15010 - 15011

Double Drive Tube

Station 9A

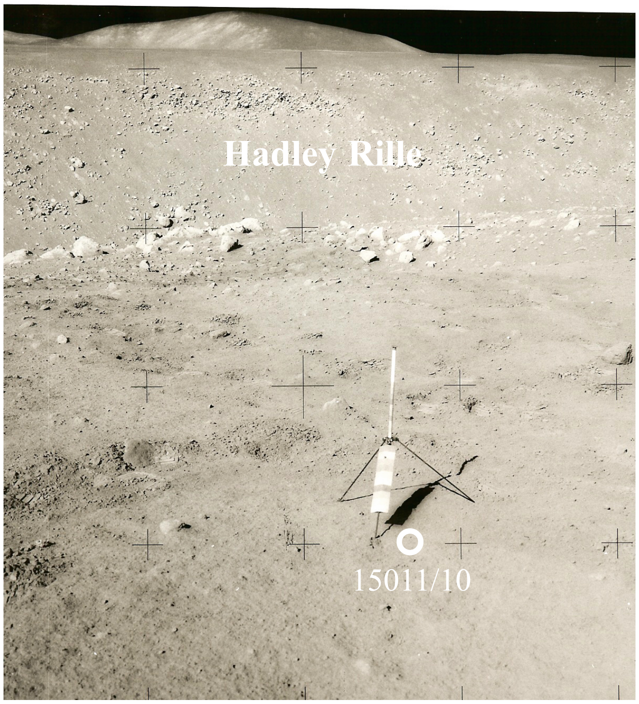


Figure 1: Location of 15011/10, with Hadley Rille in background (~ 1 km away!). Perfect weather. AS15-82-11159

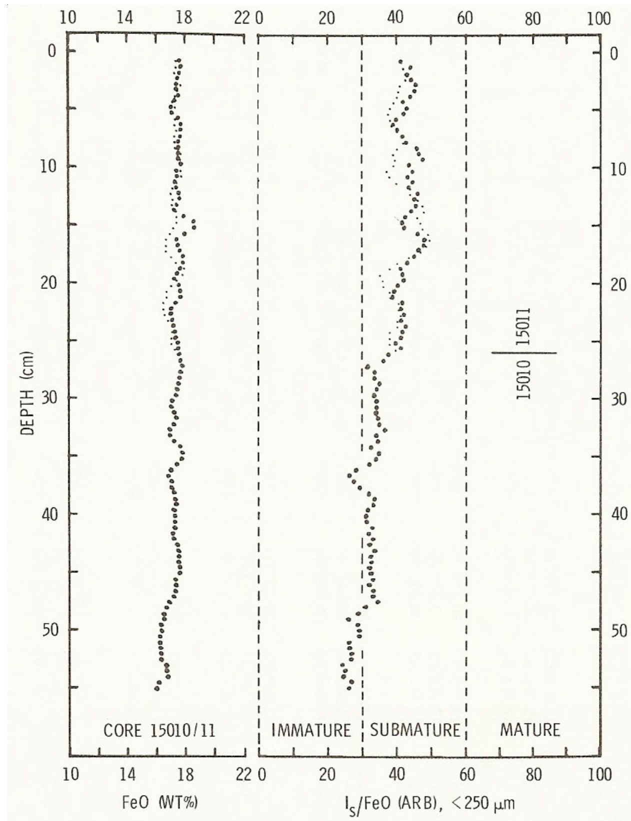


Figure 2: Maturity index along 15011/15010 double drive tube (Bogard et al 1981).

Introduction

Lunar core 15011/10 was collected near the edge of the Hadley Rille (figure 1). Surface soil samples 15531 and rake sample 15600 should be compared with the top of 15011. No chemistry is available.

The original observations obtained during dissection are recorded in Newsletters #18 and 24

Petrography

Papike et al. (1982) gives an *indepth* summary of the results obtained by the study of 15011/10, comparing it with the deep drill core collected some distance away. The maturity (I_s/FeO) decreases with depth (figure 2). McKay et al. (1980) gives the mode and average grain size analysis which increases with depth (figure 3). Walker and Papike (1981) and Griffiths et al. (1981) carefully determined the modal mineralogy.

Mineralogical Mode for 15010

From McKay et al. 1980

depth	28 cm	34cm	40.5cm	46 cm	48 cm	54.5cm
Agglutinate	32.1%	26.7	29.2	26.2	21.9	20.6
Mare Basalt	12.5	13.3	12.1	15.5	12	11.4
KREEP Basalt	0.4	0.9	0.3	0.5	1.7	1.8
Breccia	7.5	7.8	8.3	8.9	7.8	11.3
Plagioclase	8.5	7.7	7.2	7.9	7.2	8.8
Pyroxene	22.5	29.9	26.8	27.3	30.8	27.1
Olivine	1.8	1.7	2.6	2.3	2.6	2.3
Ilmenite						
Glass other	9.8	9.5	9.8	8.9	8.4	10.4

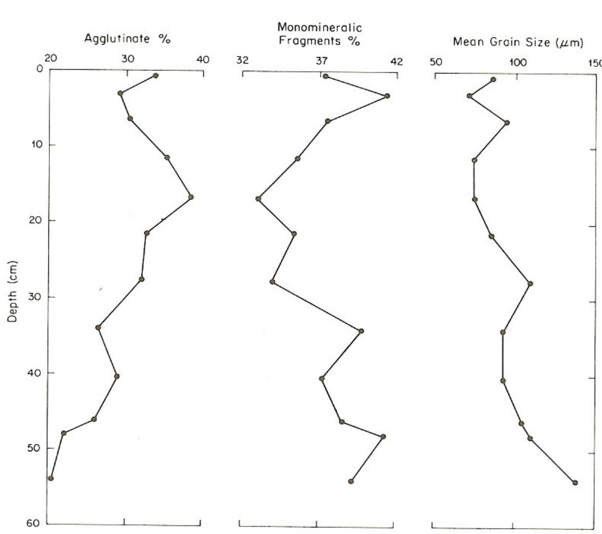


Figure 3: Agglutinate content, mineral fragments and average grain size as function of depth in 15011/10 double drive tube (Griffiths et al. 1981).

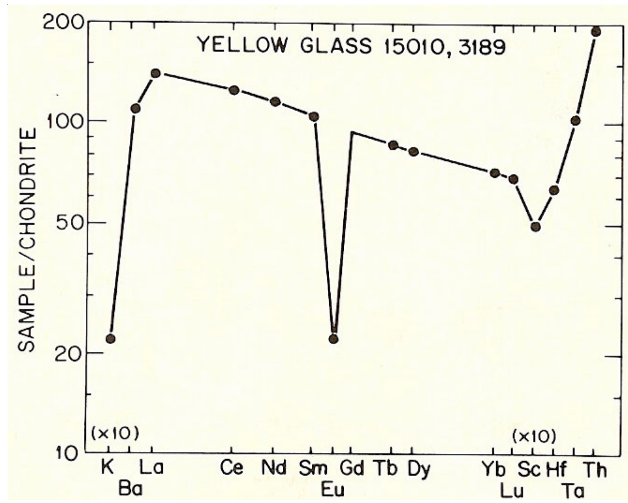


Figure 4: Normalized rare-earth-element diagram for yellow glass found in 15010 (Delano et al. 1982).

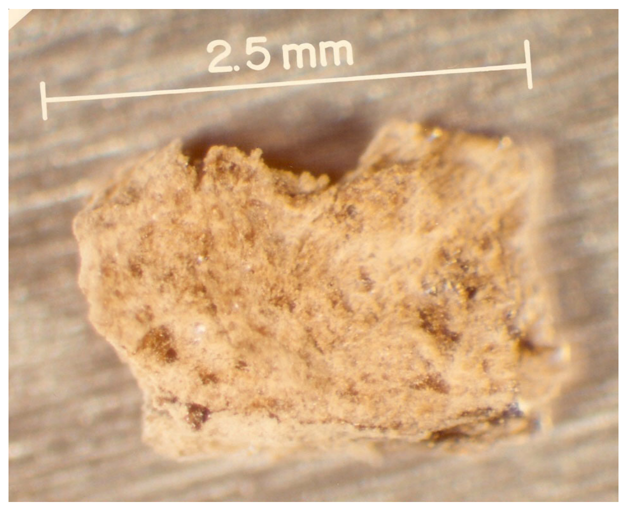


Figure 5: Photo of 15010,3189 before analysis. S79-32007.

Two notable features of core 15011/10 are: 1) at a depth of 41 cm there was an 8 mm diameter clod of yellow glass (figures 5 and 6) and 2) at about the 50 cm level, there was a 44 gram chunk of mare basalt (15010,3115)!

Chemistry

Blanchard received samples along the core, but no data was published. Presumably the top portion of the core would be the same as surface soils 15531 or 15601.

The composition of the yellow glass clod found near the bottom of the core has been determined by Delano et al. (1982) and by Ebihara et al. (1992) (table 1). It is KREEP (figure 4).

Cosmogenic isotopes and exposure ages

Fruchter et al. (1981) determined the depth dependence of ^{26}Al (figure 9) and Nishiizumi et al. (1983) determined ^{53}Mn (figure 10). Below about 10 cm the ^{26}Al and ^{53}Mn data agree with the Reedy-Arnold model for cosmic-ray activation of an in-place core. However the excess activity in the top 10 cm means that previously irradiated material has been added in the past 10 m.y.

Other Studies

Bogard et al. (1980) determined the rare gas content of sample along the whole core (figure 8).

Blandford et al. (1980) and Crozaz (1980) determined the density of solar flare tracks (figure 11).

Processing

Double drive tube 15011/10 was driven all the way in (figure 14). Some material found on top of the core "keeper" was found to have high ^{53}Mn (see Nishiizumi et al. 1983).

Allton (1979) performed the dissection of the core; reported in Newsletters #18 and 24 (figures 12 and 13).

Figure 6: Photomicrograph of thin section of 15010,3189 (S79-33396 an 33401). Scale about 2 mm.

