are less than 10 cm in size. sediment sample was collected from an area between craters.

SUMMARY OF SAMPLING

Sample 75120-24

Type: Sedimentary, unconsolidated.

Weight: 375.21 g.

Depth: From upper few centimeters.

Location: Between Victory and Horatio craters on the valley floor. Illustration: Figure 129.

Petrographic description: 75120-24, dominantly basalt, some fine-grained breccia and (or) metaclastic rock, and glass.

Components of 90-150-um fraction of 75121,14 (Heiken and McKav.1974 Volum Components

Percent

Agglutinate	63.0
Basalt, equigranular	5.7
Basalt, variolitic	2.3
Breccia:	
Low grade ¹ - brown	2.0
Low grade ¹ - colorless	.3
Medium to high grade ²	3.7
Anorthosite	
Cataclastic anrthosite ³	
Norite	
Gabbro	
Plagioclase	4.0
Clinopyroxene	8.7
Orthopyroxene	
Olivine	
Ilmenite	.7
Glass:	
Orange	3.0
"Black"	3.7
Colorless	1.7
Brown	1.0
Grav "ronv"	
Other	3
Total number of grains	300

Metamorphic groups 1-3 of Warner (1972).

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

STATION 5

LOCATION

Station 5 is located on the blocky southwest rim of Camelot crater (figs. 7C and 130).

OBJECTIVES

Exploration objectives at station 5 were to observe subfloor and dark mantle materials in the floor, rim, and walls of Camelot crater and to sample them on the rim.

GENERAL OBSERVATIONS

Camelot is a low-rimmed 650-m crater. Abundant Rocks are exposed in a few places around the crater rim. They extend downward on the crater walls but are absent from the crater floor. The block abundance decreases markedly within a few meters outward from the

rim crest, where the terrain is smooth and undulating. In the station area, the rocks of the blocky rim cover about 30 percent of the surface (pans 19, 20). They range in size from a few centimeters to over 3 m, are subrounded to subangular, and are moderately to deeply buried. Filleting appears to be minimal. The crew described the boulder tops as free of sediment except for one flat 3-m boulder.

Younger craters up to 20 m in size are scattered around the rim and on the floor of Camelot, and a 100-m crater is superposed on the north rim. Most of the younger craters have subdued smooth rims and shallow floors.

Undisturbed fine regolith material at station 5 displays the "raindrop" pattern observed at some of the previous stations such as LRV-2 and LRV-3.

Samples from station 5 were four basalt fragments chipped from boulders and two sediment samples, one from on top of a boulder and one from between boulders.

GEOLOGIC DISCUSSION

Camelot crater is the largest crater visited by the Apollo 17 crew. Boulders on its rim most probably represent the deepest sampled part of the subfloor basalt, perhaps from a depth of more than 100 m.

The three boulder samples (75015, 75035, and 75055) are chemically unique among the Apollo 17 basalt samples; they have higher than normal concentrations of SiO₂, A1₂O₃, and CaO, and lower than normal concentrations of FeO, MgO, TiO₂, and Cr₂O₃. Interpreting trace-element as well as major-element distributions, Rhodes and others (1976) suggested that the major-element variations in the Apollo 17 basalt were produced largely by shallow-level fractional crys-



FIGURE 129.-Station LRV-8 area and probable location of sample 75120-24 collection site. (NASA photograph AS 17-133-20315.)

tallization in three or more lava flows. They viewed the relatively coarse and chemically unique Camelot boulders as samples of highly fractionated basalt from deep within a thick, slowly cooled lava flow; samples from other stations include less fractionated basalt of the same magma type.

Sediment samples from station 5 are rich in basaltic debris. Their chemical compositions (fig. 131) are like those associated with the basalt-rich cluster ejecta.

The rim of Camelot looks smoother than the rims of craters in the large cluster south and east of the landing point. Hence, on photogeologic grounds, Camelot was interpreted as older (Lucchitta, 1972). However, topographic profiles made by analytical stereoplotter show that the depth-to-diameter ratio for Camelot is similar to that for the clustered craters to the southeast. Their appearance of greater freshness may be due to the abundant smaller craters, not present at Camelot, that have distinctly roughened the topography.

The many exposures ages determined for the three boulder samples from station 5 range from 70 to 95 m.y. Because of their unusual composition and their occurrence among the large concentration of boulders on the crater rim, we confidently interpret the three sampled boulders as excavated from the subfloor basalt by the Camelot impact. Hence 70-95 m.y. approximates or is at least a younger limit for the age of Camelot crater. Arvidson and others (1976b) discussed the possibility that 75015 and 75035 (exposure ages approximately 72-92 m.y.) had undergone a pronounced shielding change, perhaps due to catastrophic rupture of a single boulder to form the two sampled boulders. If so, the exposure ages of these two samples are less than the age of Camelot crater.



FIGURE 130.-Planimetric map of station 5.

SUMMARY OF SAMPLING

Sample 75015

Type: Basalt.
Size:10x9x6 cm.
Weight: 1,006 g.
Location: From boulder in block field on southwest rim of Camelot.
Illustrations: Pan 19; figures 132,133 (LRL).
Comments: Subfloor basalt ejected from Camelot crater.
Petrographic description: Coarse-grained vesicular basalt.
Intergranular to subophitic groundmass.

Major-element composition:

Chemical analysis of 75015

SiO ₂	41.92
Al ₂ O ₃	10.06
FeO	18.77
MgO	6.20
CaO	12.15
Na ₂ O	.48
K ₂ O	.06
TiO ₂	9.56
P2O5	.05
MnO	.29
Cr ₂ O ₃	.17
Total	99.71

70035, 1 (Apollo 17 PET, 1973).

Exposure age: Kr-Kr: 92 ± 4 m.y. (Arvidson and others, 1976b).

Sample 75035

Type: Basalt.
Size: 16x14x7 cm.
Weight: 1,235 g.
Location: From boulder in block field on southwest rim of Camelot.
Illustrations: Pan 19; figures 132,134 (LRL).
Comments: Subfloor basalt ejected from Camelot crater.
Petrographic description: Medium-grained basalt with plumose to subophitic (?) groundmass.

Major- element composition:

	Chemical analyses of 75035			
	1	2	3	4
SiO ₂	42.31	41.1	42.61	42.01
Al ₂ O ₃	10.30	9.24	10.05	9.86
FeO	18.57	19.2	18.08	18.6
MgO	6.28	6.12	6.25	6.22
CaO	12.15	11.68	12.53	12.12
Na ₂ O	53	.460	.39	.46
K ₂ O	061	.084	.08	.08
TiO ₂	8.95	10.09	9.59	9.54
P ₂ O ₅	084	.080	.06	.07
MnO		.266	.27	.27

TRAVERSE GEOLOGY AND SAMPLES-STATION 5

Chemical analyses of 75035-Continued

	1	2	3	4
Cr ₂ O ₃	.207	.235	.26	.23
Total	99.704	98.558	100.17	99.46

75035,19 (Duncan and others, 1976). 75035,46 (Wanke and others, 1975). 1.

2. 3. 75035,65 (Rose and others, 1975).

Average of 1 through 3.

Age

⁴⁰⁻³⁹Ar: 75035,21, 3.77±0.04 b.y. (Turner and Cadogan, 1975). Rb-Sr isochron: 75035,43, 3.81 ±0.14 (20) b.y. (Murthy, 1976).

Exposure age:

Ar: 75035,21, 80 m.y. (Turner and Cadogan, 1975). Kr: 75035, 71.7 \pm 1.8 m.y. (Crozaz and others, 1974).

Sample 75055

Type: Olivine basalt. Size: 21x14x1.8 cm. Weight: 949.4 g. Location: From boulder in block field on southwest rim of Camelot. Illustrations: Pan 19; figures 135, 136 (photomicrograph). Comments: Subfloor basalt ejected from Camelot crater. Petrographic description: Coarse-grained olivine basalt



FIGURE 131.-Relative amounts of TiO2, A12O3, and FeO+MgO in sediment samples 75061 and 75081 (crosses), from station 5, 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).

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with subophitic groundmass composed а of plagioclase, clinopyroxene, ilmenite, and accessory minerals.

Major-element composition:

Chemical analyses of 75055			
	1	2	3
SiO ₂	41.27	39.93	40.60
Al ₂ O ₃	9.75	9.58	9.66
FeO	18.24	17.77	18.00
MgO	6.84	7.26	7.05
CaO	12.30	12.40	12.35
Na ₂ O		.42	.43
K ₂ O	09	.06	.08
TiO ₂	10.17	11.41	10.79
P ₂ O ₅	07	.06	.06
MnO	29	.27	.28
Cr ₂ O ₃	.27	.31	.29
Total	99.73	99.47	99.59

75055,6 (Apollo 17 PET, 1973). 75055,75 (Rhodes and others, 1976). 2

3. Average of 1 and 2.

Age:

Rb-Sr isochron:

75055, 3.77±0.06 (2o) b.y. (Tera and others, 1974b). 75055, 3.83±0.10 (2o) b.y. (Tatsumoto and others, 1973).

