JSC 09252

LUNAR CORE CATALOG

COMPILED BY M.B. DUKE AND J.S. NAGLE

JUNE, 1976

National Aeronautics and Space Administration
LYNDON B. JOHNSON SPACE CENTER
Houston, Texas

CONTENTS

Section | Page

TABLES

FIGURES

INTRODUCTION

The lunar surface is covered nearly everywhere by a layer of rubble, which varies in thickness from one to a few tens of meters, and is derived primarily from meteorite impacts on the lunar surface. This rubble, or regolith, which ranged from fine materials to rocks as large as 10 kilograms, provided essentially all the samples collected by the Apollo lunar missions.

The study of the regolith, therefore, is basic to understanding the collection of lunar samples. The regolith can be studied at its surface by a variety of techniques, including remote sensing, but its development can only be studied if it can be sampled in three dimensions. Cores, which would preserve an intact and undisturbed section through the uppermost lunar surface, were given a high priority in planning the Apollo surface experiments.

Drive tubes were designed to be driven into the surface by hand. On Apollo 11, 12 and 14 a small diameter drive tube was employed, while on Apollo 15, 16 and 17 a large diameter drive tube was available. With these drive tubes, a total depth of sampling of about 70 cm was possible by using two tubes joined together (double drive tube). A rotary percussive drill was used for Apollo 15, 16 and 17, capable of drilling to a depth of 250 - 300 cm. In all, 52 drill stem and drive tube sections were collected, which contained over 1500 cm of lunar regolith sample. Table I summarizes the collection of lunar cores.

The work on these drill stem and drive tube sections has been carried out in three phases; preliminary examination, utilizing X-radiographs and small samples taken from the ends of the tubes; dissection and description; and distribution for analytical study by the scientific community. The preliminary examination has been completed for all sections; dissection, description and initial sample distribution for approximately 15 percent of the sections; and limited amounts of analytical data are available in the scientific literature.

This catalog is intended to provide a basic source of lunar core and drive tube information. This will be of use to investigators who are carrying out lunar core tube investigations, and to gather together the preliminary description, dissection description, and sample distribution information that has been developed in the curatorial facilities at JSC. The catalog is viewed as an open-end document. Updates will be provided as new information becomes available as additional tubes are dissected and described. The bibliography will be updated at intervals to allow published information to be readily accessible.

G. H. Heiken contributed major portions of the effort involved in this initial compilation. S. Haynes and S. Chazen assisted in the editorial phases. None of it could be accomplished without the efforts of a large number of individuals over the past 5 years, who developed the techniques and labored to describe the core materials (noted by reference to their publications, but not individually cited). My thanks go to all of them. Readers' comments, questions, and critiques will be appreciated.

Michael B. Duke
Lunar Sample Curator
Johnson Space Center
Houston, Texas 77058
August, 1974

TABLE I. - APOLLO CORE AND DRIVE TUBE STATUS 10/1/75

SAMPLE NO.	SAMPLE TYPE 1	SAMPLE WT.(gms.)	SAMPLE L.(cm.)	SAMPLE X-RAYED	DIS-SECT 2	PEEL 3	IMPGD 4	EARLY ALLOC 5	ALLOC. 6
10004	SDT	65.	13.5		X				
10005	SDT	51.	10.		X				
12025	DDT-U		9.5		X			X	X
12028	DDT-L		31.6		X			X	X
12026	SDT	106.6	19.3		X			X	
12027	SDT	95.0	17.4	X					
14210	DDT-L		32.5	X					
14211	DDT-U		7.5	X					
14220	SDT	80.7	16.5	X					
14230	SDT	70.7	12.5	X	X			X	X
15001	Drill	232.8		X	X	X*	X*	X	X
15002	Drill	210.2		X	X	X*	X*	X	X
15003	Drill	223.0	242.	X	X	X	X	X	X
15004	Drill	210.6		X	X	X*	X*	X	X
15005	Drill	239.9		X	X	X*	X*	X	X
15006	Drill	227.9		X	X	X*	X*	X	X
15007	DDT-L	768.2	35.6	X				X	X
15008	DDT-U	510.2	30.4	X					X
15009	SDT	622.1	38.5	X					X
15010	DDT-L	740.6	35.	X					
15011	DDT-U	660.7	32.	X					

*Thick peels were taken from 15001, 15002, 15004, and 15006; parts of the sections are not represented in impregnated cores. 15005 was completely encapsulated in methacrylate and is unsitable for preparation of thin sections.

TABLE I. - APOLLO CORE AND DRIVE TUBE STATUS 10/1/75

SAMPLE NO.	SAMPLE TYPE 1	SAMPLE WT.(gms.)	SAMPLE L.(cm.)	SAMPLE X-RAYED	DIS-SECT 2	PEEL 3	IMPGD 4	EARLY ALLOC.5	ALLOC 6
60001	Bit	30.1	42.5	X	X			X	X
60002	Drill	211.8		X	X	X	X	X	X
60003	Drill	215.5	39.9	X	X	X	X	X	X
60004	Drill	206.7	39.9	X	X	X	X	X	X
60005	Drill	76.1		X	X				
60006	Drill	165.6	35.5	X	X	X	X	X	X
60007	Drill	105.7	22.2	X	X	X	X	X	X
64001	DDT-L	1336.4	65.6	X					
64002	DDT-U			X					
60009	DDT-L	1395.1	65.4	X	X				X
60010	DDT-U			X					
68001	DDT-L	1424.2	62.3	X					
68002	DDT-U			X					
69001	SDT	558.4							
60013	DDT-L	1327.	63.1	X					
60014	DDT-U			X					
70001	Bit	29.8		X	X			X	
70002	Drill	207.8		X				X	
70003	Drill	237.8		X				X	
70004	Drill	238.8		X				X	
70005	Drill	240.7	298.6	X				X	
70006	Drill	234.2		X				X	
70007	Drill	179.4		X	X	X	X		
70008	Drill	261.0		X	X	X	X	X	X
70009	Drill	143.0		X	X	X	X		X
70012	SDT	434.8	18.4	X					

TABLE I. - APOLLO CORE AND DRIVE TUBE STATUS 10/1/75

SAMPLE NO.	SAMPLE TYPE	SAMPLE WT.(gms.)	SAMPLE L.(cm.)	SAMPLE X-RAYED	DIS-SECT 2	PEEL 3	IMPGD 4	EARLY ALLOC 5	ALLOC 6
73001	DDT-L	1263.0	56.						
73002	DDT-U			X					
76001	SDT	711.7	34.5	X					
74001	DDT-L	2032.0	68.2	X				X	
74002	DDT-U								
79001	DDT-L	1152.7	51.3	X					
79002	DDT-U			X					

The table summarizes the basic information on lunar drill stem drive tube sections.

Columns include:

1. Type: SDT - single drive tube; DDT-L = double drive tube, lower section; DDT-U - double drive tube, upper section; drill = drill stem section; bit = bit from drill core.
2. Section has been dissected or other wise subdivided.
3. A peel has been made.
4. An impregnated section has been prepared*.
5. Special allocations were made prior to detailed dissection.
6. Allocations of dissected material were made.

COLLECTION AND PREPARATION PROCEDURES

LUNAR SURFACE PROCEDURES

Coring equipment of the Apollo program consisted of three principal types: Small diameter drive tubes (Apollo 11, 12, and 14), large diameter drive tubes (Apollo 15, 16, and 17), and a small diameter coring device operated by a rotary percussive motor (Apollo 15, 16, and 17).

Small Diameter Drive Tubes

The drive tubes were hollow anodized aluminum tubes, designed to be pushed or driven into the lunar surface. Each of the small diameter tubes was 1.95 cm inside diameter and 31.84 cm long (Figs. 1 and 2). Two tubes could be connected to obtain a double length section. The tubes consisted of an inner thin aluminum shell comprised of two semicircular cylinders surrounded by a Teflon liner to hold the aluminum shell together. These were jacketed by an outer aluminum tube. A detachable steel bit was discarded on the lunar surface and replaced by a protective Teflon cap. The upper end of the core was retained by a spring loaded Teflon follower.

The drive tubes could be pushed to a depth of several centimeters, with an extension handle attached (Fig. 3); however, most had to be driven to greater depths using a hammer (Figs. 4 and 5). The bits for the Apollo 11 cores were designed to taper inward (Fig. 6). This design led to compaction at the bit and severely limited the depth to which the bit could penetrate into the lunar regolith, which proved to be very cohesive in most sample sites. (An attempt to collect a drive tube at Cone Crater on Apollo 14 failed, due to lack of cohesion.) For Apollo 12, the bit was redesigned and subsequently double length cores were collected in cohesive lunar regolith. In several cases, the astronauts believed that sampling was terminated when an especially resistant layer was encountered.

Simulations with terrestrial materials demonstrated that the small diameter drive tubes did not collect an undistorted stratigraphic section (Carrier et al., 1971). Compaction of material in the tube increased the resistance to further penetration and tended to push material around the outside of the tube, rather than into it. Thus, a foreshortening of the stratigraphic section occurred which has been estimated on the basis of simulations (Figs. 7, 8, and 9). Significant displacement may have occurred between the central portions and edges of the Apollo 11 drive tubes.

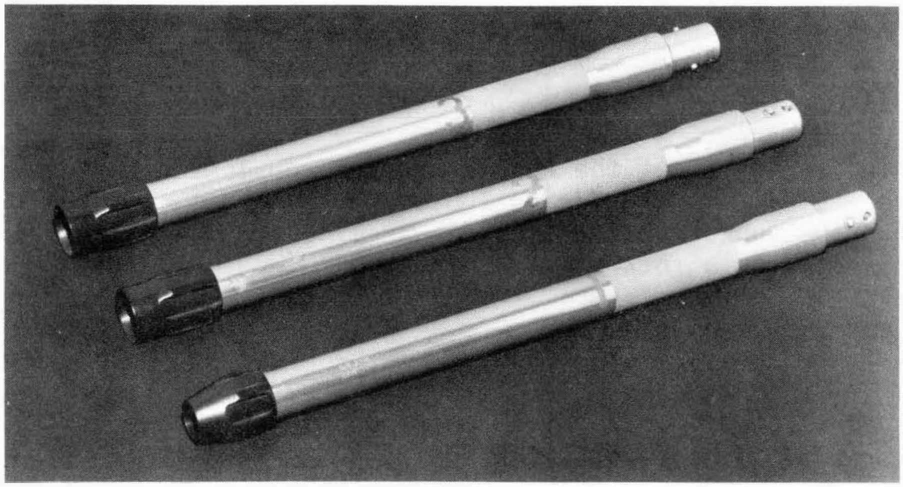


Figure 1.- Small drive tubes.

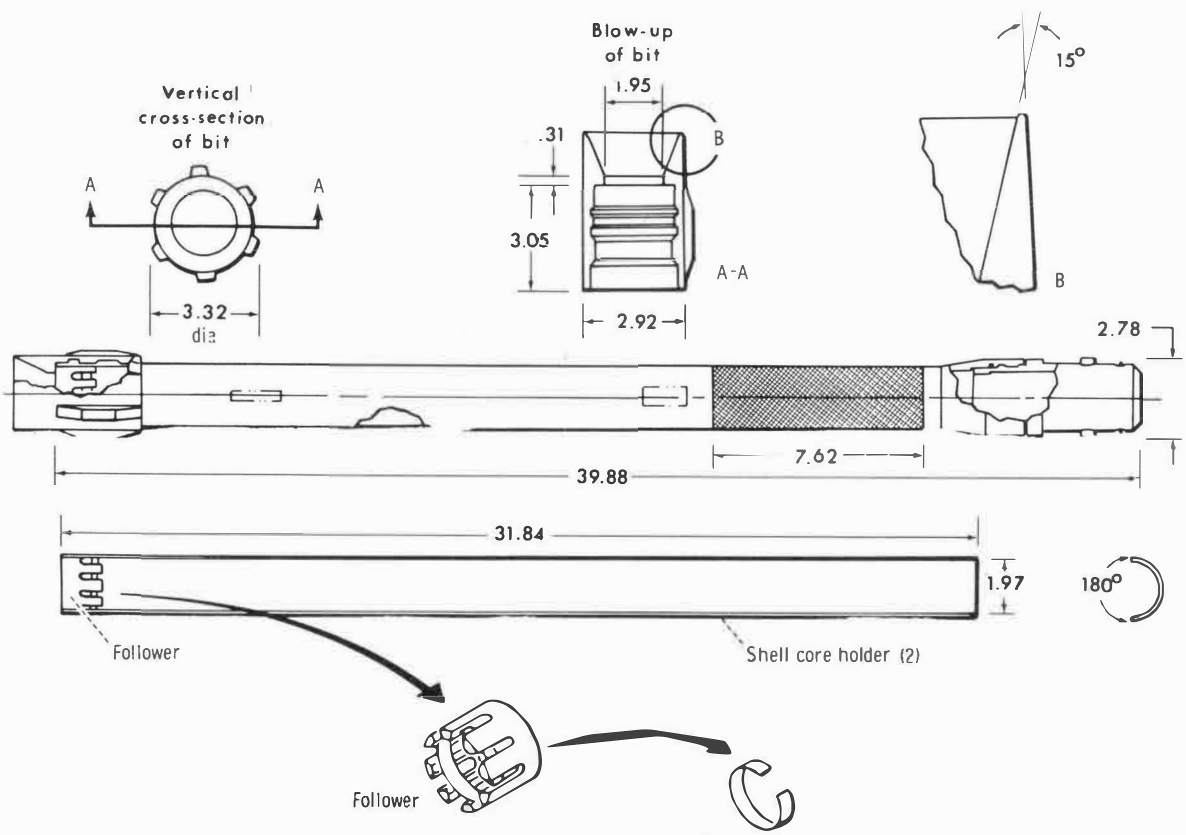


Figure 2.- Core tube sampler and bit used on the Apollo 11 mission (measurements in centimeters).

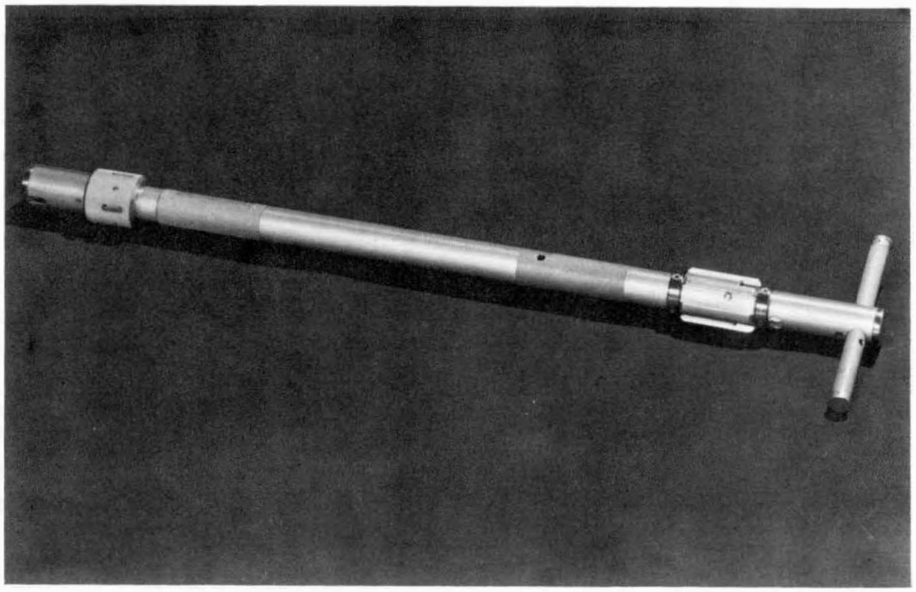


Figure 3.- Extension handle used in sinking core tubes.

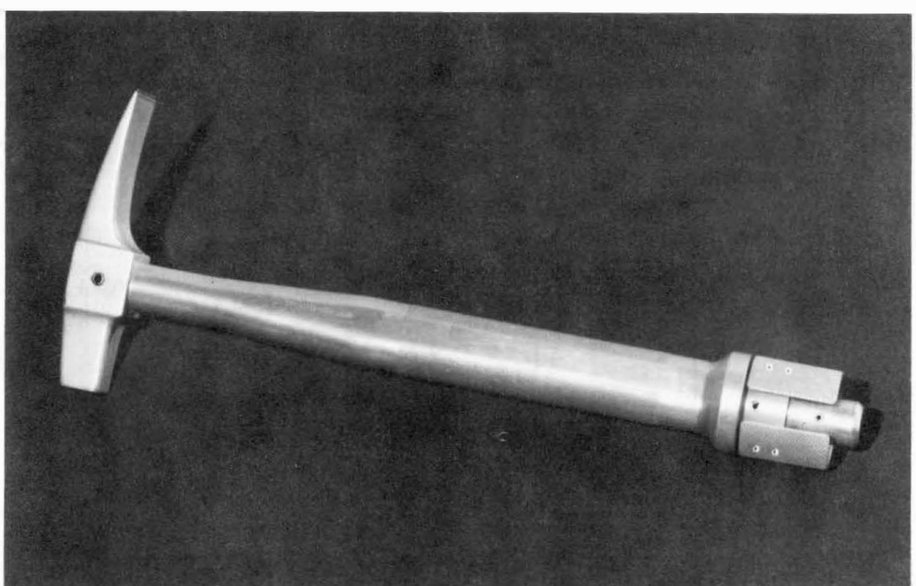


Figure 4.- Hammer used in driving core tubes.

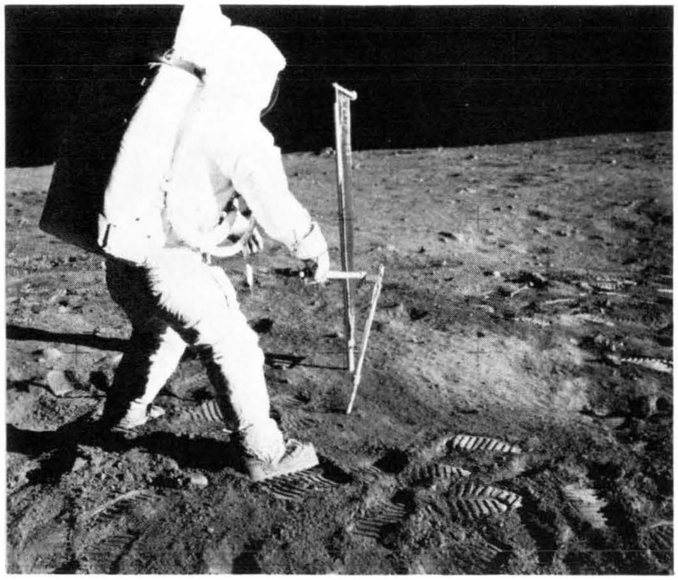


Figure 5.- Collection of the first lunar drive tube sample (10005) at the Apollo 11 landing site, Sea of Tranquillity. Obstruction of the drive tube sampler either by a rock or an exceptionally coherent layer necessitated use of a hammer to drive it and resulted in penetration at an angle. After compaction, the sample returned was approximately 10 cm long.

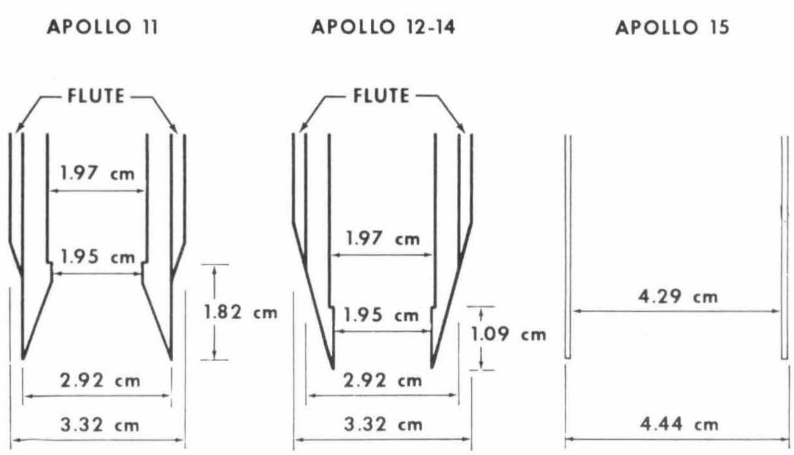


Figure 6.- Comparison of Apollo core bits.

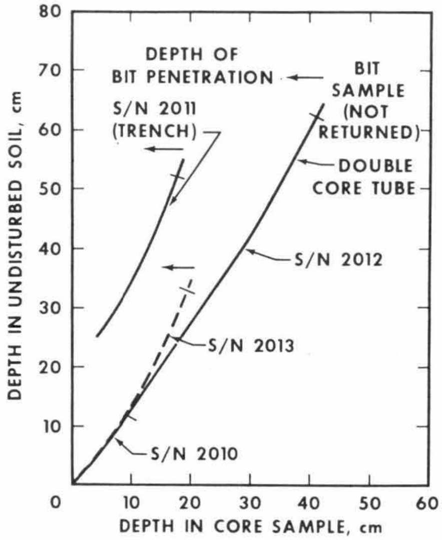


Figure 7.- Depth relationship: Apollo 12 returned core samples. The arrows denote (on the ordinate axis) the actual depth to which each core tube was driven.

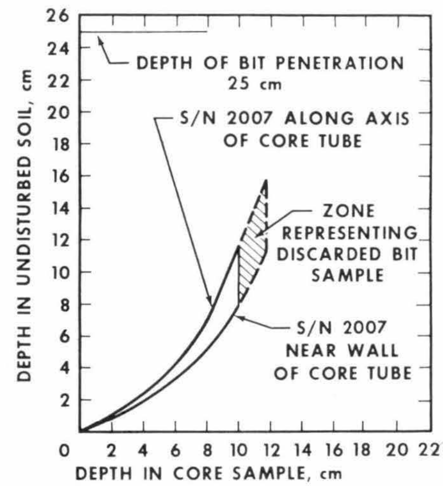


Figure 8.- Depth relationship: Apollo 11 core tube S/N 2007. The bit penetrated to a depth of at least 25 cm but the core tube recovered material from less than 12 cm depth.

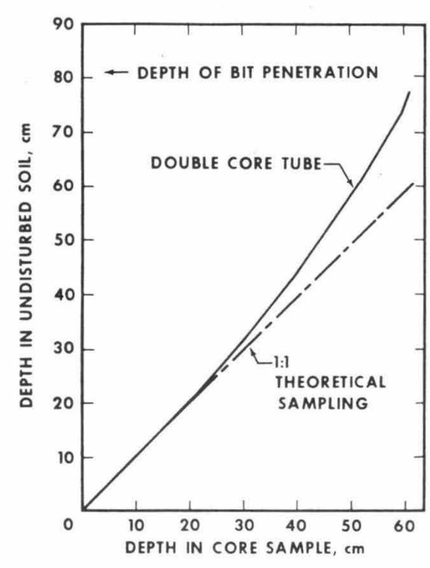


Figure 9.- Depth relationship: Apollo simulated double core tube sample. The bit penetrated to a depth of 81.3 cm, core recovered was 60 cm, and core contained material from depths to 77.8 cm.

Large Diameter Drive Tubes

A complete redesign of drive tubes was undertaken which led to the large diameter drive tubes used by Apollo 15 - 17. These tubes had an inside diameter of 4.13 cm and were over 36 cm long (Fig. 10), which allowed an increase of about a factor of four in the amount of sample that could be collected. The bit was attached to the lower tubes and had the same inside diameter as the tube. Upper sections without bits were provided for double drive tubes. Each tube was a single piece, with 1.3 mm thick walls; the resistance to penetration was greatly reduced.

Upon extraction from the lunar surface a Teflon cap was placed over the bit end. The tube had no follower; either a cap was placed over a filled tube or a plug was inserted using the "rammer-jammer" lunar hand tool (Fig. 10).

Simulations with the Apollo 15 - 17 drive tubes showed little distortion in sample recovery vs depth, in comparison to the smaller drive tubes (Carrier et al., 1971). Most were returned nearly filled, indicating close to a 1:1 sampling of the regolith with depth.

Apollo Lunar Surface Drill

The Apollo Lunar Surface Drill was a rotary percussive type which consisted basically of a power head and a string of extension core tubes (Figs. 11 and 12). The power head consists of a cam-actuated, motor-driven, ram for percussion (2270 spm) and a power train assembly for rotation (280 rpm). The core tubes, constructed of titanium steel, were 2.04 cm inner diameter and helically fluted on the outside to allow excess soil to be carried to the surface. Each section was 40 cm long. Six lengths were carried by Apollo 15 and 16, and eight by Apollo 17. After extraction from the lunar surface, Teflon caps were placed on the ends of the separated sections. The bit is detachable from the lowermost section, which was slightly shorter than the remaining sections. The solid face drill bit consists of a hy-tuf steel matrix into which five tungsten-carbide tips were brazed. In addition, a solid plug with a tungsten-carbide cutter is brazed into the center of the bit.

Although sampling efficiency was related in a complex way to the speed of penetration of the drill, simulations indicate that the drill sampled the regolith at nearly a 1:1 ratio (Carrier et al., 1972).

Initial lead isotope analyses of Apollo 15 drill stem material indicated massive amounts of terrestrial lead contamination. It was then discovered (Silver et al., in preparation) that one step in the manufacturing process included anodization in a lead electrode system. Milligram quantities of lead deposited on the core tubes during the processing could be removed from the surface of the drill sections with

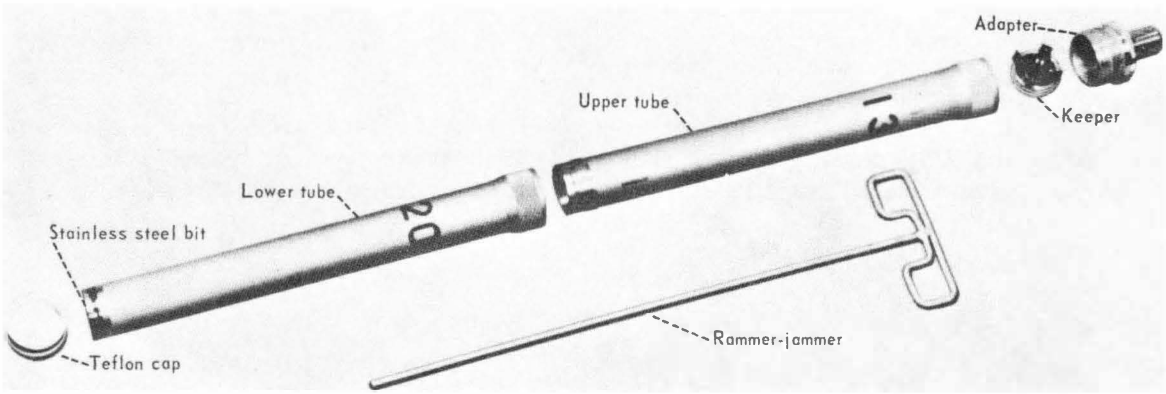


Figure 10.- Apollo 15 drive tube and associated equipment including "rammer-jammer".

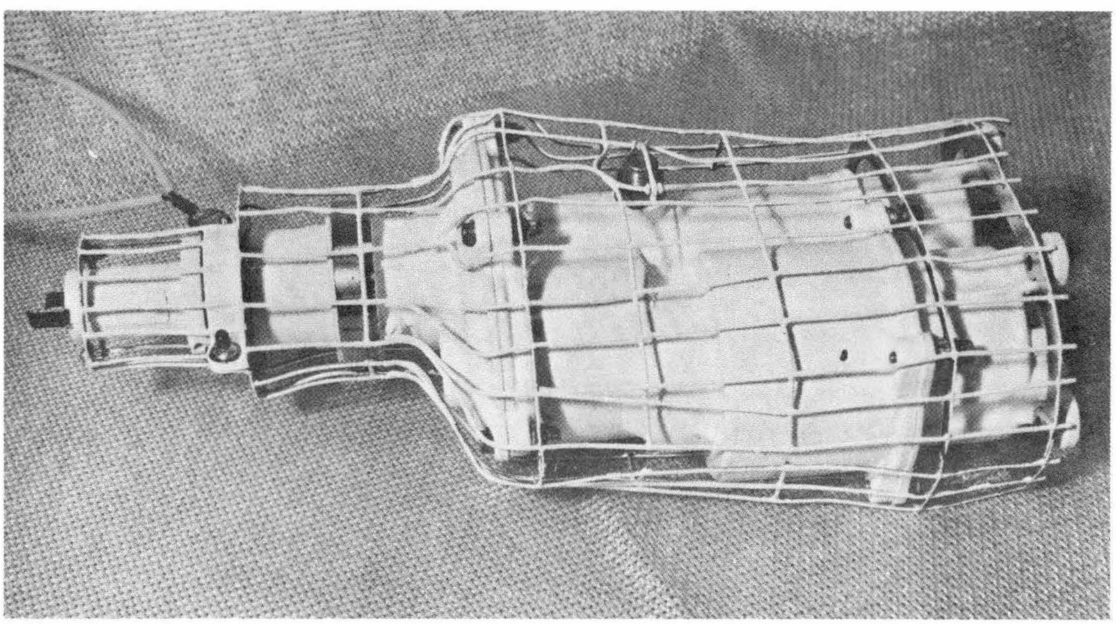


Figure 11.- Power head and thermal guard.

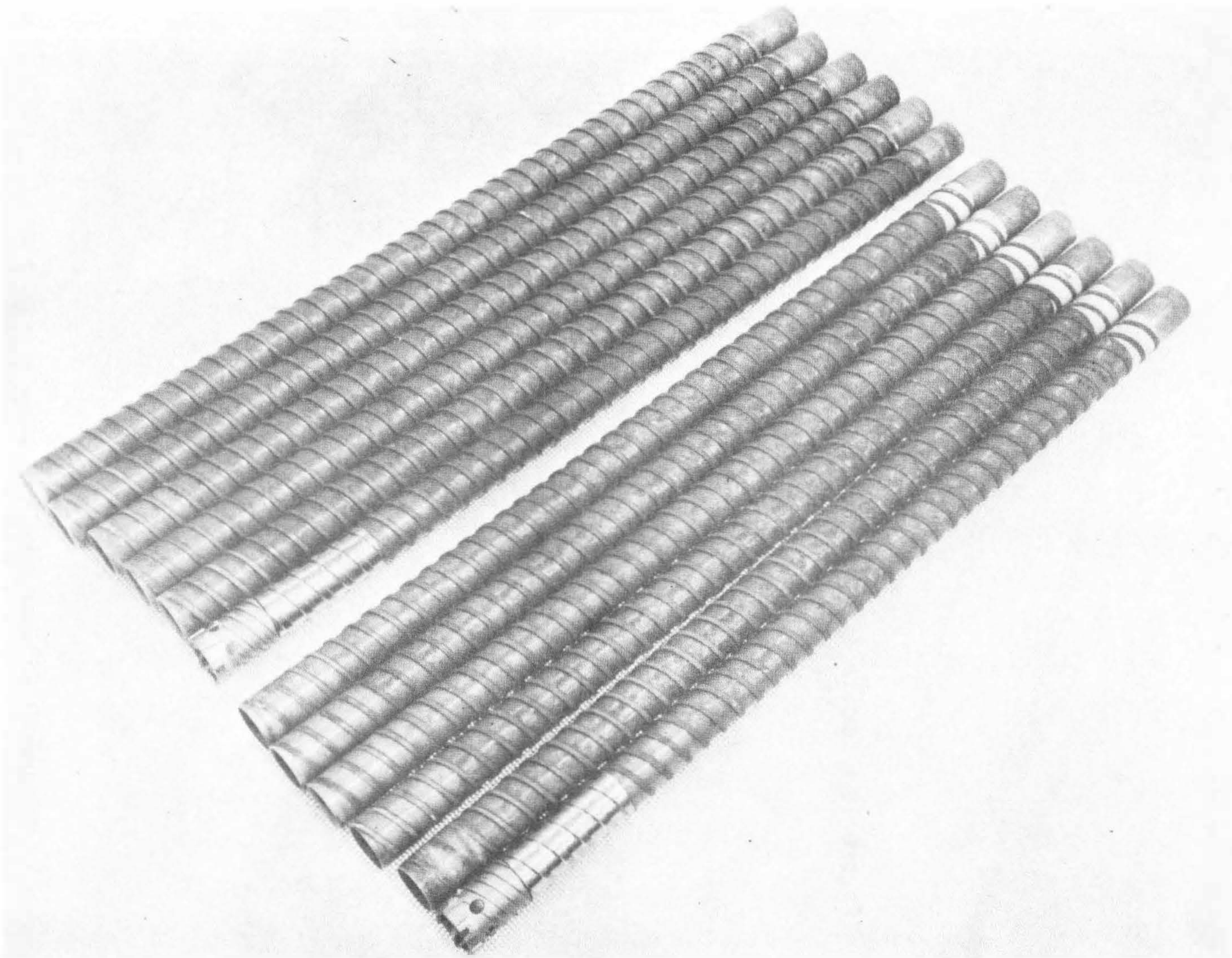


Figure 12.- Bore stems and bits.

dilute nitric acid. The problem was isolated too near to Apollo 16 launch time to modify that set but immediate steps were taken to eliminate contaminants in Apollo 17 drill stems. They were successfully cleaned-up in a crash effort, which involved stripping surface contamination by vapor honing and nitric acid, relubricating the joints between stems, replacing necessary external color coding with Teflon-based coating rather than materials previously used (MoS_2 lubricant, titanium pigmented paint) and recleaning the hardware (Council, 1972). An effort was made also to reduce the amount of brazing material on the bit, which had previously led to contamination of the Apollo 15 and Apollo 16 sections with silver and copper.

RETURN OF CORES TO EARTH

The cores were designed to fit into the Apollo Lunar Sample Return Container (ALSRC), a sealable box designed to provide protection from the terrestrial atmosphere. In general, those drive tubes collected on lunar traverses where rock boxes were filled were packed in the rock boxes. On later missions, cores collected on the last traverse were returned outside of the boxes. Because of an error in premission assembly of the wrench used to disconnect the Apollo 15 drill stem sections on the Moon, they were returned in sets of three connected sections and would not fit into the ALSRC. (This was not all bad, as it was later discovered that the drill sections were badly contaminated with lead.) Because the procedure developed for returning the Apollo 15 cores saved considerable lunar surface time, the Apollo 16 and 17 drill stems were returned in two or three section lengths outside of the ALSRC.

Table II gives the sample return containers for each of the core tubes and drill stems. It indicates the nature of the sealing characteristics of the containers. All samples returned outside of rock boxes must be assumed to be equilibrated with spacecraft cabin atmosphere, as pressurization/depressurization cycles pumped contaminants into the cores at unknown rates. All samples were inserted into high purity nitrogen environments as soon as possible upon return to the Lunar Receiving Laboratory (LRL). Because the cap on the Apollo 15 drill stem had to be taped to the stem, a procedure for cleaning the outside of the drill stem prior to inserting it into the nitrogen cabinets was developed. The outside of each core section was swabbed with cellulose wipes (specially treated to remove organic contaminants) wet with isopropyl alcohol and distilled Freon TF. All work was performed in a laminar flow clean bench (Fig. 13). This procedure was repeated with the Apollo 16 and 17 drill stem sections.

TABLE II.- SAMPLE RETURN CONTAINER LISTING FOR DRIVE TUBES AND DRILL STEMS

Sample No.	Mass g	Item	Container No.	Vacuum on Return to LRL
10004	51.	DT	SRC	160μ
10005	65.	DT	SRC	160μ
12025	56.1	DT-U	SRC	1/2 atmosphere
12026	101.4	DT	SRC	1/2 atmosphere
12027	80.	DT	SRC	1/2 atmosphere
12028	189.6	DT-L	SRC	1/2 atmosphere
14210	169.7	DT-L	Bag 3N	60μ
14211	39.5	DT-U	Bag 4N	60μ
14220	80.7	DT	Bag 20	60μ
14230	76.7	DT	Bag 21	60μ
14411	5.5	DT-B	Bag 3N	60μ
14414	5.5	DT-B	Bag 20	60μ
15001	232.8	DS-L	SCB-4	atmosphere
15002	210.1	DS	SCB-4	atmosphere
15003	223.	DS	SCB-4	atmosphere
15004	210.6	DS	SCB-2	atmosphere
15005	239.1	DS	SCB-2	atmosphere
15006	227.9	DS-U	SCB-2	atmosphere
15007	768.2	DT-L	SCB-1	35μ
15008	510.2	DT-U	SCB-1	35μ
15009	622.	DT-S	SCB-5	atmosphere
15010	740.4	DT-L	SCB-7	atmosphere
15011	653.6	DT-U	SCB-7	atmosphere
60001	30.1	DT-B	DSB[b]	atmosphere
60002	211.9	DS	DSB[b]	atmosphere
60003	215.5	DS	DSB[b]	atmosphere
60004	202.7	DS	DSB[b]	atmosphere
60005	76.1	DS	DSB[b]	atmosphere

TABLE II.- SAMPLE RETURN CONTAINER LISTING FOR DRIVE TUBES AND DRILL STEMS - Continued

Sample No.	Mass g	Item	Container No.	Vacuum on Return to LRL
60006	165.6	DS	DSB[b]	atmosphere
60007	105.7	DS	DSB[b]	atmosphere
60009	759.8	DS-L	SRC-2[a]	80μ
60010	635.3	DS-4	SRC-2[a]	80μ
60013	757.3	DS-L	SCB-7[b]	atmosphere
60014	570.3	DS-4	SCB-7[b]	atmosphere
64001	752.3	DS	SCB-3[b]	atmosphere
64002	584.1	DS	SRC-2[a]	80μ
68001	840.7	DS	SCB-3[b]	atmosphere
68002	583.5	DS	SRC-2[a]	80μ
69001	558.3	DS	SRC-2[a]/ CSVC	80μ
70001	29.78	DS-B	DSB	atmosphere
70002	207.8	DS	DSB	atmosphere
70003	237.8	DS	DSB	atmosphere
70004	238.8	DS	DSB	atmosphere
70005	240.7	DS	DSB	atmosphere
70006	234.2	DS	DSB	atmosphere
70007	179.4	DS	DSB	atmosphere
70008	261.	DS	DSB	atmosphere
70009	143.3	DS-U	DSB	atmosphere
70010	3.92	F	DSB	atmosphere
70012	485.	DT	BSLSS	atmosphere
73001	809.	DT-L	SRC-2/ CSVC	28μ
73002	429.7	DT-U	SRC 2	28μ
74001	1072.	DT-L	SRC 2	28μ
74002	909.6	DT-U	SRC 2	28μ

TABLE II.- SAMPLE RETURN CONTAINER LISTING FOR DRIVE TUBES AND DRILL STEMS - Concluded

Sample No.	Mass g	Item	Container No.	Vacuum on Return to LRL
76001	711.6	DT-L	SCB-7	atmosphere
79001	743.4	DT-L	SCB-7	atmosphere
79002	409.4	DT-U	SCB-7	atmosphere

NOTES:

[a] = In vacuum sealed SRC-2 (i.e., not exposed to spacecraft environment).

[b] = In open SCB (i.e., exposed to spacecraft environment).

ACRONYMS:

DT = Drive tube
DS = Drill stem
-L = Lower
-U = Upper
-B = Bit
-S = Single

F = Fines outside stem
SCB = Sample Collection Bag
SRC = Sample Return Container (rock box)
CSVC = Core Sample Vacuum Container
DSB = Drill Stem Bag
BSLSS = Buddy Secondary Life Support System (bag)

Figure 13.- Apollo 17 core samples in laminar flow clean bench.

PROCESSING OF CORES

X-radiograms

Starting with Apollo 12, stereographic X-radiograms of all cores were taken, with a medical X-ray unit,[1] as the initial stage of their study. Each sample was heat sealed in three layers of Teflon bags in nitrogen cabinets. The cores were laid in an aluminum block designed to compensate for the different path lengths through the circular core. Two stereographic pairs were taken of each core at 90° rotation. Table III gives the exposure data for all stereographic X-ray photographs.

X-radiographs have been used successfully as a preliminary guide to stratigraphy and dissection. Changes in texture and structure, including grain size and shape, degree of packing, density, bedding types, and contacts, are clearly seen in the films. Particles with a metallic composition are readily detected. Particles with low X-ray absorption, such as feldspars, tend to be invisible. Data on grain size distribution, sorting and density are ambiguous, and the exact location of components may be uncertain because of parallax distortion. The X-ray photographs do not reproduce satisfactorily, so the data are reproduced for this compilation in the form of interpretive drawings.

SAMPLE SEPARATION

Initial removal of material: Table I lists Apollo 15, 16, and 17 sections from which material was scooped from the end of the tube, prior to detailed dissection. This was done in order to provide samples rapidly for quarantine studies and for limited sample allocation soon after the mission.

Removal of core from liner: In order to examine the core material, encapsulated in an opaque liner, it is necessary to remove the core material from the core liner. Procedures for doing this differ, depending on the construction of the core. For the small diameter drive tubes, the inner tube with its Teflon sheath is extruded from the outer tube. Then the Teflon sheath is split with a scalpel and the two semicylinders separated to expose the lunar material.

The drill stems, being of solid, tough titanium steel, are opened by using a milling machine (Fig. 14), operated within a nitrogen cabinet, to split the sections longitudinally (Fig. 14). Considerable care was taken to minimize the potential contamination of cores during the milling

---

[1] See Table III for exposure data.

TABLE III.- EXPOSURE DATA FOR X-RADIOGRAPHS

Core	Total Exposures	Number of Stereopairs	Potential kv	Current ma	Time sec	Distance m	Type Rad	Tech
10004-5	not X-rayed							
12025 12026	not X-rayed							
12027	2	1	72	300	1/3	0.9	Tungsten	Cantu
12028	not X-rayed							
14210	4	2	72	300	1/30	0.9	Tungsten	Cantu
14211	4	2	72	300	1/30	0.9	Tungsten	Cantu
14220	4	2	72	300	1/30	0.9	Tungsten	Cantu
14230	4	2	72	300	1/30	0.9	Tungsten	Cantu
15001-6	2	1	93	100	1/5	0.9	Tungsten	Cantu
15007	4	2	76	20	not avail.	1.0	Tungsten	Cantu
15008	4	2	76	20	not avail.	1.0	Tungsten	Cantu
15009	6	2	76	300	1/5	1.0	Tungsten	Cantu
15010	4	2	115	100	4.0	1.0	Tungsten	Cantu
15011	4	2	115	100	4.0	1.0	Tungsten	Cantu
60001	4	1	90	50	5.0	1.0	He-Fe	Howell
60002	2	1	90	50	5.0	1.0	He-Fe	Howell
60003	2	1	90	50	5.0	1.0	He-Fe	Howell
60004	2	1	90	50	5.0	1.0	He-Fe	Howell
60005	2	1	90	50	5.0	1.0	He-Fe	Howell
60006	2	1	90	50	5.0	1.0	He-Fe	Howell
60007	4	1	90	50	5.0	1.0	He-Fe	Howell
60009	4	2	90	50	5.0	1.0	He-Fe	Howell
60010	4	2	90	50	5.0	1.0	He-Fe	Howell
60013	4	2	90	50	5.0	1.0	He-Fe	Howell

TABLE III.- EXPOSURE DATA FOR X-RADIOGRAPHS - Continued

Core	Total Exposures	Number of Stereopairs	Potential kv	Current ma	Time sec	Distance m	Type Rad	Tech
60014	4	2	90	50	5.0	1.0	He-Fe	Howell
64001	4	2	90	50	5.0	1.0	He-Fe	Howell
64002	4	2	90	50	5.0	1.0	He-Fe	Howell
68001	4	2	90	50	5.0	1.0	He-Fe	Howell
68002	4	2	90	50	5.0	1.0	He-Fe	Howell
69001	in CSVC; not X-rayed							
70001-9	2	1	90	50	5.0	1.0	He-Fe	Howell
70012*	2	0	90	50	5.0	1.0	He-Fe	Howell
73001	in CSVC; not X-rayed							
73002	4	2	90	50	5.0	1.0	He-Fe	Howell
76001	4	2	90	50	5.0	1.0	He-Fe	Howell
79001	4	2	90	50	5.0	1.0	He-Fe	Howell
79002	4	2	90	50	5.0	1.0	He-Fe	Howell
74002	4	2	90	50	5.0	1.0	He-Fe	Howell
74001	4	2	90	50	5.0	1.0	He-Fe	Howell
74001**	2	1	80	300	0.1	1.0	He-Fe	Howell

*Core was partially empty, placed in foil in tray and covered. Position, etc. not known at time of X-radiography.

**Because of capacity of core, additional exposure at increased power was taken.

Essentially, no X-rays taken of 11 and 12 cores - first experimentation taken with 12 - core 12027.

TABLE III.- EXPOSURE DATA FOR X-RADIOGRAPHS - Concluded

Apollo 14 and 15 cores were X-rayed in the LRL medical unit; Apollo 15 and 16 cores in room 161, Building 8, JSC (X-ray room, Kelsey-Seybold Clinic). Because of experimentation in an attempt to obtain a good exposure. Apollo 15 drive tubes were subjected to different settings. 60001 and 60007 were given extra exposures before final setting was determined. The orange soil cores were especially opaque and after X-raying by normal procedure, were X-rayed at higher intensity to obtain a better picture.

operation. As much of the hardware as possible was constructed of stainless steel, extraneous paints or surface coatings were removed, and organic lubricants replaced by MoS_2 (later, Teflon). The motor drive was enclosed in a specially purged case. All tools and equipment are specially cleaned (LRL cleaning procedures). The major potential contaminant of the cores is the metal from the core tube itself, which occasionally has been observed as small shavings at the edge of the core material. The milling blade is carbide steel, but is not believed to represent a serious contamination threat, as the final cut is made with a very sharp cutting edge which barely penetrates the core. A special clamping cradle designed to secure the drill stem during the milling process and to protect it during transfer to the nitrogen cabinet in which it is dissected is shown in Figure 14.

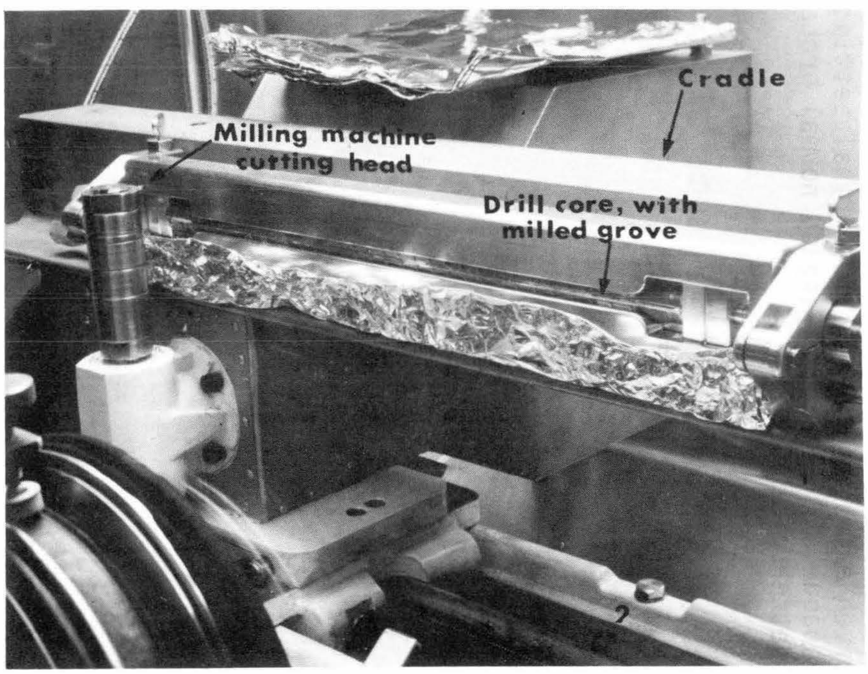


Figure 14.- Milling machine within nitrogen cabinet with longitudinally split core tube held in clamping cradle.

Vibration during the milling process is a severe problem which cannot be eliminated entirely. This problem motivated a search for alternate means of opening the large diameter solid aluminum drive tubes. A core extruder, modified from the device used to extrude the inner liner from the small diameter tubes, has been developed (Fig. 15) to extrude the large diameter tubes into an aluminum/fused silica receptacle, which will permit several successive longitudinal layers to be removed (Fig. 16). The core is extruded with the same direction of motion as the initial entry of material; disruption (smearing) along the tube walls is not believed to be substantially different than that experienced on the Moon.

Stratigraphic Subsampling: Procedures for stratigraphic subsampling of the cores along their long axis involve removal of approximately 80 percent of the volume of sample and follow basic procedures for sampling of microstratigraphy of terrestrial sediments outlined by Fryxell and Smith (n.d.). No subsample is taken across a recognizeable stratigraphic boundary, and morphologic units thicker than 5 mm are subdivided arbitrarily into units of 2.5 - 5.0 mm. Thinner subdivisions are sampled adjacent to contacts if texture and cohesion permit. Lack of cohesion of the sediment, and disturbance caused by removal of coarse particles, frequently limit precision of sample boundaries to approximately ±0.5 - 2.0 mm depending on texture.

Tools utilized in dissection include stainless steel spatulas, scoops, forceps, triceps, and brushes employing basic archaeological methods developed for exposure and removal of detailed terrestrial stratigraphic features (Fig. 17). Matrix sediment of the 1 mm fraction is removed a few milligrams at a time, and groups of coarse particles or particularly distinctive fragments are treated as features, isolated, photographed *in situ*, and removed as individual daughter samples.

The procedures have varied with time, and the time available for dissection. Initial examination of the Apollo 11 cores by the Preliminary Examination Team (PET) was performed in 45 minutes. Current practice with drill stems requires on the order of 3 weeks, if all steps go without incident. Descriptions of each identified unit are prepared and individual lithic fragments are described separately and packaged.

Due to the potential degradation of thermoluminescence properties, if samples are exposed to white light, a selection of subsamples has been removed without exposure to white light starting with Apollo 14 cores. A special "red light" sampling procedure was devised which allows the removal of a portion of a selected horizon (randomly selected) under a red light (Kodak 1A red light).

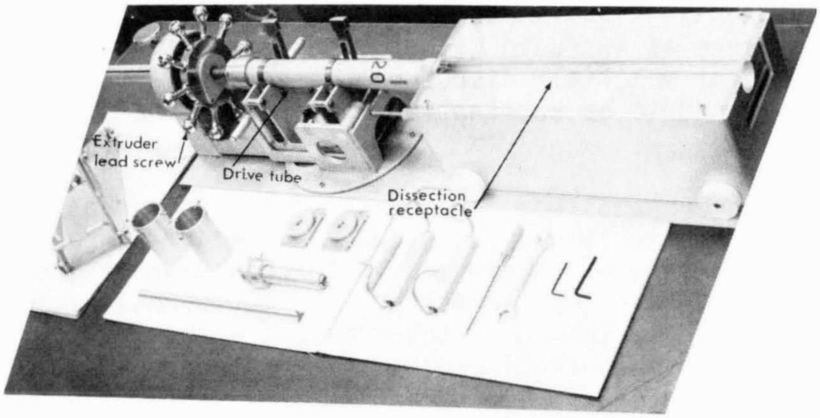


Figure 15.-Core extruder and associated tools.

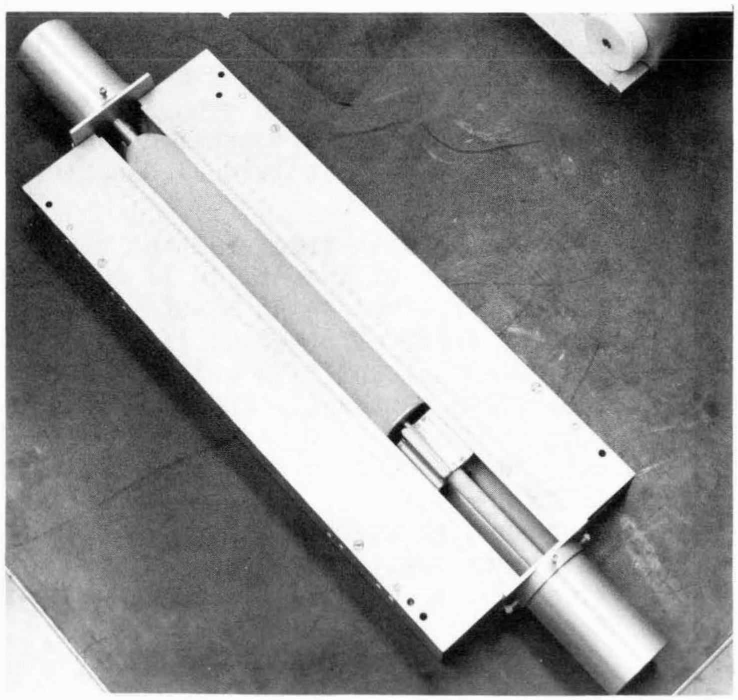


Figure 16.- Aluminum/fused silica receptical with simulated extruded core.

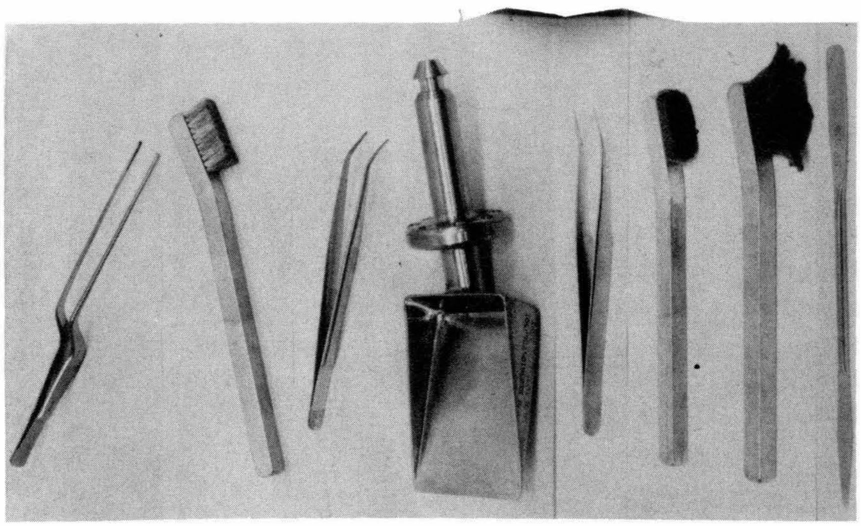


Figure 17.- Stainless steel spatulas, scoops, tweezers, and brushes.

Each step in the core dissection procedure is documented photographically as necessary. Detailed photographic information is contained in the lunar core data packs, maintained by the Curator's Office.

Core subsamples are packaged in one of two types of containers. The "white light" subsamples are normally stored in stainless steel containers with Teflon caps (Fig. 18), "red light" samples and other special samples are stored in hollow stainless steel bolts with an aluminum gasket and aluminum screw cap (Fig. 19).

Encapsulation: Encapsulation of a small portion of the core in peels and impregnated section has been used to preserve a permanent stratigraphic record of intact material.

Peels: After half or more of the sediment has been removed by dissection and subsampling along the axis of the tube, the remaining, relatively undisturbed portion of these cores may be stabilized by partial impregnation with poly-butyl methacrylate. Differential permeability of texturally different features allows layers and structures to stand in relief along the length of the core. The stratigraphic section thus preserved retains; (1) individual rock or mineral fragments in their original positions; (2) primary depositional structures; (3) secondary

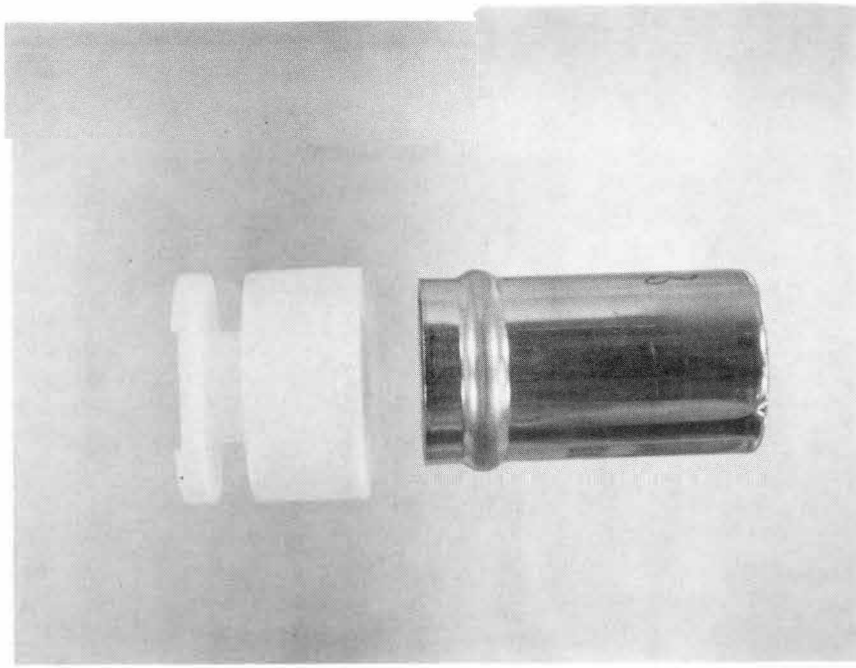


Figure 18.- FTH container (stainless steel with Teflon cap).

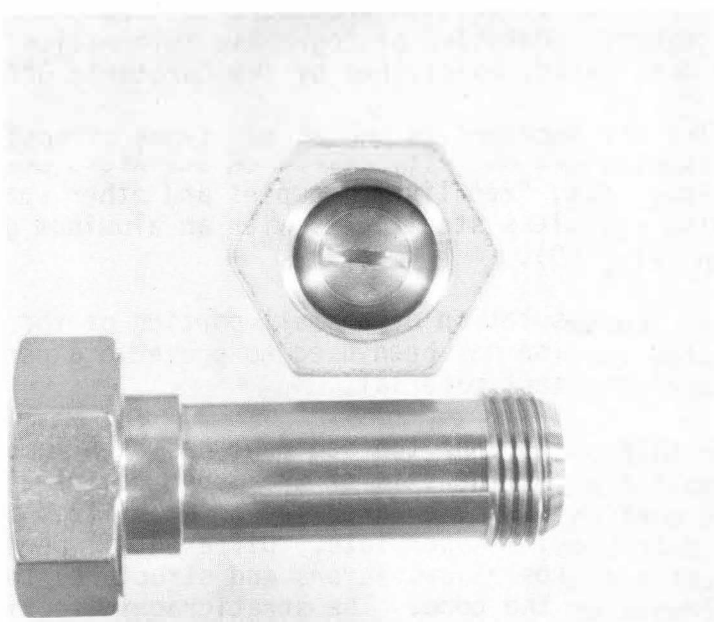


Figure 19.- McKinney container (hollow bolt).

deformational features including disturbance by drive tube or drill stem equipment; and (4) permits removal of individually oriented grains for future study, if desired, by dissolving the methacrylate bond with acetone (Fryxell and Heiken, 1974).

To take thin peels (Nagle and Duke, 1974), a controlled thickness of poly-butyl methacrylate adhesive is spread onto a Plexiglas backing strip, precut to the length and width of the core. The methacrylate surface is wet with a solvent and thoroughly impressed against the flat, dissected surface for 5 minutes, which removes a layer 1 mm or less in thickness (Fig. 20). After removal, the fresh face of the peel is sprayed with a surface fixative. This process is repeated and the peels preserved as a permanent record. It is possible to later remove individual grains from these preparations. An alternate method was used on Apollo 14 and 15 cores, which led to somewhat thicker peels (Fryxell and Heiken, 1974) (Fig. 21).

Impregnation: The remaining material is then stabilized with epoxy applied under vacuum. When diluted 1:1 with its solvent, butyl glycidyl ether, and poured under vacuum, the epoxy Araldite 506 completely impregnates lunar cores with minimum bubbling and particle displacement. To minimize particle displacement, the core and diluted epoxy are simultaneously loaded into a vacuum chamber, which is slowly evacuated for 8 hours, and then held under vacuum for 16 hours to ensure outgassing of both the core and the epoxy. A mechanical system allows the epoxy to be added gently to the core material. After complete impregnation, the chamber is slowly repressurized, the core removed, and cured at 30 - 35° C. The impregnated core material is secondarily encapsulated in epoxy to form a stable block, suitable for preparation of polished thin sections and is stable in hot caustic used in track etching studies (Fig. 22). Several Apollo 15 drill stems were impregnated with methacrylate, rather than epoxy.

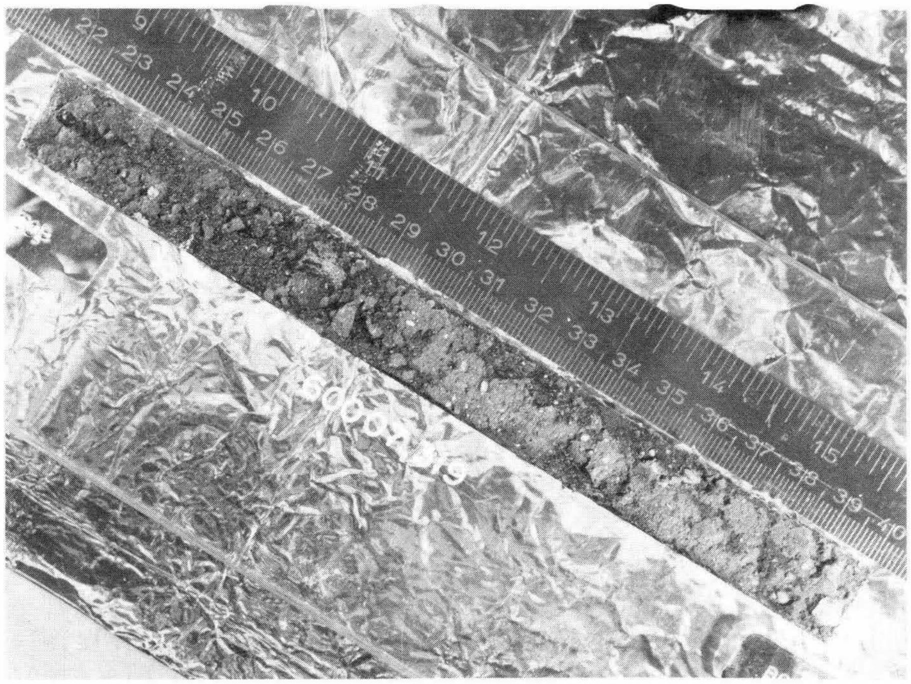


Figure 20.- Preparation of core for taking of thin peels.

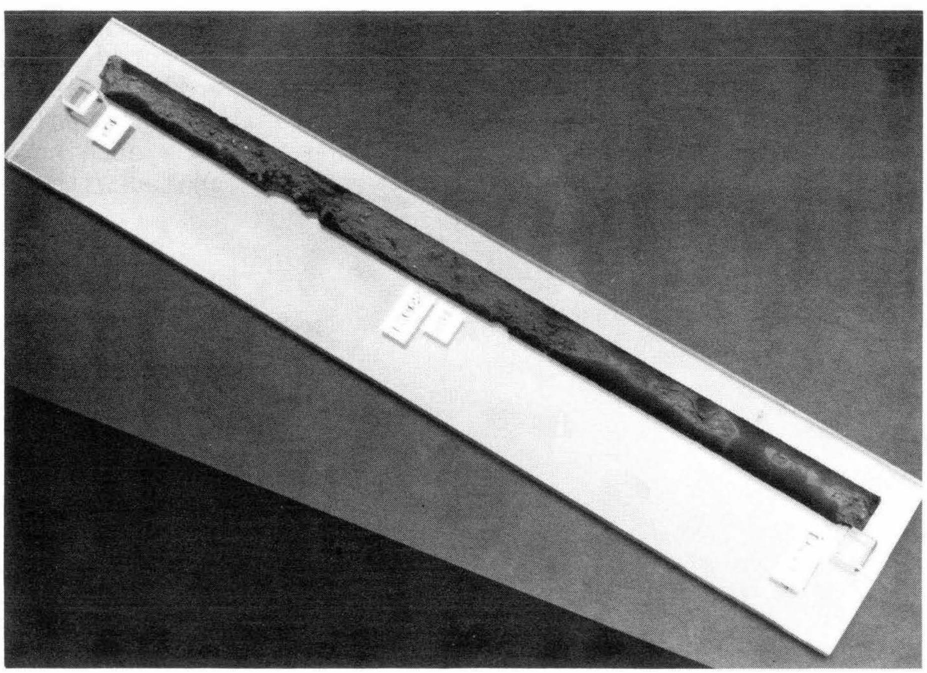


Figure 21.- Preparation of core for taking of impregnations.

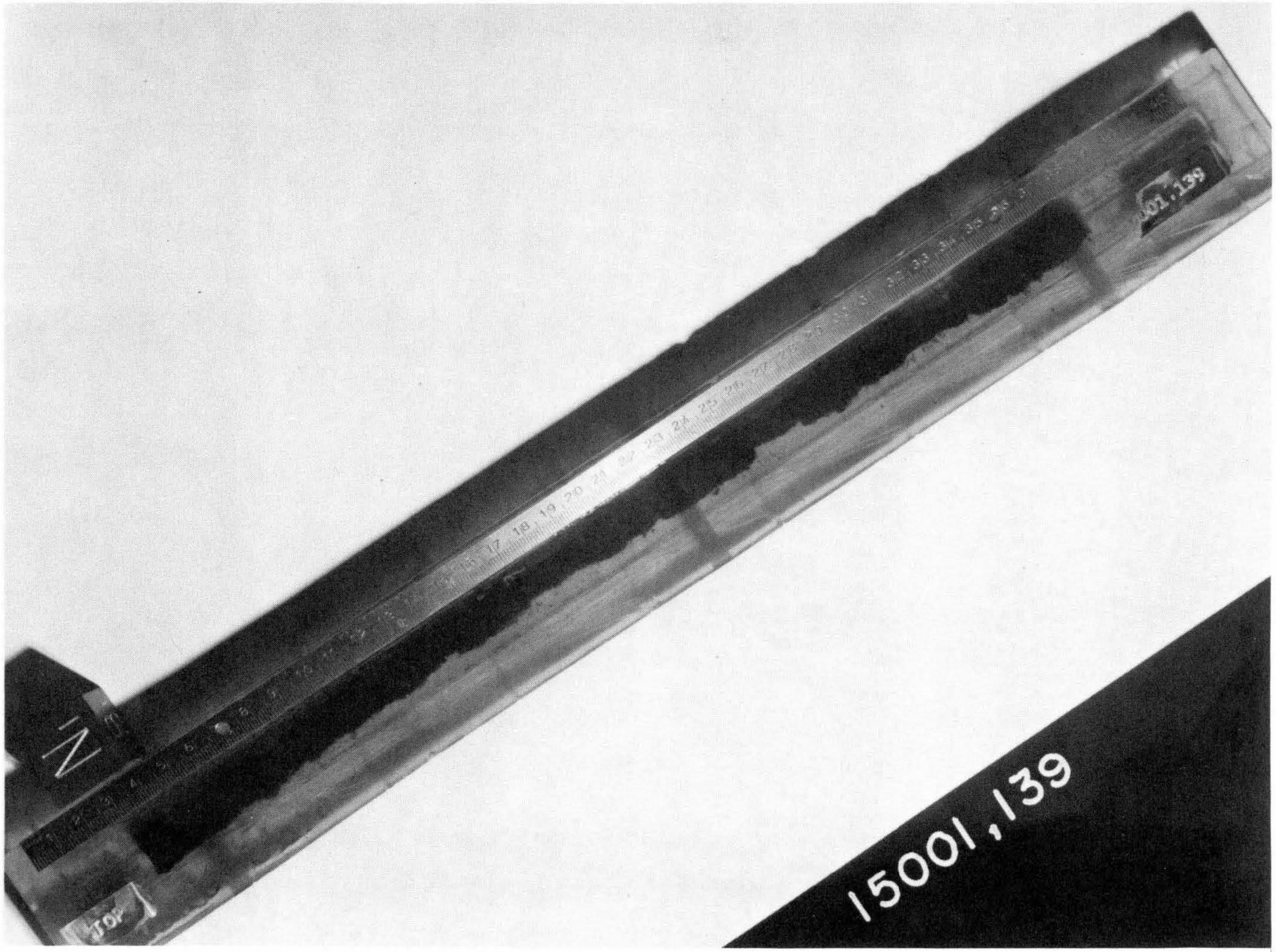


Figure 22.- Encapsulated core sample.

DETAILED CORE DESCRIPTIONS

The purpose of this section is to draw together the basic preliminary descriptive information for each lunar core. This includes lunar surface location, any anomalies in the collection of the core, preliminary X-ray description, and the detailed results of the dissection and subsampling procedures. The information is not complete for many cores, as the work of dissecting and subsampling the large number of cores is only about 15 percent complete. Additional information will be incorporated into this catalog as it becomes available.

Sample numbers have been assigned to each core tube length (generic number) and to each subsample excavated during its dissection and description. For the drill stems and drive tubes of missions from Apollo 14 on, generic numbers have been assigned serially to joined core tubes, starting from lowest to highest. The number 12027, refers to specific sample 27 from drive tube 12027. The numbering system for lunar samples requires that each subsample split from a specific numbered sample be assigned a new specific number. For example, 12025,132 (daughter) is a subsample of 12025,66 (parent), which was the number of the initially dissected material. Therefore, in order to place any specific subsample in its proper location, the parent/daughter relationship must be known.

APOLLO 11

Two single drive tubes were collected by Apollo 11, taken approximately 10 ft apart, 20 ft northwest of the Lunar Module (LM) (Fig. 11-1). The LM landed in a flat region in the southwest part of the Mare Tranquillitatis approximately 50 km from the closest highland material (LSPET, 1969).

No difficulty was encountered penetrating the first 12 cm, but from that depth on the drive tubes had to be hammered. It was later concluded that the design of the bit used on the drive tubes increased the resistance and reduced the amount of the core material recovered.

X-Ray and Core Descriptions

Tube 1, 10005, contained 10 cm of material and tube 2, 10004, contained 13.5 cm, with a total mass of 116 g of lunar material. As the biological testing requirement of the lunar quarantine required the immediate use of half of the core material, little observational data exists for these cores, which were neither X-rayed nor dissected. The Teflon follower was not properly inserted into the drive tube 10004, with the result that the material moved in the tube, potentially disrupting it (Carrier et al., 1971). Both tubes were opened in the Biological Preparations Laboratory, a temporary facility established at the last minute for preliminary descriptions and photography in nitrogen atmosphere. From preliminary examinations of core tube 10005, the sample showed weak coherence and was fractured in places (Carrier et al., 1971). Accurate measurements of grain size and bulk density could not be made.

The LSPET (1969) reported that neither core had obvious grain size stratification. Core 10004 had a slightly lighter 2 - 5 mm thick zone about 6 cm from the top of the core, which had a sharp upper boundary and gradational lower boundary.

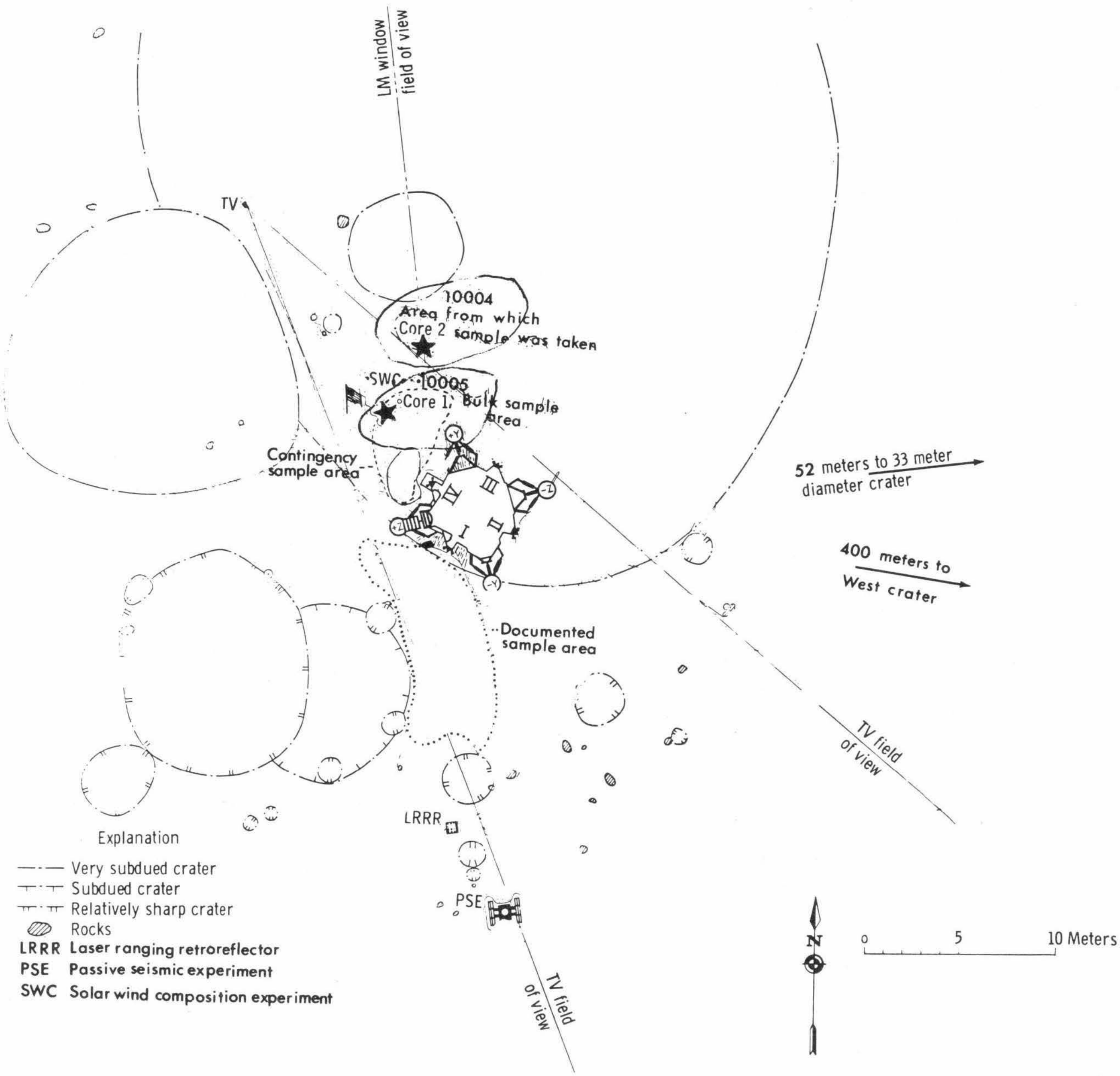


Figure 11-1.- Location of Apollo 11 cores of Mare Tranquillitatis region.

APOLLO 12

The cores recovered by Apollo 12 mission in Mare Procellarium (Fig. 12-1) includes two single drive tubes and one double drive tube (LSPET, 1970). The lunar regolith is much thinner than in the area from which the Apollo 11 cores were recovered. Partly due to the redesigned bit, there was no great difficulty encountered driving the tubes into nor removing them from the lunar surface.

Core Description: Preliminary examination was made of two of the cores, one single (12026) and a double tube sample 12025 - 12028) immediately after transfer to the LRL. The last core, 12027, has remained stored in nitrogen unopened. Preliminary investigation of the double core tube sample revealed distinct stratigraphic units, sharp contacts of fine materials, coarser grained material with depth, and strongly bonded aggregates in various layers (Fig. 12-2) (LSPET, 1970).

Descriptions of these three core samples were made by Lindsay, Fryxell and Heiken. Photographs and reference materials relating to the cores are cited after the descriptions. As has been discussed by Carrier et al. (1971) the true lunar surface depths are not known, but an approximation can be obtained from his graphical results of simulated coring.

Sample 12026: Sample 12026 was collected in drive tube 1 near the LM at the end of the first Extra Vehicular Activity (EVA) period on the northeast edge of Surveyor Crater.

The core was 19.3 cm long and contained 106.6 g of soil (Fig. 12-3). Three small samples were taken from near the top, middle, and bottom of the core for gas analyses then the core was dissected and split longitudinally. The split was divided into three samples - the top, middle, and lower thirds. Each sample was sieved, then recombined to form part of the bioprime sample (sample used by biologists in the quarantine studies). The median grain size changes from 62μm in the surface sample to 74μm for the middle sample and 110μm for the deepest sample.

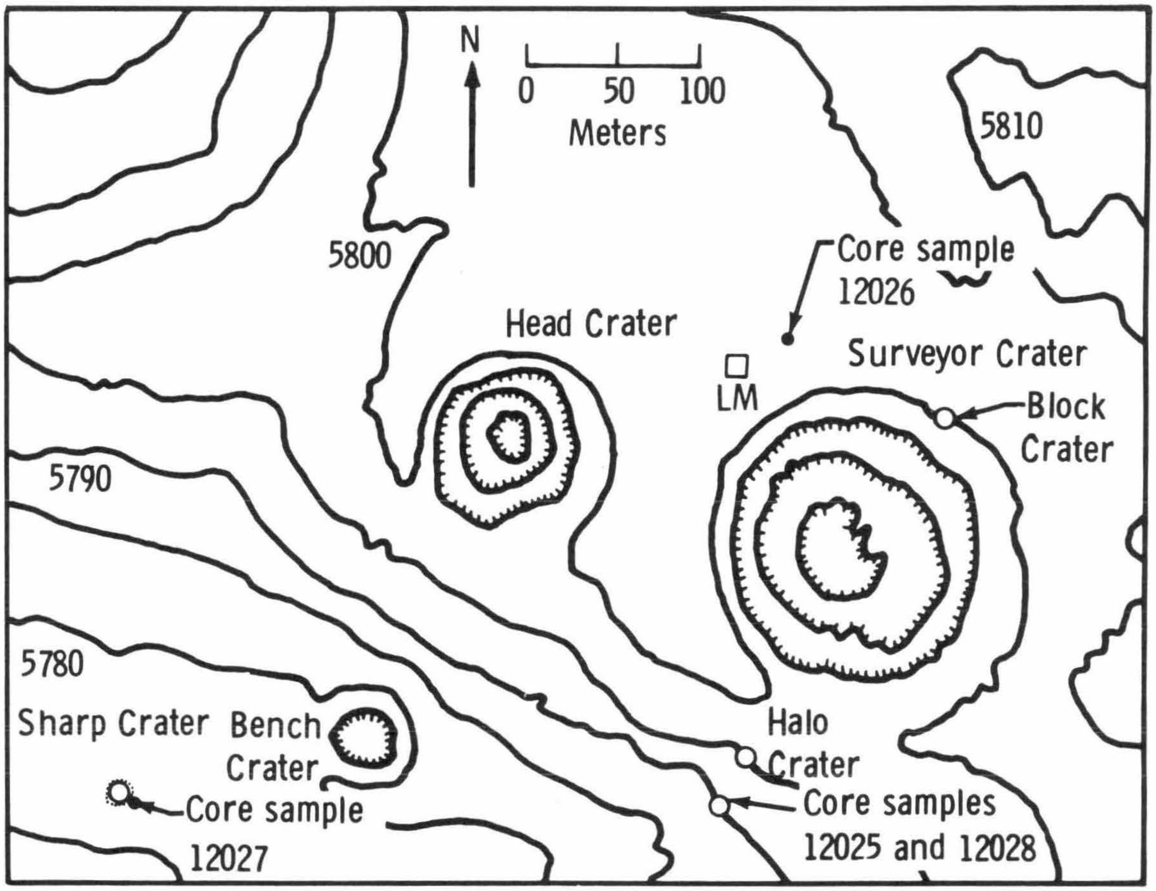


Figure 12-1.- Location of Apollo 12 cores from the Mare Procellarium area.

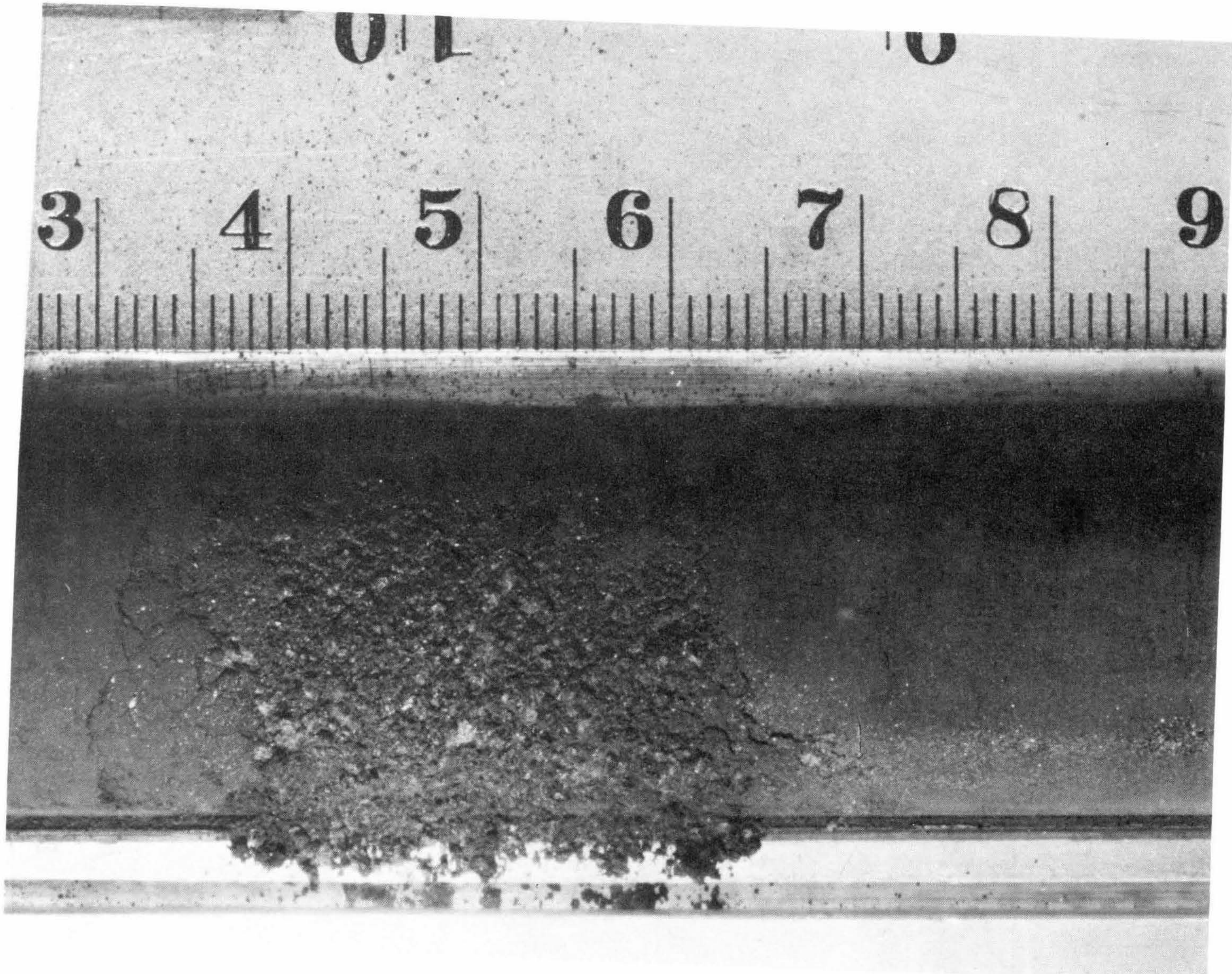
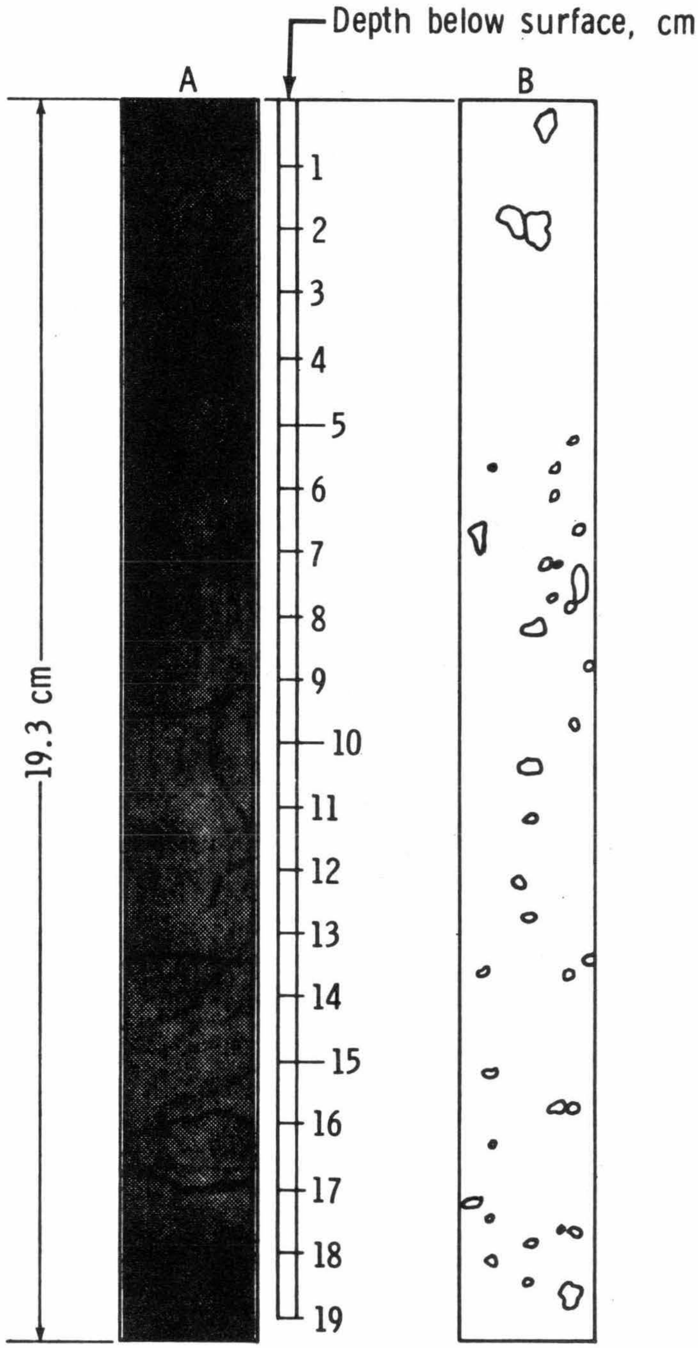


Figure 12-2.- Unit VI of 12028 core tube.



A Core sample before dissection, showing fractures observed after removal of core liner

B Location and orientation of soil particles greater than 1 mm diameter in the half of the core sample dissected

Figure 12-3.- Fracture zones and fragment orientation based on X-radiographs of 12026.

The core is uniformly medium-dark gray (N4-3) to dark gray (10YR4/1)[2] in color and layering is not apparent in the core. However, the number of rock fragments increases abruptly below a transverse fracture at a depth of 5.9 cm. The core was taken close to the rim of Surveyor Crater and appears not to have penetrated the Surveyor Crater ejecta blanket.

Photograph.- See NASA S-69-62760 (postdissection).
References.- See references.

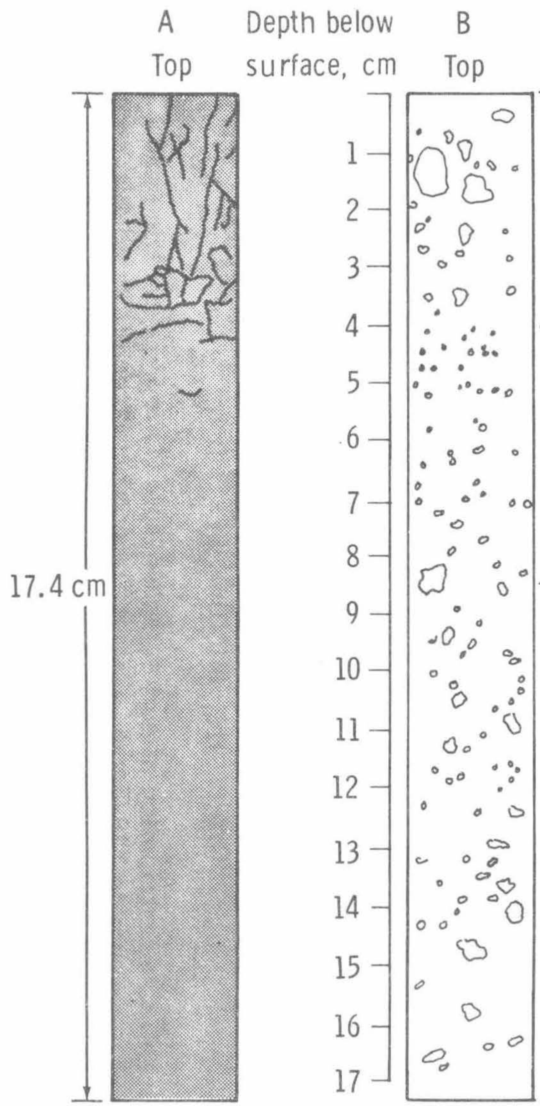
Sample 12027: Sample 12027 was taken during the second EVA period in the bottom of a 20 centimeter-deep trench at the edge of Sharp Crater. The tube was driven to an approximate depth of 37 cm below the lunar surface and contained 17.4 cm of sample. A stereoscopic pair of X-radiographs was taken (Fig. 12-4). In texture, sample 12027 appears similar to sample 12026 (obtained near the LM) and to the thicker layers in sample 12025 and 12028 (double core taken at Halo Crater).

Samples 12025 and 12028 (Double Drive Tube Cores): The third and final core sample was collected during the second EVA period on the rim of a 10 meter-diameter crater south of Halo Crater. The core was collected by joining two drive tubes and driving them into the surface. The upper tube 1, contained 9.5 cm of core, which was designated sample 12025. The lower tube 3, contained 31.6 cm of core, which was designated sample 12028. Unlike sample 12026 and the Apollo 11 cores, the double drive tube core sample has easily recognizable stratigraphy. During LSPET dissection and sampling (Fig. 12-5), 10 morphologic units were identified and numbered sequentially from bottom to top, as I to X. Stratigraphic unit III then was subdivided into four smaller units on the basis of textural breaks. The four subdivisions are labeled A to D, beginning at the bottom. Later study indicates that a total of 16 depositional events may be recorded in the sequence sampled by the double drive tube.

The double drive tube core sample is described in the following section on a unit by unit basis. Unit numbers are the same as those used in the original LSPET report. Depths and thicknesses given for units have not been corrected for compaction resulting from the sampling procedure.

---

[2]*Munsell Book of Color*, Munsell Color Col., Inc., Baltimore, Md.



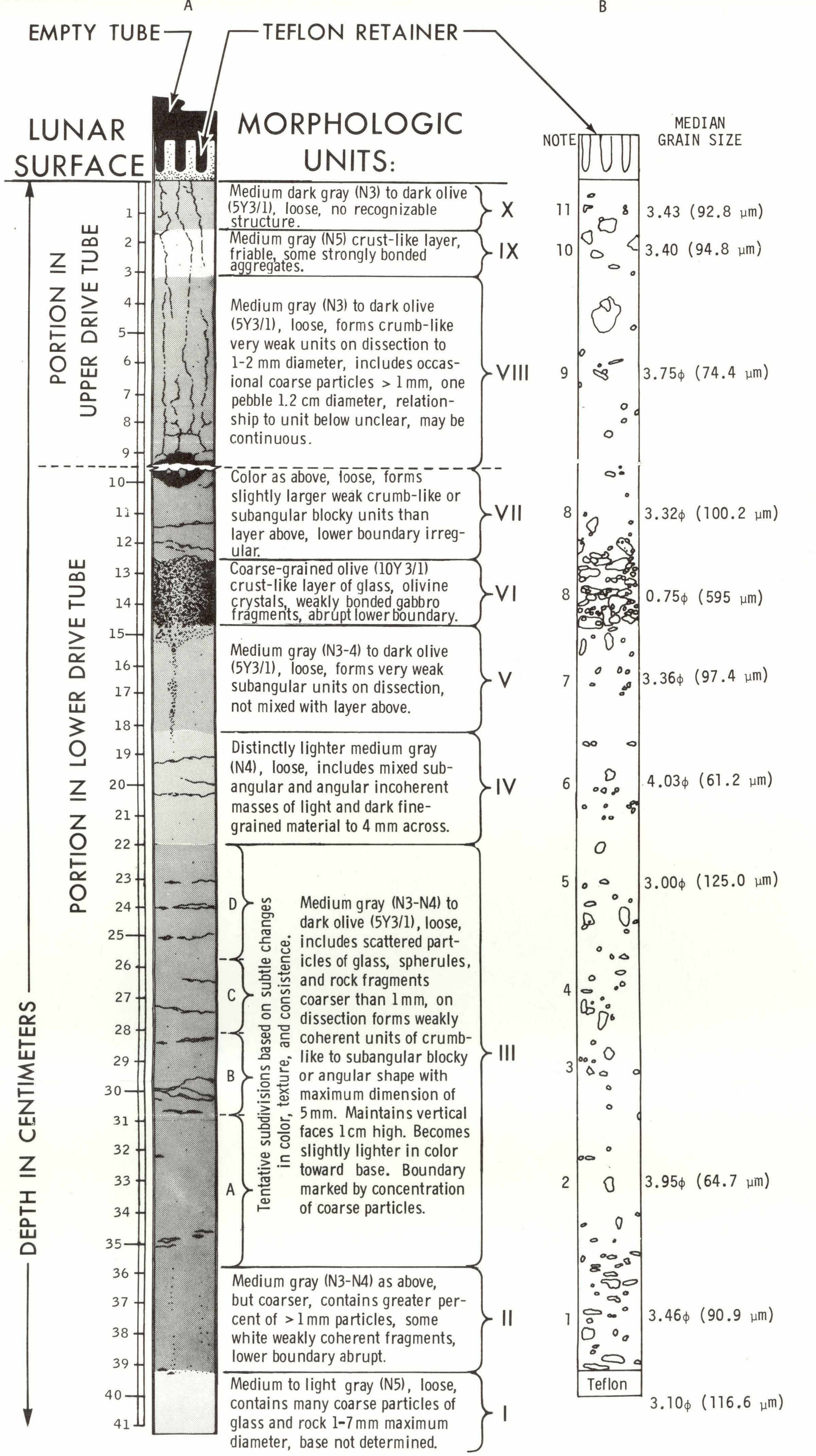
Section disturbed by trenching. It consists of 5 to 10 percent angular particles greater than 1 mm long; probably lithic fragments. The soil is broken into moderately cohesive blocks up to 6 mm long, increasing in size near the base of the disturbed zone. This area was disturbed by digging the trench. It is possible that some of the larger lithic fragments were concentrated in the trench bottom by slump from the walls.