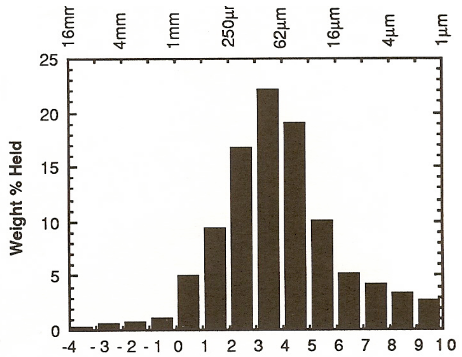
Table 1. Composition of 15010 yellow glass.

reference	Delano82			Ebihara92	
weight					
SiO2 %					
TiO2	4.2	(a)			
Al2O3	9.5	(a)			
FeO	18.9	(a)			
MnO	0.24	(b)			
MgO	9.3	(a)			
CaO	9.5	(a)			
Na2O	0.32	(a)			
K2O	0.22	(a)			
P2O5	0.22	(a)			
S %					
sum					
Sc ppm	39	(b)			
V	99	(b)			
Cr	2121	(a)			
Co	41	(b)			
Ni			110	91.9	(c)
Cu					
Zn			0.12	0.12	(c)
Ga					
Ge ppb					
As					
Se			17	24	(c)
Rb			6.08	4.81	(c)
Sr					
Y					
Zr	460	(b)			
Nb					
Mo					
Ru					
Rh					
Pd ppb			21	1.9	(c)
Ag ppb			0.8	0.16	(c)
Cd ppb			45	4.9	(c)
In ppb			1.7	0.73	(c)
Sn ppb					
Sb ppb			2.5	1.3	(c)
Te ppb			39	2	(c)
Cs ppm			0.151	1.66	(c)
Ba	410	(b)			
La	48.3	(b)			
Ce	106	(b)			
Pr					
Nd	74	(b)			
Sm	20.3	(b)			
Eu	1.61	(b)			
Gd					
Tb	4.06	(b)			
Dy	27.6	(b)			
Ho					
Er					
Tm					
Yb	15.6	(b)			
Lu	2.35	(b)			
Hf	12.6	(b)			
Ta	2.3	(b)			
W ppb					
Re ppb			0.104	0.052	(c)
Os ppb			1.45	1.81	(c)
Ir ppb	4	(b)	1.48	1.21	(c)
Pt ppb					
Au ppb	26	(b)	0.27	0.035	(c)
Th ppm	8.3	(b)			
U ppm	3	(b)	2.48	2.13	(c)

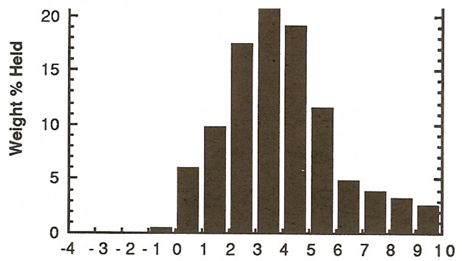
technique: (a) elec. Probe, (b) INAA, (c) RNAA

15011

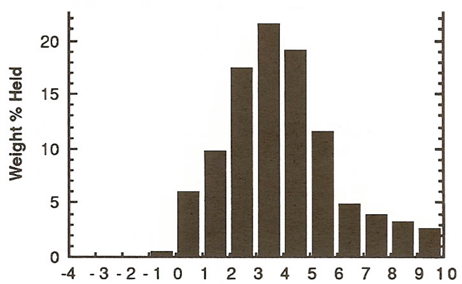
1 cm



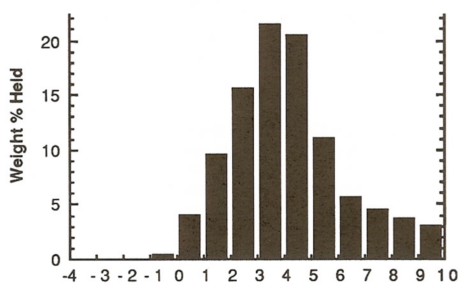
4 cm



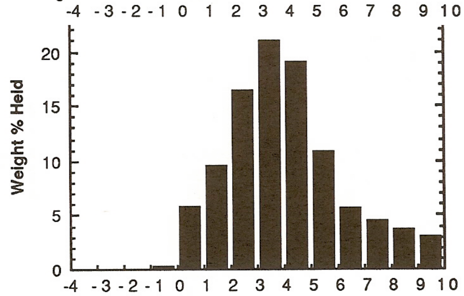
7 cm



12 cm



17 cm



22 cm

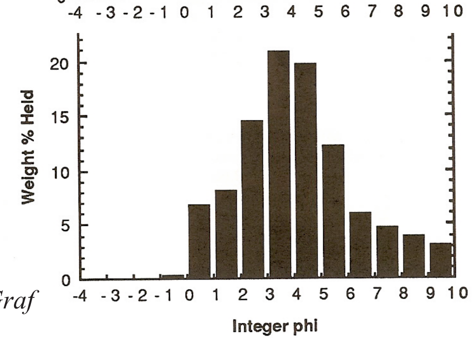
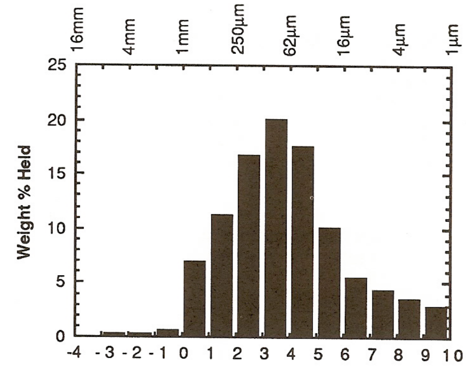


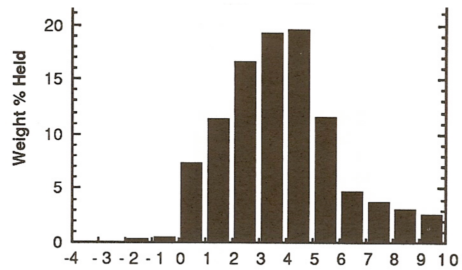
Figure 7: Grain size distribution (Graf 1993).

15010

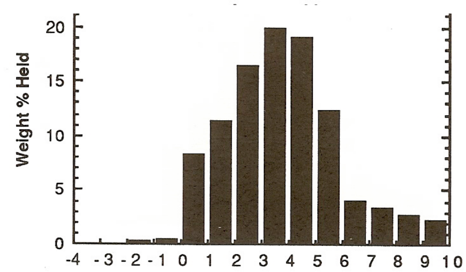
27.5 cm



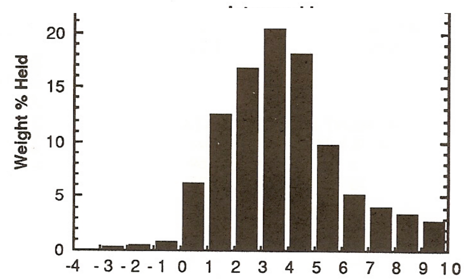
34 cm



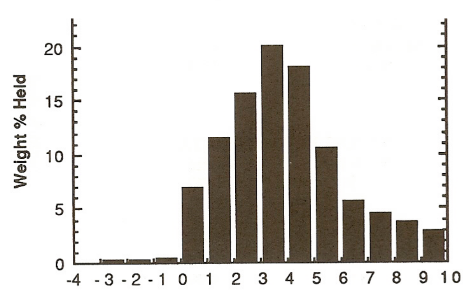
40.5 cm



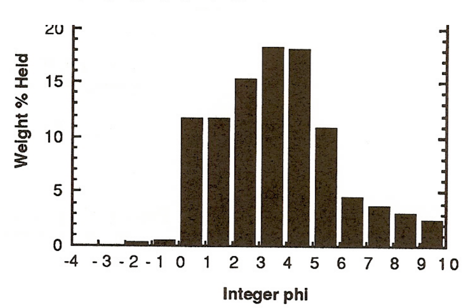
46 cm



48 cm



54.5 cm



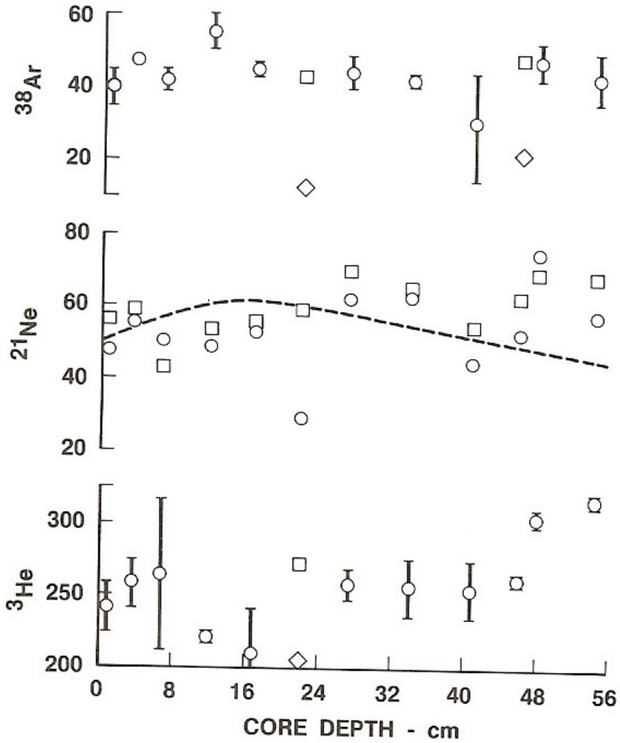


Figure 8: Rare gas content in 15011/10 (Bogard et al. 1980).

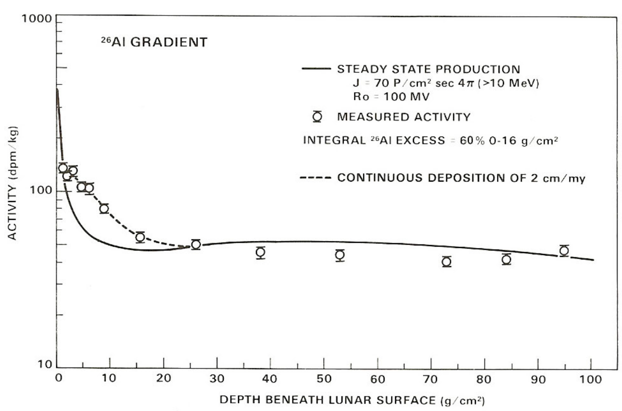


Figure 9: 26Al as function of depth in double drive tube 15011/15010 taken near Hadley Rill (Fruchter et al. 1981).

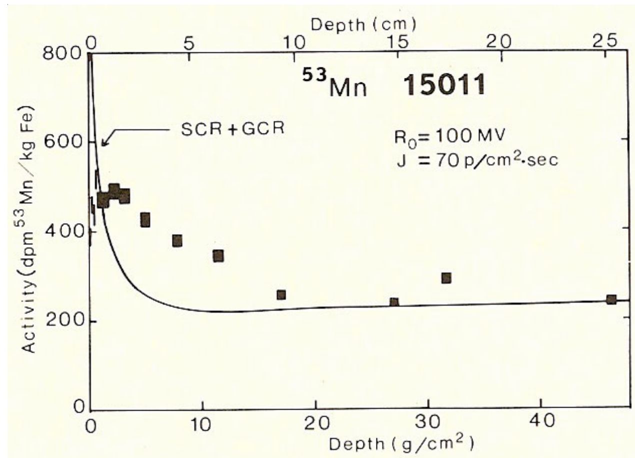


Figure 10: 54Mn as function of depth in 15011 (Nishiizumi et al. 1982).