⁴⁰⁻³⁹Ar:

75055,11,2, 3.82±0.05 b.y. (Kirsten and Horn, 1974). 75055, 3.78±0.04 b.y. (Huneke and others, 1973). 75055, 3.76±0.05 b.y. (Turner and others, 1973).

Exposure age: Ar:

75055,11,2, 85±10 m.y. (Kirsten and Horn, 1974). 75055,95 m.y. (Huneke and others, 1973). 75055,90 m.y. (Turner and others, 1973).

Tracks:

75055,70 m.y. (Kirsten and others, 1973).

Sample 75060-66

Type: Sedimentary, unconsolidated (75060-64), basalt (75065), and breccia (75066).

Size: 75065,1x1x1 cm; 75066, 1.2x1x0.5 cm.

Weight: 75060-64, 184.86 g; 75065, 1.263 g; 75066,

0.98 g.

Depth: 0-1 cm.

Location: Top of boulder in block field on southwest rim of Camelot.

Illustrations: Pan 19; figure 137.

Comments: Mantling material from small centimeter deep hollow in the upper surface of a flat 3-m boul-

der; sample collected one-half m in from east side of boulder. Petrographic description: 75060-64, dominantly basalt with minor metaclastic rock and (or) breccia, rare glass.

Components of 90-150-um fraction of 75061,2 (Heiken and McKay, 1974 Voluma Componente

Components	Percent
Agglutinate	24.0
Basalt, equigranular	26.6
Basalt, variolitic	26.6
Breccia:	
Low grade ¹ - brown	2.6
Low grade ¹ - colorless	2.0
Medium to high grade ²	.3
Anorthosite	
Cataclastic anrthosite ³	
Norite	
Gabbro	
Plagioclase	4.6
Clinopyroxene	29.6
Orthopyroxene	
Olivine	.3
Ilmenite	5.3
Glass:	
Orange	1.0
"Black"	
Colorless	1.6
Brown	1.6
Gray, "ropy"	
Other	
Total number of grains	299

Metamorphic groups 1-3 of Warner (1972).

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

Major-element composition:

Chemical analyses of 75061

	1	2	3
SiO ₂	39.32	39.70	39.51
Al ₂ O ₃	10.42	10.60	10.51
FeO	18.19	17.86	18.02
MgO	9.53	9.65	9.59
CaO	10.72	10.72	10.72
Na ₂ O	33	.37	.35
K ₂ O	08	.08	.08
TiO ₂	10.31	10.46	10.38
P ₂ O ₅	06	.06	.06
MnO	25	.24	.24
Cr ₂ O ₃	.48	.48	.48
Total	99.69	100.22	99.94

75061,4 (Apollo 17 PET, 1973). 75061,27 (Rose and others, 1974).

3

Average of 1 and 2.

Exposure age:

Minimum track density:

75061, 32 m.y.

75062, 40 m.y., interpreted as concordant ages of 36±4 m.y. for the top centimeter of sediment mantling the 75075 boulder (Fleischer and Hart, 1974).

Sample 75075

Type: Olivine basalt. Size: 15x12x5 cm.

Weight: 1,008 g.

Location: Top of boulder in block field on southwest rim of Camelot. *Illustrations:* Pan 19; figures 137, 1:38 (photomicrograph), 1:39.

Comments: Sample 75075 was a loose fragment on top of a 3-ili flat boulder. It differs significantly front the three station 5 boulder samples (75015, 75035, and 75055) in both composition and exposure history; hence, it is probably a fragment ejected from the



FIGURE 132.-Locations of samples 75015 and 75035 before collection. Inset shows 75035 with reconstructed lunar surface orientation and lighting. (NASA photographs AS-17-145-22138; S-73-19593.) regolith by a post-Camelot impact.

Petrographic description: Medium-grained vesicular porphyritic olivine basalt. Scarce clinopyroxeneilmenite aggregates in a locally plumose groundmass of plagioclase, clinopyroxene, ilmenite, and accessory minerals.

Major-element composition:

Chemical analyses of 77075			
	1	2	3
SiO ₂	37.64	38.51	38.08
Al ₂ O ₃	8.20	8.29	8.24
FeO		18.85	18.82
MgO	9.49	9.68	9.58
CaO	10.29	10.17	10.23
Na ₂ O		.37	.38
K ₂ O		.11	.08
ΓiO ₂	13.45	13.33	13.39
P ₂ O ₅		.12	.08
MnO		.25	.26
Cr ₂ O ₃	.57	.55	.56
Total	99.26	100.23	99.70

75075,58 (Rhodes and others, 1974). 75075,72 (Rose and others, 1974). Average of 1 and 2.

3

Age:

Rb-Sr	isochron:
	75075,57, 3.82±0.06 (20) b.y. (Murthy, 1976).
	75075,58, 3.84±0.12 (20) b.y. (Nyquist and others,
	1975).
⁴⁰⁻³⁹ Ar	:
	75075, 3.74 \pm 0.06 b.y. (Jessberger and others, 1975).
Sm-N	d isochron:
	75075, 3.69±0.08 (26) b.y. (Lugmair and others,
	1975a).
Exposure age.	:
Ar:	
	144 m.y. (Lugmair and others, 1975b).
	120±15 m.y. (Jessberger and others, 1975).
Kr:	
	143±5 m.y. (Lugmair and others, 1975b).
	143 m.y. (Arvidson and others, 1975).

Sample 75080-89

Type: Sedimentary, unconsolidated (75080-84) and basalt fragments (75085-89).



FIGURE 133.-Sample 75015. Coarse-grained vesicular basalt. (NASA photograph S-73-16666.)

Size: Largest fragment (75087) is 2x2 x1 cm.

Weight: 75080-84,1,549.71 g; 75085-89, 12.65 g.

Depth: 0-5 cm.

Location: Between boulders in block field on southwest rim of Camelot.

Illustrations: Pan 19; figure 139.

Comments: Collected from regolith surface adjacent to boulder from which samples 75060-66 and 75075 were collected.

Petrographic description: 75080-84, dominantly basalt with some glass, possible agglutinates.

Components of 90-150-um fraction of 75081,36 (Heiken	and
McKay, 1974)	

Components	Volume Percent
Agglutinate	41.7
Basalt, equigranular	1.3
Basalt, variolitic	1.3
Breccia:	
Low grade ¹ - brown	9.3
Low grade1 - colorless	6.3
Medium to high grade ²	19.3
Anorthosite	1.0
Cataclastic anrthosite ³	1.3
Norite	.7
Gabbro	
Plagioclase	6.7
Clinopyroxene	3.0
Orthopyroxene	3.3
Olivine	.7
Ilmenite	.3
Glass:	
Orange	.3
"Black"	.3
Colorless	1.3
Brown	1.0
Gray, "ropy"	.3
Other	
Total number of grains	300

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

3.

Major-element compositions:

Chemical analyses of 75081

	1	2	2	4
	1	2	3	4
SiO ₂	40.27	40.00	40.12	40.13
Al ₂ O ₃	11.31	11.18	11.31	11.27
FeO	17.20	17.30	17.29	17.26
MgO		9.42	9.44	9.48
CaO	10.97	10.87	10.89	10.91
Na2O		.38	.36	.36
K ₂ 0		.08	.074	.08
ñO ₂	9.41	9.40	9.60	9.47
P ₂ O ₅		.07	.082	.07
		.25	.228	.24
Cr_2O_3	.46	.45	.470	.46
Total	99.94	99.40	99.864	99.73

 1.
 75081,3 (Apollo 17 PET, 1973).

 2.
 75081,56 (Rhodes and others, 1974).

 3.
 75081,66 average of four analyzed size fractions (Duncan and others, 1974).

 4.
 Average of 1 through 3.

AloO ₂ 10		
10/03).4	8.7
FeO).4	20.6
MgO	3.9	9.8
CaO 11	.8	10.0
Na ₂ O	.379	.394
K ₂ 0	.060	.065
TiO ₂ 11	.9	13.2
P ₂ O ₅		
MnO	.255	.240
Cr ₂ O ₃	.310	.531

1. 75088,1 (Warner and others, 1975a).

2. 75089,1 (Warner and others, 1975a).

Ages of 2-4-mm. basalt fragments in 75083:

⁴⁰⁻³⁰Ar:

75083,2,1, olivine-porphyritic ilmenite basalt, 3.77±0.05 b.y.



FIGURE 134.-Sample 75035. Medium-grained basalt. (NASA photograph S-73-16252.)

75083,2,3, Apollo 11 type basalt, 3.75±0.04 b.y.
75083,2,4, olivine-porphyritic ilmenite basalt, 3.67±0.10 b.y.
75083,2,5, intermediate between olivineporphyritic ilmenite basalt and plagioclase-poikilitic ilmenite basalt, 3.74±0.04 b.y.

