

REGOLITH BRECCIAS FROM APOLLO 15 AND 16: PETROLOGY, RARE GASES, AND FMR MATURITY. D. D. Bogard, D. S. McKay, and R. V. Morris, (Mail Code SN4, NASA/Johnson Space Center, Houston TX 77058) S. J. Wentworth (Lockheed/LEMSCO, 2400 NASA Rd. 1, Houston TX 77058), and P. Johnson (Northrup Services Inc. at NASA JSC, Houston TX 77058).

BACKGROUND We are studying the regolith breccia suite from Apollo 15 and 16 using several types of analytical techniques, including modal analyses of breccia thin sections, SEM surveys of breccia matrices, electron probe analysis of mineral and glass phases, rare gas analysis of bulk samples, and ferromagnetic resonance (FMR) analysis of bulk samples. We are disaggregating some of the breccias and analyzing grain size separates (1). In addition R. Korotev of Washington Univ., St. Louis, is doing neutron activation analyses of the same breccias (2, 3). Our objectives include comparing the regolith breccias to the soils at both sites, determining whether the breccia forming event has modified the properties of the regolith from which they were made, and searching for samples of ancient regolith which may contain information on the early history of the Moon, the sun, and the meteorite environment.

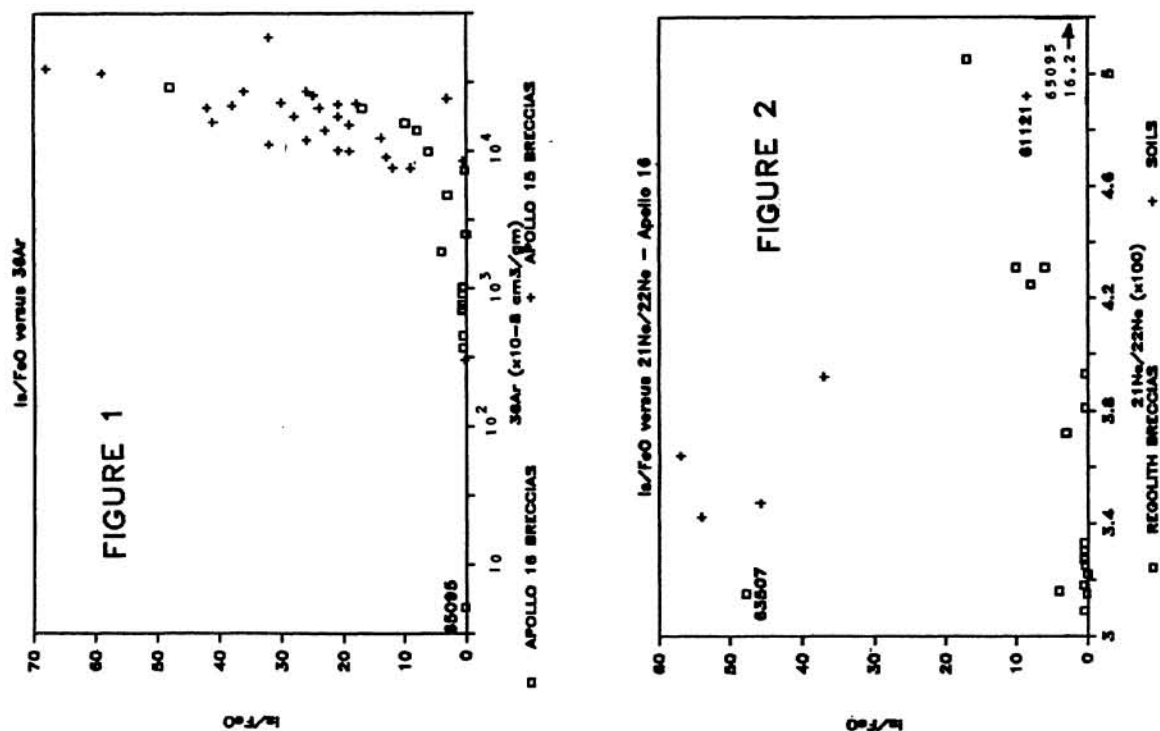
REGOLITH BRECCIA MATURITY We have analyzed nearly all of the regolith breccias (>1cm) from the Apollo 15 and 16 sites. All of the 47 breccias analyzed contain measureable amounts of implanted, solar-wind gases, and detectable amounts of magnetic, fine-grained iron represented by the iron-normalized parameter, Is/FeO (Fig. 1). Samples analyzed were from interior chips so that the solar-wind gases and fine-grained iron reflect a lunar surface exposure history of the breccia material prior to its incorporation into a breccia. The presence of solar gases and magnetic iron indicates that all breccias contain some lunar soil component, confirming the previous identification of these breccias as regolith breccias based on petrographically recognizable soil components such as glass spheres or agglutinates. We had noted previously that the Apollo 15 regolith breccias and especially the Apollo 16 regolith breccias are immature compared to most soils (4). Our new data even more strikingly make that point. Figure 1 shows the Is/FeO FMR index plotted against the ^{36}Ar for Apollo 15 and 16 breccias. Many of the breccias, mainly from Apollo 16, have Is/FeO values <1 which is lower than virtually all soils in the Apollo collection (5). The ^{36}Ar content of these breccias is more than two orders of magnitude lower than typical soils. Values of Is/FeO and solar gas contents for most Apollo 16 breccias are considerably smaller than both the Apollo 15 breccias and typical Apollo 16 soils, and indicate that many, but not all, Apollo 16 breccias contain no more than a few percent of a typical Apollo 16 soil. Values of Is/FeO for all Apollo 15 breccias are in the same range as immature and submature soils, their solar gas contents are generally typical of Apollo 15 soils, and we conclude that most Apollo 15 breccias contain a sizeable component that resembles Apollo 15 soil. Agglutinate contents for these breccias correlate roughly with Is/FeO , although agglutinate contents are generally lower for a given value of Is/FeO compared to soils. However, some breccias, particularly the more compact ones, have few if any identifiable agglutinates yet contain appreciable Is/FeO and ^{36}Ar . Examples include 15295, 15505, and 60255, all of which have compact textures. We conclude that agglutinates become modified during the breccia forming event, and become progressively more difficult to identify in more compact breccias.

