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16. Abstract

A cluster of boulders at Station 6 (Apollo 17 landing site) consists of breccias derived from the North Massif. Three preliminary lithologic units were established, on the basis of photogeologic interpretations; all lithologies identified photogeologically were sampled. Breccia clasts and matrices studied petrographically and chemically fall into two groups by modal mineralogy: a) Low-K Fra Mauro or High Alumina basalt composition, consisting of 50-60% modal feldspar, ∿45% orthopyroxene and 1-7% Fe-Ti oxide. b) Clasts consisting of highland basalt composition, consisting of 70% feldspar, 30% orthopyroxene and olivine and a trace of Fe-Ti oxide.

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SUMMARY

The North Massif at the Taurus-Littrow (Apollo 17) landing site is characterized by high albedo; it has been interpreted as ejecta from the Serenitatis Basin. The cluster of boulders at Station 6 may be derived from one larger boulder which rolled to its present location from an outcrop high on the North Massif.

Three lithologic units within the boulder cluster have been identified, based on photography and descriptions by the crew of Apollo 17. Unit A is characterized by abundant vesicles >5 cm long, flattened along a plane parallel to the contact with the adjacent unit. Unit B is characterized by well-developed foliation or banding. Unit C is massive, with no obvious foliation and contains angular clasts up to 0.8 m long.

All samples collected from the boulder clasts are breccia; impact melts with a variety of clasts. Matrix samples were collected from all of the photogeologic units and the large clasts were sampled from unit C.

Clasts and matrices fall into two groups: (a) breccias containing 50-60% modal feldspar, ~45% orthopyroxene and 1-7% Fe-Ti oxide [low K Fra Mauro or High Alumina basalt composition],(b) breccia clasts containing 70% feldspar, 30% orthopyroxene and olivine and a trace of Fe-Ti oxide [Highland basalt composition].

Rock surfaces exposed to the lunar environment are pitted by micrometeorite impact craters and covered with a thin patina of brown glass. Estimated cosmic ray exposure ages range from 6.4 to 15 m.y.

INTRODUCTION

In preparation for an integrated consortium approach to the study of large boulder samples from Station 6 at the Apollo 17 landing site a number of preliminary studies have been accomplished. This report summarizes these studies which should serve as background information for principal investigators who will continue further detailed investigations. Lunar surface photographs allowed rather detailed mapping of the large boulders as well as the determination of locations for six of the seven samples chipped from the boulder (76315 could not be accurately located). Maps of the individual samples and the locations of chips for preliminary analysis have been compiled. Other preliminary studies reported here include petrographic descriptions (with representative photomicrographs), chemistry, gamma-ray counting results, rare gas contents (with estimated exposure ages), and natural remanent magnetization data. Table I presents a summary of the samples with all of their daughters and studies to August 1973.

GEOLOGIC SETTING

The North Massif rises about 2200 m above the Valley of Taurus-Littrow and is characterized by steep slopes (20°-30°) and high albedo; it has been interpreted as ejecta from large ring basins, subsequently uplifted by the impact which formed the Serenitatis Basin (reference 1). Apollo 15 orbital photography of the site indicated that several large boulders at low elevations were derived from outcrops high on the slopes of the massif; the boulders left tracks as they rolled downslope. According to photogeologic interpretation (reference 1), the boulders at Station 6 rolled somewhat cross-slope for 1230 m while dropping from an altitude of 5030 m to 4590 m (440 m). The first half of this report provides maps of both the boulders at Station 6 and the samples collected from them.

BOULDERS

DESCRIPTION

A cluster of boulders covering an area 10 x 24 m constituted Station 6. It appears that many (or most) of these may be derived from one larger boulder which split into several pieces when it stopped rolling or afterwards. The largest boulders in the cluster were numbered, north to south, 1 through 5 (figure 1). They were photographed on all sides except within the narrow cracks between boulders 1 and 2 and the northwest side of boulder 1. The maps (figures 2-6) are based on the photographs and astronaut descriptions.

All boulders at Station 6 appear to be breccias; the samples collected are from large clasts and matrices. Boulders 1, 2, and 3 readily fit together; the fit of boulders 4 and 5 is less obvious. Three basic lithologic units are here defined photogeologically; they are labeled A, B, and C for convenience and do not imply a top or base. Descriptions of these units, based mainly on boulders 1, 2, and 3, are outlined in figure 7. In boulders 4 and 5 and parts of boulder 2, the contact between units A and B is sharp; in boulder 2 it defines a plane oriented about N20W and dipping 65°W. In other parts of boulder 2 (see figure 1) zones A and B are not well defined and a contact zone or transitional area, several meters wide, has been defined. If this plane were originally horizontal, the boulders are now turned on their sides relative to their original position. The foliation in boulder 2 is defined by aligned, flattened vesicles, "trains" of small clasts, and differentially eroded linear depressions in the rock surface; it is parallel to the contact between units A and B.

A sharp contact cuts across boulder 5 then folds over the present top of the boulder at a steep angle (figure 5). It is possible that this contact is equivalent to that between units A and B; this relationship places samples 76015 and 76215 in unit B. If this is the case, then boulders 4 and 5 rolled over during separation from boulder 2. Folds defined by the foliation are visible in several places on the face of boulder 4.

DISCUSSION OF "FIELD" OBSERVATION

The stratigraphic "section" of breccia units defined in the boulders at Station 6 is given in figure 7. It is not possible at present to determine which end is top or bottom. Unit A is a highly vesicular unit (est. 30-35%), with large, flattened vesicles up to 15 cm long and 5-6 cm wide in sharp contact with the foliated, less vesicular unit B. Unit C is a massive unit exhibiting low vesicularity and large (up to 0.8 m long) clasts.

An apparently close terrestrial analogue is a 8-40 m thick ash flow tuff unit in Central Oregon (reference 2). From the base upward, it consists of (1) ~1-2 m thick, densely welded vitrophyre zone, (2) 1-2 m thick vesicular (or vuggy) lithophysal zone, (3) 4-5 m thick strongly foliated zone which is internally deformed in places, forming slump structures, and (4) unwelded to welded tuffs (>10 m thick) which exhibit only poor foliation. The zonation of the ash flow tuff results from different degrees of compaction and welding and from primary and secondary vapor-phase crystallization. The relation between the vesicular zone and foliated zone may be analogous to units A and B, respectively,in the boulders at Station 6. If this analogy is carried through, then unit A is below unit B in the Station 6 "section." Unit C is also compatible with this model.

At present, there is no way to establish the thickness of the depositional unit from which the Station 6 boulders are derived or the composition of the gases which formed the vesicles.

ROCK SAMPLES

DESCRIPTION OF SAMPLES

Sample 76315 is from the south face of boulder 2. Astronaut descriptions and photographs indicate that it is from a highly vesicular zone, probably photogeologic unit A.

Samples 76215 and 76015 are from vesicular, banded areas of boulders 4 and 5. If this unit is the same as the banded unit in boulder 2, then they are characteristic of photogeologic unit B.

Samples 76275, 76295, 76255, and 76235 are from the east and southeast faces of boulder 1 in photogeologic unit C. Samples 76275 and 76295 are characteristic of the matrix. Sample 76255 is partially from a 0.5 m long tan clast but partially mixed with matrix. Sample 76235 is from a 0.8 m long, irregular white clast from which a total of eight fragments (76235-76239 and 76305-76307) were collected.

The description of the rocks in the laboratory is purely surficial, using only a binocular microscope. Mapping of the individual samples and their surface features was based on these descriptions and recorded on orthogonal photographs. Previous descriptions are available in the Apollo 17 Lunar Sample Information Catalog (Patrick Butler, Jr., MSC 03211, 447 pages).

Sample 76315 - Blue-Gray Breccia

The lithologic character of the rock (figure 8) is generally obscured by pitting and patination on all but the fresh B_1 surface. The dark gray, fine-grained, breccia that forms about two-thirds of the B_1 face seems to compose an even greater part of the rest of the rock since the large, irregular patches of pinkish-gray material on the B_1 face should be visible on the other surfaces if they were present. The various types of gray clasts visible on B_1, however, would be obscured on the other faces if present. The occurrence of relatively large minerals, both as individual clasts and as parts of lithic clasts, is mapped in the few cases where they occur.

Sample 76215 - Green-Gray Breccia; 643.9 gms

On a fresh face, this breccia is medium light gray (N6 to N7)-See figure 9. The "matrix" or groundmass has a crystalline, equigranular texture and is vesicular to vuggy. It consists of about 75% 50-120 µm long plagioclase crystals, 15-20% pale reddish-brown pyroxene and very pale green olivine crystals, and 5% 20-200 µm long flakes of opaque minerals. There is a trace of a 100 µm diameter pale red mineral.

Clasts consist of ~2% 0.5 to 1.0 mm long plagioclase grains, 1-2% olivine crystals (up to 2.4 mm long), and 1% gray anorthosite (5-8 mm diameter). On a fresh surface, 4-5 mm diameter white oikocrysts are visible.

The most remarkable feature of the rock is vugs ranging from 25 µm to 8 cm long. One whole side of the rock is a large vug or vesicle wall; rounded and smooth. The vug walls are covered by patches of sugary-textured, pale yellow minerals (1-3.5 mm long), pale gray feldspar crystals, and metal grains. There are traces of gold- and gray-colored metallic crystals, 120-500 µm in diameter. Several of the metallic crystals are tarnished to peacock blue and red colors.

The large vug has a glassy patina, which thins toward one end. The thickest part is heavily pitted by micrometeorite craters. It is possible that the thickest patina and heaviest pitting are located at the former open end of this large vug (prior to its separation from the boulder).

Sample 76015 - Green-Gray Breccia; 2819 gms

This breccia (figure 10) is a very vesicular rock with <0.1 mm to 5 cm long, irregular vesicles comprising about 20% of the rock by volume. The flattened vesicles define a preferred orientation best seen on the west (W_1) side of the rock.

The matrix has an equant, holocrystalline texture and consists of ~40% low Ca pyroxene, ~18% vesicles (<1 mm), ~2% olivine "clasts" and ~40% plagioclase.

Clasts >1 mm in diameter make up less than 2% of the rock. These range up to 1.5 cm and consist of pale green to medium gray, aphanitic lithic types with green and brown phenocrysts or possibly xenocrysts.

Coarse-grained "pseudoclasts," up to 4.5 cm in diameter, consist of matted, interwoven pyroxene and feldspar crystals. These appear to be a coarser version of the matrix lining vesicle walls. The largest "pseudoclast" is surrounded on all sides except one by large vesicles.

Much of the rock surface (including exposed vesicle walls) has been coated with a very thin layer of brown glass (patina).

Sample 76275 - Blue-Gray Breccia; 55.93 gms

The matrix is brownish-gray, having a fine-grained, equigranular, holocrystalline texture; it consists of ~40-60% colorless to dull white feldspar, ~5% cinnamon brown pyroxene, ~1% pale lime-green olivine, ~3-5% thin, short, opaque minerals, and 30-50% clast type 1. See figure 11 for clast descriptions. The rock has less than 1% vesicles or vugs; these are concentrated in several elongate zones of <0.5 mm voids and scattered voids up to 0.25 cm in diameter.

Most of the rock is covered by a glassy, dark olive gray (5Y3/1) patina. Lithic types present on all but two sides are marked by this patina.

Sample 76295 - Blue-Gray Breccia; 26.07 gms

Two lithologic types with complex interrelationships compose most of the rock. See figure 12. A pale brown breccia is predominant on the best-exposed (N_1-T_1) face where it appears to form a matrix to clasts of the other abundant lithology, gray breccia which is fine-grained and recrystallized. On the other well-exposed surface (one side of the B_1 face), the gray breccia forms nearly all of the rock. Surface features, such as pitting, patina, and powder, obscure the underlying lithology.

A direct relationship of the very fine powder covering much of the S_1-T_1 face and part of the W_1 face to the underlying lithology is suggested by the presence of a white powder coating part of a white clast. If the relationship is consistent, the buff color of most of the powder reflects the presence of underlying light brown breccia.

Sample 76255 - Banded Tan and Blue-Gray Breccia; 406.6 gms

There are bands of three matrix types interwoven throughout this rock; in some parts of the rock, they are so finely banded that it was mapped as undifferentiated matrix. See figure 13. The matrix types are: (1) tan matrix: ~40% pale brown pyroxene and 60% feldspar, (2) gray matrix: ~92% colorless feldspar, ~5% pale brown pyroxene, and ~3% opaque minerals. Several varieties of this matrix type contain up to 10% equant, possibly aphanitic vitric fragments, (3) "white" matrix (actually yellowish gray, but white relative to the other matrix types): ~15% 0.5 to 0.8 mm long red-brown pyroxene and colorless feldspar crystals and 20% 0.1 to 0.4 mm long crystals of tan pyroxene and white feldspar, and 65% feldspar plus glass grains less than 0.05 mm in diameter.

The main clast type consists of 0.1 mm to 5.5 cm diameter, rounded clasts of gray (~5%) glass; these consist of 1.0 mm, equant, colorless fedlspar crystals in vitreous or aphanitic groundmass. Some of the larger clasts contain feldspar crystals up to 4 mm long. There is a trace of spherical, 0.1 mm diameter vesicles.

Other clasts include a crushed version of the gray clast type, large plagioclase grains (>2 mm), and basalt. The last type may not be clasts but rather vugs completely filled with coarse, well-developed crystals of pale brown pyroxene (40%), plagioclase (50%), and ilmenite (10%).

The surface of the rock is covered in part by a dark patina and in part by white powder. The olive gray (5Y 5/1) patina covers most of the T_1 side of the rock, broken only by micrometeorite pits. Along the edges the patina grades into what is definitely a thin glass coating. Several parts of the rock are covered by a 0.1 to 1 mm thick coating of very fine-grained white powder.

The "exposed" face of this sample has been differentially eroded, with the more resistant gray, aphanitic clasts standing 0.1 to 2 mm above the matrix.

Sample 76235 - Brecciated Gabbro; 26.56 gms

Very light gray (N8) to light bluish gray (5B 8/1) breccia with uniform, equigranular, fine-grained texture. See figure 14. The rock is composed of ~45% plagioclase, ~40% pale gray to pale gray-brown pyroxene present as patchy oikocrysts and tabular crystals up to 0.7 mm long, and ~5% opaque minerals. Vugs are rare, ranging up to 0.35 mm in diameter; they are lined with euhedral crystals of plagioclase, pyroxene and ilmenite. There is also a trace of metal droplets within the vugs. Clasts are rare.

There are several thin (0.01-0.07 mm) glass veins, 1.6 to 13 mm long.

PETROGRAPHY

General Description

Chips for polished thin sections were taken from several clasts and each variety of matrix of each rock. Chips were obtained by prying off loose pieces and clipping off corners with dykes. At least two chips were taken from each macroscopically homogeneous matrix to test for petrographic homogeneity.

Each section was examined in both transmitted and reflected light. All comments about the textures of matrices are based on the reflected light observations.

On the basis of modal mineralogy, virtually all clasts and matrices fall into two groups.

1. Compositions with 50-60% modal feldspar, about 45% orthopyroxene and 1 to 7% Fe-Ti oxide. The chemically analyzed portion of 76315 falls into this category and may indicate that this group of rocks has a composition range known as low-K Fra Mauro, low-K KREEP or High Alumina Basalt. Textures of rocks with this modal mineralogy are either poikilitic, like many Apollo 16 crystalline rocks, or fine-grained and subophitic.

2. Compositions with about 70% feldspar plus orthopyroxene and olivine and relatively few opaque minerals. Sample 76230 falls into this category and its chemical composition falls into the Highland Basalt range which is slightly more aluminous than VHA basalt. All of the rocks with this modal mineralogy are brecciated textures, which have been annealed to various degrees.

