TAURUS-LITTROW CHRONOLOGY: IMPLICATIONS FOR EARLY LUNAR CRUSTAL DEVELOPMENT. L.E. Nyquist, NASA Johnson Space Center, Houston, TX 77058; B.M. Bansal, H. Wiesmann, Lockheed Electronics Corp., Houston, TX 77058; and B.M. Jahn, NRC, NASA Johnson Space Center, Houston, TX 77058.

Rocks returned by the Apollo 17 mission to the Taurus-Littrow region consist predominantly of high-titanium mare basalts, noritic breccias, and anorthositic gabbros (1,2). We reported a preliminary mineral isochron for mare basalt 70035 at the Fourth Lunar Science Conference. Additional data (Table 1 and Figure 1) lead to a refined determination of the age, 3.73 ± .11 AE and initial ratio, 0.69924 ± .00005. The age agrees with Rb-Sr ages by other workers (3,4) and the $^{39}Ar/^{40}Ar$ age (5). Similar ages have been reported for 75055 (6,7,8,9,10). The age of these basalts is taken as the age of the valley subfloor.

The noritic (blue-gray, green-gray) breccias and the anorthositic gabbros are presumably derived from the massifs bordering the valley (2). Several investigators (8,9,10) have determined $^{39}Ar/^{40}Ar$ ages of 3.97 to 4.05 AE for breccia 76055. Whole rock Rb-Sr data for rocks of this type fall along a 4.01 ± 0.09 AE isochron (Figure 2). Included on the isochron are samples of matrix and clast material from the Station 6 boulder (Phinney consortium). The chemical compositions of the rocks have been used as a criteria for grouping them and are discussed in the companion papers(2,11). Apparently whole rock Rb-Sr systematics for these rocks were reset by the event recorded in the $^{39}Ar/^{40}Ar$ ages. Because of the metamorphic texture of these rocks and their derivation from Serenitatis ejecta, this age has been consistently identified with the Serenitatis event (8,9,10). We agree that this conclusion is the most probable one and note that analogous Rb-Sr systematics were also found for high grade breccias at the Fra Mauro site (12).

Whole rock data for anorthositic gabbros do not allow a precise age determination but strongly suggest that their Rb-Sr systematics were also reset by the 4.0 AE event. Thus the precursors of the massif breccias were apparently present as crustal rocks prior to 4.0 AE ago. We have previously applied the whole rock method to attempt to "see through" the metamorphic events which dominate the radiometric ages for highland rocks (12,13). The KREEP-like noritic breccias fit the pattern established for VHA and KREEP basalts (13). Relative REE abundance patterns are similar but intermediate to those for KREEP and VHA basalts (11). Likewise, Rb/Sr is intermediate to that for KREEP and VHA, as was $^{87}Sr/^{86}Sr$ 4.0 AE ago. Adopting the hypothesis that rocks with KREEP-like relative REE abundance patterns differentiated contemporaneously from the same or similar source materials leads to construction of the primary 4.22 AE isochron shown in Figure 3 which is essentially the same as that determined from VHA and KREEP alone (13). The validity of this construction rests on the final understanding of the petrogenesis of these rocks. Alternatively, the average model age (∿4.5 AE) may be considered as an upper limit to the time of chemical differentiation of the noritic breccias. Note, however, that there is considerable variation in model age and that no individual rock may *a priori* be considered as remaining a closed system during the 4.0 AE metamorphism.

A mineral isochron (Figure 4) was determined for a 69 mg fragment of

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crystalline (i.e. with igneous textures) KREEP from the Apollo 15 sample return. The age obtained, 3.91 ± .04 AE, is the same as that obtained on rake sample 15382 by the $^{39}Ar/^{40}Ar$ technique (5,9), and within error of that of Apollo 14 crystalline KREEP basalts (14,15). The initial ratio I = 0.70070 ± .00010 is slightly higher than that found for Apollo 14 crystalline KREEP (14, 15), within error of that found for a whole rock isochron for high grade Apollo 14 breccias (12), and perhaps slightly lower than that for breccia clast 14321,184-53 (16). The relationship between brecciated and crystalline KREEP varieties remains to be clarified. Two alternatives suggest themselves: (a) The crystalline varieties represent impact melts, in a sense the highest grade of metamorphism, (b) They are unmetamorphosed flows which were extruded at or near the time when similar rocks already on the lunar surface were metamorphosed, i.e. they represent impact triggered lava flows from previously differentiated magma chambers.

