76577, metaclastic rock with porphyroclasts of olivine and plagioclase (and a possible "dunite" cataclasite) in an aphanitic matrix.

*Major- element compositions:*

*Chemical analyses of 76535,76537, 76539*

| | 1 | 2 | 3 |
|---|---|---|---|
| $SiO_2$ | 42.88 | 38.25 | 38.21 |
| $Al_2O_3$ | 20.73 | 8.69 | 8.80 |
| FeO | 4.99 | 19.60 | 19.42 |
| MgO | 19.09 | 8.01 | 7.87 |
| CaO | 11.41 | 10.67 | 10.91 |
| $Na_2O$ | .23 | .40 | .39 |
| $K_2O$ | .03 | .05 | .06 |
| $TiO_2$ | .05 | 13.05 | 12.65 |
| $P_2O_5$ | .03 | .11 | .10 |
| MnO | .07 | .29 | .29 |
| $Cr_2O_3$ | .11 | .37 | .34 |
| Total | 99.62 | 99.49 | 99.04 |

1. 76535,21 (Rhodes and others, 1974).
2. 76537,1 (Rhodes and others, 1976).
3. 76539,3 (Rhodes and others, 1976).

*Age:*

K-Ar:

76535, 4.34±0.08 b.y.; determined for plagioclase, includes attempted correction for trapped Ar (Bogard and others, 1974).

76535 (plagioclase), 4.23 b.y.; actual age is less if trapped $^{40}Ar$ is present (Huneke and Wasserburg, 1975).

$^{40-39}$ Ar:

76535, 4.26±0.02 b.y. (Husain and Schaeffer,1975).

76535, Ar release patterns complex, possibly complicated by trapped Ar. Rock may have been subjected to a metamorphic event <4.08 b.y. ago (Huneke and Wasserburg,1975).

Sm-Nd isochron:

76535, 4.26±0.06 (2*o*) b.y., interpreted as crystallization age (Lugmair and others, 1976).

Rb-Sr isochron:

76535, 4.61 ±0.07 (2*o*) b.y. Preferred interpretation is that this is the age of formation of the troctolite, possibly in a major magmatic differentiation event that also produced the dunite represented by sample 72415-18. One out of five olivine separates is discordant and was not included in defining the isochron; its model age, 4.09±0.12 b.y., may indicate a disturbance at a time later than 4.09 b.y. ago (Papanastassiou and Wasserburg, 1976).

$^{207}Pb$ /$^{206}Pb$:

76535, baddeleyite, 4.271 ±0.029 (2*o*) b.y. (Hinthorne and others, 1975).

76535, "pyrochlore," 4.274±0.021 (2*o*) b.y. (Hinthorne and others, 1975).

U-Pb:

76535, rock was recrystallized or isotopically homogenized approximately 4.0 b.y. ago (Tera and others, 1974a).

Fission track:

76535, apatite, 4.07 b.y.; may record metamorphic event. A possible complication arises, however, from laboratory data that suggest that fission tracks in apatite may be partially annealed over long periods of time at lunar surface temperatures; hence, it may be unlikely that tracks formed in the interval since a 4.07-b.y. event would be fully preserved (Braddy and others, 1975).

Papanastassiou and Wasserburg (1976) suggested that the seemingly disparate age determinations (4.61 b.y. and ~4.25 b.y.) might be accounted for if the troctolite formed initially 4.61 b.y. ago but remained, until 4.25 b.y. ago, at temperatures sufficiently high to permit degassing of argon and chemical and isotopic exchange of Sm and Nd. Rb-Sr systems, in small inclusions within olivine, were sealed to exchange by the impervious (with respect to Rb and Sr) jacket of olivine that enclosed them during magmatic crystallization 4.61 b.y. ago.

*Exposure age:*

Ar:

200 m.y. (Bogard and others, 1974).
200 m.y. (Huneke and Wasserburg,1975).
156±8 m.y. (Husain and Schaeffer, 1975).

Kr: 221 m.y. (Lugmair and others, 1976).
211±7 m.y. (Crozaz and others, 1974).
223±16 m.y. (Lugmair and others, 1976).

Tracks:

2.0± 1 m.y. (Crozaz and others, 1974).

Lugmair and others (1976) have interpreted the spallation and neutron-capture record as indicative of exposure at an average shielding depth in the regolith of ~30 cm for 223±16 m.y.

## STATION 7

### LOCATION

Station 7 is located one-half km east of station 6 on the lower slope of North Massif just above the break in slope between the massif and valley floor (figs. 7*D* and 144).

### OBJECTIVES

The objectives at station 7 were the same as those for station 6-to characterize and sample the massif and dark mantle materials.

## GENERAL OBSERVATIONS

The southward slope toward the valley at station 7 is about 9°. Less than one percent of the surface is covered by blocks and fragments, which appear to have a bimodal distribution (pans 23, 24). Fragments up to 2 or 3 cm in size are abundant, and blocks 30 cm or larger are common, but rock fragments in the 3-30-cm size range are scarce. Blocks larger than 30 cm are in clusters, whereas the smaller fragments are randomly scattered over the surface.

Blocks range from angular to rounded and their burial from none to nearly complete. The sampled 3-m breccia boulder overhangs the surface on three sides. Nearby half-meter boulders are almost totally buried, and most fragments less than 1 m in size are at least partially buried. Fillets are restricted to the uphill sides of the blocks; they are well developed on blocks larger than one-half meter but poorly developed or absent on smaller blocks.

Scattered craters are up to about 4 m in size. Most are less than one-half meter in diameter; some of those have raised blocky rims with the ejecta deposited preferentially downslope. Ejecta deposits are indistinguishable around the subdued nonblocky craters.

Samples at station 7 consisted of four rocks from the 3-m breccia boulder, seventeen rocks from the surface, and two surface sediment samples (fig.178 ).

## GEOLOGIC DISCUSSION

We interpret the massifs as fault blocks composed of southern Serenitatis basin ejecta that was faulted as part of the basin-forming process. Slumping from the fault scarps produced thick colluvial wedges against the lower parts of the massifs. The colluvial wedges were later partly buried by subfloor basalt; additional material has been added to their surfaces by mass wasting and deposition of ejecta since extrusion of the subfloor basalt. Station 7, like station 6, is on the surface of a colluvial wedge that extends about one-third of the way up the massif. Above the wedge, bedrock (southern Serenitatis basin ejecta) is close to the surface although mantled by impact-generated regolith.

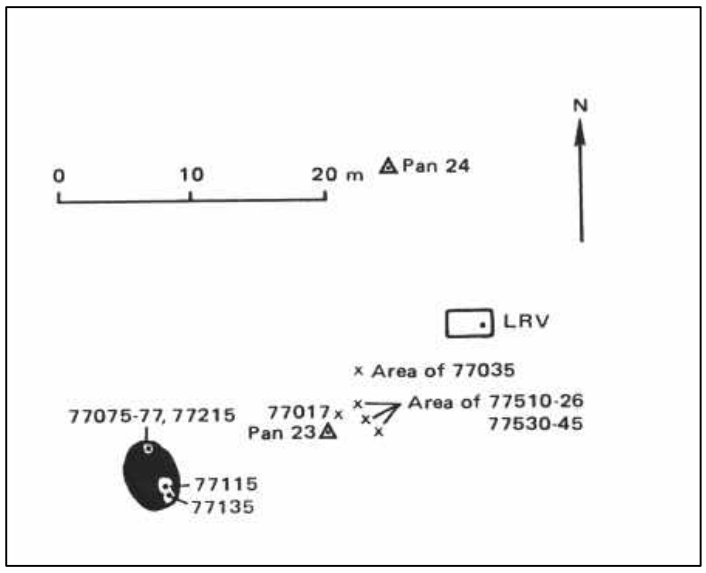



FIGURE 178.-Planimetric map of station 7.

The major feature of interest at station 7 is a 3-m breccia boulder. There is no visible boulder track. However, it is so like the station 6 boulder in lithology and in chemical composition (fig. 179) there is little doubt of its North Massif origin. Repeated exposure age determinations suggest that it was emplaced near the base of the massif 25 to 30 m.y. ago.

Three major lithologic types are recognized in the station 7 boulder. In order of decreasing age, as interpreted from geologic relations in the boulder (fig. 180), these are light-gray, blue-gray, and greenishgray breccia. Light-gray breccia is represented primarily by a clast of norite cataclasite approximately 0.5x1.5 m in size. Blue-gray breccia envelops and intrudes (dikes of fig. 180) the large clast of norite cataclasite. Systematic fractures cut both the clast and the blue-gray breccia. Vesicular greenish-gray breccia in contact with blue-gray breccia is interpreted as the youngest matrix of the boulder because (1) the fracture sets of the light-gray clast and the blue-gray breccia are not recognized in the greenish-gray breccia and (2) the vesicles of the greenish-gray breccia are both elongated and alined in trains parallel to the contact with the blue-gray breccia (fig. 190).

The greenish-gray breccia and the blue-gray breccia (both envelope and dike) are texturally similar. Like the matrices of boulders 2 and 3 at station 2, sample 73215 from station 3, and the station 6 boulder, they consist of mineral and lithic clasts in fine-grained crystalline groundmasses, which Chao and others (1974, 1975) have interpreted as having crystallized from melts.

The greenish-gray and blue-gray matrix samples have a narrow range of major-element composition (fig. 179) that is similar to the compositions of most of the other highlands boulder matrices and virtually identical to the station 6 boulder matrix (fig. 150). Winzer and others (1975a) concluded that in large-ion lithophile-element composition, the station 7 boulder matrix samples are so similar to each other and to samples from the other breccia boulders of the Apollo 17 site that they appear to be identical.

The chemical similarity of the greenish-gray and blue-gray breccias of the station 7 boulder implies that they formed from identical target materials. Their textural similarity implies similar histories of mobilization, aggregation, and cooling; that is, the two breccia types represent similar ejecta facies. The blue-gray

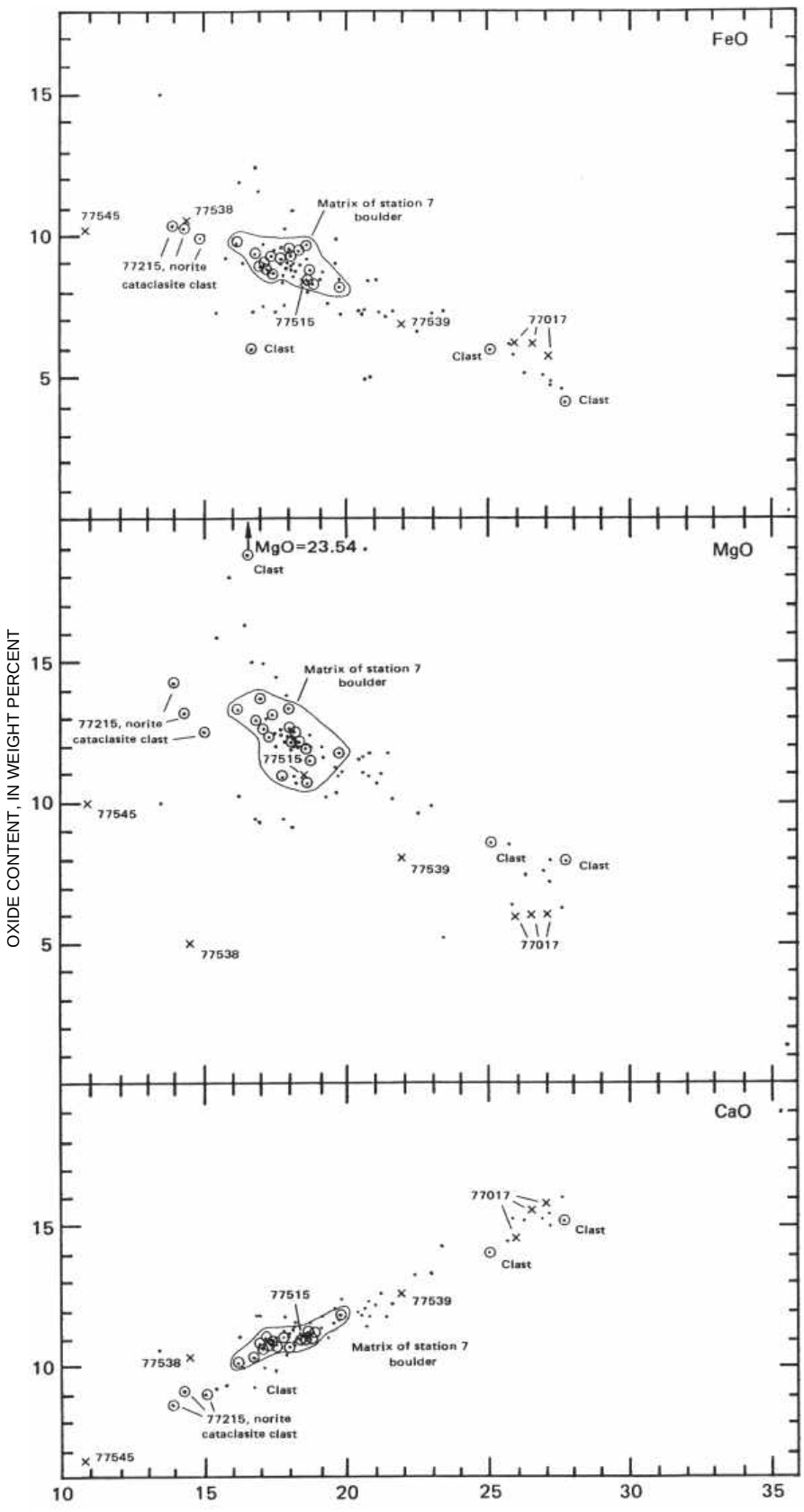



FIGURE 179.-Plots of FeO, MgO, and CaO contents in relation to $A1_20_3$ content for analyzed highlands rocks, at station 7 in comparison with all analyzed Apollo 17 highlands rocks. Circled dots, station 7 boulder (matrix samples except where identified as clasts); x, other station 7 highlands rocks; dots, all other Apollo 17 highlands rocks.

breccia, although fractured, does not record the cataclasis that might be expected if it were a sample of older rock excavated by the impact that formed the greenish-gray breccia, as previously suggested (Chao and others, 1974; Chao and others, 1975b; Reed and Wolfe, 1975). We believe that a model in which the two breccias were produced by the same impact is more likely.

Norite and troctolite, included among the target rocks, were crushed and partly disaggregated to form some of the mineral and lithic clasts; the large lightgray norite cataclasite clast is one of the larger observed remnants of preexisting noritic target rock. The mobilized ejecta consisted of a mixture of dust- to boulder-sized clasts and impact melt. Parts of it aggregated during transport and formed clots sufficiently coherent to sustain systematic fractures (as in the blue-gray breccia and its large noritic clast) while being incorporated in more highly mobile ejecta (unfractured vesicular greenish-gray breccia).

Radiometric age determinations for samples from the station 7 boulder are summarized graphically in figure 181. Crystallization about 4.4 b.y. ago or earlier is clearly implied for the norite parent of the large catalasite clast.

Chronological interpretation of the enclosing breccias is less straightforward. Rb-Sr isochron ages with mean values of 3.75 and 3.8 b.y. have been reported for the blue-gray and greenish-gray breccias; the same workers have reported a 3.8-b.y. Pb disturbance in the cataclasite clast. Although the geologic significance of these determinations is unclear, it is improbable that they are related to formation of the breccia for three reasons. (1) They overlap many of the ages determined

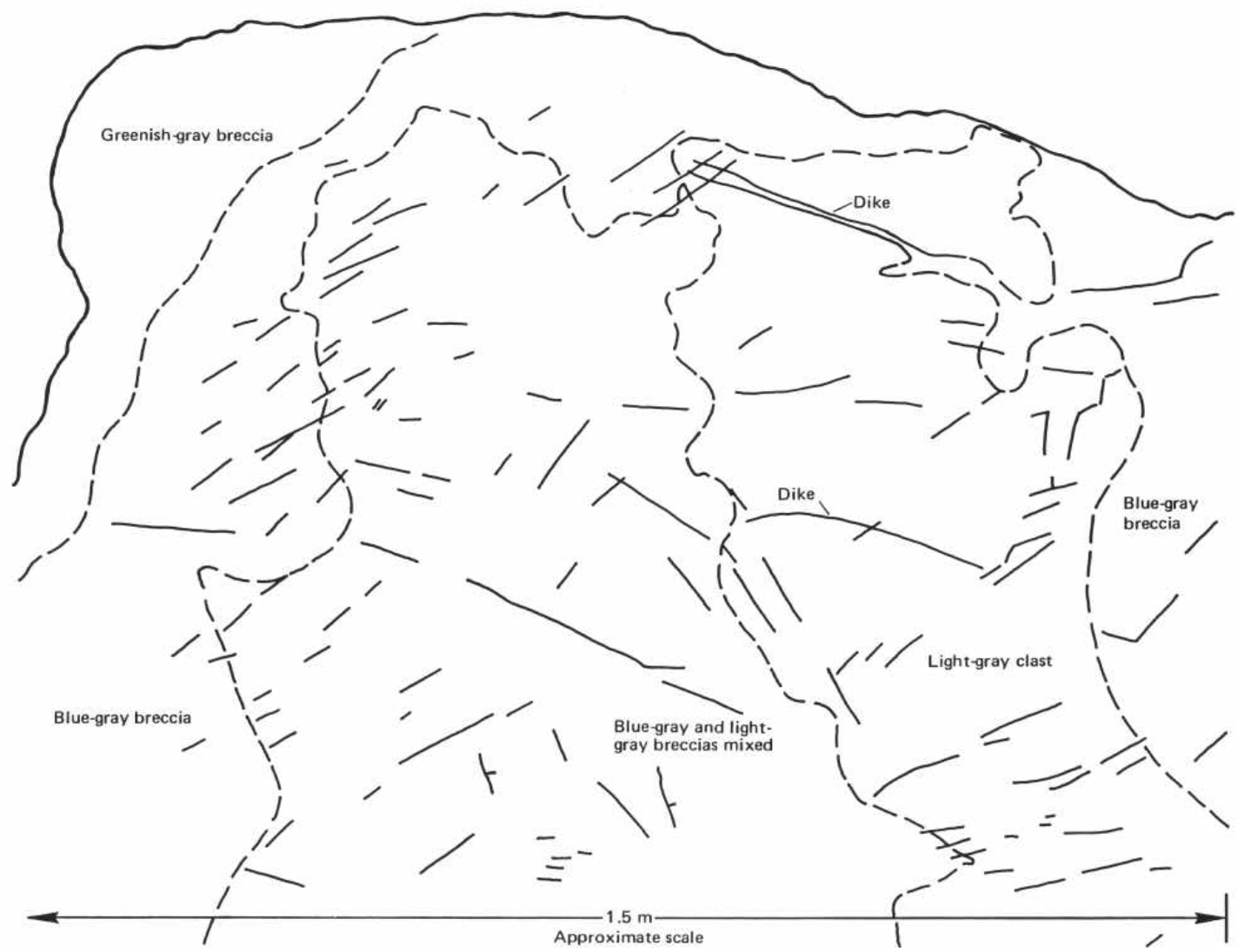



FIGURE 180.-Map of station 7 boulder. Same view as in figure 185. Dashed lines are contacts between lithologic units mapped from color photographs taken on lunar surface. Solid lines show fractures, outline of boulder, and dikes (labeled). (From Muehlberger and others, 1973.)

subfloor basalt. Photogeologic and field evidence include the possibility that North Massif materials are younger than the sampled part of the subfloor basalt. (2) The station 7 boulder breccias are texturally and compositionally part of the Apollo 17 massif breccia suite. With few exceptions, ages determined for many samples from this suite are $\geq$3.92 b.y. It is improbable that breccia of the station 7 boulder was deposited in the same area ~200 m.y. later than identical breccia represented by samples from the other stations. (3) Acceptance of the young Rb-Sr ages as geologically significant requires the improbable condition of an event that caused Rb-Sr equilibration without resetting the argon clock.

Two $^{40-39}$Ar ages of ~3.8 b.y. were interpreted for the greenish-gray breccia by Stettler and others (1974), who regarded them as uncertain results based on short poorly defined high-temperature plateaus. At the older end of the spectrum, Nakamura and others (1976) have disavowed their 4.14-b.y. Rb-Sr age for the greenishgray breccia on the grounds that its apparently excessive antiquity might be due to contamination by older xenocrysts. Disregarding the doubtfully young and doubtfully old ages, we are left with five argon ages and one Rb-Sr age that suggest that the breccia represented by the station 7 boulder was probably assembled between -3.9 and 4.0 b.y., a result compatible with the ages generally inferred for other massif breccia samples.

