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SIZE, COMPOSITION, AND PROVENANCE OF FRAGMENTAL PARTICLES IN APOLLO 14 BRECCIAS

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The understanding of the pre-Imbrian selenologic history of the lunar crust and of the Imbrian event itself depends largely on the interpretation of the textural and compositional properties of the Fra Mauro breccias. Through the combined analyses of the size distribution, the modal composition of the constituent particles and the chemical composition of fragmental plagioclase we attempt to obtain more information about the provenance of the fragmental and in situ formed components and their mode of aggregation in the Frau Mauro breccias.

Grain size distributions were obtained from photomicrographs of polished thin sections at various magnifications in the size range from Ø = 0 to Ø = 4.75 (1-0.037 mm). The measured diameters are the diameters of equal area circles. The results are plotted in Fig. 1 as grain number frequencies. For comparison weight percent frequencies were recalculated for lunar soils (1) and a terrestrial pyroclastic base surge (2). It can be inferred from calculated "apparent" statistical measures that the "graphic mean" shows a negative linear correlation with the "sorting" in the Ø scale. The overall grain size decreases in the sequence metabreccias (14006, 14321) regolith breccia (14055) immature soil, (14149) mature soil (14259) whereas the "apparent" degree of sorting increases. Suevite and the base surge plane beds (2) fall off this correlation, the former is coarser and poorer sorted, the latter is finer than the lunar breccias but similar in the degree of sorting. The clast population of the Ries glass bomb 618 falls onto the "lunar" correlation but has a finer grain size and higher degree of sorting as compared to the lunar polymict breccias. In a preliminary interpretation it could be stated that the clast population of the metabreccias seems to be produced by impact comminution which remained in the state of high immaturity more similar to a single impact formation than any other of the measured lunar impactoclastic materials. Additional data are needed for a more thorough interpretation.

In Fig. 2 the clast population for plagioclase and mafic minerals > 25 μ is opposed to the proportion of these minerals in some main types of possible "igneous" source rocks. The metabreccias 14006, 14321 (dark matrix) and 14311 are characterized by a ratio of plagioclase and mafic minerals which is about 2:1. Most Apollo 14 basalts have a much lower ratio of up to about 1:3 (3). Only Group I basalts (4) and certain sections of 14310 (4) have ratios similar to those of the breccias. Furthermore

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the clast population (> 25 μ) of the regolith breccias and the soil 14259 is distinctly different from the population of the metabreccias. This confirms the well known fact that the two types of breccias are not genetically related. Inspection of the matrices of the metabreccias reveal higher proportions of mafic minerals compared to the clasts. This can also be seen if the mineral norms calculated from whole rock chemical analyses (5) are compared with the clast population (Fig. 2). In contrast, the norm of breccia 14318 does not differ from the mode with respect to the plag : mafics ratio. Consequently the primary matrix material of the metabreccias must be different from the clast material whether it is derived from glassy or from detrital material before the recrystallization took place.

Mineral chemistry. The following results for the chemical composition of the plagioclase clasts in breccias 14006 and 14321 are significant (Fig. 3-5): 1) The range of An- and Fe-content is broader than that of plagioclase from a single major type of igneous rock. 2) There is a moderately pronounced negative correlation between Fe- and An-content. 3) There is a weakly pronounced negative correlation between Fe-content and grain size of the measured plagioclase. Data from various authors (e.g. 6,7) demonstrate that the Fe-content of plagioclase and to some extent also the An-content is characteristically different in the major types of lunar "primary" igneous rocks. The highest reported FeO-value for an Apollo 14 basalt is near 0.9 (8). Comparison with these data leads to the conclusion that the plagioclase clast population of the metabreccias is a mixture of plagioclase from at least three sources: a) anorthosites b) different types of Apollo 14 basalts and possibly c) rocks with iron-rich plagioclase obviously unknown so far from the Apollo 14 site. Plagioclase fragments from noritic, troctolitic and dunitic rocks could be admixed as well. This is consistent with the lithic clast population of the metabreccias. The well documented complexity of lithic clasts in 14321 (9, 10) is duplicated in the younger matrix by the plagioclase clast population. The results show that the mineral clast population is an useful petrogenetic indicator in order to elucidate the impact history of small-sized lunar breccias such as 14006. Similar analyses on all types of Fra Mauro breccias may eventually give more insight in the sequence of pre-Imbrian and Imbrian impact and thermal events recorded in these rocks.

