THE PETROLOGY OF 77215, A NORITIC IMPACT EJECTA BRECCIA.

77215, an off-white friable breccia, is the oldest of four samples collected from the Apollo 17 station 7 boulder and studied by the International Consortium (1,2). Sample 77215 now comprises more than 65 separate pieces because of its friable nature. Megascopically it consists of highly to moderately fractured clasts of milky white to colorless anorthite and pale greenish yellow orthopyroxene with dark gray to black specks and clasts of partly devitrified impact glass.

Doubly polished thin sections 77215, 8; 9, 12; 13; 138; 139; 140; 142; 152; 156; 158; and 159 were studied by petrographic and interference microscopy; minerals in the underlined sections were analyzed by electron microprobe.

77215 consists of one major, one subordinate and three accessory lithic components. The major component is a medium to coarse-grained norite and the subordinate component consists of clasts of dark gray to black impact glass. The three minor components are anorthosite, olivine-bearing breccia, and an assemblage that contains abundant troilite, FeCo metal, a silica phase, and a phosphate mineral. Most of the lithic clasts have been crushed and fractured and some have been intensely granulated and stretched out to form schlieren; thus the relict host rock type is represented by clasts rarely exceeding a few mm across.

Norite-- Out of many clasts studied only two are large enough to indicate in texture and mineral assemblage that the dominant rock type is norite. The norite consists of greater than millimeter-size anorthite (An0.09-0.92Ab0.10-0.97) and orthopyroxene (Wo4-5En67-63Fs29-32) with minor augite (Wo43-47En47-44Fs12-13). A K-rich mesostasis with an aligned or exsolved (?) pure silica phase, and an assemblage of troilite, FeCo metal, ilmenite, and free silica are also present. The modal analysis based on more than 2,000 counts on a total of 7 norite clasts is (vol. %): plagioclase, 51.8; orthopyroxene, 44.6; clinopyroxene, 0.9; troilite, 1.5; K-feldspar, 1.0; silica, 0.1; and ilmenite, 0.1.

The anorthite crystals were determined by interference microscopy to be unzoned. They often contain abundant square to rectangular blebs of exsolved K-feldspar (An0.09-0.92Ab0.10-0.97) which in turn contain round metallic particles. One of these metallic particles large enough to be analyzed contains 93.6% Fe, and 1.19% Co. Ni was not detected. Other K-feldspar blebs in the plagioclase contain inclusions that are tentatively identified optically as ilmenite. The orthopyroxenes contain coarse exsolved augite similar in composition to the discrete grains of augite in the rock. The orthopyroxenes have previously been investigated by us (1) and by Huebner et al. (3). Fractures in both the plagioclase and the orthopyroxenes have been filled in places by very fine veinlets of troilite. We have not been able to determine whether these veinlets are the products of condensation of the impacting particles or filling by solutions after crystallization of the norite.

Glass clasts-- These occur as irregular fragments containing abundant shocked brownish-white plagioclase xenocrysts and metallic spherules. Although most of the latter are too small for probe analysis, of three which
are barely large enough two were found to contain about 95% Fe, 1% Co and no detectable Ni, while the third contained 89% Fe, 0.8% Co and 6.2% Ni. The glass clasts are all crushed or fractured, probably as a result of shock subsequent to their incorporation into 77215.

Table 1 shows that these glassy areas are very similar in bulk composition to noritic breccia 77215, indicating that the glass could well have formed from impact melting of noritic breccia.

Accessory lithic components-- These components are separate and appear to be unrelated to each other.

Anorthosite-- Clasts are usually small. They show effects of extensive microfracturing or evidence of shock-induced heating such as mosaic crystallization. The calcic plagioclases are unzoned and are generally similar in composition to those in the norite. It is difficult to determine whether the mineral fragments of plagioclase are derived from broken anorthosite or from norite.

A fine-grained olivine-bearing breccia is present in significant amounts only in thin section 77215,13. The olivine is unzoned and highly magnesian with a wide range of composition (FeO03-87); is intimately associated with calcic plagioclase. Unfortunately these xenoliths are so small and rare that their significance cannot be assessed.

The component that contains free silica, phosphate mineral, troilite, FeCo metal and ilmenite occurs in scattered areas in 77215, as mesostasis inside norite or as smeared-out streaks or clusters in the breccia. The silica occurs in small birefringent grains, darker in reflectivity than K-feldspar. Electron microprobe analyses show that it is pure silica, but we have not yet identified the phase specifically.