The single analyzed sediment sample from station 7 (fig. 182) is approximately a 2:1 mixture of massif debris and valley floor debris. The valley-floor component, basaltic debris with some ash, presumably was emplaced in the station 7 area as ejecta from some of the many valley-floor craters. The massif component is chemically identical to sediment derived from the South Massif at station 2 and in the light mantle.

## SUMMARY OF SAMPLING

### Sample 77017

*Type:* Olivine gabbro breccia with a glassy matrix.
Size: 17x12.5x9 cm.
*Weight:* 1,730 g.
*Location:* From surface approximately 10 m southwest of the LRV.
*Illustrations:* Pans 23, 24; figure 183 (LRL).
*Comments:* Sample 77017 is a regolith fragment.
*Petrographic description:* Monomict breccia with clasts of olivine gabbro or metagabbro in a matrix of vesicular glass.

With respect to major elements, glass of sample 77017 (cols. 4-6 of table below) is inhomogeneous. The least aluminous glassy material (col. 6) is chemically like the older regolith of the valley floor, which is highlands debris with about 30 to 50 percent basalt and ash debris from the valley floor. Major elements of the glassy portions of the sample (cols. 4-6) and of the gabbro itself (cols. 1-3) have ap-

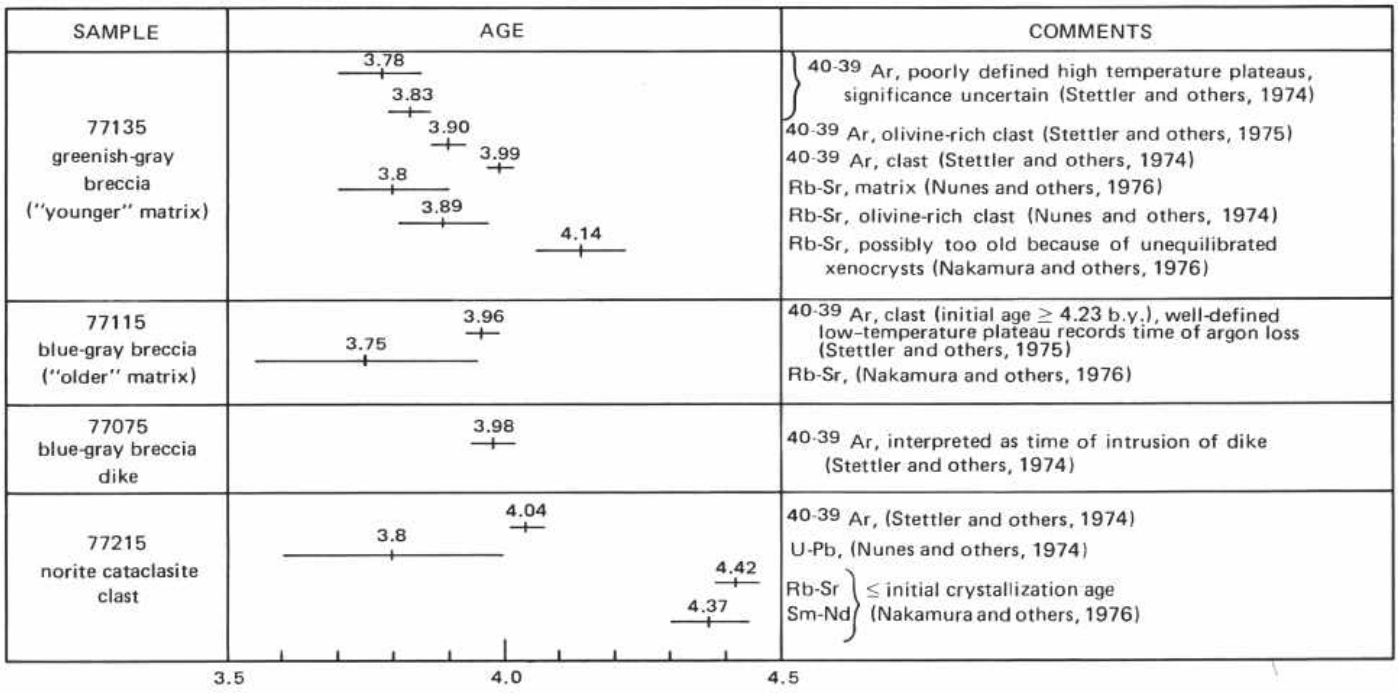



FIGURE 181.-Summary of radiometric ages for station 7 boulder.

proximately linear distributions with respect to Al 203. The linear distributions are mixing lines indicative of incomplete mixing of impact melts derived from the older regolith of the valley floor and from the gabbro fragment, which apparently was a clast in the regolith. At one time the gabbro presumably was a clast in highlands breccia. Kirsten and Horn (1974) also interpreted the glassy matrix as regolith material fused approximately 1.5 b.y. ago.

*Major-element composition:*

*Chemical analyses of 77017*

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| $SiO_2$ | 44.09 | -- | -- | 43.17 | -- | 42.82 |
| Al2O3 | 26.59 | 26.0 | 27.1 | 23.11 | 18.9 | 13.67 |

*Chemical analyses of* 77017-Continued

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| FeO | 6.19 | 6.2 | 5.7 | 9.02 | 12.1 | 14.91 |
| MgO | 6.06 | 6 | 6 | 7.77 | 8 | 9.29 |
| CaO | 15.43 | 14.5 | 15.7 | 13.96 | 11.7 | 12.29 |
| $Na_2O$ | .30 | .31 | .36 | .37 | .39 | .41 |
| $K_2O$ | .06 | .050 | .076 | .20 | .10 | .22 |
| $TiO_2$ | .41 | .75 | .35 | 2.31 | 5.3 | 6.01 |
| $P^2O^5$ | .03 | -- | -- | .07 | -- | .09 |
| MnO | .08 | .085 | .077 | .12 | .155 | .19 |
| $Cr_2O_3$ | .13 | .140 | .126 | .26 | .290 | .45 |
| Total | 99.37 | | | 100.36 | | 100.35 |

1. 77017,2 (Apollo 17 PET, 1973).
2. 77017,57 bulk composition (Laul and others, 1974).
3. 77017, gray fragment (Laul and others, 1974).
4. 77017, glass veinlet, microbe analyses (Helz and Appelman, 1974).
5. 77017, dark matrix (Laul and others, 1974).
6. 77017, glass rim microbe analyses (Helz and Appelman, 1974).

Data from columns 4-6 not included in figure 179.

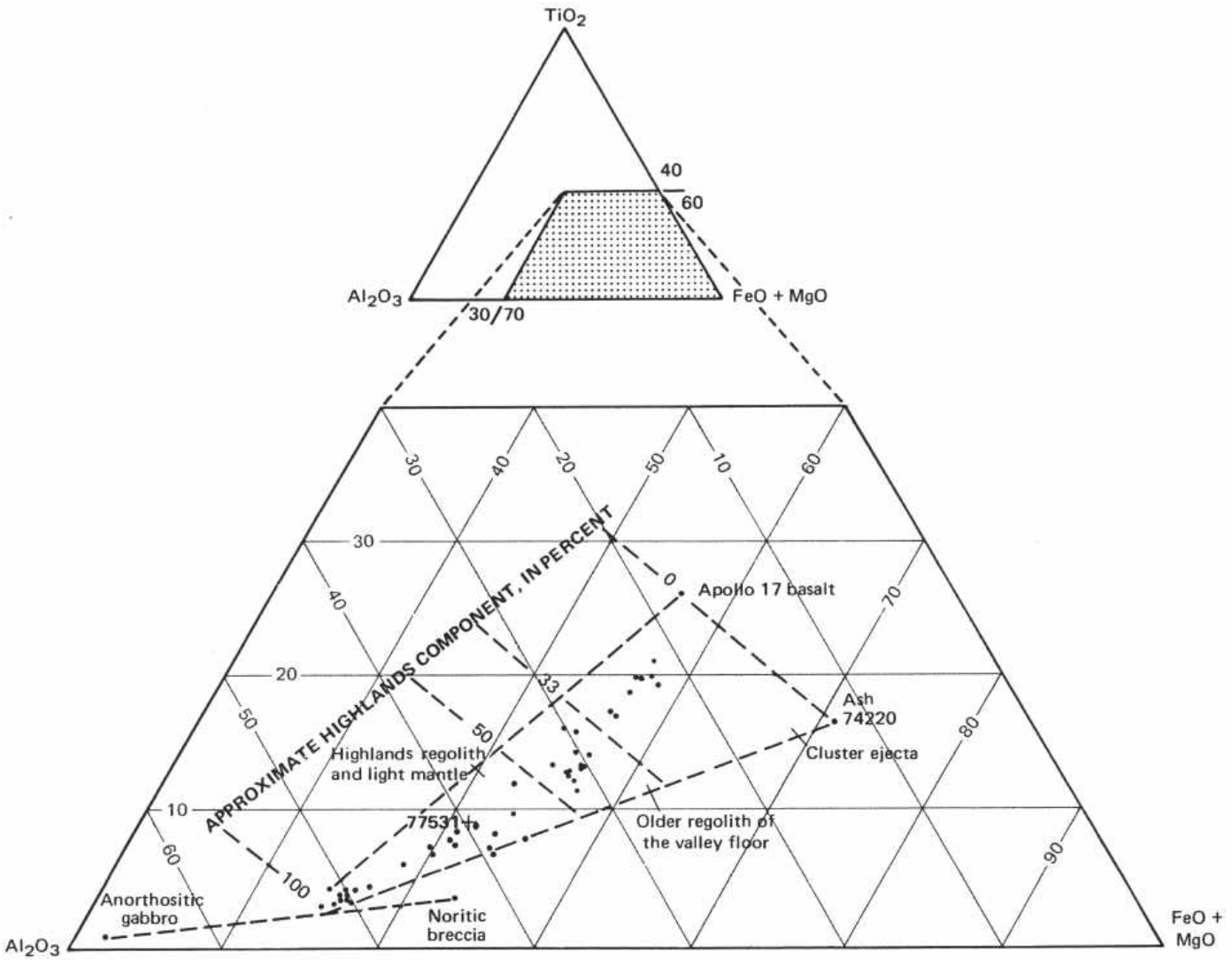



FIGURE 182.-Relative amounts of $Ti0_2$, $A1_20_3$, and FeO+MgO in sediment sample 77531, from station 7 (cross), in comparison with sediment samples from rest of traverse region (dots). Apollo 17 basalt, anorthositic gabbro, and noritic breccia values from Rhodes and others (1974).

*Age:* $^{40-39}$Ar:

77017,32A, anorthositic breccia (carefully separated from black glass vein material), 4.04±0.05 b.y.; interpreted as dating the time when the augite and pigeonite poikiloblasts crystallized (Kirsten and Horn, 1974).

77017,32B, black glass vein, 1.5±0.3 b.y. (Kirsten and Horn, 1974).

Trapped solar-wind gases indicate that the glass and the host rock of sample 77017 are genetically unrelated; glass is interpreted as impact-melted regolith injected into fractures in host rock - 1.5 b.y. ago without obliterating the previous metamorphic record (Kirsten and Horn, 1974).

77017,46, 3.97±0.02 b.y. (Phinney and others, 1975).

*Exposure age:*

Ar:

77017,32A, anorthositic breccia, 80±10 m.y. (Kirsten and Horn, 1974).

77017,328, black glass vein, 90±40 m.y. (Kirsten and Horn, 1974).

77017,46, 224±20 m.y. (Phinney and others, 1975).

Sample 77035

*Type:* Polymict breccia with an aphanitic matrix.
*Size:* 22x15.5x15 cm.
*Weight:* 5,727 g.
*Location:* From surface about 6 m southwest of the LRV.
*Illustrations:* Pans 23, 24; figure 184 (LRL).
*Comments:* Sample 77035, a fragment from the regolith

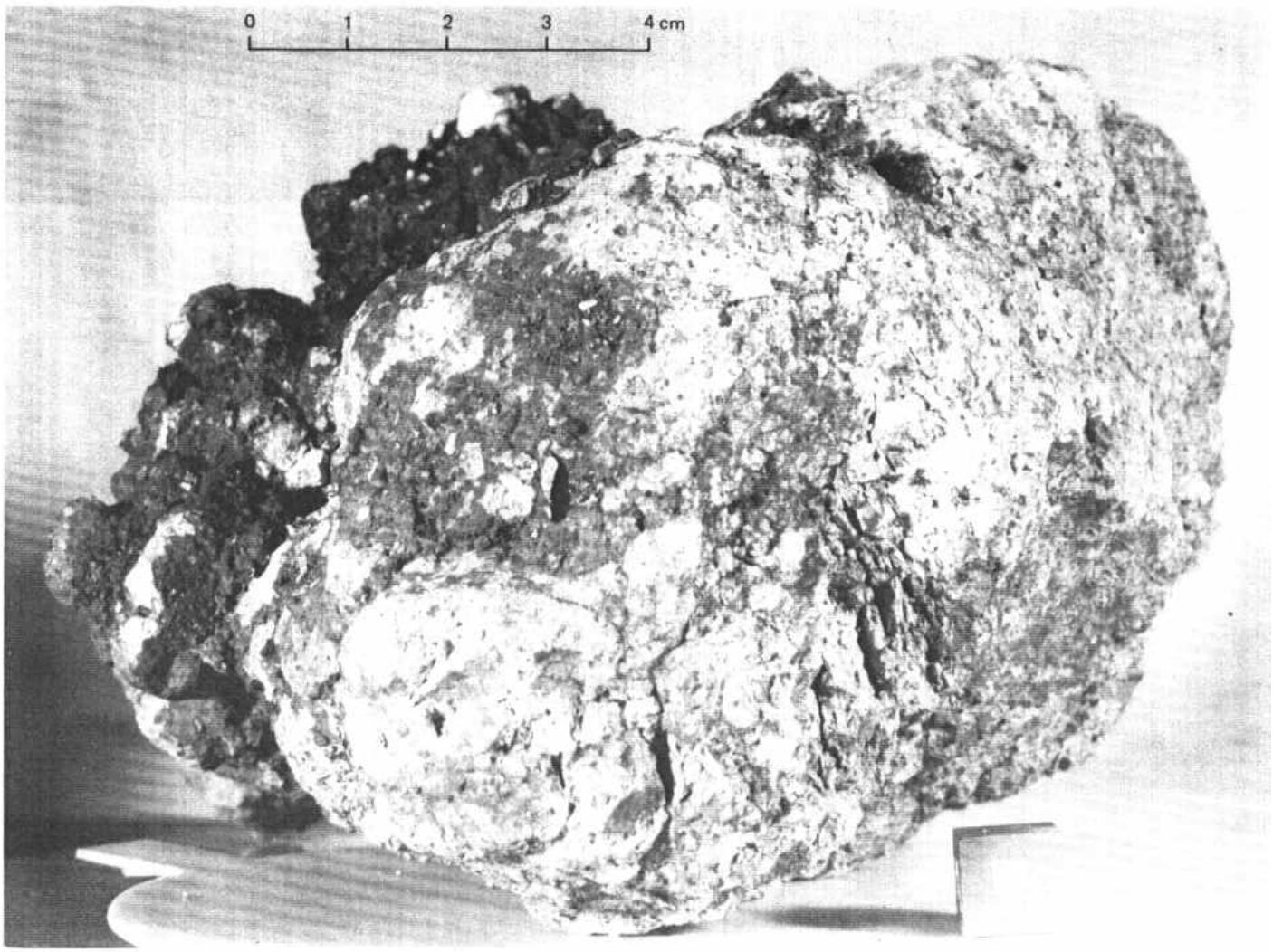



FIGURE 183.-Sample 77017. Monomict breccia with clasts of olivine gabbro in glassy matrix. (NASA photograph S-73-17771.)

at station 7 , is presumably North Massif material.

*Petrographic description:* Polymict breccia with clasts of gabbro (?) or metagabbro (?), fine-grained metaclastic or breccia fragments, vitreous (?) fragments, feldspathic metaclastic rocks, and plagioclase and olivine in an irregularly and faintly banded aphanitic matrix with slitlike cavities.

*Major-element composition:*

*Chemical analysis of 77035*

| | |
|---|---|
| $SiO_2$ | 46.8 |
| $Al_2O_3$ | 18.1 |
| FeO | 8.88 |
| MgO | 12.19 |
| CaO | 11.22 |
| $Na_2O$ | .623 |
| $K_2O$ | .261 |
| $TiO_2$ | 1.50 |
| $P_2O_5$ | .264 |
| MnO | .112 |
| $Cr_2O_3$ | .197 |
| Total | 100.147 |

77035,61 (Wanke and others, 1975).

Sample 77075-77

*Type:* Monomict (?) breccia with an aphanitic matrix; includes adhering norite cataclasite.

*Sizes:* 77075, three fragments, 4x4x4 cm, 1.5x1.5x1.2 cm, 1x1x0.5 cm; 77076, 3x2x2 cm; 77077, 2x2x1.5 cm.

*Weights:* 77075, 172.4 g total; 77076, 13.97 g; 77077, 5.45 g.

*Location:* 3-m boulder.

*Illustrations:* Pan 24; figures 1135, 18G (LRL).

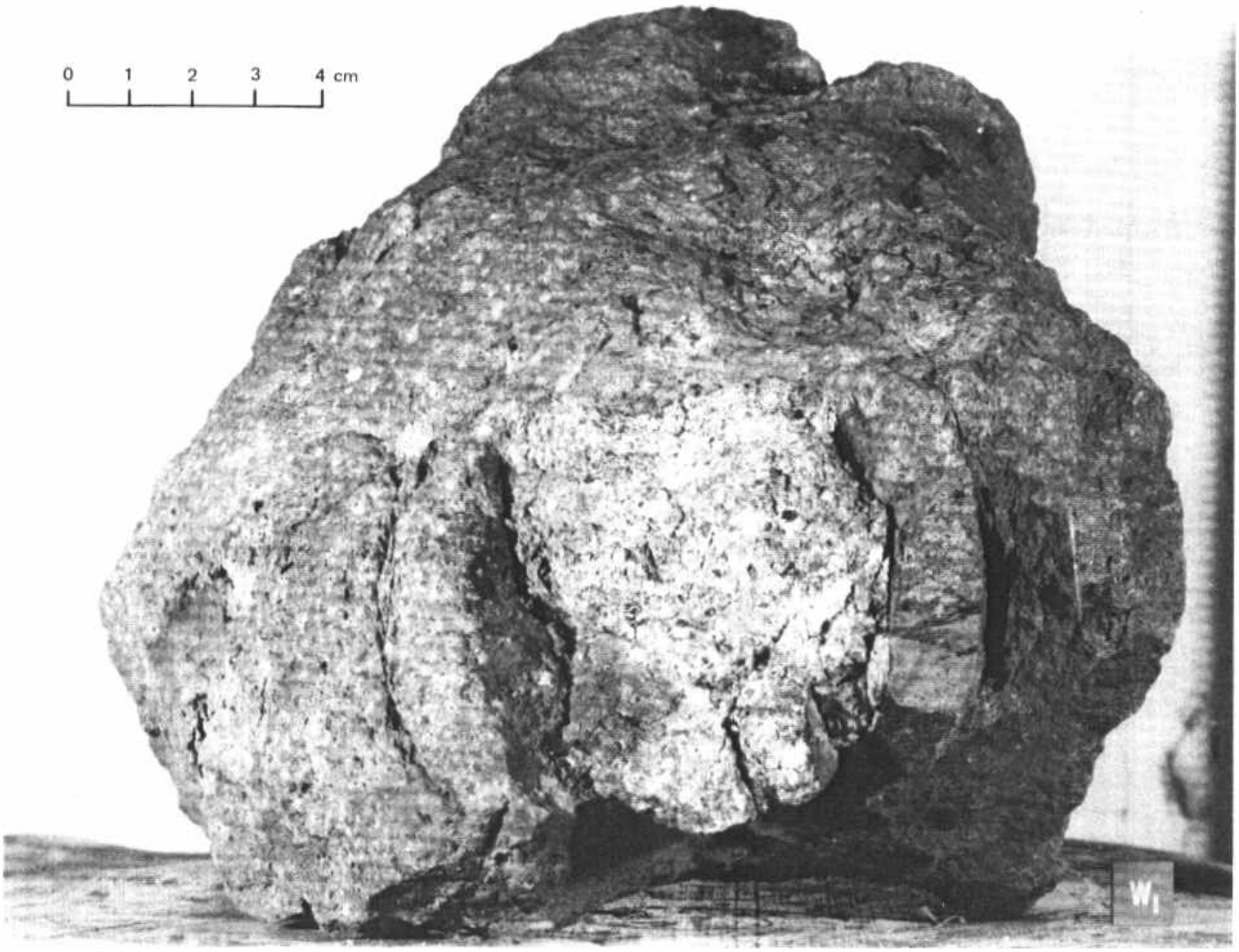



FIGURE 184.-Sample 77035. Polymict breccia with aphanitic matrix. Faint banding and slitlike cavities are alined parallel to margin of lightgray gabbroid (?) clast. (NASA photograph S-73-15902.)