Table II summarizes the rock types by rock and polished thin section numbers.

Sample 76015

The rock as a whole is a green-gray poikilitic rock with abundant relict clasts. The texture and mineralogy are similar to other Apollo 16 and 17 KREEP-like poikilitic rocks. The typical material is found in sections ,8 ,13 ,17. A unique clast surrounded by large vugs was sampled as ,15.

Green-gray matrix (76015,8 ,13 ,17).- The matrix consists of a nearly continuous mass of elongated orthopyroxene oikocrysts up to 700 μm long and 200 μm wide (figure 15(a), (b), and (c)0. Opaque minerals, pores, and angular relics tend to be concentrated between groups of two or three oikocrysts. The modal mineralogy of the matrix is about 50% feldspar, 40% orthopyroxene, 7% augite, and 3% Fe-Ti oxide. The rocks have about 5% porosity. Most pores are round, or at least equidimensional, and from 100 to 1000 μm across. Protruding crystals of feldspar or apatite are found on the walls of some vesicles. A smaller set of pores that are about 10 μm across are bounded by crystal faces of plagioclase and pyroxene grains.

The matrix feldspar consists of laths 5-20 μm long with most grains being 2-5 times as long as wide and having slightly rounded corners. The pyroxene oikocrysts enclose the tablet-shaped feldspars. The Fe-Ti oxide forms poikilitic grains up to 200 μm long between pyroxene oikocrysts. Chadacrysts in the Fe-Ti oxide oikocrysts are feldspar. Rutile-spinel exsolution is abundant in the Fe-Ti oxide. Also concentrated between oikocrysts are sub-5 μm areas of a dark reflecting mesostasis or K-feldspar. Small blebs of metal and metal-sulfide are found between oikocrysts.

Relict grains make up about 10% of the rock. Feldspar comprises about half of the relicts, olivine 1/3, and lithic grains the remainder.

Feldspar relicts are typically angular grains 30 μm to 1.5 mm across. Shock features are rare but a few chert-like maskelynite clasts are found. A small proportion of the relic feldspar contains abundant melt inclusions. Many of the grains have feldspar rims which extinguish separately from the interior of the grain. The transition to the rim is sharp.

Olivine grains, as in all of the melt rocks, are smaller than feldspar relicts, rarely exceeding 150 μm in diameter, and are typically unzoned. Melt inclusions occur in about half of the olivine grains.

Lithic clasts are listed below by thin section.

,8

a. Poikilitic orthopyroxene-feldspar fragment with over 70% feldspar. Feldspars are 40-60 μm across and blocky.

b. Polycrystalline olivine or dunite grain.

,13 - none.

,17 - One polycrystalline feldspar or anorthosite grain.

Pyroxene-rich clast (76015,15).- Sample 76015,15 is taken from a large relatively coarse-grained clast in 76015. The clast appears to be a metamorphosed and brokendown piece of a pyroxene-rich, plagioclase-poor rock with prismatic pyroxenes having grain size in excess of 5 mm. The plagioclase is anhedral, equant, and about 300 μm across. The sample is unique among the entire lunar sample collection.

The original pyroxenes appear to have been subhedral prisms up to 5 mm long, which have partially broken down into other pyroxenes that are complexly twinned or exsolved. The optically continuous pyroxene cores of the prisms are hypersthene which is in sharp contact with the complexly twinned, or exsolved, pyroxene (figure 16(a) and 16(b) . The original low-calcium pyroxene cores seem to be rimmed by augite, some of which has also broken down, or reacted, to form the complexly twinned, or exsolved, phase. Numerous metal and Fe-Ti oxide grains occur in the augite.

The feldspars are much smaller than the pyroxenes, being only 300 μm across, and contain melt and opaque inclusions. In some grains the inclusions are at the center, and in others they are confined to the rim. Rims with a different composition than the cores are typical of the feldspars.

The fragment lacks obvious porosity.

Sample 76215

All three thin sections ,8 ,10 and ,12 are of the greenish-gray matrix. All are poikilitic orthopyroxene rock, with abundant angular relics, similar in texture and model mineralogy to other poikilitic rocks from Apollo 16 and 17 as well as the blue-gray subophitic basalts.

The matrix of the rock is a solid mass of orthopyroxene oikocrysts up to .2 mm wide and 1 mm long. The modal matrix mineralogy is about 50% feldspar, 45% orthopyroxene, 4% augite also as oikocrysts, and 1% Fe-Ti oxide. Nonrelic olivine was not positively recognized. The thin sections have about 5% porosity, generally as round holes approximately 100 μm across. A few euhedral feldspar grains extend into the pores. Small angular pores are abundant between the oikocrysts. These pores are invariably bounded by euthedral feldspar or pyroxene. The feldspar chadacrysts are 5-20 μm long laths with most having long dimension 2-5 times their width. Chadacrysts in the augite oikocrysts are also feldspar but smaller and more equant. The corners of most chadacrysts are slightly rounded. Fe-Ti oxide occurs between oikocrysts as poikilitic grains up to 100 μm long with feldspar and, rarely, spinel chadacrysts. Exsolution of spinel-rutile is noted in some Fe-Ti oxide grains. Metal and metal sulfide form irregular blebs 1-30 μm across.

Clasts make up about 10% of the rock. Virtually all clasts are single grains of olivine or feldspar, with the feldspar being the more abundant.

Olivine relics range in size from 20 to 200 μm. Most have melt or opaque inclusions a few microns across. Some of the smaller clasts are very irregular in outline and are included in the oikocrysts. Most of the larger relics are concentrated between oikocrysts.

Feldspar relics are angular with sizes of 200-400 μm. Undulose extinction, probably due to shock, is found in some grains. Many of the grains have compositionally defined feldspar rims 10 μm thick. Most, but not all, of the rims are continuous around each clast. Melt inclusions are abundant in some feldspar relics.

Lithic clasts are listed below.

A vug-rich clast in section ,10 occurs as a 800 μm across pod with euhedral feldspar tablets 100 μm long and granular olivine. The clast has about 20% porosity.

One polycrystalline olivine fragment in ,10 could be either dunite or a shocked olivine grain.

No patinas were cut by any sections.

Sample 76235

The section is numbered 76230,15 and is a loose piece found in the bag with the friable rock 76235 and believed to be typical of the rock.

The rock appears to be an intensely metamorphosed breccia which was later shocked, and made friable. The only recognizable relic clasts are a few larger-than-normal feldspar grains and possibly one olivine grain and one pink spinel (figure 17). The mode of the rock as a whole is about 70% plagioclase, 20% pyroxene and 10% olivine. The rock has no obvious porosity. Metal is the dominant opaque, but makes up less than 1% of the rock. The basic texture of the rock is a series of pyroxene oikocrysts up to 600 μm long which are completely surrounded by mildly shocked feldspar grains 20-80 μm across (figure 17). Equant but irregular olivine grains 20 μm across are also completely encased by these feldspar grains. The pyroxene oikocrysts are badly fractured and the only recognizable optical characteristics are lower reflectivity than olivine and a high birefringence indicative of pigeonite or augite. Feldspar chadacrysts in the pyroxene oikocrysts are round and less than 20 μm across. The shock features in the feldspar range from chert-textured maskelynite (rare) to fractured grains with rather wavy extinction. Round olivine inclusions about 10 μm across are abundant in some feldspars. The single, large, pink, spinel grain is about 300 μm long, irregular in shape and completely surrounded by feldspar.

Unlike virtually all other highland rocks,metal is the dominant opaque. It occurs as irregular blebs, not associated with sulfide. The blebs are associated with the plagioclase-olivine parts of the rock rather than the oikocrysts. Traces of spinel and Fe-Ti oxide are noted as <2 μm grains.

No patinas were noted.

Sample 76255

Having been collected from the contact zone between a large tan clast and the blue-gray breccia matrix, this is the most complex of the Station 6 boulder samples. The sample consists primarily of a banded, tan and white, friable breccia, which is the large clast within the blue-gray breccia portion of the boulder as a whole. One corner of sample 76255 is blue-gray and gradational into the typical blue-gray breccia. The banded tan material is sampled in 76255,12 and the larger part of 76250,4. (76250,4 consists of two loose chips from the sample bag which contained 76255. The larger of the two loose chips looked like the tan matrix, the smaller like the blue-gray material.) Section ,14 is a portion of the banded white material. Section ,16 is made from a highly feldspathic part of the banded white material. Section ,10 was made directly from a chip of the blue-gray area; and the smaller chip of 76250,4 is presumably from the same material.

Due to the rock's complexity each major part will be described separately.

Banded tan (76250,4 larger piece; 76255,12).- Both samples are friable, clast-supported breccias made up of angular fragments 20-700 μm across. The angular crystalline clasts are bound together by partially crystallized melt, or glass with low reflectivity (figure 18(a) and 18(b)0. The partially crystallized parts are plagioclase, pyroxene, and Fe-Ti oxide with interstitial glass. The rock lacks a matrix in the usual sense of sintered particles ranging in size from 10 μm down to less than 1 μm. The melted material is spread unevenly through the rock ranging from <5% to 20%. The porosity of the rock ranges from 25% where little melt is present to less than 5% where virtually all clasts are surrounded by melts. The pores are very irregular in outline reflecting the shape of the spaces between the clasts. However, none of the pores have sharp corners, because of the surface tension of the melt at the point of contact between grains.

Virtually all of the clasts are single mineral grains which are, in order of abundance, feldspar (∿70%), exsolved pigeonite (figure 18(c), augite, olivine, orthopyroxene, and Fe-Ti oxide. A few glassy-matrix-breccia clasts like section 76250,4 (small part) and 76255,10 are also noted.

All feldspar grains are extremely angular, 20-700 μm across and, with few exceptions, free of shock features. Melt inclusions are present in less than 1% of the feldspar grains. One feldspar grain is intergrown with olivine. Compositionally defined rims are absent.

Exsolved pigeonite grains are angular. The host crystals are bronzite or hypersthene (2V = 50°-90° (-)) with elongated blebs or planar bands of augite about 30 μm thick. Reaction rims are not noted.

Augite consists of angular grains less than 100 μm across; virtually all have laminar twinning.

Olivine occurs as relatively small (<100 μm) angular grains.

Orthopyroxene is comprised of angular grains, most of which are small and could be broken fragments from exsolved pigeonite.

Fe-Ti oxide grains are angular with rutile-spinel exsolution.

The difference in color between the tan layers and the white layers may be due either to a difference in the proportion of clasts over 100 μm or it may be due to differences in the amount of the melt between grains.

Blue-gray material (76250,4 smaller piece; 76255,10).- Both sections of dark blue-gray material are made up of 50% or more melted matrix containing clasts similar to those listed above with the exception that virtually all feldspar is chert-textured maskelynite. The melted matrix consists of a fine-grained, subophitic basalt with about 50% feldspar, 1-2% Fe-Ti oxide, and a remainder of pyroxene (figure 18(d)). Grain sizes vary from sample to sample. Section 76250,4 is the coarsest with subhedral feldspar tablets up to 20 μm long and 15 μm anhedral pyroxene. Section 76255,10 is the finest with 10 μm feldspar and 3 μm pyroxene. Pores form less than 5% of the melt areas and most are irregular features less than 20 μm across.

The different mineral clasts in the dark material have about the same proportions as in the tan banded layers. However, virtually all feldspar is chert-textured maskelynite. One unique clast in 76250,4 (dark portion) is a shocked norite with about 70% feldspar and 30% orthopyroxene which appears to have remnants of an earlier plutonic texture.

Banded white (76255,14; 76255,16).- The white banded part of the rock in 76255,14 is intermediate in texture between the melt-poor, banded tan material and the melt-rich, dark blue-gray material. Section 76255,16 consists primarily of two fragments of chert-textured maskelynite plus a small amount of matrix similar to that of 76255,10.

The dark melted matrix forms rinds around the larger clasts in 76255,10 ,12 and ,14. In 76250,4 the melt surrounds virtually the entire sample. The rimming of samples by the melt appears to predate deposition and appears to have coated the clasts.

Patinas of thin brown glass layers with a few crystals are cut on the feldspar-rich side of 76255,16.

Sample 76275

The two sections of this rock ,4 and ,6 are similar. Both are very fine-grained basalts with 60% feldspar and abundant relic clasts. Some of the clasts are concentrated in vein-like structures. The matrix in ,6 is relatively homogeneous. The matrix of ,4 is heterogeneous with some parts having higher concentrations of small relics and coarser opaque minerals.

The matrix is a fine-grained, subophitic basalt with approximately 60% feldspar, 40% pyroxene and 1% Fe-Ti oxide. Pores make up <1 to 20% of the matrix, virtually all as 3 to 10 μm irregular holes lacking any well developed crystals protruding into the cavities. Plagioclase grains are typically about 10 μm long and range from tablets to anhedral forms. Pyroxenes are anhedral and about 25 μm across. The opaque phases rarely exceed 4 μm and tend to be equant to slightly rounded plates. The coarser areas of section ,4 have 25 μm pyroxene, 20 μm feldspar, and 5-10 μm opaques. Flow structures around the larger clasts are not obvious.

The opaques are mostly Fe-Ti oxide. Some of the larger grains have visible spinel-rutile exsolution. Metal occurs mostly as submicroscopic blebs but there are a few 30-40 micron irregular masses. There is no schreibersite.

Clasts larger than 10 μm make up 10% to 15% of the section. Feldspar clasts are the most abundant, olivine is much less abundant and possible pyroxene is very rare. Only a few lithic fragments were noted, all in section ,4. The vein-like concentrations of clasts are best developed in ,6 and display typical matrix material between the clasts.

The largest feldspar clasts are about 4 mm, but more commonly they are less than 100 μm and all are angular. Shock features range from none to chert-like maskelynite. The 4 mm feldspar clast has numerous 200 μm inclusions of olivine--most of which extinguish as a unit. Grains with numerous melt inclusions and others with no inclusions are noted. Optically zoned rims are rare.

Olivine grains, in general, are smaller than the feldspars and more irregular in shape.

Several pyroxene grains in ,6 have lamellae that look like pigeonite exsolution; however, the host appears to be augite. One grain in ,6 has thick lamellae of possibly two phases in what seems to be an orthopyroxene host.

Lithic clasts are listed below.

A vuggy clast in section ,4 is about .5 mm across and nearly round. It contains plagioclase (or orthopyroxene) as euhedral tablets about 60 μm long. Some orthopyroxene is smaller and possibly sheathed with augite. One possible metal cube (or other euhedral form) was observed.

The only other lithic clasts are two poikilitic plagioclase-orthopyroxene-olivine fragments in ,4. They are more feldspathic than KREEP. The oikocrysts are orthopyroxene with blocky plagioclase chadacrysts 20 μm across. The texture is quite unlike that of the poikilitic rocks having KREEP-like composition.

No patinas were noted in either section.

Sample 76295

Both sections ,11 and ,13 are basically blue-gray, subophitic to micropoikilitic basalt with concentrations of mineral relics in tan-colored, vein-like bands (especially in ,13).

The matrix consists of about 60% feldspar and 40% mafic minerals most of which are pyroxene, but with about one percent Fe-Ti oxide. The matrix has about 5% porosity in 1-10 μm, irregularly-shaped pores. Section ,13 has a small area with 25% porosity containing smooth-walled pores over 100 μm across. Euhedral crystals do not protrude into the pores. The matrix feldspars are tabular to anhedral, up to 15 μm long, and partially or totally encased in euhedral to elongated pyroxene patches up to 20 μm long (figure 19(a)). The Fe-Ti oxide occurs as poorly formed plates up to 7 μm across. They contain some rutile-spinel exsolution. There are suggestions of alignment of feldspar laths around some of the larger clasts. Metal grains are irregular in outline and larger than the Fe-Ti oxide, some as much as 30 μm across.

