MATURITY OF REGOLITH BRECCIAS AS REVEALED BY FERROMAGNETIC AND PETROGRAPHIC INDICES. D. S. McKay, R. V. Morris, SN4, and S. J. Wentworth, Lockheed, NASA Johnson Space Center, Houston TX 77058

Lunar regolith breccias are those fragmental breccias which contain identifiable regolith components such as agglutinates or glass spheres (1).They are normally thought of as the indurated equivalent of lunar soil. We have been looking at lunar regolith breccias in some detail because they have the exciting potential that at least some of them contain ancient lunar regolith frozen in time and consequently can reveal properties of the ancient solar wind, an early meteorite population, and the early lunar surface environment. We have previously reported on a general petrographic survey of Apollo 15 and 16 regolith breccias (2,3). We now have determined more detailed petrographic properties on some of these breccias and have also determined their ferromagnetic resonance maturity index, Is/FeO, for 45 breccias (Table 1).

All of these breccias have at least some petrographically identified agglutinates or glass spheres, although in some cases the abundances of these constituents are very low. In Table 1, a range of values for Is/FeO is given for some samples for which FeO contents are not available and a likely range of FeO values is assumed. From Table 1 it is apparent that regolith breccias having high values of Is/FeO are rare. Only two of the 28 AP15 breccias would be considered mature by soil standards (4); more than half are immature. The AP15 regolith breccias have a mean value of 24.6 (using the midpoint of the FeO range) which is less than half of the mean value of 55.6 for 27 AP15 soils (4). For AP16, the difference is even more pronounced. Only one of the 17 regolith breccias has a value extending into the mature range; all the rest are immature. The mean for the analyzed AP 16 breccias is 6.6 which is nearly an order of magnitude lower than the mean value of 62.0 for 43 AP16 soils (4).

Do these FMR index numbers reflect the true maturity and true surface exposure history of the components of the breccias or has their FMR index been altered by the breccia forming event or some subsequent event? Preliminary petrographic evidence indicates that for the porous breccias for which we have petrographic data, the petrographic maturity indicators are also low and are in essential agreement with the FMR index. We are performing modal analyses by optical point counts for grains larger than 20 micrometers and by Scanning Electron Microscope (SEM) point counts for smaller matrix grains. We classify as glasses all matrix grains which are clearly single phase and do not fit a mineral composition. For comparison and to help calibrate our technique, we also have analyzed a thin section from core tube 15010. We have previously analyzed the grain size distribution of material from this core tube and determined grain populations of each size fraction coarser than 20 micrometers (5). Table 2 shows the agglutinate content, glass sphere abundance (including crystallized varieties), and total glass for some porous breccias from AP15 and AP16. For reference, the Is/FeO value is also shown in the table for most of the samples.

The bottom of core 15010 is considered a relatively immature soil with Is/FeO of 26 (5) and agglutinate content (bulk) of 20.6 (6). Yet this sample contains significantly higher agglutinates, total glass, and matrix glass than the other samples in Table 2. We interpret the difference between the agglutinate content of the 15010 grain mounts and the 15010 continuous thin section to be an artifact of the difficulty of identifying the entire margins of agglutinates when they are closely packed into soil rather than separated as in the grain mounts. This difference provides a calibration between the two techniques. Using this calibration, the agglutinate contents of the regolith breccias can be normalized upward to values likely to be more comparable to grain mount data on soils and cores and this normalized value is also shown in Table 2. Even using this normalized value, the agglutinate contents of the breccias are quite low. The highest, 15086, has an agglutinate content about equal to that of 15010. The FMR index is also similar. The other breccias have much lower agglutinate contents, much lower total glass, and somewhat lower matrix glass. The petrographic data, therefore, are in good agreement with the FMR data for these samples and the low maturity is reflected by both kinds of indices.

Our survey petrographic data also show that the correlation between agglutinate abundance and the FMR index does not hold for many compact breccias. For example, compact breccias 15028 and 15245 both have submature FMR indices yet contain almost no identifiable agglutinates. Either the agglutinates are destroyed or made unrecognizable by the breccia forming event or the FMR index is somehow altered. We are currently trying to determine which explanation is more likely.

The reasons for the relatively low exposure maturity of most of the regolith breccias in our study remains elusive. Perhaps they were formed from soils which were immature or perhaps they were formed as a mixture of more mature soils and freshly comminuted bedrock. More detailed analyses should allow us to choose between these and other alternatives.

REFERENCES: (1) Stoffler, D., D. Knoll and U. Maerz (1979) Proc. Lunar Planet. Sci. Conf. 10th, P. 639-675. (2) McKay D. and S. Wentworth (1983) Lunar and Planet. Sci. 14, LPI, P. 481-482. (3) McKay D. and S. Wentworth (1983) Past and Present Solar Radiation: LPI workshop, Mainz, Germany, P.19-21. (4) Morris, R. (1978) Proc. Lunar Planet. Sci. Conf. 9th, p.2287-2297. (5) Bogard, D., R. Morris, W. Hirsch, and H. Lauer (1980) Proc. Lunar Planet Sci. Conf. 11th, p. 1511-1529. (6) McKay, D., A. Basu and G. Nace (1980) Proc. Lunar Planet. Sci. Conf. 11th, p. 1531-1550.

SAMPLE	I_s/FeO	SAMPLE	I_s/FeO	SAMPLE	I_s/FeO	SAMPLE	I_s/FeO
15015,167	3	15268,8	22-34	15505,90	27	61525,9	2-4
15025,10	42	15286,42	9-15	15528,7	16-25	61536,8	7-12
15026,6	61-94	15287,10	19-29	15558,33	22	63507,15	52-78
15028,10	22-34	15295,30	36	15565,117	14	63588,6	0
15059,321	32-49	15298,59	46-71	15688,13	0	63595,5	0
15086,97	18-27	15299,205	22-34	60255,93	15	65095,78	0
15205,114	0	15426,126	0-1	60275,56	4	65715,11	0-1
15245,118	29-44	15427,71	20-30	61135,29	0	66035,32	0-1
15245,120	29-45	15459,226	17-27	61175,206	8	66036,10	0
15257,7	20-30	15465,89	12	61195,57	0	66075,76	1
15265,66	23	15467,5	6-9	61295,47	6		
15266,23	10-15	15498,126	19-29	61516,8	0		

Table 1. Ferromagnetic Index I_s/FeO for regolith breccias.

SAMPLE	Is/FeO	>20 µm AGGLUTINATES	>20 µm AGGLUTINATES NORMALIZED (SEE TEXT)	>20 µm TOTAL NON-MATRIX GLASS	<20 µm MATRIX GLASS	<20µm MATRIX SPHERES
60016	N.D.	0.3	7.2	9.6	18.9	1.6
66035	0-1	2.5	6.0	13.3	18.4	1.0
66075	1	<0.3	<7.2	5.3	14.0	0.4
15086	18-27	8.1	19.4	26.8	22.8	2.7
15010[1]	26	8.6	20.6	27.9	30.1	1.4
15010[2]	26	20.6	20.6	34.0	30.8[3]	n.d.

[1]. SAMPLE 15010,6037; A CONTINUOUS THIN SECTION OF IMPREGNATED CORE AT 55 CM.
[2]. Grain mount of sieved core: 15010,1134. [3]. 20-45 micrometer data.

Table 2. Comparison of FMR and petrographic maturity indices. All values except I_s/FeO are in volume percent. I_s/FeO is in arbitrary units.