75083,2,8, plagioclase-poikilitic ilmenite

basalt, 3.68±0.10 b.y. 75083,2,9, plagioclase-poikilitic ilmenite basalt, 3.68±0.07 b.y. 75083,2,15, plagioclase-poikilitic ilmenite basalt, 3.75±0.05 b.y. Above dates by Schaeffer and Husain, reported in

Papike and others (1974): basalt classification of Papike and others (1974).



FIGURE 135.-Location of sample 75055 before collection. Inset shows 75055,1 with reconstructed lunar surface orientation and lighting. (NASA photographs AS17-145-22149; S-73-17796.)

Exposure age of 75081:

Tracks:

Estimate for 5 cm burial, 97 m.y.

Estimate for 3 cm burial, 56 m.y. (Bull and Durrani, 1976).

Minimum track density:

Estimate for 5 cm burial, -146 m.y., based on 110-m.y. exposure at 4-cm depth prior to being covered by 1 cm -36 m.y. ago (75061, 75062 data) (Fleischer and Hart, 1974).

STATION LRV-9

LOCATION

Station LRV-9 is about 1.5 km north of the LM/ ALSEP/SEP area, about halfway between the LM and station 6, and about 500 m, slightly less than a crater diameter, south of Henry crater (figs. 6 and 7D).

OBJECTIVES

LRV-9 was a planned Rover sample and photography stop.

GENERAL OBSERVATIONS

The surface in the area of LRV-9 is flat to gently rolling. There are scattered craters up to 10 m in size and smaller rimless depressions in the area. Rock fragments up to a few tens of centimeters in size are sparse and appear to have been excavated from the local craters. The fragments cover less than 1 percent of the surface, are angular to subrounded, and are slightly to mostly buried. Filleting is rare in the area.

The sample came from a small crater with abundant clods on its rim.



FIGURE 136.-Sample 75055. Photomicrograph showing coarsegrained ophitic intergrowths of clinopyroxene, plagioclase, and ilmenite.

SUMMARY OF SAMPLING

Sample 76120-24

Type: Sedimentary, unconsolidated.

Weight:: 303.92 g. *Depth: From* upper few centimeters.

Location: Meter-size crater at LRV-9.

Illustration: Figure 140.

Comments: Sample 76120-24 represents local regolith material that may include ejecta from Henry crater. Petrographic description: 76120-24, dominantly fine. grained

breccia and (or) metaclastic rock, some agglutinate.

STATION LRV-10

LOCATION

Station LRV-10 is located adjacent to Turning Point rock (fig. 144), about 2.8 km north of the LM/ALSEP/SEP area (figs. 6 and 7D).

OBJECTIVES

Station LRV-10 was an unplanned sampling and photography stop.

GENERAL OBSERVATIONS

The station area is near the gradational contact between valley floor and North Massif; it is on a moderate slope of about 10° to the south with fairly distinct breaks in slope both above and below the sampling site.

Turning Point rock is about 6 m high and perhaps 10 m across in its longest dimension. It is surrounded by a halo of smaller boulders and rock fragments that are rounded, partly buried, and filleted on their uphill sides. Outside the halo of boulders around Turning Point rock, fragments large enough to be recognized in photographs make up less than 1 percent of the surface material.

Sparse subdued 1-5-m craters, generally without blocks or clods, are, scattered around the sample area.

Samples included sediment and three rock fragments collected about 4 m north of Turning Point rock.

SUMMARY OF SAMPLING

Sample 76130-37

Type: Sedimentary, unconsolidated (76130-34); metaclastic rock with a poikilitic matrix (76135); olivine

basalt (76136), and small rock fragment (76137).

Size: 76135, 7x6x4 cm; 76136, 6x4x3 cm; 76137,

1.8 x1.5 x1 cm.

Weight: 76130-34, 180.77 g; 76135, 133.5 g; 76136, 86.6g; 76137, 2.46 g.

Depth: From upper few centimeters.

Location: Approximately 4 m north of Turning Point

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rock at LRV-10.

- *Illustrations:* Figures 141, 142 (LRL, 76135), 143 (photomicrograph, 76136).
- *Comments:* LRV-10 is in a zone where North Massif and valley floor material, represented respectively by samples 76135 and 76136, are mixed.

Petrographic descriptions:

- 76130-34, no description available.
- 76135, vesicular metaclastic rock with scarce metatroctolitic clasts in poikilitic matrix of

pyroxene oikocrysts enclosing both newly

crystallized plagioclase and abundant mineral clasts of plagioclase and olivine. Clusters and fragments of intergrown spongy

plagioclase and brown pyroxene that line cavities in other rocks are present.

76136, medium-grained olivine basalt with a variolitic groundmass composed of plagioclase, clinopyroxene, ilmenite, and accessory minerals.



FIGURE 137-Locations of samples 75060-66 and 75075 before collection. Inset shows- 75075 with reconstructed lunar surface orientation and lighting. (NASA photographs AS17-145-22155; S-73-17800.)

Major – element composition:

Chamical	anabysas	of 76136
Chemicai	unuiyses	0170150

38.60	
8.65	
19.12	
8.61	
10.53	
.38	
.06	
12.64	
.06	
.28	
.44	
99.37	
	38.60 8.65 19.12 8.61 10.53 .38 .06 12.64 .06 .28 .44 99.37

76136,8 (Rhodes and others, 19736).

STATION 6

LOCATION Station 6 is in a blocky area on the south slope of the North Massif about 0.4 km northeast of Turning Point rock (figs. 7D and 144).

OBJECTIVES

The objectives at station 6 were to characterize and sample (1) the blocks and sediment of the North Massif and (2) dark mantle materials that extend upward locally onto the lower slopes of the massif.

GENERAL OBSERVATIONS

Station 6 is on an 11° slope, about 250 m north of the break in slope between the valley floor and the massif. The most prominent local feature is a cluster of five large blocks alined downslope from the end of a single boulder track that originates from a point about onethird of the way up the face of the massif (figs. 144, 145). Several other tracks originating near the same level, about 500 m above the valley floor, can be seen



FIGURE 138-Sample 75075. Photomicrograph showing large aggregate of clinopyroxene-ilmenite with small olivine core (left half)

groundmass that is locally plumose intergrowth of plagioclase, inopyroxene, and ilmenite. Crossed polarizers.

in figure 145. Fields of blocks are abundant from this level upward; at about this same level the slope increases from about 21.5° in the lower one-third for about 25° in the upper two-thirds of the massif.

Fragment distribution is bimodal in the station area. There are relatively few fragments in the 3-15-cm size range. Blocks greater than one-half' meter in size are generally gathered in clusters, but fragments less than one-half meter in size are scattered over the area. Most of the blocks are subrounded to rounded, but a few are angular. Some of the larger boulders have well developed fillets on the uphill sides, but fillets are absent or only slightly developed on the smaller blocks. Smooth-rimmed and relatively block free craters up to 10 m in size appear randomly scattered over the surface in the station area. A few small fresh craters have blocky rims with the ejecta deposited preferentially downslope. Near crater rims, bootprints and LRV wheel marks indicate that the sediment is relatively soft; however, the regolith surface between craters is moderately firm.

Samples at station 6 include a single drive tube, ten rock samples, seven sediment samples, and one rake sample (fig. 146). Of the ten rock samples, three were from the surface, four were from block 1, and one each came from blocks 2, 4, and 5. Three of the sediment samples were taken from between major blocks. One sediment sample was collected downslope from the blocks, another from the boulder track, another from on top of block 1, and the last from the ejecta blanket of a small crater. The rake collected 23 chips from the ejecta blanket of the small crater.

GEOLOGIC DISCUSSION

The North Massif, like the South Massif, is interpreted as a fault-bounded block of ejecta deposited and faulted by the impact that formed the southern Serenitatis basin. In the upper two-thirds of the massif, where concentrations of boulders abound (fig. 145), bedrock is probably close to the surface. The less steep slope of the lower one-third is probably the surface of a thick colluvial wedge (fig. 242) onto which boulders from the upper part of the massif have rolled.

The five large blocks at station 6 are alined and probably represent a single fragmented boulder (fig. 146). Blocks 1 and 2 and 2 and 3 can be pieced back together as shown in figures 147 and 148. Blocks 4 and 5 can also be easily rejoined with minimal manipulation. However, fit between the blocks 1-2-3 reconstruction and the blocks 4-5 reconstruction is uncertain. Block 2, the largest of the five, is about 10 m across. Reassembled, the whole boulder would measure approximately 18x10x6 m.

On the basis of lunar surface photographs and de-

scriptions as well as preliminary sample descriptions, Muehlberger and others (1973) distinguished two major breccia types, greenish-gray and blue-gray breccia. Blocks 3, 4, and 5 and part of block 2 are greenish-gray breccia. Block 2 shows an irregular contact zone about 50 cm wide between greenish-gray breccia to the southwest and blue-gray breccia to the northeast. Block 1 is also blue-gray breccia. Light-colored inclusions occur in both breccia types.

A modified classification (fig. 149), utilizing, in particular, differences in degree of vesicularity and foliation, was developed by Heiken and others (1973); it provides the stratigraphic frame of reference used in subsequent reports by members of the consortium to study the station 6 boulder (for example, Simonds, 1975).

