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LUNAR SURFACE CLOSEUP STEREOSCOPIC PHOTOGRAPHY AT FRA MAURO (APOLLO 14 SITE)

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ABSTRACT

A total of 17-1/2 stereopairs of lunar surface rocks and soil was taken on the Apollo 14 mission. The closeup stereopair photographs are presented with a preliminary interpretation for further study by those interested in lunar soil formation, impact phenomena, and soil mechanics.

LUNAR SURFACE CLOSEUP STEREOSCOPIC PHOTOGRAPHY AT FRA MAURO (APOLLO 14 SITE)

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SUMMARY

On the Apollo 14 mission, a total of 17-1/2 stereopairs of various surfaces was returned. Two stereopairs are of the track in the lunar soil left by a wheel of the modular equipment transporter, or "rickshaw, " that Astronauts Alan B. Shepard and Edgar D. Mitchell used on their traverses to carry all of their tools and equipment. Three stereopairs are of astronaut bootprints in the lunar soil. Seven stereopairs are of samples of thermal coatings taken in support of the thermal degradation samples experiment. Two stereopairs are of undisturbed lunar soil exhibiting a "raindrop" texture, and the remaining 3-1/2 pairs are of the surfaces of rocks that are partially obscured by lunar soil.

INTRODUCTION

Closeup photographs of soil and rock in place on the lunar surface were obtained during the Apollo 14 mission by means of the Apollo lunar surface closeup camera (ALSCC). The ALSCC is a stereoscopic camera with an internal strobe light, capable of photographing an area 72 by 82.8 millimeters and of resolving objects as small as 0.085 millimeter in diameter. The ALSCC, build under contract to NASA Manned Spacecraft Center (MSC), was also used on the Apollo 11 and 12 missions.

CLOSEUP STEREOSCOPIC PHOTOGRAPHY

All of the photographs were taken by Astronaut Shepard on the second traverse. Figure 1 shows the ALSCC mounted on the modular equipment transporter (MET), and table I identifies all stereopairs. The first four pairs were taken at a location midway between the lunar module (LM) and station A on their traverse (fig. 2), while the crew paused to check their route. The next 11 pairs were taken in the vicinity of station A. An additional pair was probably taken at station A as well. The unexposed pair was probably taken at station B2, and the last 1-1/2 pairs were taken at the LM just before the film was removed from the camera. Although photographs at other locations along the traverse had been planned, no additional shots could be taken because of a shortage of time.

On the Apollo 11 and 12 missions, most of the closeup stereoscopic photographs were taken very near the LM, where the surfaces had been affected by the rocket exhaust of the LM during the landing. All of the Apollo 14 photographs, except for the last 1-1/2 pairs, were located at some distance from the LM in areas not affected by gases from the LM descent engine. Details concerning the camera as well as descriptions of the Apollo 11 mission photographs may be found in references 1 and 2. The Apollo 12 photographs are in references 3 and 4.

THERMAL DEGRADATION SAMPLES EXPERIMENT

The purpose of the thermal degradation samples (TDS) experiment was to evaluate the effect of lunar dust on the optical properties (absorptivity and emissivity) of a dozen candidate thermal coatings. These coatings may be used in subsequent lunar missions on such items as the lunar communications relay unit, the lunar roving vehicle, the television camera, and the Apollo lunar surface experiments package. Thus, it was deemed important to measure the degradation of optical properties after exposure to lunar dust. Two duplicate arrays (serial numbers 1001 and 1002), each containing samples of the 12 thermal coatings (table II(a)), were taken to the moon. Astronaut Shepard took a series of seven stereopairs (table II(b)) of the arrays for three conditions: pristine, that is, not exposed to lunar dust; soil sprinkled on the arrays; soil brushed off the arrays. The arrays were then packaged and returned to earth for extensive examination and testing.

THE STEREOPAIRS

The complete stereopairs are reproduced in black and white (figs. 3 to 21) in natural scale so that any measurements can be made directly without a scale change. There is, however, a 2:1 depth exaggeration. Investigators desiring color stereopairs may order them from: Goddard Space Flight Center, Greenbelt, Maryland 20721.

A sundial located on the ALSCC permitted Astronaut Shepard to report the orientation of most of the photographs; lunar north is indicated for these stereopairs.

Where appropriate, comments made by the crewmembers while the photographs were being taken have been included with each stereopair. Ground elapsed time (g.e.t.) for the Apollo 14 mission is shown in days:hours:minutes:seconds.

CONCLUDING REMARKS

This photography is the first close look at undisturbed lunar regolith surfaces. Closeup photography from the Apollo 11 and 12 lunar landing sites was taken in areas disturbed by LM descent engine exhaust.

The astronauts described the surface at the Apollo 14 lunar landing site as powdery (also visible in 70-millimeter photography). The surface is covered with loose and partly buried, equant aggregates of soil and fragments of fragmental rocks, of less than 0.1 to several millimeters in diameter. The equant aggregates give the powdery appearance to the surface. Within the resolution of the photography, no individual grains were visible. The coherence of these aggregates is easily destroyed, as can be seen in the photographs of modular equipment transporter and boot tracks.

Although the behavior of the lunar soil at the Apollo 14 landing site is qualitatively similar to that of the soil at the Apollo 11 and 12 lunar landing sites, the cohesion appears to be slightly less. Yet, this cohesion is still relatively stronger than the adhesion and produces clean, distinct impressions of any object placed against it.

The "raindrop" patterns noticed by the astronaut are pits formed by the impact of micrometeorites into the lunar soil. This photography is excellent documentation of the "raindrop" effect and should be studied further by investigators interested in crater morphology.

Photographs of the contact between the soil surface and rocks buried in the soil demonstrated that many of the rocks are partly covered with soil ejected from nearby impacts of all magnitudes and that a pileup or "fillet" can form when a debris cloud sweeps by a rock projecting from the surface.

This paper is just a preliminary look. Hopefully, some of the investigators interested in the morphology of the regolith surface will use these photographs to aid their studies of lunar soil formation and impact phenomena.

Manned Spacecraft Center
National Aeronautics and Space Administration
Houston, Texas, January 6, 1972
640-03-01-DJ-72

REFERENCES

1. Anon.: Lunar Surface Closeup Stereoscopic Photography. Apollo 11 Preliminary Science Report. NASA SP-214, 1969, pp. 187-193.

2. Greenwood, W. R.; Jones, R. L.; Heiken, G. H.; Bender, M. J.; and Hill, R. O.: Lunar-Surface Closeup Stereoscopic Photography on the Sea of Tranquility (Apollo 11 Landing Site). NASA TM X-58077, 1971.

3. Gold, T.; Pearce, F.; and Jones, R.: Lunar Surface Closeup Stereoscopic Photography. In Apollo 12 Preliminary Science Report. NASA SP-235, 1970, pp. 183-188.

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5. Swann, G. A.; Bailey, N. G.; Batson, R. M.; Eggleton, R. E.; et al.: Preliminary Geologic Investigations of the Apollo 14 Landing Site. Apollo 14 Preliminary Science Report. NASA SP-272, 1971, pp. 39-86.

6. Lunar Sample Preliminary Examination Team: Preliminary Examination of Lunar Samples from Apollo 14. Science, vol. 173, no. 3998, Aug. 20, 1971, pp. 681-693.

7. Gault, Donald E.; Quaide, William L.; and Oberbeck, Verne R.: Impact Cratering Mechanics and Structures. In Shock Metamorphism of Natural Materials, edited by Bevan M. French and Nicholas M. Short, Mono Book Corp., Baltimore, 1968, pp. 87-100.

TABLE I. - LUNAR SURFACE CLOSEUP CAMERA STEREOSCOPIC PHOTOGRAPHS

Description	NASA photograph no.	Frame no.	Figure no.
MET track	AS14-77-10357	301	3
MET track	AS14-77-10358	302	4
Astronaut bootprint	AS14-77-10359	303	5
Astronaut bootprint	AS14-77-10360	304	6
TDS experiment	AS14-77-10361	305	7
TDS experiment	AS14-77-10362	306	8
TDS experiment	AS14-77-10363	307	9
TDS experiment	AS14-77-10364	308	10
TDS experiment	AS14-77-10365	309	11
TDS experiment	AS14-77-10366	310	12
TDS experiment	AS14-77-10367	311	13
Undisturbed soil	AS14-77-10368	312	14
Bootprint	AS14-77-10369	313	15
Undisturbed soil	AS14-77-10370	314	16
Soil-covered rock surface	AS14-77-10371	315	17(a)
Soil-covered rock surface	AS14-77-10372	316	18
Unexposed		317	
Soil-covered rock surface	AS14-77-10373	318	20
Soil-covered rock surface	AS14-77-10374 (half)	319	21

TABLE II. - THERMAL DEGRADATION SAMPLES EXPERIMENT

(a) Coating materials tested

Block no.	Thermal coating sample
1	White paint, S-13G
2	White paint, Z-93, zinc oxide and potassium silicate
3	White paint, Goddard MS-74
4	Vacuum-deposited silver and Inconel on Teflon with Teflon side exposed
5	Vacuum-deposited silver on quartz with quartz side exposed
6	White paint, Dow-Corning 92-007, titanium dioxide and silicone
7	White paint, Cat-a-lac White, titanium dioxide and epoxy
8	White paint, 3M White Velvet (400 series), titanium dioxide and epoxy polyester
9	White fabric, Dacron on aluminized Mylar laminate
10	Oxidized silicon monoxide over vacuum-deposited aluminum on Kapton with oxidized silicon monoxide side exposed
11	Vacuum-deposited aluminum on Kapton with Kapton side exposed
12	Anodized 6061 aluminum MIL-A-8625, type II, class I

TABLE II. - THERMAL DEGRADATION SAMPLES EXPERIMENT - Concluded

(b) Photograph summary

Figure no.	Thermal degradation samples array serial no.	Description
7	1002	Pristine blocks, 9 to 12
8	1002	Soil sprinkled on blocks 1 to 6
9	1002	Soil sprinkled on blocks 7 to 12
10	1002	Soil brushed off blocks 1 to 6
11	1002	Soil brushed off blocks 7 to 12
12	1001	Soil sprinkled on blocks 1 to 6
13	1001	Soil sprinkled on blocks 9 to 12

DESCRIPTION OF FIGURE 1

Astronaut Shepard has just taken a double core tube sample at point A on the traverse (fig. 2); a few minutes before, he took 12 of the closeup stereoscopic photographs reproduced in this report. The MET is in the foreground, packed with various pieces of equipment. The ALSCC was used to take the photographs.