Fine-grained soil with no granule- or pebble-sized particles. This is possibly a layer.

Particles greater than 1 mm long that are 3 to 5 percent angular in a fine-grained matrix.

A Orientation of fractures in the soil (based on X-ray photographs)
B Location of visible fragments in the fine-grained soil (based on X-ray photographs)

Figure 12-4.- Diagram of X-ray photograph of unopened core 12027.



Note: Teflon is tetrafluoroethylene.

A Core sample prior to dissection, showing fractures developed after removal of core liner and color variations indicating stratigraphy

B Location and orientation of soil particles greater than 1 mm diameter in the half of the core tube dissected (Note relationship between stratigraphy and clusters of larger particles.)

Figure 12-5.- Stratigraphy of the Apollo 12 double drive tube core 12025 and 12028.

Note 1.- The soil of unit II is inhomogeneous in color and texture and contains more particles 1 mm or larger in diameter than most units. Generally, the particles are distinctly angular. Several white particles were quite friable and disintegrated when picked up. The soil is slightly coarser than that of the overlying unit.

Note 2.- The soil of unit III-A is similar in color to stratigraphic units above and below but is more uniform in color and has a coarser texture than unit III-B. The soil is weakly cohesive and forms aggregates up to 3 mm in diameter. It contains a few particles 1 mm or larger in diameter, except near the lower contact where a marked concentration of larger particles is found. Some of these coarser particles are light in color and disintegrate when picked up. The particles appear to be feldspathic breccias. Particles of a similar nature also are present in unit IX.

Note 3.- The lower portion of unit III-B is homogeneous in color and texture and weakly cohesive. However, the upper centimeter of the unit contains lighter colored (N5) masses with the same cohesive properties as the surrounding darker colored soil. The noncoherent masses are 1 to 2 mm in diameter and are associated with a slight coarsening of the texture of the soil. The unit contains nine particles 1 mm or larger in diameter. Unit III-B, like some other stratigraphic units in the sequence, is probably a composite and consists of soil deposited by at least two events. The second event resulted in the deposit of a thin layer of light-colored soil, which was disrupted by subsequent micrometeorite reworking as inferred previously for similar features in the Apollo 11 cores.

Note 4.- The lower portion of unit III-C is homogeneous in color and texture. The upper 0.5 cm of the unit contains lighter colored (N5), incohesive masses of soil up to 2 mm in diameter, suggesting that, like unit III-B, unit III-C probably was formed by more than one depositional event. This unit contains a higher density of particles 1 mm or larger in diameter than units III-A and III-B. The particles are distributed uniformly throughout the unit.

Note 5.- The soil forming unit III-D is weakly cohesive and forms aggregates up to 3 mm in diameter, which readily break into subrounded masses 1 mm in diameter when probed. The unit is characterized by faint color mottling throughout, suggesting incomplete mixing during deposition. In texture, the unit is homogeneous except for a concentration of 1 mm and larger particles 1.5 to 3.0 cm below the upper contact.

Note 6.- Unit IV is lighter in color than adjacent stratigraphic units and consists of loose, weakly cohesive soil which formed angular to subangular aggregates up to 4 mm in diameter during sampling. Unit IV contains subrounded masses of lighter colored soil (N5) approximately 1 cm below the upper contact. The masses are up to 1 mm in diameter and have the same cohesive properties as the soil. Texturally, it is similar to unit III-D but is noticeably less cohesive. Particles 1 mm and larger are concentrated between 1.5 and 3.0 cm below the upper contact.

Note 7.- Texturally, unit V is relatively homogeneous, although a slight increase in grain size is apparent toward the upper contact of the unit. There is also a general lightening of the soil color upward. (See NASA Photograph S-69-23733.) A few light-colored patches are present near the base of the unit and toward the top of the unit.

The lower-contact demarcation of unit V is defined well by a color change. Consequently, it is possible to study the irregularities of the contact in some detail. In cross section, the contact is not smooth but consists of a series of wavelike projections of lighter material from unit IV which extend 1 to 2 mm above the general level of the contact into unit V. Several patches of lighter colored material from unit IV are isolated in the darker soil of unit V. Apart from a 1 mm zone at the edges, the contact appears relatively undisturbed by the coring. The waves and projections appearing in cross section at the contact are similar to flame structures found in turbidite sequences, which suggests that they may be the result of drag at the depositional interface as unit V was deposited.

Note 8.- Unit VI is unique in composition and grain size. It consists of angular rock and mineral fragments, many of which approach 1 cm in longest dimension. Many of the grains are roughly oblate or flake shaped. The particles are mostly olivine with smaller proportions of pyroxene, plagioclase, and basaltic rock fragments. Dark-brown glass is present in small amounts. The well defined upper contact and the lack of mixing across this boundary suggest rapid burial, which is consistent with exposure ages.

Note 9.- Units VII and VIII are parts of what may have been a single unit, but which lay across the junction of the two drive tubes. The combined units VII and VIII is the thickest encountered by the core tubes. In color and texture, it appears homogeneous. The soil is weakly cohesive and formed loose aggregates 1 to 2 mm in diameter during LSPET sampling. In general, the soil contains few particles 1 mm or larger in size. However, this unit contained one rock fragment 1.2 cm in diameter, the largest single particle encountered in the core sample. (See NASA photograph S-69-23806.)

Note 10.- Unit IX is markedly lighter in color than stratigraphic units above and below. It contains five angular fragments that are larger than most particles encountered except those in unit VI. Some of these particles are light in color and appear to be feldspathic breccias. The unit is homogeneous in color, but the texture is slightly coarser in the upper most centimeter.

Note 11.- In general, unit X is homogeneous in color and texture but appears slightly coarser grained in the lower 4 mm. The soil is loose and weakly cohesive.

APOLLO 14

The Apollo 14 crew landed on the Fra Mauro formation approximately 180 km from the Ocean of Storms where the Apollo 12 Lunar Module landed some months earlier (LSPET, 1971). This region selected for coring and other lunar activity was composed of much lighter soil than the soil sampled on the earlier missions. The premission plan was to procure three drive tube samples, a triplet, a double and a single. However, the subsurface was more resistant than anticipated, and the soils were less cohesive. Several attempts were made to recover triple cores and double cores at different locations, the crew finally had to settle for a partially filled double drive tube sample, and two singles (Fig. 14-1). Two of the six core tubes taken on the mission were assumed empty by the astronauts and left behind on the Moon. The three cores obtained were poorer in quality than those returned by previous missions. The core sample-depth relationship is presented by Carrier et al. (1972).

The following is a table of the preliminary data for the core samples returned by Apollo 14.

TABLE XIV-1.- PRELIMINARY DATA ON APOLLO 14 CORE TUBE SAMPLES

Core Tube No.	LRL Sample No.	Returned Sample Weight g	Returned Sample Length cm	Bulk Density	Core Tube Depth cm
2045[a]	14211	39.5			13;[b] 64[c]
2044[a]	14210	169.7	31.9	1.75	15;[b] <36[c]
2022	14220	80.7			23
2043[d]	14230	76.0			45

[a]Double core tube.

[b]Depth before final driving.

[c]Crew estimates (no photograph taken).

[d]This drive tube was driven twice: First, on Cone Crater, where some or all of the sample fell out; and, second, at North Triplet Crater during the second attempt at a triple core, where some of the sample fell out.

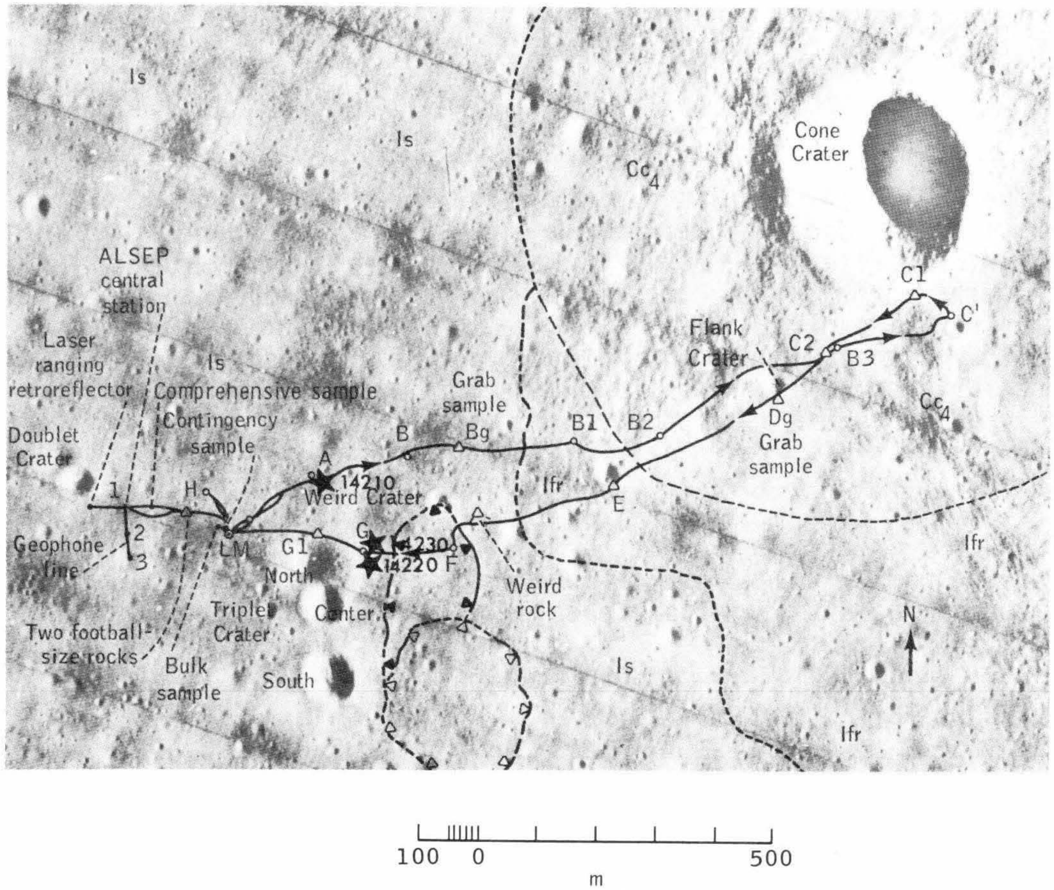


Figure 14-1.- Location of Apollo 14 drive tubes.

X-Radiograph Description

The following report is a preliminary interpretation of the X-radiographs by Heiken.

14210 Lower Tube (Fig. 14-2).

Layering.- There are abrupt textural changes which may define layering. There are possibly five layers (if one counts several other subtle textural changes, there is a total of eight layers).

Grain Size and Particle Shape.- There is a dramatic decrease in grain size from the bottom to the top of the core. Near the base there are 10 percent to 15 percent rock fragments greater than 5 mm long; the largest being 1.2 cm long. Near the top of the core there are only a few particles greater than 2 mm long.

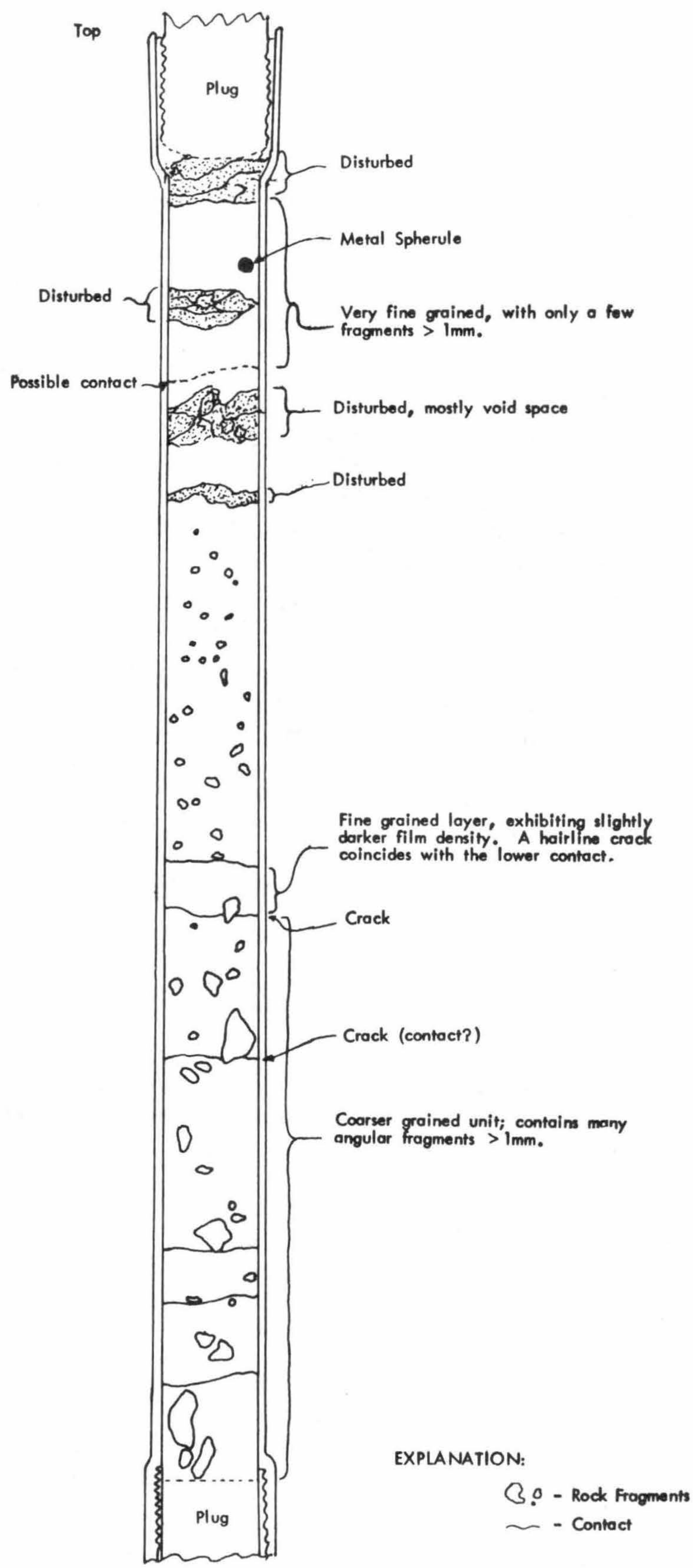


Figure 14-2.- Sketch of X-radiograph of lower 14210.

Most of the fragments are elongate and angular to subangular. 2.2 cm below the liner top is a 3 mm diameter metal sphere.

Disturbance.- The upper 8 cm of core has been disturbed, with three irregular void areas up to 1 cm wide. Below 8 cm, the sample is undisturbed.

When the two parts of the double core were separated, some sample probably fell out of the top of the lower tube. The upper cap did not screw on properly, probably due to soil on the threads, allowing sample to drain out of the upper portion of the core tube. The void at the top allowed several small "slugs" to slide, causing the disturbance and voids in the upper 8 cm portion of the core.

14211 Upper Tube (Fig. 14-3).

Layering.- The lower 4.5 cm of the core consists of fine sand or coarse silt-size soil with about 5 percent particles greater than 2 mm long. The upper 3 cm consists of uniform, moderately well sorted, coarse sand-size particles in a fine-grained matrix. These are the only two textural divisions proposed as layers in this core.

Grain Size and Particle Shape.- The largest rock fragments are 3, 4, and 6 mm long; they range from angular to subrounded.

Disturbance.- None. Both followers are firmly seated. It appears that the bottom was capped successfully before any sample fell out.

14220 (Fig. 14-4).

Layering.- On the basis of textural and film density changes, there are three layers with possibly a thin fourth layer. The two thin layers are fine-grained, with a few large fragments and are slightly darker grey (on the X-ray image).

Grain Size and Particle Shape.- The soil is generally of pebbly fine-sand or coarse-silt size. There are about 20 percent particles greater than 2 mm long, the largest fragment being 1 cm long. Most of the larger fragments are angular to subangular.

Disturbance.- There is no apparent disturbance of the core sample. The soil in the upper 2.2 cm is fractured and broken; probably due to normal surface disturbance by small primary and secondary impacts.

14230 (Fig. 14-5).

This tube was first used at Station C (Cone Crater) as a single

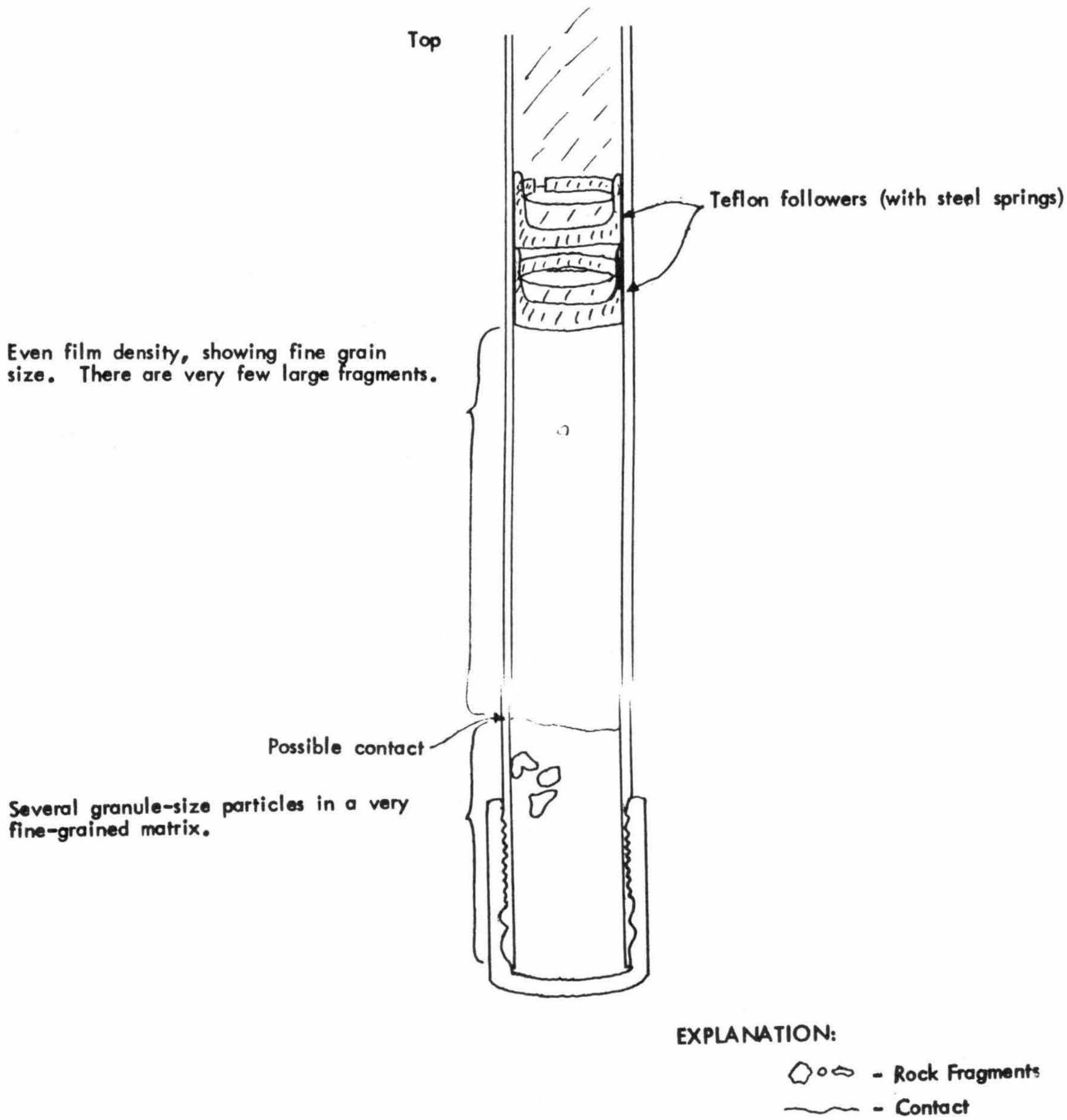


Figure 14-3.- Sketch of X-radiograph of upper 14211.

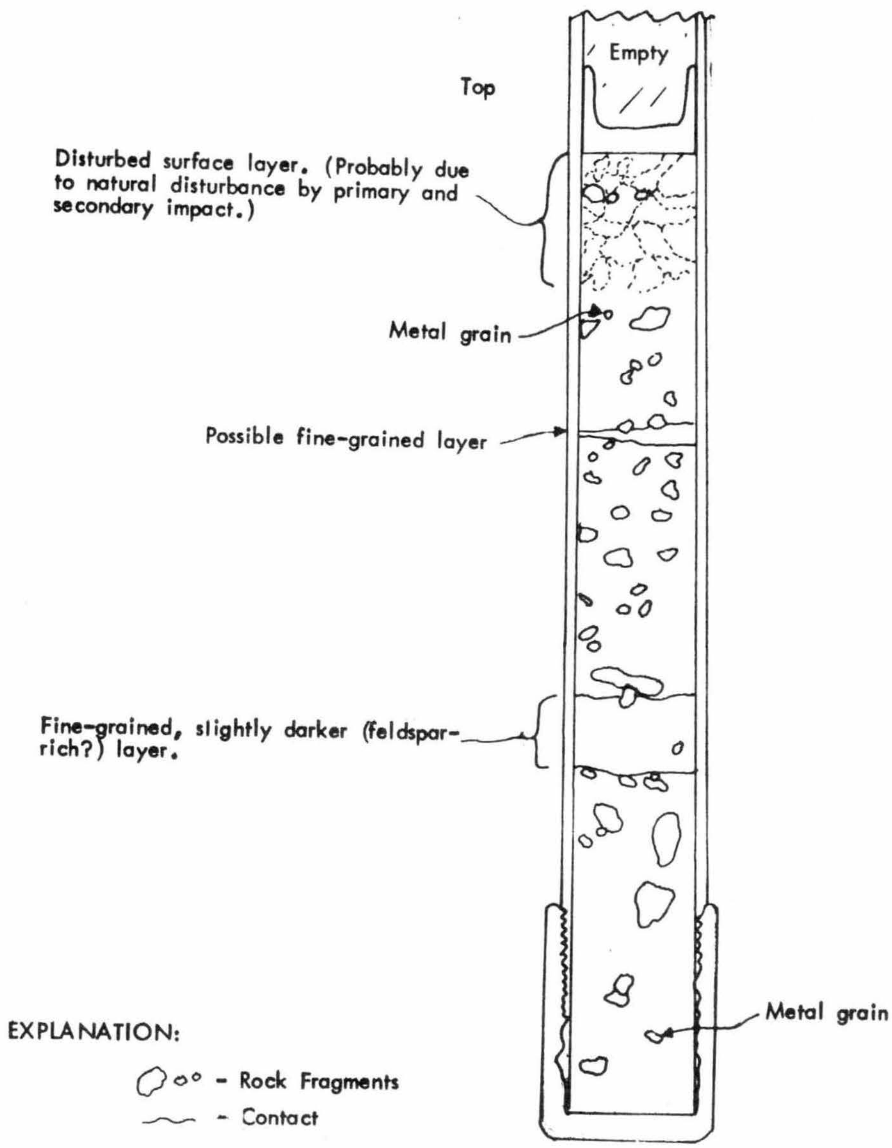


Figure 14-4.- Sketch of X-radiograph of 14220.

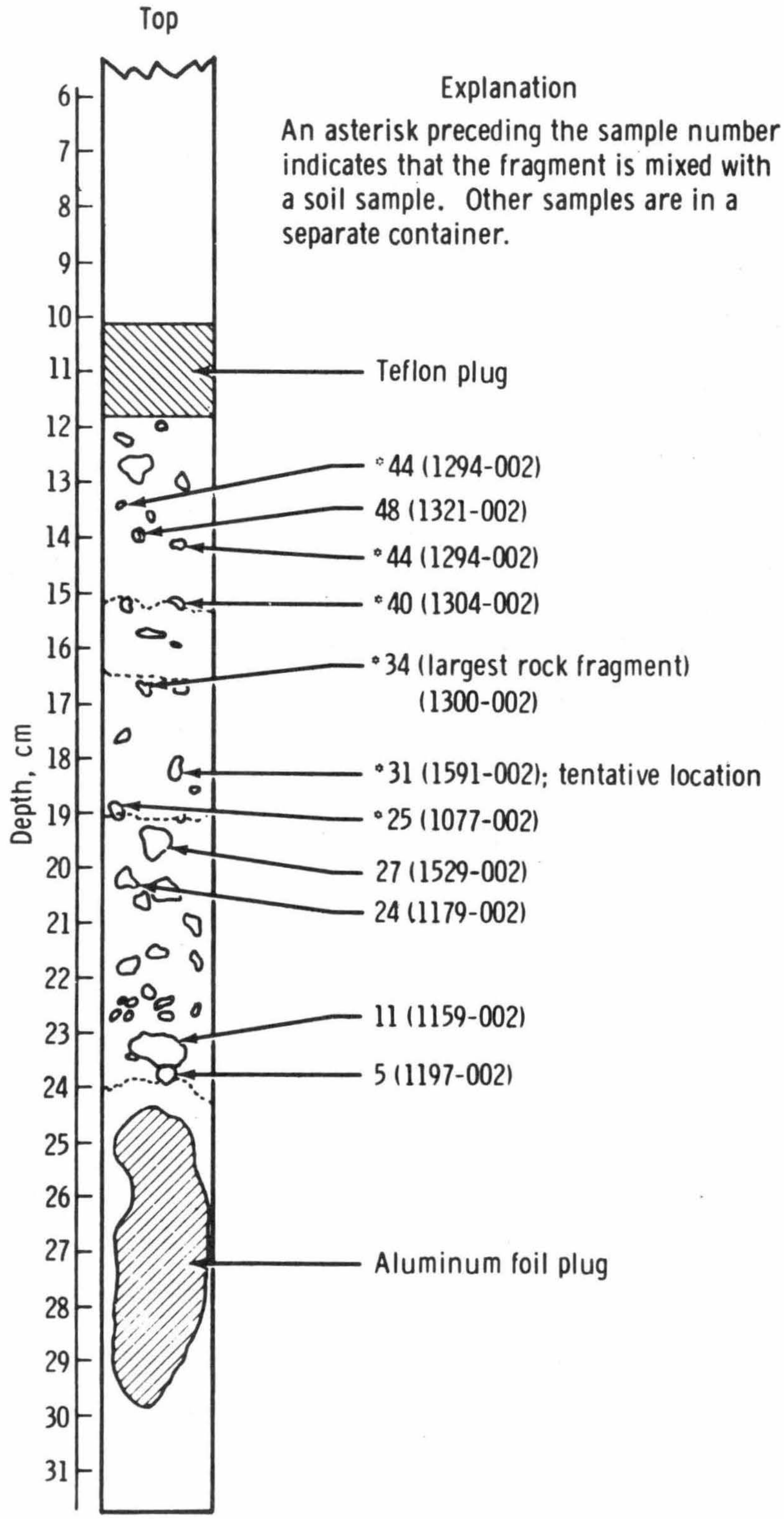


Figure 14-5.- Sketch of X-radiograph of 14230.

core, driven to a depth of 3/4-tube. As the core was removed, the sample fell out. It was reused at Triplet Crater.

Length of Core.- A solid core 12.5 cm long in the center of the tube, with both ends slumped.

Layering.- If the sample has not been homogenized, there is the possible division into two layers on the basis of texture. The lower layer is coarser grained.

Grain Size and Particle Shape.- There are about 15 percent particles greater than 2 mm long in a fine-grained matrix. The larger particles are equant to elongate and subrounded to subangular. The largest rock fragment is 1.2 cm long and 0.5 cm wide.

Disturbance.- The tube has no follower; it fell out on the lunar surface. As a result, the top and bottom, and possibly the whole core, are highly disturbed. The "slug" of soil in the center of the tube may have retained its integrity by sliding as a single unit. On the other hand, it may have broken up, been homogenized, and resettled before sliding into the present position. If the textural change visible in the center is supported by a color change seen after opening the core, then the sample may still be useful for stratigraphic work. The dissection of core 14230 has been reported by Fryxell and Heiken.

Sample 14230 was collected using drive tube 1, (used initially at Station C near Cone Crater) but failed to retain a sample. The tube was reused at Triplet Crater, Station G (Fig. 14-1), in an attempt to obtain a core three drive tube sections long. At that time, the base of drive tybe 1 was driven to a depth of 45 cm greater than the actual length of the core tube (Mitchell et al., 1971). At the time of withdrawal, the sample appeared to have been lost both from the base of the tube and from the upper end (the Teflon follower was lost also when the core tube segments were disassembled and the ends were capped *in situ*). As a result, the sample was not supported at either end during transport from the Moon, and sliding within the tube may have caused much of the severe cracking observed in the sample when the split tube-liner was opened. The sampling locality was documented by the commander's reference to the drive tube by number and by photographs.

Despite the problems that occurred during sample collection, a core 12.5 cm long, weighing 70.7 g, was retained in the drive tube. Because some of the sample was lost from the top of the tube, the uppermost portion of the core did not contain lunar-surface material. Neither does the base of the sample represent material from the maximum depth of 45 cm to which the tube was driven, because (1) an unknown amount of sediment was lost from the tube when it was extracted and (2) 6.47 g of sediment were taken from the base of the tube on February 14, 1971, in the LRL for the biotest prime sample. Plugs of Teflon and of aluminum foil were inserted at the ends of the sample at that time.

Although sample 14230 is the least satisfactory core that has been obtained during any lunar landing mission, it is the first to be dissected and subsampled without the constraints of quarantine conditions. As a result, the greater time and care made possible for this work yielded subsamples providing opportunities for detailed study not possible with subsamples dissected previously.

Examination of X-radiograms of sample 14230 showed slumping of the unsupported ends of the core, severe fracturing and void spaces in the upper one-third of the sample, and two or three probable layers. Particles 2 mm or greater in diameter were estimated to comprise approximately 15 percent of the matrix. Most fragments appeared to be equant to elongated and subangular to subrounded. By examination of several groupings or alignments of coarse particles, it was possible to infer that the sample had not necessarily been homogenized by sliding in the tube and that additional layers might be found during dissection. One large fragment, 1.2 cm long, was visible near the base of the core and was situated such that the long axis was horizontal to that of the core sample.

Three distinct morphologic units and 11 morphologic subdivisions of those units were recognized in sample 14230. The boundaries of these morphologic units were defined on the basis of coincident changes in characteristics such as color, texture, structure, consistency, distribution of coarse particles and alignment of the long axes, and the nature of both coherent and incoherent materials within the units. On these bases, it is evident that the core, although crushed at both ends and fractured more than any other core yet collected, has not been mixed stratigraphically except at the ends.

Except for the lower half of the double core tube collected at Halo Crater on Apollo 12, the core is browner overall, coarser in texture, less cohesive, and more complexly stratified than Apollo 11 and 12 cores. In the upper one-third of the core, fractures that were open the entire diameter of the core defined fragile, blocky structures up to 5 cm or more across. The middle layer is slightly lighter in color, finer in texture, and more cohesive than the adjacent layers (Fig. 14-6; Table XIV-2).

No crustlike or stringly contrasting layers comparable with those of the Apollo 12 double core tube from Halo Crater (layers VI and IX, for example) were observed. Three incoherent ellipsoidal bodies of light gray material, occurring in alignment in morphologic unit IIIA, resemble those first observed in Apollo 11 cores and may be remnants of a thin but distinctive layer. Because of the incoherence and small size (<1 mm), the layers were impossible to separate with the tools available. Other types of material included in the matrix--glass spheres, rock fragments (many of which are lighter gray than the matrix), weakly coherent aggregates resembling the matrix, and small, weakly coherent (~ 1 mm) whitish pellents (most common in morphologic unit III)--were separable from the matrix and superficially resemble features previously observed in other cores. Particles coarser than 0.5 mm frequently were found in alignment, often with the long axes oriented in subhorizontal positions, and were especially useful in providing evidence of depositional surfaces separating morphologic subdivisions (Fig. 14-6).

Bedding planes intersect the core obliquely at several points. Because the tube was driven at an angle, some of these planes actually may have been horizontal at the sampling site. Reorientation of the core to the proper position may be possible through further study of X-ray stereopairs and surface photography. However, not all boundary planes are parallel. Therefore, not all depositional surfaces were flat or sedimentary units of even thickness. A systematic morphologic description of the core, with a listing of subsamples removed from each recognized unit, is contained in Table XIV-2. Figure 14-7 shows the subsampling of 14230.

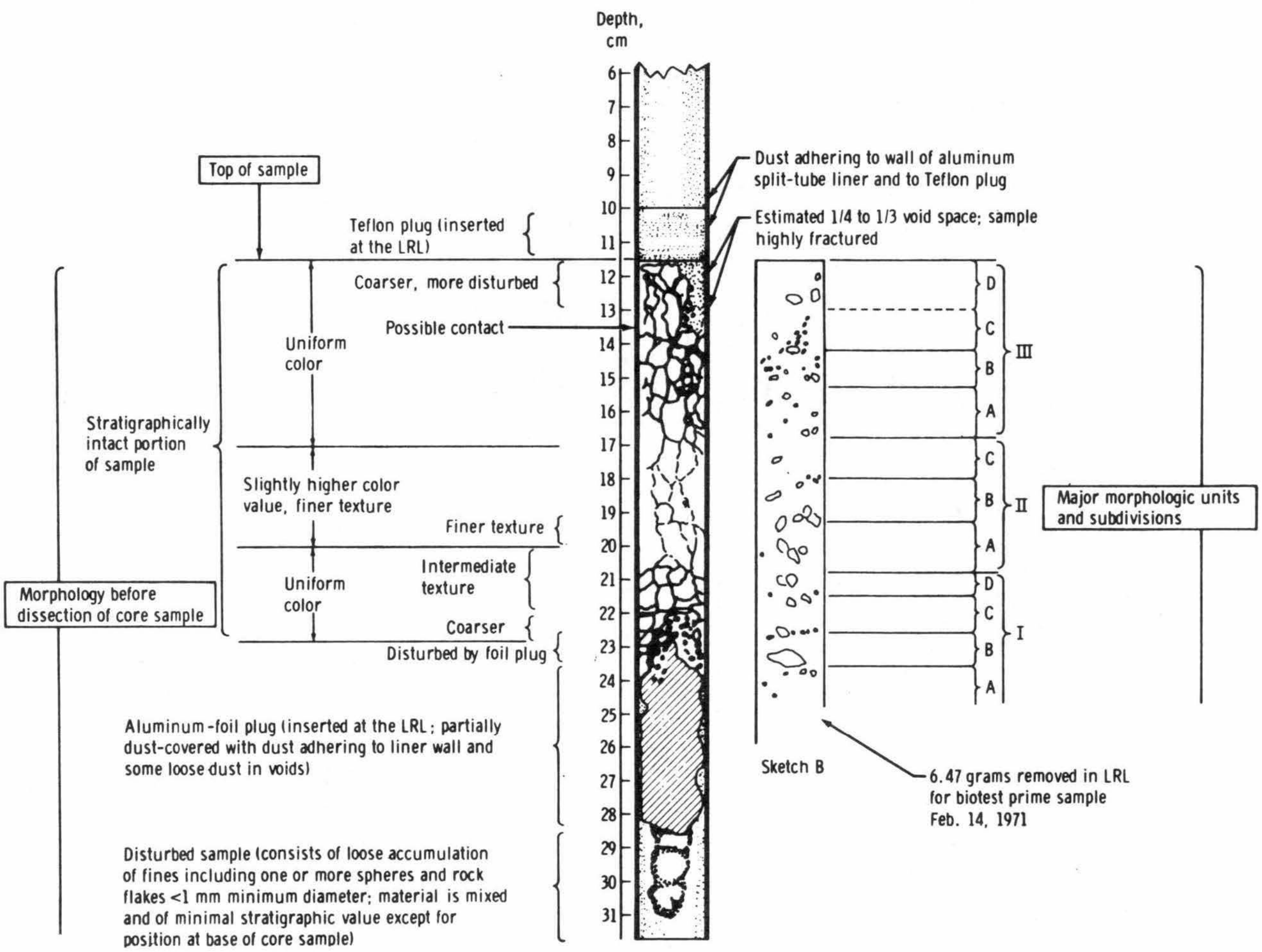


Figure 14-6.- Drawing of core sample 14230. Relative positions of morphologic units I to III and the respective subdivisions are shown.

TABLE XIV-2.- MORPHOLOGIC DESCRIPTION OF SAMPLE 14230

Color	Texture	Structure	Consistency	Special features	Morphologic subunits	Nature of boundary
				Unit III[a]		
Dark grayish-brown (10YR 4/2)	Matrix of fine to very fine sand and silt	Distinct, fragile prismatic to subangular, blocky aggregates, 2 to 5 mm across, breaking to blocks approximately 2 mm in diameter to single grains	Loose to very weakly coherent; reforms fragile clumps less than 1 mm in diameter	Unit is fractured throughout with open cracks penetrating entire diameter of core; includes coarse fragments to 5 mm in diameter, grouping of alined incoherent ellipsoidal light gray inclusions less than 1 mm in diameter, scattered and weakly coherent round to subrounded white inclusions (aggregates?), and weakly coherent subangular aggregates same color as matrix.	IIID: 11.6 to 13.0 cm; severely disturbed; estimated 1/4 to 1/3 void space; "fluffy" behavior; contains weakly coherent white inclusions and piece of ropy glass (gray, curved, 5 by 1.2 mm); see subsamples 14230,51 to to 14230,54. IIIC: 13.0 to 14.2-14.3 cm; very fractured; loose; coarser texture with more visible sand grains than IIIB; some void space at edge of tube; contains subrounded whitish inclusions to 0.5 mm in diameter; see subsamples 14230,46 to 14230,50. IIIB: 14.2-14.3 to 15.3 cm; fractured throughout; cross-fracture at top coincides with alined coarse grains, hence, probably is a bedding plane; slightly more cohesive than IIIA; see subsamples 14230,42 to 14230,45. IIIA: 15.3 to 16.7-17.1 cm; more fractured and coarser than IIC; less cohesive; contains visible, fine sand grains, light gray incoherent inclusions, and aggregates same color as matrix; see subsamples 14230,36 to 14230,41.	Contact recognized on basis of color (slightly lower value than II), texture (finer below), structure (less fractured below), consistency (more coherent below), and coincidence of coarse particles with long axes alined with contact; plane of contact crosses core obliquely as an open fracture
				Unit II[b]		
Dark grayish-brown (10YR 4/2 to 5/2)	Matrix of silt and smaller particles with few visible individual grains	Distinct, fragile, prismatic to subangular, blocky aggregates, 5 to 8 mm across, breaking to angular or subangular blocks 1.5 to 2 mm in diameter	Weakly coherent; reforms fragile crumblike clumps to 1.5 mm in diameter	Unit is most coherent portion of core; contains angular to subangular coarse fragments to 5 mm in maximum diameter, some lighter in color than matrix, and weakly coherent aggregate same color as matrix, 2.0 by 2.5 mm	IIC: 16.7-17.1 to 18.0 cm; abrupt decrease in fracture size, frequency, and texture, and increase in coherence compared with IIIA; contains subangular fragments to a maximum dimension of 4 mm; see subsamples 14230,32 to 14230,35. IIB: 18.0 to 19.0-19.8 cm; slightly lower color value than adjacent subunits; few more visible sand grains; separates by cross-fracture from IIA; see subsamples 14230,25 to 14230,31. IIA: 19.0-19.8 to 20.0-20.8 cm; more coherent and less separation along fractures than adjacent subunits; finer texture than IIB or ID; boundaries cross core obliquely but are approximately parallel to each other; see subsamples 14230,20 to 14230,24.	Contact recognized on basis of color (slightly higher value than I), texture (coarser below), consistency (more coherent than below), structure (prismatic in contrast to subangular blocky with some open fractures below), cross-fracture coinciding with other changes; plane of contact crosses core obliquely but not parallel to top of II
				Unit I[c]		
Dark grayish-brown (10YR 4/2)	Matrix of very fine sand and silt	Distinct, fragile, subangular, blocky aggregates, 3 to 5-mm maximum dimension; breaking to smaller blocks or single grains; highly fractured at base	Loose to very weakly coherent; reforms clumps 1 mm or smaller in diameter	Base was disturbed by sample removal and aluminum foil plug inserted at the LRL; contains subangular to subrounded coarse fragments to a minimum diameter of 5 mm (most fragments smaller than 3 mm, most lighter gray than matrix); also contains occasional weakly coherent whitish inclusions smaller than 0.2 mm in diameter.	ID: 20.0-20.8 to 21.5 cm; texture of matrix intermediate compared with adjacent units; contains subangular fragments to 5 mm in diameter, lighter gray than matrix, occasional whitish inclusions, one black sphere observed; see subsamples 14230,15 to 14230,19. IC: 21.5 to 22.6 cm; boundaries marked by alinements of coarse fragments and transverse bedding-plane fracture at base; see subsamples 14230,10 and 14230,12 to 14230,14. IB: 22.6 to 23.6 cm; partially disturbed; contains large fragment 1.4 by 0.9-0.6 cm; see subsamples 14230,4 to 14230,9 and 14230,11 (rock fragment). IA: 23.6 to 24.0+ cm; disturbed and loose at base of core but otherwise disaggregated and mixed; see subsamples 14230,2 to 14230,3 and 14230,1 (fines swept from interior of upper half of split-tube liner).	Not applicable

[a] Depth of 11.6 to 16.7-17.1 cm below top of drive-tube liner.

[b] Depth of 16.7-17.1 to 20.0-20.8 cm below top of drive-tube liner.

[c] Depth of 20.0-20.8 to 24.0+ cm below top of drive-tube liner (6.47 grams removed in LRL for biotest prime sample on Feb. 14, 1971).

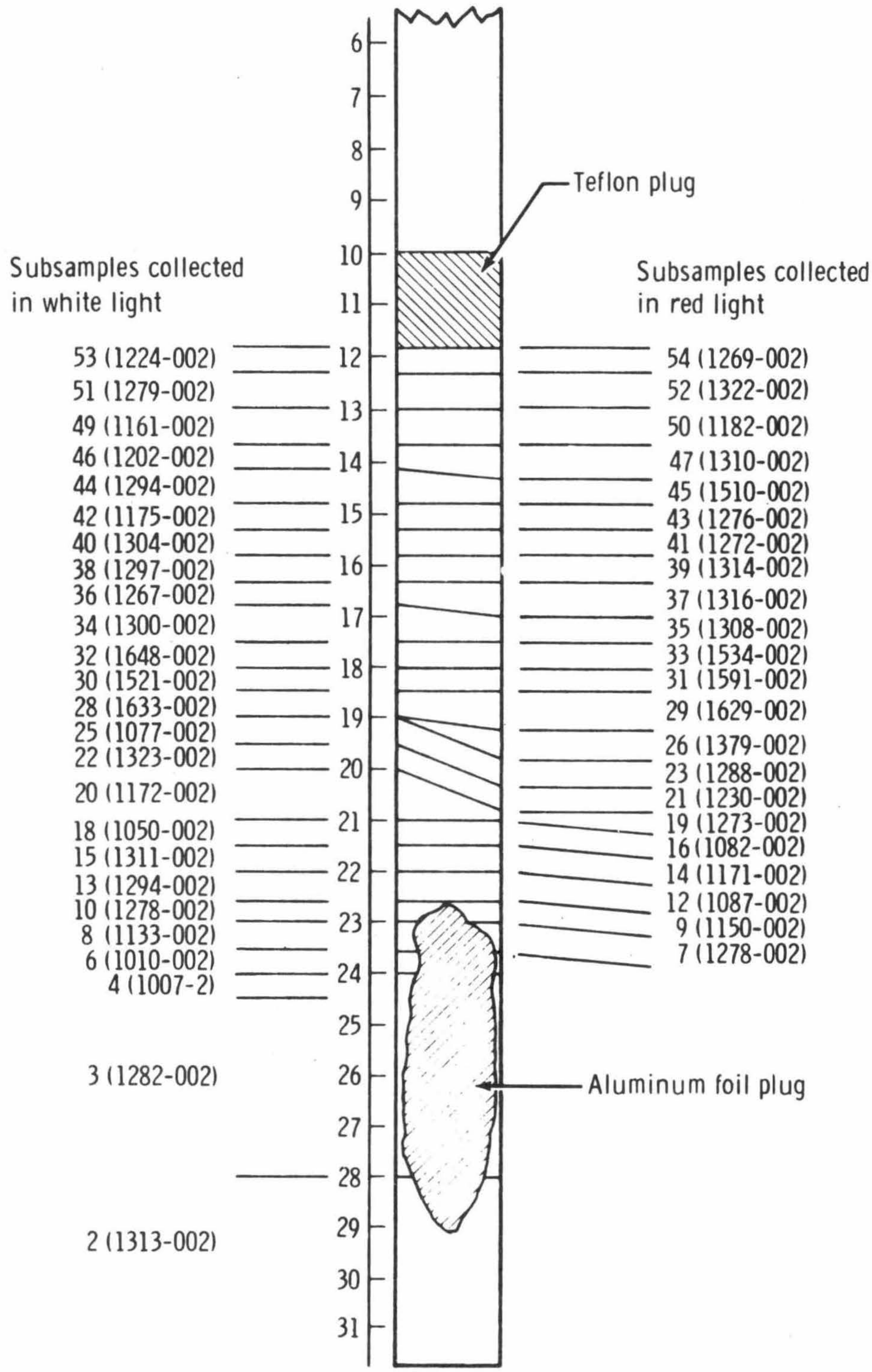


Figure 14-7.- Subsampling of sample 14230. Numbers in parentheses indicate container number.

APOLLO 15

CORE TUBES COLLECTED BY THE APOLLO 15 MISSION

A substantial portion of the soil brought back by the crew of Apollo 15 from the Rima Hadley landing site (LSPET, 1973) was in the form of undisturbed cores of the regolith. Five drive tubes, with a total sample weight of 2708.2 g were collected (Fig. 15-1)

After experiencing difficulty in extracting the drill string and uncoupling it, and spending considerable time and effort, the Apollo 15 astronauts collected a deep (2.65 m) drill core at the Apollo Lunar Surface Experiment Package (ALSEP) site on the mare surface (LRL - 15001 - 15006). The complete drill core (six sections) contained a total sample weight of 1333.2 g.

Drive Tube Samples

One drive tube sample was recovered on each of the Apollo 15 EVA; a double on EVA 1, a single on EVA 2 and another double on EVA 3.

The first core was taken at Station 2 on the traverse (Swann et al., 1971) on the rim of a 10 m crater between Elbow and St. George at the Front (LRL - 15008 and 15007). The double core was pushed into the lunar surface to the depth of a single core and driven to full depth with 35 hammer blows (Table XV-1). The second core was taken at Station 6 inside the rim of a 10 m crater approximately 500 m east of Spur, also at the Front (15009). That single core was pushed to full depth and no hammering was necessary. The third core was recovered at Station 9A at the edge of Hadley Rille, roughly 200 m west of Scarp. That double tube was pushed to a depth of only 2/3 of a single tube and approximately 50 hammer blows were required to drive it to full depth. The additional driving effort was undoubtedly due to a higher relative density at this location (the ground surface was observed to heave during driving) as well as many coarse rock fragments in the soil matrix.

X-Radiograph description

A detailed description of the core samples based on X-radiographs has been made by LSPET (1972) (Fig. 15-2, Fig. 15-3). Considerable stratigraphy has been noted and careful study of the drive tube samples should be most enlightening. The large rock fragment (approximately 4.8×2.6×2.2 cm) located at a depth of roughly 55 to 60 cm should be of particular interest.

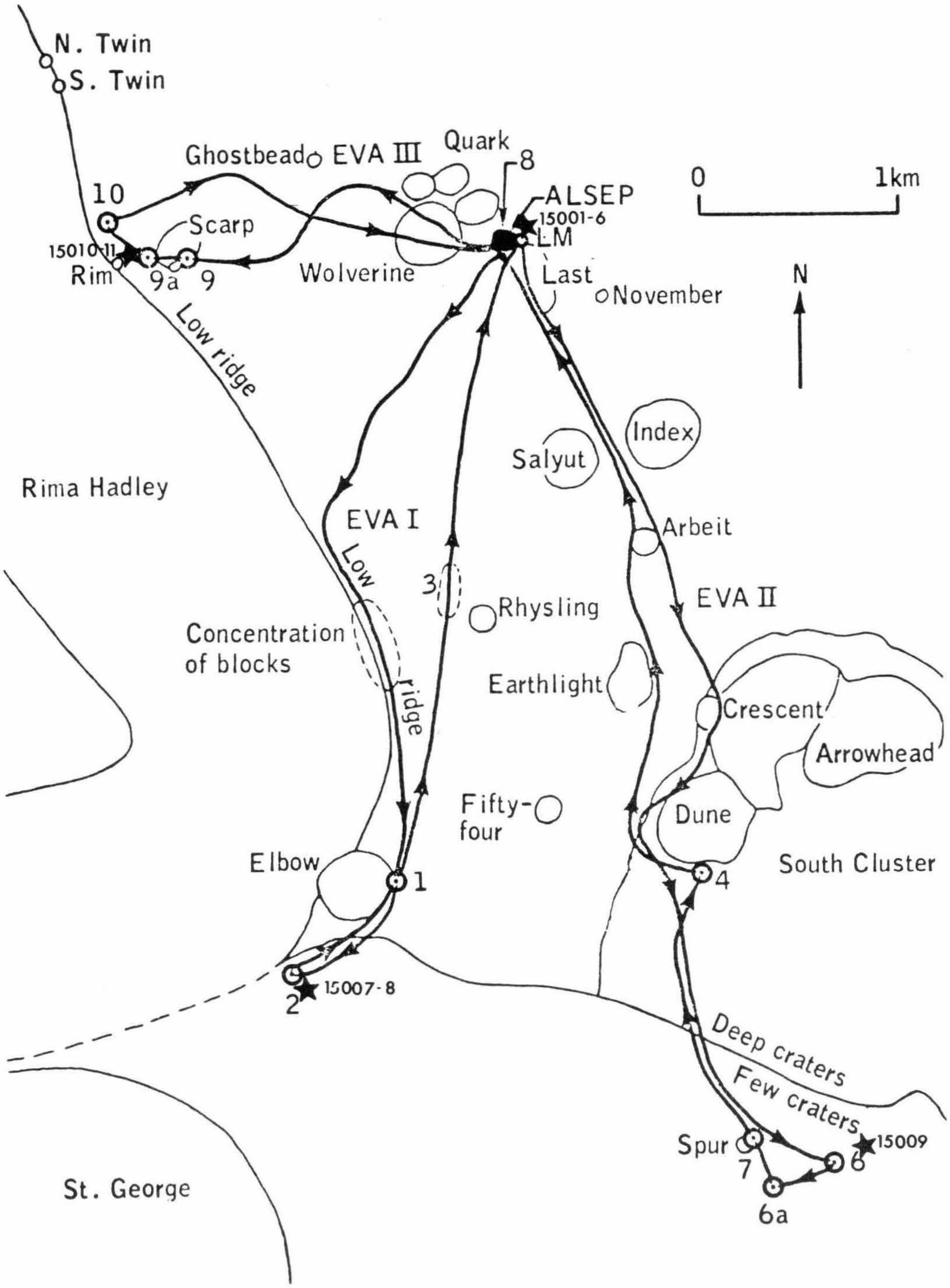


Figure 15-1.- Location of Apollo 15 drill stems and drive tubes.

TABLE XV-1.- PRELIMINARY DATA ON APOLLO 15 CORE SAMPLES

Serial no.	Sample no.	Station	Weight, g	Length, cm	Bulk density, g/cc	Tube depth (pushed), cm	Total depth (pushed and driven), cm	Hammer blows, no.	Core recovery, percent
Drive tube (4.13 cm inside diameter)									
EVA-1									
[a]2003	15008	2	510.1	28±1	1.36±0.05	34.6	70.1	35	88 to 93
[a]2010	15007		768.7	[b]33.9 to 34.9	1.64 to 1.69				
EVA-2									
2007	15009	6	622.0	[c]36.2 to 34.9	1.35	34.6	34.6	0	100 to 105
EVA-3									
[a]2009	15011	9A	660.7	29.2±0.5	1.69±0.03	22.4	67.6	~50	91 to 96
[a]2014	15010		740.4	[b]32.9 to 34.9	1.79 to 1.91				
Drill stem (2.04 cm inside diameter)									
022 (top)	15006	8	210.6	32.9 to 39.9	1.62 to 1.96	[d]~236			100 to 102
023	15005		239.1	39.9	1.84				
011	15004		227.9	39.9	1.75				
020	15003		223.0	39.9	1.79				
010	15002		210.1	39.9	1.62				
027 (bottom)	15001		232.8	[e]33.2±0.5 by 42.5	215±0.03				

[a]Double.

[b]Sample either fell out of top of lower half of tube or was compressed when keeper was inserted.

[c]Nominal length is 34.9 cm; keeper slipped out of position.

[d]Drilled full depth.

[e]Sample fell out of the bottom of the drill stem.

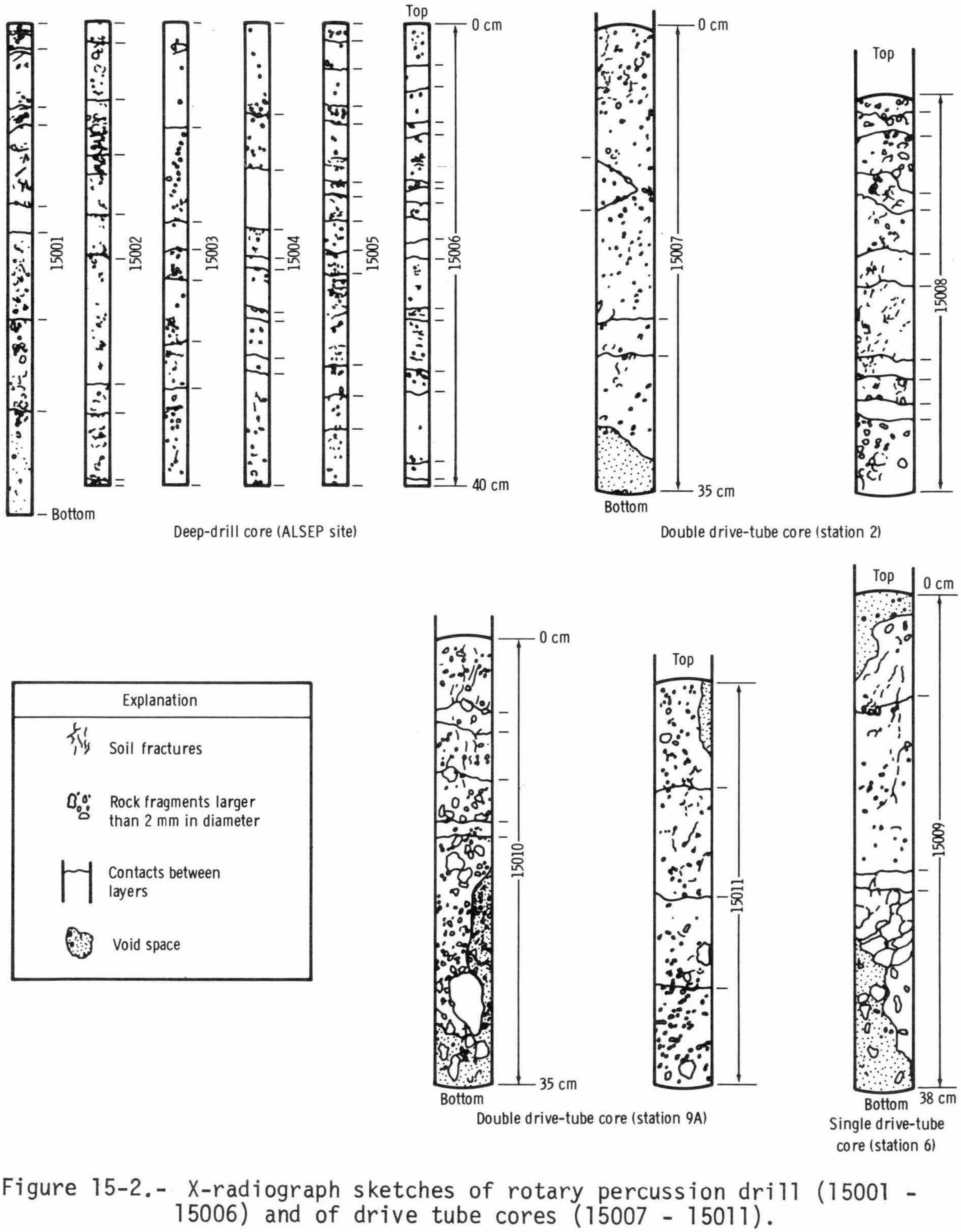
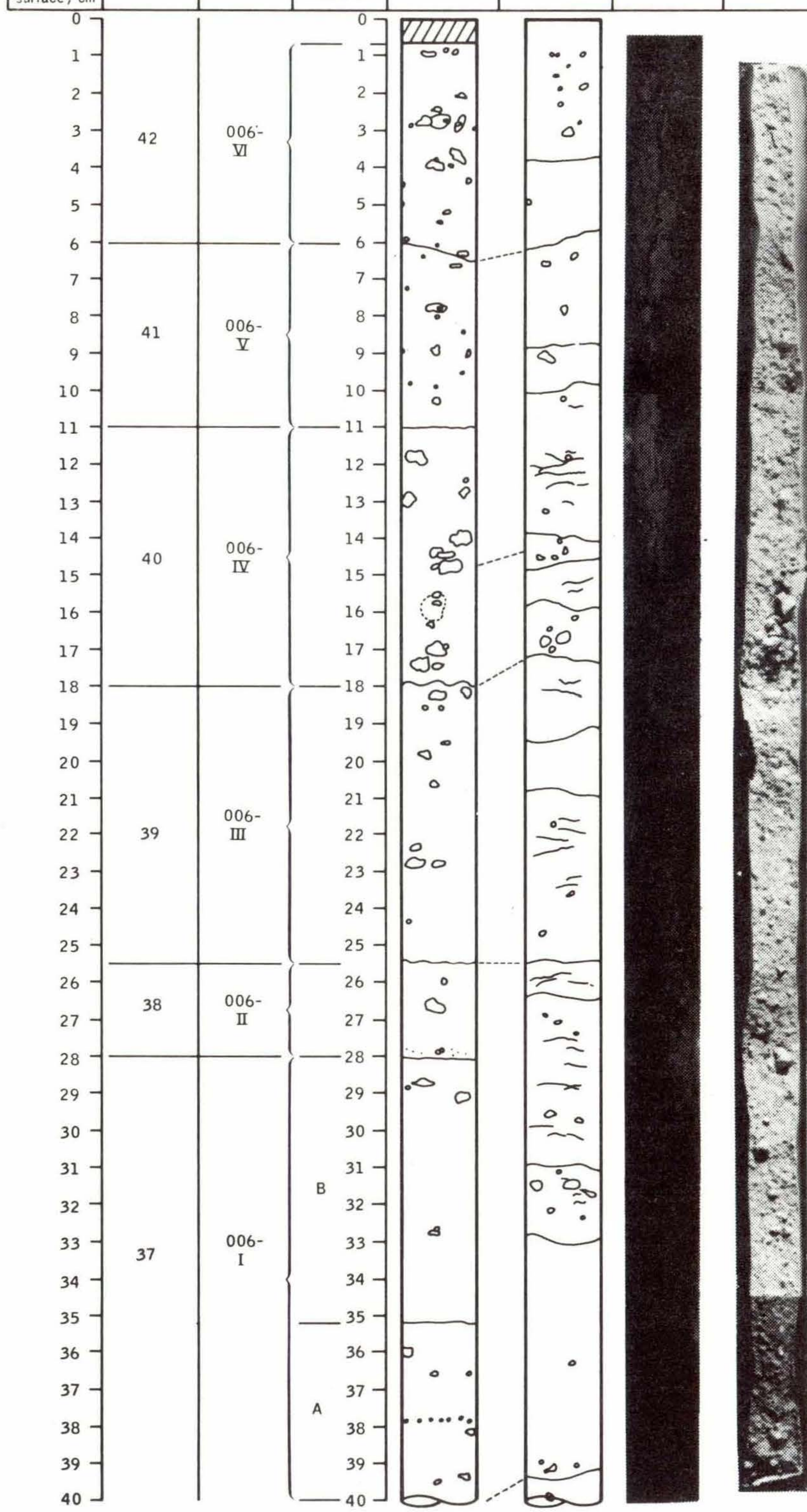


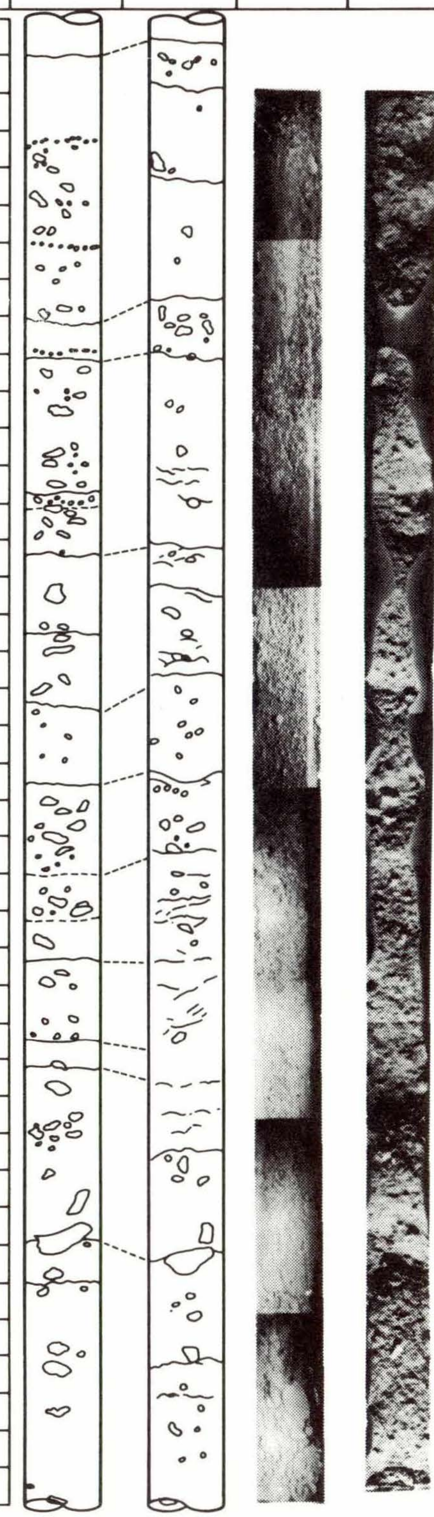
Figure 15-2.- X-radiograph sketches of rotary percussion drill (15001 - 15006) and of drive tube cores (15007 - 15011).



Permanent unit designations	Temporary unit designations	**Color	Texture	Structure	Composition of larger rock fragments	Subunits
42	006-VI	10 YR 3/1 (Very dark grey)	Fine sand-bearing silt-size soil. Contains about 1-3% particles greater than 1 mm in diameter. Poorly sorted. Coarser than Unit V.	Subangular to angular blocky structures, 3-4 mm long. Upper 2.5 cm has been somewhat disrupted by the plug. There are some 1-2 mm long cohesive aggregates from 4-5 cm below the top of the core.	1. Black or dark brown glass fragments and spheres, generally less than 1 mm in diameter. 2. Medium to light grey, subrounded to subangular (breccia?) fragments. 3. Subrounded to subangular, white (anorthosite?) fragments.	None
41	006-V	10 YR 3/1-4/1 (Dark grey to very dark grey)	Sand-bearing, silt-size soil. Only a trace of particles greater than 1.mm in diameter.	Less coherent than Units VI and IV. Weak, subangular blocky structures, 3-5 mm long.	1. Black to dark brown glass spheres and fragments. 2. Light grey to grey (breccia?) fragments. 3. White (anorthosite?) fragments.	None
40	006-IV	10 YR 4/1 (Dark grey)	Sand-bearing silt-size to silt-size soil; poorly sorted. Trace to 3% particles greater than 1 mm in diameter.	Weakly coherent with irregular weak prismatic (3 x 10 mm) structures. Some light grey cohesive aggregate (clods).	1. Dark brown to black glass agglutinates and fragments (some are vesicular). 2. Light to dark grey (breccia?) fragments. 3. White (anorthositic?) rock fragments.	None
39	006-III	10 YR 5/1 (Grey)	Silt-size soil; poorly sorted. Trace to 5% particles greater than 1 mm in diameter.	Weak, subangular blocky to prismatic structures (2-7 mm long) strong tendency to form slabs along wall of open core. 3 to 10% of the soil consists of lighter grey, irregular, blocky patches of soil. These "patches" have nearly the same coherence as the surrounding darker grey soil.	1. Light grey to grey breccia fragments (subrounded). 2. Black to dark brown glass fragments and spheres. 3. Fragile, powdery white fragments; possibly anorthosite. 4. Green glass spheres at 24.5 cm below the top of the core.	None
38	006-II	10 YR 5/1 (Grey)	Sand-bearing silt-size soil; very poorly sorted. 0 to 5% (near base) particles greater than 1 mm in diameter; may be graded.	Subangular, blocky structures, 1-5 mm long. Weakly coherent.	1. Fine sand size to 2 mm white (anorthositic?) fragments. 2. Light grey (breccia?) fragments. 3. Trace of black glass fragment.	None
37	006-I (B, A)	10 YR 4/1-5/1 (Grey to dark grey) for Subunit B 10 YR 5/1 (Grey) for Subunit A	Sand-bearing silt-size soil; 0 to 2% particles greater than 1 mm long. (Very fine grained).	Weakly coherent, subangular, blocky structures (less than 2 mm in diameter) Subunit B is less coherent than Subunit A. Some 1-2 mm diameter cohesive aggregates (clods).	1. Dark brown to black glass fragments and droplets. 2. Light grey, subangular (breccia?) fragments. 3. White (anorthositic?) fragments.	B. Less coherent, darker grey. A. More coherent, lighter grey.

*The individual sample locations are based on this scale.
**Munsell Color Co., Inc., Munsell Soil Color Charts, 1954 ed., Baltimore, Md.

Figure 15-3.- Description of the Apollo 15 drill core.

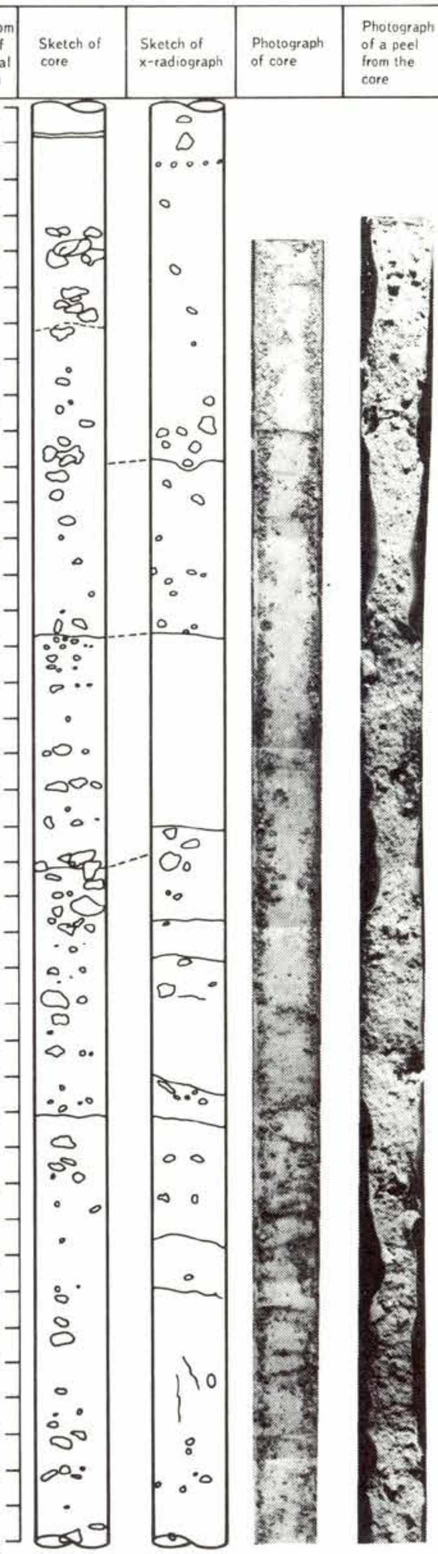


Permanent unit designations	Temporary unit designations	**Color	Texture	Structure	Composition of larger rock fragments	Subunits
37	006-I-A (Cont)	See previous page for description of unit.				
36	005-VIII	10 YR 5/1-6/1 grey	Sandy silt-size soil	Forms coarse friable aggregates. Slumped along edges.	Subunit 4 has a lense of small white and grey soil aggregates. Some grey microbreccia.	None
35	005-VII	10 YR 4/1-4/2 dark grey to dark greyish brown	Silt-size; very uniform. Some sand-size particles at base; may be graded.	Less cohesive than the units above; few aggregates.	—	None
34	005-VI	10 YR 5/1 grey	Fine sand size to silt size; containing 5-10% coarse sand to granule-size particles.	Slumps along edge. Soil breaks into loosely coherent aggregates.	Coarser fragments appear to be mostly grey to white microbreccias.	C. Contains white aggregates (See textural description). B. Lens of granule-size rock fragments and abundant white, friable aggregates. A. Similar to Subunit C.
33	005-V	10 YR 4/1 (dark grey) near the top; grades down to 10 YR 5/1-5/2 (grey to greyish brown)	Silt-size soil with 2-5% coarse sand or granule size particles.	Consist of coherent aggregates; most are the same color as the matrix, but some are lighter. Probably a coherent layer broken by the drill.	Light grey microbreccias and crystal fragments.	G. Slightly finer grained than the over and underlying units. F. Slightly lighter color than the over and underlying units. E. Abundant white or light grey coherent aggregates 0.S.-1.0 mm long. D. Coarser than B. Contains abundant coherent aggregates which are the same color and texture at the matrix. C. Lens containing about 10% particles > 1 mm. B. Finer grained than C. A. Slightly darker than Subunit B.
32	005-IV	10 YR 4/1 (dark grey)	15% coarse sand to granule-size particles in silty matrix.	—	—	None
31	005-III	10 YR 5/1 (grey) near the top, grading down to 10 YR 6/1 (grey) near the base.	10-20% particles > 2 mm in a silt-size matrix.	Forms cohesive aggregates (clods). This was probably a very cohesive layer; broken up by the drilling.	Microbreccia fragments in coarse fraction.	C. Contains a Lens of coarse-sand and granule-size particles. B. Large microbreccia fragments. A. Fractured unit; lighter than Subunit B.

*The individual sample locations are based on this scale.

**Munsell Color Co., Inc., Munsell Soil Color Charts, 1954 ed., Baltimore, Md.

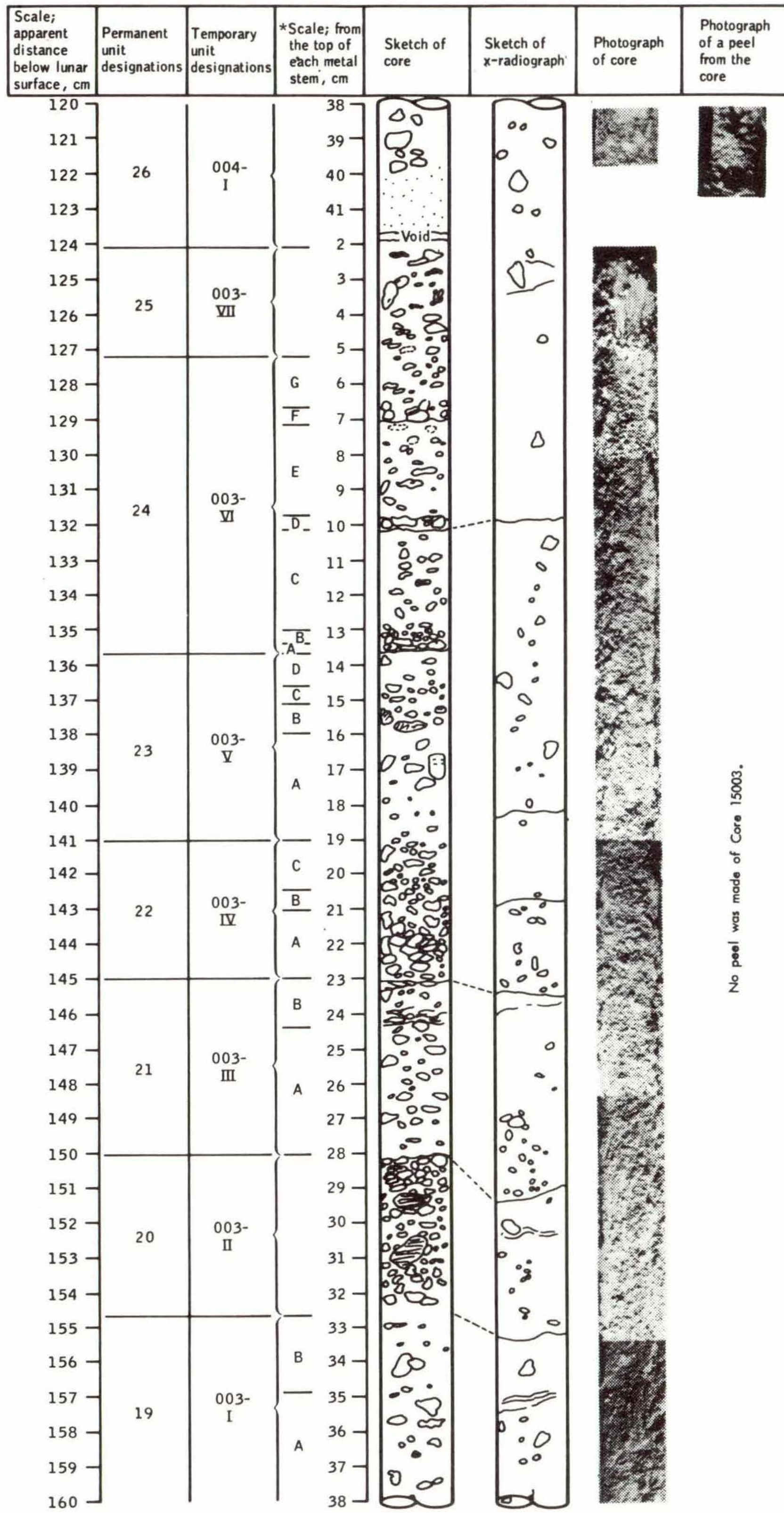
Figure 15-3.- Description of the Apollo 15 drill core (continued).



Scale; apparent distance below lunar surface, cm	Permanent unit designations	Temporary unit designations	*Scale; from the top of each metal stem, cm	**Color	Texture	Structure	Composition of larger rock fragments	Subunits
80–81	31	005-II	40–41	10 YR 5/2 greyish brown	Coarse sandy soil.	Uniform, unbroken layer.	Abundant brown glass droplets and agglutinates.	None
81–83	30	005-I	41–43	10 YR 6/1 grey	Granule and coarse sand bearing silt size soil.	Cohesive; forming small clumps up to 5 mm long.	(1) abundant microbreccia fragments	None
83–95	29	004-IV	43, 2–13	10 YR 5/1 to 10 YR 5/1 grey	Poorly sorted granule-bearing silt-size soil. Coarser fragments vary from 10% near the top to 0 near the base of the bed; it is reversely graded.	Moderate slumping; forming 4-5-mm long clumps.	1. Light grey to dark grey breccias; some with dark brown glass coatings. 2. Clastic rocks consisting of green glass spheres and isolated spheres. 3. Trace of small, powdery white "anorthositic" fragments.	None
95–101	28	004-III	13–19	10 YR 5/2 greyish brown (patches of lighter grey soil)	0-5% granule to coarse sand-size particles in silt-size soil.	Moderate slumping; forming 4-5-mm long clumps.	1. White, powdery "anorthosite" fragments. 2. Light grey breccia fragments; a few have dark grey-brown glass coatings. 3. White aggregates of "clods".	None
101–108	27	004-II	19–26	10 YR 5/1 grey	Coarse sand to granule-bearing fine sand-size soil. Possible reversely graded.	Forms very fragile blocks, 2 x 4 to 10 mm long; slumps easily.	1. Light to dark grey breccia fragments. 2. Grey and black angular glass fragments. 3. Trace of green glass.	None
108–120	26	004-I	26–38	10 YR 5/1 grey	Moderately well-sorted silt-size material. 1-3% of the volume is composed of fragments greater than 1 mm long.	Forms coherent blocks 2-5 mm long. There was little collapse when the core was opened.	1. Light grey breccia fragments. 2. Trace of dark brown and grey glass fragments.	None

*The individual sample locations are based on this scale.
**Munsell Color Co., Inc., Munsell Soil Color Charts, 1954 ed., Baltimore, Md.

Figure 15-3.- **Description of the Apollo 15 drill core (continued).**

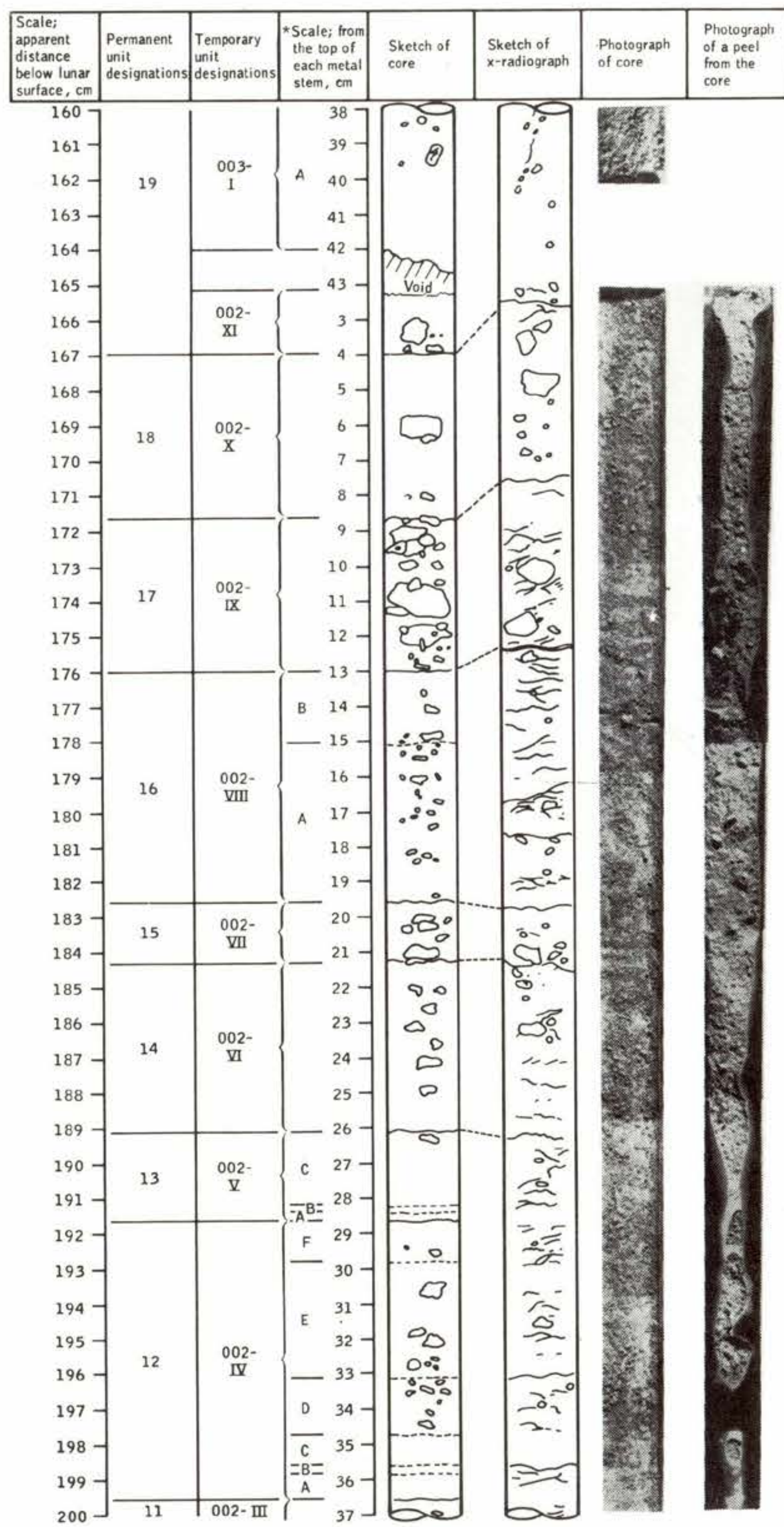


**Color	Texture	Structure	Composition of larger rock fragments: Coarse fraction	Fines	Subunits
See previous page for lithologic description of 004-I.					
5 Y 3/1 dark drab grey	Clayey siltsoil 15-20% vf-f sand 2.94% avg rock fragments. Matrix support.	Only zone with slight collapse when core was opened, forms coherent blocks up to 1.3 cm long, mostly about 0.3 cm.	Soil matrix breccia with glass aggregates and whitish granules 50.0% Lumpy and frothy, very dark brown to black glass aggregates 23.7% Non-crystalline lithic fragments, soil-like appearance, but with no clasts or inclusions 7.8% Microcrystalline dark grey rock fragments, (basalt?) 7.8% White-matrix breccia, sugary texture 5.2% Anorthositic rock fragments, chalky appearance 5.2%	20-25% feldspar cleavage frag 1-2% whitish granules	
5 Y 3/1 to 5 Y 4/1 medium to dark drab grey	Clayey fine sandsoil, 20-60% sand, up to 22% rock fragments, avg 5.5% framework support in some zones.	Variable slumping, some portions collapse readily, others moderately breaks into blocks or pellet like clumps up to 4 mm diameter, mostly 1 mm.	(A, B, C / D, E / F, G) Soil-matrix breccia 40.3 / 51.5 / 64.0% Dark, frothy spattered glass 1.7 / 12.5 / 8.0% Aphanoxtalline dark blocky lithic fragments 7.0 / 2.5 / 8.0% Anorthositic rock fragments, chalky 15.8 / 2.5 / 8.0% Sintered-appearing brownish breccia 12.3 / 2.5 / 8.0% Non-xtalline, dull granular lithic fragments 15.8 Coarsely xtalline anothosite 7.0 / 5.0 / 4.0% Dark crystalline (gabbro?) fragments 7.5 Glass sphere (dark greenish brown) 2.5 White-matrix breccia, sugary texture 7.5	35-50% feldspar cleavage frag 1-2% whitish granules	G. Matrix-rich layer. F. Rock layer, white granules. E. Matrix-rich layer. D. Rock layer, sugary breccia. C. Matrix-rich layer. B. Layer of 1-2 mm rock fragments. A. Layer of 2-6 mm breccia fragments.
10 Y 4/1 to 5/1 medium neutral drab grey	Muddy siltsoil, 20-25% vf sand, 3.14% rock fragments, matrix support, poorly sorted.	Slumps easily into blocky and crumb-like clumps 0.2-4 mm long, average diameter 1.5-2 mm.	Soil-matrix breccia fragments with glass aggregates and fragments 60.3% Non-crystalline, soil colored, rounded lithic fragments 13.8% Anorthositic rock fragments with chalky appearance 10.3% Sintered-appearing, brownish breccia fragments 5.2% Aphanocrystalline dark grey, blocky lithic fragments (basalt?) 5.2% Splintery drab lithic fragments, indet composition 3.4% Frothy, dark brown to blackish glass aggregates 1.7%	35-50% feldspar cleavage frag 1-2% whitish granules	D. Basic composition of unit. C. Concentration of anorthositic granule. B. Concentration of frothy glass. A. Basic composition of unit.
5 GY 5/1 to N5 neutral to drab grey	Muddy sandsoil, 25% vf-med sand, 10.36% avg rock fragments very poorly sorted. Some framework support.	Moderate slumping forms crumb-like clumps 0.1-2.5 mm long, variable sizes averaging 1 mm.	White-matrix breccia, sugary texture, dark grey to brown clasts 22.8% Soil-matrix breccia with glass aggregates and fragments 21.5% Irregularly angular, dark grey microcrystalline (basalt?) fragments 15.2% Non-crystalline grey lithic fragments, soil-like appearance, rounded 13.9% Sintered-appearing, tan to brownish breccia fragments 10.1% Frothy to finely divided, dark-brown to black glass 3.8% Non-crystalline, dark grey, indet lumpy lithic fragments 3.8% Anorthositic rock fragments, chalky appearance 3.8% Feldspar cleavage fragments, medium bluish grey 2.5% Blackish glass bead 1.3% Cindery-appearing, dark grey glass fragments 1.3%	25-35% feldspar cleavage frag 1-2% whitish granules	C. Basic composition of unit. B. Concentration of rounded soil matrix breccia fragments A. Basic composition of unit.
5 GY 5/1 medium neutral drab grey	Clayey siltsoil, 20-25% sand, 7.01% avg rock fragments. Matrix support.	Moderately slumping, forms crumb-like clumps 0.1-1 mm long, mostly 0.5-1 mm.	Soil-matrix breccia with glass fragments and aggregates 36.4% Irregularly jagged, very dark grey lithic fragments (basalt?) 20.4% Sintered-appearing tan-brownish crystalline breccia 11.4% Non-crystalline lithic fragments, soil-like appearance 11.4% Vesicular to frothy, dark greenish brown to black glass 9.1% Anorthositic rock fragments with chalky appearance 6.8% Indet, splintery grey crystalline lithic fragments 4.5%	25-35% feldspar cleavage frag Tr-1% whitish granules	B. Permeated by cracks. A. Resistant bed.
5 Y 5/1 medium neutral drab grey	Rock fragmental sandsoil. Moderate to well sorted, 21.93% rock fragments. Grain support.	Slumps easily, forms crumb-like clumps 0.5 to 3 mm long, mostly in 1 mm range.	Soil-matrix breccia with glass fragments and aggregates 21.6% Anorthositic rock fragments with chalky appearance 17.0% Irregularly jagged, very dark grey lithic fragments (basalt?) 17.0% Frothy to finely divided, dark greenish to black glass aggregates 14.8% Sintered-appearing, brownish to tan, crystalline breccia 9.1% Dark grey, metallic-appearing, angular crystalline fragments 8.0% Non-crystalline lithic fragments, soil-like appearance 4.5% Cindery glass fragments, dull grey 2.3% Sugary-textured, white matrix breccia, dark grey clasts 2.3% Indet splintery, drab grey lithic fragments 2.3% Feldspar cleavage fragments 1.1%	10-15% feldspar cleavage frag Tr whitish granules	
10 YR 5/1 medium neutral to brownish grey	Clayey siltsoil. Moderately to poorly sorted, 4.55% avg rock fragments.	Slumps readily, collapsing into blocky or pellet-like aggregates 0.5 to 3 mm long.	Irregularly jagged, very dark grey lithic fragments (basalt?) 44.3% Frothy to finely divided pale brown or dark glass aggregates 16.5% Soil-matrix breccia or lithified soil-matrix fragments 15.2% Anorthositic rock fragments, chalky appearance, angular 11.4% Dark grey, metallic-appearing, angular crystalline fragments 2.5% Indet splintery, drab grey lithic fragments 2.5% Sintered-appearing brownish crystalline breccia fragment 1.3%	2-5% feldspar cleavage frag 0-Tr whitish granules	B. Relatively less slumping forms pellet-like clumps, Tr anorthositic nodules. A. Collapses easily.

*The individual sample locations are based on this scale.

**Munsell Color Co., Inc., Munsell Soil Color Charts, 1954 ed., Baltimore, Md.

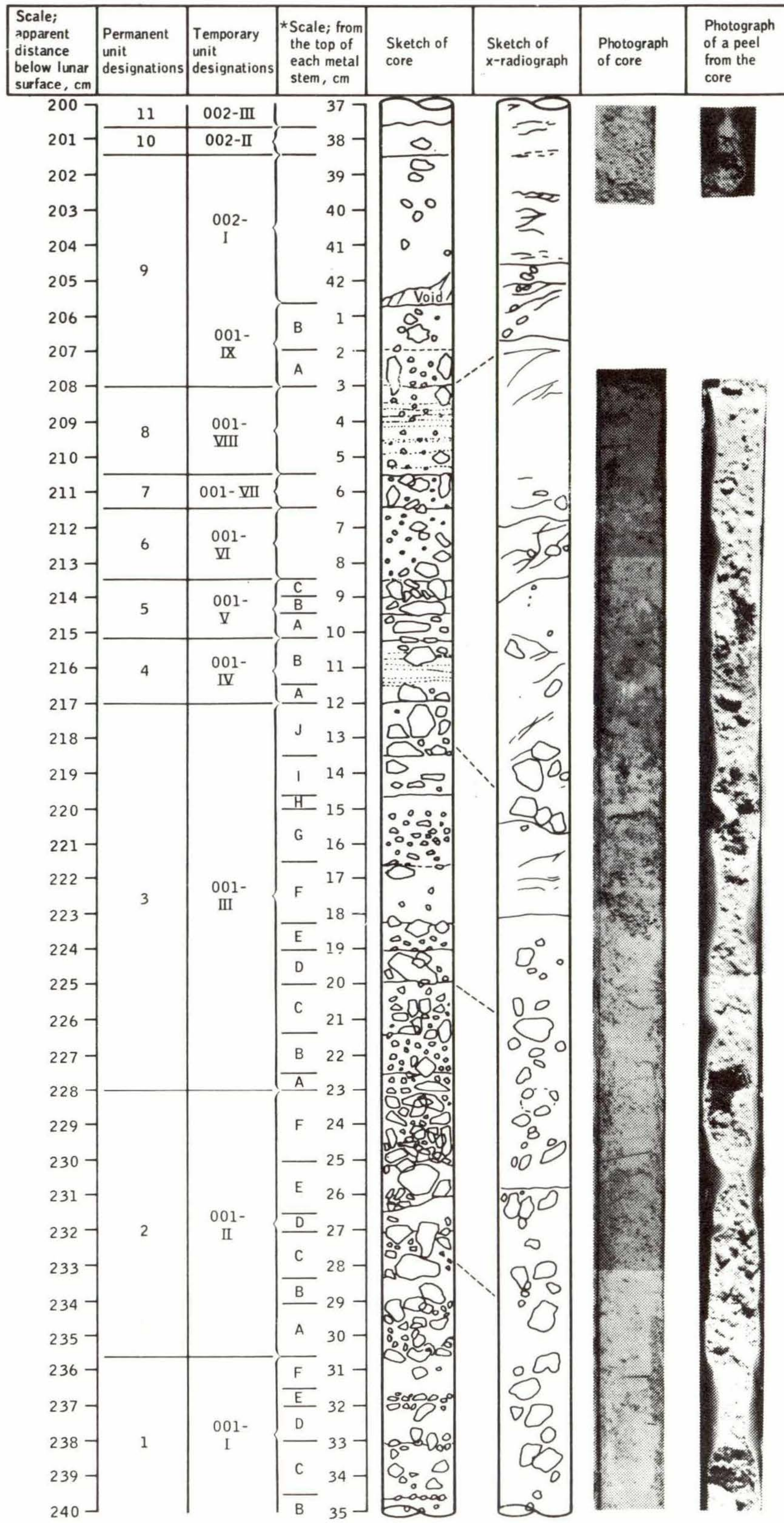
Figure 15-3.- Description of the Apollo 15 drill core (continued).



Permanent unit designations	Temporary unit designations	**Color	Texture	Structure	Composition of larger rock fragments	Subunits
19	003-I; 002-XI	Between grey and dark grey	Coarse sand and granule bearing silt size; very poorly sorted.	No cohesive aggregates.	1. Black glass 2. White "anorthosite"	None
18	002-X	Darker grey than IX; lighter grey than XI	Granule-bearing silt size; poorly sorted.	Cohesive aggregates present: 1. Equant, same color as soil. 2. Equant, 1 mm diameter light grey.	N.D. (dusty).	None
17	002-IX	Grey	Pebbly medium sand size; very poorly sorted.	No cohesive aggregates.	1. Medium grey breccia. 2. White "anorthosite".	None
16	002-VIII	Grey to light grey	Silt to fine sand size; moderately sorted.	Some 1 mm diameter cohesive aggregates.	1. Dark grey breccia. 2. Light grey glass fragments. 3. "Anorthosite".	B. Grey soil forms irregular clumps. A. Light grey; more porous than B
15	002-VII	Grey	Pebbly fine sand size; poorly sorted.	No cohesive aggregates.	1. Grey glass. 2. Grey breccia.	None
14	002-VI	Light grey; grading to darker grey at top	Granule-bearing silt size; poorly sorted.	There are small granule size, light to medium grey cohesive aggregates.	1. Dark grey breccia. 2. Light grey breccia. 3. "Anorthosite".	None
13	002-V	Grey (5 Y 5/1) to light grey	Coarse-sand bearing silt size; poorly sorted.	No cohesive aggregates.	1. White "anorthosite".	C. Light grey. B. Two distinct. A. Light grey color bands.
12	002-IV	Grey (5 Y 5/1) to dark grey (5 Y 4/1)	Silt-size soil to coarse-sand and granule-bearing silt-size soil; moderately sorted.	Light grey to white cohesive aggregates (<4 mm diameter).	1. White "anorthosite". 2. Grey breccia. 3. Trace of black glass.	F. Grey, coherent. E. Light grey, with darker grey patches. D. Grey, smooth surface; coarser. C. Light grey, coherent; grades into B. B. Dark grey; smooth surface A. Light grey; smooth surface.
11	002-III	See next page for a description of this unit.				

*The individual sample locations are based on this scale.
**Munsell Color Co., Inc., Munsell Soil Color Charts, 1954 ed., Baltimore, Md.

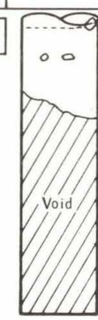
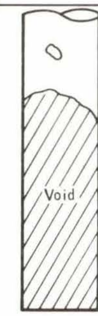
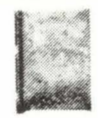
Figure 15-3.- Description of the Apollo 15 drill core (continued).



