REPORT ON DRILL STEM 70006

Drill stem 70006 is the fourth stem below the top of the Apollo 17 Drill String. Calculations based on X-radiographs and previous dissections of other drill stems in the string place the top of 70006 at 93.2 cm below the lunar surface. Due to various factors such as mechanical compaction, this figure is only a close approximation. The drill string, with a total length of about 294.5 cm, has three major stratigraphic units: an upper, coarse-grained, basaltic unit, 107 cm thick; a middle, fine-grained zone 56 cm thick, high in anorthosite; and a lower zone of alternating coarse and fine basaltic and breccia material, 131.5 cm thick. Part of each of the upper major units are contained in drill stem 70006. The Apollo 17 Drill String was taken about 40 meters north of the ALSEP central station.

SAMPLE HISTORY

Upon extraction of the drill string from the drill hole, the string was separated into three segments for packing. Drill stem 70006 was the top half stem of the middle segment. A cap was installed on the top end at this time. A plug was inserted at the bottom end when the separation from 70005 was made in the LRL. Burrowed end samples were taken totalling slightly more than 9 grams. Based on a length of 40 cm and weight of 234.2 grams, the end samples are equivalent to about 16 mm of soil column, which leaves 38.4 cm of soil column remaining in the tube.

On March 11, 1977, the drill stem was longitudinally split on a milling machine. Previous to this operation, the drill stem was fitted with a special plug for the thermal conductivity experiment. This plug protruded about 15 mm from the tube opening and was subsequently forced further into the tube due to requirements of the milling operation.

The "upper" split half was lifted off the soil column after the "lower" split half had been affixed in a troughed dissection table on March 16, 1977. Because of excessive burring along the cut edge, a portion of the soil remained in the upper half in the region of 3 to 5 cm depth.

The stratigraphically highest end of the tube was, by convention, set to the zero cm mark on the scale. The upper soil/plug interface thus became established at the 2.8 cm mark and the lower interface at 40.0 cm. The length of soil column is easily calculated to be 37.2 cm, which indicates that 2.8 cm of column was "lost" by compaction and early burrowed end sampling.

S. Waltz 1977

PRE-DISSECTION DESCRIPTIONS

From x-radiographs of drill stem 70006, twelve units were interpreted on the basis of size distributions and inferred compositions. (See attached chart.) Examination of the exposed surface revealed eleven units on the basis of observable coarse particles, tonal contrasts, and fracturing of the developed rind. In conjunction with the x-ray units, these units served as guides to dissection and may or may not be actual physical units below the rind or smear zone. The overall color was 10YR 3/1 on Munsell's Color Chart. The visually estimated average soil matrix grain size was about 6 phi or 16 microns.

PROCESSING PROCEDURES

A slight departure from standard dissection procedures was necessary in order to extract the large particle wedged in the otherwise empty upper split half of the drill stem. Simaltaneous dissection was performed in both upper and lower halves and the excavated material was combined in order to reduce statistical bias. Standard five millimeter intervals were observed except at 6.5-8.0 cm and 27.0-28.5 cm where special lead-free and red light samples were obtained. Additional red light samples were taken at 17.0-17.5 cm and 37.5-38.0 cm. Dissection was begun at the upper end in order to be able to empty and remove the upper split half as soon as possible. The first interval was taken seven millimeters wide in order to even up the remaining intervals. Unusual or large particles transcending interval boundaries (such as the particle wedged in the upper half) were individually containerized as special samples. Wherever possible, large particles were located on a diagram of the interval in order to record orientations. All particles not passing through a 1 mm sieve were classified, photographed, and containerized for each dissection interval. Voids created by extraction of large particles extending below standard dissection depth were maintained if possible. It was necessary to remove these particles in order to obtain a peel sample. At 11-14 cm, nearly all the remaining soil adhered to the peel. The excess soil was removed from the peel relatively intact and impregnated with epoxy separately from the soil yet in the tube, which was done under vacuum conditions. The impregnated core was then encapsulated with more epoxy in a mold. The block thus formed is later split longitudinally and one resulting half is used for making thin sections.