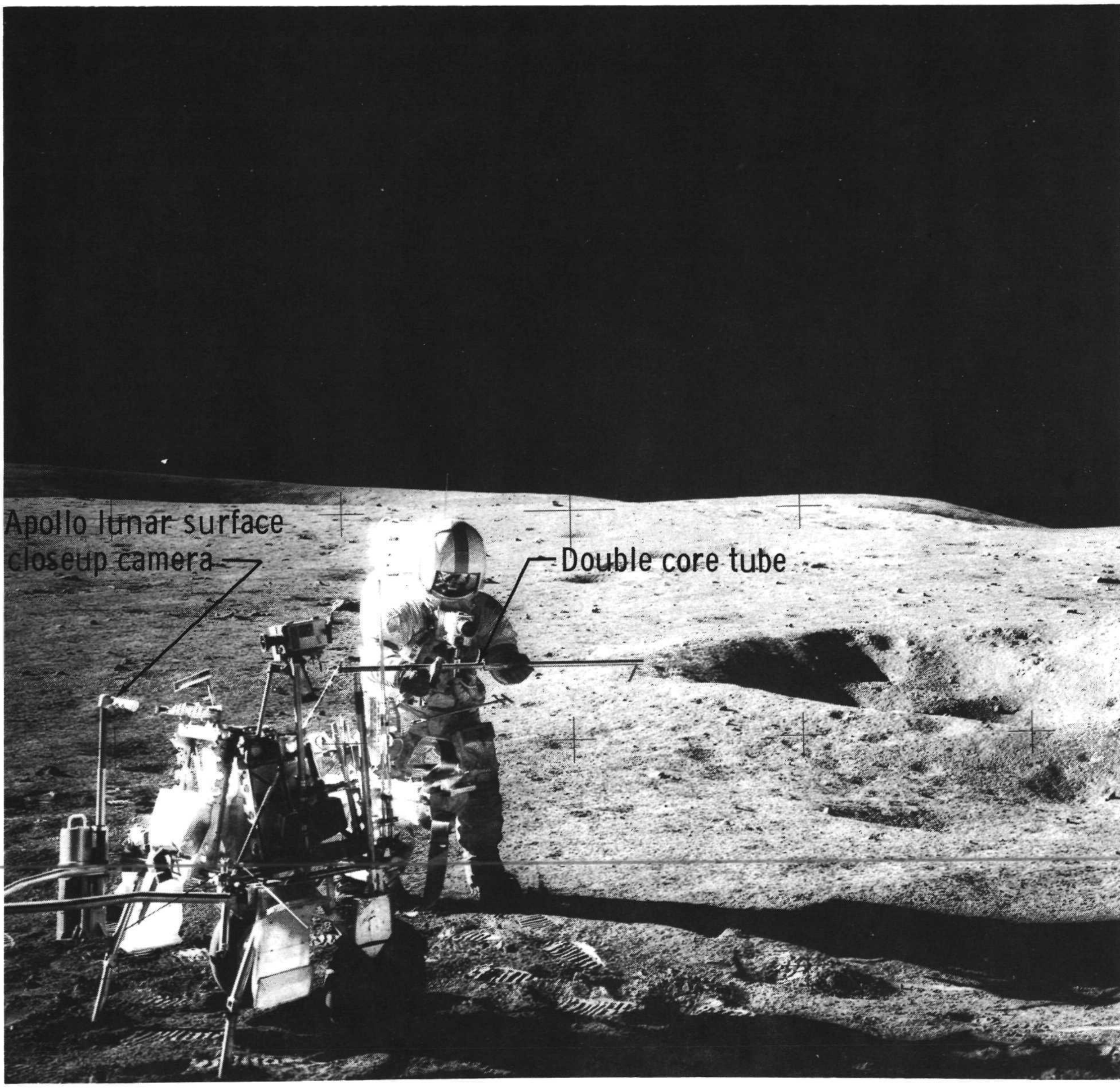


Figure 1. - Astronaut Shepard at point A (NASA no. AS14-68-9405).

DESCRIPTION OF FIGURE 2

Apollo 14 traverses. The map, prepared by members of the Lunar Geology Experiment Team, is reproduced from figure 3-1 of their report (ref. 5).

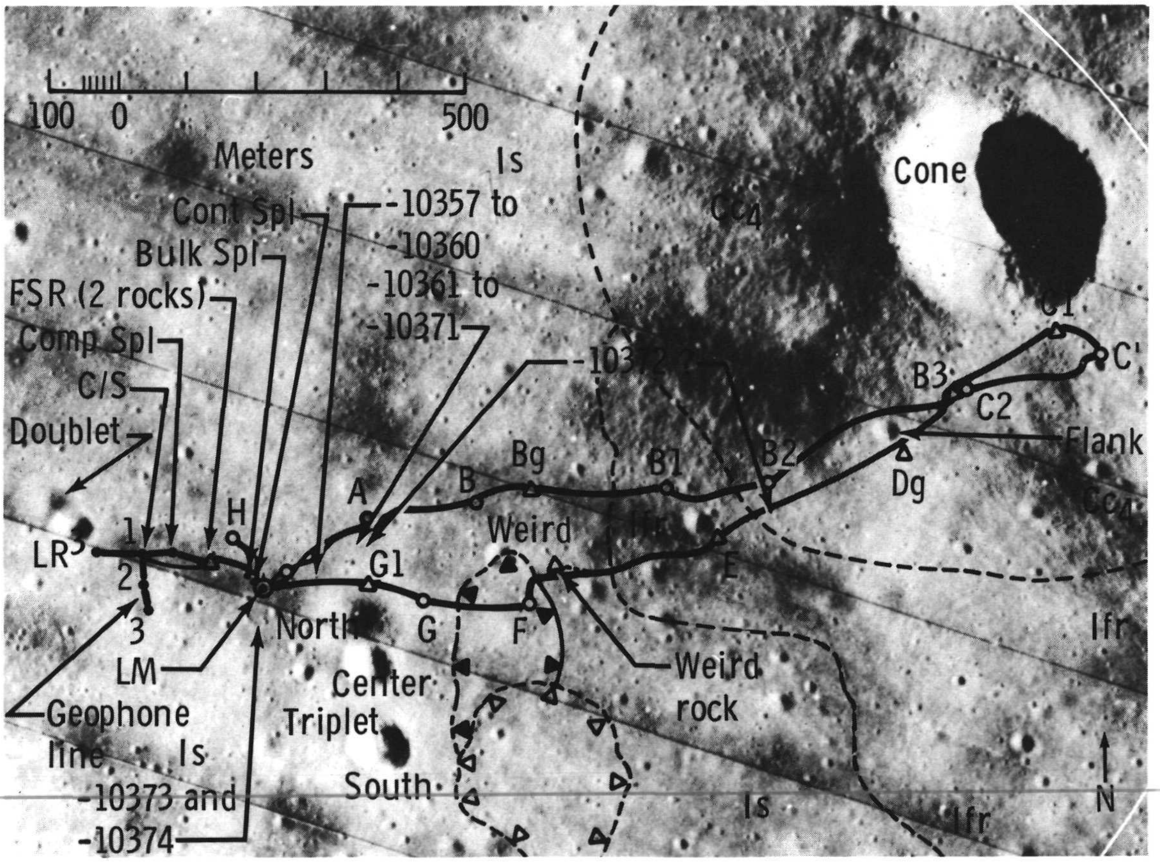


Figure 2. - Lunar traverse map, Apollo 14 mission.

DESCRIPTION OF FIGURE 3

The MET has two smooth, nitrogen-filled rubber tires. Each tire applies a pressure of 0.3 to 0.5 N/cm^2 to the lunar surface when the MET is loaded. The fine line along the middle of the track was formed by the tire mold mark. The crew reported that the depth of the tracks varied from 1 to 2 centimeters, which is consistent with the applied loads. The cracked and uplifted blocks in the photograph indicate that the adhesion between the tire and the soil was sufficient to cause some disturbance, but was not enough to overcome completely the weight and the cohesion of the soil. The crew reported that the MET did not produce a significant "rooster tail" as it was rolling along.

05:11:47:02 CDR "While you're checking our position, I'll be using the closeup. Okay. Taking the picture of the MET track, Houston. With the closeup and the sunrise at - at 11 o'clock."

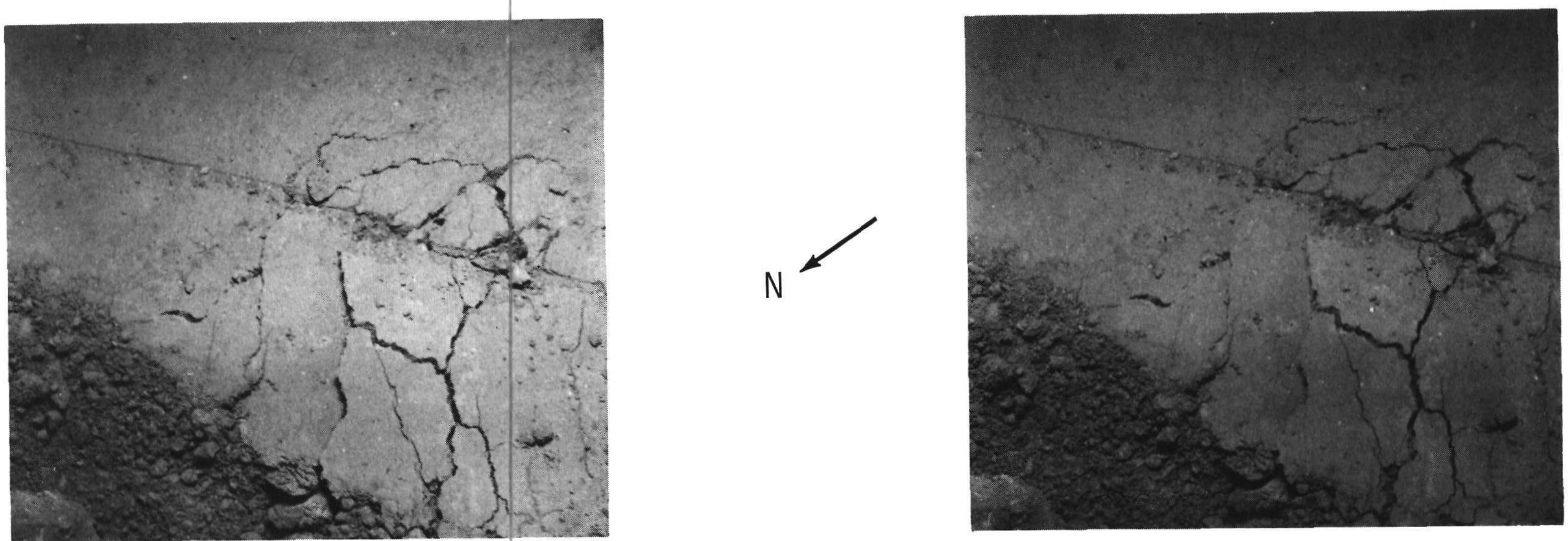


Figure 3. - A track of the **MET** (ALSCC frame 301, NASA no. AS14-77-10357).

DESCRIPTION OF FIGURE 4

The MET track is narrower in this photograph than in the previous one. The narrower track indicates less sinkage. The MET has evidently rolled across slightly firmer soil. In addition, there has been considerably less tendency for the soil to adhere to the wheel, although fine cracks cross the track traverse to the direction of motion.

A small white rock has been pushed into the soil by the MET wheel as shown in the upper left-hand corner of the photograph. The indentation shown at the upper right-hand corner of the photograph was probably produced by the edge of the camera while Astronaut Shepard was positioning it.

05: 11: 48: 11 CDR "Okay, 301 and 302. MET tracks at 11..."

And later, at station A,

05: 12: 07: 46 CDR "Okay. And since I've already taken a couple of pictures of the MET tracks, I won't do it - anymore of that here, and probably won't again unless we see some difference in these tracks. They're fairly what you might expect because they're smooth; and they're well packed and vary in depth only as a function of the - of the surface tension."