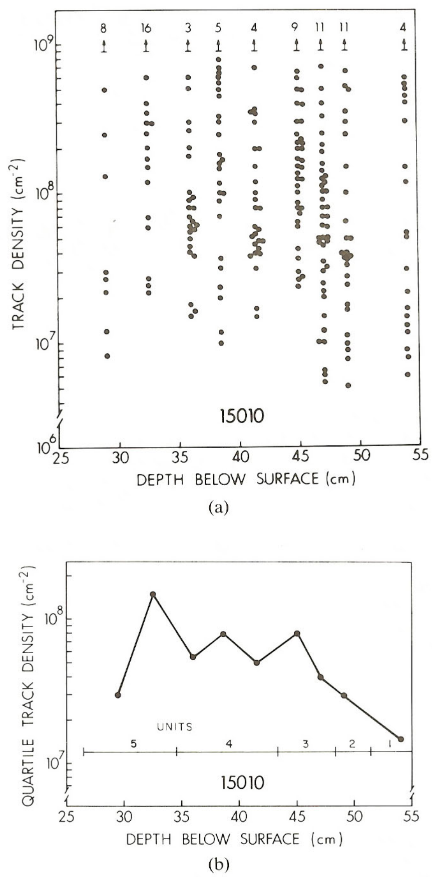


Figure 11: Tracks in 15010 (Crozaz 1980).