The vein-like areas consist principally of concentrated clasts, which are 30 μm and larger in size but also contain small amounts of typical blue-gray matrix between the clasts (figure 19(b)). The veins are over 0.5 mm wide in the plane of section. The clasts in the vein show no obvious alignment. The abundance of veins in section ,13 causes the veins to appear as matrix and the blue-gray matrix to appear as clasts.

Feldspar grains make up about 2/3 of the relics, the remainder is about equally divided between olivine, pyroxene, and lithic fragments.

Feldspar relicts are usually blocky and angular, the largest being about 400 μm and the smallest about 30 μm in diameter. Solid state shock features range from none to chert-like maskelynite. A few grains contain abundant, brown, melt inclusions. Some grains have sharply bounded, optically defined feldspar rims.

Olivine relicts are, as a rule, smaller and more irregularly shaped than the feldspar, the largest grain being about 200 μm across. Melt inclusions are noted in a few grains.

Pyroxene with exsolution texture, possibly once pigeonite, is found in about 5 grains in ,13; smaller pyroxene grains may be abundant in the matrix where it cannot be easily differentiated from olivine. One pink pyroxene was found in ,13 (possibly a mare component).

Lithic clasts are listed below for each thin section.

,13

a. Granoblastic to poikilitic, highly feldspathic rock with orthopyroxene.

b. More poorly developed granoblastic texture in fragment similar to a.

,11

a. Poikilitic fragment with about 60% feldspar, orthopyroxene oikocrysts up to 100 μm long. Feldspar chadacrysts are tabular to anhedral and 15 μm long. Abundant Fe-Ti oxide.

b. Partially annealed feldspathic breccia with light colored matrix and 1% opaques.

c. Spherulitic, devitrified glass containing about 70% feldspar, 0.1% opaques, and remainder of very fine pyroxene.

Patina of thinly laminated glass containing a few crystals occurs on the T_1 edge of section ,13.

Sample 76315

The rock is dominantly a blue-gray subophitic basalt with approximately 60% feldspar. Polished thin sections ,12 and ,16 sample this blue-gray material. Section ,14 is taken from a friable, light colored area which is a clast of granoblastic-textured, feldspathic norite.

Blue-gray (76315,12 and 76315,16).- The blue-gray basaltic material is a compositionally banded, slightly porous melt-rock with about 5% mineral and lithic clasts. The matrix consists of about 60% feldspar, 30% low calcium pyroxene, 5% Fe-Ti oxide and 5% olivine in a subophitic to poikilitic texture. Pores 25 microns or less in diameter and irregular in outline form a porosity of 1-25%. Euhedral crystals do not protrude into the pores. Feldspar grains are generally tabular and rarely exceed 25 μm. Pyroxene grains are anhedral and a bit larger than the feldspar. Olivine occurs as granular grains about 25 μm across. The Fe-Ti oxide occurs as blebs or plates up to 15 μm long concentrated at grain boundaries as if it were a late precipitating phase. Metal and metal-sulfide intergrowths are somewhat larger than the oxides being about 25 μm across and very irregular in outline.

Compositional banding up to 5 mm thick occurs in the plane of the section. It is marked by changes from 2.5 to 5% in opaque content, slight changes in grain size, and marked changes in the abundance of relic clasts (figure 20(a)). In ,16 a transition in matrix texture from subophitic to poikilitic, with 700 μm oikocrysts, occurs across one of the compositional boundaries.

Clasts in blue-gray matrix.- Mineral clasts are olivine and feldspar in about equal proportions with a few pink spinels. Lithic clasts make up less than 25% of the total clast population.

Feldspar clasts, 40 to 400 μm in size, are angular and range from free of shock features to chert-textured maskelynite; relatively unshocked grains are the most common. Melt inclusions are abundant in some grains and absent in others. Compositionally zoned rims are rare.

Olivine grains are irregular to angular and a bit smaller than the feldspar, being 80 μm or less. Most have melt inclusions. One large grain is compositionally zoned radial to its fractured grain boundary.

Lithic clasts are quite variable and are listed by thin section.

,12

a. Poikilitic feldspathic norite.
b. Granulated pink spinel troctolite.
c. Intensely shocked allivalite with chert-textured maskelynite.
d. Poikilitic feldspar - pink spinel-olivine rock.
e. Feldspar-olivine rock, plagioclase has olivine cores.
f. Granoblastic textured allivalite.

,16

a. Polycrystalline olivine (dunite or shocked olivine).

Troctolitic clast (76315,14).- This section is all one clast. It consists of about 75% feldspar, 25% olivine and less than 1% metal and Fe-Ti oxides. The feldspar grains are 20-30 μm across, the olivine about 10 μm. The polygonal grain boundaries characteristic of thermal metamorphism are well displayed. A few feldspar grains are large, and the blocky angular outline of their original form as clasts in a breccia is recognizable (figure 20(b)).

No patinas occur in the sections.

CHEMISTRY

Major Element

Table III lists whole rock and soil analyses obtained by the PET. Sections 76315,2 and 76055,5 are analyses of blue-gray and green-gray material, respectively, although petrographically the texture of 76055,5 is similar to the blue-gray material. The latter is not part of the consortium but does come from Station 6. Sample 76230,4 is a white clast with a crushed and annealed texture. The analysis of soil 76501,2 indicates that analyses of 76315 and 76055 are more typical of Station 6 as a whole rather than the more feldspathic 76230 analysis. Analyses of Station 2 soils are listed as representatives of massif soils relatively free of mare contamination which makes up several percent of 76501.

Gamma Counting

The gamma ray counting data for Station 6 rocks (table IV), obtained primarily during the Apollo 17 preliminary examination, indicates that all analyzed rocks have over 0.2% K_2O and confirms the estimates made from modal mineralogy (see petrographic section) that with the exception of 76230 all samples should have low-K KREEP chemistry. The K/U ratio of 5000 for 76255 is unique in accord with its unusual texture, which includes feldspar and exsolved pigeonite bound together with a low-K KREEP-like melt. Analyses of three soils from Station 6 are included to show the lower K, U, and Th values than exist in the rock.

Noble Gas Studies

Noble gases were measured in small chips of three different rocks taken from the Station 6 boulders in order to determine concentration levels of these gases. The data obtained (table V) show that all three rock chips contained trapped solar gases at approximately 1% of the concentrations present in lunar fines. Photography indicates that our sample chips from rocks 76315 and 76295 came from freshly broken surfaces, or at least from surfaces without craters or a developed weathering patina. Our sample chip from 76255 was undocumented. If the three samples analyzed were not from exterior surfaces and had not been somehow contaminated with fines, these solar gases would have to be indigenous to the breccia. If this proves to be the case, these solar gases should have been acquired before brecciation, when the material was disseminated on the lunar surface. However, the presence or absence of trapped gases in the breccia will be determined conclusively upon analysis of interior samples. Even with the measured concentration levels of solar gases, ^{40}Ar is primarily radiogenic in origin, and ought to allow accurate determination of gas retention ages by the $^{40}Ar/^{39}Ar$ technique. Appreciable amounts of radiogenic ^{4}He are also apparently present.

Calculated concentrations of cosmogenic gases in these samples are given in table VI. The small variations among samples in cosmogenic ^{21}Ne and ^{38}Ar can probably be accounted for by measurement uncertainties and by target element variations; however, small shielding differences may also be involved. We have estimated cosmic ray exposure ages for these samples using production rates (reference 3) and the chemistry of 76315 given by Apollo 17 PET. These ages are given in parentheses in table VI. The consistent difference between ^{21}Ne and ^{38}Ar ages reflects an uncertainty in either the chemical compositions used or in the relative production rates. The ^{126}Xe age for 76315 is calculated with an estimated Ba abundance, and is certainly less accurate. In addition, we have assumed 2π irradiation geometry for these samples, which, because of self-shielding of the boulders, is probably an over estimate. Corrections for such shielding could raise all exposure ages as much as a factor of two, but probably by less. However, it is obvious that the total cosmic ray exposure time of the east face of boulders 1 and 2 has been of the order of 10^7 years. This would be the maximum elapsed time since the boulder rolled to its present position. Other portions of the boulder could have longer exposure times if our samples had been shielded from cosmic rays by the mass of the boulder during its history in a position of high elevation on North Massif, including its point of origin.

MAGNETIC STUDIES

During the first stage allocation, three loose samples—76015,2 (7.14 gm); 76215,1 (0.73 gm) and 76307,0 (2.49 gm)—were made available to D. W. Strangway for nondestructive magnetic measurements. All three possess a natural remanent magnetization (NRM) that is directionally stable to strong alternating field demagnetization (200-300 Oe.). In addition the intensities of the NRM in samples 76015 and 76215 are not appreciably affected by the demagnetization. They have no soft component of NRM, only a very hard stable component which is almost certainly lunar in origin. The NRM of 76307,0, although as stable directionally as that of the other samples, is decreased in intensity from 8×10^{-5} emu/gm to 1.5×10^{-6} emu/gm by demagnetization in a field of 250 Oe. The behavior of this NRM is not similar to remanent magnetizations produced in the sample by strong fields in the laboratory and is most likely of thermo-remanent origin and acquired on the moon. If the NRM seen in these samples is common to all samples from the boulder and if it is consistent in direction throughout each boulder fragment, then it is possible that the NRM may help in fitting the boulder fragments back to their original configurations. Suitable samples for determination of the constancy of NRM directions throughout each rock is the next step in establishing the usefulness of magnetic measurements in this matter.

Preliminary studies for fission track quality of small chips from six different rocks by R. M. Walker (written communication, July 1973) indicate that all samples are measurable but not ideal. It should be possible, therefore, to determine some exposure ages by this method. X-ray diffraction analysis of 76295,3 indicates that the fine-grained white powder that coats much of the surface consists primarily of orthopyroxene with perhaps some plagioclase.

CONCLUSIONS

The following conclusions are drawn from this preliminary study:

1. The cluster of boulders at Station 6 may be derived from one larger boulder which rolled to its present location from an outcrop high on the North Massif, Apollo 17 landing site.

2. There are possibly three units which were sampled in the boulder cluster: (a) Highly vesicular unit A with abundant large vesicles; many are flattened along a plane parallel to the contact with the adjacent unit. (b) Unit B, characterized by well-developed foliation or banding; vesicular, with only a trace of vesicles >5 cm long. Few large clasts are visible. (c) Unit C is massive, with no obvious foliation. It contains blue-gray to white clasts up to 0.8 m long.

3. All of the samples collected from the boulder cluster are breccia; impact melts with a variety of clast types. Matrix samples were collected from photogeologic units A, B, and C and two different large-scale clast types were sampled from unit C.

All clasts and matrices fall into two groups:

a. Breccias containing 50-60% modal feldspar, ~45% orthopyroxene and 1-7% Fe-Ti oxide. Preliminary chemical analysis indicates that the matrix has the composition range of low K-Fra Mauro or High Alumina basalt.

b. Breccia clasts containing 70% feldspar, 30% orthopyroxene and olivine and a trace of opaque minerals. The chemical composition is that of a Highland basalt.

4. Several samples have numerous vugs and vesicles ranging from 25 μm to 8 cm long. Many of the vug walls are lined with patches of well-developed silicate and metal crystals.

5. Samples exposed to the lunar environment are partly coated with a thin patina of brown glass.

6. Estimated cosmic ray exposure ages for three samples range from 6.4 to 15 m.y.

7. Three samples analyzed all possess a natural remanent magnetization that is directionally stable to strong alternating field demagnetization (200-300 Oe).

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TABLE I.- SAMPLES AND STUDIES OF BOULDER CONSORTIUM ROCKS,
STATION 6, APOLLO 17

Sample	Daughter	Weight, gm	Study	Orientation	Comments
76015	,0	2819	gamma ray	known	
	,1	4.38	PTS ,8	known	
	,2	7.14	Magnetics	known	Fell off during handling but documented
	,3	0.10	PTS ,13	known	
	,4	0.05	PTS ,15	known	
	,5	0.06	PTS ,17	known	
	,6	0.05	Etch study for tracks	not known	Loose chip, undocumented
76215	,0	642.8	gamma ray	known	Orientation in spalled slab on ground is known but exact orientation of spall on boulder is not certain
	,1	0.73	magnetics	known	
	,2	0.37	not studied	not known	Fell off during handling, undocumented
	,3	0.08	PTS ,7 and ,8	known	
	,4	0.15	PTS ,10	known	
	,5	0.03	PTS ,12	known	
	,6	0.02	Etch study for tracks	known	
	,11	0.03	not studied	not known	Loose chip from ,1, not documented
[a]76230	,3	.31	PTS ,11 and ,12	not known	
	,4	1.24	chem	not known	
76235	,0	26.56		not known	All of these 8 fragments were chipped from a rather friable clast and collected by catching them in a scoop. Therefore, although the chips are all derived from a rather restricted area within a large clast the exact location and orientation of each chip is unknown
36	,0	19.18		not known	
37	,0	10.31		not known	
38	,0	8.21		not known	
39	,0	6.23		not known	
76305	,0	4.01		not known	
06	,0	4.25		not known	
07	,0	2.49	magnetics	not known	

TABLE I.- SAMPLES AND STUDIES OF BOULDER CONSORTIUM ROCKS, STATION 6, APOLLO 17 - Continued

Sample	Daughter	Weight, gm	Study	Orientation	Comments
[a]76250	,3	0.81	PTS ,4 and ,5		Two fragments mounted together
76255	,0	393.22	gamma ray	known	
	,1	13.15	not studied	known	Loose chip, documented
	,2	0.18	not studied	not known	Loose chip, undocumented
	,3	1.45	not studied	known	Loose chip, documented
	,4	0.05	PTS ,10	known	
	,5	0.07	PTS ,12	known	
	,6	0.06	PTS ,14	known	
	,7	0.05	PTS ,16	known	
	,8	0.09	Etch study for tracks	known	
	,9	0.08	noble gas	not known	Loose chip, undocumented
76275	,0	55.93	gamma ray	known	
	,1	0.09	PTS ,4	known	
	,2	0.045	PTS ,6	known	
	,3	0.01	Etch study for tracks	known	
76295	,0	260.7	gamma ray	known	
	,1	0.13	PTS ,11	known	
	,2	0.05	PTS ,13	known	
	,3	0.01	x-ray diffraction	N/A	powder from joint surface
	,4	0.025	Etch study for tracks	known	
	,5	0.025	noble gas	known	
	,6	0.41	not studied	known	
76315	,0	669.16	gamma ray	not known	
	,1	0.64	PTS ,11 ,12 and ,13	not known	Loose chip, undocumented but can be mated to parent on basis of lithology but not oriented
	,2	1.30	chem	known	Those orientations marked known are known with respect to sample 76315,0 but not with respect to boulder.
	,3	0.08	PTS ,14	known	

TABLE I.- SAMPLES AND STUDIES OF BOULDER CONSORTIUM ROCKS,
STATION 6, APOLLO 17 - Concluded

Sample	Daughter	Weight, gm	Study	Orientation	Comments
76315 (cont)	,4	0.06	PTS ,16	known	
	,5	0.04	Etch study for tracks	known	
	,6	0.02	noble gas	known	

[a]76250 and 76230 are residues from the sample bags which contained rocks 76255 and 76235-39, 305-307 respectively. Essentially no soil was present in these bags and the selected fragments 76230,3; 76230,4; and 76250,3 are believed to be derived from the parent rocks. The selected fragments were compared with the parent rocks by binocular microscopic examination to further verify this relationship.

PTS - polished thin section.