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. Each size range is also divided into seven compositional types. Frequencies are computer-normalized to the standard interval width and average weight. Graphs of normalized frequencies versus depth are plotted in eight groupings: by compositional type for each of the three size ranges; by compositional type for the combined sizes; by combined compositions for each of the three sizes; and by combined compositions for the combined size ranges. When combining sizes, scale factors are used. In addition to the frequency graphs, a weight percent coarseness indicator is plotted. The percentages are computed by dividing the weight of material greater than 1 mm in size by the weight of all the material per unit.

Bias is introduced by the sampling size of the drill stem, in that the presence of a particle approaching tube diameter in size eliminates the possibility of occurence of other particles. Other statistical error is brought about by the discrete size categorization, rather than a continuous size measurement of each particle. This error is demonstrated by comparing the weight percent coarseness graph with the combined composition/ combined sizes graph. The lack of congruence that can be seen is partially due to this "pidgeonhole" effect and partially due to generalizing assumptions that had to be made in order to combine the discrete size categories. Other biases or errors include -- sampling below standard dissection level, measurement error, assumptions of uniform density, and misclassification of lithology. Bearing these limitations in mind, interpretation of the constructed graphs was not attempted at the order of resolution provided.

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COMPOSITIONAL DESCRIPTION

Seven compositional categories were used to classify particles greater than 1 mm in grain size: anorthositic breccia (ANBX); agglutinates (AGGL); devitrified or partially-crystallized glasses (PXGL); recrystallized or high-grade breccia (RXBX); vesicular, droplet, or fresh glasses (VSGL); soil or low-grade breccia (SOBX); and basaltic or crystalline rock fragments (BSRF). Of these seven, SOBX is by far the most abundant.

The category "BSRF" includes any particle which is apparently no recrystallized material, but is polycrystalline and contains plagioclase and pyroxene. In practice, some of the smaller particles classified as BSRF's may be monomineralic. Also, many particles are soil or glass coated to the point of being barely recognizable. Some soil coated BSRF's may have been misclassified as SOBX's for this reason. Most occur as fairly equant chunks with coarsely-textured surfaces. When the rough pockets in the surface are filled with soil, they are easily mistaken for the equant, smooth-surfaced SOBX's. Effort was taken to remove as much loose soil as possible SOBX's without significantly damaging the normally friable SOBX's in the process. Some BSRF's have shocked plagioclase or anorthositic material. ANBX's may be derived directly from this source, in which case they are more likely to display some evidence of crystal structure. When found as clasts in SOBX's, they tend to be sugary in texture. Some particles classified as "ANBX" may either be soil coated ANBX's or anorthositic clasts from broken SOBX's. SOBX's therefore, exclude white, sugary masses of supposed anorthositic material, even though the only difference may be the color of the soil matrix in which it is formed. "SOBX" refers to a particle of welded, non-white soil matrix. Welding may have been brought about by heat, pressure, small amounts of molten glass, or some combination of these. When glass welding creates a more spindly particle, it is considered to be an "AGGL" rather than a more massive and rounded SOBX. SOBX's are usually friable and occasionally break open to reveal an interior of crystalline mash. Others simply disintegrate when broken. Certain SOBX's are distinguished as medium grade in that they are tougher and seemingly transitional to the category of RXBX. "RXBX" is an angular, waxy-appearing particle that would seem to be the high grade equivalents of SOBX or ANBX. "PXGL" is somewhat similar in appearance to RXBX, but readily distinguishable by a duller surface luster and glass fracture shape characteristics, as it is a devitrified form of VSGL. "VSGL" refers to fresh, vitreous glass which occurs as beads, shards, or coatings. It is often found as coatings on SOBX and causes some difficulty in classification, as SOBX may be glass welded.

DESCRIPTIONS OF PHYSICAL UNITS

Drill stem 70006 contains parts of two major units of the drill string. The boundary is marked by a reverse gradational sequence in the upper unit, as well as by sharp tonal contrast at the contact. The upper unit continues in drill stems 70007, 70008, and 70009 up to the lunar surface and is characterized by large crystalline rock fragments and a relatively light tone. The unit below the boundary (middle unit of three in the entire drill string) is moderately dark and very fine-grained. Compositionally, it is glass-rich but with no dominant particle type. The unit continues as part of 70005.

In drill stem 70006, five minor units are marked off -- two in the lower and three in the upper major unit. The minor units are further divided into nineteen sub-units, mostly based on coarseness or slight tonal differences seen post-peel.

