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LITHOLOGICAL MAPS OF SELECTED  
APOLLO 14 BRECCIA SAMPLES

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## Preface

This booklet of mapped surfaces of some Apollo 14 samples was prepared as an intermediate step towards the preparation of a new Apollo 14 sample catalog. It contains recently obtained observations and pictures of some of the largest and less well documented Apollo breccia samples. These observations are published at this time to stimulate new interest in highland breccias. We would appreciate your comments on these or other Apollo 14 samples so that they might be incorporated in the new catalog. Anyone interested in these rocks should order some of the color photographs.

Some of the samples (14303, 14305, 14306 and 14311) were chosen because they have large sawn surfaces. These were carefully dusted and mapped using a binocular microscope through the window of the nitrogen cabinet. Enlarged color photographs were found to be most helpful in preparation of these lithological maps. The rest of the samples were dusted and newly photographed while they were in the processing cabinet for chipping to make new thin sections. These were mapped without help of the binocular microscope.

This kind of lithological mapping is inherently difficult because of dust and patina on the exterior surfaces and metallic saw smear on the sawn surfaces. We have chosen to include these exterior features in our attempt to map the underlying clastic lithology. In some cases (i.e. 14051) the exterior patina completely obscures the internal lithology.

We have followed the Simonds et al. (1977) method of classification, in which the matrix character is the main distinguishing criterion. We have designated clast types as:

DG = Dark grey microbreccia - usually aphanitic, sometimes with white inclusions.

LG = Light grey microbreccia.

W = White or plagioclase-rich - perhaps just large pieces of plagioclase.

MB = Mare basalt? Usually with honey brown pyroxene, plagioclase and opaques.

KREEP Basalt = Subophitic texture. None recognized.

N = Norite? = Relatively coarse grained clasts with discernable white and light greenish-grey mineralogy.

B = Brown clast, probably pyroxene.

G = Green clast.

DB = Dark brown clast.

LB = Light brown clast.

As can be seen from the maps, we found a relatively large number of clasts of the DG type but very few of any other type. This was also the experience of the Preliminary Examination Team (PET) (1971), the Imbrium Consortium (Adams et al., 1977), and Wilshire and Jackson (1972). If these rocks were generated by the Imbrium Impact (as is widely thought), then which clasts represent the pre-Imbrium "Lunar Crust", which represent the "Fra Mauro Formation" and which represent units derived from other impacts?

The recently published field geology report by Swann et al. (1977) gives the geological setting for these samples.

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Sample	Mass In Grams	Breccia Type*	Mapped Samples		Side**	Surface	NASA Photo # 77
			Piece	Mass In Grams			
14051	191	CMB	14051,0	186	N <sub>1</sub>	Exterior	23487
					S <sub>1</sub>	Exterior	23488
14055	111	VMB	14055,0	96	T <sub>1</sub>	Exterior	23604
					B <sub>1</sub>	Exterior	23605
14066	510	CMB	14066,0	369	N <sub>1</sub>	Exterior	23486
					S <sub>1</sub>	Sawn	23485
14301	1361	VMB	14301,24	731	E <sub>1</sub>	Exterior	23456
					T <sub>1</sub>	Exterior	23455
14303	898	CMB	14303,7	470	B <sub>1</sub>	Broken	23369
					S <sub>1</sub>	Exterior	23371
					E <sub>1</sub>	Sawn	23372
					N <sub>1</sub>	Exterior	23367
					T <sub>1</sub>	Exterior	23368
					W <sub>1</sub>	Broken	23370
14304	2499	CMB	14304,0	2468	S <sub>1</sub>	Exterior	23099
					N <sub>1</sub>	Exterior	23098
					T <sub>1</sub>	Broken	21972
14305	2498	CMB	14305,30	158	B <sub>1</sub>	Sawn	21470
					W <sub>1</sub>	Sawn	21472
					E <sub>1</sub>	Sawn	21471
					S <sub>1</sub>	Exterior	21475
					W <sub>1</sub>	Sawn	21476
14306	872	CMB	14306,21	283	W <sub>1</sub>	Sawn	22103
			14306,104	36	N <sub>1</sub>	Exterior	22104
			14306,103	122	T <sub>1</sub>	Sawn	22105
14309	42	CMB?	14309,0	39	T <sub>1</sub>	Exterior	23603
14311	3204	CMB?	14311,0	2442	N <sub>1</sub>	Exterior	22155
					S <sub>1</sub>	Exterior	22156
					T <sub>1</sub>	Exterior	22159
					E <sub>1</sub>	Exterior	22158
					W <sub>1</sub>	Sawn	22154
14314	116	CMB	14314,0	96	B <sub>1</sub>	Exterior	23606
14316	38	VMB	14316,0	30	B <sub>1</sub>	Broken	23602

\*CMB = Crystalline Matrix Breccia  
VMB = Vitric Matrix Breccia  
After Simonds et al., 1977

\*\*Laboratory Orientation

14051

14051 is a crystalline matrix breccia with several percent vuggy cavities - some up to 3 mm in size. All surfaces are covered with a thick patina and a large number of small zap pits indicating that it had more than one lunar orientation. Many of these pits have chalky white spall zones. Clastic lithology is hard to observe through the patina.

#### 14051,0 S<sub>1</sub> Exposed Surface

**Surface:** Approximately 75% of the surface contains vugs, some up to 3 mm in size. The surface is generally irregular, but has no visible penetrative fractures. Numerous glass-lined pits up to 1 mm in diameter are visible. A small amount of patina can be observed in small depressions on the sample surface.

**Clasts:** There are several white areas of apparent plagioclase concentration which could be classified as clast material. This white material is crystalline to crushed, with a 0.1-0.3 mm crystal size where observed. Overall the sample is approximately 70% plagioclase, 25% pyroxene, 5% glass and opaque.

#### 14051,0 N<sub>1</sub> Exposed Surface

**Surface:** Same basic description as S<sub>1</sub> surface. This surface is more heavily pitted, with a large pit on the N<sub>1</sub>/T<sub>1</sub> edge.

## 14055

14055 is a vitric matrix breccia somewhat like the soil breccias from other missions. Approximately half of the surface of this rock is coated with a thin glossy glass splash. The glass coating ranges from dark brown to black and is vesicular around its edges. Some of the glass has broken off. A few zap pits penetrate the glass coating. The matrix of this sample is darker than that of the other Apollo 14 breccias. It has the color and appearance of a soil sample.

### 14055,0 B<sub>1</sub> Exterior Surface

Surface: A few pits are present on the B<sub>1</sub> face, both in the glassy splash and the matrix.

Clasts: W = 100% aphanitic white material, some more crystalline than others. The size range is from 4 mm to < 1 mm, most of which are < 1 mm.

LG = These clasts appear to be of the same composition as the matrix material, but lighter in color. Most of these clasts have a sharp contact between clast and matrix.

G = 100% crushed green material, could be olivine or orthopyroxene.

### 14055,0 T<sub>1</sub> Exterior Surface

Surface: There are a few zap pits on the glass splash and on the matrix surface. There is one fracture which is non-penetrative.

Clasts: Several small grains of cinnamon-brown pyroxene are present as clasts in the matrix indicating the possible presence of mare basalt.

Approximately 10-20% of small white (plagioclase) clasts are scattered through matrix.

14066

14066 is a typical crystalline matrix breccia with subrounded, dark grey aphanitic clasts in a lighter-grey fragmented groundmass.

14066,0 S<sub>1</sub> Part Sawn-Part Exposed Surface

**Surface:** The surface is covered by a large amount of saw smear. The rock is moderately friable accounting for many rough gaps in this surface. Several small non-penetrative fractures can be observed. The surface area on the large "DG" type clast is rough, having had several large pieces which have fallen from it. This would indicate the dark grey clast type is more friable than the lighter matrix material. Some pits are present on the exposed surface.

**Clasts:** The majority of the clasts are of the DG classification (99% dark grey aphanitic) with a small percentage of plagioclase material mixed in. Most of the W-type clasts are a "dirty" white, because of saw smear. There is a pale green clast which is approximately 4 x 8 mm in size. This clast is inside a very dark grey clast which is in turn inside the light grey (ground up) material. There appear to be four generations of breccia inside one another. Mineral percentages are difficult to determine because of the degree of saw smear on the clast. Contact between clasts and matrix is moderately to well-defined.

14066,0 N<sub>1</sub> Exposed Surface

**Surface:** The surface is covered with 1-2 mm pits. Some pits on the large DG clast are up to 4 mm in size. There is a moderate surface coverage of patina, making clast classification difficult. Two large penetrative fractures at right angles to each other are present in the 2nd quadrant of the N<sub>1</sub> face.

**Clasts:** Same as on the S<sub>1</sub> face. The large "DG" type clast on the N<sub>1</sub>/T<sub>1</sub> border extends over from the S<sub>1</sub> surface. This clast appears lighter in color than most "DG" clasts because it is covered by a light patina. There are several 1-2 mm plagioclase-rich clasts and one 1 x 1 mm green clast similar to the one on the S<sub>1</sub> surface.



## 14301

14301 is a typical vitric matrix breccia. It is relatively friable and clasts are held loosely in their matrix. This sample is probably some form of soil breccia and would be a good candidate for clast studies, because it contains several large clasts.

The light grey matrix (60%) contains both lighter and darker clasts. Overall there are only a few zap pits, but most pits were probably eroded away due to the friability of the sample.

### 14301,24 E<sub>1</sub> Exterior Surface

Surface: Few zap pits are present on this surface. A few small fractures are present. The surface is covered with loosely adhering dust.

Clasts: DG<sub>1</sub> = Dark grey, aphanitic microbreccia. The clast boundary is sharp - ready to be plucked out. It is 20 mm x 15 mm in size.

White = 100% aphanitic white material, probably plagioclase.

MB<sub>1</sub> = A clast of coarse grained material, apparently mare basalt.

### 14301,24 T<sub>1</sub> Exterior Surface

Surface: The T<sub>1</sub>/S<sub>1</sub> interface is rounded and may have small zap pits. Most have been abraded.

Clasts: DG<sub>2</sub> = Large (40 x 40 mm) fractured clast of dark grey microbreccia with 10% small white plagioclase-rich areas.

DG<sub>3</sub> = Dark grey microbreccia. It is slightly darker in color than most DG clasts. Clast size 8 x 5 mm.

White = 100% aphanitic white material, probably plagioclase. It is the same as that on the E<sub>1</sub> surface.

14303 and 14304

These two pieces were collected as a single rock, which broke in two during transport from the moon. They were inventoried and allocated as separate samples. Their relationship was not recognized until 1976. The 14304 sample is a posterity sample, but 14303 has undergone extensive allocation.

The rock is a crystalline matrix breccia with zap pits on all of the exterior faces, indicating that its lunar orientation was not constant.

14303,7 E<sub>1</sub> Sawn Face

Surface: Sawn surface. Some grains have fallen out. No vugs or fractures.

Clasts: W<sub>1</sub> = 100% chalky white, aphanitic plagioclase. Clast size 4 x 5 mm.

W<sub>2</sub> = 90% plagioclase; 8% light green mineral, possibly pyroxene; 2% platy elongated ilmenite. Clast size 4 x 5 mm.

G<sub>1</sub> = 50% light green material and 50% white plagioclase. Clast size 2 x 3 mm.

G<sub>2</sub> = Same components as G<sub>1</sub>. Clast size 4 x 4 mm.

LB<sub>1</sub> = 100% aphanitic light brown-pyroxene (?). Clast size 10 x 8 mm. The clast is poorly defined, and has matrix material intertwined with it.

LB<sub>2</sub> = Same as LB<sub>1</sub>. Clast size 3 x 3 mm.

DB<sub>1</sub> = Dark brown aphanitic clast. Clast size 1 x 1 mm.

DB<sub>2</sub> = Same as DB<sub>1</sub>.

DG<sub>1</sub> = 99% dark grey aphanitic material. There is 1% light material, probably matrix, within the clast. Clast size 2 x 1 mm.

DG<sub>2</sub> = Same as DG<sub>1</sub>. Clast size 5 x 10 mm.

LG<sub>1</sub> = Aphanitic microbreccia with light grey color. Clast size 2 x 2 mm.



### 14303,7 T<sub>1</sub> Exterior Surface

Surface: Covered with zap pits, with one large 8 x 8 mm pit on the T<sub>1</sub>/N<sub>1</sub> corner. All of the T<sub>1</sub> surface has a moderate coating of patina. All clasts are poorly defined. Only a small number of non-penetrative fractures.

Clasts: DG<sub>3</sub> = Clast extends into the W<sub>1</sub> face. (See W<sub>1</sub> description)  
Clast boundary difficult to map.

There are a few small plagioclase-rich clasts.

### 14303,7 W<sub>1</sub> Broken Surface

Surface: Contains no pits and only a small amount of patina. Fracturing is confined to the DG<sub>3</sub> clast area. Much of this view is out of focus.

Clasts: DG<sub>3</sub> = Large dark grey clast. 90% aphanitic. Several non-penetrative fractures are located within this clast. Several areas of chalky white material are seen within this large clast. Clast size 30 x 25 mm.

### 14303,7 N<sub>1</sub> Exterior Surface

Surface: Covered with pits, with one beautiful glass lined zap pit (0.8 cm) which is also visible on T<sub>1</sub> view. There is a moderate amount of patina throughout the face.

Clasts: A portion of the DG<sub>3</sub> clast is also visible on this surface.

### 14303,7 B<sub>1</sub> Broken Surface

Surface: No pits are visible, but small patches of patina are present. 2 large penetrative fractures with a few small non-penetrative fractures associated with them are present. This face adjoined 14304.

14303,7 S<sub>1</sub> Exterior Surface

Surface: Heavy cover of pits and patina.

Clasts: W<sub>3</sub> = 4 x 8 mm plagioclase-rich clast with coarse-grained equigranular texture.

## 14304

This piece is covered with small zap pits and patina on all surfaces except  $T_1$  where it adjoined 14303. It is made up of clasts of dark grey microbreccia and a few small clasts of white plagioclase-rich material in a lighter grey matrix. No mare basalt clasts were observed.

### 14304,0 $N_1$ Exterior Surface

**Surface:** Zap pits with a concentration of approximately 6 to 8 pits per square centimeter cover the surface. Glass lined pits up to 2 mm in diameter can be seen, but spall zones are not preserved. The heavy coating of patina makes clast population difficult to determine. Fresh penetrative fractures are parallel to each other.

**Clasts:** Several small clasts of the DG type (100% dark grey aphanitic material) are present. The largest on the  $B_1$  surface is approximately 10 x 10 mm. There are also a few plagioclase-rich clasts (100% aphanitic crushed plagioclase) which are up to 4 mm in size.

### 14304,0 $S_1$ Exterior Surface

**Surface:** The same degree of pit coverage and patination as the  $N_1$  face. One large penetrative fracture crosses approximately the full length of the face. Some smaller non-penetrative fractures associated with the larger fracture are also present.

**Clasts:**  $DG_1$  = Large aphanitic dark grey clast displaying numerous fractures. Clast size 20 x 15 mm. May be back side of  $DG_2$ .

The average size of plagioclase-rich clasts is approximately 2-3 mm.

### 14304,0 $T_1$ Broken Surface

**Surface:** Most of this surface is freshly broken and it is this face that was shared with 14303. Several large penetrative fractures can be seen on this face. The portion not shared with 14303 is covered with patina and a few small zap pits.

**Clasts:**  $DG_2$  = Large aphanitic dark grey clast with sharp outline with matrix. Darker than average DG type clast. Clast size 30 x 40 mm.

14305 is a clast-rich, holocrystalline breccia that has been well sintered together. It is composed of a light grey fragmental matrix ( $\sim 70\%$ ) with an average grain size less than 0.1 mm. The mineralogy of the matrix is indeterminate in binocular observation, but appears to be plagioclase rich. Only a few percent of mafic silicates are recognizable, but may be visible in thin section. The rock has a seriate texture with clasts ranging in size from 10 cm down to the crystallites comprising the matrix. Approximately 30% of the rock is composed of clasts larger than 1 mm. Most of these clasts (80%) are themselves microbreccias of an older generation. A dominant clast lithology is a dark grey aphanitic microbreccia (DG). Only a small percentage of the clasts are of a non-fragmental nature. These include white plagioclase-rich clasts (W) (15%) and brown mare basalt clasts (5%) (MB). All of the clasts are well-cemented to the matrix and cannot be broken free. One dark clast has a black glassy matrix containing 15% phenocrysts and microphenocrysts of subhedral white feldspar and pale green olivine. These phenocrysts are approximately 0.2 mm long set in the crystalline matrix. Sample 14305 is classified by Simonds et al. (1977) as a crystalline matrix breccia of the Fra Mauro type.

#### 14305,18 S<sub>1</sub> Exterior Surface

**Surface:** This piece of 14305 broke off during transport from the moon and was originally 14302. Dirt covered - won't dust off. Several regions of thin coating of bubbly black glass. (As if someone had applied a blow torch). No spall zones around these regions of glass.

**Matrix:** Composed of both light (60%) and dark grey (40%) fragmental microbreccia relatively well mixed together. Dark grey lithology is aphanitic and occurs as clasts within lighter grey lithology. Light grey lithology is composed of mineral fragments of plagioclase, pyroxene, opaques as well as small clasts of various lithologies. Some (10%) of the dark grey clasts have sharp outlines but most (30%) are gradational with light grey matrix.

**Clasts:** W<sub>1</sub> = 100% aphanitic chalky white plagioclase. Clast size 7 x 5 mm.

W<sub>2</sub> = This clast is composed of 55% chalky white plagioclase, 40% translucent white plagioclase, and 5% light greenish yellow mineral. Texture is equigranular with an average size of 0.25 mm. Clast size 5 x 5 mm.

W<sub>3</sub> = This clast is composed of 50% chalky white plagioclase, 48% translucent white plagioclase, and 2% opaques. The texture is equigranular with an average grain size of 0.5 mm. Clast size 6 x 5 mm.



- W<sub>4</sub> = 100% crushed crystalline plagioclase with a grain size of 0.2 mm. Clast size 2 x 2 mm.
- W<sub>5</sub> = 100% chalky white plagioclase. Clast size 2 x 2 mm.
- DG<sub>1</sub> = Aphanitic glass (?) exhibiting sharp clast/matrix contact. Clast size 3 x 3 mm.
- DG<sub>2</sub> = Aphanitic microbreccia with a small green mineral (olivine?) in the middle. Clast size 3 x 4 mm.
- DG<sub>3</sub> = Typical aphanitic dark grey microbreccia. Clast size 4 x 5 mm.
- DG<sub>4</sub> = Similar to DG<sub>1</sub>. Clast size 2 x 2 mm.

14305,27 W<sub>1</sub> Sawn Face

- Surface: Pits can be seen on the exposed surface surrounding the sawn portion, but they are too small to map.
- Matrix: 60% light, 40% dark grey fragmented breccia. Dark grey is aphanitic, and appears as small fragments in the lighter grey material. There is a small percentage of plagioclase crystals in isolated areas throughout the matrix. The dark material is evenly distributed throughout the lighter material. Most contacts between light and dark material are fairly well defined, but not sharp.
- Clasts: W<sub>6</sub> = Sugary white within a dark grey clast. Grain size 0.2-0.3 mm. Equigranular texture. Clast size 4.5 x 4.0 mm.
- W<sub>7</sub> = Chalky white. Grain size aphanitic. Clast size 1.5 x 2 mm.
- W<sub>8</sub> = Same as W<sub>6</sub>. Clast size 2 x 1 mm.
- W<sub>9</sub> = 50% crystalline plagioclase. 50% light green crystalline pyroxene (?). Clast size 1 x 1 mm.
- MB<sub>1</sub> = 60% crystalline to crushed plagioclase, 20% opaque, 20% light brown to green-crystalline to crushed pyroxene. Clast size 1 x 1 mm. Overall grain size approximately 1 mm. Highly shocked; originally igneous.
- DG<sub>5</sub> = Medium dark grey - aphanitic. 90% grey material, 10% crystalline to sugary plagioclase. Clast size 20-32 mm. Depth into S<sub>1</sub> face = 20 mm. Best example of breccia within breccia (Duncan et al. 1975).

DG<sub>6</sub> = Medium light grey - aphanitic. Sharp contact between this clast and matrix. It is more fractured than others and has broken away.

G<sub>1</sub> = Green crystalline. Equigranular grain size 0.2 mm. Clast size 1.5 x 2.0 mm.

B<sub>1</sub> = Brown glass (?). Glassy aphanitic texture. Clast size 1 x 1 mm.

B<sub>2</sub> = Light brown to grey within a DG clast. Grain size 0.3-0.8 mm. Clast size 5.5 mm.

#### 14305,30 B<sub>1</sub> Sawn Surface

Surface: The B<sub>1</sub> sawn surface is marred by saw smear.

Clasts: DG<sub>7</sub> = 98% aphanitic dark grey material, 2% white crushed plagioclase (?). This clast extends approximately 10 mm into the B<sub>1</sub> face on the B<sub>1</sub>/N<sub>1</sub> corner. Clast size 15 x 22 mm.

DG<sub>8</sub> = Same as DG<sub>7</sub> with a slightly higher white mineral concentration. Clast size 19 x 17 mm.

DG<sub>9</sub> = Same as DG<sub>8</sub>. Clast size 10 x 8 mm.

B<sub>3</sub> = 100% crystalline brown pyroxene. The grain size is approximately 0.2-0.3 mm. Clast size 0.8 x 0.7 mm.

LG<sub>2</sub> = Light grey clast with equal proportions of light and dark component. The texture is aphanitic. This is another example of breccia within breccia (Duncan et al. 1975). Clast size 2 x 5 mm.

#### 14305,30 E<sub>1</sub> Sawn Surface

Clasts: W<sub>10</sub> = 98% chalky white plagioclase, 2% crystalline white plagioclase aphanitic. Clast size 5 x 5 mm.

W<sub>11</sub> = Crystalline white within DG clast. Grain size 0.3-0.5 mm. Clast size 2.0 x 1.5 mm.

W<sub>12</sub> = Crystalline to crushed plagioclase (100%). Grain size 0.3-0.4 mm. Clast size 1 x 1 mm.



- W<sub>13</sub> = Aphanitic, light brown to white. Clast size 1 x 1 mm.
- W<sub>14</sub> = Same as W<sub>12</sub>.
- W<sub>15</sub> = Same as W<sub>12</sub>. Clast size 1.0 x 1.1 mm.
- G<sub>3</sub> = Green crystalline, grain size 0.3-0.4 mm. Clast size 1.5 x 1.0 mm.
- MB<sub>2</sub> = 50% cinnamon brown crystalline pyroxene. 30% white crystalline plagioclase. 20% glass and/or opaque minerals. Slightly crushed, fairly equigranular.
- DG<sub>10</sub> = 70% dark grey aphanitic material. 30% light plagioclase (?). Aphanitic. Clast size 8 x 6 mm.
- DG<sub>11</sub> = 100% aphanitic dark grey. Clast size 8 x 6 mm.
- DG<sub>12</sub> = Same as DG<sub>11</sub>. Clast size 6 x 5 mm.
- DG<sub>13</sub> = Same as DG<sub>11</sub>. Clast size 5 x 4 mm.
- DG<sub>14</sub> = Same as DG<sub>11</sub>. Clast size 3 x 3 mm.
- DG<sub>15</sub> = Same as DG<sub>11</sub>. Clast size 4.0 x 2.5 mm.
- DG<sub>16</sub> = Same as DG<sub>10</sub>. Clast size 7 x 5 mm.
- DG<sub>17</sub> = Same as DG<sub>10</sub>. Clast size 4.9 x 5.0 mm.
- DG<sub>18</sub> = Same as DG<sub>10</sub>. Clast size 3 x 5 mm.