Lithologic Description				
**Color	Texture	Structure	Composition of larger rock fragments	Subunits
Grey (5 Y 5/1)	Silt size; moderately well sorted.	No cohesive aggregates.	None	None
Grey (5 Y 5/1)	Coarse sand and granule-bearing silt-size soil.	No cohesive aggregates.	Too dusty for identification.	None
Grey (5 Y 5/1)	Granule-bearing fine silt-size soil.	Some white cohesive aggregates. Prismatic fracture pattern.	1. White "anorthosite" 2. Feldspar crystals.	B. Abundant black glass droplets. A. Some anorthositic fragments; about 20% fragments > 1 mm.
10 YR 7/1 light grey	Silt-size soil; moderately well sorted.	No cohesive aggregates.	1. Light grey to white breccia fragments. 2. Some black glass fragments.	None
10 YR 7/1 light grey	Granule-bearing silt-size soil.	≈ 2% cohesive, grey aggregates.	1. Vesicular black glass fragments. 2. Light grey breccias.	None
10 YR 7/1 light grey	Silt-size soil.	Some brown and white cohesive aggregates.	1. Light grey breccia fragments. 2. Black glass fragments and droplets.	None
10 YR 7/1 light grey	Pebbly silt-size soil.	Abundant white and grey cohesive aggregates.	1. Grey breccia fragments. 2. Black glass fragments. 3. Basalt(?) fragments.	C. 20-30% granule-size fragments; abundant black glass. B. > 20% granule-size fragments; abundant clods. A. ≈ 5% granule-size fragments; abundant clods.
10 YR 8/1 white	Silty fine sand-size soil.	Distinct fine (0.5 mm) laminae. Less coherent than Unit V.	1. Abundant black glass droplets and fragments. 2. Grey breccia fragments.	B. Slightly coarser and more black glass than Unit A. A. Abundant coherent aggregates (clods).
10 YR 7/1 to 10 YR 8/1 light grey to white (Subunits A-D are white)	Granule-bearing silt-size to sandy silt-size soil.	Weak angular blocky structures, 2-3 mm long. Very few weakly consolidated clods.	1. Light grey to white breccia fragments. 2. Basalt(?) fragments. 3. Most fragments coated with dust; are nearly impossible to identify. 4. Trace of black glass fragments and droplets.	J. 10-20% fragments > 1 mm; basalt fragments. I. Silt-size material with trace of granules. H. Silt-size soil. G. 5-15% fragments (Basaltic?) in a silt matrix. F. Trace of clods in a silty matrix. E. 10% fragments of basalt (?) > 1 mm in a silty matrix. D. Lighter grey than E; coarser grained matrix than C. C. Some weakly consolidated clods. B. Silty fine sand-size matrix, with ≈ 20% fragments > 1 mm. A. Silty fine sand-size matrix, with ≈ 30% fragments > 1 mm.
10 YR 7/1 light grey	Granule-bearing sandy silt-size soil.	Angular, 1-2 mm blocky structures, with thin, long prisms along the interior of the drill stem.	1. Light grey breccia fragments. 2. Medium grey, aphanilic basalt fragments. 3. Trace of black glass.	F. Possible graded bed, with 10-40% fragments > 1 mm. E. Less basalt(?) fragments than Unit E. D. Silt-size sand. C. 25% fragments > 1 mm. B. Silt-size soil. A. 12-50% fragments (light-grey breccias) > 1 mm.
10 YR 7/1 light grey	Silt-size soil.	A few clods present.	1. Light grey breccia fragments. 2. Vesicular grey basalt. 3. Dark brown glass.	F. Silt-size soil. E. 10-20% particles > 1 mm, in a silty matrix. D. Silt-size soil. C. Some aggregates (clods) present. B. Silt-size soil. A. Silt size, with some > 1 mm diameter clods.

*The individual sample locations are based on this scale.
**Munsell Color Co., Inc., Munsell Soil Color Charts, 1954 ed., Baltimore, Md.

Figure 15-3.- Description of the Apollo 15 drill core (continued).

Scale; apparent distance below lunar surface, cm	Permanent unit designations	Temporary unit designations	*Scale; from the top of each metal stem, cm	Sketch of core	Sketch of x-radiograph	Photograph of core	Photograph of a peel from the core	Lithologic Description: **Color	Texture	Structure	Composition of larger rock fragments	Subunits
240	1	001-I	B 35					See previous page for description.				
241			A 36									
242												
243												
244												
245												
246												
247												
248												

*The individual sample locations are based on this scale.
**Munsell Color Co., Inc., Munsell Soil Color Charts, 1954 ed., Baltimore, Md.

Figure 15-3.- Description of the Apollo 15 drill core (concluded).

The X-radiographs also permit the determination of the core sample lengths and thereby the bulk densities, which are also presented in Figure 15-3. In the lower half of the first double core, the keeper was found to be still in its stowed location in the adapter, indicating either that it was not properly inserted on the Moon or that it slipped back. In either case the result was that the sample expanded to the present length of 36.2 cm, corresponding to a bulk density of 1.59 g/cc. When the nominal sample length of 34.9 cm is used, the original density of the sample in the tube is calculated to be 1.64 g/cc.

In addition, the X-radiographs reveal a void along one side at the bottom of this tube. The Lunar Module Pilot (LMP) described this sample location as having a coarser grain size distribution than at other points at Station 6, and this would probably account for part of the sample falling out of the tube before it was capped. The void was estimated to occupy 6 cc (less than 2 percent of the total volume) and the bulk density was corrected to 1.35 g/cc.

The densities in the single core and the top half of the first double core are approximately 14 percent lower than in any of the core tubes previously returned on the Apollo missions.

From the lower half of the second double core approximately 54 cc of soil fell out of the bottom of the tube before it was capped. In addition, the sample length was found to be less than the nominal length. This would indicate either that sample fell out of the top when the two core halves were unscrewed, or that the sample was compressed when the keeper was inserted. The high relative density at this location argues against the latter interpretation and supports the former. Until further studies can be made, a range of possible densities is shown in Table XV-1.

Apollo 15 Drill Cores

The Hadley Rille-Apennine Mountains area of the Moon (3°29'20"E, 26°26'00"N) was explored by the crew of Apollo 15. The Apollo 15 crew collected a 242 cm long drill core. The core, which was collected from the regolith developed on Palus Putredinis, is hopefully a representative section of the regolith developed on the mare surface, although its location at Station 8, 50 m from the ALSEP central station, may have been on the edge of a ray. The cores have been described by Heiken et al. (1972).

After drilling was completed, the drill was removed, capped and plugged, then placed in a nylon bag for return. Three of the sections on the Apollo 15 core would not separate and were returned as one section to be broken apart in the laboratory. The uncovered three sections that would not separate (15001 - 15003) were plugged on the lunar surface and taped in the LM. The exteriors of the linked core sections were exposed to the atmosphere of the LM and CM cabins and had water spots on them (probably caused by sea water splashing into the cabin through an open door after splashdown). The remaining sections were protected by the nylon bag, but the exteriors were exposed to the air in the cabin.

Interpretive drawings made from the X-rays of Apollo 15 drill stem sections were prepared by G. Heiken and J. S. Nagle (LSPET, 1972) (Fig. 15-3). Over 50 distinctive units were recognized in this manner. The immediate availability of the stratigraphic information played a major part in the continuation of the deep drilling experiment on subsequent missions. The nearly disastrous expenditure of lunar surface time to collect the drill string had raised significant discussions among scientific advisors with respect to the tradeoff between deep drilling and additional lunar surface traverse time.

The early dissection of the junctions of sections of the Apollo 15 deep drill string requires a detailed description.

According to the plan, the lower end of each drill stem was to be unplugged, and any soil adhering to the plug was to be recovered and assigned a sample number. Soil was then to be removed in four 0.5 cm increments or excavation levels, until at least 3.75 g of soil was recovered. Soil from alternate increments was then to be split four ways. After reserving 0.25 g of sample, the increment was passed through a 0.250 mm sieve. An allotment of 1.2 g of the fine fines was made for biomedical experiments and the balance of the fine fines as well as the coarse fines were set aside for allocation to Principal Investigators (PI). As can be seen on the sample split diagrams (Fig. 15-4), the general plan was carried out, but there were significant modifications for every drill stem. 15001 had an extensive basal void, not permitting even-sized increments. 15002 and 15003 contained basal solid Teflon plugs which prevented excavation from the bottom of the core, although sampling took place more-or-less according to plan after the plugs were removed. Soil in 15004, 15005, and 15006 was confined by hollow basal caps, and the soil was retained in and removed with these caps in 15004 and 15005. Accordingly, excavation increments are measured from the top of the cap in 15004, and the increments are reversed with respect to the other cores. Because of similar difficulties no excavation or depth levels were assigned to the increments in 15005. And because of a partial void near the bottom of 15006, increments I and III were unusually thick, although removed in planned sequence.

General Description of the Core: The identification of stratigraphic units was based on changes in combinations of color, texture, structure. and estimated composition of the coarser rock fragments (Fig. 15-3). Only limited identification of coarser particles with the unaided eye were made during the description and dissection.

The most common particle type was medium to dark gray microbreccia, generally subangular to subrounded, with equant to elongate shapes. Less common were white, feldspar-rich basalt and anorthositic fragments. Near the base of the core, there were medium grey, vesicular and non-vesicular basalt fragments. Details of clast types, and so forth, were generally masked by dust coatings. Black or dark brown glass droplets and angular glass fragments were present in the soils but were more abundant near the top and bottom of the core.

Several layers at 24.5 cm and 83.2 - 94.7 cm contained green glass spheres and clastic rocks composed of green glass spheres. This unique glass was present in many of the surface soil samples and was most abundant at Station 7, along the Apennine Front.

Textures ranged from silt-size to pebbly, medium sand-size soils. The silt-size matrix was ubiquitous and present, to varying degrees, in all layers. All of the soils were poorly sorted to extremely poorly sorted. The grain size determinations were based on subjective visual and tactile impressions of the soils.

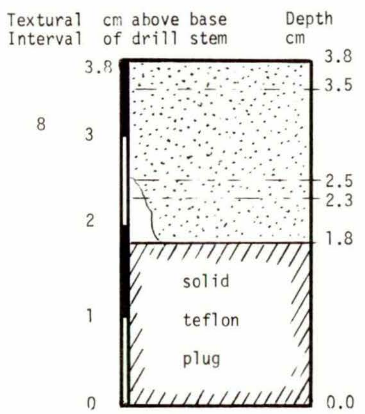
Colors varied from very dark grey (10YR3/1) to white (10YR8/1). The most common soil color was grey, modified only slightly in value and chroma.

Boundaries between units were generally quite distinct and could be easily outlined during the dissection. With the exception of less than 1 mm of soil along the tube walls, there appeared to be no distortion or smearing of the soil or mixing of layers during the drilling process.

Individual layers ranged from a few millimeters to 13 cm thick. A total of 42 major textural units were described within the core. Grading (normal and reverse) of several beds implied that they might have been deposited by turbulent flows, possibly a base-surge type of ejecta cloud. It is also possible that the sorting in an individual layer might have been caused by the pelting of the developing soil surface by micrometeoroids.

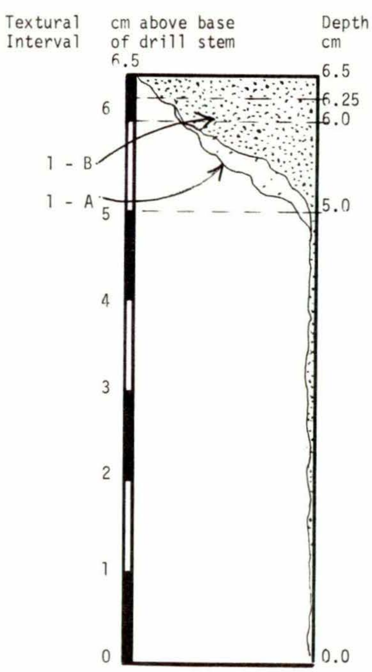
Coarse particles were separated and many have been described by Drake (1974) using a binocular microscope. When it was discovered that the samples were contaminated by lead, a special dissection procedure was developed for 15003, in which material near the core walls was removed to expose interior material, which was separately packaged for several intervals.

SECTION 15002



Dissection Level	Primary Splits	Early Splits: Finer Than 0.250 mm	Early Splits: Coarser Than 0.250 mm
IV	15002,15 15002,14		
III	15002,13 15002,9	15002,11 (PI) 15002,10 (Biomed)	15002,12 (alloc.)
II	→ 15002,8 15002,7		
I	↘ 15002,6 15002,2	15002,4 (PI) 15002,3 (Biomed)	15002,5 (alloc.)

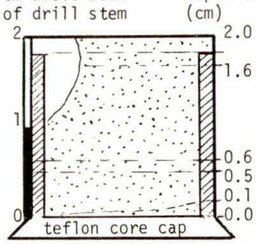
SECTION 15001



Dissection Level	Primary Splits	Early Splits: Finer Than 0.250 mm	Early Splits: Coarser Than 0.250 mm
IV	15001,19		
III	15001,18 15001,14	15001,16 (PI) 15001,15 (Biomed)	15001,17 (allocated)
II	15001,11 15001,10 15001,9 15001,7	15001,12 (Biomed) (from 1B, sieved, not allocated)	15001,8
I	15001,5	(split as..,14, but not numbered	15001,6 (allocated)
	15001,4 15001,3	soil from ṗlug at bottom of drill stem dust from bottom cap	

Figure 15-4.- Splits for early allocations, Apollo drill string section 15001 and 15002.

SECTION 15004

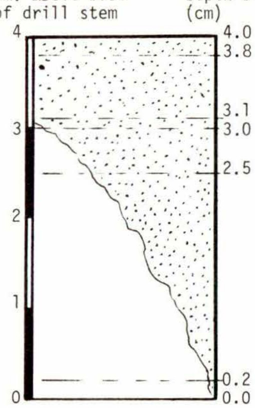


Textural Interval	Dissection Level	Primary Splits	Early Splits: Finer Than 0.250 mm	Early Splits: Coarser Than 0.250 mm
26	IV-B →	15004,15		
			15004,4 (PI)	
	I*	15004,2	15004,3 (Biomed.)	15004,5 (alloc.)
		15004,6		
	→	15004,7		
	II →	15004,8	15004,11 (PI)	
	III	15004,9	15004,10 (Biomed.)	15004,12 (alloc.)
	IV-A →	15004,13		
		15004,14		
		15004,1 loose soil in bag		

(Column heads as printed: Textural Interval; Cm above base of drill stem; Depth (cm); Dissection Level; Primary Splits; Early Splits: Finer Than 0.250 mm, Coarser Than 0.250 mm)

* In this core, dissection levels were taken from the top of the teflon cap.

SECTION 15003

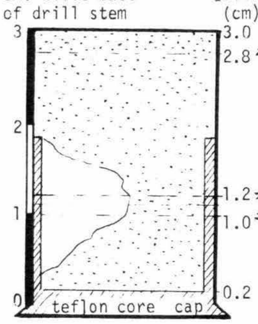


Textural Interval	Dissection Level	Primary Splits	Early Splits: Finer Than 0.250 mm	Early Splits: Coarser Than 0.250 mm
19	IV	15003,17		
	→	15003,16	15003,14 (PI)	
	III	15003,12	15003,13 (Biomed.)	15003,15 (alloc.)
	→	15003,11		
	II	15003,10		
	→	15003,9		
	I	15003,5	15003,6 (Biomed.)	15003,8 (alloc.)
			15003,7 (PI)	
		15003,4 loose dust from plug		
		15003,3 loose soil in bag		

(Column heads as printed: Textural Interval; Cm. above base of drill stem; Depth (cm); Dissection Level; Primary Splits; Early Splits: Finer Than 0.250 mm, Coarser Than 0.250 mm)

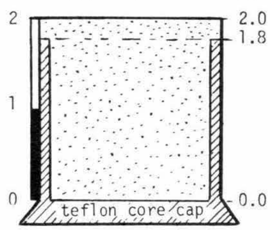
Figure 15-4.- Splits for early allocations, Apollo drill string section 15003 and 15004 (continued).

SECTION 15006



Textural Interval	Depth (cm)	Dissection Level	Primary Splits	Early Splits Finer Than 0.250 mm	Coarser Than 0.250 mm
	2.8	IV	15006,15 15006,14		
43		III	15006,10	15006,12 (PI) 15006,11 (Biomed.)	15006,13 (alloc.)
	1.2 1.0	II	15006,9 15006,8 15006,7		
42		I	15006,3	15006,5 (PI) 15006,4 (Biomed.)	15006,6 (alloc.)
			15006,2	dust from outside of cap	
			15006,1	loose soil in bag	

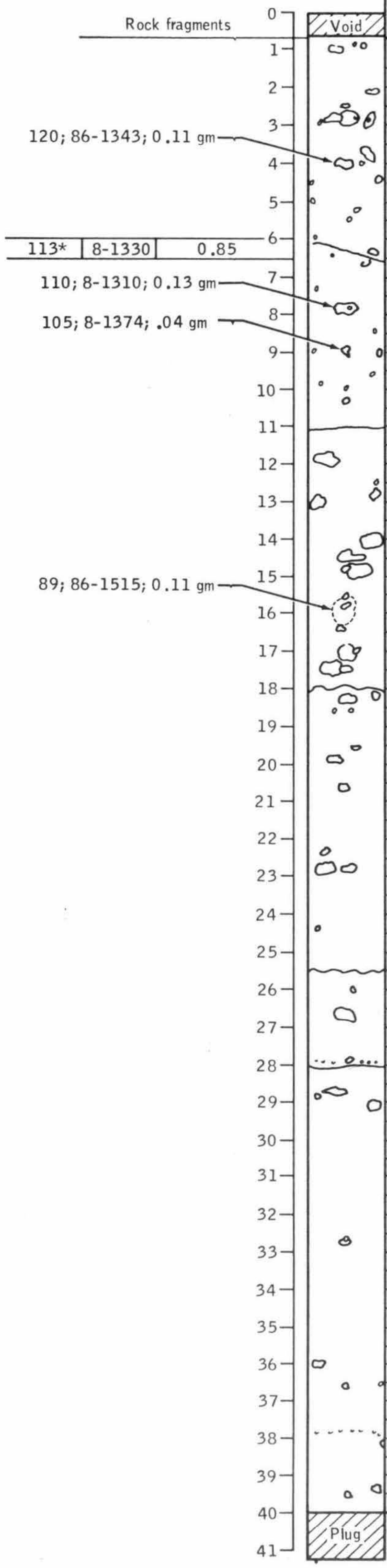
SECTION 15005



Textural Interval	Depth cm	Dissection Level	Primary Splits	EARLY SPLITS Finer Than .250 mm	Coarser Than .250 mm
	2.0		15005,13		
	1.8	IV	15005,14		
30		III	15005,9	15005,10 (Biomed.)	15005,12 (alloc.)
			15005,8	15005,11 (PI)	
		II	15005,7		
			15005,6	15005,4 (PI)	
			15005,2	15005,3 (Biomed.)	15005,5 (alloc.)
	0.0		15005,1	loose soil in bag	

Figure 15-4.- Splits for early allocations, Apollo drill string section 15005 and 15006 (concluded).

During dissection, each sample was documented according to position in the drill stem, and placed in a uniquely marked vial or container. Fig. 15-5 indexes all such samples removed from each drill stem. Sample intervals in this figure are directly comparable to intervals in the descriptive summary of the deep drill string, Fig. 15-3. In order to obtain sample depth below lunar surface, one should compare interval within the drill stem, seen in Fig. 15-5 and 15-3 to apparent distance below lunar surface, column 1 in Fig. 15-3.



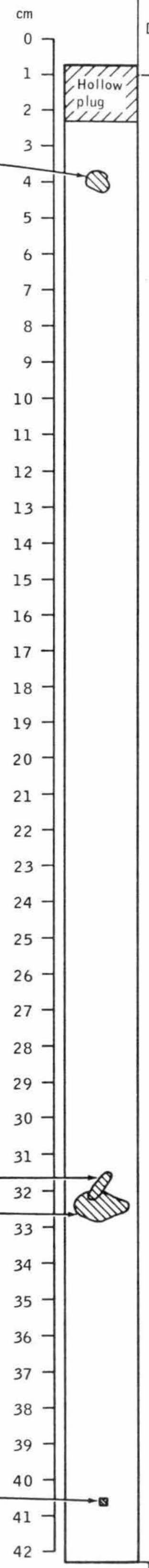
Daughter no.	Container no.	Mass, gm	Daughter no.; mass, gm; and container no. of red light samples
126	8-1379	2.94	
125	8-1422	1.96	
124	8-1375	1.59	
123	8-1402	2.29	
122	8-1420	1.54	
121	8-1319	2.45	
119	8-1339	1.59	
118	8-1311	2.12	
116	8-1396	1.51	117; 86-1089; 1.74
115	8-1360	1.91	
114*	8-1318	1.39	
112	8-1384	1.78	
111	8-1408	2.24	
109	8-1350	2.05	
108	8-1313	2.05	
106	8-1303	1.63	107; 86-1557; 0.58
104	8-1290	2.26	
103	8-1363	1.88	
102	8-1424	2.03	
101	8-1314	1.86	
100	8-1370	2.02	
99	8-1390	1.88	
98	8-1287	1.70	
97	8-1367	1.83	
95	8-1340	2.15	96; 86-1415; 0.32
94	8-1292	1.80	
93	8-1317	1.77	
92	8-1357	1.78	
91	8-1376	1.98	
90	8-1304	2.00	
88	8-1332	2.07	
87	8-1423	2.02	
86	8-1306	1.91	
85	8-1344	2.08	
84	8-1323	1.97	
83	8-1378	2.16	
82	8-1327	2.44	
81	8-1329	1.99	
80	8-1282	2.35	
79	8-1355	1.92	
78	8-1296	2.33	
77	8-1316	2.60	
76	8-1326	1.51	
75	8-1315	2.50	
74	8-1414	1.89	
73	8-1352	2.30	
72	8-1336	1.43	
70	8-1358	1.74	71; 86-1433; 0.46
69	8-1312	1.87	
68	8-1365	2.00	
67	8-1415	1.89	
66	8-1417	2.09	
65	8-1398	1.60	
64	8-1298	1.92	
63	8-1389	1.50	
62	8-1392	1.75	
61	8-1387	1.78	
61	8-1380	1.25	
58	8-1286	1.66	59; 86-1431; 0.54
57	8-1294	1.46	
56	8-1299	1.27	
55	8-1419	1.79	
54	8-1285	1.46	
53	8-1345	1.52	
52	8-1406	1.59	
51	8-1308	1.53	
50	8-1356	1.35	
49	8-1361	1.40	
48	8-1410	1.40	
46	8-1382	1.20	47; 86-1436; 0.31
45	8-1341	1.46	
44	8-1369	1.53	
43	8-1372	1.31	
42	8-1346	1.56	
41	8-1342	1.10	
40	8-1349	1.43	
39	8-1425	1.10	
38	8-1371	1.45	

*Samples 113 and 114 are from below and above the sloping contact, respectively

Figure 15-5.- Sample location information, Apollo 15 deep drill string section 15006.

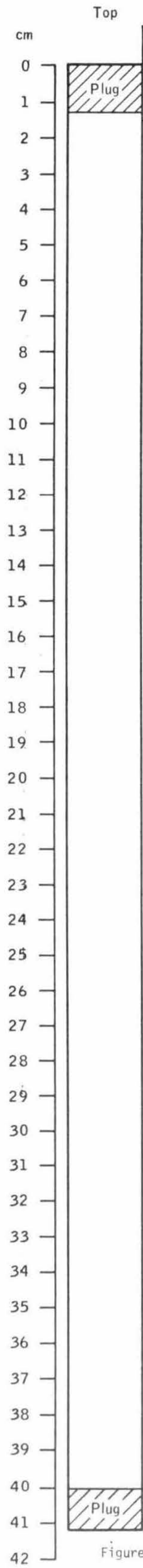
Rock fragments

Daughter no.	Container no.
34	8-1023
93	87-2804
96	87-2835
*13	87-2890



Daughter no.	Container no.	Daughter no. and container no. of red light samples (*red light samples)
113	87-2047	
30	8-1033	
31	8-1029	
32	8-1031	
33	8-1018	
35	8-1013	
36	8-1006	*37; 87-3065
38	8-1030	
39	8-1010	
40	8-1005	
41	8-1038	
42	8-1016	
43	8-1002	
44	8-1035	*45; 87-3044
46	8-1045	
47	8-1036	
48	8-1009	
49	8-1034	
50	8-1032	
51	8-1027	
52	8-1042	
53	8-1041	
54	8-1007	
55	8-1047	
56	8-1021	
57	8-1049	
58	8-1014	
59	8-1004	
60	8-1019	
61	8-1028	
62	8-1039	
63	8-1020	
64	8-1050	
65	8-1048	
66	8-1024	
67	8-1003	
68	8-1015	*116; 87-3055
69	8-1040	
70	8-1044	
71	8-1025	
72	8-1022	
73	8-1017	
74	8-1026	
75	8-1012	
76	8-1008	
77	8-1046	
78	87-3070	
79	87-3061	
80	8-1037	
81	87-2718	*82; 87-2834
83	8-1043	
84	8-1011	
85	8-1001	
86	87-2167	
87	87-2265	
88	87-3127	
89	87-2909	
90	87-2970	
91	87-2720	
92	87-2289	
94	87-2838	
95	87-2001	
97	87-2026	
98	87-2077	*99; 87-2844
100	87-2045	
101	87-2058	
102	87-2719	
103	87-2849	
104	87-2880	
105	87-2140	
106	87-2910	
107	87-2748	
108	87-2810	
109	87-3022	
110	87-2926	
111	87-2971	
112	87-3031	
2	87-2874	Early sample allocation
3	87-2791	
4	87-2893	
5	87-2819	
6	87-2903	
7	87-2797	
8	87-2747	
9	87-2826	
10	87-2833	
11	87-2949	
12	87-2927	
14	87-2809	

Figure 15-5. (continued) Sample location information, Apollo 15 deep drill string section 15005

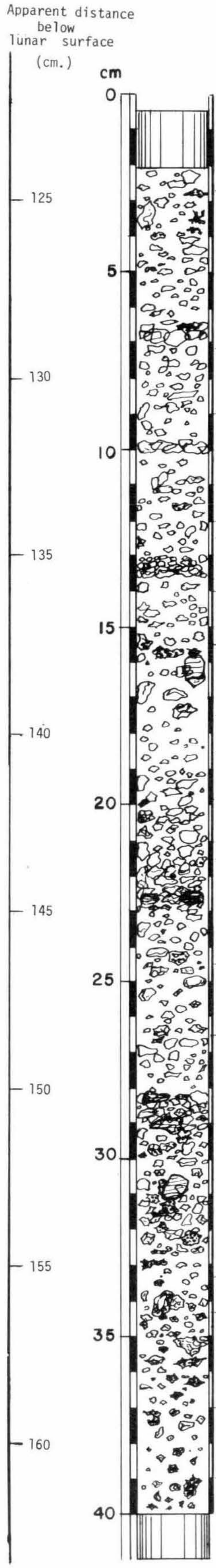


Daughter no.	Container no.	Mass, gm	Daughter no; mass, gm; and container no. of red light samples
48	86-1440	3.34	
49	86-1239	2.22	
50	86-1472	2.16	
51	86-1245	2.48	
52	86-1455	1.65	
53	86-1236	2.67	
54	86-1598	1.98	
55	86-1097	1.84	
56	86-1471	2.45	
57	86-1326	1.76	
58	86-1024	1.58	
59	86-1360	1.78	
60	86-1054	2.15	
61	86-1339	1.83	
62	86-1573	2.23	
63	86-1346	2.36	
64	86-1450	2.24	
65	86-1546	2.20	
66	86-1430	1.89	67; 0.44; 86-1513
68	86-1590	2.25	
69	86-1073	2.32	
70	86-1579	2.08	
71	86-1361	2.35	
72	86-1330	2.23	
73	86-1470	1.88	
74	86-1421	1.68	
75	86-1327	2.28	
76	86-1373	1.45	
77	86-1102	2.35	
78	86-1392	1.83	
79	86-1419	2.09	
80	86-1434	1.61	
81	86-1209	2.38	
82	86-1136	2.09	
83	86-1475	2.32	
84	86-2820	2.08	85; 0.34; 86-2891
86	86-1144	2.37	
87	86-1398	2.27	
88	86-2814	2.14	
89	86-2962	1.90	
90	86-2852	2.04	
91	86-2845	2.09	
92	86-2901	2.39	
93	86-1634	1.75	
94	86-1211	1.51	
95	86-1165	2.43	
96	86-1345	1.55	
97	86-1559	2.03	
98	86-1309	2.17	
99	86-1583	1.32	100; 0.5; 86-1366
101	86-1364	1.81	
102	86-1118	1.72	
103	86-1537	2.45	
104	86-1554	1.75	
105	86-1333	2.22	
106	86-1378	1.55	
107	86-1427	1.98	
108	86-1468	1.57	
109	86-1425	1.91	
110	86-1460	1.80	
111	86-1120	2.01	
112	86-1103	1.89	
113	86-1536	1.57	
114	86-1353	1.87	
115	86-1377	1.45	
116	86-1347	1.31	117; 0.51; 86-1355
118	86-1485	2.24	
119	86-1051	1.75	
120	86-1063	2.17	
121	86-1504	2.02	
122	86-1021	1.87	
123	86-1349	2.05	
124	86-1268	1.75	
125	86-1567	1.66	
126	86-1575	2.06	127; 0.56; 86-1492
128	86-1363	1.31	
129	86-1334	2.27	

Figure 15-5.- (continued).

Sample location information, Apollo 15 deep drill string section 15004

15003 DISSECTION



INTERVAL SAMPLES / SPECIAL SAMPLES

Fine Fraction (<1mm) Daughter No.	Container No.	Sample Wt. (gm.)	Coarse Fraction (>1mm) Daughter No.	Container No.	Sample Wt. (gm.)	Special Samples Daughter No.	Container No.	Sample Wt.(gm) and Type *
197	8-2195	2.634	198	8-2203	0.133			
194	8-2169	1.819	195	8-2189	0.064	196	87-1057	0.37 RL
192	8-2143	1.883	193	8-2156	0.363			
190	8-2114	2.534	191	8-2133	0.031			
188	8-2093	1.794	189	8-2100	0.058			
185	8-2076	2.417	186	8-2079	0.053	187	87-1388	0.41 RL
182	8-2054	1.940	183	8-2066	0.024	184	87-1478	0.34 RL
180	8-2036	1.649	181	8-2047	0.026			
178	8-1997	2.618	179	8-1998	0.058			
175	8-1992	2.340	176	8-1996	0.278	177	87-1541	0.23 RL
173	8-1949	2.097	174	8-1971	0.030	inner core, possibly Pb-free		
171	8-1928	5.136	172	8-1946	0.197	wall contact sample, contaminated		
168	8-1903	2.492	169	8-1925	0.092	170	87-1514	0.62 RL
166	8-1863	1.300	167	8-1870	0.364			
164	8-1848	1.937	165	8-1851	0.013			
161	8-1816	1.721	162	8-1838	0.037	163	87-1511	0.57 RL
159	8-1795	2.145	160	8-1815	0.065			
157	8-1756	2.273	158	8-1779	0.026			
155	8-2216	2.052	156	8-2250	0.060			
152	8-2171	1.573	153	8-2177	0.066	154	87-1474	0.49 RL
150	8-2140	1.491	151	8-2167	0.050			
148	8-2130	1.057	149	8-2131	0.189			
146	8-2102	2.072	147	8-2124	0.025			
144	8-2083	2.122	145	8-2085	0.052			
142	8-2071	1.937	143	8-2077	0.090			
139	8-2-43	2.132	140	8-2062	0.091	141	87-1432	0.64 RL
						202	8-2247	0.265 RF*
137	8-1995	1.545	138	8-2007	0.105	inner core, possibly Pb-free		
135	8-1991	5.162	136	8-1993	0.214	wall contact sample, contaminated		
132	8-1915	1.944	133	8-1981	0.043	134	87-1068	0.32 RL
130	8-2163	1.761	131	8-2185	0.049			
127	8-2236	1.775	128	8-2239	0.038	129	87-1365	0.48 RL
125	8-2196	1.932	126	8-2225	0.158			
123	8-2158	2.093	124	8-2186	0.074			
121	8-2141	2.182	122	8-2144	0.249			
119	8-2113	1.692	120	8-2134	0.138			
117	8-2056	2.162	118	8-2067	0.090			
114	8-1988	1.768	115	8-2031	0.366	116	87-1023	0.41 RL
112	8-1966	2.047	113	8-1969	0.117			
110	8-1948	2.050	111	8-1959	0.101	201	8-2243	0.099 RF
108	8-1933	1.949	109	8-1949	0.129			
105	8-1910	1.718	106	8-1927	0.061	107	87-1417	0.61 RL
103	8-1904	2.241	104	8-1909	0.156			
101	8-2251	1.549	102	8-2252	0.146	inner core, possibly Pb-free		
99	8-2110	3.719	100	8-2241	0.235	wall contact sample, contaminated		
97	8-2088	1.896	98	8-2096	0.125			
94	8-2078	1.899	95	8-2080	0.112	96	87-1382	0.44 RL
92	8-2059	2.030	93	8-2061	0.044	200	87-2222	0.063 RF
90	8-1954	1.647	91	8-1967	0.142			
88	8-1917	1.623	89	8-1923	0.161			
86	8-1691	2.104	87	8-1713	0.122	199	8-2214	0.323 RF
83	8-1662	1.759	84	8-1667	0.138	85	87-1303	0.37 RL
80	8-2255	1.768	81	8-1590	0.078	82	8-1956	0.747 RF
78	8-1864	1.753	79	8-1899	0.103			
76	8-1760	1.427	77	8-1844	0.179			
74	8-1547	1.975	75	8-1741	0.132			
72	8-1542	1.468	73	8-1546	0.116			
69	8-1501	1.356	70	8-1516	0.064	71	87-1302	0.29 RL
67	8-1568	1.697	68	8-2253	0.035			
65	8-1525	0.980	66	8-1556	0.076	inner core, possibly Pb-free		
63	8-1498	2.978	64	8-1521	0.200	wall contact sample, contaminated		
61	8-1839	1.735	62	8-1859	0.058			
59	8-1761	0.956	60	8-1763	0.053			
56	8-1714	1.562	57	8-1722	0.088	58	87-1258	0.48 RL
54	8-2056	1.799	55	8-2126	0.111			
52	8-1837	1.776	53	8-1947	0.092			
49	8-1715	1.298	50	8-1727	0.029	51	87-384	0.51 RL
47	9-1929	1.348	48	8-1935	0.054	inner core, possibly Pb-free		
45	8-1787	3.459	46	8-1830	0.900	wall contact sample, contaminated		
42	8-1429	1.967	43	8-1757	0.089	44	87-1243	0.67 RL
40	8-1876	1.596	41	8-1889	0.040			

*RL- red light sample
RF- rock fragment

Figure 15-5.- (continued) Sample location information, Apollo 15 deep drill string section 15003

Sample locations for core 15002

- Fragment (no. 120) in container 8-1077; 0.30 gm → 3 cm
- Fragment (no. 113) in container 8-1052; 1.08 gm → 5.5 cm
- Fragment (no. 105) in vial 8-1100; 0.38 gm → 9 cm
- Fragment (no. 100) in vial 8-1115; 2.58 gm → 11 cm
- Fragment (no. 98) in vial 8-1084; 0.66 gm → 12 cm
- Fragment (no. 78) in vial 8-1051; 0.49 gm → 21 cm

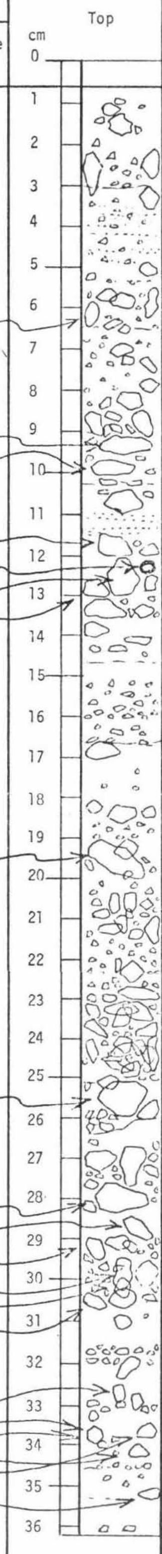
Top; Plug (0–2 cm); Plug (40–41 cm)

Daughter no.	Container no.	Mass, gm	Daughter no.; mass, gm; and container no. of red light samples
121	8-1056	3.45	
119	8-1081	1.86	
118	8-1144	1.91	
116	8-1120	1.42	117; 0.60; 87-2902
115	8-1125	1.20	
114	8-1118	1.76	
112	8-1091	1.34	
111	8-1092	1.92	
110	8-1124	1.87	
109	8-1110	1.08	
108	8-1063	1.97	
107	8-1127	1.78	
106	8-1095	1.12	
104	8-1112	3.38	
103	8-1105	1.44	
102	8-1119	1.22	
101	8-1141	1.89	
99	8-1132	1.66	
97	8-1059	1.96	
96	8-1089	1.75	
94	8-1134	1 96	95; 0.13; 87-2839
93	80-1128	1.64	
92	80-1061	1.62	
91	8-1096	1.62	
90	8-1108	1.74	
89	8-1130	1.43	
88	8-1138	1.56	
87	8-1073	1.32	
86	8-1078	1.90	
85	8-1086	1.67	
84	8-1106	1.80	
83	8-1140	1.16	
82	8-1123	1.71	
81	8-1057	1.71	
80	8-1053	2.00	
79	8-1111	1.87	
77	8-1137	1.60	
76	8-1104	1.90	
75	8-1074	1.14	
74	8-1066	2.15	
73	8-1145	2.02	
72	8-1121	1.90	
71	8-1054	2.24	
70	8-1065	2.12	
69	8-1102	2.13	
68	8-1060	1.83	
67	8-1085	1.84	
66	8-1094	1.92	
64	8-1072	1.25	65; 0.62; 003-2854
63	8-1080	2.60	
62	8-1090	1.99	
61	8-1135	2.42	
60	8-1082	1.84	
59	8-1117	2.09	
58	8-1142	2.23	
57	8-1107	1.72	
56	8-1099	1.87	
55	8-1101	2.46	
54	8-1076	2.03	
53	8-1069	1.69	
52	8-1116	1.97	
51	8-1109	2.05	
50	8-1139	2.01	
49	8-1079	1.79	
48	8-1113	1.61	
47	8-1098	1.84	
46	8-1083	2.11	
45	8-1071	1.99	
44	8-1088	1.69	
43	8-1058	2.23	
42	8-1087	1.81	
41	8-1075	1.73	
40	8-1129	1.67	
39	8-1070	1.89	

Figure 15-5.- (continued) Sample location information, Apollo 15 deep drill string section 15002

COARSE FRACTION

Sample No.	Container No.	Sample Wt.
126	8-1399	0.17
117	8-1174	0.77
116	8-1195	0.27
110	8-1277	0.49
107	8-1278	0.18
105	8-1252	1.14
103	8-1211	0.32
90	8-1256	0.40
75	8-1224	1.51
70	8-1255	1.02
67	8-1202	0.39
65	8-1214	0.24
64	8-1265	0.82
63	8-1201	0.57
60	8-1264	0.30
53	8-1190	0.06
50	8-1221	0.08
49	8-1216	0.01
48	8-1192	0.12
47	8-1248	0.11
43	8-1276	0.16
	EARLY SPLITS	
8	87-2790	0.250
6	87-2931	0.370



INTERVAL SAMPLES

Sample No.	Container No.	Sample Wt.
137	8-1373	1.00
136	8-1288	1.03
135	8-1335	1.70
134	8-1404	1.51
133	8-1405	2.40
132	8-1359	2.38
131	8-1394	2.16
130	8-1386	2.41
129	8-1388	1.78
128	8-1403	2.75
127	8-1400	2.90
125	8-1343	1.48
124	8-1181	2.01
123	8-1157	2.55
122	8-1122	1.83
121	8-1207	2.07
119	8-1159	1.02
118	8-1237	1.84
115	8-1219	2.48
114	8-1191	1.30
112	8-1222	2.53
111	8-1251	1.44
108	8-1213	2.22
105	8-1246	1.62
104	8-1197	1.59
102	8-1253	1.91
101	8-1232	1.95
100	8-1223	3.02
99	8-1233	3.19
98	8-1274	2.00
96	8-1236	2.07
95	8-1229	2.42
94	8-1249	2.20
93	8-1227	1.80
92	8-1198	2.18
91	8-1210	1.33
89	8-1208	2.65
88	8-1230	1.60
87	8-1228	2.56
86	8-1243	2.62
85	8-1205	2.78
83	8-1231	1.28
82	8-1238	2.08
81	8-1267	1.93
80	8-1186	3.34
79	8-1209	1.92
78	8-1226	2.81
77	8-1220	3.43
76	8-1200	2.02
74	8-1259	2.40
73	8-1235	2.04
72	8-1204	1.64
71	8-1242	3.35
69	8-1258	1.29
68	8-1193	1.58
66	8-1265	3.86
62	8-1270	1.87
61	8-1188	2.64
59	8-1240	2.13
58	8-1261	2.66
57	8-1268	2.12
56	8-1199	2.16
54	8-1225	1.15
52	8-1203	2.49*
51	8-1234	1.64
46	8-1275	2.63
45	8-1215	1.68
44	8-1280	1.87
42	8-1196	1.92
41	8-1206	1.38
	EARLY SPLITS	
19	87-2815-003	1.010
18	87-2788-003	0.080
17	87-2831-003	0.530
14	87-2780-003	0.760
9	87-2916-003	0.950
7	87-2823-003	0.410
5	87-2837-003	0.340

SPECIAL SAMPLES

Sample No.	Container No.	Sample Wt.
120	86-1161-002	0.69 RL
109	86-1006-002	0.35 RL
97	86-1371-002	0.91 RL
84	86-1131-002	0.67 RL
55	8-1261	0.98 RL
*USSR		
113	8-1062	0.350

Sample locations for core 15001

APOLLO 16 CORE SAMPLES

Four double drive tubes and one 2.25 m drill core were taken at Stations 4, 8, and 10 and in the ALSEP area (Figs. 16-1 and 16-2). A total length of approximately 480 cm of core materials was returned. These cores were X-rayed shortly after they were unpacked. The following preliminary descriptions made by S. Nagle are based on the resulting X-radiographs and have been partially reported by LSPET (1973).

PRELIMINARY EXAMINATION, DRIVE TUBES 64002 AND 64001

Drive tubes 64002 and 64001 may be the only samples from Apollo 16 Station 4 to contain lunar material from beneath the South Ray ejecta blanket. At any rate, the total reversal in texture within the cored interval strongly supports this possibility. The upper 51 cm of the section is notably coarse-grained, with an abundance of rock fragments of several varieties, as seen in X-ray section (Fig. 16-3). In contrast, the lower 19 cm is considerably finer grained, and what rock fragments there are show different transmission properties than those of the upper zone.

The upper interval is further subdivided into five major zones or beds. The uppermost zone (7) is characterized by an abundance of rock fragments, many of which are over 1 cm in diameter. Next is a thin bed (zone 6) with distinctly fewer, smaller rock fragments, and a matrix which is less grainy in appearance, probably because of finer grain size. Zone 5 contains the highest percentage of rock fragments in the entire core, greater than 50 percent over most of the interval. Furthermore, the rock fragments show a great variety of types, including opaque, semi-opaque with distinct outlines, semi-opaque with vague outlines, most of which may be equant as well as elongate. Zone 4 contains fewer rock fragments than zone 5, but shape and X-ray characteristics of the rocks appear to be similar in both zones. The lowest coarse-grained bed (zone 3) is a thin horizon with over 50 percent coarse rock debris, 0.5 to 1.5 cm in diameter with most of the rock fragments in this bed very irregular in outline.

The lower interval contains two stratigraphic horizons. The upper one (zone 2) appears to have a uniformly fine-grained matrix, and contains few rock fragments, most of which are semi-opaque, with a vague, raggedy outline. Matrix of the lower interval (zone 1) is "denser" appearing in X-radiograph, as well as being more granular with a higher percentage of rock fragments and opaque material present. In contrast to the rest of the core, opaque material in zone 1 is angular to subangular, instead of being rounded and spherical.

A preliminary observation, to be kept in mind during subsequent physical inspection of 64001 and 64002, is the significance of textural

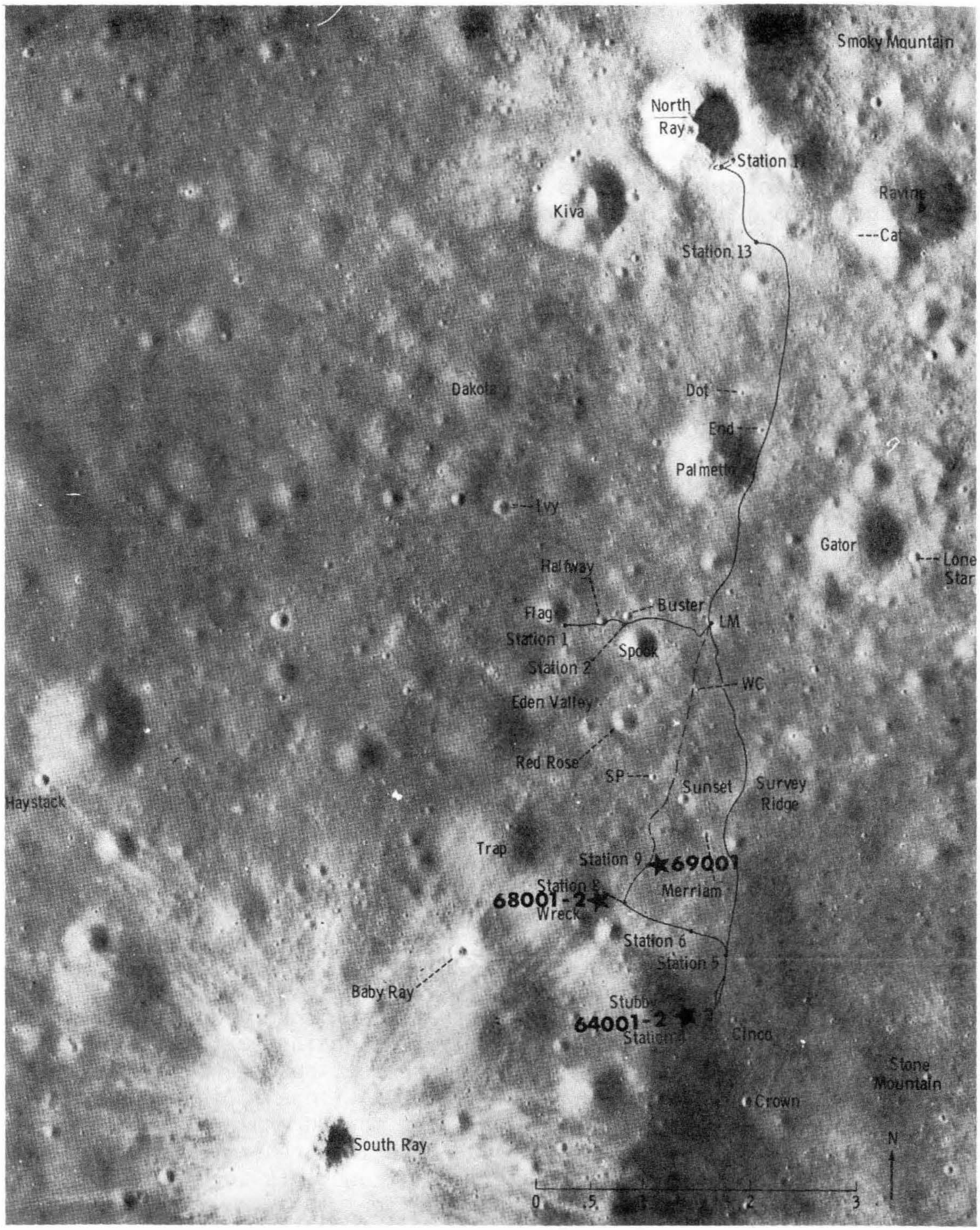


Figure 16-1.- Location of Apollo 16 cores in Descartes area.

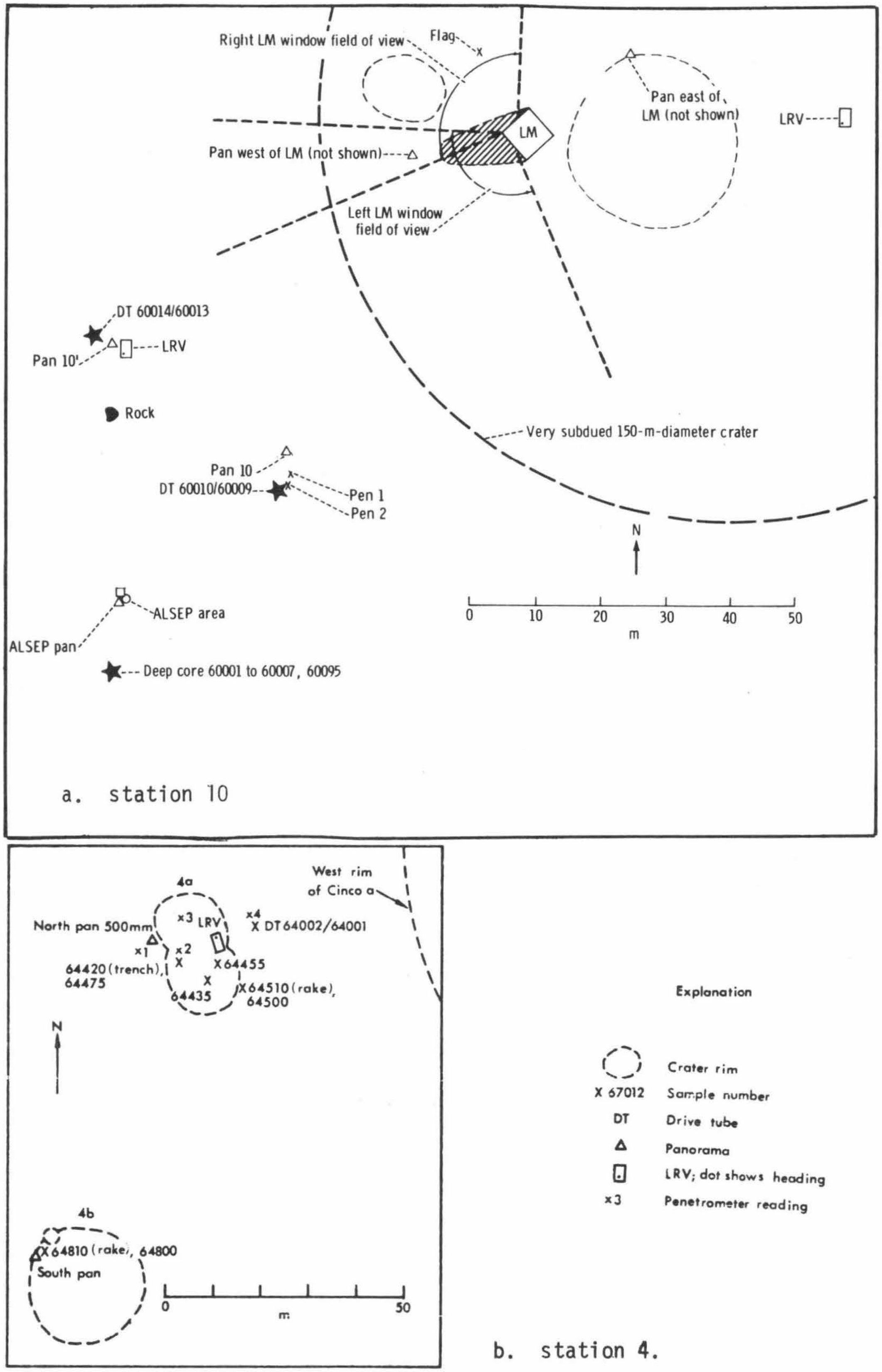
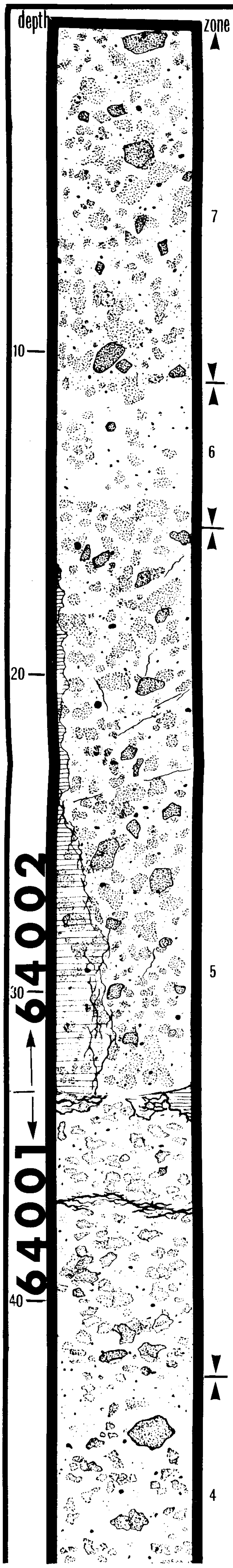


Figure 16-2.- Location of Apollo 16 cores at (a) station 10, and (b) station 4 in the Descartes area. (b was revised December, 1974).



ZONE 7 DEPTH: 0 - 11 cm THICKNESS: 11 cm

CHARACTERIZED BY ABUNDANT, COARSE ROCK FRAGMENTS.

2% OPAQUE, ALL UNDER 1.2 mm DIAMETER. MOST BETWEEN 0.5 AND 1.0 mm; APPEAR TO BE OF EVEN SIZE DISTRIBUTION (WELL-SORTED), MOSTLY SPHERICAL AND WELL ROUNDED.

10% SEMI-OPAQUE WITH SHARP OUTLINE, 0.5 TO 1.3 cm LONG, MOSTLY ABOUT 1.0 cm, SUBANGULAR, WITH NOTICEABLY STRAIGHT EDGES.

50% SEMI-OPAQUE WITH VAGUE OUTLINE, 0.1 TO 1.2 cm, MOSTLY BETWEEN 0.3 AND 0.5 cm. CLOD-LIKE APPEARANCE, BUT PROBABLY NOT CLODS, WHICH TEND TO BE TRANSPARENT TO X-RAYS.

ZONE 6 DEPTH: 11 - 14.5 cm THICKNESS: 3.5 cm

FINER-GRAINED THAN ABOVE, WITH FEWER ROCK FRAGMENTS.

1% OPAQUE, UP TO 0.8 DIAMETER, MOSTLY 0.3 TO 0.8 mm, WELL SORTED AND ROUNDED.

30% SEMI-OPAQUE, WITH VAGUE OUTLINE, LARGEST ROCK FRAGMENTS 0.8 cm IN DIAMETER, IN CONTRAST TO ABOVE. MOST FRAGMENTS ARE UNDER 0.5 cm, AND APPEAR TO HAVE A MORE EVEN SIZE DISTRIBUTION THAN ABOVE.

ZONE 5 DEPTH: 14.5 - 42 cm THICKNESS: 27.5 cm

CHARACTERIZED BY VERY ABUNDANT, LARGE, VARIED ROCK FRAGMENTS.

2% OPAQUE, UP TO 2.0 mm DIAMETER, MOSTLY ABOUT 0.2 TO 0.5 mm, RELATIVELY GREAT SIZE DISTRIBUTION, MOST PIECES EQUANT, WELL ROUNDED.

20% SEMI-OPAQUE, WITH DISTINCT OUTLINE, MOSTLY 0.5 AND 1.0 cm DIAMETER, BUT RANGING UP TO 1.4 cm. MOST FRAGMENTS ARE EQUANT, BUT ABOUT 5% (OF TOTAL ROCK) DISTINCTLY ELONGATE. MARGINS STRAIGHT, SUBANGULAR.

60% SEMI-TRANSPARENT, WITH VAGUE OUTLINE, SIMILAR TO ZONE 1.

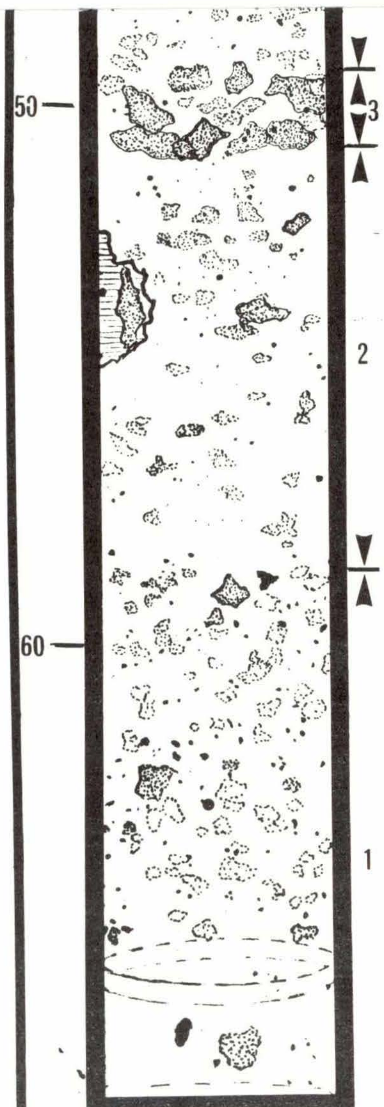
ZONE 4 DEPTH: 42 - 49 cm THICKNESS: 7 cm

SIMILAR TO ABOVE, BUT WITH FEWER ROCK FRAGMENTS, MORE MATRIX.

2% OPAQUE, UP TO 1.5 mm DIAMETER, SORTING AND ROUNDING AS ABOVE.

15% SEMI-OPAQUE WITH DISTINCT OUTLINE, SIMILAR TO ABOVE, EXCEPT FOR ABSENCE OF ELONGATE ROCK FRAGMENTS.

10% SEMI-OPAQUE WITH VAGUE OUTLINE, AS IN ZONE 1.



ZONE 3 DEPTH: 49 - 51 cm THICKNESS: 2 cm

CHARACTERIZED BY ABUNDANT, LARGE ROCK FRAGMENTS.

1% OPAQUE, UP TO 0.8 mm DIAMETER, MOSTLY 0.3 TO 0.5 mm DIAM., WITH FAIRLY EVEN SIZE DISTRIBUTION, GOOD SPHERICITY AND ROUNDING.

60% SEMI-OPAQUE ROCK FRAGMENTS WITH MODERATELY INDISTINCT OUTLINE. IN CONTRAST TO UPPER LAYERS, ROCK FRAGMENTS IN THIS ZONE DO NOT SHOW DISTINCT OUTLINES THROUGHOUT, BUT SOME ARE DISTINCT AND OTHERS VAGUE. ROCK FRAGMENTS RANGE FROM 0.3 TO 1.6 cm. MOST BETWEEN 0.5 AND 1.1 cm., AND MOST ARE ELONGATE AND IRREGULAR.

10% SEMI-OPAQUE WITH VAGUE OUTLINE, "CLODS," AS ABOVE.

ZONE 2 DEPTH: 51 - 58 cm THICKNESS: 7 cm

FINEST-GRAINED SECTION IN THE CORE.

1% OPAQUE, AS IN ZONE 5.

10% SEMI-OPAQUE ROCK FRAGMENTS WITH MODERATELY INDISTINCT OUTLINE, AS IN ZONE 3, EXCEPT THAT MOST ARE 0.3 TO 0.8 mm DIAMETER.

10% SEMI-OPAQUE ROCK FRAGMENTS WITH INDISTINCT, IRREGULAR OUTLINE, UP TO 1.1 mm DIAMETER, MOSTLY 0.5 to 1.0 mm DIAMETER, EQUANT, SCATTERED IN INDISTINCT LAYERS AT ABOUT 53 AND 56 cm.

AT 54 cm IS A PARTIALLY VOID SPACE SURROUNDING A LARGE, ELONGATE ROCK FRAGMENT. THE VOID IS HEREIN INTERPRETED AS BEING CREATED BY DISTURBANCE OF THE ROCK FRAGMENT DURING SAMPLING.

ZONE 1 DEPTH: 58 - 70 cm THICKNESS: 12 cm

CHARACTERIZED BY ANGULAR TO SUBANGULAR OPAQUES, COARSER THAN ABOVE.

2% OPAQUE, UP TO 5 mm DIAMETER, MOSTLY 0.5 TO 1.0 mm, BUT WITH ONLY MODERATELY GOOD SORTING, MOST FRAGMENTS EQUANT BUT NOTABLY ANGULAR TO SUBANGULAR, SOME WITH IRREGULAR OUTLINE.

5% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE, 0.3 TO 0.8 cm DIAMETER, MOSTLY ABOUT 0.5 cm., WITH IRREGULAR, EQUANT, SUBANGULAR OUTLINE.

25% SEMI-OPAQUE ROCK FRAGMENTS WITH INDISTINCT, MOTTLED OUTLINE, UP TO 1.0 cm DIAMETER, BUT MOST APPEAR TO BE IN THE RANGE OF 0.5 cm. FRAGMENTS APPEAR TO BE EQUANT TO SLIGHTLY ELONGATE, AND IRREGULAR IN OUTLINE.

Figure 16-3.- Description from X-radiograph sketches of Apollo 16 drive tubes 64002 - 64001.

changes in the lowest 21 cm of the core - which textural change reflects the major change in depositional events?

Fifty-nine cm below the lunar surface (11 cm from the base of the core) is the only major change in character of the X-ray opaque particles. Higher in the core, the particles are mostly spherical, whereas in the lower portion they tend to be irregular and lumpy. Because opaques reflect the textural make-up of the core as a whole, the change indicates a major textural reversal. On the other hand, the principal grain size change takes place at 51 cm (19 cm from the base of the core); with very coarse, granular material above, and principally fine-grained material below. To further complicate matters, the major change in coarse clasts takes place at a depth of 49 cm, 21 cm from the base. Below this depth, nearly all coarse particles are elongate, with irregular, raggedy outlines in X-ray section. Higher, most coarse fragments tend to be equant to subequant, with more-or-less regular outlines.

PRELIMINARY EXAMINATION, DRIVE TUBES 68002 AND 68001

Drive tubes 68002 and 68001 were taken 1 and 2 m from the edge of a 10 to 15 m crater that appears to be about 2 m deep (on the panoramic photograph of the station). Sample site photographs A16-108-17682 through -685 show that small craters, less than 0.5 m are common in the area. Stereopair examination of these photographs also reveals concentric ridges of coarser material, scalloped and lineated radially to the 10 to 15 m crater. Position of these is indicated on the sketch Figure 16-4;field configuration of the coarse and fine material suggests ejecta from the 10 to 15 m crater. This material should be represented in the drive tube section.

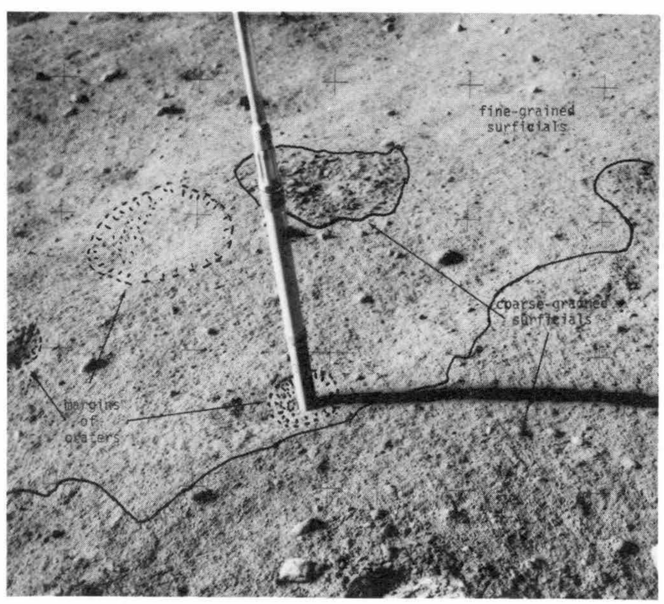


Figure 16-4.- Major surface fractures.

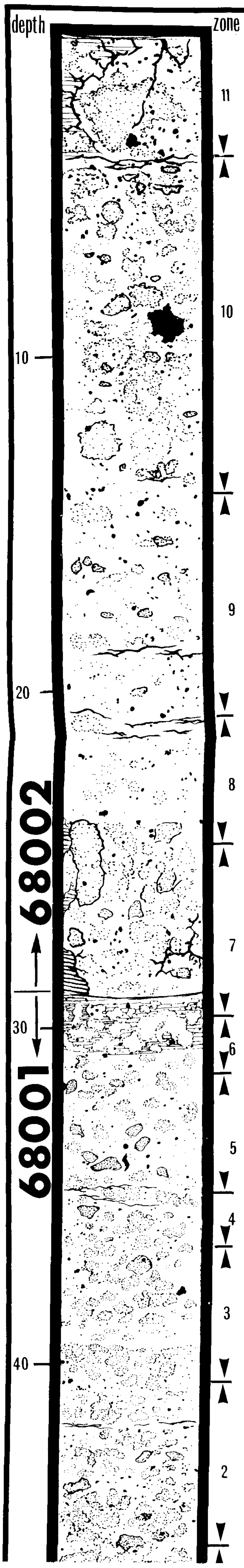
Within the core (Fig. 16-5) the upper 13.5 cm is notably coarse-grained, with diverse rock types. The upper 3 cm is highly fractured, possibly the effect of impact and generation of the small crater from which the sample was taken, or a sampling artifact, or a combination of both. The coarse material overlies two finer-grained units, 7 and 3 cm thick, respectively. The lower unit (8) is distinctive in having no rock fragments and a very low content of X-ray opaque material in the matrix. Beneath the finer-grained units is a bed with very coarse, abundant rock fragments that are notably lumpy, in contrast to the smooth-outlined rock fragments of other coarse-grained beds. Below the coarse-grained bed are two finer-grained layers with scattered rock fragments, soil fractures, and nodules. Opaques of the matrix in these beds are notably blocky and angular, in strong contrast to opaques of the other beds, in which there is a strong component of spherical opaques. The lowest 26 cm of the core (possibly even more below the core) is very coarse-grained, and consists of a singly graded bed with a great diversity of rock fragment types. The top surface of this interval is gently undulating, and may represent a buried topographic surface.

The basal graded bed represents the strongest strata-generating event in the core, in terms of bringing together a diversity of rock types of coarse dimension. The event is comparable to action which generated coarse-grained lithologically diverse beds in other cores from Apollo 16. Other, thinner units represent less energetic impacts, bringing in material from more restricted sources; and at least one of the upper, coarse-grained units should be derived from the adjacent 10 to 15 m crater.

PRELIMINARY EXAMINATION, DRIVE TUBES 60010 AND 60009

This core sample was taken on the eastern margin of a 50 to 60 cm shallow, subdued crater, about 100 m southwest of the LM site, and 6 m SSE of Station 10, as documented on photograph 115-18557. It can be seen on that photograph that the core was taken at the crest of the crater rim. From the USGS Report 51 (p. 21) it appears that there is no visible ejecta from the crater, and that the surface of the area is covered with relatively fine-grained material, including fines, pea-sized fragments, and other rocks, none larger than a few centimeters.

The basal unit of the core (Figure 16-6) 8 cm thick, is noticeably finer grained than any other interval in the section, consisting of 80 percent matrix. Within the matrix, opaques, approximately 1 percent are less abundant than in the rest of the core and the coarse fraction consists of indistinct mottles. In contrast, unit 2 is extremely coarse-grained, with a wealth of large rock fragments, a greater percentage of opaques (2 percent) than the underlying unit, distinctively shard-shaped, and anomalous sorting between the coarse rock fragments and the mottles and opaques. Interestingly enough, the matrix of this interral



UNIT 11 DEPTH: 0 - 3.5 cm THICKNESS: 3.5 cm

FRACTURED INTERVAL WITH ABUNDANT ROCK FRAGMENTS

MATRIX: 40%, NOT VERY DENSE, PROBABLY BECAUSE OF VOID SPACE, FINELY GRANULAR, WITH ABOUT 4% OPAQUE, RANGING FROM LIMIT OF RESOLUTION TO 1.5 mm DIAMETER, MOST FRAGMENTS 0.5 TO 0.7 mm, MODERATELY POORLY SORTED, WITH ABOUT 50% SPHERICAL AND THE REST LUMPY AND SUBANGULAR.

FRAMEWORK: 30%, OCCUPIED BY ONE LARGE FRAGMENT, 2.7 cm DIAMETER, AN EQUIDIMENSIONAL BLOCK, SUBRHOMBOIDAL IN OUTLINE, WITH MODERATELY IRREGULAR MARGINS, ANGULAR CORNERS.

30% SEMI-OPAQUES WITH VAGUE OUTLINE, 0.2 TO 0.5 cm DIAMETER, WELL SORTED, MOSTLY EQUIGRANULAR AND LUMPY, REMINISCENT OF LUMPS OF COTTON.

THE ENTIRE INTERVAL APPEARS TO BE SOMEWHAT FRACTURED, WITH MUCH VOID SPACE. THIS IS PROBABLY A SAMPLING ARTIFACT, BUT THE CORE WAS COLLECTED FROM THE CENTER OF A SMALL CRATER, AND FRACTURING COULD BE A RESULT OF THE CRATER.

UNIT 10 DEPTH: 3.5 - 13.5 cm THICKNESS: 10 cm

COARSE-GRAINED BED WITH DIVERSE ROCK TYPES

MATRIX: 50%, DISTINCTLY FINELY GRANULAR, WITH 3% OPAQUE, LIMIT OF RESOLUTION TO 1.6 mm DIAMETER, MOSTLY 0.5 TO 1.0 mm, ONLY MODERATELY WELL SORTED. AS BELOW (UNIT 9) NEARLY ALL FRAGMENTS ARE EQUANT AND SPHERICAL, WITH A SMALL BUT DISTINCT COMPONENT OF BLOCKY, OVOID, ROD OR COMMA-SHAPED PARTICLES.

FRAMEWORK: 5% OPAQUE; ONE LARGE FRAGMENT, 1.2 cm DIAMETER, EQUANT, WITH JAGGED, ANGULAR PROTUBERANCES ON ALL SIDES.

20% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE, 0.1 TO 1.3 cm DIAMETER, POORLY SORTED WITH ALL SIZES EQUALLY REPRESENTED. ROCK FRAGMENTS ARE MOSTLY ELONGATE-POLYGONAL, WITH SOME EQUANT PARTICLES: A FEW ELONGATE FRAGMENTS HAVE SMOOTH EDGES AND ANGULAR CORNERS: THE REST HAVE IRREGULAR TO LUMPY MARGINS AND ARE ANGULAR TO SUBANGULAR.

25% SEMI-OPAQUE WITH INDISTINCT OUTLINE, 0.1 TO 1.2 cm DIAMETER, MODERATELY POORLY SORTED AS THE FRAGMENTS WITH DISTINCT OUTLINES, BUT THESE PARTICLES HAVE VERY IRREGULAR, SUBROUNDED (WHERE VISIBLE) LUMPY OUTLINES.

UNIT 9 DEPTH: 13.5 - 20.5 cm THICKNESS: 7 cm

FINE-GRAINED UNIT WITH SPARSE ROCK FRAGMENTS

MATRIX: 85% DEFINITELY FINELY GRANULAR, WITH 3% OPAQUES UP TO 1.5 mm DIAMETER, MOST BETWEEN 0.5 TO 1.0 mm AND ONLY MODERATELY ASSORTED. 80% OF THE OPAQUES ARE EQUANT, MOSTLY ROUNDED AND SPHERICAL, ALTHOUGH ABOUT 10% ARE BLOCKY. THE REMAINING 20% OF THE OPAQUES ARE OVOID, ROD, OR COMMA-SHAPED WITH WELL ROUNDED CORNERS.

FRAMEWORK: 10% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE; 0.3 TO 0.5 cm DIAMETER, OVOID TO EQUANT-POLYHEDRAL WITH STRAIGHT MARGINS AND ROUNDED TO SUBROUNDED CORNERS. THERE IS A THIN LAYER OF THESE ROCK FRAGMENTS AT 16 cm DEPTH.

5% SEMI-OPAQUE, PROBABLY ROCK FRAGMENTS, WITH INDISTINCT OUTLINE, 0.2 TO 0.8 cm DIAMETER, POORLY SORTED WITH EQUAL SIZE DISTRIBUTION THROUGHOUT, EQUIGRANULAR LUMPY TO NODULAR APPEARANCE, WITH ROUNDED TO SUBROUNDED CORNERS, WHERE VISIBLE.

FRACTURED ZONE MARKS CONTACT BETWEEN UNIT 8 AND UNIT 9

UNIT 8 DEPTH: 20.5 - 23.5 cm THICKNESS: 3 cm

FINE-GRAINED BED WITH SPARSE MOTTLES

MATRIX: 75%, DISTINCTLY FINELY TO VERY FINELY GRANULAR, WITH ABOUT 1% OPAQUES, UP TO 0.9 mm DIAMETER, MODERATELY WELL SORTED WITH MOST PARTICLES ABOUT 0.5 mm EQUIGRANULAR, SUBGRANULAR TO SUBROUNDED.

FRAMEWORK: 25% SEMI-TRANSPARENT DENSITY CONCENTRATIONS WITH INDISTINCT OUTLINES, POSSIBLY ROCK FRAGMENTS, 0.1 TO 0.9 cm DIAMETER, POORLY SORTED WITH ALL SIZES PRESENT IN EQUAL ABUNDANCES; MOSTLY EQUANT TO SUB-EQUANT WITH LUMPY, NODULAR OUTLINES, MORE MOTTLED APPEARING THEN ROCK-FRAGMENTAL APPEARING.

CONTACT BETWEEN UNITS 7 AND 8 IS ABRUPT, BUT INDISTINCT

UNIT 7 DEPTH: 23.5 - 28 cm THICKNESS: 4.5 cm

COARSE-GRAINED BED, ABUNDANT ROCK FRAGMENTS

MATRIX: 30%, DISTINCTLY AND IRREGULARLY GRANULAR TO FINELY LUMPY, WITH 3 - 4% OPAQUES, LIMIT OF RESOLUTION TO 1.5 mm DIAMETER, MOSTLY ABOUT 1.0 mm, TENDING TO BE EQUANT AND BLOCKY, WITH ONLY A FEW ELONGATE, COMMA-SHAPED PARTICLES. ABOUT 10% OF OPAQUES SHOW ROUNDING, REST ARE ANGULAR.

FRAMEWORK: 40% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE, 0.2 TO 2.3 cm LENGTH, POORLY SORTED, EQUANT TO ROD-SHAPED, WITH IRREGULARLY LUMPY EDGES, SUBROUNDED CORNERS. THESE LUMPY ROCK FRAGMENTS CONTRAST STRONGLY WITH ROCK FRAGMENTS OF SOME OTHER INTERVALS, WITH NOTICEABLY STRAIGHT SIDES. THE LARGE ELONGATE FRAGMENT AT 25 cm DEPTH HAS A LONG AXIS PARALLEL TO THE TUBE, AND IS ASSOCIATED WITH SOME CRACKING AND VOID SPACE, AND APPEARS TO HAVE BEEN ROTATED TO THIS CONFIGURATION DURING SAMPLING.

30% SEMI-OPAQUE WITH INDISTINCT OUTLINES, PROBABLY ROCK FRAGMENTS, 0.1 TO 1.3 CM DIAMETER, MOSTLY ABOUT 1.5 cm, ALTHOUGH MODERATELY POORLY SORTED. MOST FRAGMENTS EQUANT, IRREGULARLY LUMPY.

UNIT 6 DEPTH: 28 - 29.5 cm THICKNESS: 1.5 cm

FRACTURED ZONE AT TOP OF CORE

MATRIX: 40%, DISTINCTLY LESS DENSE THAN UNDERLYING LAYERS, PRINCIPALLY BECAUSE OF VOID SPACE, BUT ALSO NOTICEABLY LESS FINELY GRANULAR, WITH ABOUT 4% OPAQUE, 0.1 TO 2.1 mm DIAMETER, MOSTLY 0.6 TO 0.8 mm, PRINCIPALLY EQUANT, TO TEAR-DROP SHAPED, WITH BLOCKY OUTLINES, ANGULAR TO SUBANGULAR CORNERS.

FRAMEWORK: 60%, SEMI-OPAQUE DENSITY CONCENTRATIONS WITH IRREGULAR OUTLINES, FRAGMENTS RANGE FROM 0.2 TO 1.3 cm DIAMETER, POORLY SORTED, WITH EQUANT, LUMPY OUTLINES. INTERNAL FRACTURES IN SOME OF THESE FRAGMENTS COULD BE A RESULT OF DISTURBANCE DURING SAMPLING AND HANDLING.

UNIT 5 DEPTH: 34.0 - 29.5 cm THICKNESS: 4.5 cm

FINE-GRAINED BED WITH SCATTERED ROCK FRAGMENTS, BLOCKY, ANGULAR OPAQUES

MATRIX: 80% FINELY GRANULAR, WITH ABOUT 3% OPAQUES, LIMIT OF RESOLUTION TO 2.5 mm DIAMETER, POORLY SORTED WITH MEDIAN SIZE ABOUT 0.8 mm. FRAGMENTS ARE EQUANT-BLOCKY WITH ABOUT ONLY 10% SPHERICAL, 5% ELONGATE TO COMMA-SHAPED AND IRREGULAR, THE REST BLOCKY WITH SUBANGULAR TO ANGULAR CORNERS.

FRAMEWORK: 10% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE, 0.2 - 0.5 cm DIAMETER, EQUANT TO ELONGATE, RECTANGULAR TO WEDGE-SHAPED, WITH RELATIVELY STRAIGHT EDGES AND SUBANGULAR TO SUBROUNDED CORNERS.

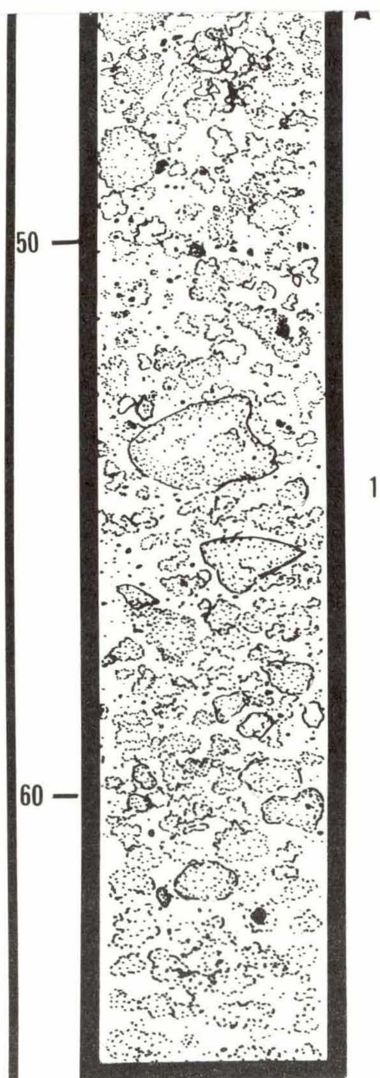
10% SEMI-OPAQUE WITH INDISTINCT OUTLINES: 0.1 TO 0.4 cm DIAMETER, MOSTLY AROUND 0.3 cm, EQUANT, AND LUMPY IN OUTLINE.

UNIT 4 DEPTH: 34.5 - 34.0 cm THICKNESS: 0.5 cm

INTERVAL AS BELOW (UNIT 3) IN COMPOSITION, BUT PENETRATED BY NUMEROUS EN-ECHELON CRESCENTIC FRACTURES, UP TO 8 mm LONG, 1 mm ACROSS.

UNIT 3 DEPTH: 34.2 - 38 cm THICKNESS: 3.5 cm

FINE-GRAINED BED WITH SCATTERED ROCK FRAGMENTS, BLOCKY, ANGULAR OPAQUES



MATRIX: 80%, DISTINCTLY LESS "DENSE" THAN BELOW, ALTHOUGH FINELY GRANULAR. THIS BED CONTAINS ABOUT 2% OPAQUES, UP TO 1.5 mm DIAMETER, POORLY SORTED WITH MEDIAN SIZE ABOUT 0.7 mm; FRAGMENTS ARE ALL EQUANT, BLOCKY, WITH SUBANGULAR TO ANGULAR CORNERS, ROUNDED AND ELONGATE PARTICLES ARE NOTICEABLY ABSENT.

FRAMEWORK: 5% SEMI-OPAQUE WITH DISTINCT OUTLINE, EQUANT, BLOCKY ROCK FRAGMENTS 0.1 TO 0.6 cm DIAMETER, MOSTLY ABOUT 0.2 cm, WITH RELATIVELY STRAIGHT SIDES, SUBANGULAR CORNERS.

15% SEMI-OPAQUE, VAGUE OUTLINE, 0.1 TO 0.8 cm DIAMETER, MOST FRAGMENTS ABOUT 0.3 cm DIAMETER, VERY INDISTINCTLY EQUANT, LUMPY TO ROUNDED.

NOTE: LITHOLOGIC UNITS 1 AND 2 FORM A CONTINUOUS GRADED BED, WITH A SHARP UPPER CONTACT MARKED BY A GENTLY UNDULATING SURFACE.

UNIT 2 DEPTH: 38 - 42.5 cm THICKNESS: 4.5 cm

THIN BED WITH WELL SORTED SMALL ROCK FRAGMENTS, SPHERICAL OPAQUES

MATRIX: 70%, AS UNIT 1, NOTABLY DENSER THAN OVERLYING UNIT (#3), AND WITH MUCH HIGHER PERCENTAGE OF ROUNDED, SPHERICAL OPAQUE FRAGMENTS THAN OVERLYING BED, WHICH CONTAINS MOSTLY BLOCKY, ANGULAR FRAGMENTS.

FRAMEWORK: 30%, SEMI-OPAQUE DENSITY CONCENTRATIONS WITH INDISTINCT OUTLINE. SIZE 0.1 TO 0.5 cm, MOSTLY 0.3 cm, WELL SORTED, EQUANT TO 1:1.5 ELONGATE WITH LONG AXES, WHERE PRESENT, HORIZONTAL; NOTABLY LUMPY, ROUNDED EDGES.

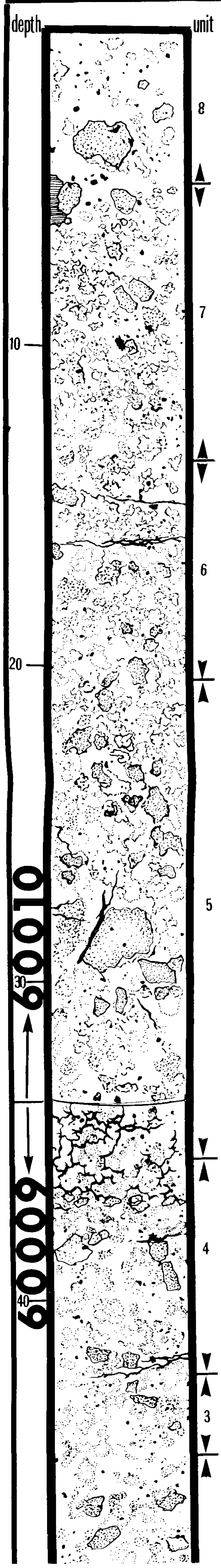
UNIT 1 DEPTH: 42.5 - 64 cm THICKNESS: 22 cm +

COARSE-GRAINED UNIT WITH DIVERSE ROCK TYPES

MATRIX: 40%, X-RADIOGRAPHICALLY VERY "DENSE" AND DISTINCTLY GRANULAR, OPAQUES, ABOUT 4% OF TOTAL, RANGE FROM LIMIT OF VISION TO 3.5 mm DIAMETER, AND APPEAR TO BE VERY POORLY SORTED, WITH EQUAL NUMBERS OF EACH SIZE CLASS. ABOUT 80% OF THE FRAGMENTS ARE EQUANT, THE REMAINDER ARE ELONGATE, COMMONLY COMMA-SHAPED. HALF OF THE FRAGMENTS ARE WELL ROUNDED, THE REST TEND TO BE BLOCKY AND ANGULAR.

FRAMEWORK: 25% SEMI-OPAQUE, ROCK FRAGMENTS WITH DISTINCT OUTLINES: 0.3 TO 2.6 cm LENGTH, WITH VERY POOR SORTING BUT WITH MANY LARGE FRAGMENTS, OVER 1 cm DIAMETER. THESE ROCK FRAGMENTS TEND TO BE EQUANT TO POLYGONAL TO WEDGE-SHAPED, WITH STRAIGHT TO SLIGHTLY CURVED EDGES AND ANGULAR TO SUBANGULAR CORNERS. 35% SEMI-OPAQUE DENSITY CONCENTRATIONS WITH INDISTINCT OUTLINE, PROBABLY ROCK FRAGMENTS (SOME PARTICLES MAY BE SOIL CLODS, BUT CLODS TEND TO BE MORE TRANSPARENT TO X-RAYS), 0.1 TO 2.0 cm, MOSTLY EQUANT, WITH LUMPY OUTLINE TENDING TO ROUNDED EDGES. LESS THAN 5% OF THESE FRAGMENTS ARE ELONGATE; THE ELONGATE PARTICLES, HOWEVER, TEND TO BE RAGGEDY IN OUTLINE, WITH LONG AXES HORIZONTAL; AND THEY MAY BE GLASS FRAGMENTS.

Figure 16-5.- Description from X-radiograph sketches of Apollo 16 drive tubes 68002 - 68001.



UNIT 8 DEPTH: 0 - 5.0 cm THICKNESS: 5 cm

FINE-GRAINED INTERVAL WITH SCATTERED ROCKS

MATRIX: 70%, VERY FINELY GRANULAR, AND "THIN" APPEARING, ABOUT 4% OPAQUES, RANGING FROM LIMIT OF RESOLUTION TO 2.5 mm, MODERATELY WELL SORTED WITH MOST PARTICLES ABOUT 0.5 mm DIAMETER, ABOUT 1/3 ARE SPHERICAL, 1/2 EQUANT AND LUMPY SUBANGULAR, THE REMAINDER ELONGATE AND COMMA-SHAPED TO NOTABLY DENDRITIC.

FRAMEWORK: 25% ROCK FRAGMENTS WITH DISTINCT OUTLINE: 0.2 TO 1.7 cm DIAMETER, POORLY SORTED, EQUANT TO SLIGHTLY ELONGATE WITH STRAIGHT TO SLIGHTLY CURVED MARGINS, ANGULAR CORNERS, NOTICEABLY DIFFERENT FROM LUMPY ROCKS BELOW. 5% DENSITY CONCENTRATIONS WITH VAGUE OUTLINES: 0.1 TO 0.3 cm DIAMETER, BUT MOSTLY ALL ABOUT 0.2 cm, AND WELL SORTED. LUMPY AS BLOW.

UNIT 7 DEPTH: 5.0 - 14.5 cm THICKNESS: 9.5 cm

LOOSELY COMPACTED ZONE WITH MODERATE NUMBER OF ROCK FRAGMENTS, ABUNDANT OPAQUES

MATRIX: 50%, LOOSELY COMPACTED, LESS DENSE THAN UNDERLYING BED, VERY FINELY GRANULAR, WITH 4% OPAQUES, LIMIT OF RESOLUTION TO 3.5 cm DIAMETER, POORLY SORTED WITH MEDIAN DIAMETER ABOUT 0.5 mm. 1/4 OF OPAQUE FRAGMENTS ARE SPHERICAL, ABOUT HALF ARE EQUANT TO SLIGHTLY ELONGATE AND NOTABLY LUMPY-SUBANGULAR; THE REST ARE ELONGATE TO COMMA-SHAPED, BUT NOT DENDRITIC.

FRAMEWORK: 15% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE: 0.1 TO 0.8 cm DIAMETER, MOSTLY ABOUT 0.4 TO 0.5 cm, AND MODERATELY WELL SORTED. MOST ROCK FRAGMENTS ARE EQUANT TO ONLY SLIGHTLY ELONGATE, WITH A TENDENCY TO IRREGULARLY JAGGED, SUBROUNDED TO SUBANGULAR OUTLINES, WITH ONLY A FEW FRAGMENTS HAVING STRAIGHT TO SLIGHTLY CURVED OUTLINES WITH ANGULAR, SHARP CORNERS.
35% SEMI-OPAQUE WITH INDISTINCT OUTLINE: 0.1 to 0.5 cm, MOSTLY IN THE 0.2 cm RANGE AND MODERATELY WELL SORTED. AS BELOW, THESE PARTICLES APPEAR AS EQUANT INDIVIDUALS OR LUMPY CONCENTRATIONS OF PARTICLES, FADING TO NOTHINGNESS AS SUBROUNDED PARTICLES.

UNIT 6 DEPTH: 14.5 - 21.5 cm THICKNESS: 7 cm

COARSE-GRAINED, "DENSE" ZONE

THIS INTERVAL IS GRADATIONALLY TRANSITIONAL WITH THE IMMEDIATELY UNDERLYING UNIT 5, AND IS SEPARATED HERE ARBITRARILY AT THE HIGHEST OCCURRENCE OF 1 cm ROCK FRAGMENTS.

MATRIX: 35%, FINELY GRANULAR, "DENSE" IN X-RADIOGRAPH, TRANSITIONAL TO THE UNDERLYING UNIT, WITH ABOUT 3% OPAQUES, RANGING IN SIZE FROM THE LIMIT OF RESOLUTION TO 1.2 mm DIAMETER, AVERAGE SIZE ABOUT 0.5 mm. SHAPE DISTRIBUTION IS ABOUT EQUAL BETWEEN SPHERICAL PARTICLES, LUMPY TO BLOCKY SUBANGULAR PARTICLES, AND ELONGATE TO DENDRITIC MATERIAL.

FRAMEWORK: 25% SEMI-OPAQUE WITH DISTINCT OUTLINE: 0.1 TO 0.8 cm DIAMETER, AVE. DIAMETER ABOUT 0.4 cm, MODERATELY WELL SORTED, FRAGMENTS EQUANT TO SLIGHTLY ELONGATE, WITH STRAIGHT TO SLIGHTLY CURVED OUTLINES, ABOUT 1/3 WITH IRREGULAR SCALLOPED OUTLINES, BUT ALL FRAGMENTS ANGULAR TO SUBANGULAR.
40% SEMI-OPAQUE WITH INDISTINCT OUTLINE: 0.1 TO 0.7 cm, MOST FRAGMENTS ABOUT 0.2 cm DIAMETER, MODERATELY WELL SORTED, EQUANT, OR IN CLUMPS OF EQUANT PARTICLES, WITH LUMPY OUTLINE.

UNIT 5 DEPTH: 21.5 - 36.5 cm THICKNESS: 15 cm (3 in '09, 12 in '10)

COARSE-GRAINED, LOOSELY COMPACTED ZONE WITH FINE OPAQUES

MATRIX: 35%, NOTABLY LESS DENSE THAN UNDERLYING OR OVERLYING BEDS, OPAQUES, 3%, RANGE FROM LIMIT OF RESOLUTION TO 1.2 mm DIAMETER, BUT ARE NOTICEABLY MUCH FINER-GRAINED THAN THE UNDERLYING BEDS, AVERAGE SIZE ABOUT 0.5 mm. ABOUT 1/3 OF THE OPAQUES TEND TO BE SPHERICAL, ABOUT HALF ARE BLOCKY TO LUMPY AND SUBANGULAR, AND THE REMAINDER ARE ELONGATE, COMMA-SHAPED TO DENDRITIC.

FRAMEWORK: 65% IS SIMILAR COMPOSITIONALLY TO BED 2, BUT IS DISTINCTLY MORE TIGHTLY PACKED, AND APPEARS TO HAVE A FRAMEWORK-SUPPORTED TEXTURE IN NOTABLE CONTRAST TO THE MATRIX-SUPPORTED TEXTURE OF BED 2.
40% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE: 0.1 TO 2.4 cm DIAMETER, WITH AVERAGE SIZE ABOUT 0.7 cm, BUT WITH POOR SORTING. MOST OF THE ROCK FRAGMENTS ARE SLIGHTLY TO MODERATELY ELONGATE (1:1.5 TO 1:2.5) AND BLOCKY-POLYGONAL TO WEDGE-SHAPED, WITH STRAIGHT TO SLIGHTLY CURVED EDGES AND ANGULAR CORNERS.
25% SEMI-OPAQUE DENSITY CONCENTRATIONS WITH INDISTINCT OUTLINE: 0.1 TO 0.6 cm DIAMETER, MOSTLY ABOUT 0.3 cm AND MODERATELY WELL SORTED. DENSITY CONCENTRATIONS APPEAR AS NODULAR MULTIPLE LUMPS WITH NO RAGGED FRAGMENTS.

UNIT 4 DEPTH: 36.5 - 43.0 cm THICKNESS: 6.5 cm

ROCKY BED WITH SMALL ROCK FRAGMENTS, DENDRITIC OPAQUES

MATRIX: 60%, VERY FINELY GRANULAR AND NOTICEABLY MORE DENSE THAN THE OVERLYING UNIT, WITH ABOUT 3% OPAQUES, LIMIT OF RESOLUTION TO 3.5 mm DIAMETER, AVERAGE SIZE 0.8 TO 1.2 mm, AND MODERATELY POORLY SORTED. ABOUT HALF OF THE OPAQUE FRAGMENTS ARE SPHERICAL TO SLIGHTLY ELONGATE; THE REMAINDER ARE JAGGEDLY LUMPY TO ELONGATE, MANY SHOWING A DENDRITIC OUTLINE.

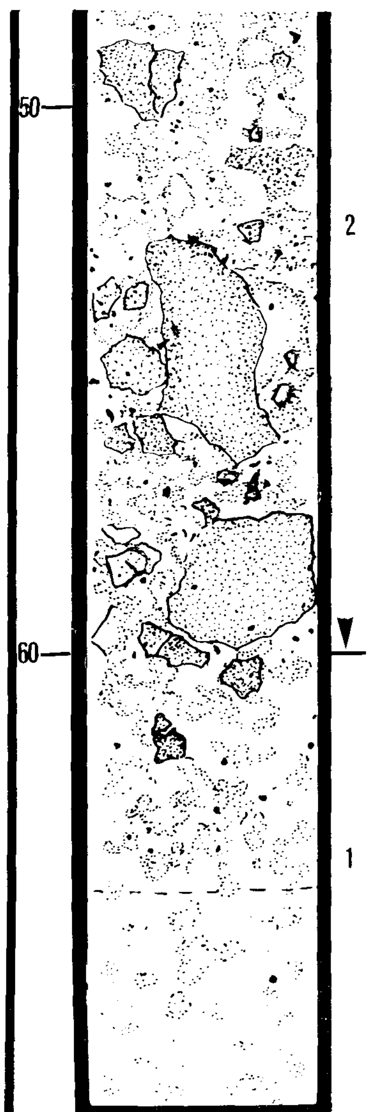
FRAMEWORK: 15% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE: 0.1 TO 1.1 cm, AVERAGING ABOUT 0.6 cm AND BEING MODERATELY WELL SORTED, ESPECIALLY IN THE TWO LAYERS AT THE TOP OF THE INTERVAL. FRAGMENTS NEARLY ALL ELONGATE, WEDGE-SHAPED TO POLYGONAL WITH STRAIGHT TO SLIGHTLY CURVED MARGINS, ANGULAR TO SUBANGULAR CORNERS.
25% SEMI-OPAQUE WITH VAGUE OUTLINE: 0.1 TO 1.3 cm DIAMETER, MOSTLY EQUIDIMENSIONAL TO SLIGHTLY ELONGATE, DISTINCTLY LUMPY.