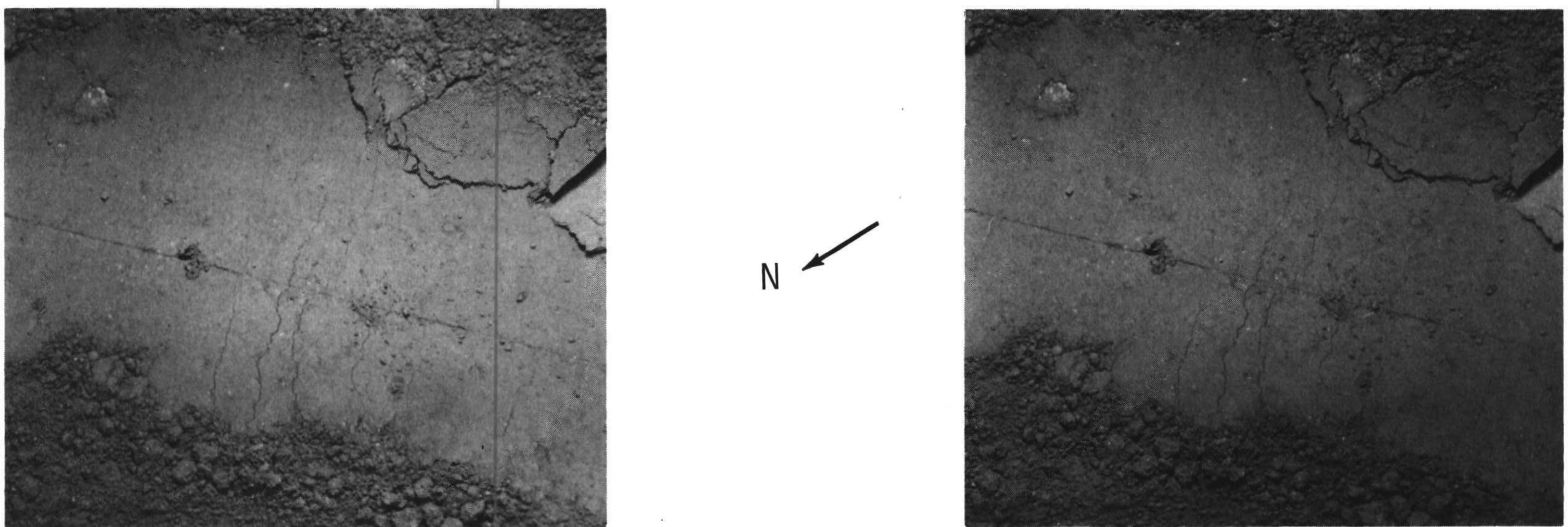


Figure 4. - A track of the MET (ALSCC frame 302, NASA no. AS14-77-10358).

DESCRIPTION OF FIGURE 5

One of three stereoscopic pairs showing astronaut bootprints in the lunar soil. Other views are presented as figures 6 and 15.

The boot treads are slightly trapezoidal in cross section. The depth of the tread is 4.6 millimeters.

Standing on one foot, the astronaut applies a pressure of approximately $0.7\ N/cm^2$ on the lunar surface. This pressure generally results in a sinkage of about 2 centimeters, except on the rims of small, fresh craters, where bootprints up to 10 centimeters deep have been observed.

The lunar soil is able to retain the shape of the bootprint, including the nearly vertical sides of the treads, because it is slightly cohesive; that is, the soil particles tend to stick to each other. The relatively smooth surface over most of the imprint indicates that this cohesion is relatively stronger than the adhesion between the soil and the sole of the boot. Although similar behavior has been observed on Apollo 11 and 12 missions, the cohesion of the lunar soil shown in these photographs appears to be less than at the other sites because these imprints are not nearly so clean and crisp as previously described bootprints (ref. 4). The lunar soil cohesion is due to many factors; one of these is the grain size distribution. There appear to be more resolvable particles (>0.085 millimeter) in the Apollo 14 bootprint photographs than in the Apollo 12 photographs. This coarser grain size distribution may help explain the lesser cohesion. Only a few preliminary sieve analyses have been performed on the Apollo 14 returned lunar soil (ref. 6), and a definitive answer must await more detailed analyses.

05:11:48:11 CDR "...303 and 304: *footprints, sun at 10 o'clock.*"

05:11:48:22 CC "Roger, Al. I copied the frame numbers. And we still have you in the picture."

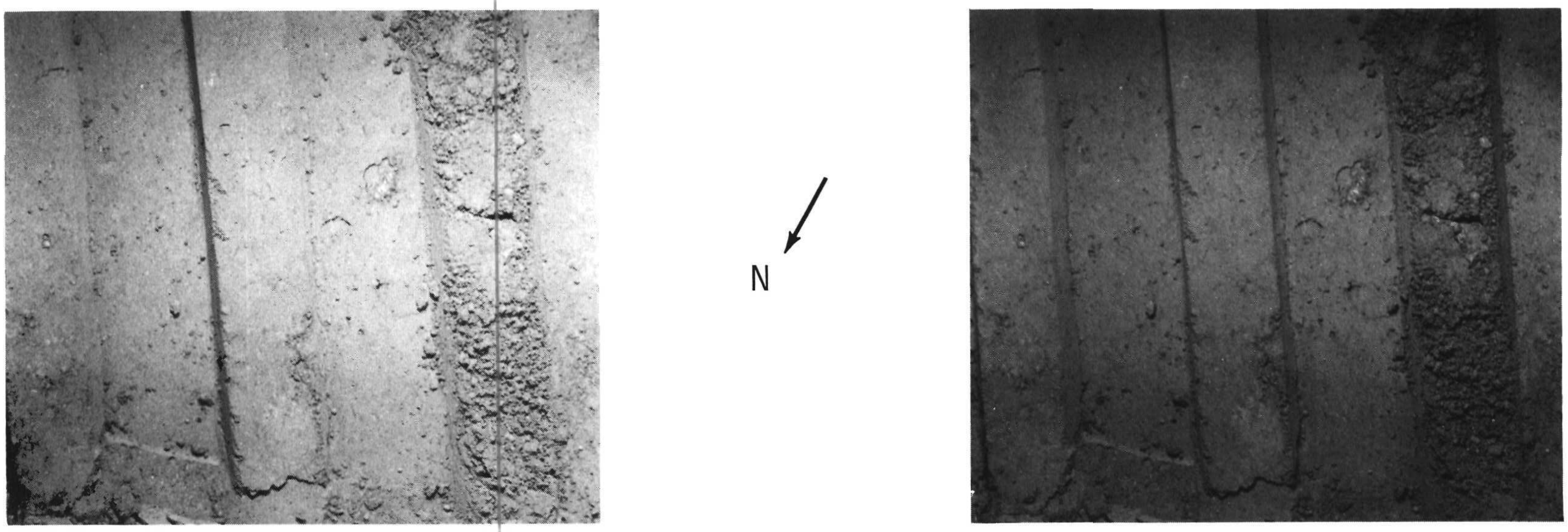


Figure 5. - Astronaut bootprint (ALSCC frame 303, NASA no. AS14-77-10359).

DESCRIPTION OF FIGURE 6

This photograph was taken very near the site of the photograph in figure 5 and shows similar features. Again, although the cohesive nature of the lunar soil is clearly evidenced by the clumps of soil particles and the sides of the boot treads, the imprints are not as sharp as those from Apollo 12. The treads are broken through in many places, which indicates the fragility of the bonds holding the soil particles together.

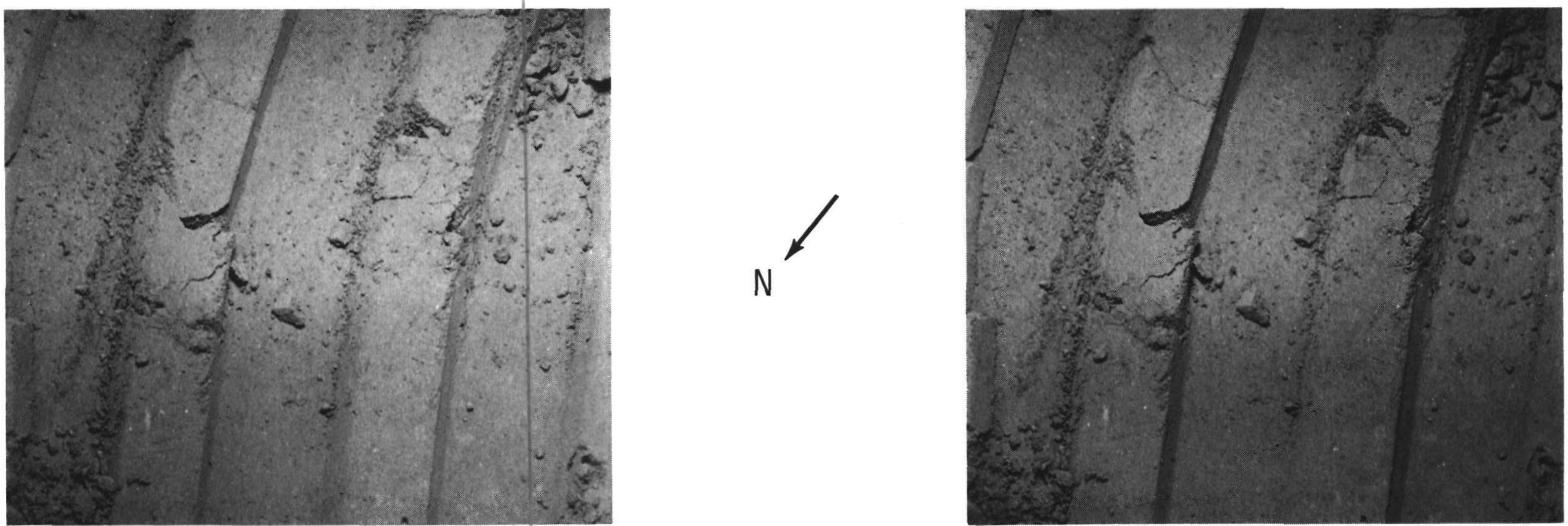


Figure 6. - Astronaut bootprint (ALSCC frame 304, NASA no. AS14-77-10360).

DESCRIPTION OF FIGURE 7

Thermal degradation samples array, serial number 1002, before Astronaut Shepard sprinkled lunar soil on it. Blocks 9 to 12 are visible. (See table II(a) for material identification.)

The array is lying on a fiberglass table on the MET. Some lunar soil has fallen on the table. Note the white particles in the soil.

05: 11: 55: 13 CDR "Okay, I'll start with the TDS."

05: 11: 56: 39 CDR "Okay. In the TDS, Houston: serial number 1002. And the frame counter on the closeup is now 305."