14305,30 W<sub>1</sub> Sawn Surface

- Clasts: MB<sub>3</sub> = 45% dark brown pyroxene. 40% white crystalline to crushed plagioclase. 15% opaque material. Grain size 0.1-0.2 mm. Clast size 7 x 4 mm.
- B<sub>4</sub> = Honey brown pyroxene, crushed (100%). Grain size 0.4-0.5 mm. Clast size 1 x 1 mm.
- G<sub>4</sub> = 65% dark grey aphanitic. 35% white crushed aphanitic. Clast size 10 x 9 mm.
- G<sub>5</sub> = 50% aphanitic white material. 5% aphanitic dark material. Clast size 4.0 x 4.5 mm.
- G<sub>6</sub> = Same as G<sub>5</sub>. Clast size 10 x 11 mm.

DG<sub>19</sub> = 85% dark grey aphanitic. 15% white crushed to crystalline plagioclase. Clast size 10 x 8 mm. This clast can be traced into the S<sub>1</sub> face.

DG<sub>20</sub> = 100% aphanitic dark grey material. Could be glass. Clast size 5 x 2 mm.

DG<sub>21</sub> = Same as DG<sub>19</sub>. Clast size 10 x 20 mm.

DG<sub>22</sub> = Same as DG<sub>20</sub>. Clast size 10 x 7 mm.

DG<sub>23</sub> = Same as DG<sub>19</sub>. Clast size 10 x 7 mm.

14306,21 W<sub>1</sub> Sawn Surface

Surface: The W<sub>1</sub> face of this piece is a sawn surface; all others have abundant zap pits and have a thin layer of patina. The sample is 60% clasts of dark grey aphanitic microbreccia which include the clasts of other rock types. The area between the dark grey microbreccia is lighter in color and apparently crushed and ground up material. It was very difficult to map the boundaries between the dark and light grey lithologies.

Clasts: W<sub>6</sub> = 100% aphanitic plagioclase with a powdery texture. Clast size 4 x 4 mm.

W<sub>7</sub> = Same as W<sub>6</sub> only more crystalline. Clast size 3 x 6 mm.

N<sub>1</sub> = Large yellowish-green clast within DG clast. 4% opaque mineral, 46% yellowish-green mineral, 50% chalky white plagioclase. The plagioclase grain size is approximately 0.2 mm and has equigranular texture. Clast size 6 x 4 mm.

N<sub>2</sub> = Same as N<sub>1</sub>. Clast size 4 x 4 mm.

N<sub>3</sub> = Same as N<sub>1</sub>.

N<sub>4</sub> = Same as N<sub>1</sub> but grain size is 1 mm. It appears to be considerably shocked or annealed.

N<sub>5</sub> = Same as N<sub>4</sub>.

G<sub>1</sub> = 100% green crystalline mineral. Grain size approximately 0.1-0.3 mm.

MB<sub>1</sub> = 65% honey brown pyroxene, 35% plagioclase, <1% opaques. Grain size 0.2 mm. Clast size 1 x 2 mm.

MB<sub>2</sub> = Same as MB<sub>1</sub>. It has a poorly determined boundary and has a honey brown aphanitic, possibly annealed, matrix. Clast size 2 x 2 mm.

MB<sub>3</sub> = Same as MB<sub>1</sub>. Clast size 1 x 1 mm.

DG<sub>1</sub> = Aphanitic dark grey microbreccia containing 15% chalky white crushed plagioclase, and 5% translucent green materials as in G<sub>1</sub>.

S<sub>1</sub> = Translucent red mineral. Grain size 0.5 mm.

14306,103 T<sub>1</sub> Partial Sawn Surface

Surface: Mostly out of focus.

Clasts: W<sub>8</sub> = 50% crystalline to crushed plagioclase, 30% crystalline green mineral possibly pyroxene. Grain size 0.8 mm. Clast size 5 x 3 mm.

W<sub>9</sub> = 100% crushed aphanitic plagioclase. Clast size 1 x 1.5 mm.

G<sub>2</sub> = 100% crystalline green mineral possibly same as in W<sub>8</sub>. Clast size <1 mm.

N<sub>6</sub> = See N<sub>1</sub> on 14306,21. The grain size is approximately 0.2 mm. Clast size 4 x 3 mm.

LG<sub>1</sub> = Light grey aphanitic clast, with small white plagioclase clasts within. There is a well defined contact between clast and matrix. Clast size 9 x 5 mm.

DG<sub>2</sub> = 100% dark grey aphanitic material. Clast size 6 x 4 mm.

General Note:

The norite clasts (N) in this rock seem to distinguish it from 14303, 14304, 14305, in which norite was not found. The light matrix which is between some of the dark clasts may be like the fragmental material in 14082, 14063, 14064, but it is less than 10% of this rock.

14306,104 N<sub>1</sub> Broken Face

Matrix: Tough aphanitic dark grey glass with white clasts less than 1 mm in size evenly distributed throughout. Contact between clasts and matrix is sharp, and clasts are usually angular to subangular. Most clasts are of the W<sub>1</sub> type (see below). On this broken face one does not observe the light grey fragmental material seen on the sawn face of 14306,21.

Clasts: W<sub>1</sub> = 10 x 10 mm aphanitic crystalline, white to crushed white. There is a small amount of dust cover on the clast.

W<sub>2</sub> = Same as W<sub>1</sub>, not as much crystalline material. Clast size 10 x 11 mm.

W<sub>3</sub> = 100% aphanitic white material. Clast size 5 x 6 mm.

W<sub>4</sub> = 99% aphanitic white material, 1% semi-opaque platy material that could be ilmenite. Clast size 2.5 x 1.0 mm.

W<sub>5</sub> = 60% crushed to crystalline plagioclase with 40% light green crystalline pyroxene. Grain size 0.2-0.3 mm. Clast size 2.5 x 2.0 mm.

General Note:

This surface seems to indicate a higher proportion of white clasts than other Apollo 14 breccias. Simonds et al. (1977) noted the unusual chemistry of this rock.



14309

14309 is a relatively coherent crystalline matrix breccia of the Fra Mauro type. There are no sawn surfaces and the sample has not been previously allocated.

14309,0 T<sub>1</sub> Exterior Surface

Surface: The surface is moderately covered with pits up to 1 mm in size. The surface is also lightly coated with patina, with a heavy coating in patches. Spall zones are lacking around zap pits.

There is one penetrative fracture on the T<sub>1</sub>/S<sub>1</sub> corner, with very few non-penetrative fractures.

Some small patches of glassy spatter are present, but are extremely friable and may break off with continued handling.

Clasts: DG<sub>1</sub> = 100% dark grey aphanitic material. The contact between matrix and clast is well defined. Several of these clasts are present. Clast size 10 x 12 mm.

W<sub>1</sub> = 100% crushed chalky white plagioclase. Clast size 5 x 2 mm.

G<sub>1</sub> = 100% aphanitic dark green material. Could possibly be one crystal due to the presence of what appears to be crystal faces. Only one clast observed. Clast size 1 x 1 mm.



14311

This is a very hard rock. Most clasts are digested into melted matrix. It is also unusual in its large vug content (~ 10%). Clasts and vugs commonly are elongate in shape and appear to have flowed.

14311,0 W<sub>1</sub> Sawn Surface

Surface: W<sub>1</sub> is a sawn face with a small amount of broken surface on the N<sub>1</sub> corner. Saw streaks are predominant on the sawn face, but a series of vugs (approximately 15% surface coverage) is revealed by the cut. Note the elongation of the vugs and clasts indicating flow.

Clasts: W<sub>1</sub> - 100% aphanitic plagioclase (white).

14311,0 T<sub>1</sub> Exterior Surface

Surface: There are few pits and a heavy coating of patina is present on this surface.

Clasts: W<sub>2</sub> - Aphanitic plagioclase with a light coating of patina.

14311,0 S<sub>1</sub> Exterior Surface

Surface: There is soil adhering to most of the surface. Several large vugs are present in the center of the sample. There are few pits and less patina than on the T<sub>1</sub>.

S<sub>1</sub>/T<sub>1</sub> edge is rounded and ablated with micrometeorite bombardment. Most of the S face is flat and ablated although it contains a few small zap pits.

Clasts: Only a few plagioclase (W) clasts are present on this face.

14311,0 E<sub>1</sub> Exterior Surface

Surface: Few non-penetrative fractures. Some pits and a light patina are present at the E<sub>1</sub>/T<sub>1</sub> corner. The vugs are commonly elongate and interconnected. A major part of the surface is relatively fresh and irregular.

- Clasts: G<sub>1</sub> - 100% light green aphanitic, probably orthopyroxene. Clast size 3 x 1 mm.
- B<sub>1</sub> - 100% light brown aphanitic pyroxene. Clast size 1 x 1 mm.
- B<sub>2</sub> - Same as B<sub>1</sub>.
- B<sub>3</sub> - Same as B<sub>1</sub>.

There are also a few small ( 1 x 2 mm ) white, plagioclase rich clasts.

#### 14311,0 N<sub>1</sub> Exterior Surface

Surface: There are a large number of small pits and large amount of patina. There is a large cavity (1 cm) on the N<sub>1</sub>/E<sub>1</sub> corner.

- Clasts: W<sub>3</sub> - Same as W<sub>1</sub>. Clast size 15 x 18 mm.
- W<sub>4</sub> - Same as W<sub>1</sub>. Clast size 4 x 2 mm.

14314

14314 is a crystalline matrix breccia. It is somewhat friable. It contains both light and dark clasts in a light grey matrix. Clast molds (areas where clasts have fallen out) are common on this sample. This sample also has a large number of well defined glass lined pits.

14314,0 B<sub>1</sub> Exterior Surface

Surface: The B<sub>1</sub> surface is covered with glass-lined pits and covered with patina such that clast identification is difficult.

Clasts: W = White - 100% crushed material, could be plagioclase.

DG = Dark grey - 80% aphanitic dark material with 20% white areas included in it that could be the same as the white clasts in the matrix.

14316

14316 is a vitric matrix breccia with one flat face ( $B_1$ ). The round surface of this rock is covered with zap pits. This rock has a dark matrix with a high proportion of lighter colored clasts.

14316,0  $B_1$  Exterior Surface

Surface: The surface has no pits, although it has one large glass splash and several areas of apparent patina. This face is covered by a small network of glass lined fractures (glass veins). No penetrative fractures are visible, but surface is hackly.

Clasts: LG = 94% aphanitic light grey material, 5% white plagioclase, 1% pale green to yellow orthopyroxene (?). Clast size 20 x 10 mm.

$W_1$  = 98% crushed white plagioclase, 2% glass veins and a small amount of ilmenite. Clast size 7 x 4 mm.

$W_2$  = Same as  $W_1$ . Clast size 5 x 5 mm.

$W_3$  = Same as  $W_1$ . Clast size 5 x 4 mm. Covered with adhering soil.

$W_4$  = Same as  $W_1$ . Clast size 6 x 2 mm.

## References

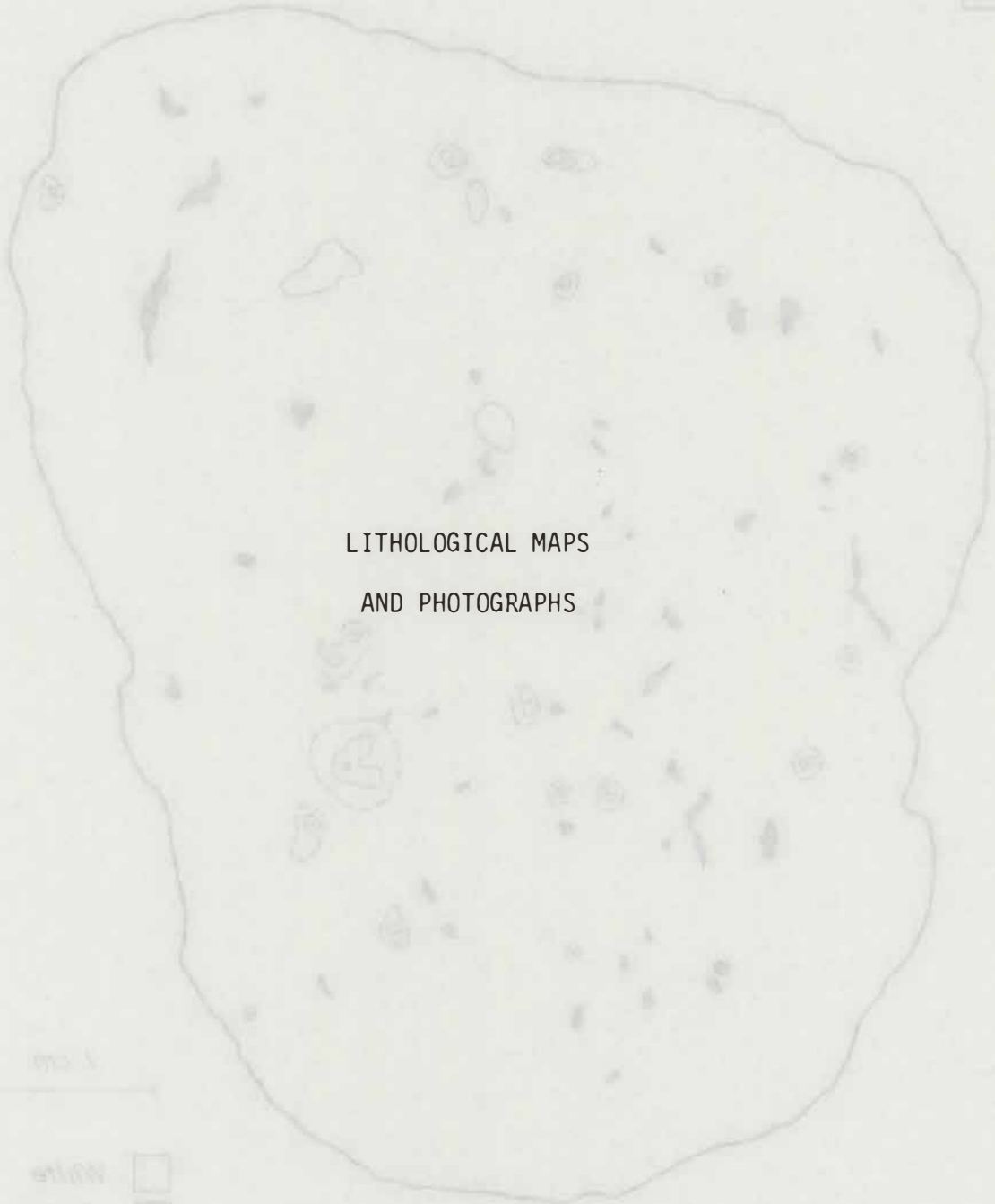
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14051.0

21



LITHOLOGICAL MAPS  
AND PHOTOGRAPHS

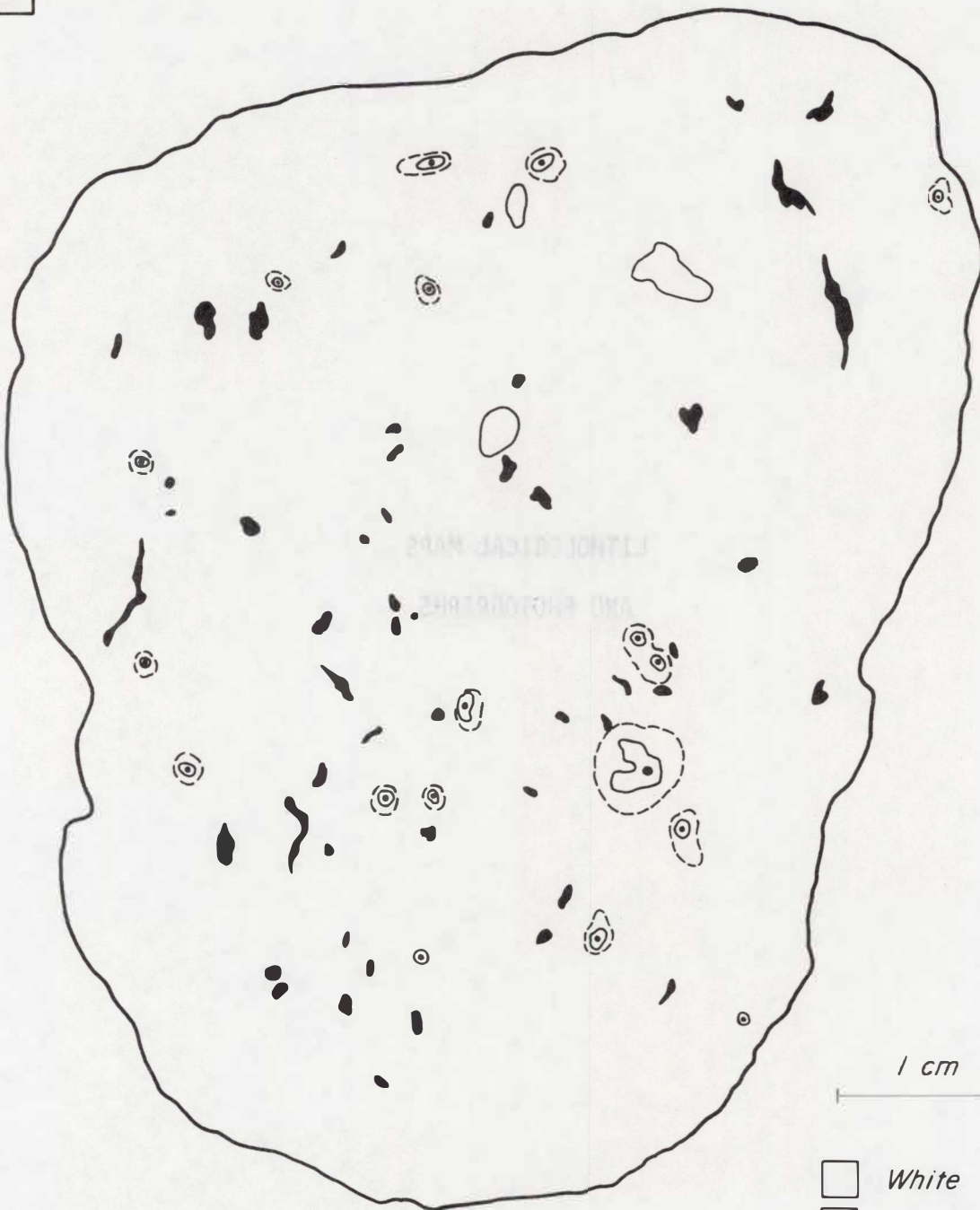
1 cm

- Water
- Sand
- Soft zone
- Wp







W  
S

14051,0



1 cm

-  White
-  Zappit
-  Spall zone
-  Vug

14051,0

SI  
M

14051,0



1 cm

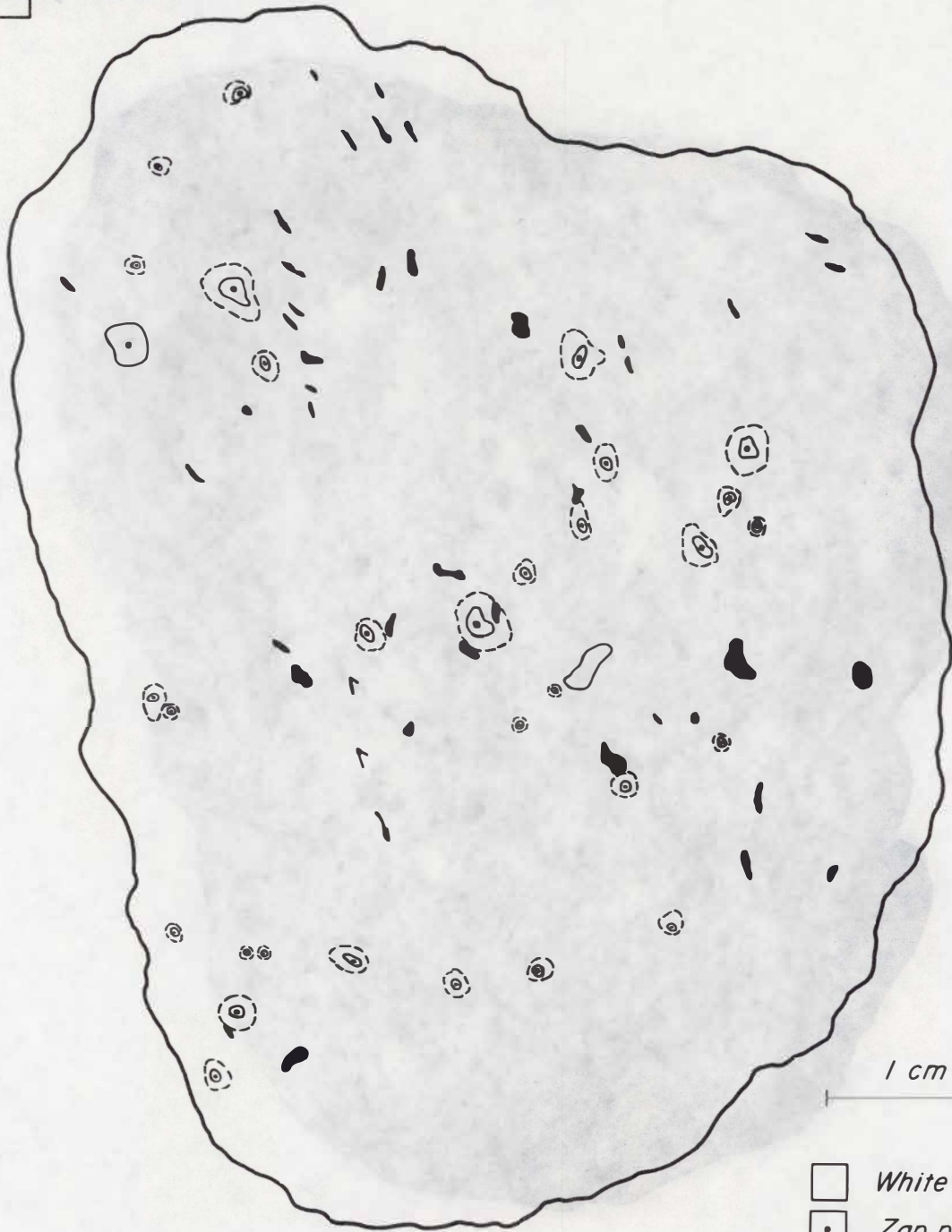
White   
Top pit   
Spall zone

S77-23488

1 cm

N.W.