*Comments:* Samples 77075-77 are from a blue-gray hreccia dike that intrudes a light-gray 1.5-m inclusion enveloped by blue-gray breccia that is continuous with the dike. The blue-gray breccia is in turn enclosed in gTeenish-gray vesicular breccia.

*Petrographic description:* Breccia dike in norite cataclasite. The dike has plagioclase. olivine, and orthopyroxene porphyroclasts and rare metaclastic fragments in an aphanitic matrix.

According to Chao and others (1974), the black dike material of sample 77075 consists of xenocrysts of calcic plagioclase, olivine, and rare orthopyroxene in a very fine holocrystalline matrix composed of

*Major-element composition:*

*Chemical analysis of 77075*

| | |
|---|---|
| $SiO_2$ | 46.4 |
| $Al_2O_3$ | 18.17 |
| FeO | 9.31 |
| MgO | 12.57 |
| CaO | 10.55 |
| $Na_2O$ | .65 |
| $K_2O$ | .23 |
| $TiO_2$ | 1.38 |
| $P_2O_5$ | .11 |
| MnO | .26 |
| $Cr_2O_3$ | .17 |
| Total | 99.90 |

77075,21 dark vein, matrix (Winzer and others, 1973).

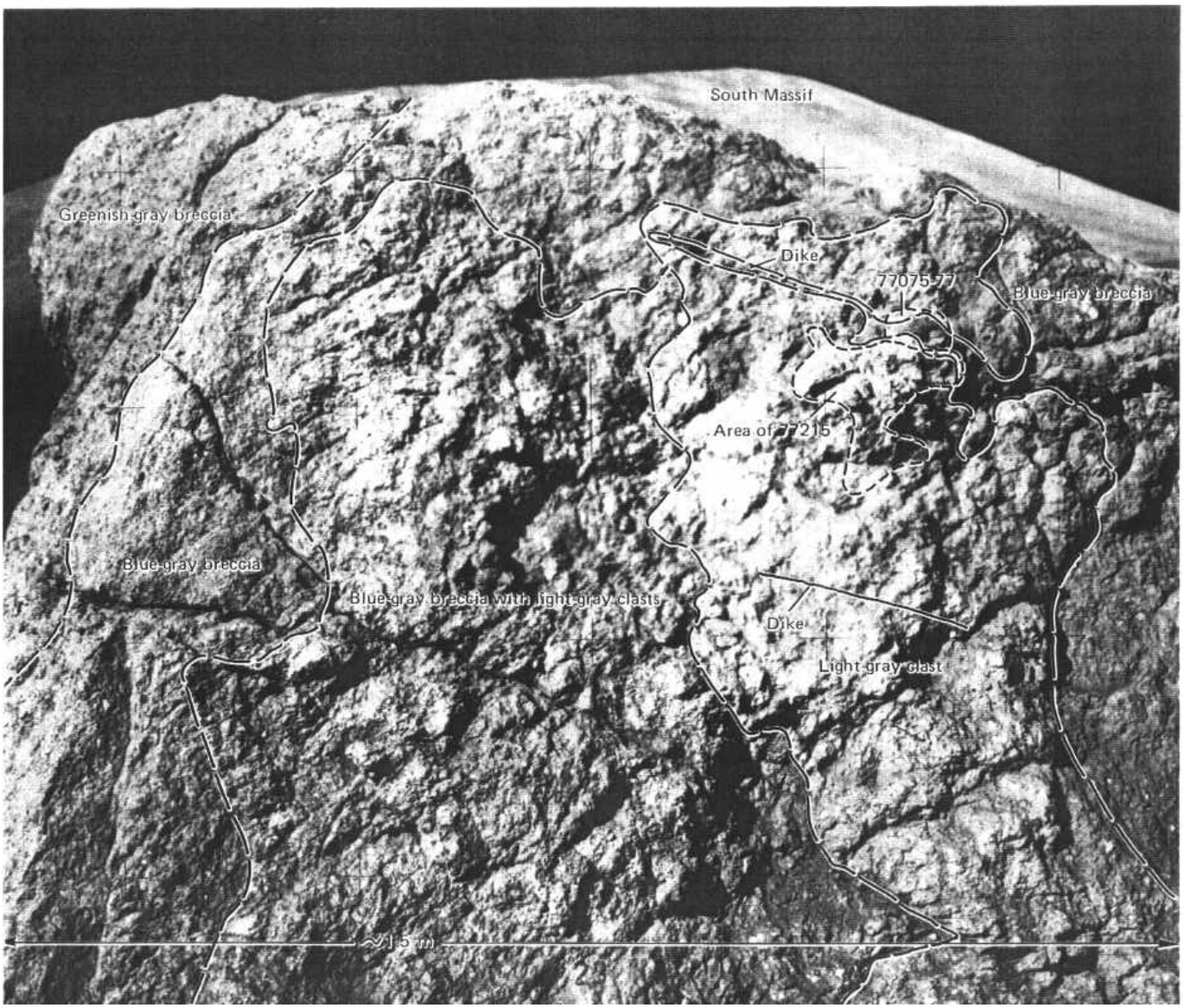



FIGURE 185.-Distribution of rock types and locations of samples 77075-77 and 77215 in 3-m breccia boulder at station 7, before sampling. Light-gray clast is enclosed in blue-gray breccia, which is in turn enclosed in greenish-gray vesicular breccia. Dashed lines separate rock units. View is to southwest. (NASA photograph AS 17-146-22305.)

intimately intergrown plagioclase and pyroxene with subordinate olivine and ilmenite.

*Age:* $^{40-39}$Ar: 77075,18, 3.98±0.04 b.y., interpreted as representing time of intrusion of the veinlet (Stettler and others, 1974).

*Exposure* age: Ar: 77075,18, 25.5 m.y., includes correction for shielding effects (Stettler and others, 1974).

Sample 77115

*Type:* Polymict breccia with an aphanitic matrix.
Size: 6.5x5.5x3.5 cm.
*Weight:* 115.9 g.
*Location:* 3-m boulder.
*Illustrations:* Pan 24; figures 187, 188 (LRL), 189 (photomicrograph), 190.

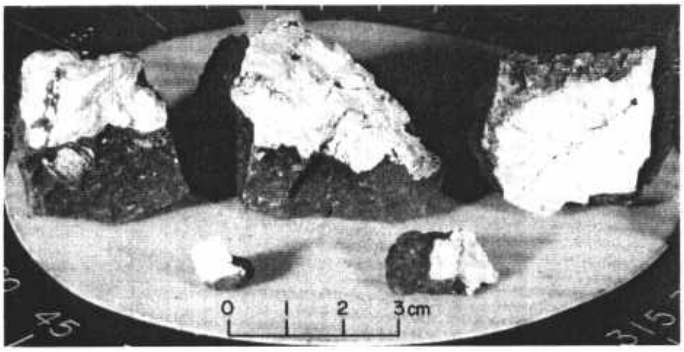



FIGURE 186.-Sample 77075. Fragments of dark, fine-grained breccia dike in norite cataclasite. (NASA photograph S-73-17186.)

*Comments:* Sample 77115 is from blue-gray breccia that contains conspicuous clasts including the 1.5-m-long light-gray clast represented by norite cataclasite sample 77215. The blue-gray breccia, which is highly fractured, is in turn incorporated in relatively unfractured greenish-gray breccia.

*Petrographic description:* Polymict breccia with clasts of very fine grained feldspathic metaclastic rock, finegrained dark breccia or metaclastic rocks, and plagioclase, orthopyroxene, and olivine porphyroclasts in an irregularly banded inhomogeneous aphanitic matrix. Irregular banding is in part the result of disaggregation and cataclastic flow of troctolite cataclasite.

Chao and others (1974, 1975a, 1975b) classified and described rock 77115 as fragment-laden feldspathic pigeonite basalt consisting of a vuggy microsubophitic to micropoikilitic matrix with scattered xenocrysts and xenoliths that are coarser than the matrix crystals. The matrix shows chill effects against the inclusions. Matrix minerals, generally smaller than 0.2 mm, are mainly plagioclase, clinopyroxene (mainly pigeonite), olivine, and ilmenite. Xenocrysts, commonly with zoned rims, are dominantly plagioclase (65 percent), clinopyroxene (4 percent), orthopyroxene (7 percent), and olivine (20 percent); xenoliths are fragments of anorthosite-troctolite-norite rocks that commonly have been brecciated and recrystallized.

Chao and others (1975b) argued that 77115 is not metamorphic but crystallized from a melt that was

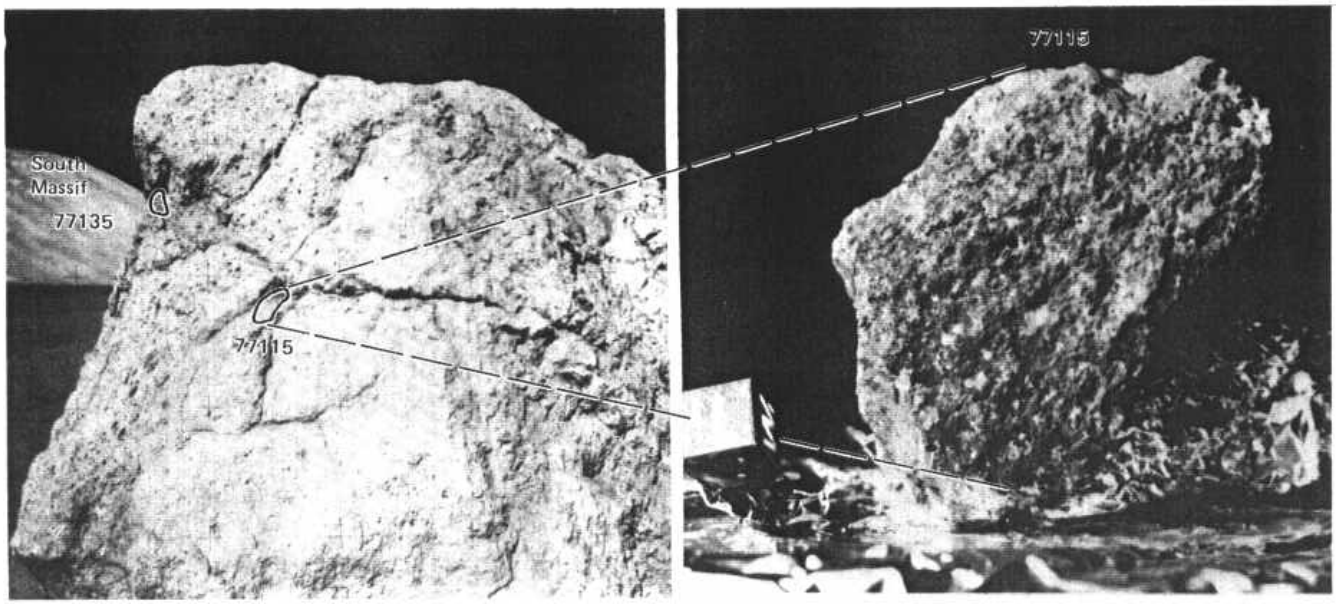



FIGURE 187.-Left, locations of samples 77115 and 77135 in 3-m breccia boulder at station 7, before sampling. View is to southwest. (NASA photograph AS 17-146-2229.)
Right. Sample 77115 with reconstructed lunar surface orientation and lighting. (View similar to NASA photograph S73-33505.)

inferred from the fine matrix grain size (~10 um) and from the abundance of vugs and vesicles to have crystallized rapidly near the surface. They suggested a two-stage cooling history: (1) a period of slow cooling during which xenocrysts reacted with the melt to form zoned rites and (2) a rapid quench to form the fine matrix. Igneous rather than impact origin for the melt was suggested because (1) 99 percent of the xenoliths and xenocrysts show no evidence of shock and (2) the inferred two-stage cooling history seemed more likely for a melt of endogenous igneous origin than for impact melt that might be expected to cool at a uniform rate.

Huebner (in Chao and others, 1975b) gave an alternate interpretation that the xenocryst rims were formed by subsolidus reaction with the matrix rather than by reaction with a melt. He cited the following arguments:

1. Olivine xenocrysts become more fayalitic toward the rims, pyroxene becomes more magnesian; hence the mafic silicates approach supposed equilibrium from opposite directions.

2. Plagioclase xenocrysts form two populations ($An_{71-79}$ and $An_{93-95}$). Both types are zoned outward to margins that are $An_{86}$; thus "equilibrium" appears to have been approached from both more sodic and more calcic directions. Textural evidence indicates that xenocrysts were neither mantled nor resorbed as a result of contact with a melt.

3. Experimental data suggest that the matrix is too magnesian to have been in equilibrium as a melt with the pyroxene and olivine rims; the rims should have been resorbed by a melt of the matrix composition.

4. Phase-equilibrium data suggest that the pigeonite and orthopyroxene xenocrysts would have been resorbed by a liquid of the composition of the matrix of 77115; instead, the low-calcium pyroxene xeno-crysts survived and developed rims.

*Major-element composition:*

*Chemical analyses of 77115*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 41.8 | 46.6 | 47.0 | 46.5 | 47.1 | 47.1 | 47.2 | 47.1 | 46.1 | 46.1 |
| $Al_2O_3$ | 16.78 | 18.63 | 17.59 | 17.06 | 17.35 | 18.86 | 17.55 | 16.26 | 18.8 | 18.7 |
| FeO | 6.08 | 8.44 | 8.73 | 8.99 | 8.90 | 8.39 | 9.51 | 9.74 | 8.8 | 9.7 |
| MgO | 23.54 | 11.96 | 12.01 | 13.77 | 12.33 | 10.98 | 12.43 | 13.34 | 11.5 | 10.7 |
| CaO | 10.24 | 11.01 | 10.74 | 10.60 | 10.79 | 11.11 | 10.89 | 10.07 | 11.1 | 11.0 |
| $Na_2O$ | .31 | .67 | .66 | .66 | .66 | .69 | .67 | .61 | .68 | .65 |
| $K_2O$ | .08 | .25 | -- | .26 | .26 | .32 | .24 | -- | .15 | .16 |
| $TiO_2$ | .17 | 1.15 | 1.26 | 1.30 | 1.31 | 1.23 | 1.34 | 1.21 | 2.48 | 3.03 |
| $P_2O_5$ | .53 | .37 | .31 | .29 | .33 | .31 | .31 | .24 | .09 | -- |
| MnO | .06 | .11 | .11 | .12 | .11 | .11 | .11 | .12 | .07 | -- |
| $Cr_2O_3$ | .04 | .19 | .16 | .17 | .17 | .16 | .18 | .17 | .21 | -- |
| Total | 99.63 | 99.38 | 98.57 | 99.72 | 99.31 | 99.26 | 100.43 | 98.86 | 99.98 | 100.04 |

1. 77115,19 clast, classified as troctolite by Winzer and others (1977).
2. 77115,19.
3. 77115,69, 70, 71,
   Cols. 2 and 3, contact zone between clast (col. 1) and matrix (col. 4-8).
4. 77115,19.
5. 77115,69.
6. 77115,70.
7. 77115,71.
8. 77115,72.
   Col. 4-8, matrix
9. 77115, bulk composition, matrix plus xenocrysts.
10. 77115, matrix only, does not include xenocrysts (~19 volume percent). Samples 9 and 10, calculated from mineral modes and microprobe analyses from three thin sections (Chao and others, 1975b).

Analyses 1-8 from splits from a single 2.44g chip (Winzer and others, 1974).
NOTE. – Additional analyses by defocused beam microprobe have been published by Stoesser and others (1974a, b) and Ryder and others (1975).

*Age:*

$^{40-39}$Ar: 77115,75, plagioclase from clast shows well-defined low-temperature plateau at 3.96±0.03 b.y., which records a time of argon

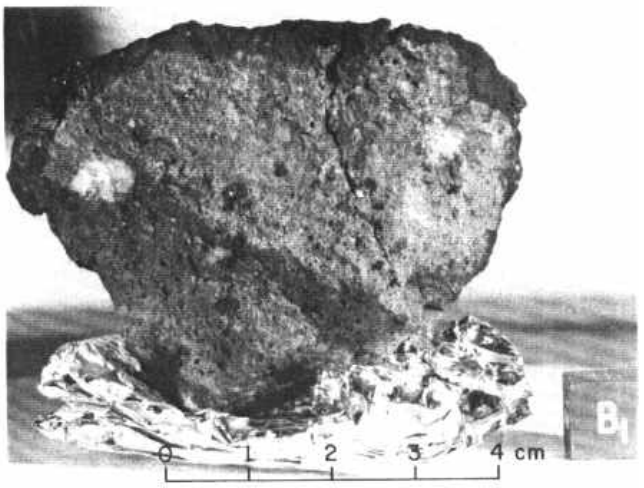



FIGURE 188.-Sample 77115. Polymict breccia with aphanitic matrix. (NASA photograph S-73-15011.)

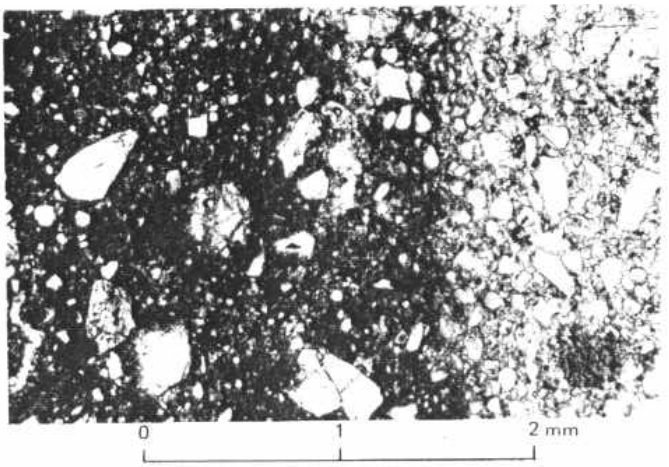



FIGURE 189.-Sample 77115. Photomicrograph showing contact between pink spinel troctolite cataclasite clast (right) and aphanitic matrix with mineral and lithic debris (left).

loss. Argon loss was incomplete at 3.96 b.y.; additional heating shows clast formed >/= 4.23 b.y. ago ( Stealer and others, 1975).

Rb-Sr isochron: 77115,35, 3.75±0.20 b.y. (Nakamura and others, 1976).

Sample 77135

*Type*: Polymict breccia with a poikilitic matrix.
*Size*: 10.3x8x4 cm.
*Weight*: 337.4 g.
*Location:* 3-m boulder.
*Illustrations:* Pan 24; figures 187, 190, 191 (LRL).
*Comments:* Sample 77135 is from the vesicular greenish-gray breccia matrix that encloses the blue-gray breccia represented by sample 77115. Fracture sets developed in the blue-gray breccia are not seen in the greenish-gray breccia, and vesicles of the greenish-gray breccia are elongated and alined in trains parallel to the contact with the blue-gray breccia.
*Petrographic description:* Polymict breccia with small clasts of "dunite." feldspathic metaclastic rocks, and abundant porphyroclasts of olivine and plagioclase in a highly vesicular poikilitic matrix.

According to Chao and Minkin (1974) and Chao and others (1974). 71135 is a fragment-laden pigeonite basalt that originated from a melt of either impact or igneous origin. The melt crystallized to a find poikilitic aggregate of plagioclase, pigeonite, and olivine, with minor augite and ilmenite. Both pigeonite

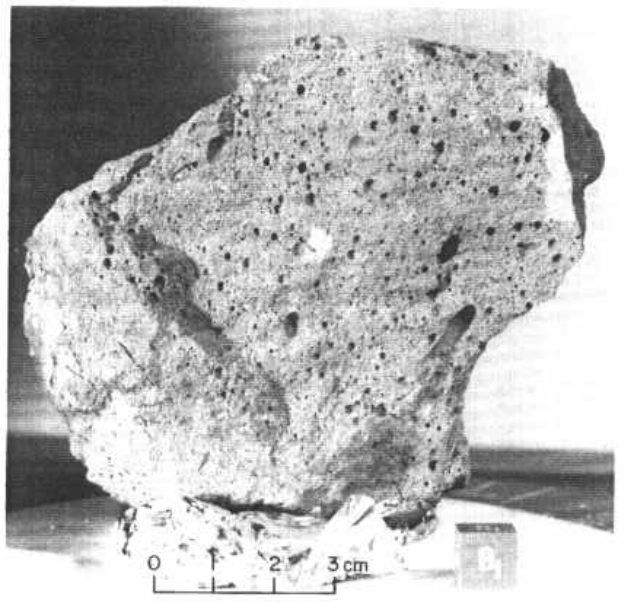



FIGURE 191.-Sample 77135. Polymict breccia with poikilitic matrix. (NASA photograph S-72-56391.)

