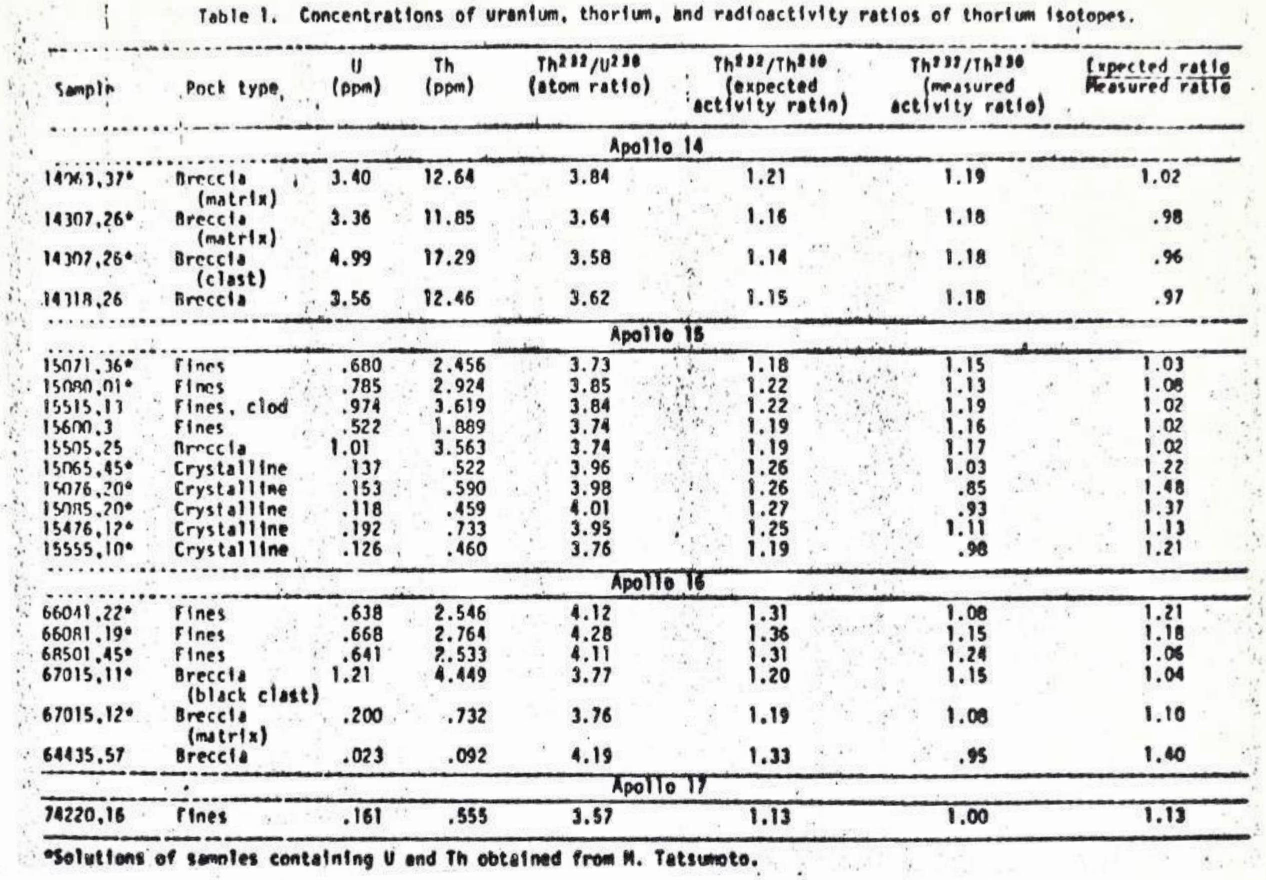


Table 1. Concentrations of uranium, thorium, and radioactivity ratios of thorium isotopes.

Sample	Rock type	U (ppm)	Th (ppm)	Th^{232}/U^{238} (atom ratio)	Th^{232}/Th^{230} (expected activity ratio)	Th^{232}/Th^{230} (measured activity ratio)	Expected ratio / Measured ratio
				Apollo 14			
14063,37*	Breccia (matrix)	3.40	12.64	3.84	1.21	1.19	1.02
14307,26*	Breccia (matrix)	3.36	11.85	3.64	1.16	1.18	.98
14307,26*	Breccia (clast)	4.99	17.29	3.58	1.14	1.18	.96
14318,26	Breccia	3.56	12.46	3.62	1.15	1.18	.97
				Apollo 15			
15071,36*	Fines	.680	2.456	3.73	1.18	1.15	1.03
15080,01*	Fines	.785	2.924	3.85	1.22	1.13	1.08
15515,11	Fines, clod	.974	3.619	3.84	1.22	1.19	1.02
15600,3	Fines	.522	1.889	3.74	1.19	1.16	1.02
15505,25	Breccia	1.01	3.563	3.74	1.19	1.17	1.02
15065,45*	Crystalline	.137	.522	3.96	1.26	1.03	1.22
15076,20*	Crystalline	.153	.590	3.98	1.26	.85	1.48
15085,20*	Crystalline	.118	.459	4.01	1.27	.93	1.37
15476,12*	Crystalline	.192	.733	3.95	1.25	1.11	1.13
15555,10*	Crystalline	.126	.460	3.76	1.19	.98	1.21
				Apollo 16			
66041,22*	Fines	.638	2.546	4.12	1.31	1.08	1.21
66081,19*	Fines	.668	2.764	4.28	1.36	1.15	1.18
68501,45*	Fines	.641	2.533	4.11	1.31	1.24	1.06
67015,11*	Breccia (black clast)	1.21	4.449	3.77	1.20	1.15	1.04
67015,12*	Breccia (matrix)	.200	.732	3.76	1.19	1.08	1.10
64435,57	Breccia	.023	.092	4.19	1.33	.95	1.40
				Apollo 17			
74220,16	Fines	.161	.555	3.57	1.13	1.00	1.13

*Solutions of samples containing U and Th obtained from M. Tatsumoto.

(Rosholt, 1974)

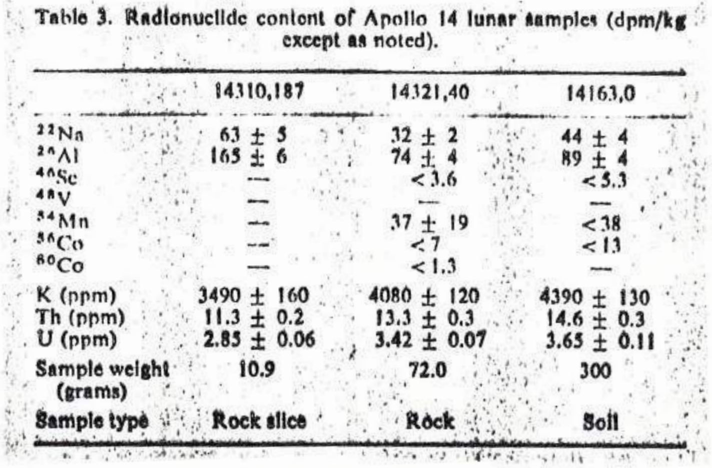


Table 3. Radionuclide content of Apollo 14 lunar samples (dpm/kg except as noted).

	14310,187	14321,40	14163,0
^{22}Na	63 ± 5	32 ± 2	44 ± 4
^{26}Al	165 ± 6	74 ± 4	89 ± 4
^{46}Sc	—	< 3.6	< 5.3
^{48}V	—	—	—
^{54}Mn	—	37 ± 19	< 38
^{56}Co	—	< 7	< 13
^{60}Co	—	< 1.3	—
K (ppm)	3490 ± 160	4080 ± 120	4390 ± 130
Th (ppm)	11.3 ± 0.2	13.3 ± 0.3	14.6 ± 0.3
U (ppm)	2.85 ± 0.06	3.42 ± 0.07	3.65 ± 0.11
Sample weight (grams)	10.9	72.0	300
Sample type	Rock slice	Rock	Soil

(Rancitelli, *et al*, 1972)

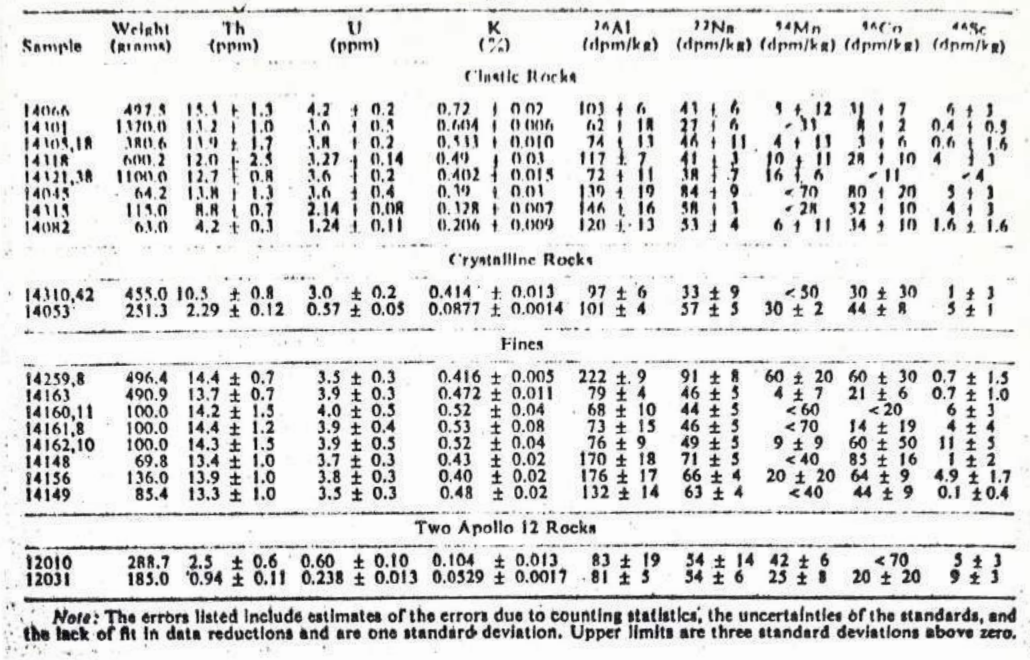


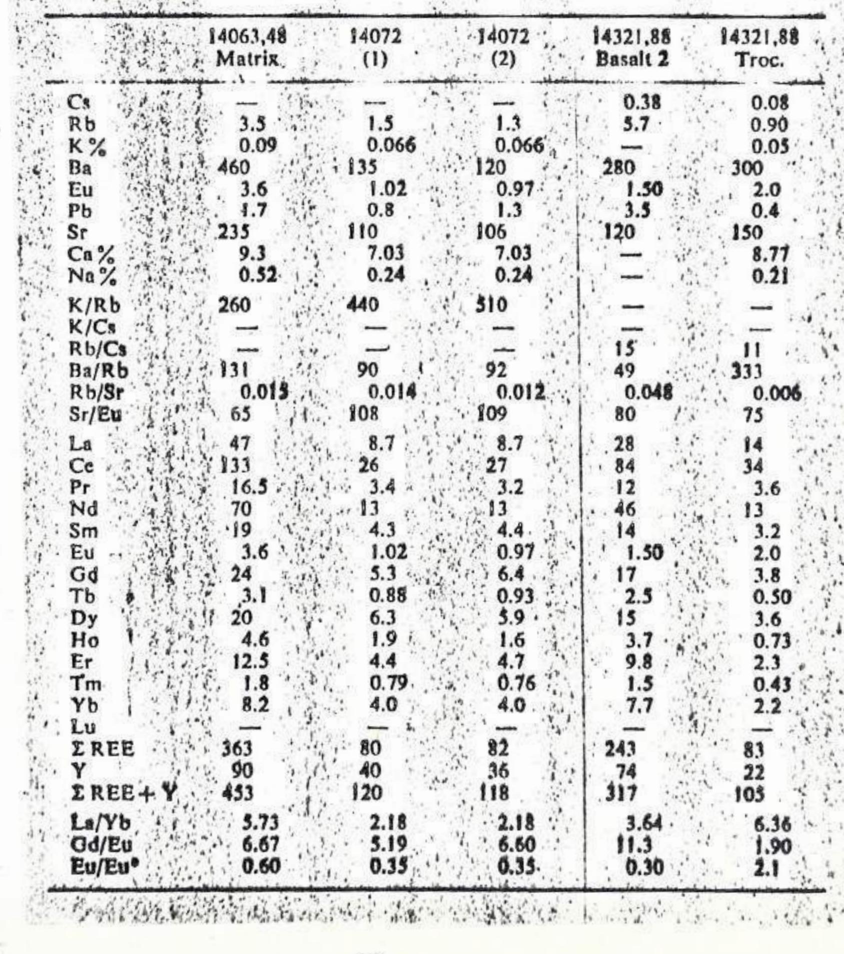
Table 1. Apollo 12 and 14 results.

Sample	Weight (grams)	Th (ppm)	U (ppm)	K (%)	^{26}Al (dpm/kg)	^{22}Na (dpm/kg)	^{54}Mn (dpm/kg)	^{56}Co (dpm/kg)	^{46}Sc (dpm/kg)
				Clastic Rocks					
14066	497.5	15.1 ± 1.3	4.2 ± 0.2	0.72 ± 0.02	103 ± 6	43 ± 6	5 ± 12	31 ± 7	6 ± 3
14301	1370.0	13.2 ± 1.0	3.6 ± 0.5	0.604 ± 0.006	62 ± 18	27 ± 6	<33	8 ± 2	0.4 ± 0.5
14305,18	380.6	13.9 ± 1.7	3.8 ± 0.2	0.533 ± 0.010	74 ± 13	46 ± 11	4 ± 11	3 ± 6	0.6 ± 1.6
14318	600.2	12.0 ± 2.5	3.27 ± 0.14	0.49 ± 0.03	117 ± 7	41 ± 3	10 ± 11	28 ± 10	4 ± 3
14321,38	1100.0	12.7 ± 0.8	3.6 ± 0.2	0.402 ± 0.015	72 ± 11	38 ± 7	16 ± 6	<11	<4
14045	64.2	13.8 ± 1.3	3.6 ± 0.4	0.39 ± 0.01	139 ± 19	84 ± 9	<70	80 ± 20	5 ± 3
14315	115.0	8.8 ± 0.7	2.14 ± 0.08	0.328 ± 0.007	146 ± 16	58 ± 3	<28	52 ± 10	4 ± 3
14082	63.0	4.2 ± 0.3	1.24 ± 0.11	0.206 ± 0.009	120 ± 13	53 ± 4	6 ± 11	34 ± 10	1.6 ± 1.6
				Crystalline Rocks					
14310,42	455.0	10.5 ± 0.8	3.0 ± 0.2	0.414 ± 0.013	97 ± 6	33 ± 9	<50	30 ± 30	1 ± 3
14053	251.3	2.29 ± 0.12	0.57 ± 0.05	0.0877 ± 0.0014	101 ± 4	57 ± 5	30 ± 2	44 ± 8	5 ± 1
				Fines					
14259,8	496.4	14.4 ± 0.7	3.5 ± 0.3	0.416 ± 0.005	222 ± 9	91 ± 8	60 ± 20	60 ± 30	0.7 ± 1.5
14163	490.9	13.7 ± 0.7	3.9 ± 0.3	0.472 ± 0.011	79 ± 4	46 ± 5	4 ± 7	21 ± 6	0.7 ± 1.0
14160,11	100.0	14.2 ± 1.5	4.0 ± 0.5	0.52 ± 0.04	68 ± 10	44 ± 5	<60	<20	6 ± 3
14161,8	100.0	14.4 ± 1.2	3.9 ± 0.4	0.53 ± 0.08	73 ± 15	46 ± 5	<70	14 ± 19	4 ± 4
14162,10	100.0	14.3 ± 1.5	3.9 ± 0.5	0.52 ± 0.04	76 ± 9	49 ± 5	9 ± 9	60 ± 50	11 ± 5
14148	69.8	13.4 ± 1.0	3.7 ± 0.3	0.43 ± 0.02	170 ± 18	71 ± 5	<40	85 ± 16	1 ± 2
14156	136.0	13.9 ± 1.0	3.8 ± 0.3	0.40 ± 0.02	176 ± 17	66 ± 4	20 ± 20	64 ± 9	4.9 ± 1.7
14149	85.4	13.3 ± 1.0	3.5 ± 0.3	0.48 ± 0.02	132 ± 14	63 ± 4	<40	44 ± 9	0.1 ± 0.4
				Two Apollo 12 Rocks					
12010	288.7	2.5 ± 0.6	0.60 ± 0.10	0.104 ± 0.013	83 ± 19	54 ± 14	42 ± 6	<70	5 ± 3
12031	185.0	0.94 ± 0.11	0.238 ± 0.013	0.0529 ± 0.0017	81 ± 5	54 ± 6	25 ± 8	20 ± 20	9 ± 3

Note: The errors listed include estimates of the errors due to counting statistics, the uncertainties of the standards, and the lack of fit in data reductions and are one standard deviation. Upper limits are three standard deviations above zero.

(Keith, et al, 1972)

Table 2a. Analytical data for large cations and rare earth elements for Apollo 14 samples from Cone Crater unit (Cc4) of Fra Mauro Formation. (Format as for Table 1a).



	14063,48 Matrix	14072 (1)	14072 (2)	14321,88 Basalt 2	14321,88 Troc.
Cs	—	—	—	0.38	0.08
Rb	3.5	1.5	1.3	5.7	0.90
K %	0.09	0.066	0.066	—	0.05
Ba	460	135	120	280	300
Eu	3.6	1.02	0.97	1.50	2.0
Pb	1.7	0.8	1.3	3.5	0.4
Sr	235	110	106	120	150
Ca %	9.3	7.03	7.03	—	8.77
Na %	0.52	0.24	0.24	—	0.21
K/Rb	260	440	510	—	—
K/Cs	—	—	—	—	—
Rb/Cs	—	—	—	15	11
Ba/Rb	131	90	92	49	333
Rb/Sr	0.015	0.014	0.012	0.048	0.006
Sr/Eu	65	108	109	80	75
La	47	8.7	8.7	28	14
Ce	133	26	27	84	34
Pr	16.5	3.4	3.2	12	3.6
Nd	70	13	13	46	13
Sm	19	4.3	4.4	14	3.2
Eu	3.6	1.02	0.97	1.50	2.0
Gd	24	5.3	6.4	17	3.8
Tb	3.1	0.88	0.93	2.5	0.50
Dy	20	6.3	5.9	15	3.6
Ho	4.6	1.9	1.6	3.7	0.73
Er	12.5	4.4	4.7	9.8	2.3
Tm	1.8	0.79	0.76	1.5	0.43
Yb	8.2	4.0	4.0	7.7	2.2
Lu	—	—	—	—	—
Σ REE	363	80	82	243	83
Y	90	40	36	74	22
Σ REE + Y	453	120	118	317	105
La/Yb	5.73	2.18	2.18	3.64	6.36
Gd/Eu	6.67	5.19	6.60	11.3	1.90
Eu/Eu*	0.60	0.35	0.35	0.30	2.1

(Taylor, et al, 1972)

Table 3. Isotope dilution data for Apollo 14 samples.