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Table I. Rb and Sr Analytical Results

Sample	wt (mg)	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$ [a]	$^{87}Sr/^{86}Sr$ [b]	T_B [c]	T_L [d]
I. Apollo 17 Noritic Breccias							
72275,2	52.8	8.97	122.7	0.2115 ± 17	0.71188 ± 6	4.22 ± .05	4.24 ± .05
72435,1	53.7	3.93	171.6	0.0662 ± 6	0.70360 ± 5	4.73 ± .09	4.80 ± .09
76055,5	47.7	5.17	156.6	0.0955 ± 8	0.70511 ± 9	4.39 ± .10	4.44 ± .10
76315,2	52.4	5.88	179.5	0.0948 ± 8	0.70515 ± 5	4.45 ± .08	4.50 ± .08
76315,35M	49.2	5.78	174.4	0.0960 ± 8	0.70521 ± 7	4.44 ± .09	4.49 ± .09
76315,30C3	66.7	3.85	171.5	0.0650 ± 6	0.70351 ± 10	4.72 ± .14	4.80 ± .14
77135,2	52.6	7.32	172.2	0.1230 ± 10	0.70688 ± 7	4.41 ± .08	4.45 ± .08
II. Apollo 17 Anorthositic Gabbros							
76230,4	78.1	0.448	145.9	0.0089 ± 2	0.69982 ± 7	5.60 ± .65	6.12 ± .66
77017,2	68.4	1.310	141.5	0.0268 ± 3	0.70072 ± 6	4.22 ± .20	4.40 ± .20
78155,2	51.6	2.06	146.7	0.0406 ± 4	0.70164 ± 6	4.37 ± .14	4.48 ± .14
III. Apollo 17 Soils and Soil Breccia							
71501,3	52.1	1.171	159.4	0.0213 ± 3	0.70058 ± 10	4.83 ± .32	5.05 ± .32
75061,4	58.3	1.106	165.8	0.0193 ± 3	0.70030 ± 5	4.34 ± .18	4.58 ± .32
76501,1	44.5	2.403	150.8	0.0461 ± 5	0.70217 ± 14	4.64 ± .20	4.74 ± .20
78501,2	53.8	1.959	153.7	0.0369 ± 4	0.70154 ± 9	4.61 ± .16	4.73 ± .16
79135,1	46.1	1.937	168.6	0.0332 ± 4	0.70119 ± 5	4.39 ± .10	4.53 ± .10
79261,12	47.6	1.80	154.3	0.0338 ± 4	0.70125 ± 6	4.44 ± .12	4.58 ± .12
70181,3	50.0	1.468	169.8	0.0250 ± 4	0.70082 ± 4	4.79 ± .10	4.98 ± .10
IV. 15434,73 Mineral Separates (69 mg. crystalline KREEP fragment).							
200-325 Mesh	6.1	15.77	140.7	0.3242 ± 26	0.71894 ± 4	4.27 ± .05	4.29 ± .05
Plag	4.6	2.826	314.4	0.0260 ± 3	0.70214 ± 6		
Mesostasis + Px	4.0	53.37	169.3	0.912 ± 7	0.75138 ± 6		
V. 70035 Mineral Separates (mare basalt)							
70035,1	58.5	0.461	173.7	0.00772 ± 23	0.69967 ± 6	4.78	5.64
70035,6	53.2	0.628	161.3	0.01126 ± 29	0.69980 ± 6		
Plag	4.4	0.0948	687.5	0.00040 ± 4	0.69924 ± 10		
Ilm 1	11.9	0.8345	47.79	0.05053 ± 37	0.70195 ± 8		
PX	22.7	0.3738	43.73	0.02473 ± 28	0.70059 ± 8		
PX + Ilm	26.9	0.6334	52.01	0.03524 ± 39	0.70112 ± 20		
Ilm 2	8.9	0.832	66.01	0.03647 ± 50	0.70116 ± 4		

a. Uncertainties correspond to last figures.
b. Uncertainties correspond to last figures and represent 2σm. Normalized to $^{86}Sr/^{88}Sr$ = 8.7521.
c. Model age assuming I = 0.69910 (BABI plus our bias).
d. Model age assuming I = 0.69903 (Apollo 16 anorthosites for T = 4.6 AE).