15011,6002
epoxy
encapsulated
core

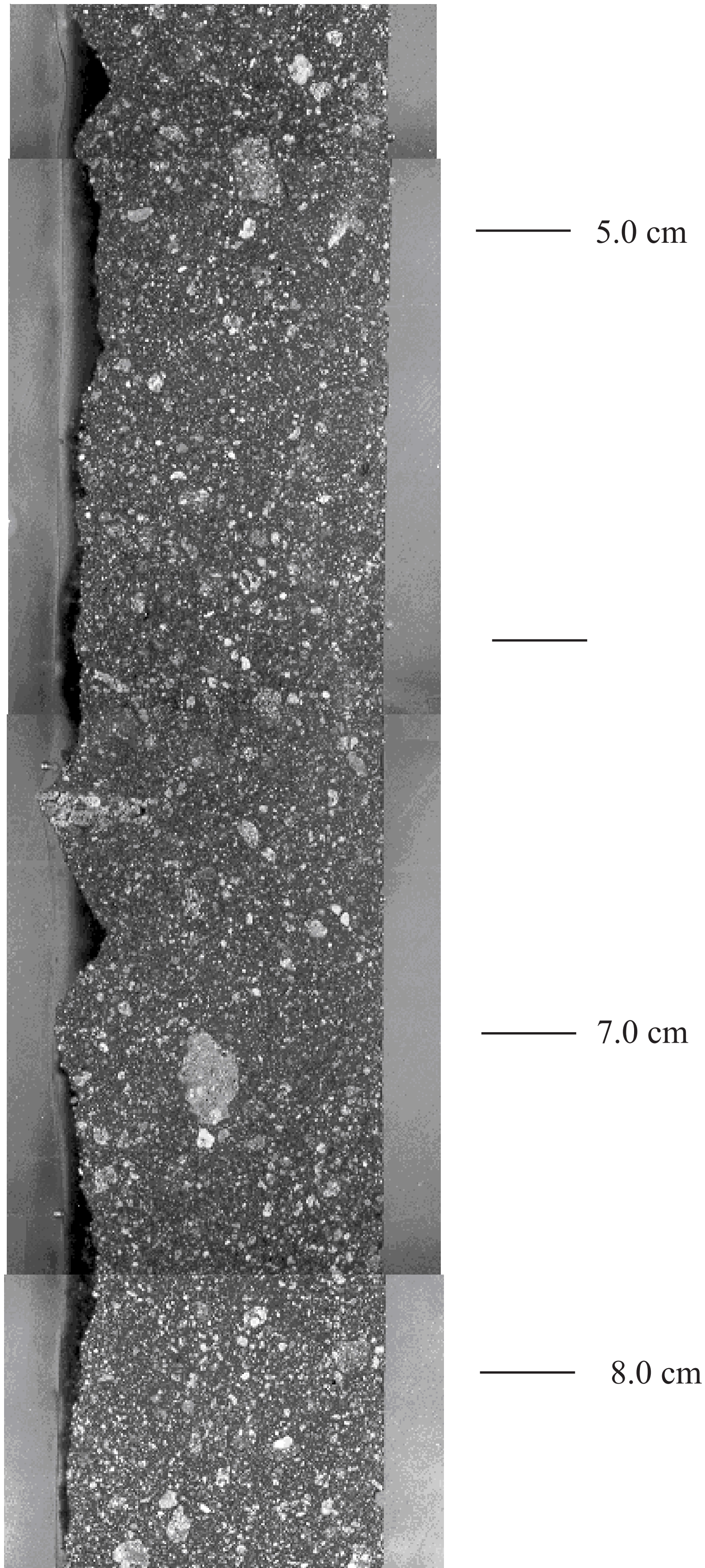
top

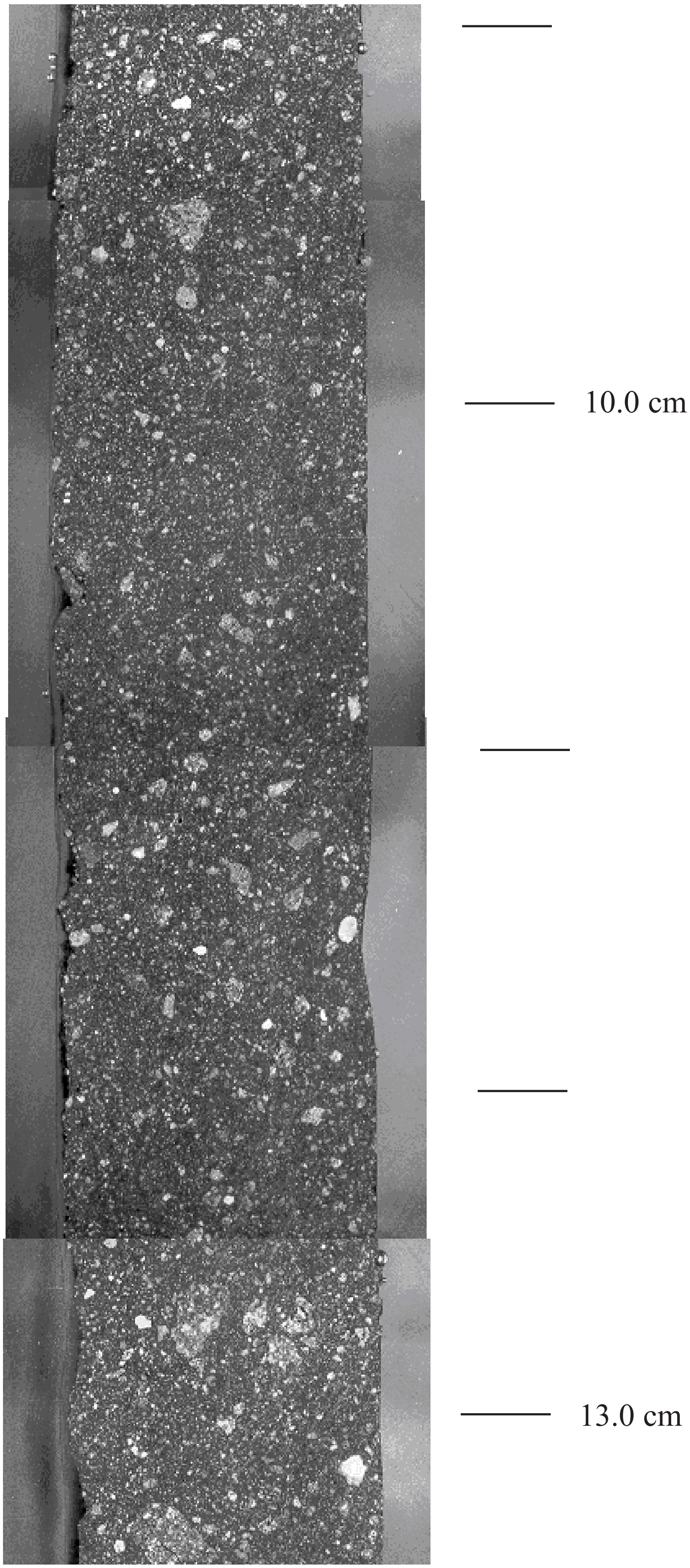
0.5 cm

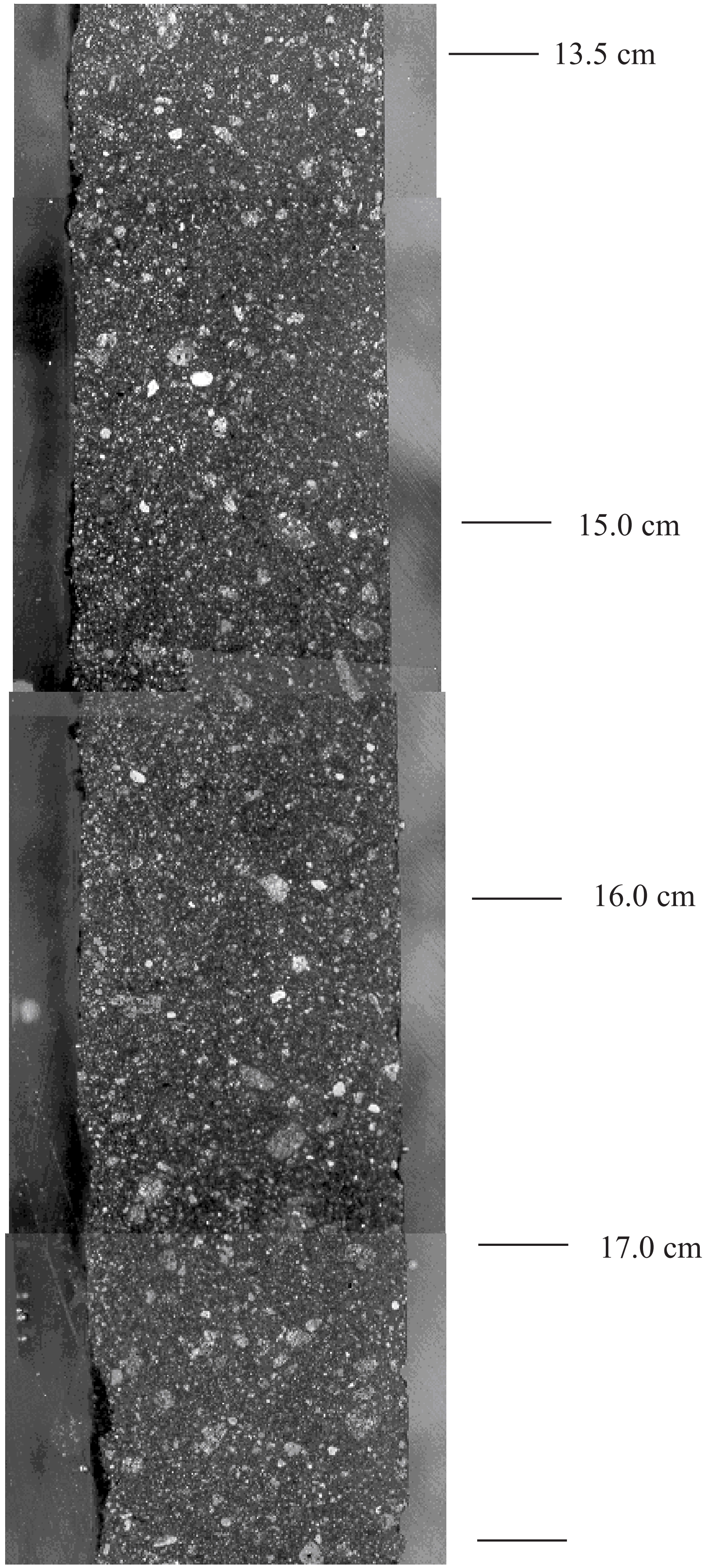
2.0 cm

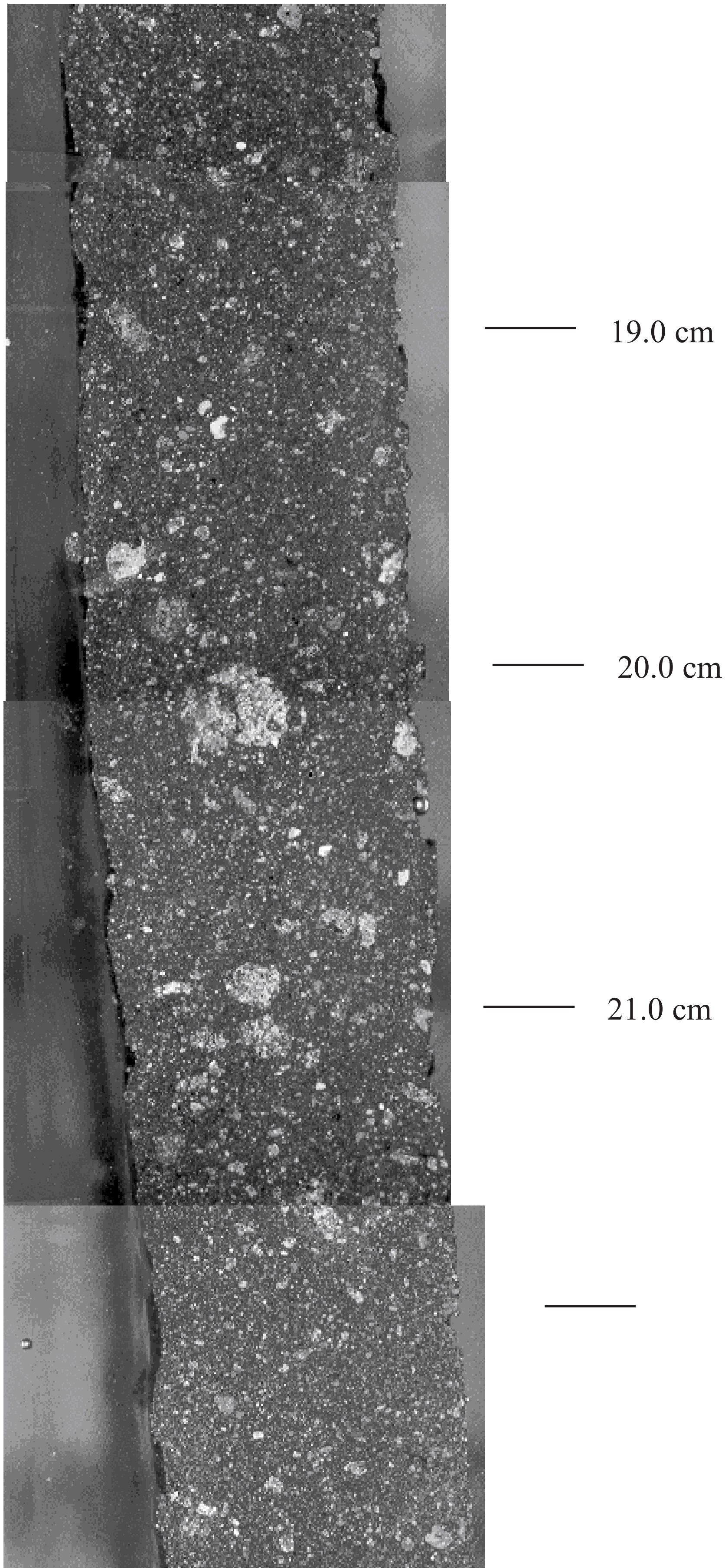
3.0 cm

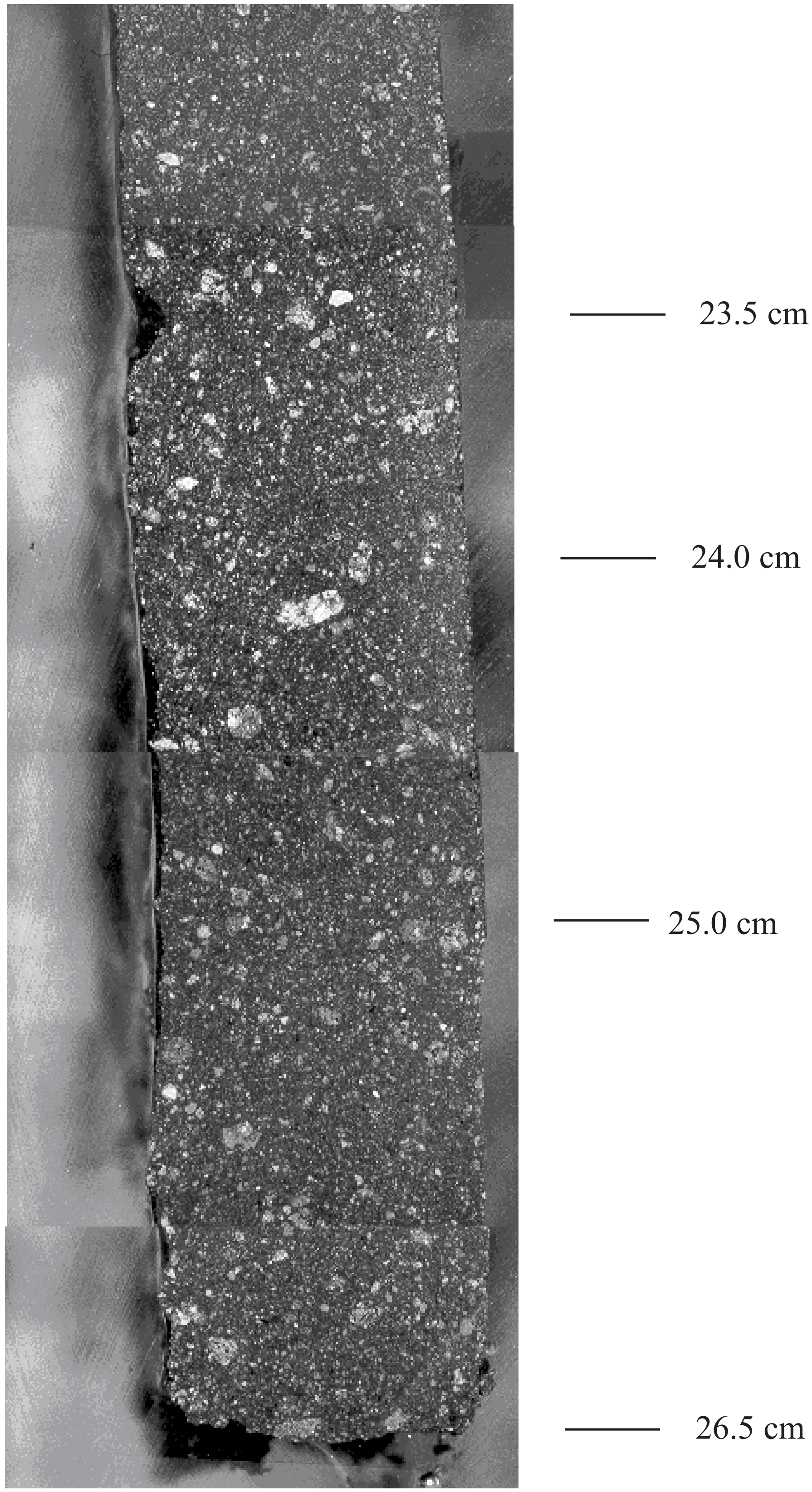
4.0 cm


5.0 cm
7.0 cm
8.0 cm

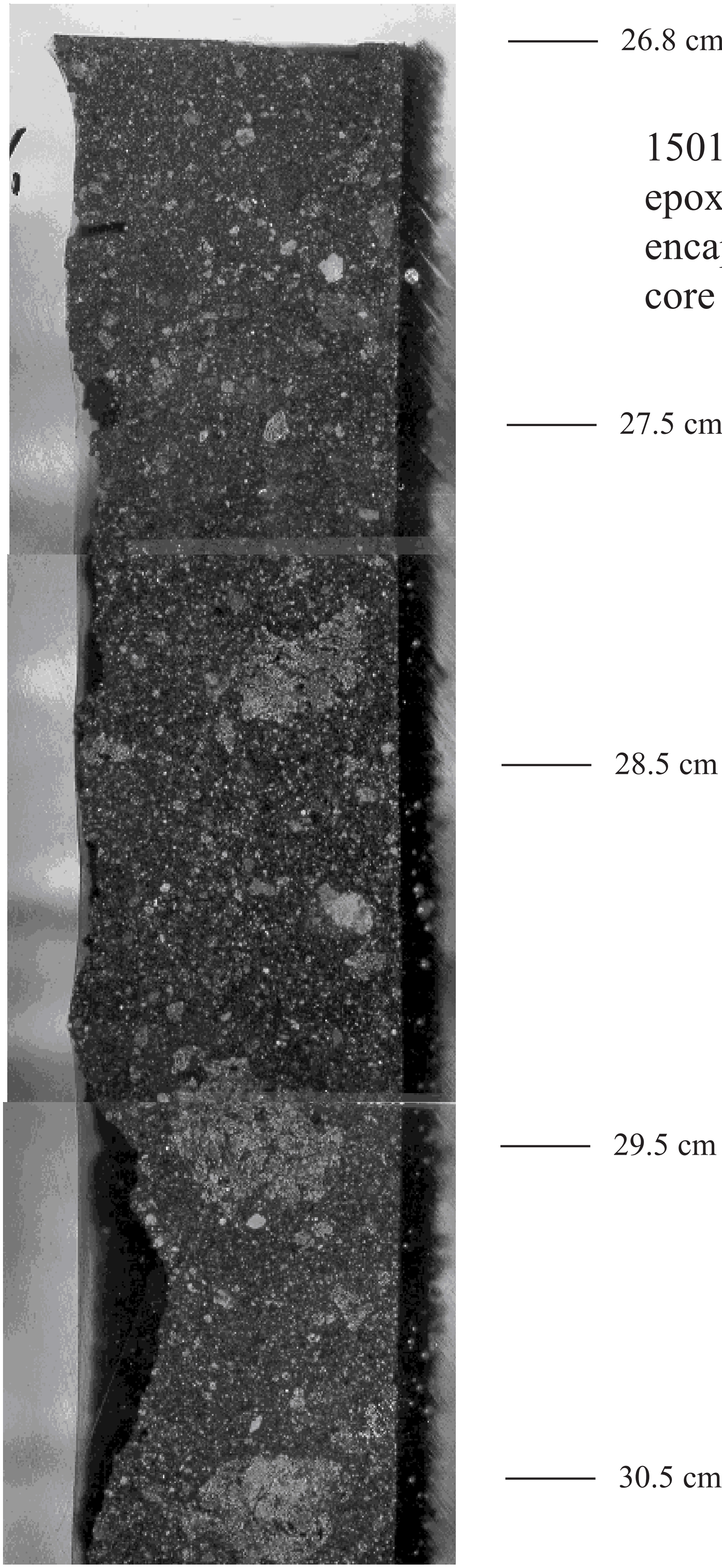

10.0 cm
13.0 cm


13.5 cm
15.0 cm
16.0 cm
17.0 cm

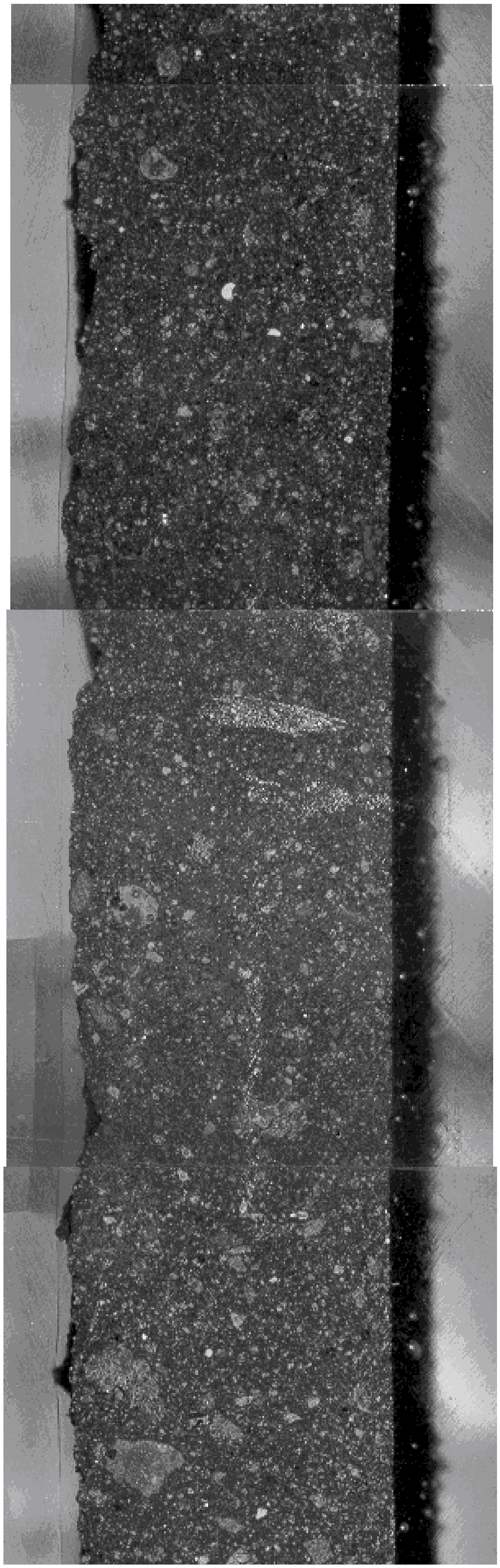

19.0 cm
20.0 cm
21.0 cm

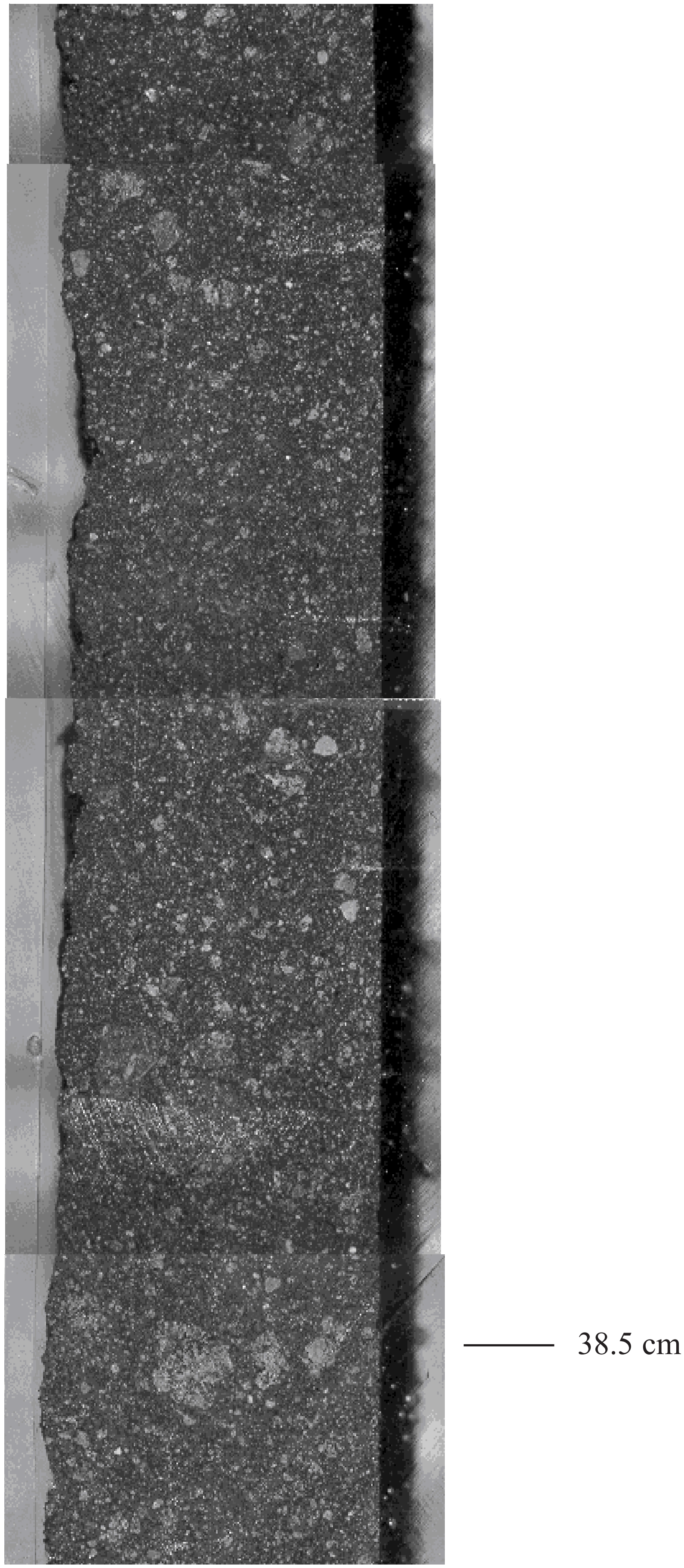