14051,0



- White
- Zap pit
- Spall zone
- Vug





14051,0

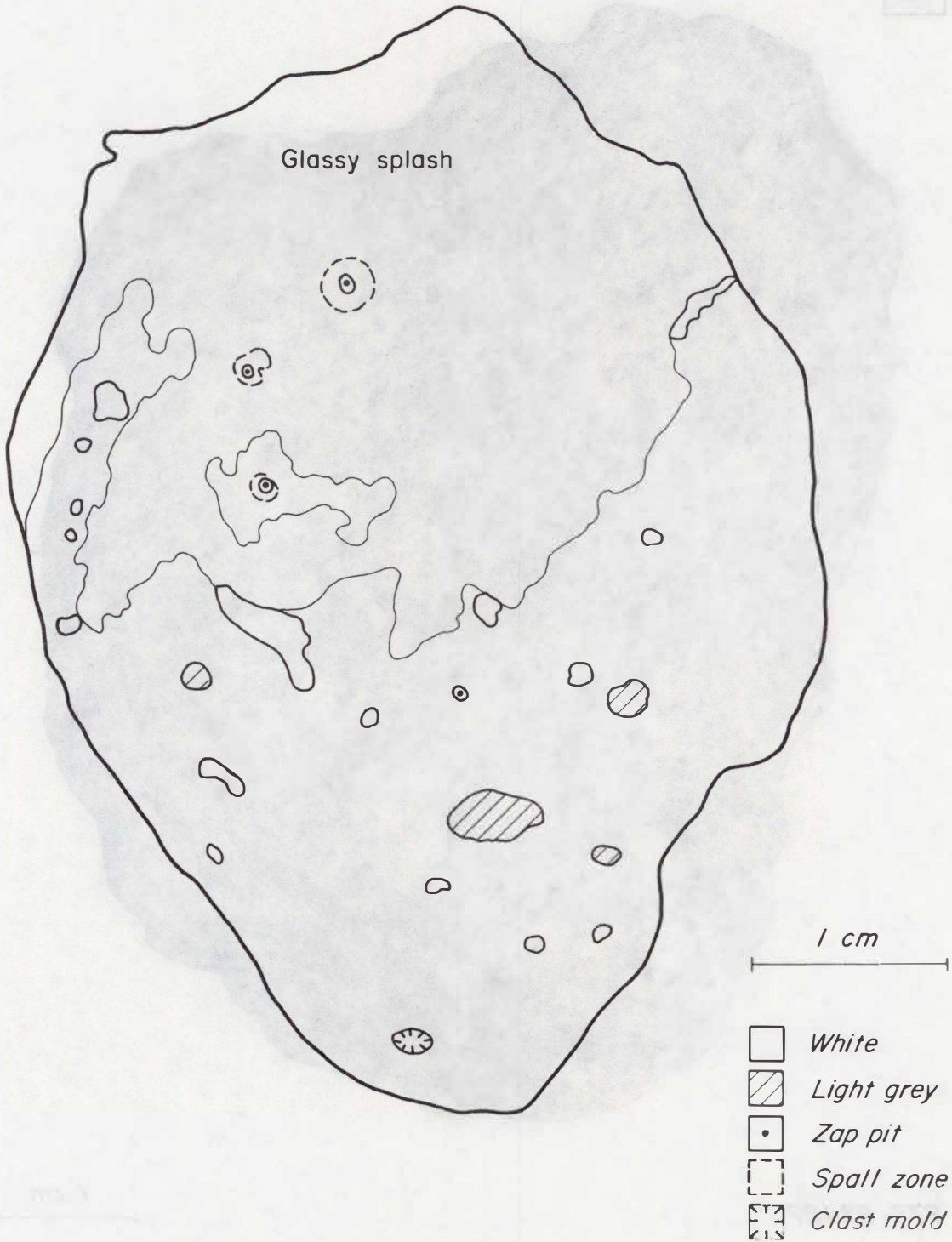


1 cm  
White   
Light grey   
Dark grey   
Black   
S77-23487

1 cm

B<sub>1</sub><sup>w</sup>

14055,0

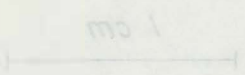
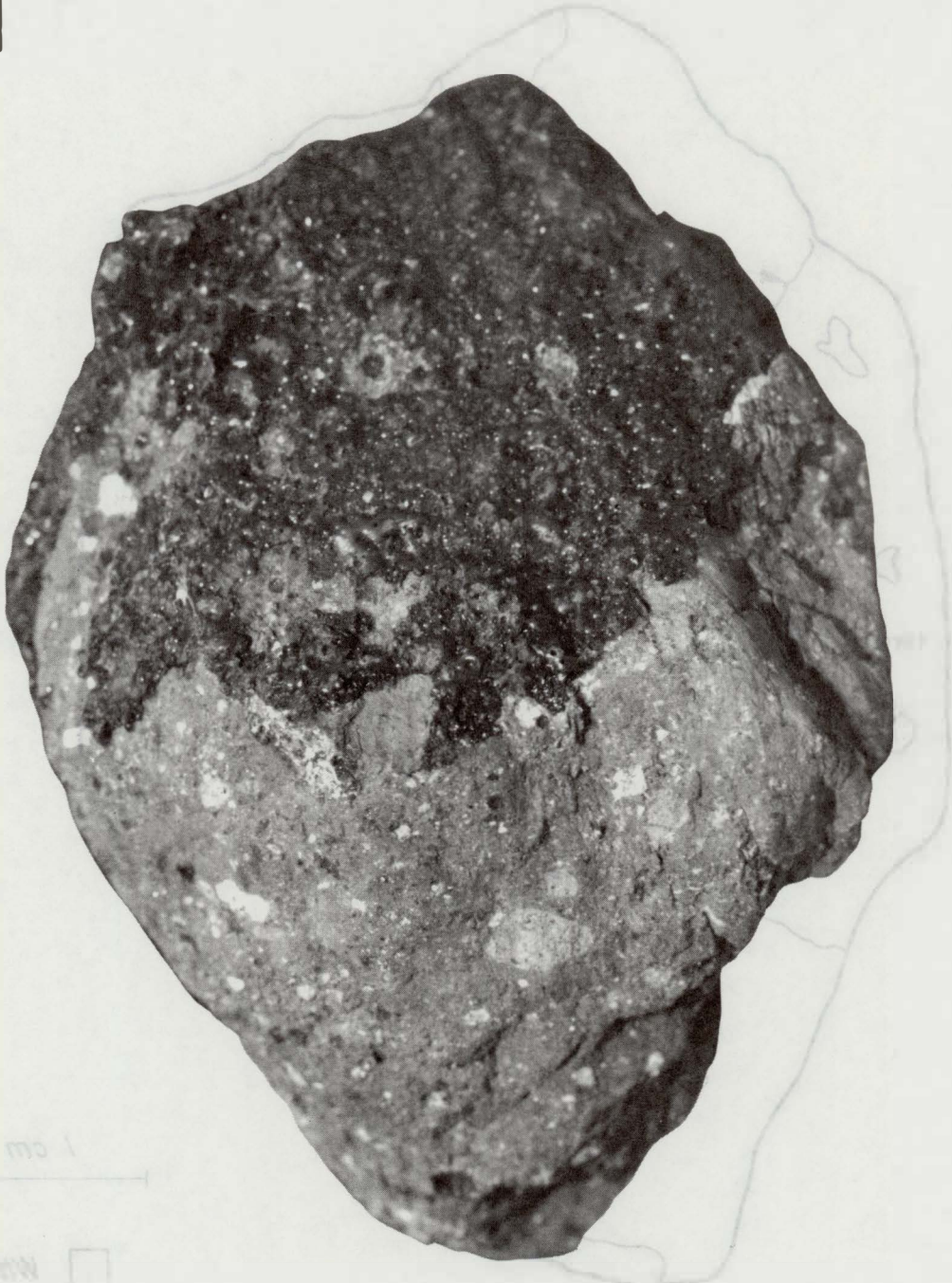