TABLE II.- PETROGRAPHIC GROUPINGS

50% Modal Feldspar

Poikilitic texture (green-grey rocks)

76015 matrix (,8 ,13 ,17)
76215 matrix (,8 ,10 ,12)

Subophitic basalt (blue-grey rocks)

76250,4 (small part)
76255 (,14 ,16)
76275 (,4 ,6)
76295 (,11 ,13)
76315 (,12 ,16)

70% Modal Feldspar

Crushed and annealed texture

76230,12
76250,4 (large part)
76255 (,10 ,12)

One Unique Clast

76015,15

TABLE III.- MAJOR ELEMENT ANALYSES OF ROCKS AND SOILS FROM STATION 6

Major elements	Green-grey poikilitic rock	Loose blue grey sample not part of consortium	Friable annealed feldspathic breccia	Soil	Station 2 soils possibly less mare contamination than station 6 soil	
Sample number	76315,2	76055,5	76230,4	76501,2	72501,2	72701,2
SiO_2 (%)	45.82	44.65	44.52	43.41	45.12	44.87
TiO_2 (%)	1.47	1.24	0.20	3.15	1.56	1.52
Al_2O_3 (%)	18.01	16.47	27.01	18.63	20.64	20.60
FeO (%)	8.94	9.11	5.14	10.32	8.77	8.65
MnO (%)	0.11	0.11	0.06	0.14	0.11	0.12
MgO (%)	12.41	16.33	7.63	11.08	10.08	9.97
CaO (%)	11.06	9.93	15.17	12.28	12.86	12.80
Na_2O (%)	0.57	0.48	0.35	0.35	0.40	0.40
K_2O (%)	0.27	0.20	0.06	0.10	0.16	0.16
P_2O_5 (%)	0.29	0.19	0.05	0.08	0.13	0.15
S (%)	0.08	0.07	0.03	0.07	0.09	0.07
Cr_2O_3 (%)	0.19	0.19	0.11	0.26	0.23	0.23
TOTAL (%)	99.22	98.97	100.33	99.87	100.15	99.54
Norm						
Quartz	--	--	--	--	--	--
Orthoclase	1.60	1.18	0.35	0.59	0.95	0.95
Albite	4.82	4.06	2.96	2.96	3.38	3.38
Anorthite	45.79	42.20	71.95	48.97	54.05	53.94
Diopside	5.96	4.78	2.44	9.30	7.29	7.04
Hypersthene	24.66	19.21	8.74	16.98	19.29	19.32
Olivine	12.70	24.52	13.25	14.58	11.62	11.39
Ilmenite	2.79	2.36	0.38	5.98	2.96	2.89
Apatite	0.63	0.42	0.11	0.17	0.28	0.33
TOTAL	98.95	98.73	100.18	99.53	99.82	99.24
Trace elements						
Sr (ppm)	175	155	145	147	153	155
Rb (ppm)	5.8	5.1	0.3	2.5	4.2	3.9
Y (ppm)	111	76	12	46	64	54
Zr (ppm)	510	341	42	158	271	275
Nb (ppm)	33	23	3.2	13	18	18
Ni (ppm)	149	155	166	206	241	227
Zn (ppm)	4	1	2	29	21	22

Analysts: J. M. Rhodes, K. V. Rodgers, B. M. Bansal.

TABLE IV.- GAMMA-RAY COUNTING DATA FOR STATION 6 ROCKS

	Green-grey poikilitic rock	Green-grey poikilitic rock	Complex breccia with blue-grey area	Blue-grey impact basalt	Blue-grey impact basalt		Shadowed soil	Unshadowed soil nearby		Unshadowed soil
Sample	76015,0	76215,0	76255,0	76275,0	76295,0	76295,0	76240,2	76261,1	76261,1	76501,4
WEIGHT (g)	2819.0	642.8	393.2	55.93	260.7	260.7	104.98	100.7	100.7	97.89
LAB[a]	ES	RCL	BNW	BNW	ORNL	BNW	BNW	RCL	BNW	ORNL
Th (ppm)	8 ± 3	4.6 ± .2	2.33 ± .05	5.4 ± .4	5.30 ± .27	5.76 ± .17	2.30 ± .06	2.1 ± .3	1.92 ± .04	1.39 ± .14
U (ppm)	2 ± .3	1.27 ± .06	.58 ± .02	1.39 ± .10	1.50 ± .08	1.55 ± .05	.60 ± .02	.49 ± .02	.51 ± .02	.38 ± .04
K (%)	.30 ± .06	.215 ± .014	.291 ± .006	.222 ± .009	.227 ± .011	.230 ± .009	.110 ± .005	.102 ± .003	.097 ± .004	.090 ± .005
^{26}Al (dpm/kg)	detected	56 ± 3	79 ± 4	111 ± 9	67 ± 5	71 ± 4	151 ± 6	182 ± 17	171 ± 5	90 ± 9
^{22}Na (dpm/kg)	detected	60 ± 4	71 ± 4	95 ± 6	54 ± 4	64 ± 3	42 ± 2	148 ± 8	142 ± 4	90 ± 9
^{54}Mn (dpm/kg)	detected	22 ± 17	38 ± 9	103 ± 20	38 ± 15	70 ± 30	31 ± 8	93 ± 7	106 ± 8	60 ± 10
^{56}Co (dpm/kg)	detected	45 ± 6	37 ± 4	64 ± 6	41 ± 7	35 ± 5	27 ± 3	240 ± 20	245 ± 8	120 ± 12
^{46}Sc (dpm/kg)	detected	5 ± 3	3.9 ± 1.3	7 ± 2	5 ± 2	6.4 ± 2.6	8 ± 4	23 ± 2	27 ± 3	18 ± 4
^{48}V (dpm/kg)		<24	5.7 ± 2.6				2.6 ± 1.4	18 ± 12	19 ± 10	15 ± 10
^{60}Co (dpm/kg)		<.4		<1.1		<1.2	.8 ± .4	12 ± 5	<1.5	
^{7}Be (dpm/kg)	detected									
^{51}Cr (dpm/kg)	detected									
^{57}Co (dpm/kg)										
^{58}Co (dpm/kg)	detected									
Th/U	4 ± 1.6	3.6 ± .2	4.0 ± .2	3.9 ± .4	3.5 ± .3	3.7 ± .2	3.3 ± .2	4.3 ± .6	3.8 ± .2	3.7 ± .5
K/U	1500 ± 400	1690 ± 140	5000 ± 200	1600 ± 130	1510 ± 110	1500 ± 80	1800 ± 100	2100 ± 100	1900 ± 110	2400 ± 300

[a]Key to laboratories

BNW - L. A. Rancitelli, R. W. Perkins, W. D. Felix and N. A. Wogman
Battelle, Pacific Northwest Laboratories

RCL - J. E. Keith and R. S. Clark
NA NASA-Johnson Space Center
W. R. Portenier and M. K. Robbins
Northrop Services, Incorporated

ES - Ernest Schonfeld
NASA-Johnson Space Center

ORNL - G. D. O'Kelley, J. S. Eldridge and K. J. Northcutt
Oak Ridge National Laboratory

TABLE V. - NOBLE GAS ABUNDANCES

[Chips of three rock samples from the Station 6 boulders. Abundances in cm^3 STP/g are estimated as ±5%, except ^{84}Kr which is ±10%. Blank corrections of <2% for all cases have been applied]

Sample No.	Sample wt. (mg)	^{3}He 10^{-6}	^{4}He 10^{-6}	^{22}Ne 10^{-6}	^{36}Ar 10^{-6}	^{40}Ar 10^{-6}	^{84}Kr 10^{-10}	^{132}Xe 10^{-10}
76315,6	19.6	0.395	1560	0.85	2.26	72.1	26.5	4.56
76295,5	22.0	0.466	1940	1.73	5.09	127	60.2	6.64
76255,9	50.5	0.217	1870	0.53	1.69	105	18.4	2.00

TABLE VI. - CALCULATED COSMOGENIC GAS CONTENTS AND ESTIMATED EXPOSURE AGES FOR THREE SAMPLES FROM THE STATION 6 BOULDERS

[Abundances have been calculated in cm^3 STP/g assuming a two component mixture of trapped solar and spallogenic gases. Exposure ages (given in parentheses) are in millions of years, and have been calculated from production rates for ^{21}Ne, ^{38}Ar, and ^{126}Xe given by Bogard et al. (1971) and from the measured chemical composition of 76315,2 given by the Apollo 17 PET (1973)]

Sample No.	^{21}Ne 10^{-8}	^{38}Ar 10^{-8}	^{126}Xe 10^{-12}	^{80}Kr 10^{-12}
76315,6	1.60 (9.9)	0.92 (6.7)	5.0 (15)	19.5 --
76295,5	1.33 (8.2)	0.86 (6.4)	6.3 --	<38 --
76255,9	1.45 (9.0)	1.03 (7.7)	1.7 --	16 --

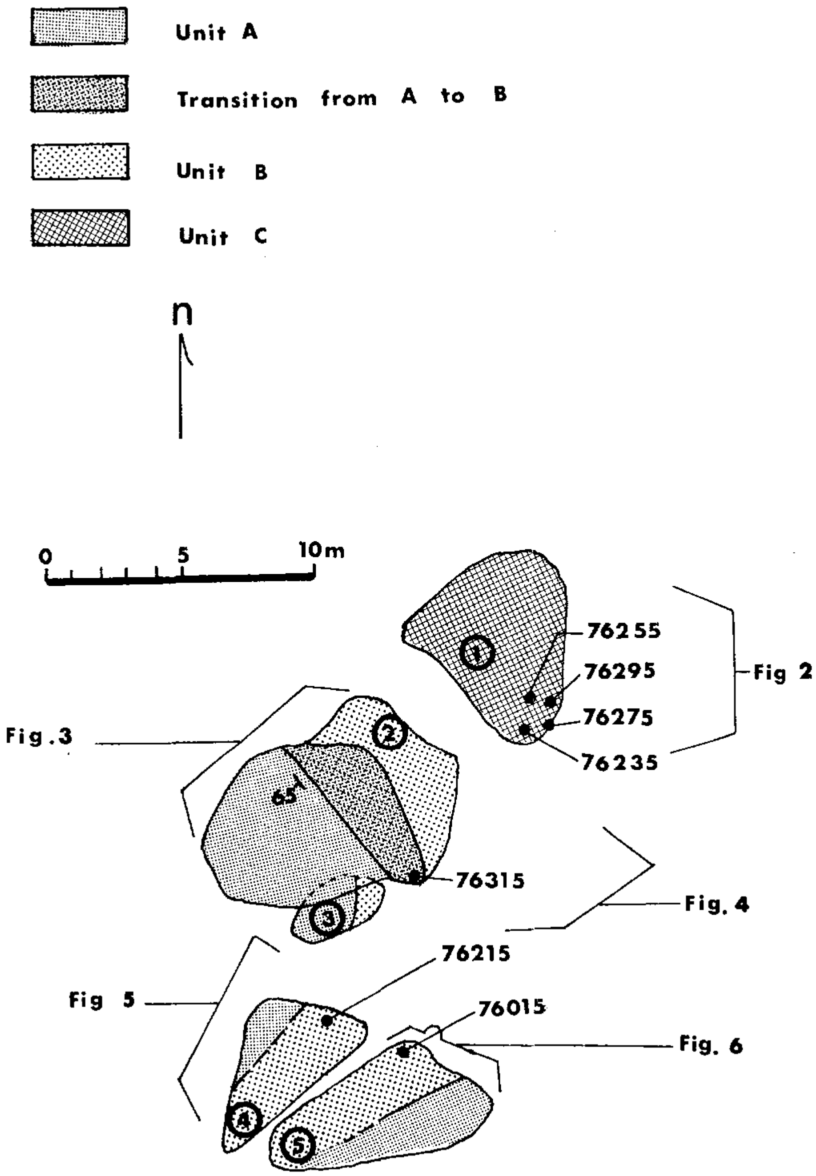


Figure 1. - Map of the boulder cluster at Station 6, showing sample locations, location of lithologic units, and index to boulder maps.

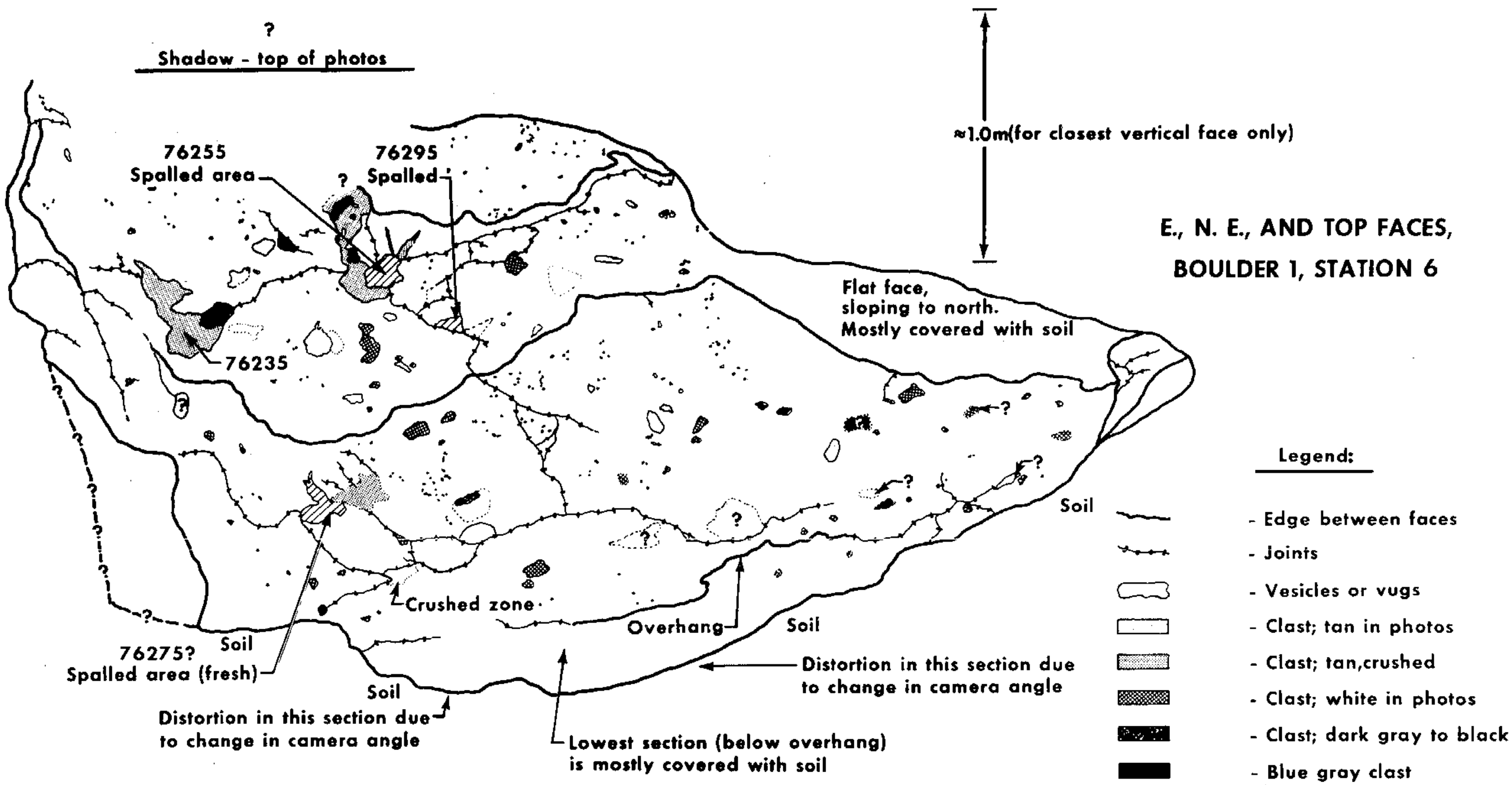


Figure 2. - Map of the East,Northeast and top faces of Boulder 1.