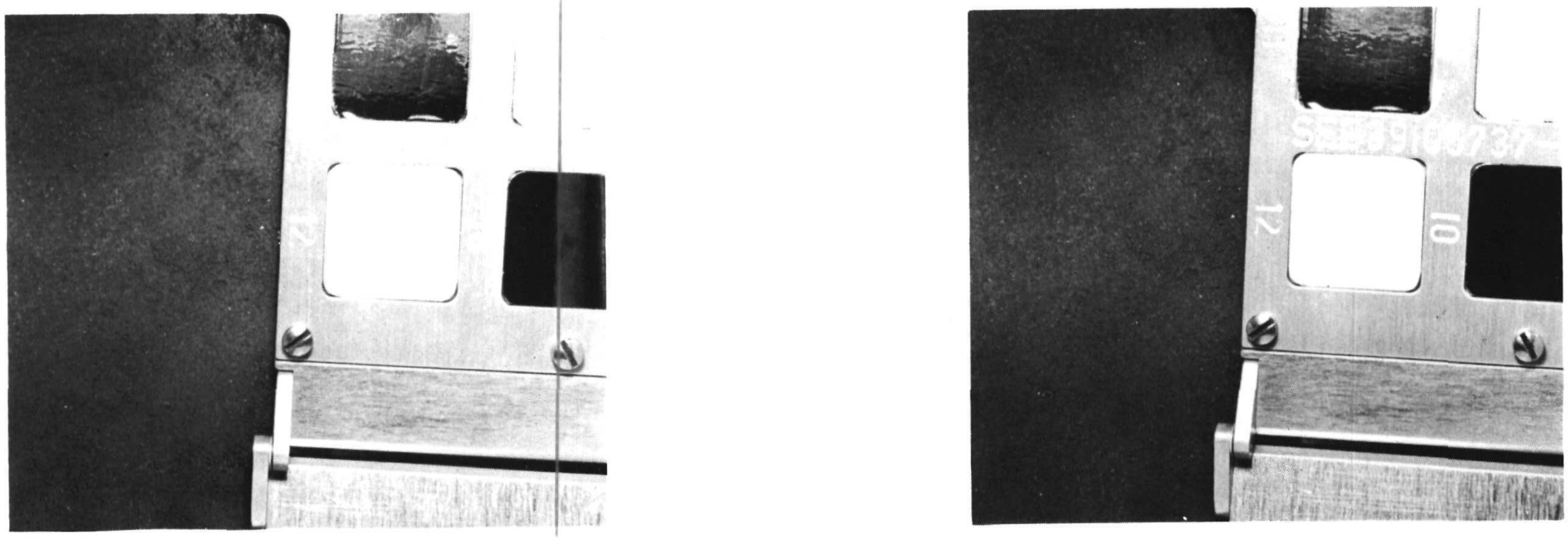


Figure 7. - The TDS experiment (ALSCC frame 305, NASA no. AS14-77-10361).

DESCRIPTION OF FIGURE 8

Thermal degradation samples array, serial number 1002, after Astronaut Shepard sprinkled lunar soil on it. Blocks 1 to 6 are visible.

05:11:57:28 CDR "Roger. And I'm now dusting that sample. Remark before he starts, that number 3 block on this sample appears to have a smudge on it, before I start - a very light black smudge."

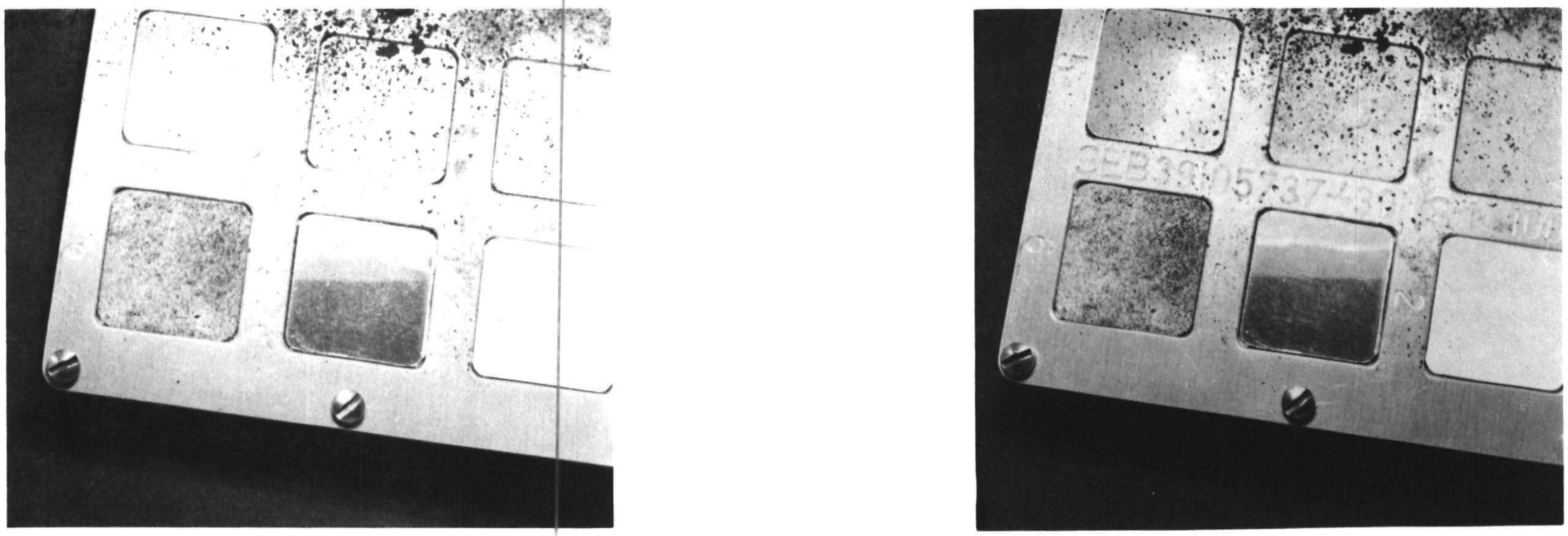


Figure 8. - The TDS experiment (ALSCC frame 306, NASA no. AS14-77-10362).

DESCRIPTION OF FIGURE 9

Thermal degradation samples array, serial number 1002, after Astronaut Shepard sprinkled lunar soil on it. Blocks 7 to 12 are visible. Much of the soil sticks together in clumps and appears similar to damp beach sand, even though it is known that there is no moisture in lunar soil.

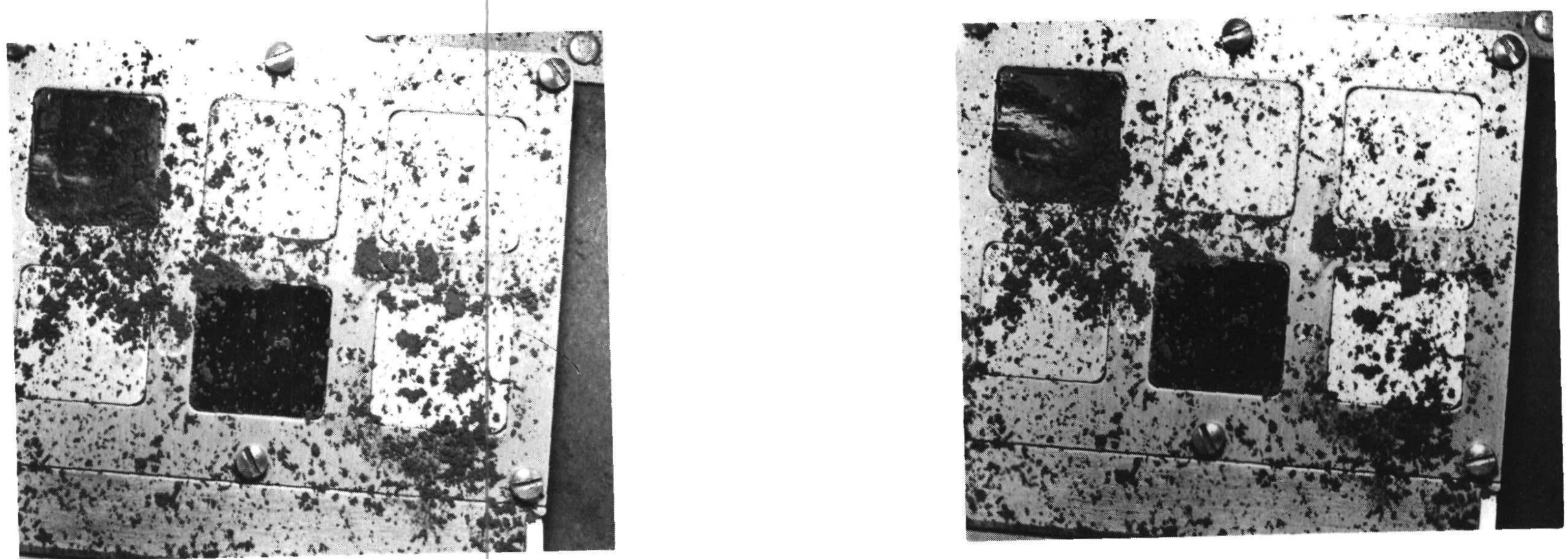


Figure 9. - The TDS experiment (ALSCC frame 307, NASA no. AS14-77-10363).

DESCRIPTION OF FIGURE 10

Thermal degradation samples array, serial number 1002, after Astronaut Shepard brushed off the lunar soil with a nylon-bristle brush (also used for cleaning their suits after each extravehicular activity (EVA)). Blocks 1 to 6 are visible.

Most of the soil has been removed by the brushing action, which indicates the low value of the adhesion between lunar soil and the various thermal surfaces. However, the brush has scratched some of the surfaces slightly. The overall impact on the thermal behavior of the samples is being studied.

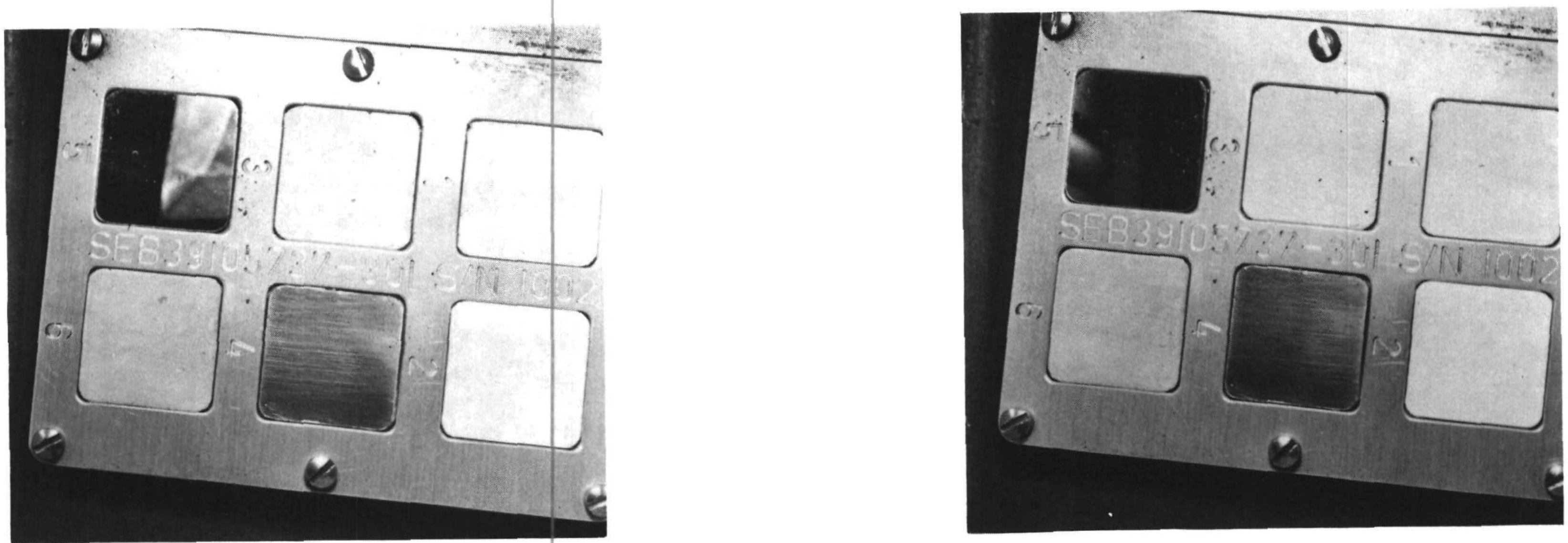


Figure 10. - The TDS experiment (ALSCC frame 308, NASA no. AS14-77-10364).