14055,0



14055,0

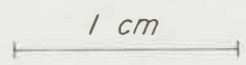


White

Brown

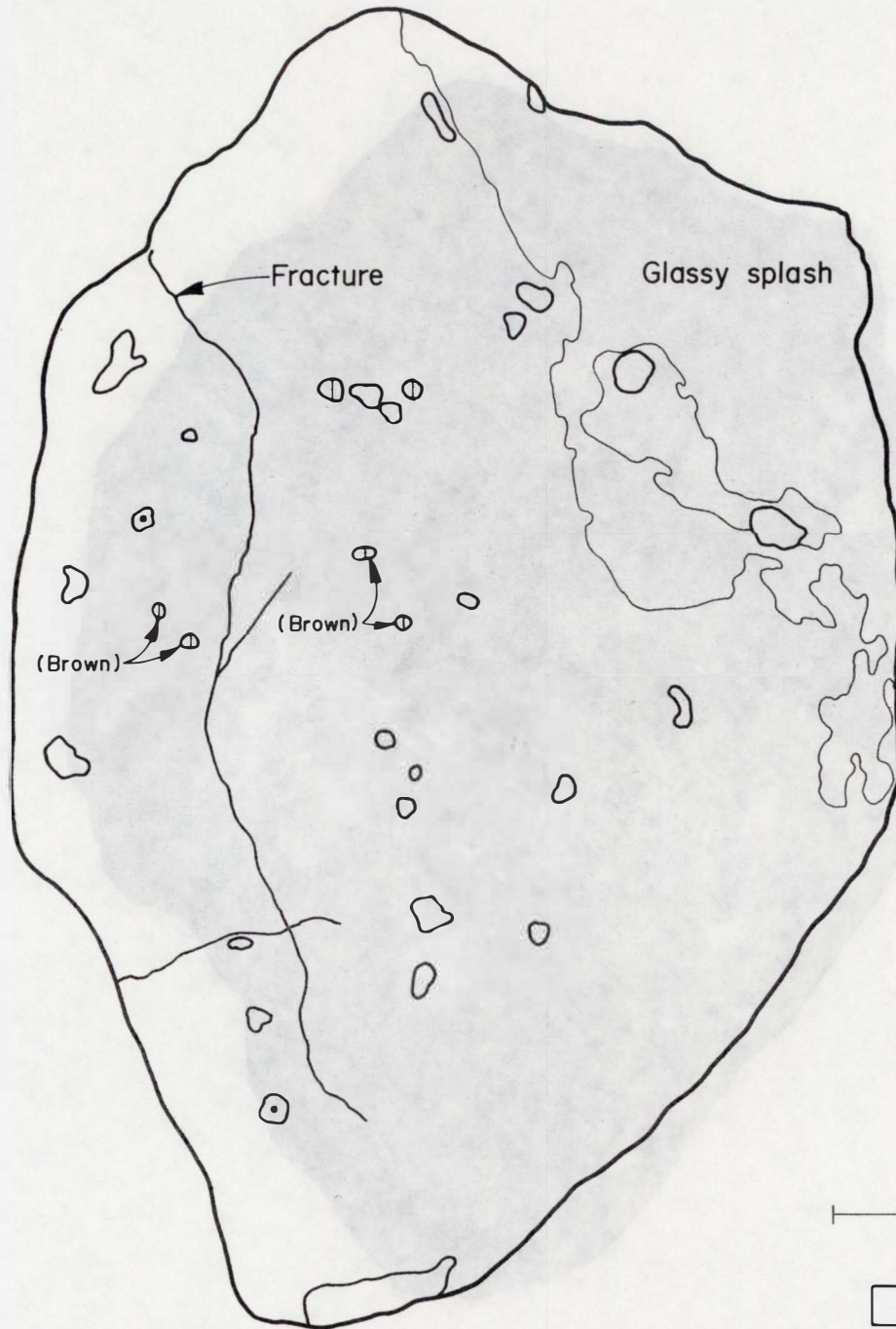
Black

S77-23605








14055,0



1 cm

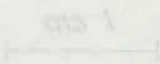
-  White
-  Brown
-  Zap pit



0,23041

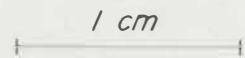


14055,0



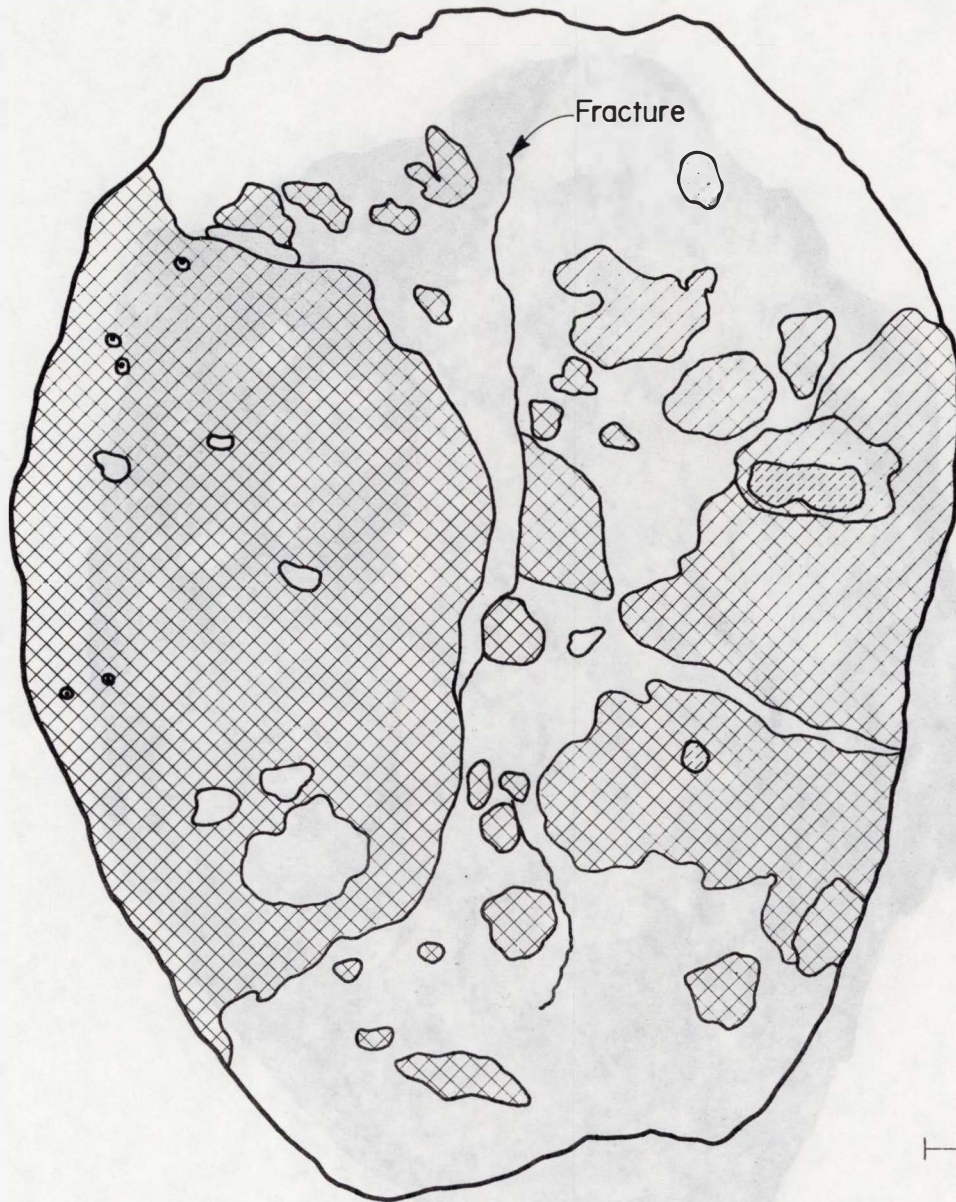
- White
- Dark grey
- Green
- Black

S77-23604



S<sub>1</sub>E

14066,0



1 cm

-  White
-  Dark grey
-  Green
-  Zap pit



SI

14066,0



1 cm

Green

White

S77-23485

Fig. 10

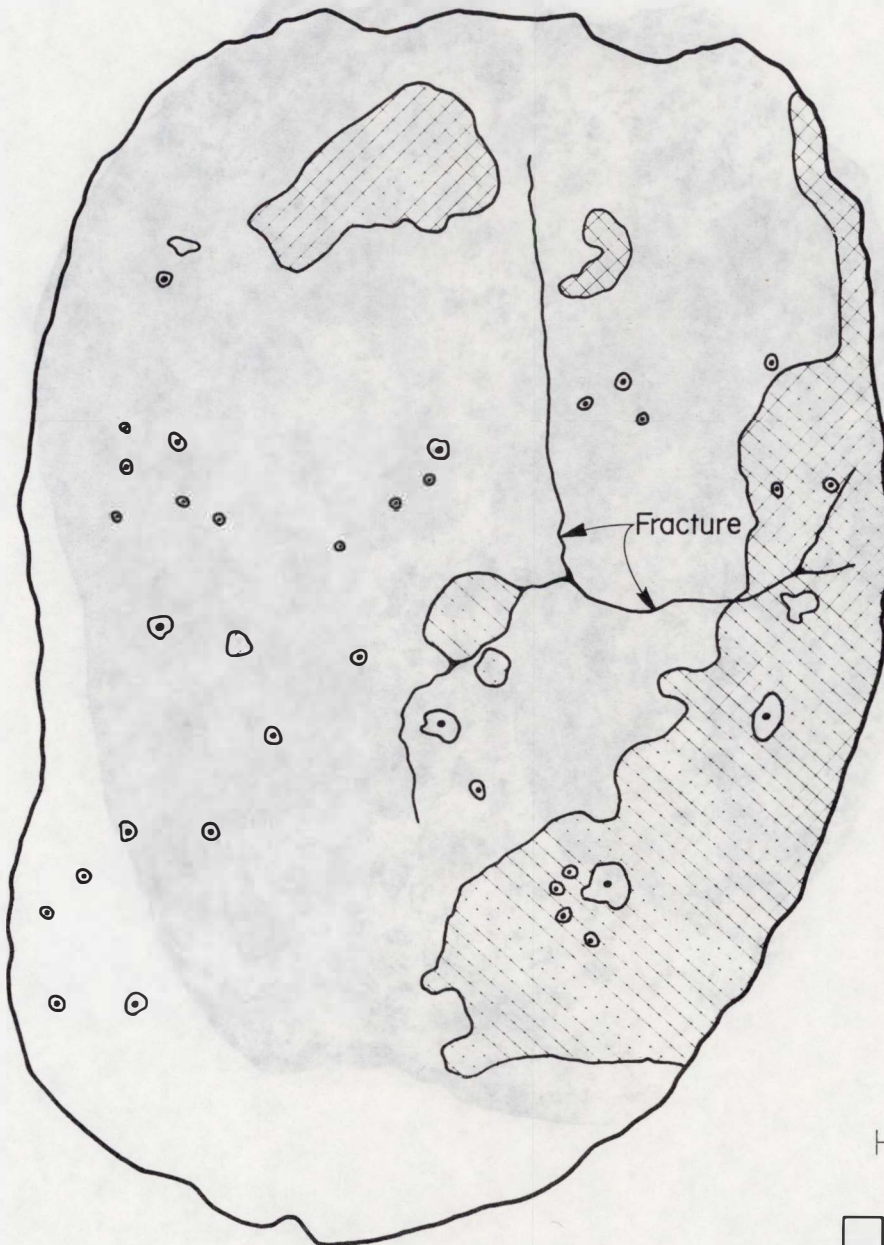
1 cm









14066,0

14066,0



1 cm

-  Green
-  White
-  Dark grey
-  Zap pit



14066,0

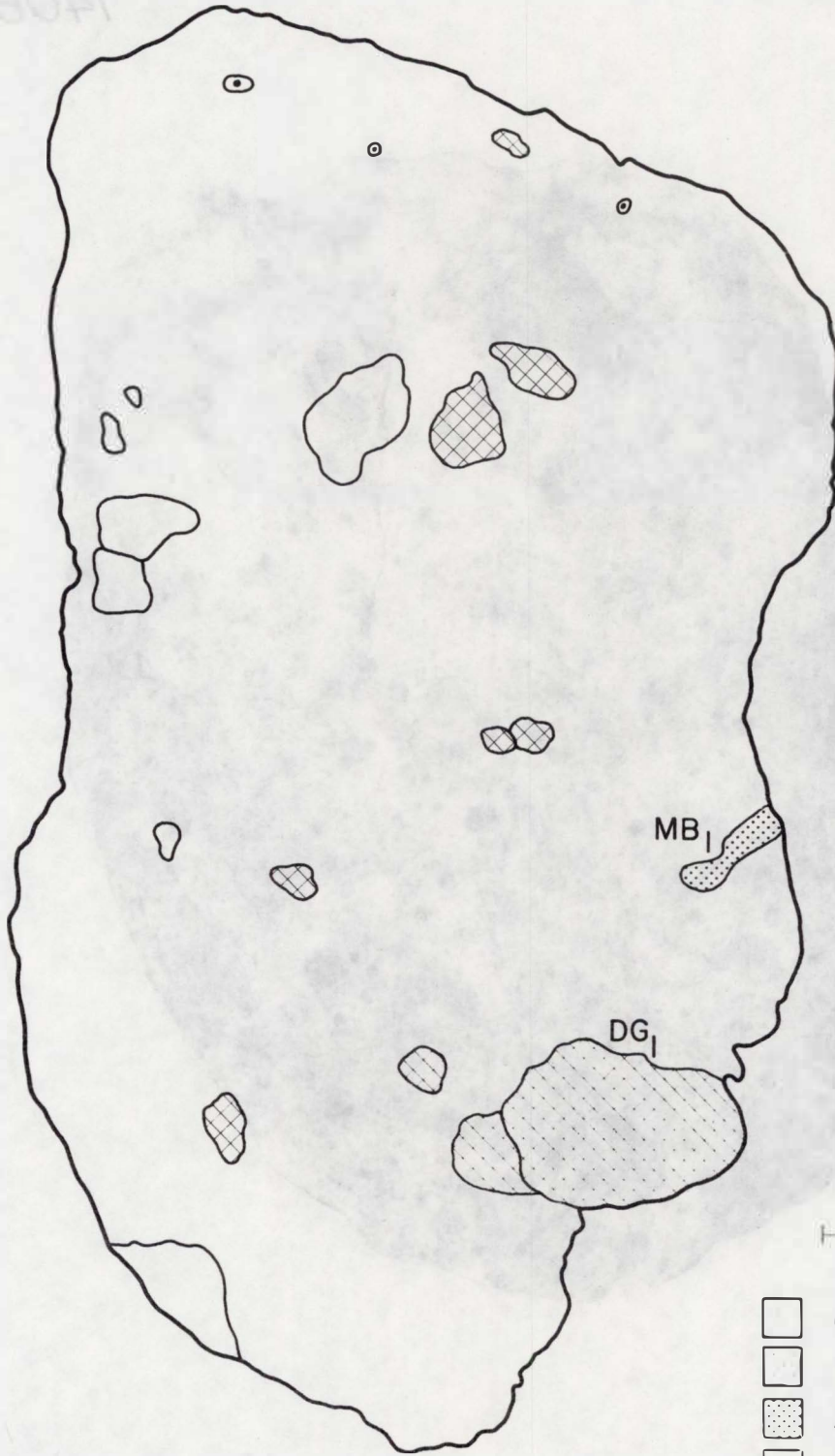


1 cm  
White   
Dark grey   
White   
Dark grey   
S77-23486

1 cm

SEI

14301, 24



1 cm

-  *White*
-  *Dark grey*
-  *Mare basalt*
-  *Zap pit*



14301, 24

14301, 24

SEI



1 cm

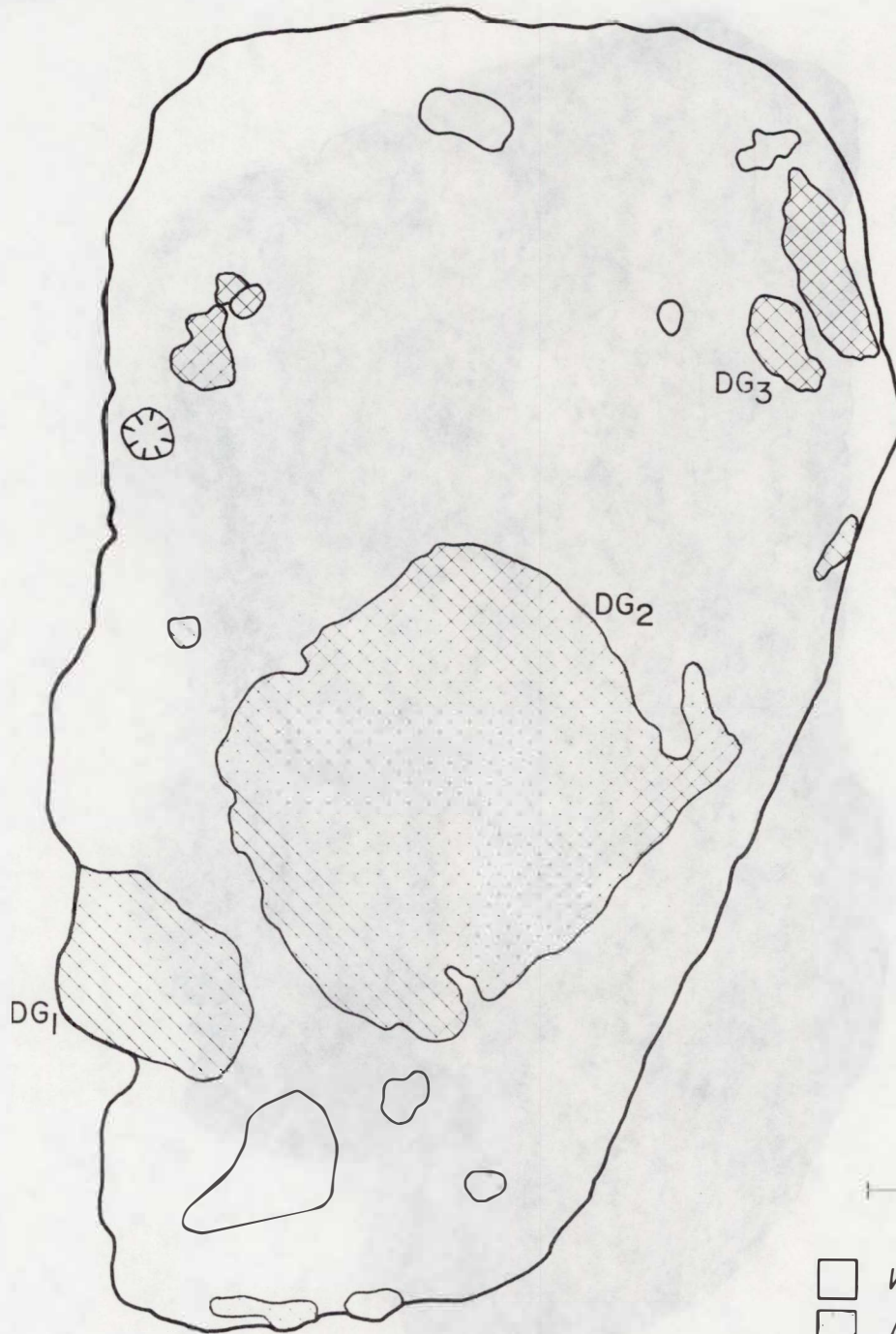
- White
- Dark grey
- Char. field

S77-23456




1 cm



14301, 24



1 cm

-  White
-  Dark grey
-  Clast mold



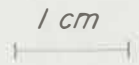


14301, 24



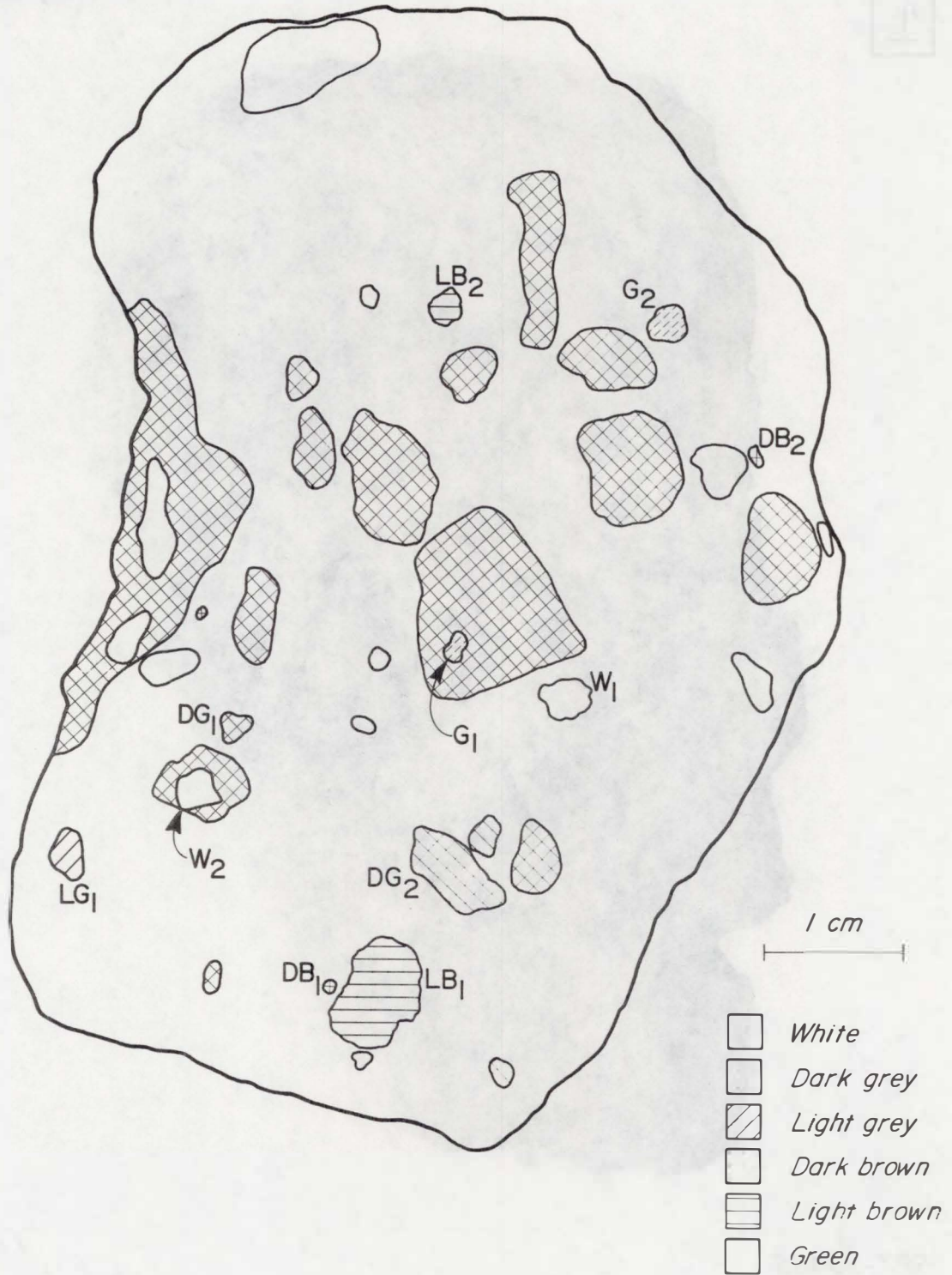
White  
Dark grey  
Light grey  
Dark brown  
Light brown

S77-23455



SEI

14303,7





SEI

14303,7

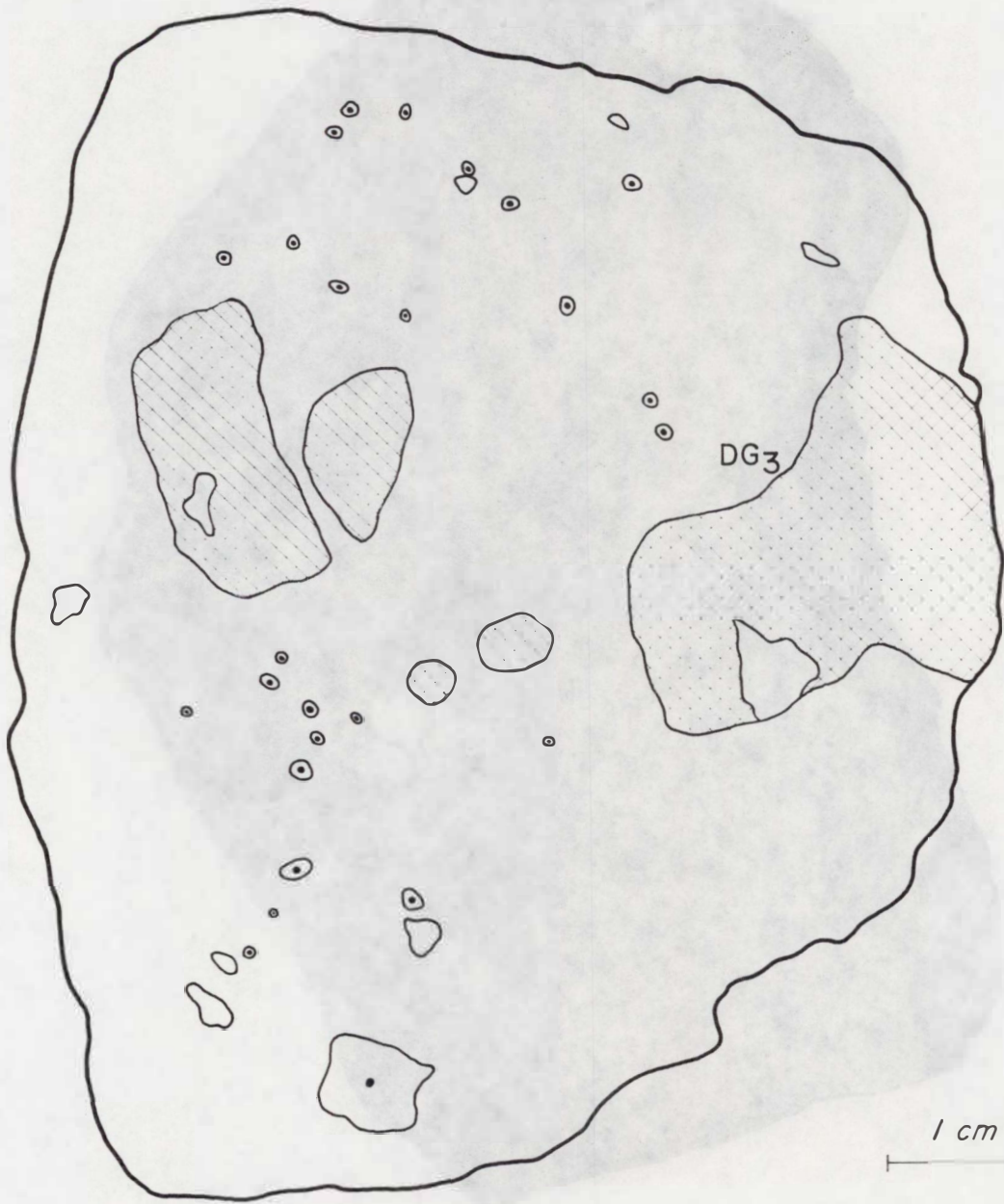


S77-23372

1 cm



14303,7



- White
- Dark grey
- Zap pit





14303,7



1 cm

S77-23368

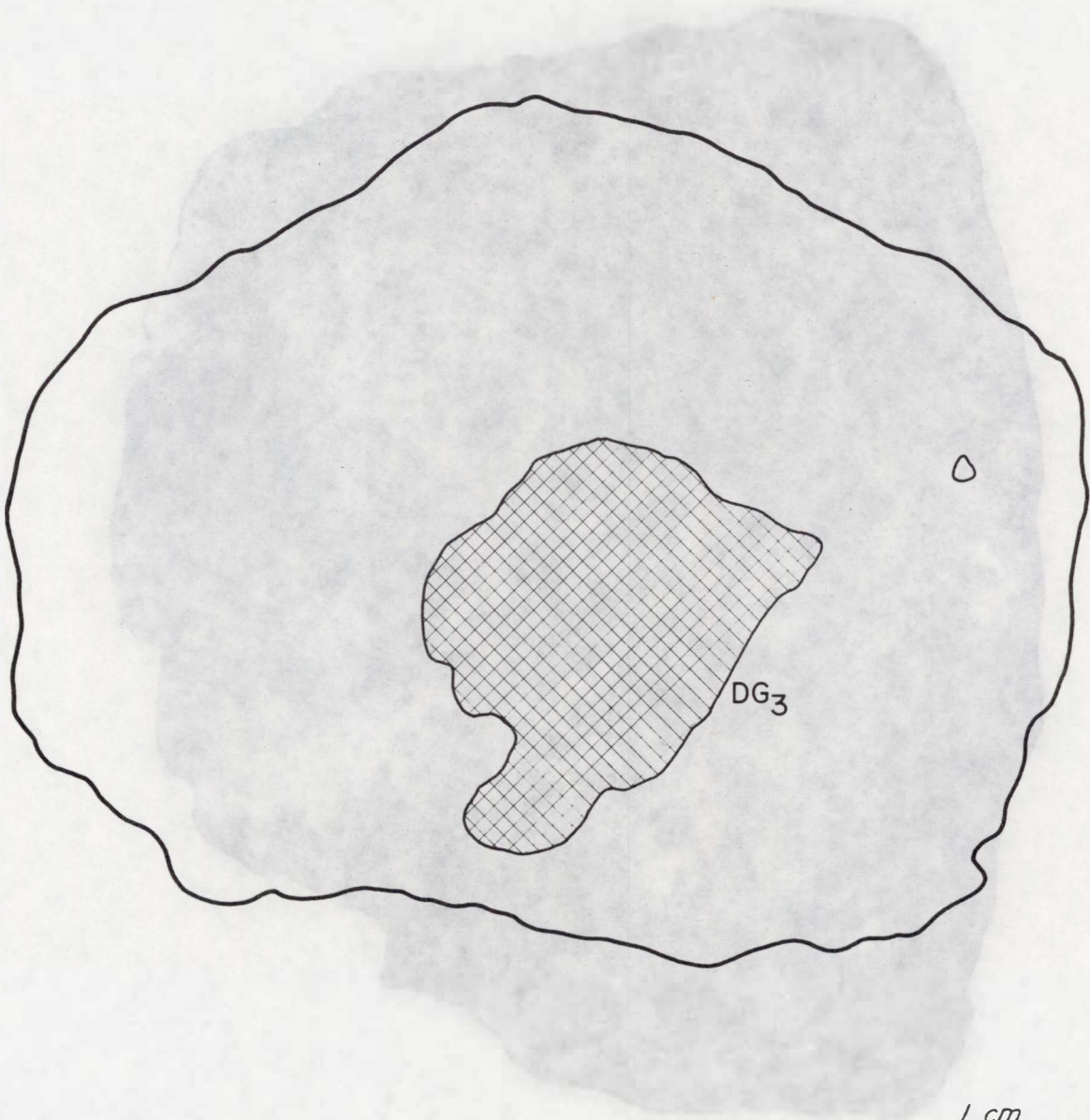
1 cm





14303,7

14303,7

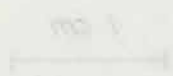
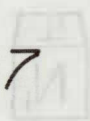