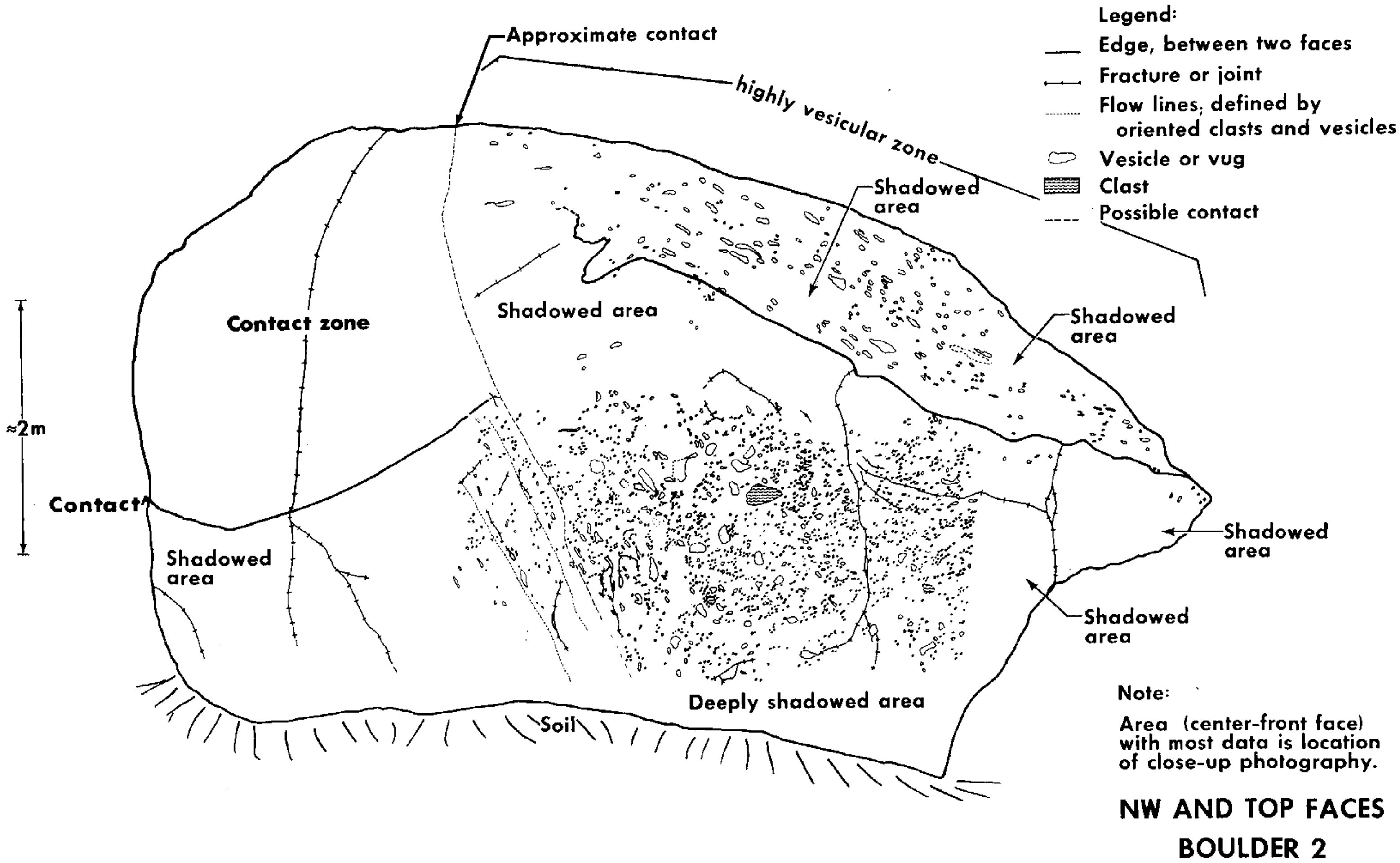


Figure 3. - Map of the Northwest and top faces of Boulder 2.

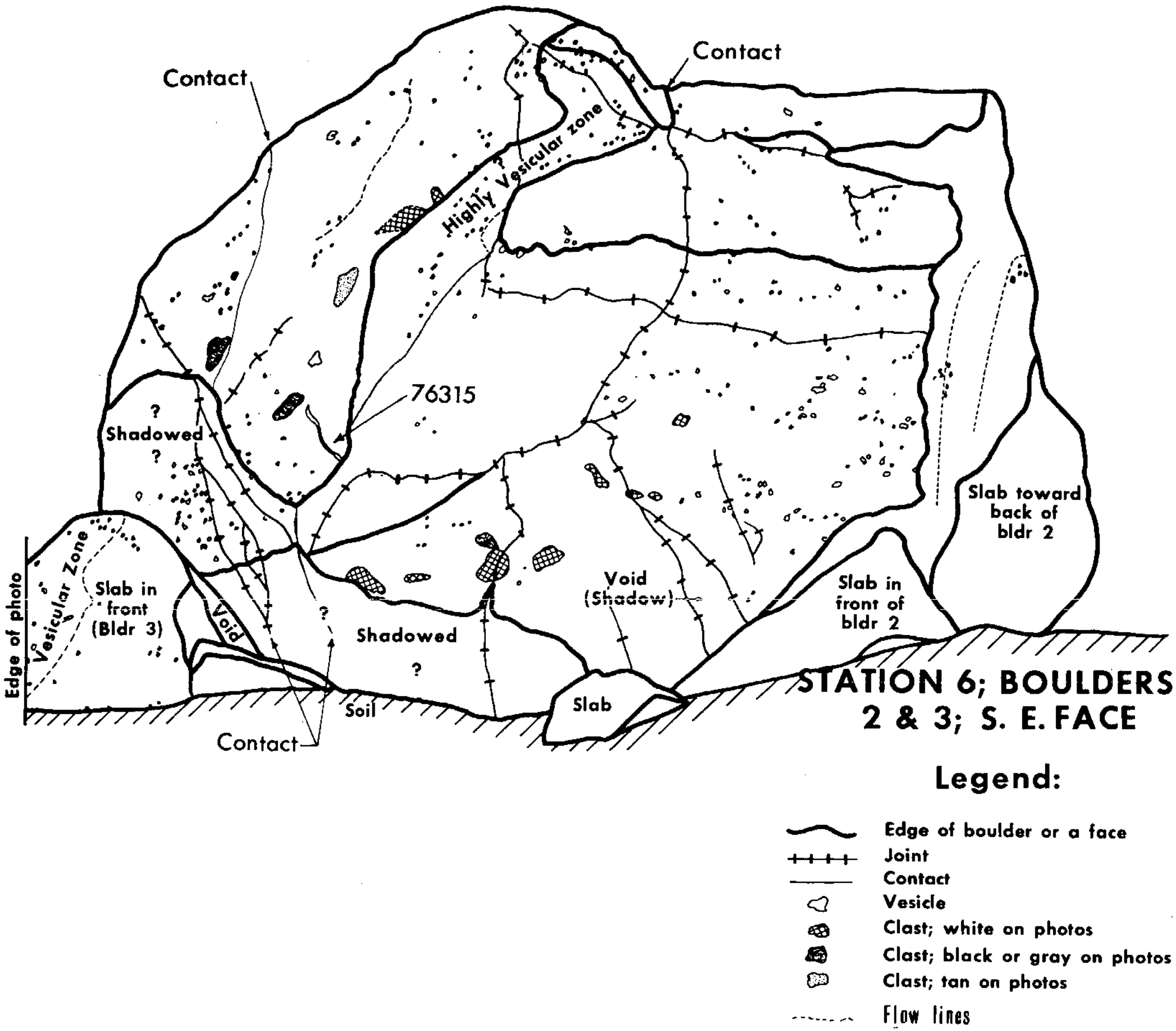


Figure 4. - Map of the Southeast face of Boulders 2 and 3.

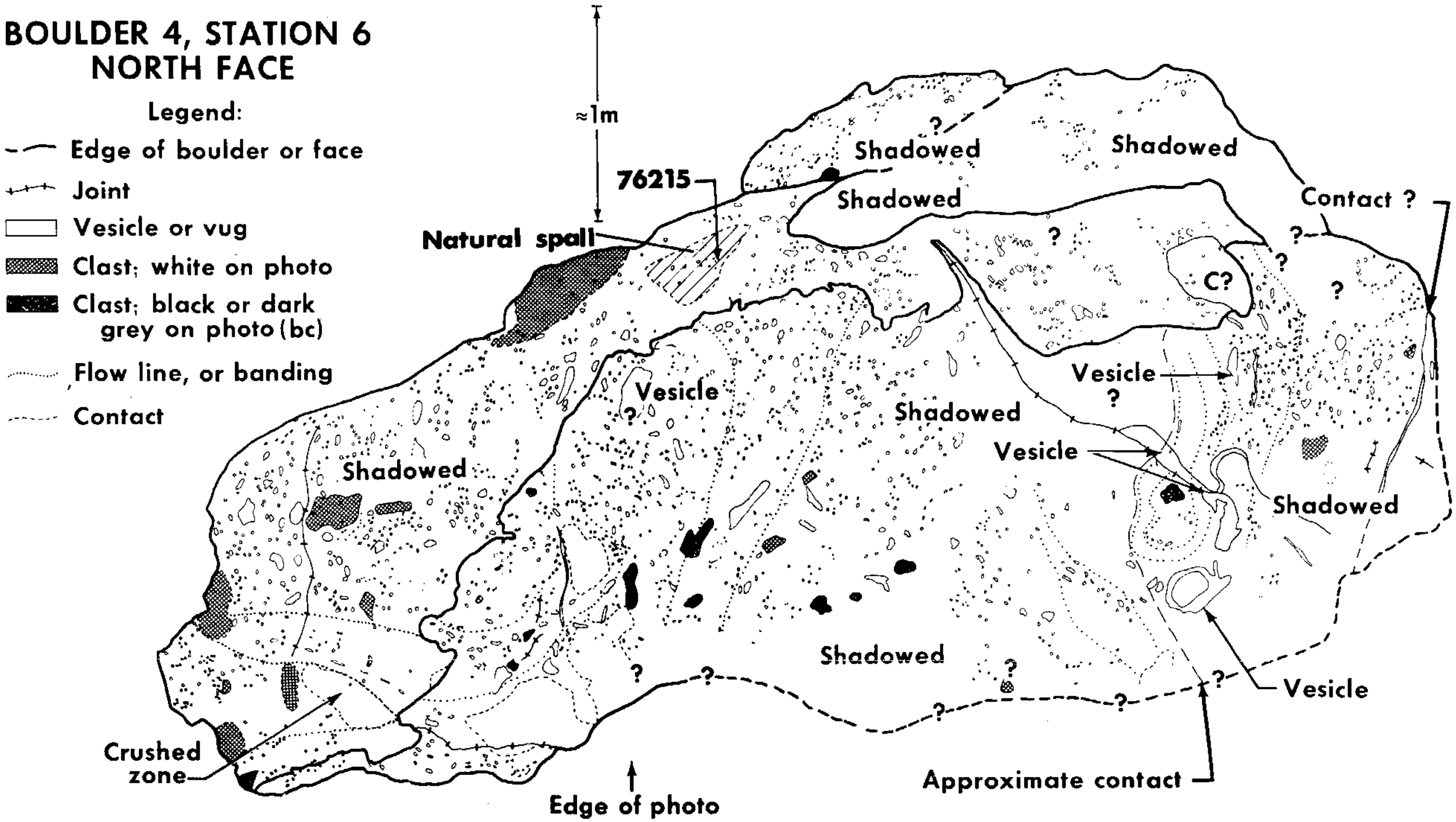


Figure 5. - Map of the North face of Boulder 4.

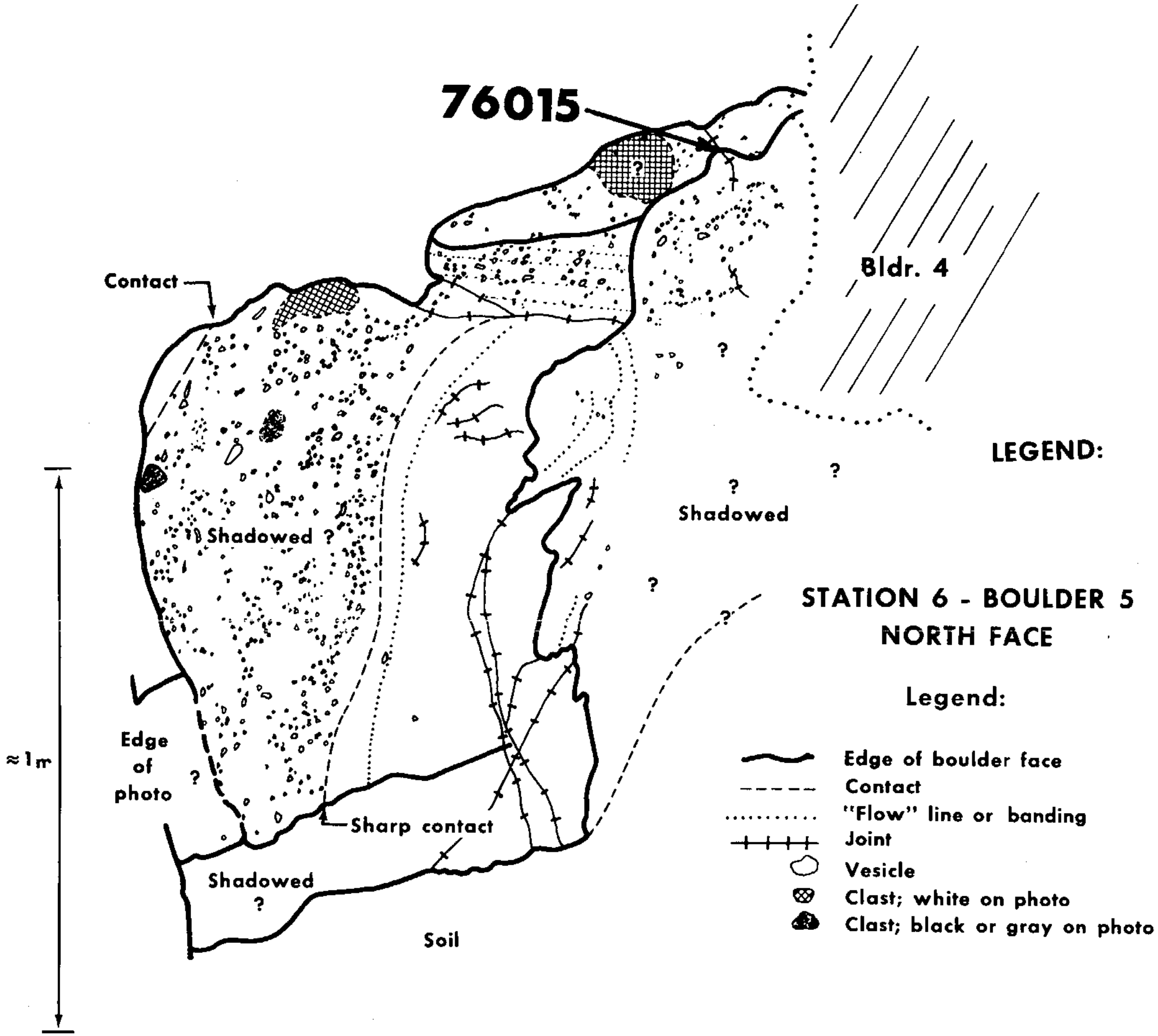


Figure 6. - Map of the North face of Boulder 5.