In spite of variable vesicularity, color, and degree of foliation, the station 6 boulder consists of a chemically



FIGURE 139-Locations from which samples 75075 and 75080-8 were collected. (NASA photograph AS 17-145-22158.)

uniform matrix (fig. 150) with clasts up to about a meter in size of anorthosite-norite-troctolite suite rocks or their impact-modified derivatives. According to Simonds (1976), the matrix is a clast-bearing rock formed from a mechanical mixture of cold, generally little shocked clasts and superheated impact melt that was quenched to form a very fine subophitic to ophitic crystalline groundmass. The approximate mode of the groundmass is 50 percent plagioclase, 30 percent pigeonite, 13 percent olivine, 5 percent augite, and 2 percent ilmenite and accessory minerals. Clast abundance ranges from about 2 to 40 percent (Simonds, 1975; Warner and others, 1976).

Simonds (1975) has described several properties of the clasts and the crystallized groundmass that vary systematically with the groundmass grain size. With increasing groundmass grain size, (1) clast abundance decreases, (2) the ratios of mafic to feldspathic clasts and of pyroxene to olivine clasts decrease, and (3) groundmass pyroxene and plagioclase become, respectively, more magnesian and more calcic. Simonds has interpreted these systematic variations as related to initial clast content in the clast-melt mixture. Where the clast-melt ratio was high, the matrix was rapidly quenched; its grain size is extremely fine; little or no digestion of clasts occurred. Where there was initially more melt. the melt was less rapidly quenched; its grain size is coarser, and its composition was modified by digestion of the smaller and less refractory clasts. Modeling the cooling of the clast-melt mixture inferred by Simonds for the station 6 boulder, Onorato and others (1976) have suggested that thermal equilibrium between clasts and melt is achieved in a time on the order of 100 seconds, with 90 percent of the change from initial melt temperature to the equilibrium temperature occurring within about 1 second.

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The ${}^{40-39}$ Ar age of the station 6 boulder has been ilitensively examined by Cadogan and Turner (1976), who concluded that the impact event that aggregated the boulder occurred 3.96 ± 0.04 b.y. ago. Exposure age measurements by Crozaz and others (1974) suggest that the boulder rolled to its present position, forming its prominent track, about 22 m.y. ago.

Other rocks collected at station 6 include breccia, a few subfloor basalt. fragments. and a metatroctolite (76535) that has been interpreted as a metamorphosed derivative of a deep-seated plutonic rock that could have been an early lunar differentiate formed during the same magmatic event as the one represented by dunite sample 72415-18 from station 2.

Unconsolidated sediment of the station 6 regolith is highlands debris like that of the South Massif and light mantle with a 20 to 30 percent admixture of basalt debris and ash from the valley floor (fig. 151).

SU MMARY OF SAMPLING

Sample 76001

Type: Single drive tube. *Weight:* 711.6 g.



FIGURE 140. - Station LRV-9 sampling area. (NASA photograph AS 17-141-21543.)

FIGURE 141.-Station LRV-10 area after sampling. Sample 76130-37 was probably collected from behind rock in foreground. (NASA photograph AS 17-140-21396.)

GEOLOGIC INVESTIGATION OF THE TAURUS-LITTROW VALLEY: APOLLO 1 7 LANDING SITE

Length: 35.5 cm. Depth: Approximately 37.1 cm. Location: 3-4 m southeast, of the LRV at station 6. Illustrations: Pans 21, 22; figure 152. Comments: Drive tube has not been opened.

Sample 76015

Type: Metaclastic rock with a poikilitic matrix. *Size:* 20x16x14 cm. Weight: 2 ,819 g. *Location:* North side of block 5 at station 6.

Illustrations: Pans 21, 22; figures 153, 154 (LRL).

Comments: Sample 76015 is a greenish-gray breccia similar in texture and color to sample 76215 from block 4. Both are from well-foliated unit B (fig. 149) defined by Heiken and others (1973).

Petrographic description: Vesicular metaclastic rock with scarce lithic Blasts of plagioclase-, pyroxene-, or (rare) olivine-rich hornfels arid mineral clasts of plagioclase and some olivine in a poikilitic matrix with low-calcium pyroxene oikocrysts enclosing newly crystallized plagioclase and broken mineral debris. Cavities are irregular to spherical.

Simonds (1975) interpreted sample 76015 as a clast-bearing poikilitic impact melt. The crystallized melt is now represented by a continuous network of interlocking pigeonite oikocrysts enclosing small plagioclase crystals. Mineral and lithic clasts make up about 14 volume percent of the sample. Most mineral clasts lack definitive shock features. Larger plagioclase fragments commonly have overgrowths up to 20 um wide that tend to make theta euhedral. As determined by



FIGURE 142.-Sample 76135. Metaclastic rock with poikilitic matrix. (NASA photograph S-73-15405.)

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FIGURE 143.-Sample 76136. Photomicrograph showing medium grained olivine basalt with variolitic texture. Crossed polarizers.

Major-element composition:

Chemical analyses of 76015

	1	2	3	4
SiO ₂	46.16	46.38	46.38	46.59
Al ₂ O ₃	17.17	17.78	17.77	18.00
FeO	9.81	9.65	9.07	9.10
MgO	13.03	12.40	12.67	12.43
CaO	10.77	11.13	11.11	11.10
Na ₂ O	.70	.72	.69	.75
K ₂ Ō	.26	.26	.26	.29
TiO ₂	1.52	1.55	1.53	1.48
P ₂ O ₅	.27	.29	.29	.28
MnO	.13	.13	.12	.12
Cr ₂ O ₃				
Total	99.82	100.29	99.89	100.14

76015,22, matrix (Rhodes and others, 1974).

76015,37, matrix (Rhodes and others, 1974).
 76015,41, matrix (Rhodes and others, 1974).

4. 76015,64, matrix (Rhodes and others, 1974).

Age: 40 39 Ar:

1.

76015,38 (matrix), 3.93±0.04 b.y. (Cadogan and rurner, 1976).



FIGURE 144.-View from LRV of North Massif showing Turning Point rock (LRV-10) and stations 6 and 7. Dark boulder is at end of boulder track originating, high on massif, and station 6 boulder is at end of barely visible track originating at point labeled "source." Figure 145 gives a telephoto view of some of these features. (NASA photographs AS 17 141-21549, 21550.)



FIGURE 145.-Telephoto view of North Massif, taken from LM area, shows scattered fields of blocks on massif face and source of track made by station 6 boulder. Upper ends of three other boulder tracks are identified by the word "track." (NASA photographs AS 17-144-21991, 22119 to 22122, and 22127 to 22130.)

76015,38 (plagioclase concentrate),	polymict breccia with an aphanitic matrix (76035); breccia
3.96±0.06 b.y. (Cadogan and Turner,	(76036); and basalt (76037).
1976).	Size: 76035, 12x5.5x5 cm; 76036, 2.5x2x0.6 cm; 76037, 1.7x1.2x0.8
76015,36 (plagioclase concentrate), 3.96±0.04 b.y.	cm.
(Cadogan and Turner, 1976).	Weight: 76030-34, 180.96 g; 76035, 376.2 g; 76036, 3.95 g; 76037,
Exposure age:	2.52 g.
Kr: 17.5±0.5 m.y. (Crozaz and others, 1974).	Depth: Upper few centimeters.
Track: 18.3±3 m.y. (Crozaz and others, 1974).	Location: Small crater about 20 m east of blocks. 76035 and possibly
The difference between this exposure age and the slightly	76036 from a one-third-meter boulder in the small crater.
greater exposure age measured on 76351 is interpreted as due	Illustrations: Pan 21, 22; figures 155, 156 (photomicrograph, 76035)
to a change in shielding, perhaps in the event that separated	,166.
block 5 from the rest of the station 6 boulder. On the basis of	Comments: Sample 76035 was chipped from a one third-meter
solar flare track measurements, Crozaz and others (1974)	boulder that may represent electa from a crater higher up on the

Sample 76030-37

estimate that block 5 was broken away about 1 m.y. ago.

Type: Sedimentary, unconsolidated (76030-34);

,166. Comments: Sample 76035 was chipped from a one third-meter boulder that may represent ejecta from a crater higher up on the North Massif. Sample 76036 may also have been chipped from the boulder or may be a regolith fragment. Sample 76037 is probably a chip of subfloor basalt from the local regolith. Sediment sample 76030-34 represents the local regolith, presumably a mixture of North Massif and valley floor material.



FIGURE 146.-Planimetric map of station 6.

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Petrographic description:

76030-34, no description available.

76035, vesicular polymict breccia with clasts of metatroctolitic rocks with relict plagioclase and olivine in a poikilitic matrix, polycrystalline olivine aggregates, fine-grained intersertal rocks of basaltic mineralogy, and fine-grained plagioclase-rich metaclastic rocks in an aphanitic matrix of recrystallized pyroxene, plagioclase, and abundant plagioclase and olivine mineral clasts with scarce spinel clasts.