- White
- Dark grey

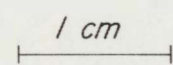
14303, 7



14303, 7



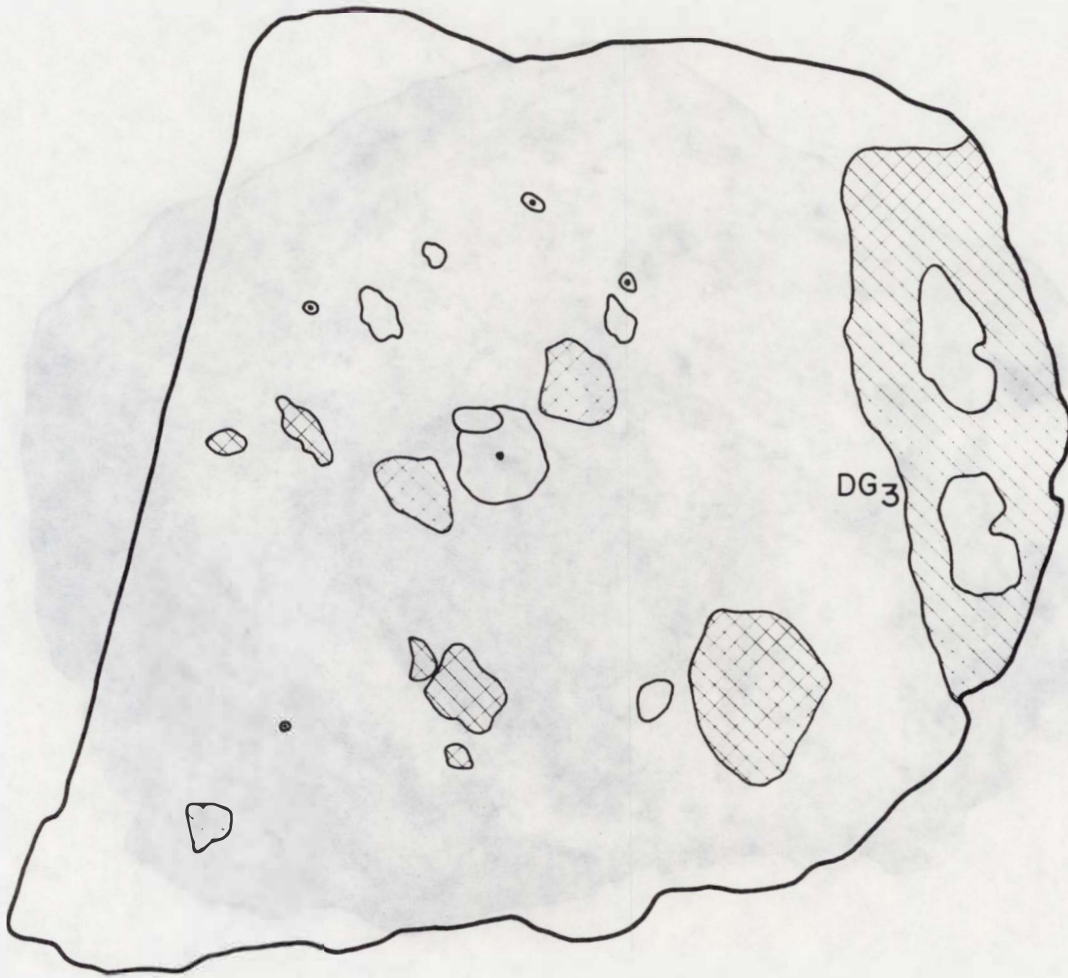
White   
Dark grey   
S77-23370








14303

14303,7



1 cm



-  White
-  Dark grey
-  Zap pit



I  
N<sub>1</sub>

14303,7



1 cm  
White   
Dark grey   
Dark brown   
S77-23367

1 cm

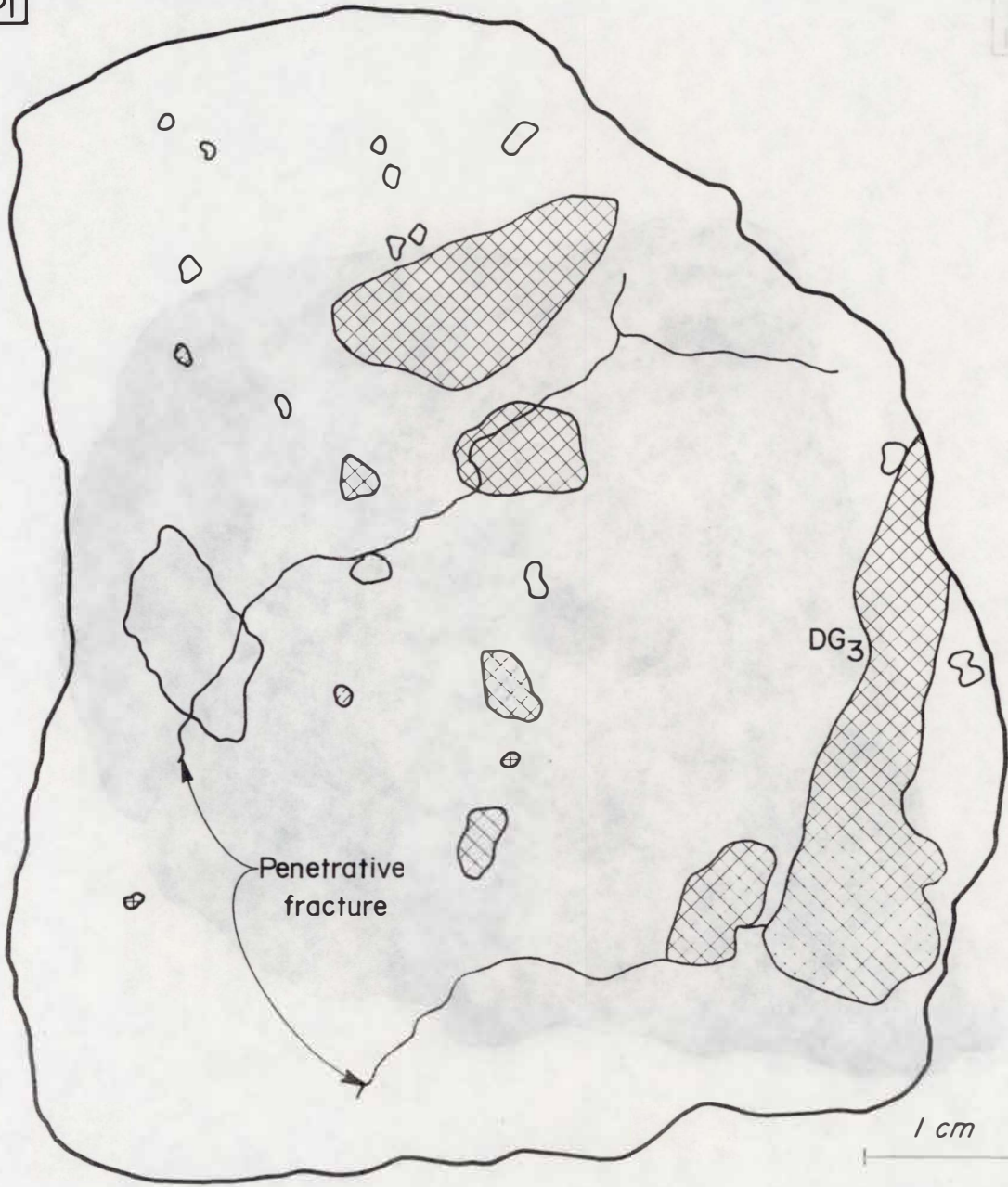






N<sub>1</sub>  
B<sub>1</sub>

ΕΟΒΑΙ

14303,7

✓



-  White
-  Dark grey
-  Dark brown
-  Green

14303,7

N<sub>1</sub>  
B<sub>1</sub>

14303,7



cm

White  
Top of

S77-23369

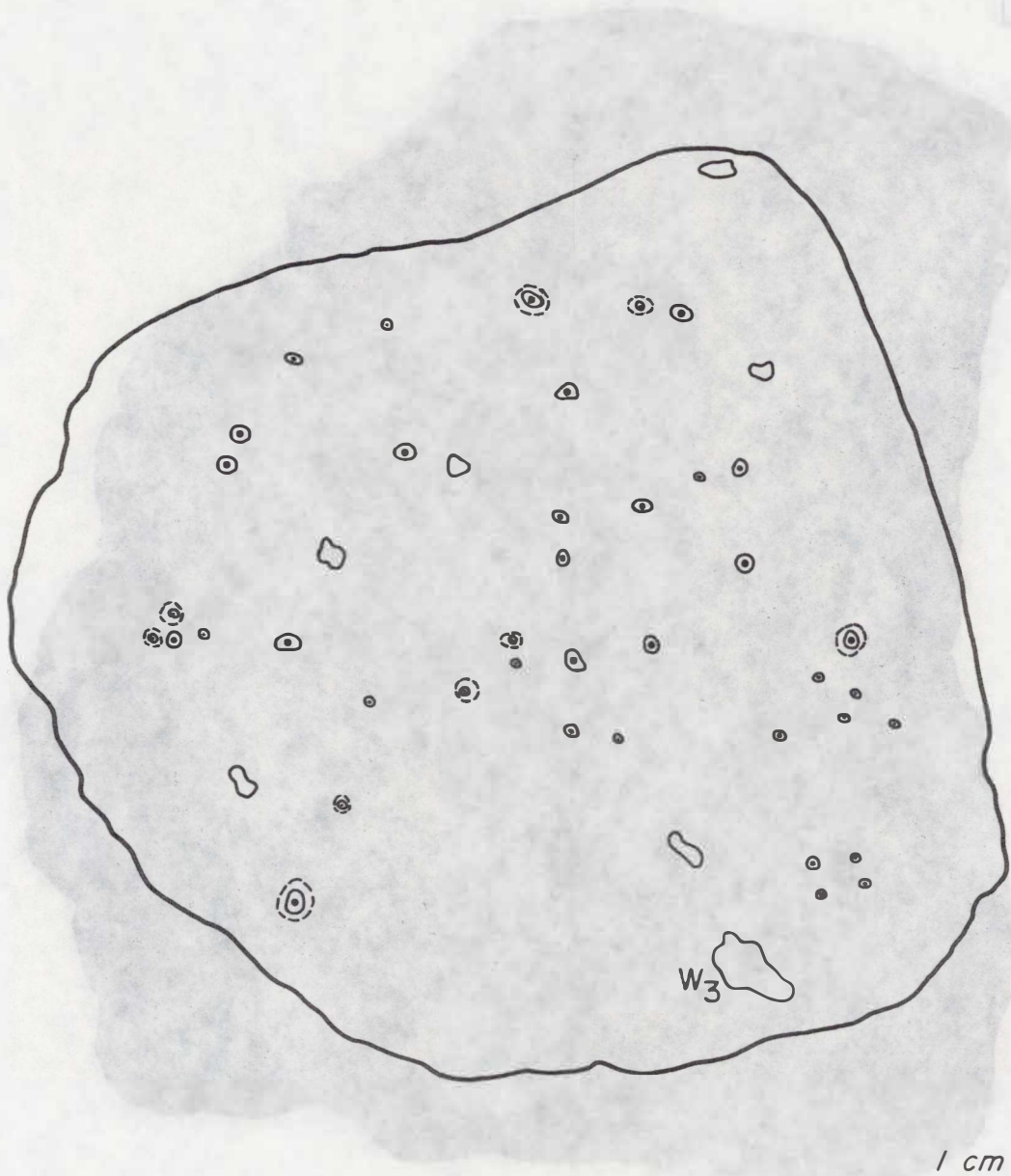
1 cm






T<sub>1</sub>  
S<sub>1</sub>

14303,7

14303,7



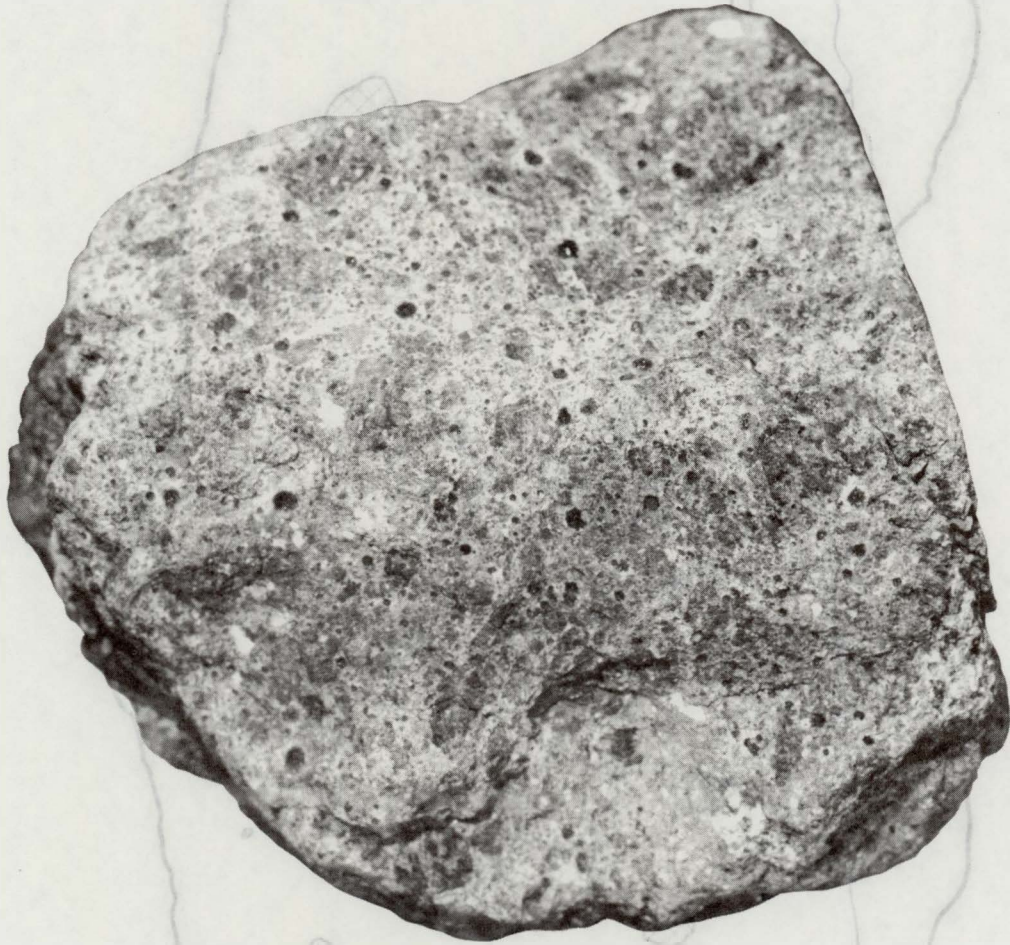
1 cm

-  White
-  Zap pit
-  Spall zone

14303,7

Ti  
Si

14303,7



1 cm

White   
Dark grey

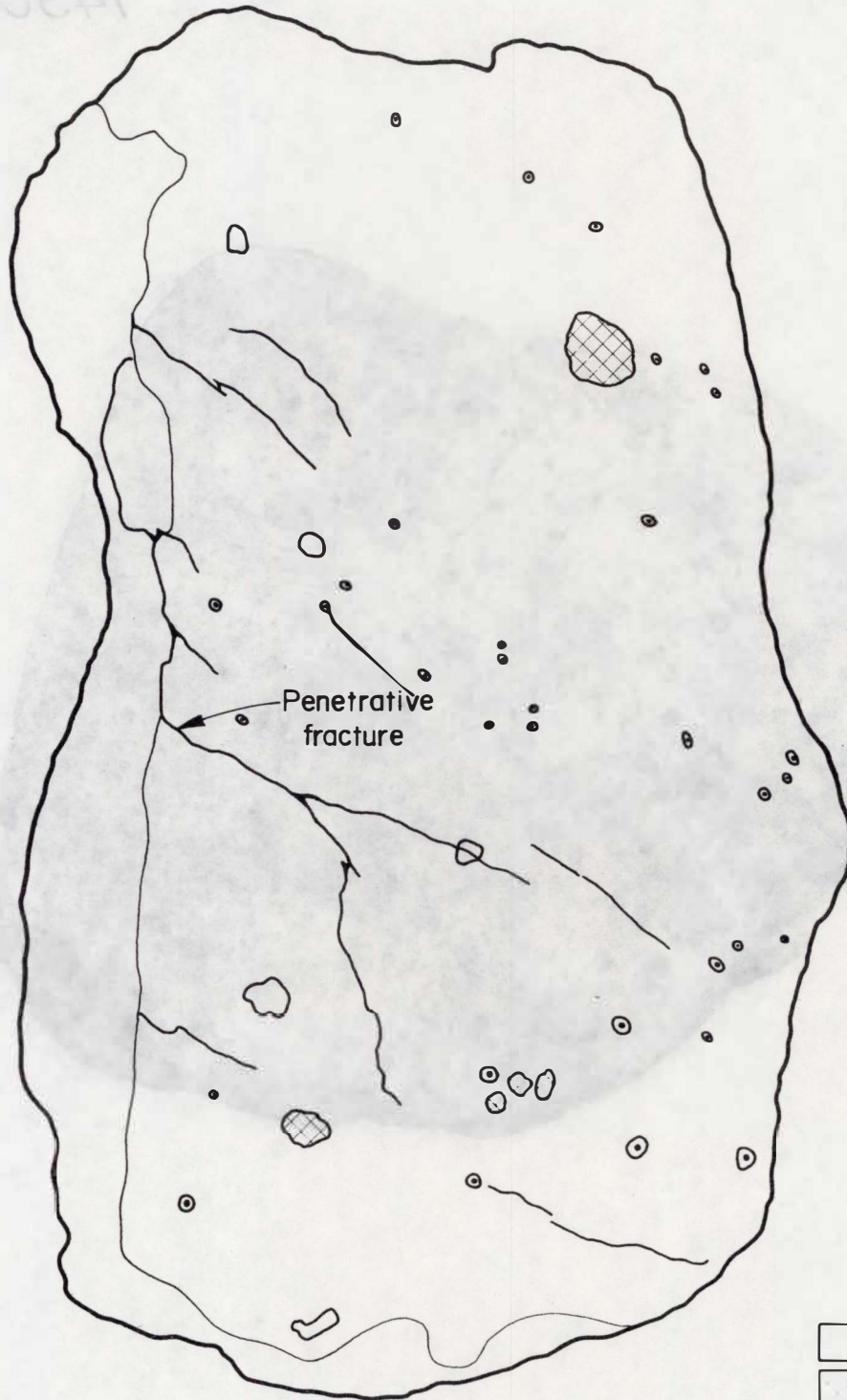
S77-23371

1 cm








14304,0



Penetrative fracture

1 cm  
|-----|

-  White
-  Dark grey
-  Zap pit



14304,0

14304,0



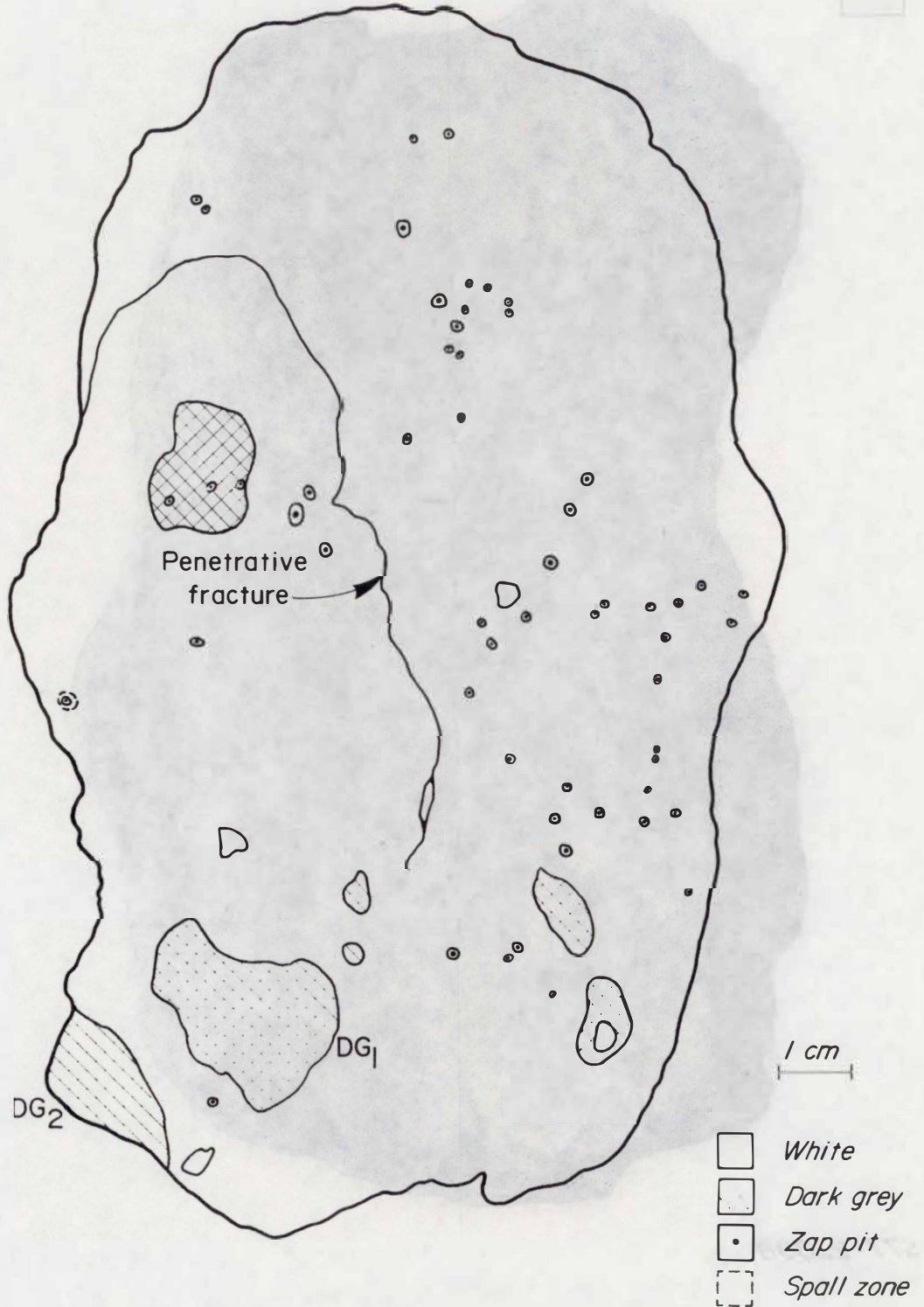
1 cm

White   
Dark Gray   
577-23098   
Spall zone

1 cm

S1E

14304,0





SI E

14304, 0

Thin, shiny  
black glass

etched  
surface

1 cm

577-23099

White  
Dark gray  
- on pt

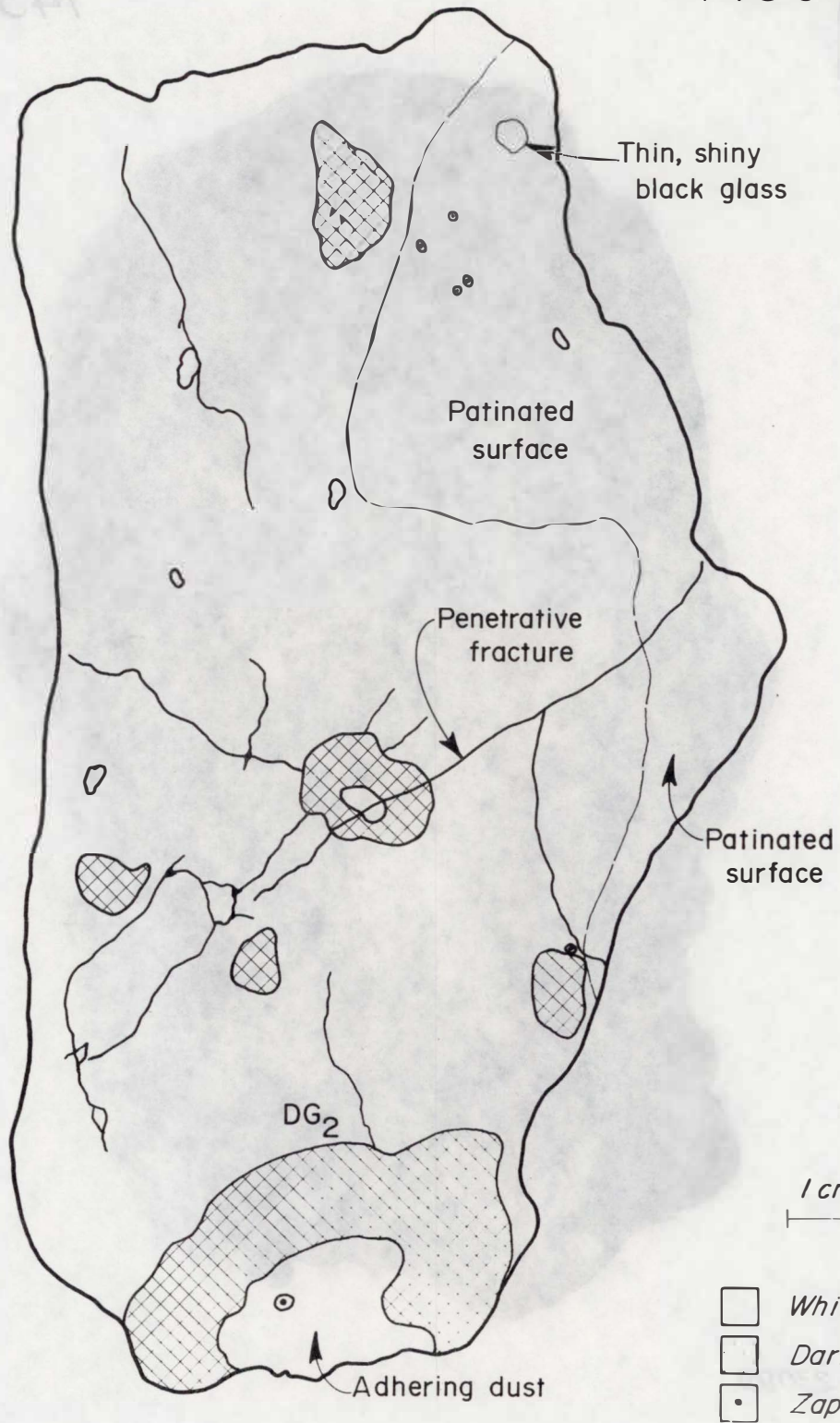
Adhering dust

1 cm

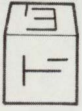




14304,0



14302, 18



14304, 0



1 cm

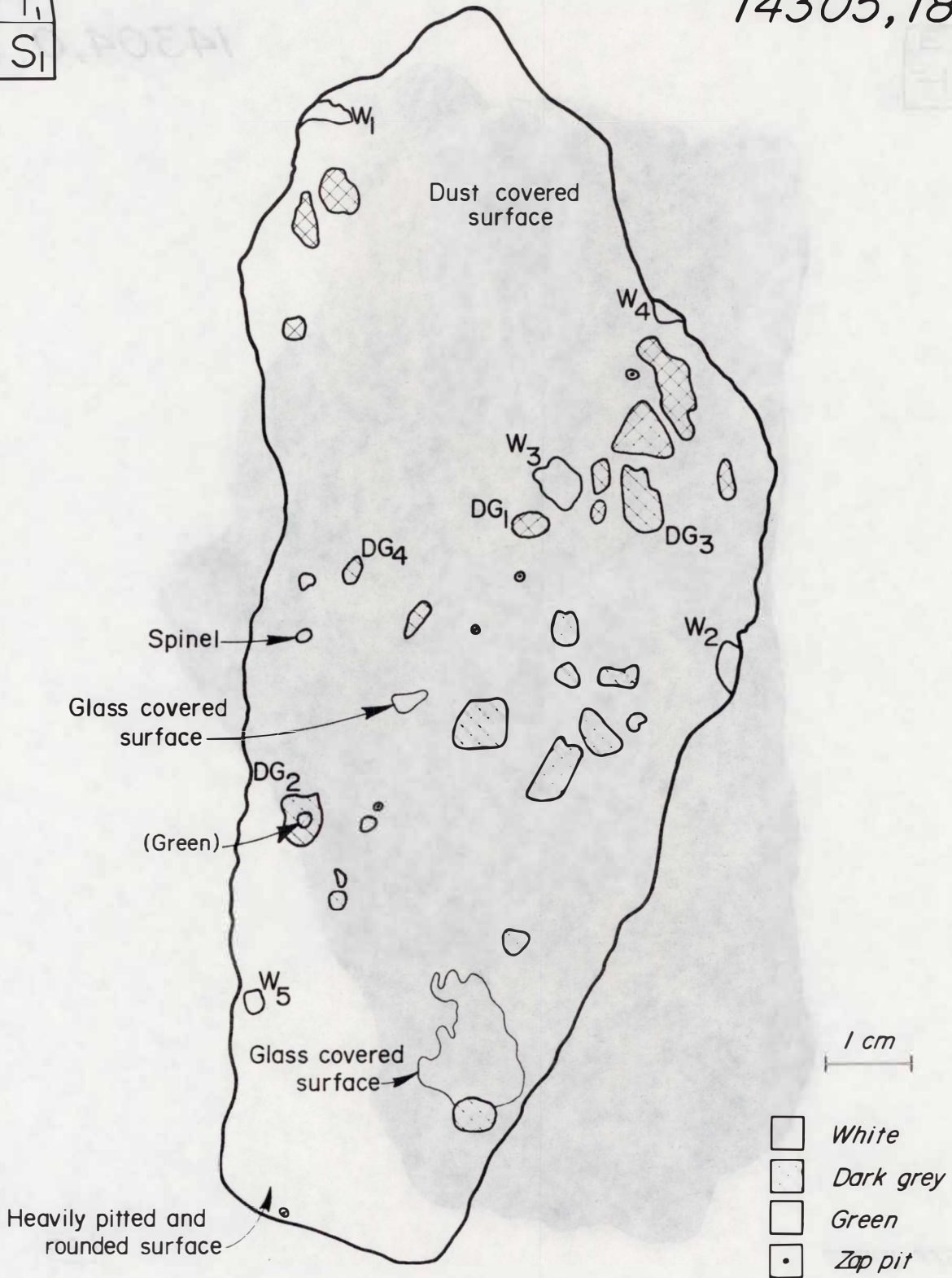
- White
- Dark grey
- Green
- 

S77-21972

Glass cover surface  
 (Green)  
 Glass cover surface  
 Heavily pitted and  
 Glass cover surface  
 1 cm