UNIT 3 DEPTH: 43.0 - 45.5 cm THICKNESS: 2.5 cm

FINE-GRAINED INTERVAL WITH SPARSE ROCK FRAGMENTS

MATRIX: 75%, VERY FINELY GRANULAR, WITH 1% OPAQUES, LIMIT OF RESOLUTION TO 1.2 mm, RELATIVELY COARSE GRAINED, AVERAGING ABOUT 0.8 mm DIAMETER, EQUANT, SPHERICAL TO SUBROUNDED BLOCKY. THE SHARD-LIKE COMPONENT IS NOTABLY ABSENT IN THIS THIN BED.

FRAMEWORK: 25% SEMI-OPAQUE WITH INDISTINCT OUTLINE: 0.1 TO 0.8 cm DIAMETER, MOSTLY ABOUT 0.3 TO 0.4 cm, MODERATELY WELL SORTED. 80% OF FRAGMENTS HAVE A LUMPY OUTLINE, BUT THE REST ARE NOTABLY DENDRITIC TO FRAGMENTAL IN APPEARANCE, WITH RAGGED OUTLINE.



UNIT 2 DEPTH: 45.5 - 60.0 cm THICKNESS: 14.5 cm

ROCKY MUDSTONE WITH SHARD-SHAPED OPAQUES

MATRIX: 60% (UNUSUALLY HIGH FOR INTERVAL WITH THIS DEGREE OF COARSENESS) FINELY GRANULAR, WITH ABOUT 2% OPAQUES, LIMIT OF RESOLUTION TO 2.5 mm, MODERATELY WELL SORTED, COARSE, WITH AVERAGE GRAIN SIZE ABOUT 0.9 mm, WITH ABOUT 90% OF FRAGMENTS EQUANT, AND SPHERICAL TO LUMPY SUBROUNDED; AND WITH ONLY ABOUT 10% ELONGATE, ALTHOUGH MANY ELONGATE FRAGMENTS ARE SHARPLY ANGULAR AND SHARD-SHAPED.

FRAMEWORK: 30% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE, 0.1 TO 3.3 cm DIAMETER, MOST ROCKS RELATIVELY COARSE, FROM 0.5 AND 1.5 cm DIAMETER, BUT WITH A POOR DEGREE OF SORTING. MOST ROCK FRAGMENTS ARE SLIGHTLY TO MODERATELY ELONGATE (1:1.5 TO 1:2.5) AND POLYGONAL TO BLOCKY WITH STRAIGHT TO SLIGHTLY CURVED EDGES, ANGULAR CORNERS. DISTRIBUTION OF THESE PARTICLES INDICATES MATRIX, RATHER THAN FRAMEWORK SUPPORT, RELATIVELY UNCOMMON IN APOLLO 16 ROCKS.
10% SEMI-OPAQUE WITH INDISTINCT OUTLINE: 0.5 TO 0.8 cm DIAMETER, AVERAGING ABOUT 0.3 cm AND FAIRLY WELL SORTED, EQUANT, WITH A TENDENCY TO A LUMPY OUTLINE. SORTING OF THESE PARTICLES IS COMPARABLE TO THAT OF THE OPAQUES, AND STEMS TO BE VERY DIFFERENT FROM THAT OF THE DISTINCT ROCK FRAGMENTS.

UNIT 1 DEPTH: 60.0 - 68.0 cm THICKNESS: 8 cm

FINE-GRAINED UNIT, SPARSE IN OPAQUES

MATRIX: 80%, INDISTINCTLY GRANULAR, LESS THAN 1% OPAQUES, LIMIT OF RESOLUTIDN TO 1.5 mm, POORLY SORTED, EQUIGRANULAR, AND GENERALLY SUBROUNDED.

FRAMEWORK: 5% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE: 0.2 TO 0.6 cm DIAMETER, BLOCKY, EQUANT, AND SUBANGULAR TO ANGULAR.
15% SEMI-OPAQUE DENSITY CONCENTRATIONS, INDISTINCT OUTLINE: 0.1 TO 0.4 cm DIAMETER, MODERATELY WELL SORTED, EQUIDIMENSIONAL TO SLIGHTLY ELONGATE, WITH LUMPY OUTLINE.

Figure 16-6.- Description from X-radiograph sketches of Apollo 16 drive tubes 60010 - 60009.

60 percent is unusually high for a coarse-grained unit, and there is a size-gradation of the coarse material, which becomes finer-grained upwards. Unit 3 seems to be largely a repetition of unit 1, with a small percentage of rock fragments mixed in. Correspondingly, unit 4 appears to be a fine-grained repetition of unit 2, with a lesser abundance of very coarse material. At the top of unit 4 is the most distinctive stratigraphic break in the section, consisting of a gently rolling, slightly irregular surface, emphasized by the density contrast between the matrix of units 4 and 5.

The matrix of unit 5 and all overlying units, is much less densely compacted than that of the underlying beds, and contains a higher percentage of opaques, which tend to be finer-grained but less well sorted than in the underlying interval. Some of the opaques are relatively large ovoid objects. Units 5 and 6 form a massive bed, graded normally, from coarse at the bottom to finer at the top. Additionally, rock fragments with distinct outline in X-radiographs are much more abundant at the base of the bed, and disappear toward the top, to be replaced by material with indistinct outline. There is an indistinct density break at the top of units 5 and 6, and unit 7 is similar in nearly all respects to unit 5.

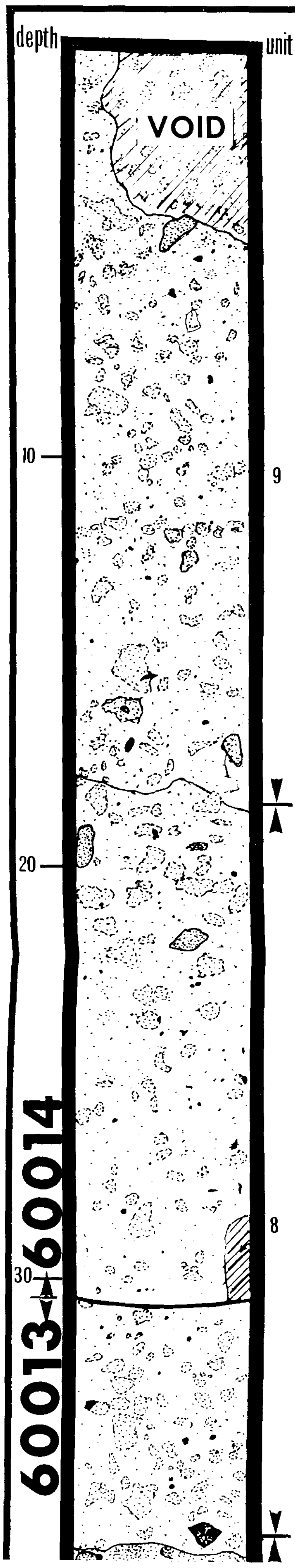
Unit 8, as unit 2, is classified as a pebbly mudstone, with a relatively low percentage of variable, poorly sorted, but coarse rock fragments. This surficial unit penetrates the highest point on the rim of a small crater, and the 5 cm of material probably represents ejects from the crater.

This poorly sorted material appears to reflect proximity to the source; if so, sorting should increase with distance from source.

PRELIMINARY EXAMINATION, DRIVE TUBES 60014 AND 60013

Drive Tubes 60014 and 60013 are fine-grained, in comparison to the other Apollo 16 cores. Interestingly enough, the surface material is relatively coarse, with 50 to 20 cm diameter blocks moderately abundant (USGS Rept 51: p.23). However, the area is unusual in that there are few small craters, even though there are some large 10 to 20 m craters.

The basal 8 cm of the core section appears to be fine-grained in the X-radiograph (Fig. 16-7) (although it may contain an abundance of whitish nodular material as noted by the LMP on the moon, if so, the whitish nodules would not show up on the X-radiograph because they are transparent to X-rays) with sparse opaques, and a few percent of rock fragments. What rock fragments there are appear as indistinct, mottled density concentrations. Bed 2 shows a concentration of similar objects, but with a matrix similar to unit 1, and probably is genetically akin to unit 1.



UNIT 9 DEPTH: 18.5 - 0 THICKNESS: 18.5 cm

MASSIVE FINE-GRAINED UNIT, SPARSE EQUANT ROCK FRAGMENTS

MATRIX: 60%, LIGHT APPEARING, NOT DENSELY GRANULAR, MEDIUM TO FINELY GRANULAR, WITH 3% OPAQUES, LIMIT OF RESOLUTION TO 3 mm, BUT WITH BIMODAL DISTRIBUTION, WITH THE COARSER FRAGMENTS, ALL 2 - 3 mm DIAMETER BEING ELONGATE, DENDRITIC OR SHARD-SHAPED; AND WITH THE FINER FRAGMENTS ALL UNDER 1 mm, MOSTLY 0.6 mm, ALL TENDING TO BE EQUANT, WITH ABOUT 1/3 SPHERICAL, 1/10 ELONGATE DENDRITIC, AND THE REST BLOCKY TO LUMPY EQUANT WITH SUBANGULAR CORNERS.

FRAMEWORK: 15% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE: 0.1 TO 0.9 cm DIAMETER, MEDIAN ABOUT 0.5 cm. THESE ROCK FRAGMENTS ARE EQUANT, MOSTLY WITH A LUMPY TO ROUNDED-IRREGULAR OUTLINE, AND ONLY A FEW WITH RELATIVELY STRAIGHT MARGINS AND SUBANGULAR CORNERS. MANY ARE CONCENTRATED IN AN INDISTINCT LAYER AT 12 cm DEPTH. 25% SEMI-TRANSPARENT WITH INDISTINCT OUTLINE: 0.1 TO 0.8 cm DIAMETER, MOSTLY ABOUT 0.2 TO 0.3 cm, MODERATELY WELL SORTED, DENSITY CONCENTRATIONS WHICH GIVE APPEARANCE OF COMPOUND LUMPS.

UNIT 8 DEPTH: 38.5 - 18.5 THICKNESS: 20 cm

MASSIVE FINE-GRAINED UNIT WITH SPARSE ROCK FRAGMENTS

MATRIX: 70%, THIN (VS. DENSE), FINELY GRANULAR, 3% OPAQUE, LIMIT OF RESOLUTION TO 2.2 mm, POORLY SORTED, AVERAGING ABOUT 0.5 mm. ABOUT 1/3 OF THE PARTICLES ARE SPHERICAL, ABOUT 1/4 ARE ELONGATE-DENDRITIC, AND THE REMAINDER ARE BLOCKY TO LUMPY, TENDING TO BE EQUANT, WITH SUBANGULAR TO SUBROUNDED CORNERS.

FRAMEWORK: 10% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE: 0.2 to 1.1 cm DIAMETER, MOSTLY ON COARSE SIDE, WITH MEDIAN ABOUT 0.8 cm. ROCK FRAGMENTS IN THIS ZONE DIFFER FROM OTHER HORIZONS IN BEING NOTICEABLY ELONGATE, IRREGULARLY RECTANGULAR TD WEDGE SHAPED WITH SLIGHTLY IRREGULAR EDGES, SUBANGULAR CORNERS. 20% SEMI-OPAQUE WITH INDISTINCT OUTLINE: 0.1 TO 1.1 cm DIAMETER, WITH MEDIAN IN LOWER PART OF BED ABOUT 0.3 cm, GRADUALLY INCREASING UPWARD TO ABOUT 0.6 AT TOP OF BED. PARTICLES APPEAR AS DENSITY CONCENTRATIONS, TENDING TO BE EQUANT AND NOCULAR, TO LUMPY APPEARING WHERE INDIVIDUAL PARTICLES COALESCE.

UNIT 7 DEPTH: 36.5 - 38.5 cm THICKNESS: 2 cm

CONCENTRATION OF CENTIMETER-SIZED ROCK FRAGMENTS

MATRIX: 30%, MODERATELY DENSE, MEDIUM TO FINELY GRANULAR; WITH ABOUT 2% OPAQUE, LIMIT OF RESOLUTION TO 1.8 mm, GENERALLY COARSE, BUT BIMODAL WITH ONE MODE ABOUT 0.6 mm, THE REMAINDER OF FRAGMENTS 1.2 TD 1.8 mm, EQUANT TO SLIGHTLY ELONGATE WITH 90% OF PARTICLES OVOID TO SPHERICAL. 25% LUMPY EQUIGRANULAR, 15% ELONGATE AND SMOOTH-SIDED, AND 10% SHARD-SHAPED. MATRIX IS DISTINCTLY MUCH DENSER THAN MATRIX OF OVERLYING UNIT.

FRAMEWORK: 50%, SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE: 0.2 TO 1.0 cm MOSTLY ABOUT D.7 TO 0.8 cm, WELL SORTED, BLOCKY TO IRREGULAR, STRAIGHT TO SLIGHTLY CURVED SIDES, SOME EDGES LOOK CONCHOIDAL, ANGULAR TO SUBANGULAR. 20% SEMI-TRANSPARENT WITH INDISTINCT OUTLINES: 0.1 TO 0.4 cm, WELL SORTED WITH MEDIAN DIAMETER ABOUT 0.2 cm. FRAGMENTS APPEAR AS EQUANT DENSITY CONCENTRATIONS, OR ARRANGED INTO ELONGATE LUMPS AS COMPOSITES OF INDIVIDUALS.

UNIT 6 DEPTH: 38.5 - 44.5 THICKNESS: 6 cm

FINE-GRAINED INTERVAL, ABUNDANT PEA-SIZED FRAGMENTS

MATRIX: 60%, MODERATELY DENSE IN APPEARANCE, WITH DENSITY NOTICEABLY INCREASING TOWARD TOP OF INTERVAL, MEDIUM TD FINELY GRANULAR; WITH ABOUT 3% OPAQUE, LIMIT DF RESOLUTION TD 1.8 mm, AVE. GRAIN SIZE ABOUT 0.5 mm, AND MODERATELY PODRLY SORTED, WITH ABDUT 10% SPHERICAL FRAGMENTS, 10% SHARDS, AND THE REMAINING FRAGMENTS EQUANT TO SLIGHTLY ELONGATE, BLOCKY SUBANGULAR TO LUMPY SUBROUNDED.

FRAMEWORK: 10% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE: 0.2 TO 0.5 cm DIAMETER, WELL SORTED WITH MOST FRAGMENTS ABOUT 0.4 cm. FRAGMENTS ARE POLYGONAL WITH RELATIVELY STRAIGHT TO SLIGHTLY CURVED SIDES, SUBANGULAR CORNERS. 30% SEMI-TRANSPARENT WITH INDISTINCT OUTLINE: 0.1 to 0.5 cm, MOSTLY ABOUT 0.3 cm, EQUANT OR ELONGATE OBJECTS COMPRISED OF CLUMPS OF EQUANT PARTICLES, GIVING LUMPY TEXTURE.

UNIT 5 DEPTH: 44.5 - 50.5 THICKNESS: 6 cm

ZONE WITH LARGE ROCK FRAGMENTS, SHARDLIKE OPAQUES

MATRIX: 40%, DENSER THAN BELOW, MEDIUM TO FINELY GRANULAR; WITH 2% OPAQUES, LIMIT OF RESOLUTION TO 1.7 mm, AVE. 0.5 mm, MODERATELY TO POORLY SORTED.
SHAPE: 10% SPHERICAL, 5% SHARDS, REMAINDER EQUANT TO SLIGHTLY ELONGATE, BLOCKY TO LUMPY, WITH SUBROUNDED TO SUBANGULAR CDRNERS.

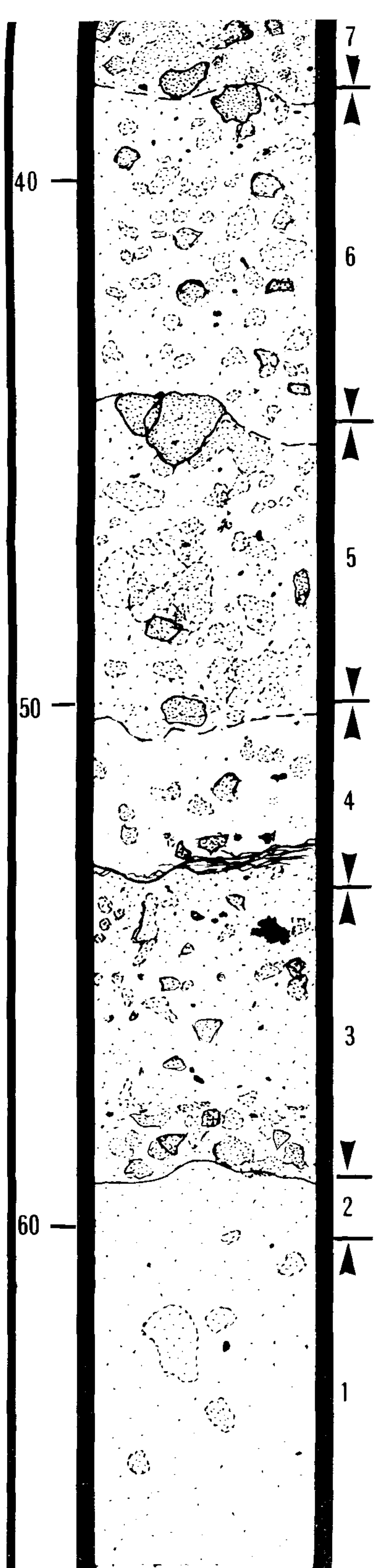
FRAMEWORK: 20% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT DUTLINE: 0.2 TO 2.3 cm DIAMETER, POORLY SORTED WITH ALL SIZES APPROXIMATELY EQUALLY REPRESENTED. FRAGMENTS ARE CLOCKY AND EQUANT, WITH STRAIGHT TO SLIGHTLY CURVED (SOME APPEAR CONCHOIDAL) EDGES, ANGULAR TO SUBANGULAR CORNERS. 40% SEMI-OPAQUE TO SEMI-TRANSPARENT, INDISTINCT OUTLINE: 0.1 TO 1.3 cm, MODERATELY WELL SORTED, WITH MOST FRAGMENTS ABOUT 0.3 cm DIAMETER, LUMPY TO NODULAR APPEARANCE WITH MANY ELONGATE PARTICLES COMPRISED OF MULTIPLE NODULES.

UNIT 4 DEPTH: 50.5 - 53 cm THICKNESS: 2.5 cm

FINE-GRAINED UNIT WITH "THIN" MATRIX, BIMODAL OPAQUES

MATRIX: 80%, LESS DENSE THAN BELOW, FINELY GRANULAR, WITH 2% OPAQUES, LIMIT OF RESOLUTION TO 1.8 mm DIAMETER, NOTICEABLY BIMODAL, WITH MOST FRAGMENTS WELL SORTED, ABOUT 0.4 mm DIAMETER, THE REMAINDER 1.3 TO 1.8 mm DIAMETER WITH NONE IN-BETWEEN. FINEST-GRAINED OPAQUES ARE EQUANT, ROUNDED TD SUBROUNDED BLOCKY, COARSER FRAGMENTS ARE EQUANT LUMPY-SHARD LIKE.

COARSE FRACTION: 20% SEMI-TRANSPARENT ROCK FRAGMENTS WITH MODERATELY DISTINCT OUTLINE: 0.2 TO 0.5 cm DIAMETER, FAIRLY WELL SORTED; EQUANT POLYGONAL WITH SUBROUNDED TO SUBANGULAR CORNERS; SIDES SLIGHTLY CURVED TO STRAIGHT, NOT IRREGULARLY ROUNDED OR LUMPY. FRAGMENTS SCATTERED THROUGH MATRIX, AND DO NOT FDRM FRAMEWORK.



UNIT 3 DEPTH: 58 - 53 cm THICKNESS: 5 cm

FINE-GRAINED BED WITH DENSE MATRIX, SPARSE ROCK FRAGMENTS, VARIED OPAQUES

MATRIX: 85% FINELY IRREGULARLY (VS. UNIFORMLY) GRANULAR, MODERATELY DENSE; WITH 3% OPAQUES, LIMIT OF RESOLUTION TO 7 mm, AVE. ABOUT 1 mm, OVER HALF OF WHICH ARE EQUANT AND ANGULARLY LUMPY TO DENDRITIC, ONLY 10% ARE SPHERICAL AND 1/3 ARE ELONGATE TO ROD-SHAPED WITH SMOOTH EDGES, ROUNDED CORNERS, NOT SHARD-SHAPED.

COARSE FRACTION: 5% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINES: 0.2 TO 0.8 cm DIAMETER MODERATELY TO POORLY SORTED WITH RELATIVELY EVEN DISTRIBUTED THROUGHOUT SIZE RANGES. THESE ROCK FRAGMENTS ARE EQUANT TO RECTANGULAR, WITH RAPEZOIDAL OR POLYHEDRAL OUTLINE, RELATIVELY SMOOTH EDGES, ANGULAR TO SUBANGULAR CORNERS. 10% SEMI-TRANSPARENT, INDISTINCT OUTLINE: 0.1 TO 0.4 cm, MODERATELY WELL SORTED, AVERAGE SIZE ABOUT 0.3 cm, OVERALL EFFECT IS OF ELONGATE PARTICLES OR CLUMPS OF EQUANT LUMPS DISPOSED INTO ELONGATE ROCK FRAGMENTS.

UNIT 2 DEPTH: 58 - 59 cm THICKNESS: 1.0 cm

LAYER OF SMALL ROCK FRAGMENTS

MATRIX: 50%, AS IN UNIT 1.

FRAMEWORK: 50% SEMI-OPAQUE ROCK FRAGMENTS, DISTINCT OUTLINE: 0.2 TO 0.6 cm WITH MEDIAN DIAMETER ABOUT 0.4 TO 0.5 cm, INDICATING GOOD SORTING. ROCK FRAGMENTS ARE EQUIDIMENSIONAL-POLYHEDRAL TO SLIGHTLY ELONGATE WITH RELATIVELY STRAIGHT MARGINS, SUBANGULAR TO SUBROUNDED CORNERS.
THIS LAMINA MAY BE A MICROMETEORITICALLY-WINNONED CONCENTRATION OF COARSE PARTICLES AT THE TOP OF UNIT 1, AS MATRIX AND ROCK TYPES ARE SIMILAR AND OPAQUES AND SEMI-OPAQUES AT THE TOP OF THE INTERVAL ARE ALIGNED HORIZONTALLY.

UNIT 1 DEPTH: 59 - 67 cm THICKNESS: 8 cm

FINE-GRAINED INTERVAL WITH SPARSE OPAQUES, INDISTINCT MOTTLES

MATRIX: 95% X-RADIOGRAPHICALLY DENSE, MEDIUM TO FINELY GRANULAR; OPAQUES APPROXIMATELY 1%, 0.3 to 1.0 mm; AVE. DIAMETER APPROXIMATELY 0.6 mm, WITH GOOD SORTING, CONSISTENTLY EQUANT, SOMEWHAT LUMPY AND SUBROUNDED TO SUBANGULAR, WITH ONLY A TRACE OF SPHERICAL PARTICLES.

COARSE FRACTION: 5%, SEMI-TRANSPARENT WITH INDISTINCT OUTLINE: 0.2 TO 1.6 cm, MOSTLY ABOUT 0.6 cm, EQUANT, FADING OUT OVER BROAD AREAS, OR IN WELL ROUNDED CURVES, DISTINCTLY DIFFERENT FROM THE LUMPY PARTICLES, WHICH COMMONLY OCCUR IN APOLLO 16 CORES.

Figure 16-7.- Description from X-radiograph sketches of Apollo 16 drive tubes 60014 - 60013.

The next 22.5 cm is relatively coarse-grained, relatively thinly laminated, and terminates at the top in a very noticeable surface. The intermediate bedded zones are more or less transitional, distinguished on the basis of grain size and type. Opaques within this interval are distinctively varied, with shard-like and dendritic fragments being abundant, in addition to the spheres, lumpy particles, elongate rods, and comma-shaped fragments so common in Apollo 16 cores.

Units 3 and 5 are similar in containing the dense matrix with a fair scattering of equant, sharp-edged rock fragments. Unit 4, in between, seems to contain a mixture of properties of the lower beds, with the matrix of the basal units and the rock fragments characteristic of unit 3. Furthermore, opaques in the matrix of unit 4 are bimodal with coarse particles as in unit 3, and fines resemblying those of unit 1. Unit 6 seems to be similar to unit 5, but better sorted. Unit 7 exhibits the matrix properties of units 5 and 6, but is distinctly coarser grained.

The uppermost 36 cm is much more massively layered, with a less grainy and less compact matrix. There is a noticeable component of oval, 2 to 4 mm matrix opaques, and ragged-edge-appearing semi-opaque density concentrations that probably represent a rock type not found in lower intervals.

Units 1 and 2 may represent fine-grained Cayley of the highland plains. Units 3 through 7 are petrographically similar, and are believed to represent variations on one major event, presumably ejecta from a major, near-by crater. Position in the section, 36 cm from the surface, suggests a North Ray origin for this horizon, with thin laminae representing local reworking by small-scale cratering events. The upper surface, with concentration of rock particles, may be winnowed by micrometeorites.

The upper massive zone, differs petrographically from the lower zones, indicating a different source. Its massiveness suggests less reworking by small-scale cratering events, as a result of newness. On the basis of this evidence, it is inferred that this zone resulted from South Ray activity.

STRATIGRAPHY, 60010/9 TO 60014/13

The drive tubes at station 10 and 10' were taken about 60 m apart. Despite the irregularities of the lunar surface, it is possible to establish a correlation of major units between the two cores.

The basal bed of both sections is fine-grained in X-radiograph, with 80 percent to 95 percent matrix (much higher than overlying units), and a very low percentage of material opaque to X-rays. What opaques there are tend to be relatively large-sized (~0.6 mm diameter) and are spherical.

The overlying 20 to 25 cm is generally the coarsest in the section and includes beds 2 through 4 in 60009 and 2 through 7 in 60013. X-radiographically, the matrix of these beds is noticeably more dense and the opaque fraction contains distinctive shard-like opaques. Rock fragments in both cores are similar in that there is a relatively high percentage of large, semi-opaque, blocky fragments with distinct straight to conchoidally curved margins with angular to subangular corners. The top of this unit in each core is a slightly irregular surface, separating beds with a major density contrast.

In both cores, the upper units, about 35 cm thick, tend to be more massive and have a matrix that tends to be less compacted and less dense appearing. Petrographically, these units contain finer, more poorly sorted opaques with a distinctive trace of large, oval fragments; and rock fragments show a lumpy-ragged outline in contrast to mottled or distinctly outlined rock fragments of lower zones.

Because major units reflect principal events of the area, it is believed that the lower rock-bearing beds are modified North Ray ejecta overlying fine-grained Cayley. The thinner layering probably is a result of micro- and small-scale-meteoritic reworking of the older North Ray materials. The massively layered upper zones are accordingly assigned to the more recent South Ray event.

APOLLO 16 DEEP DRILL STRING

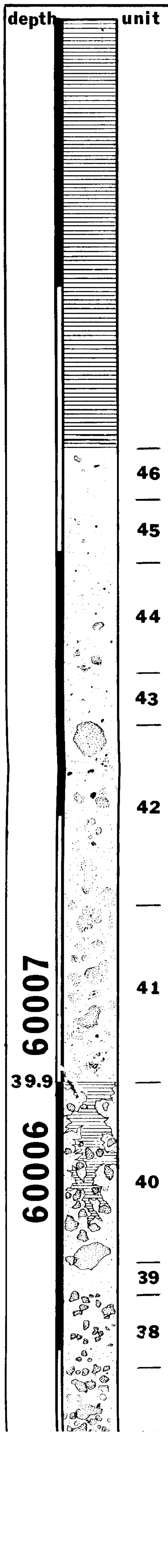
The Apollo 16 deep drill string sampled nearly 2 m of lunar soil. The coarse-grained upper part of the core probably reflects the relatively recent, local, South Ray cratering event. The lower finer-grained, thinly layered portion evidently represents a multiplicity of earlier events.

The deep drill, including sections 60001 (drill bit) through 60007 (uppermost section of the drill string) was collected by astronauts J. W. Young and C. M. Duke on EVA 1. The drilling was performed at Station 10, 105 m southwest of the LM landing site (Fig. 16-2).

Interpretive drawings of the X-radiographs have been prepared by S. Nagle (Fig. 16-8). Preliminary data are given in Table XVI-1.

D. Carrier made the initial description of the nature of the core sections.

Preliminary Allocations: It was intended for preliminary allocations to be taken from the base of each drill stem section, in order to provide as even spacing as possible. However, because the material in 60005 was highly disturbed, the early allocation procedure was modified slightly (Fig. 16-9).



UNIT 46 DEPTH: 0 - 1.5 cm THICKNESS: 1.5 cm

SURFICIAL BED WITH OBSCURE ROCK FRAGMENTS, DIVERSE OPAQUES

MATRIX: 85%, FINELY GRANULAR, GENERALLY OF LOW X-RAY DENSITY, WITH VAGUE AND POORLY DEFINED DENSITY CONCENTRATIONS, AND APPROXIMATELY 2% OPAQUES, LIMIT OF VISION TO 1.5 mm DIAMETER, BUT POORLY SORTED, WITH EQUAL DISTRIBUTIONS OF ALL SIZE RANGES, AND WITH A GREAT DIVERSITY OF SHAPES RANGING FROM SPHERES TO CHIP-LIKE DENDRITIC FRAGMENTS.
COARSE FRACTION: 5% SEMI-OPAQUE WITH DISTINCT OUTLINE: 0.5 TO 0.8 cm DIAMETER, EQUANT WITH MORE OR LESS SMOOTH SIDES AND SUBROUNDED TO ANGULAR CORNERS. 10% SEMI OPAQUE WITH VAGUE OUTLINE: 0.1 TO 0.6 cm DIAMETER, POORLY SORTED WITH ALL SIZES EQUALLY REPRESENTED, MOST FRAGMENTS APPEAR TO BE VAGUELY LUMPY AND CLOD-LIKE WITH CRENULATED TO IRREGULAR, POORLY-DEFINED MARGINS.

UNIT 45 DEPTH: 1.5 - 3 cm THICKNESS: 1.5 cm

THIN, UNIFORMLY FINE-GRAINED BED WITH SPARSE OPAQUES

MATRIX: 95%, VERY FINELY GRANULAR, WITH MOTTLES AND GRANULATION NEAR THE LIMIT OF RESOLUTION OF THE X-RADIOGRAPH, AND WITH ONLY A TRACE AMOUNT OF OPAQUES, 0.1 mm OR LESS, APPEAR SPHERICAL.
COARSE FRACTION: 5% SEMI-OPAQUE WITH VAGUE OUTLINE: 0.1 TO 0.8 cm DIAMETER, POORLY SORTED, APPEARING AS INDISTINCT, MOTTLE-LIKE DENSITY CONCENTRATIONS.

UNIT 44 DEPTH: 3 - 8 cm THICKNESS: 5 cm

MASSIVE BED WITH SCATTERED, VARIED ROCK FRAGMENTS

MATRIX: 70%, OF RELATIVELY LOW DENSITY, AND ONLY FAINTLY GRANULAR, WITH APPROXIMATELY 1% OPAQUES, LIMIT OF VISION TO 1.2 mm DIAMETER, WITH MEDIAN ABOUT 0.5 mm, BUT WITH A WIDE RANGE OF SIZES AND POOR SORTING. FRAGMENTS ARE VARIED IN OUTLINE, RANGING FROM SPHERICAL TO SHARD, DENDRITE, AND COMMA-SHAPED, WITH ROUNDED TO ANGULAR CORNERS.
FRAMEWORK: 10%, SEMI-OPAQUE WITH DISTINCT OUTLINE: 0.5 TO 1.2 cm IN DIAMETER, BUT MOSTLY ABOUT 0.8 cm, EQUANT TO SUBEQUANT, WITH REGULAR MARGINS AND SUBANGULAR TO SUBROUNDED CORNERS. 20% SEMI-OPAQUE WITH VAGUE OUTLINE: 0.1 TO 1.2 cm DIAMETER, WITH THE MAJORITY OF FRAGMENTS BEING 0.2 TO 0.4 cm. ABOUT 1/4 HAVE A MOTTLED, RAGGED OUTLINE, BUT THE REMAINDER OF THE FRAGMENTS FADE OUT EVENLY ALONG MORE-OR-LESS REGULAR EDGES AND EQUANT SIDES.

UNIT 43 DEPTH: 8 - 9 cm THICKNESS: 1 cm

THIN BED, UNIFORMLY FINE-GRAINED, WITH SPARSE OPAQUES

MATRIX: 95% UNIFORMLY FINE-GRAINED, WITH A TRACE OF SPHEROIDAL, ROUNDED OPAQUES, 0.2 TO 0.5 mm DIAMETER.
COARSE FRACTION: 5% SEMI-OPAQUE WITH VAGUE OUTLINE: 0.1 - 0.6 cm DIAMETER, WITH A WIDE WIZE DISTRIBUTION AND POOR SORTING, AND WITH MOTTLED TO CRENULATED OUTLINE.

UNIT 42 DEPTH: 9 - 15.7 cm THICKNESS: 6.7 cm

FINE-GRAINED BED WITH SPARSE LARGE ROCK FRAGMENTS

MATRIX: 80%, RELATIVELY LOW DENSITY AND HIGH TRANSPARENCY ON X-RADIOGRAPH, FINELY GRANULAR WITH SPARSE MOTTLING, AND CONTAINING APPROXIMATELY 1% OPAQUES, POORLY SORTED, LIMIT OF VISION TO 2.0 mm, AVERAGING ABOUT 0.8 mm. OPAQUES SHOW A RANGE OF VARIETIES, RANGING FROM SPHERICAL TO EQUANT-IRREGULAR TO ELONGATE AND COMMA-SHAPED WITH SUBROUNDED CORNERS.
FRAMEWORK: 10% SEMI-OPAQUE WITH DISTINCT OUTLINE: 0.1 TO 0.3 cm DIAMETER, WITH ONE DISTINCTIVE, LARGE ROCK FRAGMENT WHICH IS 1.3 cm IN DIAMETER. OTHER FRAGMENTS ARE EQUANT TO VERY SLIGHTLY ELONGATE, WITH NEARLY SMOOTH EDGES AND ROUNDED TO SUBROUNDED CORNERS. 10% SEMI-OPAQUE WITH VAGUE OUTLINE: 0.1 TO 0.8 cm DIAMETER, AVERAGING 0.4 cm, BUT TENDING TO BE POORLY SORTED. FRAGMENTS TEND TO FADE OUT OVER BROAD, SMOOTH MARGINS RATHER THAN RAGGEDLY.

UNIT 41 DEPTH: 15.7 - 22.2 cm THICKNESS: 6.5 cm

DENSE BED WITH ABUNDANT ROCK FRAGMENTS

MATRIX: 60%, RELATIVELY DENSE, COMPARED TO ABOVE, AND UNIFORMLY FINELY GRANULAR, WITH ONLY A TRACE OF OPAQUES, LIMIT OF VISION TO 0.2 mm DIAMETER, MOSTLY SHARD-LIKE IN APPEARANCE.
FRAMEWORK: 25% SEMI-OPAQUE WITH DISTINCT OUTLINE: 0.1 TO 1.3 cm DIAMETER, WITH MOST FRAGMENTS RELATIVELY COARSE, IN 0.5 TO 1.0 cm RANGE, BUT POORLY SORTED, AND IRREGULARLY ELONGATE, WITH ANGULAR TO SUBANGULAR CORNERS. 15% SEMI-OPAQUE WITH VAGUE OUTLINE: 0.1 TO 0.6 cm DIAMETER, MODERATELY SORTED, MOSTLY 0.3 TO 0.4 cm IN DIAMETER, AND TENDING TO BE EQUANT, FADING OUT BROADLY OVER THE ENTIRE SIDE, WITH ONLY A SLIGHT TENDENCY TO CRENULATED EDGES.

UNIT 40 DEPTH: 22.2 - 24.0 cm THICKNESS: 1.8 cm

FRACTURED INTERVAL WITH LARGE ROCK FRAGMENTS (IN X-RADIOGRAPH IS HIGH IN VOID SPACE)

MATRIX: 75%, WITH 10% TO 20% INDISTINCT MOTTLES, 1% OPAQUES, 1.1 mm TO LIMIT OF RESOLUTION, VARIETY OF SHAPES, BUT ELONGATE CHIPS AND DENDRITES ARE MORE COMMON THAN BLOCKS AND SPHERES.
COARSE FRACTION: 25% SEMI-OPAQUE WITH DISTINCT OUTLINE: 0.2 TO 1.6 cm DIAMETER, MODERATELY TO POORLY SORTED (SIMILAR TO UNIT 41); FRAGMENTS ARE RELATIVELY LARGE, AVERAGING 0.5 cm DIAMETER, EQUANT TO OVOID (IN CONTRAST TO BLOCKS AND WEDGES OF LOWER UNITS) WITH LUMPY TO NEARLY STRAIGHT EDGES AND ROUNDED CORNERS.

UNIT 39 DEPTH: 24 - 25 cm THICKNESS: 1 cm

THIN, FINE-GRAINED UNIT

MATRIX: 100%, NEARLY UNIFORMLY FINE-GRAINED, WITH APPROXIMATELY 10% MOTTLING, ONLY TRACE AMOUNTS OF EQUANT, APPARENTLY SPHERICAL OPAQUES, NEAR LIMIT OF RESOLUTION.

UNIT 38 DEPTH: 25 - 28 cm THICKNESS: 3 cm

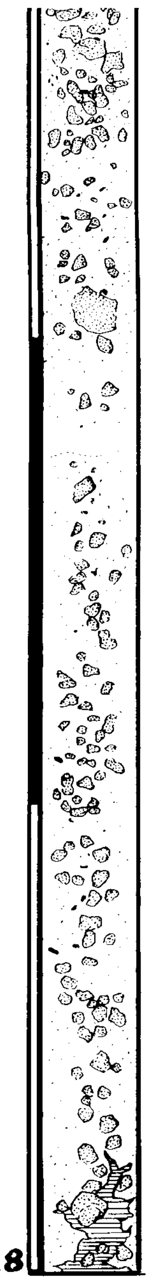
MEDIUM THIN UNIT WITH SCATTERED, SMALL ROCK FRAGMENTS

MATRIX: 80%, INDISTINCTLY MOTTLED, LESS THAN 1% OPAQUES, 0.5 mm TO LIMIT OF RESOLUTION, FRAGMENTS EQUANT TO IRREGULARLY ELONGATE, ANGULAR.
COARSE FRACTION: 15% SEMI-OPAQUE WITH DISTINCT OUTLINE, POORLY SORTED, 0.1 TO 0.5 cm, GENERALLY BLOCKY TO WEDGE SHAPED PARTICLES WITH SUBANGULAR TO SUBROUNDED CORNERS. 5% SEMI-OPAQUE WITH INDISTINCT OUTLINE, APPEARING AS EQUANT MOTTLES, 0.2 TO 0.4 cm DIAMETER, WITH CRENULATE FADE OUT.

UNIT 37 DEPTH: 28.0 - 33.0 cm THICKNESS: 5 cm

MASSIVE UNIT PACKED WITH POORLY SORTED ROCK FRAGMENTS

MATRIX: 50%, TENDING TO BE UNIFORMLY FINE-GRAINED, WITH LESS THAN 10% INDISTINCT GRANULES, FINER THAN 1 mm DIAMETER, AND 1% OPAQUES, 1.4 mm TO LIMIT OF RESOLUTION, POORLY SORTED WITH A VARIETY OF SHAPED, BUT BLOCKY TO WEDGE SHAPED FRAGMENTS ARE MOST CONSPICUOUS. IN GENERAL, OPAQUES REFLECT SIZE AND SHAPE SORTING OF COARSE FRACTION.
FRAMEWORK: 50% OF WHICH 40% IS SEMI-OPAQUE WITH DISTINCT OUTLINE: 0.2 TO 0.9 cm DIAMETER, POORLY SORTED WITH ALL SIZES WELL REPRESENTED, FRAGMENTS GENERALLY ELONGATE, BLADED TO WEDGE SHAPED WITH SMOOTH TO SLIGHTLY IRREGULAR SIDES, ANGULAR TO SUBANGULAR CORNERS. FRAGMENTS IN THE UPPER PART OF THE UNIT ARE ALIGNED HORIZONTALLY, BUT THOSE IN THE LOWER PART TEND TO BE ALIGNED VERTICALLY, AS IF STRUNG OUT DURING SAMPLING. 10% SEMI-OPAQUE WITH INDISTINCT OUTLINE, SIMILAR IN SIZE TO REMAINDER OF COARSE FRACTION, BUT PARTICLES ARE OVOID TO SPHERICAL, FADING OUT OVER SMOOTH MARGINS. TOP CONTACT OF THIS UNIT IS MARKED BY A ROCK LAYER.



79.8 | 37 | 36 | 35 | 34 | 33 | 32 | 31 | 30 | 29

UNIT 36 DEPTH: 33 - 37 cm THICKNESS: 4 cm

MASSIVE, POORLY SORTED UNIT WITH LARGE ROCK FRAGMENTS

MATRIX: 70%, DISTINCTLY MOTTLED AND COARSELY GRANULAR, WITH 2 TO 3% CONSPICUOUS OPAQUES, WHICH ARE EQUANT-BLOCKY TO SPHERICAL, UP TO 1 mm DIAMETER.
COARSE FRACTION: 30%, SEMI-OPAQUE WITH MODERATELY DISTINCT TO DISTINCT OUTLINE, VERY POORLY SORTED, PARTICLES RANGING FROM 0.1 TO 1.2 cm, POLYGONATE AND WEDGE SHAPED TO EQUANT, WITH STRAIGHT, RATHER THAN IRREGULAR SIDES. TRANSITION TO UNDERLYING INTERVAL TAKES PLACE OVER 1 cm DISTANCE.

UNIT 35 DEPTH: 37 - 39.5 cm THICKNESS: 2.5 cm

THIN, FINE-GRAINED BED, SPARSE IN ROCK FRAGMENTS

MATRIX: 90%, DISTINCTLY FINELY GRANULAR, WITH ONLY A TRACE OF OPAQUES, NEAR LIMIT OF RESOLUTION, NOTICEABLY DIFFERENT FROM OVERLYING UNITS.
COARSE FRACTION: 10% SEMI-OPAQUE WITH INDISTINCT OUTLINE, POORLY SORTED, 0.1 TO 0.4 cm, OVOID TO POLYGONAL FRAGMENTS APPEAR TO HAVE MORE-OR-LESS EVEN OUTLINES, BUT ARE VAGUE AND INDISTINCT.

UNIT 34 DEPTH: 39.5 - 44.5 cm THICKNESS: 5 cm

MASSIVE INTERVAL WITH SCATTERED ROCK FRAGMENTS

MATRIX: 65%, FINELY GRANULAR, MUCH MORE DISTINCTLY SO THAN UNDERLYING BED, WITH APPROXIMATELY 2% OPAQUES, UP TO 2 mm DIAMETER, POORLY SORTED, WITH NEARLY ALL SIZES PRESENT, IN EQUAL AMOUNTS PARTICLES TENDING TO BE ELONGATE, BUT WITH GOOD ROUNDING.
COARSE FRACTION: 10% SEMI-OPAQUE WITH DISTINCT OUTLINE, 0.2 TO 0.6 cm LONG, POORLY SORTED WITH ALL SIZES PRESENT IN EQUAL AMOUNTS, OVOID TO ELONGATE WITH NODULAR TO IRREGULAR MARGINS. 25% SEMI-OPAQUE WITH INDISTINCT OUTLINE: 0.1 TO 0.5 cm, POORLY SORTED, AS OTHER PARTICLES, MOSTLY ELONGATE, WITH RAGGED TO LUMPY FADE-OUT.
AS UNIT 30, THIS INTERVAL SHOWS SIMILAR "STRUNG OUT" TEXTURE WITH ROCK FRAGMENTS CONCENTRATED IN THE MIDDLE OF THE CORE, AND MAY HAVE BEEN DISTURBED AFTER SAMPLING.

UNIT 33 DEPTH: 44.5 - 47.5 cm THICKNESS: 3 cm

THIN LAMINA OF SMALL ROCK FRAGMENTS

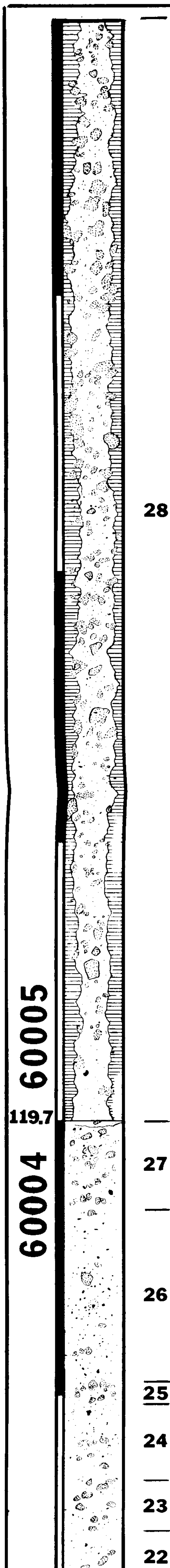
MATRIX: 50%, VERY FINELY TO INDISTINCTLY GRANULAR, WITH ONLY A TRACE OF OPAQUES, NEAR LIMIT OF RESOLUTION AND INDETERMINATE IN SHAPE.
FRAMEWORK: 50%, ROCK FRAGMENTS, SIMILAR TO UNIT 32, SEMI-TRANSPARENT TO SEMI-OPAQUE WITH INDISTINCT OUTLINE, 0.2 TO 0.6 cm, MODERATELY WELL SORTED, AVERAGING 0.3 cm, EQUANT TO OVOID, WITH MOST FRAGMENTS BEING NODULAR, WITH LUMPY APPEARANCE, ALTHOUGH APPROXIMATELY 1/4 OF THE FRAGMENTS, ESPECIALLY THE ELONGATE FORMS, HAVE RAGGED APPEARANCE. FRAGMENTS ARE DEPLOYED IN 0.5 TO 0.7 cm LAYERS.

UNIT 32 DEPTH: 47.5 - 51.0 cm THICKNESS: 3.5 cm

POORLY SORTED INTERVAL WITH DISPERSED ROCK FRAGMENTS

MATRIX: 75%, DISTINCTLY FINELY GRANULAR WITH APPROXIMATELY 1% OPAQUES, 0.8 mm TO LIMIT OF RESOLUTION, POORLY SORTED, BUT OBSERVABLE PARTICLES ARE SPHERICAL AND ROUNDED.
COARSE FRACTION: 25%, SEMI-TRANSPARENT TO SEMI-OPAQUE WITH INDISTINCT OUTLINE, 0.2 TO 0.6 cm, POORLY SORTED, EQUANT TO SLIGHTLY ELONGATE, TENDING TO SPHERICAL, SMOOTH OUTLINE, WHERE VISIBLE.

Figure 6-8.- Description from X-radiograph sketches of Apollo 16 deep drill string 60007 - 60001.



UNIT 31 DEPTH: 51.0 - 52.5 cm THICKNESS: 1.5 cm

FINELY GRANULAR THIN BED

MATRIX: 50%, FINELY TO MODERATELY FINELY GRANULAR, OPAQUES APPROXIMATELY 2%, 0.6 TO 0.2 mm, AVERAGING 0.3 mm, EQUANT, BLOCKY, SUBANGULAR.
FRAMEWORK: 35% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE, WELL SORTED, 0.2 TO 0.3 cm DIAMETER, EQUANT, POLYGONAL WITH SHORT, SMOOTH FACES, SUBROUNDED TO ROUNDED CORNERS. 15% SEMI-OPAQUE WITH INDISTINCT OUTLINE, WELL SORTED, 0.2 TO 0.4 cm DIAMETER, EQUANT FRAGMENTS WITH INDISTINCTLY CRENULATE MARGINS.

UNIT 30 DEPTH; 52.5 - 54.5 cm THICKNESS: 2 cm

FINE-GRAINED UNIT WITH INDISTINCT ROCK FRAGMENTS

MATRIX: 75%, MODERATELY FINELY GRANULAR, WITH FAINT GRANULARITY ON 0.1 mm SCALE, OPAQUES AS IN IMMEDIATELY UNDERLYING UNIT.
COARSE FRACTION: 25%, SEMI-OPAQUE TO SEMI-TRANSPARENT WITH INDISTINCT TD MODERATELY DISTINCT OUTLINE; PARTICLES WELL SORTED, 0.2 TO 0.4 cm IN DIAMETER, WITH LUMPY TO SMOOTH EDGES FADING TO NOTHINGNESS WHERE VIABLE CORNERS ROUNDED TO SUBROUNDED, PORB. NOT GLASS. ROCK FRAGMENTS IN THIS INTERVAL TEND TO BE CONCENTRATED IN THE CENTER OF THE CORE, GIVING A "STRUNG OUT" TEXTURE, AND THIS EVIDENCE, TOGETHER WITH FRACTURING OF UNDERLYING ZONE, SUGGEST SOME DISTURBANCE.

UNIT 29 DEPTH: 54.5 - 55.0 cm THICKNESS: 0.5 cm

FRACTURED UNIT WITH SCATTERED LARGE ROCK FRAGMENTS

MATRIX: 40%, FINELY GRANULAR WITH APPROXIMATELY 2% OPAQUES, WELL-SORTED, 0.2 TO 0.4 mm DIAMETER, EQUANT BLOCKY, SUBANGULAR FRAGMENTS.
COARSE FRACTION: 15% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE, UP TO 1.3 cm DIAMETER, PARTICLES ARE POORLY SORTED, BLOCKY, SUBEQUANT, WITH ANGULAR TO SUBANGULAR CORNERS. 20% SEMI-OPAQUE DENSITY CONCENTRATIONS WITH INDISTINCT OUTLINE, 0.1 TO 0.5 cm, MOSTLY 0.3 cm, SUBEQUANT, INDISTINCTLY ROUNDED WITH RAGGED TO CRENULATE FADE-OUT.
25% OF INTERVAL APPEARS AS AN IRREGULARLY-MARGINED VOID AND FRACTURED INTERVAL.

UNIT 28 DEPTH: 55.0 - 70.1 cm THICKNESS: 15.1 cm (equiv.)

PARTIALLY VOID, DISRUPTED CORE

CORE IS PARTIALLY VOID, WITH 76.1 cm OF SOIL SPREAD OUT MORE-OR-LESS EVENLY OVER THE ENTIRE LENGTH OF THE DRILL STEM, AND CALCULATED TO REPRESENT A COMPACTED THICKNESS OF 15.1 cm OF SOIL. SOIL IN THIS CORE IS OBVIOUSLY DISTURBED, AND ANY ATTEMPT AT DETERMINING STRATIFICATION WOULD BE ESSENTIALLY MEANINGLESS. ACCORDINGLY, THIS ENTIRE CORE IS LUMPED INTO ONE STRATIGRAPHIC INTERVAL.
THIS UNIT CONTAINS APPROXIMATELY 80% MATRIX: FINELY GRANULAR WITH APPROXIMATELY 10% OPAQUES OF 1.5 mm TO LIMIT OF RESOLUTION, IN A VARIETY OF SHAPES FROM SPHERICAL TO ELONGATE AND DENDRITIC. THE 20% COARSE FRACTION IS REPRESENTED BY APPROXIMATELY 5% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE: 0.1 TO 0.8 cm DIAMETER, GENERALLY EQUANT, BLOCKY TO STRAIGHT-SIDED, SUBROUNDED TO SUBANGULAR POLYGONS. 15% IS SEMI-OPAQUE WITH INDISTINCT OUTLINE, 0.1 TO 1.1 cm DIAMETER, WITH FRAGMENTS EQUANT TO 2.1 ELONGATE FADING OUT OVER STRAIGHT-SIDED MARGINS, GENERALLY SMOOTH.

UNIT 27 DEPTH: 70.1 - 72.6 cm THICKNESS: 2.5 cm

TRANSPARENT BED WITH ABUNDANT, SMALL ROCK FRAGMENTS

MATRIX: 50%, RELATIVELY TRANSPARENT TO X-RAYS, SPARINGLY GRANULAR WITH APPROXIMATELY 1 - 2% DENDRITIC AND SHARD-LIKE OPAQUES.
COARSE FRACTION: 50%, SEMI-OPAQUE PARTICLES WITH DISTINCT TO SEMI-DISTINCT OUTLINE, PARTICLES TENDING TO BE EQUANT, WELL-SORTED, 1.5 - 3 mm DIAMETER, MODERATELY TO WELL ROUNDED, WITH NO DISTINCT ALIGNMENT.

UNIT 26 DEPTH: 72.6 - 78.1 cm THICKNESS: 6 cm

TRANSPARENT BED WITH ABUNDANT OPAQUES, SPARSE ROCK FRAGMENTS

MATRIX: 95%, RELATIVELY TRANSPARENT TO X-RAYS, VERY INDISTINCTLY FINELY GRANULAR, BUT WITH 2 - 3% DISTINCTIVE AND ABUNDANT OPAQUES, LIMIT OF RESOLUTION TO 1 mm DIAMETER, GENERALLY EQUANT, BUT WITH IRREGULAR TO DENDRITIC OUTLINE.
COARSE FRACTION: 5% SEMI-OPAQUE WITH DISTINCT OUTLINE, SPARSE FRAGMENTS 2 - 4 mm DIAMETER, APPEARING TO BE EQUANT, INDISTINCT TO ROUNDED OUTLINE.

UNIT 25 DEPTH: 78.1 - 79.1 cm THICKNESS: 1 cm

THIN LAMINA PACKED WITH EQUANT, BLOCKY, SORTED ROCK FRAGMENTS

MATRIX: 40%, MODERATELY TRANSPARENT TO X-RAYS, INDISTINCTLY GRANULAR, WITH 1% EQUANT IRREGULAR OPAQUES LESS THAN 0.5 mm DIAMETER.
FRAMEWORK: 40%, SEMI-OPAQUE WITH DISTINCT OUTLINE, MODERATELY TO WELL SORTED FRAGMENTS, 1 - 4 mm DIAMETER, TENDING TO BE EQUANT, WITH BLOCKY OUTLINE. 20% SEMI-OPAQUE WITH INDISTINCT OUTLINE; SIMILAR IN SIZE AND SORTING TO OTHER FRAGMENTS, BUT FADING OUT OVER MORE-OR-LESS EVEN MARGINS.

UNIT 24 DEPTH: 79.6 - 83.1 cm THICKNESS: 3.5 cm

TRANSPARENT BED WITH ABUNDANT OPAQUES, SPARSE ROCK FRAGMENTS

MATRIX: 90%, MODERATELY TRANSPARENT TO X-RAYS, INDISTINCTLY GRANULAR, WITH 1 - 2% OPAQUES, RANGING FROM LIMIT OF RESOLUTION TO 1.5 mm, GENERALLY EQUANT WITH DENDRITIC TO IRREGULAR OUTLINE.
COARSE FRACTION: 10%, SEMI-OPAQUE WITH INDISTINCT OUTLINE; MODERATELY POORLY SORTED RANGING FROM 1 - 3 mm DIAMETER, FADING OUT OVER EQUANT, REGULAR MARGINS.

UNIT 23 DEPTH: 83.1 - 84.6 cm THICKNESS: 1.5 cm

THIN, RELATIVELY OPAQUE BED WITH ABUNDANT, SORTED ROCK FRAGMENTS

MATRIX: 75%, RELATIVELY OPAQUE TO X-RAYS, AND ACCORDINGLY, INDISTINCTLY GRANULAR, WITH APPROXIMATELY 1% OPAQUES, MOST OF WHICH ARE MINUTE SPHERES NEAR LIMIT OF RESOLUTION.
COARSE FRACTION: 25%, SEMI-OPAQUE WITH DISTINCT TO MODERATELY DISTINCT OUTLINE, RELATIVELY LARGE FRAGMENTS, 3 - 4 mm IN DIAMETER, WHICH ARE WELL SORTED, BLOCKY, AND EQUANT, WITH SMOOTH, STRAIGHT MARGINS.

UNIT 22 DEPTH: 84.6 - 87.1 cm THICKNESS: 2.5 cm

TRANSPARENT THIN BED WITH SPARSE ROCK FRAGMENTS

MATRIX: 90%, RELATIVELY TRANSPARENT TO X-RAYS, WITH LESS THAN 5% INDISTINCT GRANULES LESS THAN 1 mm DIAMETER, AND LESS THAN 1% OPAQUE SPHERES, 0.2 mm OR SMALLER.
COARSE FRACTION: 10%, SEMI-OPAQUE ROCK FRAGMENTS WITH SEMI-DISTINCT TO INDISTINCT OUTLINE, 2 - 4 mm IN DIAMETER, MODERATELY SORTED, SLIGHTLY ELONGATE, SMOOTH-SIDED SUBROUNDED TO ROUNDED FRAGMENTS.

UNIT 21 DEPTH: 87.1 - 91.6 cm THICKNESS: 4.5 cm

FRACTUPED INTERVAL WITH SPARSE ROCK FRAGMENTS

MATRIX: 95%, PERMEATED WITH CRACKS AND CONTAINING SMALL AREA OF VOID SPACE, WITH APPROXIMATELY 2% OPAQUES, 1 mm TO LIMIT OF RESOLUTION, GENERALLY EQUANT-SPHERICAL TO TEAR-DROP SHAPED, WITH FEW IRREGULARITIES.
COARSE FRACTION: 5%, SEMI-OPAQUE WITH DISTINCT OUTLINE; 1 - 5 mm DIAMETER, AND RELATIVELY POORLY SORTED, ELONGATE, WITH IRREGULAR, LUMPY OUTLINE.

UNIT 20 DEPTH: 91.6 - 93.1 cm THICKNESS: 1.5 cm

1596

21

THIN INTERVAL WITH ABUNDANT, POORLY SORTED ROCK FRAGMENTS

MATRIX: 60%, RELATIVELY OPAQUE, WITH INDISTINCT GRANULARITY, AND LESS THAN 1% OPAQUE SPHERES, 0.3 mm DIAMETER OR LESS.
COARSE FRACTION: 30%, SEMI-OPAQUE, DISTINCT OUTLINE; POORLY SORTED, RANGING IN SIZE FROM 1 - 5 mm, EQUANT TO SUBEQUANT, BLOCKY TO SUBROUNDED; 10% SEMI-OPAQUE WITH INDISTINCT OUTLINE; SIMILAR IN SIZE AND SORTING TO ABOVE, BUT TENDING TO BE EQUANT, WITH REGULAR FADE-OUT OVER SMOOTH EDGES.

20

19

UNIT 19 | DEPTH: 93.1 - 95.1 cm | THICKNESS: 2 cm

FRACTURED INTERVAL WITH SPARSE ROCK FRAGMENTS

IDENTICAL TO UNIT 7, FOR ALL ESSENTIAL PURPOSES.

18

UNIT 18 | DEPTH: 95.1 - 97.1 cm | THICKNESS: 2 cm

THIN INTERVAL WITH ABUNDANT, POORLY SORTED ROCK FRAGMENTS

MATRIX: 50%, RELATIVELY OPAQUE, WITH APPROXIMATELY 20% INDISTINCT, MILLIMETER-SIZE MOTTLES AND 3 - 5% OPAQUES, 0.5 mm OR LESS, RANGING IN SHAPE FROM SPHERULES TO DENDRITES.
FRAMEWORK: 40% SEMI-OPAQUE WITH DISTINCT OUTLINE; POORLY SORTED, 1 - 6 mm DIAMETER, EQUANT TO SLIGHTLY ELONGATE, WITH BLOCKY TO SUBROUNDED OUTLINE. 10% SEMI-OPAQUE WITH INDISTINCT OUTLINE; SIMILAR TO ABOVE, BUT FADING OUT OVER EVEN MARGINS.

17

16

UNIT 17 | DEPTH: 97.1 - 100.1 | THICKNESS: 3 cm

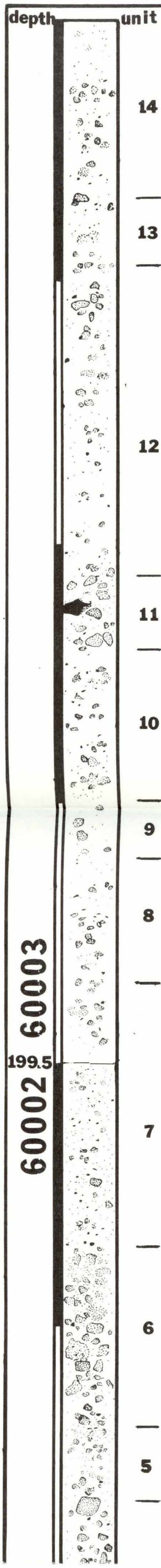
THIN BED WITH SPARSE ROCK FRAGMENTS

MATRIX: 90%, RELATIVELY OPAQUE, WITH 30% SWIRLED-APPEARING MOTTLES, 3% OPAQUES LESS THAN 0.5 mm DIAMETER, RANGING IN SHAPE FROM SPHERULITES TO SHARDS AND DENDRITES, BUT PREDOMINANTLY MINUTE, EQUANT, LUMPY FRAGMENTS.
COARSE FRACTION: 10% ROCK FRAGMENTS WITH SEMI-DISTINCT OUTLINE, RELATIVELY LARGE (3 - 5 mm DIAMETER), AND WELL SORTED, WITH ELONGATE, SUBANGULAR, LUMPY OUTLINE.

15

14

Figure 6-8.- Description from X-radiograph sketches of Apollo 16 deep drill string 60007 - 60001 (continued).



UNIT 16 DEPTH: 100.1 - 101.1 cm THICKNESS: 1 cm

THIN LAMINA PACKED WITH SMALL ROCK FRAGMENTS

MATRIX: 50%, RELATIVELY OPAQUE TO X-RAYS, WITH APPROXIMATELY 1% OPAQUE PARTICLES LESS THAN 0.5 mm DIAMETER, MOST OF WHICH ARE SPHERULITIC.
FRAMEWORK: 50% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE; MODERATELY SORTED, FROM 1 - 5 mm DIAMETER, EQUANT TO ELONGATE, WITH SUBANGULAR TO ANGULAR CORNERS, BLOCKY OUTLINE, AND WITH LONG AXES ALIGNED HORIZONTALLY.

UNIT 15 DEPTH: 101.1 - 107.1 cm THICKNESS: 6 cm

MASSIVE, VERY POORLY SORTED, INTERVAL

MATRIX: 85%, MODERATELY OPAQUE TO X-RAYS, WITH 25% INDISTINCT, SWIRLED MOTTLES AND GRANULES LESS THAN 1 mm DIAMETER, AND WITH APPROXIMATELY 3% OPAQUE EQUANT IRREGULAR TO SHARD-SHAPED PARTICLES LESS THAN 1 mm DIAMETER.
COARSE FRACTION: 15%, SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT TO SEMI-DISTINCT OUTLINE; POORLY SORTED, 1 - 9 mm DIAMETER, EQUANT TO SLIGHTLY ELONGATE, FRAGMENTS GENERALLY WITH IRREGULAR TO LUMPY, SUBANGULAR TO SUBROUNDED OUTLINE, IRREGULAR SIDES.

UNIT 14 DEPTH: 107.1 - 115.9 cm THICKNESS: 8.9 cm

DENSE-MATRIX THIN UNIT WITH POORLY SORTED ROCK FRAGMENTS

MATRIX: 80%, RELATIVELY OPAQUE, AS A CONSEQUENCE, INDISTINCTLY MOTTLED, AND WITH APPROXIMATELY 1% OPAQUE FRAGMENTS LESS THAN 1 mm DIAMETER, GENERALLY IRREGULAR TO SHARD-LIKE IN SHAPE.
COARSE FRACTION: 5% SEMI-OPAQUE WITH DISTINCT OUTLINE; MODERATELY SORTED, 2 - 4 mm FRAGMENTS, SUBEQUANT TO ELONGATE, WITH BLOCKY MARGINS AND SMOOTH SIDES; 15% SEMI-OPAQUE WITH INDISTINCT OUTLINE; MODERATELY TO POORLY SORTED, 1 - 5 mm FRAGMENTS, EQUANT TO SLIGHTLY ELONGATE, FADING OUT OVER MORE-OR-LESS REGULAR MARGINS.

UNIT 13 DEPTH: 115.9 - 118.4 cm THICKNESS: 2.5 cm

THIN BED WITH SCATTERED LARGE ROCK FRAGMENTS

MATRIX: 90%, NOTICEABLY FINE TEXTURE, WITH TRACE GRANULES, APPROXIMATELY 1% OPAQUES, 0.5 mm TO LIMIT OF RESOLUTION, MOSTLY SPHERICAL PARTICLES.
COARSE FRACTION: 5% SEMI-OPAQUE WITH DISTINCT OUTLINE, POORLY SORTED, 0.1 TO 0.7 cm, TENDING TO BE BLOCKY TO RECTANGULAR IN OUTLINE, SUBROUNDED. 5% SEMI-OPAQUE WITH INDISTINCT OUTLINE, 0.3 ± 0.1 cm DIAMETER, EQUANT, FADING OUT OVER IRREGULAR MARGINS.

UNIT 12 DEPTH: 118.4 - 126.4 cm THICKNESS: 8 cm

REVERSE GRADED BED WITH SCATTERED ROCK FRAGMENTS

MATRIX: 85%, DISTINCTLY GRANULAR, WITH 10% DENSITY CONCENTRATIONS LESS THAN 1 mm DIAMETER; 1% OPAQUES UP TO 1.5 mm DIAMETER, VARIABLE SIZES, POORLY SORTED, WITH NEARLY ALL PARTICLES LUMP-SHAPED TO SPHERICAL.
COARSE FRACTION: 10% SEMI-OPAQUE ROCK FRAGMENTS WITH MODERATELY DISTINCT OUTLINES, 0.1 TO 0.4 cm DIAMETER, MOSTLY 0.2 TO 0.3, WELL SORTED, POLYGONAL, SMOOTH-SIDED, BLOCKY AND SUBANGULAR. A SUBORDINATE FRACTION IS ROUNDED TO SUBSPHERICAL, AND ELONGATE-LUMPY.
FRAGMENTS INCREASE IN SIZE AND ABUNDANCE UPWARD.

UNIT 11 DEPTH: 126.4 - 129.4 cm THICKNESS: 3 cm

THIN BED PACKED WITH ROCK FRAGMENTS

MATRIX: 35% FINELY GRANULAR, WITH APPROXIMATELY 1% OPAQUES, 0.5 TO 0.8 mm, MOSTLY 0.8 mm FRAGMENTS, MOSTLY SPHERICAL IN OUTLINE.
COARSE FRACTION: 10% OPAQUE ROCK FRAGMENTS, 1.2 cm LENGTH, FRAGMENTS WEDGE-SHAPED, WITH RELATIVELY STRAIGHT EDGES, SHARPLY ANGULAR CORNERS. 40% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINE, 0.5 TO 1.1 cm LONG. MANY ARE SLIGHTLY ELONGATE, LONG AXIS HORIZONTAL TO SLIGHTLY INCLINED WHERE FRAGMENTS ARE IN CONTACT; SHAPE SIMILAR TO ABOVE, WITH A TENDENCY TO STRAIGHT EDGES WITH RELATIVELY EVEN OUTLINES. 15% SEMI-OPAQUE WITH INDISTINCT OUTLINES; UP TO 0.6 cm DIAMETER, MOSTLY 0.3 TO 0.3 cm, WITH A TENDENCY TO RAGGEDY AND IRREGULAR EDGES, MOSTLY EQUIDIMENSIONAL.

UNIT 10 DEPTH: 129.4 - 135.4 cm THICKNESS: 6 cm

COARSELY GRANULAR INTERVAL WITH SCATTERED ROCK FRAGMENTS

MATRIX: 95%, WITH 25% INDISTINCT GRANULES, LESS THAN 1 mm IN DIAMETER, AND WITH APPROXIMATELY 3% OPAQUE PARTICLES UP TO 1.5 mm DIAMETER, MOSTLY 0.5 TO 0.7 mm, EQUANT, NOT ELONGATE, ROUNDED, SPHERICAL TO ROUNDED-LUMPY.
COARSE FRACTION: 5% SEMI-OPAQUE ROCK FRAGMENTS WITH INDISTINCT OUTLINES, 0.2 TO 0.5 cm DIAMETER, GENERALLY OVOID TO SLIGHTLY ELONGATE, WELL ROUNDED, WITH SPARSE FRAGMENTS WITH WEDGE TO BLOCK SHAPES. AS UNITS 7 AND 8, SHAPE SORTING OF ALL SIZE FRACTIONS SEEM TO BE SIMILAR.

UNIT 9 DEPTH: 135.4 - 137.4 cm THICKNESS: 2 cm

THIN, FINE-GRAINED UNIT WITH SCATTERED ROUNDED FRAGMENTS

MATRIX: 95%, UNIFORMLY FINE-GRAINED, WITH NO DISCERNABLE GRANULES AND ONLY A TRACE OF OPAQUES, NEAR LIMIT OF RESOLUTION.
COARSE FRACTION: 5%, SEMI-OPAQUE ROCK FRAGMENTS, DISTINCT OUTLINE; WELL SORTED, 0.1 TO 0.3 cm DIAMETER, EQUANT, SMOOTH-SIDED AND SOMEWHAT ROUNDED.

UNIT 8 DEPTH: 137.4 - 146.9 cm THICKNESS: 9.5 cm

FINE-GRAINED UNIT WITH SCATTERED, SMALL ROCK FRAGMENTS, FLAKE-LIKE OPAQUES.

MATRIX: 90%, SIMILAR TO THAT OF UNDERLYING UNIT, BUT WITH ABOUT 1% OPAQUES, UP TO 1.2 mm LONG, BUT MOST IN RANGE OF 0.3 TO 0.8 mm; OPAQUES ARE NOTICEABLY IRREGULAR, WITH ELONGATE TO COMMA-SHAPED OUTLINE.
COARSE FRACTION: 10% SEMI-OPAQUE ROCK FRAGMENTS WITH DISTINCT OUTLINES; 0.2 TO 0.5 cm MAXIMUM DIAMETER, MOST PARTICLES ARE ELONGATE, WITH LONG AXIS TENDING TO BE HORIZONTALLY ALIGNED.
SHAPE SORTING PROCESSES MUST HAVE BEEN STRONGLY OPERANT DURING GENERATION OF THIS AND UNDERLYING BED IN THAT COARSE AND FINE PARTICLES HAVE SIMILAR SHAPES.

UNIT 7 DEPTH: 146.9 - 156.9 cm THICKNESS: 10.0 cm

THICK, FINE-GRAINED UNIT WITH ABUNDANT ROUNDED PARTICLES OF ALL SIZES

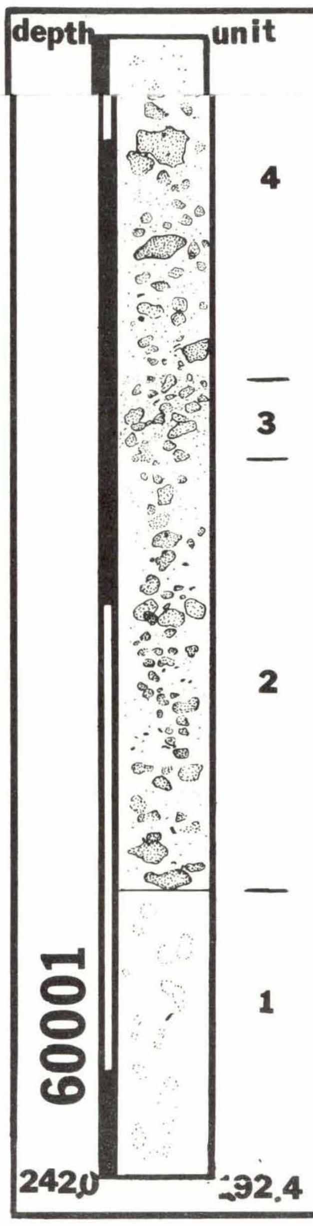
MATRIX: 90%, 25% OF WHICH IS INDISTINCT GRANULES LESS THAN 1 mm DIAMETER; 5% IS OPAQUE, VARYING IN SIZE FROM LIMIT OF RESOLUTION OF FILM TO 1.2 mm BUT AVERAGING 0.2 - 0.5 mm. OPAQUES TEND TO BE EQUANT, GENERALLY POLYGONALLY-BLOCKY WITH ROUNDED CORNERS AND STRAIGHT EDGES TO SPHERICAL DROPLETS, WITH VERY SPARSE CHIPS AND FLAKES.
COARSE FRACTION: 10% SEMI-OPAQUE, MODERATELY DISTINCT OUTLINE, RELATIVELY FINE-GRAINED, RANGING FROM 0.1 TO 0.4 cm WITH AN AVERAGE OF 0.2, AND AS WITH FINE OPAQUES, FRAGMENTS ARE EQUANT, BLOCKY-POLYGONAL WITH ROUNDED CORNERS TO EQUANT AND SPHERICAL.

UNIT 6 DEPTH: 156.9 - 163.9 cm THICKNESS: 7.0 cm

MASSIVE UNIT WITH ABUNDANT, LARGE ROCK FRAGMENTS

MATRIX: 60%, WITH 20% GRANULES AND INDISTINCT DENSITY CONCENTRATIONS LESS THAN 1 mm DIAMETER, 1% OPAQUES, AS IN UNIT 5.
COARSE FRACTION: 15% SEMI-OPAQUE WITH DISTINCT OUTLINE; 0.2 TO 0.8 cm DIAMETER, MODERATELY WELL SORTED, GENERALLY ELONGATE, ANGULAR TO SUBANGULAR WITH SMOOTH SIDES, POLYGONAL TO BLOCKY OUTLINE. 25% SEMI-OPAQUE WITH INDISTINCT OUTLINE, UP TO 1.0 cm DIAMETER, MOSTLY 0.3 TO 0.4 cm, MODERATELY TO POORLY SORTED, RELATIVELY TRANSPARENT, FADING OUT OVER CRENULATE AND IRREGULAR MARGINS.

UNIT 5 DEPTH: 163.9 - 167.4 cm THICKNESS: 2.5 cm



FINE-GRAINED THIN BED WITH ABUNDAND SMALL ROCK FRAGMENTS

MATRIX: 75%, NOTICEABLY FINE-GRAINED, LACKING IN GRANULARITY, LESS THAN 1% OPAQUES, NEARLY ALL UNDER 0.5 mm DIAMETER, LUMPILY TO IRREGULARLY SUBANGULAR AND EQUANT.
COARSE FRACTION: 25%, SEMI-OPAQUE WITH MODERATELY DISTINCT OUTLINE, 0.1 TO 0.3 cm DIAMETER, PARTICLES MODERATELY WELL SORTED, IRREGULARLY EQUANT AND SUBROUNDED.

UNIT 4 DEPTH: 167.4 - 174.9 cm THICKNESS: 8.5 cm

MASSIVE, POORLY SORTED UNIT WITH LARGE ROCK FRAGMENTS

MATRIX: 65%, FINELY GRANULAR, WITH APPROXIMATELY 20 % GRANULES LESS THAN 1 mm DIAMETER, AND 2% OPAQUE FRAGMENTS, LIMIT OF RESOLUTION TO 1.5 mm DIAMETER, AVERAGING APPROXIMATELY 0.5 mm, FRAGMENTS MOSTLY EQUANT TO BLOCKY, POORLY SORTED, WITH ONLY A MINOR COMPONENT OF FLAKE-LIKE MATERIAL.
COARSE FRACTION: 20% OPAQUE WITH DISTINCT OUTLINE, 0.2 TO 1.5 cm DIAMETER, MOSTLY 0.5 cm, BUT POORLY TO MODERATELY SORTED, FRAGMENTS TENDING TO ELONGATE, WITH EITHER SMOOTH EDGES AND SUBROUNDED CORNERS, OR LUMPILY IRREGULAR. 15% SEMI-OPAQUE WITH INDISTINCT OUTLINE, UP TO 1.2 cm LONG, AVERAGING 0.4 cm, WITH POOR SORTING, FADING OUT OVER INDISTINCT, LUMPY MARGINS.

UNIT 3 DEPTH: 174.9 - 176.4 cm THICKNESS: 1.5 cm

THIN, INCLINED BED WITH SORTED, SMALL ROCK FRAGMENTS

MATRIX: 50%, NOTABLY FINE-GRAINED, WITH LESS THAN 1% OPAQUES, ALL UNDER 0.3 mm DIAMETER, AND WELL SORTED AND SPHERICAL.
FRAMEWORK: 50% SEMI-OPAQUE, WITH IRREGULAR BUT DISTINCT OUTLINE, ELONGATE ROCK FRAGMENTS, 0.3 TO 0.6 cm, WAVY TO LUMPY OUTLINE, SUBROUNDED TO ROUNDED EDGES. MOST FRAGMENTS HAVE ELONGATE AXIS INCLINED APPROXIMATELY 20°, AND ARE PARALLEL.

UNIT 2 DEPTH: 176.4 - 185.9 cm THICKNESS: 9.5 cm

MASSIVE UNIT WITH SCATTERED ROCK FRAGMENTS IN FINELY GRANULAR MATRIX

MATRIX: 65%, FINELY GRANULAR, GRANULARITY NEAR LIMIT OF RESOLUTION, 2% FINELY DIVIDED OPAQUES UP TO 1.5 mm DIAMETER, AVERAGING 0.5 mm, AND POORLY SORTED AS TO SHAPE AND SIZE WITH MIXED SHAPES RANGING FROM SPHEROIDS TO DENDRITIC CHIPS.
COARSE FRACTION: 15% SEMI-OPAQUE WITH DISTINCT OUTLINE, 0.2 TO 0.5 cm DIAMETER, EQUANT ROCK FRAGMENTS WITH MORE-OR-LESS BLOCKY OUTLINES, SUBROUNDED CORNERS. 20% SEMI-OPAQUE WITH INDISTINCT OUTLINE, FRAGMENTS 0.2 TO 1.5 cm IN DIAMETER, AVERAGING 0.3 TO 0.5 cm, BUT POORLY SORTED. FRAGMENTS TEND TO BE EQUANT, CLOD-LIKE IRREGULAR, TO IRREGULARLY ROUND AND LUMPY.

UNIT 1 DEPTH: 185.9 - 192.4 cm THICKNESS: 6.5 cm

MASSIVE UNIT WITH SCATTERED ROCK FRAGMENTS

MATRIX: 75% INDISTINCT, APPEARS TO BE UNIFORMLY FINE-GRAINED, WITH 1% MINUTE SHARD-SHAPED OPAQUES.
COARSE FRACTION: 25%, APPEARS TO CONTAIN SCATTERED ROCK FRAGMENTS, 0.2 - 0.5 cm DIAMETER, RANDOMLY DISTRIBUTED THROUGH SECTION. MOST ROCK FRAGMENTS APPEAR TO BE EQUANT TO SLIGHTLY ELONGATE, OVOID TO MANY DETAILS ARE OBSCURED BY THE THICK WALLS OF THE DRILL BIT.

Figure 6-8.- Description from X-radiograph sketches of Apollo 16 deep drill string 60007 - 60001 (concluded).

TABLE XIV-1.- PRELIMINARY DATA X-RADIOGRAPHS APOLLO 16 DEEP DRILL STRING

Drill Stem Serial No.	LRL Sample No.	Returned Sample Mass g	Returned Sample Length cm	Bulk Density g/cc	Drill Stem Depth cm	Percent Core Recovery
	60007	105.7	22.2	1.46		
	60006	165.6	35.5 ±0.5	1.43 ±0.02		
	60005	76.1				
015	60004	202.7	39.9	1.56	223 ±2	8 - 100%
019	60003	215.5	39.9	1.66		
018	60002	211.9	42.5	1.75		
180(bit)	60001	30.1				

The drill string was returned from the Moon in two sections; the bit and lowest three stems (60001 through 60004), and the uppermost three stems (60005, 60006, 60007). The lower section, up to and including string section 60004 was completely filled with sample. In contrast, none of the upper stems was completely filled. Only 76.1 g of soil were scattered about in 60005, whereas the lower stems each contained over 200 g of soil. The lowest 7 cm of 60006 was empty, and the soil, where present, was fluffed-up and loosely compacted. The uppermost section (60007) was only about 2/3 filled, although the material that was present appeared to be densely compacted.

Soil was excavated in 0.5 cm increments from the bases of the drill stems, until 2.7 g of material was removed. All material coarser than 1 mm was picked out, described, and packaged separately (Fig. 16-9).

The drill bit (60001) and uppermost drill string (60007) were dissected within 2 weeks of transfer into the LRL. Accordingly, in addition to regular dissection allocations, samples were taken to complete early allocations.

Early allocations were excavated from the base of the bit, first, and second drill stem sections (60001, 60002, 60003). It was necessary to make two excavations to obtain the needed 2.7 g from the base of 60002 as indicated in Figure 16-9. Sample was removed from both the base and top of 60004, to compensate for the lack of sample in 60005. Two samplings were needed to complete the 2.7 g from the top of stem 60004 as well as from the base of 60006. Splits for allocation were taken from near the top and base of material present in 60007.

RELATIONSHIP TO GEOLOGY

Sample 60007: The uppermost sample (60007,83) was taken from the surface layer, a very loosely granular, medium neutral-gray sandy silt, with less than 1 percent whitish nodules, and glass beads. (Immediately underlying and sharply contacting the surface layer is a zone that is similar in grain size, but with a high percentage of whitish nodules, and a higher degree of cohesiveness than the surface layer.) The coarse fraction from this zone, contains spatter glass, vitreous feldspar fragments, grey lithic fragments, and whitish nodules.

The lowermost zone, represented in 60007,6, is a brownish medium-grey, silty-fine sand which is moderately coherent with only a trace of whitish granules. The coarse fraction includes spatter glass, whitish nodules, and unidentified lithic fragments.

Sample 60006: This sample is silty-fine sand, with a trace of whitish fragments, and glass.

Section	Sample number*	Weight g	over 1 mm.	Weight g
60007				
	60007,83	1.491	60007,82	0.019
	60007, 6	1.636	60007,10	0.151
60006				
	60006,4	4.735		
	60006,3	1.477		
60005				
	no sampling			
60004	60004,5	2.165	60004,6	0.103
	60004,7	1.727	60004,8	0.084
	60004,3	2.886	60004,4	0.224
60003				
	60003,3	2.974	60003,4	0.190
60002				
	60002,5	3.136	60002,6	0.198
	60002,3	1.461	60002,4	0.248
60001	60001,13	2.004	60001,12	0.159
	60001,3	0.738	60001,4	0.110

*arrow indicates location of sample

Figure 16-9.- Early allocations from Apollo 16 drill string.

Sample 60004: The matrix from the upper sample, (60004,5), consists of brownish grey, poorly cohesive, very fine sand to silt, which is fairly well sorted, with about 1 percent very fine reflecting surfaces (metallic or glass?), and about 1 percent, 0.2 - 0.5 mm diameter whitish granules. The coarse fraction (60004,6) from this interval consists of irregular, cohesive, whitish, splintery-rock fragments, blocky to subrounded medium grey lithic fragments, and spatter glass.

From the base of 60004, the fines are neutral brownish-grey, moderately cohesive, very fine sand to silt, moderately sorted, with "pepper and salt" appearance due to about 3 percent whitish granules under 0.5 mm diameter. The corresponding coarse fraction has a wealth of rock types including very dark grey, hackly lithic fragments, metallic grey, faceted rock fragments, spatter glass, glass beads, splintery and nodular whitish fragments, and brownish grey blocky lithic fragments.

Sample 60003: The matrix of this sample is brownish grey, moderately cohesive, very fine sand to silt, moderately to poorly sorted, with a trace of larger granules, most of which are whitish and rounded. The coarse fraction (60003,4) includes mostly irregular, angular, grey lithic fragments with irregularly planar faces. Whitish particles, of similar shape to grey lithic fragments (as distinguished from rounded whitish particles), and spatter glass are present also.

Sample 60002: Matrix of this interval is light grey, "salt and pepper" textured, poorly cohesive, very fine sand to silt. The coarse fraction, 60002,4 is distinctive in that all rock fragments are rounded to subrounded, with more-or-less regular surfaces. Most are dark to very dark grey lithic fragments. The remainder are similar-shaped whitish fragments.

Sample 60001: Layering in the bit was not directly observed, but through description of the coarse fraction, appears to be relatively thin (on the centimeter level), and characterized by major changes in mineralogy of the coarse fraction. The early allocation sample from the bit is relatively fine-grained with a coarse fraction comprised principly of whitish nodules and greenish feldspar cleavage fragments.

PRELIMINARY THOUGHTS ON APOLLO 16 DRILL STEM SAMPLE

According to Carrier (1972, informal communication), there are three competing hypotheses that have been advanced to explain the sample disturbance in the Apollo 16 drill stem. The three hypotheses, simply stated, contend that the disturbance that produced this result occurred either after, during, or before the drill stem was separated into two three-section segments on the lunar surface for Earth return.

HYPOTHESIS 1: AFTER SEPARATION

This hypothesis suggests that the original core recovery was roughly 80 percent; i.e., that the drill stem was initially full to approximately 4-1/2 sections, leaving a void of 1-1/2 sections in the top three sections when the drill stem was separated. Later, during lift-off, zero g, re-entry, splashdown, transport to, and handling in the LRL, the sample migrated up the sections, finally ending up being distributed in various states of compaction over a length of 2-1/2 sections.

Evidence for this hypothesis is: The proposed initial core recovery is consistent with the apparent soft soil (high penetration rate). Migration of this sort is not without precedence, as it also occurred in an Apollo 11 core tube.

A preliminary depth relationship based on Hypothesis 1 is shown in Figure 16-10. This relationship assumes that the stratigraphic sequence has been preserved in the top three sections, which is not necessarily a safe assumption. Soil fabric has undoubtedly been altered.

HYPOTHESIS 2: DURING SEPARATION

The second hypothesis suggests that the original core recovery was approximately 100 percent; i.e., that the drill stem was initially full to its present height of 5-1/2 sections. Then, when the stem was being separated, some of the sample fell out the bottom of the top three sections and was lost.

Evidence for this hypothesis is: John Young noticed some sample was falling out while Charlie Duke was separating the sections and attempted to call this to his attention. Duke evidently did not hear his remark and did not recall that any sample had spilled. There may have been additional spillage which Young did not notice.

A preliminary depth relationship based on Hypothesis 2 is shown in Figure 16-10.- The length of the gap in the sample recovery has been computed assuming the original density of the soil in the third section was 1.5 g/cc and then calculating how much volume the remaining 76 g would have occupied in the third section and the bottom of the second section. This implies that there are approximately 29 cm missing.

HYPOTHESIS 3: BEFORE SEPARATION

The last hypothesis suggests that the original percent core recovery was also approximately 100 percent, but that the majority of the sample fell out when the power head was used to "burp" the drill stem while it was still in the ground to help loosen it. This implies that the missing 29 cm of soil occurs at the bottom of the drill stem, rather than in the middle.

Evidence for this hypothesis is: This sort of behavior has been experienced in simulation exercises.

A preliminary depth relationship based on Hypothesis 3 is shown in Figure 16-10.

DISSECTION AND SAMPLING OF DRILL STEM 60007

Lunar Surface Procedures and Related Information

The deep drill, including sections 60001 (drill bit) through 60007 (uppermost section of drill string) was recovered by astronauts J. W. Young and C. M. Duke on 28 April, 1972, on EVA 1; 5 days, 1 hour and 25 - 44 minutes into the Apollo 16 mission. The actual drilling was performed at the ALSEP site (station 10) located approximately 105 m southwest of the LM landing area. Figure 16-2 indicates the location, as of the most current photographic reconstruction of the sampling site (Butler, et al. 1972, revised from USGS Prelim. Rept. 51, 1972).

The core was taken in a flattish spot in an area of gently rolling topography, with abundant but subdued, 4 to 6 m craters. There were also sparse 1 to 2 m craters, some of which showed fresh-looking unimpacted ejecta deposits. Although there was an area of deep, loose soil located a few meters to the East of the drilling site, soil in the immediate vicinity of the drill appeared to be fairly compact, with blocks of up to 10 - 15 cm abundant (USGS Rept. 51, p. 19). Lunar Module Pilot Duke used the electric rotary percussion drill to obtain the core, sections of which are 44 cm long, with an inside length of 40 to 42 cm. Before and during sampling, sections were joined to the drill in pairs; but after sampling was completed, the entire string was broken into two sections of three stems each. A Teflon cap was placed on both ends of each section on the lunar surface. The drill sections were then placed in a special return container, and placed in the LM; during return, the cores were subjected to cabin and terrestrial atmospheric conditions for a period of approximately 7 days.

Samples were removed from the lunar return container on 4 May, 1972, under sterile nitrogen atmosphere conditions in the LRL, weighed, and photographically documented by 8 May, 1972, at which time each core section was triple bagged in 5 mil Teflon and transferred to the Sample Processing and Packaging Laboratory. All subsequent processing has been under nitrogen atmosphere conditions, in special, high-cleanliness glove cabinets.

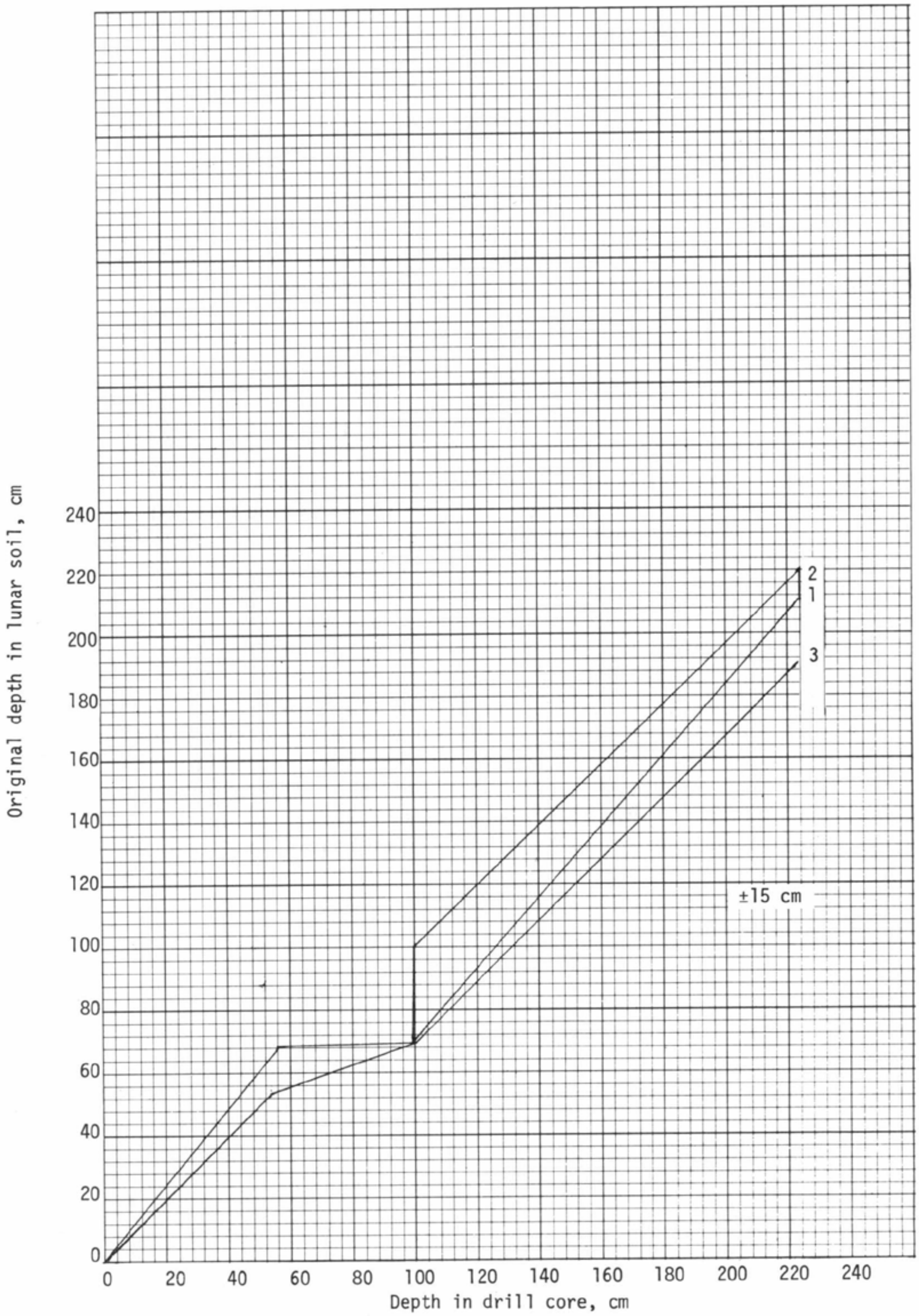


Figure 16-10.- Preliminary depth relationship for Apollo 16 deep drill core.

PRELIMINARY DESCRIPTION OF THE DRILL STRING

X-radiographs provide considerable information on textural and stratificational properties of the cores, by recording size, shape, sorting and distribution of many rock fragments, and by giving a clear-cut indication of the abundance of metallic objects which appear opaque to X-rays. The packaging and completeness of distribution of soil in the core tube shows up clearly by X-ray. X-radiographs, for example, showed that the Apollo 16 drill string was not completely filled with soil missing from near the middle of the drill string.