				Individual 2–4 mm Coarse Fines												
Sample No.	006,3	053,50	068,3	161,35,2	161,35,3	161,35,4	161,35,5	161,35,6	163,65	163,65,1	163,65,2	301,48,1	307,26,1	307,26,2	310,130	15023,2,5
	263 mg Brec.	13.1 mg Basalt	106 mg Brec.	55.0 mg Brec.	27.8 mg Brec.	27.6 mg Brec.	30.1 mg Brec.	39.8 mg Brec.	300 mg Soil < 100 mm	14.7 mg 33 Similar Soil Frag.	5.5 mg 13 Similar Soil Frag.	64.8 mg Brec.	6.8 mg White Clast	68.4 mg Matrix	177 mg Basalt	5.5 mg Apollo 15 KREEP Basalt
La (ppm)	84.7	13.0	—	55.6	—	—	—	—	68.2	—	—	71.8	—	—	56.4	—
Ce (ppm)	214	34.5	157	252	205	266	165	212	176	227	188	201	230	164	144	193
Nd (ppm)	131	21.9	93.4	149	122	158	106	132	103	129	106	121	138	99.2	87.0	114
Sm (ppm)	36.0	6.56	28.1	42.8	34.4	44.3	29.7	38.7	29.0	36.5	30.0	34.7	38.8	28.0	24.0	32.0
Eu (ppm)	2.73	1.21	2.01	2.76	2.74	3.04	2.49	2.76	2.54	2.92	2.42	2.69	2.74	2.25	2.15	2.60
Gd (ppm)	42.5	8.59	29.1	49.1	43.0	—	34.9	43.6	—	42.7	35.9	40.3	—	34.0	28.1	—
Dy (ppm)	47.1	10.5	35.1	55.8	45.6	56.8	40.3	49.3	38.3	46.9	39.7	46.0	52.0	37.2	32.7	44.0
Er (ppm)	28.8	6.51	—	—	31.2	—	24.6	—	23.8	28.5	24.5	28.0	30.1	22.9	19.7	28.3
Yb (ppm)	25.8	6.00	20.0	—	26.1	—	23.4	27.4	23.6	30.6	24.6	25.5	28.0	20.6	18.4	21.5
Na (ppm)	0.68	0.46	0.56	0.60	0.58	—	0.54	0.56	0.51	0.67	0.95	—	0.67	0.56	0.53	0.61
K (ppm)	2700	912	4508	4733	2372	5107	4700	5699	4840	6010	5300	6874	5300	4940	4250	4110
Rb (ppm)	6.07	2.19	14.5	12.9	3.38	15.2	14.7	16.9	15.3	17.9	18.1	21.7	16.0	15.3	12.8	13.2
Mg (%)	6.38	5.09	10.6	7.45	6.84	5.88	7.44	6.88	5.44	6.20	4.96	5.33	6.63	5.71	4.37	5.16
Ca (%)	7.40	7.92	5.62	6.51	7.02	7.24	6.21	6.72	7.83	7.17	7.35	7.37	7.68	7.47	8.93	6.74
Sr (ppm)	180	98	139	171	180	197	170	182	186	—	—	185	192	—	188	—
Ba (ppm)	781	146	780	1022	775	811	817	916	926	1076	1634	959	890	735	617	683
U (ppm)	4.07	0.60	3.47	5.03	4.08	4.71	3.92	4.61	—	—	—	4.32	4.90	3.28	—	3.09
Ti (%)	—	1.63	0.82	1.10	0.94	1.18	0.97	0.96	—	—	—	1.04	1.05	1.19	—	1.28
K/Rb	445	416	311	373	702	336	319	337	3.16	336	293	317	331	323	332	311
K/U	663	1520	1300	914	582	1085	1200	1236	1370	—	—	1591	1082	1500	—	1330

(Hubbard, _et al_, 1972)

Table 1. Apollo 14 regolith samples.

	Soils					Trench			Core			Representative
Sample	14163,89	14259,34	14049,31A	14049,31B	14141,33	14148,26	14156,26	14149,42	14230,112	14230,119	14230,129	% Error
Wt. (mg)	162.8	95.7	512.5	473.9	191.2	156.0	235.6	197.5	132.6	148.9	103.4	
Al (%)	—	—	—	—	8.75	9.13	8.97	9.16	—	—	—	2
Na	5630	5020	5780	6070	5870	5050	5060	5260	5020	5310	5410	2
K	4300	—	—	—	5300	4150	4000	4200	3950	4200	3800	5–10
Cs	0.78	0.75	—	—	0.62	0.40	0.54	0.66	—	—	—	10–20
Ba	950	740	900	830	900	750	780	740	750	780	700	8
La	67.3	57.8	69.8	70.2	71.4	64.3	65.1	65.1	62.3	66.1	65.1	2
Ce	194	178	216	185	200	176	175	177	167	170	176	3
Nd	100	—	98	95	104	98	—	100	—	—	100	10
Sm	29.6	26.5	31.1	31.8	34.7	31.5	31.4	31.6	27.8	29.9	29.4	2
Eu	2.75	2.63	2.97	3.04	2.82	2.68	2.66	2.76	2.91	3.26	3.44	3
Tb	7.1	5.9	7.0	7.0	7.4	6.6	6.6	6.7	5.0	6.7	6.9	5
Yb	22.0	21.4	21.0	23.8	23.8	21.7	21.5	21.7	22.5	22.8	21.5	3
Lu	3.21	3.05	3.26	3.26	3.35	3.18	3.05	3.08	3.15	3.28	3.28	2
Th	15.2	14.0	—	—	15.3	13.8	13.8	13.6	—	—	—	5
U	—	3.0	3.6	3.4	—	—	—	—	—	—	2.1	10
Hf	25.3	22.5	24.3	24.0	25.0	25.7	23.2	23.0	22.4	23.4	—	3
Zr	720	590	750	860	760	690	700	660	990	900	—	8
Ta	4.3	3.9	5.0	4.8	5.7	4.7	4.8	4.8	3.9	4.5	5.0	5
Fe (%)	8.3	8.3	8.1	8.3	7.9	8.0	8.1	7.9	8.1	8.3	8.0	2
Ti (%)	—	—	—	—	0.98	1.01	0.99	0.93	—	—	—	4
Sc	21.4	21.9	21.7	21.9	21.5	21.0	20.9	20.5	20.9	22.0	21.5	2
V	—	—	—	—	—	44	36	—	—	—	—	8
Cr	1280	1290	1260	1280	1350	1310	1350	1300	1290	1350	1260	2
Mn	—	—	—	—	960	985	965	910	—	—	—	3
Co	36.0	37.5	35.6	36.4	31.0	34.4	36.2	40.0	42.4	36.2	36.4	2

(Lindstrom, et al, 1972)

Table 2b. Analytical data for large high-valency cations and ferromagnesian elements for Apollo 14 samples from Cone Crater unit (Cc4) of Fra Mauro Formation. (Format as for Table 1b).

	14063,48 Matrix	14072 (1)	14072 (2)	14321 Basalt 2	14321 Troc.
K	902	[illegible]	[illegible]		[illegible]
Th	3.2	0.78	1.04	2.9	0.56
U	0.82	0.22	0.29	0.71	0.16
Zr	325	160	172	440	110
Hf	6.8	3.0	3.2	7.5	2.8
Sn	—	—	0.3	0.2	—
Nb	20	9.9	13	22	3.2
Ti%	0.76	1.54	1.54	—	0.11
W	0.4	0.2	0.1	0.2	0.1
Th/U	3.90	3.55	3.59	4.08	3.50
K/U	1100	3000	2300	—	3125
Zr/Hf	48	53	54	59	53
Cr	1100	2500	2500	—	—
V	23	—	—	—	—
Sc	12	—	—	—	—
Ni	99	—	—	—	—
Co	17	—	—	—	—
Cu	10	—	—	—	—
Fe%	4.5	13.9	13.9	—	3.54
Mn	650	2100	2100	—	4.60
Zn	—	—	—	—	—
Mg%	5.8	5.18	5.18	—	9.54
Li	—	—	—	—	—
Ga	3	—	—	—	—
Al%	12.2	5.86	5.86	—	12.3
Si%	21.3	21.1	21.1	—	20.3
P	—	570	570	—	130
V/Ni	0.23	—	—	—	—
Cr/V	48	—	—	—	—
Ni/Co	5.8	—	—	—	—
Fe/Ni	455	—	—	—	—
Al/Ga (× 10^2)	4.1	—	—	—	—

(Taylor, et al, 1972)

Table 3. Major element data expressed as oxides, (wt.%) for Apollo 14 samples.

	Smooth Terrain Unit (Is)				Cone Crater (Cc4)		
	14047	14306 Matrix	14306 Dark	14306 White	14063 Matrix	14072	14321 Troctolite
SiO_2	47.16	50.3	50.4	49.4	45.5	45.15	43.5
TiO_2	1.75	1.16	1.58	—	1.27	2.57	0.19
Al_2O_3	18.22	21.6	15.2	20.7	23.0	11.07	23.3
FeO	10.52	6.83	10.66	7.87	5.82	17.82	4.56
MnO	0.14	0.13	0.18	0.17	0.10	0.27	0.06
MgO	8.89	5.76	10.17	9.79	9.67	12.16	15.82
CaO	11.49	12.12	9.00	11.28	13.0	9.84	12.27
Na_2O	0.68	0.63	1.04	0.32	0.70	0.32	0.28
K_2O	0.48	0.79	0.66	—	0.11	0.08	0.06
P_2O_5	0.50	—	—	—	—	0.08	0.03
S	0.08	—	—	—	—	0.51	—
Cr_2O_3	0.15	0.13	0.15	0.05	0.16	0.12	—
Σ	100.06	99.46	99.05	99.6	99.3	99.99	100.06
Analyst	BWC	NW	NW	NW	NW	BWC	NW
Method	XRF	EP	EP	EP	EP	XRF	EP

—: No data; XRF = X-ray fluorescence; EP = electron microprobe.

(Taylor, et al, 1972)

Table 2. Gamma-ray analysis of lunar samples; dpm, disintegrations per minute; ppm, parts per million.

Sample, number	Weight (g)	K (wt. %)	Th (ppm)	U (ppm)	^{26}Al (dpm/kg)	^{22}Na (dpm/kg)	^{60}Co (dpm/kg)	Remarks
Clastic rocks								
14045	65	0.36 ± 0.04	13.8 ± 1.4	3.7 ± 0.5	130 ± 40	83 ± 25		
14066	510	.69 ± 0.07	15.3 ± 1.5	4.1 ± 0.6	110 ± 20	52 ± 10		
14082	63	.18 ± 0.02	4.6 ± 0.5	1.4 ± 0.2	140 ± 30	68 ± 14		White clasts
14301	1361	.55 ± 0.05	12.8 ± 1.3	3.6 ± 0.5	53 ± 11	36 ± 7		
14302	381	.55 ± 0.05	14.3 ± 1.4	3.8 ± 0.6	85 ± 17	52 ± 10		
14315	115	.30 ± 0.03	9.1 ± 0.9	2.5 ± 0.4	160 ± 30	60 ± 12		
14318	600	.49 ± 0.05	12.8 ± 1.3	3.3 ± 0.5	120 ± 20	36 ± 7		
Crystalline rocks								
14053	251	.088 ± 0.009	2.24 ± 0.22	0.64 ± 0.10	98 ± 20	59 ± 12		
14310	3425	.49 ± 0.06	13.7 ± 1.7	3.7 ± 0.6	80 ± 20	55 ± 15	25 ± 5	Ge(Li) detector used
< 1-mm fines								
14163	491	.48 ± 0.05	13.9 ± 1.4	3.9 ± 0.6	78 ± 16	45 ± 9		Bulk soil
14259	495	.42 ± 0.04	13.4 ± 1.3	3.8 ± 0.6	220 ± 40	84 ± 17		Comprehensive soil
14148	70	.41 ± 0.04	14.9 ± 1.5	4.1 ± 0.6	190 ± 40	70 ± 14		Top trench
14156	136	.40 ± 0.04	14.5 ± 1.4	3.9 ± 0.6	180 ± 40	66 ± 13		Middle trench
14149	85	.44 ± 0.4	14.8 ± 1.5	3.9 ± 0.6	150 ± 30	58 ± 12		Bottom trench

(LSPET, 1971)

Table 6. Average composition at Apollo 14 site, Fra Mauro Formation. (1. Abundances in parts per million (wt.) or wt.%. 2. Values in column 1 divided by abundances in Type 1 carbonaceous chondrites giving relative enrichment or depletion. Meteoritic data from Mason (1971).)

	1	2		1	2
Cs	0.7	3.8	La	74	246
Rb	13	5.4	Ce	217	258
K	0.40%	10	Pr	26	217
K/Rb	310	--	Nd	104	179
Ba	700	280	Sm	29	138
Sr	180	21	Eu	2.4	32
Rb/Sr	0.072	—	Gd	32	100
Ca	8.2%	7.7	Tb	4.7	96
Na	0.50%	1.0	Dy	32	103
Li	27	21	Ho	7.8	107
Th	12	270	Er	21	100
U	3.2	260	Tm	3.4	103
Th/U	3.75	—	Yb	17.5	103
K/U	1250	—	Σ REE	571	—
Zr	900	100	Y	190	106
Hf	19	100	Σ REE + Y	761	--
Zr/Hf	47	—	La/Yb	4.2	—
Nb	44	—	Gd/Eu	13.4	—
W	0.7	—	Eu/Eu*	0.27	—
Ti	1.05%	24		%	—
Cr	1400	0.58	SiO_2	47.2	—
V	44	1.0	TiO_2	1.8	—
Sc	22	4.3	Al_2O_3	18.2	—
Ni	340	—	FeO	10.5	—
Co	34	0.07	MgO	8.9	—
Fe	8.2%	0.44	CaO	11.5	—
Mg	5.4%	0.56	Na_2O	0.50	—
Cu	8	0.06	K_2O	0.48	—
Ga	4	0.4	P_2O_5	0.50	—
Al	9.6%	11	S	0.08	—
Si	22%	2.1	Cr_2O_3	0.15	—

(Taylor, et al, 1972)

Table 1. Gamma-ray analyses of rocks and fines from Apollo 14. (Concentration values have been corrected for decay to 1848 hours, GMT, 5 February 1971.)

Sample No.	Weight (g)	K* (ppm)	Th* (ppm)	U* (ppm)	^{26}Al (dpm/kg)	^{22}Na (dpm/kg)
			Clastic Rocks			
14169.0	78.66	5500 ± 300	14.2 ± 0.2	3.9 ± 0.1	82 ± 6	54 ± 7
14170.0	26.34	5850 ± 300	14.9 ± 0.5	4.1 ± 0.1	88 ± 6	39 ± 9
14265.0	65.79	4100 ± 200	10.9 ± 0.6	3.3 ± 0.2	102 ± 8	70 ± 7
14271.0	96.58	5250 ± 250	15.6 ± 0.2	4.5 ± 0.3	118 ± 6	61 ± 5
14272.0	46.20	4500 ± 200	11.3 ± 0.5	3.3 ± 0.2	94 ± 6	78 ± 9
14273.0	22.40	4560 ± 200	11.7 ± 0.5	3.1 ± 0.2	73 ± 7	66 ± 8
14321.38	1100.0	4050 ± 220	12.7 ± 0.5	3.9 ± 0.4	50 ± 20	35 ± 20
14321.256	200.2	3900 ± 200	10.8 ± 0.5	2.9 ± 0.4	70 ± 7	42 ± 5
			Fines of less than 1 mm			
14148,0	45.3	4150 ± 200	11.4 ± 0.5	3.3 ± 0.2	130 ± 10	74 ± 7
14149,62	50.0	4650 ± 200	11.4 ± 0.5	3.2 ± 0.2	105 ± 10	66 ± 6
14156,46	100.0	4410 ± 200	11.9 ± 0.5	3.3 ± 0.2	148 ± 12	68 ± 7

* Standardization for the assay of K, Th, and U made with reference standards of terrestrial isotopic abundances. Equilibrium of Th and U decay series is also assumed.

(Taylor, et al, 1972)

Elemental and Mineral Abundances in Lunar Samples

(a) Elemental Abundance

Element	Sample no.											
	14053	*14321,14*	*14049*	*14310*	*14321,9*	*14042*	*14301*	*14065*	*14066*	*14305*	*14259*	*Fines (average)*
						Elemental abundance, percent						
Si	22.6	22.4	22.9	23.5	23.5	24.0	22.9	22.6	24.0	23.0	22.6	22.5
Al	6.4	7.4	9.0	10.6	9.5	8.5	9.0	11.1	8.0	8.5	9.5	9.3
Mg	5.0	7.2	6.6	4.8	6.6	5.2	6.6	5.0	5.7	7.8	5.5	5.9
Fe	12.6	10.1	7.6	6.0	7.0	7.4	7.6	5.3	7.3	7.4	7.8	8.0
Ca	8.5	6.1	6.4	7.8	5.8	7.4	6.3	8.5	7.1	5.3	7.8	7.4
Ti	.9	1.4	1.0	.8	.9	1.1	1.0	.6	1.1	1.0	1.1	1.1
Na	.28	.30	.63	.47	.42	.36	.58	.68	.42	.63	.38	.42
K	.12	.28	.44	.44	.46	.52	.60	.83	1.0	1.0	.42	.43
Mn	.22	.20	.14	.11	.12	.12	.15	.09	.12	.14	.14	.15
Cr	.30	.29	.13	.11	.11	.12	.12	.07	.09	.12	.14	.14
						Elemental abundance, ppm						
Ba	190	380	670	630	730	820	920	820	960	930	570	638
Co	48	33	40	31	32	56	44	19	39	32	39	44
Cu	13	13	16	11	7	19	17	6	7	13	14	18
La	10	40	63	36	65	70	92	32	72	54	46	49
Li	11	18	20	19	19	19	20	20	25	23	18	21
Ni	14	180	260	165	240	280	230	60	210	205	320	304
Nb	19	22	52	43	46	68	63	57	60	49	40	48
Rb	2	7	14	15	14	14	17	33	29	31	10	13
Sc	90	43	25	20	16	30	31	16	24	22	21	24
Sr	180	140	200	250	180	210	240	250	220	200	170	206
V	135	85	48	35	32	74	63	46	52	52	50	51
Yb	10	20	28	30	28	27	33	27	31	28	24	24
Y	90	160	220	180	220	110	260	200	250	210	170	210
Zr	310	670	880	930	860	1030	1000	980	970	900	720	922

(b) Mineral Abundance, Percent

Element	*14053*	*14321,14*	*14049*	*14310*	*14321,9*	*14042*	*14301*	*14065*	*14066*	*14305*	*14259*	*Fines (average)*
SiO_2	48	48	49	50	50	51	49	48	51	49	48	48
Al_2O_3	12	14	17	20	18	16	17	21	15	16	18	18
MgO	8.4	12	11	8.0	11	8.6	11	8.3	9.5	13	9.2	9.9
FeO	16	13	10	7.7	9.0	9.5	9.8	6.8	9.4	9.5	10	10
CaO	12	8.5	8.9	11	8.2	11	8.8	12	10	7.4	11	11
TiO_2	1.5	2.4	1.7	1.3	1.5	1.8	1.7	.95	1.9	1.6	1.8	1.8
Na_2O	.38	.40	.85	.63	.58	.48	.78	.92	.58	.85	.52	.57
K_2O	.14	.33	.53	.53	.56	.63	.72	1.0	1.2	1.2	.50	.52
MnO	.29	.26	.18	.14	.15	.16	.19	.12	.16	.18	.18	.19
Cr_2O_3	.44	.42	.19	.16	.16	.18	.17	.10	.13	.18	.20	.20
ZrO_2	.04	.05	.07	.13	.12	.14	.07	.13	.13	.12	.10	.12
Total	**99.2**	**99.4**	**99.5**	**99.5**	**99.4**	**99.5**	**99.3**	**99.3**	**99.0**	**99.1**	**99.5**	**100.3**

(LSPET, 1971)

Table 1. Major and trace elements in lunar samples and in basaltic achondrites.