DESCRIPTION OF FIGURE 11

Thermal degradation samples array, serial number 1002, after Astronaut Shepard brushed off the lunar soil. Blocks 7 to 12 are visible. When the photography was completed, the array was packaged for return to earth.

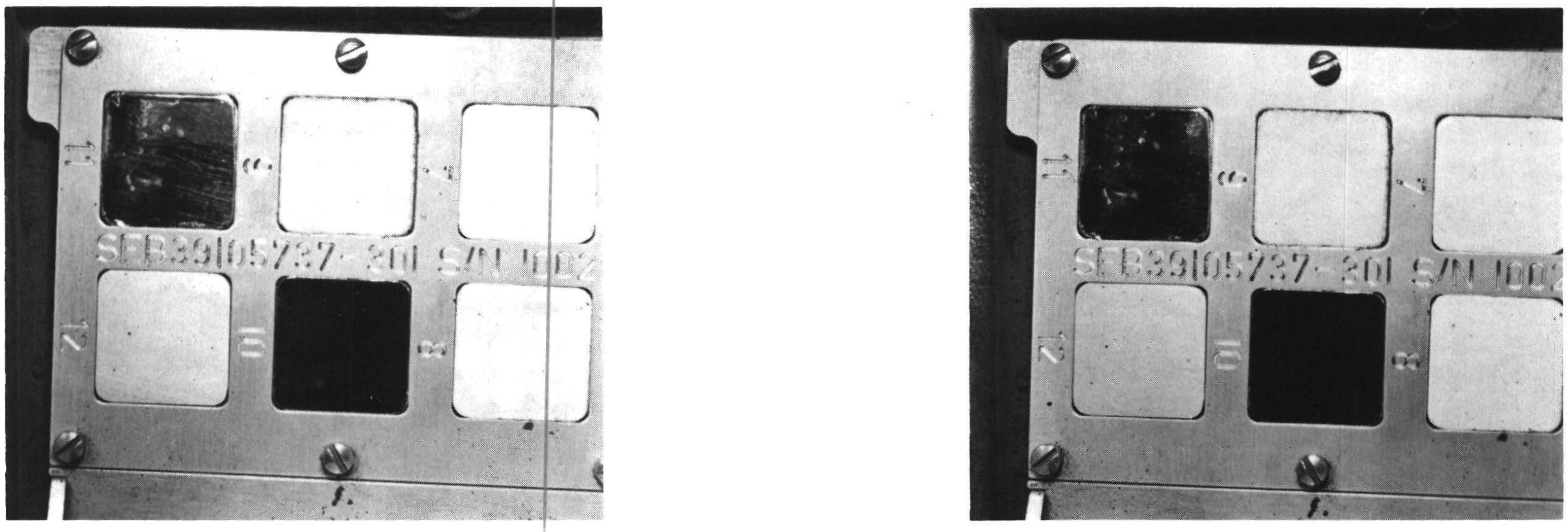


Figure 11. - The TDS experiment (ALSCC frame 309, NASA no. AS14-77-10365).

DESCRIPTION OF FIGURE 12

Thermal degradation samples array, serial number 1001, after Astronaut Shepard sprinkled lunar soil on it. Blocks 1 to 6 are visible. The soil behavior is similar to that shown in figure 9.

05: 12: 01: 25 CDR "And, Al, now verifying the second TDS, serial number 1001."

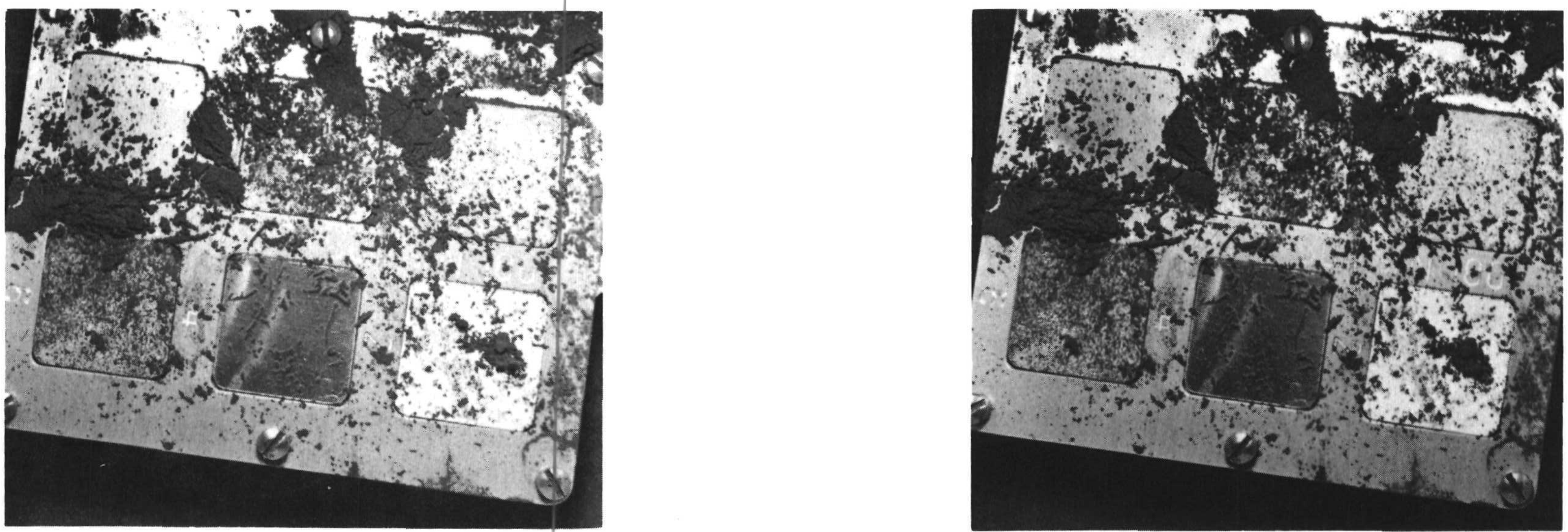


Figure 12. - The TDS experiment (ALSCC frame 310, NASA no. AS14-77-10366).

DESCRIPTION OF FIGURE 13

Thermal degradation samples array, serial number 1001, after Astronaut Shepard sprinkled lunar soil on it. Blocks 9 to 12 are visible. When the photography was completed, the array was packaged without brushing for return to earth.

The array was evidently moved slightly just before this photograph was taken, and the soil that was filling some of the inset numbers had jiggled out, still retaining the shape of the numbers.

05: 12: 03: 54 CDR "Okay, Houston, the TDS sampling is complete, and the final counter closeup is reading 311."

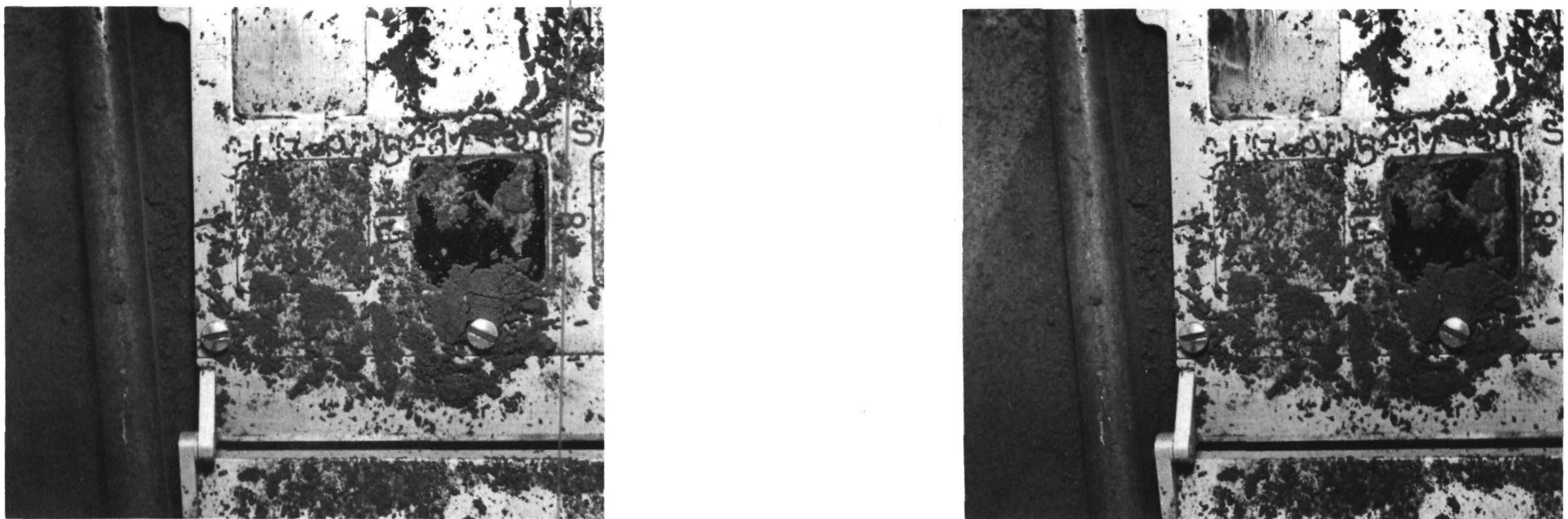


Figure 13. - The TDS experiment (ALSCC frame 311, NASA no. AS14-77-10367).

DESCRIPTION OF FIGURE 14

The soil surface has a fluffy, powdery appearance in surface (70 millimeter) photography because of the abundant 0.5- to 10-millimeter clumps of soil protruding from the surface. The "raindrop" pattern is due to small craters formed by the impact of meteoritic particles into the soil surface (or possibly secondary impacts of fragments from larger events).

Particle sizes (mostly cohesive clumps) range from less than 0.1 to 7 millimeters. Most of the clumps are equant and angular to subrounded. The only individual fragments visible are elongate white minerals or white finely crystalline or glassy rocks, 0.5 millimeter long. Generally, the soil making up the clumps is fine grained (less than 0.1 millimeter). Most of the soil particles are included in cohesive clumps and rarely occur as individual particles.

One of the best defined craters (F8 to 1.5) is steep walled, rather than bowl shaped. (Experimentally formed bowl-shaped craters were formed in loose sand by Gault, Quaide, and Oberbeck, ref. 7.) This crater shape implies that there may be a resistant layer in the uppermost few millimeters of soil.

05:12:05:50 CDR "Okay, we got closeup shots: 12, 13 and 14; and 12 - all at 9 o'clock shadow - 12 and 14 are two typical examples of the raindrop picture pattern which Ed - of which he spoke. Now, 13 is a picture of a foot track in the same area."