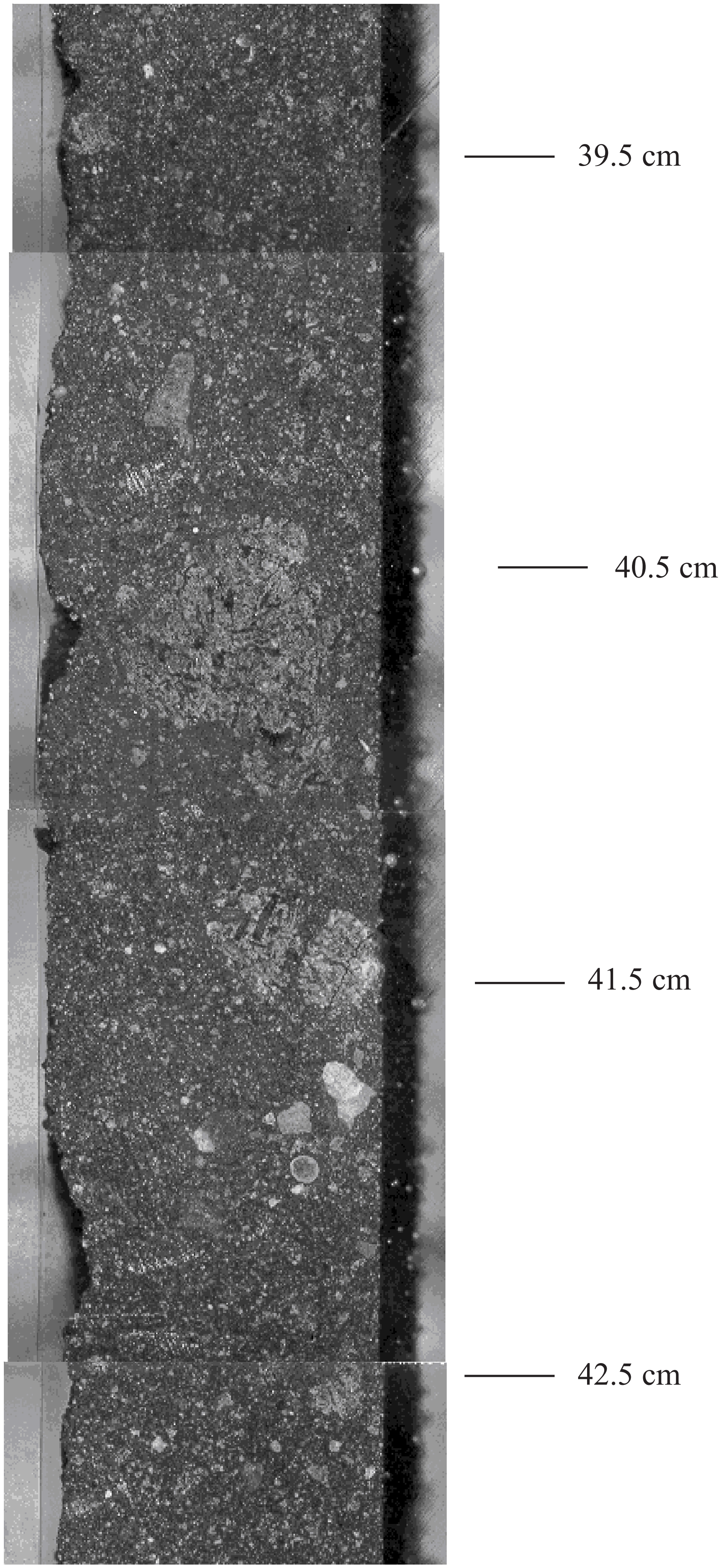
middle

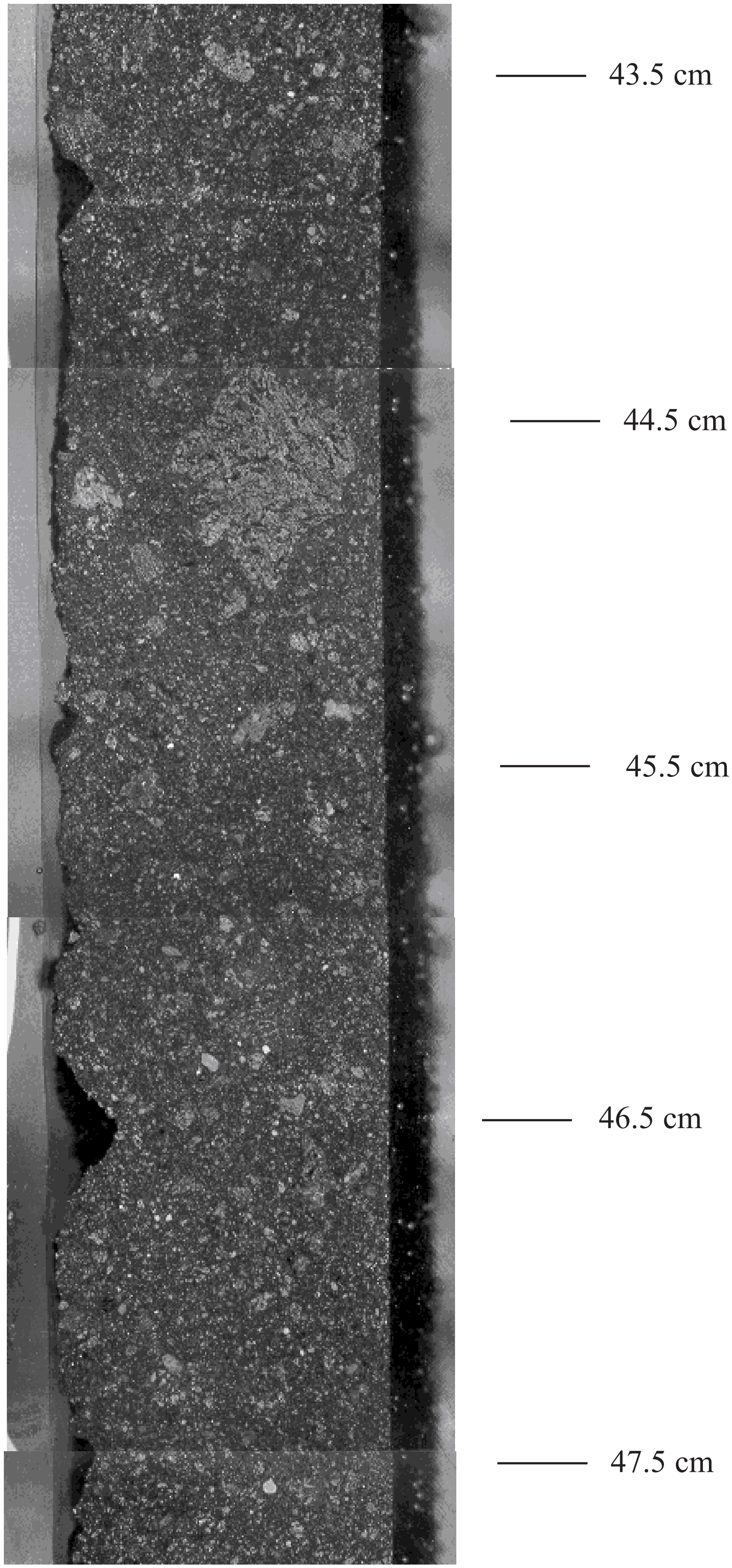


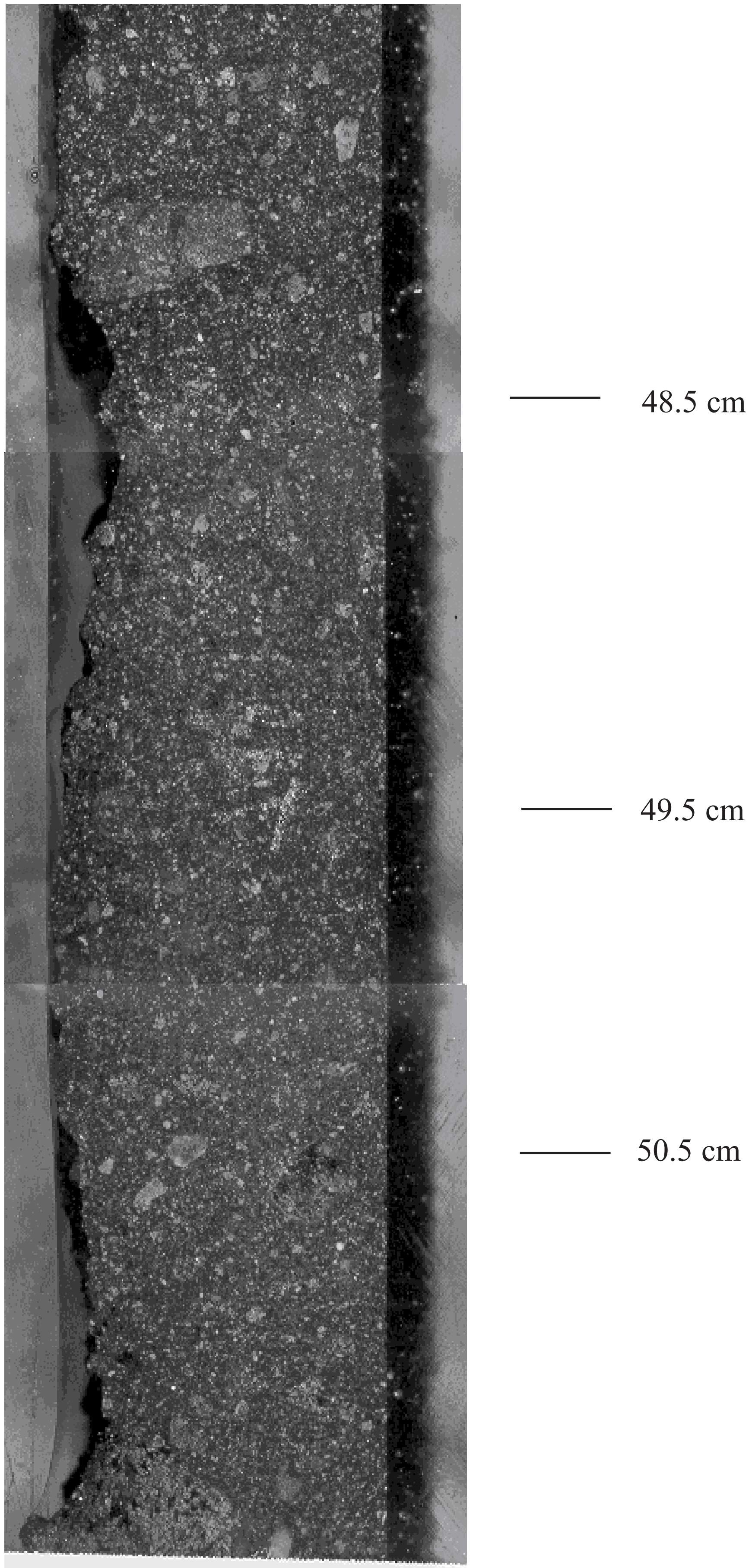
15010,6001
epoxy
encapsulated
core

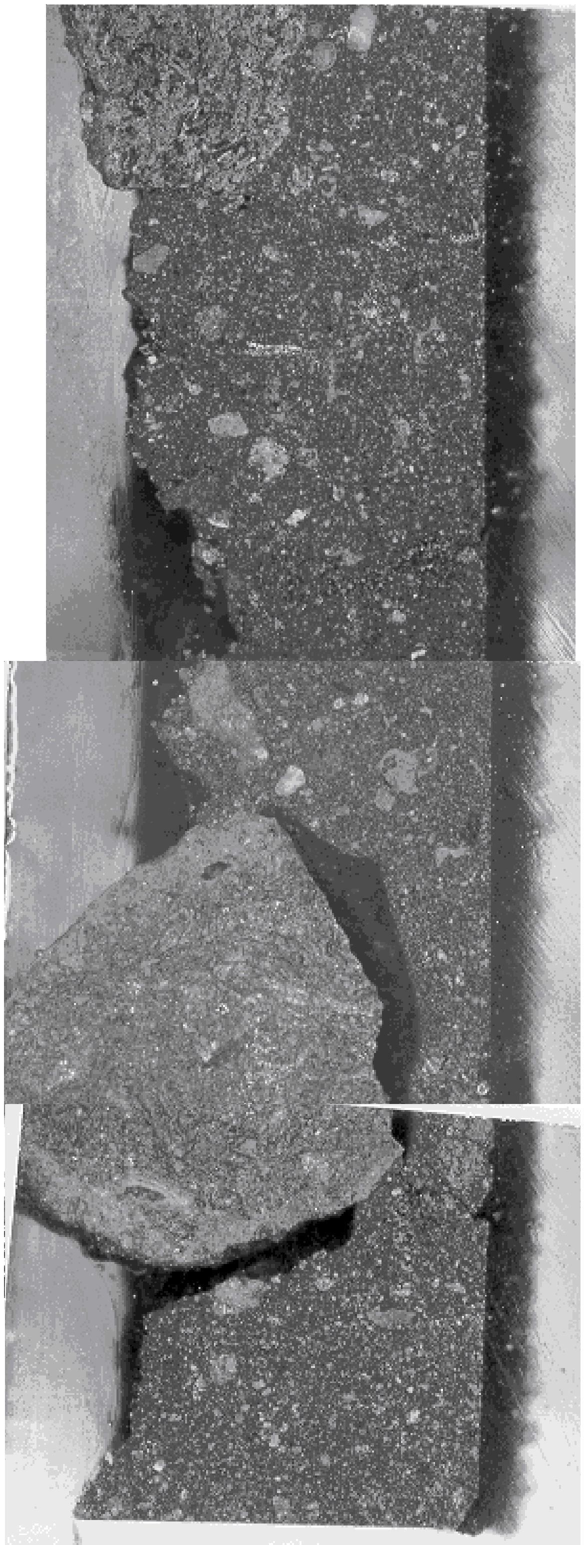



38.5 cm


39.5 cm
40.5 cm
41.5 cm
42.5 cm


43.5 cm
44.5 cm
45.5 cm
46.5 cm
47.5 cm


48.5 cm
49.5 cm
50.5 cm

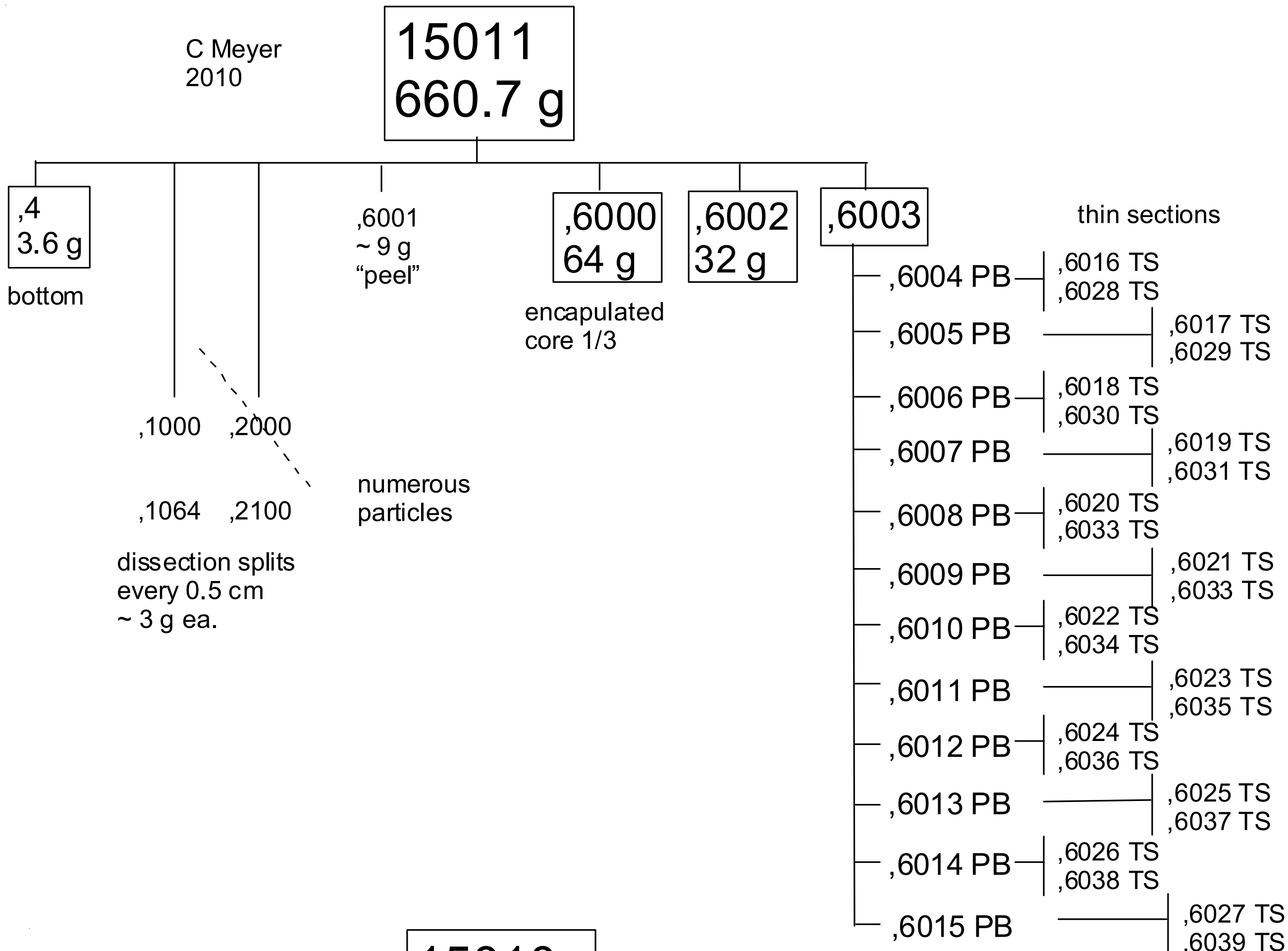


52 cm

53.5 cm

55 cm

bottom


C Meyer
2010
15011
660.7 g
,4
3.6 g
bottom
,1000
,1064
,2000
,2100
dissection splits
every 0.5 cm
~ 3 g ea.
numerous
particles
,6001
