CHARACTERIZATION OF THE BASIC TYPES OF LUNAR HIGHLAND BRECCIAS BY QUANTITATIVE TEXTURAL ANALYSIS

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Automated line scanning of thin sections was successfully used to quantify the textural variation of the Apollo 14 breccias (1). Based on textural properties such as grain size parameters of the fragmental constituents, modal composition (V_i), specific surface area (S_i/V_i), inner specific surface area (S_i/V) and specific contact area of in situ crystallized matrix constituents, a new classification and genetic model of the Fra Mauro breccias was derived (1). This model adopts impact melt, melt agglomerates and suevitic breccias as parent rocks for the crystalline and clastic matrix breccias of the Apollo 14 landing site.
Recognizing the insufficiency of bulk chemical analysis for breccia classification (2, Fig.1), and postulating a common genetic framework for all types of impact-generated lunar highland breccias we extended quantitative textural analyses to breccias of the Apollo 15, 16, and 17 landing sites. Selection of samples was made according to the type of matrix using qualitative criteria similar to those applied by other classification models (4,5). The following types of breccias have been studied (including some previously analyzed Apollo 14 breccias): breccias with clastic matrix (CM; 14063, 76255), breccias with dark, fine-grained, equigranular crystalline matrix which partly contain areas of light, coarser grained matrix (DM+LM;14006, 14306,14066,14311, 14319, 14320, 14312, 14321, 72215, 72255, 73215, 73235), breccias with poikilitic crystalline matrix (PM; 65015, 77135), one breccia with granulitic crystalline matrix (79215), and breccias with intrusive-like dark, fine-grained crystalline matrix known as black-and white rocks (15405,15455).
The first aim of the study is to substitute the qualitative criteria of breccia classifications which often use ill-defined, descriptive terms such as "light-gray", "blue-gray", "porphyritic", "aphanitic", "microhornfelsic", etc. by quantitative textural paramaters. The second aim is to check whether the current classification models can be confirmed or have to be modified and whether they can be reconciled with a genetic interpretation based on geologically well defined terrestrial impact breccias.
The grain size distribution of the clasts (Fig. 2) reveals characteristic differences among the various groups of breccias. According to the criteria developed in (3) the clastic fraction of all breccias obviously has undergone modest reworking by multiple impact comminution. The mean grain size is typically smaller for the clast population of the breccias with poikilitic matrix and intrusive-like, dark matrix (black and white rocks) compared to the bulk of breccias with dark, fine-grained equigranular crystalline matrix. This could possibly be interpreted as a result of a single impact event in which fine-grained clastic material was mixed into an impact melt similar to the fragment-laden Ries glass bomb (Fig. 2).

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Substantial differences among the breccia groups have been observed with respect to the grain size distribution and other textural parameters such as specific surface area and contact area of the in-situ crystallized matrix minerals. The matrix minerals of breccias with poikilitic and granulitic crystalline matrix have a larger mean grain size and standard deviation (worse sorting) than breccias with dark and light, fine-grained, equigranular crystalline matrix including the black and white rocks (Fig. 3). In Fig. 4 the specific surface area of plagioclase and pyroxene+olivine of the matrix is plotted versus their modal content. Again the poikilitic and granulitic breccias lie outside the field of dark (and light) matrix breccias.

A good criterion for the distinction of the different types of crystalline matrix is the modal mesostasis content. In Fig. 5 it is plotted versus the inner specific surface area of matrix plagioclase. The granulitic matrix has a very low specific surface area of plagioclase and a very low mesostasis content. The poikilitic matrix has a low specific surface area and a medium mesostasis content. The light crystalline matrix of Apollo 14 breccias has a medium specific surface area and a medium to high mesostasis content, whereas the dark crystalline matrix and the intrusive-like, dark crystalline matrix of the black and white rocks have a high specific surface area of plagioclase and a low to medium mesostasis content.

In Fig. 6 the specific contact area of plagioclase and of pyroxene+olivine is plotted versus the modal mesostasis content. The light crystalline matrix of breccias 14311 and 14066 are lying far outside the field of the other breccias which constitute a rather homogenenous group in this plot. This is due to the very high specific contact areas between plagioclase and mesostasis and pyroxene+olivine and mesostasis in these two breccias which prevents a high frequency of plagioclase-pyroxene+olivine contacts.

The results discussed above and the confusion which has been caused by the currently inconsistent classification models of lunar highland breccias support our opinion that these classifications have to be revised on the basis of quantitative microscopic and macroscopic textural properties of the breccias and observations obtained from terrestrial impact craters. These data combined with appropriate selenological information provide a genetically oriented classification model of the lunar highland breccias which is given by (6) in this volume.