The following statement summarizes the condition of the Apollo 16 drill string, as found by X-radiography in May of 1972 (Fig. 16-8). 60007 was only about 60 percent filled, but the sample was well-compacted, showing no evidence of sliding or disturbance, and contained six recognizable stratigraphic units. 60006 showed considerable slumping and fracturing of soil near both ends, but within the core, it was possible to define 12 stratigraphic zones, on the basis of abundance of rock fragments, matrix density, and type and shape of opaque particles. 60005 was completely disturbed, with the soil loosely partially filling the entire length of the core. No units could be distinguished within 60005, and the entire drill stem was placed as number 28 in the sequence. The upper three stems were returned from the moon coupled together as one section; similarly, the bit and lowest three stems, 60004 through 60001, were returned as one. Slippage and disturbance were confined to the upper section, and the lower section was almost completely filled, with very little slumping, and well-defined stratification. The bit and lower part of 60002 were much coarser than the upper 6 cm of 60002 or 60003 and 60004. Basal coarse layers were numbered 1 through 6; with the middle finer-grained sequence comprising layers 7 through 27. An opaque particle in layer 11 of 60003 is distinctive because it is an order of magnitude larger than most opaques; near it lies a large but indistinct spherule.

DISSECTION AND STRATIGRAPHY

Much of the descriptive information concerning cores is gained from detailed examination of the samples during dissection, as well as examination of the peels and pre-impregnational surface. This information is summarized in Figs. 16-11 and 16-12 with stratigraphic information in Fig. 16-11, dissection and sample location data in Fig. 16-12. Most samples listed in Fig. 16-12 are routine splits, indexed with respect to LCL sample inventory, as well as unit and depth below lunar surface. Attention is also called to special samples, which were dealt with separately because of unique properties of the sample, or because of a special purpose of study.

A variety of special samples have been removed from Apollo 16 drill stems. Because the bit was short and thick-walled, and because of the need for early allocation of samples from it, the soil was extracted in standard 0.5 cm increments, from the bottom end of the bit, removing all soil from the core. Fragments larger than 1 mm were identified, extracted, and packaged separately; the less than 1 mm fines were passed through a .350 mm sieve. A major portion of these finest fines were used for biomedical experimentation soon after return from the moon.

Red light samples, taken for differential thermoluminescence studies, were never exposed to white light; the outermost rind of soil was scraped away under red light illumination, and an 0.5 cm increment extracted from the inner part of the core. A special procedure designed to reduce the lead contamination from the drill stem required. Soil to be extracted with special acid-cleaned tools in sample increments. Some particles from 60002 were found to be oxidized, and rusty in appearance; these were extracted, photographed, packaged and allocated separately. Several large platelets of material adjacent to the wall of the core tube were extracted and impregnated separately for study of the primary structures and small-scale strata they contained.

TIMELINES

The drill bit and uppermost section (60007) were dissected in May, 1972, immediately after return from the moon. 60006 and 60004 were dissected in October and November of 1972. Processing of the Apollo 16 drill string was again interrupted in 1973, for preliminary examination of the Apollo 17 core material, and for development of procedures for core stabilization. Processing was resumed in early 1974, with dissection of 60002, and 60003 was completed by the third quarter of 1974. Both 60002 and 60003 contained distinctive particles and posed special problems which slowed processing. 60005 was completed in December, 1974.

SPILLAGE ACCIDENT

There was an accidental spillage of samples from 60001 and 60007 on 9 June, 1972, caused by the inadvertent placement of a vacuum on the FTH containers during transfer. As a result, tops of 60 of the 85 FTH containers popped open, with some overturning of containers and spillage of sample. Samples which remained intact, with no opening of tops, are indicated by an asterisk on Figure 16-13. Likewise, samples with opened tops but little evidence of contamination are not marked, but samples with weight loss or gain through cross-contamination are specially designated. Allocations have been made from samples which were either unaffected by the accident, or which showed no evidence of cross-contamination during the spillage.

STRATIGRAPHIC SUMMARY

A stratigraphic summary of the Apollo 16 drill string is presented in Fig. 16-11, based on information collected during dissection.

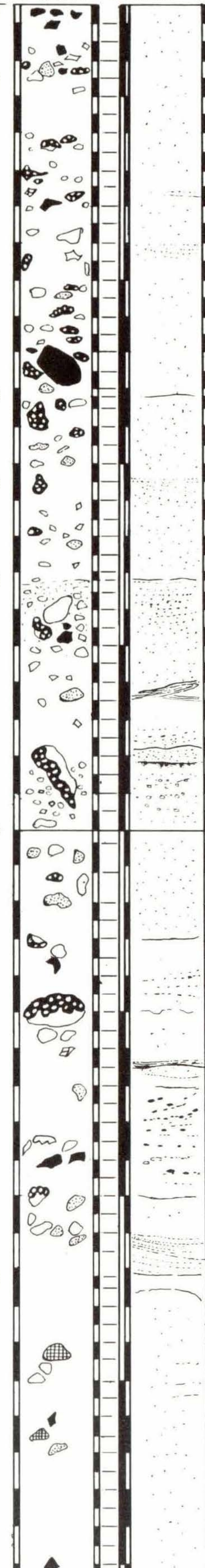
Although a total of 46 layers was recognized, it should be noted that the lower part of 60006 and 60005 was slumped, incompletely filled, and appeared massive and homogeneous probably because of mixing and disruption of strata. In 60005, the X-rays showed no massive units. During subsequent handling the core material became again lightly packed. Techniques for recognizing primary structures improved with experience of the dissection personnel, so structures are better defined and described in later dissections such as 60002 and 60003 than in earlier studies. Because of an exceptionally good peel, a wealth of fine structures were also noted in 60007. 60003 split longitudinally during removal of the upper half of the drill stem, revealing an extensive suite of structures that would have otherwise been missed.

In gross terms, the Apollo 16 drill string can be subdivided into three major subdivisions. The uppermost zone takes in lithostratigraphic units 39 - 46, including all of 60006 and 60007, the middle subdivision occupies 60005, 60004, 60003 and the upper 7 cm. of 60002, including units 13 through 38, and the basal zone takes in the rest of the core, including units 1 through 12.

All units of the uppermost subdivision have in common, an abundance of fresh-appearing crystalline anorthosite and plagioclase cleavage fragments, and are relatively coarse-grained. The surficial abundance of fresh material suggests that this subdivision may be related to the relatively recent North Ray or South Ray Craters; however the thickness of this interval -43 to 55 cm- cannot be accounted for by primary ejecta from these craters, and is either from an additional source, or fresh material from these craters subsequently reworked by action of secondaries.

In addition to being much finer-grained, the middle subdivision is intraclastic in nature, with almost all units dominated by particles such as soil breccias or agglutinates, which originated as intraclasts within the regolith, rather than as allochems derived from external sources. Coarse units, such as No. 20 or 33, are packed with large agglutinates and may be deposits from glass-bottomed craters. Otherwise, large rock fragments are relatively rare and bedrock material is especially fine-grained and highly comminuted. Such evidence points to either slow accumulation of this interval, or an episode of extensive reworking by small impacts.

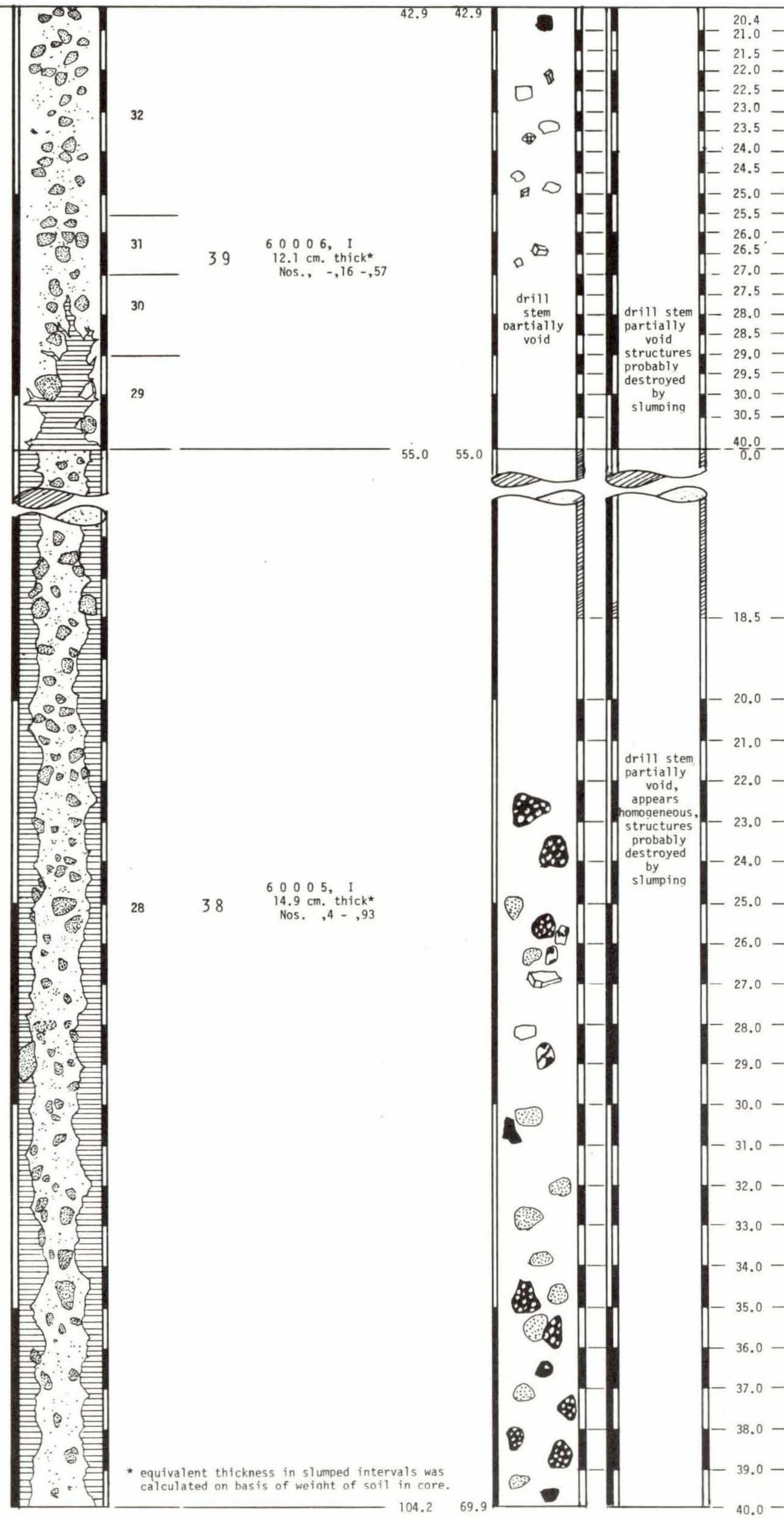
In contrast, the lowest part of the core is coarse-grained, being especially rich in higher-grade breccias such as melt-matrix breccias and black-and-white breccias. Crystalline rock fragments are abundant in some layers, whereas large agglutinates and glass droplets are uncommon. Such textural and compositional properties suggest faster accumulation or deeper cratering than is the case for the middle subdivision.



X-RAY	ENTIRE DRILL STRING	THIS CORE unit (numeral) unit thickness samples in unit	APPARENT DISTANCE BELOW LUNAR SURFACE (CM.)	SAMPLE INTERVAL (LCL INVENTORY)	COLOR	COHESIVENESS, FRACTURE PATTERNS	TEXTURE	COMPOSITION OF COARSE FRACTION	DISTINCTIVE FINES	SUB-UNITS, PRIMARY STRUCTURES	DOCUMENTATION PHOTOGRAPHS (NASA photo number)
46	46	60007, V 2.0 cm. thick Nos. ,83-,92	0.0 – 2.0	17.5 – 20.5	10 YR 4/1 to N4 medium neutral grey	Loose, fine-textured, tending to slump into 1 - 3 mm crumb-like clumps rather than prismatic blocks; 40% to 90% single-grain disaggregation.	Sandy siltsoil, with up to 50% very fine sand, moderately well sorted, matrix support, tr. to 5% rock fragments, most common in basal layer.	Crystalline anorthosite ....11.1 Plagioclase cleavage fragments ....11.1 Anorthositic breccia ....16.7 Fresh glass droplets ....11.1 Fresh glass agglutinates ....22.2 Dark melt rock and breccia matrix .... 5.5 Soil Breccia ....22.2 Total Particles Counted 18	Approx. 5% whitish granules, fine-sand size; 1 - 2 minute feldspar cleavage fragments	B. 17.5-19.0. relatively fine-grained, rich in melt-matrix breccia A. 19.0-19.5. relatively coarse-grained polymict.	S-74-17345
45 44 43	45	60007, IV 8.7 cm. thick Nos. ,47 -,82	2.0 – 10.8	20.5 – 28.2	10 YR 4/1 to N4 medium neutral grey	Mixed, inconsistent cohesiveness, as over-all unit collapses readily, but into large clumps as much as 8 mm diameter, clumps hold cast of core tube to some extent. Relatively slight degree of collapse into lumps, and only approx. 10% disaggregates into single grains.	Very fine sandy siltsoil, poorly sorted, with enough clay for fair cohesiveness, small, but variable rock component (ave. 2%), and with matrix support throughout.	Plagioclase cleavage fragments .... 7.3 Anorthositic breccia ....31.7 Fresh glass agglutinates ....29.3 Soil Breccia .... 4.8 Total Particles Counted 41	Approx. 1% sand-sized whitish anorthosite granules; 1 - 3% fine-sand sized feldspar cleavage fragments with strong reflecting surfaces	D. 19.5-21.0. massive, relatively fine-grained C. 21.0-24.0. indistinct horizontal fabric, bedding plane at 22.7 B. 24.0-24.5. indistinctly but thinly stratified. A. 24.5-28.2. massive, relatively coarse-grained.	S-74-17362 S-74-17342 S-74-17359 S-74-17359
	44	60007, III 1.8 cm. thick Nos. ,39 -,46	10.8 – 13.0	28.2 – 30.5	N4 medium neutral grey	Moderately cohesive, slumping into crumbly prismatic blocks as much as 3X 5 mm, as well as spherical, pellet-like lumps, and irregular, crumb-like fragments. Approximately 10% disaggregates into single, fine-sand-sized grains.	Rock-bearing, clayey, sandy siltsoil, moderately to poorly sorted, and moderately compacted, with a high precentage of rock fragments (ave. 7%) but with matrix support.	Anorthositic breccia ....41.7 Fresh glass agglutinates ....16.7 Dark melt rock and breccia matrix ....25.0 Soil Breccia ....16.7 Total Particles Counted 14	Approx. 5% fine sand-sized whitish anorthosite granules, 1 - 2% feldspar cleavage fragments	28.2 bedding plane	S-74-17341 S-74-17361 S-72-39046
42	43	60007, II 3.2 cm. thick Nos. ,28 -,38	13.0 – 15.7	30.5 – 33.2	10 YR 4/1 to N4 medium neutral grey	Distinctively incoherent and very loose, slumping into irregular 0 to 3 mm crumb-like fragments, less compacted than above or below, and at least 30% disaggregates into individual, fine-sand-size grains.	Fine sandy siltsoil, moderately well sorted and well compacted, with very sparse rock fragments.	Crystalline anorthosite ....81.3 Plagioclase cleavage fragments ....33.3 Anorthositic breccia ....25.0 Fresh glass agglutinates ....16.7 Dark melt rock and breccia matrix ....16.7 Total Particles Counted 12	2 - 5% silt to fine-sand sized anorthosite granules, 1 - 2% feldspar cleavage fragments.	B. 30.5-31.0. indistinct but thinly laminated A. 31.0-33.2. massive 33.2 bedding plane	S-74-17363
41	42	60007, I 6.7 cm. thick Nos. ,2 -,27	15.7 – 22.5	33.2 – 40.0	10 YR 5 to N 5.5 medium drab grey (strong contrast to overlying beds)	Relatively coherent, slumping less than 3 mm, and breaking into irregular, prismatic clumps up to 3 X 6 mm that show a cast of the core tube wall very distinctly. There is almost no disaggregation into individual grains.	Sand and rock bearing clayey siltsoil, very poorly sorted, with an average of 8% rock fragments, most with long axis horizontal, with matrix support, possible framework concentration at top of bed.	Plagioclase cleavage fragments ....11.1 Anorthositic breccia ....55.5 Fresh glass agglutinates ....14.8 Soil Breccia ....18.5 Total Particles Counted 29	5 - 10% silt to sand-sized anorthosite granules; Tr - 1% feldspar cleavage fragments	G. 33.2-34.5. indistinct fabric shows F. 34.5-36.5. massive 36.0. distinct bedding plane E. 36.0-36.5. two sets of very fine laminaes the upper of which truncate the lower D. 36.5-38.0. thin sub unit with indistinct subhorizontal fabric C. 37.5-38.0. finely laminated sub-unit 38.0± irregular bedding plane B. 38.0-38.5. irregular dark lamina, smooth upper surface A. 38.5-40.0. indistinct fabric marked by anorthosite granule concentration	S-74-17360 S-74-17343 S-74-17358 S-74-17344 S-74-17359
40 39 38	41	60006, III 11.8 cm. thick Nos. ,91 -,133	22.5 – 34.5	0.4 – 12.2	10 YR 5 medium drab grey	Relatively coherent, appears similar to base of 60007, with 5±% single-grain disaggretation, breaks into 2-6 mm reticulate surface blocks that further disaggregate into equant pellet-like lumps.	Granular sandy siltsoil; moderately to poorly sorted but with scattered large rock fragments, more than 1 cm in diameter, most of coarse fraction is sparsely distributed but some intervals are almost packed.	Crystalline anorthosite .... 3.3 Plagioclase cleavage fragments ....38.3 Anorthositic breccia ....26.6 Fresh glass droplets .... 3.1 Fresh glass agglutinates ....10.1 Fresh glass chips .... 1.5 Dark melt rock and breccia matrix .... 9.1 Grey and white breccia .... 1.5 Soil Breccia .... 6.5 Total Particles Counted 583	Abundant whitish anorthosite granules, and plagioclase cleavage fragments, reflective particles common to rare	H. 0.4-3.0. massive 3.0 bedding plane G. 3.0-4.0. massive F. 4.0-5.0. indistinct fabric shows gradual changes in inclination 5.0 irregular bedding plane E. 5.0-6.0. massive D. 6.0-6.5. very thinly laminated C. 6.5-10.0. indistinct fabric shows gradual changes in inclination B. 10.0-11.0. massive A. 11.0-12.2. very thinly laminated	S-74-17824 S-72-53894 S-73-20363 S-73-20364 (coated agglutinate) S-72-53894 S-74-17823 S-72-53895 S-74-17822
37	40	60006, II 8.2 cm. thick Nos. ,50 -,90	34.5 –	12.2 – 20.4		Moderately crumbly with approximately 5-10% single-grain disaggregation fractures into fine equant clumps less than 2 mm in diameter, weakly holds cast of core tube.	Finely granular-clayey siltsoil; generally moderately to poorly sorted with relatively sparse coarse fraction, most fragments of which are fine-grained.	Crystalline anorthosite .... 4.8 Plagioclase cleavage fragments ....37.8 Anorthositic breccia ....26.6 Fresh glass droplets .... 2.9 Fresh glass agglutinates .... 6.9 Fresh glass chips .... Tr Dark melt rock and breccia matrix ....11.1 Grey and white breccia .... 4.0 Soil Breccia .... 5.7 Total Particles Counted 376	Abundant anorthosite granules and plagioclase cleavage fragments; reflective particles common to rare.	Massive, with indistinct fabric; original stratification possibly disrupted by slumping	S-72-53896 S-74-17821 S-72-53897 S-74-17820

Figure 16-11.- Stratigraphic summary of the Apollo 16 deep drill string.

DRAWING OF X-RADIOGRAM	UNIT: X-RAY	UNIT: ENTIRE DRILL STRING	UNIT: THIS CORE unit (numeral) unit thickness samples in unit	APPARENT DISTANCE BELOW LUNAR SURFACE (CM.) Max.	Min.	DIAGRAM OF DISSECTED CORE	DRAWING OF PRIMARY STRUCTURES	SAMPLE INTERVAL (LCL INVENTORY)	COLOR	COHESIVENESS, FRACTURE PATTERNS	TEXTURE	COMPOSITION OF COARSE FRACTION	DISTINCTIVE FINES	SUB-UNITS, PRIMARY STRUCTURES	DOCUMENTATION PHOTOGRAPHS (NASA photo number)
	32, 31, 30, 29	39	6 0 0 0 6, I 12.1 cm. thick* Nos., -,16 -,57	42.9 – 55.0	42.9 – 55.0	drill stem partially void	drill stem partially void structures probably destroyed by slumping	20.4 – 40.0	10 YR 5 Medium drab grey	Does not hold cast of core tube but maintained 0.5-1.2 cm face during dissection collapses into 0.5-2 mm equant blocky fragments with 5-20% single-grain disaggregation.	Sandy, granular siltsoil; generally moderately sorted. Sparsely rock fragmental, with many fresh-appearing fragments.	Crystalline anorthosite .... 1.9% Plagioclase cleavage fragments ....37.5% Anorthositic breccia ....31.1% Fresh glass droplets .... 2.2% Fresh glass agglutinates .... 6.7% Fresh glass chips .... Tr Dark melt rock and breccia matrix ....13.8% Grey and white breccia .... 1.1% Soil Breccia .... 5.4% Total Particles Counted ..... 720 Composition of coarse fraction not significantly different from that of overlying units in 60006	Abundant anorthosite granules and plagioclase cleavage fragments; common dark or reflective particles.	Sample **not** subdivided; core appeared structureless and slumped, and showed no distinguishable composition trends.	S-72-53097 S-72-53891 S-72-53898 S-72-53899 S-72-53900
	28	38	6 0 0 0 5, I 14.9 cm. thick* Nos. ,4 - ,93	55.0 – 104.2	55.0 – 69.9		drill stem partially void, appears homogeneous, structures probably destroyed by slumping	0.0 – 40.0	Medium to dark drab gray 2.5R 5/1	Cohesive enough to retain cast of core tube where contact was made; breaks into irregular clumps up to 5 mm long, but most ave. 1-2 mm: 5-10% single-grain disaggregation.	Appears similar to average texture of 60004 rather than of 60006, but is disturbed and slumped. In general is a gravelly siltsoil with abundant large intraclastic agglutinates, sparse quantities of granular material present in 60006 and 60007	Crystalline anorthosite .... 0.4% Plagioclase cleavage fragments .... 5.4% Anorthositic breccia .... 9.4% Fresh glass droplets .... 4.1% Fresh glass agglutinates ....11.8% Fresh glass chips .... 0.4% Dark melt rock and breccia matrix ....21.3% Grey and white breccia .... 9.2% Soil Breccia ....37.9% Total Particles Counted ..... 688 Note: Figures represent a numerical percentage of particles counted; large agglutinates account for a higher weight present of total than represented here. Composition of coarse fraction resembles that of underlying units in 60004.	Anorthosite granules and plagioclase cleavage fragments are rare to present; dark reflective particles are common		S-74-32549 S-74-32548 S-74-32547 S-74-32546 S-74-32545 S-74-33190- S-74-33192 Distinctive large agglutinates. S-74-32544 S-74-32543



* equivalent thickness in slumped intervals was calculated on basis of weight of soil in core.

EXPLANATION OF COMPOSITION SYMBOLS

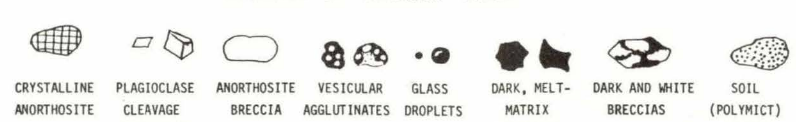
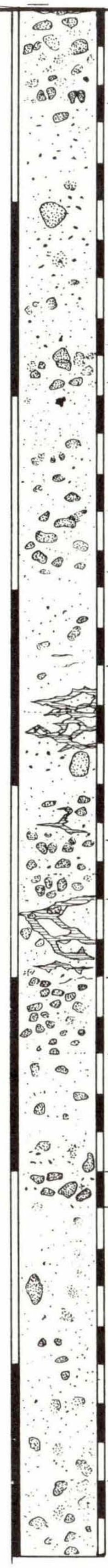
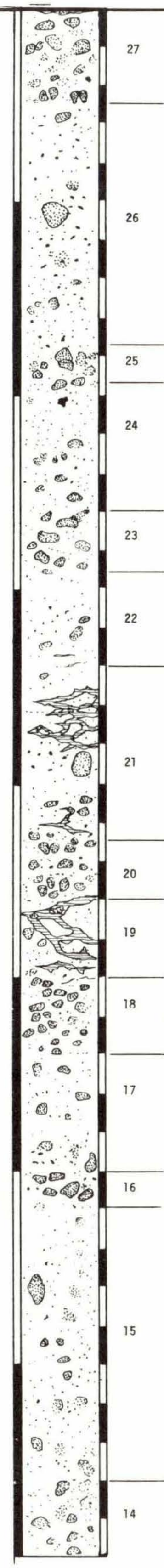


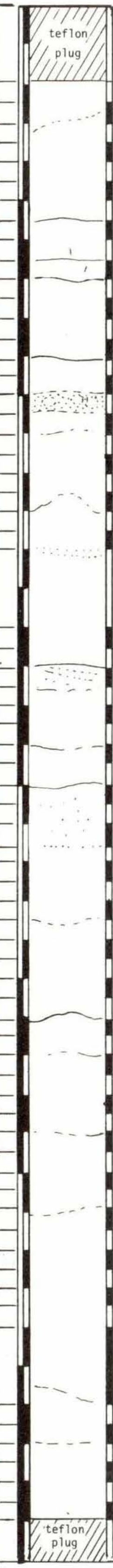
Figure 16-11.- Stratigraphic summary of the Apollo 16 deep drill string (continued).



X-RAY	ENTIRE DRILL STRING	THIS CORE unit (numeral) unit thickness samples in unit	APPARENT DISTANCE BELOW LUNAR SURFACE (CM.) Max.	Min.	SAMPLE INTERVAL (LCL INVENTORY)	COLOR	COHESIVENESS, FRACTURE PATTERNS	TEXTURE	COMPOSITION OF COARSE FRACTION	DISTINCTIVE FINES	SUB-UNITS, PRIMARY STRUCTURES	DOCUMENTATION PHOTOGRAPHS (NASA photo number)
27	37	6 0 0 0 4, X 5.5 cm thick Nos. ,330-,345	104.2	69.9	1.9 2.5 3.0 3.5 4.0 4.5 5.0	Dark Drab to Dark Gray 10Y 4/1	Relatively cohesive, does not slump and holds cast of core. 1st breaks to equant blocks up to 8 mm, then to vari-sized crumb-like particles. 5 - 10% single-grain disaggregation.	"Clayey"-fine sandy siltsoil; moderately to poorly sorted, sparsely rock-fragmental, less than 10% coarse fraction, which is sub-rounded and equigranular.	Anorthositic breccia ......46% Fresh glass droplets ......23% Fresh glass agglutinates ......13% Dark melt matrix breccia ...... 5% Soil Breccia ...... 8% Total Particles Counted 93	Anorthosite granules very abundant, reflective particles, and droplets and dark shards are present to common.		S-72-52254 S-74-18347 S-74-18380 S-72-52253
26	36	6 0 0 0 4, I X 3.6 cm thick Nos. ,314-,329	108.6	74.3	5.5 6.0 6.5 7.0 7.5 8.0 8.5	Dark Drab to Dark Gray 10Y 4/1	Incoherent, crumbly, poorly cohesive, with 25% slump, 20-25% single-grain disaggregation, remainder breaks to 2-4 mm crumbs. Relatively planar basal contact.	Fine-sandy siltsoil, moderately well sorted, loosely compacted, sparsely rock fragmental, angular to fragmental texture.	Anorthositic breccia ......44% Fresh glass droplets ......10% Fresh glass agglutinates ......10% Dark melt rock and breccia matrix ...... 7% Soil Breccia ......21% Total Particles Counted 73	Anorthosite granules are abundant; reflective particles are common to abundant.	C. 5.5-6.5. Light-colored sub-units, separated B. 6.5-7.0. by distinct bedding planes A. 7.0-9.1. Relatively dark, finer-grained	S-74-18345 S-72-52252
25 24	35	6 0 0 0 4, V I I I 3.9 cm thick Nos. ,296-,313	112.2	77.9	9.1 9.5 10.0 10.5 11.0 11.5 12.0 12.5	Dark Drab to Dark Gray 10Y 4/1	Relatively cohesive to crumbly, upper part holds cast of core tube, 5-10% single-grain disaggregation.	Fine sandy-clayey siltsoil, sparsely rock fragmental uncompressed, angular to subangular.	Crystalline anorthosite ......11% Anorthositic breccia ......46% Fresh glass agglutinates ...... 8% Dark melt matrix breccia ...... 4% Soil Breccia ......20% Total Particles Counted 137	Anorthosite granules and dark particles are abundant; reflective particles are common.	D. 9.1-9.5. Relatively light-colored C. 9.5-10.0 Marbled, light clods in dark matrix B. 10.5-11.0 Relatively light colored, indistinctly laminated. A. 11.0-13.0 Massive characters of unit.	S-72-52251 S-74-18349
23 22	34	6 0 0 0 4, V I I 4.5 cm thick Nos. ,279-,295	116.1	81.8	13.0 13.5 14.0 16.0 16.5 17.0	Dark Drab to Dark Gray 10Y 4/1	Relatively cohesive, holding cast of drill stem, holds 1.5 cm face, 5-10% single-grain disaggregation, 1st breaks to sharp-edged prisms up to 4 mm (arc 1-2) thence is pulverized to pellet-like crumbs.	Clayey, fine-sandy siltsoil, moderately to poorly sorted, sub-rounded, sparsely rock fragmental.	Anorthositic breccia ......66% Fresh glass droplets ...... 8% Fresh glass agglutinates ...... 8% Dark melt rock and breccia matrix ...... 6% Soil Breccia ...... 7% Total Particles Counted 103	Anorthosite granules and dark particles are abundant: reflective particles are common.	C. 13.0-14.0. Characters of unit. B. 14.0± Laminae of anorthosite granules A. 14.0-17.0. Massive, characters of unit.	S-72-52250 S-74-18344
21	33	6 0 0 0 4, V I 4.1 cm thick Nos. ,260-,278	120.6	86.3	17.5 18.0 18.5 19.0 19.5 20.0 20.5 21.0	Dark Drab to Dark Gray 10Y 4/1	Relatively crumbly, first breaking to square or equant blocks up to 7m, thence breaks to 0.5-3mm equant pelletiferous clumps, with 5-20% single-grain disaggregation.	Sandy siltsoil: bimodal, moderate to well sorted, with areas containing framework packing.	Crystalline anorthosite ...... 8% Anorthositic breccia ......55% Fresh glass agglutinates ......18% Dark melt rock and breccia matrix ...... 5% Soil Breccia ...... 4% Total Particles Counted 76	Anorthosite granules and reflective particles are present to common.	D. 17.0-17.5. Indistinctly laminated. C. 17.5-19.0. Sub-units separated by distinct bedding. B. 19.0-20.0. Planes A. 20.0-21.6. Sub-unit rich in coarse anorthosite granules.	S-74-18348 S-72-52249
20	32	6 0 0 0 4, V 1.9 cm thick Nos. ,251-,259	124.7	90.4	21.6 22.0 22.5 23.0	Dark Drab to Dark Gray 10Y 4/1	Cohesive, holding cast of drill stem and 1.5 cm face, further broken into 0.5-1.5 mm blocky clods, with 15-20% single-grain disaggregation.	Clayey siltsoil, poorly to moderately sorted, compact, distinctly angular, very sparingly to moderately rock fragmental.	Anorthositic breccia ......58% Fresh glass agglutinates ......27% Dark melt rock and breccia matrix ...... 6% Soil Breccia ...... 6% Total Particles Counted 33	Anorthosite granules are very abundant, reflective particles are rare to present.		
19	31	6 0 0 0 4, I V 2.6 cm thick Nos. ,239-,250	126.6	92.3	23.5 23.9 24.5 25.0 25.5	Dark Drab to Dark Gray 10Y 4/1	Very crumbly and non-cohesive, 10% single-grain disaggregation, breaks into 2-4 mm pellet-like clods and fragments.	Fine sandy siltsoil, moderately well sorted, mostly sparsely rock fragmental but becomes coarse upward, relatively few, but large rock fragments.	Crystalline anorthosite ......26% Anorthositic breccia ......26% Fresh glass droplets ...... 9% Dark melt rock and breccia matrix ......26% Soil Breccia ......12% Total Particles Counted 35	Anorthosite granules are abundant; other distinctive particles rare.	B. 23.0-23.5 Rock fragment concentration A. 23.0-26.1 Sparsely rock fragmental.	S-72-52248 S-74-18346
18 17	30	6 0 0 0 4, I I I 4.8 cm thick Nos. ,216-,238	129.2	94.9	26.1 26.5 27.0 27.5 28.0 28.5 29.0 29.5 30.0 30.5	Dark Drab to Dark Gray 10Y 4/1	Very cohesive, holds cast of drill stem, dissected with difficulty, 1st broken to 1-3 cm. coarse fines, then to irregular lumps 1 ± mm, 5% or less single-grain disaggregation.	Clayey, fine-sandy siltsoil, moderately to poorly sorted angular, sparsely-rock fragmental.	Crystalline anorthosite ......12% Anorthositic breccia ......46% Fresh glass droplets ......17% Fresh glass agglutinates......13% Soil breccia ...... 7% Total Particles Counted 82	Anorthosite granules are abundant, and reflective particles are present.	D. 26.1± Dark fine-grained lamina. C. 26.1-27.0. Rich in droplets, sharp bedding plane at base. B. 27.0-29.0. Rich in agglutinates; sharp bedding plane at base. A. 29.0-30.9. Rich in glass droplets, bedding plane at base.	S-72-52250
16 15	29	6 0 0 0 4, I I 6.1 cm thick Nos. ,193-,215	134.0	99.7	30.9 31.5 32.0 32.5 33.0 33.5 34.0 36.0 36.5	Dark Drab to Dark Gray 10Y 4/1	Very cohesive, holds cast of drill stem, crumbles only with strong contact, with 5 - 10% single grain disaggregation, reworked broken 1st to 1 cm prisms, then grain-coated 0.5-1 mm crumbs.	Clayey-fine sandy siltsoil; poorly sorted, subangular to subrounded, sparse to very sparce rock fragments.	Crystalline anorthosite ...... 5% Anorthositic breccia ......35% Fresh glass droplets ...... 7% Fresh glass agglutinates ......11% Dark melt rock and breccia matrix ...... 9% Soil Breccia ......32% Total Particles Counted 71	Anorthosite granules are abundant, and reflective particles present.	B. 30.9-36.0. Characters of entire unit generally poorly sorted and sparsely rock fragmental; indistinct bedding plane at base. A. 36.0-37.0. Rock fragment concentration	S-72-52247 S-74-18343 S-72-52246
14	28	6 0 0 0 4, I 2.5 cm thick Nos. ,184-,192	140.1 142.6	105.8 108.3	37.0 37.5 38.0 38.5 38.9	Dark Drab to Dark Gray 10Y 4/1	Very cohesive, holds cast of drill stem as well as 2 cm face during dissection, 10% or less single grain disaggregation, fractures naturally into cm-sized longitudinal prisms, thence to grain-coated 0.5-1m crumbs.	Very fine siltsoil, est'd 5% fine sand, poorly sorted, subangular to subrounded, sparse to very sparse rock fragments.	Plagioclase cleavage fragments ...... 5% Anorthositic breccia ......21% Fresh glass agglutinates ......16% Fresh glass chips ...... 5% Dark melt rock and breccia matrix ......26% Soil Breccia ......26% Total Particles Counted 19	Anorthosite granules are common to abundant but other distinctive types are rare.	Massive texture and composition distinguishes this unit.	S-74-18342 S-72-52245

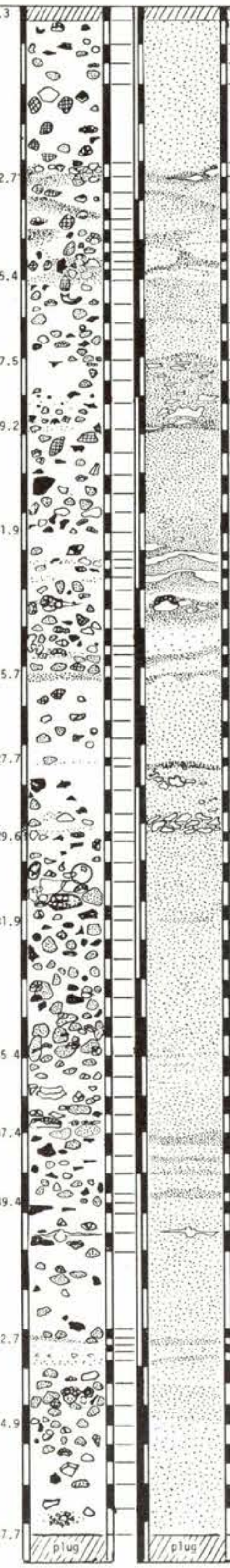
Figure 16-11.- Stratigraphic summary of the Apollo 16 deep drill string (continued).





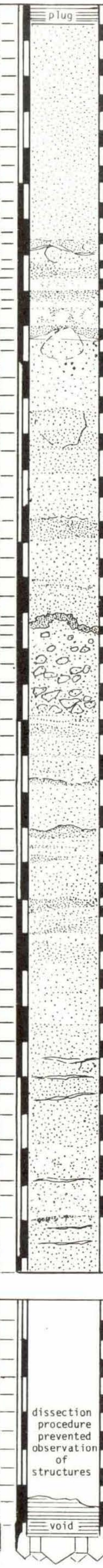
ENTIRE DRILL STRING	THIS CORE unit (numeral) unit thickness samples in unit	APPARENT DISTANCE BELOW LUNAR SURFACE (CM.) Max.	Min.	SAMPLE INTERVAL (LCL INVENTORY)	COLOR	COHESIVENESS, FRACTURE PATTERNS	TEXTURE	COMPOSITION OF COARSE FRACTION	DISTINCTIVE FINES	SUB-UNITS, PRIMARY STRUCTURES	DOCUMENTATION PHOTOGRAPHS (NASA photo number)
		104.2	69.9	1.9							
37	60004, X 5.5 cm thick Nos. ,330-,345			2.5 – 5.0	Dark Drab to Dark Gray 10Y 4/1	Relatively cohesive, does not slump and holds cast of core. 1st breaks to equant blocks up to 8 mm, then to vari-sized crumb-like particles. 5 - 10% single-grain disaggregation.	"Clayey"-fine sandy siltsoil; moderately to poorly sorted, sparsely rock-fragmental, less than 10% coarse fraction, which is subrounded and equigranular.	Anorthositic breccia ....46% Fresh glass droplets ....23% Fresh glass agglutinates ....13% Dark melt matrix breccia .... 5% Soil Breccia .... 8% Total Particles Counted 93	Anorthosite granules very abundant, reflective particles, and droplets and dark shards are present to common.		S-72-52254 S-74-18347 S-74-18380 S-72-52253
		108.6	74.3	5.5							
36	60004, IX 3.6 cm thick Nos. ,314-,329			6.0 – 8.5	Dark Drab to Dark Gray 10Y 4/1	Incoherent, crumbly, poorly cohesive, with 25% slump, 20-25% single-grain disaggregation, remainder breaks to 2-4 mm crumbs. Relatively planar basal contact.	Fine-sandy siltsoil, moderately well sorted, loosely compacted, sparsely rock fragmental, angular to fragmental texture.	Anorthositic breccia ....44% Fresh glass droplets ....10% Fresh glass agglutinates ....10% Dark melt rock and breccia matrix .... 7% Soil Breccia ....21% Total Particles Counted 73	Anorthosite granules are abundant; reflective particles are common to abundant.	C. 5.5-6.5. Light-colored sub-units, separated B. 6.5-7.0. by distinct bedding planes A. 7.0-9.1. Relatively dark, finer-grained	S-74-18345 S-72-52252
		112.2	77.9	9.1							
25 24 35	60004, VIII 3.9 cm thick Nos. ,296-,313			9.5 – 12.5	Dark Drab to Dark Gray 10Y 4/1	Relatively cohesive to crumbly, upper part holds cast of core tube, 5-10% single-grain disaggregation.	Fine sandy-clayey siltsoil, sparsely rock fragmental uncompressed, angular to subangular.	Crystalline anorthosite ....11% Anorthositic breccia ....46% Fresh glass agglutinates .... 8% Dark melt matrix breccia .... 4% Soil Breccia ....20% Total Particles Counted 137	Anorthosite granules and dark particles are abundant; reflective particles are common.	D. 9.1-9.5. Relatively light-colored C. 9.5-10.0 Marbled, light clods in dark matrix B. 10.5-11.0 Relatively light colored, indistinctly laminated. A. 11.0-13.0 Massive characters of unit.	S-72-52251 S-74-18349
		116.1	81.8	13.0							
34	60004, VII 4.5 cm thick Nos. ,279-,295			13.5 – 17.0	Dark Drab to Dark Gray 10Y 4/1	Relatively cohesive, holding cast of drill stem, holds 1.5 cm face, 5-10% single-grain disaggregation, 1st breaks to sharp-edged prisms up to 4 mm (arc 1-2) thence is pulverized to pellet-like crumbs.	Clayey, fine-sandy siltsoil, moderately to poorly sorted, subrounded, sparsely rock fragmental.	Anorthositic breccia ....66% Fresh glass droplets .... 8% Fresh glass agglutinates .... 8% Dark melt rock and breccia matrix .... 6% Soil Breccia .... 7% Total Particles Counted 103	Anorthosite granules and dark particles are abundant: reflective particles are common.	C. 13.0-14.0. Characters of unit. B. 14.0± Laminae of anorthosite granules A. 14.0-17.0. Massive, characters of unit.	S-72-52250 S-74-18344
		120.6	86.3	17.5							
33	60004, VI 4.1 cm thick Nos. ,260-,278			18.0 – 21.0	Dark Drab to Dark Gray 10Y 4/1	Relatively crumbly, first breaking to square or equant blocks up to 7m, thence breaks to 0.5-3mm equant pelletiferous clumps, with 5-20% single-grain disaggregation.	Sandy siltsoil: bimodal, moderate to well sorted, with areas containing framework packing.	Crystalline anorthosite .... 8% Anorthositic breccia ....55% Fresh glass agglutinates ....18% Dark melt rock and breccia matrix .... 5% Soil Breccia .... 4% Total Particles Counted 76	Anorthosite granules and reflective particles are present to common.	D. 17.0-17.5. Indistinctly laminated. C. 17.5-19.0. Sub-units separated by distinct bedding. B. 19.0-20.0. Planes A. 20.0-21.6. Sub-unit rich in coarse anorthosite granules.	S-74-18348 S-72-52249
		124.7	90.4	21.6							
32	60004, V 1.9 cm thick Nos. ,251-,259			22.0 – 23.0	Dark Drab to Dark Gray 10Y 4/1	Cohesive, holding cast of drill stem and 1.5 cm face, further broken into 0.5-1.5 mm blocky clods, with 15-20% single-grain disaggregation.	Clayey siltsoil, poorly to moderately sorted, compact, distinctly angular, very sparingly to moderately rock fragmental.	Anorthositic breccia ....58% Fresh glass agglutinates ....27% Dark melt rock and breccia matrix .... 6% Soil Breccia .... 6% Total Particles Counted 33	Anorthosite granules are very abundant, reflective particles are rare to present.		
		126.6	92.3	23.5							
31	60004, IV 2.6 cm thick Nos. ,239-,250			23.9 – 25.5	Dark Drab to Dark Gray 10Y 4/1	Very crumbly and non-cohesive, 10% single-grain disaggregation, breaks into 2-4 mm pellet-like clods and fragments.	Fine sandy siltsoil, moderately well sorted, mostly sparsely rock fragmental but becomes coarse upward, relatively few, but large rock fragments.	Crystalline anorthosite ....26% Anorthositic breccia ....26% Fresh glass droplets .... 9% Dark melt rock and breccia matrix ....26% Soil Breccia ....12% Total Particles Counted 35	Anorthosite granules are abundant; other distinctive particles rare.	B. 23.0-23.5 Rock fragment concentration A. 23.0-26.1 Sparsely rock fragmental.	S-72-52248 S-74-18346
		129.2	94.9	26.1							
30	60004, III 4.8 cm thick Nos. ,216-,238			26.5 – 30.5	Dark Drab to Dark Gray 10Y 4/1	Very cohesive, holds cast of drill stem, dissected with difficulty, 1st broken to 1-3 cm. coarse fines, then to irregular lumps 1 ± mm, 5% or less single-grain disaggregation.	Clayey, fine-sandy siltsoil, moderately to poorly sorted angular, sparsely-rock fragmental.	Crystalline anorthosite ....12% Anorthositic breccia ....46% Fresh glass droplets ....17% Fresh glass agglutinates....13% Soil breccia .... 7% Total Particles Counted 82	Anorthosite granules are abundant, and reflective particles are present.	D. 26.1± Dark fine-grained lamina. C. 26.1-27.0. Rich in droplets, sharp bedding plane at base. B. 27.0-29.0. Rich in agglutinates; sharp bedding plane at base. A. 29.0-30.9. Rich in glass droplets, bedding plane at base.	S-72-52250
		134.0	99.7	30.9							
29	60004, II 6.1 cm thick Nos. ,193-,215			31.5 – 36.5	Dark Drab to Dark Gray 10Y 4/1	Very cohesive, holds cast of drill stem, crumbles only with strong contact, with 5 - 10% single grain disaggregation, reworked broken 1st to 1 cm prisms, then grain-coated 0.5-1 mm crumbs.	Clayey-fine sandy siltsoil; poorly sorted, subangular to subrounded, sparse to very sparce rock fragments.	Crystalline anorthosite .... 5% Anorthositic breccia ....35% Fresh glass droplets .... 7% Fresh glass agglutinates ....11% Dark melt rock and breccia matrix .... 9% Soil Breccia ....32% Total Particles Counted 71	Anorthosite granules are abundant, and reflective particles present.	B. 30.9-36.0. Characters of entire unit generally poorly sorted and sparsely rock fragmental; indistinct bedding plane at base. A. 36.0-37.0. Rock fragment concentration	S-72-52247 S-74-18343 S-72-52246
		140.1	105.8	37.0							
28	60004, I 2.5 cm thick Nos. ,184-,192			37.5 – 38.9	Dark Drab to Dark Gray 10Y 4/1	Very cohesive, holds cast of drill stem as well as 2 cm face during dissection, 10% or less single grain disaggregation, fractures naturally into cm-sized longitudinal prisms, thence to grain-coated 0.5-1m crumbs.	Very fine siltsoil, est'd 5% fine sand, poorly sorted, subangular to subrounded, sparse to very sparse rock fragments.	Plagioclase cleavage fragments .... 5% Anorthositic breccia ....21% Fresh glass agglutinates ....16% Fresh glass chips .... 5% Dark melt rock and breccia matrix ....26% Soil Breccia ....26% Total Particles Counted 19	Anorthosite granules are common to abundant but other distinctive types are rare.	Massive texture and composition distinguishes this unit.	S-74-18342 S-72-52245
		142.6	108.3								

Figure 16-11.- Stratigraphic summary of the Apollo 16 deep drill string (continued).



X-RAY UNIT	UNIT ENTIRE DRILL STRING	THIS CORE unit (numeral) unit thickness samples in unit	APPARENT DISTANCE BELOW LUNAR SURFACE (CM.) Max.	Min.	SAMPLE INTERVAL (LCL INVENTORY)	COLOR	COHESIVENESS, FRACTURE PATTERNS	TEXTURE	COMPOSITION OF COARSE FRACTION	DISTINCTIVE FINES	SUB-UNITS, PRIMARY STRUCTURES	DOCUMENTATION PHOTOGRAPHS (Nasa photo number)
14	28	60003, XV 4.4 cm. thick Nos. ,184-,196	142.6	108.3	0.4 1.0 1.5 2.0	Medium Drab Gray 5GY 5/1	Moderately to extremely crumbly, increasing in friability upwards, collapsing into wedge-shaped polygons averaging ? mm in diameter, with single-grain disaggregation increasing upward from trace quantities to 15%.	Clayey sand soil; very poorly sorted relatively coarse-grained sand soil with sparse but large rock fragments.	Crystalline anorthosite ....31.6% Anorthositic breccia ....17.7% Dark melt matrix breccia ....14.3% Grey and white breccia ....8.7% Soil Breccia ....18.6% Total Particles Counted 351	Anorthosite granules and plagioclase cleavage fragments are abundant; reflective particles are rare to present.	B. 4.0-0.4. massive unit A. 4.3-4.0. basal concentration of soil breccia	S-74-27778 S-74-28006
	27	60003, XIV 2.7 cm. thick Nos. ,166-,183	147.0	112.7	4.0 4.3 4.7 4.9 5.1 5.6 5.8 6.0 6.4	Irregularly interbedded Dark Olive Gray 10Y 4/1 Medium Drab Gray 5GY 4/1 to 5/1	Cohesive, splitting into two subequal positions, with a tending to fracture into rhomboidal clods averaging 1 mm in diameter: 5% single-grain disaggregation.	Interlaminated dark, well-sorted fine sandy silt soil with authigenic agglutinates and lighter moderately poorly sorted clayey sand soil with sparse polymict rock fragments.	Crystalline anorthosite ....13.1% Anorthositic breccia ....12.8% Fresh glass agglutinates ....8.3% Fresh glass chips ....7.3% Dark melt matrix breccia ....17.0% Grey and white breccia ....7.7% Soil Breccia ....30.7% Total Particles Counted 404	Reflective particles and glass droplets are abundant; anorthosite granules are common to abundant.	I. 4.7-4.3. dark lamina with light-colored lens H. 4.9-4.7. light, thin, homogeneous lamina G. 5.1-4.9. dark, inclined lamina F. 5.6-5.1. light, thin, internally planar laminated E. 5.8-5.6. dark, planar-laminated, thin sub-unit D. 6.0-5.8. light, internally planar-laminated sub-unit C. 6.4-6.0. light, internally massive, patchy sub-unit B. 6.6-6.4. dark, thin, inclined sub-unit A. 7.0-6.6. light, planar-laminated thin subunit	
13	26	60003, XIII 2.1 cm. thick Nos. ,158-,165	149.7	115.4	6.6 7.0 7.6 8.1 8.6	Dark Olive Gray 10Y 3/1	Crumbly, most of soil collapsed out of tube into equant to globular polygons, 1 - 5 mm diameter: 10 - 15% single-grain disaggregation.	Massive fine-grained sandy silt soil; moderately sorted, moderately coarse-grained with abundant authigenic agglutinates.	Anorthositic breccia ....12.2% Fresh glass chips ....6.1% Dark melt matrix breccia ....14.5% Soil Breccia ....57.4% Total Particles Counted 237	Reflective particles and anorthosite granules are common to abundant.	C. 8.1-7.0. moderately light, massive sub-unit B. 8.6-8.1. indistinct dark lamina at top of (A) A. 9.1-8.6. moderately dark, massive interval	S-74-27777
	25	60003, XII 1.7 cm. thick Nos. ,151-,157	151.8	117.5	9.1 9.6 10.2	Intraclastic Matrix is Dark Olive 10Y 3/1 clasts are Light Olive 5GY 5/1	Crumbly; most of soil collapsed out of tube into massive, rectangular polygons 0.5 - 8 mm in diameter: 10 - 15% single-grain disaggregation.	Intraclastic silty sand soil: poorly sorted with sparse rock fragments, notably rich in reworked detrital agglutinates.	Crystalline anorthosite ....18.0% Anorthositic breccia ....11.2% Fresh glass agglutinates ....14.9% Dark melt matrix breccia ....21.3% Soil Breccia ....23.0% Total Particles Counted 179	Reflective particles and anorthosite granules are common to abundant.	C. 9.6-9.1. B. 10.2-9.6. A. [?] 8-10.2. soil-chip breccia, sub-units based on relative abundance of friable soil fragments and compositional succession	S-74-28014
	24	60003, XI 2.7 cm. thick Nos. ,140-,151	153.5	119.2	10.8 11.4 12.0 12.5 13.0	Dark Olive Gray 10Y 3/1	Cohesive, with approximately 1/3 of soil remaining in upper half of tube. Soil tends to crumble into equant polygons approx. 1 mm max. 5 mm in diameter: 5% single-grain disaggregation.	Massive sandy silt soil; moderately sorted, with sparse but large rock fragments, relatively coarse-grained.	Crystalline anorthosite ....9.6% Anorthositic breccia ....28.2% Dark melt matrix breccia ....41.4% Soil Breccia ....9.4% Total Particles Counted 356	Reflective particles are abundant.	D. 10.8- very thin dark, sorted, fine-grained lamina C. 12.0-10.8. massive, crystallines predominant B. 12.5-12.0. massive, high-grade breccia predominant A. 13.5-12.5. massive, soil breccia predominant	
12	23	60003, X 3.8 cm. thick Nos. ,118-,139	156.2	121.9	13.5 14.1 14.3 14.5 14.7 15.0 15.5 16.0 16.5	Irregularly laminated Light-colored areas. Light Gray 5GY 6/1 Matrix: Dark Olive Gray 10Y 4/1	Very cohesive, fracturing into two subequal portions, with slight internal crumbling into 1 - 2 mm equant fragments, little single-grain disaggregation.	Varies between laminae from poorly sorted clayey sand-soil with common rock fragments to moderately well sorted fine grained dark sandy silt soil.	Anorthositic breccia ....10.6% Fresh glass droplets ....4.6% Fresh glass agglutinates ....25.3% Fresh glass chips ....8.1% Dark melt matrix breccia ....15.2% Soil Breccia ....27.9% Total Particles Counted 424	Droplets and reflective particles are common to abundant in dark laminae and anorthosite granules are rare: all are rare in light-colored laminae.	J. 14.1-13.5. dark lamina, irregular light patches I. 14.3-14.1. light lamina H. 14.5-14.3. dark lamina G. 14.7-14.5. light lamina F. 15.0-14.7. gradational, dark to light lamina E. 15.5-15.0. irregular mottled lamina, draped over rock D. 16.5-15.5. thin, but massive [?]-unit, light in color C. 16.7-16.5. dark lamina B. 17.0-16.7. light, thin lamina A. 17.3-17.0. dark, clean, fine-grained lamina	S-74-28013 S-74-27776
	22	60003, IX 2.0 cm. thick Nos. ,109-,117	160.0	125.7	16.7 17.0 17.3 17.8 18.3 18.7	Dark Olive Gray 10Y 4/1	Very cohesive fracturing into two subsequent portions very little single-grain disaggretation.	Intraclastic sandy silt soil; moderately well sorted, packed with irregular clasts of unlithified light-colored soil.	Crystalline anorthosite ....10.6% Anorthositic breccia ....14.0% Fresh glass agglutinates ....14.6% Dark melt matrix breccia ....11.6% Grey and white breccia ....13.1% Soil Breccia ....26.8% Total Particles Counted 210	Droplets, dark shards and reflective particles are very abundant; anorthosite granules are common.	massive unit	S-74-28011
	21	60003, VIII 1.9 cm. thick Nos. ,98 -,108	162.0	127.7	19.3 19.5 20.1 20.8	Matrix as above: 10Y 4/1 Intraclasts: Light Drab 5GY 6/1	Very cohesive, fracturing cleanly into two equal portions, very little single-grain disaggregation.	Intraclastic sandy silt soil; moderately well sorted, packed with irregular clasts of unlithified light-colored soil.	Anorthositic breccia ....16.0% Fresh glass agglutinates ....7.0% Dark melt matrix breccia ....41.6% Soil Breccia ....23.4% Total Particles Counted 129	Reflective particles and anorthosite granules are abundant; droplets are present to common.	D. 19.5-19.3. thin, dark, clean, fine-grained lamina C. 20.1-19.5. rich in intraclasts B. 20.8-20.1. sparse in intraclasts A. 21.2-20.8. rich in intraclasts	S-74-27775 S-74-28010
11	20	60003, VII 2.3 cm. thick Nos. ,86 - ,97	163.9	129.6	21.2 21.4 22.0 22.5 23.1	Dark Olive Gray 10Y 4/1	Moderately cohesive, approx. 1/3 remaining in upper half of tube; fractures into wedge-shaped chunks up to 8 mm in diameter; 10 - 15% single-grain disaggregation.	Distinctively coarse-grained rock-fragmental silt soil; moderately to poorly sorted with framework of authigenic glass-coated large agglutinates and droplets with dust only on the base.	Anorthositic breccia ....8.8% Fresh glass droplets ....11.2% Fresh glass agglutinates ....52.5% Dark melt matrix breccia ....15.0% Soil Breccia ....7.1% Total Particles Counted 313	Anorthosite granules are abundant; reflective particles are common.	B. 21.4-21.2. thin, dark, clean, fine-grained lamina A. 23.5-21.4. massive unit	S-74-29055 S-74-29056
10	19	60003, VI 3.5 cm. thick Nos. ,71 - ,85	166.2	131.9	23.5 24.0 24.5 25.0 25.5 26.0 26.5	Mostly Medium Drab 5GY 4/1 Scattered dark laminae 5GY 3/1	Most crumbly unit in core, fractures into elongate prismatic blocks up to 1.5 cm long, approx. 10% single-grain disaggregation.	Rock-fragmental sandy silt soil: moderately poorly sorted with framework of soil breccia at base of unit, abundant very fine fines.	Anorthositic breccia ....5.2% Fresh glass agglutinates ....12.5% Dark melt matrix breccia ....12.6% Soil Breccia ....61.9% Total Particles Counted 409	Glass droplets and anorthosite granules are abundant; reflective particles are present.	B. 24.0-23.5. thin, dark, clean, fine-grained lamina A. 27.0-24.0. massive unit	S-74-28009
	18	60003, V 2.0 cm. thick Nos. ,60 - ,70	169.7	135.4	27.0 27.5 28.0 28.5	Medium-Dark Drab 5GY 3/1	Crumbly but slightly more cohesive than surrounding units; fractures into blocky chunks up to 8 mm in diameter, 5 - 10% single-grain disaggregation.	Intraclastic sandy silt soil, moderately sorted with sparse rock fragments that include some light-colored soil intraclasts.	Anorthositic breccia ....11.1% Fresh glass agglutinates ....34.0% Fresh glass chips ....4.8% Dark melt matrix breccia ....7.0% Soil Breccia ....37.9% Total Particles Counted 109	Glass droplets, reflective particles and anorthosite granules are abundant.	D. 27.5-27.0. indistinctly planar laminated sub-unit C. 28.0-27.5. massive sub-unit, darker color B. 28.5-28.0. massive sub-unit, relatively light color A. 29.0-28.5. massive, coarse-grained sub-unit	S-74-27774
9	17	60003, IV 1.7 cm. thick Nos. ,52 - ,59	171.7	137.4	29.0 29.5 30.0 30.5	Thinly laminates Medium-Dark Drab 5GY 3/1 Medium-Light Drab 5GY 4/1	Relatively crumbly, fracturing into elongate prismatic blocks as much as 1.2 cm long; up to 10% single-grain disaggregation.	Alternating moderately well sorted dark sandy silt soil and lighter-colored poorly sorted clayey sand soil.	Anorthositic breccia ....12.6% Fresh glass agglutinates ....6.6% Dark melt rock and breccia matrix ....35.9% Soil Breccia ....29.4% Total Particles Counted 186	Glass droplets, reflective particles and anorthosite granules are abundant.	F. 29.5-29.0. thin, dark, clean, fine-grained lamina C-E. 30.0-29.5. alternating, very thin light and dark lamina B. 30.5-30.0. light, thin lamina A. 30.7-30.5. dark lamina	
	16	60003, III 3.6 cm. thick Nos. ,39 - ,51	173.4	139.4	30.7 31.0 31.5 32.0	Medium-Dark Drab 5GY 4/1	Moderately split unequally but clearly cohesive, very little single-grain disaggregation.	Massive, sparingly clayey silt soil: moderately well sorted, sparsely rock fragmental; average abundance of coarse fraction.	Anorthositic breccia ....6.2% Fresh glass agglutinates ....5.1% Dark melt matrix breccia ....39.8% Grey and white breccia ....6.0% Soil Breccia ....40.1% Total Particles Counted 239	Glass droplets and reflective particles are abundant; anorthosite granules are common.	C. 31.5-30.7. continuation of massive unit B. 31.5. anorthosite rock fragment and fillet A. 34.3-31.5. massive unit	S-74-27780 S-74-28008
8	15	60003, II 2.2 cm. thick Nos. ,26 - ,38	177.0	142.7	34.0 34.3 34.5 34.7 34.8 35.4 36.0	Laminae of Dark Drab 5GY 3/1 and Light Drab 5GY 4/1	Moderately cohesive, split nearly equally on opening, 5% single-grain disaggretation.	Thinly laminated rock fragmental, sandy silt soil, light laminae moderately poorly sorted, abundant rock fragments; dark laminae better sorted, appear to be finer-grained.	Anorthositic breccia ....25.4% Fresh glass agglutinates ....6.3% Dark melt matrix breccia ....15.1% Soil Breccia ....49.6% Total Particles Counted 191	Glass droplets and reflective particles are abundant; anorthosite granules are common.	D. 34.5-34.3. dark thin lamina C. 34.7-34.5. light thin lamina B. 34.8-34.7. dark thin lamina A. 36.0-34.8. dark, relatively thick lamina	S-74-28007
7	14	60003, I 2.8 cm. thick Nos. ,16 - ,25	179.2	144.9	36.5 37.0 37.5 38.0 38.6 39.3	Medium-Dark Drab 5GY 4/1	Cohesive, split evenly across the core very little single-grain disaggregation.	Silty fine sand soil: moderately to poorly sorted, very sparingly rock fragmental, fewer coarse fines than average.	Plagioclase cleavage fragments ....4.6% Anorthositic breccia ....13.9% Fresh glass agglutinates ....15.2% Fresh glass chips ....4.6% Dark melt matrix breccia ....36.1% Soil breccia ....19.9% Total Particles Counted 106	Glass droplets and reflective particles are common to abundant, anorthosite granules rare.	massive unit	S-74-27779
			182.0	147.7								

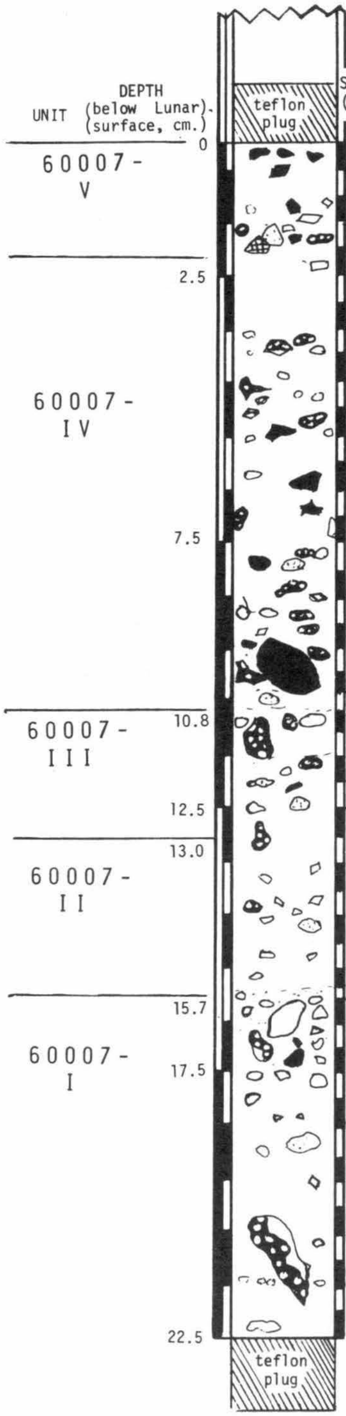
Figure 16-11.- Stratigraphic summary of the Apollo 16 deep drill string (continued).



X-RAY	ENTIRE DRILL STRING	THIS CORE unit (numeral) unit thickness samples in unit	APPARENT DISTANCE BELOW LUNAR SURFACE (CM) Max. Min.	SAMPLE INTERVAL (LCL INVENTORY)	COLOR	COHESIVENESS, FRACTURE PATTERNS	TEXTURE	COMPOSITION OF COARSE FRACTION	DISTINCTIVE FINES	SUB-UNITS, PRIMARY STRUCTURES	DOCUMENTATION PHOTOGRAPHS (NASA photo number)
7	13	6 0 0 0 2, X I I 6.6 cm (in 60002) Nos. ,21-,57	182.5 148.2	0.6, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.4, 6.7, 7.2	Dark Drab 5GY 6/1	Moderately friable, fracturing into 0.1 - 0.6 cm, thin, prism-shaped flat platelets; 10 - 15% single-grain disaggregation.	Very fine sandsoil to siltsoil; moderately sorted, and sparingly rock fragmental, generally finer than the rest of the core	Plagioclase cleavage fragments .... 6.8% Anorthositic breccia .... 6.6% Fresh glass droplets and agglutinates .. 6.1% Dark, melt-matrix breccia ....32.6% Dark gray and white breccia .... 9.1% Soil breccia ....36.9% Total Particles Counted 339	Anorthosite granules and reflective particles are common.	D. 0.6-3.0. clumps of crushed anorthosite breccia with interdigitations into surrounding soil characterize this sub-unit. C. 3.0-6.4. frothy to vesicular spattered glassy agglutinates are especially abundant in this sub-unit. B. 6.4-6.7. fine-grained, equant fragments A. 6.7-7.2. fine-grained, with flake shaped rock fragments.	S-74-22087 through 22091
6	12	6 0 0 0 2, X I 4.2 cm thick Nos. ,58-,83	189.7 155.4	7.4, 7.7, 8.0, 8.3, 8.5, 9.1, 9.4, 9.7, 10.4, 10.9, 11.4	Medium Neutral Gray N5 to N 5.5	Moderately cohesive, fracturing into 0.4 - 1 cm, platelets and chunks; 10% single-grain disaggregation.	Thinly laminated, laminae of sandy to sparsely rock-fragmental siltsoil. Sorting varies from poor to good, generally better in darker-colored laminae, worst in coarsest-grained laminae.	Anorthositic breccia ....14.8% Dark, melt-matrix breccia ....20.4% Dark, gray and white breccia .... 5.8% Soil breccia ....54.4% Total Particles Counted 744	Variably intermediate in reflective particles, anorthosite granules are common to abundant.	I. 7.2-7.4. very coarse-grained, packed H. 7.4-7.7. fine-grained, flake-like rocks G. 7.7-8.0. light, moderately coarse F. 8.0-8.3. fine-grained, equant rock fragments E. 8.3-8.5. moderately coarse-grained D. 8.5-9.1. marbled texture C. 9.1-9.4. fine-grained, flake-like rocks B. 9.4± whitish lamina, fillet from anorthositic rock fragment A. 9.4-11.4 massive, moderately coarse-grained.	S-74-23413 S-74-22903 22904
	11	6 0 0 0 2, X 3.0 cm thick Nos. ,84-,95	193.9 159.6	12.0, 12.5, 13.2, 13.8, 14.4	Dark Drab 5GY 5/1 to 5GY 6/1	Cohesive, fracturing into 1 to 4 cm prisms, less than 5% single-grain disaggregation.	Gravelly siltsoil; poorly sorted, with framework of rock fragments.	Plagioclase cleavage fragments .... 4.0% Anorthositic breccia .... 8.7% Dark, melt-matrix breccia ....46.1% Dark gray and white breccia .... 7.9% Soil breccia ....31.8% Total Particles Counted 562	Reflective particles are abundant, anorthosite granules are common to abundant.	C. 11.4±. thin lamina, fine-grained, darker than underlying soil, well-sorted. B. 11.4-13.2. representative of unit. A. 13.2-14.4. marbled texture	S-74-22909 22910
5	10	6 0 0 0 2, I X 2.8 cm thick Nos. ,96-,108	196.9 162.6	14.9, 15.5, 16.1, 16.6, 17.2	Medium Neutral Gray N 5	Cohesive, fracturing into 1 to 4 cm prisms, less than 5% single-grain disaggregation.	Sandy siltsoil; moderately to poorly sorted, sparse in rock fragments, many of which are rounded, notable in this core.	Plagioclase cleavage fragments .... 4.5% Anorthositic breccia ....25.6% Fresh glass chips and fragments .... 3.4% Dark, melt-matrix breccia ....26.3% Dark gray and white breccia ....13.2% Soil breccia ....23.1% Total Particles Counted 896	Variably intermediate in reflective particles, which are common to abundant; anorthosite granules are present to common.	D. 14.4-14.9. fine-grained dark lamina C. 14.9-16.1. representative of unit as a whole B. 16.1-16.6. fine-grained, dark lamina A. 16.6-17.2. representative of unit as a whole	S-74-22905 through 22908
	9	6 0 0 0 2, V I I I 2.8 cm thick Nos. ,109-,120	199.7 165.4	17.4, 17.6, 18.0, 18.5, 19.0, 19.5, 20.0	Medium Neutral Gray (N 5) with whitish particles	Cohesive, fracturing inot 1 to 4 cm prisms, less than 5% single-grain disaggregation.	Gravelly to clayey siltsoil; moderately sorted, with fewer rock fragments at top of unit.	Plagioclase cleavage fragments .... 2.7% Anorthositic breccia ....36.3% Dark, melt-matrix breccia ....14.8% Dark gray and white breccia ....22.2% Soil breccia ....15.5% Total Particles Counted 657	Anorthosite granules are common; reflective particles are rare to present.	B. 17.2-17.4. thin dark fine-grained well-sorted lamina A. 17.4-20.0. graded unit, finer toward the top of the unit	S-74-23414 through 23417 (rusty spherule)
4	8	6 0 0 0 2, V I I 1.7 cm thick Nos. ,121-,126	202.5 168.2	20.5, 21.0, 21.7	Dark Drab 5GY 5/1	Cohesive, fracturing onto 1 to 4 cm prisms, less than 5% single-grain disaggregation.	Gravelly siltsoil; poorly sorted, with abundant rock fragments packed to form a framework texture.	Anorthositic breccia .... 9.4% Dark, melt-matrix breccia .... 9.9% Dark gray and white breccia ....11.3% Soil breccia ....66.4% Total Particles Counted 333	Anorthosite granules and reflective particles are rare to present.	B. 20.0-20.5. fine-grained, dark, sorted lamina A. 20.5-21.7. representative of unit as a whole	S-74-23035 through 23037
	7	6 0 0 0 7, V I 1.4 cm thick Nos. , 127-,131	204.2 169.9	22.4, 23.1	Dark Drab 5GY 5/1	Cohesive, fracturing into 1 to 4 cm prisms, less than 5% single-grain disaggregation.	Gravelly claysoil; very poorly sorted, with abundant rock fragments packed to form a framework texture.	Anorthositic breccia ....48.1% Dark, melt-matrix breccia .... 9.0% Dark gray and white breccia ....25.5% Soil breccia ....10.9% Total Particles Counted 270	Anorthosite granules and reflective particles are abundant.	B. 21.7-22.4. fine-grained, dark, sorted lamina A. 22.4-23.1. representative of unit as a whole, rich in fresh but broken glass	
	6	6 0 0 0 2, V 1.9 cm thick Nos. ,132-,139	205.6 171.3	23.7, 24.1, 24.6, 25.0-.1, 25.2±, 25.6-.8	Medium Neutral Gray N 5	Cohesive, fracturing into 1 to 2 cm prisms, less than 5% single-grain disaggregation.	Silty sandsoil; moderate to good sorting, very sparsely rock fragmental.	Crystalline anorthosite .... 2.7% Anorthositic breccia ....12.9% Dark, melt-matrix breccia ....23.6% Dark gray and white breccia ....21.1% Soil breccia ....34.1% Total Particles Counted 436	Reflective particles are abundant; anorthosite granules are common to abundant.	C. 23.1-23.7. thinly laminated B. 23.7-24.1. relatively fine-grained A. 24.1-25.0. relatively coarse-grained	
3	5	6 0 0 0 2, I V 2.6 cm thick Nos. ,140-,152	207.5 173.2	26.0, 26.5, 27.0, 27.6	Dark Drab 10Y 5/1 to 10Y 6/1	Cohesive, fracturing into 0.5 cm blocks, less than 5% single-grain disaggregation.	Gravelly to sandy siltsoil; moderately sorted, some sub-units packed with rock fragments to form a framework texture.	Anorthositic breccia ....21.9% Dark, melt-matrix breccia ....23.6% Dark gray and white breccia ....21.1% Soil breccia ....31.3% Total Particles Counted 564	Anorthosite and reflective particles are common to abundant.	E. 25.0-25.2. dark, fine, sorted lamina D. 25.2-25.8. sub-units B,C, and D are similar C. 25.8-26.0. in composition, but are inclined B. 26.0-26.5. at different angles A. 26.5-27.6. massive sub-unit	
	4	6 0 0 0 2, I I I 0.9 cm thick Nos. ,153-,156	210.1 175.8	28.1, 28.5	Medium Drab 10Y 5/1	Moderately crumbly, fractures into 0.3 cm rhomboidal blocks, 5 to 10% single-grain disaggregation.	Gravelly claysoil; poorly sorted, with sparse rock fragments.	Plagioclase cleavage fragments .... 4.5% Anorthositic breccia ....10.9% Fresh glass chips and fragments .... 2.5% Dark, melt-matrix breccia ....27.2% Dark gray and white breccia ....11.5% Soil breccia ....29.8% Total Particles Counted	Anorthosite granules are abundant; reflective particles are present.		S-74-21095 21096
2	3	6 0 0 0 2, I I 4.4 cm thick Nos. ,157-,173	211.0 176.7	29.0, 29.5, 30.0, 30.5, 31.1, 31.8, 32.2, 32.9	Medium Drab 10Y 5/1	Very crumbly and friable, fractures into 0.1 to 1.2 cm transverse blocks with 25% single-grain disaggregation.	Gravelly to sandy claysoil; moderately to poorly sorted, with sparse rock fragments, mostly not packed in framework texture.	Crystalline anorthosite .... 4.5% Anorthositic breccia ....43.9% Dark, melt-matrix breccia ....11.9% Dark gray and white breccia ....10.7% Soil breccia ....27.9% Total particles counted 866	Anorthosite granules and reflective particles are rare to present.	E. 28.5-29.5. relatively dark gravelly siltsoil with abundant glass droplets D. 29.5-30.0. light, rich in rock fragments, bounded by crenulate anorthosite lamina C. 30.0-30.5. bounded by anorthosite lamina B. 30.5-31.5. light, coarse, marbled A. 31.5-32.9. fine-grained, light sub-unit	
	2	6 0 0 0 2, I 2.6 cm thick Nos. ,174-,181	215.4 181.1 218.0 183.7	33.3, 33.9, 35.5	Medium Drab 10Y 5/1	Extremely cohesive, disaggregates only when cut by a spatula.	Gravelly claysoil; poorly sorted, with some parts of unit packed with rock fragments.	Crystalline anorthosite .... 9.3% Anorthositic breccia .... 6.2% Dark, melt-matrix breccia ....12.6% Dark gray and white breccia ....56.9% Soil breccia ....10.6% Total Particles Counted 457	Anorthosite granules and reflective particles are abundant.	B. 32.9-33.9. coarse-grained, framework texture, marbled color A. 33.9-35.5. relatively light color, very cohesive, sparse rock fragments with associated anorthosite laminae	S-74-21339 21340 S-74-21091, 21092 S-74-21128, 21129
		Early (P.E.T.) split of 0.5 cm	218.5 184.2								
1	1	6 0 0 0 1, I 5.5 cm thick Nos. ,3 -,4 and ,13 -,31 most of,14-,16-,18 -,20-,22-,24-,26 and-,28 were combined in bio-prime allocation	224.0 189.7	0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0	7.5B 8/2 to 5B 7/1 Dark grey	Not comparable to milled sections, soil moderately crumbly, easily cut by spatula but did not collapse spontaneously.	Granular sandy siltsoil; sparsely rock fragmental, most rock fragments seem angular, sorting not observable.	Plagioclase cleavage fragments ....13.5% Anorthositic breccia ....19.2% Fresh glass chips and fragments ...... 5.8% Dark, melt-matrix breccia ....34.6% Soil Breccia .... 9.6% Misc. unidentified .... 7.7% Total Particles Counted 52	Plagioclase cleavage fragments appear to be abundant, but dark reflectives and anorthosite granules are relatively rare.	No textural sub-units observed.	Photos could not be taken during dissection of drill bit from end.

Figure 16-11.- Stratigraphic summary of the Apollo 16 deep drill string (continued).

DRILL STEM 60007 SAMPLE LOCATION INFORMATION



Sample Interval (LCL inventory)	Fine Fraction Sample No.	Fine Fraction Vial No.	Fine Fraction Sample Wt.	Coarse Fraction Sample No.	Coarse Fraction Vial No.	Coarse Fraction Sample Wt.	Special Samples Sample No.	Special Samples Vial No.	Special Samples Sample Wt.	Special Samples Sample Type
17.5–18.0	90	8-1536	0.970	92	8-1558	0.041	91	86-1466	0.025	red light
18.0–18.5	88	8-1441	1.106	89	8-1460	0.004				
18.5–19.0	85	8-1495	1.003	86	8-1522	0.001	87	86-1498	0.025	red light
19.0–19.5	83	8-1850	0.754	84	8-1502	0.069				
19.5–20.0	80	8-1472	2.231	82	8-1484	0.019	81	86-1638	0.025	red light
20.0–20.5	79	8-1463	1.856							
20.5–21.0	78	8-1486	2.021							
21.0–21.5	76	8-1510	1.842	77	8-1749	0.131				
21.5–22.0	73	8-1561	0.862	74	8-1532	0.007	75	86-1148	0.025	red light
22.0–22.5	71	8-1511	0.617	72	8-1479	0.053	283	10-5901	0.220	air fines, pre-impreg.
22.5–23.0	69	8-1464	1.314	70	8-1428	0.030	284	10-5910	0.320	air fines, pre-impreg.
23.0–23.5	68	8-1767	0.983				285	10-5911	0.350	air fines, pre-impreg.
23.5–24.0	66	8-1635	0.806	67	8-1473	0.052	286	10-5920	0.440	air fines, pre-impreg.
24.0–24.5	64	8-1480	1.260	65	8-1544	0.011	287	10-5934	0.450	air fines, pre-impreg.
24.5–25.0	62	8-1455	1.604	63	8-1459	0.120	288	10-5992	0.500	air fines, pre-impreg.
25.0–25.5	59	8-1559	1.413	60	8-1430	0.131	61	8-1434	0.174	spillage (289*)
25.5–26.0	57	8-1503	1.378	58	8-1553	0.023	290	10-5955	0.500	air fines, pre-impreg.
26.0–26.5	55	8-1985	1.002	56	8-1461	0.023	291	10-5959	0.450	air fines, pre-impreg.
26.5–27.0	53	8-1440	1.065	54	8-1497	0.002	292	10-5965	0.510	air fines, pre-impreg.
27.0–27.5	51	8-1723	1.068	52	8-1885	0.029	293	10-5975	0.430	air fines, pre-impreg.
27.5–28.0	49	8-1716	0.308	50	8-1458	0.022	294	10-5982	0.820	29.0 - 27.5 Soil at RF
28.0–28.2	47	8-1576	0.232	48	8-1892	0.006				
28.2–28.5	45	8-1611	0.104	46	8-1517	0.118	316	9-1540	2.170	Vitreous Bx RF
28.5–29.0	43	8-1538	0.611				44	86-1020	0.025	red light
29.0–29.5	41	8-1491	0.508	42	8-1621	0.085	295	10-5990	0.640	
29.5–30.0	39	8-1807	1.370	40	8-1845	0.087				
30.0–30.5	38	8-1533	1.301				296	10-5993	0.860	Lge. spatter Aggl. 30.5-29.5
30.5–31.0	36	8-1682	1.423	37	8-1482	0.027	297	10-6014	0.440	air fines, pre-impreg.
31.0–31.5	34	8-1819	1.262	35	8-1564	0.004	298	10-6015	0.275	air fines, pre-impreg.
31.5–32.0	32	8-1806	1.218	33	8-1555	0.051	299	10-6017	0.390	air fines, pre-impreg.
32.0–32.5	30	8-1718	1.053	31	8-1777	0.069	300	10-6019	0.370	air fines, pre-impreg.
32.5–33.0	29	8-1964	1.185				301	10-6020	0.350	air fines, pre-impreg.
33.0–33.2	28	8-1585	0.559							
33.2–33.5	27	8-1798	0.710				302	10-6039	0.470	air fines, pre-impreg.
33.5–34.0	25	8-1724	1.094	26	8-1802	0.051	303	10-6041	0.270	air fines, pre-impreg.
34.0–34.5	23	8-1860	0.364	24	8-1852	0.480	304	10-6049	0.550	Rounded Bx frag.
34.5–35.0	21	8-1873	1.352	22	8-1839	0.091	305	10-6055	0.360	air fines, pre-impreg.
35.0–35.5	19	8-1613	1.044	20	8-1871	0.123	306	10-6059	0.470	air fines, pre-impreg.
35.5–36.0	17	8-1446	0.664	18	8-1797	0.030	307	10-6066	0.330	air fines, pre-impreg.
36.0–36.5	15	8-1646	1.346	16	8-1700	0.403	308	10-6068	0.350	air fines, pre-impreg.
36.5–37.0	13	8-1506	0.621	14	8-1884	0.010	309	10-6080	0.270	air fines, pre-impreg.
37.0–37.5	11	8-1665	0.941				12	86-1465	0.025*	red light
37.5–38.0	9	8-1726	1.596	10	8-1573	0.151	311	10-6095	0.310	air fines, pre-impreg.
38.0–38.5	8	8-2199	1.010				312	10-6102	0.220	air fines, pre-impreg.
38.5–39.0	6	8-1607	0.888				7	8-1856	1.454*	air fines, pre-impreg.
39.0–39.5	4	8-1560	1.330	5	8-1636	0.028	314	10-6116	0.420	air fines, pre-impreg.
39.5–40.0	2	8-1705	1.410	3	8-1591	0.044	315	10-6122	0.440	air fines, pre-impreg.

*289 10-5952 0.490 25.5-25.0 pre-impreg.
*310 10-6087 0.330 37.5-70 pre-impreg.
*313 10-6111 0.310 29.0-85 pre-impreg.

EXPLANATION OF COMPOSITION SYMBOLS

Figure 16-12.

DRILL STEM 60006 SAMPLE LOCATION INFORMATION

UNIT	DEPTH (below Lunar surface, cm.)	SAMPLE INTERVAL (LCL inventory)	FINE FRACTION Sample No.	Container No.	Sample Wt.	COARSE FRACTION Sample No.	Container No.	Sample Wt.	SPECIAL SAMPLES Sample No.	Container No.	Sample Wt.
60006-III	22.5 cm	0.4 – 1.2	131	8-2563	3.174	132	8-2567	0.161	133	86-1465	0.450 red light
		1.2 – 2.0	129	8-2556	2.787	130	8-2560	0.233			
		2.0 – 2.5	127	8-2549	1.840	128	8-2555	0.447			
		2.5 – 3.0	125	8-2545	1.269				126	86-1527	0.50 red light
		3.0 – 3.5	123	.8-2536	1.760	124	8-2537	0.162			
		3.5 – 4.0	122	8-2523	1.359	121	8-2519	0.677			
		4.0 – 4.5	120	8-2516	1.892						
	27.5 cm	4.5 – 5.0	118	8-2501	1.440	119	8-2504	1.060			
		5.0 – 5.5	116	8-2498	1.659				117	86-1383	0.80 red light
		5.5 – 6.0	115	8-2497	1.970	114	8-2496	0.276			
		6.0 – 6.5	113	8-2495	1.917						
		6.5 – 7.0	111	8-2487	1.460	112	8-2494	0.246			
		7.0 – 7.5	109	8-2478	1.368				110	86-1379	0.65 red light
		7.5 – 8.0	107	8-2474	1.552	108	8-2477	0.276			
		8.0 – 8.5	105	8-2467	1.815	106	8-2470	0.312			
		8.5 – 9.0	103	8-2453	1.298	104	8-2454	0.946			
		9.0 – 9.5	101	8-2451	1.894	102	8-2452	0.063			
	32.5 cm	9.5 – 10.0	99	8-2428	1.502	100	8-2433	0.657			
		10.0 – 10.5	97	8-2423	1.614				98	86-1285	0.60 red light
		10.5 – 11.0	95	8-2411	1.584	96	8-2422	0.344			
		11.0 – 11.5	93	8-2408	1.904	94	8-2409	0.122			
		11.5 – 12.2	91	8-2395	2.205	92	8-2398	0.123			
60006-II		12.2 – 12.5	89	8-2380	1.345	90	8-2381	0.108			
		12.5 – 13.0	87	8-2374	1.340				88	86-1277	0.82 red light
		13.0 – 13.5	85	8-2366	1.630	86	8-2371	0.060			
		13.5 – 14.0	83	8-2353	1.853	· 84	8-2354	0.080			
		14.0 – 14.4	81	8-2335	1.174	82	8-2337	0.817			
		14.4 – 15.0	79	8-2323	1.933	80	8-2327	0.148			
	37.5 cm	15.0 – 15.5	77	8-2303	2.354	78	8-2305	0.073			
		15.5 – 16.0	75	8-2300	1.434				76	86-1233	0.60 red light
		16.0 – 16.5	73	8-2294	1.863	74	8-2298	0.121			
		16.5 – 17.0	71	8-2282	1.457	72	8-2285	0.094			
		17.0 – 17.5	69	8-2191	1.676	70	8-2271	0.132			
		17.5 – 18.0	67	8-1983	1.228	68	8-2121	0.083			
		18.0 – 18.5	65	8-1982	1.621				66	86-1225	0.56 red light
		18.5 – 19.0	63	8-1930	1.282	64	8-1951	0.129			
		19.0 – 19.5	61	8-1902	2.039	62	8-1908	0.063			
		19.5 – 20.0	59	8-1853	1.899	60	8-1862	0.275			
	42.5 cm	20.0 – 20.4	58	8-1843	1.206						
60006-I	42.9 cm	20.4 – 21.0	56	8-1829	2.340	57	8-1840	0.343			
		21.0 – 21.5	54	8-1826	1.971	53	8-1825	0.100	55	86-1217	0.93 red light
		21.5 – 22.0	52	8-1824	2.352						
		22.0 – 22.5	50	8-1811	2.383	51	8-1813	0.123			
		22.5 – 23.0	48	8-1805	2.583	49	8-1808	0.082			
		23.0 – 23.5	46	8-1789	1.936	47	8-1791	0.371			
		23.5 – 24.0	44	8-1784	2.101				45	86-1042	0.65 red light
		24.0 – 24.5	42	8-1781	2.379	43	8-1783	0.098			
		24.5 – 25.0	40	8-1772	2.388	41	8-1773	0.086			
		25.0 – 25.5	38	8-1736	2.310	39	8-1750	0.104			
		25.5 – 26.0	36	8-1717	2.447	37	8-1731	0.050			
		26.0 – 26.5	34	8-1679	2.595	35	8-1707	0.257			
		26.5 – 27.0	32	8-1569	1.830				33	86-1041	1.23 red light
		27.0 – 27.5	30	8-1545	2.206	31	8-1554	0.087			
		27.5 – 28.0	28	8-1520	2.108	29	8-1537	0.185			
		28.0 – 28.5	26	8-1505	1.810	27	8-1513	0.124			
		28.5 – 29.0	24	8-1456	1.578				25	86-1026	0.78 red light
		29.0 – 29.5	22	8-1437	1.606	23	8-1447	0.243			
		29.5 – 30.0	20	8-1391	1.561	21	8-1433	0.070			
		30.0 – 30.5	18	8-1351	1.872	19	8-1366	0.192			
		30.5 – 31.2	16	8-1309	3.377	17	8-1333	0.203	134	8-2575	1.873 sweepings
	55.0 cm										

EARLY ALLOCATIONS

4	8-1572	7.735 (7.5 - 9.0 cm from base; 2.75 gm removed in 8 early allocations)
3	8-1606	1.477 (7.0 - 7.5 cm from base of drill stem)

*An unknown amount of slumping and de-densification has disturbed 60004 below 20.4 cm; accordingly, the entire diameter of the core was dissected from 20.4 cm to the base. Because of possible mixing during de-densification, depth below Lunar surface for the lower part of the core is computed only for the interval as a whole.

EXPLANATION OF COMPOSITION SYMBOLS

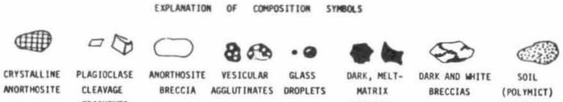
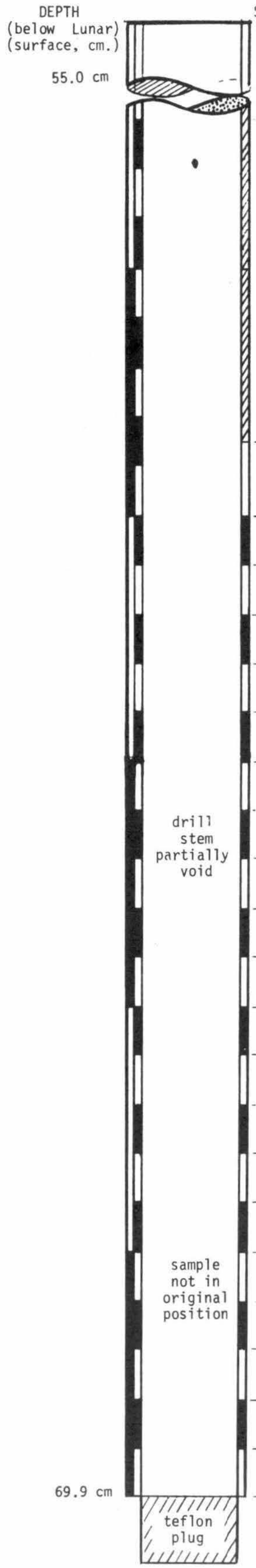


Figure 16-12.- (continued).

DRILL STEM 60005 SAMPLE LOCATION INFORMATION



SAMPLE INTERVAL (LCL inventory)	FINE FRACTION Sample No.	Vial No.	Sample Wt.	COARSE FRACTION Sample No.	Vial No.	Sample Wt.	SPECIAL SAMPLES Sample No.	Vial No.	Sample Wt.	Sample type
	4	9-1606	4.800	5	9-1630	0.145	94	9-5470	1.000	table sweepings
	(entire contents of drill stem between 0.0 cm and 18.5 cm)			(same as #4 - both may include metal and teflon from milling)			95	10-4482	0.003	
	6	9-1679		7	9-1709	0.385	96	9-3050	2.679	(bulk spillage from cap, prior to dissection)
18.5	8(U)	9-1767	0.485	9(U)	9-1777	0.090				
	51(1)	9-4002	1.185	52(L)	9-4007	0.057				
20.0	8 (as above)			9 (as above)						
	53(L)	9-4020	0.829	54(L)	9-4026	0.015				
21.0	8 (as above)			9 (as above)						
	55(L)	9-4024	0.913	56(L)	9-4029	0.044				
22.0	8 (as above)			9 (as above)						
	57(L)	9-4031	1.024	58(L)	9-4032	0.029				
23.0	10(U)	9-1797	0.995	11(U)	9-1827	0.195				
	59(L)	9-4041	1.003	60(L)	9-4072	0.038				
24.0	10 (as above)			11 (as above)						
	61(L)	9-4076	0.942	62(U)	9-4084	0.105				
25.0	12(U)	9-1854	1.295	13(U)	9-1867	0.080				
	63(L)	9-4086	0.873	64(L)	9-4088	0.354	65(L)	9-4091	0.001	Metal Particle
26.0	14(U)	9-1869	1.350	15(U)	9-1981	0.075				
	66(L)	9-4123	0.992	67(L)	9-4129	0.109				
27.0	16(U)	9-1995	1.655	17(U)	9-2057	0.125	18(U)	9-2082	0.012	Shocked Plagioclase w/Metal Inclusion
	68(L)	9-4137	1.131	69(L)	9-4128	0.039				
28.0	19(U)	9-2093	1.700	20(U)	9-2213	0.390				
	70(L)	9-1445	1.117	71(L)	9-4152	0.043				
29.0	21(U)	9-2219	2.270	22(U)	9-2226	0.190				
	72(L)	9-4160	1.057	73(L)	9-4168	0.070				
30.0	23(U)	9-2236	2.227	24(U)	9-2233	0.407				
	74(L)	9-4176	0.970	75(L)	9-4209	0.092				
31.0	25(U)	9-2237	2.735	26(U)	9-2261	0.295				
	76(L)	9-4224	0.941	77(L)	9-4233	0.163				
32.0	27(U)	9-2268	2.250	28(U)	9-2279	0.246				
	78(L)	9-4245	0.920	79(L)	9-5281	0.082				
33.0	29(U)	9-2296	2.575	31(U)	9-2439	0.180	30(U)	87-2598	0.260	Red light
	80(L)	9-5288	0.980	81(L)	9-5290	0.002				
34.0	32(U)	9-2475	2.760	33(U)	9-3001	0.275	34(U)	9-3021	0.191	Frothy Agglutinate w/soil
	82(L)	9-5294	0.945	83(L)	9-5297	0.058				
35.0	35(U)	9-3022	2.372	36(U)	9-3025	0.127	37(U)	9-3027	0.156	Frothy Agglutinate w/soil
	84(L)	9-5019	1.040	85(L)	9-5101	0.165				
36.0	38(U)	9-3033	2.729	39(U)	9-3034	0.188	40(U)	9-3036	0.069	Fragment of glass droplet
	86(L)	9-5117	1.114	87(L)	9-5150	0.076				
37.0	41(U)	9-3048	2.668	43(U)	9-3051	0.273	42(U)	87-2799	0.400	Red light
	88(L)	9-5183	1.065	89(L)	9-5209	0.020	44(U)	9-3055	0.043	Frothy Agglutilate w/soil
38.0	45(U)	9-3060	2.714	46(U)	9-3070	0.214	47(U)	9-3074	0.324	Frothy Agglutinate w/soil
	90(L)	9-5257	1.060	91(L)	9-5289	0.005	48(U)	9-3076	0.057	Frothy Agglutinate w/soil
39.0	49(U)	9-3077	3.665	50(U)	9-3089	0.178				
	92(L)	9-5291	1.140	93(L)	9-5299	0.040				
40.0										

(U) / (L) Entire diameter of drill stem was excavated, in two phases. Upper portion removed, as shown here, is designated (U); lower portion, approximately 1/4 to 1/3 of interval, is designated (L).