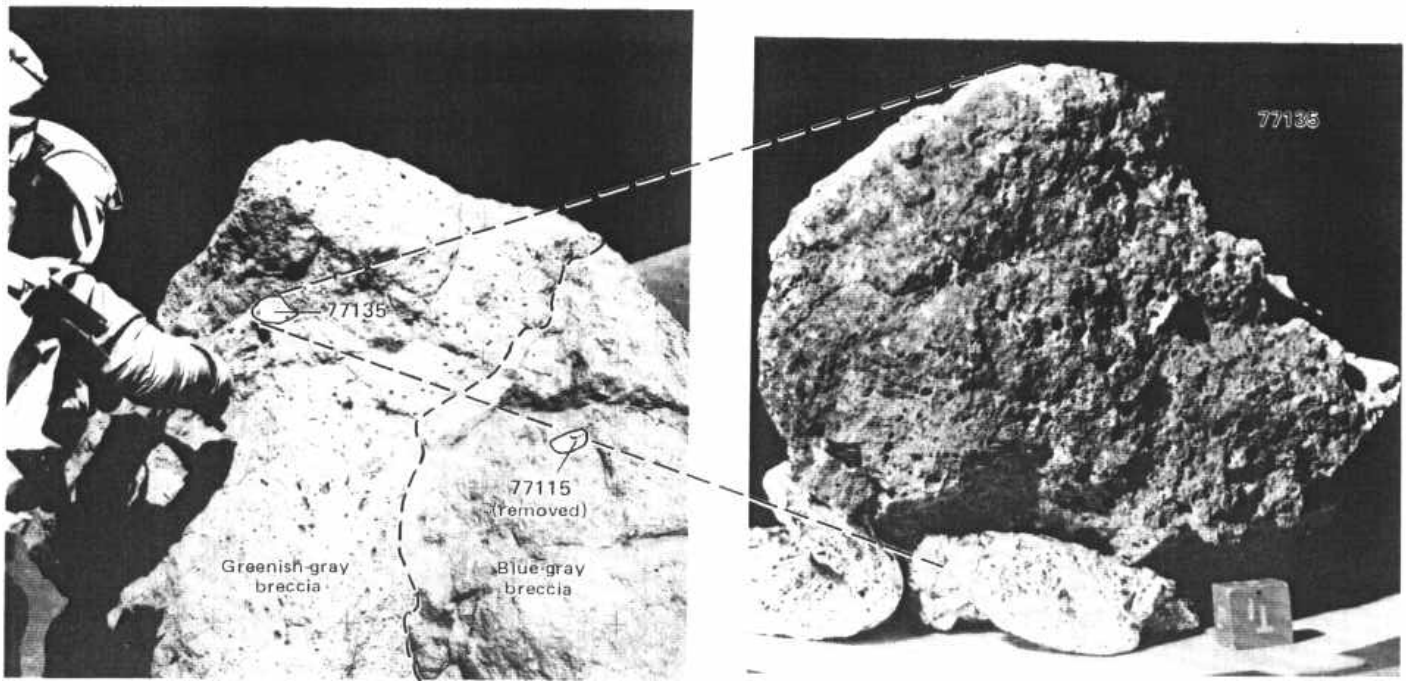



FIGURE 190.-Left, Sample 77135 (before collections and location from which sample 77115 was collected. Irregular dashed line is contact between fractured blue-gray breccia and vesicular greenish-gray breccia. Note preferred orientation and alinement of vesicles parallel to contact. View is to southwest. (NASA photograph AS 17-146-22338.) Right, Sample 77135 with reconstructed lunar surface orientation and lighting. (NASA photograph S-73-19386.)

and augite form oikocrysts enclosing plagioclase and olivine. Xenoliths are highly feldspathic crystalline rocks; most of the xenocrysts, dominantly olivine and plagioclase, may be mineral fragments disaggregated by crushing of rocks like those of the xenoliths.

*Major-element composition:*

*Chemical analyses of 77135*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 45.3 | 44.4 | 46.13 | 46.17 | 45.3 | 46.3 | 47.5 | 46.3 |
| $Al_2O_3$ | 25.13 | 27.81 | 18.01 | 17.83 | 18.03 | 18.39 | 17.18 | 19.82 |
| FeO | 5.98 | 4.19 | 9.11 | 9.14 | 9.56 | 9.48 | 9.01 | 8.28 |
| MgO | 8.59 | 7.96 | 12.63 | 12.39 | 13.38 | 12.19 | 12.66 | 11.78 |
| CaO | 13.95 | 15.09 | 11.03 | 11.08 | 10.64 | 10.96 | 10.91 | 11.74 |
| $Na_2O$ | .40 | .41 | .53 | .69 | .61 | .65 | .66 | .56 |
| $K_2O$ | .09 | .07 | .30 | .27 | .22 | .23 | .41 | .21 |
| $TiO_2$ | .43 | .24 | 1.54 | 1.53 | 1.72 | 1.48 | 1.45 | 1.31 |
| $P_2O_5$ | .10 | .03 | .28 | .30 | .28 | .28 | .29 | .21 |
| MnO | .06 | .05 | .13 | .13 | .11 | .11 | .11 | .10 |
| $Cr_2O_3$ | .13 | .09 | .20 | .21 | .18 | .18 | .18 | .16 |
| Total | 100.16 | 100.34 | 99.89 | 99.74 | 100.03 | 100.25 | 100.36 | 100.47 |

1. 77135,41, clast (Winzer and others, 1974).
2. 77135,52, troctolite clast (Winzer and others, 1974).
3. 77135,2 (Apollo 17 PET, 1973).
4. 77135,5 (Rhodes and others, 1974).
5. 77135,66, less vesicular matrix (Wiinzer and others, 1974).
6. 77135,77, more vesicular matrix (Winzer and others, 1974).
7. 77135,82, matrix (Winzer and others, 1976).
8. 77135,91, matrix (Winzer and others, 1976).

*Age:*

Rb-Sr isochron:

77135,34, 4.14±0.08 b.y., regarded as suspect because it seems too old; possibly analyzed separates included older xenocrysts that had not equilibrated with the matrix (Nakamura and others, 1976).

77135,57, clast, 3.89±0.08 (2*o*) b.y. (Tatsumoto and others, 1974; Nunes and others, 1974).

77137,34, vesicular matrix, station 7 boulder, 3.8±0.1 b.y. (Nunes and others, 1976).

$^{40-39}$Ar:

77135,51, clast, 3.99±0.02 b.y. (Stettler and others, 1974).

77135,57, olivine-rich clast, 3.90±0.03 b.y. (Stettler and others, 1975). (Similar to Rb-Sr age, above, on same clast.)

77135,71, vesicular matrix, short poorly defined high-temperature plateaus at 3.83±0.04 b.y., 3.78±0.08 b.y. (Stettler and others, 1974).

*Exposure age:*

Ar:

77135,51, clast, 28.5 m.y. (Stettler and others, 1974).

77135,71, vesicular matrix, 29.6 m.y. (Stettler and others, 1974).

77135,71, vesicular matrix, 20±2 m.y. (Eberhardt and others, 1975).

Exposure ages of Stettler and others (above) include their recommended 3/2 correction for shielding effects. Application of the same correction to the 20-m.y. result, which Eberhardt and others indicate is too low because of uncorrected shielding effects, produces a concordant age of ~30 m.y.

Kr:

77135, 28.6±1.4 m.y. (Crozaz and others, 1974).

77135,71, 31.8±1.6 m.y. (Eberhardt and others, 1975).

Tracks:

77135, 5.4±1 m.y. (Crozaz and others, 1974) , discordantly young track age could reflect any minor spalling event; hence it is a firm younger limit but does not necessarily date the emplacement of the station 7 boulder.

Sample 77215

*Type:* Norite cataclasite.

*Size:* 41 pieces that range from 1 cm to 6.5 x4.5 x2.5 cm.

*Weight:* 846.4 g total.

*Location:* From 3-m boulder approximately 22 m southwest of the LRV.

*Illustrations:* Pan 24, figures 185,192 (LRL).

*Comments:* Sample 77215 is from the large (approximately 0.5x1.5m) light-gray clast enclosed in and intruded by blue-gray breccia.

*Petrographic description:* Norite cataclasite. Sample is in many pieces, some of which contain dark finegrained breccia veins similar to those of 77075, and some troctolitic cataclasite fragments.

A mode determined by Chao and others (1976b) shows that sample 77215 consists of about 8 percent norite fragments, 10 percent "anorthosite" fragments (aggregated anorthite crystals interpreted as representing orthopyroxene-free portions of the noritic parent rock), 6 percent glass fragments similar in composition to the bulk composition of the noritic breccia itself, rare olivine-plagioclase breccia fragments, and 75 percent mineral fragments. Mineral fragments are dominantly orthopyroxene (31 percent) and plagioclase (40 percent) that are assumed to be largely derived from the norite parent.

Chao and others have interpreted the norite as a plutonic rock that crystallized at a depth of 8 or more kilometers. They suggest that a cratering event delivered crushed norite to the surface, where it was

mixed with noritic glass and olivine-plagioclase breccia (troctolite cataclasite) that are interpreted as probable products of separate cratering events. Subsequently, in their model, the noritic breccia was intruded by the blue-gray breccia dike and later enveloped in the greenish-gray vesicular breccia.

*Major- element composition:*

*Chemical analyses of 77215*

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| $SiO_2$ | 46.8 | 47.2 | 46.0 | 51.1 | 51.1 | 51.3 |
| Al2O3 | 17.44 | 16.89 | 17.75 | 14.32 | 13.98 | 15.06 |
| FeO | 9.39 | 9.36 | 9.04 | 10.32 | 10.38 | 10.07 |
| MgO | 13.16 | 12.93 | 12.74 | 13.23 | 14.31 | 12.56 |
| CaO | 10.88 | 10.76 | 10.94 | 9.08 | 8.65 | 8.96 |
| $Na_2O$ | .65 | .68 | .68 | .55 | .39 | .43 |
| $K_2O$ | .24 | .23 | .24 | .15 | .18 | .14 |
| $TiO_2$ | 1.37 | 1.35 | 1.32 | .37 | .30 | .32 |
| $P^2O^5$ | .28 | .27 | .26 | .10 | .14 | .11 |
| MnO | .12 | .12 | .11 | .17 | .17 | .16 |
| $Cr_2O_3$ | .19 | .20 | .14 | .36 | .36 | .32 |
| Total | 100.52 | 99.99 | 99.22 | 99.75 | 99.96 | 99.43 |

1. 77215,115, black dike (Winzer and others, 1976).
2. 77215,119 dike (Winzer and others, 1976).
3. 77215,121 dike (Winzer and others, 1976).
4. 77215,130 gray glass (Winzer and others, 1976); impact fused equivalent of the noriite (Chao and others, 1974).
5. 77215,152 matrix (Winzer and others, 1976); equals norite breccia (Chao and others, 1976b).
6. 77215,45 (Winzer and others, 1974); represents bulk composition of noritic breccia 77215 (Chao and others, 1976a).

Age:

Rb-Sr isochron:

77215,37 and 77215,145, 4.42±0.04 (2*o*) b.y. (Nakamura and others, 1976) corresponds with Pb-Pb model age of 4.42 b.y. (Nunes and others, 1974) and may be primary crystallization age of the norite or the age of its cataclasis; crystallization age preferred by Nakamura and others because of concordance with Sm-Nd age.

Sm-Nd isochron:

77215,37, 4.37±0.07 (2*o*) b.y. (Nakamura and others, 1976 ).

U-Pb isochron:

77215,37, 3.8±0.2 b.y., interpreted as recording an impact event (Nunes and others, 1974 ).

$^{40\text{-}39}$Ar:

77215,45A, 4.04±0.03 b.y. ( Stettler and others, 1974 ).

*Exposure age:* Ar: 77215,45A, 27.1 m.y. includes correction calculated to compensate for partial shielding (Stettler and others, 1974).

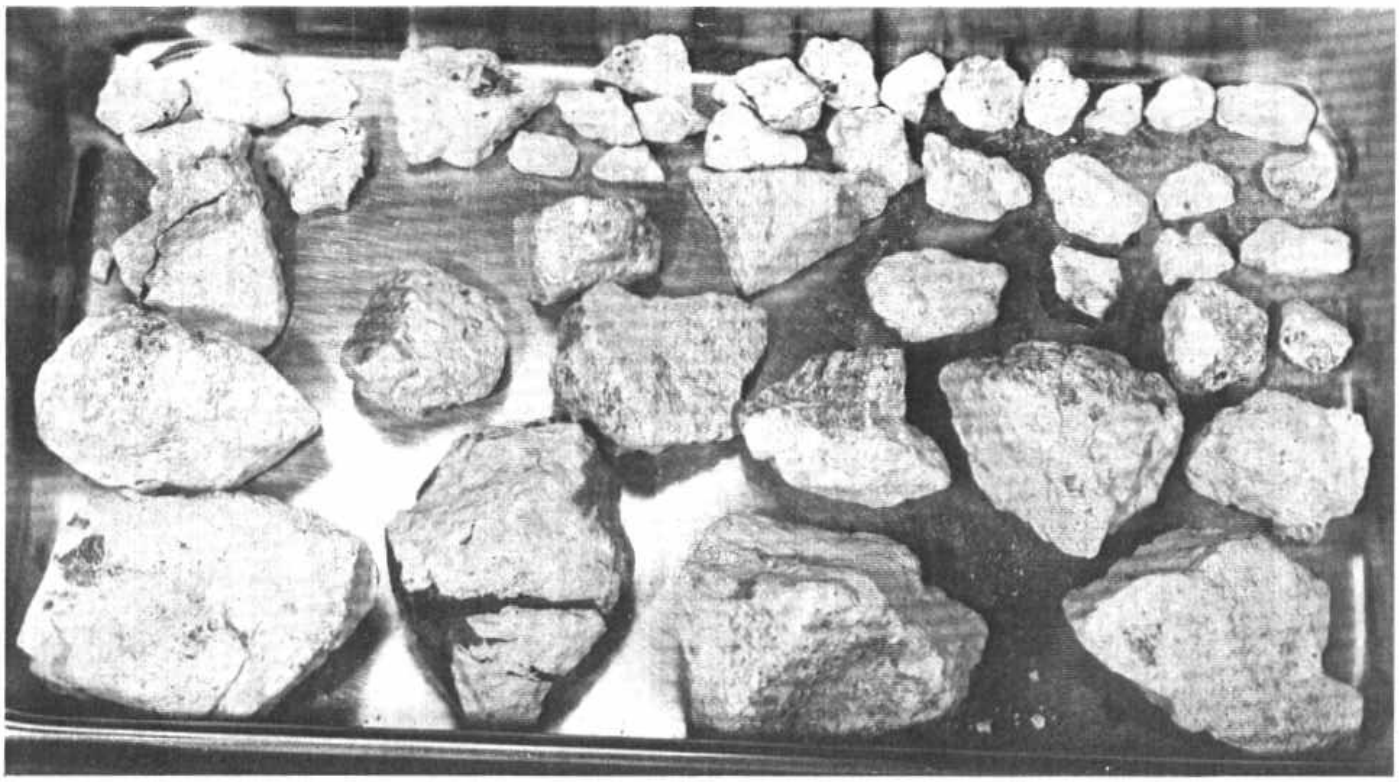


FIGURE 192.- Sample 77215. Fragments of norite cataclasite with some dark, fine-grained breccia veins similar to sample 77075. Largest fragment is 6.5x4.5x2.5 cm. (NASA photo graph S-73-17778.)

Sample 77510-l9, 25-26

*Type*: Sedimentary, unconsolidated (77510-14); breccia or polymict breccia fragments with aphanitic or polkilitic (?) matrices (77515, 77517-19); olivine basalt (77516); and two small breccia fragments (77525-26).

*Size:* 77515, 7.5x6.5x5.5 cm; 77516, 6x4x2.5 cm; 77517, 4x4x3 cm; 77518, 3.5x3.5x2.5 cm; 77519, 3.5x2.5x2 cm; 77525 and 77526, near centimeter size.

*Weight:* 77515, 337.6 g; 77516, 103.7 g; 77517, 45.6 g; 77518, 42.5 g; 77519, 27.4 g; 77525 and 77526, 2.26 g total.

*Depth:* From upper few centimeters.

*Location*: Regolith surface about 10 m southwest of the LRV.

*Illustrations:* Pan 24; figures 193 (LRL, 77515), 194 (LRL, 77516), 195 (LRL, 77517), 196 (LRL, 77519).

*Comments:* Sample is regolith material with breccia fragments probably derived from the North Massif. Sample 77516 is basalt presumably ejected from some crater on the valley floor.

Pe*trographic descriptions:*

77510-14, dominantly fine-grained breccia and (or) inetaclastic rock, some agglutinate.

7 1515. polymict breccia with clasts of breccia, metatroctoilte (?) , feldspathic metaclastic rock, and porphyroclasts of plagioclase and olivine in a fine-grained poikilitic (?) matrix with slitlike and spherical cavities loosely concentrated in a 1-cm-thick band.

77516, medium-grained olivine basalt with an intersertal or intergranular groundmass.

77517, polymict breccia with fragments of breccia, fine-grained metaclastic rock, and porphyroclasts of olivine and plagioclase in a feldspathic aphanitic matrix..

17518, breccia with few small porphyroclasts of pyroxene(?), olivine (?), and plagioclase in a fine-grained poikilitic (?) matrix.

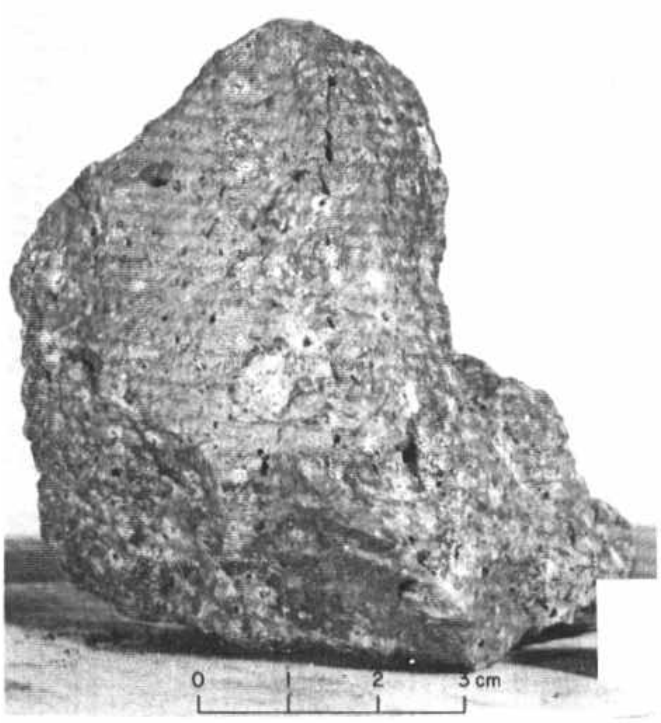
77519, polymict breccia with small clasts of metatroctolite with granoblastic-polygonal texture, and porphyroclasts of plagioclase, olivine, and pyroxene (?) in a fine-grained poikilitic (?) matrix.

Major-element composition:

*Chemical* an*alysis of 77515*

| | |
|---|---|
| $SiO_2$ | 37.84 |
| $Al_2O_3$ | 8.85 |
| FeO | 18.46 |
| MgO | 9.89 |
| CaO | 10.07 |
| $Na_2O$ | .35 |
| $K_2O$ | .06 |
| $TiO_2$ | 12.97 |
| $P_2O_5$ | .05 |
| MnO | .28 |
| $Cr_2O_3$ | .61 |

775155,3 tan-gray breccia (Lau and Schmitt, 1975a).




FGURE 193.-Sample 77515. Polymict breccia with poikilitic (?) matrix. (NASA photograph S-73-19416.)

Sample 77530-39, 45

*Type:* Sedimentary, unconsolidated (77530-34); basalt

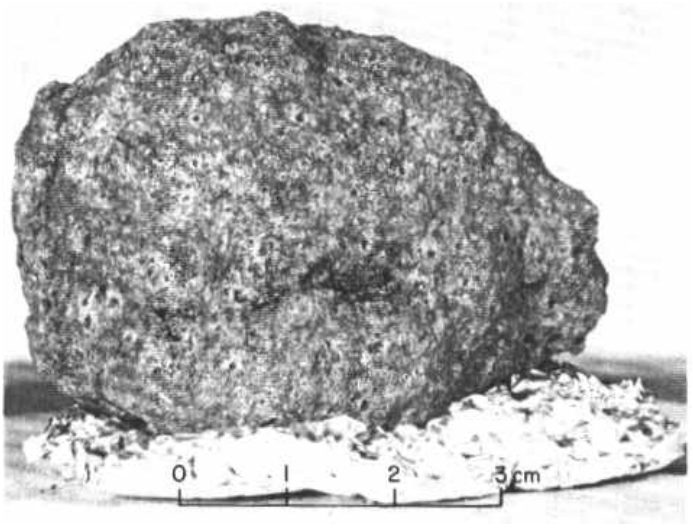



FIGURE 194.-Sample 77516. Medium-grained olivine basalt. (NASA photograph S-73-19409.)