Sample 76055

Type: Polymict breccia with a granoblastic matrix. *Size:* 23x13x13 cm. *Weight:* 6,412 g. *Location:* Regolith surface within a few meters of the south side of the LRV at station 6.

Illustrations: Pans 21, 22; figures 157 (LRL), 166.

Comments: Sample 76055 is a greenish-gray breccia fragment from the North Massif.

Petrographic description: Polymict breccia with a finegrained vesicular granoblastic matrix. Lithic clasts include (1) metatroctolite with a poikiloblastic matrix that is much coarser grained than the breccia matrix, (2) "dunite" cataclasite, (3) "anorthosite" cataclasite, and (4) felsic melt rock with an uneven ophitic to intersertal texture. Mineral clasts include plagioclase, olivine, and pink spinel. Cavities in youngest matrix are slitlike en echelon openings with drusy linings.

Major-element composition:

Chemical analyses of 76055

	1	2
SiO ₂	45.7	44.65
Al ₂ O ₃	15.84	16.47
FeO		9.11



FIGURE 147 .-Blocks 1 and 2 of station 6 boulder. Arrow indicate probable matchpoints between two blocks. Sample 76320-24 was collected from sediment deposited on near surface of block 1. (NASA photograph AS 17- 140-21496.)

TRAVERSE GEOLOGY AND SAMPLES-STATION 6

Chemical analyses of 76055 - Continued

	1	2
Ja2O		.31
20		.08
iO ₂	7.36	8.30
2O5		.10
InÖ		.23
r ₂ O ₃	.384	.41
Total	100.52	98.90

76055,3 (Nava, 1974).
 76055,5 (Apollo 17 PET, 1973).

Age:

⁴⁰⁻³⁹Ar:

76055, 3.98±0.05 b.y. (Turner and others, 1973). 76055,4,1 , 4.05±0.07 b.y. (Kirsten and Horn, 1973).

76055,6, 3.97±0.04 b.y. (Huneke and others, 1973).

Rb-Sr isochron:

76055,6, 3.86±0.04 b. y. (Tera

others, 1974b). Two-point isochron based on Rb-Sr measurements for total rock and for a separate dominated by fine-grained potassium-rich phases. Plagioclase separates are off of this isochron and were in terpreted as not equilibrated with the finer grained recrystallized matrix. Model age for potassium-rich fine-grained mate rial, calculated with respect to BABI (basaltic achondrite best initial) is 4.08 b.y., interpreted as a strict older limit on the age of metamorphism (Tera and others, 1974b).



FIGURE 148.- Blocks 2 and 3 at station 6. Arrows connect fractures that would be alined if the blocks were fitted together. (NASA photograph AS17-146-22293.) (After Muehlberger and others, 1973.)

Exposure age:

Ar:

76055, 125 m.y. ('Turner and others, 1973). 76055,4,1, 120± 15 m.y. (Kirsten and Horn, 1974). 76055,6, 140 m.y. (Huneke and others, 19 73).

Sample 76215

Type: Metaclastic rock with a dominantly poikilitic matrix. *Size:* 10.5x8x6 cm.

Weight: 643.9 g.

- *Location:* From rock lying on surface at northeast corner of block 4 at station 6.
- *Illustrations:* Pan 21; figures 158, 159, 160 (LRL), 161 (photomicrograph).
- *Comments:* Sample 76215, a greenish-gray breccia, was broken from a rock that the crew identified as having spalled from block 4. The sample is from the

Unit A, highly vesicular

Unit B, well foliated

Unit C, massive, clast-rich, low-porosity



FIGURE 149.-Map showing lithologic divisions inferred by Heiken and others (1973) for station 6 boulder.

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A1203 CONTENT, IN WEIGHT PERCENT FIGURE 150.-Plots of FeO, MgO, and. CaO contents in relation to A1₂0₃ content for analyzed highlands rocks at station 6 (circled dots, station 6 boulder; X, other station 6 rocks) in comparison with all analyzed Apollo 17 highlands rocks (dots). well-foliated unit B of Heiken and others (1973).

Petrographic description: Vesicular metaclastic rock with scarce lithic clasts of fine-grained feldspathic hornfels and mineral clasts of plagioclase and olivine in a poikilitic matrix that grades, toward vesicles, to an ophitic melt texture. Poikilitic part is dominant and has oikocrysts of low-calcium pyroxene enclosing newly crystallized plagioclase as well as relict broken grains of plagioclase and olivine.

Simonds (1975) interpreted sample 76215 as a poikilitic and ophitic impact melt largely represented by clast-laden poikilitic rock consisting of a network of pigeonite and subordinate augite oikocrysts enclosing abundant tiny feldspar grains and some olivine. Mineral clasts, largely with no evidence of shock metamorphism, are feldspar, pyroxene, and olivine; overgrowths tend to make the feldspars euhedral. Lithic clasts are anorthosite and dunite.

Major-element composition:

Chemical analyses of 76215

	1	2
SiO ₂	46.13	46.02
Al ₂ O ₃		17.83
FeO		8.70
MgO	12.43	12.21
CaO	11.50	11.10
Na ₂ O		
K ₂ O		.27
TiO ₂	1.24	1.52
P ₂ O ₅		.28
MnO		
Cr ₂ O ₃		

76215,28,29 and 48, matrix (Simonds, 1975).
 76215,26, and 27, matrix (Simonds, 1975).

Age: ⁴⁰⁻³⁹Ar: 76215,30 (matrix), 3.94±0.04 b.y. (Cadogan and Turner, 1976).

Sample 76220-24

Type: Sedimentary, unconsolidated.

Weight: 612.84 g.

Depth: From upper few centimeters.

Location: Station 6 boulder track depression approximately 10 m north of boulder area.

Illustrations: Pans 21, 22; figure 162.

Comments: Sample 76220-24 is probably a mixture of North Massif and valley floor material.

Sample 76235-39, 76305-07

Type: Olivine metanorite cataclasite.

Sizes: 1.5X1.5X0.5 cm to 5X3X2 cm.

Weight: 81.24 g total.

Location: From light-gray clast on southeast side of block 1 at station 6.



Simonds (1975) described 76235 as olivine-bearing feldspathic norite with poikilitic pyroxene. The rock contains 70 percent plagioclase, 20 percent pigeonite, and 10 percent olivine. Major- element composition:

44.52

27.01

Chemical analyses of 70035

SiO₂

Al₂O_{3...}

Chemical analysis of 76230 -Continued

FeO	5.14
MgO	7.63
CaO	15.17
Na ₂ O	.35
K ₂ O	.06
TiO ₂	.20
P ₂ O ₅	.05
MnO	.06
Cr ₂ O ₃	.11
Total	100.30

76230,4 (Apollo 17 PET, 1973).

The analysis was made of a small chip from the sample residue; according to Butler (1973), the 76230 chip is representative of the



FIGURE 151.-Relative amounts of TiO₂, AI₂O₃, and FeO+MgO in sediment samples 76241, 76261, 76281, 76321, and 76501 (crosses) from station 6, 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:

ge: ⁴⁰⁻³⁹Ar:

76235,3, 3.93±0.06 b.y. (Cadogan and Turner, 1976). 76235,3, 3.95±0.06 b.y.



FIGURE 152.-Drive tube sample 76001 during sampling. (NASA photograph AS 17-146-22292.)

Ages from two separate runs are in agreement with each other and with ages determined for the enclosing breccia. Strong heating and complete outgassing of argon during the impact that assembled the station 6 boulder materials are inferred (Cadogan and Turner, 1976).

Sample 76240-46

- *Type:* Sedimentary, unconsolidated (76240-44) and metaclastic rock with a poikilitle (?) matrix (76245-46).
- *Size:* 76245, two pieces, 2x2x1 cm and 1x1x0.5 cm; 76246, 3x2x2 cm.

Weight: 76240-44, 475.8 g; 76245, 8.24 g; 76246, 6.5 g.

Depth: 0 to 5 cm.

Location: From shadowed area immediately north of block 4 at station 6.

Illustrations: Pan 21; figures 165, 166.

Comments: Sediment sample 76240-44 is a mixture of North Massif and valley floor material. The two breccia fragments (76245-46) presumably came from the North Massif.

Petrographic description:

76240-44, basalt, some feldspathic metaclastic rocks.

Components of 90-150-um fraction o 76241,24 (Heiken and McKay, 1974)

	Vol

·	Percent
Agglutinate	48.0
Basalt, equigranular	2.3
Basalt, variolitic	1.0

Components



FIGURE 153.- Left, Location 76015 on block 5 before collection. Shadowed area marks northeast-southwest split between blocks 4 and 5. (NASA photograph AS 17-140-21411.) Right, Sample 76015 with reconstructed lunar surface orientation and lighting. (NASA photograph S-73-19376.)