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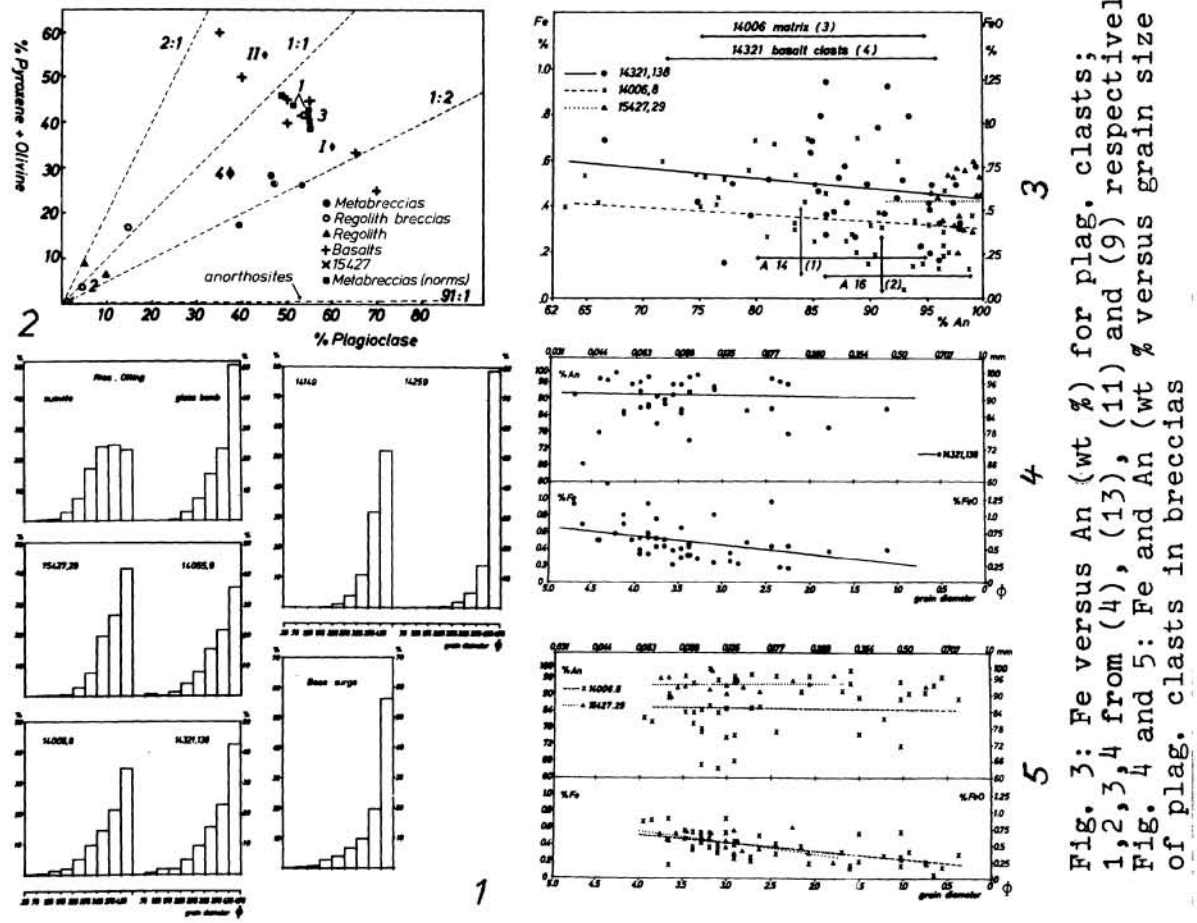

Fig. 3: Fe versus An (wt %) for plag. clasts; 1,2,3,4 from (4), (13), (11) and (9) respectively. Fig. 4 and 5: Fe and An (wt % versus grain size of plag. clasts in breccias

Fig. 2: Modal abundances (vol.%) I,II=group I and II A 14 basalts (4); 1=dark and light metabreccias from A 14 coarse fines (14)2= 14318 (mode) 3=14318 (norm), 4=14006 (norm); other data in part from (12). Fig. 1: Grain number frequency versus grain size.