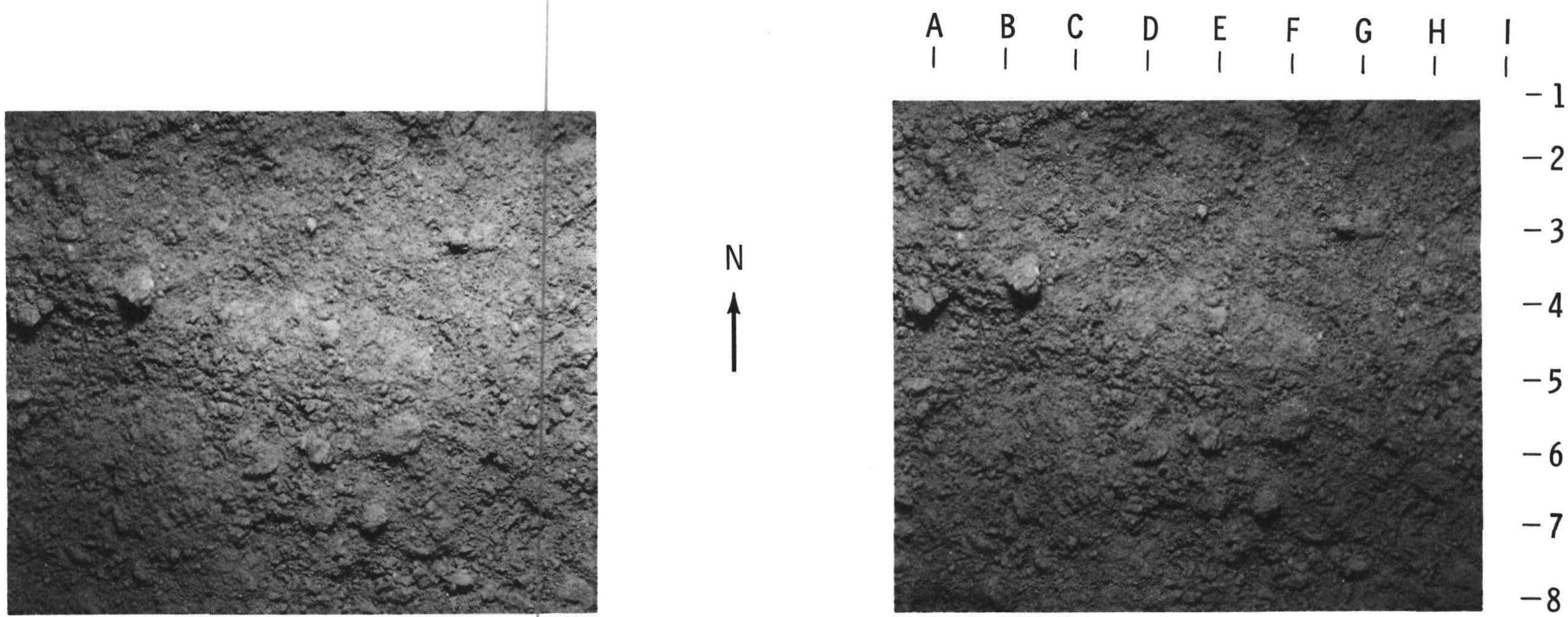


Figure 14. - A "raindrop" pattern in undisturbed lunar soil (ALSCC frame 312, NASA no. AS14-77-10368).

DESCRIPTION OF FIGURE 15

This photograph is similar to the two bootprint photographs (figs. 5 and 6). It was taken at station A on the traverse (fig. 2). The other two photographs of bootprints were taken at a point midway between the LM and station A.

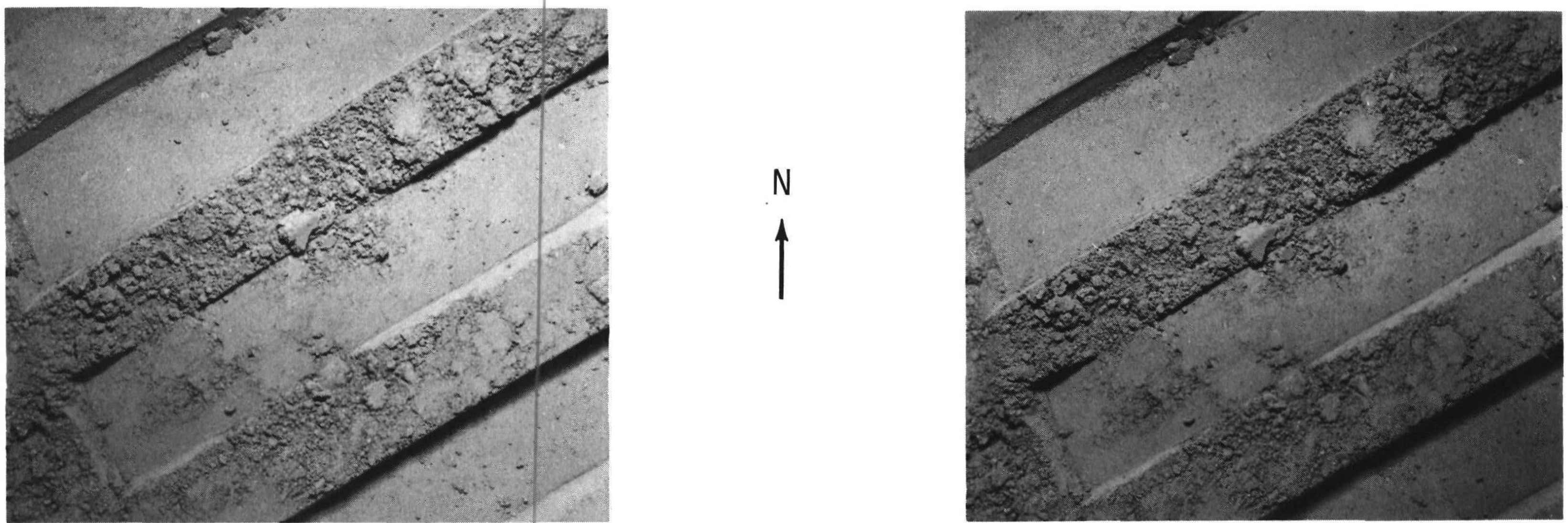


Figure 15. - Astronaut bootprint (ALSCC frame 313, NASA no. AS14-77-10369).

DESCRIPTION OF FIGURE 16

Examples of micrometeorite (or secondary) impacts into the soil surface are visible in this photograph. The only individual fragments resolvable on the photograph are white, equant to elongate, angular fragments, which may be white crystalline or fragmental rocks or feldspar crystals. All of the particles visible are in clumps of fragmental material.

The soil surface appears to be coherent. A 3- by 1. 5-centimeter "ridge" of coherent soil, relatively free of loose particles, is visible at D-4. The soil surface has been sculptured by impacts, but not broken into clods. Most of the clods protrude from the general soil surface and are bound into the finer matrix (example at G. 2 to 4. 7). Only a few aggregates or clods appear to be loose on the surface (example at E. 2 to 5. 1).

Clod sizes range from 0. 1 to 0. 6 millimeter. As in figure 14, most clods are equant.

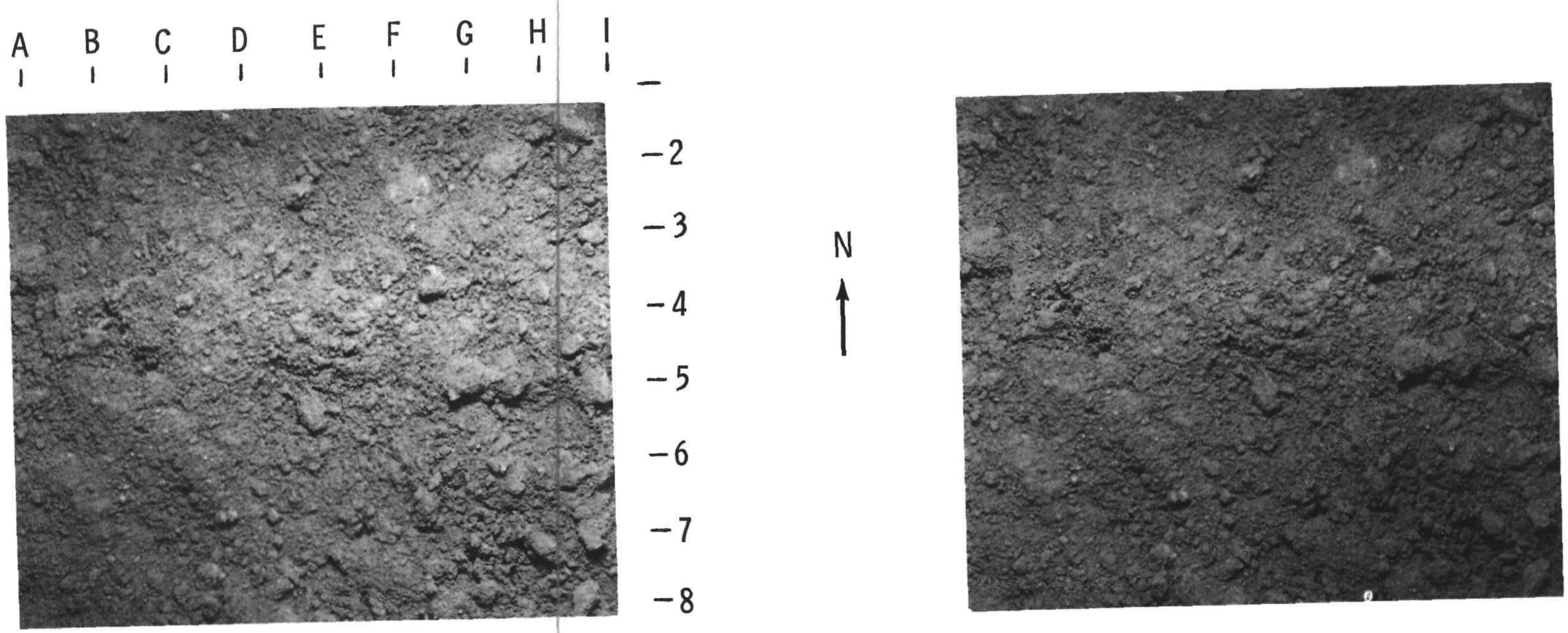


Figure 16. - A "raindrop" pattern in undisturbed lunar soil (ALSCC frame 314, NASA no. AS14-77-10370).