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Figure captions: Fig.1; Bulk chemical analysis of some lunar highland breccias. Crosses: primary lunar igneous rocks I-VIII analyses from (7), IX-XII analyses from 8-13, RB = 14055, 15427; Fig.2; Medium grain size (Graphic Mean) versus sorting (Inclusive Standard Deviation) (14) of clasts embedded in various lunar highland breccias; Fig.3; Medium grain size versus sorting of matrix plagioclase of various lunar crystalline matrix breccias; Fig.4; Specific surface area (15) of matrix minerals (plagioclase, pyroxene+olivine) versus their modal content; Fig.5; Inner specific surface area (15) of matrix plagioclase versus modal mesostasis content; Fig.6: Specific contact area (15) of plagioclase and pyroxene+olivine versus modal mesostasis content. - For symbols see Fig.3.

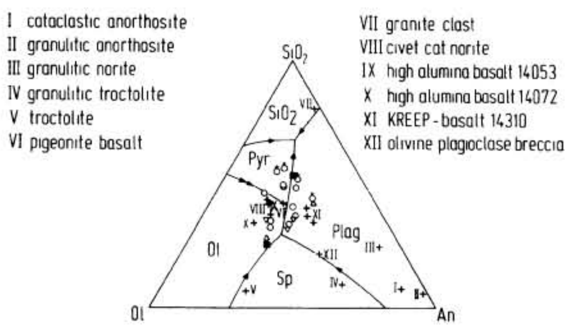

Fig. 1

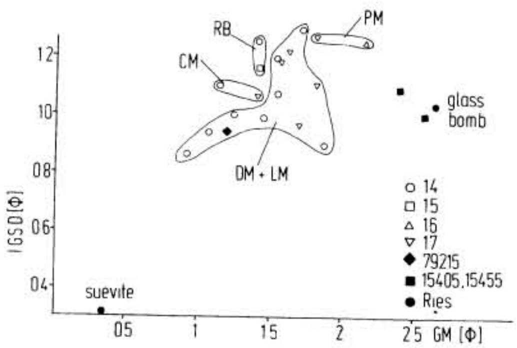

Fig. 2

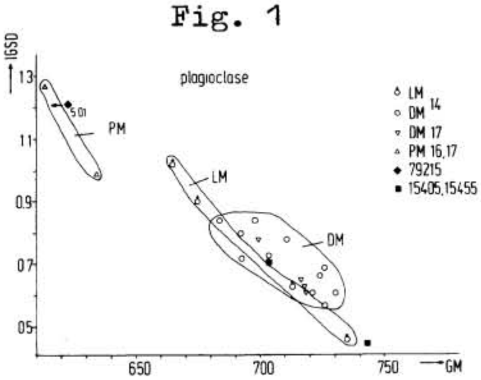

Fig. 3

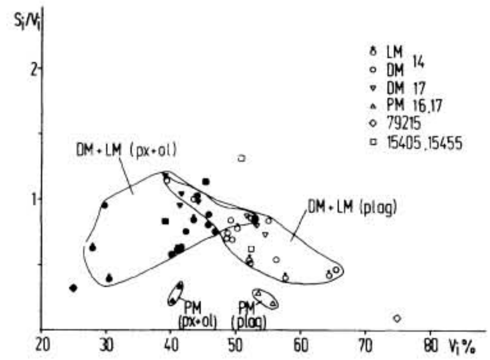

Fig. 4

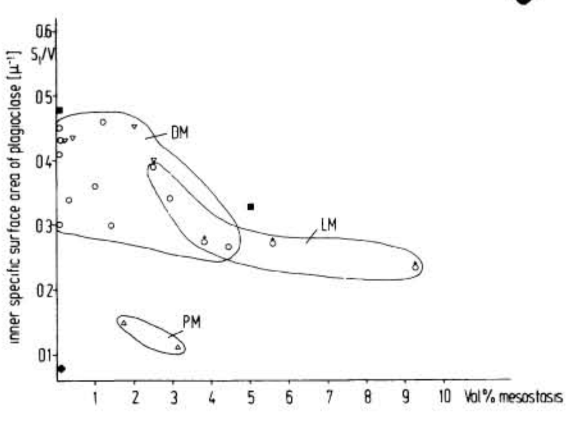

Fig. 5

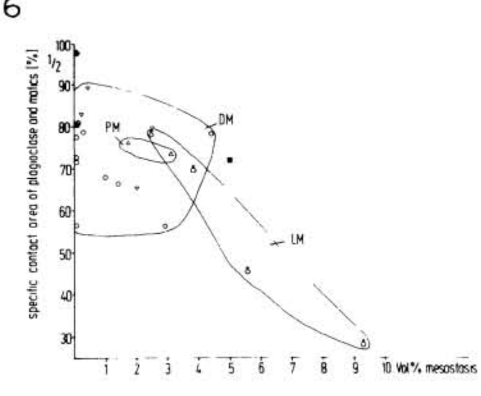

Fig. 6