Unit I (28.5-40.0) is 96% matrix. Matrix is here defined as that soil fraction passing through a 1 mm sieve. The compositional type of what few particles do occur is non-specific. The tonal appearance is not uniform although differences are not great. Cohesiveness, as evidenced in the peel, is moderate.

Sub-unit IA (38.5-40.0) is 91% matrix. The minor peak in coarseness due to ANBX defines this sub-unit. The tonal aspect is moderately dark with vague light blotches. Cohesion to the peel strip was slightly better than in the rest of the unit.

Sub-unit IB (37.5-38.5) is 96% matrix. This is a type sub-unit for Unit I. The tone is nearly even.

Sub-unit IC (36.0-37.5) is 96% matrix. SOBX dominates slightly. The tone is blotchy.

Sub-unit ID (33.0-36.0) is 97% matrix. Glass is the most frequent coarse particle. This is the darkest sub-unit and has an even albedo. The lower contact is apparent but not idstinct.

Sub-unit IE (31.5-33.0) is 97% matrix. The tone is unchanged but fairly sharp white streaks occur. The coarse fraction is mostly glass and SOBX rather than ANBX, however.

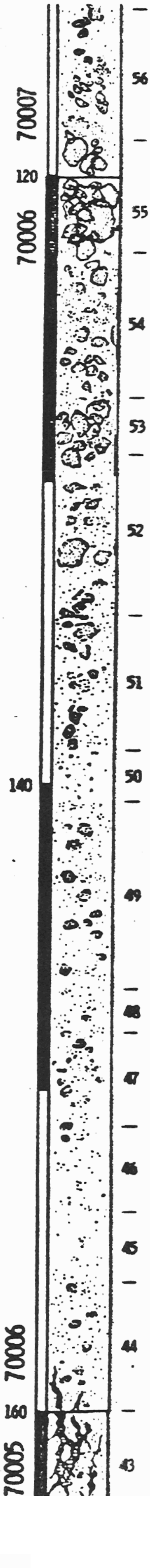
Sub-unit IF (28.5-31.5) is 98% matrix. The tone is noticeably lighter and even. The coarse fraction is negligible. Cohesion is better.

Unit II (18.5-28.5) is 95% matrix. The coarseness varies with occasional peaks of SOBX and smaller amounts of glass. The tonal appearance is an even, moderate dark. Cohesiveness varies from moderate to low.
Sub-unit IIA (26.5-28.5) is 96% matrix. SOBX and VSGL are the most common coarse particles. Tone is moderate and evenly dark.
Sub-unit IIB (25.5-26.5) is 94% matrix. The tone is slightly darker than A. SOBX and VSGL occur in larger quantities.
Sub-unit IIC (24.0-25.5) is 96% matrix. The tone is slightly lighter again. VSGL is plentiful.
Sub-unit IID (22.0-24.0) is 96% matrix. Tone is darker again, but almost imperceptibly.
Sub-unit IIE (19.5-22.0) is 96% matrix. Tone darkens again, very slightly. SOBX and VSGL are still the most common. Cohesiveness is low.
Sub-unit IIF (18.5-19.5) is 95% matrix. Tone is at its darkest. The compO-sition is variable.

Unit III (14.0-18.5) is 89% matrix. The lower contact is laso the major unit boundary. The tonal contrast is sharp across this line but the line is wavy. Compositionally, the coarse fraction shows an overturned gradational sequence. The cohesiveness is moderate.
Sub-unit IIIA (16.5-18.5) is 92% matrix. SOBX is suceeded by RXBX, then VSGL. Coarseness increases upwards linearally. The tone is light and vaguely blotchy.
Sub-unit IIIB (14.0-16.5) is 86% matrix. BSRF dominates. Cohesiveness is moderately low. Particle size is greatest at mid-unit.

Unit IV (4.5-14.0) is 87% matrix. SOBX is dominant. Cohesiveness is very high. The tone is light with occasional light blebs.
Sub-unit IVA (12.5-14.0) is 79% matrix. SOBX occurs as a very large particle and as smaller chunks.
Sub-unit IVB (10.5-12.5) is 91% matrix. SOBX still dominates but at reduced levels. Glass is found both as shards and as beads.
Sub-unit IVC (8.5-10.5) is 83% matrix. Large SOBX particles outweigh a diverse collection of other small particles.
Sub-unit IVD (4.5-8.5) is 90% matrix. Cohesivity is lower. Glass is beady, SOBX shows some orange, and BSRF appears shocked. SOBX dominates somewhat.