T<sub>1</sub>  
S<sub>1</sub>

14305, 18





14305, 18

T<sub>1</sub>  
S<sub>1</sub>

14305, 18

W



Fracture  
Formative

DC2

1 cm

- White
- Dark grey
- Light brown
- Green

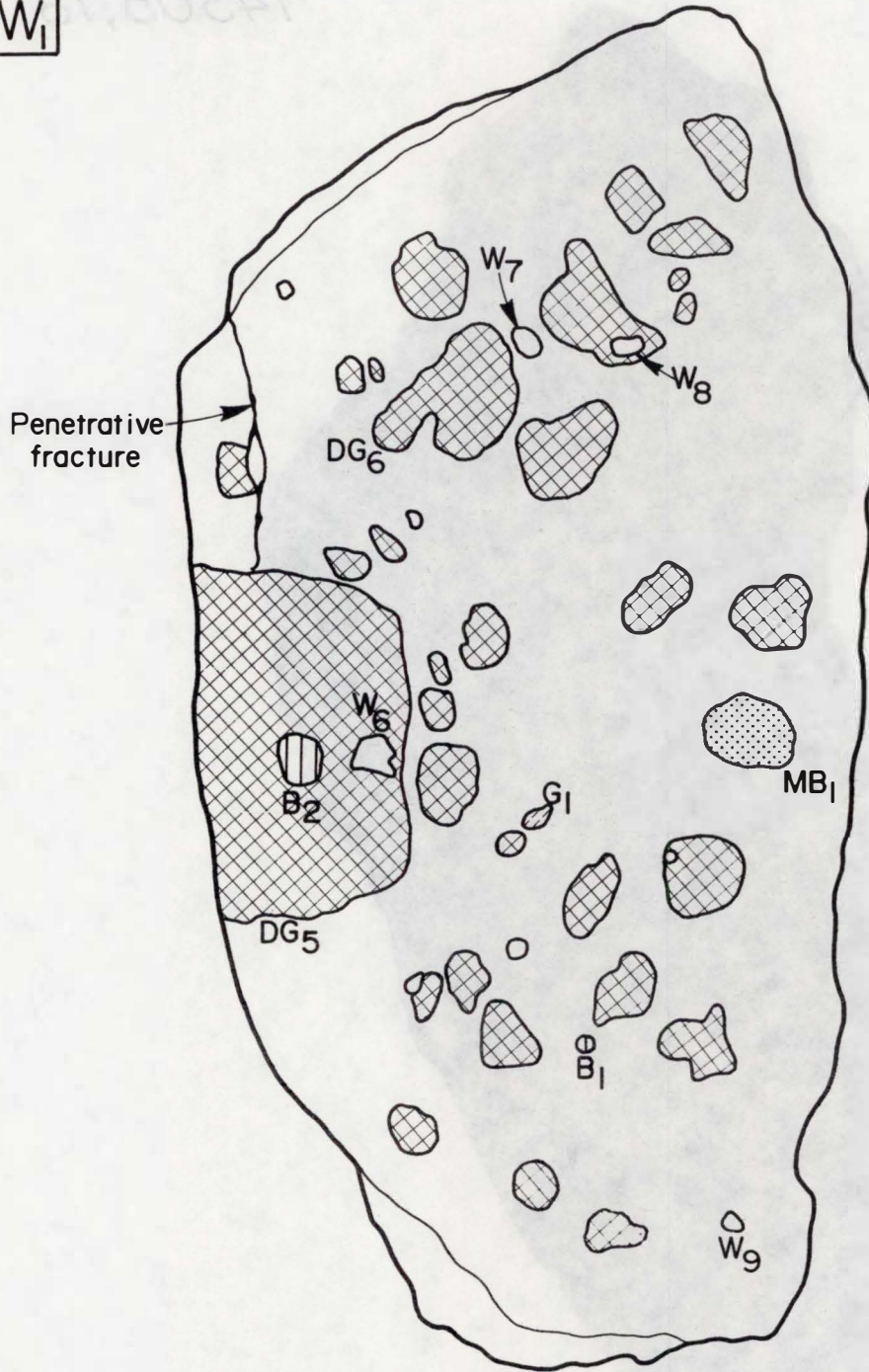
S77-21475

1 cm










14305, 27



1 cm

-  White
-  Dark grey
-  Mare basalt
-  Green
-  Brown

14305, 27

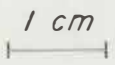
14305, 27



Scale bar

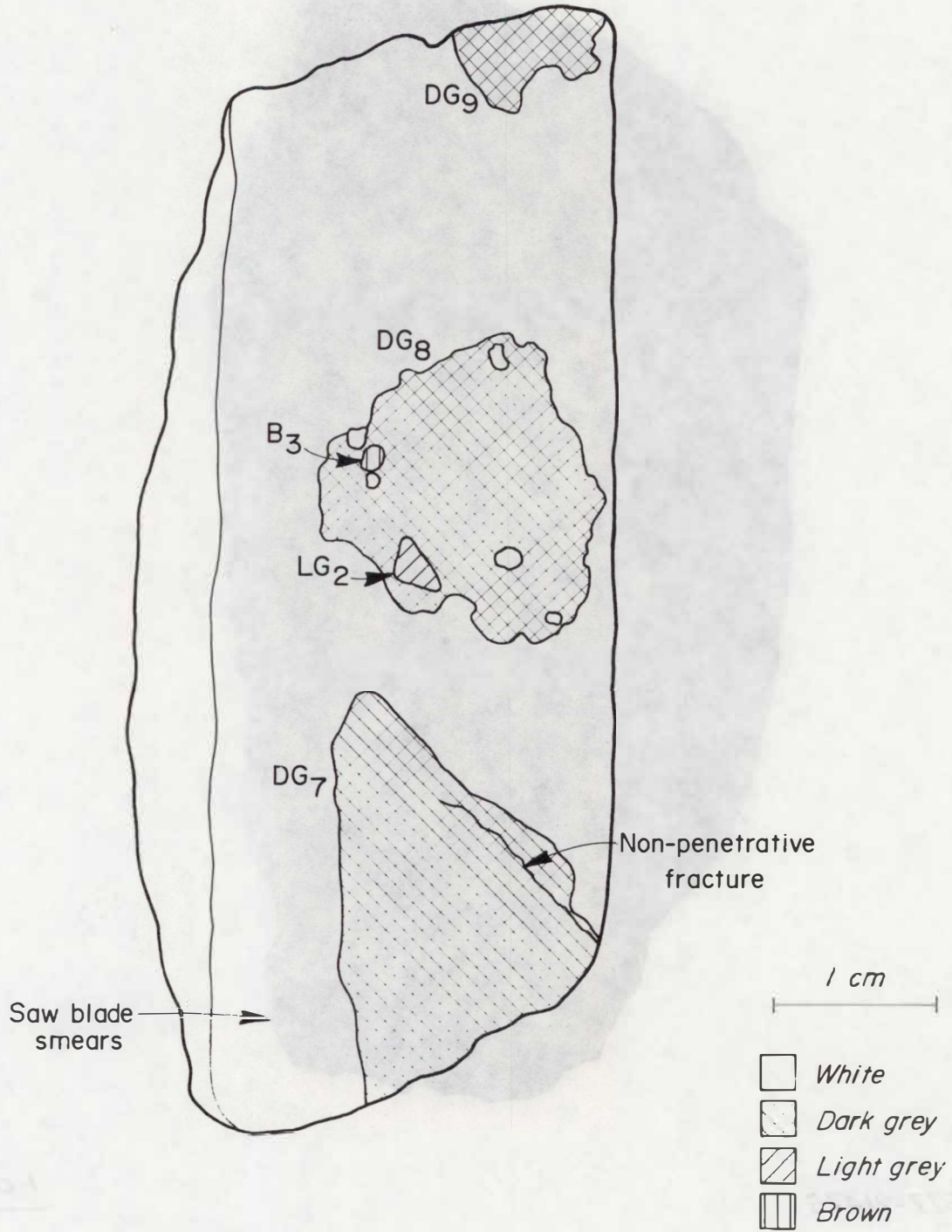
- white
- Dark grey
- Light grey

S77-21476

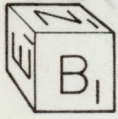




14305,30







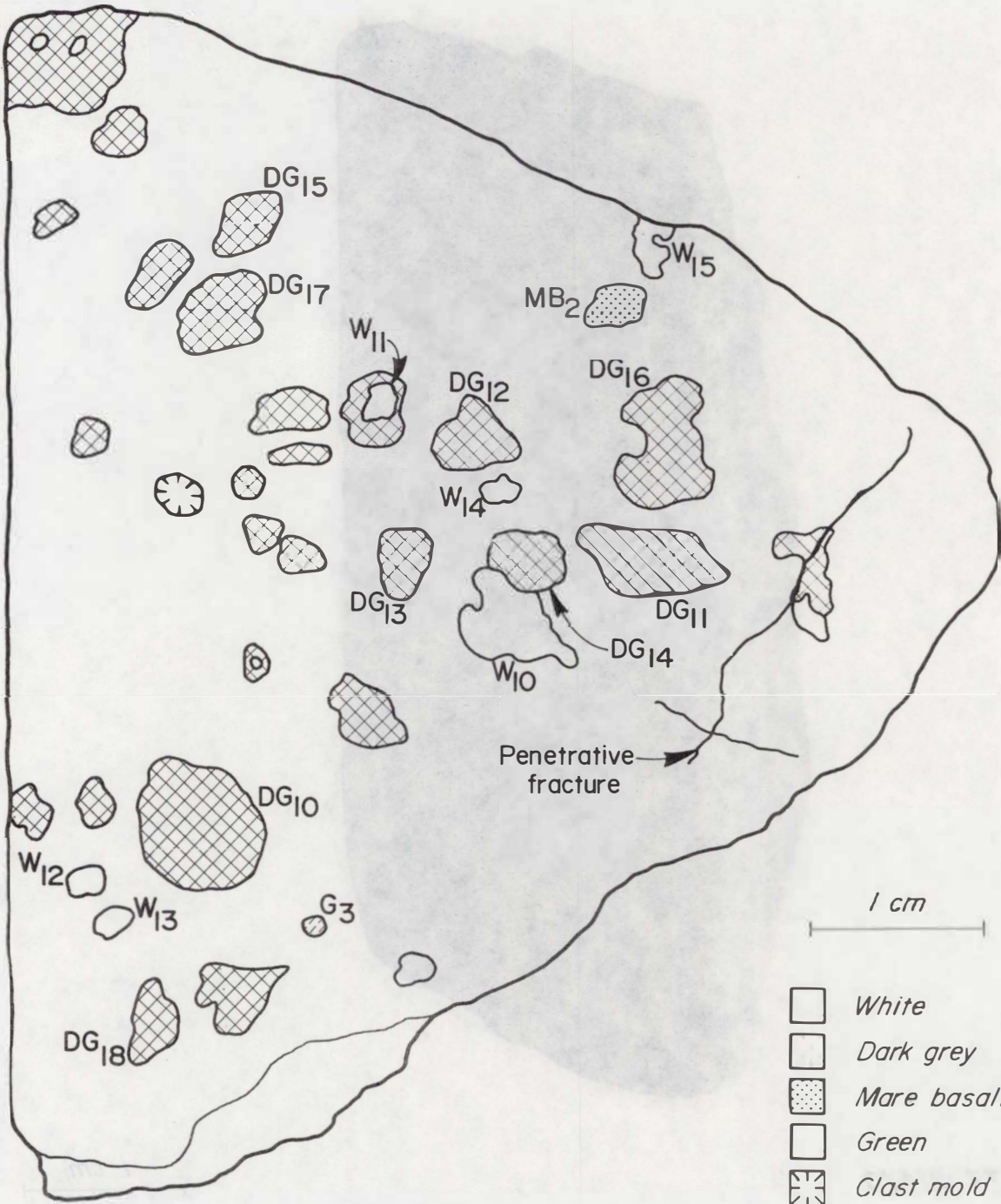
14305,30



- 1 cm
- White
  - Dark grey
  - Blue buff
  - Green
  - S77-21470

S  
E

14305,30

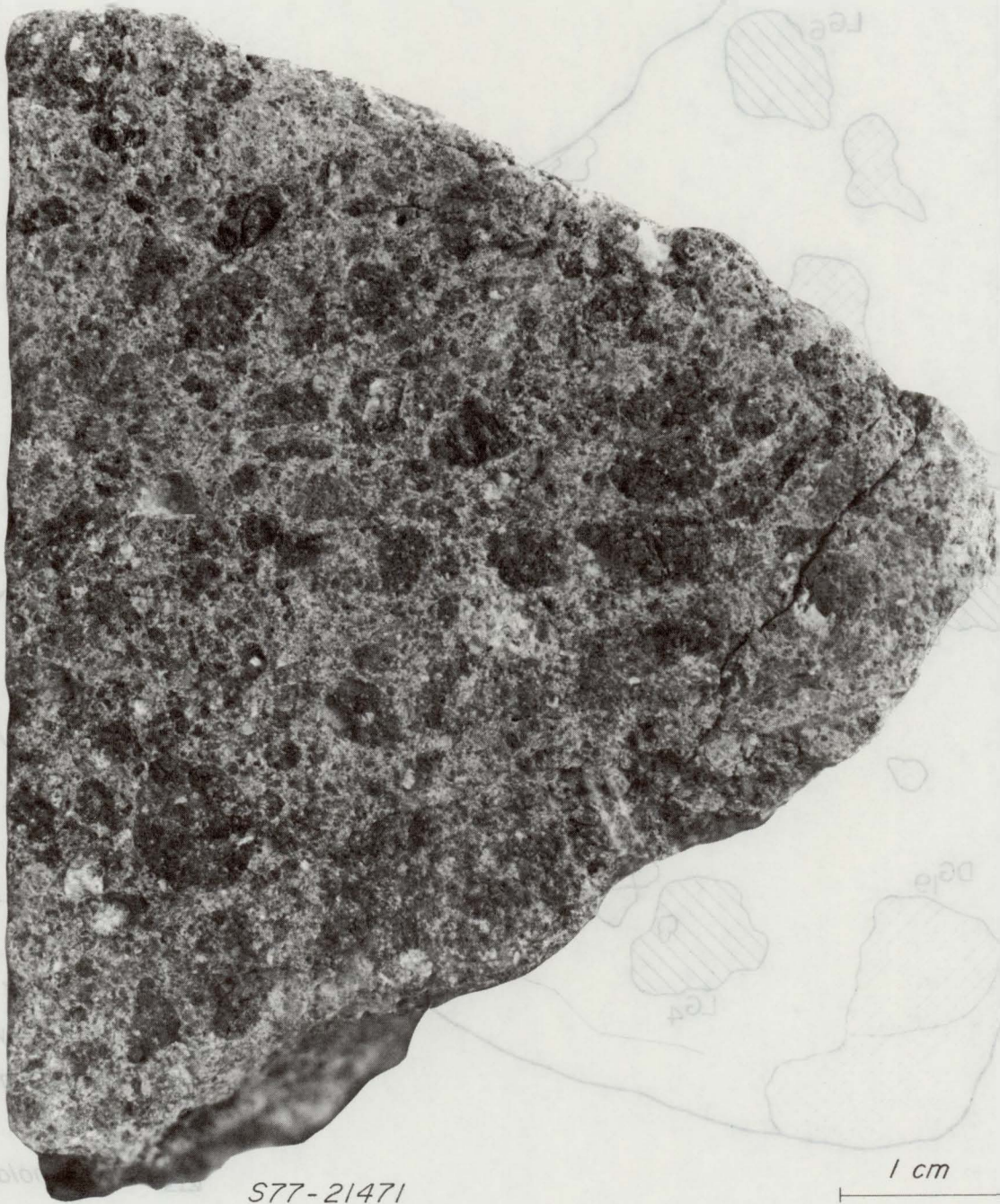




14305,30

S  
E

14305,30

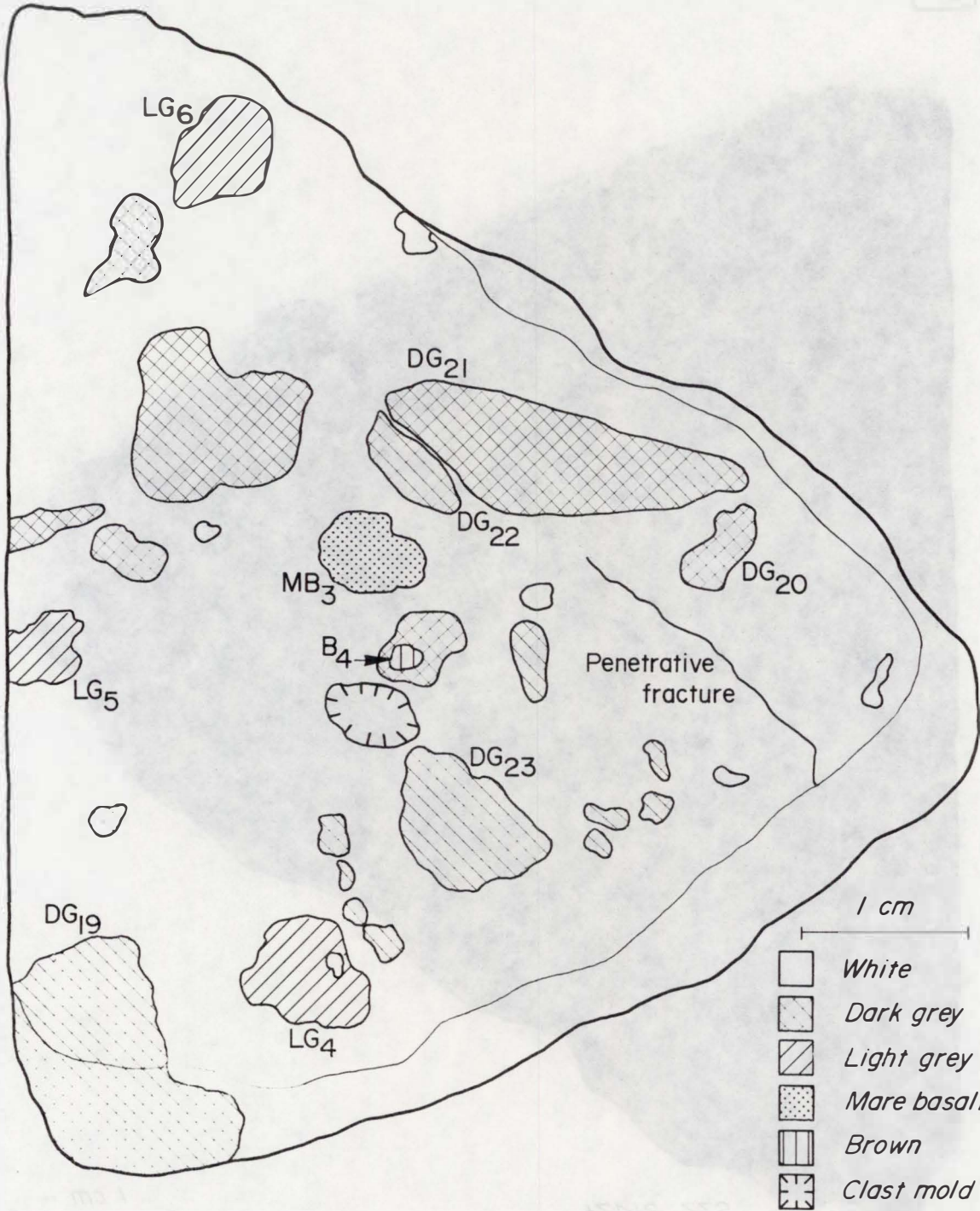


S77-21471

1 cm



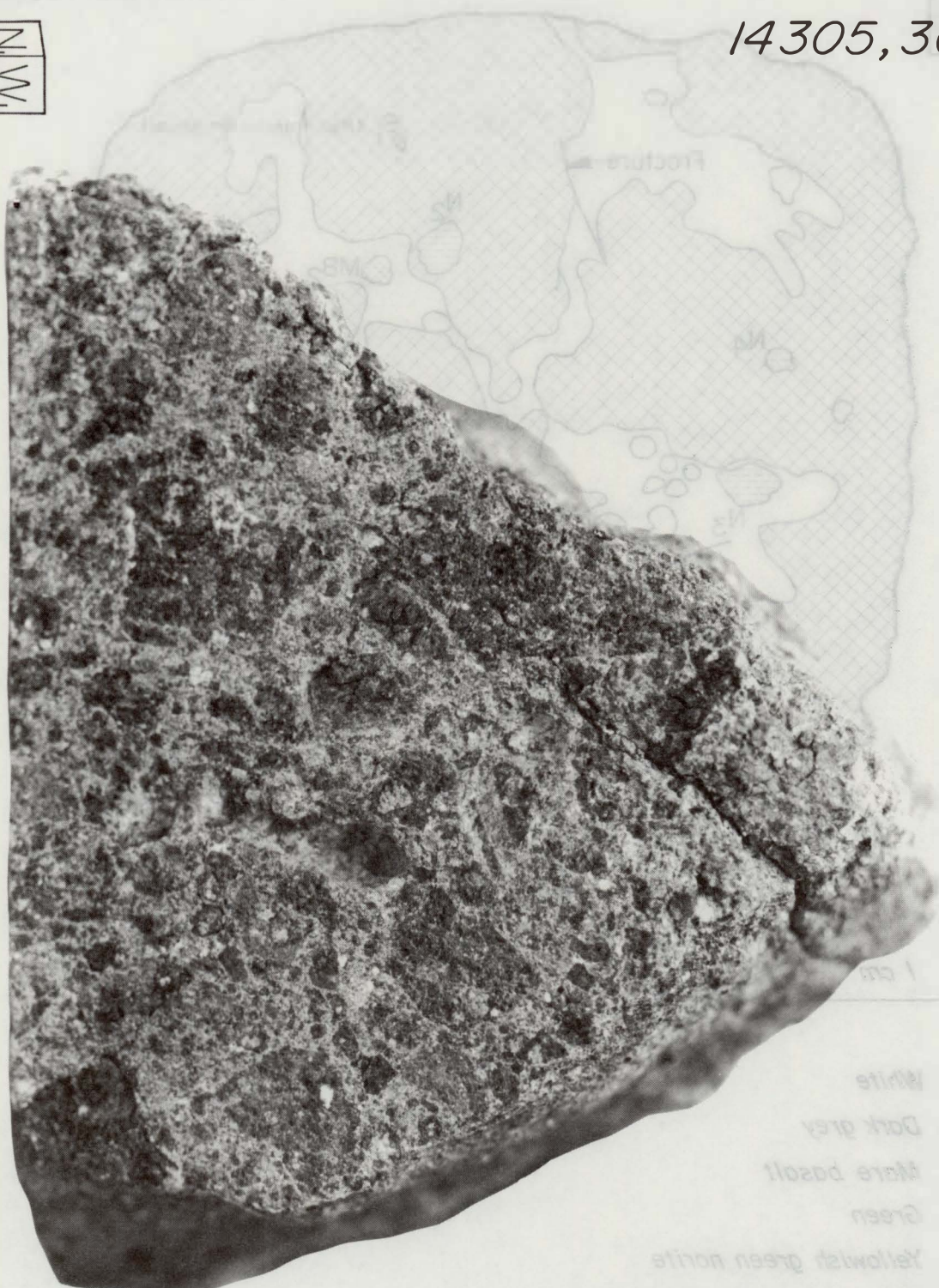
14305, 30



14305.30



14305, 30



S77-21472

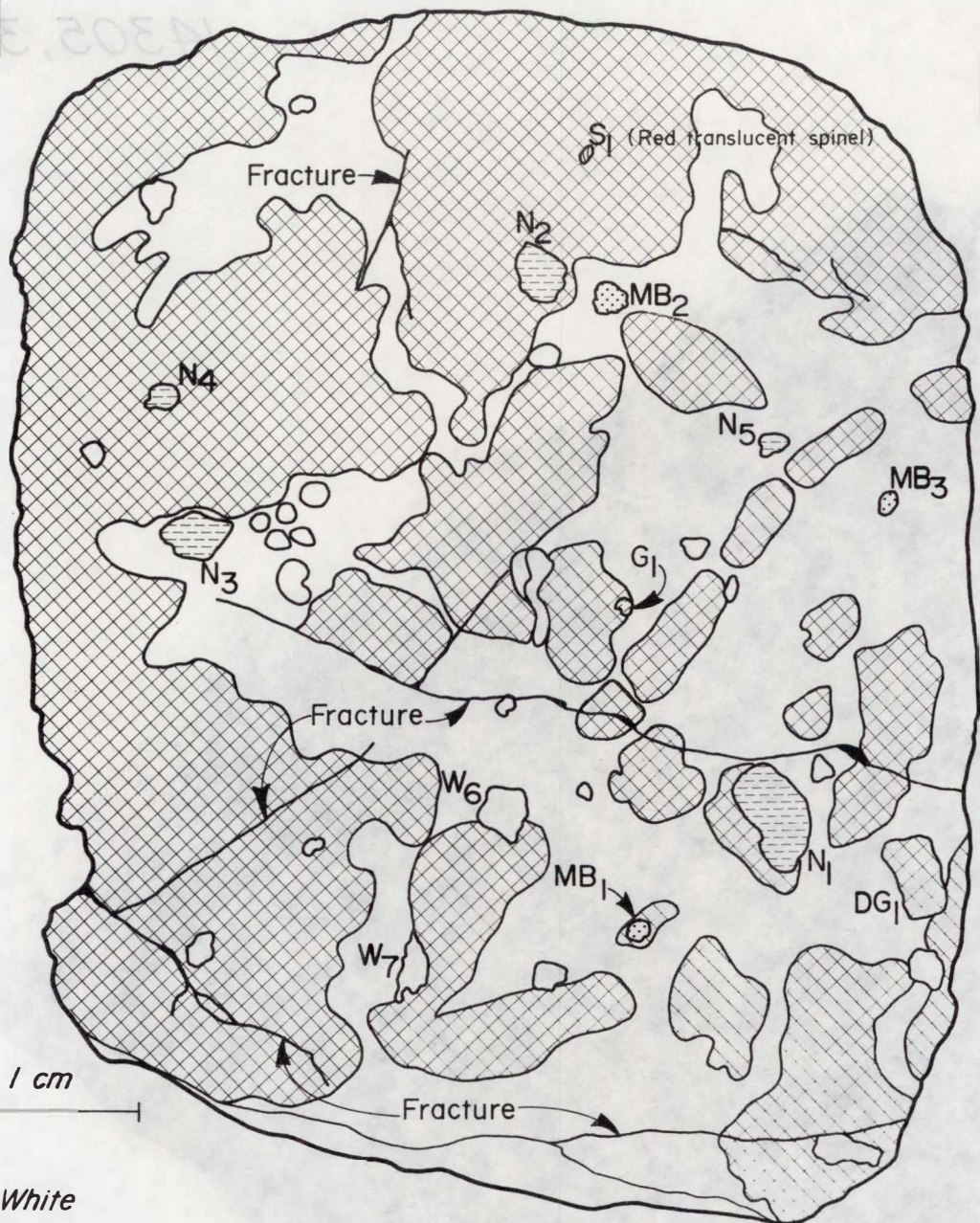
1 cm

White	<input type="checkbox"/>
Dark grey	<input checked="" type="checkbox"/>
Light basalt	<input type="checkbox"/>
Green	<input type="checkbox"/>
Yellowish green matrix	<input type="checkbox"/>
(transparent) (green)	<input type="checkbox"/>

1 cm



14306, 21



-  White
-  Dark grey
-  Mare basalt
-  Green
-  Yellowish green norite
-  Red translucent (spinel)