UNIT AND THICKNESS	A; 6m +	GRADATION FROM A TO B; 0-2.5 m	B; 2-4 m	C; 6m +
Description	Highly vesicular, with abundant large vesicles (>5 cm); many vesiclés are flattened along a plane parallel to the contact with unit B. There is an increase in the number of large vesicles toward the "center" of this unit.	Irregular zone across present top side of Boulder 2 (see map)	Characterized by well-developed foliation or banding. Some of the bands are folded. Vesicular, with only a trace of vesicles >5 cm long. There are very few clasts visible in the photographs.	Contains blue-gray to white clasts, up to 0.8 m long, in a pale borwn to light gray matrix. There is no obvious banding or foliation. Vesicular, with only a trace of vesicles >5 cm long.
Samples	76315	--	76215 and 76015	76295, 76275 (matrix) 76235, 76255 (clasts)
Comments	Near the ground surface on the NW side of Boulder 2, the contact between A and B is very sharp.			Contact with unit B may be gradational?

Figure 7. - Stratigraphic "Section" represented in the boulders of Station 6.

76315

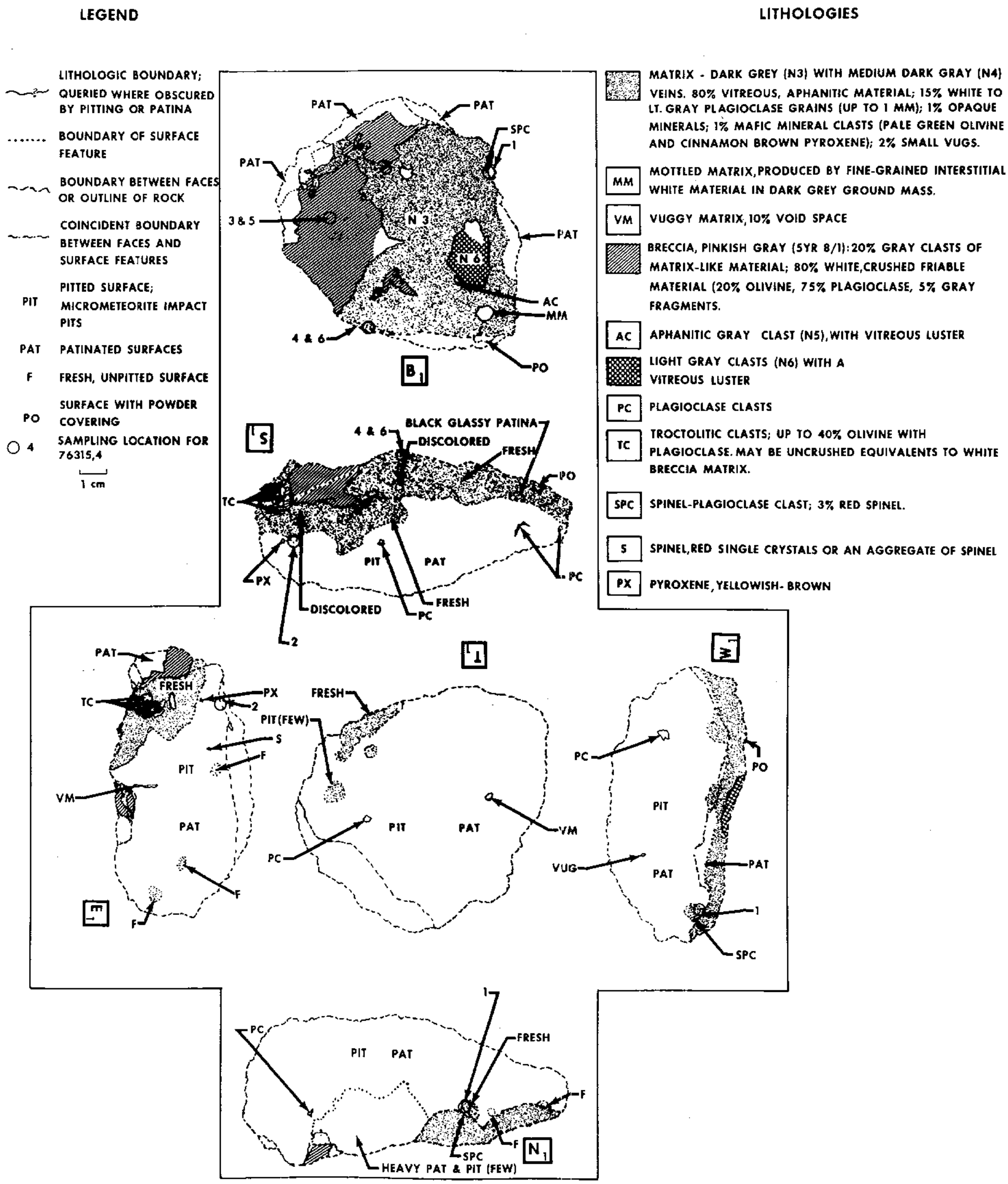


Figure 8. - Map of sample 76315.

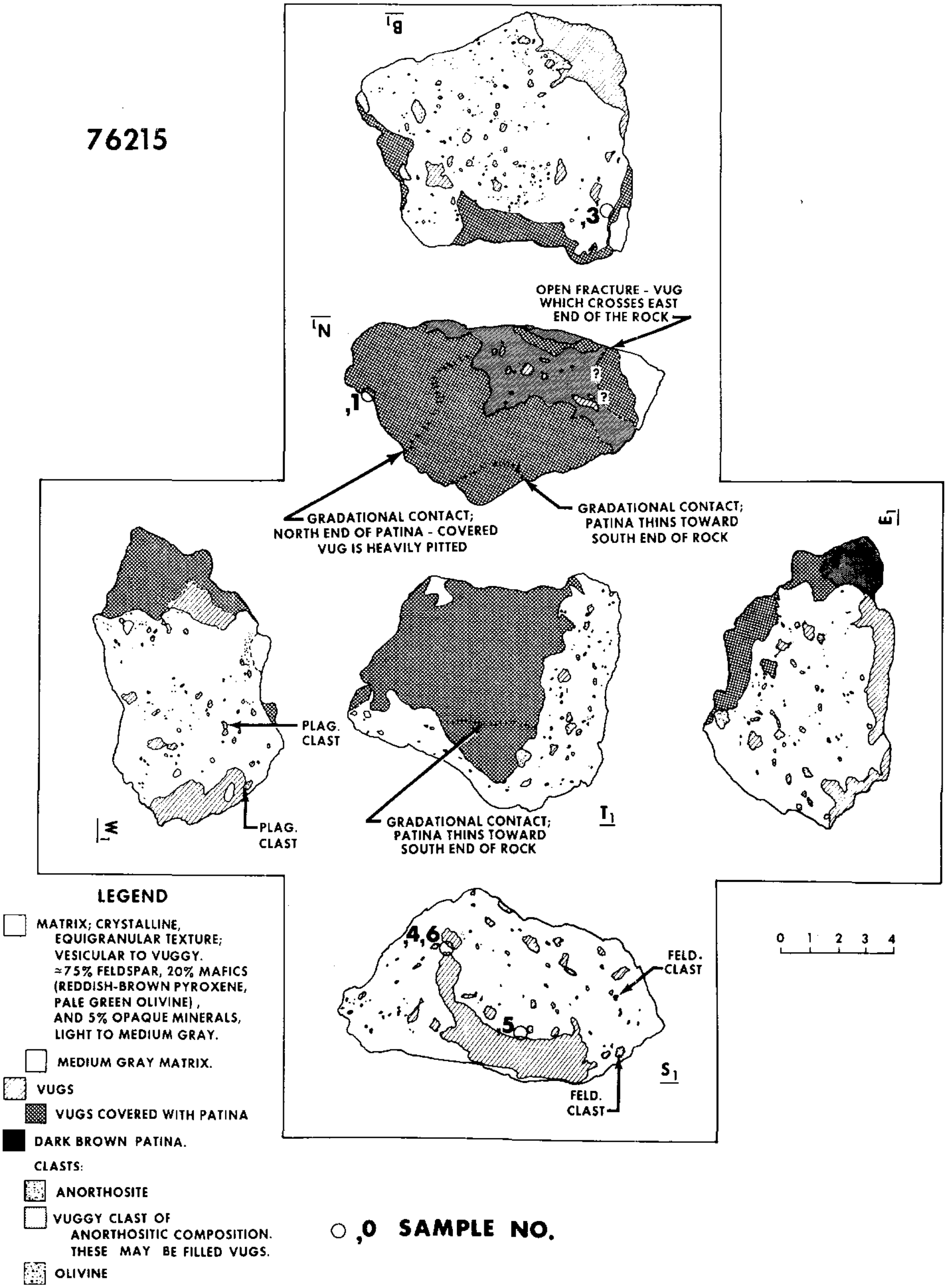


Figure 9. - Map of sample 76215.

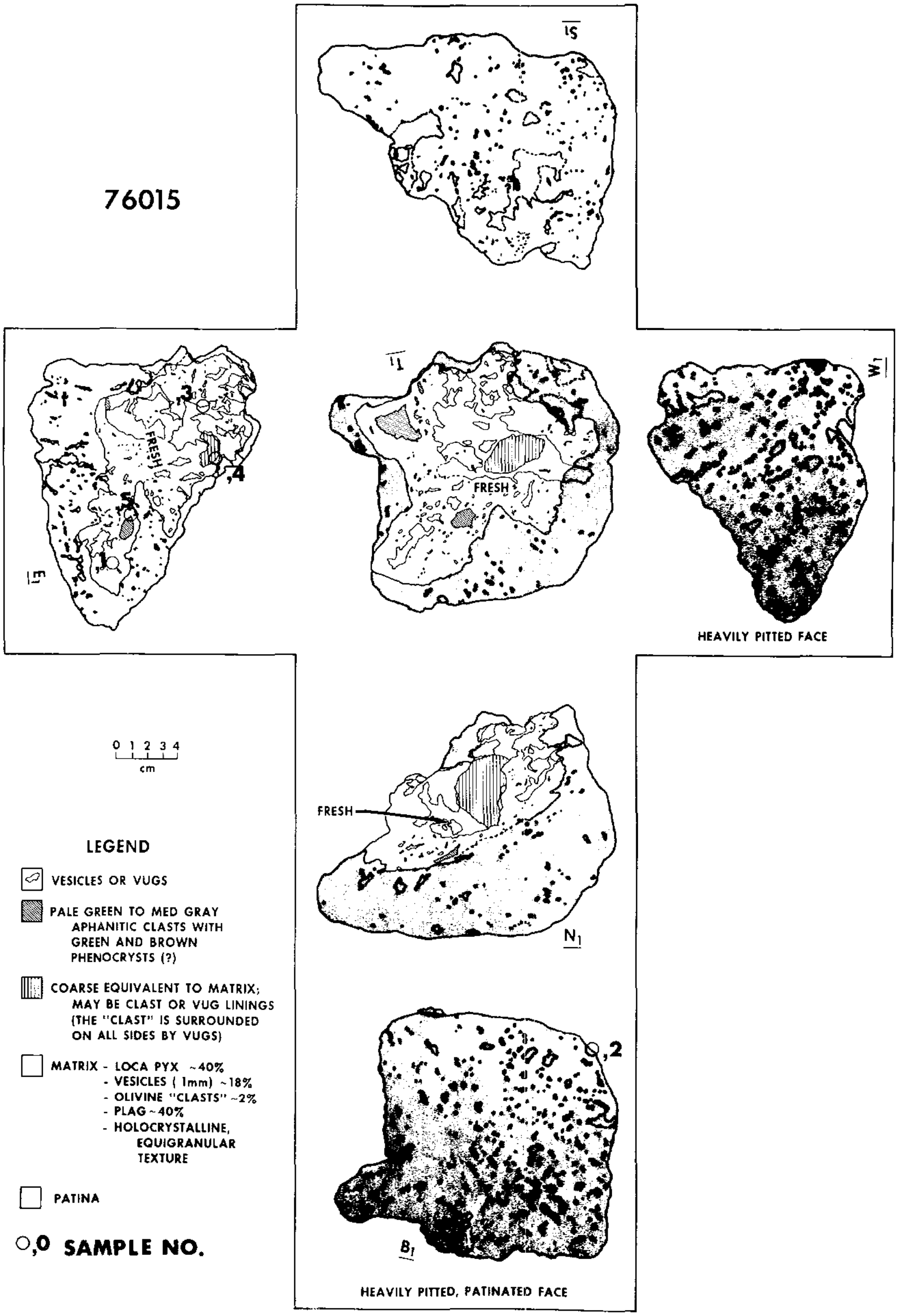


Figure 10. - Map of sample 76015.

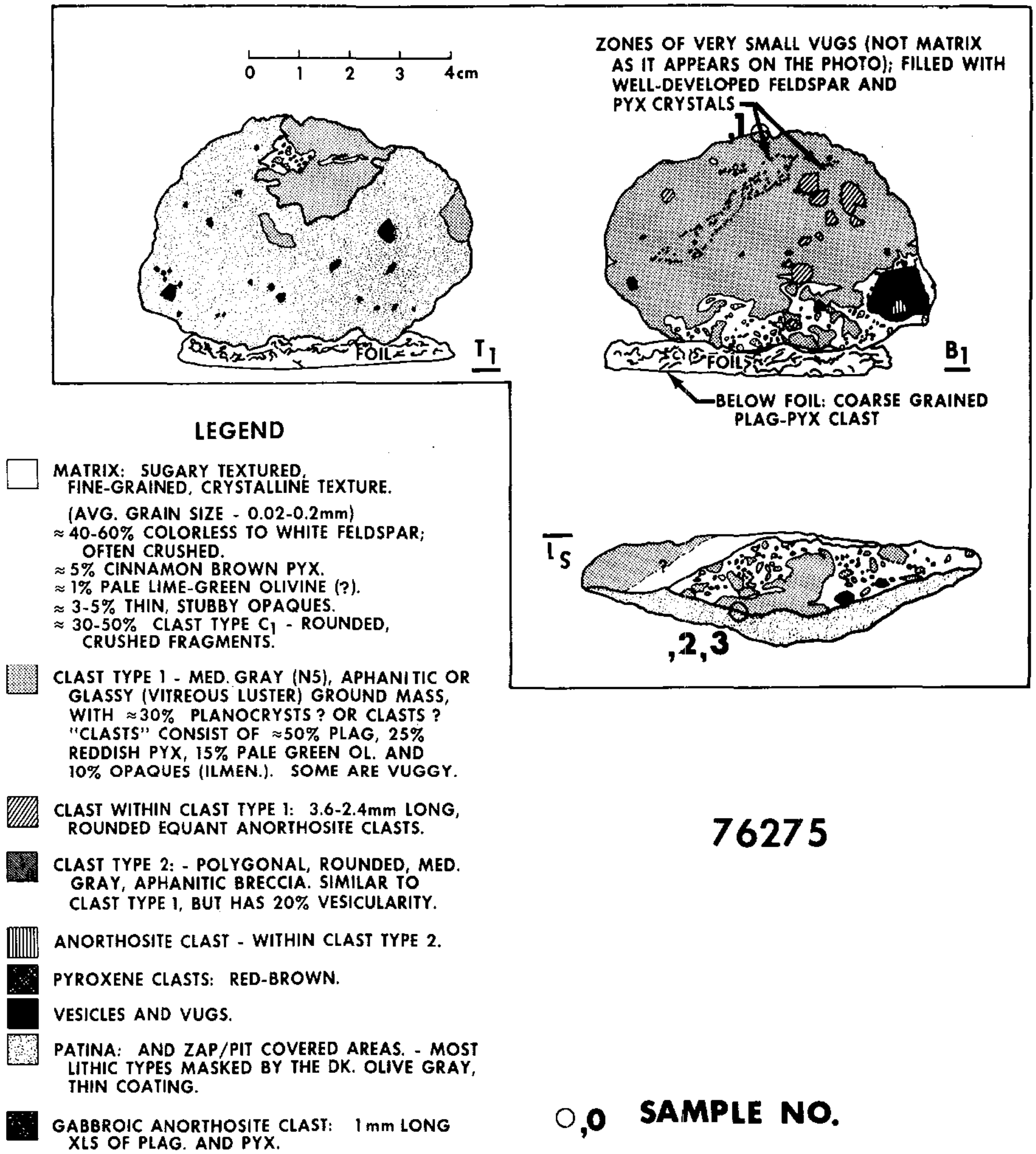


Figure 11. - Map of sample 76275.