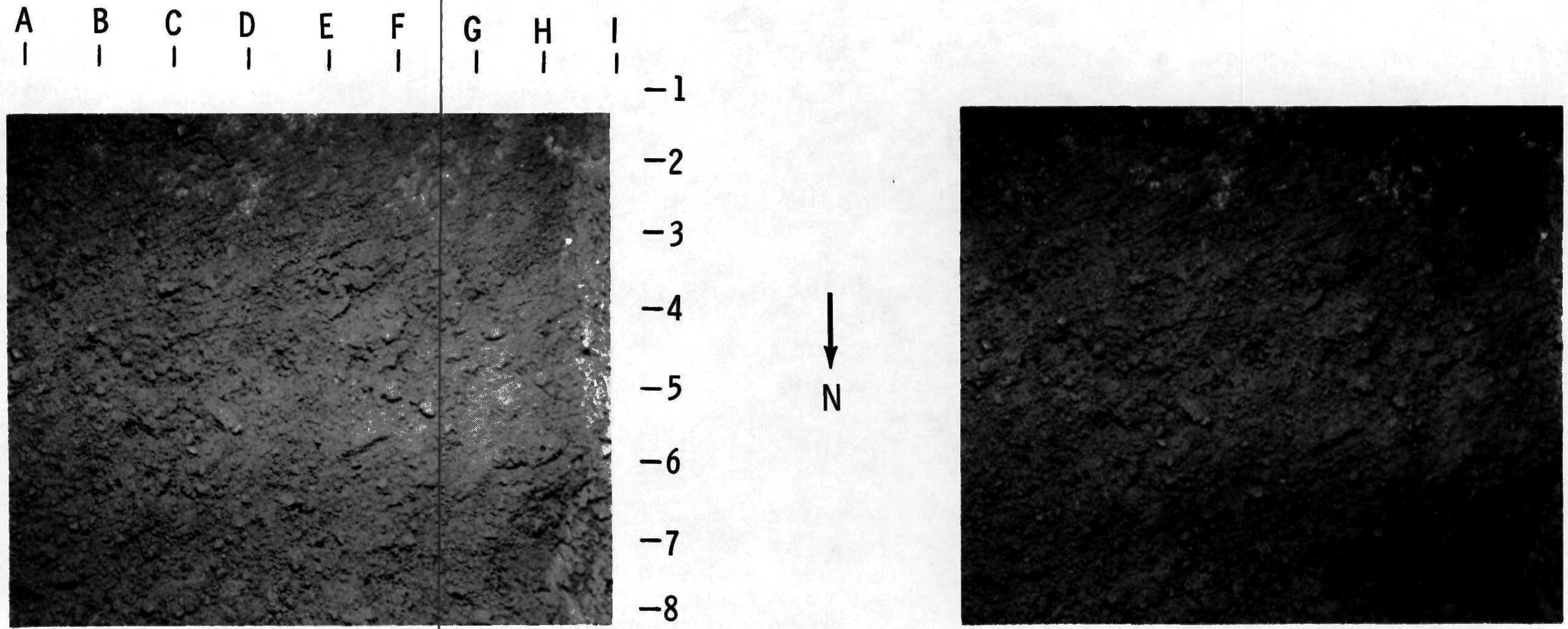
DESCRIPTION OF FIGURE 17(a)

This photograph appears to have been taken at the soil-rock contact, either at the rock base or where soil has lapped up onto the rock.

Little can be seen of the rock, which is white (crystalline or clastic ?) and appears to have a relatively smooth surface. A glass-lined, small impact pit in the rock is visible at D. 3 to 1. 9. There are suggestions of other pits on the rock surface, but they are dust covered. The dust cover on the rock ranges up to about 3 millimeters thick with clod or aggregate fragments as large as 2 millimeters in diameter adhering to the surface.

The soil surface appears to be fairly cohesive, with clods bound into the surface and a very irregular, pitted surface. The cratered surface is very similar to the "raindrop" pattern described in AS14-77-10370 and AS14-77-10368. As in the other photographs, all resolvable particles are clods or aggregates of fine-grained fragments, ranging in size from 0. 1 to 6 millimeters in diameter. Again, most of the particles are equant.

05: 12: 06: 23 CDR "And I see some - I see a fairly large rock here at the - at the north of these three craters. It's embedded right at the rim. It's about 2 feet long. I can see some crystals in it. It has a good fillet pattern. I'm shooting a closeup of that. And the sun angle again will be 9 o'clock."

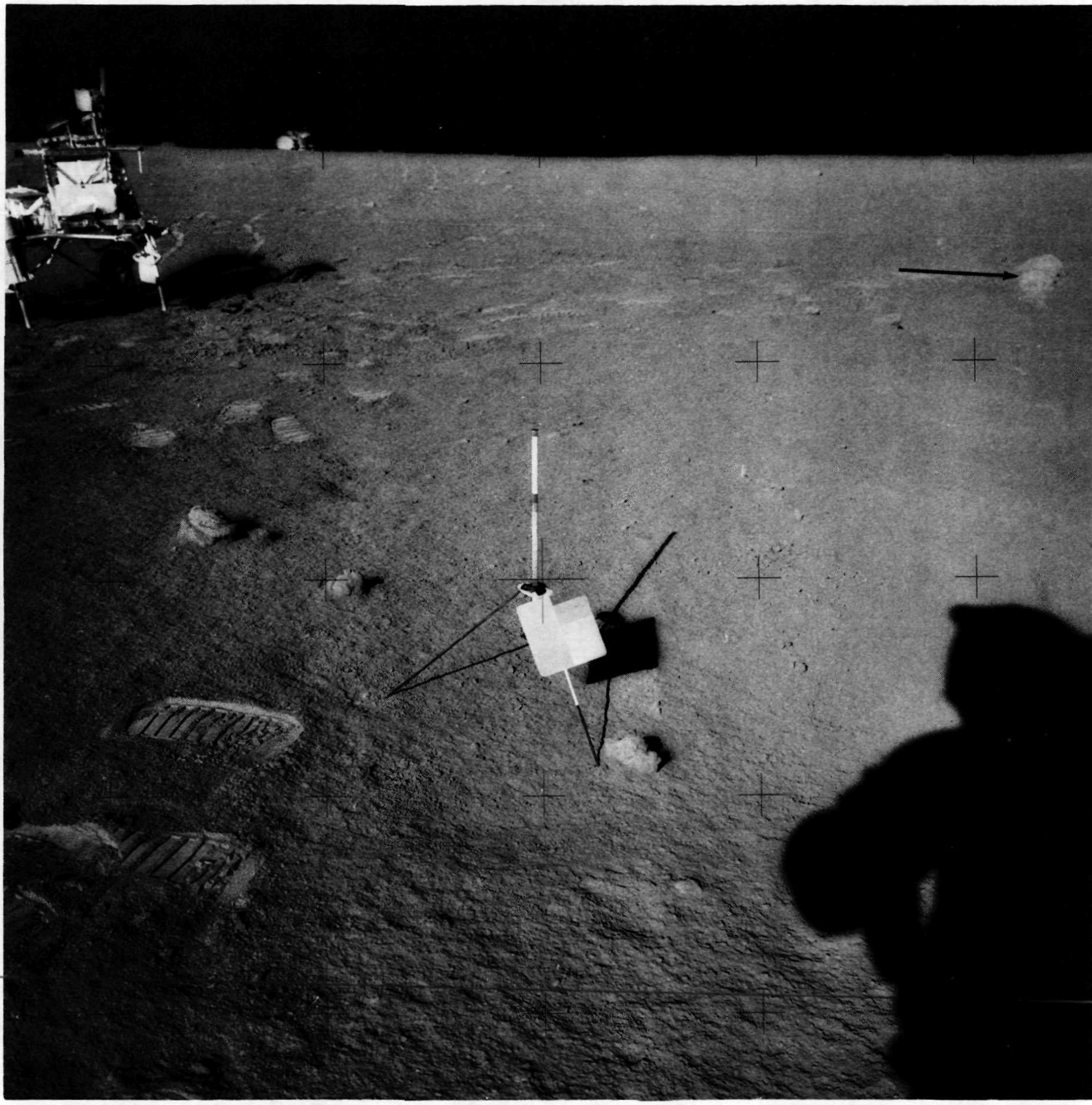


(a) Soil-covered rock surface (ALSCC frame 315, NASA no. AS14-77-10371).

Figure 17. - Lunar rocks.

DESCRIPTION OF FIGURE 17(b)

The arrow indicates the rock that was photographed in figure 17(a) and probably in figure 18. The location of the rock was determined by members of the Lunar Geology Experiment Team (ref. 5).



(b) Photograph of the rock shown in figure 17 (a) and probably figure 18 (NASA no. AS14-68-9409).

Figure 17. - Concluded.

DESCRIPTION OF FIGURE 18

The rock surface is partly visible above a horizontal line across the photograph at about 4.2. The rock surface is covered with depressions possibly caused by micrometeorite pitting. The rock is a clastic rock, with clasts visible at C-3.2 and F.8-1.8. The clast at C-3.2 appears to be clastic, with equant to elongate white clasts in a gray matrix.

The soil is similar to that described in other photographs and is composed of coherent aggregates (clods) partly buried or resting on an irregular, coherent soil surface. There are abundant circular depressions in the soil that may be small craters (example at C.9-7.0).

05:12:07:17 CDR "...and the last fillets picture, shadow 9 o'clock, was 18."

NOTE

During the EVA, the authors believe they heard Astronaut Shepard say 18 with reference to the ALSCC frame number for this photograph; and indeed, the written transcripts record 18, as shown above. However, it is clear from other statements that the actual number is 15 or 16 (315 or 316 in table I) and that either we misunderstood Shepard or he misread the counter. Two minutes prior to this quote he referred to 314 (which is unambiguously identifiable as AS14-77-10370, "raindrop" pattern) and 40 minutes later he referred to 317.

If the actual number is 316, then Shepard must have taken two photographs (AS14-77-10371 and AS14-77-10372) of the rock at station A (fig. 17(b)). The unexposed set of frames that follow AS14-77-10372 would then be 317 and would correspond to the photograph of the rock at station B2 (fig. 19).

If the actual number is 315, then Shepard must have taken only one photograph (AS14-77-10371) of the rock at station A. Then number 316 (AS14-77-10372) would be an inadvertent photograph of a shadowed area with the camera lifted off the surface. However, this action would have had to have happened after Shepard photographed the rock at station B2 and before he looked at the counter and reported the frame number.

Astronaut Shepard cannot recall for certain how many photographs he took of the rock at station A, but he does feel that the most likely explanation is that he took two.

In any case, AS14-77-10371 and AS14-77-10372 are closeup photographs of either one or two rocks and the associated fillet material, which has never been photographed in detail before.

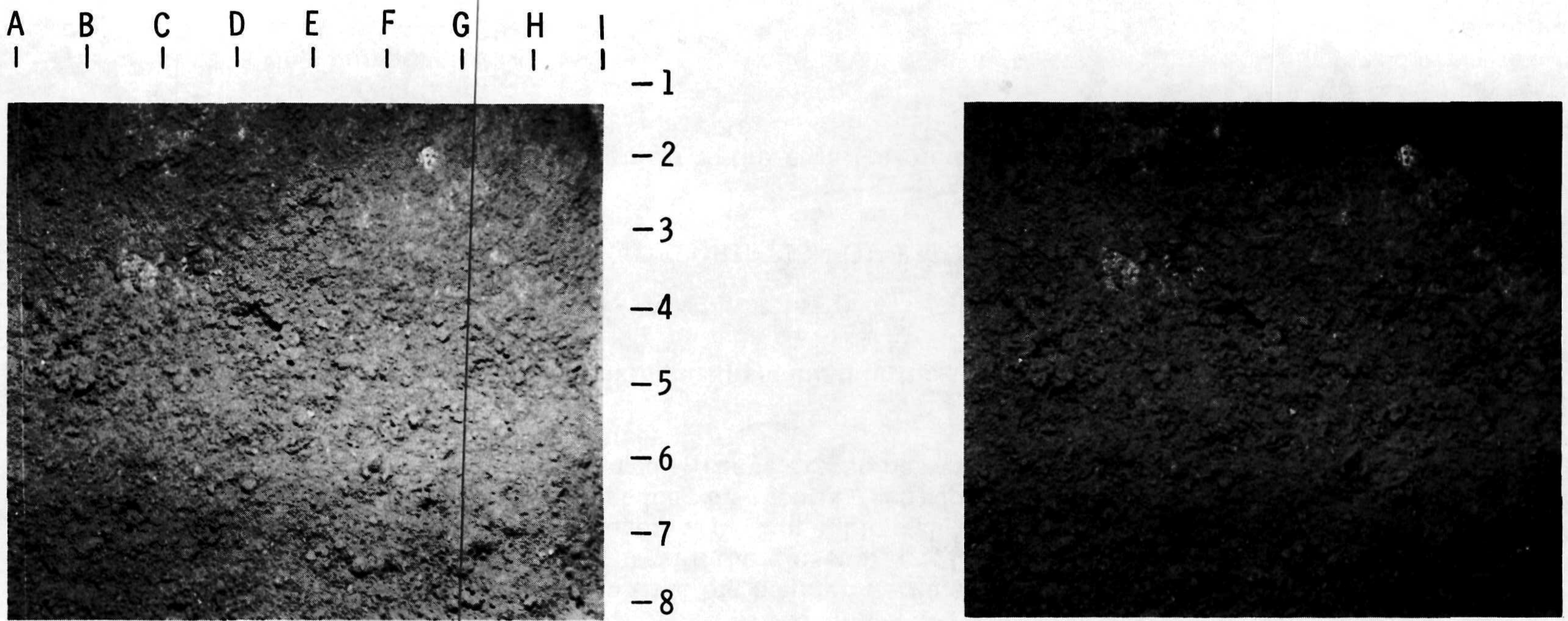


Figure 18. - Soil-covered rock surface (ALSCC frame 316, NASA no. AS14-77-10372).