(77535); olivine basalt (77536); and breccia or polymict breccia fragments with aphanitic to poikilitic (?) matrices (77537-39, 45).

*Size:* 77535, 10.5x8.5x3.5 cm; 77536, 11x7x3.5 cm; 77537-39, 45, 3 to 5 cm maximum dimension.

*Weight:* 77530-34, 219.46 g; 77535, 577.8 g; 77536, 355.3 g; 77537-39, 45, 188 g total.

*Depth:* From upper few centimeters.

*Location:* Regolith surface about 10 m southwest of the LRV.

*Illustrations:* Pan 24; figures 197 (LRL, 77535) , 198 (LRL, 77536) , 199 (LRL, 77537) , 200 (LRL, 77538) , 201 (LRL, 77539) , 202 (LRL, 77545) .

*Comments:* Sample is regolith material largely derived from the North Massif and the valley floor. Samples 77535-36 are basalt fragments probably ejected from craters on the valley floor. The breccia samples are highlands material presumably eroded from the North Massif.

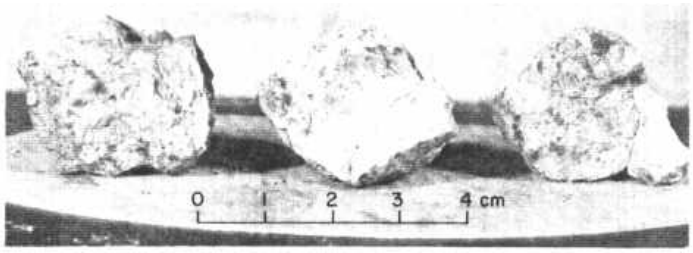



FIGURE 195.-Sample 77517. Polymict breccia with aphanitic matrix. (NASA photograph S-73-19104.)

*Petrographic descriptions:*

77530-34, dominantly fine-grained breccia and (or) metaclastic rock, some basalt and agglutinate, minor glass.

*Components of 90-150-um fraction of 77531,1 (Heiken and McKay, 1974)*

| *Components* | *Volume Percent* |
|---|---|
| Agglutinate | 54.0 |
| Basalt, equigranular | 4.0 |
| Basalt, variolitic | .7 |
| Breccia: | |
| Low grade[1] - brown | 5.6 |
| Low grade[1] - colorless | 2.3 |
| Medium to high grade[2] | 9.7 |
| Anorthosite | .7 |
| Cataclastic anrthosite[3] | 1.0 |
| Norite | -- |
| Gabbro | -- |
| Plagioclase | 9.3 |
| Clinopyroxene | 3.3 |
| Orthopyroxene | 1.0 |
| Olivine | .7 |
| Ilmenite | 1.3 |
| Glass: | |
| Orange | .3 |
| "Black" | 3.3 |
| Colorless | .3 |
| Brown | 2.0 |
| Gray, "ropy" | -- |
| Other | -- |
| Total number of grains | 300 |

1. Metamorphic groups 1-3 of Warner (1972).
2. Metamorphic groups 4-8 of Warner (1972).
3. Includes crushed or shocked feldspar grains.

77535, medium-grained slightly vesicular porphyritic basalt. Aggregates of clinopyroxeneilmenite in a subophitic groundmass of plagioclase, clinopyroxene, ilmenite. and accessory minerals.

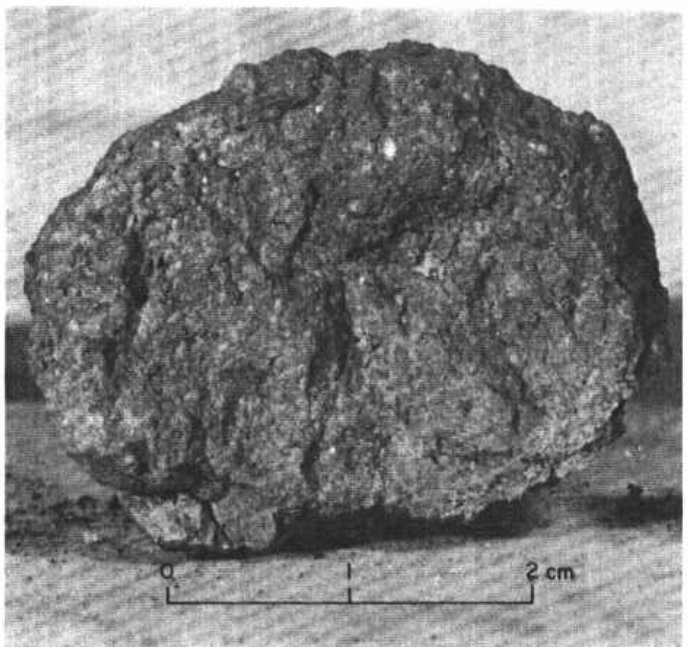



FIGURE 196.-Sample 77519. Polymict breccia with poikilitic (?) matrix. (NASA photograph S-73-19134.)

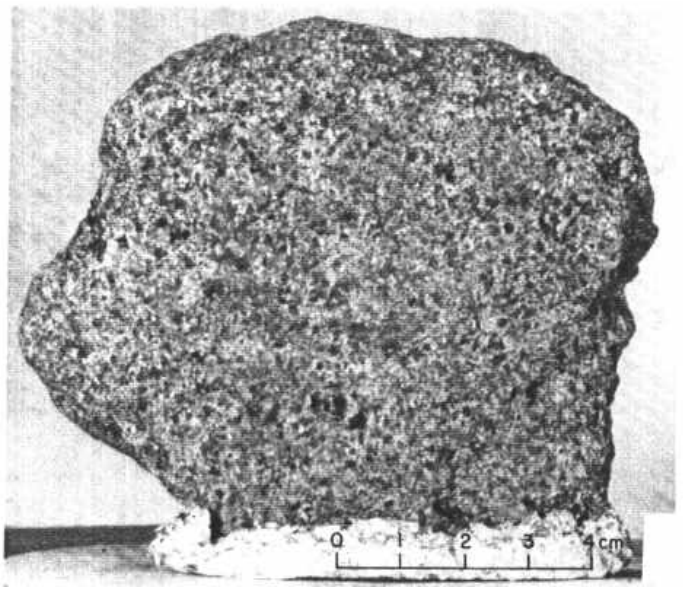



FIGURE 197.-Sample 77535. Medium-grained basalt. (NASA photo graph S-73-19122.)

77536, medium-grained vesicular porphyritic olivine basalt. Aggregates of clinopyroxeneilmenite in a subophitic groundmass of plagioclase, clinopyroxene, ilmenite, and accessory minerals.

77537, breccia with very scarce fine-grained metaclastic rocks and porphyroclasts of olivine (?) and plagioclase in a vesicular finegrained poikilitlc (?) matrix.

77538, polymict breccia with scarce small finegrained dark metaclastic rocks, feldspathic cataclasite, and dominantly plagioclase porphyroclasts in an aphanitic matrix.

77539, polymict breccia with clasts of metaanorthosite, metatroctolite (?) and porphyroclasts of plagioclase in a vesicular tine-grained poikilitic (?) matrix.

77545, polymict breccia with clasts of mafic troctolite or meta-troctolite, "dunite," and porphyroclasts of plagioclase and olivine in a vesicular fine-grained poikilitic (?) matrix.

*Major-element compositions:*

*Chemical analyses of 77531, 77535, 77538, 77539, 77545*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| $SiO_2$ | 43.07 | 38.57 | -- | -- | -- |
| Al2O3 | 17.16 | 8.95 | 14.5 | 22.0 | 10.9 |
| FeO | 11.70 | 18.53 | 10.6 | 6.9 | 10.3 |
| MgO | 10.19 | 8.85 | 5.0 | 8.0 | 10 |
| CaO | 11.93 | 10.66 | 10.3 | 12.5 | 6.6 |
| $Na_2O$ | .44 | .39 | .75 | .56 | .47 |
| $K_2O$ | .11 | .05 | 1.04 | .20 | .14 |
| $TiO_2$ | 3.91 | 12.39 | 1.2 | 1.1 | 1.2 |
| $P^2O^5$ | .08 | .04 | -- | -- | -- |
| MnO | .17 | .27 | .150 | .082 | .110 |
| $Cr_2O_3$ | .31 | .43 | .240 | .136 | .520 |
| Total | 99.07 | 99.13 | | | |

1. 77531,3 (Rhodes and others, 1974).
2. 77535,6 (Rhodes and others, 1976).
3. 77538,2 tan-gray breccia (Lau and Schmitt, 1975a).
4. 77539,8 tan-gray breccia (Lau and Schmitt, 1975a).
5. 77545,1 tan-gray breccia (Lau and Schmitt, 1975a).

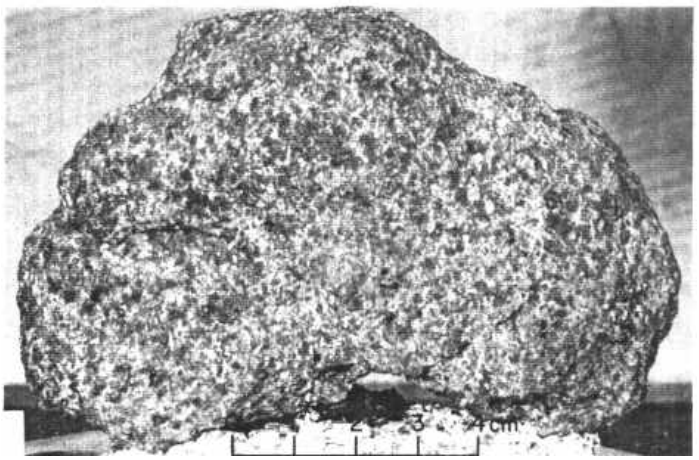
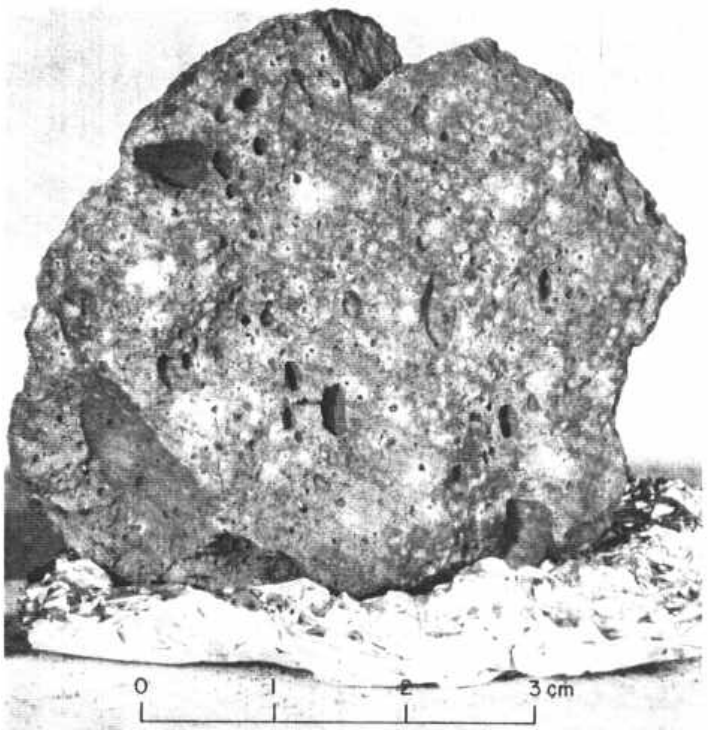



FIGURE 198.-Sample 77536. Medium-grained vesicular olivine basalt. (NASA photograph S- 73-19154.)




FIGFURE 199.-Sample 77537. Polymict breccia with poikilitic (?) matrix. (NASA photograph S-73-19145.)

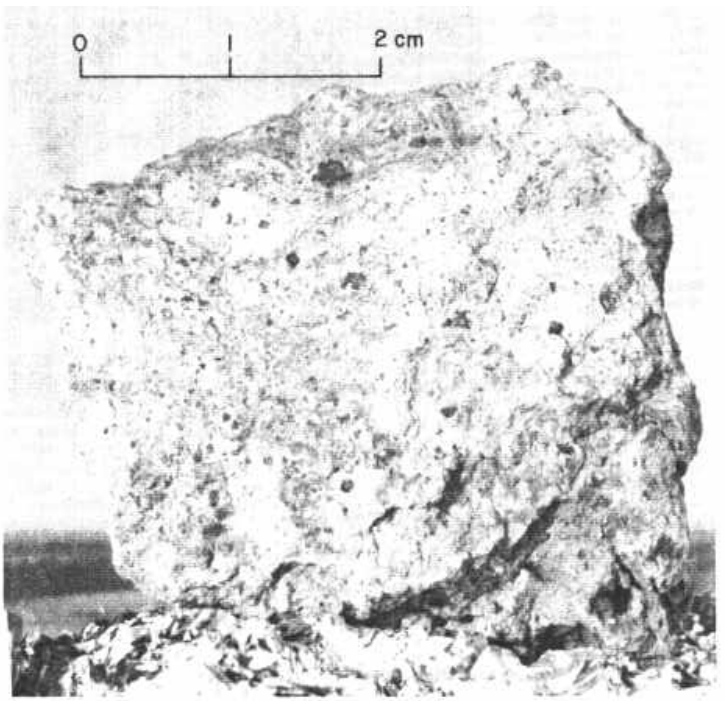



FIGURE 200.-Sample 77538. Polymict breccia with aphanitic matrix. (NASA photograph S-73-19064.)

**STATION LRV-11**

LOCATION

Station LRV-11 (fig. 7*D*) is located on the southeastern rim of SWP crater (now called "Bowen-Apollo" on NASA lunar photomap, edition 1, sheet 43D1S2(25)).

OBJECTIVES

Station LRV-11 was an unplanned LRV stop to sample ejecta of a fresh small dark-rimmed crater on the rim of SWP crater.

GENERAL OBSERVATIONS

The small dark-rimmed crater was estimated to be 30 or 40 m in diameter. It has a raised blocky rim and a blocky ejecta blanket made up of angular clods (fig. 203) that disintegrated easily under the LRV wheels. The clods cover as much as 70 percent of the surface at the crater rim and up to 50 percent of the surface at the sampling site. They range in size from a few centimeters to about 30 centimeters. Many have rounded tops; soiree are partly buried.

The sediment between clods is the same color and probably has the same composition as the clods. The area surrounding the ejecta blanket of the small crater appears typical of other dark regolith surfaces on the valley floor, with fragment populations of less than one percent.

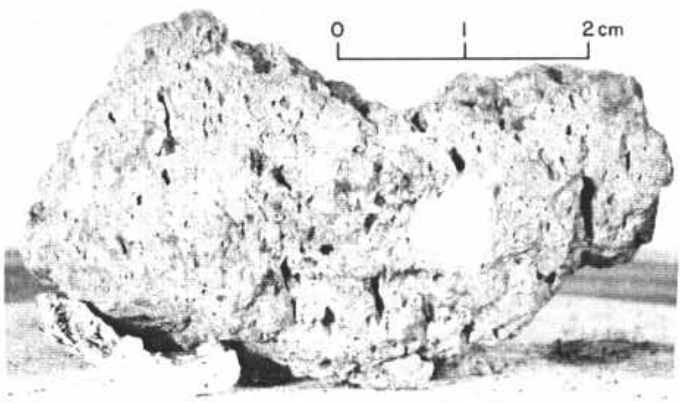



FIGURE 201.-Sample 77539. Polymict breccia with poikilitic (?) matrix (NASA photograph S-73- 19062.)

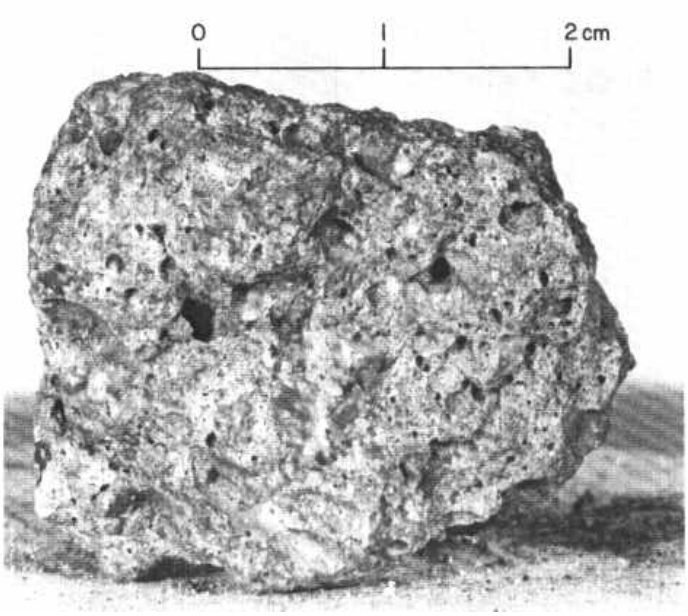



FIGURE 202.-Sample 77545. Polymict breccia with poikilitic (?) matrix. (NASA photograph S-73-19128.)

SUMMARY OF SAMPLING

Sample 78120-24.

*Type*: Sedimentary, unconsolidated.
*Weight:* 209.94 g.
*Depth:* From upper few centimeters.
*Location:* From ejecta blanket of small crater on the southeastern rim of SWP crater.
*Illustrations:* Pan 26; figure 203.
*Comments*: Sampled sediment was probably excavated from a depth of no more than a few meters in the regolith on the rim of SWP.

**STATION 8**

LOCATION

Station 8 is located near the base of the Sculptured Hills (figs. 7*D* and 204) and about 4 km northeast of the LM. It is within the zone shown as dark mantle in the premission geologic maps (Scott and others, 1972; Wolfe and Freeman, 1972).

OBJECTIVES

The objectives at station 8 were to photograph and sample the Sculptured Hills and dark-mantle map units and to compare the materials from these units with massif and subfloor materials.

GENERAL OBSERVATIONS

The terrain at station 8 is undulating and forms a gently inclined transition zone between the Sculptured Hills to the northeast and the valley floor to the southwest. The Sculptured Hills differ strikingly from the massifs because of the undulating, gentler slopes, greater abundance of dark streaks and patches, distinctive hummocky topographic form, absence of resistant ledges, and near-absence of boulders (fig. 204; pl. 2).

In the immediate station area, craters up to 10 m in diameter are common. They range froth fresh to subdued. None have prominently raised or blocky rims, but many of the craters less than 1 m in size are lined

with small clods.

Pebble-size fragments are common; larger ones are sparse. The largest rock seen is less than 1 m in size. While approaching station 8, the crew noted that rocks larger than 20 cm are rare on the Sculptured Hills slopes compared with the foot of the North and South Massifs. The few visible rocks range from subangular to subrounded. Some are partly buried, but the sampled norite boulder is perched on the surface. The crew thought that except for the norite boulder all of the examined rocks larger than 20 cm were probably subfloor basalt.

Surface sediment of the station 8 area is dark like the dark sediment of the valley floor; it is fine grained and cohesive on the surface and in the 25-cm-deep trench. Tracks made by the downhill movement of clods were noted by the crew.

Samples at station 8 (fig. 205) consisted of fragments from the norite boulder, sediment from beneath the boulder, four trench samples, a loose rock from the surface, rock fragments from a small crater, and sediment and a suite of small rocks collected by rake from the rim of a 15-m crater.

## GEOLOGIC DISCUSSION

Sculptured Hills material surrounds the massifs and projects locally through the fill of the Taurus-Littrow valley (pl. 1). Interpreting these relations and drawing support from better preserved analogous features in the Orientale Basin (Scott and others, 1977), we suggest that. the Sculptured Hills material is ejecta emplaced during formation of the southern Serenitatis basin but after initiation of the faulting that formed the Taurus-Littrow graben and the massif blocks.


FIGURE 203.-Sampling; area at station LRV-11 before sampling. (NASA photograph AS17-142-21693.)

The morphologic difference between the Sculptured Hills and the massifs, the absence of resistant ledges and boulder clusters on the upper slopes, and the near absence of boulders on the Sculptured Hills slope near station 8 (fig. 204) imply a lithologic difference between the two units. A reasonable interpretation is that the coherent breccia with its clast-laden crystalline matrix is scarce or absent in the Sculptured Hills unit.