76295

EXPLANATION

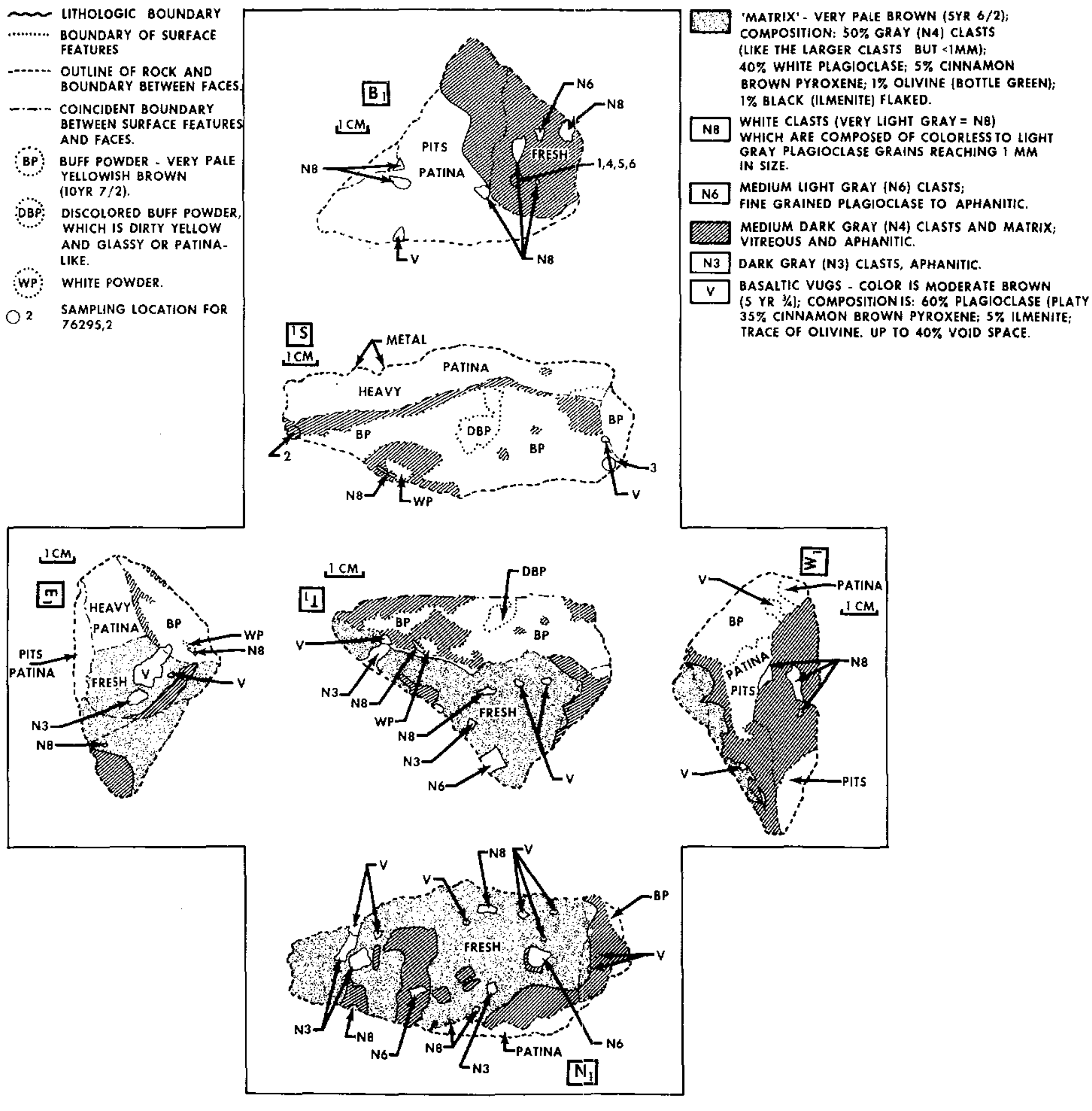


Figure 12. - Map of sample 76295.

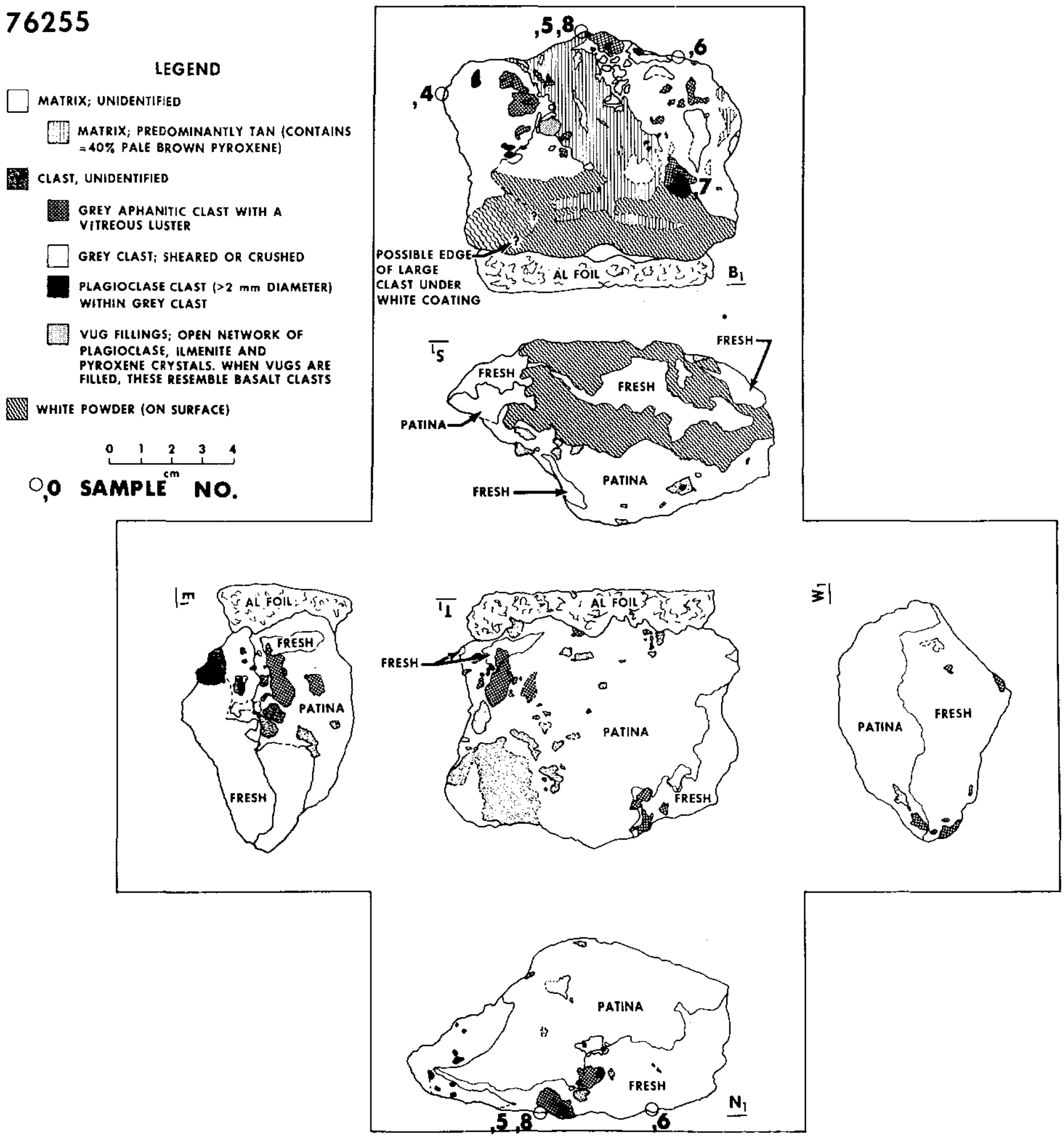


Figure 13. - Map of sample 76255.

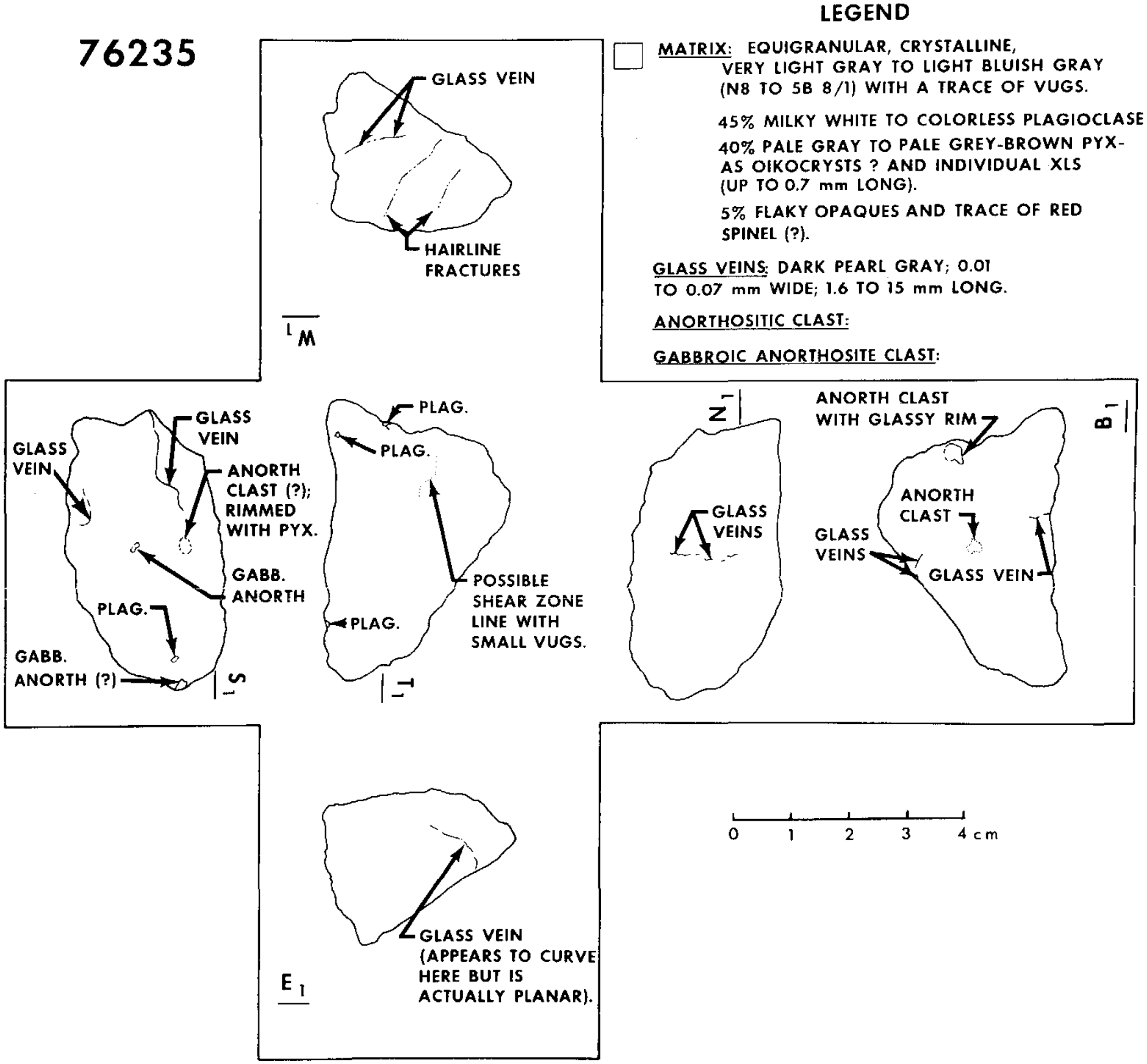
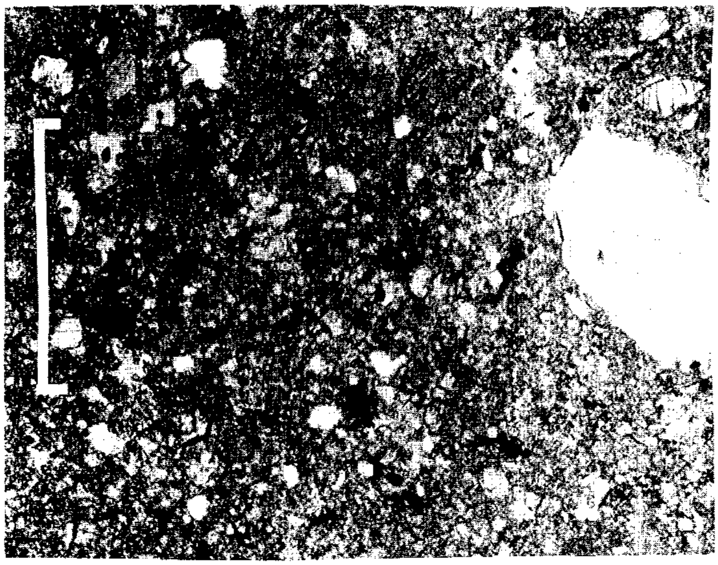
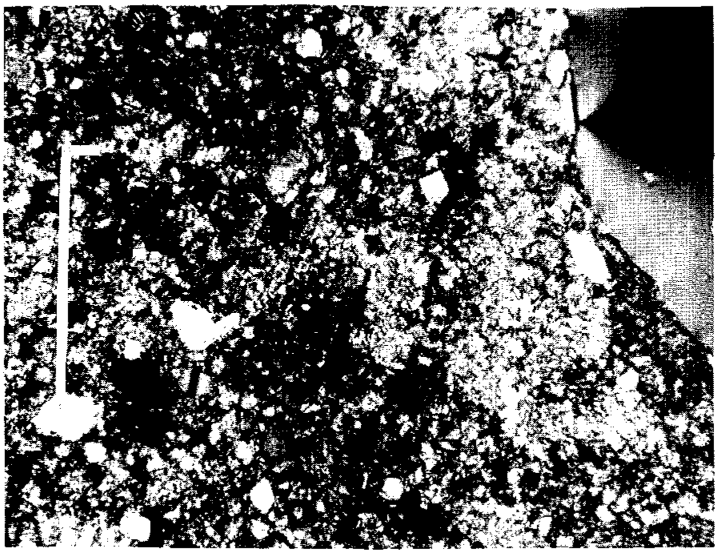


Figure 14. - Map of sample 76235.



(a) General view of poikilitic rock. The light colored clasts are feldspar, the darker gray clasts are olivine. The matrix of the rock consists of the pyroxene oikocrysts and included chadacrysts. Scale bar = 1 mm, single polarizer.



(b) General view of matrix in upper center of figure 15(a) showing oikocrysts at varying degrees of extinction. Scale bar = 0.5 mm, crossed polarizers.

Figure 15. - Photomicrographs of typical matrix in poikilitic rock 76015.

(c) View of single oikocryst and surroundings. Plagioclase chadacrysts are the dark phase, pyroxene the lighter gray, and Fe-Ti oxide is white. The view shows an oikocryst filling most of the bottom two-thirds of the view. Note the increased plagioclase content in the region between oikocrysts. Also note the tabular form of plagioclase chadacrysts. Scale bar = 0.1 mm, reflected light.