~ 9 g
"peel"
,6000
64 g
encapulated
core 1/3
,6002
32 g
,6003
thin sections
,6004 PB
,6016 TS
,6028 TS
,6005 PB
,6017 TS
,6029 TS
,6006 PB
,6018 TS
,6030 TS
,6007 PB
,6019 TS
,6031 TS
,6008 PB
,6020 TS
,6033 TS
,6009 PB
,6021 TS
,6033 TS
,6010 PB
,6022 TS
,6034 TS
,6011 PB
,6023 TS
,6035 TS
,6012 PB
,6024 TS
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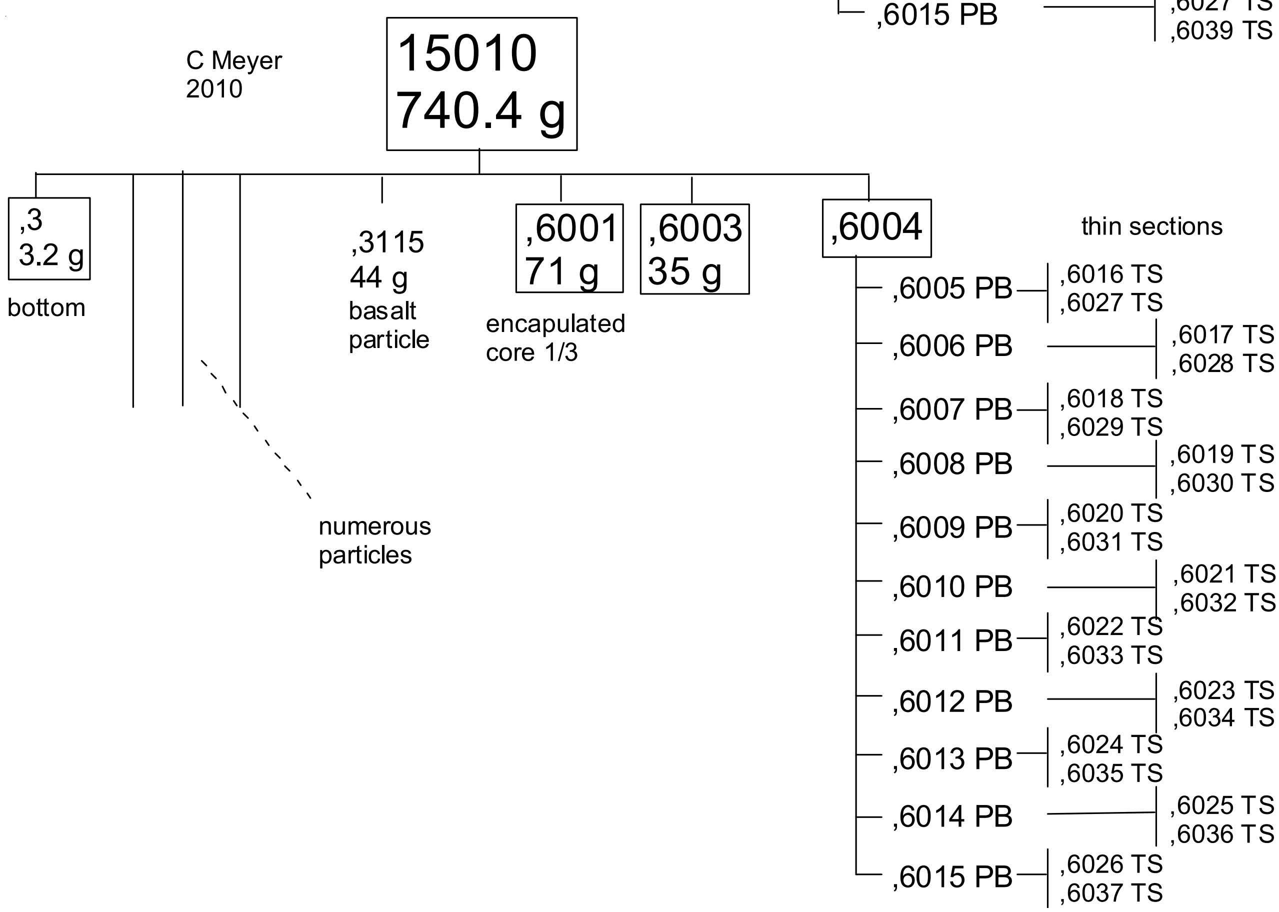
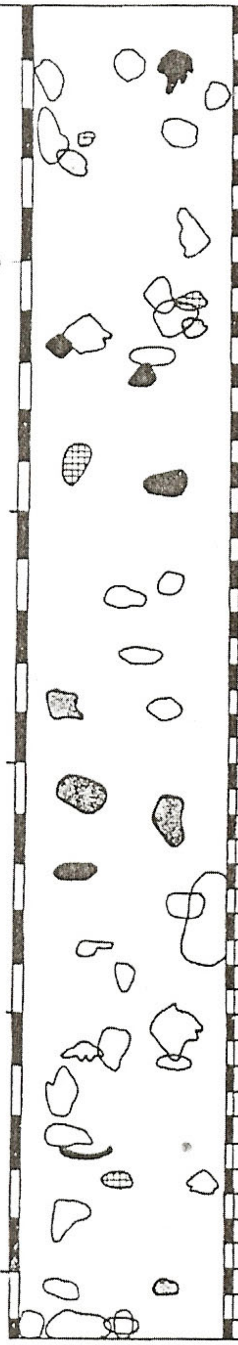
,6025 TS
,6037 TS
,6014 PB
,6026 TS
,6038 TS
,6015 PB
,6027 TS
,6039 TS


C Meyer
2010
15010
740.4 g
,3
3.2 g
bottom
numerous
particles
,3115
44 g
basalt
particle
,6001
71 g
encapulated
core 1/3
,6003
35 g
,6004
thin sections
,6005 PB
,6016 TS
,6027 TS
,6006 PB
,6017 TS
,6028 TS
,6007 PB
,6018 TS
,6029 TS
,6008 PB
,6019 TS
,6030 TS
,6009 PB
,6020 TS
,6031 TS
,6010 PB
,6021 TS
,6032 TS
,6011 PB
,6022 TS
,6033 TS
,6012 PB
,6023 TS
,6034 TS
,6013 PB
,6024 TS
,6035 TS
,6014 PB
,6025 TS
,6036 TS
,6015 PB
,6026 TS
,6037 TS

DRIVE TUBE 15011

LOCATION OF SAMPLES, THIRD DISSECTION (STANDARD)