Components of 90-150-um fraction of 76241,24 (Heiken and
McKay, 1974)-Continued

Components	
Breccia:	
Low grade ¹ - brown	4.7
Low grade ¹ - colorless	2.7
Medium to high grade ²	12.3
Anorthosite	.3
Cataclastic anrthosite ³	1.3
Norite	
Gabbro	
Plagioclase	12.0
Clinopyroxene	5.0
Orthopyroxene	2.0
Olivine	1.3
Ilmenite	2.0
Glass:	
Orange	.7
"Black"	2.3
Colorless	.7
Brown	1.3
Gray, "ropy"	
Other	
Total number of grains	300

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

76245,76246, vesicular metaclastic (?) rocks with scarce mineral relics in a poikilitic (?) matrix. No thin sections available.

Major-element composition:

Chemical analysis of 76241

SiO ₂	43.20
Al ₂ O ₃	17.85
FeO	10.92
MgO	11.05
CaO	11.97
Na ₂ O	.43
K ₂ O	.12
TiO ₂	3.31
P ₂ O ₅	.09
MnO	.16
Cr ₂ O ₃	
Total	99.10

76241,14 (Rhodes and others, 1974).

Sample 76255

Type: Polymict breccia with a cataclastic matrix. Size: 11x8x6 cm.

Weight: 406.6 g.

Location: Southeast side of block 1 at station 6.

- Illustrations: Pans 21, 22; figures 163, 167, 168 (LRL), 169 (map of slab).
- Comments: Sample 76255 was collected from the contact zone between a large tan clast (fig. 167) and the blue-gray breccia of the massive low-porosity unit C of Heiken and others (1973).
- Petrographic description: Polymict breccia formed by disruption of an older polymict breccia with large clasts of olivine norite or olivine metanorite. Resultant rock is banded polymict breccia (older matrix, reworked) and olivine-norite cataclasite containing fragments of the older polymict breccia. The resulting polymict breccia has clasts of fine-grained

feldspathic metaclastic rock and elongate cavities with linings of delicate brown pyroxene-spongy plagioclase intergrowths. Some vug linings were disrupted and incorporated in the cataclasite but were formed by local melting of the older polymict breccia.

Warner and others (1976), members of the consortium studying the station 6 boulder in detail, have described sample 76255 as predominantly a clast of norite cataclasite (unit 3 in fig. 169) in a matrix of fine-grained polymict breccia (unit 1 in fig. 169), with a zone of mixed lithology (unit 2 in fig. 169) separating the two units. They have interpreted the polymict breccia as crystallized clastladen impact melt and regard it as a portion of the matrix of the massive unit C (fig. 149). Additional small clasts in the sample include gabbro, troctolite, and two basalt fragments that resemble mare basalt.

Age: ⁴¹⁻³⁹Ar: 76255,46 (clast, presumably norite cataclasite), 4.02±0.04 b.y. (Cadogan and Turner, 1976).

Sample 76260-65

Type: Sedimentary, unconsolidated (76260-64) and breccia fragment (76265).

Size: 76265, 2x1.5x0.7 cm.

Weight: 76260-64, 291.18 g; 76265, 1.75 g.

- Depth: From 0 to 2 cm.
- Location: Regolith surface north of block 4 at station 6. Same site as sample 76280-86.
- Illustrations: Pan 21; figures 165,166.
- Comments: Sediment sample 76260-64 is regolith derived from the North Massif with some admixed valley floor material. Sample 76265 is presumably a chip of North Massif material.
- Petrographic description: 76260-64, dominantly finegrained breccia and (or) metaclastic rock, scarce glass.

Components of 90-150-, um fraction of 76261, 26 (Heiken and McKav. 1974)

Components	Volume Percen
Agglutinate	45.3
Basalt, equigranular	3.3
Basalt, variolitic	1.0
Breccia:	
Low grade ¹ - brown	2.3
Low grade ¹ - colorless	3.3
Medium to high grade ²	12.6
Anorthosite	1.0
Cataclastic anrthosite ³	
Norite	.3
Gabbro	
Plagioclase	10.3
Clinopyroxene	9.3
Orthopyroxene	3.3
Olivine	.7
Ilmenite	1.0
Glass:	
Orange	.7

Components of 90-150-, um fraction of 76261, 26 (Heiken and McKay, 1974) - Continued

Components	Volume Percent
Glass - Continued	
"Black"	1.3
Colorless	2.0
Brown	1.9
Gray, "ropy"	
Other	
Total number of grains	300

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

Major-element composition:

Chemical analyses of 76261

SiO ₂	43.64
Al ₂ O ₃	17.96
FeO	10.93
MgO	10.75
CaO	12.11
Na ₂ O	.45
K ₂ O	.12
TiO ₂	3.38
P ₂ O ₅	.11
MnO	.16
Cr ₂ O ₃	.28
Total	99.89

76261,15 (Rhodes and others, 1974).



FIGURE 154.-Sample 76015. Metaclastic rock with poikilitic matrix. (NASA photograph S-73-15014.)

Sample 76275 Type: Polymict breccia with an aphanitic matrix. Size: 6.8x4x3 cm. *Weight: 55.93 g.*



FIGURE 155.-Sample 76030-37 area (before collection) and sample 76320-24 site (after collection.) (NASA photograph AS 17-140-21500.)

Location: From southeast side of block 1 at station 6.

Illustrations: Pans 21, 22; figures 163,170 (LRL).

Comments: Sample 76275 is blue-gray breccia from the massive clast-rich low-porosity unit C (Heiken and others, 1973) that makes up block 1 (fig. 149).

Petrographic description: Polymict breccia with clasts of



FIGURE 156.-Sample 76035. Photomicrograph showing clast with coarse poikilitic texture and porphyroclasts of plagioclase and olivine in aphanitic matrix with abundant slit cavities. Crossed polarizers.



FIGURE 157. -Sample 76055. Polymict breccia with fine-grained vesicular granoblastic matrix. (NASA photograph S-73-15714.)

fine-grained breccia or metaclastic rock with an aphanitic matrix, breccia with a highly vesicular matrix, noritic (?) cataclasite, and mineral fragments in an aphanitic matrix. Intergrowths of brown pyroxene and spongy plagioclase occur as clasts. Youngest matrix may be impact fused.

Simonds (1975) has described 76275 as a clastbearing fine subophitic inelt rock identical in petrogn'aphy to sample 76295. *Age:* ${}^{40.39}$ Ar: 76275,39, 4.02±0.04 b.y. (Cadogan and Turner, 1976).

Sample 76280-86

Type: Sedimentary, unconsolidated (76280-84), with two small rock fragments (76285, 86).

Size: 76285, 3x1.5x1.5 cm; 76286, 1.5x1x1 cm.

Weight: 76280-84, 442.47 g; 76285, 2.208 g; 76286, 1.704 g. *Depth:* From 2 to 8 cm.

Location: Regolith surface north of block 4 at station 6. Same site as sample 76260-65.

Illustrations: Pan 21; figures 165, 166.

Comments: Sample is regolith derived from the North Massif with some admixed valley floor material.

Petrographic description: 76280-84, dominantly finegrained breccia and (or) metaclastic rock, scarce glass, agglutinate.



FIGURE 158.-Area of block 4 from which source rock for sample 76215 was spalled. (NASA photograph AS 17-140-21416.)



FIGURE 159.-Top, Location of sample 76215, before sampling, on rock spalled from block 4. (NASA photograph AS17-140-21410.) Bottom. Sample 76215 with reconstructed lunar surface orientation and lighting. (NASA photograph S-73-33506.)

TRAVERSE GEOLOGY AND SAMPLES-STNITION 6

Components of 90-150-, um fraction Of 76281,6 (Heiken and McKay, 1974)

Components	Volume Percent
Agglutinate	45.3
Basalt, equigranular	5.0
Basalt, variolitic	1.7
Breccia:	
Low grade ¹ - brown	5.3
Low grade ¹ - colorless	.7
Medium to high grade ²	10.3
Anorthosite	1.0
Cataclastic anrthosite ³	.3
Norite	
Gabbro	
Plagioclase	10.7
Clinopyroxene	6.3
Orthopyroxene	4.7
Olivine	
Ilmenite	1.3
Glass:	
Orange	1.3
"Black"	3.7
Colorless	1.7
Brown	
Gray, "ropy"	.3
Other	.3
Total number of grains	300

1.

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

Major-element composition:

Chemical analyses of 76281

SiO ₂	48.56
Al ₂ O ₃	17.80
FeO	11.26
MgO	10.55
CaO	12.18
Na ₂ O	.43
K ₂ O	.11
ГіО2	3.83



FIGURE 160.-Sample 76215. Metaclastic rock with poikilitic matrix. (NASA photograph S-72-56373.)

Chemical analyses of 76281 - Continued



Sample 76295





FIGURE 161. - Sample 76215. Photomicrograph showing abrupt transition from ophitic texture (lower left) to poikilitic texture (upper right). Ophitic texture is best developed around vesicles. Poikilitic part has much more abundant broken mineral debris than ophitic part. Crossed polarizers.



FIGURE 162.-Boulder track depression from which sample 76220-24 was collected, before sampling. (NASA photograph AS 17-141-21588.)



Wfeight: 260.7 g.

