^{39}Ar-^{40}Ar AGES OF LUNAR ROCKS

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The ^{39}Ar-^{40}Ar temperature release patterns for 21 lunar samples from Apollo 14, 15, 16, and 17 have been studied. The plateau ages, total K-Ar ages, exposure ages, and Ca and K contents are presented in Table 1.

Our previous value for 14310 (1) did not agree with other values in the literature (2). We have rerun this rock and our new value is in good agreement with the Rb-Sr and other K-Ar ages.

Rock 15075 is a slowly cooled pyroxene-phyric basalt (3), and we have obtained a well defined plateau age of 3.45 ± 0.2 G.y. This basalt is one of the oldest Apollo 15 mare basalt samples.

Anorthositic rocks 61135, 67035, and 67455 are similar to the light matrix breccia coarse-fine samples for which we previously found a number of ages in excess of 4 G.y. (4). These were analyzed in the hopes of finding a large rock sample similar to the light matrix breccia with an age in excess of 4 G.y. As can be seen in Table 1, samples 611315 and 67035 gave ages below 4 G.y., while sample 67455 does not give a well defined plateau age. For the three separate runs on 611315, only one sample gave a well defined plateau. This sample was a whole rock fragment. The two samples which did not give a plateau were made up of crushed material. The crushed material contained a large amount of solar wind which made the plateau age unrecognizable.

Sample 60618 is a melt rock (5). Its age of 4.00 ± .02 G.y. may well represent the time of a relatively large impact during which this rock was melted. 65777, a recrystallized nortic breccia, gave a plateau age of 3.72 ± .02 G.y. This sample gives a relatively young age for a highland rock and is probably related to a cratering event over 200 m.y. post Imbrium while breccia 68516, with a plateau age of 3.80 ± .05 G.y., is over 150 m.y. post Imbrium. These two samples were probably reset during large cratering events but not basin forming events. Spinel troctolite 65785 gave a plateau age of 3.97 ± .02 G.y., very similar to the Imbrium event. The mare basalt 70255 gave a well defined plateau age of 3.84 ± .02 G.y. and represents one of the oldest mare basalts from Apollo 17. We have also studied one 2-4 mm coarse-fine from Apollo 16 and seven 2-4 mm coarse-fine fragments from Apollo 17. These samples represent the completion of our coarse-fine survey for Apollo 16 and 17.

Adding the highland rock ages from the present investigation to those presently in the literature, we have plotted a histogram, Fig. 1, of the ages of the Apollo 17 and Apollo 16 highland samples. Most of these are ^{39}Ar-^{40}Ar ages which are ages determined relative to a standard sample. In the histograms, to remove some of this possible bias, we have stipled the samples which were determined with the same reference standard, namely that used at Stony Brook and Heidelberg. As can be seen, there does not appear to be an appreciable change in the histogram when the ages determined in other laboratories with other standards are added to the figure. The distinct differences at the Apollo 16 and 17 sites appear to be that for Apollo 16 highland rocks the peaking in ages is not as pronounced as for the Apollo 17 highland rocks. For Apollo 16, there appears to be a rather large distribution in ages with most

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Table 1: ^{39}Ar-^{40}Ar Ages

Sample No.	Type	Plateau Range, °C	Plateau Age, G.y.	%(1)	Total K-Ar Age, G.y.	E.A.(2)	% Ca	ppm K
Large Rocks								
Apollo 14								
14310,101	Bas	675-1025	3.92±0.01	72	3.78±0.01	X38	10.1±0.2	4481
Apollo 15								
15075,24	Bas	800-1300	3.45±0.20	71	3.39±0.01	250	11.4±0.2	426
15075,24	Bas	900-1200	3.45±0.20	65	3.39±0.08	280	12.0±0.2	307
15505,72	Brec	No Plateau			5.18±0.05	600	10.3±0.2	1554
Apollo 16								
60618,13	Melt	900-1100	4.00±0.02	41	3.50±0.01	X38	11.9±0.2	410
61135,10	Ant	725-1100	3.90±0.10	52	3.94±0.01	30	8.4±0.1	4855
61135,10	Ant	No Plateau			5.70±0.05	80	12.2±0.2	714
61135,10	Ant	No Plateau			6.27±0.05	50	14.7±0.5	799
62237,12	Brec	No Plateau			3.59±0.05	100	11.3±0.2	81
65777,2	Rnb	750-1050	3.72±0.02	56	3.29±0.10	10	7.9±0.1	3095
65785,13	Troc	750-1100	3.97±0.02	50	3.40±0.01	300	8.6±0.2	2552
67035,20	Ant	1000-1300	3.95±0.05	65	3.89±0.01	36	11.6±0.2	428
67455,58	Ant	No Plateau			3.81±0.01	38	13.8±0.2	297
67618,1	Cry	No Plateau			2.59±0.01	50	8.4±0.2	1810
68516,2	Brec	1300-1600	3.80±0.05	54	3.65±0.01	50	9.9±0.2	1286
Apollo 17								
70255,36	Bas	850-1000	3.84±0.02	34	3.67±0.01	250	6.3±0.2	565
Coarse Fines								
Apollo 16								
61503,1,11	Poik	800-1100	4.02±0.02	61	3.67±0.01	40	10.0*	2637
Apollo 17								
72703,9,5	Dmb	800-1600	4.01±0.01	97	3.98±0.01	110	13.0±0.4	1271
73263,1,1	R Ant	1150-1600	4.23±0.05	53	4.19±0.01	95	11.7±0.2	763
73263,1,3	I Ant	800-1300	3.90±0.20	72	4.09±0.02	100	13.3±0.2	116
73263,1,6	R Ant	800-1100	3.99±0.03	38	4.16±0.01	260	11.2±0.2	820
73263,1,9	Dmb	1000-1550	3.99±0.05	70	3.97±0.01	200	6.3±0.2	1322
74243,2,1	Il Var	700-1000	3.85±0.05	53	3.76±0.01	50	7.5*	751
76503,6,5	Brec	800-1150	3.99±0.01	52	4.04±0.01	150	10.0±0.2	684