	Fines		Clastic rocks					Fines			Achondrites		
			micro breccias			igneous fragm.							
Percent	14163.126	14259.24	14066,31	14305,81	14321 184,25	14321, 184,1E	14321,223	15021,80	15471,29	15601,45	Eucrite Juvinas	Howardite Kapoeta	Accuracy (%)
O	43.7	43.8	44.4	44.2	44.0	42.2	42.3	43.8	42.7	41.8	42.8	43.3	1
Mg	5.6	5.6	6.8	6.2	6.8	5.4	5.3	6.3	7.0	6.8	4.0	9.5	4
Al	9.6	9.2	8.4	8.6	8.7	6.5	6.4	7.5	7.1	5.7	7.1	4.4	2
Si	22.6	22.2	23.0	22.6	22.3	22.3	22.2	22.0	22.6	21.8	23.0	23.5	1
Ca	7.3	7.7	7.2	7.1	6.7	7.4	8.1	6.4	7.1	6.7	7.7	3.72	15
Ti	0.87	0.85	0.60	0.91	0.78	1.07	1.08	1.05	0.69	0.94	0.38	0.18	15
Fe	8.1	8.0	7.8	8.1	8.3	12.8	12.3	11.6	12.8	15.0	14.5	13.6	3
ppm													
Li	27	14									5.1		15
F	145	106	—	119	—	—	131	59	—	45	19	13	8
Na	5000	4710	6230	5670	5880	4060	3720	2890	2470	2260	2800	2050	5
Cl	280	40									18		20
K	4430	4020	7870	5300	4630	1430	1050	1650	1000	870	222	180	5
Sc	22.8	23.0	20	24	20	61	55	26.6	31	36.3	28.5	20.7	5
Cr	1290	1310	1190	1330	1070	3070	2800	2500	2980	3540	2090	4750	5
Mn	1010	1040	920	1040	970	1820	1720	1420	1560	1880	3990	3830	5
Co	43	36	30	31	39	30	28	42	45	51	3.8	28	5
Ni	400	380	—	200	—	—	39	—	—	90		410	15
Cu	15.6	12.3	—	10.9	—	—	8.2	—	—	8.2	1.65	4.83	10
Zn*	—	22	—	2.1	—	—	5.1	—	—	1.33	1.1	4.2	10
Ga	8.3	7.6	—	5.0	—	—	4.0	—	—	3.4	2.16	1.04	10
Ge	—	0.59	—	0.44	—	—	0.47	—	—	0.20	0.06	0.31	10
As	0.087	0.076	—	0.077	—	—	0.0087	—	—	0.0153	0.18	0.092	15
Rb	23	19	—	25	—	—	6.7	—	—		—		15
Sr	180	—	—	190	—	—	100	—	—	104	—		10
Pd	0.028	0.020	—	0.015	—	—	0.001	—	—	0.0062	≤0.001	0.016	20
In	1.01	0.034	—	0.0047	—	—	0.0065	—	—	—	~0.0015	~0.002	10
Cs	0.74	0.67	—	1.36	—	—	0.32	—	—	0.27			20
Ba	775	—	—	830	—	—	100	—	—	120	—		15
La	68	66	75	109	91	21	22	25	14.6	12.9	2.58	1.39	5
Ce	180	170	200	200	230	65	60	65	49	35	—	—	15
Pr	22	21	—	26	—	—	7.4	—	—	4.6	0.94	0.83	10
Nd	130	120	—	140	—	—			—	—	5.07		20
Sm	28	26	—	23	—	—	8.6	8.8	—	4.6	1.48	0.54	10
Eu	2.45	2.29	2.76	2.60	3.03	1.40	1.17	1.34	1.12	1.03	0.61	0.32	5
Gd	35	34	—	38	—	—	14.4	—	—	9.4	2.3	1.25	10
Tb	6.6	6.3	7.8	7.4	8.9	2.5	2.5		1.78	1.60	0.60	0.29	10
Dy	40	38	39	43	48	13	13	15	8.8	8.6	3.2	1.26	10
Ho	6.6	6.0	—	6.5	—	—	2.2	2.3	—	1.4	0.42	0.23	10
Er	28	26	—	32	—	—	9.3	—	—	6.1	2.3	0.79	10
Yb	23.5	21.5	25.1	24.2	28	7.5	6.8	8.3	5.05	4.71	1.72	0.89	5
Lu	2.7	2.7	3.6	3.5	3.9	1.20	0.94	1.20	0.72	0.77	0.28	0.14	10
Hf	23	21	30	26	31	8.0	7.1	8.8	5.5	4.4	1.3	0.6	10
Ta	3.2	2.8	3.6	3.2	4.0	1.2	1.0	1.20	0.68	0.46	0.12	0.10	15
W	1.95	1.70	—	1.94	—	—	0.55	—	—	0.28	0.041	0.036	10
Ir	0.019	0.016	—	0.010	—	—	0.0011	—	—	0.0041	0.0270	0.020	20
Au	0.0061	0.0055	—	0.0067	—	—	0.0006	—	—	0.0016	0.0079	0.0068	15
Th	[illegible]	14.3	—	17.4	—	—	2.6	—	—	1.8	—		10
U	4.07	3.79	—	5.45	—	—	0.54	—	—	0.57	0.089	0.051	10
Σ (%)	99.0	98.4	99.5*	99.3	98.9	98.7	98.7	99.5	100.8	99.6	100.4	99.4	

*The values for sample 14066 were corrected for 6 % contamination, see text. No entry means not determined. Samples 14066,31, 14321,184,25, 14321,184,1E, 15021,80, and 15471,29 were analyzed by INAA only.

(Wänke, et al, 1972)

Ta[illegible]umoto- et a
1972

Table 1. Concentrations of selected elements and elemental ratios in some Apollo 14 samples.

Sample number	Fraction analyzed	Sample weight (mg)	Concentrations (ppm)						Ratios			Approx. initial Pb (ppb)
									Atomic	Weight		
			K	U	Th	Pb	Rb	Sr	^{232}Th/^{238}U	K/U	K/Rb	
					Soil							
14003,37a*	Whole	242	2790	2.52	—	7.18	11.59	142.7	—	1100	242	755
14003,59b	Whole	167	—	3.31	11.66	8.16	—	—	3.64	—	—	493
14003,37	Acetone floats	23	—	4.04	14.60	13.16	—	—	3.73	—	—	1604
14003,37	$\rho = 2.9$–3.3	222	—	4.05	14.64	11.16	—	—	3.74	—	—	569
14163,156	Whole	59	4250	3.51	12.46	9.97	14.61	182.1	3.66	1370	291	362
14259,16a	Whole	150	3990	3.43	12.15	7.87	14.06	182.6	3.66	1160	284	265
14259,16b		215	—	3.47	12.35	7.52	—	—	3.68	—	—	185
					Breccia							
14063,37,M	Matrix	303	—	3.40	12.64	7.95	20.65	180.9	3.84	—	—	117
14063,37,C	Clast	29	3115	1.56	5.42	3.70	10.10	231.3	3.58	1997	308	194
14307,26,M	Matrix	230	4930	3.36	11.85	11.45	16.44	171.1	3.64	1467	300	548
14307,26,C1	Clast 1	178	3700	4.86	16.46	8.24	17.44	147.0	3.50	761	212	96
14307,26,C2	Clast 2	36	—	4.99	17.29	9.60	—	—	3.58	—	—	119
14318,26,M	Matrix	328	—	3.67	12.67	12.19	17.59	170.9	3.56	—	—	304
14318,26,C1	Clast 1	76	—	5.32	16.69	10.70	—	—	3.24	—	—	236
14318,26,C2	Clast 2	14	1490	—	—	—	5.35	141.7	—	—	279	
14318,40	Sawdust	419	—	3.29	11.35	13.9†	—	—	3.56	—	—	(271)
					Basalt							
14053,27	Whole	103	—	0.592	2.101	1.71	—	—	3.67	—	—	92
14310,71a	Whole	464	4010‡	3.10	10.42‡	6.18	9.79	154.8	3.43‡	1294	410	45
14310,71b	Whole	35	—	3.22	11.36	6.10	—	—	3.64	—	—	45
14310,71,M1	$\rho = 2.4$–2.67	29	—	4.64	18.66	10.70	—	—	4.15	—	—	—
14310,71,M2	$\rho = 2.67$–2.89	154	3790	2.59	8.73	4.91	10.48	270.1	3.49	1463	362	—
14310,71,M3	$\rho = 2.89$–3.3	95	—	6.23	22.41	11.61	—	—	3.71	—	—	—
14310,71,M4	$\rho > 3.3$	192	1410	2.31	8.66	4.12	4.12	26.86	3.87	610	342	—

* a—lead was analyzed by double electroplating; b—analyzed by barium coprecipitation and anodic electroplating. M and C in sample numbers indicate matrix and clast, respectively. M1–M4 of 14310 indicate density fractions.

† The lead concentration corrected to provide reasonable U–Th–Pb systematics compared with other fractions of the sample would be 11.1 ppm.

‡ Uncertainty of the data is about 10 percent.

(Tatsumoto, <u>et</u> <u>al</u>, 1972)

Table 2. Apollo 15 results.

Sample	Weight (gms)	Th (ppm)	U (ppm)	K (%)	^{26}Al (dpm/kg)	^{22}Na (dpm/kg)	^{54}Mn (dpm/kg)	^{56}Co (dpm/kg)	^{46}Sc (dpm/kg)
				Clastic Rocks					
15206	85.5	12.0 ± 1.3	3.2 ± 0.4	0.487 ± 0.018	40 ± 5	49 ± 5	7 ± 8	< 30	< 8
15205	334.4	12.0 ± 0.4	2.9 ± 0.5	0.440 ± 0.008	48 ± 6	48 ± 4	50 ± 30	< 13	< 7
15465	364.9	5.9 ± 0.11	1.46 ± 0.13	0.234 ± 0.004	120 ± 30	56 ± 14	31 ± 18	< 19	< 5
15265	314.2	5.05 ± 0.12	1.27 ± 0.07	0.211 ± 0.08	72 ± 8	37 ± 3	12 ± 15	8 ± 6	< 15
15558	1333.3	3.42 ± 0.18	1.01 ± 0.04	0.170 ± 0.006	84 ± 5	36 ± 5	23 ± 5	9 ± 3	3.0 ± 0.7
15255	240.4	3.5 ± 0.3	0.92 ± 0.07	0.156 ± 0.019	111 ± 7	43 ± 4	26 ± 3	11 ± 8	4 ± 4
15466	117.8	3.5 ± 0.2	0.86 ± 0.08	0.156 ± 0.004	79 ± 8	36 ± 4	4 ± 5	5 ± 4	0.5 ± 1.3
15086	172.1	3.2 ± 0.2	0.76 ± 0.03	0.143 ± 0.003	39 ± 6	50 ± 6	22 ± 6	11 ± 3	2.5 ± 0.7
15459	92.0	2.9 ± 0.4	0.70 ± 0.04	0.137 ± 0.004	120 ± 40	39 ± 3	16 ± 13	8 ± 9	3.9 ± 1.7
15455	881.1	2.0 ± 0.3	0.53 ± 0.16	0.106 ± 0.004	70 ± 30	42 ± 4	10 ± 6	6 ± 2	5 ± 11
15445	270.8	2.40 ± 0.18	0.63 ± 0.08	0.106 ± 0.014	81 ± 16	45 ± 5	< 50	< 18	0.8 ± 1.5
15426	125.7	1.89 ± 0.09	0.41 ± 0.02	0.090 ± 0.008	61 ± 5	39 ± 3	20 ± 20	7 ± 3	3.1 ± 1.2
15418	1127.5	0.102 ± 0.016	0.043 ± 0.002	0.0086 ± 0.0007	120 ± 5	26.6 ± 1.5	7.7 ± 0.9	1.9 ± 0.8	0.8 ± 0.2
				Crystalline Rocks					
15085	471.0	0.57 ± 0.05	0.138 ± 0.010	0.0404 ± 0.0009	84 ± 10	37 ± 3	23 ± 3	12 ± 2	3.9 ± 1.1
15256	201.0	0.42 ± 0.04	0.139 ± 0.009	0.030 ± 0.005	97 ± 6	37 ± 3	25 ± 5	6 ± 7	3.6 ± 1.8
15415	269.4	0.028 ± 0.014	0.003 ± 0.005	0.0124 ± 0.0005	116 ± 9	36 ± 5	0.4 ± 0.9	3 ± 4	< 8
				Fines					
15021	132.3	5.0 ± 0.16	1.32 ± 0.04	0.161 ± 0.006	179 ± 9	51 ± 2	18 ± 6	15 ± 4	3.3 ± 1.5
15031	142.4	4.85 ± 0.12	1.25 ± 0.08	0.184 ± 0.006	55 ± 4	34 ± 3	10 ± 20	< 7	6.8 ± 1.9
15041	145.7	4.64 ± 0.14	1.20 ± 0.05	0.174 ± 0.008	127 ± 8	61 ± 4	15 ± 30	35 ± 13	5.4 ± 1.9
15211	104.2	3.75 ± 0.17	0.98 ± 0.06	0.149 ± 0.002	130 ± 13	59 ± 6	19 ± 8	16 ± 4	3.4 ± 1.0
15271	527.9	4.1 ± 0.4	1.21 ± 0.04	0.162 ± 0.008	130 ± 30	37 ± 4	9 ± 6	5 ± 11	3 ± 2
15301	557.2	3.38 ± 0.19	0.80 ± 0.19	0.122 ± 0.002	104 ± 6	45 ± 6	22 ± 7	< 12	3.6 ± 1.6
15401	86.3	3.4 ± 0.2	0.90 ± 0.11	0.143 ± 0.002	73 ± 13	58 ± 12	29 ± 17	12 ± 4	4.1 ± 1.3
15431	145.4	4.86 ± 0.15	1.12 ± 0.09	0.186 ± 0.005	66 ± 7	36 ± 4	< 12	12 ± 12	3 ± 4

Note: The errors listed include estimates of the errors due to counting statistics, the uncertainties of the standards, and the lack of fit in data reductions and are one standard deviation. Upper limits are three standard deviations above zero.

(Keith, et al, 1972)

Table 1. Radionuclide content of Apollo 15 lunar samples from near St. George Crater, Station 2 (dpm/kg except as noted).

	15205,0	15206,0	15211,2	15221,1	15231,1	15091,15
^{22}Na	48 ± 2	50 ± 4	64 ± 3	72 ± 3	44 ± 1	50 ± 1
^{26}Al	52 ± 2	46 ± 4	152 ± 4	169 ± 5	104 ± 3	166 ± 5
^{46}Sc	3.3 ± 1.6	< 4	< 2.1	1.9 ± 1.9	2.8 ± 2.0	5 ± 4
^{48}V	6.7 ± 2.9	—	—	6 ± 6	9 ± 5	
^{54}Mn	17 ± 20	< 30	12 ± 9	< 19	9 ± 7	< 40
^{56}Co	< 8	< 11	6 ± 6	5 ± 5	< 8	< 26
^{60}Co	< 6	< 3	—	< 2.7	< 3.1	< 3
K (ppm)	4680 ± 200	4980 ± 200	1440 ± 60	1360 ± 70	1410 ± 70	1440 ± 80
Th (ppm)	12.6 ± 0.3	12.4 ± 0.2	3.95 ± 0.08	3.57 ± 0.18	3.59 ± 0.18	3.97 ± 0.06
U (ppm)	3.28 ± 0.10	3.22 ± 0.10	1.02 ± 0.03	0.97 ± 0.03	0.94 ± 0.03	0.93 ± 0.04
Sample weight (grams)	334	85.5	104	96	96	96
Sample type	Boulder-chips		Boulder fillet	Soil	Soil	Soil

(Rancitelli, et al, 1972)

Table 2. Radionuclide content of Apollo 15 lunar samples from Stations 6, 8, 9, and 9a (dpm/kg except as noted).

	15261,15 (6)	15271,19 (6)	15031,14 (8)•	15041,14 (8)	15501,2 (9)	15505,0 (9)	15535,0 (9a)	15557,1 (9a)	15556,0 (9a)
^{22}Na	37 ± 3	50 ± 4	33 ± 2	65 ± 2	62 ± 3	44 ± 2	39 ± 2	39 ± 2	40 ± 2
^{26}Al	50 ± 4	136 ± 3	60 ± 2	123 ± 4	74 ± 2	44 ± 2	61 ± 2	75 ± 2	103 ± 6
^{46}Sc	—	—	6.3 ± 2.7	2.9 ± 1.6	7 ± 5	<3.0	<3.1	3.4 ± 1.7	6.5 ± 1.0
^{48}V	—	—	<14	<11	—	—	—	—	12 ± 4
^{54}Mn	—	—	24 ± 8	14 ± 8	<20	42 ± 30	21 ± 5	34 ± 9	41 ± 12
^{56}Co	—	—	6 ± 6	27 ± 6	<31	<12	<16	<13	11 ± 4
^{60}Co	—	—	4.3 ± 2.8	<1.5	<3.6	<1.2	<1.2	<0.8	<1.7
K (ppm)	1670 ± 70	1620 ± 70	1780 ± 60	1640 ± 60	1250 ± 100	1550 ± 70	490 ± 50	340 ± 20	440 ± 30
Th (ppm)	4.64 ± 0.09	4.87 ± 0.10	4.74 ± 0.12	4.56 ± 0.14	4.15 ± 0.12	3.64 ± 0.07	0.45 ± 0.03	0.44 ± 0.02	0.56 ± 0.00
U (ppm)	1.18 ± 0.04	1.22 ± 0.06	1.33 ± 0.04	1.28 ± 0.04	1.03 ± 0.03	0.94 ± 0.02	0.104 ± 0.010	0.131 ± 0.008	0.15 ± 0.01
Sample weight (grams)	104	104	142	146	46.6	862	230	408	1514
Sample type	Trench soil	Soil	Trench soil	Trench soil	Soil clod	Breccia	Porphyritic basalt	Basalt	Basalt, vesicular

• Sampling station.

(Rancitelli, et al, 1972)

Table 4. Gamma-ray analyses of Apollo 15 samples. Only the last three digits of each sample number are given here; ppm, parts per millio
dpm, disintegrations per minute.

Sample or section number	Weight (g)	Depth (cm)	*K* (% weight)	Th (ppm)	U (ppm)	K/U	^{26}Al (dpm/kg)	^{22}Na (dpm/kg)	β^+ (dpm/k
				Soils (< 1 mm)					
431	145.4		0.19 ± 0.02	4.8 ± 0.7	1.1 ± 0.2	1730	68 ± 14	36 ± 5	
021	132		0.16 ± 0.02	5.1 ± 0.7	1.3 ± 0.2	1230	175 ± 25	50 ± 7	
271,16	527.9		0.16 ± 0.03	4.2 ± 0.8	1.2 ± 0.2	1330	130 ± 20	34 ± 5	
211,2	104.2		0.15 ± 0.03	3.8 ± 0.8	0.96 ± 0.20	1530	130 ± 20	57 ± 9	
301	557.2		0.12 ± 0.02	3.2 ± 0.5	0.88 ± 0.15	1360	104 ± 20	40 ± 10	
				Breccias and metaigneous rocks					
206	92.0		0.45 ± 0.06	11 ± 2	3.0 ± 0.6	1500	38 ± 15	45 ± 10	
265	314.2		0.19 ± 0.03	5.1 ± 1.0	1.3 ± 0.2	1460	79 ± 15	38 ± 9	
558	1333.3		0.17 ± 0.02	3.4 ± 0.4	1.0 ± 0.1	1700	84 ± 15	36 ± 10	
466	118.0		0.15 ± 0.03	3.5 ± 0.7	0.93 ± 0.20	1610	84 ± 15	40 ± 9	
086	172.1		0.14 ± 0.03	3.2 ± 0.5	0.76 ± 0.11	1840	39 ± 15	40 ± 15	
455	881.1		0.090 ± 0.020	1.9 ± 0.4	0.50 ± 0.10	1800	65 ± 20	39 ± 15	
426,1	125.7		0.082 ± 0.01	1.9 ± 0.4	0.43 ± 0.10	1900	59 ± 12	38 ± 8	
418	1140.7		0.0086 ± 0.0010	0.13 ± 0.04	0.04 ± 0.01	2150	120 ± 40	25 ± 10	
				Crystalline rocks					
085	471.3		0.041 ± 0.005	0.51 ± 0.10	0.13 ± 0.03	3150	71 ± 15	33 ± 10	
256	201.0		0.034 ± 0.004	0.46 ± 0.10	0.15 ± 0.02	2260	95 ± 15	36 ± 8	
X415	269.4		0.012 ± 0.002	0.007 ± 0.030	0.0024 ± 0.007		115 ± 15	36 ± 5	
				Drill stems					
6-3		11–21	0.19 ± 0.03	4.7 ± 1.0	1.3 ± 0.3	1460	57 ± 20	33 ± 18	77 ± 1
4-2		106–117	0.17 ± 0.03	4.3 ± 1.0	1.1 ± 0.3	1550	16 ± 18	34 ± 15	45 ± 1
1-2		234–245	0.19 ± 0.03	3.7 ± 1.0	1.1 ± 0.3	1730	< 11	< 10	< 9

(LSPET, 1972)

Table 2. Trace element data for Apollo 15 basaltic rocks.*

	Olivine normative			Quartz normative				Ultramafic
	15545,13	15256,22	15555,8	15475,35	15076,21	15103,3,4	15682,4	15385,2
K (ppm)	387	316	—	415	411	477	568	481
Rb (ppm)	0.750	0.68, *0.6*	*0.6*	0.514, *1.2*	0.917, *1.1*	0.999	1.15	—
Sr (ppm)	104	100, *98*	*92*	*117*	112, *120*	114	130	—
Ba (ppm)	46.7	49.9	—	61.2	62.7	64.4	88.1	63.8
La (ppm)	4.93	4.82	—	5.76	—	6.54	8.04	6.96
Ce (ppm)	13.9	14.5	—	15.5	15.1	19.2	22.8	18.0
Nd (ppm)	9.92	10.5	—	11.5	10.6	13.4	16.3	13.4
Sm (ppm)	3.29	3.43	—	3.66	3.52	4.28	5.08	4.51
Eu (ppm)	0.895	0.893	—	0.961	0.970	1.03	1.31	0.873
Gd (ppm)	4.48	4.65	—	—	4.95	5.72	6.80	6.08
Dy (ppm)	4.68	4.98	—	5.45	5.60	5.58	7.26	5.89
Er (ppm)	2.67	2.75	—	3.2	3.40	3.33	4.28	3.19
Yb (ppm)	2.16	2.25	—	2.6	2.77	2.82	3.45	2.72
Lu (ppm)	0.308	0.330	—	—	0.326	—	—	—
U (ppm)	0.132	0.139	—	0.153	0.149	—	0.213	—
Li (ppm)	—	—	—	6.3	—	—	5.56	—
Zr (ppm)	—	*89*	*76*	*89*	*97*	—	—	—
Nb (ppm)	—	*5.3*	*4.3*	*5.9*	*6.2*	—	—	—
Y (ppm)	—	*25*	*23*	*29*	*29*	—	—	—
Ni (ppm)	—	*48*	*42*	*9*	*11*	—	—	—

*Figures in italics by X-ray fluorescence analysis, the rest by stable isotope dilution mass spectrometry.