Rocks collected at station 8 are dominantly basalt, presumably deposited as ejecta from the valley floor, and fragments of weakly sintered polymict breccia, which are samples of regolith material compacted by impact. Only three highland rocks were sampled: metagabbro cataclasite (78155) , the norite (78235, 36, 38, 78255), and a noritic rake fragment (78527) compositionally like the fused norite of 78235 (fig. 206). Any or all of the three could have been introduced to the station 8 area by impacts excavating material from outside of the Sculptured Hills. However, if they are fragments of the Sculptured Hills material and if the coherent breccia so common in the massifs is really absent from the Sculptured Hills, then perhaps the Sculptured Hills unit is dominantly cataclasite formed by crushing of plutonic anorthosite-norite-troctolitesuite rocks in a basin-forming impact.

Sediment compositions (fig. 207) show that the fine regolith material at station 8 is a mixture of highlands and valley-floor debris. Several of the plotted points are close to the join connecting ash 74220 and the alumina-rich sediment samples of the South Massif and light mantle. In agreement with the photogeologic observation that station 8 is in an area of dark surficial material, this suggests that ash may be the dominant valley-floor component represented at station 8. However, a component of relatively magnesian noritic debris similar in composition to rake fragment 78527 and the 78235 glasses would also place the sediment compositions near this join.

Compositions of five of the six analyzed weakly lithified polymict breccia samples plot in the same general region of figure 207 as the sediment samples. They presumably are samples of locally indurated regolith compositionally like the unconsolidated station 8 sediment.

## SUMMARY OF SAMPLING

### Sample 78135

*Type*: Olivine basalt.
*Size*: 5x4x3 cm.
*Weight*: 133.9 g.

*Location:* About 10 m north of' LRV.
*llustrations:* Pans 25, 26; figures 203, 209 (LRL), 210.
*Comments:* 78135 is a regolith fragment of subfloor basalt.

*Petrographic description:* Fine- to medium-grained olivine basalt.

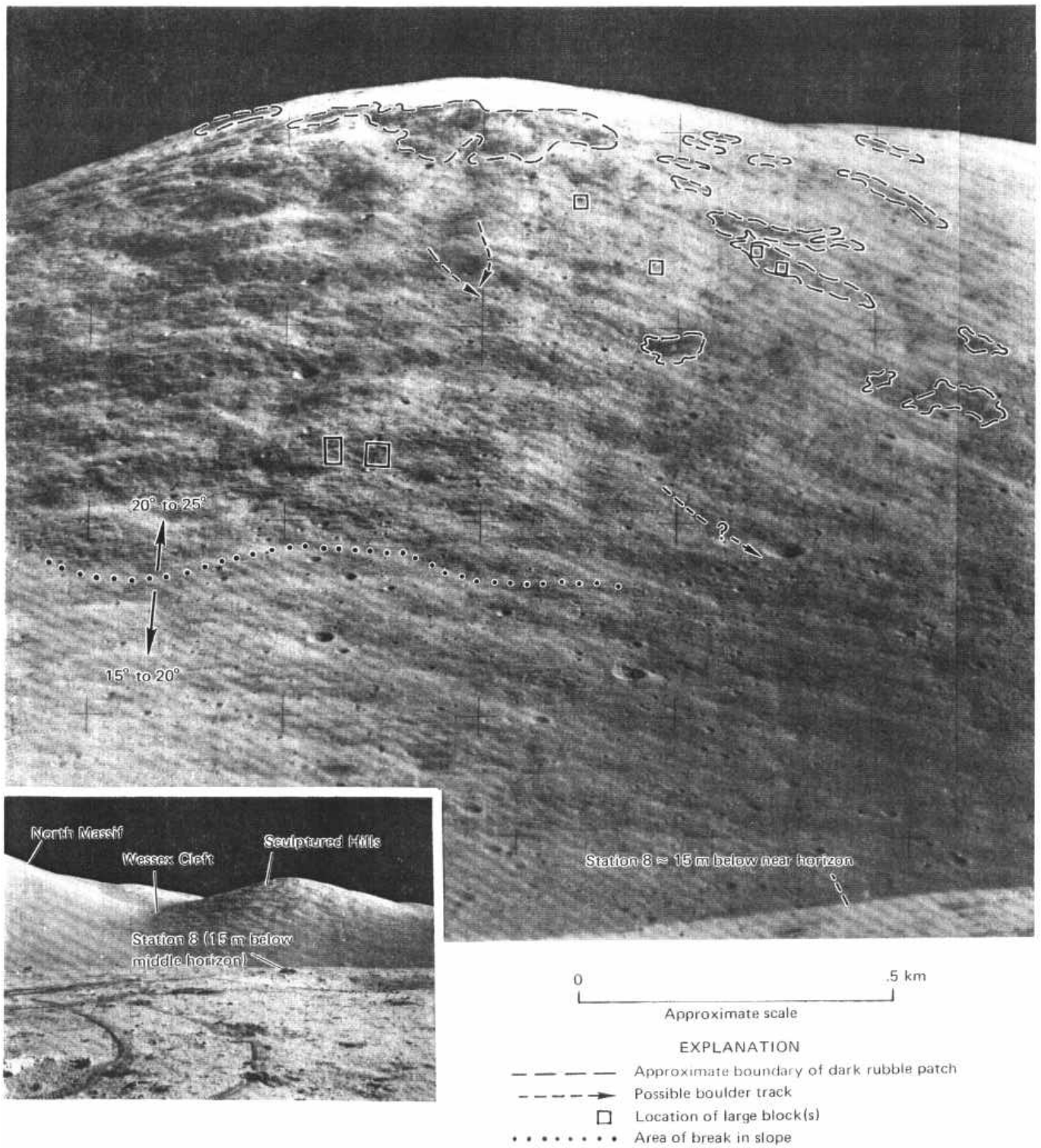



FIGURE 204.-Telephoto mosaic of Sculptured Hills slope above station 8 as viewed from station 2a. Sun elevation is 28°. (NASA photograph AS17-144-22034 and 22035.) (From Muehlberger and others, 1973.) Inset, Station 8 area at Sculptured Hills as viewed from the LM, 4 km away. (NASA photograph AS17-137-20876.)

*Major-element composition:*

*Chemical analyses of 78135*

| | |
|---|---|
| $SiO_2$ | 37.98 |
| $Al_2O_3$ | 8.38 |
| FeO | 19.05 |
| MgO | 8.69 |
| CaO | 10.71 |
| $Na_2O$ | .36 |
| $K_2O$ | .05 |
| $TiO_2$ | 12.89 |
| $P_2O_5$ | .04 |
| MnO | .27 |
| $Cr_2O_3$ | .45 |
| Total | 98.87 |

78135,5 (Rhodes and others, 1976).

Sample 78155

*Type:* Metagabbro cataclasite.
Size: 52 pieces, largest is 6.5x4.5x3 cm.
*Weight:* 401.1 g total.
*Location:* From meter-size "pit crater" in southwest wall of a 15-m crater located about 20 m north of the LRV.
*Illustrations:* Pans 25, 26; figures 210, 211 (photomicrograph), 217, 221.
*Petrographic description:* Metagabbro cataclasite. Relict lithic fragments are dominantly metaclastic rocks with textures ranging from aphanitic to granoblastic-polygonal and, locally, melt texture with newly crystallized plagioclase laths.

*Major- element composition:*

*Chemical analyses of 78155*

| | |
|---|---|
| $SiO_2$ | 45.57 |
| $Al_2O_3$ | 25.94 |
| FeO | 5.82 |
| MgO | 6.33 |
| CaO | 15.18 |
| $Na_2O$ | .33 |
| $K_2O$ | .08 |
| $TiO_2$ | .27 |
| $P_2O_5$ | .04 |
| MnO | .10 |
| $Cr_2O_3$ | .14 |
| Total | 99.80 |

78155,2 (Apollo 17 PET, 1973).

*Age:*

U-Pb: 78155, complex history with three or more events in the U-Th-Pb evolution; 3.81 +0.25/-0.18 (2*o*) b.y. interpreted as age of last resetting (Nunes and Tatsumoto, 1975).

$^{40-39}$Ar: 78155,29, 4.22±0.04 b.y.; extremely well defined plateau age, identical to its total argon age (Turner and Cadogan, 1975).

*Exposure age:* Ar: 78155,29, 30 m.y. (Turner and Cadogan, 1975).

Sample 78220-24

*Type:* Sedimentary, unconsolidated.
*Weight:* 344.78 g.
*Depth:* From upper few centimeters.
*Location:* Beneath sampled norite boulder about 50 m northeast of the LRV.
*Illustrations:* Pan 26; figure 212.
*Comments:* Sample 78220-24, collected after the norite boulder was rolled, is a mixture of highlands and valley-floor debris.
*Petrographic description:* 78220-24, dominantly finegrained breccia and (or) metaclastic rock, some agglutinate.

*Components of 90-150-um fraction of 78221,8 (Heiken and McKay, 1974)*

| *Components* | *Volume Percent* |
|---|---|
| Agglutinate | 57.0 |
| Basalt, equigranular | 1.0 |
| Basalt, variolitic | -- |
| Breccia: | |
| Low grade[1] - brown | 6.3 |
| Low grade[1] - colorless | -- |
| Medium to high grade[2] | 7.0 |
| Anorthosite | 1.3 |
| Cataclastic anrthosite[3] | -- |
| Norite | -- |
| Gabbro | .3 |
| Plagioclase | 5.0 |
| Clinopyroxene | 8.9 |
| Orthopyroxene | 3.6 |
| Olivine | 1.7 |
| Ilmenite | 1.0 |
| Glass: | |
| Orange | .7 |
| "Black" | 3.0 |
| Colorless | 1.3 |
| Brown | 2.0 |
| Gray, "ropy" | -- |
| Other | -- |
| Total number of grains | 302 |

1. Metamorphic groups 1-3 of Warner (1972).
2. Metamorphic groups 4-8 of Warner (1972).
3. Includes crushed or shocked feldspar grains.

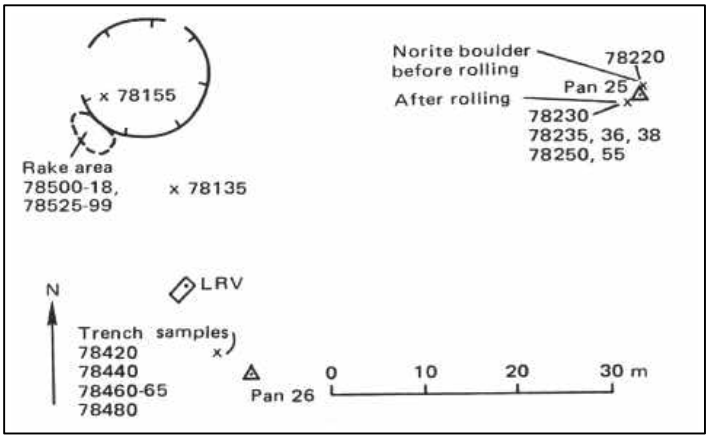



FIGURE 205.-Planimetric map of station 8.

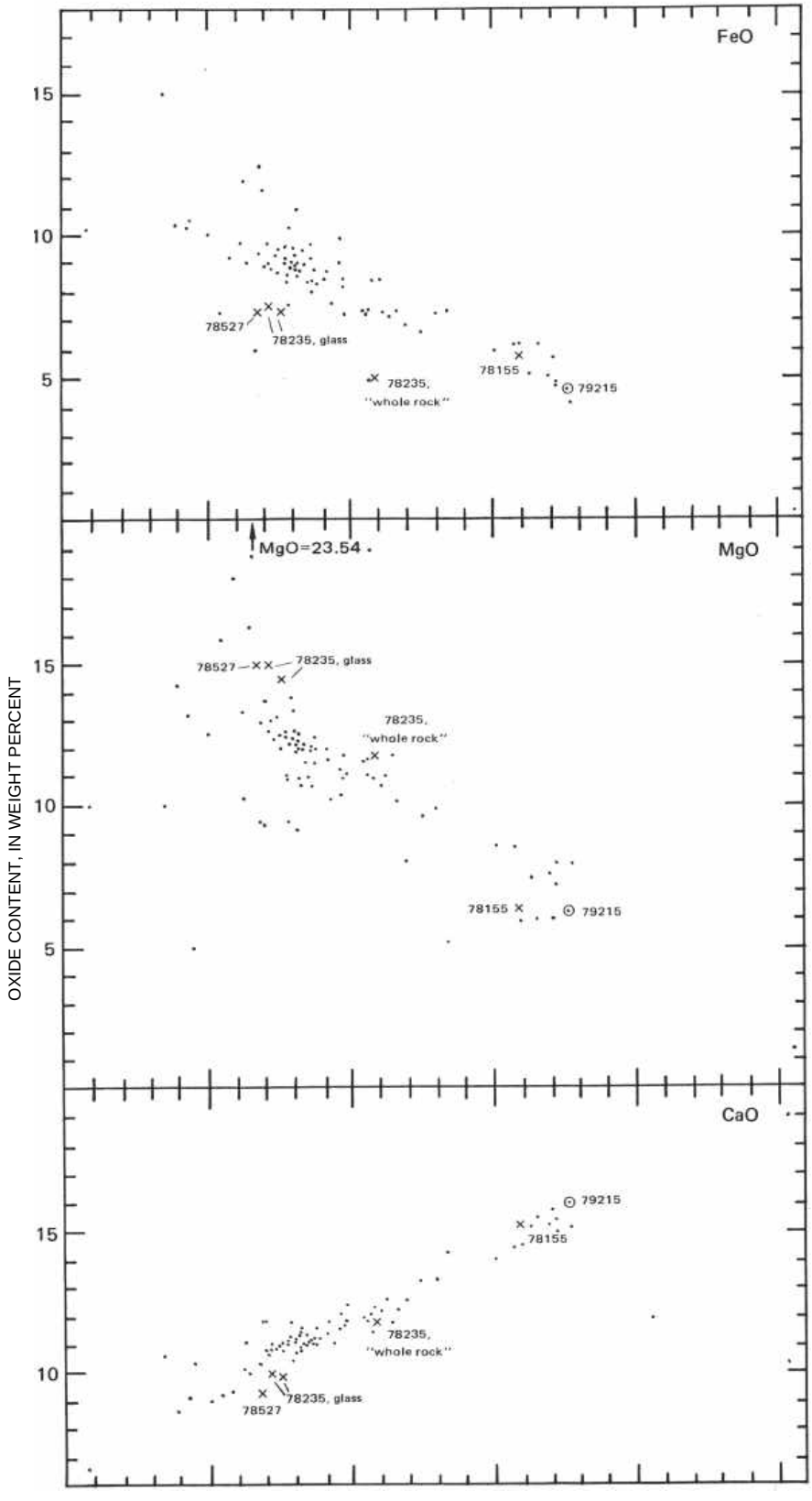



FIGURE 206.-Plots of FeO, MgO, and CaO contents in relation to $A1_2O_3$ content for analyzed highlands rocks from stations 8 (X) and 9 (circled dot) in comparison with all analyzed Apollo 17 highlands rocks (dots).

*Major-element composition:*

*Chemical analyses of 78221*

| | |
|---|---|
| $SiO_2$ | 43.67 |
| $Al_2O_3$ | 17.13 |
| FeO | 11.68 |
| MgO | 10.55 |
| CaO | 11.79 |
| $Na_2O$ | .37 |
| $K_2O$ | .092 |
| $TiO_2$ | 3.84 |
| $P_2O_5$ | .080 |
| MnO | .157 |
| $Cr_2O_3$ | .321 |
| Total | 99.680 |

78221,1 (Duncan and others, 1974).

Sample 78230-36, 38

*Type:* Sedimentary, unconsolidated (78230-34) and orite fragments (78235,36, 38) from boulder.

*Size: 78235, 2* pieces, 5x4x3.5 cm and 5.5x5x4 cm; 78236, 7.5x5.5x2 cm; 78238, 5x4.5x3.5 cm.

*Weight:* 78230-34, 210.5 g; 78235, 199.0 g; 78236, 93.06 g; 78238, 57.58 g.

*Location:* At half-meter norite boulder about 50 m northwest of the LRV.

*Illustrations:* Pans 25, 26; figures 213, 214 (LRL, 78236) , 215.

*Comments:* Samples 78230-36, 38 were collected after the norite boulder was rolled downhill; samples came from what had been the boulder top. Sediment sample 78230-34 was scooped up from the surface with rock fragments 78235, 36, and 38. The boulder was perched on the surface; there was no visible boulder track. Presumably it arrived fairly recently in the station 8 area as ejecta from an unidentified crater. A highly detailed account of the field occurrence and

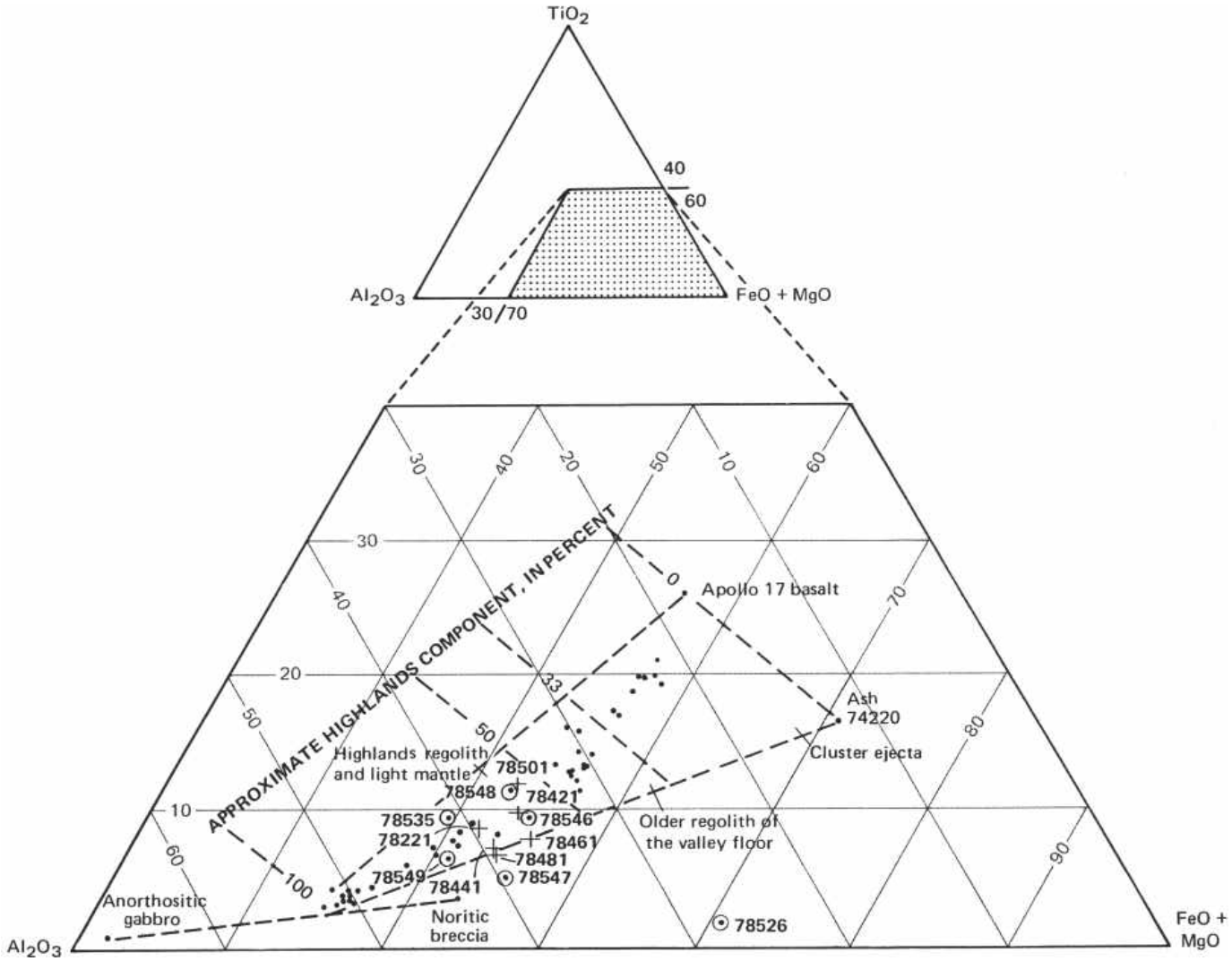



FIGURE 207.-Relative amounts of $Ti0_2$, $A1_20_3$, and FeO +MgO in sediment samples (crosses) and weakly lithified polymict breccia (circled dots) from station 8 in comparison with sediment samples from elsewhere in traverse region (dots). Apollo 17 basalt, anorthositic gabbro, and noritic breccia values from Rhodes and others (1974).

sampling has been given by Jackson and others (1975).

*Petrographic description:* Plagioclase-orthopyroxene cumulate. Approximately equal proportions of cumulus plagioclase and orthopyroxene; dominantly plagioclase and orthopyroxene postcumulus material with minor clinopyroxene.