Figure 16-12.- (continued).

DRILL STEM 60004 SAMPLE LOCATION INFORMATION

UNIT	DEPTH (below Lunar surface, cm.) Max.	Min.
	104.2	69.9
60004-X		
	108.6	74.3
60004-IX		
	112.2	77.9
60004-VIII		
	116.1	81.8
60004-VII		
	120.6	86.3
60004-VI		
	124.7	90.4
60004-V		
	126.6	92.3
60004-IV		
	129.2	94.9
60004-III		
	134.0	99.7
60004-II		
	140.1	105.8
60004-I		
	142.6	108.3

SAMPLE INTERVAL (LCL inventory)	FINE FRACTION sample no.	container no.	sample wt.	COARSE FRACTION sample no.	container no.	sample wt.	SPECIAL SAMPLES sample no.	container no.	sample wt.
1.9 – 2.5	344	8-2570	2.048	345	8-2320	0.091			
2.5 – 3.0	342	8-2548	1.994	343	8-2559	0.059			
3.0 – 3.5	339	8-2511	2.022	340	8-2518	0.226	341	87-3183	0.48 red light
3.5 – 4.0	337	8-2448	1.782	338	8-2480	0.071			
4.0 – 4.5	334	8-2432	1.989	335	8-2434	0.055	336	87-5125	0.65 red light
4.5 – 5.0	332	8-2425	2.432	333	8-2430	0.161			
5.0 – 5.5	330	8-2407	1.529	331	8-2421	0.070			
5.5 – 6.0	328	8-2401	1.942	329	8-2406	0.078			
6.0 – 6.5	325	8-2376	1.124	326	8-2386	0.095	327	87-1473	0.39 red light
6.5 – 7.0	323	8-2293	2.342	324	8-2315	0.132			
7.0 – 7.5	320	8-2572	1.327	321	8-2284	0.040	322	87-5118	0.94 red light
7.5 – 8.0	318	8-2568	1.615	319	8-2571	0.052			
8.0 – 8.5	316	8-2557	2.670	317	8-2564	0.020			
8.5 – 9.1	314	8-2546	2.098	315	8-2547	0.039			
9.1 – 9.5	312	8-2539	1.660	313	8-2540	0.054			
9.5 – 10.0	309	8-2528	1.850	310	8-2533	0.080	311	87-5118	0.65 red light
10.0 – 10.5	307	8-2524	1.601	308	8-2525	0.055			
10.5 – 11.0	305	8-2514	1.956	306	8-2517	0.115			
11.0 – 11.5	303	8-2510	1.714	304	8-2513	0.031			
11.5 – 12.0	300	8-2505	1.673	301	8-2508	0.055	302	87-1582	0.55 red light
12.0 – 12.5	298	8-2502	2.352	299	8-2503	0.065			
12.5 – 13.0	296	8-2492	1.638	297	8-2499	0.043			
13.0 – 13.5	294	8-2484	1.987	295	8-2489	0.069			
13.5 – 14.0	291	8-2482	2.120	292	8-2483	0.065	293	87-2571	0.60 red light
14.0 – 16.0	289	8-2479	1.495	290	8-2481	0.100	inner core, possibly Pb-free		
	287	8-2471	5.526	288	8-2473	0.108	outer, wall contact sample		
16.0 – 16.5	284	8-2465	2.793	285	8-2468	0.024	286	87-5440	0.87 red light
16.5 – 17.0	282	8-2461	1.195	283	8-2463	0.031			
17.0 – 17.5	279	8-2455	1.335	280	8-2457	0.073	281	87-5435	0.51 red light
17.5 – 18.0	276	8-2447	1.600	277	8-2450	0.004	278	87-5315	0.52 red light
18.0 – 18.5	274	8-2445	1.224	275	8-2446	0.013			
18.5 – 19.0	272	8-2438	2.134	273	8-2444	0.004			
19.0 – 19.5	269	8-2436	1.81[illegible]	270	8-2437	0.009	271	87-5313	0.57 red light
19.5 – 20.0	267	8-2427	1.928	268	8-2435	0.139			
20.0 – 20.5	265	8-2425	1.944	266	8-2426	0.015			
20.5 – 21.0	263	8-2418	1.406	264	8-2420	0.005			
21.0 – 21.6	260	8-2414	2.602	261	8-2417	0.280	262	87-5392	0.80 red light
21.6 – 22.0	258	8-2410	1.673	259	8-241[illegible]	0.032			
22.0 – 22.5	256	8-2402	1.618	257	8-2404	0.047			
22.5 – 23.0	254	8-2397	1.484	255	8-2399	0.006			
23.0 – 23.5	251	8-2394	1.512	252	8-2396	0.005	253	87-5296	0.66 red light
23.5 – 23.9	249	8-2392	1.884	250	8-2393	0.091			
23.9 – 24.5	246	8-2388	2.222	247	8-2391	0.016	248	87-5096	0.60 red light
24.5 – 25.0	244	8-2384	1.574	245	8-2385	0.050			
25.0 – 25.5	242	8-2379	1.706	243	8-2382	0.133			
25.5 – 26.1	239	8-2377	2.081	240	8-2378	0.4[illegible]8	241	87-5095	0.56 red light
26.1 – 26.5	237	8-2372	1.261	238	8-2373	0.064			
26.5 – 27.0	234	8-2369	1.815	235	8-2370	0.105	236	87-5295	0.55 red light
27.0 – 27.5	232	8-2367	1.724	233	8-2368	0.193			
27.5 – 28.0	229	8-2360	1.858	230	8-2362	0.065	231	87-5080	0.30 red light
28.0 – 28.5	227	8-2357	1.669	228	8-2358	0.101			
28.5 – 29.0	225	8-2352	1.794	226	8-2356	0.024			
29.0 – 29.5	223	8-2349	2.327	224	8-2351	0.004			
29.5 – 30.0	220	8-2344	1.664	221	8-2347	0.057	222	87-5196	0.58 red light
30.0 – 30.5	218	8-2342	2.092	219	8-2343	0.191			
30.5 – 30.9	216	8-2332	1.811	217	8-2336	0.017			
30.9 – 31.5	214	8-2322	1.293	215	8-2330	0.094			
31.5 – 32.0	211	8-2318	2.334	212	8-2321	0.147	213	87-5020	0.51 red light
32.0 – 32.5	209	8-2313	1.634	210	8-2316	0.575			
32.5 – 33.0	207	8-2311	1.990	208	8-2312	0.120			
33.0 – 33.5	205	8-2308	1.847	206	8-2309	0.030			
33.5 – 34.0	202	8-2299	2.897	203	8-2301	0.181	204	87-5197	0.63 red light
34.0 – 36.0	200	8-2295	1.356	201	8-2297	0.072	inner core, possibly Pb-free		
	198	8-2291	4.947	199	8-2292	0.205	outer, wall contact sample		
36.0 – 36.5	195	8-2280	1.579	196	8-2289	0.131	197	87-5060	0.61 red light
36.5 – 37.0	193	8-2278	1.971	194	8-2279	0.120			
37.0 – 37.5	190	8-2274	1.871	191	8-2276	0.052	192	87-5107	0.62 red light
37.5 – 38.0	188	8-2269	1.829	189	8-2273	0.002			
38.0 – 38.5	186	8-2266	1.772	187	8-2267	0.038			
38.5 – 38.9	184	8-2263	1.763	185	8-2264	0.064			

EARLY ALLOCATIONS

(taken from both ends of this core, because of void and disturbed sample in overlying core)

3	8-1427	2.886gm.	0 - 0.7 cm. from base, finer than 1 mm
4	8-1451	0.224gm.	0 - 0.7 cm. from base, coarser than 1mm
5	8-1454	2.165gm.	0 - 0.5 cm. from top, finer than 1 mm
6	8-1481	0.103gm.	0 - 0.5 cm. from top, coarser than 1 mm
7	8-1465	1.727gm.	0.5 - 1 cm. from top, finer than 1 mm
8	8-1490	0.084gm.	0.5 - 1 cm. from top, coarser than 1 mm

EXPLANATION OF COMPOSITION SYMBOLS

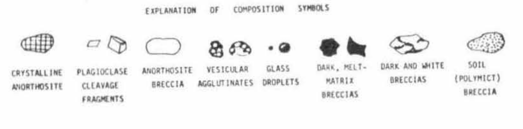


Figure 16-12.- (continued).

DRILL STEM 60003 SAMPLE LOCATION INFORMATION

UNIT	DEPTH (below Lunar surface, cm.) Max.	Min.
60003-XV	142.6	108.3
60003-XIV	147.0	112.7
60003-XIII	149.7	115.4
60003-XII	151.8	117.5
60003-XI	153.5	119.2
60003-X	156.2	121.9
60003-IX	160.0	125.7
60003-VIII	162.0	127.7
60003-VII	163.9	129.6
60003-VI	166.2	131.9
60003-V	169.7	135.4
60003-IV	171.7	137.4
60003-III	173.4	139.4
60003-II	177.0	142.7
60003-I	179.2	144.9
	182.0	147.7

SAMPLE INTERVAL (LCL inventory)

SAMPLE INTERVAL (LCL inventory)
0.4
1.0
1.5
2.0
4.0
4.3
4.7
4.9±
5.1±
5.6±
5.8±
6.0±
6.4±
6.6±
7.0
7.6
8.1
8.6
9.1
9.6
10.2
10.8
11.4
12.0
12.5
13.0
13.5
14.1
14.3
14.5
14.7
15.0
15.5
16.0
16.5
16.7
17.0
17.3
17.8
18.3
18.7
19.3
13.5
20.1
20.8
21.2
21.4
22.0
22.5
23.1
23.5
24.0
24.5
25.0
25.5
26.0
26.5
27.0
27.5
28.0
28.5
29.0
29.5
30.0
30.5
30.7
31.0
31.5
32.0
34.0
34.3
34.5
34.7
34.8
35.4
36.0
36.5
37.0
37.5
38.0
38.6
39.3

FINE FRACTION Sample No.	Vial No.	Sample Wt.	COARSE FRACTION Sample No.	Vial No.	Sample Wt.	SPECIAL SAMPLES Sample No.	Container	Sample Wt.	Sample Interval	Distinctive Features
195	9-2485	2.329	196	9-2500	0.155					
193	9-2459	1.552	194	9-2467	0.176					
190	9-1944	1.088	191	9-1991	0.147	192	87-1075	0.280	2.0-1.5	Red light
188	9-1934	1.680	189	9-1940	0.418					OUTER
186	9-1866	2.163	187	9-1923	0.375					INNER
184	9-1852	0.512	185	9-1861	0.165					
182	9-1804	0.504	183	9-1825	0.036					
180	9-1737	0.417	181	9-1753	0.034					
178	9-1725	0.798	179	9-1735	0.072					
176	9-1661	0.360	177	9-1672	0.070					
174	9-1583	0.181	175	9-1637	0.004					
172	9-1568	1.157	173	9-1570	0.143					
170	9-1526	0.284	171	9-1542	0.027					
168	9-5279	0.857	169	9-1506	0.136					
166	9-5276	0.674	167	9-5278	0.064					
164	9-5267	1.011	165	9-5269	0.116					
162	9-5262	1.136	163	9-5265	0.414					
160	9-5259	1.434	161	9-5260	0.140					
158	9-5248	1.592	159	9-5252	0.143					
156	9-5244	1.232	157	9-5246	0.063					
154	9-5237	1.509	155	9-5240	0.092					
151	9-5223	1.522	152	9-5225	0.179	153	9-5230	0.022	10.6	Intraclast
149	9-5220	1.409	150	9-5221	0.168					
147	9-5217	1.154	148	9-5218	0.170					
145	9-5207	0.906	146	9-5210	0.508					
143	9-5054	0.853	144	9-5204	0.167					
140	9-4248	0.674	141	9-5035	0.090	142	87-1539	0.230	13.5-13.0	Red light
138	9-4228	0.948	139	9-4229	0.064					
136	9-4204	0.446	137	9-4227	0.038					
134	9-4200	0.288	135	9-4203	0.024					
132	9-4169	0.103	133	9-4195	0.024					
130	9-4155	0.566	131	9-4158	0.054					
128	9-4183	0.784	129	9-4136	0.168					
126	9-4124	0.893	127	9-4132	0.162					
124	9-4120	0.972	125	9-4122	0.134					
122	9-4106	0.251	123	9-4107	0.028					
120	9-4075	0.361	121	9-4093	0.056					
118	9-4057	0.275	119	9-4068	0.010					
116	9-4038	0.888	117	9-4045	0.090					
114	9-4017	0.951	115	9-4022	0.060					
112	9-2401	0.898	113	9-4015	0.095					
109	9-2343	0.841	111	9-2358	0.058	110	9-2348	0.002	19.0	Rusty particle
107	9-2318	0.458	108	9-2325	0.028					
104	9-2312	0.779	105	9-2317	0.087	10$	9-2314	0.175	19.9-19.5	Light area
102	9-2291	0.945	103	9-2305	0.086	100	9-2280	0.308	21.2-21.0	Dark soil
98	9-2274	0.635	101	9-2289	0.043	99	9-2275	0.034	21.2-21.0	Light clasts
96	9-2257	0.640	97	9-2265	0.083					
94	9-2240	1.461	95	9-2252	0.106					
91	9-2199	1.483	92	9-2200	0.149	93	9-2223	0.292	22.7-22.0	Glass spherule
88	9-2196	1.758	89	9-2197	0.411					
86	9-2194	1.194	87	9-2195	0.307					
84	9-2192	1.664	85	9-2193	0.215					
82	9-2190	1.315	83	9-2191	0.355					
80	9-2188	1.599	81	9-2189	0.173					
78	9-2186	1.660	79	9-2187	0.231					
75	9-2184	1.526	76	9-2185	0.228	77	87-1433	0.040	26.0-25.5	Red light
73	9-2182	1.288	74	9-2183	0.306					
71	9-2180	1.729	72	9-2181	0.421					
69	9-2178	1.663	70	9-2179	0.109					
67	9-2176	1.516	68	9-2177	0.168					
62	9-2172	1.585	66	9-2175	0.170	65	Foil pan	0.080	28.5-28.1	Impgd. An. Agg
60	9-2170	1.491	61	9-2171	0.545	64	9-2174	0.047	28.5-28.1	Adj. soil
58	9-2168	1.159	59	9-2169	0.122	63	9-2173	0.005	29.5	An. intraclast
56	9-1993	1.911	57	9-1996	0.175					
54	9-1982	1.064	55	9-1987	0.174					
52	9-1972	0.868	53	9-1973	0.062					
50	9-1947	0.774	51	9-1964	0.137					
48	9-1925	1.166	49	9-1946	0.101					
45	9-1909	1.376	46	9-1918	0.168	47	Foil pan	0.318	32.0-30.9	Impgd. Agg.
43	9-1846	2.534	44	9-1902	0.284					OUTER
41	9-1799	1.962	42	9-1829	0.227					INNER
39	9-1785	1.159	40	9-1788	0.119					
37	9-1775	0.281	38	9-1783	0.035					
35	9-1712	0.360	36	9-1773	0.025					
34	9-1706	0.155								
32	9-1680	0.904	33	9-1691	0.266					
30	9-1666	1.173	31	9-1674	0.323					
28	9-1660	1.333	29	9-1664	0.127					
26	9-1648	1.320	27	9-1649	0.122					
24	9-1618	0.937	25	9-1639	0.063					
21	9-1594	0.990	22	9-1617	0.073	23	87-5286	0.570	38.0-37.5	Red light
19	9-1591	0.919	20	9-1592	0.046					
16	9-1553	0.86-	17	9-1564	0.041	18	9-1582	0.011	38.7	Plag. clump

EARLY ALLOCATIONS

3 8-1489 2.974gm. 0 - 0.5 cm. from base, finer-than 1 mm
4 8-1605 0.190gm. 0 - 0.5 cm. from base, coarser-than 1 mm

EXPLANATION OF COMPOSITION SYMBOLS

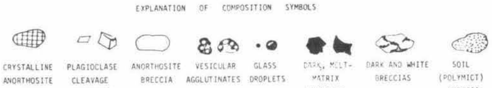


Figure 16-12.- (continued).

DRILL STEM 60002 SAMPLE LOCATION INFORMATION

UNIT	DEPTH (below Lunar surface, cm.) Max.	Min.
	182.5	148.2
60002-XII		
	189.7	155.4
60002-XI		
	193.9	159.6
60002-X		
	196.9	165.6
60002-IX		
	199.9	165.6
60002-VIII		
	202.5	168.2
60002-VII		
	204.2	169.9
60002-VI		
	205.6	171.3
60002-V		
	207.5	173.2
60002-IV		
III	210.1	175.8
	211.0	176.7
60002-II		
	215.4	181.1
60002-I		
	218.0	183.7

SAMPLE INTERVAL (LCL inventory): 0.6, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.4, 6.7, 7.2, 7.4, 7.7, 8.0, 8.3, 8.5, 9.1, 9.4, 9.7, 10.4, 10.9, 11.4, 12.0, 12.5, 13.2, 13.8, 14.4, 14.9, 15.5, 16.1, 16.6, 17.2, 17.4, 17.6, 18.0, 18.5, 19.0, 19.5, 20.0, 20.5, 21.0, 21.6-7, 22.4, 23.1, 23.7, 24.1, 24.6, 25.0-1, 25.2, 25.6-8, 26.0, 26.5, 27.0, 27.6, 28.1, 28.5, 29.0, 29.5, 30.0, 30.5, 31.1, 31.8, 32.2, 32.9, 33.3, 33.9, 35.5

FINE FRACTION Sample No.	Vial No.	Sample Wt.	COARSE FRACTION Sample No.	Vial No.	Sample Wt.	SPECIAL SAMPLES Sample No.	Container	Sample Wt.	Sample Interval	Distinctive Features
21	9-5001	0.561	22	9-5002	0.012					
23	9-5003	2.636	24	9-5005	0.088					
25	9-5006	1.890	26	9-5007	0.128					
27	9-5008	2.236	28	9-5009	0.159					
29	9-5010	2.437	30	9-5011	0.104					
31	9-5012	1.515	32	9-5014	0.280	33	87-5351	0.470	3.5- 3.0	Red light
34	9-5015	2.242	35	9-5017	0.175					
36	9-5018	1.623	37	9-5020	0.198					
38	9-5021	2.274	39	9-5022	0.114					
40	9-5023	1.950	41	9-5024	0.142	42	87-5048	0.370	5.5- 5.0	Red light
43	9-5025	1.976	44	9-5027	0.151					
45	9-5029	1.296	46	9-5030	0.095	47	impg. agg.	0.029	7.1- 6.5	Stratal contact
51	9-5031	0.989	52	9-5032	0.057	48	impg. agg.	0.054	7.6- 6.4	Thin lamination
53	9-5034	1.162	54	9-5036	0.060	55	9-5037	0.055	6.7- 6.8	Intraclast
56	9-5038	2.202	57	9-5039	0.497	49	impg. agg.	0.025	8.2- 7.5	Thin lamination
58	9-5040	0.635	59	9-5042	0.072	50	impg. agg.	0.121	9.0- 8.0	Marbled structure
61	9-5043	0.904	62	9-5044	0.181		impg. agg.	0.012	7.5- 7.2	Stratal contact
63	9-5045	0.781	64	9-5046	0.210	67	9-5049	0.052	8.5- 8.2	Light marbled
65	9-5047	1.444	66	9-5048	0.421	68	9-5050	0.049	8.5- 8.2	Dark marbled
69	9-5051	1.330	70	9-5053	0.171	71	9-5053	0.340	9.2- 8.5	B&W Bx. RF.
73	9-5057	0.718	74	9-5059	0.080	72	9-5056	0.123	9.0- 8.5	Soil Bx. Rf.
75	9-5060	0.636	76	9-5061	0.281	77	9-5062	0.377	10.2- 9.4	An. Bx. RF.
78	9-5053	3.018	79	9-5064	0.974	185	impg. agg.	0.056	10.1- 9.4	Marbled structure
80	9-5065	1.557	81	9-5066	0.479					
82	9-5067	1.841	83	9-5068	0.421	186	impg. agg.	0.180	11.2-10.1	Stratal contact
84	9-5069	1.397	85	9-5070	0.564	86	9-5071	0.682	12.3-11.0	Devit. Glass RF.
87	9-5072	1.707	88	9-5073	0.886	187	impg. agg.	0.408	12.5-11.2	Thin lamination
89	9-5074	2.304	90	9-5083	0.814	91	87-5146	0.200	13.2-12.5	Red light
92	9-5084	1.959	93	9-5085	0.472	188	impg. agg.	0.180	13.1-12.5	White laminae
94	9-5086	2.048	95	9-5087	0.897	189	impg. agg.	0.097	14.3-13.6	Marbled structure
96	9-5089	1.867	97	9-5090	0.343	190	impg. agg.	0.110	15.1-14.5	Marbled structure
98	9-5092	1.893	99	9-5093	0.587					
100	9-5094	2.135	101	9-5095	0.610					
102	9-5096	2.128	103	9-5097	0.593					
104	9-5098	2.170	105	9-5100	0.456					
106	9-5079	0.911	107	9-5081	0.230	108	9-5082	0.001	17.2 ±	Rusty spherule
109	9-2101	0.131								
110	9-2102	1.752	111	9-2103	0.381					
112	9-2104	2.005	114	9-2106	0.515	113	9-2015	0.530	18.5-18.0	Rext. Glass RF.
115	9-2107	1.540	116	9-2108	0.576	191	impg. agg.	0.158	19.1-18.3	Stratal contact
117	9-2109	1.666	118	9-2110	0.614					
119	9-2111	2.015	120	9-2112	0.681					
121	9-2113	1.458	122	9-2114	0.171					
123	9-2115	1.492	124	9-2116	1.374	192	impg. agg.	0.157	21.7-21.0	Marbled structure
125	9-2117	2.758	126	9-2118	0.799					
127	9-2119	1.673	128	9-2120	0.448					
129	9-2121	2.611	130	9-2122	1.041	131	9-2123	1.006	23.1-22.4	Glass-coated An. RF.
132	9-2124	2.384	133	9-2125	0.660					
134	9-2126	1.370	135	9-2127	0.305					
136	9-2128	1.782	137	9-2129	0.499					
138	9-2130	1.190	139	9-2131	0.476					
140	9-2132	0.391	141	9-2133	0.033					
142	9-2134	1.732	143	9-2135	0.949	193	impg. agg.	0.602	26.6-25.0	Inclined laminae
144	9-2136	1.492	145	9-2137	0.478					
146	9-2138	1.697	147	9-2139	0.547	148	87-5147	0.240	26.5-26.0	Red light
149	9-2140	1.692	150	9-2141	0.561					
151	9-2142	1.898	152	9-2143	0.906					
153	9-2144	2.038	154	9-2145	0.547					
155	9-2146	1.518	156	9-2147	0.307					
157	9-2148	1.736	158	9-2149	0.667					
159	9-2150	2.040	160	9-2151	0.597					
161	9-2152	2.060	162	9-2153	0.443	194	impg. agg.	0.016	30.1-30.0	White laminae
163	9-2154	2.338	164	9-2155	0.899					
165	9-2156	1.954	166	9-2157	0.436					
167	9-2158	2.580	168	9-2159	0.575					
169	9-2160	1.827	170	9-2161	0.263					
171	9-2162	2.048	172	9-2163	1.459	173	87-5148	0.260	32.9-32.2	Red light
174	9-2164	1.623	175	9-2165	0.959					
176	9-2166	2.414	177	9-2167	1.065					
179	9-5075	3.245	181	9-5078	0.988	178	impg. agg.	0.888	35.5-33.9	Rusty spherule
						180	9-5077	0.888	35.5-33.9	Inner, chem. pure

EARLY ALLOCATIONS

3	8-1656	1.461gm.	0 - 0.5 cm. from base, finer-than 1 mm
4	8-1457	0.248gm.	0 - 0.5 cm. from base, coarser-than 1mm
5	8-1643	3.136gm.	0.5 - 1 cm. from base, finer-than 1mm
6	8-1468	0.198gm.	0.5 - 1 cm. from base, coarser-than 1 mm

EXPLANATION OF COMPOSITION SYMBOLS

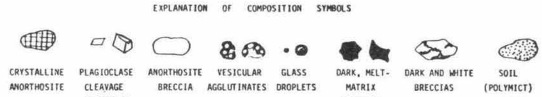


Figure 16-12.- (continued).

DRILL STEM 60001 SAMPLE LOCATION INFORMATION

UNIT: 60001-I

DEPTH (below Lunar) (surface; cm.): Max. 218.5, Min. 184.2 (top); 224.0, 189.7 (bottom)

SAMPLE INTERVAL (LCL inventory) (cm.)	FINE FRACTION Sample No.	Vial No.	Sample Wt.	COARSE FRACTION Sample No.	Vial No.	Sample Wt.	SPECIAL SAMPLES Sample No.	Vial No.	Sample Wt.	Sample Type	SIEVED RESIDUE Sample No.	Remaining Wt.
0.0–0.5							30	8-1792[A]	2.201	Not sieved		
0.5–1.0	28	8-1598	2.794[B]	29	8-1570	0.153	31	8-1650	0.101	Reserve fines	28	0.984[B]
1.0–1.5	26	8-1751[A]	2.473[B]	27	8-1865[A]	0.683					26	0.690
1.5–2.0	24	8-1888[A]	2.787[B]	25	8-1732[A]	0.331					24	0.787
2.0–2.5	22	8-1810[A]	2.902[B]	23	8-1786[A]	0.270					22	0.959
2.5–3.0	20	8-1733[A]	3.220[B]	21	8-1901[A]	0.374					20	0.929
3.0–3.5	18	8-1788[A]	4.668[B]	19	8-1775[A]	0.329					18	1.719
3.5–4.0	16	8-1835[A]	4.559[B]	17	8-1823[A]	0.158					16	1.610
4.0–4.5	14	8-1776[A]	0.940[B]	15	8-1893[A]	0.038					14	0.341
4.5–5.0	13	8-1599[A]	2.199	12	8-1693[A]	0.159						
5.0–5.5	3	8-1609	0.731	4	8-1669	0.110						
6.0							2	8-1608	0.010	Joint Mat'l.		
							33	8-1593	0.700	Fines from throughout core, not		
							34	8-1701	1.670	used in bioprime sample (732)		
							35	8-1882	0.081	Sweepings		
							36	8-1729	0.086	Sweepings		

[A]Original container replaced by container indicated here after evacuation, spillage accident. Vacuum forced lids open, but cross-contamination and spillage was generally minor.

[B]Original weight, finer than 1 mm fraction. Samples 14-28 were sieved at .125 mm, with .125-1mm fraction retained in core storage. 12 gm of FT .125 mm used for bioprime allocation, remainder (-,33,-,34) in storage.

EXPLANATION OF COMPOSITION SYMBOLS

Figure 16-12.- (continued).

DRIVE TUBE 60009

Drive tubes 60009/60010 were collected on 21 April, 1972, at the ALSEP site during EVA 1 of the Apollo 16 mission, but were stored until 1975 awaiting technology to extrude the soil from the drive tube into the study receptacle. 60009, the lower of the two drive tubes, was the first large diameter core to be opened; it was extruded on March 14, 1975. Initial removal of the smeared surface against the core wall showed that this core contained a suite of structures never before recognized in a lunar core. To define genetic units and examine the exposure history before dissection, a preliminary examination team was formed, with S. Nagle preparing a lithologic description and G. Crozaz, D. Morrison and G. Blanford performing a preliminary analysis of galactic and solar cosmic ray tracks. At the same time, dissection of the upper increment of the extrusion receptacle was undertaken.

Initially, a zone containing approximately 15 percent of the core's volume is dissected along the entire length of the core; subsequently, the process can be repeated, allowing a three-dimensional sampling of the core to be obtained. At this writing, two levels have been dissected and documented, as reported herein.

Location

The double drive tube was taken on the edge of a 1 m crater rim in a level area (Fig. 16-2) in the vicinity of the ALSEP site, approximately 65 m southwest from the Lunar Module, 50 m northeast from the deep drill string, and an equal distance southeast from another double drive tube, 60014/60013. To aid in correlation, a penetrometer section was run between the drill string and 60010/60009 (Carrier et al. 1972, p. 8-7 to 8-13).

Preliminary Examination by X-radiography

Shortly after return from the moon, the cores were X-rayed to give a preliminary idea of stratification and to provide a permanent record of major features. Orthogonal stereopairs in two orientations enable one to distinguish many rock fragments and metallic particles.

The X-radiograms of 60009 have been described in the Apollo 16 Preliminary Examination report (1972, p. 7-49).

Four units were recognized on the basis of X-radiography, (Fig. 16-6) a basal fine-grained unit approximately 8 cm thick, overlain by a very coarse-grained interval, 14.5 cm thick, in turn succeeded by a fine-grained unit 2.5 cm thick finally followed by a medium-fine unit 6.5 cm thick. Unit 2 is especially notable in its content of very large rock fragments, much larger than those generally found in lunar cores. The finer-grained units generally corresponded adequately to stratigraphic units found after the core was opened. In contrast, units found during dissection showed little relationship to the coarse-grained part of the X-radiograph; nevertheless, the X-ray study was very valuable in locating these large fragments.

Compaction During Extrusion

The core was extruded from the drive tube into the dissection receptacle on 14 March, 1975. Following extrusion, the core was 31 cm long, instead of the 34 cm pre-extrusion length. Because the drive tube was completely filled immediately before extension, it is certain that the 3 cm shortening of section is due to compaction which took place during extrusion.

Because of the presence of notable "landmarks" in the core, it was possible to ascertain the specific amount of compaction in each part of the core. The following points of comparability were found and noted after dissection. (1) The base of the upper dissection unit is located approximately 5 cm below the top of the core; this corresponds to the base of the relatively transparent unit at the top of the X-radiograph which is also at 5 cm, indicating no measurable compaction. (2) The top of dissection unit 9 is relatively fine-grained and somewhat inclined; it can be picked out at 8.5 cm in dissection and 9 cm in the X-ray, indicating 0.5 cm compaction. (3) The base of unit 9 is at 11.2 cm on the exposed core, but at 12.5 cm on the X-ray, indicating a compaction of 1.3 cm. (4) The top of the largest rock fragment is at 17 cm in the dissected core, 19 cm in the X-ray, indicating a 2 cm compaction. (5) The base of the coarse zone in unit 4 is at 26 cm in the dissected core, and at 28.5 in the X-ray, indicating a compaction of 2.5 cm.

Figure 16-13 shows that compaction is not uniform along the length of 60009, as there is almost no compaction at the top of the core, even though the X-radiogram shows the top of the core was originally less compacted than the lower part. The greatest increase in compaction occurs between 5 and 12 cm; where the rate of compaction is approximately 2 mm per cm of core. Below 12 cm depth there is a relatively uniform rate of compaction of approximately 1 mm per cm. The compaction is greatest at the base of the core, where pressure was exerted by the extruder piston against the resistance of the entire core.

Preliminary Examination of Exposed Core

Following extrusion of the core, longitudinal streaking indicated smearing of the outside of the core, next to the tube wall, but differences in texture and color of the smeared material pointed to the possibility of extensive structure inside the core. The outer 1 mm of smeared soil was carefully scraped away, revealing a suite of mottled and apparently inclined stratification of a type never before seen in lunar cores. To help develop a reasonable sampling plan, the surface lithology along

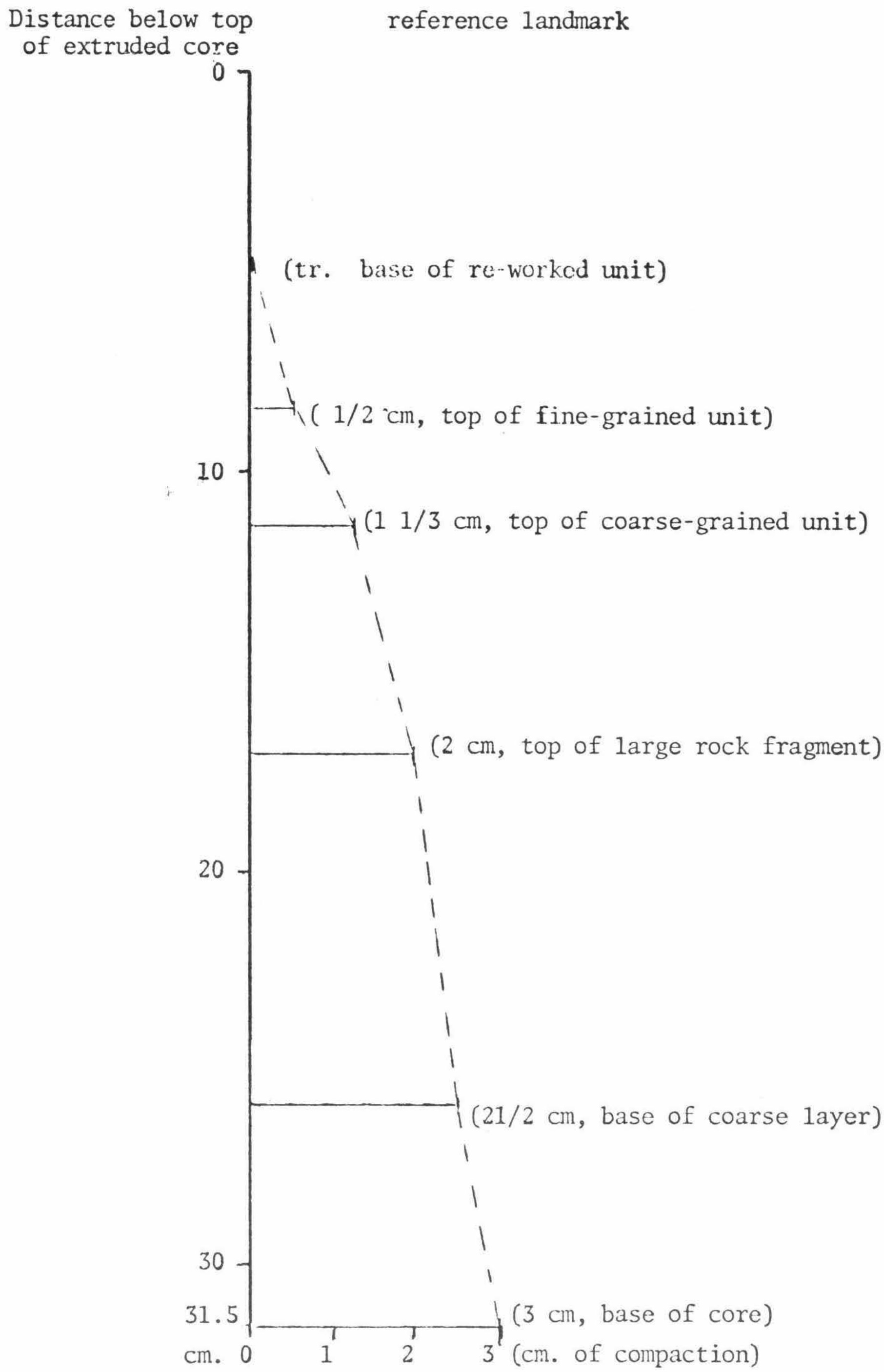


Fig. 16-13 Compaction attributed to extrusion, Drive Tube 60009.

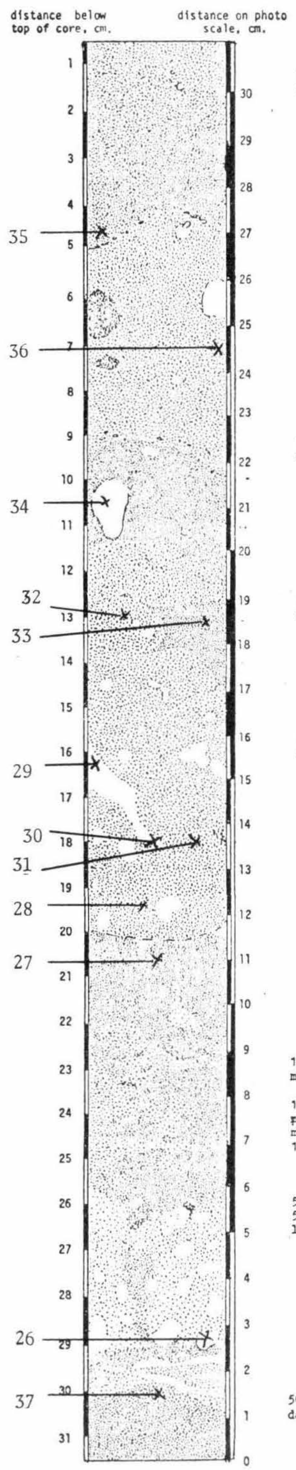
the core was described *in situ* on the basis of binocular microscope study (Nagle, Fig. 16-14). To attempt to determine the significance of the different strata, especially the inclined-appearing unit, a series of samples was taken for preliminary examination of particle track abundances (Crozaz, Morrison, and Blanford, Fig. 16-15); these studies were completed before the inclined interval was dissected. Location of these samples are given in Fig.16-14 and track abundances are presented in the facing diagram, Fig.16-15.

The lowest sample shows a great spread of points, suggesting mixing of fresh and pre-irradiated soil. In contrast, the next overlying sample No. 26 from an anorthosite clast near the base of the coarse white layer shows extremely low track abundances, suggesting that this material was unirradiated when it was deposited and had little subsequent irradiation. In contrast, sample 27, from the dark, agglutinate-rich layer at the top of the marbled zone, shows extremely high irradiation with the majority of particles saturated with solar flare tracks to give the crystals a "measled" appearance. The track abundances suggests high irradiation and reworking, which is consistent with the abundance of agglutinates and glass droplets in this soil.

Tracks from samples of pure anorthosite in layers 7 and 8 show less spread of points than those from bulk soil, apparently indicating that the anorthosite had less pre-irradiation. In general, track abundance is low through the inclined zone, and there is a weak trend of increase upward in the section. The increase is interpreted as a pattern graded by deep-penetrating galactic cosmic ray tracks, not solar flare tracks, supporting the hypothesis that the interval was deposited at one time and has remained undisturbed since. As discussed later, evidence uncovered during dissection suggests that the apparent stratal inclination is an artifact of sampling.

The uppermost unit, represented in sample #35, shows a great spread of points, representative of mixed material, and is consistent with the petrographic observations that this is the basal part of an accumulation sequence, mostly consisting of material reworked from immediately below the unit.

Exposure data (Fig. 16-15) supports the stratigraphic interpretation that the lower three levels are part of one accumulation unit, with the lower soils having a low degree of exposure suggesting penecontemporaneous accumulation and the dark soils of level 3 having a mixed but somewhat higher exposure, indicating surface



COLOR MATRIX	CLASTS	TEXTURE AND COMPOSITION	FABRIC AND STRUCTURE
10Y 5/1 medium drab		sandy siltsoil with abundant sand-sized grains, 0.5 - 2mm sparse very fine fines, abundant droplets, An. Px, dark-matrix breccia, plag.	weak horizontal alignment of rock fragments
			coated agglutinated on surface crenulate surface marks change in composition and textural units.
10Y 4/1 medium drab	10GY 9/1 off-white anorthosite clasts 5Y 3/1 dark drab	sparsely intraclastic siltsoil with large intraclasts of 5, 8, 8, 3, and 2mm diameter scattered in unit, much less sand-sized material than above, seems texturally less mature, with more matrix and fine fines, less sand-sized and coarse material; composition of rock fragments as above but plag. sheds dust more readily.	massive, plums in pudding fabric, clast contacts are sharp and distinct and clasts are well rounded, as opposed to those from below which are irregular and apparently crushed.
			indistinct clasts or strata
10Y 4/1 medium drab			contact between dark soil and light gray soil is sharp, but crenulate and rounded on a large scale
5 GY 5/1 medium drab-gray	10GY 9/1 light lamina and clasts; 10Y 4/1 dark laminae	gravdlly sandly siltsoil, poorly sorted but relatively coarse with very abundant sand-sized particles. Light intraclasts are present, plagioclase fragments are abundant to common, finely divided plagioclase, in abundance, gives light gray color to soil.	boundaries within grey area are inclined at approximately 56° and tend to be indistinct or crenulate
			sharp contact, slightly wavy but on a broad scale, not crenulate
10Y 4/1 medium drab		sandy siltsoil; moderately poorly sorted, with abundant 0.5-2mm particles, relatively sparse very fine fines, plagioclase and dark breccia common, anorthosite rare	clasts are rounded with sharp boundaries, but dark soil interfingers with clast unit
10Y 4/1 medium drab mottled with 10Y 5/1	5Y 3/1 dark clasts	intraclastic breccia siltsoil, very poorly sorted, most clasts, of soft soil, are in 2 - 6mm range, are subequant, but interpenetrate and seem to be somewhat crushed. Rock fragments of dark breccia, plag. fragments are present to common, and reflective particles are common to abundant in fines. Great amount of very fine fines.	clasts tend to be aligned with a horizontal fabric
5GY 5/1 - 5GY 6/1 light grey-drab	5GY 7/1 - 5GY 8/1 light gray clasts		clasts chaotically aligned, with indistinct, interfingering, crenulate margins, giving a marbled appearance to soil.
			distinct and sharp boundaries, base of unit appears scoured, with one layer truncating the underlying lamina
5GY 3/1 dark drab	5GY 7/1 light laminae	clayey siltsoil, with very sparse coarse material, especially rare in 0.5-1mm fraction, common dark breccia, sparse reflectives	basal unit is massive and appears structureless

Fig. 16-14 Preliminary description and location of preliminary examination splits, Core 60009.

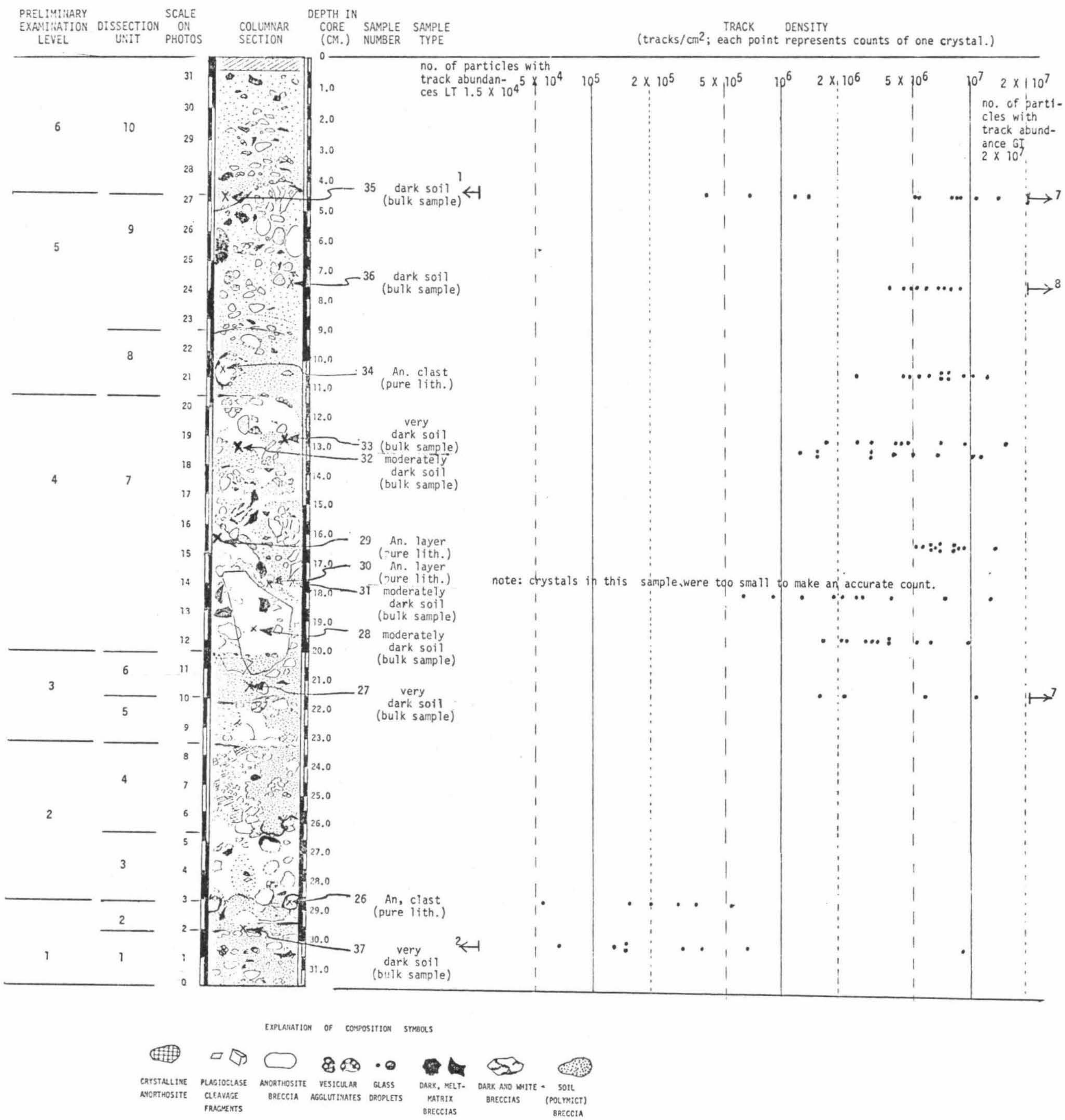


Fig.16-15. Track abundances, preliminary examination of 60009.

residence and reworking after the unit was laid down. The profile of levels4 and 5 appears to be relatively simple, indicating the same amount of galactic exposure after deposition of the unit and no evidence of surface exposure. The wide spread of values in the base of level 6 is consistent with the level being a zone of material reworked from below.

DISSECTION

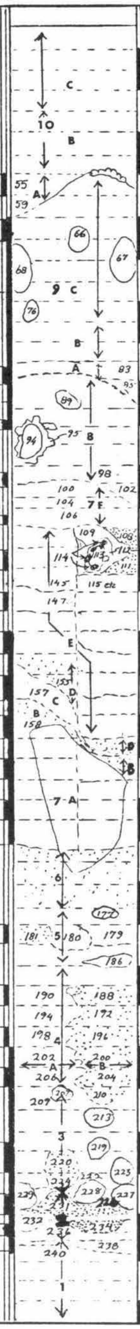
Following preliminary examination, an overall sampling plan was prepared which was subsequently somewhat modified as dissection proceeded. A detailed listing of dissected samples is found in Fig. 16-16 A,B, and C. Samples normally are taken in 5 mm increments along the length of the core, except at obvious contacts or changes in lithology, where smaller increments are extracted to obtain a sample which is not cross-contaminated. Where marbled or mottled lithology was encountered in 60009, small samples of pure material were taken from each soil type, and the remainder was included in general interval samples through the inclined interval in the middle of the core. Right and left halves were dissected separately to provide a comparison of lithologic and depth variations. During dissection, samples were sieved with a 1 mm stainless steel mesh to obtain coarse and fine size fractions. A different 1 mm screen was used for each interval to avoid cross-contamination. Orientation of large rock fragments was sketched and photographed as part of the dissection procedure. Rock fragments recovered in the screen are classified and photographed as a group for each interval. By comparing data from all dissection increments it was possible to subdivide the core into 10 stratigraphic units.

Designation of Units

For reference purposes, the core is generally subdivided into units, which by convention, are numbered from the base of the core up. As studies proceed, criteria for defining units become more precise and complete, and it becomes necessary to re-number and redefine the stratigraphic units making up the core. Fig. 16-17 shows the succession of unit designations, for reference purposes and for historical comparison. Only four units were recognized in 1972, during the preliminary examination (LSPET, 1972, p. 7-49) because the major textural changes near the middle of the core were partially obscured by the large rock fragments. During examination immediately after extrusion, strata were assigned the term level, to distinguish them from the potentially different intervals that might be recognized after dissection. Based on dissection descriptions, 60009 was subdivided into 10 lithologic units, which represent the maximum number of distinct subdivisions that can be recognized on the basis of textural and compositional changes (Fig. 8). It may be possible to further subdivide these units on the basis of more detailed criteria, such as exposure studies. Dissection units and sampling increments (Figs. 16 & 17) are entered in the Lunar Curatorial

LOCATION OF SAMPLES, UPPER DISSECTION, DRIVE TUBE 60009

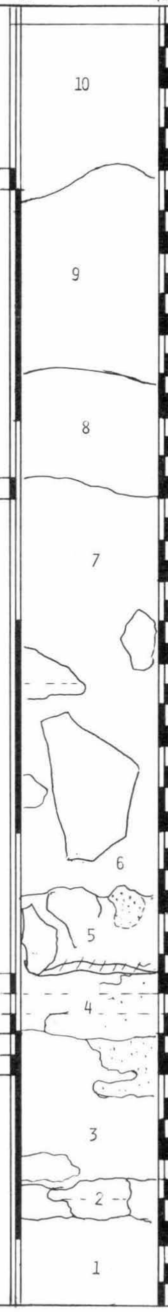
Alternate interval samples Sample No.	Vial No.	Sample Wt.	Alternate coarse fraction Sample No.	Vial No.	Sample Wt.	Sample interval (LCL inventory)
55	9-1017	.588	56	9-1018	.041	4.5–5.0
59	9-1022	.225	60	10-4886	.005	5.0–5.5
						5.5–5.7
			68	10-4801 Dark clast	.144	5.7–6.8
83	9-1050	.519	84	9-1051	.072	8.5–9.1
85	9-1053	.386	86	9-1054	.026	9.1–9.7
						9.7–10.0
94	9-1066 Pure, inside of clast	.161	95	9-1067 Mixed, outside of clast	.490	10.0–11.2
						11.2–11.5
102	9-1077	.164	103	9-1081	.017	11.5–12.2
						12.2–12.4
141	9-1354	.299	142	9-1357	.042	12.4–13
143	9-1359	.505	144	9-1360	.028	13–13.5
145	9-1363	.462	146	9-1369	.067	13.5–14.0
147	9-1372	.424	148	9-1377	.162	14.0–14.5
149	9-1378	.347	150	9-1381	.092	14.5–15.0
151	9-1387	.390	151	9-1401	.194	15.0–15.5
153	9-1404	.434	154	9-1405	.041	15.5–16.0
155	9-1407	.696	156	9-1416	.074	16.0–16.8
157	9-1414	.084	white layer			15.5-17.0
158	9-1418	.444	159	9-1423	.053	–17.5
160	9-1425	.246	161	9-1429	.009	17.5–18.0
162	9-1431	.171	163	9-1433	.092	18.0–18.5
164	9-1435	.232	165	9-1438	.022	18.5–19.0
166	9-1439	.091	167	9-1441	.009	19.0–19.5
168	9-1442	.341	169	9-1445	.023	19.5–20.0
181	9-1470	.222	Lt. gray lith.			
190	9-1489	.440	191	9-1490	.179	23.5–24.0
194	9-8008	.498	195	9-8009	.108	24.0–24.5
198	9-8015	.457	199	9-8020	.210	24.5–25.0
202	9-8037	.340	203	9-8040	.104	25.0–25.5
206	9-8045	.436	208	9-8065	.299	25.5–26.8
220	9-8141	.505	221	9-8143 Dk. lithology	.049	27.3–28.0
224	9-8153	.210				28.0–28.5
231	9-8199	.277	229	9-8169	.212 An Bx	28.5–29.0
236	9-8338	.722	237	9-8346	.093 (Lt)	29.0–29.3–29.5
238	9-8352	.214	239	9-8370	.038	29.5–29.8



Sample interval (LCL inventory)	Interval samples Sample No.	Vial No.	Sample Wt.	Coarse fraction Sample No.	Vial No.	Sample Wt.	Special samples Sample No.	Vial No.	Sample Wt.	Sample Type
0.5–1.0	40	9-1002	.719	41	9-1003	.078				
1.0–1.5	42	9-1005	.656	43	9-1006	.041	44	10-4770	.015	An. clast
1.5–2.0	45	9-1007	.859	46	9-1008	.039				
2.0–2.5	47	9-1009	.952	48	9-1010	.136				
2.5–3.0	49	9-1011	.813	50	9-1012	.173				
3.0–3.5	51	9-1013	.862	52	9-1014	.107				
3.5–4.0	53	9-1015	.950	54	9-1016	.165				
4.0–4.5	57	9-1020	.339	58	9-1021	.148				
4.5–5.0	61	9-1025	.464	62	9-1026	.218				
5.0–5.5	63	9-1028	.688	64	9-1029	.201				
5.5–6.0	65	9-1030	.906	69	9-1034	.092	66	9-1031	.034	An. clast
6.0–6.5	70	9-1035	.667	71	9-1036	.155	67	9-1033	.140	An. clast
6.5–7.0	72	9-1037	.631	73	9-1038	.101				
7.0–7.5	74	9-1039	.903	75	9-1040	.169	76	10-10050	.045	dark clast
7.5–8.0	77	9-1041	.685	78	9-1042	.218				
8.0–8.5	79	9-1043	.804	80	9-1045	.121				
8.5–9.0	81	9-1047	.623	82	9-1048	.062				
9.0–9.7	87	9-1055	.564	88	9-1056	.016	89	9-1057	.041	An. clast
9.7–10.0	90	9-1059	.684	91	9-1060	.048				
10.0–10.5	92	9-1062	.650	93	9-1065	.036				
10.5–11.0	96	9-1069	.655	97	9-1070	.039				
11.0–11.3	98	9-1071	.651	99	9-1072	.042		–		
11.3–11.5	100	9-1074	.344	101	9-1076	.083				
11.5–12.0	104	9-1083	.826	105	9-1084	[illegible]				
12.0–12.6	106	9-1085	.216	107	9-1086	.129	108	9-1088	.204	Dk. fines
12.6–13.0	109	9-1090	.170	110	9-1091	.239	111	9-1093	.010	Pure dk. soil
13.0–13.5	112	9-1094	.437	114	9-1098	.070	113	9-1097	.027	An. from clast
13.5–14.0	115	9-1099	.431	116	9-1215	.018				
14.0–14.5	117	9-1225	.288	118	9-1255	.021				
14.5–15.0	119	9-1258	.467	120	9-1262	.024				
15.0–15.5	121	9-1280	.342	122	9-1283	.051				
15.5–16.0	123	9-1293	.366	124	9-1302	.395				
16.0–16.5	125	9-1303	.398	126	9-1305	.138				
16.5–17.0	127	9-1307	.411	128	9-1310	.106				
17.0–17.5	129	9-1312	.471	130	9-1315	.202				
17.5–18.0	131	9-1317	.405	132	9-1320	.014				
18.0–18.5	133	9-1324	.362	134	9-1336	.036				
18.5–19.0	135	9-1338	.319	136	9-1339	.096				
19.0–19.5	137	9-1343	.167	138	9-1345	.096				
19.5–20.1	139	9-1346	.165	140	9-1353	.031				
20.1–20.5	170	9-1448	.475	171	9-1452	.209				
20.5–21.1	172	9-1455	.653	173	9-1456	.135				
21.1–21.7	174	9-1457	.781	175	9-1458	.189				
21.7–22.0	176	9-1459	.858	178	9-1465	.212	177	9-1464	.060	An. clast
22.0–22.5	179	9-1468	.702	182	9-1473	.073	180	9-1469	.064	dark lithology
22.5–23.0	183	9-1477	.591	185	9-1482	.061	184	9-1478	.050	An. clast
23.0–23.5	186	9-1484	.841	187	9-1486	.251				
23.5–24.0	188	9-1487	.281	189	9-1488	.025 (Dark lithology)				
24.0–24.5	192	9-1496	.282	193	9-1499	.060				
24.5–25.0	196	9-8013	.320	197	9-8014	.061				
25.0–25.5	200	9-8024	.477	201	9-8026	.042				
25.5–25.9	204	9-8041	.434	205	9-8043	.040	207	9-8053	.055	An. clast
25.9–26.5	209	9-8066	.748	211	9-8078	.158	210	9-8069	.209	Dark lithology
26.5–27.0	212	9-8093	.806	214	9-8119	.199	213	9-8118	.093	Dk.-coated An. clast
27.0–27.5	215	9-8084	.651	216	9-8121	.147				
27.5–28.0	217	9-8131	.485	218	9-8136	.030	219	9-8134	.029	An. clast
28.0–28.5	222	9-8149	.515	225	9-8154	.127	223	9-8152	.031	An. Bx clast
28.5–29.0	226	9-8157	.682	230	9-8185	.033	227	9-8161	.016	An. clast
29.0–29.3	232	9-8301	.397	233	9-8309	.038	228	9-8166	.101	An. clast
29.3–29.5	234	9-8325	.201	235	9-8333	.016 (Dark lithology)				
29.5–30.0	240	9-8394	.935	241	9-8404	.053				
30.0–30.5	242	9-8414	.769	243	9-8424	.295				
30.5–31.0	244	9-8429	1.194	245	9-8465	.102				
31.0–31.5	246	9-8474	1.100	247	9-8476	.178				

Fig. 16-16 (A). Dissection summary of Drive Tube 60009.

LOCATION OF SAMPLES, SECOND DISSECTION, DRIVE TUBE 60009



Interval samples, coarse fraction and special samples

Sample interval (LCL inventory)	Interval samples Sample No.	Vial No.	Sample Wt.	Coarse fraction Sample No.	Vial No.	Sample Wt.	Special samples Sample No.	Vial No.	Sample Wt.	Sample Type
0.5–1.0	1000	9-1101	0.941	1001	9-1107	0.068	1018	9-1150		
1.0–1.5	1002	9-1108	0.874	1003	9-1109	0.142				
1.5–2.0	1004	9-1120	1.059	1005	9-1121	0.109				
2.0–2.5	1006	9-1123	1.176	1007	9-1125	0.076				
2.5–3.0	1008	9-1126	1.027	1009	9-1130	0.151				
3.0–3.5	1010	9-1132	0.948	1011	9-1135	0.179				
3.5–4.0	1012	9-1140	1.126	1013	9-1142	0.170				
4.0–4.5±	1016	9-1145	0.909	1017	9-1147	0.337	1018	9-1150	0.095	An. clast
4.5±–5.0	1019	9-1160	0.990	1020	9-1167	0.124				
5.0–5.5	1021	9-1169	0.968	1022	9-1172	0.154				
5.5–6.0	1024	9-1174	0.941	1025	9-1175	0.155	1026	9-1183	1.062	An. clast
6.0–6.5	1028	9-1187	0.946	1029	9-1191	0.142	1027	9-1185	0.318	Dark clast
6.5–7.0	1030	9-1193	0.908	1031	9-1194	0.256				
7.0–7.5	1032	9-1203	1.101	1033	9-1204	0.178	1034	9-1211	0.038	Dark clast
7.5–8.0	1035	9-1212	0.922	1036	9-1214	0.057				
8.0–8.5	1037	9-1217	1.235	1038	9-1219	0.108				
8.5–9.1±	1039	9-1239	1.320	1040	9-1256	0.161				
9.1±–9.5	1041	9-1264	1.229	1042	9-1274	0.146	1043	9-1279	0.108	An. clast
9.5–10.0	1044	9-1282	0.991	1045	9-1287	0.072				
10.0–10.5	1046	9-1294	0.794	1047	9-1298	0.082	1051	9-7104	0.164	An. clast
10.5–11.0	1048	9-7101	1.556	1049	9-7102	0.091	1050	9-7103	0.015	Rusty particle
11.0–11.5	1052	9-7105	1.117	1053	9-7106	0.173				
11.5–12.0	1054	9-7107	0.796	1055	9-7108	0.044	1056	9-7109	0.130	An. clasts
12.0–12.5	1059	9-7113	0.368	1060	9-7114	0.190				
12.5–13.0	1061	9-7116	1.061	1062	9-7117	0.091				
13.0–13.5	1063	9-7120	1.122	1064	9-7121	0.119				
13.5–14.0	1065	9-7123	1.229	1066	9-7125	0.210				
14.0–14.5	1067	9-7126	1.285	1068	9-7128	0.229				
14.5–15.0	1069	9-7129	0.801	1070	9-7130	1.289				
15.0–15.5	1071	9-7131	1.146	1072	9-7133	0.136	1073	9-7134	0.744	An. clast
15.5–16.0	1074	9-7135	0.883	1075	9-7136	0.216				
16.0–16.5	1076	9-7137	0.787	1077	9-7138	0.143	1157	9-7140	0.326	An. clast upper half
16.5–17.0	1078	9-7142	1.818	1079	9-7143	0.105	1158	9-7141	0.174	An. clast lower half
17.0–17.5	1080	9-7145	1.245	1081	9-7146	0.214				
17.5–18.0	1082	9-7147	0.678	1083	9-7149	0.070				
18.0–18.5	1084	9-7152	0.585	1085	9-7154	0.182				
18.5–19.0	1086	9-7156	0.489	1087	9-7158	0.068				
19.0–19.6±	1088	9-7161	0.762	1089	9-7163	0.077	1090	9-7164	0.217	An. clast
19.6±–20.0	1091	9-7165	0.685	1092	9-7166	0.089				
20.0–20.5	1093	9-7167	0.440	1094	9-7168	0.051				
20.5–21.0	1095	9-7169	0.827	1096	9-7170	0.288				
21.0–21.5	1097	9-7173	1.057	1098	9-7174	0.319				
21.5–22.0±	1099	9-7175	0.959	1100	9-7176	0.123				
22.0±–22.5	1101	9-7177	0.824	1102	9-7178	0.247	1103	9-7179	0.326	Dark soil
22.5–23.0	1105	9-7181	0.704	1106	9-7182	0.151	1104	9-7180	0.528	Crystalline An. fgm.
23.0–23.5	1107	9-7183	0.921	1108	9-7184	0.282	1109	9-7185	1.327	Crystalline An. fgm.
23.5–24.0	1112	9-7189	0.302	1113	9-7190	0.037				
24.0–24.5	1116	9-7193	0.415	1117	9-7192	0.047				
24.5–25.1±	1120	9-7199	0.612	1121	9-7200	0.073				
25.1±–25.5	1124	9-7204	0.621	1125	9-7206	0.125				
25.5–26.0	1128	9-7211	0.589	1129	9-7213	0.132				
26.0–26.5±	1132	9-7217	0.392	1133	9-7218	0.016				
26.5±–27.0	1134	9-7221	1.414	1135	9-7222	0.109				
27.0–27.5	1136	9-7223	1.662	1137	9-7224	0.177				
27.5–28.0	1138	9-7225	1.526	1139	9-7226	0.080				
28.0–28.5±	1140	9-7227	1.311	1141	9-7229	0.150	1142	9-7231	0.370	An. clast
28.5±–29.0	1143	9-7232	1.181	1144	9-7234	0.196	1145	9-7236	0.229	An. clast, upper half
29.0–29.5±	1147	9-7238	1.335	1148	9-7239	0.076	1146	9-7237	0.260	An. clast, lower half
29.5±–30.0	1149	9-7242	1.109	1150	9-7243	0.094				
30.0–30.5	1151	9-7244	1.305	1152	9-7245	0.286				
30.5–31.0	1153	9-7247	1.516	1154	9-7248	0.156				
31.0–31.5	1155	9-7249	1.419	1156	9-7250	0.179				

Alternate interval samples and alternate coarse fraction

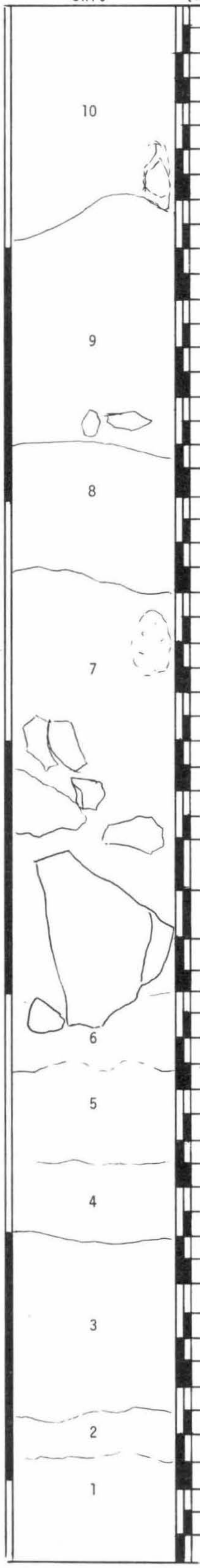
Alternate interval samples Sample No.	Vial No.	Sample Wt.	Alternate coarse fraction Sample No.	Vial No.	Sample Wt.	Sample interval (LCL inventory)
above contact, in unit 10						
1014	9-1143	0.504	1015	9-1144	0.055	4.0–4.5±
below contact, in unit 7						
1057	9-7110	0.735	1058	9-7112	0.097	11.5–12.0
LIGHT LITHOLOGY						
1110	9-7186	0.628	1111	9-7187	0.357	23.5–24.0
1114	9-7191	0.519	1115	9-7192	0.485	24.0–24.5
1118	9-7196	0.382	1119	9-7198	0.142	24.5–25.1±
1122	9-7202	0.863	1123	9-7203	0.090	25.1±–25.5
1126	9-7208	0.673	1127	9-7209	0.181	25.5–26.0
1130	9-7214	1.200	1131	9-7216	0.162	26.0–26.5±

Units (from the drawn core log)

Unit	Sample interval (LCL inventory)
10	0.5–4.5±
9	4.5±–9.1±
8	9.1±–11.5
7	11.5–15.0
6	15.0–22.0±
5	22.0±–23.5
4	23.5–25.1±
3	25.1±–28.5±
2	28.5±–29.5±
1	29.5±–31.5

Fig. 16-16B

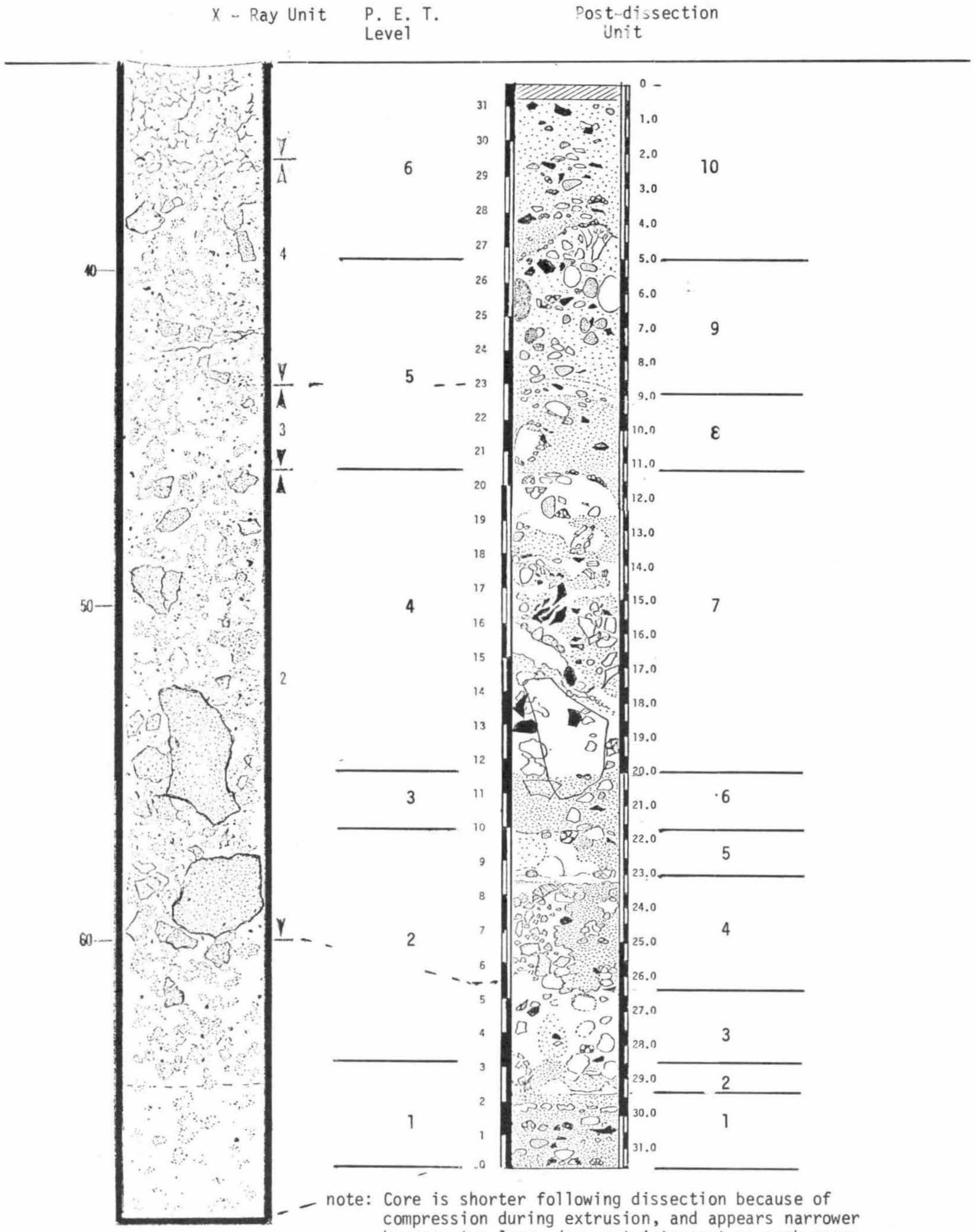
LOCATION OF SAMPLES, THIRD DISSECTION, DRIVE TUBE 60009



Unit	SAMPLE INTERVAL (LCL inventory)	INTERVAL SAMPLES Sample No.	Vial No.	Sample Wt.	SPECIAL SAMPLES Sample No.	Vial No.	Sample Wt.	Sample Type	Sample Interval
	0.5								
	1.0	2000	9-7257	0.990					
	1.5	2001	9-7259	1.329					
10	2.0	2002	9-7262	1.593					
	2.5	2003	9-7263	1.743					
	3.0	2004	9-7264	1.712					
	3.5	2005	9-7265	1.540					
	4.0	2006	9-7266	1.607	2007	9-7267	0.548	BxRF	046-35
	4.5	2008	9-7268	1.263					
	5.0	2009	9-7269	1.316					
	5.5	2010	9-7272	1.645					
	6.0	2011	9-7273	1.541					
	6.5	2012	9-7276	1.904					
9	7.0	2013	9-7278	1.869					
	7.5	2014	9-7281	1.515					
	8.0	2015	9-7282	1.527					
	8.5	2016	9-7283	1.134	2018	9-7286	0.256	AnBx MeltBx	090-80
	9.0	2017	9-7284	1.224					
	9.5	2019	9-7288	1.365					
8	10.0	2020	9-7289	1.588					
	10.5	2021	9-7290	1.550					
	11.0	2022	9-7291	1.433					
	11.5	2023	9-7292	1.421					
	12.0	2024	9-7293	1.556					
	12.5	2025	9-7294	1.647					
	13.0	2026	9-7295	1.447	2028	9-7297	0.476	SoBx	136-25
7	13.5	2027	9-7296	1.314					
	14.0	2029	9-7298	1.146					
	14.5	2030	9-7299	1.672					
	15.0	2031	9-7312	1.009					
	15.5	2033	9-7319	0.963	2032	9-7318	0.274	An clast	163-50
	16.0	2034	9-7320	0.652	2035	9-7323	5.043	MeltBx's	179-44
	16.5	2036	9-7341	1.124					
	17.0	2037	9-7345	1.552					
	18.0	2038	9-7370	1.732					
	19.0	2039	9-7402	1.101	2069	83-	23.690	MeltBx (large rock fragment)	210-71
	19.0±	2040	9-7403	0.936					
	20.0	2041	9-7404	0.866					
	20.5	2042	9-7405	0.827					
6	21.0	2043	9-7406	1.416	2044	9-7407	0.554	MeltBx	210-04
	21.5	2045	9-7410	1.529					
	22.0	2046	9-7411	1.135					
5	22.5	2047	9-7413	0.766					
	23.0	2048	9-7414	0.990					
	23.5	2049	9-7415	0.773					
	24.0	2050	9-7416	0.947					
4	24.5	2051	9-7418	1.435					
	25.0	2052	9-7420	1.014					
	25.5	2053	9-7421	1.352					
	26.0	2054	9-7422	1.301					
	26.5	2055	9-7423	1.272					
3	27.0	2056	9-7426	1.415					
	27.5	2057	9-7428	1.257					
	28.0	2058	9-7429	1.342					
	28.5	2059	9-7433	1.397					
2	29.0	2060	9-7434	1.870					
	29.5	2061	9-7435	1.327					
1	30.0	2062	9-7438	1.384					
	30.5	2063	9-7440	1.408					
	31.0	2064	9-7442	1.555					
	31.5	2065	9-7445	1.402					

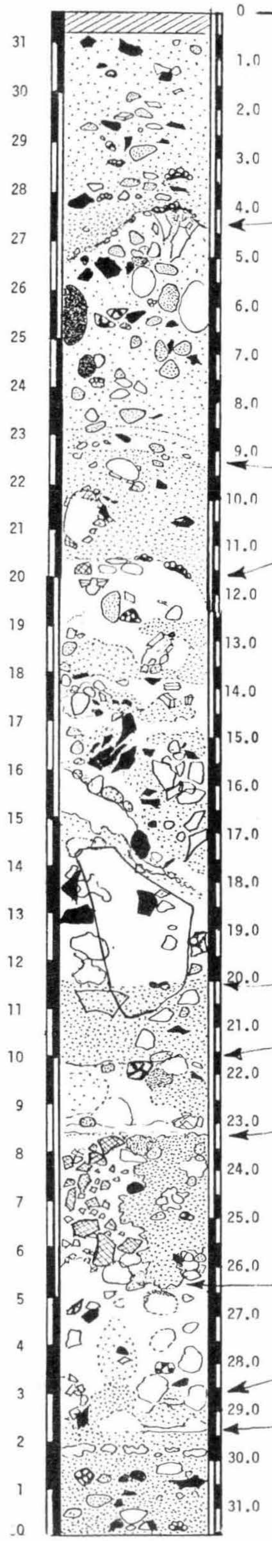
Fig. 16-16C

Fig. 16-17. Comparison of unit designation, drive tube 60009, for X-radiography, for Preliminary Examination, and for Initial Dissection.



note: Core is shorter following dissection because of compression during extrusion, and appears narrower because top layer does not intercept as much cross-section as does X-radiogram.

STRATIGRAPHIC SUMMARY, APOLLO CORE 60009



UNIT	DEPTH	SAMPLES	CHARACTERISTICS	SUB-UNITS
10	0.5-5.0 cm	60009,40-60	Fine-grained polymict unit with abundant intraclasts and authigenic agglutinates, wide range of exposure.	C. 0.5-2.5, Detrital interval B. 2.5-4.0, Agglutinate interval A. 4 to 5.0, fine-grained interval
			sharp contact with truncated and agglutinate-coated An. Breccia.	
9	4.0-9.7 cm	60009,57-84	Friable breccia unit, moderately coarse grained with an abundance of rounded soil and anorthosite breccia clasts, moderately high galactic cosmic ray exposure.	C. 4.0-7.5, chaotic to vertical fabric upward increasing size of clasts. B. 7.5-8.5, fine-grained laminar fabric A. 8.5-9.7, inclined-laminated with flake-shaped clasts
			transitional boundary marked by increase in size and sorting, compositional change from anorthositic to soil breccias	
8	9.1-12.3 cm	60009,88-103	Fine-grained dark unit with scattered armored anorthosite clasts, moderate galactic cosmic ray exposure.	Not subdivided.
			sharp contact, marked in part by authigenic agglutinates	
7	11.3-20.0 cm	60009,100-169	Apparently coarse-grained unit consisting of relatively discrete domains of dark, fine-grained soil, irregularly crenulate anorthosite clasts, partially dispersed fractured rock fragments and anorthosite laminae, all somewhat disturbed and moved by sampling. Low galactic cosmic ray exposure.	F. 11.3-12.7 E. 12.7-17.5±, Alternating light-dark domains D. 15.5-17.5, Darker soil with rounded clasts immediately above anorthosite C. 16.0-18.0±, Anorthosite lamina B. 16.5-17.5±, Darker part of unit immediately above rock A. 17.5-20.0, Soil which was squeezed around large rock fragment
			Apparently sharp planar contact	
6	20.0-21.7 cm	60009,170-175	Dark, very cohesive, fine-grained interval, rich in breccia fragments, poor in crystallines, with high exposure	Not subdivided
			transitional boundary	
5	21.7-23.0 cm	60009,176-185	Indistinctly stratified unit with equant, rounded soil clasts.	Not subdivided.
			indistinct, crenulate subhorizontal boundary	
4	23.0-26.0 cm	60009,186-208	Unit is very coarse-grained, comprised of very large, somewhat crushed soil clasts.	A. Light-colored clast is very coarse, consists mostly of crushed crystalline anorthosite B. Dark clast is fine-grained with scattered small breccia fragments.
			crenulate to transitional boundary.	
3	25.6-28.5 cm	60009,209-225	Unit contains sparse light-colored soil clasts and anorthosite clasts in a poorly sorted very light, anorthosite-rich matrix, very low exposure.	Not subdivided
			crenulate to transitional boundaries above	
2	28.5-29.5 cm	60009,226-237	Mixed lithologies, similar to overlying and underlying units	
			planar to crenulate boundaries below	
1	29.5-31.5 cm	60009,238-247	Dark, relatively sorted unit with indistinct stratification, common agglutinates at base, low-grade breccias throughout plus increasing anorthosite upward.	Not subdivided

Fig.16-18. Stratigraphic summary, Apollo core 60009.

Laboratory's Lunar Sample Inventory. If an investigator wishes to study a sample from a certain unit, he can compare the unit to the depth scale designated "sample interval, LCL inventory" to determine the specific split number that corresponds to the depth interval. This scale corresponds to the numerical scale etched onto the dissection receptacle, and represents the earliest quantitative depth designation that can be directly applied to all parts of the core.

Stratigraphic Summary

Ten textural and compositional units have been identified and verified as a result of two dissections of 60009 (Fig. 16-18). These units are interpreted to represent two major accumulation sequences (Units 1-6 and 7-9) and one episode of reworking (Unit 10). In general the sequences grade from reworked, poorly sorted soil with agglutinate fragments to poorly sorted coarse-grained soil with abundant crushed, fresh, rock fragments to finer-grained soil with rounded soil clasts, capped with an agglutinate rich reworked zone. Tracks increase upward in each sequence. Unit 10 is finer-grained, richer in agglutinates, better sorted, but contains a mixture of small clasts similar to those immediately below and seems to be reworked from the underlying regolith.

Study by Principal Investigators

Allocations from the upper dissection increment are listed in Table A 16-6, p. A-29 of the appendix.

APOLLO 17 CORES

GENERAL

Cores were taken at six separate locations on the Apollo 17 mission, and range from a deep drill string at the ALSEP site (70001-70009) to a last-minute grab sample at the LM site (70012). A single drive tube was taken at station 6 (76001), and double drive tubes were used to profile the coarse ejecta at van Serg Crater (79002/79001), the orange and black soil at Shorty Crater (74002/74001) and the light mantle (73002/73001). 73001 was placed in the vacuum container(CSVC)immediately after sampling; the others have been handled by standard procedures.

APOLLO 17 DEEP DRILL STRING

The drill string, consisting of eight detachable stems and a drill bit, contained a total section of approximately 294.5 cm, representing the deepest lunar core yet sampled.

Sample collection took place at the ALSEP site, 180M west (azimuth of 285°) from the LM (Fig. 17-1). The location is approximately one crater diameter east from the 700M crater Camelot, and lies near the northwest margin of the central cluster ejecta; deposits from both crater sequences, as well as older regolith, were expected to occur in the drill string.

LUNAR SURFACE PROCEDURES

The Apollo 17 deep drill core was collected on 11 December, 1972, 3 1/2 to 4 hours into EVA 1, concurrently with deployment of the ALSEP experiments. After drilling the neutron probe was inserted into the empty hole. Nine separate hardware items comprised this drill string; these included seven standard 40 cm. stems, plus a shortened bottom stem, 36 cm. long, to which was attached a 6.5 cm. drill bit.

Sections were added two-at-a-time during the drilling operation. Despite the fact that TV coverage during drilling was limited, it was possible to ascertain that the penetration rate varied. According to notes supplied by the crew, drilling the lowest 20 cm. was very difficult because the basal material was very cohesive and contained abundant rock fragments.

Upon completion of the drilling operation, Cernan and Schmitt extracted the core with great difficulty, and returned to the LRV 1 where it was disassembled into three sections consisting of: upper three stems, 70007-70009, the middle two stems, 70006 and 70005, and the lowest three stems plus the bit, 70004 through 70001. Sections were capped on the LRV with minimal loss of material from open ends of the drill stems, and securely tied into a specially constructed beta cloth bag for return to earth. Thus contained, the drill string was found to be in secure and undisturbed condition when initially opened in the laboratory.

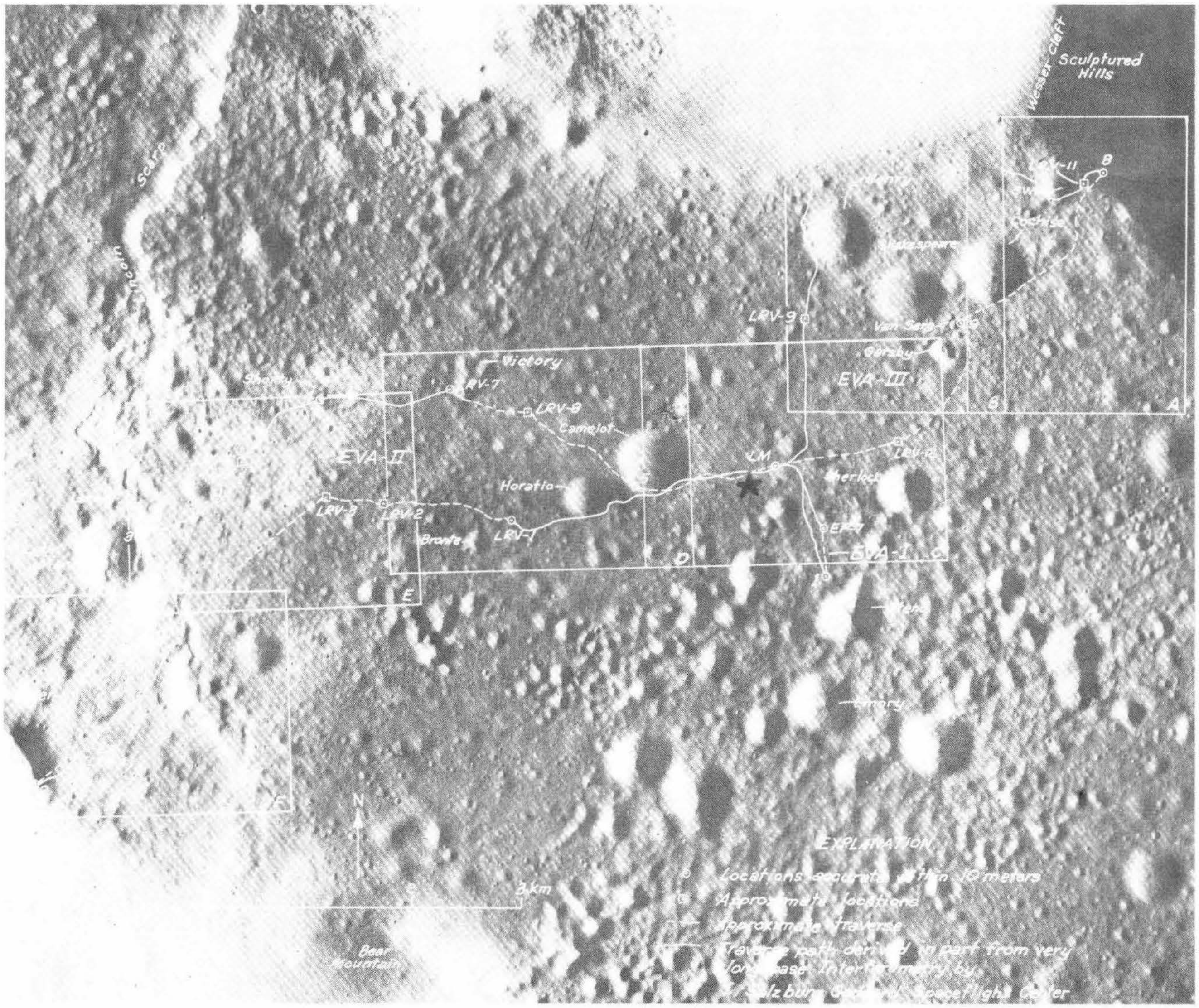


Figure 17-1.- *Apollo 17 deep core sample collection site.

INITIAL LABORATORY PROCEDURE

Samples were removed from the beta cloth bag on the laminar flow bench in the Clean Room of the LRL (photo documentation, NASA S-72-56449 through 56454) early on 22 December, 1972, and immediately transferred to the Core Tube Preparation Cabinet of the SSPL*. All stems were uncoupled, weighed, and triplebagged in teflon, the same day, in preparation for X-radiography and Preliminary Examination.

PRELIMINARY EXAMINATION OF THE DRILL STRING

Preliminary examination of the Apollo 17 drill string included; (1) X-radiography, (2) determination of mechanical properties, (3) removal of limited amounts of lunar soil from the upper ends of each stem, for early allocation and study, (4) dissection of the drill bit, 70001, for early allocation and biomedical analysis, and (5) dissection of 70008, the section that would provide critical early data on abundance of short-lived radionucleides.

X-radiography

X-radiography was performed on 27 December, 1972, according to the procedure outlined in Chapter 1, p. 20, under conditions listed in Table III. Description of the X-radiographs commenced the same day; results are presented in Fig. 17-3 and covered in detail in LSPET, 1973, p. 777-25 through 7-36. Compositional control was provided through examination of the X-radiographs and early samples, the Apollo 17 drill string appears to contain three major stratigraphic intervals: a lower zone of alternating coarse and fine basaltic and breccia material, 131.5 cm. thick, a middle, fine-grained zone 56 cm. thick, high in anorthosite, and an upper, coarse-grained, basaltic unit, 107 cm. thick.

Mechanical Properties of the Drill String

Mechanical properties, summarized in Table XVII-i, were originally calculated by D. Carrier, immediately after the cores were weighed and after it was possible to determine the length of soil in each core from the X-radiographs. (Apollo 17 Preliminary Science Report, P. 8-7). More accurate data are now available for drill stems 70007-70009, following opening of the drill stems and direct measurement of the length of soil in each core tube. In general, bulk density of the Apollo 17 drill string is greater than that of the Apollo 15 and 16 cores (Fig. 17-2) and differs somewhat in pattern. Whereas the Apollo 16 core shows a steady increase in density with depth, and the Apollo 15 core a series of wide fluctuations, the lower part of the Apollo 17 deep drill core is relatively constant (1.79 ± 0.05 gm/cc) with a dense layer (2.11 gm/cc) rich in unshocked crystallines, occurring just below the lunar surface.

Within the limits of measurable error, core recovery was essentially 100 percent. On return, voids inside the drill stem were found to total approximately 30 cm., agreeing with the length of undrilled core on the

*Sample Storage and Preparation Laboratory, Curatorial Facility, Johnson Space Center.

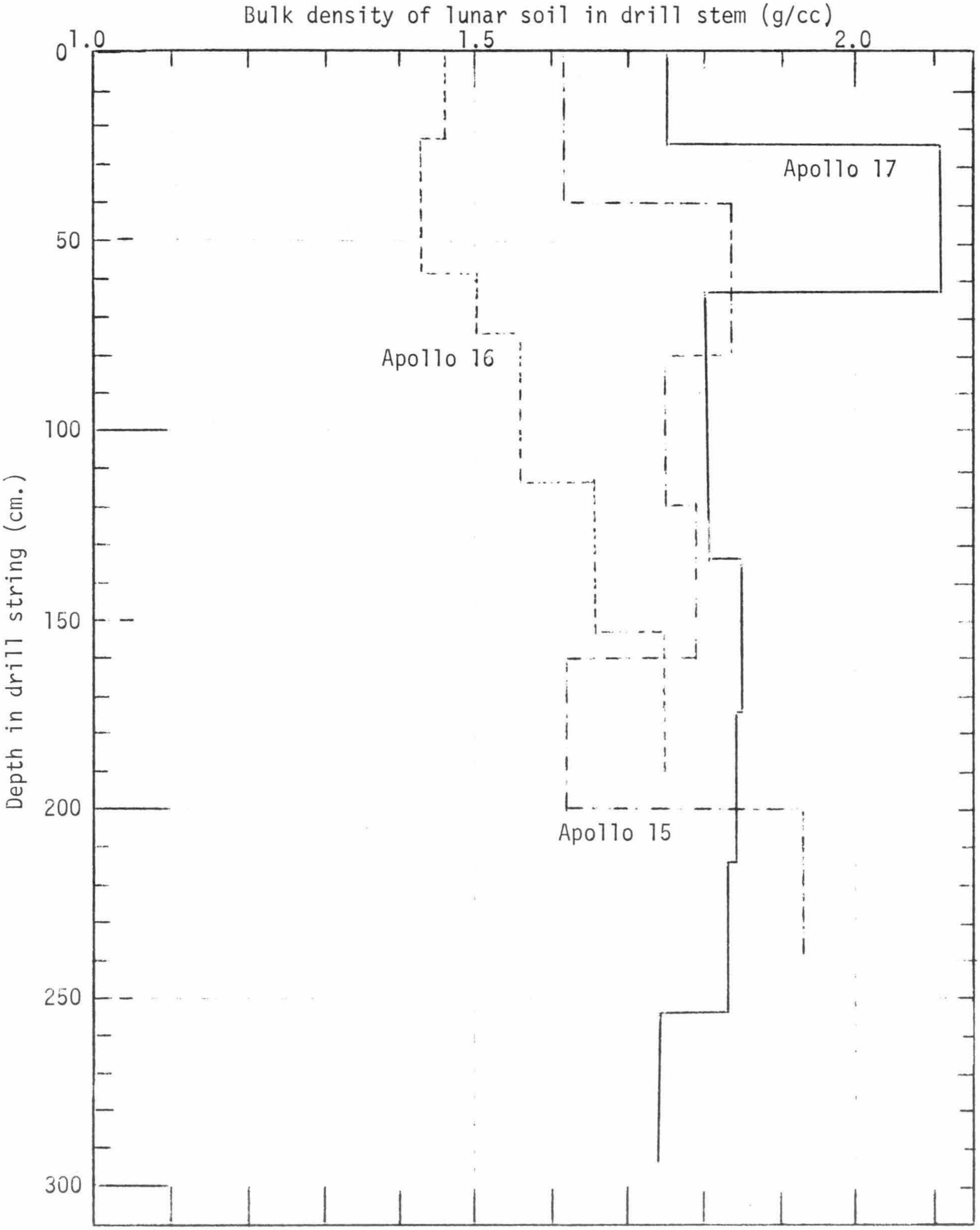


Figure 17-2.- Comparative density, Apollo 15, 16, and 17 drill strings.

TABLE XVII-1. - PRELIMINARY DATA ON APOLLO 17 DRILL STEM SECTIONS

	Drill Stem S/N	LRL Sample No.	Returned Sample Weight g	Returned Sample Length cm	Returned Bulk Density g/cc	Original Sample Length cm	Original Bulk Density g/cc	Drill Stem Depth cm	Percent Core Recovery
Top	061	70009	143.3	25±2	1.75±0.14	10±2 [f]	1.99±0.05 (061–063)	305±1 (all sections)	95% - 97%
	067	70008	260.9	38[c]	2.11	39.9			
	063	70007	179.4	30.5	1.80	39.9			
	065	70006	234.2	39.9	1.80	39.9	1.80		
	069	70005	240.6	39.9[a]	1.85	39.9	1.85		
	066	70004	238.8	39.9[a]	1.84	39.9	1.84		
	062	70003	237.8	39.9[a]	1.83	39.9	1.83		
	070	70002	207.7	42.0[e] (070 and 179)	1.74	42.5	1.74		
Bottom	179 (Bit)	70001	29.8						
		Total:	1772.5			292±2			

(a) Nominal length of core is 39.9 cm:
(b) Based on a sample diameter of 2.04
(c) Approximately 2 cm void at top of stem.
(d) Approximately 6 cm void at top of stem.
(e) Nominal length is 42.5 cm: 0.5 cm fell out of bottom of drill stem on lunar surface.
(f) Core tube rammer-jammer was inserted to a depth of 30±2 cm before drill stem withdrawn from soil.

moon, and with the depth Cernan inserted the plug into the top of the drill stem immediately after sampling. Because the plug did not function, soil inside the upper three sections was unconfined, and showed a distribution indicating some shifting of soil upward in the drill string. Decrease in void space at the top of 70009 is compensated by the presence of void at the junction of 70007 and 70008. The original plug, inserted on the lunar surface, was found at the top of the 70009 drill string, indicating at least one inversion of the core. On return drill stems 70007 and 70008 were found to be partially unscrewed. Slippage during inversion, plus atmospheric-induced movement at the partially opened junction of 70007 and 70008 is believed to have caused the void at this location.

Early Sampling of the Core Junctions

Because the plug had been inserted into the bottom ends of the cores during uncoupling, soil was removed from the top, and a plug inserted into this void. Preliminary examination allocations required 2.75 grams of soil finer than 1 mm. from each core. Accordingly, soil was extracted from the tops of the cores in 1/2 cm. intervals; until the required amount of fine fines was obtained; at the same time, coarse particles were picked out and stored separately; 3 gm. of unsieved soil was then extracted for cold storage and posterity study. The list of photographs taken during separation and early sampling of the ends of the drill stems, is found below (Table XVII-II).