UNEXPOSED PAIR

When the film was processed, a pair of completely unexposed frames was found between AS14-77-10372 and AS14-77-10373 (table I). Possible explanations for this occurrence are discussed in the description of figure 18.

05: 12: 56: 36 CDR "This is the first big boulder we've seen, Houston. I think it's worthwhile taking a picture of it with the closeup. ...Okay. The shot's been taken on the closeup counter number 317. Sun angle was 8 o'clock. The - this particular one is only about 12-feet long by about 4-feet wide. It's about one-third buried. It's old, very weathered. There are some evidences of some crystal shining through some of the fractures."

05: 12: 57: 39 LMP "And I'm taking a Hasselblad of the rock and will take a pan now from - at this location."

DESCRIPTION OF FIGURE 19

Astronaut Shepard is seen standing next to the rock that he attempted to photograph at station B2. This rock also appears in panorama 9, figure 3-6, reference 5.

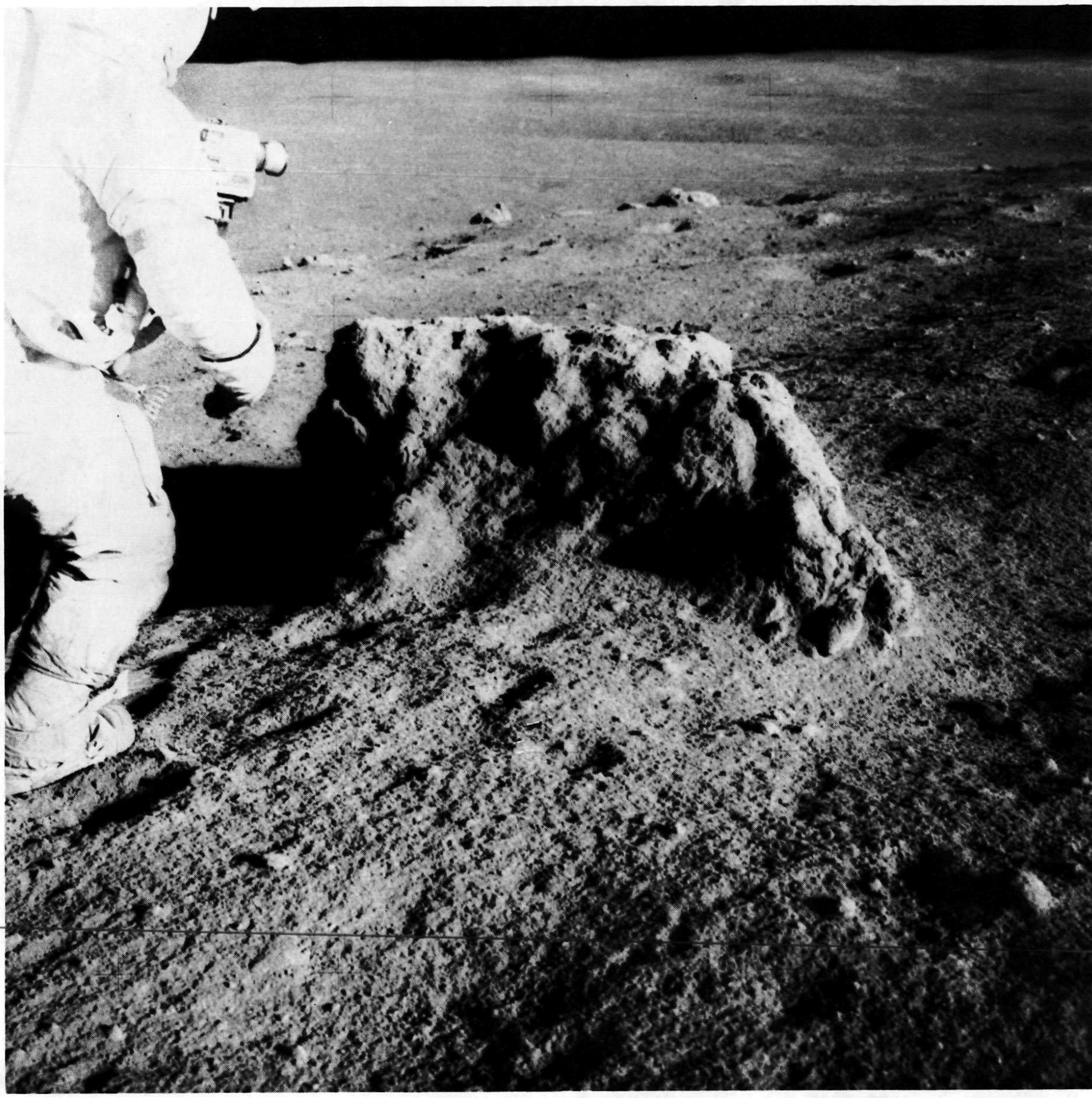


Figure 19. - Possibly a photograph of the rock shown in figure 18 (NASA no. AS14-68-9417).

DESCRIPTION OF FIGURE 20

All the fragments visible in the photograph are 0. 2-millimeter to 2-centimeter length clastic rocks or clods. Equant fragments with spinose or very irregular surfaces are aggregates of soil particles (examples in area of H-5, 6, and 7), and angular fragments exhibiting smooth fracture surfaces (examples at F-1. 3 and I-1. 5) may be clastic rock fragments.

The spiny fragment at C. 8 to 4. 3 may be soil bonded by glass spatter. The needlelike spines around the periphery of this fragment may be projections of glass.

The white fragment at A-4 is possibly a clod of feldspar-rich soil or feldspar-rich clastic rock fragment. It may also be a patch of sunlight from a space between the soil surface and camera bottom or a film defect. The photograph was taken inadvertently at the end of the EVA.

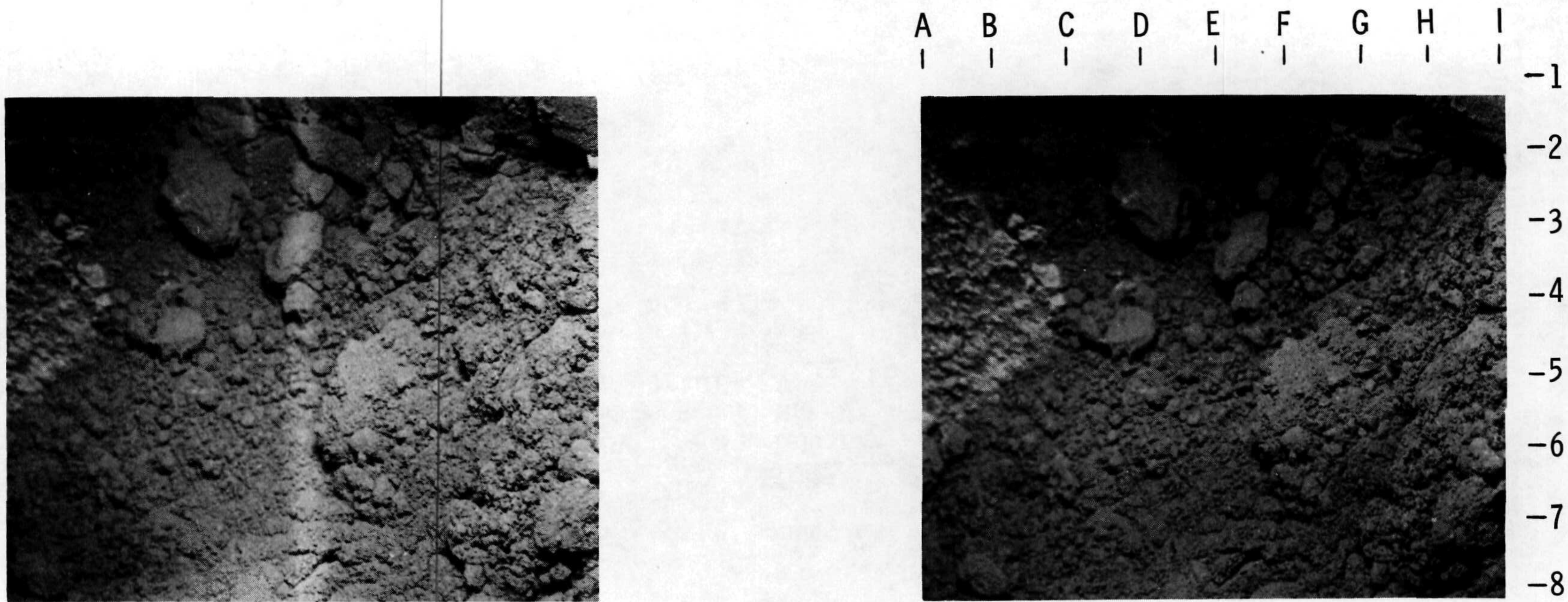


Figure 20. - Soil-covered rock surface (ALSCC frame 318, NASA no. AS14-77-10373).

DESCRIPTION OF FIGURE 21

Only one frame of this photograph is extant. This frame is a repeat of the previous photograph.

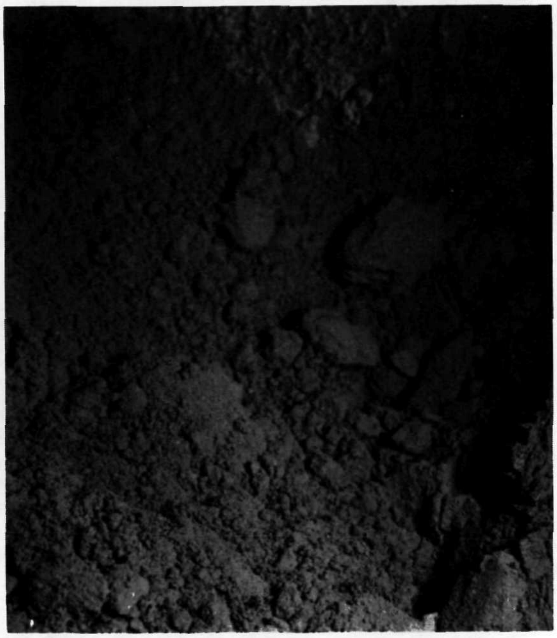


Figure 21. - One frame photograph (ALSCC frame 319, NASA no. AS14-77-10374).