(Rhodes & Hubbard, 1973)

Table 5. Apollo 15 (highland breccias). Data in ppm except where shown in wt.%.

	15	15	15	15	15	15	15	15	15	15	15	15	15
	285	285	299	299	319	324	345	455	459	459	459	455	418
	21	21	21	21	2	4	3	14	74	97	97	20	49
	total	black	total	matrix	total	total	total	black	total	black	white	white	total
Station	6	6	6	6	7	7	7	7	7	7	7	7	7
Cs	0.15	0.19	0.19	0.18	0.1	0.1	0.21	0.16	0.15	0.13	—	—	—
Rb	4.1	4.5	5.0	4.7	2.0	2.6	5.5	2.7	3.4	2.92	0.78	—	—
Ba	280	260	320	300	134	160	330	370	230	160	101	42.0	20.0
Eu	1.3	1.27	1.45	1.3	1.05	1.07	1.47	1.82	1.18	0.83	1.06	1.67	0.69
Pb	1.7	3.6	2.6	3.0	2.5	2.3	3.6	3.0	3.3	3.5	1.1	1.0	0.14
Ca%	7.4	7.7	8.3	—				7.55		8.26	9.76	10.2	—
Na%	0.33	0.28	0.33	—				0.43		0.27	0.3	0.27	—
La	23.0	22.0	26.0	26.0	9.8	13.6	27.0	32.0	19.0	15.0	8.8	3.0	1.06
Ce	58.0	59.0	68.0	65.0	26.0	31.0	73.0	81.0	51.0	41.0	24.0	6.7	2.4
Pr	8.2	7.8	9.1	9.3	3.8	4.4	10.2	11.5	6.5	5.3	3.0	0.95	0.33
Nd	33.0	31.0	38.0	36.0	16.8	18.3	41.8	47.0	27.0	20.9	12.2	3.73	1.41
Sm	10.5	10.0	10.8	10.3	5.6	5.7	12.5	12.8	8.7	5.6	3.2	0.88	0.43
Eu	1.3	1.27	1.45	1.3	1.05	1.07	1.47	1.82	1.18	0.83	1.06	1.67	0.69
Gd	12.0	11.4	11.9	12.9	7.1	7.2	15.8	15.5	11.5	7.1	3.7	0.95	0.67
Tb	1.93	1.9	2.1	1.97	1.14	1.09	2.51	2.41	1.74	1.14	0.6	0.14	0.12
Dy	12.4	12.1	12.9	12.8	6.9	6.8	15.6	16.0	10.8	7.3	4.4	0.84	0.8
Ho	2.9	2.9	3.1	3.0	1.67	1.64	3.62	3.76	2.68	1.83	0.99	0.17	0.19
Er	8.2	8.6	8.7	8.6	4.7	4.7	10.7	10.7	7.7	5.1	2.8	0.46	0.59
Tm	1.3	1.4	1.3	1.4	0.74	0.73	1.6	1.6	1.2	0.78	0.34	0.06	0.1
Yb	7.8	8.2	8.1	8.5	4.5	4.4	9.5	9.8	7.2	4.7	2.3	0.36	0.6
Lu	1.3	1.3	1.3	1.3	0.69	0.68	1.5	1.5	1.11	0.73	0.32	0.06	0.09
ΣREE	182	179	203	198	90	101	227	247	157	117	68	20	9.5
Y	80.0	65.0	82.0	76.0	35.0	47.0	91.0	93.0	63.0	46.0	30.0	4.8	5.4
ΣREE + Y	262	244	285	274	125	148	318	340	220	163	98	24.8	14.9
La/Yb	2.94	2.68	3.21	3.06	2.2	3.1	2.84	3.27	2.64	3.19	3.8	8.3	1.77
Gd/Eu	9.23	8.97	8.21	9.92	6.76	6.72	10.7	8.51	9.75	8.55	3.5	0.57	0.97
Eu/Eu*	0.39	0.4	0.43	0.39	0.56	0.57	0.35	0.43	0.41	0.45	1.05	6.4	4.3
Eu*	3.33	3.17	3.37	3.33	1.88	1.88	4.2	4.23	2.88	1.84	1.01	0.26	0.16
Th	3.5	4.2	3.77	4.31	1.8	1.79	4.94	5.31	3.71	2.52	1.03	0.23	0.10
U	0.81	1.03	0.99	1.2	0.5	0.43	1.3	1.37	0.87	0.62	0.29	0.05	—

(Taylor, et al, 1973)

Zr		340.0	322.0	385.0	393.0	156.0	200.0	415.0	480.0	294.0	240.0	—	11.0	—
Hf		6.5	7.7	7.0	7.6	3.5	3.5	8.8	9.8	6.2	4.5	1.6	0.17	0.16
Sn		0.27	0.29	0.22	0.28	0.18	0.19	0.18	0.22	0.09	0.21	0.12	—	—
Nb		24.0	23.0	27.0	27.0	10.1	15.0	29.0	33.0	19.0	15.6	—	0.95	0.43
Ti%		0.8	0.79	0.8	—	—	—	—	0.81	—	0.61	0.19	—	—
W		0.08	0.3	0.19	0.23	0.18	0.13	0.25	0.31	—	0.12	0.09	—	—
Th/Y		4.3	4.1	3.8	3.6	3.6	4.1	3.8	3.9	4.3	4.1	3.6	4.2	—
Zr/Hf		52.0	42.0	55.0	51.0	45.0	58.0	47.0	49.0	51.0	53.0	—	38	—
Zr/Nb		14.0	14.0	14.4	14.5	15.5	14.0	14.0	14.5	15.5	15.0	—	12.0	—
Cr		2600	3100	2000	1750	2400	2500	1800	1800	2150	1900	1640	440	1150
V		102.0	98.0	45.0	24.0	140.0	130.0	190.0	39.0	96.0	—	—	16.0	18.0
Sc		17.0	19.0	16.0	16.0	33.0	36.0	17.0	13.0	23.0	—	—	—	7.0
Ni		300	190	195	215	248	248	160	184	232	—	—	12.0	54.0
Co		56.0	66.0	44.0	40.0	48.0	48.0	27.0	22.0	42.0	—	—	10.0	10.0
Cu		9.2	11.2	4.7	4.2	11.0	11.0	28.0	3.3	4.4	—	—	1.3	2.0
Fe%		11.6	10.0	8.5	—	—	—	—	6.8	—	8.71	4.55	3.23	—
Mn		1300	—	—	—	—	—	—	—	—	1000	—	—	—
Mg%		7.0	6.85	6.11	—	—	—	—	8.0	—	6.85	5.69	6.55	—
Ga		3.6	4.5	3.8	2.2	4.4	5.0	2.6	3.3	4.1	—	—	2.6	2.2
Al%		8.0	8.3	9.5	—	—	—	—	9.1	—	9.1	12.4	13.8	—
Si%		21.3	21.8	21.9	—	—	—	—	22.1	—	21.8	21.9	20.7	—
SiO_2		45.6	46.7	46.9	—	—	—	—	47.3	—	46.6	46.9	44.4	
TiO_2		1.34	1.31	1.33	—	—	—	—	1.35	—	1.02	0.32	<0.07	
Al_2O_3		15.2	15.7	17.9	—	—	—	—	17.1	—	17.2	23.5	26.2	
FeO		15.0	12.9	10.9	—	—	—	—	8.79	—	11.2	5.85	4.2	
MnO		0.17	—	—	—	—	—	—	—	—	0.13	—	—	
MgO	%	11.6	11.4	10.1	—	—	—	—	13.3	—	11.4	9.43	10.9	
CaO		10.3	10.8	11.6	—	—	—	—	10.6	—	11.6	13.7	14.3	
Na_2O		0.44	0.38	0.45	—	—	—	—	0.58	—	0.41	0.41	0.36	
K_2O		—	0.15	0.17	—	—	—	—	0.17	—	0.16	0.08	<0.06	
Cr_2O_3		0.38	0.45	0.29	—	—	—	—	0.26	—	0.27	0.24	0.064	
Σ		100.3	99.8	99.6	—	—	—	—	99.5	—	100.0	100.4	100.6	

(Taylor, et al, continued)

Table 1. Chemical data for known or proposed primary lunar rock types. All data are from ion exchange procedures followed by colorimetry (Al_2O_3) atomic absorption (FeO, MgO, CaO and Na_2O) and stable isotope dilution mass spectrometry (all else).

	14143,3,100 9.2 mgms fragment	14152,5,102 11.1 mgms fragment	14161,35,7 27.3 mgms 14310 type	15076,21 61.1 mgms mare basalt	15256,22 60.2 mgms meta-mare basalt	15475,35 51.9 mgms mare basalt	15545,13 50.0 mgms mare basalt	15682,4 33.5 mgms mare basalt	15103,3,4 22.8 mgms fragment	15304,25 43.5 mgms KREEP
TiO_2%	0.527	1.17	1.11	1.90	2.47	1.66	2.35	2.25	—	1.85
Al_2O_3%	—	21.3	—	—	—	—	—	—	12.5	15.6
FeO_2%	4.7	7.5	6.1	18.5	22.2	—	22.0	18.2	—	10.3
MgO%	4.8	6.4	6.2	7.75	9.03	8.31	9.45	7.94	6.45	8.49
CaO%	15.8	13.4	12.8	—	9.93	—	—	—	11.5	9.94
Na_2O%	0.63	0.79	0.74	0.30	0.26	0.33	0.283	0.39	0.34	0.71
Cr ppm	—	—	—	—	—	—	—	—	—	2074
K ppm	1900	4100	3730	411	316	347	387	568	477	4570
Rb ppm	5.56	12.6	11.4	0.917	0.68	0.696	0.750	1.15	0.999	14.0
Sr ppm	157	202		112	100	111	104	130	114	183.0
Ba ppm	294	609	580	62.7	49.9	45.2	46.7	88.1	64.4	
La ppm	23.7	56.6	55.1	7.38	4.82	4.01	4.93	8.04	6.54	
Ce ppm	61.3	148	139	15.1	14.5	13.1	13.9	22.8	19.2	166.0
Nd ppm	37.6	85.4	83.0	10.6	10.5	8.87	9.92	16.3	13.4	103.0
Sm ppm	10.6	23.9	23.3	3.52	3.43	2.93	3.29	5.08	4.28	29.1
Eu ppm	1.34	2.28	2.04	0.978	0.893	0.481	0.895	1.31	1.03	2.53
Gd ppm	12.6	30.7	28.4	4.95	4.65	—	4.48	6.80	5.72	34.3
Dy ppm	14.3	34.0	32.1	5.60	4.98	4.59	4.68	7.26	5.58	37.4
Er ppm	8.80	19.3	19.1	3.40	2.75	2.70	2.67	4.28	3.33	21.9
Yb ppm	7.72	18.0	17.6	2.77	2.25	2.35	2.16	3.45	2.82	20.2
Lu ppm	1.16	2.59	2.56	0.326	0.330	0.350	0.308	—	—	—
U ppm	1.24	3.24	2.80	0.149	0.139	0.108	0.132	0.213	—	3.14
Li ppm	—	—	—	—	—	15.3	—	5.56	—	26.3

(Hubbard, et al, 1973)

Table 1. Abundances of Trace Elements in Apollo 16 and 14 Samples (ppb; Ni, Zn, and Rb, ppm)

	Class.*	Ir	Re	Au†	Ni	Sb†	Ge	Se	Te	Ag	Br	Bi	Zn*	Cd	Tl	Rb	Cs	U
Rocks																		
60017.6A‡	B4 DG-MMSB	1.24	0.103	*4.25*	47	0.37	9.4	21	6.8	3.4	230	0.36	3.3	5.0	1.76	0.70	41	135
60017.8B	B4 DG-MMSB	1.73	0.161	0.41	35	1.01	20	17.7	7.2	0.50	560	0.26	5.4	4.1	3.09	0.78	49	117
60095.5	Glass	25.4	2.17	7.11	560	2.62	306	167	26	1.2	136	0.59	1.55	1.8	1.66	1.67	64	670
60315.79	C2 Poik	11.0	1.36	18.3	798	11.0	625	520	4.7	0.94	23	0.13	0.30	5.0	0.20	10.8	540	2280
63335.17	B5	1.32	0.136	0.81	70	3.19	28	24	6.1	4.9	310	2.02	16.3	12.4	2.03	1.20	67	159
63355.7	B4 DG-MRB	16.6	2.27	18.4	800	5.87	1910	340	38	2.3	230	0.44	5.2	5.7	6.0	6.5	300	980
64455,25	Glass	40.6	4.11	12.7	905	3.16	500	390	12.8	1.6	830	0.63	2.4	5.2	83.2	3.9	144	860
64455,27	C2 Basalt	2.25	0.284	1.56	80	0.45	62	190	2.5	1.2	1200	0.08	2.2	5.3	109	6.6	280	1430
65016.7	Glass	26.3	2.29	7.19	532	1.66	225	96	12.8	0.59	42	0.23	0.52	1.5	0.60	1.44	82	650
67955.20	C2(B1?) LMB	5.56	0.572	1.60	231	0.23	59	26	9.7	1.2	199	0.34	6.7	4.3	0.66	1.20	64	360
68115.77	B5 DG	0.040	0.005	*2.28*	<7	0.19	6.7	3.4	0.4	0.19	700	0.22	0.47	81	130	0.043	8.1	1.8
69935,8	B4	12.7	1.55	11.9	583	3.63	325	190	2.8	1.3	220	0.19	0.88	6.6	0.25	5.9	380	870
Soil Separates																		
67702.16-5	Breccia	2.62	0.279	1.45	120	0.44	123	34	5.0	0.61	13	0.12	1.35	2.8	0.44	1.1	34	180
67702.16-6	Breccia	1.63	0.144	0.34	60	0.16	17	19.0	0.7	0.40	6.3	0.15	1.35	2.8	0.21	0.34	18	57
Apollo 14																		
14306.35.8§	B Rhyolite	3.6	0.28	2.2		11.8	39	50	23	0.92	550	1.2	2.9	10	28	114	4500	7200
14306.35.9§	B Bulk	8.14	0.64	5.3		1.41	390	99	5.3	2.5	270	0.28	2.7	31	6.0	18.6	1030	4800
14306.35.10	B Metal	950	90.2	553	45600	525	64600	98	53	73	17600	32	*41600*	1430	24.0	2.7	440	630
14306.35.11	B Nonmagn.	3.71	0.361	3.05	151	*22.8*	195	75	3.9	1.6	220	0.56	4.0	36	5.87	23	1100	5200
14258.36.14	S Metal	36.2	4.75	45.2	3570	163	129000	430	16	1.3	7.8	0.37	0.65	17	0.45	2.1	61	820

*Classified according to Wilshire *et al.* (1973) and Warner *et al.* (1973):

B = breccia
B1 = light matrix, light clast
B4 = dark matrix, light clast
B5 = dark matrix, dark clast
C2 = crystalline, metaclastic
DG = devitrified glass with plagioclase and/or lithic relics

LMB = light matrix breccia
MMSB = melted matrix shocked breccia
MRB = mesostasis-rich basalt
poik = poikilitic rock with plagioclase, olivine, and/or lithic relics

†Italicized values are high, owing to contamination.

‡Krahenbühl *et al.* (1973) Geochim. Cosmochim. Acta, Suppl. 4, 1325-1348.

§Ganapathy *et al.* (1973) Geochim. Cosmochim. Acta, Suppl. 4, 1239-1261.

(Ganapathy & Anders, 1974)

Table 1. Bulk and trace element abundances in breccias 64435, 63335, 63355 and 60017.

	64435+			63335*	63355*	60017*
Element	Matrix 271mg	Glass 38 mg	Anorthosite 53 mg	115 mg	137 mg	295 mg
TiO_2(%)	0.2	0.5	<0.1	0.34	0.88	0.37
Al_2O_3	32.1	24.5	35.5	31.5	21.5	31.2
FeO	3.0	8.0	0.61	2.6	8.3	3.6
MgO	3	8	–	2	8	3
CaO	17.0	13.3	19.0	17.6	12.0	17.0
Na_2O	0.34	0.55	0.29	0.69	0.50	0.52
K_2O	0.024	0.086	0.025	0.049	0.22	0.056
MnO	0.040	0.105	0.011	0.035	0.089	0.048
Cr_2O_3	0.064	0.170	0.0083	0.035	0.169	0.054
Sc(ppm)	5.2	6.9	0.90	4.4	12	6.7
V	15	20	<4	10	35	10
Co	7	100	1.3	5	62	7
Zr	–	100	–	–	280	~30
Ba	20	90	<9	40	280	50
La	1.5	9.6	0.16	2.6	30	3.1
Ce	4	24	–	6	74	8
Nd	3	15	<0.4	4	47	5
Sm	0.70	4.3	0.086	1.2	12.0	1.4
Eu	0.76	0.91	0.69	1.32	1.51	1.24
Tb	<0.2	0.80	0.03	0.2	2.5	0.3
Dy	0.8	5.1	0.2	1.5	16	1.7
Yb	0.58	2.8	0.06	0.9	8.8	1.2
Lu	0.082	0.43	0.008	0.13	1.3	0.16
Hf	0.41	3.2	<0.03	0.60	8.9	1.0
Ta	0.07	0.35	<0.02	0.10	1.2	0.14
Th	0.25	1.1	–	0.25	4.2	0.5
U	<0.1	0.4	<0.02	<0.1	1.2	<0.14
Ni	–	1800	–	–	940	45
Ir(ppb)	–	50	–	<3	24	<1.5
Au(ppb)	–	30	–	4	16	4

+This rock has been assigned to the Mason consortium.

*These three rocks are chips from the ≈5m Shadow Rock at Station 13. Data for 60017 were reported by Laul and Schmitt (2).

(Lau & Schmitt, 1974)

Table 1. Primordial and cosmogenic radionuclide concentrations of samples from the Apollo 16 central highland site.

Sample	Location/Remarks	Mass (gm)	Thorium (ppm)	Uranium (ppm)	Potassium (ppm)	^{26}Al (dpm/KG)	^{22}Na (dpm/KG)
Fines							
60051,27	ALSEP "Caliche-like"	41·5	1.68±0.08	0.42±0.03	820±80	115±9	56±4
61161,16	Plum Crater Radial Sample	41.9	1.97±0.09	0.54±0.03	910±80	202±16	65±5
64801,4	Stone Mtn. NW wall of Southern Crater	31.4	2.21±0.11	0.58±0.03	850±140	116±9	55±5
65701,32	Stone Mountain. S wall of crater	38.6	2.31±0.11	0.57±0.05	1030±120	131±9	56±5
68841,33	Near South Ray Fillet Reference	42.1	2.34±0.09	0.56±0.03	1000±80	91±7	39±7
69961,44	Near South Ray Under Boulder	39.9	2.33±0.13	0.52±0.04	1000±80	74±6	42±4
Rocks							
61016,173	Plum Crater Type II	132.5	0.11±0.03	0.05±0.02	70±40	104±9	36±6
67455,56	North Ray Rim Type II, from top of white breccia boulder	133.5	0.03±0.03	0.01±0.02	130±100	103±8	29±5

Notes: (i) ^{22}Na concentrations were corrected for decay to April 23, 1972. (ii) Errors for ^{26}Al concentrations in the fines include a 6% error in the ^{26}Al standard. (iii) Models of 61016,173 and 67455 were not available; a model of a similarly shaped 87 gm rock provided mock-ups for use in identical containers. (iv) Rock types are according to LSPET (1973).

(Wrigley, et al, 1973)

Table 4. $(\mathrm{He}^4/\mathrm{He}^3)_r$ and $(\mathrm{Ar}^{40}/\mathrm{Ar}^{36})_r$ after corrections.