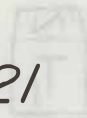
Sawn surface



14306, 21



14306, 21



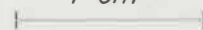
1 cm



- White
- Dark grey
- Light grey
- Green
- Yellowish

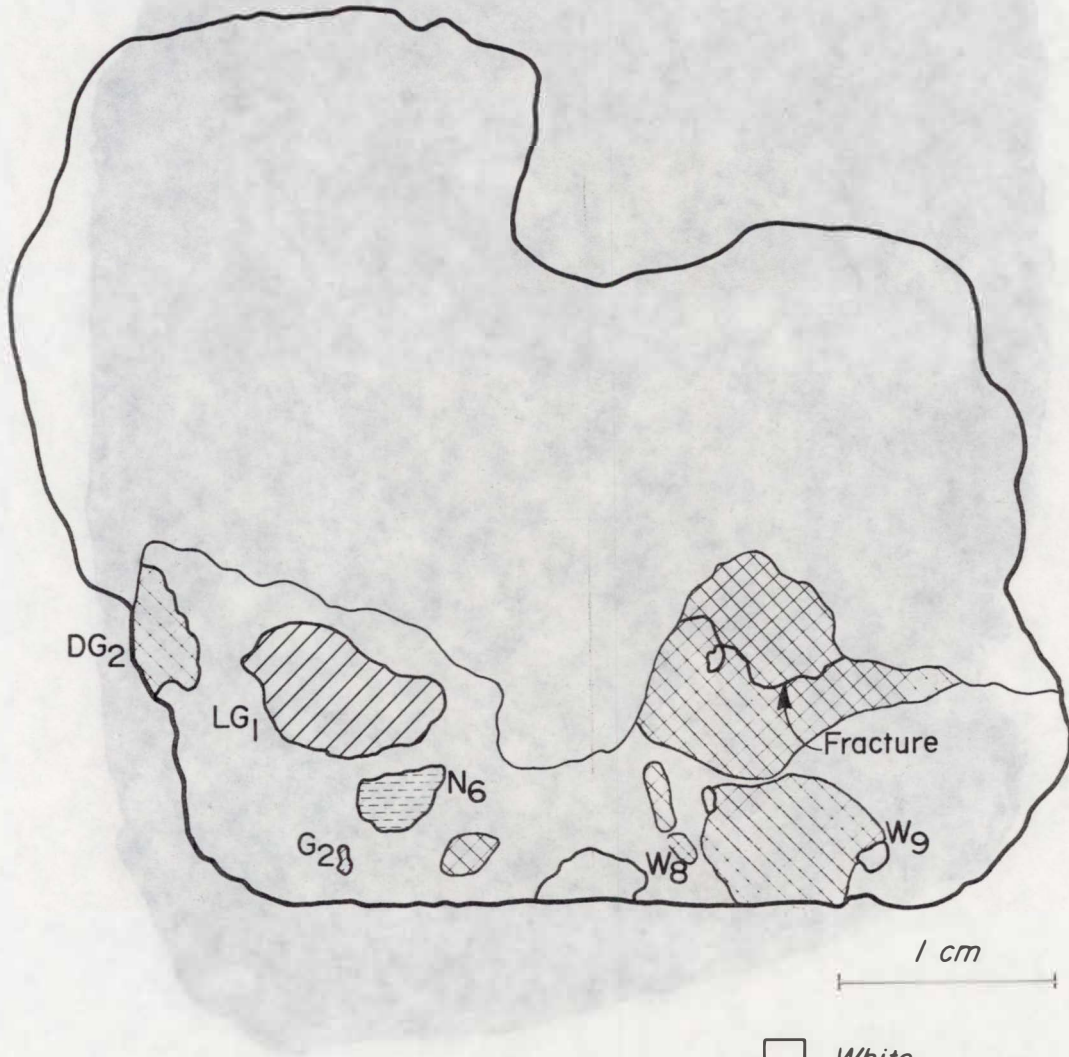
S77-22103






1 cm





14306,103



-  *White*
-  *Dark grey*
-  *Light grey*
-  *Green*
-  *Yellowish green norite*



14306,103



14306,103



Glass splint

Pitted surface

White

Dark grey

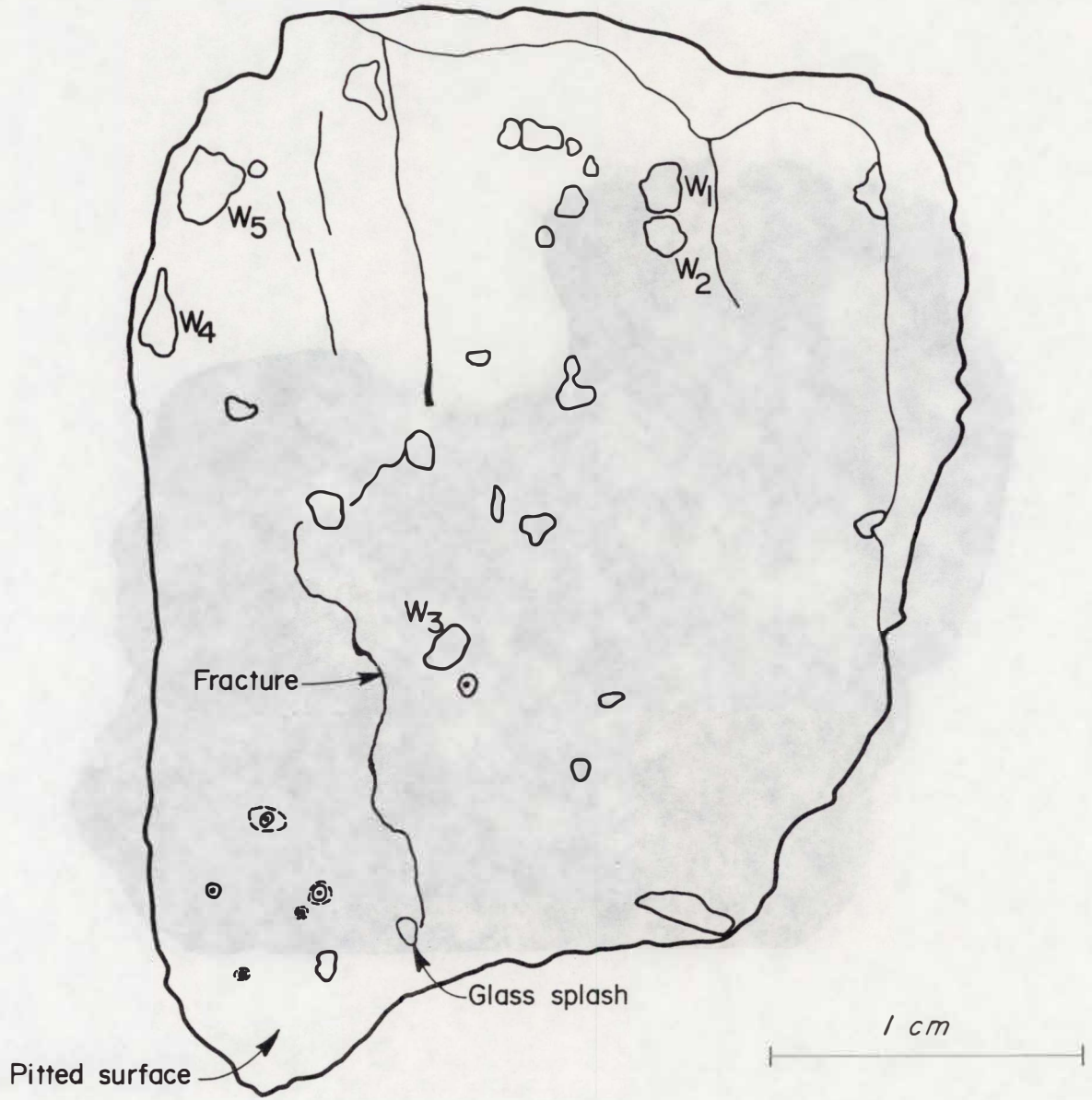
S77-22105










14306,104

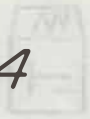


-  White
-  Zap pit
-  Spall zone

14306,104

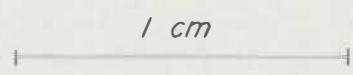


14306,104



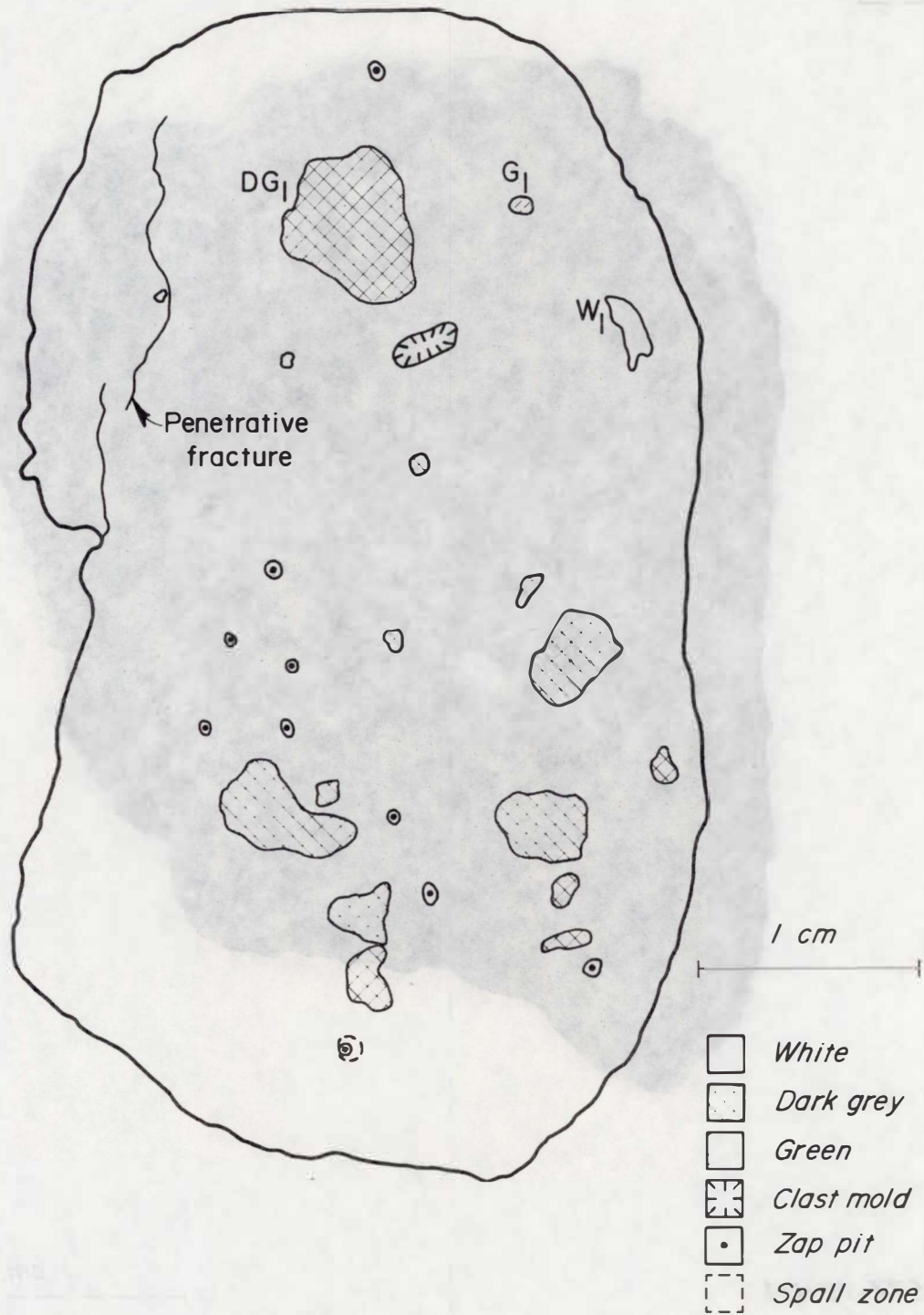
- 1 cm
- White
- Dark grey
- Green
- Light mold
- Red pit