(1) % of ^{39}Ar on plateau
(2) Exposure age, m.y. X38 means excess 38, exposure age not obtainable.

References
(1) Husain L. et al. (1971) Science 173, 1235-36. (2) Turner G., preprint of review article. (3) Taylor L. A. and Misra K. C. (1975) Proc. LSC 6, p. 165-179. (4) Schaeffer O. A. and Husain L. (1973) Proc. LSC 4, p. 1847-1863. (5) Irving A. J. (1975) Proc. LSC 6, p. 363-394. (6) Schaeffer O. A. and Husain L. (1974) Proc. LSC 5, p. 1541-1555.

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occurring from 3.85 to 4.15 G.y. For Apollo 17 on the other hand the ages are more concentrated just under 4 G.y.; in fact, over half the samples lie in the rather sharp interval between 3.95 and 4.00 G.y. The tailing off to higher ages is roughly the same for both Apollo 16 and Apollo 17 highland samples with ages occurring over 4.3 G.y. for both sites. It appears rather difficult to understand the differences in these two histograms as being caused mainly by local impacting. It should be pointed out that several ages below 3.8 G.y. have been omitted, for example 60015 (6) which has an age of 3.50 ± 0.05 G.y. It is thus clear that a number of samples post-date the end of the time of large basin formations, so that the ages are not only related to the formation of the large basins. As a result, it is almost certain that some of the older samples are also related to sub-basin forming events. The melt rocks (5) may well be such samples. Most of the peak in the Apollo 17 ages is probably related to a large basin forming event. The spread in ages at Apollo 16 is striking evidence against any moon wide peak in the cratering rate. To talk of a terminal lunar cratering rate as an intense bombardment period of short duration is incompatible with the age distribution found for Apollo 16 highland samples.

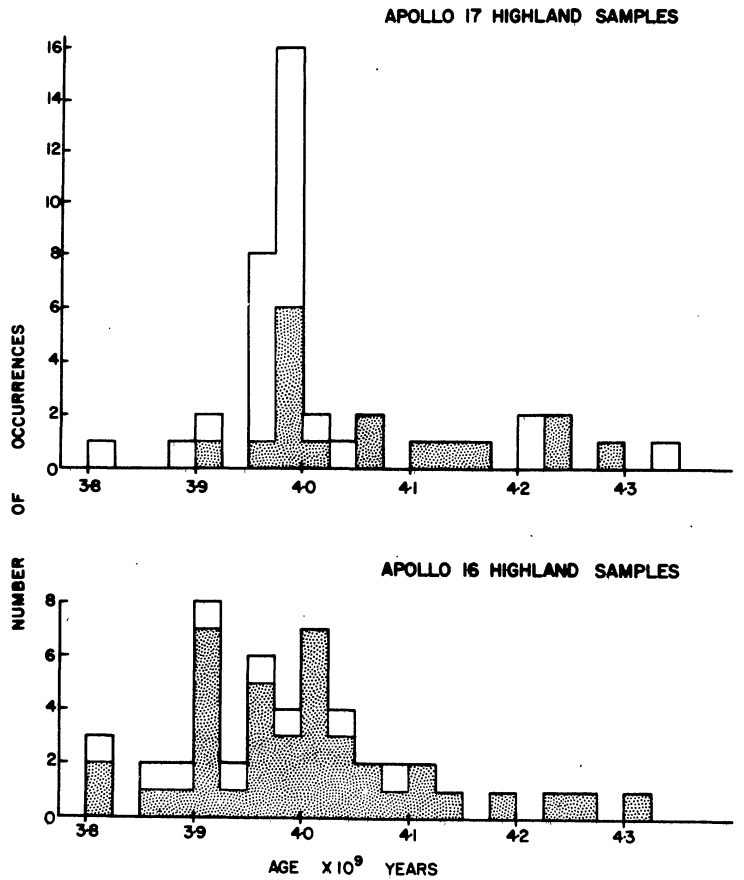

Fig. 1: Histogram of highland ages from Apollo 16 and Apollo 17.