Sample	U (ppm)	Th (ppm)	$\mathrm{He}_c^3/\mathrm{He}^3$	$(\mathrm{He}^4/\mathrm{He}^3)_r$	K (ppm)	$\mathrm{Ar}_c^{36}/\mathrm{Ar}^{36}$	$(\mathrm{Ar}^{40}/\mathrm{Ar}^{36})_r$
61221,1	0.32	1.15	0.50	4320	832	0.06	4.19
61241,15	0.555	1.98	0.07	2700	905	0.05	1.27
62241,8	0.46	1.70	0.10	2850	940	0.03	2.60
62281,7	0.597	2.063	0.09	2720	962	0.03	2.43
64801,20	0.601	2.23	0.10	2770	995	0.05	1.61
65513,20	0.74	2.74	0.12	2670	1230	0.07	2.13
65701,11	0.65	2.26	0.06	2450	1180	0.06	1.29
65701,11	0.65	2.26	0.06	2510	1180	0.05	1.71
65901,11	0.61	2.455	0.06	2530	1055	0.06	1.24
65901,11	0.61	2.455	0.07	2620	1055	0.07	1.29
66041,14	0.70	2.37	0.07	2750	1003	0.06	1.36
66081,11	0.70	2.3	0.10	2790	1100	0.04	2.69
68841,17	0.585	2.355	0.07	2690	1008	0.10	0.93
69941,17	0.676	2.40	0.06	2710	1060	0.08	1.03
60601,10	0.568	2.21	0.05	2700	1009	0.07	1.05
60601,10	0.568	2.21	0.05	2630	1009	0.08	1.06
67481,21	0.323	1.12	0.06	3190	550	0.10	1.20
67701,20	0.325	1.18	0.04	2880	636	0.14	0.83

K, U, and Th were taken from the following references: Clark and Keith (1973); Barnes *et al.* (1973); Eldridge *et al.* (1973); Jovanovic and Reed (1973); LSPET (1973); Mark *et al.* (1973); Murthy *et al.* (1973); Rancitelli *et al.* (1973); Silver (1973); Wänke *et al.* (1973); and Wrigley (1973).

When more than one value was available for a given sample, these were averaged.

(Walton, et al, 1973)

Table 2. Gamma ray analyses of Apollo 16 soils.

Sample	Density (g/cm^3)	K (ppm)	Th (ppm)	U (ppm)	^{26}Al (dpm/Kg)	^{22}Na (dpm/Kg)	K/U
61161,19	1.4	860 ± 85	1.97 ± 0.10	0.55 ± 0.03	190 ± 10	52 ± 6	1563
61181,19	1.6	910 ± 45	2.02 ± 0.10	0.56 ± 0.03	204 ± 10	40 ± 4	1625
61281,20	1.4	935 ± 60	1.85 ± 0.03	0.52 ± 0.03	192 ± 10	52 ± 5	1798
61501,39	1.6	930 ± 48	1.85 ± 0.09	0.53 ± 0.03	142 ± 7	42 ± 4	1755
62241,37	—	940 ± 47	1.70 ± 0.09	0.46 ± 0.03	130 ± 6	41 ± 3	2043
63501,3	1.4	728 ± 50	1.53 ± 0.08	0.41 ± 0.03	220 ± 11	55 ± 8	1775
64801,1	—	1060 ± 50	2.23 ± 0.10	0.60 ± 0.03	105 ± 6	50 ± 4	1766
65901,27	—	1010 ± 50	2.21 ± 0.11	0.60 ± 0.03	109 ± 5	32 ± 3	1683
66031,17	1.1	963 ± 52	1.88 ± 0.09	0.53 ± 0.04	208 ± 10	52 ± 5	1816
67941,1	—	1060 ± 53	1.89 ± 0.09	0.55 ± 0.04	158 ± 10	27 ± 5	1927
68501,2	1.6	965 ± 45	2.28 ± 0.10	0.58 ± 0.04	84 ± 6	38 ± 4	1664

(Eldridge and O'Kelley, 1973)

Table 1. Gamma ray analyses of Apollo 16 rocks.

Sample	Density (g/cm^3)	K (ppm)	Th (ppm)	U (ppm)	^{26}Al (dpm/Kg)	^{22}Na (dpm/Kg)	K/U
60135,0	1.8	146 ± 30	0.27 ± 0.03	0.068 ± 0.020	160 ± 8	40 ± 4	2147
60315,0	2.9	3180 ± 160	8.56 ± 0.43	2.34 ± 0.12	92 ± 8	47 ± 5	1359
61016,120	2.9	560 ± 30	1.84 ± 0.09	0.38 ± 0.02	65 ± 5	30 ± 5	1474
61135,1	2.0	690 ± 34	1.39 ± 0.07	0.38 ± 0.03	120 ± 6	41 ± 3	1816
61155,0	2.2	445 ± 60	1.12 ± 0.05	0.31 ± 0.02	178 ± 9	61 ± 4	1435
61156,0	2.8	720 ± 60	1.55 ± 0.07	0.55 ± 0.06	156 ± 7	56 ± 5	1309
61175,0	2.1	745 ± 38	1.42 ± 0.07	0.40 ± 0.03	137 ± 7	41 ± 3	1862
61195,0	2.5	506 ± 25	1.13 ± 0.05	0.30 ± 0.02	54 ± 3	42 ± 3	1687
61295,18	1.8	770 ± 40	1.48 ± 0.07	0.39 ± 0.03	158 ± 8	52 ± 4	1959
62295,0	2.3	630 ± 32	3.20 ± 0.15	0.82 ± 0.05	110 ± 6	59 ± 5	768
65095,0	2.5	780 ± 40	1.96 ± 0.10	0.52 ± 0.04	104 ± 5	28 ± 4	1500
66035,0	2.2	765 ± 38	1.87 ± 0.09	0.49 ± 0.02	136 ± 7	42 ± 3	1561
66075,0	2.4	795 ± 40	1.86 ± 0.09	0.51 ± 0.03	130 ± 7	49 ± 4	1559
67055,0	2.0	1620 ± 80	3.69 ± 0.18	0.98 ± 0.05	137 ± 10	56 ± 8	1653
67937,0	1.1	1650 ± 90	3.24 ± 0.16	0.96 ± 0.05	54 ± 3	50 ± 5	1719

(Eldridge and O'Kelley, 1973)

Table 1. Apollo 16 rocks and fines.

Rocks	Weight (g)	Th (ppm)	U (ppm)	K (%)	Al^{26} (dpm/kg)	Na^{22} (dpm/kg)	Mn^{54} (dpm/kg)	Co^{56} (dpm/kg)	Sc^{46} (dpm/kg)	Th/U	K/U
60115,1	83.322	1.46±0.16	0.35±0.02	0.054±0.005	98±7	44±4	25±12	11±8	3±2	4.17±0.5	1540±170
*60255,0	862.6	2.4±0.2	0.63±0.12	0.110±0.002	120±6	39±3	20±14	4±5	2±2	3.8±0.8	1750±330
*60275,0	255.2	2.99±0.18	0.88±0.03	0.115±0.002	129±8	48±6	6±5	<12	<9	3.4±0.2	1310±50
*60335,0	311.0	2.75±0.10	0.92±0.04	0.174±0.008	140±8	48±8	<23		3±2	2.99±0.17	1890±120
*62235,0	317.7	9.4±0.6	2.57±0.06	0.284±0.004	137±8	50±7	<6	13±13	5±3	3.7±0.2	1105±30
62237,0	48.59	<0.12	0.043±0.012	0.0119±0.0018	144±18	56±7	26±17	<20	6±10	<4	2800±900
62236,0	54.27	<0.10	0.016±0.010	0.0114±0.0017	119±15	53±6	17±12	36±15	5±3	<16	7100±4600
62275,0	438.6	0.009±0.006	<0.006	0.0148±0.0012	94±11	28±2	<10	<2	<4		
63335,5	27.81	0.24±0.06	0.072±0.014	0.052±0.003	111±7	30±3				3.3±1.1	7200±1500
*63355,1	43.55	4.85±0.18	1.31±0.06	0.202±0.005	98±6	48±4	25±9		<40	3.7±0.2	1540±80
*64476,0	125.14	1.19±0.08	0.31±0.03	0.066±0.002	132±11	48±5	<7		1.5±1.6	3.8±0.5	2100±200
*65055,0	500.9	1.18±0.07	0.311±0.019	0.060±0.004	109±6	31±4	3±3	5±3	0.9±0.8	3.8±0.3	1930±170
*66075,0	347.1	2.05±0.11	0.55±0.03	0.083±0.005	149±8	39±5	3±4	5±3	1.3±1.1	3.7±0.3	1510±120
67035,17	88.37	0.36±0.03	0.117±0.007	0.0441±0.0011	126±19	45±6	<12			3.08±0.4	3770±240
*67055,0	221.4	3.6±0.3	0.99±0.08	0.16±0.02	116±8	43±3	6±4	2±4	3±2	3.6±0.4	1600±240
*67115,9	187.48	0.43±0.07	0.121±0.011	0.0463±0.0014	62±6	29±3	1.7±1.9	<8	0.3±0.5	3.6±0.7	3800±400
67435,0	327.8	3.6±0.5	1.09±0.08	0.147±0.003	161±9	45±7			<30	3.3±0.5	1350±100
*67475,0	174.1	0.67±0.08	0.19±0.02	0.045±0.007	126±9	38±3	2±2	<11		3.5±0.6	2400±400
67935,5	79.87	2.90±0.13	0.84±0.03	0.163±0.003	56±8	48±11			8±5	3.45±0.2	1940±80
67936,18	35.19	3.12±0.12	0.91±0.04	0.161±0.004	52±3	48±3			12±20	3.4±0.2	1770±90
67975,0	437.0	1.76±0.11	0.513±0.13	0.0833±0.0015	68±4	23±3			4±3	3.43±0.9	1600±400
*68815,2	34.49	2.74±0.14	0.81±0.03	0.122±0.003	150±30	56±11	21±6	<15	4±2	3.4±0.2	1510±70
*60501.2	116.72	2.2±0.3	0.61±0.03	0.098±0.005	107±8	42±5	8±3	10±8	<4	3.6±0.5	1600±110
60601.32	100.03	2.21±0.08	0.565±0.018	0.1002±0.0017	109±18	36±5	9±9		2±2	3.91±1.19	1770±60
61141.22	100.0	2.04±0.08	0.556±0.018	0.0959±0.0017	170±30	58±9				3.67±0.19	1720±60
*62281.6	107.9	2.10±0.17	0.62±0.03	0.093±0.004	225±13	63±9	2±4	17±18	<7	3.4±0.3	1500±100
*64421.3	100.0	2.0±0.4	0.62±0.04	0.093±0.005	111±10	39±6	<10	19±7	<8	3.2±0.7	1500±130
64501.37	100.0	1.86±0.08	0.490±0.017	0.0877±0.0016	160±30	44±5	6±6	<11	2.2±1.4	3.8±0.2	1790±70
65901.1	109.86	2.7±0.2	0.62±0.07	0.110±0.002	124±7	42±5	30±18	9±11	<7	4.4±0.6	1800±200
*66041.4	108.44	2.5±0.4	0.66±0.04	0.096±0.006	161±11	51±7	3±4	9±5	<5	3.8±0.6	1460±130
*66041.28	100.0	2.2±0.3	0.74±0.03	0.102±0.005	159±10	54±6	2±4	11±8	<7	3.0±0.4	1380±90
*66081.25	100.03	2.3±0.4	0.70±0.03	0.110±0.006	102±7	44±5				3.3±0.6	1570±110
67031.1	49.05	0.51±0.04	0.146±0.010	0.0425±0.0018	166±9	56±3	<10		4±2	3.5±0.4	2900±230
*67481.1	100.03	1.12±0.09	0.323±0.019	0.055±0.003	168±10	60±8	6±3	9±10	<4	3.5±0.3	1700±140
67601.1	100.07	1.04±0.05	0.284±0.010	0.0601±0.0012	96±16	33±5	6±6		4±2	3.7±0.2	2120±90
67701.1	100.06	1.18±0.06	0.325±0.012	0.0636±0.0013	220±40	56±5	4±5		5±2	3.6±0.2	1960±90
68821.20	100.0	2.33±0.11	0.59±0.02	0.101±0.002	240±40	48±4		4±7	5±2	3.9±0.2	1710±70
68841.35	127.0	2.33±0.09	0.59±0.02	0.0996±0.002	87±14	33±7	10±9		2.3±1.4	3.9±0.2	1690±70

Note 1: Short-lived activities corrected for decay and reported as of April 23, 1972.

Note 2: The errors listed include estimates of the errors due to counting statistics, the uncertainties of the standards, and the lack of fit in data reductions and are one standard deviation. Upper limits are three standard deviations above zero.

Note 3: An asterisk denotes samples for which the five major isotopes were reported

(Clark and Keith, 1973)

Table 2. Major, minor and trace elements in Apollo 16 samples.

%	60601-17 Fines Stat. 10	61141-8 Fines Stat. 1	61161-7 Fines Stat. 1	61501-19 Fines Stat. 1	64421-28 Fines Stat. 4	65701-12 Fines Stat. 5	67461-17 Fines Stat. 11	61016-151 Gabbroic Anorth. Stat. 1	67455-15 Gabbroic Anorth. Stat. 11	accuracy %
O	44.4	44.7	44.7	44.1	45.0	44.3	45.3	44.5	45.1	1
Mg	3.91	3.74	3.83	3.80	3.16	3.68	2.38	6.27	2.02	4
Al	13.9	14.0	13.9	14.2	14.7	14.1	16.0	13.2	16.2	2
Si	21.2	21.0	20.9	21.1	21.1	21.1	21.3	20.3	21.1	1
Ca	12.1	10.8	11.4	11.3	11.3	10.8	12.1	10.8	12.9	7
Ti	0.33	0.32	0.35	0.33	0.32		0.20	0.45	0.12	7
Fe	4.38	4.14	4.39	4.29	3.82	4.54	3.36	4.06	3.39	3
ppm										
Li							4.5			15
F	59						27	31	14*	10
Na	3510	3350	3460	3480	3270	3290	3200	2700	2820	3
P			530				260	560	42	10
Cl							12			20
K	890	920	865	880	870	990	380	640	215	5
Sc	9.2	8.4	8.7	8.6	7.9	9.0	7.1	6.6	6.8	5
Cr	720	660	670	690	620	770	470	610	420	5
Mn	540	480	505	500	450	540	420	385	420	5
Co	31.2	24.4	29.0	29.5	25.0	30.0	12.5	36.7	9.95	5
Ni	400	400	400	470	330	420	120	510	28	7
Cu	7.0	—	—	—	—	—	4.6	—	1.65	10
Zn	24	—	—	—	—	—	11	—	8.5	10
Ga	4.6	—	—	—	—	—	4.2	—	3.4	10
Ge	1.1	—	—	—	—	—	0.35	—	—	10
As	0.16	—	—	—	—	—	0.035	—	0.010	15
Rb	6.0	—	—	—	—	—	2.0	—	—	15
Sr	170	140	150	150	160	152	145	162	130	10
Y	42	38	37	37	40		18	44	4.4	10
Zr	186	167	184	167	174		72	209	17	7
Nb	11	11	11.5	11	9.5		3.8*	13	1.3*	10
Pd	0.024	—	—	—	—	—	0.0097	—	—	15
In	0.018	—	—	—	—	—	0.004	—	—	10
Cs	0.17	—	—	—	—	—	0.14	—	—	20
Ba	120	110	120	130	115	100	57	160	40	20

(Wanke, et al, 1973)

La	13.4	12.7	12.2	12.2	12.3	13.0	4.5	16.7	1.35	5
Ce	34	33	32	32	35	38	13	41	3.7	10
Pr	4.6	—	—	—	—	—	1.7	—	0.41	15
Nd	23	23	17	17	—	19	8.0	—	—	15
Sm	6.0	5.4	5.6	5.7	5.7	5.9	2.1	6.9	0.60	10
Eu	1.29	1.17	1.15	1.17	1.14	1.17	1.05	1.39	0.84	5
Gd	7.4	—	—	—	—	—	2.8	—	0.90	10
Tb	1.1	0.92	1.0	1.0	1.1	1.2	0.4	1.2	—	10
Dy	7.4	6.9	6.7	7.3	6.8	7.5	2.5	7.9	0.92	10
Ho	1.8	1.7	1.8	1.7	1.6	1.9	0.5	2.0	0.2	10
Er	5.4	—	—	—	—	—	2.1	—	0.63	10
Yb	4.3	3.9	4.0	4.0	4.0	4.45	1.6	4.40	0.52	5
Lu	0.57	0.53	0.54	0.57	0.57	0.58	0.22	0.61	0.085	10
Hf	4.2	4.0	3.8	4.0	4.0	4.8	1.45	4.9	0.40	10
Ta	0.55	0.42	0.52	0.48	0.50	0.54	0.22	1.02	—	15
W	0.30	—	—	—	—	—	0.074	—	0.035	10
Re	0.0026	—	—	—	—	—	0.0005	—	0.0002	10
Ir	0.015	0.012	0.019	0.014	0.009	0.019	—	0.014	0.004	20
Au	0.010	0.010	0.013	0.0095	0.0075	0.0135	0.0015	0.013	0.001	10
Th	1.6	1.7	1.5	1.6	—	—	0.6	1.4	—	20
U	0.57	—	—	—	—	—	0.18	—	0.053	10
Σ	100.9	99.4	100.2	99.9	100.1	99.6	101.1	100.1	101.3	
K/La	66.4	72.4	70.9	72.1	70.7	76.2	84.4	38	159	
Zr/Nb	16.9	15.2	16	15.2	18.3		18.9	16	13	
Zr/Hf	44.3	41.8	48.4	41.7	43.5		49.6	42.6	42.5	

*Accuracy reduced by a factor of 2.

(Wanke, <u>et</u> <u>al</u>, continued)

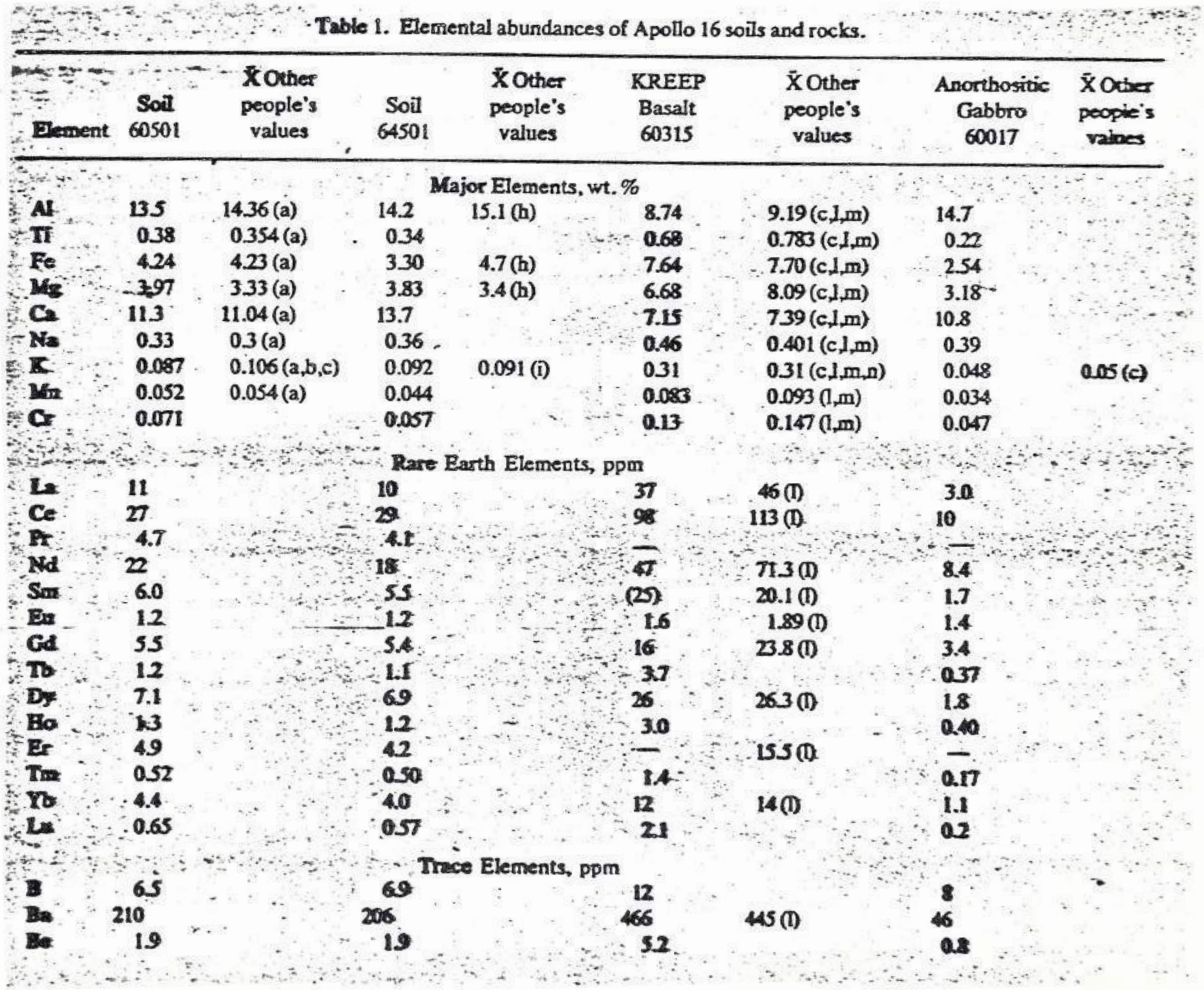


Table 1. Elemental abundances of Apollo 16 soils and rocks.