Stratigraphic Unit	Cm Depth	Cm Depth Below Lunar Surface*	Interval Samples Fine (< 1 mm) Fraction Sample No.	Interval Samples Fine (< 1 mm) Fraction Sample Wt. (g)	Interval Samples Coarse (> 1 mm) Fraction Sample No.	Interval Samples Coarse (> 1 mm) Fraction Sample Wt. (g)	Special Samples Sample No.	Special Samples Sample Wt. (g)	Special Samples Sample Type	Special Samples Sample Interval
		0.4	See special section on top 4 mm							
		1.0	,2000	3.935	,2001	0.259				
		1.5	,2002	2.654	,2003	0.601				
		2.0	,2004	3.090	,2005	0.196				
		2.5	,2006	3.070	,2007	0.523				
		3.0	,2008	2.745	,2009	0.169				
		3.5	,2010	2.837	,2011	0.655	,2012	0.282	dark soil	3.0 - 4.1 cm
		4.0	,2013	2.479	,2014	0.183				
		4.5	,2015	3.289	,2016	0.157	,2017	0.067	light soil	4.0 - 4.7 cm
	5.0	5.0	,2018	3.008	,2019	0.184				
		5.5	,2020	3.206	,2021	0.322				
		6.0	,2022	2.918	,2023	0.236				
		6.5	,2024	2.829	,2025	0.112				
		7.0	,2026	2.955	,2027	0.267				
		7.5	,2028	3.222	,2029	0.229				
		8.0	,2030	3.152	,2031	0.127				
		8.5	,2032	2.874	,2033	0.090				
		9.0	,2034	3.092	,2035	0.139				
		9.5	,2036	2.994	,2037	0.105	,2038	0.136	AnBx	8.7 - 9.4 cm
8	10.0	10.0	,2039	3.201	,2040	0.257				
		10.5	,2041	2.676	,2042	0.211				
		11.0	,2043	3.205	,2044	0.050				
		11.5	,2045	3.031	,2046	0.180	,2047	0.174	Clod	11.2 - 11.7 cm
		12.0	,2048	2.626	,2049	0.254				
		12.5	,2050	2.867	,2051	0.096				
		13.0	,2052	3.050	,2053	0.404				
		13.5	,2054	2.646	,2055	0.118				
		14.0	,2056	3.380	,2057	0.094				
		14.5	,2058	2.935	,2059	0.055				
	15.0	15.0	,2060	2.842	,2061	0.080				
		15.5	,2062	3.571	,2063	0.220				
		16.0	,2064	3.029	,2065	0.414				
		16.5	,2066	2.563	,2067	0.546				
7		17.0	,2068	3.030	,2069	0.129				
		17.5	,2070	3.563	,2071	0.191				
		18.0	,2072	2.888	,2073	0.074	,2074	2.287	Basalt	17.3 - 19.0 cm
		18.5	,2075	2.954	,2076	0.130				
		19.0	,2077	2.809	,2078	0.159				
		19.5	,2079	3.008	,2080	0.370				
	20.0	20.0	,2081	3.361	,2082	0.197				
		20.5	,2083	3.163	,2084	0.238				
		21.0	,2085	3.010	,2086	0.248				
		21.5	,2087	3.420	,2088	0.158				
		22.0	,2089	3.034	,2090	0.160				
		22.5	,2091	3.207	,2092	0.457				
		23.0	,2093	2.798	,2094	0.227				
6		23.5	,2095	3.305	,2096	0.333				
		24.0	,2097	3.145	,2098	0.366	,2099	0.095	Basalt	23.8 - 24.5 cm
		24.5	,2100	2.856	,2101	0.144				
	25.0	25.0	,2102	3.273	,2103	0.220				
		25.5	,2104	3.275	,2105	0.390				
		26.0	,2106	4.740	,2107	1.685				
		26.4								

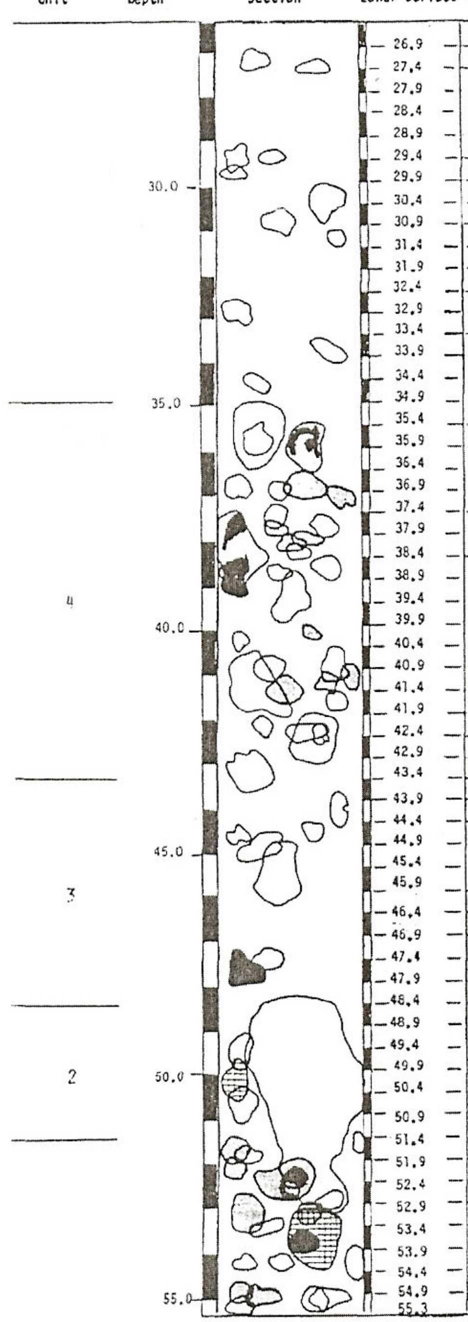
Lithologic Symbols

*Measured after extrusion

Figure 12: Dissection of top portion of 15011/15010 douber drive tube (Nagle 1979).

DRIVE TUBE 15010

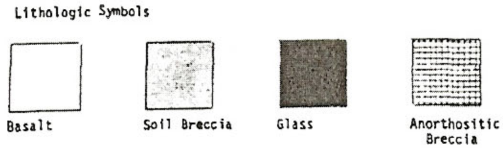
LOCATION OF SAMPLES, FOURTH DISSECTION (STANDARD)



Interval Samples Fine (< 1 mm) Fraction Sample No.	Sample Wt.	Interval Samples Coarse (> 1 mm) Fraction Sample No.	Sample Wt.	Special Samples Sample No.	Sample Wt.	Sample Type	Sample Interval
,3000	3.029	,3001	0.206				
,3002	2.844	,3003	0.134	,3004	0.209	Basalt	26.9 - 27.4
,3005	2.997	,3006	0.523				
,3007	2.716	,3008	0.182				
,3009	3.444	,3010	0.178				
,3011	2.509	,3012	0.255				
,3013	2.623	,3014	0.080				
,3015	2.837	,3016	0.174				
,3017	2.973	,3018	0,151				
,3019	2.956	,3020	0.140				
,3021	3.307	,3022	0.370	,3023	0.018	soil	31.5 - 31.7
,3024	2.790	,3025	0,142				
,3026	2.757	,3027	0.187				
,3028	2.748	,3029	0.306				
,3030	2.580	,3031	0.141				
,3032	2.947	,3033	0.109				
,3034	2.403	,3035	0.172				
,3036	2.944	,3037	0.140	,3038	0.224	soil	34.9 - 36.4
,3040	1.995	,3041	0.175	,3039	2.622	Basalt	34.9 - 36.4
,3042	2.605	,3043	0.204	,3044	0.013	soil	36.1 - 36.4
,3046	2.863	,3047	0.170	,3045	0.152	soil	35.9 - 36.9
,3048	2.754	,3049	0.279				
,3050	2.712	,3051	0.577	,3052	0.526	Basalt	37.0 - 37.8
,3053	2.030	,3054	0.275				
,3055	3.203	,3056	0.252	,3057	1.758	SoBx	37.4 - 39.1
,3058	2.771	,305	0.412	,3060	0.552	Basalt	38.5 - 39.7
,3061	2.312	,3062	0.230				
,3063	2.776	,3064	0.458				
,3065	3.138	,3066	0.172				
,3069	2.453	,3070	0.516				
,3071	2.948	,3072	0.234				
,3073	2.706	,3074	0.410	,3077	1.841	Basalt	41.7 - 43.1
,3075	2.887	,3076	0.082	,3080	0.246	soil	42.9 - 43.4
,3078	2.741	,3079	0.346	,3089	0.864	Basalt	44.8 - 46.1
,3081	3.121	,3082	0.326				
,3083	3.162	,3084	0.440	,3090	0.128	YSoil	41.0 - 41.8
,3085	3.294	,3086	0.386	,3091	0.038	GSoil	41.0 - 41.8
,3087	3.287	,3088	0.479	,3092	0.038	YSoil	41.0 - 41.8
,3093	3.254	,3094	0.153	,3137	0.066	Soil	41.0 - 41.8
,3095	2.991	,3096	0.280	,3138	0.144	soil	41.0 - 41.8
,3097	2.735	,3098	0.440	,3139	0.087	YFrag	41.0 - 41.8
,3099	2.903	,3100	0.275	,3140	0.234	YFrag	41.0 - 41.8
,3101	3.213	,3102	0.314	,3142	0.034	GFrag	41.0 - 41.8
,3103	2.932	,3104	0.466	,3143	0.039	GFrag	41.0 - 41.8
,3105	2.780	,3106	0.523	,3144	0.003	YFrag	41.0 - 41.8
,3107	2.353	,3108	0.200				
,3109	1.984	,3110	0.090	,3111	0.354	Basalt	42.9 - 50.0
,3112	1.494	,3113	0.378	,3114	1.216	Soil	48.3 - 53.1
,3116	1.958	,3117	0.328	,3115	44.050	Basalt	48.3 - 53.1
,3118	2.303	,3119	0.194				
,3120	2.135	,3121	0.344				
,3122	3.479	,3123	0.546	,3124	0.878	SoBx	51.5 - 52.3
,3125	3.304	,3126	0.415	,3127	0.530	SoBx	51.7 - 52.6
,3129	2.930	,3130	0.399	,3128	0.739	SoBx	52.5 - 53.7
,3131	3.143	,3132	0.644				
,3133	2.661	,3134	0.693				
,3135	4.615	,3136	0.732				

Yellow Glass Samples

Lithologic Symbols



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*Measured after extrusion

15010-6

Figure 13: Dissection of bottom portion of 15011/15010 double drive tube (Nagle 1979).

Figure 14: Double drive tube 15011/15010 was hammered in all the way ! AS15-82-11162.

Transcript 15010

CDR But you know, I don't know, a double core – we may find ourselves driving into bedrock if we're not careful.
LMP Yes, I'm afraid of that.
CDR I bet I can do a good one right there. And, I see some white-colored albedo near the - -
- - -
LMP Pushing. I'll push a little more.
CDR Yes, Got a half a tube – oooh. Good, nice. You got three-quarters?
LMP Yes. It feels like it's – hung up on a rock.
CDR Okay. I got the picture. Go ahead and hammer. Rock huh? No, it's going in. You're getting it. There's a full one. Have at it. You are getting a couple inches a stroke. Very nice. Ok. There's one and a half. Good. Doing good. Notice when you're hitting it the whole ground around it raises up – for about an inch anyway from the core. You've got about three more smacks, and you ought to have it all the way in. Hey, good. I'll give you a double core on that. Good show. Ok, I got the picture. Ok. I got the cap. Go ahead and pull back.
LMP Yes. Yes, we went right through a rock. No wonder it was hard pounding. Got the rock right in the bottom of the -. I'm not going to get too good a seal because – a portion of the rock – you know.

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