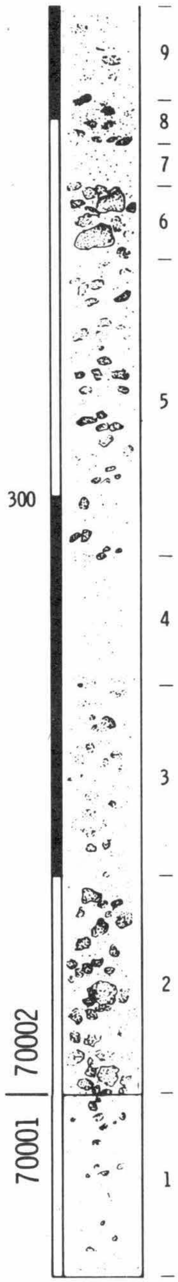
TABLE XVII-II. LIST OF PHOTOGRAPHS TAKEN

DURING PRELIMINARY EXAMINATION OF APOLLO 17 DRILL STRING

SAMPLE NO.	OPERATION	PHOTO NOS.
70001,1	Top end of core after disassembly........	[S-73-15051] [S-73-15052]
70002,1	Top end of core after disassembly........	[S-73-15049] [S-73-15050]
70002,4	Rock fragments from top of core..........	[S-73-15195]
70003,1	Top end of core after disassembly........	[S-73-15046]
70003,4	Rock fragments from top of core..........	[S-73-15194]
70004,1	Top end of core after disassembly........	[S-73-15047]
70004,4	Rock fragments from top of core..........	[S-73-15196]
70005,1	Top end of core after disassembly........	[S-73-15042]
70006,1	Top end of core after disassembly........	[S-73-15043]
70006,4	Rock fragments from top of core..........	[S-73-15193]
[70007,1] [70008,1]	Open ends of both cores shown together, after disassembly......................	[S-73-15044]
70008,1	Top end of core after disassembly........	[S-73-15045]
70009,1	Bottom end of core, after disassembly....	[S-73-15048]

Depth, cm

Unit



UNIT 9 Depth: TDS, 286.5 to 289 cm; lunar surface, 259.5 to 262 cm Thickness: 2.5 cm
Thin interval with scattered mottles.
Matrix: 95 percent; moderately transparent, indistinctly granular, with a trace of pinpoint opaques.
Coarse fraction: 5 percent; semiopaque, indistinct outline, 2- to 5-mm crenulate mottles scattered randomly throughout the interval.

UNIT 8 Depth: TDS, 289 to 290 cm; lunar surface, 262 to 263 cm Thickness: 1 cm
Thin bed with small, sorted rock fragments.
Matrix: 80 percent; high transparency with pinpoint opaques, as in unit 7.
Coarse fraction: 20 percent; semiopaque with moderately distinct outline, 1 to 3 mm in diameter, well sorted, chip-shaped fragments with relatively straight margins and angular corners. A few fragments show an indistinct outline on one side.

UNIT 7 Depth: TDS, 290 to 291 cm; lunar surface, 263 to 264 cm Thickness: 1 cm
Fine-grained thin bed with transparent matrix.
Matrix: 100 percent; as in unit 4, uniformly finely granular, high transparency, and a trace of pinpoint opaques.

UNIT 6 Depth: TDS, 291 to 293 cm; lunar surface, 264 to 266 cm Thickness: 2 cm
Thin bed with large rock fragments.
Matrix: 60 percent; high transparency, as in unit 5, but with no pinpoint opaques.
Framework: 40 percent; 30 percent is semiopaque rock fragments with distinct outline, bimodal sorting, and large fragments, 0.8 to 1.2 cm, are equant and lumpy as in unit 2, and 2- to 4-mm chip-like fragments as in unit 5; 10 percent is semiopaque mottles, 1 to 3 mm in diameter, with indistinct but smooth, not crenulate, outlines.

UNIT 5 Depth: TDS, 293 to 301 cm; lunar surface, 266 to 274 cm Thickness: 8 cm
Thick interval with transparent matrix and small, sorted rock fragments.
Matrix: 90 percent; high transparency with traces of pinpoint opaques as in unit 4.
Coarse fraction: 10 percent; semiopaque rock fragments with distinct outline, slightly elongate to chip shaped, 2 to 4 mm in diameter, sorted, with straight edges and angular corners.

UNIT 4 Depth: TDS, 301 to 305 cm; lunar surface, 274 to 278 cm Thickness: 4 cm
Fine-grained unit with transparent matrix.
Matrix: 100 percent; distinctly less dense and opaque than underlying unit, featureless except for a trace of pinpoint spherical opaques.

UNIT 3 Depth: TDS, 305 to 310 cm; lunar surface, 278 to 283 cm Thickness: 5 cm
Medium-thin bed with dense matrix and indistinct mottles.
Matrix: 85 percent; relatively high opacity, somewhat granular in appearance, with a distinct fairly planar upper boundary and a tendency to an indistinctly mottled appearance, but with no opaque particles.
Coarse fraction: 15 percent; traces of opaque, 1-mm fragment, subrounded blocky fragment; 15 percent is semiopaque, indistinct outline with highly crenulate widely sized mottles scattered throughout the entire length of the interval, no distinct layering.

UNIT 2 Depth: TDS, 310 to 316 cm; lunar surface, 283 to 289 cm Thickness: 6 cm
Medium-thick interval with poorly sorted rock fragments.
Matrix: 70 percent intermediate transparency with trace of shard-like opaques.
Framework: 30 percent; traces of 1-mm-diameter, equant, globular opaques; 20 percent is semiopaque rock fragments with distinct outline, 2 to 9 mm in diameter, average ≈3 mm, poorly sorted, equant to slightly elongate, mostly with irregular lumpy appearance, subordinate number with smooth straight outline; 10 percent is semiopaque, indistinct outlined equant mottles with vaguely crenulate outlines as much as 8 mm in diameter, but averaging 2 to 3 mm.

UNIT 1 Depth: TDS, 316 to 322.5 cm; lunar surface, 289 to 294.5 cm Thickness: 5.5 cm
Fine-grained unit with sparse rock fragments. Comprises all of 70001, the drill bit. Because of the thick walls, it is not possible to distinguish many soil characteristics.
Matrix: ≈90 percent; reveals no texture except that it appears fine grained.
Coarse fraction: ≈10 percent; appears to contain scattered, 1- to 3-mm, well-sorted rock fragments (equant, semiopaque to X-rays, but with distinct subrounded outline).

X-radiograph symbols

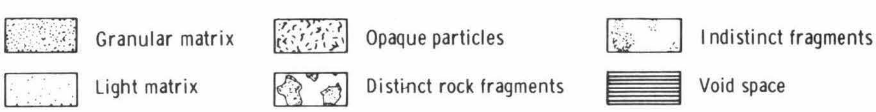
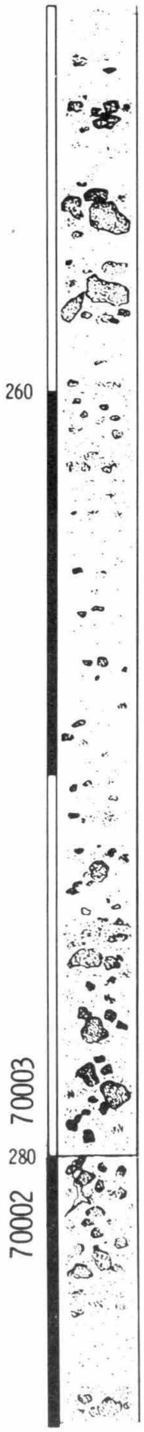


Figure 17-3.- X-radiograph of Apollo 17 deep drill core.

Depth, cm

Unit



23 UNITS 18 to 22 Depth: TDS, 252 to 258 cm; lunar surface, 225 to 231 cm Thickness: 6 cm
Alternation of rock fragments and finely mottled thin beds.
Rock fragmental layers:
22 Matrix: 50 to 60 percent; low opacity, appears to be homogeneously fine grained with only a trace of opaques, near limit of resolution.
21 Framework: 40 to 50 percent; consists of ≈40 percent rock fragments with distinct outline, 2 mm to 1.3 cm, poorly sorted, generally smooth to slightly irregular outline; 10 percent is mottled rock fragments, indistinct outline, as much as 3 mm in diameter, generally fading out evenly over smooth edges rather than over crenulate edges,
20 suggesting breccia fragments.
19 Fine-grained layers:
Matrix: 100 percent; semitransparent with ≈10 percent mottling, near limit of resolution, no opaques.

18 UNIT 17 Depth: TDS, 258 to 259.5 cm; lunar surface, 231 to 232.5 cm Thickness 1.5 cm
Thin fine-grained interval with transparent matrix.
17 Matrix: 100 percent; high transparency, nearly homogeneous with a suggestion of indistinct mottles, no opaques.

UNIT 16 Depth: TDS, 259.5 to 262 cm; lunar surface, 232.5 to 235 cm Thickness: 2.5 cm
16 Semiopaque matrix zone with mottles and rock fragments.
Matrix: 85 percent; moderately opaque with 10 to 15 percent density concentrations and semidistinct mottles, 1 mm in diameter to limit of resolution.
Coarse fraction: 15 percent; 5 percent is semiopaque rock fragments with distinct outline, well sorted, 1 to 2 mm in diameter, equant and subangular; 10 percent is semiopaque density concentrations with vague outline, equant to elongate, as much as 5 mm in diameter, fading out along smooth rather than crenulated edges.

UNIT 15 Depth: TDS, 262 to 272 cm; lunar surface, 235 to 245 cm Thickness: 10 cm
Transparent matrix zone with scattered small rock fragments.
Matrix: 95 percent; relatively transparent with 5 percent finely granular 0.5-mm to pinpoint mottles and density concentrations.
15 Coarse fraction: 5 percent semiopaque fragments with distinct outline, well sorted, all fragments are 2 to 4 mm in diameter, equant to chip shaped with relatively smooth outline, subangular corners. Traces of 1-mm opaque ovoids and spherules.

UNIT 14 Depth: TDS, 272 to 274 cm; lunar surface, 245 to 247 cm Thickness: 2 cm
Thin bed of mixed rock fragments and transparent matrix.
Matrix: 80 percent; less opaque than that of unit 13, distinctly less grainy, but also with no fine-grained opaques.
Coarse fraction: 20 percent; as in unit 13, with a variety of equant to angular, irregular rock fragments.

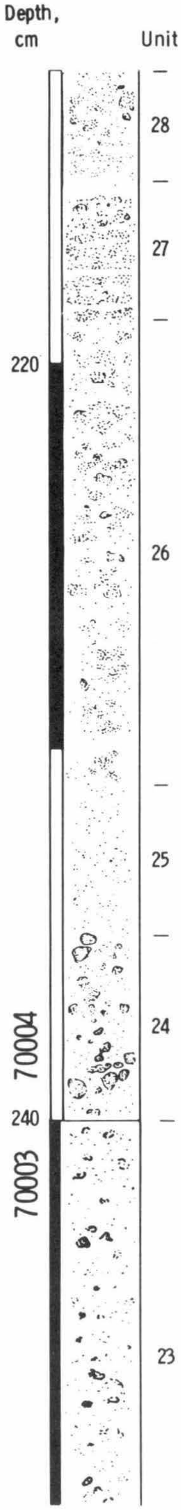
14 UNIT 13 Depth: TDS, 274 to 283 cm; lunar surface, 247 to 256 cm Thickness: 9 cm
Interval with mixed rock fragments and moderately opaque matrix.
Matrix: 75 percent; moderately opaque to semitransparent but grainy and finely indistinctly mottled with no opaques.
Coarse fraction: 25 percent; 20 percent is semiopaque rock fragments with distinct outline, tending to be irregular, 1 to 11 mm in diameter, poorly sorted, equant with subangular to angular corners; 5 percent is semiopaque mottles, varied sizes as much as 0.5 mm, tending to be equant, with relatively even outline, suggesting breccia fragments rather than irregular clods.

UNIT 12 Depth: TDS, 283 to 284 cm; lunar surface, 256 to 257 cm Thickness: 1 cm
Thin bed with well-sorted rock chips.
13 Matrix: 80 percent; as in unit 11, relatively high transparency with sparse, fine mottles and a trace of pinpoint opaques.
Coarse fraction: 20 percent; semiopaque rock fragments with semidistinct outline, 2 to 3 mm in diameter, well sorted, elongate to chip-shaped fragments, straight margins, angular corners on some edges fade to indistinctness on other margins.

UNIT 11 Depth: TDS, 284.0 to 285.5 cm; lunar surface, 257.0 to 258.5 cm Thickness: 1.5 cm
Thin fine-grained interval with transparent matrix.
Matrix; 100 percent; relatively high transparency, sparingly mottled with traces of pinpoint opaques.

12 UNIT 10 Depth: TDS, 285.5 to 286.5 cm; lunar surface, 258.5 to 259.5 cm Thickness: 1 cm
Thin bed with mixed rock fragments.
11 Matrix: 75 percent; moderately transparent, indistinctly granular, with no pinpoint opaques.
Framework: 25 percent; 15 percent is semiopaque rock fragments with distinct outline, poorly sorted, 1 to 5 mm in diameter, equant to elongate but with polygonal blocky outlines, subangular to angular corners; 10 percent is semiopaque,
10 indistinct outline, 1- to 3-mm diameter crenulate mottles.

Figure 17-3.- X-radiograph of Apollo 17 deep drill core (continued).



UNIT 29 Depth: TDS, 209.5 to 212.5 cm; lunar surface, 182.5 to 185.5 cm Thickness: 3 cm
Uniformly finely mottled zone.
Matrix: 100 percent; moderately opaque with a trace of pinpoint opaques and an abundance of uniformly distributed coarse granules as much as 0.5 mm in diameter.

UNIT 28 Depth: TDS, 212.5 to 215.5 cm; lunar surface, 185.5 to 188.5 cm Thickness: 3 cm
Coarsely mottled interval.
Matrix: 70 percent; as transparent matrix in unit 27, uniformly fine with no noticeable granules or opaques.
Coarse fraction: 30 percent; semiopaque indistinct mottles or clods as much as 1 cm in diameter, very poorly defined, with fairly crenulate outline, one blocky rock fragment.

UNIT 27 Depth: TDS, 215.5 to 219 cm; lunar surface, 188.5 to 192 cm Thickness: 3.5 cm
Thinly laminated interval with alternate laminae of relatively transparent and opaque soil.
Matrix: Transparent intervals 100 percent consisting of uniform very finely granular featureless matrix, relatively opaque intervals (90 percent) are finely to 1-mm granular, with a trace of pinpoint to 0.5-mm blocky opaques.
Coarse fraction: 10 percent; in relatively opaque intervals, semiopaque clod-like mottles with indistinct outline, poorly sorted, 2 to 5 mm in diameter.

UNIT 26 Depth: TDS, 219 to 231 cm; lunar surface, 192 to 204 cm Thickness: 12 cm
Thick bed with scattered rock fragments and mottles.
Matrix: 85 percent; moderately transparent with very fine, light granularity and trace of (1 percent) pinpoint to 0.5-mm spherical opaque.
Coarse fraction: 15 percent; 5 percent is semiopaque, distinct outline, 2- to 4-mm, subequant polygonal, subrounded to blocky rock fragments, many with at least one indistinct edge; 10 percent is semiopaque indistinct outline, 1- to 4-mm density concentrations, fading out evenly over apparently smooth edges.

UNIT 25 Depth: TDS, 231 to 235 cm; lunar surface, 204 to 208 cm Thickness: 4 cm
Fine-grained interval and high opacity matrix.
Matrix: 100 percent; moderately, densely opaque with very fine granularity and ≈1 percent pinpoint to 0.5-mm spherical opaques.

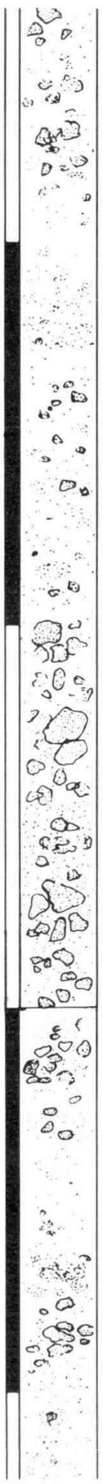
UNIT 24 Depth: TDS, 235 to 240 cm; lunar surface, 208 to 213 cm Thickness: 5 cm
Medium-thick interval with scattered 5-mm rock fragments.
Matrix: 75 percent; moderately dense and relatively highly opaque with very fine granularity and traces of scattered pinpoint opaques.
Coarse fraction: 25 percent; 15 percent is semiopaque with distinct outline, 3 to 5 mm in diameter, moderately well sorted, subequant rock fragments with semismooth outlines and subangular corners; 10 percent is semiopaque with indistinct outline, moderately well sorted, 2- to 4-mm density concentrations, most commonly with one well-defined smooth side, fading out more or less evenly elsewhere.

UNIT 23 Depth: TDS, 240 to 252 cm; lunar surface, 213 to 225 cm Thickness: 12 cm
Massive fine-grained zone with scattered small rock fragments.
Matrix: 90 percent; moderately transparent with indistinct granularity only slightly coarser than film graininess and with traces of pinpoint opaques, near limit of resolution, apparently spherical.
Coarse fraction: 10 percent; 5 percent is semiopaque rock fragments, 2 to 3 mm in diameter, well sorted, equant to ovoid, with subangular corners; 5 percent is semiopaque density concentrations with indistinct outline, as much as 4 mm in diameter, appear to be evenly sized; however, ≈2.5 mm in diameter, fading out over smooth outlines, suggesting well-sorted breccia fragments.

Figure 17-3.- X-radiograph of Apollo 17 deep drill core (continued).

Depth, cm

Unit



UNIT 38 Depth: TDS, 174.5 to 178.5 cm; lunar surface, 147.5 to 151.5 cm Thickness: 4 cm
Medium-thin interval with abundant, small, well-sorted rock fragments.
Matrix: 70 percent; moderate to high transparency, with less than 10 percent fine mottles and only a trace of pinpoint opaques, near limit of resolution.
Framework: 30 percent; 20 percent is semiopaque rock fragments with distinct outline, 2 to 4 mm in diameter, well sorted, blocky to wedge shaped with nearly straight sides and angular to subangular corners; 10 percent is semiopaque density concentrations with indistinct outline, 2 to 4 mm diameter, fading out over relatively straight and even edge, suggesting breccia fragments.

UNIT 37 Depth: TDS, 178.5 to 183 cm; lunar surface, 151.5 to 156 cm Thickness: 4.5 cm
Densely granular interval with sparse rock fragments.
Matrix: 95 percent; more opaque than unit 36, densely and finely granular with traces of minute spherical opaques.
Coarse fraction: 5 percent; semiopaque with indistinct outline, appearing as equant density concentrations 1 to 3 mm in diameter, with regular and even fadeout, sorting and type of semitransparency suggest breccia fragments rather than clods.

UNIT 36 Depth: TDS, 183 to 190 cm; lunar surface, 156 to 163 cm Thickness: 7 cm
Massive interval with sparse rock fragments and abundant opaque fragments.
Matrix: 90 percent; uniformly fine grained and noticeably transparent with ≈1 percent spherical opaques, 0.5 mm to limit of resolution.
Coarse fraction: 10 percent (decreasing upward); 5 percent is semiopaque rock fragments having distinct outline, moderately well sorted, 2 to 3 mm in diameter, best sorting at top of bed, continuous gradation upward; 4 percent is semiopaque mottles, 1 to 4 mm in diameter with crenulate fadeout; 1 percent is opaque fragments, averaging 1 mm in diameter, blocky equant to comma shaped.

UNIT 35 Depth: TDS, 190 to 194.5 cm; lunar surface, 163 to 167.5 cm Thickness: 4.5 cm
Rock fragmental zone with relatively transparent matrix.
Matrix: 60 percent; decidedly less dense in appearance than underlying unit with ≈1 percent spherical opaques, 0.5 mm in diameter to limit of resolution; matrix becomes progressively more transparent upward.
Framework: 40 percent; rock fragments, similar in appearance to unit 34, ≈30 percent is semiopaque rock fragments with distinct outline; 10 percent is crenulate mottles with indistinct outline.

UNIT 34 Depth: TDS, 194.5 to 200 cm; lunar surface, 167.5 to 173 cm Thickness: 5.5 cm
Rock fragmental zone with relatively opaque matrix.
Matrix: 65 percent; relatively opaque to X-rays, compared to unit 35, but appears to be uniformly dense throughout with no distinct mottles or opaque fragments.
Framework: 35 percent; 25 percent is semiopaque rock fragments with distinct outline, 2 to 11 mm in diameter, poorly sorted, equant to slightly elongate, polygonal, relatively straight sided, subangular corners; 10 percent is semiopaque with indistinct outline, appears as indistinct mottles, 1 to 4 mm in diameter with finely crenulate fadeout.

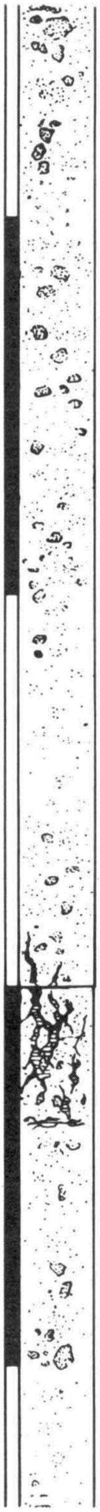
UNIT 33 Depth: TDS, 200 to 202.5 cm; lunar surface, 173 to 175.5 cm Thickness: 2.5 cm
Moderately thin bed with abundant rock fragments.
Matrix: 80 percent; intermediate transparency with some granules as unit 32.
Coarse fraction: 20 percent; 10 percent is semiopaque rock fragments with distinct outline, 2 to 5 mm in diameter, moderately well sorted, elongate-equant polygonal with straight edges, subangular corners; 10 percent is semiopaque with indistinct outline, 2- to 5-mm-diameter clods or mottles, fading out irregularly, but not on a crenulated margin.

UNIT 32 Depth: TDS, 202.5 to 205 cm; lunar surface, 175.5 to 177 cm Thickness: 1.5 cm
Thin bed with scattered rock fragments.
Matrix: 90 percent; intermediate transparency with ≈5 percent granules, 0.5 mm to limit of resolution.
Coarse fraction; 10 percent; semiopaque rock fragments with distinct outline, 2 to 3 mm, well sorted, ovoid and subrounded.

UNIT 31 Depth: TDS, 204 to 207 cm; lunar surface, 177 to 180 cm Thickness: 3 cm
Transparent matrix interval with scattered rock fragments.
Matrix: 95 percent; nearly uniformly transparent with only a trace of granularity or pinpoint opaques.
Coarse fraction: 5 percent; semiopaque, indistinct outline, 0.5- to 2-mm elongate mottles, resembling shard-like rock fragments, but indistinct.

UNIT 30 Depth: TDS, 207 to 209.5 cm; lunar surface, 180 to 182.5 cm Thickness: 2.5 cm
Finely mottled zone with sorted rock fragments.
Matrix: 70 percent; similar to unit 29 in being moderately opaque and finely mottled throughout.
Coarse fraction: 30 percent; 10 percent is semiopaque rock fragments, well sorted, 2.5 to 5 mm in diameter, elliptical, subangular to subrounded with even surfaces; 20 percent is semiopaque, indistinct to partially distinct outline, 1 to 6 mm in diameter, fading out over irregular but not highly crenulate edges.

Figure 17-3.- X-radiograph of Apollo 17 deep drill core (continued).



UNIT 48 Depth: TDS, 146.5 to 148 cm; lunar surface, 119.5 to 121 cm Thickness: 1.5 cm
Fine-grained thin bed with transparent matrix.
Matrix: 100 percent; uniformly fine grained with a trace of widely scattered and evenly distributed pinpoint mottles, near limit of resolution, no opaques.

UNIT 47 Depth: TDS, 148 to 151 cm; lunar surface, 121 to 124 cm Thickness: 3 cm
Medium-thin bed with moderately opaque matrix and scattered rock fragments.
Matrix: 85 percent; intermediate transparency because of 10 percent granularity and pinpoint density concentrations, but with a noticeable absence of opaques in contrast to unit 46.
Coarse fraction: 15 percent; semiopaque rock fragments with distinct to semidistinct outline, well sorted, 2 to 4 mm in diameter, equant to polygonal with relatively straight edges and subangular corners, slightly lumpy and irregular (not crenulate) fadeout on semidistinct edges.

UNIT 46 Depth: TDS, 151 to 154 cm; lunar surface, 124 to 127 cm Thickness: 3 cm
Transparent matrix and fine-grained interval with abundant opaque fragments.
Matrix: 100 percent; noticeably more transparent than in unit 45 with less than 5 percent pinpoint semiopaque density concentrations (in contrast to 20 percent of unit 45), 2 percent opaque particles, equant, subrounded polygons with a suggestion of straight edges or spheroids, less than 1 mm in diameter to limit of resolution.

UNIT 45 Depth: TDS, 154 to 156 cm; lunar surface, 127 to 129 cm Thickness: 2 cm
Moderately opaque interval, as in unit 44, but with no rock fragments.
Matrix: 100 percent; moderately opaque with ≈20 percent indistinct pinpoint mottles, near limit of resolution to 0.5 mm, but with no opaque spherules; contact with overlying bed appears very distinctly as an irregularly planar surface, with striking decrease in density in overlying unit 46.

UNIT 44 Depth: TDS, 156 to 160 cm; lunar surface, 129 to 133 cm Thickness: 4 cm
Moderately opaque interval with small, scattered, sorted rock fragments.
Matrix: 85 percent; moderately opaque with ≈20 percent indistinct equant mottles, near limit of resolution to 0.5 mm, 1 percent opaque spherules less than 0.5 mm in diameter.
Coarse fraction: 15 percent; semiopaque with partially distinct outline (probably partially concealed by density of matrix), 3 to 5 mm, well sorted, equant to ovoid, subrounded particles, long axes tend to be alined horizontally.

UNIT 43 Depth: TDS, 160 to 164 cm; lunar surface, 133 to 137 cm Thickness: 4 cm
Rock fragmental unit fractured at top of core.
Matrix: 70 percent; appears similar to that of unit 42, but is strongly permeated by cracks and fractures, contains ≈20 percent finely granular mottles, traces of opaque spherules, near limit of resolution.
Coarse fraction: 30 percent; clumps or rock fragments with distinct outline, 2 to 11 mm in diameter, subovoid to polygonal with irregular angularly wavy edges most commonly defined by cracks in matrix.

UNIT 42 Depth: TDS, 164 to 166 cm; lunar surface, 137 to 139 cm Thickness: 2 cm
Thin bed with moderately opaque matrix and small sorted rock fragments.
Matrix: 80 percent; intermediate opacity, finely mottled with 20 percent pinpoint mottles, less than 1 mm in diameter, but no opaques.
Coarse fraction: 20 percent; semiopaque rock fragments with moderately distinct outline, 1 to 4 mm in diameter, average 2.5 mm with few fragments being much smaller or larger, fragments with one or two relatively straight margins, but fading out along crenulate margins on other side of fragment.

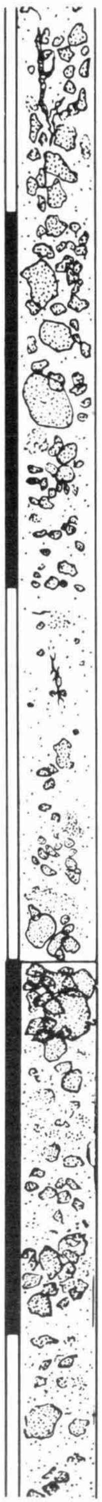
UNIT 41 Depth: TDS, 166 to 170 cm; lunar surface, 139 to 143 cm Thickness: 4 cm
Fine-grained interval with scattered fine mottles and sparse rock fragments.
Matrix: 95 percent of intermediate to low opacity, with 5 to 15 percent mottles under 1 mm in diameter and ≈1 percent spherical opaques, limit of resolution to 0.8 mm.
Coarse fraction: 5 percent; semiopaque rock fragments with distinct outline, blocky slightly elongate with relatively straight edges and angular corners.

UNIT 40 Depth: TDS, 170 to 170.5 cm; lunar surface, 143 to 143.5 cm Thickness: 0.5 cm
Thin rock layer.
Matrix: 60 percent; moderately transparent and uniformly fine grained.
Framework: 40 percent; semiopaque rock fragments with distinct outline, 1 to 4 mm in diameter, moderately well sorted, equant to slightly elongate, with smoothly faceted to blocky outline, subangular to angular corners.

UNIT 39 Depth: TDS, 170.5 to 174.5 cm; lunar surface, 143.5 to 147.5 cm Thickness: 4 cm
Fine-grained interval with indistinct granules.
Matrix: 95 percent; moderately high transparency, but with 2 percent opaques, ranging from spheroids at limit of resolution to shards 1 mm long; elongate opaques tend to have long axes alined horizontally.
Coarse fraction: 5 percent; semiopaque density concentrations with indistinct outline, 1 to 3 mm in diameter with regular and even fadeout as in unit 37.

Figure 17-3.- X-radiograph of Apollo 17 deep drill core (continued).

Depth, cm | Unit



UNIT 57 Depth: TDS, 110.5 to 115 cm; lunar surface, 83.5 to 88 cm Thickness: 4.5 cm
Medium-thin bed with sparse small rock fragments and abundant opaques.
Matrix: 90 percent; intermediate to high transparency and with 10 to 15 percent semiopaque granules, 1 mm in diameter to limit of resolution, ≈1 percent blocky to spherical opaque fragments as much as 1 mm in diameter.
Coarse fraction: 10 percent; 5 percent is semiopaque rock fragments with distinct outline, well sorted, 1 to 2 mm in diameter, equant and blocky with angular corners; 5 percent is semiopaque mottles, 2 to 3 mm in diameter with crenulate fadeout as in unit 56.

UNIT 56 Depth: TDS, 115 to 119 cm; lunar surface, 88 to 92 cm Thickness: 4 cm
Medium-thin bed with small well-sorted rock fragments.
Matrix: 80 percent; intermediate to high transparency with less than 10 percent fine granularity, only trace amounts of spherical opaques, near limit of resolution.
Coarse fraction: 20 percent; 15 percent is semiopaque rock fragments with distinct outline, well sorted, mostly 2 to 4 mm in diameter, blocky and equant to bladed and elongate with relatively straight sides and angular corners; 5 percent is semiopaque density concentrations with indistinct crenulate fadeout. These fragments range from 1 to 5 mm in diameter and are randomly distributed throughout the unit.

UNIT 55 Depth: TDS, 119 to 122.5 cm; lunar surface, 92 to 95.5 cm Thickness: 3.5 cm
Thin bed packed with basalt fragments. (2.5 cm of this unit are in core 70007, and 1 cm is in the base of core 70007.)
Matrix: 30 percent; relatively transparent, very finely granular with no opaques.
Framework: 70 percent (examined during end sampling for early allocation); packed with semiopaque rock fragments with distinct outline, equant, poorly sorted, blocky fragments with nearly straight edges; on examination of actual speci-
58 mens, they turned out to be coarsely crystalline basalt fragments with 15 to 20 percent vesicles as much as 5 mm in diameter. No other rock types were present.

UNIT 54 Depth: TDS 122.5 to 127 cm; lunar surface, 95.5 to 100 cm Thickness: 4.5 cm
Massive unit with mixed rock fragments and relatively transparent matrix. In X-radiograph, this unit appears to be very similar in composition to unit 52.

UNIT 53 Depth: TDS, 127 to 129 cm; lunar surface, 100 to 102 cm Thickness: 2 cm
57 Thin bed, packed with rock fragments.
Matrix: 50 percent; relatively transparent, sparingly mottled, apparently as in unit 52, but mostly concealed by abundant rock fragments.
Framework: 50 percent; 45 percent is semiopaque rock fragments with distinct outline, moderately well sorted, 2 to 9 mm in diameter, but mostly 5 ±1 mm, blocky, smooth-edged and subangular fragments, similar to those of unit 52, but much more abundant; 5 percent is semiopaque mottles, averaging 2 to 3 mm in diameter with irregular lumpy to indistinct outline.

56

UNIT 52 Depth: TDS, 129 to 134 cm; lunar surface, 102 to 107 cm Thickness: 5 cm
Massive unit with mixed rock fragments and transparent matrix.
Matrix: 70 percent; relatively transparent with ≈5 percent fine semiopaque mottles less than 1 mm in diameter, a trace of spherical opaques, near limit of resolution.
Coarse fraction: 30 percent; 20 percent is semiopaque rock fragments with distinct outline, poorly sorted, ranging from 1 to 8 mm in diameter, tending to be blocky to wedge-shaped equant fragments; 10 percent is semiopaque density con-
55 centrations with indistinct outline, 2 to 5 mm in diameter, fading out over an irregular to lumpy outline as in unit 51.

UNIT 51 Depth: TDS, 134 to 138.5 cm; lunar surface, 107 to 111.5 cm Thickness: 4.5 cm
Massive interval with granular matrix and abundant clods and rock fragments.
Matrix: 70 percent; moderately opaque with ≈20 percent pinpoint to 0.5-mm semiopaque granules scattered throughout, traces of opaque spherules less than 0.5 mm in diameter.
54 Coarse fraction: 30 percent; 5 percent is semiopaque rock fragments with distinct outline, 2 to 5 mm in diameter, moderately poorly sorted, blocky outline with straight to nearly straight edges; 25 percent is semiopaque mottles or clods with indistinct outline, ranging up to 8 mm in diameter, but very poorly sorted. Fragments, possibly breccias, tend to have a lumpily irregular appearance and are not crenulate. Entire interval appears to be reverse graded and is roughly coarser at the top.

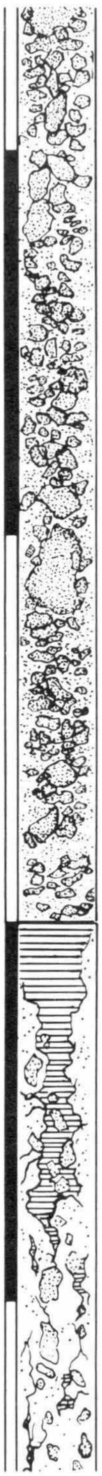
53 UNIT 50 Depth: TDS, 138.5 to 140 cm; lunar surface, 111.5 to 113 cm Thickness: 1.5 cm
Fine-grained thin bed with high transparency matrix.
Matrix: 100 percent; as in unit 48, uniform with trace of pinpoint mottles and opaques.

UNIT 49 Depth: TDS, 140 to 146.5 cm; lunar surface, 113 to 119.5 cm Thickness: 6.5 cm
Medium-thin bed with moderately opaque matrix and scattered rock fragments.
52 Matrix: 85 percent; intermediate transparency with 10 percent granularity, but with noticeable absence of opaque fragments or density concentrations.
Coarse fraction: 15 percent; semiopaque rock fragments with distinct to semidistinct outline, moderately well sorted, 2 to 5 mm in diameter, equant to polygonal with generally straight edges and subangular corners, even fadeout areas where edges are indistinct.

Figure 17-3.- X-radiograph of Apollo 17 deep drill core (continued).

Depth, cm

Unit



60

80

70008

70007

UNIT 64 Depth: TDS, 15 to 18 cm; lunar surface, 0 to 3 cm Thickness: 3 cm
Fine-grained unit with transparent matrix and scattered opaque spheroids.
Matrix: 100 percent; high transparency with ≈ 10 percent density concentrations and semiopaque granules less than 1 mm in diameter; 1 percent opaque shards and spheroids ranging from 1 mm in diameter to limit of resolution. On the X-radiograph, the unit appears to fade out over a 2-cm distance along the upper margin because of slumping.

UNIT 63 Depth: TDS, 18 to 23 cm; lunar surface, 3 to 8 cm Thickness: 5 cm
Massive fine-grained unit with coarse but indistinct mottles.
Matrix: 100 percent; intermediate to high background transparency, but with 50 to 60 percent indistinct mottles as much as 2 mm in diameter, granular density concentrations generally less than 1 mm in diameter.

UNIT 62 Depth: TDS, 23 to 26 cm; lunar surface, 8 to 11 cm Thickness: 3 cm
Fine-grained interval with sorted small rock fragments and clod-like particles.
Matrix: 75 percent; relatively opaque because of granularity, represented by 30 percent semiopaque density concentrations less than 1 mm in diameter, but with no opaques.
Coarse fraction: 25 percent; 15 percent is semiopaque rock fragments with distinct outline. Rock fragments are well sorted, 1.5 to 4 mm in diameter, equant to subequant with irregular lumpy outlines; 10 percent is semiopaque crenulate mottles less than 5 mm in diameter.

UNIT 61 Depth: TDS, 26 to 29.5 cm; lunar surface, 11 to 14.5 cm Thickness: 3.5 cm
Medium-thin bed with abundant, mixed rock fragments.
Matrix: 55 percent; moderately opaque (but noticeably less opaque than unit 60) with 20 percent semiopaque granular density concentrations, less than 0.5 mm in diameter, no opaques.
Framework: 45 percent; 35 percent is semiopaque rock fragments with distinct outline. (Of the semiopaque rock fragments, 25 percent is represented in equant rock fragments with irregular, lumpy, subangular to subrounded outline. These fragments are poorly sorted, ranging from 1 to 9 mm in diameter. The other 10 percent of distinct-outlined rock fragments is elongate chips, splinters, and blocky rock fragments with straight edges and angular to subangular corners, but these fragments are as poorly sorted as the equant fragments). Remaining 10 percent of framework consists of semiopaque crenulate mottles 2 to 6 mm in diameter.

59 UNIT 60 Depth: TDS, 29.5 to 32.5 cm; lunar surface, 14.5 to 17.5 cm Thickness: 3 cm
Fine-grained interval with clod-like coarse fraction.
Matrix: 80 percent relatively opaque, distinctly granular with 30 percent semiopaque granular density concentrations, less than 1 mm in diameter, a trace of pinpoint spherical opaques.
Coarse fraction: 20 percent; semiopaque crenulate mottles and density concentrations, 2 to 5 mm in diameter, with fairly even size distribution, indicating good sorting if these particles represent rock fragments and not soil clods.

UNIT 59 Depth: TDS, 32.5 to 106 cm; lunar surface, 17.5 to 79 cm Thickness: 61.5 cm
Note: Soil in unit 59 consists of 38 cm in 70008, 16 cm in 70007, and 7.5 cm in 70009. The 16 cm of soil in 70007 comprised 6 cm of drill stem packed with sample and 20 cm of drill stem averaging 50 percent full; thus, a total of 16 cm.
Massive unit packed with poorly sorted, large rock fragments.
Matrix: 50 percent; moderate to low transparency with 30 to 50 percent fine semiopaque granules less than 1 mm in diameter, a trace of opaque spherules, 0.5 mm in diameter to limit of resolution.
Framework: 50 percent; 45 percent is semiopaque rock fragments with distinct outline, 1 mm to 2.5 cm in diameter. Fragments are very poorly sorted, mostly equant to ovoid-elongate with blocky or irregular polygonal outline, angular to subangular corners; 5 percent is semiopaque density concentrations with indistinct outline, but fading out smoothly to slight unevenly, not fading out over crenulate margins.
In 70008, there are especially large rock fragments at approximately 16 and 30 cm from the top; otherwise, characteristics of the unit seem to apply throughout.

UNIT 58 Depth: TDS, 106 to 110.5 cm; lunar surface, 79 to 83.5 cm Thickness: 4.5 cm
Medium-thin bed with abundant, small, well-sorted rock fragments.
Matrix: 70 percent; moderate transparency with approximately 25 percent finely granular texture, granules semiopaque, less than 1 mm in diameter, a trace of spherical opaques, near limit of resolution.
Coarse fraction: 30 percent; 25 percent is semiopaque rock fragments with distinct outline, well sorted, all fragments being 2.5 ± 1 mm in diameter; most fragments are slightly elongate rectangular polygons to chips with sharply curved edges and angular corners. The other 5 percent is semiopaque crenulate mottles 1 to 3 mm in diameter, possibly breccia fragments.

Figure 17-3.- X-radiograph of Apollo 17 deep drill core (continued).

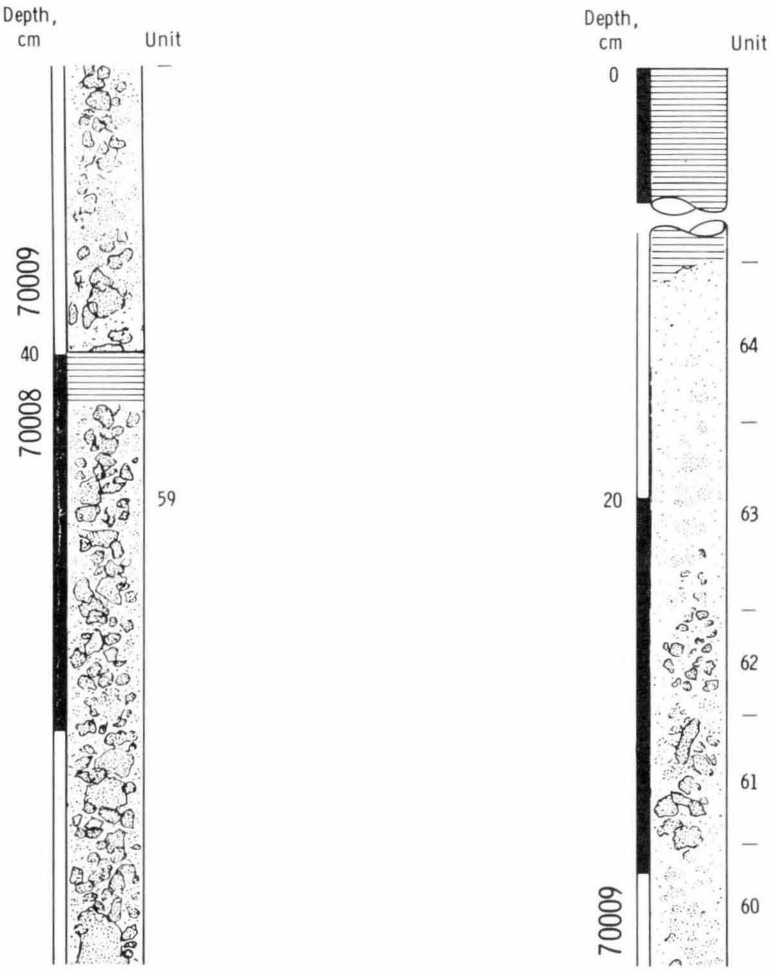


Figure 17-3.- X-radiograph of Apollo 17 deep drill core (concluded).

Early Sampling of 70008 and 70008

Although stratigraphic information is detailed subsequently, it should be noted here that 70001 and 70008 were dissected at the time of preliminary examination to provide material for biomedical study as well as analysis of fast neutrons and short-lived unstable isotopes. As with the other early splits, allocation from 70001 required only very fine fines, hence, incremental splits from 70001 were passed through a .125 mm sieve until the 12 gm. biomedical allocation was completed. The coarser-grained remains were further split at 1 mm., and are currently stored in the Lunar Curatorial Laboratory.

Two early allocations were extracted from 70008 immediately after opening and prior to dissection in order to study short half life unstable isotopes before their abundance diminished below measurability. The remainder of the core was dissected according to standard procedures.

DISSECTION AND DETAILED SAMPLING OF THE DRILL STRING

Dissection of the drill string takes place according to the standard procedure outlined in Chapter 1. Hence, only salient dates and special modifications to procedure for individual cores will be listed in this chapter. Information obtained during dissection provides a basis for defining stratigraphic units and interpreting their origin. The preliminary surface description, conducted immediately after opening, yields data on color, cohesiveness and fracture patterns, surface texture, and gives an idea of composition on the basis of visually estimated abundance of components. Quantitative data on coarse size fractions, and abundance of each component in the coarse fraction is collected during dissection, and has been reduced and compared by computer for the Apollo 17 drill string.

ANALYSIS OF DATA

The collected quantitative data consists of the weights of the fine fraction and coarse fraction of each interval, plus the weights of special samples. In addition, frequency counts of particles in the coarse fraction were taken in three size ranges-1.2 mm., 2-4 mm,, and greater than 4 mm. For most cores, each size range is also subdivided into seven compositional types. Frequencies are computer-normalized to the standard interval width and average unit weight. Normalized frequencies are plotted by interval in four groupings: by compositional type for the combined size ranges; by combined compositions for the 1-2 mm. size range; by combined compositions for the 2-4 mm. size range; and by combined compositions for the combined size ranges. The three size ranges are combined using an 8:1 factor between adjacent size ranges. It should be noted that some bias is introduced by the size of the tube relative to the size of large rock fragments.

PARAMETERS USED IN ANALYSIS

A number of parameters are analyzed in order to stratigraphically distinguish different layers within the core, and to gain evidence upon the origin of the soil. These parameters include: Color, grain size and sorting, angularity, packing, composition, and cohesiveness with its corollary, tendency to disaggregate.

Color

Color, of all samples, is matched to chips on Munsell's color chart, during examination under fluorescent house lights. It should be noted that hues and values appear different under variations in lighting conditions. Accordingly, an attempt has been made to standardize vicinity condition as much as possible, to maximize reproducibility. In general, the Apollo 17 core appears to be somewhat darker than A 15 and A 16 cores, probably reflecting high mafic content.

Grain Size and Sorting

Measurements of size classes greater than 1 mm. are determined during dissection in order to obtain quantitative data not otherwise available because textural allocations and studies are generally made only on the fine size fraction. Although complete size analyses are not available from these data, some size and sorting trends can be determined from the quantitative measure of coarse fines combined with visual estimates of fine fines. Furthermore, bimodality of sorting, an indicator of texturally immature or inverted soils can be established from the available data.

Angularity and Packing

Shape of most rock fragments in lunar soils is closely related to composition; for instance, crystalline or fractured glassy particles tend to be sharply angular, whereas friable, low-grade breccias are almost always well-rounded. Exceptions to these tendencies are noted, as they are evidence for distinctive conditions during deposition. Likewise, most lunar soils are sparse in rock fragments, which tend to be "floating" in a matrix of fines; a framework texture, with rock fragments packed, and in contact, is noted as evidence of unusual conditions of deposition.

Compositional Descriptions

Descriptions used herein differ in detail from those of large rocks described by LSPET because the scale of features in small rocks found in the cores does not always allow for comparable descriptions. For instance, foliated or coarsely vesicular rocks cannot be recognized in fragments that could fit into cores, but finely crystalline basalts or glassy agglutinates are easily distinguished. By coincidence, seven categories of rock types appear to be common in the coarse fraction of the Apollo 17 drill string, but these are not exactly comparable to the seven major categories of rock types described in the Apollo 17 Preliminary Science Report, Chapter 7. Rock types that appear to be comparable include basalts (BSRF), glass-bonded agglutinates (AGGL), and brecciated gabbroic or anorthositic rocks (ANBX). Other categories of glassy particles noted in the cores, devitrified or partially crystallized glass (PXGL) and vesicular glass (VSGL), as well as recrystallized breccias (RXBX) and soil breccias (SOBX) are not exactly comparable to the dark matrix breccias, vesicular green-gray breccias, blue-gray breccias, and layered to foliated light gray breccias reported in descriptions of larger rock fragments (LSPET, 1973, p. 7-5).

The category "basalt rock fragment" includes all particles which are polycrystalline, relatively mafic, but with plagioclase and pyroxene, and which do not appear to be recrystallized. There seems to be an intergradational suite of polycrystalline rocks in the cores, most of which seem to represent fragments of rock types listed in the Preliminary Science Report, Chapters 6 and 7, but most of which are too small to definitively characterize. In practice, some of the smaller particles which are classified as basalts may be monomineralic. Also, many particles are soil coated or glass coated to the point of being barely recognizable. Some soil coated BSRF's may have been misclassified as soil breccias. Most BSRF's occur as fairly equant chunks with coarsely-textured surfaces. When the rough "pockets" in the surface are filled with soil matrix, they are easily mistaken for the equant, smooth-surfaced soil breccias. Effort was taken to remove as much loose soil as possible from the supposed soil breccias without significantly damaging the normally friable soil breccias in the process. Also, some BSRF's have shocked plagioclase or anorthositic material.

"Soil breccia" refers to particles of cohesive soil matrix. Along with basalt fragments, soil breccias represent the most common coarse particle types found in the Apollo 17 drill string. Many soil breccias in the Apollo 17 drill string contain abundant black glass droplets, and may be partially welded by heat, pressure, small amounts of molten glass, or may simply reflect heavy compaction. Some soil breccias are partially coated with shiny, vesicular glass, and are arbitrarily defined as soil breccias if the glass is massive, not spindly, and occupies less than half of the particle. (Spindly or amoeboid glassy particles are classified as agglutinates, although such particles characteristically have soil adhering to one side. Soil breccias are usually friable, and occasionally break open to reveal an interior of crystalline "mash". Other simply disintegrate when broken. Some particles of other categories maybe misclassified as soil breccias because of heavy soil coating. Soil breccias, as well as fresh glassy agglutinates and similar particles originate within the regolith, in contrast to crystalline rocks and high-grade breccias, and a predominance of soil breccias points to a shallow regolithic source and/or high degree of reworking.

Vitreous rock types include devitrified glass and three categories of fresh glass, characterized by a fresh, lustrous surface, but occurring in genetically distinct agglutinates, droplets, and vesicular fragments. Agglutinates consist of soil welded together by dark glass, and restricted, by definition, to particles of irregular, amoeboid to spindly shape. Although relatively rare in the coarse fraction, such particles may make up a significant portion of finer grain sizes. In conjunction with textural properties, relative abundance of agglutinates provides an idea of soil maturity; furthermore, condition of agglutinates reflects amount of reworking. When frothy or shiny surfaces are <u>consistently up</u>, and fragments are not internally fractured, agglutinates are probably in situ, reflecting no reworking since deposition, whereas when soil-coated and shiny surfaces are randomly oriented and overturned, and agglutinates fragmented, reworking has taken place.

Droplets formed by condensation during flight, and tend to occur higher in a depositional sequence than agglutinates. Although common in some cores, droplets over 1 mm. have not been found in upper sections of the Apollo 17 drill string.

The third morphological type of fresh glass is "vesicular glass", a frothy, finely bubbly glass which may occur as crusts on rock fragments or soil, or as equant fragments, chips, or shards. This glass is usually dark, may be banded because of mixing with regolith components, and is distinguished from devitrified glass by the fresh vitreous appearance. The abundance of fractured pieces of vesicular glass can give an idea of the amount of reworking, because a great abundance of fractured glass indicates reworking than an abundance of whole, unbroken particles.

"Partly crystallized glass" or devitrified glass is described as "vitreous breccia, black aphanite, or melt breccia" in other core reports. It is a dark gray to blackish substance which may have vitreous inclusions, but is characteristically not clearly crystalline, and it may have relict conchoidal fracture. This category encompasses an intergradational sequence of rock types, and includes glass in all stages of devitrification, with or without breccia inclusions, and with or without micrycrystallinity, although vitreous luster is not present. In general, this "catchall" category includes material that probably represents comminuted fragments of breccias that at one time held a melted matrix; as such this category probably encompasses a number of LSPET rock types that cannot be further classified because fragments in the cores are too small. Interpretive possibilities of this rock type are relatively limited because of the large range of potential sources and indeterminate nature of disintegration during reworking.

In the Apollo 17 drill string, the ANT suite seems to be represented by crystalline anorthosites or anorthisitic gabbros, and by internally pulverized material, referred to as anorthosite breccia. Most of these rock fragments are less than 2 mm. in diameter, and tend to be rounded. Crystalline anorthosite and anorthositic gabbros is coarse-grained, and in core fragments, appears much richer in plagioclase than subfloor basalts and gabbros. Anorthosite breccias are crumbly in texture, chalky in appearance, equant and subrounded, and may or may not contain dark inclusions. Anorthositic rocks are believed to originate on the massifs, although it is possible to have pockets of locally anorthositic material in the valley floor. However, small particle size and tendency for good rounding point to a relatively distant source, and suggest that abundance of such particles can be used as an indicator of massif contribution to the local regolith.

"Recrystallized breccia: occurs as angular particles which tend to be waxy in appearance, and has the appearance of material reconstituted from anorthositic or soil breccia. This category may be called microcrystalline melt breccia in other core reports, and may include some of the blue-gray and green-gray breccias of the Preliminary Science Report. In general, this category is hard to characterize, and may include some indefinite particles; however, such particles are not common and show little effect on the overall composition of the core.

DRILL STEM 70009

Drill stem 70009 was only partly filled since it was the uppermost part of the drill string. The teflon follower that was inserted on the Moon in order to contain the soil slipped in the tube when temperature changes caused it to contract to the point where sufficient plug-to-tube contact could not be maintained. Hence, an indeterminate amount of slumping took place. The follower plus was subsequently replaced and the soil reconfined. This was done in a nitrogen cabinet on 27 February 1973. During reconfinement, some soil lodged around the new follower plug. Although the soil in this drill stem was unconfined during return, at least 60% was relatively undisturbed. This is evidenced by the intact drilling rind in the lower portion of the core. In contrast, many bits of teflon were found within the soil of the upper eight centimeters, where the rind was not intact and the core otherwise disturbed. (One piece of teflon was found in the soil of the lower portion, but it was apparently scraped off the tube joint by the rock fragment to which it adhered.) Further indication of the validity of this assumption is the presence of sharp compositional frequency peaks in the lower portion, rather than random scattering.

Pre-Dissection Description

From X-radiographs of drill stem 70009, six units were interpreted on the basis of size distributions and inferred compositions. (See the attached chart.)

On 28 March 1975, processing of the drill stem began by splitting the tube longitudinally using a milling machine. After being affixed in the dissection table, the upper half of the tube was lifted off and set aside. Reference scales were placed so that the lower plug/soil interface was aligned with the 40 cm. mark. The upper interface then became established at 14.9 cm.

Examination of the exposed surface of the core revealed no apparent color or tonal differences. Consequently, no layering could be inferred based on that parameter. The overall color was 10y 3/1 on Munsell's color chart.

Variations in the gross surface texture (development of a rind of compacted soil) give some indication of changes in physical properties of the soil. At the lower end of the core, from 40 cm. up to about 30 cm., the rind is well-developed and nearly complete. A deep fissure occurs from 38 to 40 cm. The rind is also well-developed between 25 and 28 cm. The rest of the surface has rind "platelets" scattered randomly or has no rind whatsoever.

Under binocular observation, possible textural changes were placed at 21.2, 24.4, 27.9, and 30.1 cm. These divisions were based on both gross surface texture and observable large particles.

Special Processing Procedures

Dissection commenced at the upper end of the core. The first interval consists of soil slumped and packed around the follower from

TABLE XVII -3. LIST OF PHOTOGRAPHS OF CORE 70009

Premilling, top	S-73-19382	
Premilling, bottom	S-73-15048	
Followers	S-73-19381	
Predissection	S-75-24316	(Overall Shot)
Predissection	S-75-24307	
	to - 315	(Stereo Series)
Peel & Preimpreg.	S-75-27895	(Overall Shot)
Peel & Preimpreg.	S-75-28108	
	to - 115	(Stereo Series)
Peel	S-75-28107	(Overall Shot)
Prepeel	S-75-28116	
	to - 122	(Stereo Series)

Coarse Fraction Photos

Sample Number	Photo Number	Sample Number	Photo Number	Sample	Photo
6	S-75-24759	72	S-75-26656	124	S-75-27011
8	24761	74	26655	126	27010
10	24760	76	26654	128	27008
12	24871	78	27023	129	27007
14	24870	80	27024	130	27006
16	24867	81	27025		
18	24869	82	27026		
20	24866	84	27027		
22	24856	86	27028		
24	24868	88	27029		
26	24858	89	27022		
28	24857	90	27021		
30	25103	91	27020		
32	25819	92	27019		
34	25817	93	27018		
36	25818	94	27017		
38	25887	96	27016		
40	25888	97	27015		
42	26566	98	27014		
44	26567	100	27044		
46	26568	101	27043		
48	26570	102	27042		
50	26569	104	27041		
52	26515	106	27040		
54	26517	108	27039		
56	26527	110	27037		
57	26526	111	27036		
58	26524	112	27038		
59	26525	113	27032		
60	26516	114	27031		
62	26660	116	27030		
64	26659	118	27009		
66	26658	120	27012		
70	26657	121	27013		

12.3 to 14.9 cm. The soil confined between plugs from 14.9 to 40.0 cm. was dissected in standard half centimeter intervals down to 80% of the tube diameter. A 6 mm. interval was taken from 14.9 to 15.5 cm. in order to even up the interval numbering system. Two half-standard intervals were taken between 21.0 and 21.5 cm. due to an apparent change in the nature of the core as indicated by the surface texture. Red light and "inside/outside" samples were taken from 28.5 to 30.0 cm. after the outer rind was removed. Only one of each was taken along the entire length of the stem due to the coarseness of the remaining material and the disturbed nature of the finer upper intervals. Unusual particles or large particles transcending interval boundaries were set aside as separate samples.(Fig. 17-5)

The soil matrix is coarser than that of the Apollo 16 deep drill string--like that of a fine silt compared to a clay. Large amounts of glass impart a sparkling appearance to the soil. Fracture faces on soil clods have a phyllitic-like sheen. Dark particles account for a "salt-and-pepper" appearance under magnification.

Interpretation of Stratigraphic Units (Fig. 17-4)

Before milling, the soil in the drill stem was pushed up about five millimeters when the securing hardware forced the teflon tube plug back into its proper position. Consequently, the X-radiograph interpretation depth markings are different as compared to the scale markings used in dissection. Also, photo distortion may have caused slight misalignment. Any attempt at precise correlation between the X-radiograph interpretation and the dissection interpretation should keep these facts in mind.

The dissection interpretation that follows uses grain size frequency variations and trends as its basis. (See appendices.) Compositional variations and other properties are used as additional aids in interpretation. Matrix percentages were determined by weight. The matrix material in all units was less tightly-packed and less cohesive than that of the Apollo 16 drill string. Vertical faces along interval boundaries were difficult to maintain during dissection.

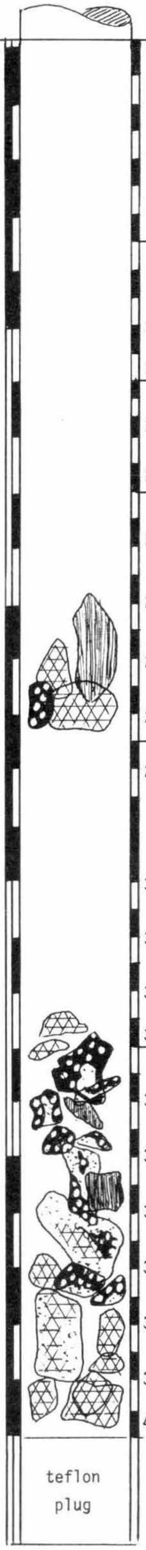
Unit VI (14.9-18.5) is composed of nearly 100% fine fines. The few particles larger than 1 mm. are mostly welded clods of matrix (soil breccias) or an occasional basalt rock fragment.

Unit V (18.5-21.0) is 95% matrix. A sharp rise in the frequency of particles in the 1-2 mm. size range places the break at 18.5 cm. This break was placed at 18.0 cm. by the X-radiograph interpretation. No break was indicated by surface texture interpretation.

Unit IV (20.5-23.0) is 90% matrix. An increase in both the 1-2 mm. and 2-4 mm. size ranges places the break at 20.5 cm. The contact between units IV and V is apparently sloped. X-radiograph interpretation combined units IV and V whereas surface texture interpretation placed a break at 21.2 cm.

Units IV, V, VI are in a zone of slumping and may reflect sorting from this source. Taken as a single unit, all properties are uniform except for a coursening downwards.

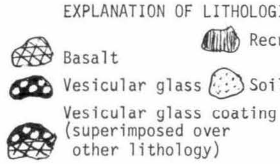
STRATIGRAPHIC UNITS IN DRILL STEM 70009



DEPTH (below lunar) (surface, cm.)	Sample Interval (LCL inventory)	Unit Thickness Samples	Characteristics	Sub-Units
	14.9, 16.0, 17.0, 18.0	70009,VI 3.6 cm. Nos.-,7-,20	Very fine-grained (over 99% FTI mm) crumbly siltsoil, rich in agglutinates.	not subdivided
3.6			-----Transition	
	19.0, 20.0, 21.0	70009,V 2.5 cm.thick Nos.,21-,30	Fine-grained (96% FTI mm) crumbly siltsoil, rich in authigenics (agglutinates and soil breccias)	not subdivided
6.1			-----Transition	
	22.0, 23.0	70009,IV 2.0 cm.thick Nos.,31-,40	Moderately fine-grained, (90% FTI mm) relatively cohesive sandy siltsoil with abundant agglutinates, soil breccias droplets and reflective particles.	B. 21.0-21.5 Relatively cohesive holding cast of core tube, and relatively rich in basalt. A. 21.5-23.0 Slightly less cohesive polymict but with abundant glass-coated soil breccia.
8.1			-----Distinct textural change from cohesive to crumbly	
	24.0, 25.0, 26.0, 27.0	70009,III 4.5 cm.thick Nos.,41-,62	Coarse-grained unit (55% FTI mm) Poorly sorted gravelly sandsoil polymict composition	B. 23.0-25.0 Coarse-grained, with crumbly surface polymict, but with agglutinaceous soil breccia common (as opposed to very rare in sub unit A) relatively crumbly Transition A. 25.0-27.5 Very coarse-grained, polymict, with breccia fragments common, surface becomes more cohesive downward breaks to equant 2-5 mm polygons.
12.6			-----Distinct textural change from relatively cohesive to crumbly	
	28.0, 30.0, 31.0, 32.0	70009,II 5.5 cm.thick Nos., 63-,84	Moderately fine-grained sandy siltsoil (75% FTI mm) with small rock fragments dominated by basalt and soil breccia	B. 27.5-30.0 Coarser than sub unit A, with more basalts and agglutinates, less cohesive with crumbly surface. A. 30.0-33.0 Sparse in rock fragments, surface is relatively cohesive, breaks to elongate prisms.
18.1	33.0		-----Transition	
	34.0, 35.0, 36.0, 37.0, 38.0, 39.0, 40.0	70009,I 7.0 cm. thick Nos.,85-,130	Very coarse-grained, poorly sorted rock fragmental unit with 65% rock fragments, compositionally with internal transition from basalts at base to glass-coated rock fragments at top.	C. 33.0-36.0 Glass-fragment sub unit, with abundant soil breccias and crystallines, nearly all of which are coated with vesicular to agglutinaceous glass. B. 26.0-37.5 Polymict sub unit with soil breccia as well as mare basalt abundant; vesicular spatter glass common. Transition A. 37.5-40.0 Basaltic sub unit, with coarse-grained gabbro ("Subfloor basalt") predominant.
25.1				

teflon plug

EXPLANATION OF LITHOLOGIC SYMBOLS



- Basalt
- Vesicular glass
- Vesicular glass coating (superimposed over other lithology)
- Recrystallized glass
- Soil breccia (may include obscuring soil coating)

Figure 17-4. Stratigraphic Units, drill stem 70009

Unit III (23.0-27.5) is 55% matrix. The rind is continuous over the main portion of this unit. The break at 23.0 cm. is indicated by a decrease in the 1-2 mm. size range frequencies accompanied by an increase in the greater than 4 mm. size range frequencies. The variation in grain sizes may have allowed greater compaction, hence the well-preserved rind and possibly the creation of a barrier to slumping. Another indication of less disturbance is the presence of a suite of frothy-glass-topped soil breccias and vesicular glass in the 26.0 to 27.5 interval, yet no evidence of their presence appears elsewhere until 31.0 cm. X-radiograph interpretation placed the break at 29.5 cm. and subdivided the unit a 26.0 cm. into units 61 and 62. Surface texture interpretation placed the break at 27.9 cm.

Unit II (27.5-33.0) is 75% matrix. At 33.0 cm. the 1-2 mm. size range frequencies increase as well as becoming more uniform. The overall coarseness decreases. X-radiograph interpretation placed the break at 32.5 cm. and the surface texture interpretation placed it at 30.1 cm. Although the X-radiograph shows a large indistinct blotch from 27.5 to 29.5 cm., no large particle(s) were encountered during dissection. It may be that a dense particle is located below dissection depth (as is indicated on the side view X-radiograph).

Unit I (33.0-40.0) is 35% matrix. It is poorly sorted as indicated by variations in the size frequency distributions. The basalt content is relatively low after a large peak at the bottom of Unit II. Towards the bottom (38-40) basalt frequencies increase again. Frothy-glass-topped soil breccias and/or vesicular glass frequencies seem to increase in response to decreases in basalt. Abundances of partially crystallized or devitrified glass and recrystallized breccias are relatively high and peaks occur seemingly in response to low basalt abundances. The same relationship generally holds for soil breccias also. Soil breccias, however, may in fact be soil-coated particles of different composition. This unit continues in drill stem core 70008.

Origin of Strata

Units IV, V, and VI may have been one unit which was physically sorted by movements during the period of unconfinement. Overall, these units are fine-grained with no outstanding features. They may represent a long period of slow accumulation from various sources or they may have been derived from Unit III either before or after the core was drilled.

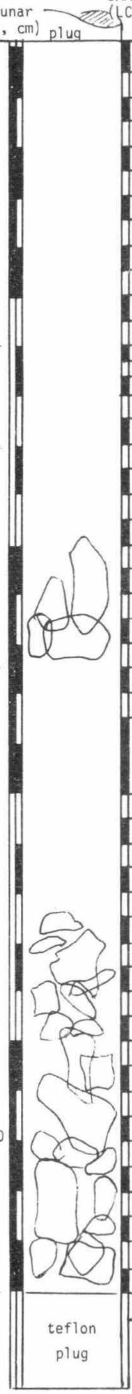
Unit II is fine-grained, yet coarser than Units IV, V, and VI. Soil breccias constitute most of the coarse fraction with a strong peak of basalt rock fragments at the bottom. It may represent slow accumulation and/or reworking of Unit I. Like Unit II, it has a peak of basalt rock fragments at its base with mostly soil breccias above. It probably represents a small or distant cratering event.

Unit I is a continuation of the upper portion of the 70008 drill stem core. Both soils have poor sorting with an abundance of large particles. Unit I has less matrix and larger particles than Unit III, also more complex lithology. At the top of the unit, reworked materials such as recrystallized breccias occur in greater frequencies. Many basalt rock

LOCATION OF SAMPLES, DRILL STEM 70009

Unit Thickness Samples / DEPTH (below lunar surface, cm):

- 70009, VI — 3.6 cm. thick — Nos. ,7 - ,20 — 3.6
- 70009, V — 2.5 cm. thick — Nos. ,21 - ,30 — 6.1
- 70009. IV — 2.0 cm. thick — Nos. ,31 - ,40 — 8.1
- 70009, III — 4.5 cm. thick — Nos. ,41 - ,62 — 12.6
- 70009, II — 5.5 cm. thick — Nos. ,63 - ,84 — 18.1
- 70009, I — 7.0 cm. thick — Nos. ,85 - ,130 — 25.1



SAMPLE INTERVAL (LCL inventory)	FINE FRACTION Sample No.	Vial No.	Sample Wt.	COARSE FRACTION Sample No.	Vial No.	Sample Wt.	SPECIAL SAMPLES Sample No.	Vial No.	Sample Wt.	Sample Interval	Distinctive Features
14.9-15.5	7	9-1555	1.560	8	9-1585	0.008					
15.5-16.0	9	9-1615	1.810	10	9-1623	0.005					
16.0-16.5	11	9-1636	1.883	12	9-1653	0.012					
16.5-17.0	13	9-1658	1.930	14	9-1665	0.006					
17.0-17.5	15	9-1668	2.025	16	9-1677	0.014					
17.5-18.0	17	9-1678	1.982	18	9-1701	0.036					
18.0-18.5	19	9-1715	1.845	20	9-1720	0.011					
18.5-19.0	21	9-1740	1.783	22	9-1749	0.067					
19.0-19.5	23	9-1770	2.010	24	9-1774	0.047					
19.5-20.0	25	9-1792	1.721	26	9-1805	0.070					
20.0-20.5	27	9-1819	1.931	28	9-1845	0.065					
20.5-21.0	29	9-1848	1.860	30	9-1911	0.110					
21.0-21.3	31	9-1921	0.987	32	9-1932	0.088					
21.3-21.5	33	9-1969	0.678	34	9-1979	0.070					
21.5-22.0	35	9-1986	2.054	36	9-1990	0.215					
22.0-22.5	37	9-2202	1.614	38	9-2204	0.184					
22.5-23.0	39	9-2217	1.718	40	9-2224	0.234					
23.0-23.5	41	9-2228	1.445	42	9-2245	0.191					
23.5-24.0	43	9-2253	1.475	44	9-2281	0.232					
24.0-24.5	45	9-2284	1.624	46	9-2300	0.138					
24.5-25.0	47	9-2302	1.591	48	9-2320	0.256					
25.0-25.5	49	9-2321	1.249	50	9-2324	0.163					
25.5-26.0	51	9-2336	1.428	52	9-2339	0.402	59	9-4047	0.820	264-48	RXBX
26.0-26.5	53	9-2369	0.955	54	9-2376	0.135	60	9-4048	0.345	267-58	BSRF
26.5-27.0	55	9-2382	1.522	56	9-2390	0.166	57	9-4004	0.800	272-61	BSRF
27.0-27.5	61	9-4050	1.402	62	9-4051	0.200	58	9-4034	0.150	272-64	VSGL
27.5-28.0	63	9-4056	1.675	64	9-4063	0.205					
28.0-28.5	65	9-4074	1.745	66	9-4104	0.126					
28.5-30.0	69	9-4125	4.367	70	9-4131	0.347	67	87-2300	0.380		RL
							68	9-4108	1.013		Low lead
30.0-30.5	71	9-4144	1.887	72	9-4146	0.150	81	9-4201	0.360	326-20	BSRF
30.5-31.0	73	9-4149	1.930	74	9-4159	0.158	82	9-4207	0.330	331-27	BSRF
31.0-31.5	75	9-4173	1.814	76	9-4178	0.135	89	9-5219	0.067	340-36	SOBX
31.5-32.0	77	9-4179	1.817	78	9-4180	0.174	90	9-5228	0.418	340-29	VSGL
32.0-32.5	79	9-4184	1.535	80	9-4189	0.127	93	9-5238	0.165	346-40	SOBX
32.5-33.0	83	9-4211	2.014	84	9-4240	0.225	94	9-5239	0.380	347-39	RXBX
33.0-33.5	85	9-4249	1.485	86	9-5099	0.100	97	9-5249	0.126	351-47	VSGL
33.5-34.0	87	9-5103	2.060	88	9-5134	0.333	98	9-5268	0.134	351-45	SOBX
34.0-34.5	91	9-5233	1.940	92	9-5236	0.361	101	9-5283	0.505	363-48	SOBX
34.5-35.0	95	9-5241	1.574	96	9-5242	0.267	102	9-5284	0.255	359-51	RXBX
35.0-35.5	99	9-5275	2.295	100	9-5280	0.460	111	9-1118	2.810	372-55	SOBX
35.5-36.0	103	9-5402	0.904	104	9-5410	0.184	112	9-1119	0.303	374-68	BSRF
36.0-36.5	105	9-5498	0.745	106	9-1102	0.192	113	9-1131	0.155	376-70	VSGL
36.5-37.0	107	9-1104	1.232	108	9-1111	0.518	114	9-1133	0.075	375-70	VSGL
37.0-37.5	109	9-1113	1.970	110	9-1116	0.504	121	9-1124	3.440	390-73	SOBX
37.5-38.0	115	9-1146	1.080	116	9-1153	0.400	122	9-1134	0.280	388-78	BSRF
38.0-38.5	117	9-1110	0.926	118	9-1114	0.450	123	9-1136	0.311	391-86	PXGL
38.5-39.0	119	9-1122	1.438	120	9-1127	0.123	124	9-1137	0.365	397-89	BSRF
39.0-39.5	125	9-1148	1.170	126	9-1154	0.302	129	9-1157	0.090	396-90	BSRF
39.5-40.0	127	9-1155	2.493	128	9-1156	0.420	130	9-1159	1.037	397-90	BSRF
14.9-12.3	5	9-1531	1.005	6	9-1545	0.005	Soil from around follower.				

Figure 17-5. Drill String 70009 Sample Location Information

fragments have chalky white "anorthositic" material replacing plagioclase. A nearby and/or large cratering event most likely formed this unit.

DRILL STEM 70008

Special Processing Procedures

Four early samples were removed for critical radiation counting early experimentation from the basal 0.5 cm., from 26.5 - 26.0 cm. from the top, from 13.5 - 13.0 cm. from the top, and 2.7 - 2.2 cm. from the top. These samples were distributed before further dissection took place.

Two intervals (26.5 - 27.5 and 20.5 - 21.5 cm. from top) were sampled in 1 cm. intervals, instead of the usual 0.5 cm. intervals, because the abundance of large rock fragments prevented the recovery of a sufficiently large sample in a normal interval.

Selected samples were passed through a 125μ screen, similar to the procedure for 70001, to determine comparativeness of size distribution, in light of the superabundance of coarse particles. In these same intervals, the larger fragments were sized according to minimum diameter and each size class (1 - 2 mm., 2 - 4 mm., etc.) weighed separately, in order to provide supplimentary sorting information on these bimodally-distributed samples.

Finally, after dissection and removal of coarse particles, small amounts of additional material were removed to a depth of 0.5 mm. with specially-constructed depth-controlled spatulas. Sample interval for these samples was 2 mm., rather than the usual 0.5 cm.; and quantities of soil removed from each interval were comparable to standard 2 cm. intervals.

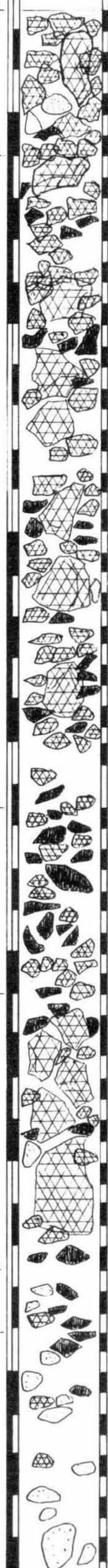
General Relationship to Drill String

In terms of the drill string as a whole (Fig.17-3), the interval represented by 70008 is part of Unit 59; that is, the 59th recognizable stratum from the base of the Apollo 17 drill stem. Unit 59 is notably coarse-grained, with no distinct stratification evident; this massive bed continues downward to include the upper 16 cm. of 70007, and upward to include the lowest 7.5 cm. of 70009. Many large rock fragments are evident in the X-radiograph. The most distinctive are oriented with long axis parallel to the wall of the drill stem, and are centered at 16 and 31 cm. below the top of the drill stem. Other rock fragments over 1 cm. in diameter appear at approximately 10 to 11 cm., and 29 cm. from the top of the drill stem.

Stratigraphic Summary (Table XVII-3)

The transitional nature of all units is evident in Figure 17-6, which shows the orientation and distribution of all particles larger than 4 mm. (Particles between 1 and 4 mm. were studied in similar detail, but it was not feasible to illustrate them in this figure.)

STRATIGRAPHIC UNITS IN DRILL STEM 70008



Apparent distance below Lunar Surface (cm)	Sample Interval (LCL inventory)	UNIT (Numeral) THICKNESS Samples in Unit	Characteristics	Sub-units
	2.3			
25.1	3.0, 4.0, 5.0	70008,VI 3.7 cm thick Nos.-,9-,19 -,151-,164-,166-,167	Very crumbly gravelly siltsoil with abundant basaltic rock fragments (40% coarser than 1 mm)	Not subdivided
28.8	6.0		Distinct change in texture	
	7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 14.4, 14.9, 15.9, 16.9, 17.1, 18.1, 19.1, 20.0, 20.5	70008,V 15.5 cm thick Nos.-,7-,8 -,84-,150 -,170-,175	Crumbly gravelly siltsoil with abundant rock fragments (45% coarser than 1 mm mare basalts and crystalline rock fragments predominant.	Not subdivided but shows a transitional increase upward in abundance of crystallines, and a corresponding decrease in glassy-matrix breccia.
44.3	21.5		Transition	
	22.0, 23.0, 24.0, 25.0	70008,IV 4.5 cm thick Nos.-,65-,83	Somewhat crumbly sparsely gravelly siltsoil, (similar to Unit II but coarser) with abundant flake-shaped fragments of dark recrystallized glassy breccia.	Not subdivided
48.8	26.0		Transition	
	26.5, 27.5, 28.0, 29.0, 30.0, 31.0, 32.0	70008,III 6.5 cm. thick Nos.-,5-,6 -,40-,64 -,165-,169	Crumbly gravelly siltsoil with abundant mare basalt fragments stuffed into core by drilling action (possibly remains of one rock) only 50% FTI mm.	Not subdivided
55.3	32.6		Sharp textural change-abrupt increase in cohesives below contact.	
	33.1, 33.6	70008,II 1.6 cm thick Nos.-,34-,39	Cohesive sandy siltsoil, with 85% finer than 1 mm, polymict with more glass-matrix breccias than Unit I, rock fragments mare angular.	Not subdivided
56.9	34.1		Transition	
	34.5, 35.0, 36.0, 37.0, 38.0, 39.0	70008,I 6.2 cm thick Nos.-,3-,4 -,11-,33	Cohesive, Sparingly gravelly siltsoil with 75% finer than 1 mm, relatively abundant soil breccia, most rock fragments distinctively rounded.	B. gradually coarser-grained with large fragments of soil breccia increasing in abundance. A. Basic composition of unit.
63.1	40.3 base of core			

teflon plug (top and base of column)

EXPLANATION OF COMPOSITION SYMBOLS

- Crystalline Basalt
- Anorthosite Breccia
- Recrystallized Breccia
- Devitrified Glass-Matrix Breccia
- Soil Breccia

Figure 17-6. Stratigraphic Units, drill stem 70008

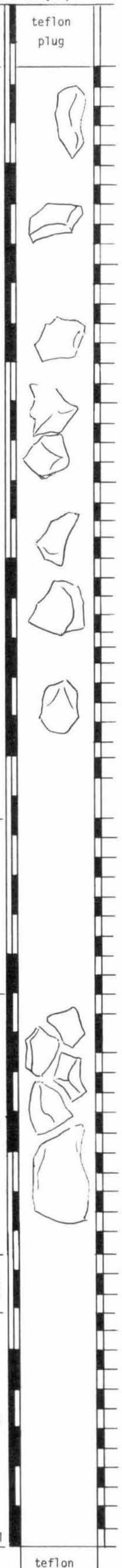
Although of differing sizes in different intervals, coarsely crystalline vesicular basalt rock fragments are common through the entire core, reflecting the ubiquitous subfloor stamp on soils of the area. Otherwise, there is a definite succession of rock types; and any particular rock shows greatest size and abundance in its distinctive unit. In Unit I, the lowest 6.2 cm. of the core, the dominant rock type is soil breccia, or lithified soil, with minute glass spheres occupying about 5 percent of the surface of the breccia fragments. This zone grades upward to Unit II, basically a fine-grained thin bed with flakes of dark to black aphanite. Unit III, extending from 26.0 - 32.5 cm., is packed with very large, coarsely crystalline, vesicular basalt fragments. Because some of these fragments are longer than the diameter of the drill stem, it is possible that the fragments are pieces of a larger rock that was disintegrated by the drilling action. Unit IV, with a thickness of 4.5 cm., appeares to be a repeat of Unit II, being relatively fine-grained, and dominated by flakes and chips of black aphanite or black devitrified glass. Unit V, extending from 6.0 - 21.5 cm., is nearly packed with basalt fragments as well as with an abundance of distinctive anorthositic gabbro with powdery-appearing plagioclase. Some breccia and aphanite fragments are also present. Unit VI, with a thickness of 3.7 cm., is packed with a variety of crystalline rock fragments; it is noticeably sparse in breccias and aphanite, and is believed to represent ejecta from fresh bedrock.

The entire section of drill stem 70008 is extremely coarse-grained and texturally immature, and appears to represent fresh ejecta, from the central cluster of Camelot Crater. It is mapped as lying near the edge of the cluster ejecta complex (Apollo 17 Preliminary Science Report, p. 6-45) and shows low exposure ages consistent with cluster ejecta (Crozaz et. al. 1974. p. 2488). On the other hand, the section lies less than one crater diamter from the 700 M crater, Camelot, and represents the principle thick deposit of coarse material near the top of the core, as would be expected with Camelot ejecta, and the compositional succession is more in keeping with a single rather than polygenetic mode of deposition, further evidence for ejecta from Camelot. However, no criteria have been found that can exclude one or the other possibility.

Basalts and fragments of basalts indicate an origin within the local valley floor, commonly referred to as the subfloor, in contrast to more anorthositic crystallines and poikilitic breccias, derived from the massifs. A tentative stratigraphic synthesis (LSPET, 1973, p. 6-40) suggests that it is possible to relate rock type to depth of crater penetration, with coarser crystalline material ejected from larger, deeper craters and lower-grade breccias ejected from smaller, shallower craters. Although the compositional succession in 70008 seems to support the stratigraphic interpretation in the Preliminary Science Report, field data are too incomplete for strong inference of this successional interpretation.

LOCATION OF SAMPLES, DRILL STEM 70008

Unit Thickness Sample Nos.	DEPTH (below lunar surface, cm)
	25.1
70008, VI — 3.7 cm. thick — Nos.-,9-,19 -,151 -,164 -,166 -,167	28.8
70008, V — 15.5 cm thick — Nos.-,7 -,8 -,84 -,150 -,170 -,175	44.3
70008, IV — 4.5 cm thick — Nos. -,65- -,83	48.8
70008, III — 6.5 cm thick — Nos. -,5 -,6 -,40 -,64 -,165 -,169	55.3
70008, II — 1.6 cm. thick — Nos.-,34-,39	56.9
70008, I — 6.2 cm thick — Nos. -,3 -,4 -,11 - ,33	63.1



Depth interval (cm)	Fine Fraction Sample No.	Fine Fraction Vial No.	Fine Fraction Sample Wt.	Coarse Fraction Sample No.	Coarse Fraction Vial No.	Coarse Fraction Sample Wt.	Special Samples Sample No.	Special Samples Vial No.	Special Samples Sample Wt.	Sample Interval	Sample Type
2.5-3.0	9	8-2676	1.599	10	8-2682	0.836					
3.0-3.5	163	8-3077	1.692	164	8-3078	0.904	213	8-3108	1.833		04-02
3.5-4.0	160	8-3074	1.211	161	8-3076	0.558	162	86-1348	0.360		Red Light
4.0-4.5	158	8-3072	0.720	159	8-3073	0.872	177	8-3113	1.303		Rock Frag.
4.5-5.0	155	8-3068	0.874	156	8-3071	0.366	157	86-1532	0.220		Red Light
5.0-5.5	153	8-3064	1.244	154	8-3066	0.881	212	8-3041	2.258		06-04
5.5-6.0	151	8-3060	1.038	152	8-3061	0.701					
6.0-6.5	149	8-3056	1.517	150	8-3057	0.143	176	8-3110	0.310		Rock Frag.
6.5-7.0	147	8-3048	1.154	148	8-3052	0.361	211	8-3029	1.816		08-06
7.0-7.5	144	8-3044	1.297	145	8-3047	0.613	146	86-1490	0.180		Red Light
7.5-8.0	142	8-3038	1.406	143	8-3042	0.925					
8.0-8.5	140	8-3035	1.230	141	8-3037	0.485					
8.5-9.0	138	8-3032	1.238	139	8-3034	1.675	210	8-3023	0.951		10-08
9.0-9.5	135	8-3022	1.374	136	8-3027	0.648	137	86-1354	0.270		Red Light
9.5-10.0	133	8-3020	1.071	134	8-3021	0.795	175	8-3109	1.511		Rock Frag.
10.0-10.5	131	8-3018	1.411	132	8-3019	1.291					
10.5-11.0	129	8-3001	0.630	130	8-3006	0.138	209	8-3017	1.623		12-10
11.0-11.5	126	8-2995	1.260	127	8-2996	0.406	171	8-3106	2.070		Rock Frag.
11.5-12.0	124	8-2989	1.297	125	8-2991	0.753					
12.0-12.5	122	8-2985	1.275	123	8-2987	0.300	173	8-3104	1.974	12.9-11.7	Rock Frag.
12.5-13.0	120	8-2975	1.090	121	8-2976	0.542					
13.0-13.5	118	8-2970	0.923	119	8-2974	0.303	208	8-3004	1.377		14-12
13.5-14.0	116	8-2959	0.918	117	8-2965	0.534					
14.0-14.4	114	8-2956	1.436	115	8-2957	0.308	172	8-3100	1.200	15.1-13.7	Rock Frag.
14.4-14.9	112	8-2951	0.796	113	8-2955	0.328					
14.9-15.4	110	8-2945	1.231	111	8-2948	0.542	207	8-3000	1.890		16-14
15.4-15.9	108	8-2943	1.006	109	8-2944	0.192	171	8-3097	3.850	16.8-15.3	Rock Frag.
15.9-16.4	105	8-2934	1.029	106	8-2942	0.187	107	87-5199	0.220		Red Light
16.4-16.9	103	8-2931	1.162	104	8-2932	0.533					
16.9-17.1	101	8-2929	0.446	102	8-2930	0.501					
17.1-17.6	99	8-2922	1.561	100	8-2924	0.335	206	8-2999	2.202		18-16
17.6-18.1	97	8-2920	1.597	98	8-2921	0.697					
18.1-18.6	95	8-2917	1.394	96	8-2919	0.346					
18.6-19.1	93	8-2913	2.211	94	8-2915	0.370	170	8-3095	1.143	19.4-18.0	Rock Frag.
19.1-19.6	91	8-2911	1.489	92	8-2912	0.734	205	8-2968	1.214		20-18
19.6-20.0	89	8-2900	1.373	90	8-2910	0.997					
20.0-20.5	87	8-2898	1.794	88	8-2899	0.221					
20.5-21.5	84	8-2894	2.364	85	8-2896	1.727	86	87-5188	0.640		Red Light
21.5-22.0	82	8-2891	1.165	83	8-2893	0.941	204	8-2953	0.892		22-20
22.0-22.5	80	8-2886	1.966	81	8-2888	1.345					
22.5-23.0	78	8-2881	1.275	79	8-2885	1.024					
23.0-23.5	76	8-2877	1.754	77	8-2878	1.279	203	8-2916	1.318		24-22
23.5-24.0	74	8-2871	1.030	75	8-2872	0.544					
24.0-24.5	72	8-2866	1.446	73	8-2867	0.768					
24.5-25.0	70	8-2858	1.767	71	8-2859	0.689	202	8-2895	1.667		26-24
25.0-25.5	67	8-2852	0.992	68	8-2854	0.457	69	87-5338	0.560		Red Light
25.5-26.0	65	8-2847	0.789	66	8-2851	0.244					
26.0-26.5	63	8-2836	0.650	64	8-2846	0.314	201	8-2892	2.304		28-26
26.5-27.5	61	8-2829	2.180	62	8-2832	0.731	169 168	8-3094 8-3091	0.237 0.652	27.5-26.3 27.9-26.7	Rock Frag. Rock Frag.
27.5-28.0	59	8-2819	0.672	60	8-2821	0.358					
28.0-28.5	57	8-2813	1.480	58	8-2816	0.096	167	8-3087	1.223	28.5-27.3	Rock Frag.
28.5-29.0	55	8-2809	0.971	56	8-2811	0.181	166	8-3084	1.787	29.4-27.9	Rock Frag.
29.0-29.5	53	8-2802	1.344	54	8-2803	0.184	200	8-2890	0.624		30-28RF
29.5-30.0	51	8-2799	0.972	52	8-2801	0.158	199				
30.0-30.5	49	8-2797	1.066	50	8-2798	0.190					
30.5-31.0	47	8-2793	0.925	48	8-2795	0.159	165	8-3082	5.800	31.8-29.3	Rock Frag.
31.0-31.5	45	8-2790	1.193	46	8-2791	0.255	198	8-2868	1.040		32-30
31.5-32.0	42	8-2785	1.090	43	8-2789	1.346	44	87-5209	0.410		Red Light
32.0-32.6	40	8-2781	1.907	41	8-2783	0.560					
32.6-33.1	38	8-2770	1.789	39	8-2772	0.339	197	8-2825	1.008		34-32
33.1-33.6	36	8-2766	1.661	37	8-2768	0.228					
33.6-34.1	34	8-2758	1.676	35	8-2763	0.167					
34.1-34.5	32	8-2755	1.743	33	8-2756	0.320					
34.5-35.0	30	8-2744	1.358	31	8-2748	0.438	196	8-2824	1.312		36-34
35.0-35.5	28	8-2737	1.942	29	8-2738	0.401					
35.5-36.0	26	8-2735	1.323	27	8-2736	0.202					
36.0-36.5	23	8-2727	1.539	24	8-2733	0.446	25	87-5214	0.510		Red Light
36.5-37.0	21	8-2723	1.693	22	8-2726	0.138	195	8-2795	1.839		38-36
37.0-37.5	19	8-2712	2.085	20	8-2713	0.217					
37.5-38.0	17	8-2705	1.504	18	8-2710	0.067					
38.0-38.5	15	8-2700	2.209	16	8-2703	0.253					
38.5-39.0	13	8-2696	1.518	14	8-2697	0.234	194	8-2773	0.654		40-38
39.0-39.7	11	8-2690	1.451	12	8-2695	1.472					
39.7-40.0	3	8-2581	1.513	4	8-2585	0.136					

Special samples include bulk soil samples taken under red light conditions for thermoluminescence analysis, rock fragments too large to package under a particular interval, and bulk samples from 2 cm. intervals, taken to complete excavation to desired depth.

Figure 17-7.- Drill string 70008 sample location information.

TABLE XVII-4. LIST OF PHOTOGRAPHS OF CORE 70008

During disassembly of drill string
S-73-15044, 15045 (B&W)

Pre-dissection
S-73-16428 through 16437 (B&W)
S-73-16441 through 16449 (C)

During dissection, rocks and surface features
S-73-17110, 17111 (B&W)
S-73-16735 through 16749 (B&W)
S-73- 16995 through 16707 (C)
S-73-16426 (B&W)

Post-dissection, with rocks in place
S-73-17990 through 18002 (B&W)
S-73-18068 through 18083 (C)

Post-dissection, representative coarse fractions and distinctive rock fragments, samples No.

70008, 12, 16, 20, 24, 31, 35, 60, 66, 73, 77, 81, 100, 117, 132, 145, 152, 166, 167, 170, 171, 174, 176, 177.

S-73-16734, 16747, 16748 (B&W)
S-73-16703, 16708, 16709 (C)
S-73-18025 through 18045 (B&W)
S-73-18005 through 18025 (C)

Post-dissection, following removal of rocks
S-73-18235 through 18240, 22792 (B&W)
S-73-18548 through 18554

DRILL STEM 70007

Sample History

Drill stem 70007 is the third section from the top of the Apollo 17 drill string and contains approximately 30.5 cm. of core. The top of this section of core is from 62.7 cm. below the lunar surface.

This core was only partly filled. A void of about 10 cm. at the top allowed slumping to disturb natural stratification down another 8 cm. according to the X-radiograph interpretation. The exact cause of the void cannot be determined, but it is thought to be related to a partly uncoupled joint between 70007 and 70008. The lower 2 cm. of 70008 was also void. The poor sorting and coarseness of 70008 may have provided plug resistance during extraction on the moon, while the finer soil of 70007 allowed movement.

Before the drill stem was opened by milling, the soil was confined by inserting a hollow teflon plug and aluminum foil stay at the upper end. For this operation, the drill stem was oriented vertically. The plug was pushed in until moderate resistance was felt at 9.5 cm. below the tube opening.

The lower end of the tube was capped by a hollow teflon flight cap. It was necessary to replace this cap by an internal-fitting teflon tube plug. Although the soil in the flight cap was loosely packed, the solid tube plug penetrated the tube only about 5 or 6 mm. of the required 26 mm. The 20 mm. or so of soil obstructing the proper placement of the plug was pushed into the tube by screw compression during mounting of the drill stem in the milling machine. It was felt that the soil was very loosely packed by the upper plug emplacement, and that more compaction was desirable for the rigors of milling. The soil in the lower end was also loosely packed due to the 26 mm. void created when the male end of 70006 was uncoupled from the lower end of 70007. The flight cap, being hollow, did not fill this void.

On August 1, 1975, drill stem 70007 was longitudinally split on a milling machine. After being affixed in a troughed dissection table, the upper half of the tube was lifted off and set aside. Soil remained in the upper split half along the lower 4 cm. and tapering up another 2.5 cm. This soil was tightly compacted by insertion of a tube plug. Reference scales were mounted so that the lower plug/soil interface was aligned with the 40 cm. mark and that the upper end of the tube was aligned with the zero cm. mark. The upper plug/soil interface then became established at 9.5 cm.

Pre-Dissection Description

From X-radiographs of drill stem 70007, four units were interpreted on the basis of size distributions and inferred compositions. (See the attached chart.)

Examination of the exposed surface of the core revealed no apparent color or tonal differences. Consequently, no layering could be inferred based on that parameter. The overall color was between 10 yr 3/1 and 5 yr 3/1 on Munsell's color chart.

Variations in the gross surface texture (development of a rind of compacted soil) give some indication of changes in physical properties of the soil. Between 9.5 and 21.5 cm., the surface is a nearly unfissured, continuous rind with pockets of relatively coarse shiny particles. The overall appearance is speckled. At 21.5 cm. a transverse crack in the rind marks the beginning of a less continuous rind with many longitudinal fissures. The overall appearance is sheen-like. It may be that slumping began at 2.15 cm. and that the transverse crack is the overlap formed by reconfinement.

Only minor compositional changes could be seen in the coarse particles, none of which were larger than 2 mm. in mean diameter. No orange glass was noted as was in 70008 and 70009. The matrix material is in the silt size range with a mean grain diameter estimated to a 5.5 phi units or about 0.02 mm.

70001

The sample numbered 70001 was generated on 22 December, 1972, when the drill string was disassembled into individual subsamples. After photography of the open end (NASA Photos S-73-15051 and 15052) and description of the material therein, the core was bagged and X-rayed on 22 December, according to standard procedures described in Chapter 2 of this catalog. On 3 January, 1973, splits 3 and 5 were removed for early allocation and time-critical deep freeze storage, and on 16-17 January, the bit was dissected. The following information details the results of the dissection.

Dissection and Sampling Procedure

Soil was excavated in approximately 1/2 cm. intervals; each interval contained approximately 2 gms. of material. The lowest half cm. equivalent, 5.5-4.7 cm. from bottom (Fig17-8)was first extracted for allocation and scientific study. Because of shifting during transport, both ends of the bit were decompacted and less cohesive than the moddle of the core, and hence, this sample was removed according to weight rather than thickness of the interval. The next 0.7 cm. from 4.7 - 4.0 cm., a bulk sample of 3.431 gm. was placed in deep freeze storage to preserve temperature-critical properties. Succeeding intervals were dissected in 0.5 cm. increments, with each increment passed through a 125 micron sieve. The finer-than 125 micron fraction was combined to make up the biomedical prime samples. The coarser fraction, remaining in the sieve, was further sized and scrutinized. Fragments larger than 1 mm. were picked out and described, and the fraction between .25 and 1 mm. described under the binocular microscope. Because each size fraction was weighed, it is possible to roughly assess size distribution; this information will be presented under "texture" and "composition."