Element	Soil 60501	X̄ Other people's values	Soil 64501	X̄ Other people's values	KREEP Basalt 60315	X̄ Other people's values	Anorthositic Gabbro 60017	X̄ Other people's values
				Major Elements, wt. %				
Al	13.5	14.36 (a)	14.2	15.1 (h)	8.74	9.19 (c,l,m)	14.7	
Ti	0.38	0.354 (a)	0.34		0.68	0.783 (c,l,m)	0.22	
Fe	4.24	4.23 (a)	3.30	4.7 (h)	7.64	7.70 (c,l,m)	2.54	
Mg	3.97	3.33 (a)	3.83	3.4 (h)	6.68	8.09 (c,l,m)	3.18	
Ca	11.3	11.04 (a)	13.7		7.15	7.39 (c,l,m)	10.8	
Na	0.33	0.3 (a)	0.36		0.46	0.401 (c,l,m)	0.39	
K	0.087	0.106 (a,b,c)	0.092	0.091 (i)	0.31	0.31 (c,l,m,n)	0.048	0.05 (c)
Mn	0.052	0.054 (a)	0.044		0.083	0.093 (l,m)	0.034	
Cr	0.071		0.057		0.13	0.147 (l,m)	0.047	
				Rare Earth Elements, ppm				
La	11		10		37	46 (l)	3.0	
Ce	27		29		98	113 (l)	10	
Pr	4.7		4.1		—		—	
Nd	22		18		47	71.3 (l)	8.4	
Sm	6.0		5.5		(25)	20.1 (l)	1.7	
Eu	1.2		1.2		1.6	1.89 (l)	1.4	
Gd	5.5		5.4		16	23.8 (l)	3.4	
Tb	1.2		1.1		3.7		0.37	
Dy	7.1		6.9		26	26.3 (l)	1.8	
Ho	1.3		1.2		3.0		0.40	
Er	4.9		4.2		—	15.5 (l)	—	
Tm	0.52		0.50		1.4		0.17	
Yb	4.4		4.0		12	14 (l)	1.1	
Lu	0.65		0.57		2.1		0.2	
				Trace Elements, ppm				
B	6.5		6.9		12		8	
Ba	210		206		466	445 (l)	46	
Be	1.9		1.9		5.2		0.8	

(Morrison, et al, 1973)

Co	30		29		89		8.0	
Cs	0.03		0.02	0.085 (p)	0.05		0.004	
Cu	7.7	4.8 (a)	5.9		10.8		2.1	
Ga	3.6	5.1 (d)	4.5		4.1		3.3	
Hf	5.4		4.4		13		0.98	
In	0.08	0.013 (d)	0.33		0.07		0.01	
Li	8		6	6.75 (j)	24		8	
Nb	13	12.1 (a)	11		33	37 (m)	2.1	
Ni	418	408 (a,d)	340	400 (k)	1380	191 (m)	59	
P	640	630 (a)	630		2500	2030 (l,m)	140	
Pb	2.3	2 (e,f)	2.2		3		3	
Rb	2.6	2.81 (a,g)	2.2	2.0 (p)	9.0	9.8 (l,m,o)	0.8	
S	480	650 (a)	450		1050	1400 (l,m)	120	
Sc	10.1		7.17		13.4		6.0	
Sr	158	167 (a,g)	158		156	156 (l,m,o)	250	
Th	2.4	2.3 (b,c,e,f)	2.6		9.2	8.11 (m,n)	0.6	0.8 (c)
U	0.62	0.61 (b,c,e,f)	0.54	0.57 (j,p)	2	2.24 (l,n)	0.13	0.2 (c)
V	17		10		31		<2	
Y	50	41 (a)	40		120	142 (m)	6	
Zn	22	22.3 (a,d)	20	23.8 (p)	<8		8.2	
Zr	210	192 (a)	218		840	640 (m)	52	

Letters in parentheses indicate the references: (a) Duncan *et al.* (1973); (b) Rancitelli *et al.* (1973); (c) MSC (1972); (d) **Baedecker** *et al.* (1972); (e) Silver (1973); (f) Tera and Wasserburg (1972); (g) Papanastassiou and Wasserburg (1972); (h) **Ehmann** *et al.* (1973); (i) Kirsten *et al.* (1973); (j) Jovanovic and Reed (1973); (k) Tsay *et al.* (1973); (l) Bansal *et al.* (1973); (m) **LSPET** (1973); (n) Eldridge *et al.* (1973); (o) Nyquist *et al.* (1973); (p) Krähenbühl *et al.* (1973).

(Morrison, et al, continued)

Table 1. Elemental composition of Apollo 16 fines, rocks, breccias, and fractions.

		62241,7 fines (1–2 mm) STA-2	62241,7/1 glass	62241,7/2 plagioclase	62241,7/4 iron nodules	61016,145 breccia STA-1	62235,57 basalt STA-2	66095,48 breccia STA-6
Na	%	0.38	0.38	0.37	—	0.25	0.40	0.34
Mg	%	5.5	6.9	1.2	—	5.5	8.5	5.6
Al	%	14.7	14.7	19.0	—	13.9	11.3	13.7
Cl	ppm	34.0	—	—	—	160.0	21.0	220.0
K	%	0.087	—	—	—	0.065	0.223	0.073
Ca	%	10.7	14.4	15.1	—	10.9	8.8	9.2
Sc	ppm	8.5	8.3	0.95	< 0.8	5.9	16.9	6.8
Ti	%	0.35	0.62	< 0.15	—	0.66	0.51	0.30
V	ppm	90.0	20.0	< 15.0	—	40.0	80.0	110.0
Cr	%	0.079	—	0.0067	—	0.065	0.127	0.086
Mn	%	0.057	0.069	0.0069	—	0.044	0.086	0.055
Fe	%	3.7	4.4	0.22	80.3	3.6	8.0	4.3
Co	ppm	24.0	36.0	2.6	3760.0	33.0	64.0	44.0
Ni	ppm	360.0	650.0	< 10.0	6.87%	540.0	1030.0	710.0
Cu	ppm	6.3	—	—	—	6.6	3.9	3.9
Zn	ppm	24.0	—	—	—	3.4	2.2	92.0
Ga	ppm	4.4	—	—	—	2.5	4.6	3.8
Rb	ppm	3.1	—	—	—	3.2	16.0	11.0
In	ppb	36.0	—	—	—	10.0	10.0	680.0
Cs	ppm	0.25	0.21	0.04	—	0.17	0.45	0.40
Ba	ppm	100.0	163.0	< 20.0	—	125.0	530.0	150.0
La	ppm	12.1	16.7	< 0.7	< 0.7	15.6	57.7	18.5
Ce	ppm	30.8	—	8.3	—	40.0	146.0	50.0
Sm	ppm	5.29	6.09	0.45	0.43	6.8	22.3	8.8
Eu	ppm	1.43	—	2.7	—	1.53	2.39	1.63
Tb	ppm	0.85	1.15	0.07	< 0.10	1.02	5.1	1.3
Dy	ppm	6.4	—	—	—	7.3	35.0	9.4
Ho	ppm	1.2	—	—	—	1.6	6.0	1.3
Er	ppm	4.2	—	—	—	4.4	18.0	4.1
Yb	ppm	3.5	—	< 0.2	—	3.9	13.5	4.9
Lu	ppm	0.63	—	< 0.02	—	0.72	2.87	0.90
Hf	ppm	3.3	3.65	< 0.1	< 0.1	4.5	20.7	5.0
Ta	ppm	0.37	0.39	< 0.03	< 0.10	0.45	2.28	0.44
Th	ppm	1.5	1.6	0.18	< 0.2	1.7	9.4	2.2
U	ppm	0.65	0.25	0.22	< 0.2	0.73	3.2	1.0

(Brunfelt, *et al*, 1973)

TABLE 7-V. Gamma Ray Analyses of Apollo 16 Lunar Samples

Sample no.	*Weight, g*	*Th, ppm*	*U, ppm*	*K, percent (by weight)*	*^{26}Al, dpm/kg*	*^{22}Na, dpm/kg*
60017,0	2102.0	0.80 ± 0.20	0.20 ± 0.04	0.050 ± 0.015	–	–
60135,0	137.6	.29 ± .04	.08 ± .03	.015 ± .003	159 ± 16	41 ± 6
60255,0	862.6	2.4 ± .2	.63 ± .12	.110 ± .002	120 ± 6	39 ± 3
60275,0	255.2	2.99 ± .18	.88 ± .03	.115 ± .002	129 ± 8	48 ± 6
60315,0	787.7	8.56 ± .90	2.34 ± .24	.318 ± .030	92 ± 9	47 ± 6
60335,0	311.0	2.75 ± .10	.92 ± .04	.174 ± .008	140 ± 8	43 ± 8
61195,0	587.9	1.1 ± .1	.31 ± .03	.057 ± .006	34 ± 7	35 ± 8
62235,0	317.7	9.4 ± .6	2.57 ± .06	.284 ± .004	137 ± 8	50 ± 7
62295,0	250.8	2.8 ± .3	.74 ± .07	.055 ± .010	95 ± 10	60 ± 12
63355,1	43.55	4.85 ± .18	1.31 ± .06	.202 ± .005	98 ± 6	48 ± 4
64435,0	1059.6	.10 ± .03	.03 ± .01	.010 ± .003	–	–
64476,0	125.14	1.19 ± .08	.31 ± .03	.066 ± .002	132 ± 11	48 ± 5
65015,0	1802.2	10.0 ± 2.0	3.0 ± .7	.40 ± .09	–	–
65055,0	500.9	1.18 ± .07	.311 ± .019	.060 ± .004	109 ± 6	31 ± 4
66075,0	347.1	2.05 ± .11	.55 ± .03	.083 ± .005	149 ± 8	39 ± 5
67055,0	221.4	3.69 ± .37	.98 ± .10	.162 ± .016	137 ± 15	56 ± 8
67055,0	221.4	3.6 ± .3	.99 ± .08	.16 ± .02	116 ± 8	43 ± 3
67095,0	339.8	3.89 ± .21	1.18 ± .06	.195 ± .010	89 ± 5	58 ± 8
67115,9	187.48	.43 ± .07	.121 ± .011	.0463 ± .0014	62 ± 6	29 ± 3
67475,0	174.1	.67 ± .08	.19 ± .02	.045 ± .007	126 ± 9	38 ± 3
68415,1	202.5	1.22 ± .10	.35 ± .03	.093 ± .008	159 ± 15	47 ± 5
68416,0	175.4	1.24 ± .13	.34 ± .04	.083 ± .008	160 ± 15	41 ± 4
68815,2	34.49	2.74 ± .14	.81 ± .03	.122 ± .003	150 ± 30	56 ± 11
69935,0	127.57	2.52 ± .15	.62 ± .06	.079 ± .008	153 ± 15	41 ± 7
69955,0	75.77	.14 ± .02	.038 ± .006	<.009	76 ± 7	35 ± 5
60501,2	116.72	2.2 ± .3	.61 ± .03	.098 ± .005	107 ± 8	42 ± 5
60501,2	116.72	2.44 ± .06	.60 ± .02	.106 ± .005	110 ± 5	38 ± 2
61241,28	106.55	1.98 ± .09	.51 ± .02	.085 ± .004	183 ± 7	62 ± 2
62281,0	107.9	2.10 ± .17	.62 ± .03	.093 ± .004	225 ± 13	63 ± 9
63501,3	100.13	1.53 ± .15	.41 ± .04	.0728 ± .008	220 ± 20	55 ± 8
63501,4	100.05	1.76 ± .15	.41 ± .03	.074 ± .003	142 ± 7	57 ± 2
64421,3	100.0	2.0 ± .4	.62 ± .04	.093 ± .005	111 ± 10	39 ± 6
64801,1	126.53	2.23 ± .22	.60 ± .06	.106 ± .011	105 ± 11	50 ± 5
66041,4	108.44	2.40 ± .06	.70 ± .04	.103 ± .005	151 ± 8	40 ± 3
66041,4	108.44	2.5 ± .4	.66 ± .04	.096 ± .006	161 ± 11	51 ± 7
66041,28	100.00	2.2 ± .3	.74 ± .03	.102 ± .005	159 ± 10	54 ± 6
66081,25	100.03	2.3 ± .4	.70 ± .03	.110 ± .006	102 ± 7	44 ± 5
67481,1	100.03	1.12 ± .09	.323 ± .019	.055 ± .003	168 ± 10	60 ± 8
67941,1	50.71	1.89 ± .19	.55 ± .06	.106 ± .011	158 ± 20	27 ± 5
68121,1	99.99	2.63 ± .08	.63 ± .03	.095 ± .004	112 ± 4	41 ± 2
68501,2	100.03	2.28 ± .23	.58 ± .06	.0965 ± .010	84 ± 9	38 ± 5
68501,3	100.03	2.59 ± .10	.64 ± .03	.092 ± .003	96 ± 3	36 ± 2
69921,1	46.96	2.47 ± .10	.67 ± .03	.087 ± .003	305 ± 10	86 ± 3

(LSPET, 1972)

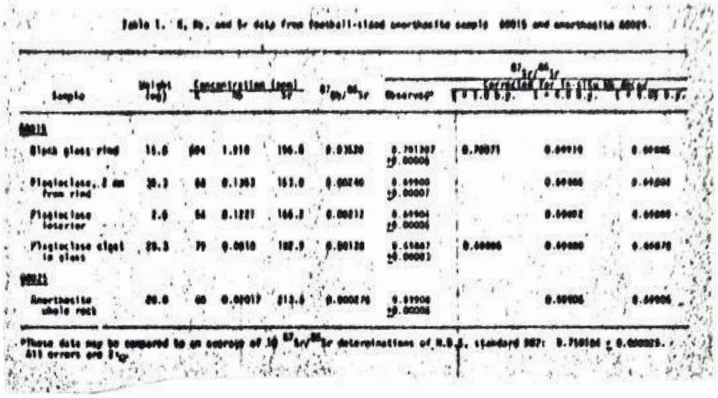


Table 1. K, Rb, and Sr data from football-sized anorthosite sample 60015 and anorthosite 60025.

Sample	Weight (mg)	Concentration (ppm) K	Rb	Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$ Observed*	Corrected for in-situ Rb decay T = 1.0 b.y.	T = 4.0 b.y.	T = 4.05 b.y.
60015									
Black glass rind	15.6	604	1.910	196.6	0.02820	0.70130 ±0.00006	0.70071	0.69910	0.69906
Plagioclase, 2 mm from rind	30.3	68	0.1263	153.0	0.00240	0.69900 ±0.00007		0.69886	0.69884
Plagioclase interior	2.0	64	0.1227	166.3	0.00212	0.69904 ±0.00006		0.69892	0.69890
Plagioclase clast in glass	20.3	79	0.0810	182.9	0.00128	0.69887 ±0.00003	0.69886	0.69880	0.69878
60025									
Anorthosite whole rock	20.0	60	0.00017	213.6	0.000270	0.69906 ±0.00006		0.69906	0.69906

*These data may be compared to an average of 10 $^{87}Sr/^{86}Sr$ determinations of N.B.S. standard 987: 0.710184 ± 0.000025. All errors are 2σ.

(Nunes, et al, 1974)

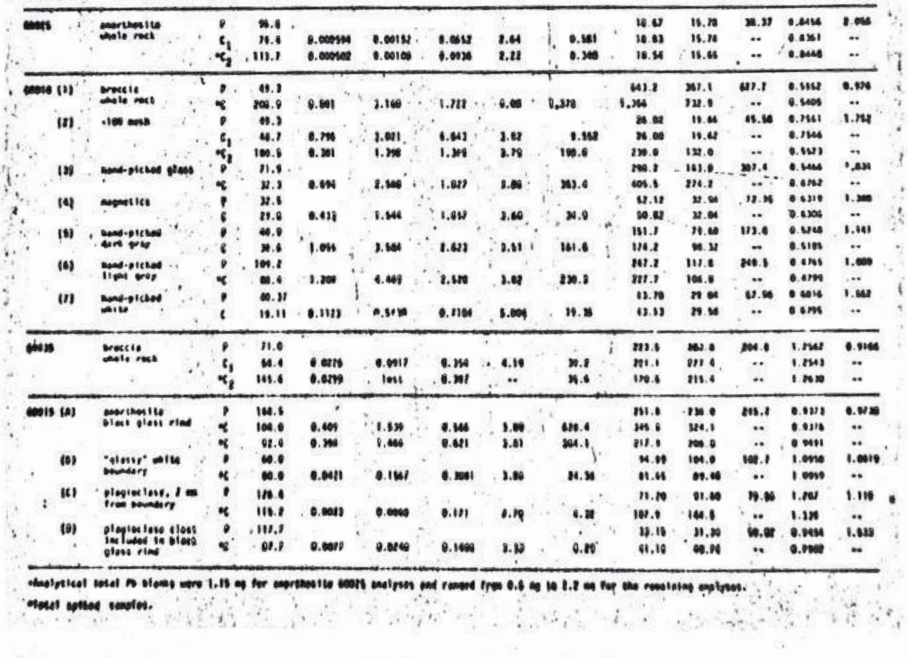


Table 2. U-Th-Pb data of some Apollo 16 samples.

Sample no.	Description	P/C	Weight (mg)	Concentration (ppm) U	Th	Pb	$^{232}Th/^{238}U$	$^{238}U/^{204}Pb$	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$
60025	anorthosite whole rock	P	96.6						18.67	15.70	38.37	0.8456	2.056
		C_1	74.4	0.000594	0.00152	0.0652	2.64	0.581	18.83	15.74	--	0.8361	--
		$^*C_2$	113.7	0.000502	0.00109	0.0936	2.22	0.340	18.54	15.65	--	0.8448	--
60018 (1)	breccia whole rock	P	49.2						643.2	357.1	627.7	0.5552	0.976
		*C	200.9	0.601	2.160	1.722	3.72	0,370	1,364	732.9	--	0.5406	--
(2)	<100 mesh	P	49.3						26.02	19.44	45.58	0.7561	1.752
		C_1	46.7	0.796	3.021	6.643	3.92	9.552	26.00	19.62	--	0.7546	--
		$^*C_2$	100.5	0.301	1.398	1.309	3.79	190.6	238.0	132.0	--	0.5523	--
(3)	hand-picked glass	P	71.9						298.2	163.0	307.4	0.5466	1,034
		*C	32.3	0.694	2.580	1.027	3.86	383.4	405.5	274.2	--	0.6762	--
(4)	magnetics	P	32.5						52.12	32.94	72.36	0.6319	1.388
		C	29.0	0.433	1.544	1.057	3.60	34.0	50.82	32.04	--	0.6304	--
(5)	hand-picked dark gray	P	40.9						151.7	78.60	173.6	0.5248	1.143
		C	30.6	1.056	3.584	2.623	3.51	161.6	174.2	90.32	--	0.5185	--
(6)	hand-picked light gray	P	109.2						247.2	117.8	248.5	0.4765	1.000
		*C	80.4	1.200	4.403	2.520	3.82	230.3	227.7	106.8	--	0.4799	--
(7)	hand-picked white	P	80.37						43.70	29.04	67.96	0.6816	1.562
		C	19.11	0.1123	0.5438	0.7104	5.004	19.35	43.53	29.58	--	0.6795	--
60035	breccia whole rock	P	71.0						223.5	280.8	204.9	1.2562	0.9166
		C_1	54.4	0.0226	0.0917	0.354	4.19	39.2	221.1	277.4	--	1.2543	--
		$^*C_2$	145.6	0.0299	lost	0.307	--	36.6	170.5	215.4	--	1.2630	--
60015 (A)	anorthosite black glass rind	P	168.5						251.8	236.0	245.2	0.9373	0.9738
		*C	108.0	0.409	1.539	0.546	3.89	628.4	345.6	324.1	--	0.9376	--
		*C	92.0	0.398	1.466	0.621	3.81	304.1	217.9	208.0	--	0.9491	--
(B)	"glassy" white boundary	P	60.0						94.99	104.0	102.7	1.0950	1.0819
		*C	80.0	0.0421	0.1567	0.3081	3.86	24.36	81.65	89.40	--	1.0959	--
(C)	plagioclase, 2 mm from boundary	P	170.6						71.70	91.60	79.86	1.267	1.116
		*C	115.2	0.0033	0.0080	0.171	2.79	4.38	107.9	144.5	--	1.339	--
(D)	plagioclase clast included in black glass rind	P	117.7						33.15	31.30	50.02	0.9454	1.533
		*C	87.7	0.0077	0.0240	0.1490	3.33	0.89	41.10	40.74	--	0.9902	--

*Analytical total Pb blanks were 1.15 ng for anorthosite 60025 analyses and ranged from 0.6 ng to 1.2 ng for the remaining analyses.

