PETROLOGY OF APHANITIC LITHOLOGIES IN CONSORTIUM BRECIA 73215.
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Introduction: Preliminary consortium studies [1,2,3] showed that the aphanitic materials that form the bulk of 73215 originated as mechanically mixed aggregates of mineral and lithic clasts plus silicate melt; after aggregation the melt crystallized as a very fine-grained groundmass. This abstract describes the aphanitic materials and presents microprobe studies aimed at determining groundmass bulk composition and compositions of clasts, groundmass minerals and reaction products; also included is a brief petrographic description of two clasts of anorthositic gabbro studied by the consortium. A companion abstract [4] presents recent results of consortium studies in fields other than petrology.

Hand-specimen character of aphanites: The bulk of the rock consists of subparallel bands of several different types of aphanite (interspersed are bands of granulated clastic materials). These aphanites have been termed "matrix"; different types differ primarily in color, coherency, and nature of included clastic material. The major types studied have been designated as 1) black, 2) gray, 3) light-gray, and 4) schlieren-rich gray matrix. Similar aphanite also forms clast-like bodies, most prominent of which are: ellipsoids and spheroids of tough dark-gray aphanite within matrix; and irregular clasts of tough, locally vesicular black aphanite within granulated feldspathic clast materials.

Petrography of aphanites: All aphanites consist of abundant small clasts set in a dark groundmass of minute grain size. Groundmass texture ranges from microgranular to microsubophitic and grain size ranges from 1 to 8µm. Point counts made in reflected light on three different types of matrix show groundmass-clast ratios ranging from 66:34 to 71:29. As only angular clasts >5µm across can be distinguished, these ratios are maximum values. Characteristics of different types of aphanite -- matrix and clasts -- were outlined in [3] and will be detailed in [5].

Petrography of anorthositic gabbro clasts: The two clasts studied by the consortium have related textures. One is coarser grained and is poikilitic: subhedral, slightly rounded 1.0-0.1mm plagioclase grains and rounded 0.2mm olivine grains are enclosed in poikilitic orthopyroxene. The bulk of the rock crystallized from a melt, but cores of some of the plagioclase and olivine grains may represent xenocrysts. The rock was not subjected to any significant post-crystallization deformation or recrystallization. The other clast is much finer grained: plagioclase ranges from 0.01-0.4mm and olivine averages 0.04mm. It contains poikilitic areas similar in texture to the coarser-grained clast, but it also contains areas of granoblastic olivine and plagioclase. Significant numbers of xenocrysts of plagioclase and olivine are present.

Bulk composition of groundmass: Bulk compositions of groundmass have been determined by defocussed beam microprobe analysis, in collaboration with K. Keil (Univ. of New Mexico). 100µm spots were analyzed, and outlines of each spot and each discernible clast therein were traced on reflected light photomicrographs. Clast analyses coupled with clast proportions (from point counts) were used to subtract clast contributions from the defocussed beam analyses. Groundmass bulk compositions so determined are listed in Table 1.

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Compositions of small clasts: Clast compositions are being surveyed to study variations in clast population between different aphanites. Such surveys have been made of typical areas in gray and schlieren-rich gray aphanitic matrix. In each area centers of all clasts >25 μm across have been analyzed. Results are as follows. Olivine—in both types of matrix, clasts range from -Fo71 to -Fo89, and distribution of compositions is strongly skewed toward the Fe-rich end of the range and peaked at -Fo73. Pyroxene—in both types of matrix most clasts fall into one of three groups, which are, in decreasing order of abundance: 1) magnesian orthopyroxene (Wo4En85Fs11 to Wo2En71Fs27), 2) pigeonite (Wo6En70Fs25 to Wo11En57Fs32), and 3) Fe-rich orthopyroxene (Wo3En65Fs32 to Wo3En49Fs49); sparse clasts of augite, Fe-rich pigeonite, and very Fe-rich orthopyroxene are also present. Plagioclase—distribution of compositions is similar in both types of matrix, with average -An95-96 and overall range -An86-98.