Physical Properties

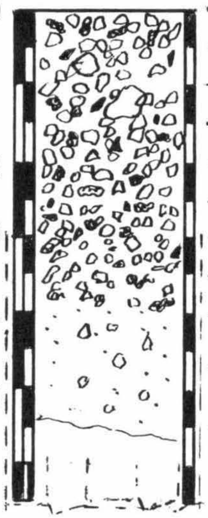
Color of all samples from the drill bit was found to be a medium neutral drab, 5 Y 5/1 on the Munsell Chart of colors.

Textural information was gained both from examination of X-radiographs, direct observation of the bulk sample during dissection, and as a result of sieving samples for biomedical allocation. Grain size results are presented in Table 17-5.

Generally, soils from the bit appear to be very sparingly to sparingly rock fragmental siltsoils, evidently unimodal in composition. The upper half cm. and the lowest 2.0 cm. were extremely crumbly and loose, probably because of de-densification through handling. The remainder of the core was compact and moderately resistant to crumbling. When disturbed by the spatula, soils from this interval fractured into 0.5 to 2.0 mm. equant, even-sized, somewhat blocky (rather than prismatic, rounded, or jaggedly crumb-like) fragments and there was nearly 50% single-grain disaggregation. Sorting is moderately poor to poor, and size distribution appears to be unimodal, as opposed to the strong bimodality of the upper coarse interval

Fig. 17-8

APOLLO 17 DRILL BIT (70001) SAMPLE LOCATION INFORMATION



SIEVED FINES Sample No.	Container No.	Sample Wt.	1.0 - 0.125mm FRACTION Sample No.	Container No.	Sample Wt.	COARSER THAN 1mm FRACTION Sample No.	Container No.	Sample Wt.
35	8-2654	1.580	36	8-2663	0.525	37	8-2665	0.111
32	*3	0.951	33	8-2652	0.307	34	8-2653	0.168
29	*2	1.941	30	8-2643	0.669	31	8-2645	0.331
26	*2	3.030	27	8-2635	1.070	28	8-2638	0.139
23	*2	1.878	24	8-2617	0.692	25	8-2632	0.134
20	*2	2.068	21	8-2611	0.710	22	8-2613	0.093
17	*2	1.257	18	8-2604	0.432	19	8-2610	0.139
14	*2	1.006	15	8-2586	0.341	16	8-2600	0.051
5	8-2573	3.431	(Bulk sample, placed in deep freeze)					
3	8-2562	2.662 *1				4	8-2562	0.167

Attrition: 70001,6 0.497
70001,40 0.148

*1 Weight listed is original weight; approximately 0.950 gms removed from this sample in allocations 70001,7-13, 70001,42.

*2 This sample combined into 70008,38, bioprime sample, total of 12.005 gms.

*3 0.866 gm of fines allocated in bioprime sample, remaining 0.085 gms of fines retained in Container #8-2649 as Sample 70001,39.

of 70007-70009. Rock fragments coarser than 1 mm. comprise slightly less than 5% of the total in the lower part of the bit(Table 17-5) then increase abruptly to slightly less than 10% near the top. Although the .125 to 1 mm. fraction comprises 24 ± 2% of the total, the bulk of all subsamples from the bit are finer than .125 mm. (66 - 72%). Most rock fragments are angular to subangular, and are sparingly distributed through the core; nowhere was there packing of rock fragments.

Two tentative units can be separated texturally at 1.5 cm. from the top of the bit. Rock fragments larger than 1 mm. comprise less than 5% of the lower unit, and abruptly increase to approximately 10% (by weight) in the upper. Similarly, rock fragments appear to be more abundant near the top of the bit, as seen in X-radiograph, although the thick walls of the bit obscure details (Fig. 17-3).

TABLE 5. GRAIN-SIZE TRENDS, APOLLO 17 DRILL BIT

DEPTH FROM TOP OF BIT	% FINER THAN .125MM	% .125-MM	% COARSER THAN 1MM
0 - 0.5 cm.	71%	24%	5%
0.5- 1 cm.	67%	22%	12%
1 - 1.5 cm.	66%	23%	11%
1.5- 2 cm.	71%	25%	3%
2 - 2.5 cm.	69%	26%	5%
2.5- 3 cm.	72%	24%	3%
3 - 3.5 cm.	69%	24%	8%
3.5- 4 cm.	72%	24%	4%

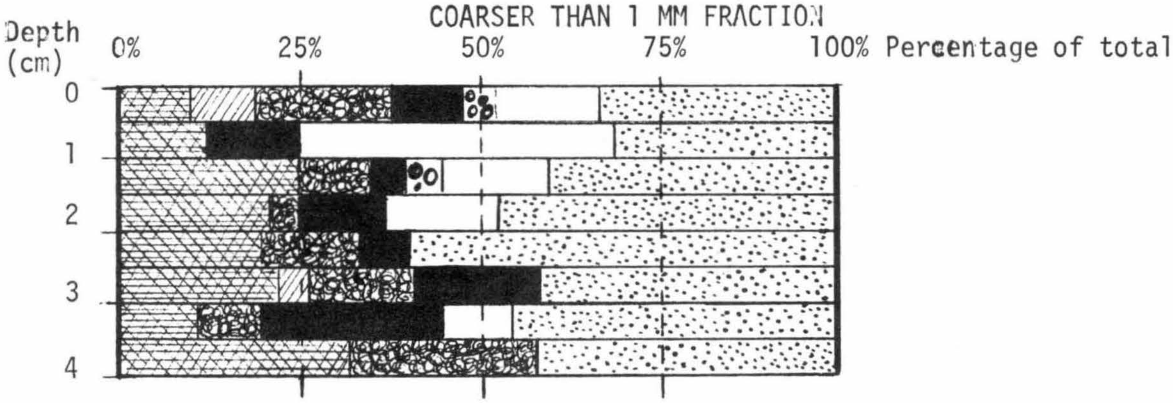
Composition

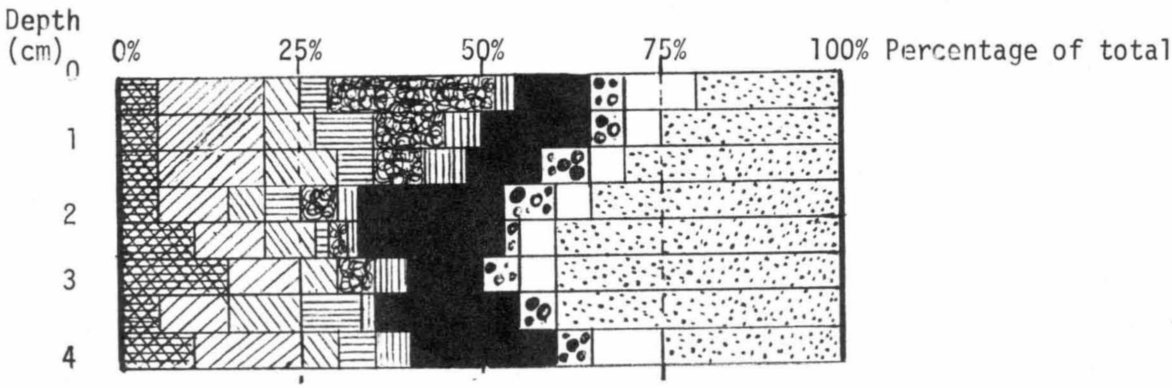
The crystalline component of the coarser fractions of the drill bit is dominated by basaltic fragments(Table17-6)with crystalline anorthosite being of very minor importance(Fig.17-9). Basaltic fragments are medium to coarse grained, moderately to strongly crushed and internally pulverized, and most are too small to show vesiculation. Crystalline anorthosite fragments are distinguished from breccias in being only moderately crushed internally, and have a distinctive olivine component. In the .125 to 1 mm. fraction are many individual grains of clear to whitish plagioclase, reddish pyroxene, yellowish olivine, and dark opaques with cleavage faces; all of which are probably derived from basalt rock fragments. Both the basaltic and anorthositic components are probably of relatively local origin, with overall proportions (19% Basalt, 2% Anorthosite) reflecting the local basaltic subfloor source and the relatively distant anorthositic massif source. The subordinate abundance of crystallines (only 21% of the coarse fraction, and an average of approximately 30% of the .125 - 1 mm. fraction) indicates that this lower part of the core was subjected to extensive reworking or derived more from a glassy and brecciated source.

The glassy component is also relatively scarce, taking up approximately 25% of the sample. Dark to black, frothy to vesicular glass is slightly more abundant than the chips and splintery fragments of dark to blackish opaque

Fig. 17-9 COMPOSITION TRENDS, APOLLO 17 DRILL BIT

COARSER THAN 1 MM FRACTION





EXPLANATION

CRYSTALLINE ROCK FRAGMENTS

basalt

plagioclase or anorthosite

reddish pyroxenes

misc. including olivine, dark fgms. w/cleavage faces other uncommon crystalline fragments.

GLASS FRAGMENTS

frothy to vesicular

green, amber, or orange glass

dark to black devitrified

dark to black glass spheres

BRECCIA FRAGMENTS

anorthositic breccia, powdery to chalky appearance

soil-matrix breccia or lithified soil

Table XVII - 6 Compositional Trends, Apollo 17 Drill Bit

COARSER THAN 1 MM

Depth:	CRYSTALLINE ROCKS Basalt	 Anorthosite	GLASS FRAGMENTS Vesicular	 Devitrified	 Beads	BRECCIAS Anorthosite	 Soil	Total Particles Counted
0-0.5cm	10%	10%	19%	10%	5%	14%	33%	21
0.5-1cm	12.5%	---	---	12.5%	--	44%	31%	16
1-1.5cm	25%	---	10%	5%	5%	15%	40%	20
1.502cm	21%	---	5%	11%	--	16%	47%	19
2-2.5cm	20%	---	13%	7%	--	---	60%	15
2.5-3cm	23%	5%	14%	18%	--	---	41%	22
3-3.5cm	10%	---	10%	25%	--	10%	45%	20
3.5-4cm	32%	---	26%	---	--	---	42%	19
SUM:	19.1%	2.0%	12.%	11.2%	1.3%	11.8%	42.1%	152

.125 - 1 MM FRACTION

Depth:	Basalt	CRYSTALLINES Plag.	 Pyrox.	 Other*1	GLASS FRAGMENTS Vesicular	 Other*2	 Devit.	 Beads	BRECCIAS Anorthosite	 Soil
0-0.5cm	5%	15%	5%	3%	20%	2%	10%	5%	10%	25%
0.5-1cm	5%	15%	7%	7%	10%	6%	15%	5%	5%	25%
1-1.5cm	5%	15%	10%	5%	7%	6%	10%	7%	5%	30%
1.5-2cm	5%	10%	5%	5%	5%	3%	20%	7%	5%	35%
2-2.5cm	10%	10%	7%	2%	---	1%	20%	2%	5%	40%
2.5-3cm	15%	10%	5%	Tr.	5%	5%	10%	5%	5%	40%
3-3.5cm	5%	10%	10%	8%	---	2%	20%	5%	--	40%
3.5-4cm	15%	15%	5%	5%	---	5%	20%	5%	10%	25%

*1 Includes olivine, dark opaques with cleavage faces evident, probably spinels.

*2 Includes orange and green glass, fresh-appearing dark chips and shards.

devitrified glass. Green, orange, or dark globules are present in the coarse fraction only in the top 1.5 cm. of the core, but comprise approximately 5% of the sample in the .125 - 1 mm. fraction. Large glass beads and small vesicular fragments are present only in the upper 1.5 cm. of the bit; otherwise no compositional trends are evident in the glass fraction of the bit (Fig. 17-9).

Breccias, in contrast, are much more abundant, making up over half of the sample studied. Most breccia fragments have the appearance of lithified soil, or appear as hardened and glassy soil that contains angular, crystalline or glassy rock fragments. A smaller percentage of breccia fragments (Fig. 17-9) is present in the .125 to 1 mm. fraction than in the coarse fraction, but abundance trends are parallel in both fractions. Anorthosite breccia, consisting of crushed anorthosite with a chalky appearance, is a minor component in both the coarser and finer than 1 mm. fractions, but is most abundant near the top of the bit.

Stratigraphy

Compositional trends, including an upward decrease in basalt and soil breccias, and an upward increase in crystalline anorthosite, vesicular glass, glass beads, and anorthosite breccias, roughly correspond to grain size trends noted earlier, but are more transitional. Trends tend to be internally consistent, allowing for separation of the bit into 2 units (Fig. 17-10) but with equal evidence for transitional and abrupt boundaries, there can be no exact placement of the contact between units. The separation point is placed at 1.5 cm. below the top of the bit, at the greatest change in grain size, between samples 70001,26 - ,28 and 70001,29 - ,31, but it must be emphasized that THERE IS NO SHARP CONTACT BETWEEN UNITS.

Greater abundance of crystalline rock fragments and soil breccia in the lower unit suggests that this bed was derived from a relatively local subfloor source, and finer grain size suggest more reworking.

In contrast, the massifs apparently contributed more material for the upper unit, especially the anorthosite and anorthosite breccia. The impact to bring in this relatively distant material was evidently more energetic as evidenced by the presence of largest grains and more melt material such as frothy, vesicular glass and glass beads.

Transitional nature of these units could be a result of mixing on the lunar surface, or it could be an artifact of handling.

UNIT	CHARACTERISTICS
2	Coarsest grains were relatively abundant, and ranged in size up to 7 mm. Vesicular glass, large dark glass beads, crystalline anorthosite fragments with olivine, and anorthosite breccias are especially abundant.
1	Coarsest grains were relatively sparse and generally less than 3 mm diameter. Basalt rock fragments and soil breccia fragments at maximum abundance.

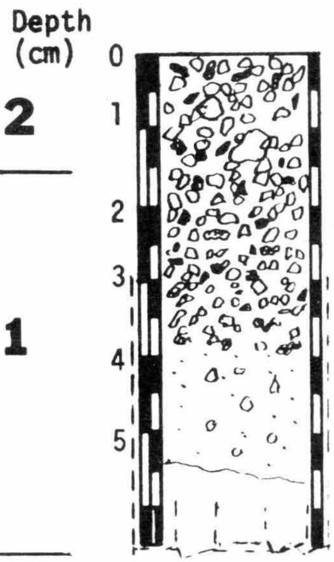
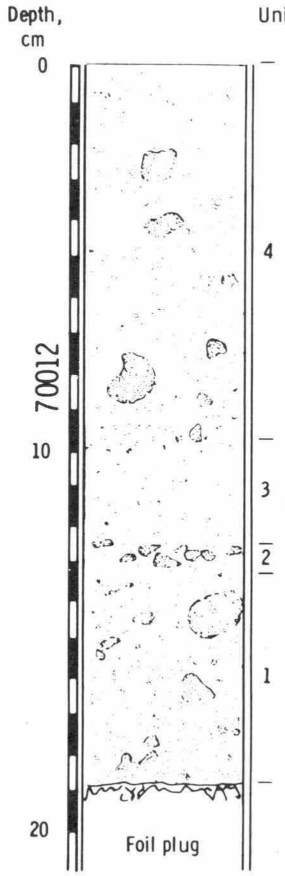


Fig. 17-10   Stratigraphic Summary, Apollo 17 Drill Bit (Sample 70001).

Drive Tube 70012 (L52)

This core was hand driven to a hard layer at 28 cm depth 0.5 m inside the plus-Y footpad of the LM. The site lies on regolith developed on basaltic subfloor, near the center of the valley, approximately 750 m equidistant between the large (300 to 400 m) craters Camelot and Sherlock. The sample was collected in a relatively flat area with common, but subdued, 10 to 30 cm-diameter craters. Most of the surface appeared fine grained with particles near the limit of resolution of the surface photographs, but 1 to 2 percent of the surface was covered with particles as much as 3 or 4 cm in diameter. Similar material is in the core. Although this core was not disturbed by footprints (AS17-147-22517), the top 1 or 2 cm were probably depleted in fine soil by the LM descent propulsion engine. When the buddy secondary life-support system (BSLSS) bag was opened in the LRL, the bottom cap of the core was off and lying nearby, and soil was spilling from the bottom. A total of 47 g of slumped material were excavated from the base of the core to provide a fresh vertical face, which was then supported by a plug of aluminum foil. The upper follower was in place, and the X-radiograph indicated no serious cracking or slumping in the remainder of the core(Fig. 17-7).



In all four units, the matrix appears to be similar, being moderately opaque and relatively granular with 40 to 50 percent fine mottles, less than 0.5 mm in diameter, and a trace of opaque particles near the limit of resolution.

UNIT 4 Depth: 0 to 10 cm Thickness: 10 cm
Massive interval with scattered large rock fragments. This unit may be distorted by footprints and exhaust gases, but evidence for such disturbance is not visible in the X-radiograph.
Matrix: 85 to 90 percent.
Coarse fraction: 10 to 15 percent; semiopaque with distinct outline, poorly sorted fragments, 0.2 to 1.5 cm in diameter, blocky, angular to subrounded with most fragments being equant to subequant.

UNIT 3 Depth: 10 to 12.5 cm Thickness: 2.5 cm
Moderately thin rock-free bed.
Matrix: 100 percent; ≈1 percent mottles and granules, less than 5 mm in diameter.

UNIT 2 Depth: 12.5 to 13 cm Thickness: 0.5 cm
Rock layer with small wedge-shaped fragments.
Matrix: 65 percent.
Coarse fraction: 35 percent; semiopaque rock fragments with distinct outline, well sorted, 3 to 6 mm in diameter, fragments predominantly wedge shaped, elongate, and straight sided.

UNIT 1 Depth: 13 to 19 cm Thickness: 6 cm
Massive unit with large rock fragments and small wedge-shaped fragments.
Matrix: 85 to 90 percent; moderately transparent with 40 to 50 percent fine mottles and granules.
Coarse fraction: 10 to 15 percent; semiopaque with distinct outline, poorly sorted fragments ranging from 0.2 to 1.4 cm in diameter. Two populations seem to be present: one set is equant and subrounded with relatively large size; the other set is small (0.2 to 0.6 cm in diameter), relatively straight sided, and wedge shaped, resembling wedge-shaped particles of unit 2.

Figure 17-7.- X-radiograph drive tube 70012. X-radiography symbols are the same as for Figure 7-3.

The excavated material was mostly fines, with 5 to 10 percent being fragments of medium-to coarse-grained vesicular basalt as much as 11 mm in diameter. Although this sample is petrographically similar to the upper beds of 70008, it is finer grained. None of the breccia fragments of coarse-grained framework-textured soil of the deep drill string appear in this core; however, the hard layer, which prevented further penetration, could be the coarse-grained deposit. If so, there is a deeper layer of fines on top of the coarse ejecta at this location. Nevertheless the basaltic coarse fraction of 70012 parallels that of 70008, indicating a subfloor source for the upper soil layers.

DRIVE TUBES 73002 AND 73001 (U31 AND L45)

A double drive tube was taken at station 3 to collect an undisturbed sample of the regolith developed on the light mantle. Although the lower drive tube was sealed in the core sample vacuum container, the 23 cm-long upper drive tube should provide significant data (Fig. 17-8).

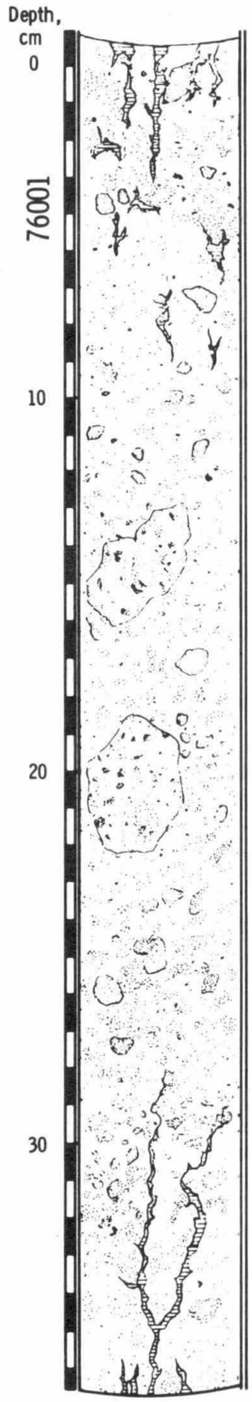
The sampling site lies near the base of a major scarp that crosses the Taurus-Littrow valley. This site is approximately 50 m east of the 700 m Lara Crater and is surrounded by small, local craters. The largest of these craters, a moderately fresh 10 m-diameter pit, lies approximately 18 m northwest of the coring site, and several other craters over 5 m in diameter lie within 20 m. Small (as much as 1 mm in diameter) craters are abundant, and the soil surface is fairly rough, with approximately 20 percent cover by 1 to 2 cm fragments (AS17-137-20981). A trench 20 cm deep near the 10 m diameter crater revealed a medium-gray 0.5 cm surface layer over a light-gray 3 cm layer, which in turn overlies a medium-gray marbled or mottled zone that seems to be representative of subsurface soils in the light mantle.

Much of 73002 is permeated by cracks possibly caused by the wedging of large fragments into the drive tube or the spillage of 4 cm of soil onto the lunar surface. Whether or not these cracks have disrupted the stratigraphy is uncertain; at least two major stratigraphic intervals seem to be present on the X-radiograph, but there is no indication of the soil profile seen in the nearby trench. The material is coarse grained and massive with distinct rock fragments (probably subfloor basalt), reflecting expected surface conditions near local craters and within the Lara Crater ejecta blanket.

DRIVE TUBE 76001 (L48)

This single drive tube from station 6 is the only certain stratigraphic sample of massif regolith and is the only core that can be oriented with certainty. It was driven into firm soil on an 11° slope to the south. The surface shows a 20 percent cover of moderate, well sorted and rounded fragments as much as 4 cm in diameter on fine-grained soils that are cohesive enough to retain the hole after the drive tube was extracted (AS17-146-22295). Subdued craters as much as 30 cm across are rare; one such crater located approximately 1 m north of the sampling site has abundant 3 to 4 cm blocks on the rim.

Core 76001 is subdivided into four units on the basis of matrix content and the size and type of included rock fragments (Fig. 17-9). Most rock fragments are indistinct, only slightly more opaque than the matrix, and probably represent anorthosites as breccias of massif origin; however, two large fragments in unit 2 are noticeably different. These fragments are distinct in outline, relatively opaque, contain abundant



Unit

UNIT 4 Depth: 0 to 6 cm Thickness: 6 cm

4 Fracture-permeated interval with distinctive dendritic opaques.
Matrix: 90 percent; high transparency, noticeably less than that of unit 3, greater tendency to crack. Fracturing seems to be most prevalent in this zone with fractures disappearing relatively abruptly at the base of the zone. There are ≈35 percent indistinct granules and mottles 1 mm or less in diameter, 4 to 3 percent opaque fragments, limit of resolution to 1.2 mm with a full suite of shapes, ranging from spherical to highly dendritic. The large 0.5- to 1.2-mm dendritic opaques appear to be unique to this bed.
Coarse fraction: 10 percent; semiopaque with distinct outline, poorly sorted rock fragments as much as 1.2 cm in diameter, polygonal, equant to subequant with few straight edges, mostly rounded corners.

UNIT 3 Depth: 6 to 13 cm Thickness: 7 cm

3 Moderately transparent interval with scattered small rock fragments.
Matrix: 90 percent; semitransparent, decidedly more opaque than unit 4 (possibly because of fewer fractures), with 10 to 15 percent indistinct mottles as much as 1 mm in diameter, 2 percent opaques, limit of resolution to 0.5 cm in diameter, appearing mostly as flakes rather than spherules, dendrites, or shards.
Coarse fraction: 10 percent; 4 percent is semiopaque rock fragments with distinct outline, 0.2 to 1.1 cm in diameter, averaging ≈0.4 cm. Fragments are equant and blocky with straight sides and subangular corners; 6 percent is semiopaque with indistinct outline, appearing as equant crenulate mottles, mostly 0.2 to 0.5 cm in diameter.

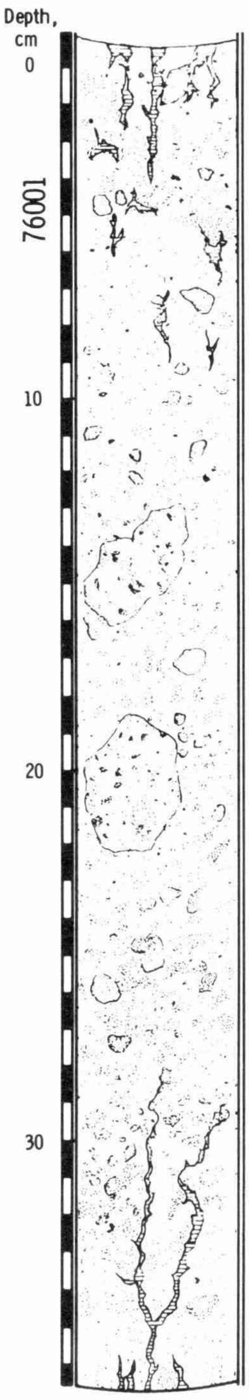
UNIT 2 Depth: 13 to 24.5 cm Thickness: 11.5 cm

2 Thick unit with scattered large rock fragments.
Matrix: 75 percent; as in unit 3.
Coarse fraction: 25 percent; 15 percent is 3- to 4-cm rock fragments that are semiopaque with distinct outline, appearing as irregular-sided chunks that are permeated with 0.2- to 1-mm opaque dots and abundant 1- to 3-mm transparent patches. Apparently, these fragments are vesicular basalts with transparent areas being vesicles; with high-iron minerals, the areas are infested with opaque dots. The remaining 10 percent of the coarse fraction appears as in unit 3.

UNIT 1 Depth: 24.5 to 36.5 cm Thickness: 12 cm

1 Massive unit packed with small well-sorted rock fragments.
Matrix: 40 percent; distinctly more dense and opaque appearing than unit 2, with top contact sharp, slightly bowed upward on edges of core. Internally, the sample appears to be mostly finely granular with less than 10 percent indistinct mottles and 1 to 2 percent pinpoint shard-like opaques.
Framework: 60 percent; 10 percent is semiopaque rock fragments with distinct outline, 0.2 to 0.6 cm in diameter, averaging 0.5 cm with blocky-appearing relatively straight margins and angular corners; 50 percent is semiopaque with indistinct outline, well sorted, 0.2 to 0.5 cm, averaging 0.3 cm, appearing as equant density concentrations with fairly regular fadeout, not crenulate.

Figure 17-8.- X-radiograph of drive tube 73001. X-radiography symbols are the same as for Figure 7-3.



Unit

4 — UNIT 4 Depth: 0 to 6 cm Thickness: 6 cm

Fracture-permeated interval with distinctive dendritic opaques.

Matrix: 90 percent; high transparency, noticeably less than that of unit 3, greater tendency to crack. Fracturing seems to be most prevalent in this zone with fractures disappearing relatively abruptly at the base of the zone. There are $\approx$35 percent indistinct granules and mottles 1 mm or less in diameter, 4 to 3 percent opaque fragments, limit of resolution to 1.2 mm with a full suite of shapes, ranging from spherical to highly dendritic. The large 0.5- to 1.2-mm dendritic opaques appear to be unique to this bed.

Coarse fraction: 10 percent; semiopaque with distinct outline, poorly sorted rock fragments as much as 1.2 cm in diameter, polygonal, equant to subequant with few straight edges, mostly rounded corners.

3 — UNIT 3 Depth: 6 to 13 cm Thickness: 7 cm

Moderately transparent interval with scattered small rock fragments.

Matrix: 90 percent; semitransparent, decidedly more opaque than unit 4 (possibly because of fewer fractures), with 10 to 15 percent indistinct mottles as much as 1 mm in diameter, 2 percent opaques, limit of resolution to 0.5 cm in diameter, appearing mostly as flakes rather than spherules, dendrites, or shards.

Coarse fraction: 10 percent; 4 percent is semiopaque rock fragments with distinct outline, 0.2 to 1.1 cm in diameter, averaging $\approx$0.4 cm. Fragments are equant and blocky with straight sides and subangular corners; 6 percent is semiopaque with indistinct outline, appearing as equant crenulate mottles, mostly 0.2 to 0.5 cm in diameter.

2 — UNIT 2 Depth: 13 to 24.5 cm Thickness: 11.5 cm

Thick unit with scattered large rock fragments.

Matrix: 75 percent; as in unit 3.

Coarse fraction: 25 percent; 15 percent is 3- to 4-cm rock fragments that are semiopaque with distinct outline, appearing as irregular-sided chunks that are permeated with 0.2- to 1-mm opaque dots and abundant 1- to 3-mm transparent patches. Apparently, these fragments are vesicular basalts with transparent areas being vesicles; with high-iron minerals, the areas are infested with opaque dots. The remaining 10 percent of the coarse fraction appears as in unit 3.

1 — UNIT 1 Depth: 24.5 to 36.5 cm Thickness: 12 cm

Massive unit packed with small well-sorted rock fragments.

Matrix: 40 percent; distinctly more dense and opaque appearing than unit 2, with top contact sharp, slightly bowed upward on edges of core. Internally, the sample appears to be mostly finely granular with less than 10 percent indistinct mottles and 1 to 2 percent pinpoint shard-like opaques.

Framework: 60 percent; 10 percent is semiopaque rock fragments with distinct outline, 0.2 to 0.6 cm in diameter, averaging 0.5 cm with blocky-appearing relatively straight margins and angular corners; 50 percent is semiopaque with indistinct outline, well sorted, 0.2 to 0.5 cm, averaging 0.3 cm, appearing as equant density concentrations with fairly regular fadeout, not crenulate.

Figure 17-9.- X-radiograph drive tube 76001. X-radiography symbols are the same as for Figure 7-3.

minute opaque particles less than 1 mm in diameter, and have 5 to 10 percent transparent circular areas as much as 2 mm in diameter; these features are typical of vesicular subfloor basalts.

Except for the large vesicular rock fragments, this core is fairly fine grained and moderately well sorted. The relatively small surface craters at station 6 have contributed little to the massive, indistinctly stratified upper 25 cm of the core. Rock types in the core, plus field evidence, indicate subfloor as well as massif contributions to this site, with massif source predominating. Possibly, the large, vesicular, presumably basaltic rock fragments in unit 2 were associated with a major cratering event large enough to propel basalt fragments from the valley to this point on the massif.

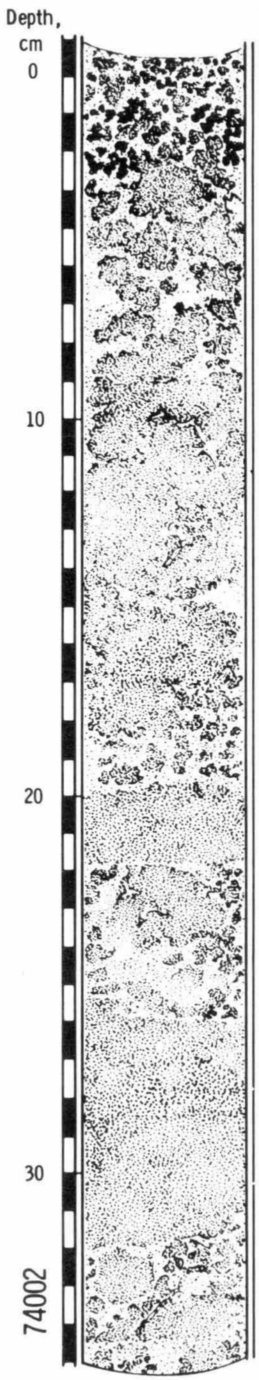
The X-radiograph of this massif-derived soil is similar to those of the Apollo 16 drive tubes, probably because the anorthositic terrain of the massifs and the Descartes highlands produce similar soil-forming components. Both soils are (1) relatively transparent to X-rays, with a very sparsely granular matrix, (2) relatively low in distinct rock fragments, possibly because of the abundance of semitransparent anorthosites, and (3) extremely high in tiny opaque fragments of diverse shapes ranging from dendritic to spheroidal.

DRIVE TUBES 74002 AND 74001 (U35 AND L44)

The double drive tube that samples the contact between the orange and black soil on the southern rim of Shorty Crater was completely filled with unusually dense soil (74001 was 2.35 g/cc and 74002 was 2.00 g/cc) and was nearly impervious to X-rays. Consequently, rather mediocre X-radiographs were obtained even after near-maximum-intensity radiation. The clod-like layering encountered is shown in Figure 17-10.

It is hoped that these cores will preserve the spatial distribution of soils in the adjacent trench, where a surficial 0.5 cm of gray soil overlies an interval of orange soil, which, in turn, overlies black ilmenite-bearing glass droplets seen in the top and bottom ends of the lower tube.

Stratification in the upper tube consists of alternating layers of massive soil, impenetrable to X-rays, and very distinctly mottled soil that appears as poorly defined clods 0.3 to 3.5 cm in diameter. Presumably, the cloddy intervals contain orange soil, and the obscured intervals contain black soil. Cloddy intervals occur in 74002 from 0 to 8, 14 to 20, 22 to 25.5, and 32 to 37 cm, including the upper 2 cm of 74001. The next 14 cm contain massive, nearly opaque (to X-rays) beds with slightly lower opacity at the base. The lowest 22 cm are massive, with subparallel lengthwise lineations of lower opacity, which may be fractures or steeply inclined bedding as observed in the trench.



Unit

11 — UNIT 11 Depth: 0 to 2 cm Thickness: 2.0 cm
Thin finely mottled zone.
Interval contains ≈60 percent fine-appearing mottles, 1 to 3 mm in diameter, in a slightly more transparent matrix. The mottles have indistinct crenulate outlines but are relatively even and uniform in size.

10 — UNIT 10 Depth: 2 to 9 cm Thickness: 7.0 cm
Massive, variably mottled zone.
Interval contains ≈70 percent irregular mottles in a slightly less dense matrix. The mottles appear to consist of uniformly fine-grained opaque material and are variably sized from 0.1 to 2.3 cm in diameter with irregular, crenulate, indistinct outlines.

9 — UNIT 9 Depth: 9 to 14 cm Thickness: 5.0 cm
Massive, uniformly fine-grained, dense, opaque interval.
Interval consists entirely of extremely dense, opaque, fine-grained-appearing material that almost completely blocks X-rays. Consequently, internal details are obscured, but boundaries are highly crenulate and fairly horizontal.

8 — UNIT 8 Depth: 14 to 20 cm Thickness: 6.0 cm
Massive, variably mottled zone that is coarser appearing above.
Interval contains ≈80 percent irregular mottles in a slightly less dense matrix. The mottles, appearing uniformly fine grained within, range from 0.2 to 3.6 cm in diameter and are much coarser above; no clear-cut boundary can be drawn within the interval to separate different crenulate mottle sizes.

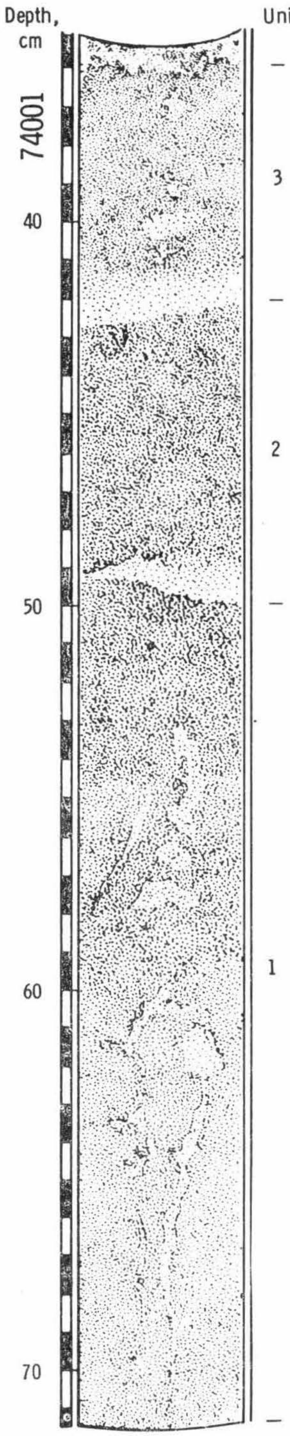
7 — UNIT 7 Depth: 20 to 22 cm Thickness: 2.0 cm
Thin, uniformly fine-grained, dense, opaque interval.
This thin zone is similar to other opaque intervals because it is dense, apparently fine grained internally, and has flat horizontal boundaries.

6 — UNIT 6 Depth: 22 to 26 cm Thickness: 4.0 cm
Massive, variably mottled zone that is coarser mottled above.
This zone contains ≈60 percent opaque fine-grained mottles in a matrix of slightly less density or opacity. The mottles, ranging in size from 0.2 to 3.6 cm, are highly crenulate and irregular and are gradationally coarser above.

5 — UNIT 5 Depth: 26 to 31 or 32 cm Thickness: 5.5 ± 0.5 cm
Massive, uniformly fine-grained, dense, opaque interval.
As in unit 6, this zone consists entirely of fine-grained opaque material, possibly black soil, with no internal features and crenulate somewhat inclined boundaries.

4 — UNIT 4 Depth: 31 or 32 to 36 cm Thickness: 4.5 ± 0.5 cm
Massive, mottled interval that is coarser above.
Except for the location, this bed is a repeat of unit 6.

Figure 17-10.- X-radiograph of drive tube 74002. X-radiography symbols are the same as for Figure 7-3.



UNITS 2 and 3 Depth: 36 to 50 cm Thickness: 7.5 and 6.5 cm
Massive fine-grained graded beds with more opaque above.
These two separate, but similar, units are described together. Strata appear uniformly fine grained, relatively transparent (to X-rays) below, gradationally becoming opaque above in 1 to 2 cm. Contacts appear to be sharp, slightly undulating, and gently inclined.

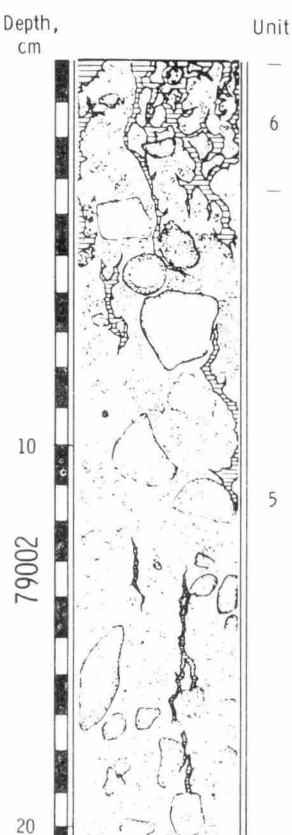
UNIT 1 Depth: 50 to 71.5 cm Thickness: 21.5 cm
Massive interval with oblique laminations or fractures.
Interval is 95 percent matrix, which is uniformly dense and impervious to X-rays, with a density equal to the maximum density of the core section as a whole. Within the uniform matrix are indistinct, elongate areas of lesser density; these areas tend to be straight to slightly curved, as much as 11 cm long with scalloped to nearly straight edges. The areas run lengthwise to a slightly oblique and could represent either fractures or nearly vertical layering reported in the trench.

Figure 17-10.- X-radiograph of drive tube 78001 (concluded). X-radiography symbols are the same as for Figure 7-3.

Approximately 2 g of material was excavated from the bottom of 74001 and examined under the binocular microscope. The material is unusually cohesive and consists of very dark to black opaque spheres and conchoidally fractured fragments.

DRIVE TUBES 79002 AND 79001 (U37 AND L50)

A double core was taken at Station 9, which is approximately 70 m southeast and downslope from the rim of Van Serg Crater. Two fresh, sharp 1 m craters lie within 10 m of the coring site, and a subdued 60 m crater occupies the area 15 m west of the sampling area. Although lunar surface photographs indicate massive boulders on or near the rim of Van Serg Crater, the largest surficial fragments in the core area range from 20 to 2 cm, are poorly sorted, angular, unfilleted, and cover less than 3 percent of the surface. A 12 cm trench approximately 1 m southwest of the coring site has medium-gray soil in the upper 7 cm but has light-gray to whitish soil in the lower part. The upper portion might represent "dark mantle" over the ejecta blanket from Van Serg Crater. However, this color change is not reflected in the X-radiograph of the drive tube, possibly because the core is permeated by fractures, which are undoubtedly a result of rocks being jammed into the coring device during sampling (Fig. 17-11).



UNIT 6 Depth: 0 to 3.5 cm Thickness: 3.5 cm

Extensively fractured relatively fine-grained interval.

Matrix: 80 percent; at least 50 percent is permeated by fractures, relatively transparent with 30 percent 1-mm density concentrations and fine mottles, ≈1 percent spherical to ovoid opaques, less than 1 mm in diameter.

Coarse fraction: 20 percent; 5 percent is semiopaque rock fragments with distinct outline. These fragments range from 0.2 to 0.7 cm in diameter, are moderately well sorted, rectangular to equant, blocky outlined, and relatively straight sided with subangular to angular corners; 15 percent is semiopaque density concentrations and indistinct but relatively smooth-edged mottles, 0.2 to 0.9 cm in diameter, but mostly less than 0.5 cm and subequant.

UNIT 5 Depth: 3.5 to 31 cm Thickness: 27.5 cm

Massive unit with very large rock fragments.

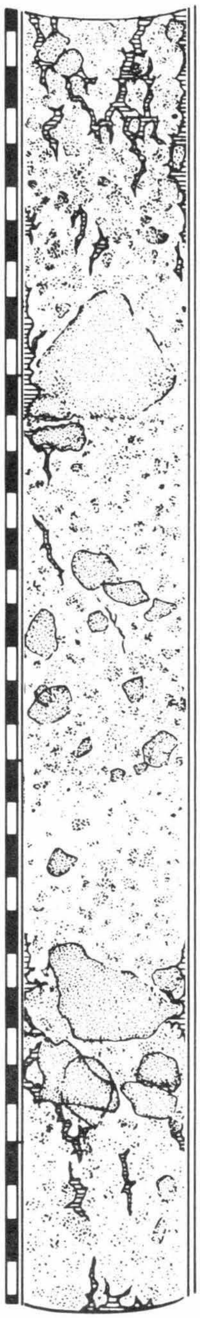
Matrix: 79 percent; somewhat fractured, of intermediate transparency with 30 to 40 percent granularity, granules less than 1 mm in diameter, a trace of spherical to ovoid opaques, limit of resolution to 1.3 mm in diameter.

Coarse fraction: 30 percent; 15 percent is semiopaque rock fragments with distinct outline, 0.1 to 3.5 cm in diameter, poorly sorted with all sizes being present. Most fragments tend to be equant to slightly elongate, relatively straight sided; 15 percent has a ragged indistinct outline with subangular to well-rounded corners and a distinctive ragged appearance.

Figure 17-11.- X-radiograph drive tube 79002. X-radiography symbols are the same as for Figure 7-3.

Depth, cm

Unit



30

40

50

79001

5

4

3

2

1

UNIT 4   Depth: 31 to 40.5 cm   Thickness: 9.5 cm

Massive unit with abundant small rock fragments.

Matrix: 80 percent; of intermediate opacity with ≈25 percent mottles and density concentrations less than 1 mm in diameter, ≈0.5 percent spherical to lumpy opaques, limit of resolution to 1.2 mm.

Coarse fraction: 20 percent; 10 percent is semiopaque rock fragments with distinct outline, moderately sorted, 0.1 to 1.1 cm in diameter, averaging 0.4 cm. These fragments tend to be distinctly different in composition from those of surrounding beds in being relatively homogeneous internally and straight sided with subrounded corners. Inclined alinement of some rocks, especially from 34.0 to 35.0 cm and 39.0 to 40.5 cm, with a planar alinement at the base of the unit suggests cross stratification. The remaining 10 percent is semiopaque density concentrations with indistinct smooth outline, ranging in size from 0.1 to 0.5 cm and appearing to be moderately sorted.

UNIT 3   Depth: 40.5 to 45 cm   Thickness: 4.5 cm

Graded bed that is sparse in rock fragments.

Matrix: 90 percent; relatively transparent with 20 percent granules finer than 1 mm in diameter, a trace of irregular opaques less than 0.5 mm in diameter.

Coarse fraction: 10 percent; there is one 0.6-cm semiopaque fragment with distinct lumpy outline, and the remainder are semiopaque density concentrations with indistinct outline, 0.5 to 0.1 cm in diameter with the coarsest particles at the bottom, decreasing in size and abundance upward.

UNIT 2   Depth: 45 to 49.5 cm   Thickness: 4.5 cm

Concentration of large rock fragments.

Matrix: 25 percent; relatively transparent, fractured, obscured by large rock fragments, but apparently low in granules and opaques.

Framework: 75 percent; semiopaque rock fragments with distinct outline, very coarse, ranging from 1 to 4 cm in diameter with average diameter ≈2 cm. These fragments have a distinctly lumpy, ragged irregular appearance with jagged margins and angular corners.

UNIT 1   Depth 49.5 to 54.5 cm   Thickness: 5 cm

Massive unit with obscure rock fragments.

Matrix: 50 percent; similar to that of unit 2 in being relatively transparent, seemingly low in granules (less than 20 percent density concentrations under 1 mm in diameter), having only a trace of opaques, near limit of resolution.

Framework: 50 percent; similar to unit 2, but of finer grain size. Rock fragments are semiopaque with distinct, but ragged outline and range in size from 0.2 to 1.3 cm, averaging 0.5 cm and having the lumpy to ragged angular appearance of fragments in units 2 and 4, in contrast to other units.

Figure 17-11.- X-radiograph of drive tube 79001 (concluded). X-radiography symbols are the same as for Figure 7-3.

APPENDIX

LUNAR CORE SAMPLE ALLOCATIONS

Allocation matrices are presented for each of the drill stems and drive tubes. These will be updated from time to time as new allocations are made for scientific study.

TABLE A12-1.- CORE 12025 ALLOCATION MATRIX

Parent Sample	Muir	Edgington	Pepin	McKay	Quaide	Arrhenius	Walker	Hapke	Gold	Becker	Wasserburg	Adams	Fleischer	Moore	Price	Nash	Nagy	Davis	Eglinton	Maurette	Geiss	Lal	Urey	Philpotts	Anders	Sellers	Housley	Reed
,14	15	16		19	26		27																					
,13							18	21	23	20	22	25														24		
,12													28		30	29		31										
,11							73													68		69		71	72	70		74
,10				33		32	35									36							34					
,9							67						63		64					65		66						
,8						37	38														39							
,7	42												40		41						44					43	42	
,6				47			49					50								45	48	46						
,5						51	52									53												
,4							57				56		54		55													
,3			62			17								58			60		59	61								

TABLE A12-2.- CORE 12028 ALLOCATION MATRIX

Parent Sample	Arrhenius	Walker	Edgington	Fleischer	Price	Sellers	Marti	Biemann	Moore	Burlingame	Reed	Maurette	Lal	Becker	McKay	Wasserburg	Short	Philpotts	Anders	Quaide	Eglinton	Hapke	Housley	Nash	Geiss	Adams	Pepin	Davis	Oro	Gold	Oyama	Nagy	USSR
,11	47	48	49																														227
,12		54		50	51	52	53	164	165	166																							
,13												55	56	57	58	59																	
,14	60	61																															
,16		67										62	63				64	65	66														228
,17	68	69				72									70					71													
,18				73	74																												229
,19		79					78		181			75	76			77					182												
,20	80	81					83								82																		
,21				84	85	86																											230
,22		91																89	90			87	88										
,23	92	93									215				95									94	96	97							
,24								171	170	172		98	99								173				100		101						
,25		169		102	103	167																			168								
,26	183	190																										191					
,27		194										192	193																				
,28				195	196										197																		231
,29	198	199					200		174	175											176												
,30				201	202																												
,31		104										203	204																				232
,32			106			107								105																			
,33	108	109						168	177	179						110					180												
,34				111	112				114												115		113						116				
,35										184		117	118								185												
,36		122																120	121			119											
,37	123	124																						125									233
,38				126	127																							129		128			
,39															206																205		
,40	130	131										132	133																				
,41		137		134	135	136																											234
,42	138	139							186												187						140						
,43												141	142		143			144	145						146								
,44		151		147	148						216									149					150								
,45		152																			188				153							207	
,46	154	163				160	162					155	156		158	161	159													157			

TABLE A14-1.- CORE 14230 ALLOCATION MATRIX

Parent Sample	Adams	Anders	Brett	Burlingame	Carr	Eglinton	Engelhardt	Gast	Glass	Gold	Goles	Griscom	Herr	Keil	King	Lal	Marti	Maurette	Moore	Perry	Reed	Schmitt	Schnetzler	Sellers	USSR	Walker	Wasserburg	Wood
55***																									151			98
54**																										136		
53	106														67	155	108				107					109		
52**																										137		
51	85		86			132																						
50**																										138		
49														68*				70				110						
48***														104														
47**																												
46										89														90				
45**																										139		
44							71				112			146											150			
43**																												
42					103																							99
41**																										140		
40												92			93			91						94				
39**																												
38											72					154												
37**																										141		
36																										135		
35**																												
34				133																								
33**																												
32		115																										
31**																										142		
30												96								95								97
29**			73																									
28		117																			118	116		74	149			
27***																												
26**																												
25	77	120							75		119				76													
24***																												
23**																										143		
22					78			121		79																	122	
21**																												
20												88				153		87	134									
19**																												
18																												
17***																												
16**																										144		
15							126										125							124	148			
14**																												
13		128													80							127						
12**																												
11***																												
10																152												100
9**																												
8			81						82		129																	
7**																												
6																								101				
5***																												
4					84			130							83										146		131	
3***																												
2***																												102
1***																												

*69 included in this allocation.
**red light samples.
***special samples.

TABLE A15-1.- CORE 15001 ALLOCATION MATRIX

Parent Sample	Adams	Arnold	Biemann	Eglinton	Epstein	Geiss	Heymann	Kaplan	Lindsay	Meinschein	McKay	Nagy	Oro	Oyama	Reed	Rho	Schopf	Walker	USSR	Wasserburg	Lal
,134							149		148												
,133		150																			
,132		151																			
,131		152					154		153												
,130		155									271										307
,129		156																			
,128		157																			
,127		158					160		159		270										
,124		161																			
,123		162					163				269										306
,122									164												
,121		165																			
,120																				217	
,119							168		167	166											
,115		169									268										
,118																					305
,112		170									267										304
,108		171																			
,100		172																			
,99		173					176		175				174								
,98		177																			303
,96		178																			
,95		179																			
,94		180									266										
,92		181																			
,89		182																			
,87														183							
,86														184							
,85														185							
,84																				216	
,82														186							
,80	192		190				187							188	191		189	214			
,79									193												
,76						194															
,74						195															
,73						196															
,71						197															302
,69												198									
,66											265	199									
,62												200									
,61												201									
,59																202					
,58																205					
,57																204					
,56																203					
,55																				215	
,52				208			206	207											113		
,46									209												301
,45					212																
,44					213											210					
,42																211					

TABLE A15-2.- CORE 15002 ALLOCATION MATRIX

Parent Sample	Adams	Burlingame	Fox	Geiss	Kaplan	Lal	Lalou	Lindsay	Maurette	McKay	Oyama	Price	Rho	Schopf	Signer	Silver	Walker	Wasserburg	Nash	USSR	Biemann	Reed	Marti	Bogard	Haskin	Philpotts	Arnold	Pepin	Turner	Gast	Meinschein
,308																															319
,305					254																										
,248							257																								
,222	250																														
,219														318																	
,186											310																				
,182											311																				
,133			317																												
,132													249																		
,121				136		137		135					132																		
,120												138																			
,119								139																							
,118								140																							
,116			133					141																							
,115			134																												
,114			142					143																							
,113			144																												
,112			145																												
,111			146			148		147																							
,110			149		305			150																							
,109			151																												
,108		306	152					153	154	334																					
,107				155		156																									
,106																	157														
,104								158		333			245				159														
,102																	160														
,100RL								247									246														
,97							248										163														
,96																	164														
,93						165																									
,90																241															
,89								166							167																
,88																242															
,87															168																
,86										332						243		169													
,85								170							171																
,84																244															
,83															172																
,82																															
,80								174		331		175	173																		
,79				176		177																									
,77											178																				
,76											179																				
,74								181			182		180																		
,73								185			183		184																		
,72						188		187			186																				
,71								191		330	189		190																		
,70								194			193		192																		
,69											195		196																		
,68											197																				
,67											198																				
,66											199																				
,65																															
,64											201																				
,63				206		207		205		329	203		204																		
,62											209		210																		
,59				211				212																							
,58				213				214																							
,56				215				216																							
,55				217		220		218		328																					
,54	222			223				224											221												
,52															225																
,51															226																
,50															227																
,46	228																														
,45						230		229		327																					
,44								231				232																			
,43						233		234		326																					
,42								235																							
,41				236		238		237																							
,40								239	240																						
,28																														313	
,12										37																					
,11									25	24								27										26			
,5										32/34																			33		
,4										17		18										16	19	20	21	22	23				
,0																8	13			131	7										

TABLE A15-3.- CORE TUBE 15003 ALLOCATION MATRIX

Parent Sample	Adams	Biemann	Burlingame	Dollfus	Eglinton	Fleischer	Geiss	Heymann	Kaplan	Lalou	Lindsay	Oro	Reed	Schopf	Silver	Walker	McKay	Price	Marti	Bogard	Haskin	Philpotts	Arnold	Turner	Maurette	Pepin	Wasserburg	Gast	Gold	Lal	Goles
,394																															475
,388																															473
,382																															469
,374																															465
,368																															462/463
,367																															461
,366																															460
,363																															458/459
,362																															456/457
,360																															455
,358																															454
,357																															453
,354																															450/451/452
,353																															449
,351																															447/448
,350																															445
,348																															443/444
,346																															440/441/442
,345																															439
,342																															437 436
,339																															434/435
,338																															432/433
,337																															431
,336																															
,325																													333		
,320																													331		
,256																															
,254						309		277		312																					
,253								277																							
,247						304																									
,246								275																							
,243						306																									
,242								273																							
,239						308																									
,238								271																							
,235														284																	
,232						307																									
,231								269																							
,227						302																									
,226								267																							
,221						305																									
,220								265																							
,218								303																							
,217						263																									
,190						218		217			216																				
,187RL										256																					
,178						221					219																				
,173															204																
,171				223							222				205																
,170RL																257															
,164											224																				
,157																	324														
,152		228				227		226			225																				
,144											229																			425	
,142																														424	
,139																														423	
,137													234		206																
,135	233					232					230				207															422	
,132																	323													421	
,127											236																				
,125																														420	
,121						239					237	240																		419	
,112																	322													418	
,110																									417						
,108																									416						
,107RL																258															
,105																									415						
,103																	321								414						
,101			209						208																						
,99			213			243			212		241														413						
,97																									412						
,94																									411						
,92											244														410						
,90																									409						
,88																									408						
,86					248	247		246			245														407						
,83																									406						
,80																									405						
,78																									404						
,76																									403						
,74																									402						
,72																									401						
,69																									400						
,67											249																				
,63							250																								
,54											251																				
,51RL																259															
,47			211												210																
,45			214			254	255	253			252				215																
,30																												283			
,15																	37							38							
,14																	26								27	28	29				
,8																	34														
,7													18				19	20	21	22	23	24	25								
,0			10												11	16															

TABLE A15-4.- CORE 15004 ALLOCATION MATRIX

Parent Sample	Adams	Arnold	Burlingame	Dollfus	Eglinton	Epstein	Geiss	Gold	Kaplan	Lal	Lalou	Meinschein	McKay	Nash	Reed	Wood	Biemann	Silver	Walker	Price	Marti	Bogard	Haskin	Philpotts	Maurette	Pepin	Wasserburg	Turner	Gast
,0																	7	8	13										
,4		23											17		16					18	19	20	21	22					
,5													32/33																
,11													24												25	26	27		
,12													36/37															38	
,28																													195
,48							148									147													
,49															149														
,50	150																												
,51				151																									
,52														152															
,56					155				154	153			133																
,63			115																										
,77													132			156													
,86							157																						
,87							158																						
,88							159																						
,89							160																						
,91						183																							
,92						182																							
,95							161			163		164	131			162													
,100											184																		
,103							166			167						165													
,114		168																											
,115		169																											
,116		170																											
,118		171																											
,119		172																											
,120		173																											
,122		175																											
,123		176																											
,124		177																											
,125		178																											
,126		179																											
,128		180																											
,129		181																											
,164											189	186																	

TABLE A15-5.- CORE TUBE 15005 ALLOCATION MATRIX

Parent Sample	Adams	Arnold	Biemann	Bogard	Dollfus	Eglinton	Fleischer	Geiss	Marti	Kaplan	Lalou	Maurette	Meinschein	McKay	Nagy	Oro	Price	Silver	USSR	Wasserburg	Wood	Burlingame	Walker	Turner	Lal
,0		292																8				7	13		
,4				19					18					16			17								
,5														123											
,11												24		23						26					
,12														127/ 129										128	
,31															131										
,32															133										
,33															134										
,35						135									137										
,36															139										
,38														395	140										
,39															141										
,41																					143				
,42																					145	146			
,43												149									147				
,44														394	150										
,45RL											151														
,46								152							156										
,47								154							153										
,48								156							155										
,49								159							158						157				
,50								161						393	160										
,51								164							163						162				
,52								166							165										
,53								168							167	169									
,54								171							170										
,55								173							172										
,56				177	176										175										
,57				180																	179				
,58																					181				413
,59				185																	183				
,60																					186				
,61																					188				
,62																					189				412
,63						192																			
,64																					194				
,66														392											411
,67																	199				198				
,68		202															201								
,70		206																							
,71		208																							
,72		210																							410
,73		212																			211				
,74		214																			213				
,75		215																							409
,76		217																			216				
,77																					218				408
,78		219																							
,80																				222					407
,83				227		224																			
,84						228								391											
,85													232					231			230				
,86																		234			233				
,87																		236			235				
,88				239														238							
,89																		241				240			
,90	244																	243							
,91																		246			245				
,92																		248			247				
,94																		250							
,95																		252							
,97				255																	254				
,98																					256				
,100						257																			
,101																					259				
,103																					261				
,105																					263				
,106				267																	265				
,107																					268				
,108			272																		270				
,109						273								390							274				
,110																			284		276				
,111																					278				
,112				283																	281	291			

TABLE A15-6.- CORE TUBE 15006 ALLOCATION MATRIX

Parent Sample	Adams	Bogard	Burlingame	Dollfus	Eglinton	Epstein	Fox	Geiss	Kaplan	Lalou	McKay	Oro	Reed	Silver	Wood	Walker	Biemann	Price	Marti	Maurette	Wasserburg	Turner	Gast	Arnold	Lal
,161									181	191															
,126			178								176		177											224	
,125																								225	
,124		174													175									226	
,123																								227	
,121	173										204		221											228	
,117RL																183									
,115													222											229	
,108											203		223												
,107RL										181						182									
,106																172									
,104																								230	
,102													171												
,99				170												169									
,95		167									202				168										240
,94								166																	
,93								165																	
,92								164																	
,91								163																	
,90																162									
,88					160					161															
,84							159																		
,83							158																		
,82	155												157			156									
,81							154																		
,80							153																		
,79							152																		
,78		149										150			151										
,77							148				201														
,75																									239
,71RL																180									
,70																147									
,66		145									200				146										232
,64	143											144													
,59RL																179									
,58																142									
,52						141																			
,51		138		137		140									139										231
,46																136									
,42			135																						
,28																							195		
,13											33/35											34			
,12											24									25	27				
,6											30														
,5											17							18	19						
,0													9			14	8								

TABLE A16-1.- DRILL STRING 60001 ALLOCATION MATRIX

Parent Sample	Arnold	Davis	Silver	Haskin	Wasserburg	Burlingame	Lindsay	Bogard	McKay	Turner	USSR
,1		13									
,3	5		6	7	8	9	10	11			
,7				63							
,13		66									
,20											61
,28									29		
,29										58	
,32				55							
,55				69							

TABLE A16-2.- DRILL STRING 60002 ALLOCATION MATRIX

Parent Sample	Turner	McKay	Carter	Haggerty	Wasson	Bogard	Philpotts	Price	Lalou	Heymann	Burlingame	Lal	Anders	Bell	Meyer	Reed	Rhodes	Geiss	Epstein	Silver
,1		6	108	178																
,6	182																			
,23					201															
,25					202															
,27					203															
,31						204	206	207												
,33									208											
,45								211		210										
,51								214		213										
,53								217		216										
,56							220	221		219										
,58								224		223										
,61								227		226										
,65						228					229									
,75										231	230									
,78							238			233										
,87							242			240		241								
,100							244	245												
,102											246									
,104		253				250	255				251		248	249	254	256	257			
,106											258									
,109										261	260									
,110										264	262									
,112						265	268				266									
,115											269									
,117											270									
,119											271									
,123						272	275					274								
,129						276	278	279												
,136						280					281									
,146						283	286					285								
,153						287	289	290												
,157																		291		
,159																		292		
,161																		293		
,163						294	298				295							297		
,165																		299		
,167																		300		
,169																		301		
,171						302	306					305						304		
,176												307								
,179		312				309	314				310			308	313	315	316		311	
,180													317							318

TABLE A16-3.- DRILL STRING 60003 ALLOCATION MATRIX

Parent Sample	Turner	Davis	Arnold	Silver	Haskin	Wasserburg	Burlingame	Lindsay	Bogard	McKay
,1										4
,3		6	7	8	9	10	11	12	13	
,4	182									
,6		187								
,9					184					

TABLE A16-4.- DRILL STRING 60004 ALLOCATION MATRIX

Parent Sample	Adams	Epstein	Gold	Heymann	Kaplan	Lal	Lalou	Maurette	Meyer	Price	Reed	Walker	Meeks	McKay	Arnold	Silver	Davis	Haskin	Wasserburg	Burlingame	Lindsay	Bogard	Turner
,342						395			396														
,336RL												394											
,334				392				391	393			408											
,318									390														
,316				389	387					388		409											
,314					386																		
,312									385														
,305						382			383														
,303						381																	
,300												410											
,289											380												
,287				379				378	376			411											
,286RL												375											
,272									374			412											
,260				372				371	373														
,254												413											
,249						369			370														
,246												414											
,241RL												368											
,223												415											
,216		367																					
,211		366		365						364													
,200											363												
,198	362								359	361		416											
,195						358																	
,192RL												357											
,190									356														
,186				354				353	355			417											
,22																		398					
,18																	406						
,13																		399					
,10																	404						
,7		407													20	21		22	23	24	25	26	
,6																							183
,5																	18						
,4																							182
,3															11	12	10	13	14	15	16	17	
,1														4/6									

TABLE A16-5.- DRILL STRING 60006 ALLOCATION MATRIX

Parent Sample	Adams	Bogard	Geiss	Housley	Maurette	McKay	Price	Reed	Walker	Arnold	Silver	Haskin	Wasserburg	Burlingame	Lindsay	Davis	Epstein
,129						184			232					226			
,122					186	185											
,117RL									187								
,115														225			
,105			189			188	190										
,103														224			
,98RL									191								
,95						192											
,93														223			
,85						193			233					222			
,81																	227
,79																	228
,77	196			197		194		195									229
,76RL									198								
,75																	231
,73																	230
,63		200				199	201										
,42			203			202	204										
,16					207	205		206	234								
,12																221	
,7												208					
,4																12	
,3		11								5	6	7	8	9	10		

Parent Sample	Adams	Fleischer	Fireman	Gold	Griscom	Lalou	McKay	Pepin	Price	Reed	Walker	Meeks	Arnold	Silver	Haskin	Wasserburg	Burlingame	Lindsay	Bogard	Turner	USSR
,225												392									
,221							256														
,218							271														
,216							268														
,211							265														
,207							262														
,206							255														
,204			259																		
,114															272						
,107															273						
,90			93				248						382				381				
,88			94							247			383								
,85			95							244	245		384								
,83							243						105	106	107	108	109	110	111		
,82																				202	
,80							241						385								253
,79	239										240		386								
,78										238											
,76			96																		
,73			97																		
,71			98																		
,69													387								
,68				237							236										
,66										235											
,64																					
,61										234											
,59							232				231										
,55																	380				
,53										229			388								
,51					226					227	228										
,49			99																		
,45			100																		
,43																	379				
,41			101																		
,39	224										223	225									
,38							222														
,34																	378				
,30							221				220										
,27		218						219													
,25							217														
,23																	377				
,21		216								215											
,19										213											
,17			102						212												
,15		211	103					210													
,13			104														376				
,11	209										208										
,10							254													202	
,9		207																			
,8																	375				
,6													112	113	114	115	116	117	118		
,4		204					206	205													
,2																	374				
,1							82/10														

TABLE A17-1.- APOLLO 17 DEEP DRILL STRING 70001

ALLOCATION MATRIX

Parent Sample	Silver	Burlingame	Wasserburg	Pepin	Reed	Haskin	Geiss	USSR
,3	7	8	9	10	11	12	13	14

TABLE A17-2.- APOLLO 17 DEEP DRILL STRING 70002

ALLOCATION MATRIX

Parent Sample	Davis	Silver	Burlingame	Wasserburg	Pepin	Reed	Haskin	Geiss
,3	6	7	8	9	10	11	12	13
,6	23							

TABLE A17-3.- APOLLO 17 DEEP DRILL STRING 70003

ALLOCATION MATRIX

Parent Sample	Davis	Silver	Burlingame	Wasserburg	Pepin	Reed	Haskin	Geiss
,3	6	7	8	9	10	11	12	13
,6	23							

TABLE A17-4.- APOLLO 17 DEEP DRILL STRING 70004

ALLOCATION MATRIX

Parent Sample	Davis	Silver	Burlingame	Wasserburg	Pepin	Reed	Haskin	Geiss
,3	6	7	8	9	10	11	12	13
,6	23							

TABLE A17-5.- APOLLO 17 DEEP DRILL STRING 70005

ALLOCATION MATRIX

Parent Sample	Davis	Silver	Burlingame	Wasserburg	Pepin	Reed	Haskin	Geiss
,3	6	7	8	9	10	11	12	13
,6	23							

TABLE A17-6.- APOLLO 17 DEEP DRILL STRING 70006

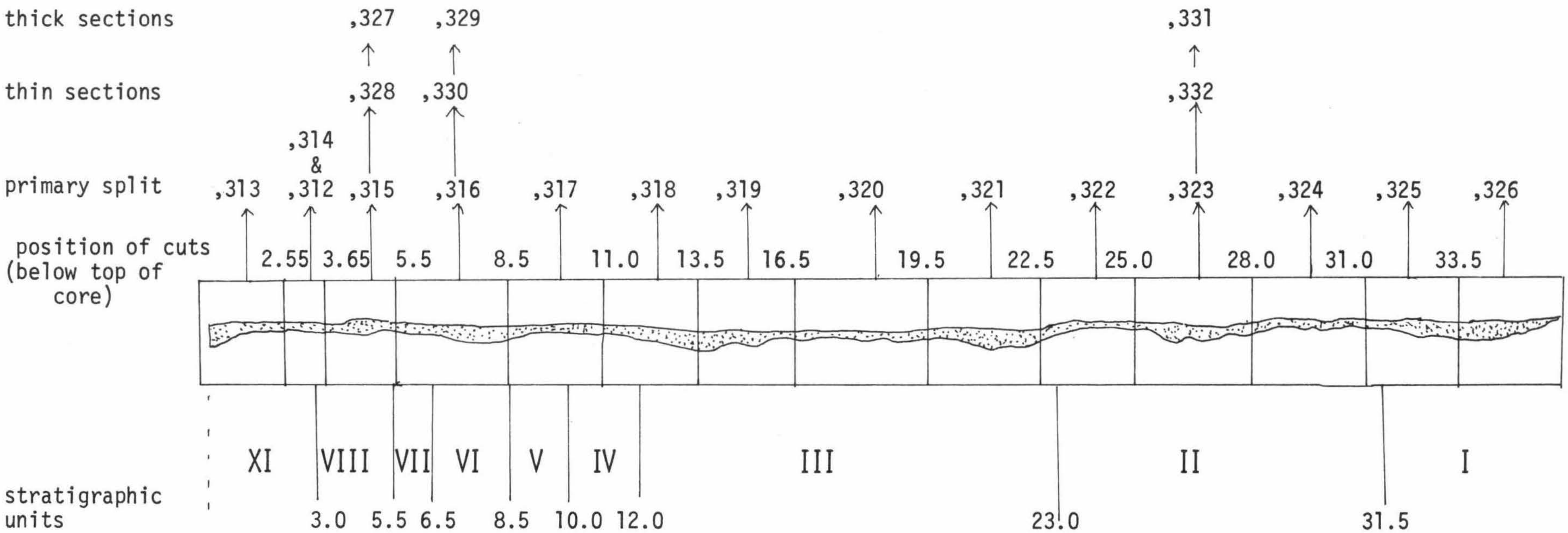
ALLOCATION MATRIX

Parent Sample	Davis	Silver	Burlingame	Wasserburg	Pepin	Reed	Haskin	Geiss
,3	6	7	8	9	10	11	12	13
,6	23							

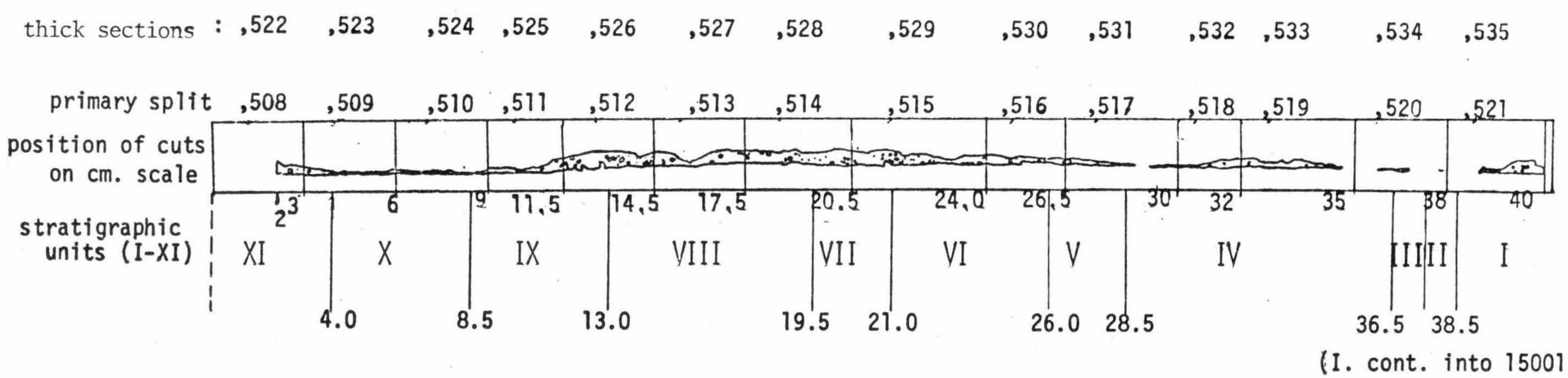
TABLE A17-7.- APOLLO 17 DEEP DRILL STRING 70008 ALLOCATION MATRIX

Parent Sample	Davis	Silver	Burlingame	Wasserburg	Reed	Haskin	Geiss	Silver	USSR	Maurette	McKay	Walker	Anders	Schmitt	Kirsten	Pepin	Philpotts	Eglinton	Bogard	Marti	Arnold	Clayton	Adams
,1	3/5/ 7/9																						
,3	268																						
,5	271																						
,7	274																						
,9	277																						
,15		181	182	183	184	185	186	187		246						285							
,19								244			245												
,21								243															
,23								242															
,25												241											
,26								240															
,45											235												
,53					234																		
,84												278											
,87												279											
,89												280											
,91												281											
,93												282											
,107												224											
,140											220		217	218	219								
,157												216											
,163			188	189	190	191	192		193							284							
,197											239	238							237				
,198												236											
,201				232						233													
,203											231	230											
,205											228	227				225/ 283	226	228					
,209				221						222													223
,213										214	215												
,247																	249			248	250	251	

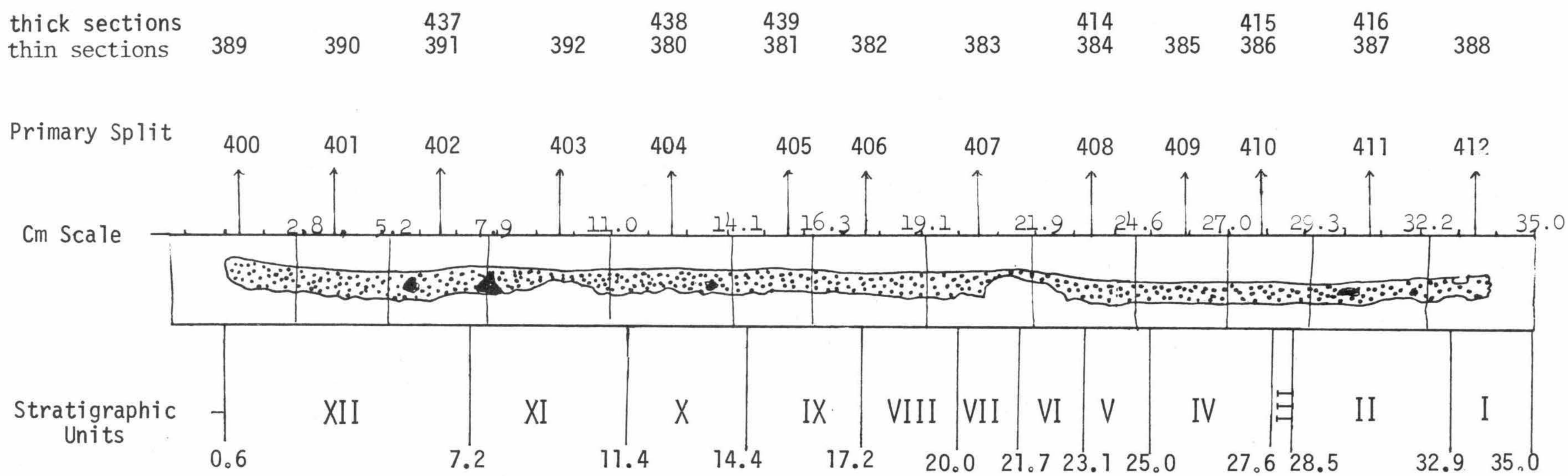
ALLOCATIONS FROM IMPREGNATED PART OF DRILL STEM 15001 (15001,222)
SHOWING INTERVAL AND GENERATIONS OF SPLITS



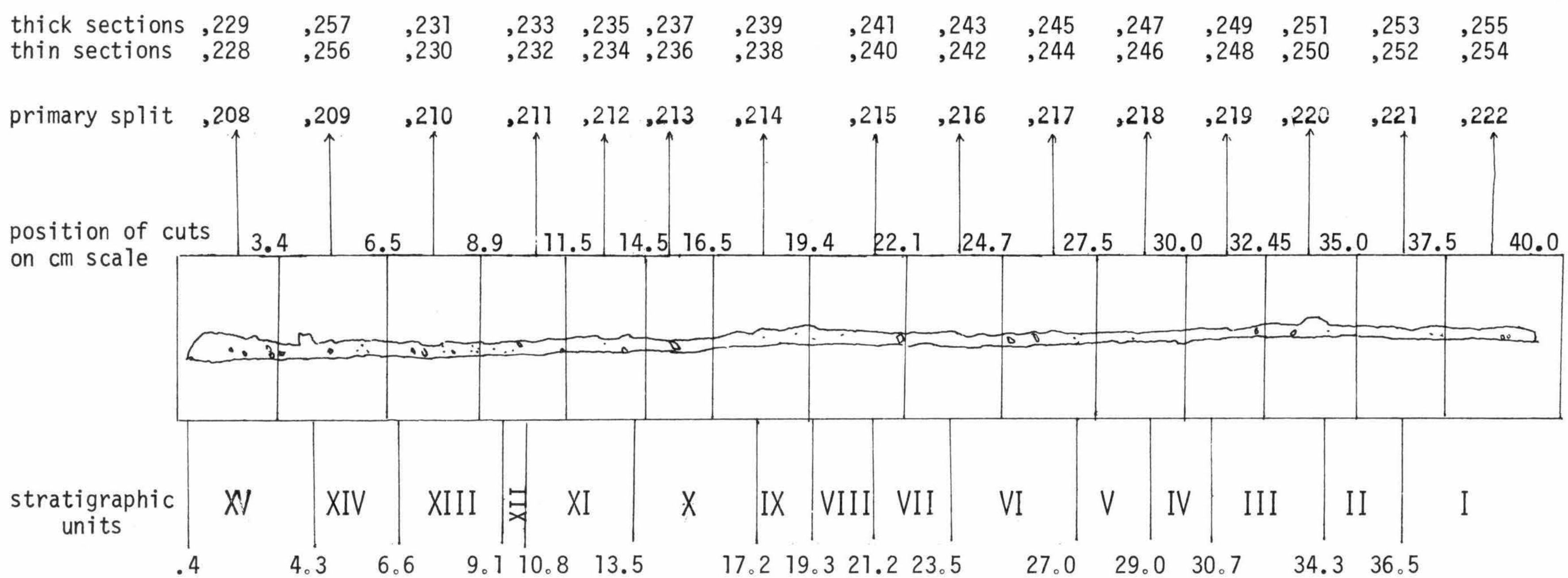
ALLOCATIONS FROM IMPREGNATED PART OF DRILL STEM 15002 (15002,357)
SHOWING INTERVAL AND GENERATIONS OF SPLITS



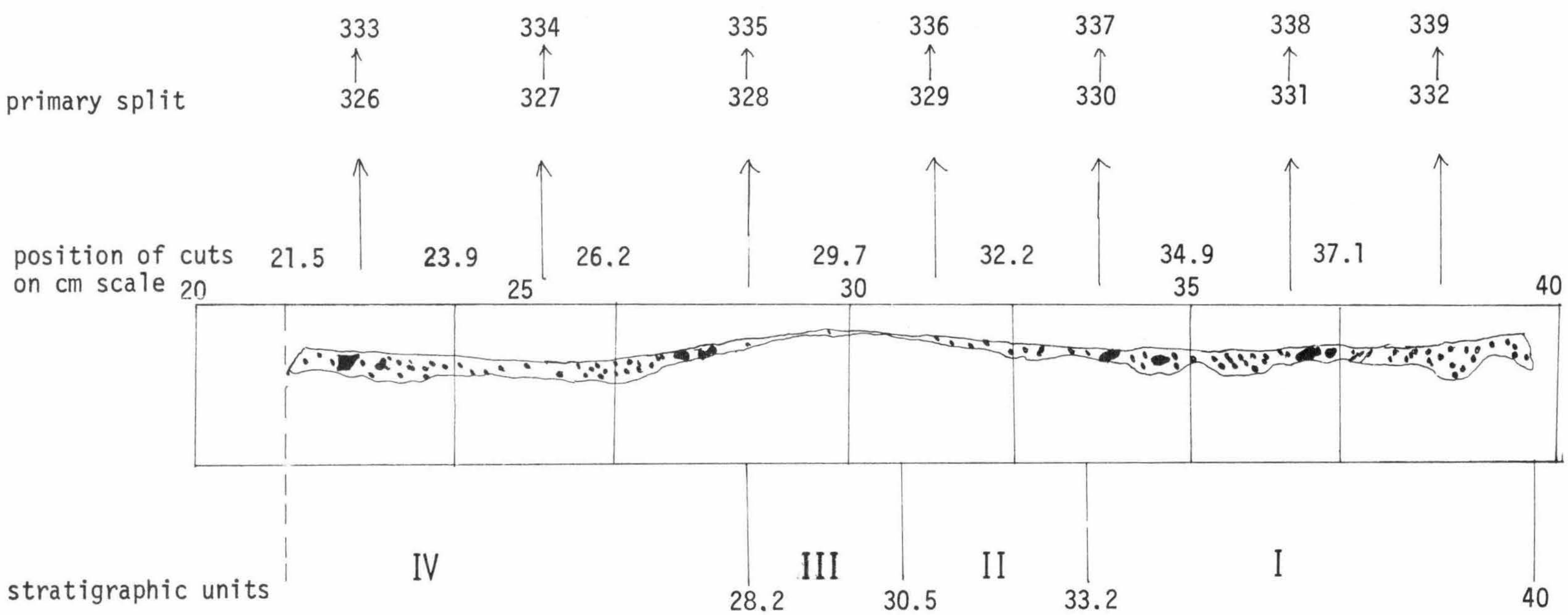
ALLOCATIONS FROM IMPREGNATED PART OF DRILL STEM 60002 (60002,328)
SHOWING INTERVAL AND GENERATIONS OF SPLITS



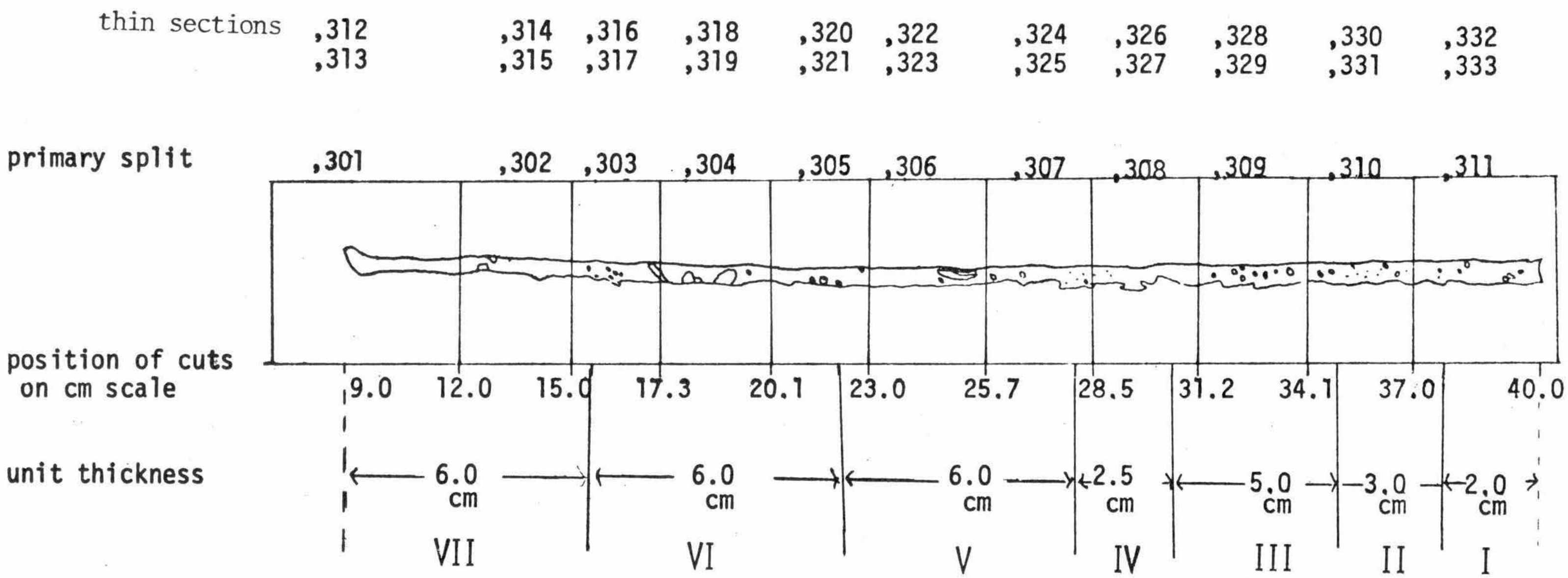
ALLOCATIONS FROM IMPREGNATED PART OF DRILL STEM 60003 (60003,207)
SHOWING INTERVAL AND GENERATIONS OF SPLITS



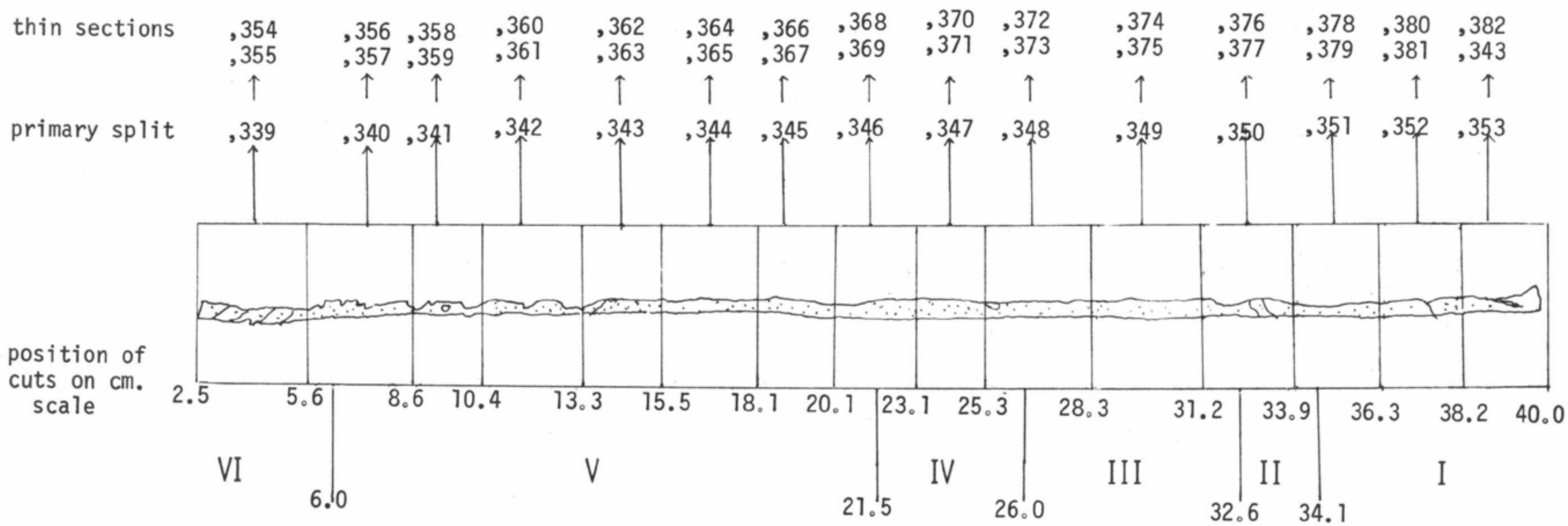
ALLOCATIONS FROM IMPREGNATED PART OF DRILL STEM 60007 (60007,325)
SHOWING INTERVAL AND GENERATIONS OF SPLITS



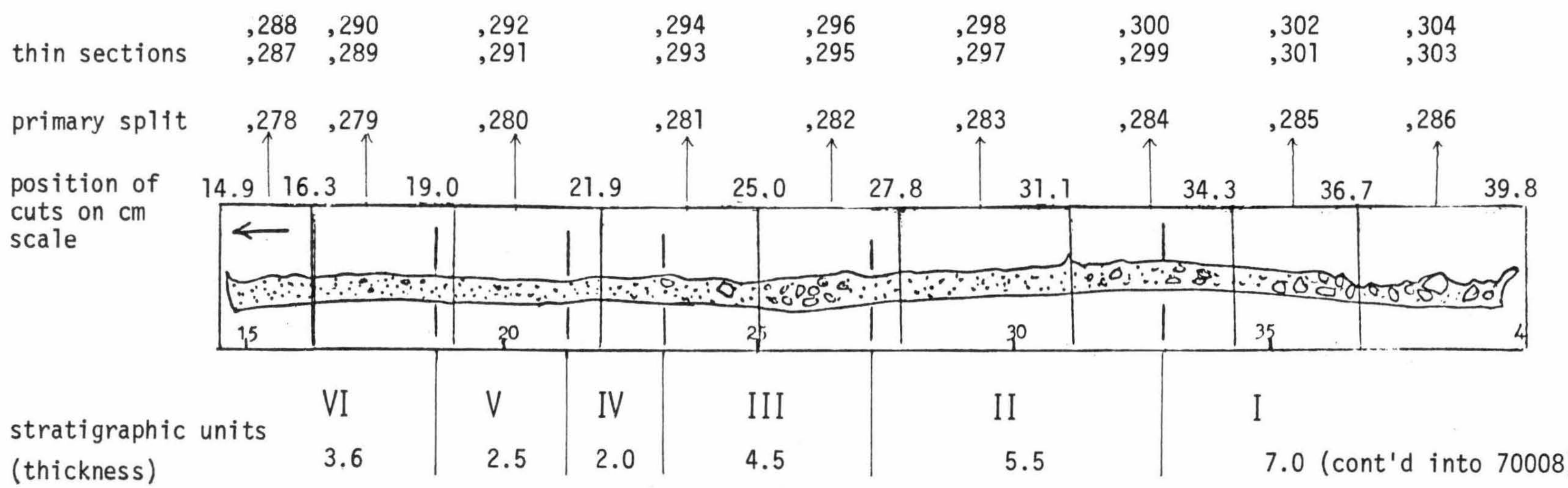
ALLOCATIONS FROM IMPREGNATED PART OF DRILL STEM 70007 (70007,300)
SHOWING INTERVAL AND GENERATIONS OF SPLITS



ALLOCATIONS FROM IMPREGNATED PART OF DRILL STEM 70008 (70008,295) SHOWING INTERVAL AND GENERATIONS OF SPLITS



ALLOCATIONS FROM IMPREGNATED PART OF DRILL STEM 70009 (70009,277)
SHOWING INTERVAL AND GENERATIONS OF SPLITS



REFERENCES

1. Carrier, W. D., III; Johnson, S. W.; Werner, R. A.; and Schmidt, R. (1971): Disturbance in Samples Recovered with the Apollo Core Tubes. Proceedings Second Lunar Science Conference, Geochimica et Cosmochimica Acta, Vol. 3, pp. 1959-1972. MIT Press.

2. Carrier, W. D., III; Johnson, S. W.; Carrasco, L. H.; and Schmidt, R. (1972b): Core Sample Depth Relationships: Apollo 14 and 15. Proceedings Third Lunar Science Conference, Geochimica et Cosmochimica Acta, Vol. 3, pp. 3213-3222. MIT Press.

3. Fryxell, R. and Smith, H. W. (n.d.): Collecting and Interpreting Useful Soil Sample from Archaeological Sites. Manuscript in preparation. Department of Agronomy and Soil Science, Washington State University, Pullman, Washington.

4. Council, C. D.: ALSD Decontamination Process for Apollo 17 Flight Hardware. Contract NAS 9-9462 Procedure No. 467A8060883, Martin-Marietta Aerospace, Denver, Colorado, August 25, 1972.

5. Fryxell, R.; Anderson, D.; Carrier, D.; Greenwood, W.; and Heiken, G. (1970): Apollo 11 drive-tube core samples: an initial physical analysis of lunar surface sediment. Proceedings of Apollo 11 Lunar Science Conference, Geochimica et Cosmochimica Acta, Vol. 3, pp. 2121-2126. (reprinted from Science, Vol. 3, pp. 734-736, 1970)

6. Nagle, J. S.; and Duke, M. B. (1974): Stabilization of Lunar Core Samples. In Lunar Science V: Abstracts of Papers Submitted to the Fifth Lunar Science Conference, Part II, p. 543.

7. Lunar Sample Preliminary Examination Team (LSPET) (1969b): Preliminary examination of lunar samples. In Apollo 11 Preliminary Science Report, NASA SP-214, pp. 123-142.

8. Lunar Sample Preliminary Examination Team (LSPET) (1969a): Preliminary examination of lunar samples from Apollo 11. Science, 165, pp. 1211-1227.

9. Lunar Sample Preliminary Examination Team (LSPET) 1970a): Preliminary examination of lunar samples from Apollo 12. Science 167, pp. 1325-1329.

10. Lunar Sample Preliminary Examination Team (LSPET) (1970b): Preliminary examination of lunar samples. In Apollo 12 Preliminary Science Report, NASA SP-235, pp. 189-216.

11. Lunar Sample Preliminary Examination Team (LSPET) (1971a): Preliminary examination of lunar samples from Apollo 14. Science 173, pp. 681-693.

12. Lunar Sample Preliminary Examination Team (LSPET) (1971b): Preliminary examination of lunar samples. In Apollo 14 Preliminary Science Report, NASA SP-272, pp. 109-132.

13. Carrier, W. D., III; and Heiken, G. (1972b): Lunar Surface Closeup Photography at Fra Mauro (Apollo 14 Site). NASA TM X-58072, Manned Spacecraft Center, Houston, Texas.

14. Mitchell, J. K.; Bromwell, L. G.; Carrier, W. D., III; Costes, N. C.; and Scott, R. F.: Soil Mechanics Experiment. Apollo 14 Preliminary Science Report, sec. 4, NASA SP-272, 1971.

15. Lunar Sample Preliminary Examination Team (LSPET) (1972a): Preliminary examination of lunar samples. In Apollo 15 Preliminary Science Report, NASA SP-289, pp. 6-1 to 6-25.

16. Lunar Sample Preliminary Examination Team (LSPET) (1972b): Preliminary examination of lunar samples. In Apollo 15 Preliminary Science Report, NASA SP-289, pp. 6-1 to 6-25.

17. Heiken, G.; Duke, M.; McKay, D. S.; and Clanton, U.S. (1973): Preliminary, stratigraphy of the Apollo 15 drill core. Proceedings Fourth Lunar Science Conference, Geochimica et Cosmochimica Acta, Suppl. 4, Vol. 1, pp. 191-213.

18. Lunar Sample Preliminary Examination Team (LSPET) (1973c): Preliminary examination of lunar samples from Apollo 16. Science 179, pp. 62-76.

19. Lunar Sample Preliminary Examination Team (LSPET) (1972d): Preliminary examination of lunar samples. In Apollo 16 Preliminary Science Report, NASA SP-315, pp. 7-1 to 7-24.

20. Apollo Lunar Geology Investigation Team: Documentation and Environment of the Apollo 16 Samples: A Preliminary Report. U.S. Geol. Survey Interagency Report., Astrogeology 51, May 26, 1972.

21. Butler, P.: Lunar Sample Information Catalog, 1972, pp. 37-39, pp. 58-59. NASA-JSC, MSC 03211, Houston, Texas

22. Nagle, J. S.: Examination and Sub-Sampling of Apollo Drill Stem 70008. NASA-JSC, Houston, Texas, 1973.

23. Lunar Sample Preliminary Examination Team (LSPET) (1973a): Preliminary examination of lunar samples from Apollo 17. Science 182, pp. 659-690.

24. Lunar Sample Preliminary Examination Team (LSPET) (1973b); Preliminary examination of lunar samples. In Apollo 17 Preliminary Science Report, NASA SP-330, pp. 7-1 to 7-46.