The norite is shocked, with plagioclase partly altered to maskelynite, and fractured. Vesicular black glass coats the samples and forms veins that intrude some of the fracture sets (Jackson and others, 1975).

Major-element data imply that the glass formed by fusion of the norite. As shown in figure 215, glass and "whole-rock" compositions (see table, columns 1-3) lie on or close to mixing lines joining low-calcium pyroxene and plagioclase (see table, columns 4 and 5). The chemical data imply ratios of plagioclase to plagioclase- plus-pyroxene of approximately 0.45 for the glasses and 0.57 for the "whole rock." Modal values for the same ratio are approximately 0.48 (McCallum and Mathez, 1975), 0.50 (Dymek and others, 1975), and 0.670.70 (Jackson and others, 1975).

Jackson and others (1975) concluded that the cumulate norite crystallized at a depth of 8 km or more. According to Dymek and others (1975), its mineral compositions are suitable for the station 8 norite to be related by crystal fractionation and liquid line of descent to the plutonic parents of metatroctolite 76535 and metadunite 72415-18.

*Major-element composition:*

*Chemical analyses of 78235*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| $SiO_2$ | 49.7 | 49.8 | 49.5 | 53.9 | 46.3 |
| Al2O3 | 17.58 | 17.15 | 20.87 | 3.44 | 33.85 |
| FeO | 7.39 | 7.52 | 5.05 | 11.16 | .23 |
| MgO | 14.51 | 14.98 | 11.76 | 27.52 | .45 |
| CaO | 9.86 | 9.92 | 11.71 | 3.26 | 17.93 |
| $Na_2O$ | .34 | .35 | .35 | .05 | .58 |
| $K_2O$ | .058 | .060 | .061 | .015 | .102 |
| $TiO_2$ | .16 | .19 | .16 | .32 | .08 |
| $P^2O^5$ | .07 | .08 | .04 | .04 | .04 |
| MnO | .11 | .12 | .08 | .20 | .003 |
| $Cr_2O_3$ | .33 | .35 | .23 | .52 | .01 |
| Total | 100.11 | 100.52 | 99.81 | 100.43 | 99.58 |

1. 78235,34, rind glass (Winzer and others, 1975b).
2. 78235,34, vein glass (Winzer and others, 1975b).
3. 78235,34, “whole rock”; analyzed sample too small with respect to grain size of rock to be necessarily representative (Winzer and others, 1975b).
4. 78235,34, pyroxene (Winzer and others, 1975b).
5. 78235,34, plagioclase (Winzer and others, 1975b).

Sample 78250, 55

*Type:* Sedimentary, unconsolidated (78250) and two glass-coated norite fragments (78255).

*Size:* 78255, 4.5x4 cm x ?.

*Weight:* 78250, 50.57 g; 78255, 48.31 g.

*Location:* Norite boulder about 50 m northwest of the LRV.

*Illustrations:* Pans 25, 26.

*Comments:* Sample 78255 was collected from the

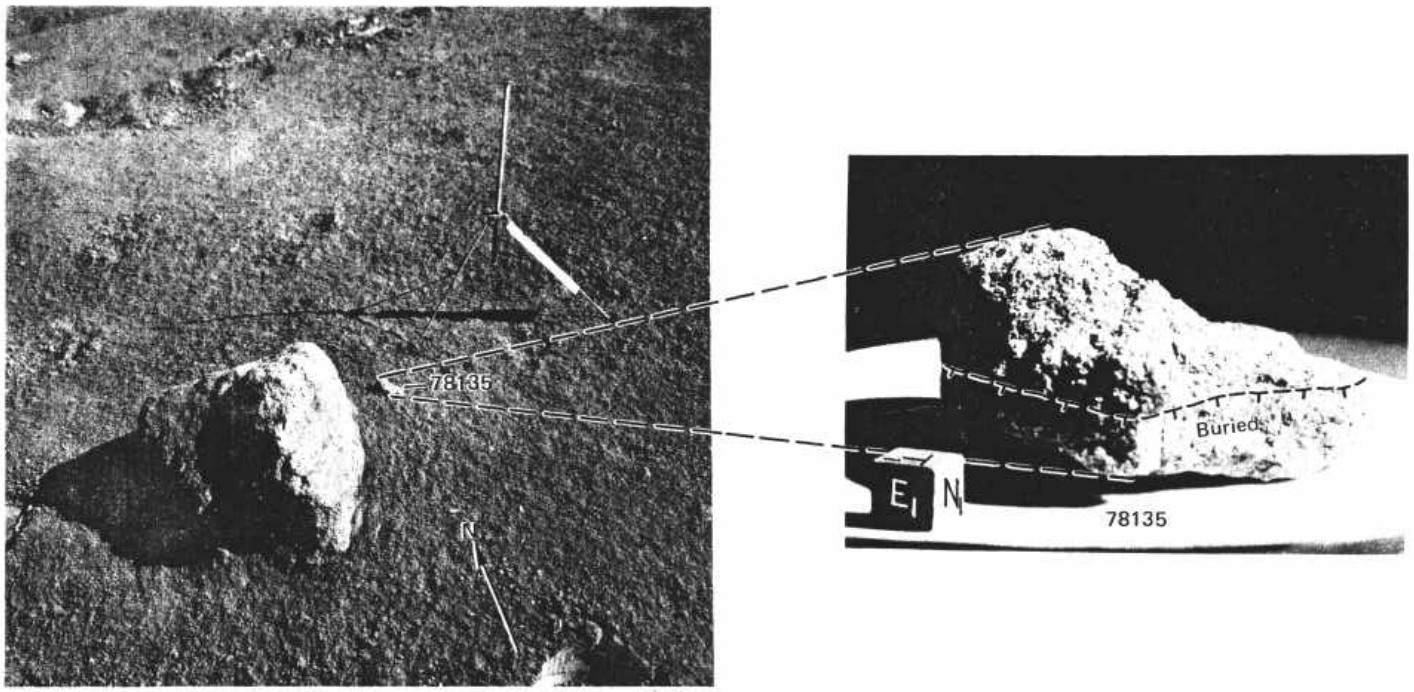



FIGURE 208.-Left, Sample 78135 before sampling. (NASA photograph AS 17-146-22365.) Right, Sample 78135 with reconstructed lunar orientation and lighting. (NASA photograph S-73-21073.)

bottom of the one-half-meter norite boulder after it was rolled downhill. Sample 78250 was scooped from the surface with the rock fragments.

*Petrographic description:* 78255, similar to sample 78235 from the same boulder.

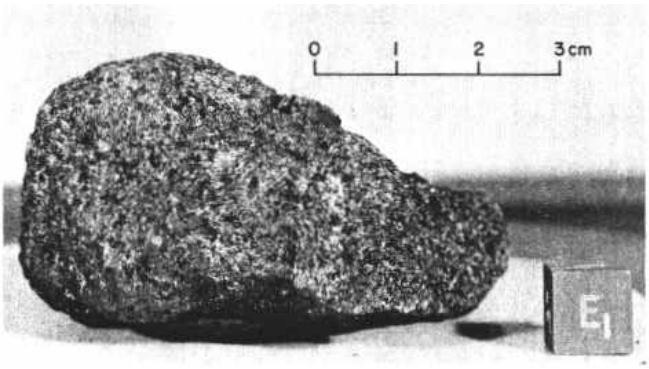



FIGURE 209.-Sample 78135. Fine-grained olivine basalt. (NASA photograph S-73-15006.)

Sample 78420-24

*Type:* Sedimentary, unconsolidated.

*Weight:* 292.62 g.

*Depth:* From lowest 10 cm of 25-em-deep trench.

*Location:* 7 m southeast of LRV.

*Illustrations:* Pans 25, 26; figure 216.

*Comments:* The lowest 5 cm of the trench exposure was described as slightly coarser than the material from higher in the trench. Sample 78420-24 represents mixed highlands and valley-floor material.

*Petrographic description:* 78420-24, Dominantly finegrained breccia and (or) metaclastic rock, some glass, minor agglutinate.

*Components of 90-150-um fraction of 78421,1 (Heiken and McKay, 1974)*

| *Components* | *Volume Percent* |
|---|---|
| Agglutinate | 62.6 |
| Basalt, equigranular | 5.7 |
| Basalt, variolitic | |
| Breccia: | |
| Low grade[1] - brown | 7.0 |

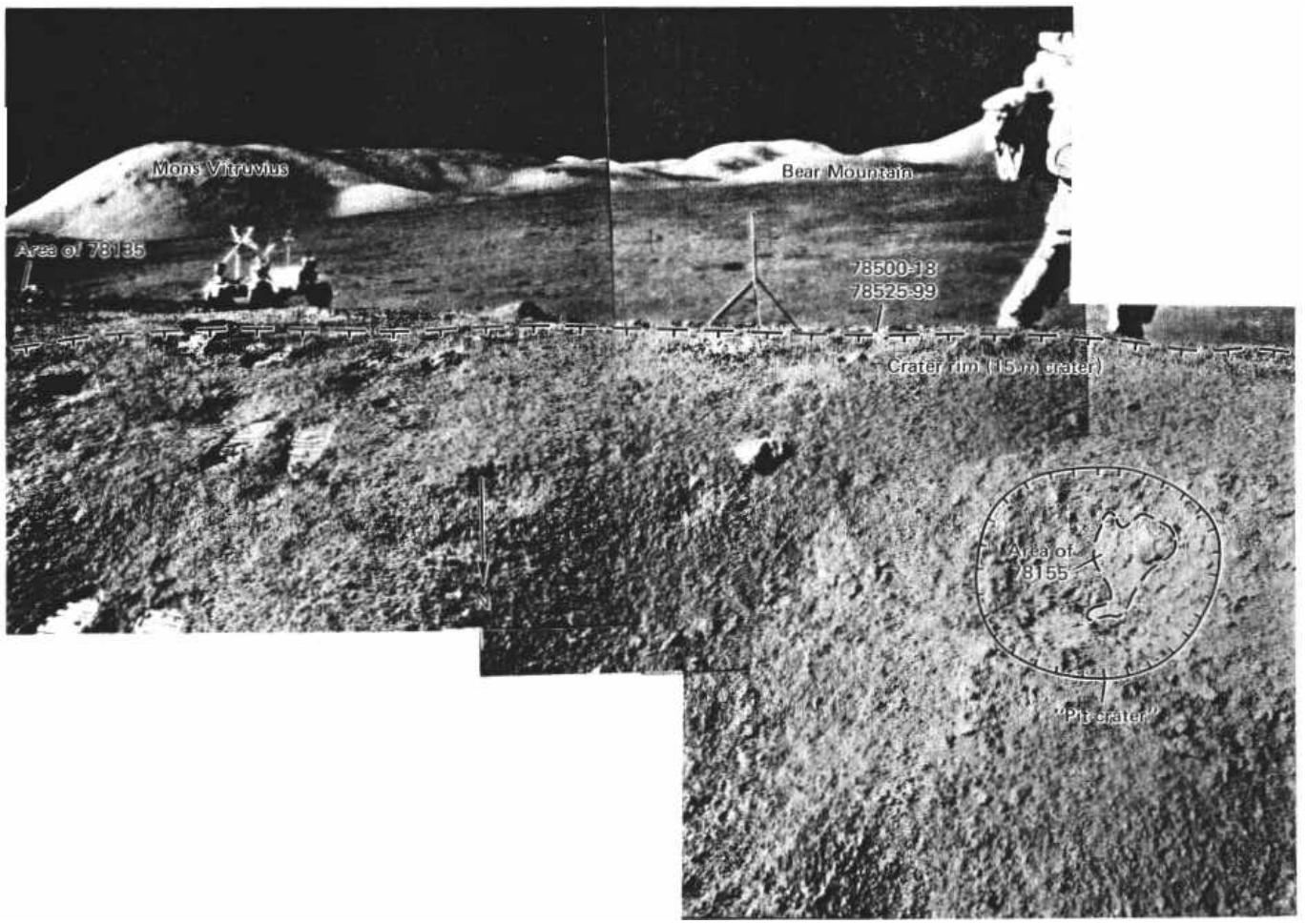



FIGURE 210.-Sample 78155, before collection, in meter-size "pit crater" in southwest wall of 15-m crater at station 8. Samples 78500-18 and 78525-99 were collected from rim of 15-m crater. (NASA photographs AS 17-146-22400-22402.)

*Cornponents of 90-150-um fraction of 78421,1 (Heiken and Mckay,1974)*-Continued

| *Components* | *Volume Percent* |
|---|---|
| Breccia-Continued | |
| Low grade[1] - colorless | 1.3 |
| Medium to high grade[2] | 2.6 |
| Anorthosite | .3 |
| Cataclastic anrthosite[3] | .6 |
| Norite | -- |
| Gabbro | -- |
| Plagioclase | 7.3 |
| Clinopyroxene | 9.0 |
| Orthopyroxene | -- |
| Olivine | .6 |
| Ilmenite | -- |
| Glass: | |
| Orange | .6 |
| "Black" | .3 |
| Colorless | 1.3 |
| Brown | .6 |
| Gray, "ropy" | -- |
| Other | -- |
| Total number of grains | 300 |

1. Metamorphic groups 1-3 of Warner (1972).
2. Metamorphic groups 4-8 of Warner (1972).
3. Includes crushed or shocked feldspar grains.

*Major-element composition:*

*Chemical analyses of 78421*

| | |
|---|---|
| $SiO_2$ | 44.7 |
| $Al_2O_3$ | 17.4 |
| FeO | 12.2 |
| MgO | 11.8 |
| CaO | 11.8 |
| $Na_2O$ | .43 |
| $K_2O$ | -- |
| $TiO_2$ | 3.8 |
| $P_2O_5$ | -- |
| MnO | .164 |
| $Cr_2O_3$ | -- |
| Total | 102.294 |

78421,23 (Miller and others, 1974).

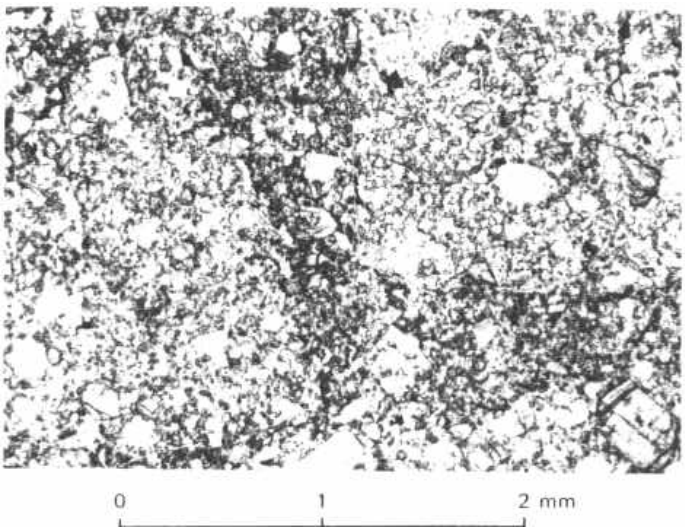



FIGURE 211.-Sample 78155. Photomicrograph showing relict lithic clasts in metagabbro cataclastic. Before crushing, rock was metaclastic with porphyroclasts of plagioclase aplhanitic to granoblastic-polygonal matrix.

Sample 7440-44

*Type:* Sedimentary, unconsolidated.
*Weight:* 251.59 g.
*Depth:* From 6 to 15 cm in 25-cm-deep trench.
*Location:* 7 m southeast of LRV.
*Illustrations:* Pans 25, 26; figure 216.
*Comments:* Sample 78440-44 represents mixed highlands and valley floor material.
*Petrographic description:* 78440-44, dominantly finegrained breccia and (or) metaclastic rock and agglutinate, some glass.

*Major-element composition:*

*Chemical analyses of 78441*

| | |
|---|---|
| $SiO_2$ | 44.1 |
| $Al_2O_3$ | 17.2 |
| FeO | 12.4 |
| MgO | 10.9 |
| CaO | 11.1 |
| $Na_2O$ | .49 |
| $K_2O$ | -- |
| $TiO_2$ | 3.2 |
| $P_2O_5$ | -- |
| MnO | .169 |
| $Cr_2O_3$ | -- |
| Total | 99.559 |

78441,9 (Miller and others, 1974).

Sample 78460-65

*Type*: Sedimentary, unconsolidated 78460-64) with small breccia fragment (78465).
*Size*: 78465, 1.5x1x1 cm.

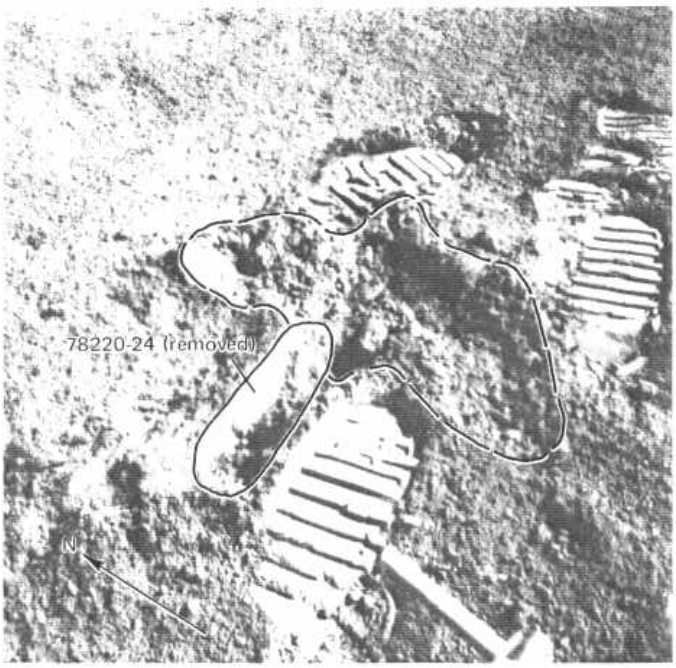



FIGURE 212.-Site of sample 78220-24, removed from surface beneath rolled norite boulder. Dashed line outlines impression made by boulder during rolling. (NASA photograph AS17-142-21704.)

*Weight:* 78460-64, 412.02 g; 78465,1.0313 g.
*Depth:* From 1 to 6 cm in 25-cm-deep trench.
*Location:* 7 m southeast of LRV.
*Illustrations:* Pans 25, 26; figure 216.
*Comments:* Sample 78460-65 represents mixed highlands and valley floor material.
*Petrographic description:* 78460-64, dominantly finegrained breccia and (or) n metaclastic rock -and agglutinate, *some glass.*
*Major-element composition:*

*Chemical analyses of 78461*

| | |
|---|---|
| $SiO_2$ | 42.6 |
| $Al_2O_3$ | 16.1 |
| FeO | 12.9 |
| MgO | 11.1 |
| CaO | 11.1 |

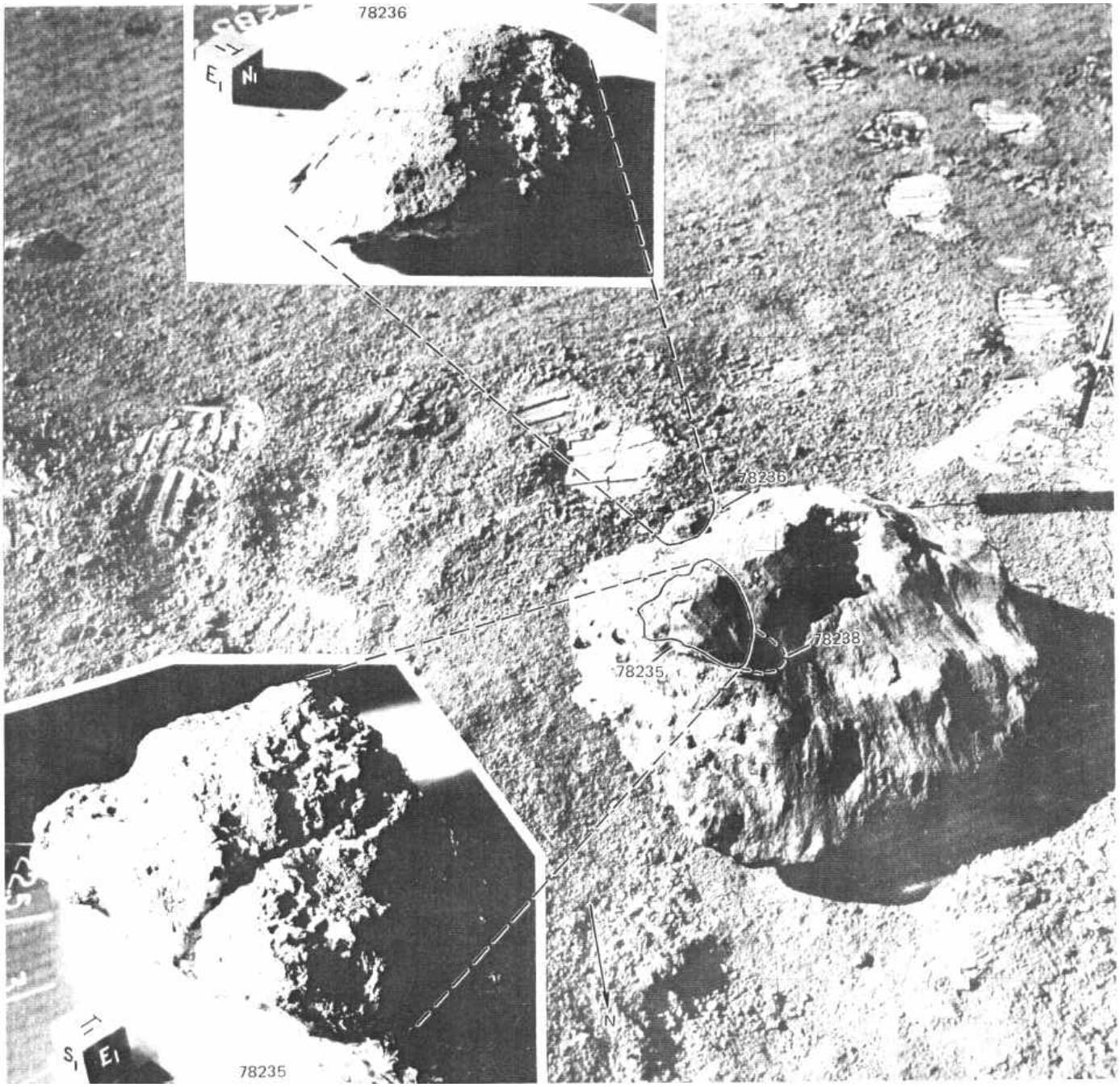



FIGURE 213.-Samples 713235, 78236, and 78238 before rolling of one-half-meter norite boulder at station 8. Insets show samples 78235 and 78236 with reconstructed lunar orientations and lighting. (NASA photographs AS17-146-22370; view similar to S-73-17962 (78235) and S-73-17817 (78236).)