APOLLO 16 BRECCIAS Fig. 2 is a plot of Is/FeO against measured $^{22}Ne/^{21}Ne$ for Apollo 16 breccias and a few submature to immature Apollo 16 soils. Is/FeO increases with surface irradiation of disseminated material, whereas $^{21}Ne/^{22}Ne$ increases due to irradiation by cosmic rays in the uppermost 1 meter or so of the regolith. One friable breccia, 63507, falls in the area of most soils, suggesting that it primarily represents indurated soil typical of the Apollo 16 site. Nine breccias with Is/FeO <1 cluster at $^{21}Ne/^{22}Ne$ of about 0.032, which is about the value of trapped solar Ne in Apollo 16 soils, and apparently have received only minor amounts of cosmic ray irradiation. Three additional breccias, 63595, 63588, and 65095, have Is/FeO <1 but show increased $^{21}Ne/^{22}Ne$ (particularly 65095). We conclude that these 12 Apollo 16 breccias were produced from fine-grained material which had little, if any, surface irradiation and that only three of these 12 breccias were significantly irradiated by cosmic rays, probably after compaction. The other breccias are not on a simple mixing line between unirradiated material and submature soils. They do appear to be on a mixing line with the unusual soil 61121. These

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breccias could, however, be made of mixtures of unirradiated material and typical submature soils which were irradiated after breccia formation causing them to move to the right in Fig. 2., in which case the apparent "linear" trend in Fig. 2 is fortuitous. Alternatively they could also be mixtures of unirradiated material, submature soils, and a highly irradiated material like 65095. Determinations of trapped $^{40}\text{Ar}/^{36}\text{Ar}$ in breccia size separates (in progress) may permit us to narrow these options.

APOLLO 15 BRECCIAS The larger solar gas contents of Apollo 15 breccias makes identification of cosmic-produced Ne more difficult, but identification of trapped $^{40}\text{Ar}/^{36}\text{Ar}$ is easier. Trapped $^{40}\text{Ar}/^{36}\text{Ar}$ is believed to have decreased significantly over lunar history, and could be a measure of the time of irradiation and compaction. After applying an estimated correction for radiogenic ^{40}Ar , trapped $^{40}\text{Ar}/^{36}\text{Ar}$ ranged from 0.55 to 4.9 and tended to group according to the lunar site of each breccia. The five station 7 breccias show ratios >3.3 , and the breccia with the highest ratio also shows considerably higher FeO (2). Trapped $^{40}\text{Ar}/^{36}\text{Ar}$ in breccias from the mature regolith at station 8 are all <1 . Trapped $^{40}\text{Ar}/^{36}\text{Ar}$ in a breccia from deeper regolith at station 9 is <1 , but these ratios are about 1.4-2.3 in three breccias from station 9A where the regolith is thin, rapidly eroding, and uncovering less mature and previously irradiated material (6).



- (1) McKay D. S. and Wentworth S. J. (1985) This volume. (2) Korotev R. L. (1985) This volume. (3) Korotev R. L. (1985) This volume. (4) McKay D. S. (1984) Maturity of regolith breccias as revealed by ferromagnetic and petrographic indices (abstract). in Lunar and Planetary Science XV, p. 530-531. Lunar and Planetary Institute, Houston. (5) Morris R. V. (1978) Proc. Lunar Planet. Sci. Conf. 9th, p.2287-2297. (6) Bogard D. D. et al. (1980) Proc. Lunar Planet Sci. Conf. 11th, p. 1511-1529.