Unit V (1.2-4.5) is 50% matrix. BSRF is strongly dominant as a very large particle and as many medium-sized chips. Cohesivity is moderate. The tone is slightly darker.



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 specimens, 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
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.

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 concentrations 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.
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.

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.
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.

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.

PHYS-ICAL UNIT	LUNAR DEPTH (CM)	THIC -N (C	* See ,2	DRILL STEM 70006 SAMPLE LOCATION INFORMATION								
				INTERVAL	FINE FRACTION		COA FRACTION		SPECIAL SAMPLES			
				Location Notation	Sample Number	Weight (MG)	Sam Num	Weight (MG)	Location Notation	Sample Number	Weight (MG)	Composit Description
70006 V	93.2	3.3							012-00*	2	90	Joint/Compac Greater than
				023-12	3	2941	4	3444				
									028-23	5	2998	Bulk, Cold S
				035-28	25	2165	26	662				
			27	040-35	28	1300	29	702	045-28	27	2904	Basalt Rock
				045-40	30	1470	31	900				
70006 IV	96.5	9.5		050-45	32	1593	33	72				
				055-50	34	1736	35	384				
				060-55	36	2072	37	188				
				065-60	38	1897	39	270				
				080-65	42	4220	43	725	080-65	40	280	Red Light
									080-65	41	1200	Lead-free
D				085-80	44	2188	45	128				
			50	090-85	46	1933	47	121				
				095-90	48	1810	49	178	095-86	50	540	Soil Breccia
				100-95	51	1941	52	348				
C				105-00	53	1488	54	425				
				110-05	55	2173	56	213				
				115-10	57	1975	58	224				
				120-15	59	1840	60	273				
B				125-20	61	1827	62	156				
			69	130-25	63	1814	64	105				
				135-30	65	1354	66	120				
A				140-35	67	1972	68	170	138-27	69	1084	Soil Breccia
70006 III	106.0	4.5		145-40	70	2052	71	175				
			78	150-45	72	1749	73	221				
				155-50	74	2064	75	210	155-48	78	306	Basalt Rock F
				160-55	76	1615	77	549				
B				165-60	79	1987	80	223				
				170-65	81	1858	82	217				
				175-70	84	1701	85	204	175-70	83	250	Red Light
				180-75	86	2111	87	161				
A				185-80	88	1983	89	103				
70006 II	110.5	10.0		190-85	90	2087	91	76				
F				195-90	92	2067	93	153				
				200-95	94	1952	95	102				
				205-00	96	1964	97	57				
				210-05	98	1801	99	62				
				215-10	100	2311	101	131				
E				220-15	102	1840	103	54				
				225-20	104	2030	105	28				
				230-25	106	1978	107	73				
				235-30	108	2010	109	191				
D				240-35	110	1955	111	72				
				245-40	112	2065	113	97				
				250-45	114	1937	115	90				
C				255-50	116	2118	117	245				
				260-55	118	1991	119	165				
B				265-60	120	1977	121	124				
				270-65	122	2080	123	49				
				275-70	124							
				285-70	124	4685	125	335	285-70	126	1000	Lead-free
A									285-70	127	290	Red Light
70006 I	120.5	11.5		290-85	128	2098	129	70				
				295-90	130	1847	131	67				
				300-95	132	2117	133	36				
				305-00	134	2250	135	33				
				310-05	136	2039	137	27				
F				315-10	138	1925	139	71				
				320-15	140	2169	141	62				
				325-20	142	2220	143	63				
E				330-25	144	2143	145	60				
				335-30	146	2107	147	32				
				340-35	148	2107	149	61				
				345-40	150	1914	151	96				
				350-45	152	2152	153	85				
				355-50	154	2082	155	75				
D				360-55	156	1904	157	48				
				365-60	158	2251	159	129				
				370-65	160	2110	161	60				
C				375-70	162	1993	163	95				
				380-75	165	1719	166	98	380-75	164	320	Red Light
B				385-80	167	2261	168	103				
				390-85	169	2060	170	151				
				395-90	171	2128	172	304				
A				400-95	173	2083	174	230				
				400-28	175	1004	177	35	400-28	176	7750	Sweepings