Location: From southeast side of block 1 at station 6.
Illustrations: Pans 21, 22; figures 163,167,171 (LRL).
Comments: Sample 76295 is blue-gray breccia of the clast-rich low-porosity unit C (Heiken and others, 1973) of block 1 (fig. 149).

Petrographic description: Polymict breccia with an



FIGURE 164.-Sample 76235. Metatroctolite cataclasite or olivine metanorite cataclasite. (NASA photograph S-73-16733.)



FIGURE 165.-Locations of samples 76240-46, 76260-65 and 76280-86, after collection. (NASA photograph AS 17-141-21606.)



FIGURE 166.-View, southeastward, of block 4, LRV area at station 6. (NASA photograph AS17-141-21597.)

aphanitic matrix. Clasts are (1) aphanitic breccia containing feldspathic metaclastic clasts and abundant plagioclase and olivine mineral debris, (2) feldspathic metaclastic rocks, and (3) abundant plagioclase and olivine. Younger matrix is lighter colored than that of the breccia clasts.

Simonds (1975) has described 76295 as nonvesicular crystalline rock that consists of mineral and noritic lithic clasts in a matrix that crystallized from an impact melt. The matrix is predominantly blue-gray, very fine grained, and subophitic with pyroxene oikocrysts. A second matrix type occurs as tan veinlike bodies in which mineral clasts are at least twice as abundant as they are in the blue-gray matrix. Both matrix types contain about 50 percent feldspar; the tan matrix material has abundant augite and no olivine, whereas the blue-gray matrix has abundant olivine and little augite.



FIGURE 167.-View, northeastward, of block 1 after sampling, showing scattered clasts, locations from which samples 76235-39, 76305-07, 76255, and 76295 were collected, and approximate outline of large clast sampled by 76255. (NASA photograph AS 17-140-21456.)

TRAVERSE GEOLOGY AND SAMPLES-STATION 6

Major-element composition:

Chemical analyses of 76295

47.03
18.25
9.09
10.78
11.54
.26
1.39
.32

76295,14 and 37, matrix (Simonds, 1975).

Age: 40-39 Ar:

76295,1 (tan matrix), 3.95±0.04 b.y. (Cadogan and Turner, 1976).
76295,3 (blue matrix), 3.96±0.04 b.y. (Cadogan and Turner, 1976).

Sample 76315

Type: Polymict breccia with an aphanitic matrix. *Size:* 12x10x4.5 cm. *Weight:* 671.1 g. *Location:* Southeast side of block 2 at station 6. *Illustrations:* Pans 21, 22; figures 172, 173 (LRL).



FIGURE 168.-Sample 76255. Polymict breccia with cataclastic matrix. Large (approximately 3x4 cm) dark oval patch at left is dark polymict breccia or fine subophitic impact melt of Warner and others (1976; see fig. 169). Remainder of rock (light-colored part) is mainly norite cataclasite. (NASA photograph S-72-56415.)

- 140
- Comments: Sample 76315 is a fragment of blue-gray breccia from the contact zone between greenish-gray and blue-gray parts of boulder 2. Heiken and others (1973) have described the zone as the foliated tran-



FIGURE 169.-Sample 76255. Map of slab cut parallel to N_1 face (that is, parallel to top view of rock shown in side view in figure 168). (From Warner and others, 1976.)

sition zone between highly vesicular unit A (greengray breccia of fig. 172) and well-foliated unit B (blue-gray breccia of fig. 172).

Petrographic description: Polymict breccia with clasts of feldspathic metaclastic rock, spinet-troctolite cataclasite, intersertal basalt with relict spinel, and plagioclase, olivine, and scarce quartz mineral fragments in an aphanitic matrix. A large feldspathic cataclasite clast appears to have been locally fused and is veined by the dark aphanitic matrix material (fig. 173).



FIGURE 170.-Sample 76275. Polymict breccia with aphanitic matrix. (NASA photograph S-73-24035B.)



FIGURE 171.-Sample 76295. Polymict breccia with aphanitic matrix. (NASA photograph S-72-56409.)

Simonds (1975) has described 76315 as nonvesicular blue-gray rock that consists of mineral and lithic clasts in a matrix crystallized from impact melt. The mineral clasts, feldspar, olivine, pyroxene, and minor spinel, generally appear unshocked. Lithic clasts are derivatives of anorthosite-noritetroctolite-suite rocks. The matrix is micropoikilitic to subophitic, with olivine and pyroxene enclosing feldspar. A foliation is defined by lines of small (<1 mm) vesicles and by variations in the matrix color.

Major-element composition:

Chemical analyses of 76315

	1	2	3	4	5	6
SiO ₂	45.82	45.64	46.45	46.21	48.57	45.10
Al2O3	18.01	17.53	18.18	18.14	17.91	26.37
FeO	8.94	9.53	8.83	8.95	7.66	5.29
MgO	12.41	12.50	12.34	12.02	13.84	7.46
CaO	11.06	10.97	11.30	11.32	10.36	15.12
Na ₂ O	57	.70	.64	.60	.47	.47
K ₂ O	27	.26	.22	.26	.15	.10
ΓiO ₂	1.47	1.50	1.43	1.50	.32	.36
P ² O ⁵		.30	.29	.29	.12	.06
MnO	11	.13	.13	.12	.13	.07
Cr ₂ O _{3.}	.19	.19	.20	.19		
Total	08.14	00.25	100.01	00.60	00.53	100.40

1. 76315,2 (Apollo 17 PET, 1973); identified as matrix sample by Phinney and others (1974).

2. 76315,30M, matrix (Rhodes and others, 1974).

3. 76315,30, 3, clast (Rhodes and others, 1974).

4. 76315,35, matrix (Rhodes and others, 1974).

5. 76315,52, clast (Rhodes and others, 1974).

6. 76315,62, clast (Rhodes and others, 1974).

Described by Simonds (1975) as 2-cm light-gray clast with 70 percent plagioclase, 17 percent pigeonite, and 13 percent olivine.

Age:

⁴⁰⁻³⁹Ar:

- 76315,36 (matrix), 3.98±0.04 b.y. (Turner and Cadogan, 1975).
- 76315,67 (dark clast), 3.97±0.04 b.y. (Turner and Cadogan, 1975).
- 76315,61 (white clast), 3.98 +-0.04 b.y. (Turner and Cadogan, 1975).

K-Ar:

76315 (matrix), 4.0 b.y. (Bogard and Nyquist, 1974).

Exposure age:

Kr: 21.7 ± 1.2 m.y. (Crozaz and others, 1974). Tracks: 21 ± 3 m.y. (Crozaz and others, 1974).

Crozaz and others (1974) have interpreted the time since emplacement of station 6 boulder to be 22 ± 1 m.y.

Smaller rare-gas exposure ages have been determined by Bogard and Nyquist (1974) and Turner and Cadogan (1975). Both sets of investigators indicate that their exposure ages are too low because of partial shielding or incorrect assumed ³⁸AR production rate.

Sample 76320-24

Type: Sedimentary, unconsolidated.

Weight: 813.74 g.

Depth: From upper few centimeters.

Location: Flat upper surface of the north side of block 1 at station 6. *Illustrations:* Pans 21, 22; figures 147,155,174.

- *Comments:* Sample 76320-24 is probably ejecta deposited on block 1 by some nearby impact.
- *Petrographic description:* 76320-24, dominantly finegrained breccia and (or) metaclastic rock, scarce basalt, agglutinate.



FIGURE 172.-Blocks 2 and 3 at station 6 before sampling. Exact location of sample 76315 is uncertain but is probably within contact zone. (NASA photograph AS17-140-21436.)



FIGURE 173.-Sample 76315. Polymict breccia with aphanitic matrix. Large feldspathic cataclasite clast at left is veined by dark aphanitic matrix material. (NASA photograph S-73-17109.)

Components of 90-150-, um fraction of 76321, 10 (Heiken and McKay, 1974)

Components	Volume Percent
Agglutinate	39.1
Basalt, equigranular	2.7
Basalt, variolitic	
Breccia:	
Low grade ¹ - brown	4.3
Low grade ¹ - colorless	
Medium to high grade ²	14.4
Anorthosite	
Cataclastic anrthosite ³	1.0
Norite	
Gabbro	
Plagioclase	15.7
Clinopyroxene	6.7
Orthopyroxene	5.7
Olivine	
Ilmenite	.3
Glass:	
Orange	1.3
"Black"	2.3
Colorless	2.3
Brown	4.0
Gray, "ropy"	
Other	
Total number of grains	300
1. Metamorphic groups 1-3 of Warner (1972).	

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

Major-element composition:

Chemical analyses of 76321

	1	2	3
SiO ₂	44.19	44.08	44.14
Al ₂ O ₃		18.41	18.54
FeO	10.36	10.53	10.44
/IgO	10.82	10.82	10.82
CaO	12.24	12.23	12.24
Na ₂ O		.46	.43
K ₂ O		.13	.13
TiO ₂	2.95	3.00	2.98
P ₂ O ₅		.09	.10
/InO		.15	.14
Cr ₂ O ₃	.272	.26	.27
Total	100.284	100.16	100.23

76321,3 (Duncan and others, 1974).