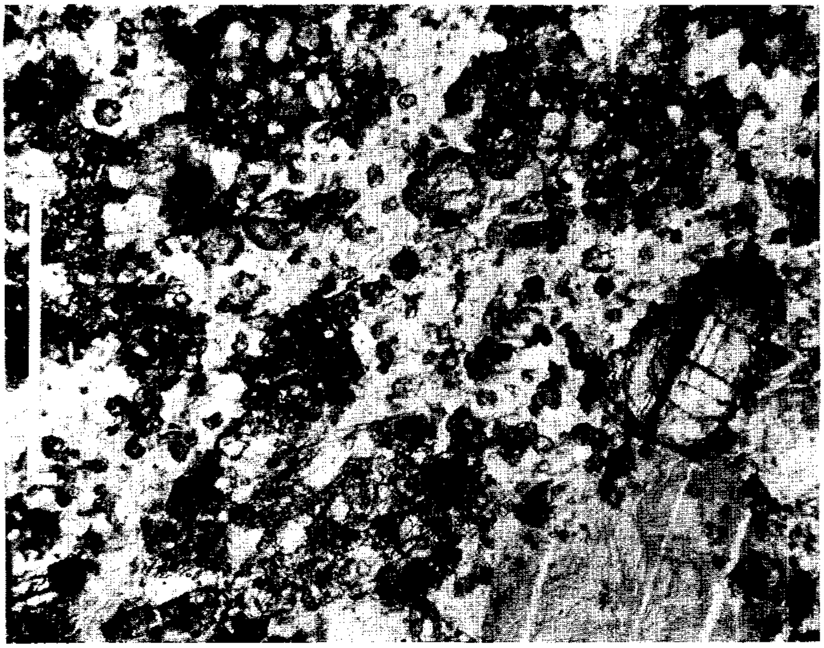
Figure 15. - Concluded.

(a) A single exsolved or reacted pyroxene fills most of the view with inclusion filled feldspar in the lower left corner. The dark phase at the center-top is hypersthene. The complexly twinned or exsolved phase extends below the hypersthene and embays it on its left side. The inclusion-filled augite forms the left third of the upper half of the view. The well-aligned inclusions in feldspars continue to the edges of the grains in the lower left corner. Scale bar = 1 mm, partially crossed polarizers.

Figure 16. - Photomicrographs of an unusual clast in 76015,15.

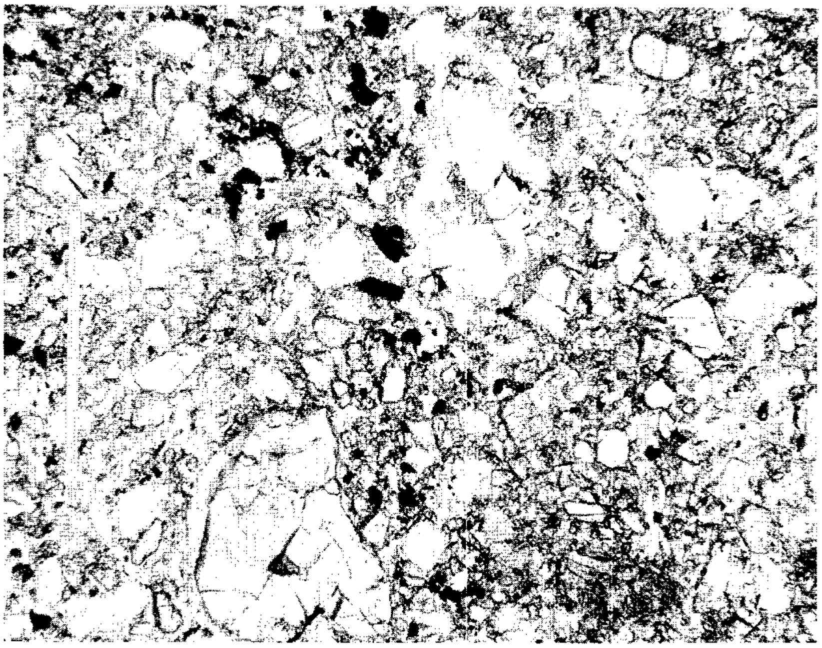
(b) Enlarged view of middle of figure 16(a) showing the abundant inclusions in augite in the left half of view, and the laminar twinned or exsolved pyroxene embaying the hypersthene in the top-center and lower right. Aligned inclusions in feldspars can be seen at lower left. Scale bar = 0.5 mm, partially cross polarized light.

Figure 16. - Concluded



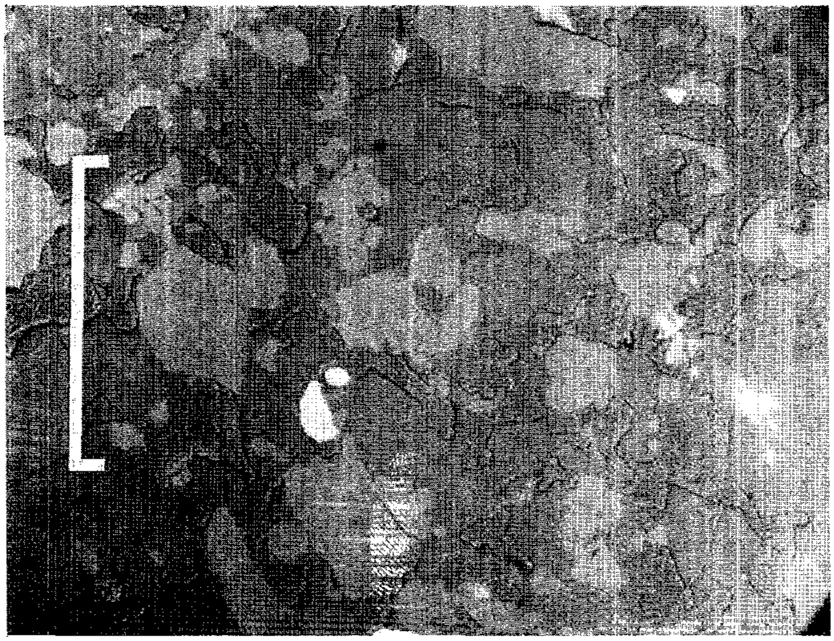
All light colored grains are complexly twinned and laminated feldspar. The large feldspar in the upper right is a possible clast as is the olivine in the center-top. The irregular dark gray patches are pyroxene oikocrysts, the smaller and isolated lighter gray grains in plagioclase are olivine. Scale bar = 0.5 mm, partially crossed polarizers.

Figure 17. - Photomicrograph of crushed feldspar-pyroxene-olivine rock, 76230,12.



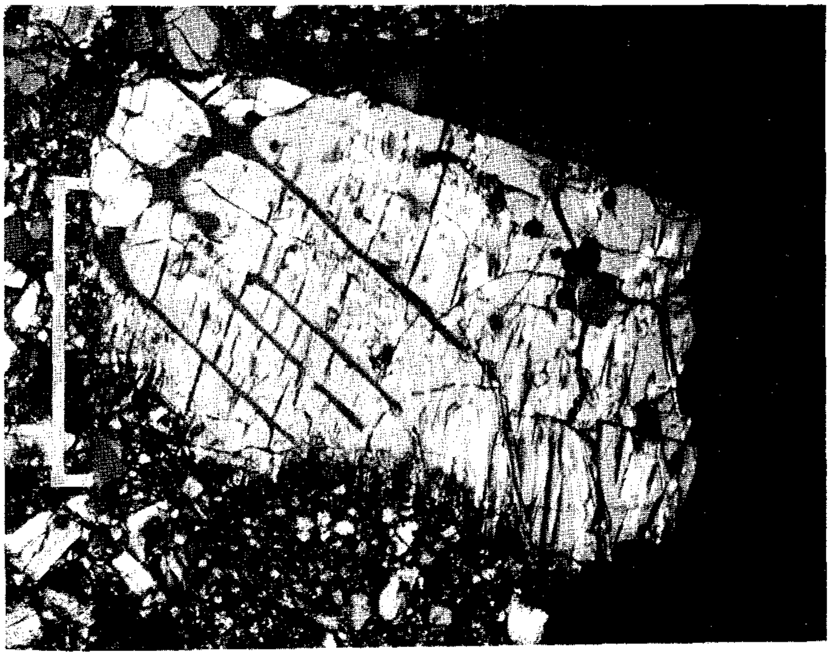
(a) General view of the banded tan material. The lightest colored clasts are feldspar, slightly darker ones are olivine and exsolved pigeonite. Note that unlike virtually all other lunar breccias this rock seems to be clast-supported. Scale bar = 0.5 mm, single polarizer.

Figure 18. - Photomicrographs of sample 76250,4.



(b) View of tan breccia showing pore shape. The bright phase is Fe-Ti oxide, light gray is pyroxene, dark gray is feldspar, very dark gray patches of glass are noted between some grains. The epoxy in the pores is dark gray with a granular texture. Scale bar = 0.1 mm, reflected light.

Figure 18. - Continued

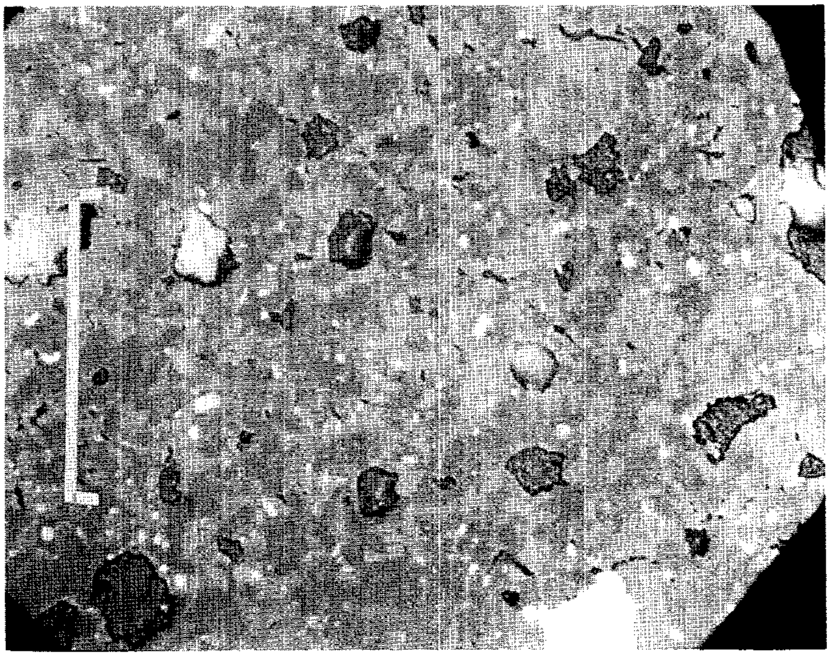


(c) One of the larger exsolved pigeonites in tan breccia. Augite lamellae near extinction. The lightest colored lamellae are not yet identified. Scale bar = 0.5 mm, crossed polarizers.

Figure 18. - Continued

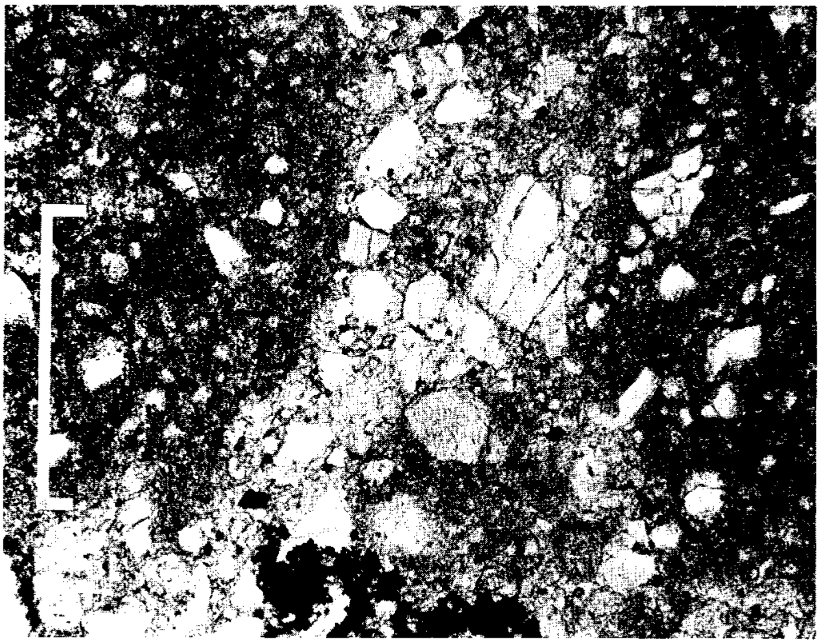
(d) View of dark clast showing small amount of porosity (irregular, dark gray areas) and very fine subophitic texture. Bright needle-like phase is Fe-Ti oxide, light gray is olivine and pyroxene, and dark gray is feldspar. Scale bar = 0.1, reflected light.

Figure 18. - Concluded



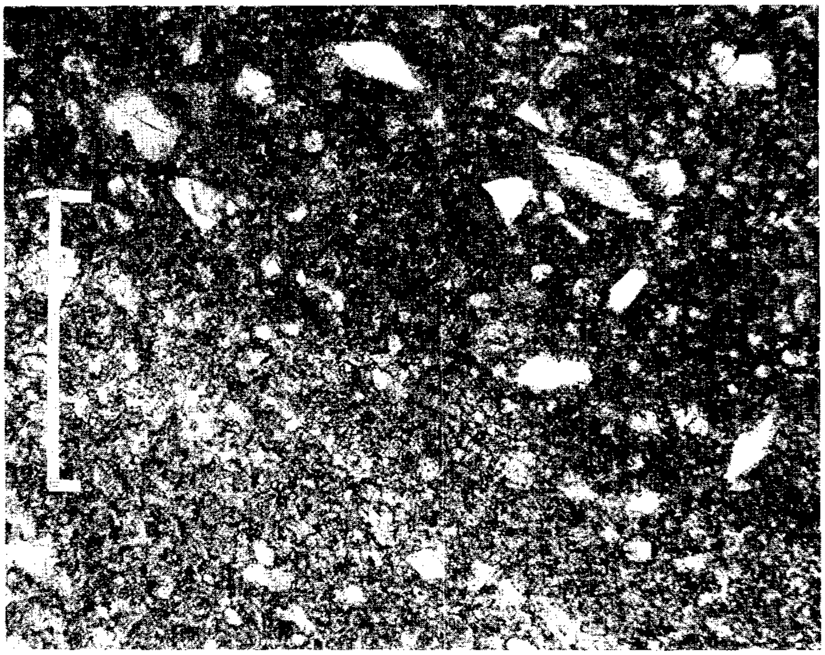
(a) View of blue-gray subophitic-textured material. Bright area in upper right is metal, small, very light gray plates are Fe-Ti oxide, light gray is pyroxene, medium gray is feldspar. The large pyroxene or olivine grain at upper left is considered to be a clast. Epoxy filled pores are dark gray with a granular texture. Scale bar = 0.1 mm, reflected light.

Figure 19. - Photomicrographs of blue-gray rock 76295,11.



(b) View of matrix with a clast-rich, vein-like area across the center of view. The fine, basaltic-textured rock is dark gray. Clasts consist of feldspar, olivine, and possible pyroxene. Scale bar = 0.5 mm, single polarizer.

Figure 19. - Concluded



(a) View of contact between opaque-rich (left half) and opaque-poor bands in the basaltic-textured portion of section 76315,12. Clasts include feldspar and olivine. Scale bar = 0.5 mm, single polarizer.

Figure 20. - Photomicrographs of rock 76315.

(b) View of friable, light-colored part of the rock in section 76315,14. Note the granoblastic texture. Light-colored phase is feldspar, smaller granular mineral is mostly olivine. Scale bar = 0.5 mm, partially cross polarized light.

Figure 20. - Concluded