Compositions of groundmass grains and 5-25 μm clasts: Analyzed olivines in this size range are between -Fo68.5 and -Fo73, m. Analyzed pyroxenes average -Wo3En73.5Fs23.5, and compositions cluster fairly tightly. In contrast, plagioclases in this size range are not significantly more uniform in composition or richer in alkalies than clasts >25 μm across; range is -An86-98, and averages in four different thin sections are from -An96 to -An92.

Clast-groundmass reactions: Most clasts of plagioclase and mafic minerals show no evidence of melting, reaction or diffusive exchange with groundmass. Prominent exceptions are: olivine clasts more magnesian than -Fo70 show Fe-rich marginal zones -50 μm thick; most augite clasts have reaction rims -5 μm thick of low-Ca pyroxene; Fe-rich pyroxene clasts show reverse zoning in Fe-Mg at their margins; silica mineral clasts have glass rinds and coronas of low-Ca pyroxene; and aluminous spinel clasts have 1-5 μm rinds of plagioclase. The low-Ca pyroxenes in these occurrences have compositions that trend toward Wo5En71Fs24. Plagioclase rims on spinel average -An9.9. Deformation, melting and recrystallization of clasts: Most clasts were not internally deformed during or after breccia aggregation, but some clasts of devitrified maskelynite and felsic glass have outlines that indicate they were plastically deformed by flow of surrounding matrix. Most lithic clasts show no evidence of heating after incorporation, but sparse clasts were partly melted; these appear to have been hot when incorporated [3,5]. Clasts of crystalline felsite show small degrees of partial melting but remained largely unmelted. Most clasts were unshocked and undeformed prior to being incorporated, but a significant number were of maskelynite and shocked crystalline plagioclase. All clasts of maskelynite and shocked plagioclase have devitrified and recrystallized; in many of these there is evidence that the devitrification and recrystallization occurred after breccia aggregation [5].

Discussion: The studies summarized above and in [1,2,3] permit a number of tentative conclusions on origin and history of the breccia, as outlined below.

Clasts incorporated in the breccia had widely varying temperatures and shock histories; most were cold and unshocked, but a significant number were hot and/or had been shocked. Clast compositions suggest derivation from a more restricted number of sources than in regolith breccias. The intimate
mixing of clasts and melt, and the fact that mixing with cold clasts did not
quench the melt implies that melt was highly fluid and probably superheated,
and that mixing was thorough and energetic. Thus the process that mixed
clasts and melt was likely related to a very large impact event.

The aggregate probably contained more than 50% melt, which crystallized
to form the groundmass. Major groundmass minerals are low-Ca pyroxene and
plagioclase; minor olivine is also present. Bulk analyses of groundmass show
that the melt was fairly homogeneous (except in MgO, Na2O, and P2O5). Al2O3
contents are lower and FeO, MgO and TiO2 contents are higher than in bulk
chips analyzed by atomic absorption spectrophotometry (AAS) and instrumental
neutron activation analysis (INAA) (Table 1). The differences indicate that
groundmass was not derived by melting of the clast suite it contains; the
clast suite is relatively anorthositic and groundmass is relatively noritic.

During aggregation cold clasts were heated, but apparently they were not
at temperatures > 1000°C for any significant time, because clasts of crystalline
feldspar with eutectic temperatures ~990°C [6] did not melt. During groundmass
crystallization silica mineral clasts partly melted, and rims of plagioclase
and low-Ca pyroxene formed around clasts of spinel and augite, respectively.
The aggregate flowed, producing lithologic banding. During subsolidus cooling,
diffusion formed marginal Fe-rich zones in magnesian olivine clasts and
marginal Mg-rich zones in Fe-rich pyroxene clasts. Nature of the composi-
tional gradients in the olivines will be used to set limits on the cooling
time of the breccia [5].

The differences in color and coherency of the various types of aphanite
are primarily due to variations in groundmass grain size and amount of shear-
duced porosity [3,5]. Relationship of the clast-like aphanites to matrix
aphanites is unclear. These may be preexisting clasts incorporated in the
breccia when it formed or they may have been generated at the same time as the
matrix; consortium studies are now in progress to resolve this question.

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References: (1) James O.B., 1975, Lunar Science VI, p. 438-

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