76321,7 (Rhodes and others, 1974). 2. 3.

Average of 1 and 2.

Sample 76335

Type: Troctolite cataclasite.

Size: Largest fragment, 8x6.5x5 cm.

Weight: 352.9 g.

- Location: From the south slope of the North Massif about 1-2 m northeast of the LRV at station 6,
- Illustrations: Pans 21, 22; figures 166, 175 (photomicrograph).
- Comments: Sample 76335 is presumably a clast from North Massif breccia.
- Petrographic description: Troctolite cataclasite. Relics of partly crushed troctolite with olivine interstitial to plagioclase.

Sample 76500-06

Type: Sedimentary, unconsolidated (76500-04) with

two breccia fragments (76505, 06). Size: 76505, less than 1 cm; 76506,1.3x1x1 cm. Weight: 76500-04, 1,019.47 g; 76505, 4.69 g; 76506, 2.81 g. Depth: From upper few centimeters. Location: Ejecta blanket of a 10-m crater about 15 m northwest of the LRV at station 6. Illustrations: Pans 21, 22; figure 176.

Comments: Sediment sample, from the rake area, rep-



FIGURE 174.-Sample 76320-24 site after collection. (NASA photograph AS 17-140-21482.)



FIGURE 175.-Sample 76335. Photomicrograph showing texture of troctolite cataclasite. Olivine (dark) has been finely pulverized, whereas larger relict plagioclase grains (light) have survived.

resents material derived from the North Massif with some admixture of valley floor debris.

Petrographic description: 76500-04, dominantly finegrained breccia and (or) metaclastic rock, some agglutinate, minor glass.

Components of 90-150-, um fraction of 76501, 1(Heiken and McKay, 1974)

Components	Volume Percent
Agglutinate	47.2
Basalt, equigranular	1.7
Basalt, variolitic	1.7
Breccia:	
Low grade ¹ - brown	3.8
Low grade ¹ - colorless	
Medium to high grade ²	8.3
Anorthosite	
Cataclastic anrthosite ³	1.4
Norite	
Gabbro	
Plagioclase	17.2
Clinopyroxene	7.6
Orthopyroxene	7.9
Olivine	.7
Ilmenite	1.7
Glass:	
Orange	.7
"Black"	.3
Colorless	1.4
Brown	
Gray, "ropy"	
Other	
Total number of grains.	300

Total number of grains..

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 compositions:

Chemical	analyses	of 76501
Chemicai	unuiyses	0,70501

	1	2	3	4
SiO ₂	43.41	43.71	43.34	43.49
Al ₂ O ₃	18.63	18.83	18.41	18.62
FeO	10.32	10.35	10.39	10.35
MgO	11.08	10.71	11.08	10.96
CaO	12.28	12.06	12.24	12.19
Na ₂ O	35	.38	.40	.38
K20	10	.11	.11	.11
TiO ₂	3.15	3.20	3.15	3.17
P ₂ O ₅	08	.08	.09	.08
MnO	14	.13	.15	.14
Cr ₂ O ₃	.26	.26	.27	.26
Total	99.80	99.82	99.63	99.75

76501,2 (Apollo 17 PET, 1973).
 76501,30 (Rose and others, 1974).

76501,30 (Rose and others, 1974).
 76501,42 (Rhodes and others, 1974).

Average of 1 through 3.

⁴⁰⁻³⁹Ar:

5 5

Age:

76503,6,4 (2-4-mm fragment-" recrystallized anorthositic" rock), 3.970±0.013 b.y. (Schaeffer and others, 1976).

76503,6,9 (2-4-mm fragment-"highland basalt"), ~3.97b.y. (Schaeffer and others, 1976).

76503,6,13 (2-4-mm fragment- "recrystallized anorthositic" rock), 4.227±0.008 b.y. (Schaeffer and others, 1976).

Exposure age: Ar:

- 76503,6,4 (2-4-mm fragment- "recrystallized anorthositic" rock), 160 ± 7 m.y. (Schaeffer and others, 1976).
- 76503,6,9 (2-4-mm fragment-"highland basalt"), 83±5 m.y. (Schaeffer and others, 1976).
- 76503,6,13 (2-4-mm fragment-" recrystallized anorthositic" rock), 106±6 m.y. (Schaeffer and others, 1976).

Sample 76535-39, 45-49, 55-59, 65-69, 75-77

Type: 23 rock fragments from rake sample:

76535, metatroctolite.

76536, olivine (?) norite cataclasite.

76537, olivine basalt.

76538, basalt.

76539, basalt.

76545, polymict breccia with glassy matrix.

- 76546, polymict breccia with glassy matrix.
- 76547, polymict breccia with glassy matrix.
- 76548, polymict breccia with glassy matrix.
- 76549, polymict breccia with glassy matrix.
- 76555, polymict breccia with an aphanitic matrix.
- 76556, polymict breccia with an aphanitic matrix.
- 76557, polymict breccia with an aphanitic matrix.
- 76558, breccia.
- 76559, breccia.
- 76565, sedimentary, weakly lithified poly mict breccia.
- 76566, friable dark breccia.
- 76567, sedimentary, weakly lithified poly mict breccia.
- 76568, basalt cataclasite.

76569. breccia.

76575, polymict breccia with an aphanitic matrix.

76576, breccia with an aphanitic matrix.

76577, metaclastic breccia with an aphanitic matrix.

Sizes: 76535, >6 cm maximum dimension; other fragments range up to about 4 cm.

Weight: 358.031 g total; 76535,155.5 g.

Location: Ejecta blanket of a 10-m crater about 15 m northwest of the LRV station 6.

- Illustrations: Pans 21, 22; figures 176, 177 (76535, LRL).
- Comments: The basalt fragments are probably

from subfloor basalt; the rest were presumably derived from the North Massif.

Petrographic descriptions:

76535, metatroctolite with symplectite intergrowths along some olivine-plagioclase boundaries; partial recrystallization to a coarsegranoblastic-polygonal texture (fig. 177).

Sample 76535 has been described as coarsegrained troctolite with 35 percent plagioclase, 60 percent olivine, and 5 percent low-calcium pyroxene (Dymek and others, 1975) and as coarse-grained troctolite granulite with 58 percent plagioclase (An₉₆), 37 percent olivine (Fo₈₈), and 4 percent orthopyroxene (En₈₆) (Gooley and others, 1974).

Gooley and others suggested that the rock formed as a cumulate and cooled slowly at a depth inferred from the occurrence of chromian spinel-bronzite-diopside symplectites to be between 10 and 30 km. Dymek and others (1975) agreed that the rock crystallized at relatively great depth, but they objected to the specific depth calculation of Gooley and others (1974) because of the large uncertainties in applying experimental thermodynamic data to sample 76535. Stewart (1975) related the granular-polygonal texture to his "Apollonian metamorphisim" and inferred all annealing time on the order of 10⁸ years at a depth greater than 7 km for rock 76535.

76536, olivine(?) norite cataelasite.

76537, aphanitic olivine basalt.

76538, coarse-grained porphyritic basalt with aggregates of clinopyroxene-ilmenite in a subophitic (?) groundmass of plagioclase, clinopyroxene, i1menite, and accessory minerals.

76539, aphanitic basalt with vitrophyric (?) groundmass.

- 76545-47, 49, polymict breccia with clasts of fine-grained feldspathic metaclastic rock, basalt, and mineral fragments in a vitreous matrix that is frothy along fractures. Prominent flow foliation.
- 76555, polymict breccia with clasts of finegrained metaclastic rock and troctolite metatroctolite and mineral fragments in an aphanitic matrix.
- 76556, polymict breccia with clasts of aphanitic breccia and in etatroctolite (?) with granoblastic-polygonal texture and mineral fragments in all aphanitic matrix.
- 76557, polymict (?) breccia with clasts of metatroctolite (?) and mineral fragments in an aphanitic matrix with slitlike cavities.
- 76565, polymict breccia with clasts of basalt, fine-grained metaclastic rock, feldspathic cataclasite, possible glass, and mineral debris in a fine-grained friable matrix.
- 76567, polyinict breccia with clasts of finegrained metaclastic rock, spinel troctolite or metatroctolite, and mineral debris in a moderately coherent fine-grained matrix.
- 76568, basalt cataclasite with uncrushed relict aphanitic basalt in finely comminuted basalt matrix; adhering sediment contains glass.
- 76575, polymict breccia with clasts of breccia and fine-grained feldspathic metaclastic rocks and mineral clasts of olivine (?) and plagioclase in an aphanitic matrix.
- 76576, breccia with fragments of aphanitic breccia in a feldspathic aphanitic matrix.



FIGURE 176.-Rake area at station 6 before sampling. (NASA photograph AS 17 -141-21622.)



FIGURE 177.-Sample 76535. Metatroctolite; partially recrystallized to coarse granoblastic-polygonal texture. (NASA photograph S-73-19460.)