S77-22104





14309,0

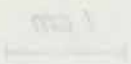




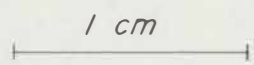
0,11541



14309,0

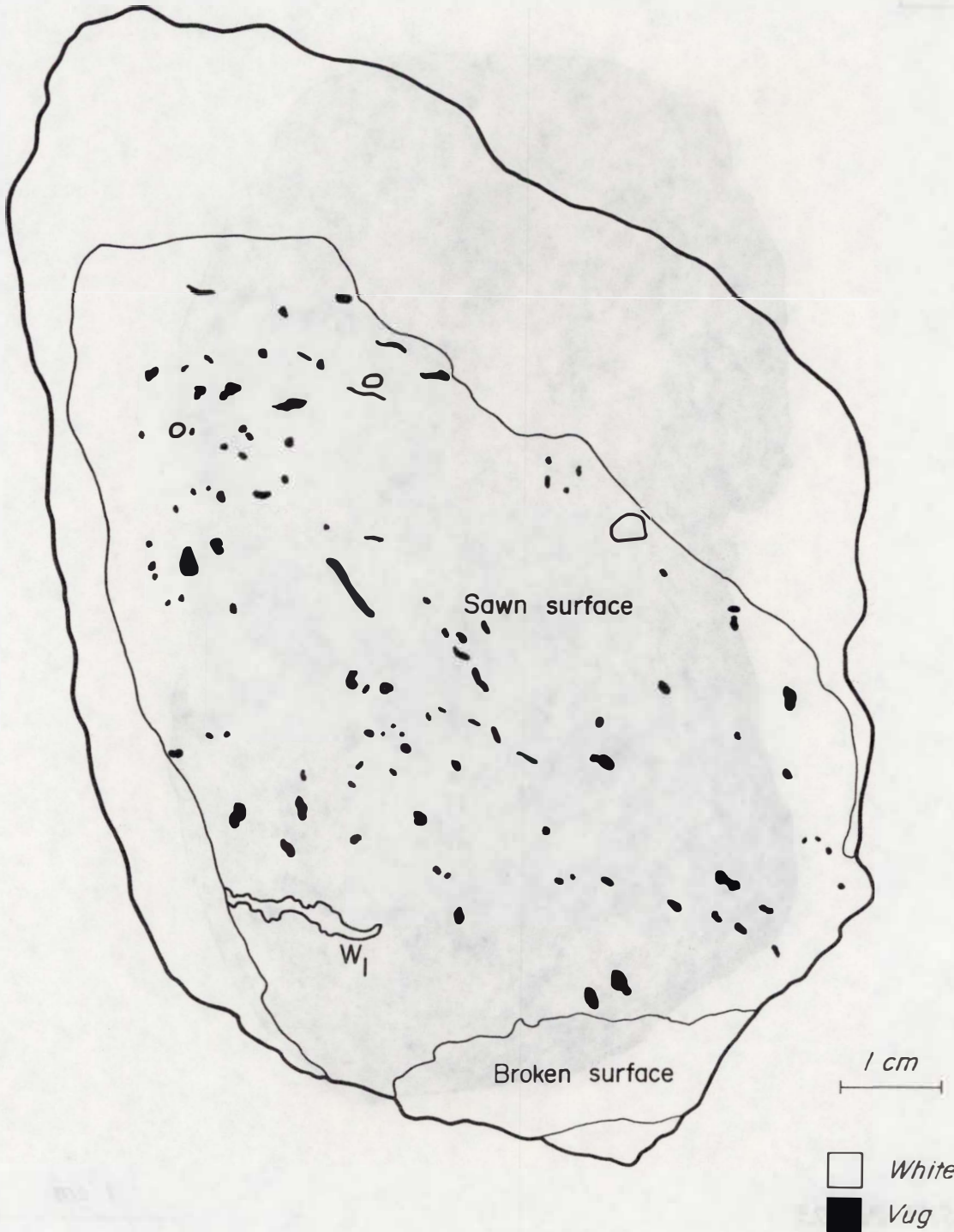


S77-23603



W<sub>1</sub>S

14311,0





W1 S

14311,0



1 cm

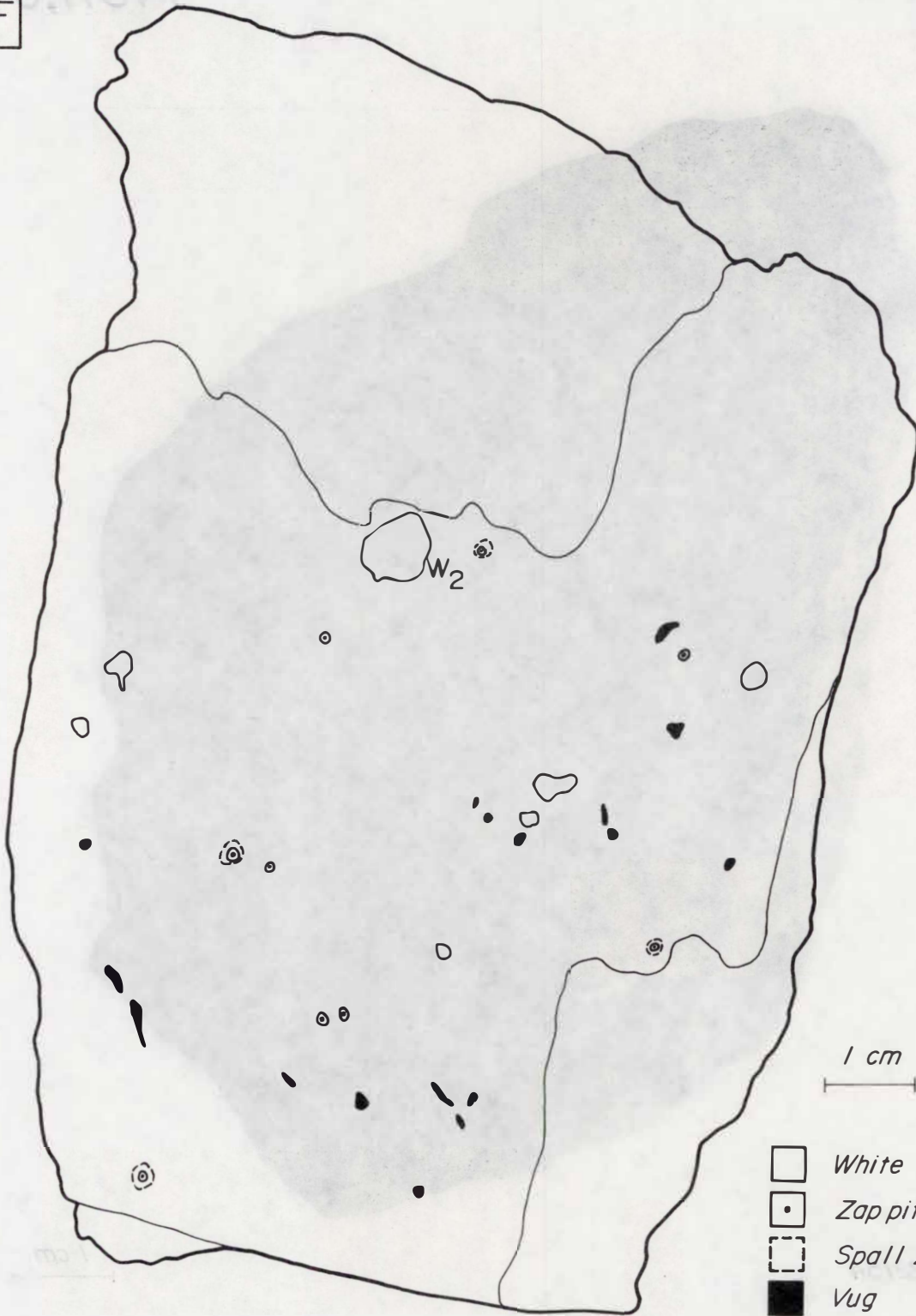
White  
Top pit  
S77-22154

1 cm









14311,0



1 cm

-  White
-  Zappit
-  Spall zone
-  Vug



14311,0

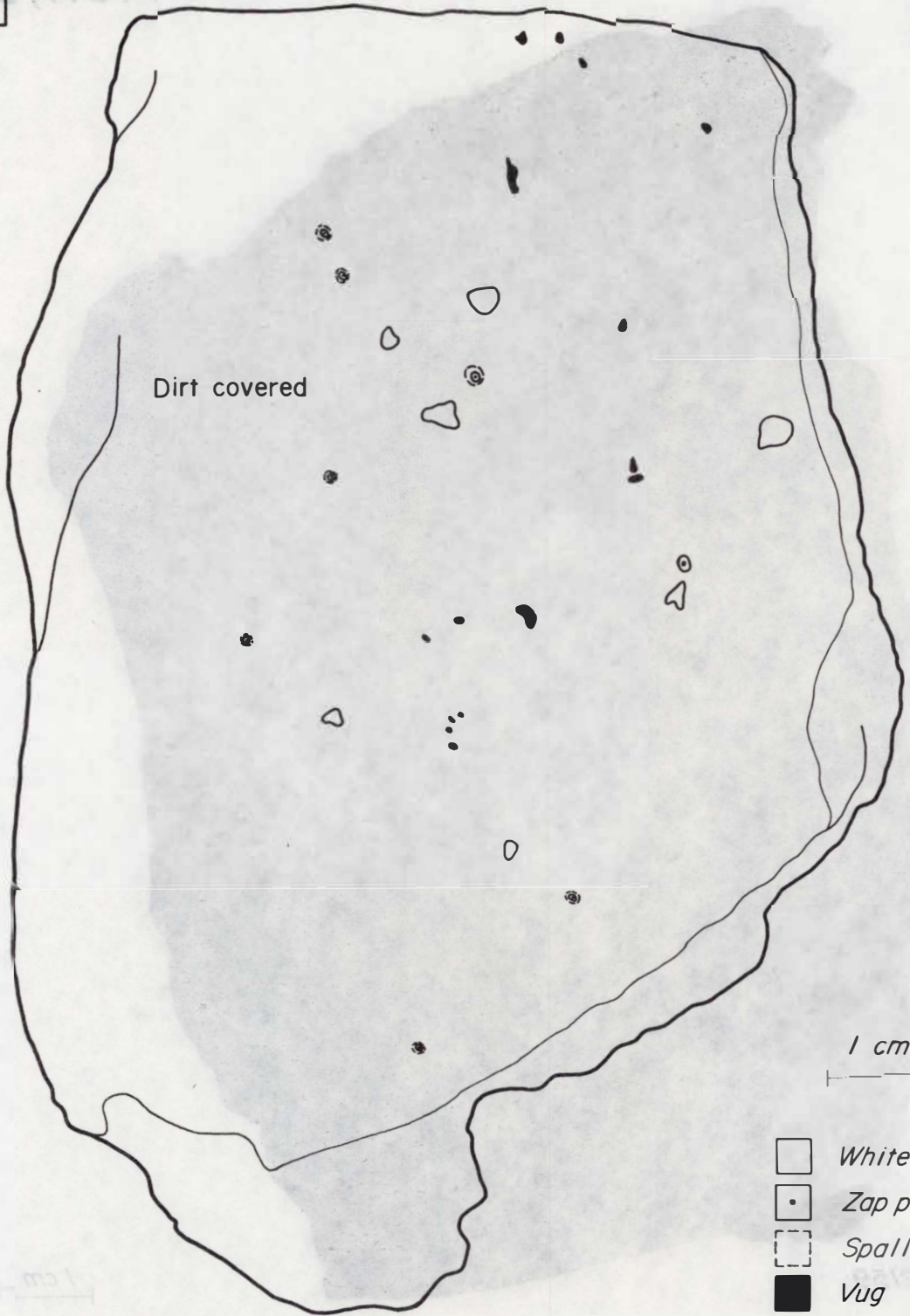


S77-22159

1 cm





MS  
14311,0

14311,0



Dirt covered

1 cm

-  White
-  Zap pit
-  Spall zone
-  Vug

1 cm



MSI

14311,0



Non-penetrative fracture

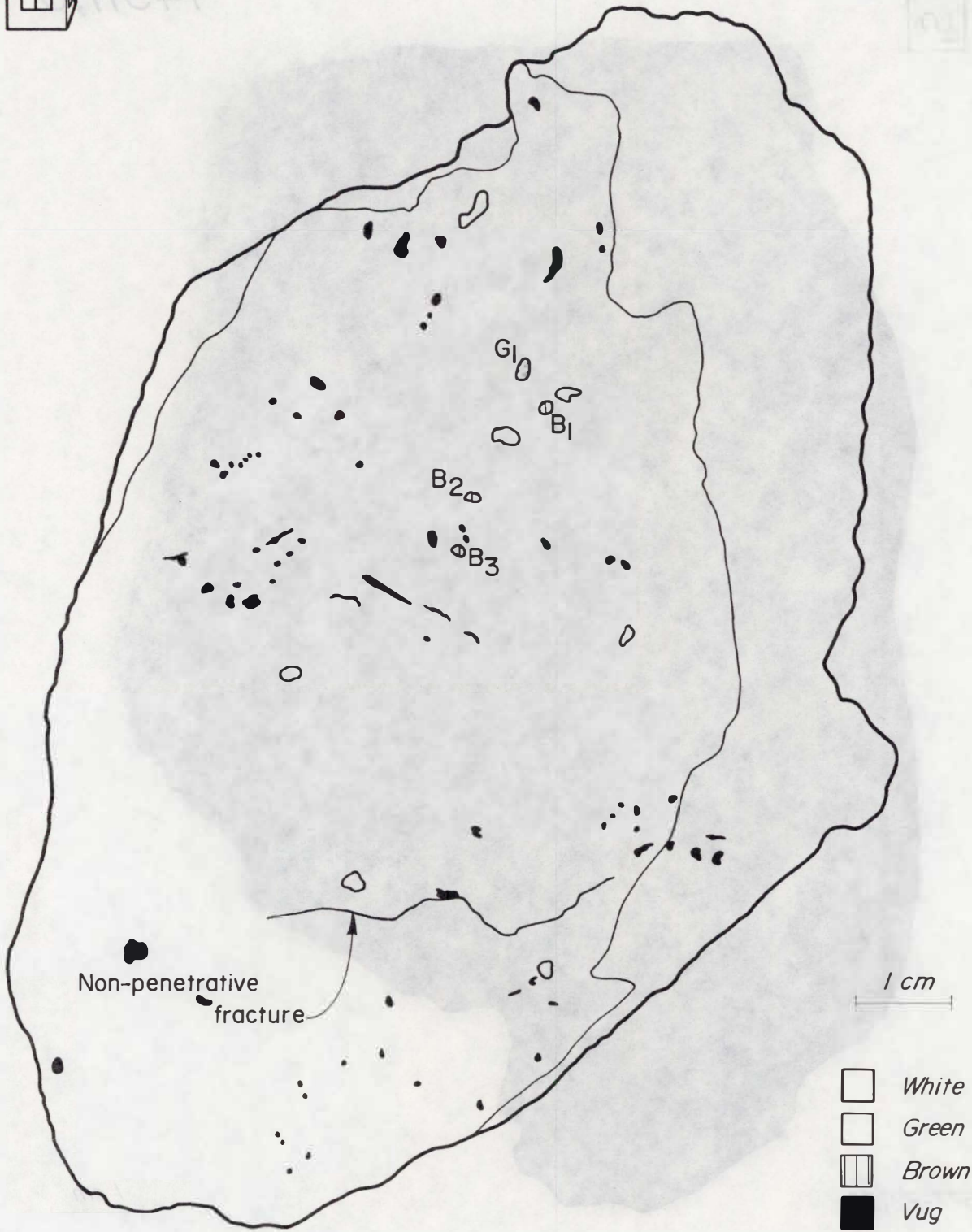
- White
- Green
- Brown

S77-22156

1 cm



14311,0







14311,0



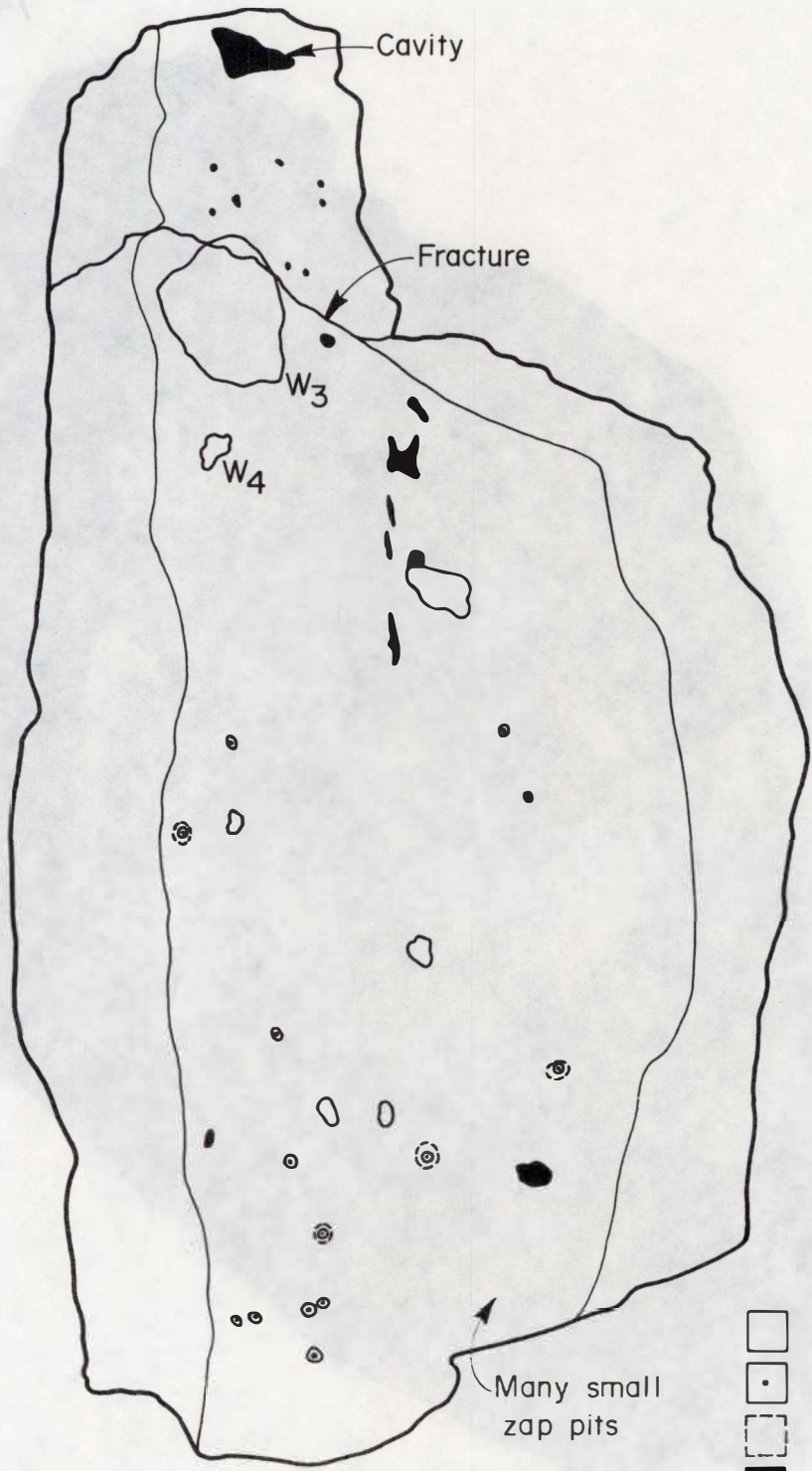
S77-22158

1 cm









14311,0



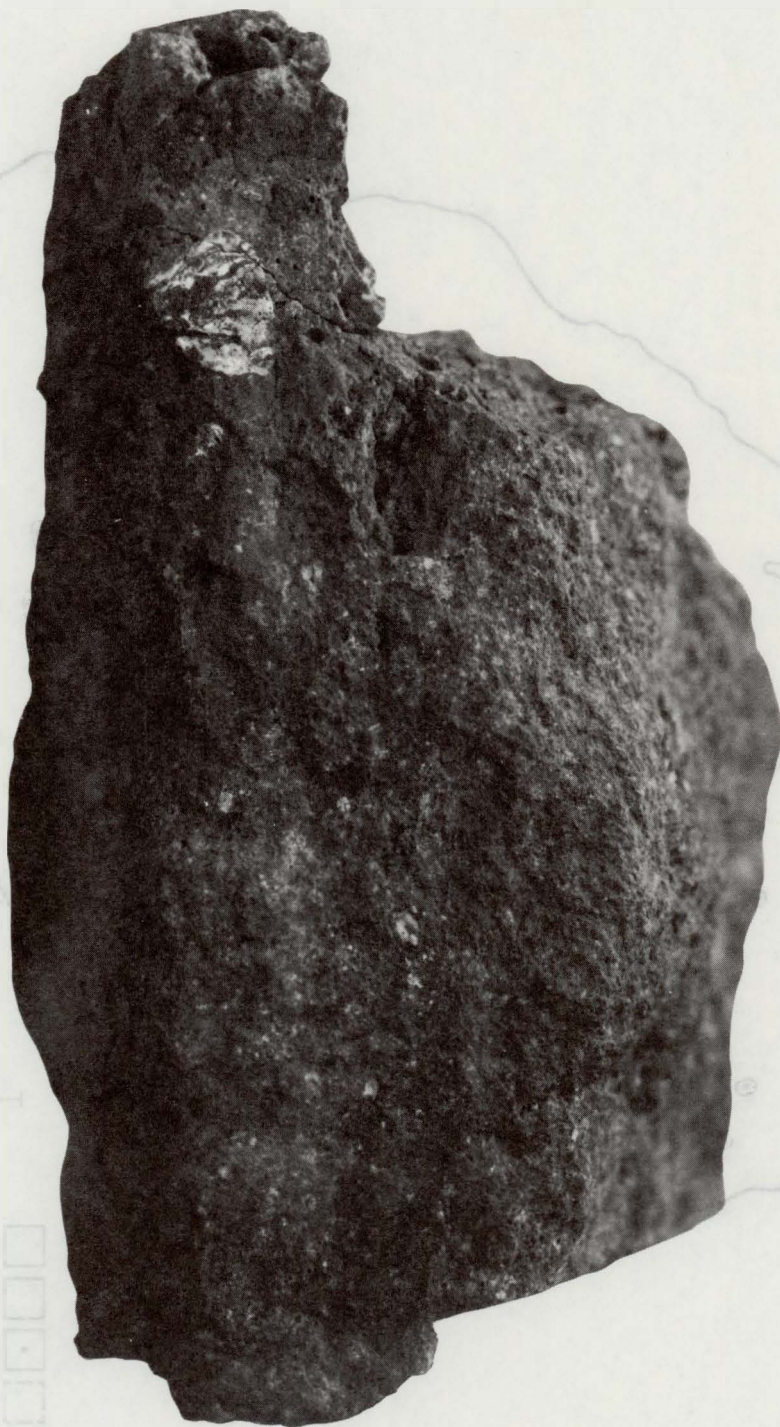
1 cm

-  White
-  Zap pit
-  Spall zone
-  Vug

0.11241

ENI

14311,0



1 cm

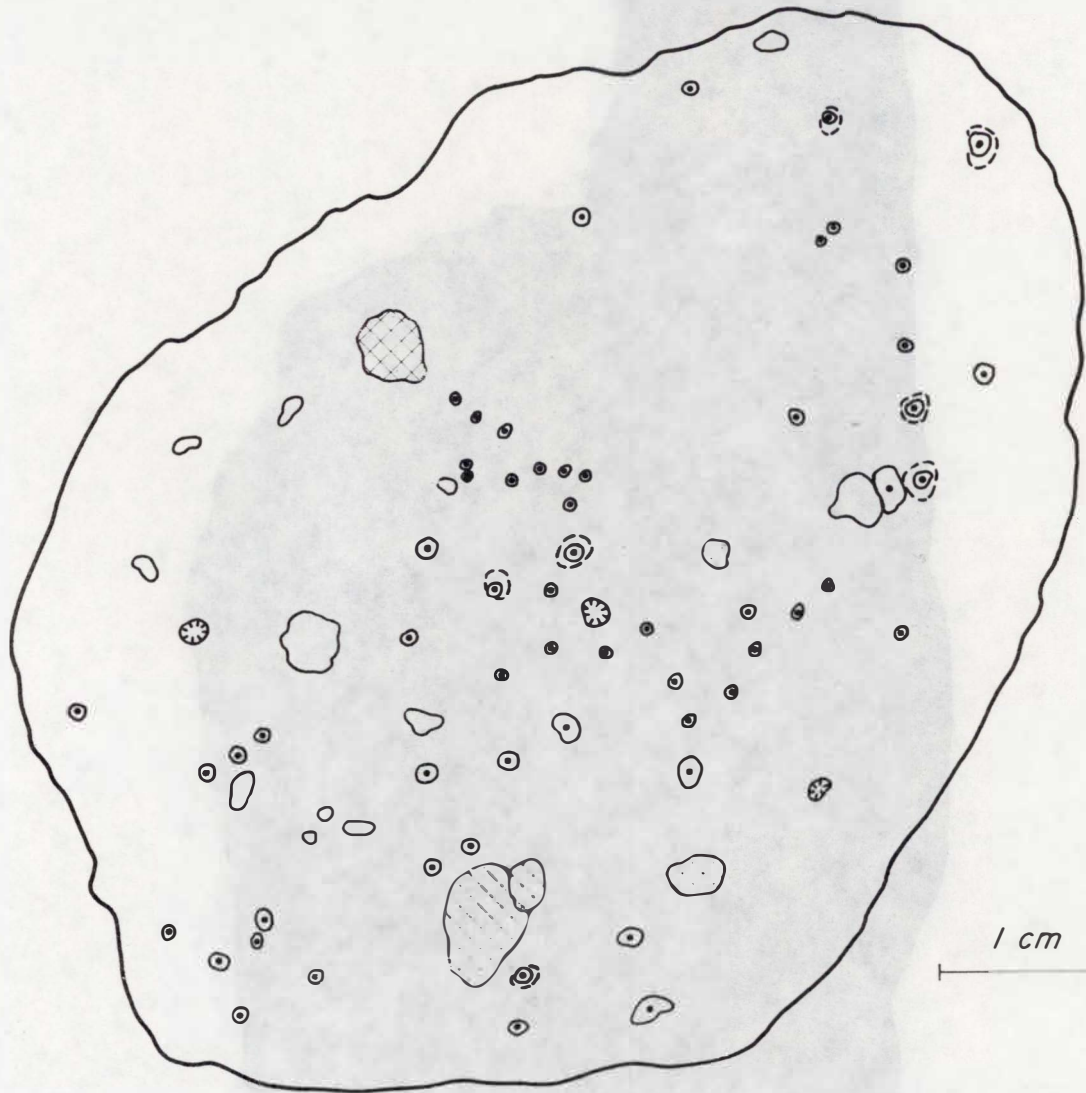
- White
- Dark grey
- Light grey
- Sooty zone

S77-22155

1 cm

N<sub>1</sub>  
B<sub>1</sub>

14314,0



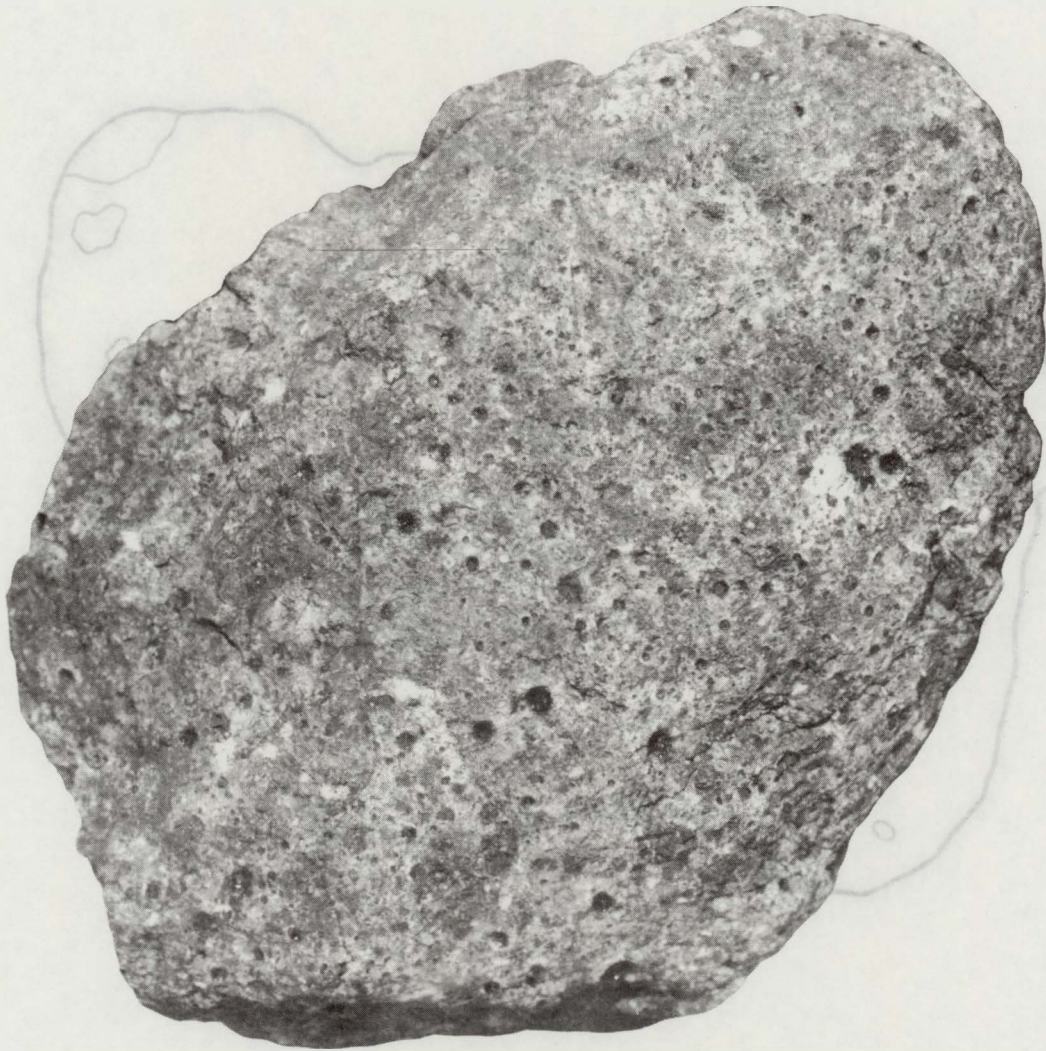
1 cm

-  White
-  Dark grey
-  Zap pit
-  Spall zone
-  Clast mold



14314,0  
B<sub>1</sub>  
Z<sub>1</sub>

14314,0



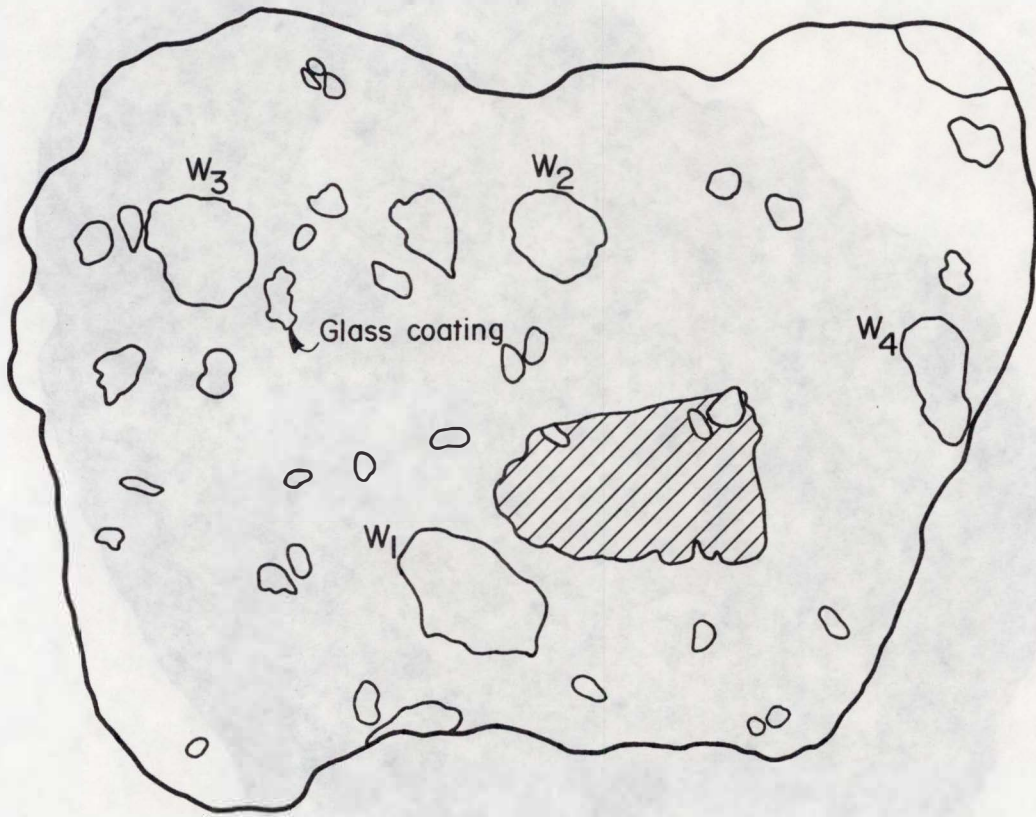
1 cm

S77-23606

1 cm

N  
B<sub>1</sub>

14316,0

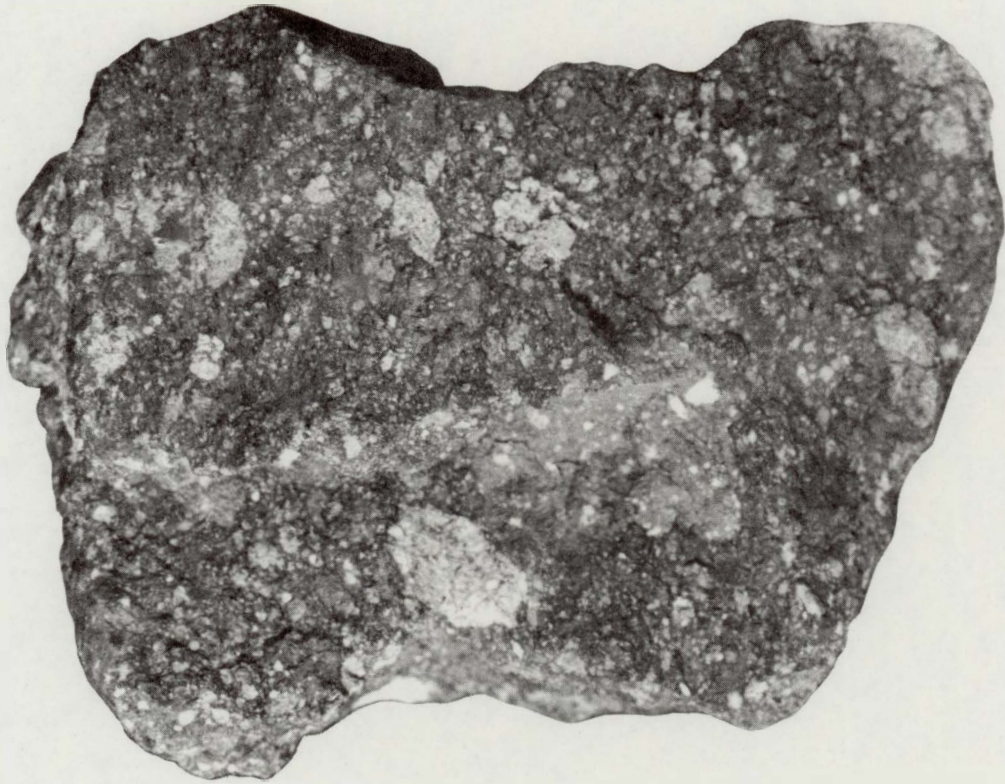


1 cm

□ White  
▨ Light grey

N  
B<sub>1</sub>

14316,0



577-23602