K-feldspar-- occurs only in association with plagioclase grains both in the norite clasts as well as throughout the breccia. Mixtures of troilite and K-feldspar have been x-rayed and identified.

Areas of granitic glass were found associated with K-feldspar in scattered anorthite grains and inside plagioclase grains in the norite. The average of three analyses in wt. % is as follows: SiO2, 81.9; TiO2, 0.43; Al2O3, 8.5; FeO, 0.16; MgO, 0.27; CaO, 1.93; MnO, 0.03; Na2O, 0.34; R2O, 4.5; Cr2O3, 0.30; total 98.4.

Possibly the K-feldspar, free silica, FeCo, troilite assemblage and the granitic glass represent the mesostasis of the norite. However we have no definitive evidence of this.

Scattered large metallic particles are also present. Most of these are probably non-meteoritic. One grain of metal over 200μm across and surrounded by troilite contains 96 wt. % Fe and 2.9% Co in the core and 94.5% Fe and 3.6% Co at the outer edge. Ni is not detected. This composition is similar to that of the metallic grains within the exsolved K-feldspar in the anorthosite crystals of the norite. No appreciable Ni was found in any of the metallic grains analyzed except for the one mentioned above in the impact glass clasts. Random zirconolite (?) or phase X (3) minerals have also been found in 77215.

PETROGENESIS

On the basis of the clast assemblage, the highly fractured friable texture, the weak shock features, and the small amounts of impact glass present, we
THE PETROLOGY OF 77215

Chao, E. C. T. et al.

classify 77215 as low-temperature, low-shock, non-regolith, impact ejecta of noritic composition. The coarse grain size of the norite suggests that it crystallized and cooled relatively slowly at depth similar to plutonic or deep-seated rocks on Earth. The uniform composition of the unzoned calcic plagioclase and the coarsely exsolved orthopyroxene suggest that the norite remained hot and cooled slowly at high but subsolidus temperatures. The K-rich mesostasis of troilite silica and Fe-Co metallic particles was the last to crystallize. There is also evidence of the occurrence of fracture-filling secondary troilite. The noritic rock was subsequently brought to the surface by cratering processes and mixed with breccias containing assemblages of unequilibrated highly magnesian olivine (3), and gray impact glasses of the same noritic composition. This assemblage was probably not reheated in a high temperature ejecta blanket, because there is no evidence of significant heating or shock during aggregation. It was then compacted and lithified by impact prior to incorporation in the 77115 melt rock near or at the surface. As suggested by the Rb/Sr age of 4.45 b.y. obtained by Tatsumoto et al. (this volume), 77215 contains components of some of the oldest and thus most important lunar rocks.

References Cited


Table 1. Composition of Glass Clasts in 77215 (Wt. %)

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<tr>
<th>77215,8</th>
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<th>77215,138</th>
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| SiO2     | 49.4    | 49.9    | 50.5    | 49.7    | 49.6    | 51.3    |
| TIO2     | 0.36    | 0.35    | 0.42    | 0.32    | 0.36    | 0.32    |
| Al2O3    | 15.8    | 12.1    | 15.6    | 18.5    | 15.9    | 15.06   |
| FeO      | 9.8     | 9.8     | 9.8     | 8.7     | 9.5     | 10.07   |
| MgO      | 12.8    | 16.9    | 11.9    | 10.7    | 13.1    | 12.56   |
| CaO      | 9.3     | 8.2     | 9.7     | 10.5    | 9.4     | 8.96    |
| Na2O     | 0.64    | 0.60    | 0.71    | 0.76    | 0.68    | 0.43    |
| K2O      | 0.20    | 0.23    | 0.20    | 0.11    | 0.19    | 0.14    |
| P2O5     | 0.12    | --      | n.d.    | n.d.    | (0.06)  | 0.11    |
| MnO      | 0.11    | 0.16    | 0.13    | 0.11    | 0.13    | 0.16    |
| Cr2O3    | 0.33    | 0.32    | 0.11    | 0.36    | 0.28    | 0.32    |
| Total    | 97.9    | 98.6    | 99.1    | 99.8    | 99.2    | 99.43   |

-- below limit of detection  n.d. not analyzed
.aexpanded beam electron microprobe analyses by J. A. Minkin
.bbulk chemical analysis by D. F. Nava (4)