*Total spiked samples.

(Nunes, et al, 1974)

Table 1. Gamma-ray analysis of Apollo 17 rocks.

Type*	Basalts					Breccia				Brecciated or shocked anorthosites to gabbros			Miscellaneous		
Subtype	Fine		Medium		Coarse	Dk. Matrix	Agglutinate	Grn-grey Matrix	Lt.-grey banded matrix	Norite	Coarse norite		Poikilitic clasts		Brecciated Dunite
Sample	70255	71155	70275	78135	75035	70175	70019	76215	72255	76535	78235	78255,1	72315,17	72355	72415
Weight (g)	224.9	25.83	171.4	133.93	499.6	338.8	128.0	642.8	402.57	145.57	128.8	31.01	84.82	347.4	29.79
Comments		Boulder chip			With soil sample	Friable	from crater floor	Boulder spall	Boulder chip	rake sample	boulder chip	boulder chip	boulder clast	boulder ch..	boulder clast
Th (ppm)	.31 ± .03	.31 ± .06	.43 ± .04	.26 ± .06	.39 ± .05	.40 ± .04	1.03 ± .10	4.6 ± .2	4.4 ± .4	.19 ± .02	.59 ± .08	.83 ± .06	4.80 ± .5	5.3 ± .3	<.15
U (ppm)	.107 ± .008	.118 ± .017	.125 ± .013	.107 ± .012	.135 ± .006	.105 ± .007	.23 ± .02	1.27 ± .06	1.20 ± .15	.054 ± .01	.196 ± .016	.227 ± .016	1.53 ± .15	1.39 ± .15	<.05
K (%)	.048 ± .004	.040 ± .003	.043 ± .006	.0525 ± .0018	.0536 ± .008	.055 ± .002	.0692 ± .0012	.215 ± .014	.184 ± .008	.0235 ± .0008	.0490 ± .0015	.059 ± .003	.284 ± .015	.284 ± .015	.007 ± .002
^{26}Al (dpm/kg)	49 ± 6	125 ± 8	51 ± 5	42 ± 4	72 ± 10	42 ± 5	45 ± 3	56 ± 3	78 ± 6	94 ± 5	77 ± 7	65 ± 6	62 ± 8	62 ± 8	77 ± 6
^{22}Na (dpm/kg)	72 ± 7	119 ± 11	85 ± 5	74 ± 5	67 ± 8	76 ± 10	110 ± 8	60 ± 4	61 ± 5	119 ± 13	111 ± 8	50 ± 5	73 ± 5	73 ± 6	250 ± 30
^{54}Mn (dpm/kg)	137 ± 15	162 ± 20	162 ± 30	180 ± 20	100 ± 6	156 ± 9	166 ± 12	22 ± 17	41 ± 6	24 ± 6	55 ± 8	10 ± 5	90 ± 9	80 ± 9	77 ± 16
^{56}Co (dpm/kg)	211 ± 18	313 ± 50	225 ± 20	242 ± 20	59 ± 13	300 ± 70	243 ± 30	45 ± 6	35 ± 15	8 ± 5	52 ± 9	30 ± 20			450 ± 30
^{46}Sc (dpm/kg)	63 ± 6	61 ± 7	83 ± 20	76 ± 5	45 ± 4	39 ± 5	50 ± 5	5 ± 3	6 ± 6	<1.3	1.4 ± .9	<15			8 ± 3
^{48}V (dpm/kg)	<30		32 ± 15	18 ± 8		17 ± 8					<12				
Th/U	2.9	2.6	3.6	2.4	2.9	3.8	4.5	3.6	3.7	3.5	3.0	3.7	3.1	3.1	
K/U	4500	3400	3600	4900	3800	5200	3000	1690	1500	4400	2500	2600	1900	1900	>1170
Group composition°	70215				75055	79135		77135	77135	76235	78155				72415
SiO_2 (%)	37.79				41.27	42.29		46.13	47.54	44.52	45.75				38.83
TiO_2 (%)	13.14				10.17	5.15		1.56	.91	.20	.27				.03
Al_2O_3 (%)	8.76				9.75	15.08		18.01	17.01	27.04	25.94				1.53
FeO (%)	19.62				18.24	14.01		9.11	11.58	5.14	5.02				11.34
MgO (%)	8.52				6.04	10.42		12.63	9.35	7.63	6.33				43.63
CaO (%)	10.43				12.20	11.46		11.03	11.71	15.17	15.18				3.94

* As classified by LSPET (1973).
° Taken from rocks in the same group (LSPET, 1973).
Shortlived activities are corrected to time of lunar liftoff.

Table 2. Gamma-ray analysis of Apollo 17 fines.

Sample*	72221,0	72241,0	72441,0	74220,92	75061,5	76240,2	76261,1
Desc.	boulder overhang fillet	boulder fillet	under boulder	orange soil	boulder top skim	shadowed soil	skim reference
Approx. depth (cm.)	0-3	0-5	70**	5-8	0-1	0-5	0-2
Th (ppm)	3.6 ± .4	3.6 ± .5	3.5 ± .4	.65 ± .09	.91 ± .13	2.5 ± .3	2.1 ± .3
U (ppm)	.89 ± .03	.94 ± .03	.83 ± .03	.164 ± .010	.248 ± .015	.618 ± .018	.49 ± .02
K (%)	.142 ± .004	.144 ± .004	.141 ± .004	.068 ± .002	.066 ± .002	.118 ± .004	.102 ± .003
^{26}Al (dpm/kg)	132 ± 12	107 ± 17	65 ± 6	45 ± 4	180 ± 16	156 ± 14	182 ± 17
^{22}Na (dpm/kg)	63 ± 4	143 ± 8	47 ± 3	51 ± 3	187 ± 10	41 ± 3	148 ± 8
^{54}Mn (dpm/kg)	48 ± 11	78 ± 13	38 ± 11	50 ± 3	200 ± 14	28 ± 6	93 ± 7
^{56}Co (dpm/kg)	<200	130 ± 90	<300	31 ± 6	490 ± 30	28 ± 17	240 ± 20
^{46}Sc (dpm/kg)	5 ± 2	11 ± 3	6 ± 2	19.1 ± 1.6	86 ± 8	7.2 ± .8	23 ± 2
^{48}V (dpm/kg)				13 ± 14	47 ± 12	7.0 ± 1.4	18 ± 12
Th/U	4.0	3.8	4.2	4.0	3.7	4.0	4.3
K/U	1600	1500	1700	4100	2700	1900	2100

* All Sample weights were approximately 100 gm.
**Approximate thickness of the boulder.

(Keith, et al, 1974)

Table 1. Primordial Radioelement Concentrations in Apollo 17 Samples.

Sample Number	Density (g/cm^3)	Type*	K (ppm)	Th (ppm)	U (ppm)	Th/U	K/U
Rocks							
70135	3.0	CB	500± 30	0.31±.02	0.12±.01	2.6	4170
70185	3.0	CB	420± 35	0.30±.03	0.10±.02	3.0	4200
70215,4	3.3	FB	320± 64	0.36±.03	0.13±.03	2.8	2500
71135	1.9	FB	310± 60	0.60±.05	0.14±.03	4.3	2214
71136	2.4	FB	370±100	0.46±.06	0.22±.05	2.1	1680
71175	2.4	MB	560± 28	0.39±.02	0.11±.01	3.5	5091
73215	2.5	BR	1665± 85	4.05±.20	1.10±.05	3.7	1514
73255	2.4	BR	1590± 80	3.47±.17	1.00±.05	3.5	1590
73275	2.2	BR	2240±112	4.53±.23	1.20±.06	3.8	1867
76295	2.4	BR	2270±114	5.30±.27	1.50±.08	3.5	1510
78597	2.6	FB	380± 20	0.38±.02	0.11±.01	3.4	3454
79155	2.6	CB	440± 30	0.32±.02	0.11±.01	2.9	4000
Soils (< 1 mm fines)							
73121		TT	1160± 60	2.63±.13	0.72±.04	3.7	1610
73131		TM	1160± 60	2.24±.11	0.63±.03	3.6	1840
73141		TB	1130± 60	2.25±.11	0.63±.03	3.6	1790
73221		TT	1180± 60	2.13±.11	0.63±.03	3.4	1870
73241		TM	1220± 60	2.25±.11	0.64±.03	3.5	1910
73261		TB	1090± 60	2.40±.12	0.67±.04	3.6	1630
73281		TB	1180±150	2.33±.11	0.58±.04	4.0	2030
76501		RS	900± 50	1.39±.14	0.38±.04	3.6	2370
78501		RS	770± 40	1.11±.11	0.28±.03	4.0	2750
79221		TT	700± 40	1.12±.06	0.36±.03	3.1	1940
79261		TB	700± 40	1.08±.05	0.31±.02	3.5	2260

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*CB = coarse basalt, FB = fine basalt, MB = medium basalt, BR = breccia, TT = trench top, TM = trench middle, TB = trench bottom, RS = rake soil [Anon. (1973) Lunar Sample Inventory for Apollo 11, 16 and 17. Proc. Fourth Lunar Sci. Conf., Geochim. Cosmochin. Acta. Suppl. 4, Vol. 3, pp. i-xliii. Pergamon.].

(Eldridge, et al, 1974)

Table 1. Elemental composition of Apollo 17 fines

	71501 Sta 1A	72501 Sta 2	74121 LRV 6	74261 Sta 4	75061 Sta 5	76321 Sta 6	78501 Sta 8	Apollo 17 mare basalt+	Apollo 11 type B basalt*	Apollo 17 non-mare component+	Apollo 16 average fines (3)	Noritic Breccias***	Anorthitic Rocks****	50% A.R. 50% N.B.
Na %	0.28	0.35	0.33	0.35	0.29	0.34	0.30	0.28	0.30 ±0.03	0.35	0.37	0.40	0.25	0.33
Mg %	5.4	6.6	4.7	5.6	4.7	5.8	5.2	4.8	4.2 ±0.5	6.1	3.8	7.6	4.0	5.8
Al %	6.31	11.28	10.58	6.90	5.55	9.98	8.45	5.0	5.4 ±0.2	11.7	14.5	9.5	14.0	11.7
K %	0.079	0.140	0.124	0.111	0.070	0.102	0.089	0.064	0.063±0.024	0.13	0.10	0.22	0.06	0.14
Ca %	8.6	10.6	10.6	8.7	6.4	8.5	10.5	7.5**	8.2 ± 0.4	9.6**	11.0	8.1	11.0	9.6
Sc ppm	62.5	17.7	25.2	49.1	65.2	25.4	39.2	71	94 ± 5	13	8.4			
Ti %	5.05	0.70	1.37	3.76	5.70	1.69	2.88	5.9	6.3 ± 0.7	0.5	0.32	1.15	0.22	0.68
V ppm	116	61	57	81	137	55	68	130	75 ± 31	45	36			
Cr ppm	7770	1590	1600	2490	2840	1640	2170	3100	2020± 760	1300	730	1360	880	1120
Mn ppm	1750	894	1030	1540	1840	1060	1370	1920	2230± 180	820	560	820	620	720
Fe %	15.2	6.58	7.56	11.1	13.1	7.66	9.91	14.0	14.4 ± 0.7	6.0	4.0	6.9	4.4	5.7
Co ppm	27.1	38	30.0	25.5	25.0	26.6	31.6		19 ± 3		26			
Ni ppm	8.9	6.4	9.0	21.6	6.9	6.7	8.5				8			
Zn ppm	74	20	18	120	30	20	26				20			
Ga ppm	4.9	[illegible]	4.8	16.0	4.1	3.9	5.0				4.8			
Rb ppm	1.3	3.8	3.2	2.6	1.3	2.3	1.9	0.8	0.8	3.5	2.5	5.6	1.3	5.5
Sr ppm	153	101	112	153	173	125	142	178	174	100	130	170	144	157
Sb ppm	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05				-			
Cs ppm	0.055	0.15	0.12	0.094	0.075	0.13	0.099	0.052		0.17	0.16			
Ba ppm	70	163	141	83	76	120	88	57		140	120			
La ppm	5.8	13.9	11.7	7.1	5.7	8.7	6.3	5.1	8.9 ±1.6	12	11.5			
Sm ppm	7.79	7.99	7.38	7.84	8.44	6.41	6.10	8.7	15.5 ±1.2	7.2	5.2			
Eu ppm	1.57	1.43	1.35	1.32	1.33	1.17	1.35	1.6	2.3 ±0.6	1.3	1.3			
Tb ppm	1.29	1.58	1.51	2.02	2.20	1.56	1.46	2.2		1.4	1.0			
Dy ppm	10.5	9.0	8.6	11.5	12.6	9.0	9.5	13		8	6.2			
Yb ppm	7.5	6.6	6.1	7.9	9.8	5.2	6.2		14.2 ±3.4	6	4.2			
Lu ppm	1.02	0.85	0.84	0.98	1.08	0.75	0.86		2.0 ±0.4		0.62			
Hf ppm	5.4	4.7	4.3	5.2	6.8	4.2	4.2		14 ±3		4.0			
Ta ppm	1.25	0.90	0.78	1.10	1.32	0.79	0.94				0.47			
W ppm	0.14	0.52	0.29	0.19	0.12	0.18	0.19				-			
Th ppm	0.56	2.24	1.96	0.95	0.61	1.46	0.88	0.5	1.6 ±0.4	2.1	1.3			
U ppm	0.20	0.75	0.66	0.34	0.22	0.43	0.30	0.16		0.7	0.5			
La/Sm	0.75	1.73	1.58	0.90	0.67	1.36	1.03	0.58	0.58 ±0.08	1.73	2.2			
% mare component	90	6	12	72	92	26	49	100		0				

*Data from Wakita et al. (4), except Rb, Sr taken from Compston et al. (5). **Based on data from Apollo 17 PET (2)
***Average of rocks 72435, 76315, 77135 (2). ****Average of rocks 76230, 77017, 78155 (2).
+Calculated from binary plots.

Table 2. Composition of fractions separated from fines 78501

	Bulk fines	Dark glass	Plagioclase	Clino-pyroxene (brown)	Ortho-pyroxene (yellow)
Na %	0.30	0.30	0.51	0.34	0.038
Mg %	5.2	6.0	-	6.2	18.7
Al %	8.45	6.63	17.3	1.54	1.00
Ca %	10.5	6.6	13.8	9.9	1.0
Sc ppm	39.2	48.6	2.25	113	17.6
Ti %	2.88	3.00	-	1.16	0.32
V ppm	68	66	<20	106	136
Cr ppm	2170	2410	170	3400	3640
Mn ppm	1370	1520	134	1060	1620
Fe %	9.91	11.0	0.93	13.0	10.1
Co ppm	31.6	34.7	6.3	19.1	32.2
La ppm	6.3	7.1	3.4	3.9	1.79
Sm ppm	6.10	6.67	1.24	9.07	1.28
Eu ppm	1.35	1.04	1.68	1.17	0.36
Tb ppm	1.46	1.50	0.131	2.17	0.27
Dy ppm	9.5	9.1	1.4	9.0	2.3
Yb ppm	6.2	4.9	-	11.9	-
Lu ppm	0.86	0.95	0.06	1.53	0.85
Hf ppm	4.2	6.9	0.30	4.9	1.0
Ta ppm	0.94	1.01	0.032	0.47	0.06
Th ppm	0.88	1.00	0.10	-	0.25
U ppm	0.30	0.25	0.05	0.22	0.18

(Brunfelt, *et al*, 1974)

	Average	72275	76315	73235	73235	68115	60016	67016	64435	61175	62255
	Highland	108	75	black	white	80	67	63	40	80	20
SiO_2	45.0	48.5	46.9	46.4	44.2	44.8	45.0	44.9	44.5	43.9	44.1
TiO_2	0.50	0.95	1.46	0.63	-	0.34	0.29	0.22	-	0.05	-
Al_2O_3	24.5	17.2	18.7	21.2	23.1	27.6	28.2	30.1	30.8	35.2	35.3
FeO	6.0	11.4	8.55	7.33	5.06	5.10	4.28	3.45	3.13	0.41	0.20
MgO	8.0	8.94	11.5	10.7	14.0	5.79	5.51	3.70	3.38	0.83	0.37
CaO	15.0	11.6	11.4	12.5	12.7	15.4	15.9	16.8	17.4	18.9	19.1
Na_2O	0.45	0.40	0.56	0.47	0.30	0.47	0.43	0.47	0.39	0.41	0.49
K_2O	0.11	0.25	0.34	0.18	0.06	0.06	0.10	0.06	0.02	0.06	0.09
Cs	0.1	0.31	0.23	0.15	-	0.13	0.10	0.04	0.02	0.07	-
Rb	2.3	6.1	6.4	3.1	-	2.6	1.91	0.71	0.39	1.28	-
Ba	150	440	460	315	100	173	173	69	28	125	14.6
Pb	1.7	4.0	4.3	3.0	1.2	3.5	2.4	0.8	2.1	2.3	0.6
La	11	42.9	32	24	5.31	14.3	13.3	4.52	1.54	9.26	0.46
Ce	31	114	88	61	13.3	38.8	38.4	12.1	3.99	25.2	0.72
Pr	4.0	17	10.9	7.92	1.76	4.95	4.95	1.54	0.47	3.51	0.07
Nd	15	73	42.4	33.5	7.33	20.0	19.2	6.25	1.95	13.8	0.32
Sm	4.5	21.3	11.5	8.95	2.17	5.48	5.21	1.82	0.53	3.90	0.11
Eu	1.5	1.57	1.64	1.20	0.79	0.99	1.17	1.00	0.68	1.12	0.80
Gd	5.4	24.4	15.3	12.1	2.73	6.96	6.34	2.42	0.72	5.01	0.10
Tb	0.85	3.86	2.49	1.88	0.48	1.09	0.99	0.37	0.13	0.78	-
Dy	5.4	24.4	15.9	11.9	2.97	7.13	6.20	2.51	0.80	5.30	-
Ho	1.3	5.85	3.85	2.85	0.67	1.71	1.52	0.59	0.19	1.24	0.02
Er	3.6	15.8	10.6	8.15	1.85	4.90	4.28	1.66	0.53	3.50	0.06
Tm	0.5	2.1	1.6	1.2	0.28	0.75	0.65	0.26	0.087	0.50	-
Yb	3.4	13.9	9.70	7.47	1.72	4.53	3.94	1.60	0.53	3.01	0.06
Lu	0.4	2.1	1.5	1.2	0.27	0.70	0.61	0.25	0.082	0.47	-
Σ REE	88	362	247	183	41.6	112	107	36.9	12.2	76.6	~2.9
Y	31	160	105	85	18	45	42	15	4.53	30	-
Th	1.8	6.70	5.7	4.3	1.0	2.66	2.10	0.73	0.23	1.56	-
U	0.5	1.70	1.51	1.1	0.27	0.74	0.51	0.17	0.12	0.35	-
Zr	150	485	450	350	85	191	158	48	17	109	0.45
Hf	3.0	13.3	10.5	6.5	1.53	4.12	3.59	1.36	0.52	2.38	-
Nb	11	31	33	21.5	5.2	11.8	12.0	4.12	1.38	8.1	0.15
Cr	680	2800	3200	1500	600	660	-	-	-	-	17
V	25	115	45	58	33	24	29	23	22	24	7
Sc	11	48	19	17	5	9	10	10	7	10	-
Ni	-	120	210	250	28	2000	330	110	56	200	-
Co	-	33	17	33	17	105	28	15	26	16	-
Cu	-	5	3	3	1	17	6	3	4	9	<1

DATA FOR FIRST EIGHT ELEMENTS IN WT.% (E.PROBE) OTHER DATA IN PPM (SPARK SOURCE MASS SPEC)

(Taylor, et al, 1974)

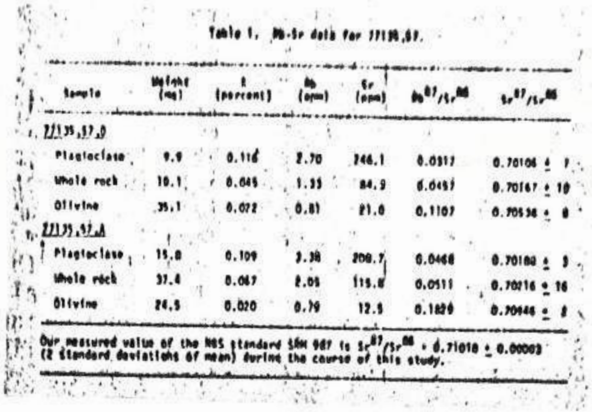

Table 1. Rb-Sr data for 77135,57.

