A COMPARATIVE STUDY ON THE MINERALOGY, CHEMISTRY, AND CHRONOLOGY OF THE APOLLO 16 CRYSTALLINE IMPACT MELT BRECCIAS. PART II: CHRONOLOGY. W. U. Reimold, LPI, Houston and Univ. Münster, D-4400 Münster, FRG; B. M. Bansal, H. Wiesmann, J. L. Wooden, and I.D.R. Mackinnon, Lockheed, 1830 NASA Rd. 1, Houston; and L. E. Nyquist, SN7, NASA/Johnson Space Center, Houston, TX 77058

The controversy on how to interpret the ages of lunar highland breccias has recently been discussed by James (1). Are the measured ages testimony of true events in lunar history; do they represent the age of the ancient crustal rocks, mixed ages of unequilibrated matrix-phenocryst relationships, or merely thermal events subsequent to the formational event? It is certain from analyses of terrestrial impact melt breccias that the melt matrix of whole impact melt sheets is isotopically equilibrated due to the extensive mixing process of the early cratering stage (2,3). It has been shown that isotopic equilibration takes place between impact melt matrix and target rock clasts therein, with the intensity of isotopic exchange depending on the degree of shock metamorphism, thermal metamorphism, and size of the clasts (4). Therefore, impact melt breccias--if they are relatively clast-poor and mineralogically well studied--can be considered to be the most reliable source for information on the impact history of the lunar highland.

We have summarized published isotopic data on Apollo 16 impact melt rocks (only well defined data are regarded) [Fig. 1, 2, and Fig. 4 from (5)], and present new Rb-Sr data on impact melt rocks (Table 1). New whole-rock data are reported for two feldspathic, microporphyritic (7) impact melts, 67715,5 and 63538,3. Together with previously published data, they define a whole-rock isochron of 3.95 ± .36 AE [I(Sr)=.69909 ∓ 11], significantly lower than the ~4.1 AE ages from (6). We previously indicated (5) that breccias of this textural type give some evidence for chemical heterogeneity (Fig.2)--evidence for generation of these rocks in multiple impact events?

A mineral isochron could be established for the coarse-grained subophitic breccia 67559,13 resulting in an age of 3.85 ± .04 AE [I(Sr)=.69916 ∓ 4]. This age and the elemental (5) and isotopic (Fig. 1) evidence clearly show that the 68415-type melt breccias are derived from one melt complex. It seems probable that samples 65055 and 63549 belong to the same sample group, whereas chemically similar 60618 is derived from an older complex (3.94 AE, Fig.2). The 67559 age is clearly determined by the mesostasis data (Table 1). In the course of the analytical procedure it became necessary to characterize the mesostasis composition and mineralogy, and a SEM and TEM study was begun. Figs. 3 and 4 give preliminary results: the chemical composition is that of a subcalcic ferroaugite, and the structure (SEM-photo of Fig. 4) is dominated by subconchoidal growth planes in three directions (arrows, Fig. 4) and intense lamellar structure. Intergranular breccia 67775 was analyzed, as it chemically [Fig. 2,4 (5)] might well represent a distinct melt sheet. This sample and 67747 (whole-rock data, Table 1--mineral analysis is in progress) are members of the VHA-"basalt" group. The new Rb-Sr data applied in a whole-rock isochron calculation for VHA-"basalts" change the 3.90 ± .07 AE [I(Sr)=.69964 ∓ 10] (6) only slightly to 3.92 ± 0.09 AE for I(Sr)=.69959 ∓ 12. Only the data point of sample 61016 deviates significantly from the best-fit line.

The age data of Fig. 2 show that the impact events so far recorded from Apollo 16 impact melt rocks mainly occurred betwen 4.05 and 3.6 AE ago, with the probability that the feldspathic microporphyritic rocks were generated even earlier. But a characteristic of these samples is that they contain numerous anorthositic clasts, which might shift the real ages to higher values (model ages, Table 1, range from 3.67 to > 5 AE). Attempts have been made to relate the age of the Nectaris event to the age of the feldspathic breccias (~ 4.1 AE) from the North Ray Crater region and granulitic breccia clasts (~ 4.0 AE) therein (1,7). Only $^{40}Ar-^{39}Ar$ age data (6) for granulitic breccias are available so far--data that have been suspected of giving lower age limits for impact melt rocks. For this reason, we started a Rb-Sr study on granulitic rock 67746,7, which is coarse-grained enough to perform mineral separation (whole-rock data given in Table 1). It seems probable that the 68415- sample group could have been produced by an impact into the more aluminous Descartes region. The isotopic data alone suggest that VHA and KREEP melts have been generated in one or two impact events respectively. From the overall picture of chemical, mineralogical and chronological evidence, it seems possible that these rocks might have been produced by multiple impact into a petrologically heterogeneous Cayley formation,as proposed by Stöffler et al.(7).

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Table 1. Rb-Sr results on Apollo 16 crystalline impact melt breccias.