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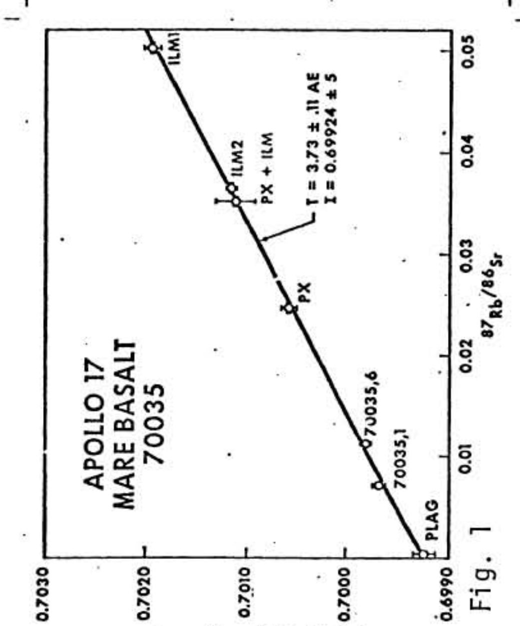

Fig. 1

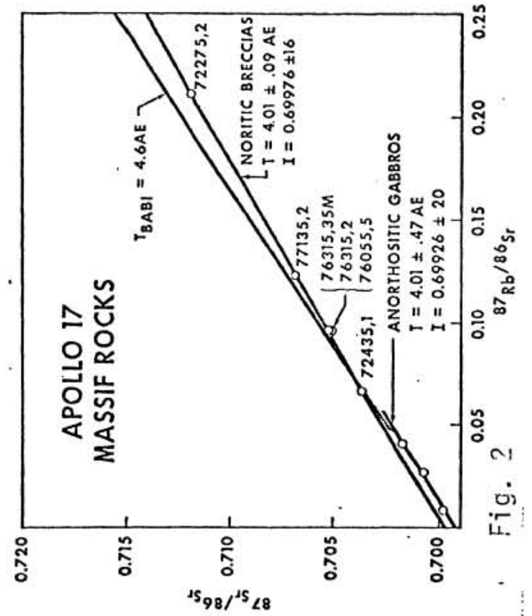

Fig. 2

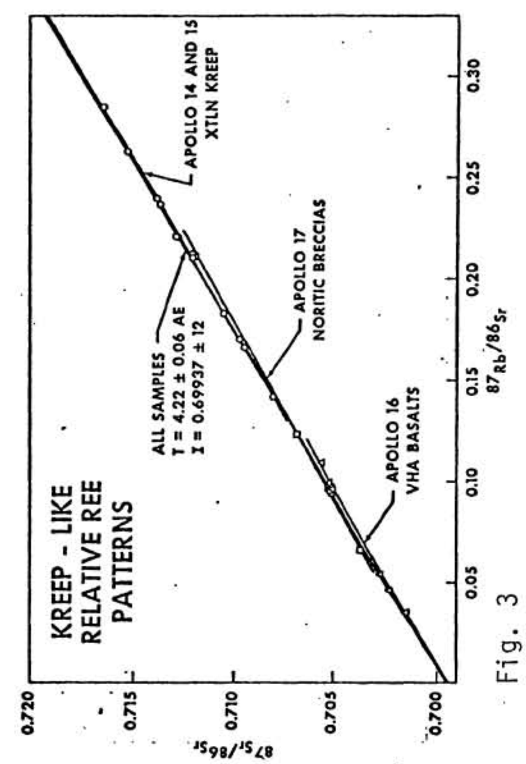

Fig. 3

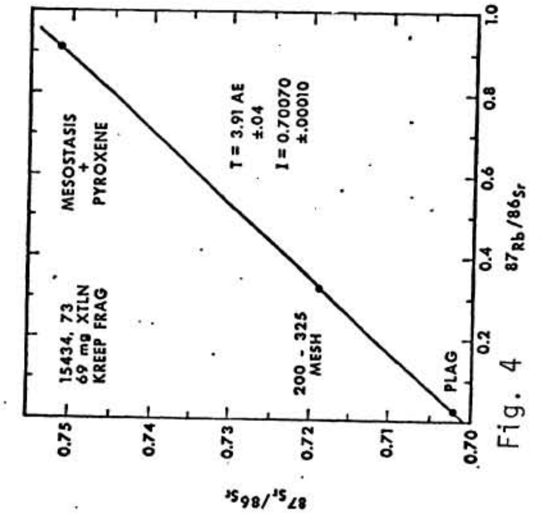

Fig. 4