Sample	Weight (mg)	K (percent)	Rb (ppm)	Sr (ppm)	Rb^{87}/Sr^{86}	Sr^{87}/Sr^{86}
77135,57,D						
Plagioclase	9.9	0.116	2.70	246.1	0.0317	0.70106 ± 7
Whole rock	10.1	0.045	1.33	84.3	0.0457	0.70167 ± 10
Olivine	35.1	0.072	0.81	21.0	0.1107	0.70538 ± 8
77135,57,A						
Plagioclase	15.8	0.109	3.38	208.7	0.0468	0.70180 ± 3
Whole rock	37.4	0.067	2.05	115.8	0.0511	0.70216 ± 16
Olivine	24.5	0.020	0.79	12.5	0.1829	0.70946 ± 8

Our measured value of the NBS standard SRM 987 is Sr^{87}/Sr^{86} = 0.71018 ± 0.00003 (2 standard deviations of mean) during the course of this study.

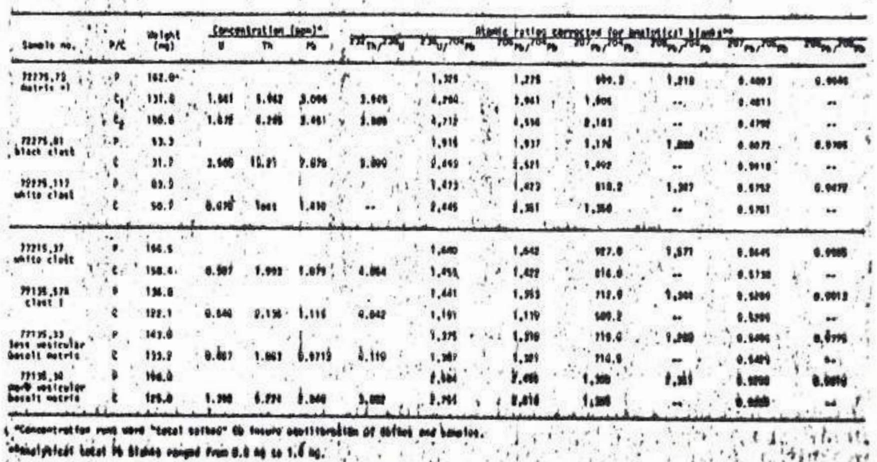

Table 2. U-Th-Pb data for Boulders 72275 (Wood Consortium) and 77135 and 77215 (Chao Consortium)

Sample no.	P/C	Weight (mg)	Concentration (ppm)*					Atomic ratios corrected for analytical blanks**				
			U	Th	Pb	$^{232}Th/^{238}U$	$^{238}U/^{204}Pb$	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$
72275,73 matrix #1	P	162.0†					1,329	1,275	999.2	1,210	0.4003	0.9046
	C_1	131.8	1.041	5.962	3.096	3.945	4,260	3,941	1,606	--	0.4011	--
	C_2	106.6	1.076	6.208	3.461	3.909	4,712	4,550	2,183	--	0.4790	--
72275,81 black clast	P	53.3					1,916	1,937	1,176	1,800	0.6072	0.9706
	C	31.7	2.900	15.21	7.070	3.800	2,469	2,521	1,492	--	0.5918	--
72275,117 white clast	P	83.3					1,473	1,423	810.2	1,307	0.5752	0.9477
	C	50.7	0.078	lost	1.410	--	2,445	2,361	1,350	--	0.5761	--
77215,37 white clast	P	166.5					1,600	1,642	927.0	1,571	0.5645	0.9585
	C	158.4	0.507	1.993	1.079	4.064	1,493	1,422	816.0	--	0.5738	--
77135,57A clast I	P	136.8					1,441	1,353	712.0	1,300	0.5200	0.9012
	C	122.1	0.540	2.156	1.116	4.042	1,191	1,119	589.2	--	0.5299	--
77135,33 less vesicular basalt matrix	P	143.0					1,375	1,370	719.0	1,280	0.5406	0.9795
	C	133.2	0.807	1.003	0.9712	4.110	1,387	1,309	710.9	--	0.5409	--
77135,38 more vesicular basalt matrix	P	146.0					2,504	2,406	1,309	2,381	0.5200	0.9890
	C	125.0	1.390	6.774	2.040	3.882	2,764	2,618	1,288	--	0.5005	--

*Concentration runs were "total spiked" to insure equilibration of spikes and samples.

**Analytical total Pb blanks ranged from 0.8 ng to 1.6 ng.

†Probably only 48 mg were analyzed since 3/4 of solution was spiked. This explains the low radiogenicity of this composition run.

(Tatsumoto, et al, 1974)

Table 1

Sample No.	Depth g/cm^2	^{37}Ar dpm/kg	^{222}Rn dpm/g	Uranium ppm	He scc/g	H_2 scc/g
70181,6	0-4.5	115 ± 3.4	0.21	0.28	0.168	0.85
75081,41-43	0-4.5	81.0 ± 3.4	0.15	0.24	0.146	0.66
78441,2	11-27	48.2 ± 5.6	0.32	0.41	0.149	1.24
78421,13	27-45	41.7 ± 5.4	0.31	--	0.150	1.13
70008,9	49	54.5 ± 3.3	0.11	0.20	0.069	0.80
70008,7	72	49.4 ± 2.7	0.088	0.22	0.066	0.85
70008,5	99	43.5 ± 3.1	0.11	0.21	0.063	0.80
70008,3	124	37.4 ± 2.4	0.16	0.29	0.110	1.07
70006,6	180	28.6 ± 2.0	0.28	0.30	0.101	0.83
70005,6	252	19.5 ± 1.5	0.26	0.41	0.176	1.18
70004,6	325	21.7 ± 1.7	0.24	0.41	0.144	1.19
70003,6	399	13.6 ± 1.1	0.30	0.48	0.176	1.41
70002,6	472	9.2 ± 1.2	0.62	0.66	0.136	1.63

(Stoenner and Davis, 1974)

Table 1. Trace elements in Apollo 17 soils and boulder-2 rocks (STA 2), (m = ppm; b = ppb)

Sample	wt (mg)	Ir^b	Re^b	Au^b	Ni^m	Co^m	Sb^b	Se^b	Ag^b	In^b	Zn^m	Cd^b	Tl^b	Rb^m	Cs^b	U^m	Ba^m	Sr^m	Ga^m
Boulder-2																			
72315,3 mostly exterior	43	4.3	0.43	2.8	180	20	1.3	110	1.1		2.6	(300)		8.5	450	1.58	320	157	-
72315,4 totally interior	33	9.0	0.98	6.1	340	33	2.0	120	0.84		2.5	8.1		9.6	530	1.53	340	165	-
72335,2 mostly exterior	36	15	1.4	5.3	360	28	1.5	67	0.70		1.7	(80)		2.0	95	0.71	120	145	-
72355,7 one ext. side	33	7.3	0.73	4.9	310	34	2.2	75	0.87		2.4	5.1		8.0	280	2.00	380	157	-
72375,2 mostly exterior	30	8.5	0.84	5.3	320	34	2.2	90	0.82		2.3	7.2		6.2	250	1.85	370	149	-
72395,3 interior	30	8.0	0.79	5.8	290	33	2.1	190	1.4		2.1	(170)		5.3	160	1.72	360	152	-
Soils<1mm																			
72321,9	117	10	-	3.7	250	28	2.2	240	7.2	3.0	18	36		3.9	180	0.91	180	155	4.7
boulder-2 shadow	87	8.1	0.83	3.7	260	28	4.8	240	6.4		18	37		4.7	220	0.83	170	145	-
72441,11	117	11	-	4.0	280	32	-	240	6.7	2.9	16	40		4.2	190	0.98	200	150	4.6
under 0.7m boulder	75	9.6	-	4.0	280	31	(8.8)	220	6.0		15	-		4.4	200	0.84	180	150	-
72461,8 under 0.7m boulder	165	11	-	4.0	280	32	-	240	6.5	3.0	15	40		4.2	190	1.10	220	145	4.5
72501,31	124	14	-	5.3	360	37	-	240	6.4	3.2	18	37		3.6	160	0.95	200	145	4.8
5m E. of boulder-2	97	8.5	-	4.0	260	27	2.3	220	6.5		20	-		3.6	160	0.83	170	150	-
75081,21 15m from Camelot C	156	5.4	-	1.7	120	31	1.3	280	9.6	2.7	31	33	1.5	1.1	47	0.26	95	160	-
66041,20	112	15	-	7.1	460	33	4.0	340	8.5	(47)	24	77	(32)	2.7	120	0.70	140	165	5.0
BCR-1	85	0.02	-	0.41	10	36	-	85	24	86	150	135	290	≡45	900	≡1.75	590	330	-
BCR-1	78	0.01	0.90	0.54	10	36	680	84	24		130	140		≡46	920	≡1.75	580	315	-

(Lau & Schmitt, 1974)

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
Rocks																		
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	GS 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	3.2	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 Ct1 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	19.8
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 Ct1/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 Ct1: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
7135,69	GGB Noeves 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
155,30	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
Soil Separates, <1 mm																		
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
Soils, < mm																		
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	53	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	850
76261,13	Control	6.46	0.671	2.52	160	1.06	300	210	13.6	7.9	65	0.59	23	39	1.50	2.7	115	490

*An = anorthite, anorthosite   B = breccia   bl = black   G = grey   Mx = matrix   Pl = plagioclase

Aph = aphanitic   BG = blue grey   Ct = clast   GG = green gray   Ol = olivine

(Morgan, et al, 1974)

Table 1. Average abundances for Apollo 17 soils and boulder-2 rocks.

Element	Ap 17 STA-2 Soils	Ap 17 Boulder-2 4 Rocks	Ap 16 Med. K KREEP Rocks*	Ap 17 Boulder-2 1 Rock	Ap 16 Soils S. of LM+	Ap 16 VHA Rocks*	Ap 14 Clastic Rocks+
	72321	72315,3	60315	72335,2		62295	14063
	72441	72315,4	62235			61156	14066
	72461	72355,7	65015			60615	14083
	72501	72375,2	60636				14318
		72395,3	65777				
TiO_2 (%)	1.5	1.6±0.1	1.2	0.60	0.62	0.62	1-2
Al_2O_3	21.2	18.8±0.5	19.2	27.3	26.5	21.6	17-22
FeO	8.6	8.8±0.3	8.9	4.8	5.7	6.5	7-10
MgO	10	12	11	8	7	13	---
CaO	12.1	11.1	11.4	15.4	15.3	12.0	10-13
Na_2O	0.48	0.67±0.02	0.52	0.45	0.46	0.41	0.7 -1.1
K_2O	0.15	0.31±0.03	0.36	0.13	0.11	0.10	0.1 -1.0
MnO	0.11	0.113±0.002	0.11	0.060	0.067	0.07	0.08-0.11
Cr_2O_3	0.21	0.192±0.014	0.22	0.100	0.11	0.13	0.1 -0.2
Sc (ppm)	18	16±1	15	8.0	10	9	13-20
V	49	50	35	30	24	30	30-50
Co	30	33	46	25	30	32	20-30
Zr	200	440	550	150	160	170	800-1000
Ba	190	360±20	450	120	140	170	300-1000
La	17.7	34±3	54	13.2	13.9	18.7	20-100
Ce	46	87	140	31	34	47	50-200
Nd	30	54	87	21	23	30	---
Sm	8.2	14.9±1.5	24	5.8	6.4	8.4	10-40
Eu	1.31	1.84±0.05	2.30	0.90	1.21	1.21	2-3
Tb	1.6	3.0	5.0	1.1	1.2	1.4	2-8
Dy	10	19	30	7.0	7.8	10.7	---
Yb	6.1	11±1	16	4.2	4.7	6.0	10-30
Lu	0.85	1.5	2.2	0.55	0.66	0.83	1-4
Hf	6.1	11±1	15	4.2	4.5	5.0	--30
Ta	0.84	1.5	1.8	0.59	0.58	0.65	--4
Th	2.8	5.7	7.0	2.4	2.2	2.7	--20
U	1.0	1.8	2.5	0.71	0.66	0.9∇	1-5
Ni	270	300	420-1100	360	490	220-490∇	---
Ir (ppb)	10	8	10-17	15	14	4-9∇	1-11‡
Au (ppb)	5	5	5-22	5	9	3-8∇	0.2-9‡

*Values for 60315, 62235, 65015, 62295 and 61156 taken from (2) Bansal *et al.* (1973) and for 60636, 65777 and 60615 from (3) Laul and Schmitt (1973)

+(3) Laul and Schmitt (1973); (4) Laul *et al.* (1972)

∇(3) Laul and Schmitt (1973) and (5) Krahenbuhl *et al.* (1973)

‡for different Ap 14 clastic rocks by (6) Morgan *et al.* (1972).

(Lau & Schmitt, 1974)

TABLE 7-VII.–*Gamma Ray Analyses of Apollo 17 Lunar Samples*

Sample no.	*Weight, g*	*Laboratory (a)*	*Th,*[b] *ppm*	*U,*[c] *ppm*	*K, percent*	^{26}*Al, dpm/kg*	^{22}*Na, dpm/kg*	^{54}*Mn, dpm/kg*
71041,4	111.1	BNW	0.86 ± 0.03	0.22 ± 0.01	0.063 ± 0.004	126 ± 4	126 ± 4	198 ± 10
71041,4	111.1	JSC	.90 ± .02	.20 ± .06	.06 ± .02	115 ± 20	135 ± 20	220 ± 30
71061,5	100.0	JSC	1.15 ± .15	.30 ± .03	.07 ± .02	45 ± 10	65 ± 10	114 ± 10
73131,1	100.18	ORNL	2.24 ± .11	.63 ± .03	.116 ± .006	54 ± 3	126 ± 5	75 ± 10
73221,0	46.0	ORNL	2.13 ± .11	.63 ± .03	.118 ± .006	197 ± 10	310 ± 15	230 ± 30
73241,1	100.06	ORNL	2.25 ± .11	.64 ± .03	.122 ± .006	93 ± 5	110 ± 5	80 ± 8
73261,4	100.52	ORNL	2.40 ± .12	.67 ± .04	.109 ± .006	57 ± 4	42 ± 4	52 ± 12
74220,92	100.0	RCL	.65 ± .09	.164 ± .010	.068 ± .002	45 ± 4	51 ± 3	50 ± 3
74220,92	100.0	JSC	.65 ± .07	.16 ± .02	.065 ± .015	43 ± 7	58 ± 8	86 ± 15
75061,5	100.0	BNW	.87 ± .03	.22 ± .01	.060 ± .003	174 ± 6	171 ± 6	286 ± 12
~~75061,5~~	100.0	RCL	.91 ± .13	.248 ± .015	.066 ± .002	180 ± 16	187 ± 10	200 ± 10
~~76240,2~~	104.98	RCL	2.5 ± .3	.61 ± .03	.119 ± .004	154 ± 14	42 ± 3	29 ± 6
76240,2	104.98	BNW	2.30 ± .06	.60 ± .02	.110 ± .005	151 ± 6	42 ± 2	31 ± 8
~~76261,1~~	100.7	RCL	2.1 ± .3	.49 ± .02	.102 ± .003	182 ± 17	148 ± 8	93 ± 7
76261,1	100.7	BNW	1.92 ± .04	.51 ± .02	.097 ± .004	171 ± 5	142 ± 4	106 ± 8
76501,4	97.89	ORNL	1.39 ± .14	.38 ± .04	.090 ± .005	90 ± 9	90 ± 9	60 ± 10
78421,1	94.51	BNW	1.58 ± .07	.41 ± .02	.084 ± .003	55 ± 2	39 ± 2	12 ± 8
78481,1	101.27	BNW	1.49 ± .05	.39 ± .02	.095 ± .003	257 ± 12	244 ± 12	264 ± 10
78481,4	101.27	JSC	1.4 ± .2	.4 ± .1	.07 ± .02	230 ± 30	290 ± 40	310 ± 40
78501,4	113.24	ORNL	1.11 ± .11	.28 ± .03	.077 ± .004	90 ± 9	105 ± 10	96 ± 10
79221,4	100.2	ORNL	1.12 ± .06	.36 ± .03	.070 ± .004	130 ± 7	165 ± 10	215 ± 20
79261,4	100.2	ORNL	1.08 ± .05	.31 ± .02	.070 ± .004	45 ± 4	43 ± 4	44 ± 6
70135,0	446	ORNL	.32 ± .06	.11 ± .02	.046 ± .010	37 ± 8	45 ± 9	42 ± 10
~~70175,0~~	338.8	RCL	.40 ± .04	.105 ± .007	.055 ± .002	42 ± 5	76 ± 18	156 ± 9
70185,0	449	ORNL	.30 ± .03	.10 ± .02	.042 ± .004	70 ± 4	50 ± 4	95 ± 10
70255,0	224.9	RCL	.31 ± .03	.107 ± .008	.048 ± .008	49 ± 6	72 ± 7	137 ± 15
~~70275,0~~	171.4	RCL	.42 ± .04	.107 ± .008	.0421 ± .0018	92 ± 9	90 ± 16	190 ± 50
71035,0	144.1	BNW	.44 ± .03	.11 ± .01	.027 ± .003	90 ± 8	97 ± 8	157 ± 15
~~71155,0~~	25.8	BNW	.29 ± .05	.13 ± .02	< .030	105 ± 4	112 ± 4	227 ± 40
71155,0	25.8	RCL	.31 ± .08	.109 ± .018	.039 ± .003	93 ± 17	112 ± 24	160 ± 80
~~72255,0~~	402.57	RCL	4.4 ± .4	1.20 ± .15	.184 ± .008	78 ± 6	61 ± 5	41 ± 6
~~72355,0~~	367.4	RCL	5.3 ± .3	1.39 ± .04	.253 ± .005	84 ± 6	87 ± 6	66 ± 7
~~72415,0~~	29.47	RCL	< .15	< .06	.012 ± .007	77 ± 6	290 ± 30	77 ± 16
75055,2	405.9	BNW	.40 ± .02	.10 ± .01	.065 ± .005	69 ± 7	85 ± 5	139 ± 15
76015,0	2819.0	JSC	8 ± 3	2 ± .3	.30 ± .06	Detected	Detected	Detected
~~76215,0~~	642.8	RCL	4.6 ± .2	1.27 ± .06	.215 ± .014	56 ± 3	60 ± 4	22 ± 17
76255,0	393.2	BNW	2.33 ± .05	.58 ± .02	.291 ± .006	79 ± 4	71 ± 4	38 ± 9
76275,0	55.93	BNW	5.4 ± .4	1.39 ± .10	.222 ± .009	111 ± 9	95 ± 6	103 ± 20
76295,0	260.7	ORNL	5.30 ± .27	1.50 ± .08	.227 ± .011	67 ± 5	54 ± 4	38 ± 15
76295,0	260.7	BNW	5.76 ± .17	1.55 ± .05	.230 ± .009	71 ± 4	64 ± 3	70 ± 30
77135,0	316.7	BNW	5.5 ± .5	1.42 ± .14	.185 ± .018	110 ± 11	100 ± 10	21 ± 15
78135,0	133.9	RCL	.26 ± .05	.107 ± .012	.0525 ± .0018	42 ± 4	74 ± 5	180 ± 20
~~78235,0~~	128.8	RCL	.59 ± .08	.196 ± .016	.0490 ± .0015	77 ± 7	111 ± 8	55 ± 8
79155,0	316	ORNL	.31 ± .06	.12 ± .03	.041 ± .004	70 ± 10	77 ± 10	110 ± 20

[a] BNW = Battelle Pacific Northwest Laboratory (L. A. Rancitelli, R. W. Perkins, W. D. Felix, and N. A. Wogman); JSC = NASA Lyndon B. Johnson Space Center (Ernest Schonfeld); ORNL = Oak Ridge National Laboratory (G. D. O'Kelley, J. S. Eldridge, and K. J. Northcutt); and RCL = Radiation Counting Laboratory at JSC (J. E. Keith and R. S. Clark (JSC) and W. R. Portenier and M. K. Robbins (Northrop Services, Inc.)).

(LSPET, 1973)