SAMPLE		Rb[ppm]	Sr[ppm]	87Sr/86Sr	87Rb/86Sr	LUNI	ROCK TYPE
67715,5	WRI	0.447	211.2	0.69935 ± 5	0.00612 ± 40	3.67	feldspathic, microporphy-ritic
	WRII	0.440	210.6	0.69950 ± 7	0.00605 ± 40	5.38	(same as above)
67775,7	WR	3.079	152.2	0.70297 ± 5	0.0589 ± 4	4.66	Inter-granular
63538,3	WR	0.843	193.3	0.69995 ± 12	0.01262 ± 9	5.06	Feldsp. micro-porphyritic
67747,8	WR	5.941	157.8	0.70564 ± 3	0.1089 ± 8	4.24	Coarse-gr. subophitic
67559,13	WR	1.816	175.1	0.70085 ± 4	0.0300 ± 2	4.17	Coarse-gr. subophitic
	PxI	0.475	29.6	0.70174 ± 12	0.0459 ± 3		
	PxII	0.690	38.3	0.70206 ± 4	0.05213 ± 37		
	Mes	5.60	74.6	0.71109 ± 6	0.21720 ± 15		
	Pl1	1.012	203.4	0.69990 ± 4	0.01439 ± 10		
	Pl2	0.985	211.1	0.69989 ± 3	0.01350 ± 10		
67746,7	WR	0.975	157.3	0.70011 ± 2	0.01793 ± 13	4.21	Granulitic noritic anorthosite

WR = whole rock; Px = pyroxene; Mes = mesostasis; Pl = plagioclase.

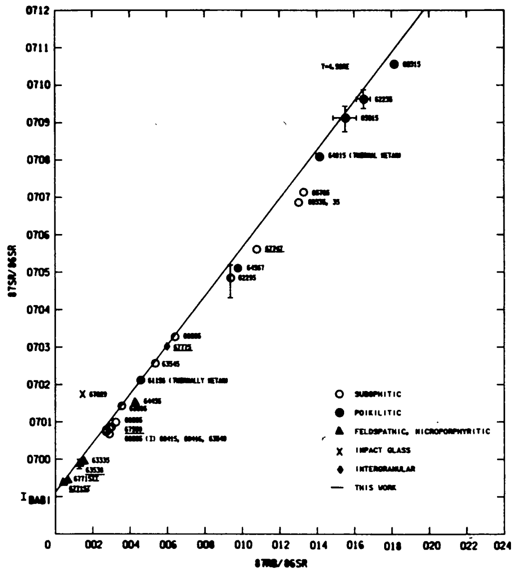

Fig. 1

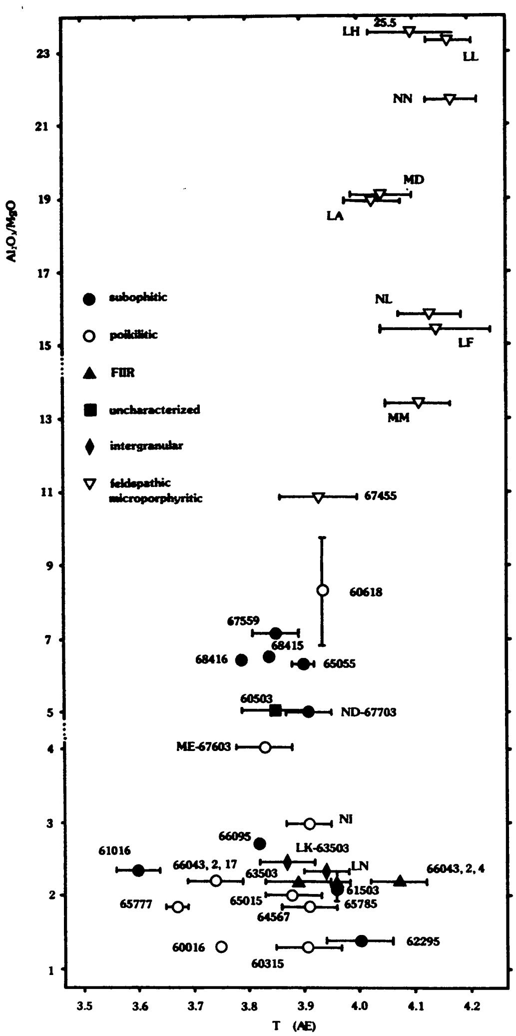

Fig. 2

Fig. 3

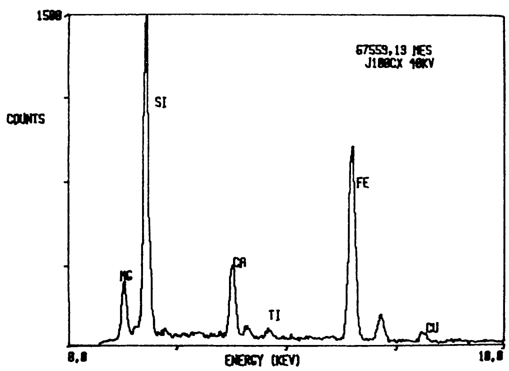

Fig. 4