*Chemical analyses of 78461- Continued*

| | |
|---|---|
| $Na_2O$ | .40 |
| $K_2O$ | -- |
| $TiO_2$ | 3.5 |
| $P_2O_5$ | -- |
| MnO | .158 |
| $Cr_2O_3$ | -- |
| Total | 99.858 |

78461,7 (Miller and others, 1974).

Sample 78480-84

*Type*: Sedimentary, unconsolidated.
*Weight:* 267 .45 g.
*Depth:* Skim sample from top centimeter of 25-cm-deep trench.
*Location:* 7 m southeast of LRV.
*Illustrations:* Pans 25, 26; figure 216.

*Comments*: Sample 78480-84 represents mixed high and valley floor material.

*Petrographic description:* 78480-84, dominantly agglutinate, fine-grained breccia and (or) metaclastic rock, glass, mid feldspathic cataclasite,

*Major element composition:*

*Chemical analyses of 78481*

| | |
|---|---|
| $SiO_2$ | 43.2 |
| $Al_2O_3$ | 17.0 |
| FeO | 12.0 |
| MgO | 11.3 |
| CaO | 10.6 |
| $Na_2O$ | .39 |
| $K_2O$ | -- |
| $TiO_2$ | 3.0 |
| $P_2O_5$ | -- |
| MnO | .160 |
| $Cr_2O_3$ | -- |
| Total | 97.65 |

78481,21 (Miller and others, 1974).

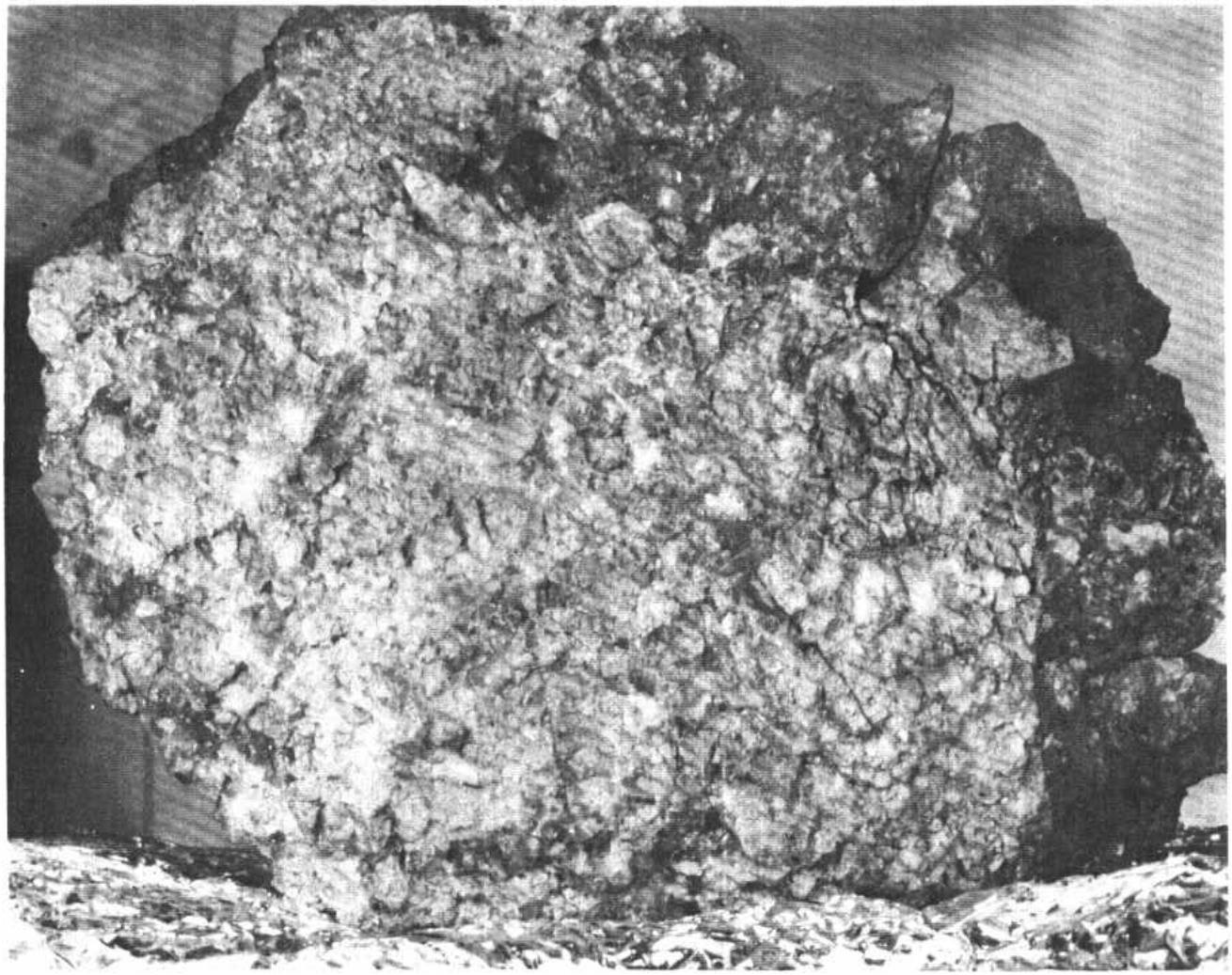


FIGURE 214.-Sample 78236. Norite composed of approximately equal proportions of cumulus orthopyroxene and plagioclase. Glass selvages at edge s of sample. As seen in this view, sample is approximately 7.5x5.3 cm. (NASA photograph S-73-17813.)

Sample 78500-09, 15-18

*Type*: Sedimentary, unconsolidated (78500-04); three fragments of olivine basalt (78505-07); sedimentary, weakly lithified polymict breccia (78508); basalt (78509); and four small breccia fragments (78515-18).

*Size*: 78505, 8x7.5x6.5 cm; 78506, 4.5x4x3 cm; 78507, 3.8x3.4x1.5 cm; 78508-09, 15-18, appreciably smaller.

*Weight:* 78500-04, 1,166.75 g; 78505, 506.3 g; 78506. 55.97 g;78507, 23.35 g; 78508-09, 15-18, 29.99 g total.

*Depth:* From upper few centimeter.

*Location:* Rim 15-m crater about 20 m northwest of the LRV.

*Illustrations: Pans* 25, 26; figures 210, 217 , 218 (78505, photomicrograph) , 219 (78506. LRL) , 220 (78507, LRL).

*Comments:* Sediment sample, collected to complement rake sample 78525-99, is a mixture of highlands and valley-floor regolith material excavated from the 15-m crater.

*Petrographic descriptions:*

78500-04, dominantly agglutinate, fine-grained breccia and (or) metaclastic rock, glass, and feldspathic cataclasite.

*Components of* 90-150-um fraction of 7 8501,1 *(Heike and McKaY, 1974)*

| *Components* | *Volume Percent* |
|---|---|
| Agglutinate | 35.3 |
| Basalt, equigranular | 11.0 |
| Basalt, variolitic | 11.0 |
| Breccia: | |
| Low grade[1] - brown | 2.3 |
| Low grade[1] - colorless | .3 |
| Medium to high grade[2] | 8.0 |
| Anorthosite | Trace |
| Cataclastic anrthosite[3] | 2.0 |
| Norite | Trace |
| Gabbro | -- |
| Plagioclase | 13.3 |
| Clinopyroxene | 6.0 |
| Orthopyroxene | 7.3 |
| Olivine | -- |
| Ilmenite | 3.7 |
| Glass: | |
| Orange | 2.0 |
| "Black" | 3.6 |
| Colorless | 1.0 |
| Brown | 2.3 |
| Gray, "ropy" | .3 |
| Other | 2.0 |
| Total number of grains | 300 |

1. Metamorphic groups 1-3 of Warner (1972).
2. Metamorphic groups 4-8 of Warner (1972).
3. Includes crushed or shocked feldspar grains.

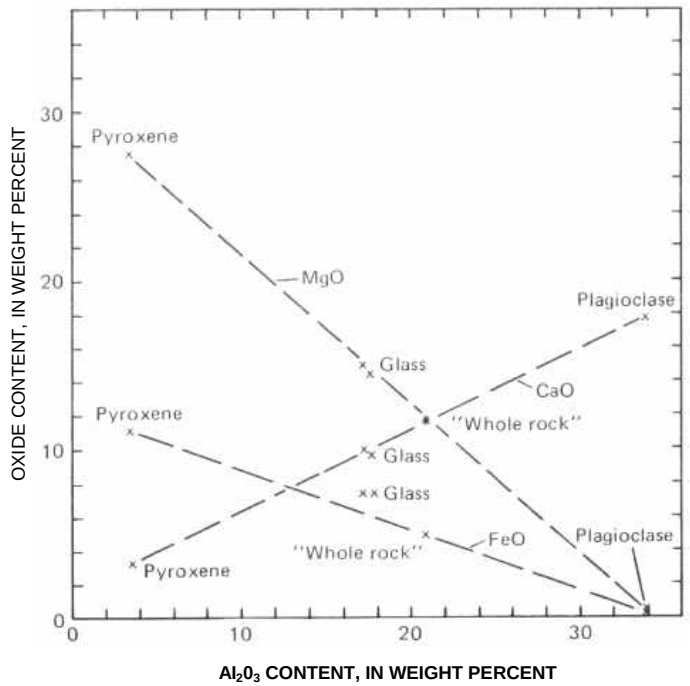



FIGURE 215.-Plot showing MgO, FeO, and CaO contents in relation to $A1_20_3$ Content for analyzed glasses, "whole-rock," low-calcium pyroxene, and plagioclase in sample 78235,34. Dashed lines are plagioclase-pyroxene joins. Plagioclase: pyroxene for glass is ~45:55 , for "whole rock" is ~57:43.

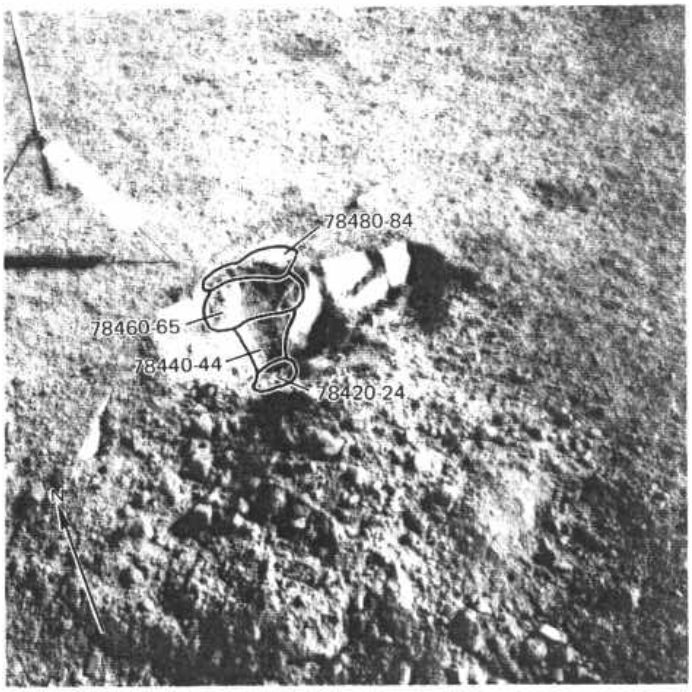



FIGURE 216.-Trench and locations of samples 78420-24, 78440-44, 78460-65, and 78480-84 at station 8. (NASA photograph AS17-142-21725.)

78505, coarse-grained vesicular porphyritic olivine basalt. Aggregates of clinopyroxeneilmenite in a locally plumose groundmass of plagioclase, clinopyroxene, ilmenite, and accessory minerals.

78506, medium-grained vesicular porphyritic olivine basalt with aggregates of clinopyroxene-ilmenite in a subophitic (?) groundmass of plagioclase, clinopyroxene, ilemenite,



78500-18

accessory minerals.

78507, medium-grained vesicular olivine basalt with an intergranular (?) groundmass.

78508 polymict breccia with clasts of basalt, fine-grained feldspathic metaclastic rock, and glass ill a moderately coherent fine-grained matrix.

78509, fine-grained vesicular basalt.

*Major-element compositions:*

*Chemical analyses of 78501, 78505, and 78506*

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| $SiO_2$ | 42.67 | 42.83 | 43.15 | 42.88 | -- | 38.5 |
| Al2O3 | 15.73 | 15.65 | 15.74 | 15.71 | 10.6 | 8.65 |
| FeO | 13.15 | 13.18 | 13.33 | 13.22 | 18.6 | 18.25 |
| MgO | 9.91 | 10.01 | 9.98 | 9.97 | 9.5 | 9.74 |
| CaO | 11.77 | 11.51 | 11.65 | 11.64 | 9.9 | 10.28 |
| $Na_2O$ | .35 | .38 | .42 | .38 | .458 | .39 |
| $K_2O$ | .09 | .090 | .11 | .10 | .070 | .05 |
| $TiO_2$ | 5.47 | 5.28 | 5.34 | 5.36 | 12.0 | 12.99 |
| $P^2O^5$ | .05 | .082 | .06 | .06 | -- | .05 |
| MnO | .18 | .177 | .18 | .18 | .227 | .25 |
| $Cr_2O_3$ | .37 | .355 | .31 | .34 | .436 | .50 |
| Total | 99.74 | 99.544 | 100.27 | 99.84 | | 100.60 |

1. 78501,2 (Apollo 17 PET, 1973).
2. 78501,12 (Duncan and others, 1974).
3. 78501,37 (Scoon, 1974).
4. Average of 1-3.
5. 78505,32 (Warner and others, 1975a).
6. 78506,29 (Rhodes and others, 1976).

Age:

$^{40-39}$Ar:

78503, 7. 1, 4.13±0.03 b.y.; 2-4-mm "gabbroic anorthosite" fragment interpreted by Bence tend others (1974) as initially plutonic (Schaeffer and Husain, 1974).

78503,7,6, 4.118±0.020 b.y.; 2-4-mm "recrystallized anorthositic" fragment (Schaeffer and others, 1976).

78503, 13A, 4.28±0.05 b.y.; 2-4-mm "poikilitic gabbro" fragment (Kirsten and Horn. 1974).

78503,13B, 3.83±0.05 b.y.; 2-4-mm basalt fragment (Kirsten and Horn, 1974).

Pb-Pb:

78503,13A, 3.96±0.03 b.y., 3.98±0.02 b.y., 3.91±0.05 b.y. determined on three zirconolites may represent an impact melt-

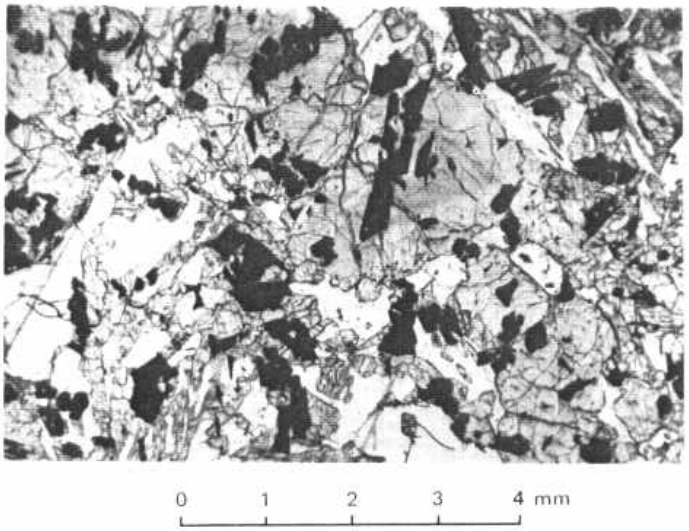



FIGURE 218.-Sample 78505. Photomicrograph showing aggregate of clinopyroxene-ilmenite (top center) in locally plumose groundmass of clinopyroxene, plagioclase, ilmenite.

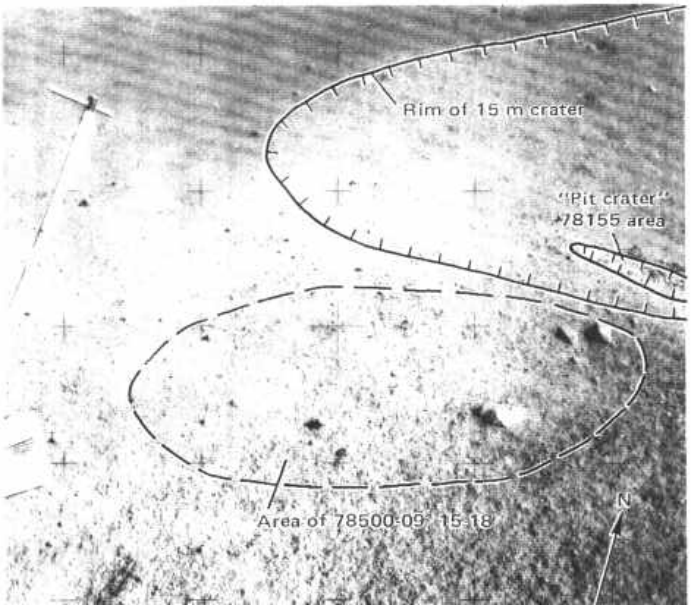



FIGURE 217.-Area of 78500-09, 15-18 before sampling. (NASA photograph AS 17-142-21707.)

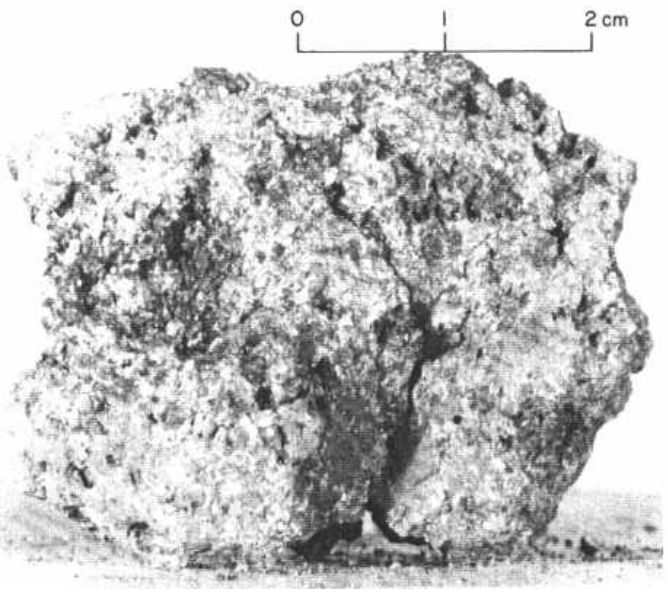



FIGURE 219. -Sample 78506. Medium-grained olivine basalt. (NASA photograph S-73-15467.)