UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Preliminary Report on the Geotechnical Properties of the Wasatch Formation at Buffalo, Wyoming

By

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PRELIMINARY REPORT ON THE GEOTECHNICAL PROPERTIES OF THE WASATCH FORMATION AT BUFFALO, WYOMING

By

R. A. FARROW

Introduction and summary

A continuous core was taken through the uppermost 132.90 m (430 ft) of soil and rock underlying Buffalo, Wyo. The NX (7.6-cm (3-in)) borehole is located in the NE 1/4 of the NW 1/4 of sec. 35, T. 51 N., R. 82 W., Johnson County, Wyo., at an estimated elevation of 1,402 m (4,600 ft). The first 5.3 m (17.4 ft) was sampled by Shelby tube, the remainder by wire-line coring apparatus using a split inner tube. Bentonite-based drilling mud was used to drill that part of the hole below 30 m (98 ft) after an unsuccessful attempt was made to use a synthetic drilling fluid.

Index tests of strength were performed at the drill site, and the core was preserved in approximately 15-cm (5.8-in) lengths in sealed glass jars. Representative samples from zones of interest were tested for fundamental engineering properties at the Engineering Geology laboratory of the U.S. Geological Survey in Denver.

Commercial geophysical logs were run in the uncased hole. The suite of logs consists of three-dimensional sonic velocity, electric (spontaneous potential and resistivity), caliper, density, and nuclear (gamma-ray and neutron) logs. Upon completion of geophysical logging, the hole was plugged with Portland cement and bentonite slurry and was abandoned.

The results of tests along with the lithologies and geophysical logs are the basis for considering five major units. The extent of each of these units is most clearly seen on the neutron log. A sandy unit, largely barren of coal, occurs from near the surface to a depth of 28 m (90 ft). An upper sequence of coal, claystone, and shale from 28 to 45 m (90-148 ft) deep is separated by about 11 m (36 ft) of sandstone and claystone from a second coal unit of different properties that extends from a depth of 56 to 100 m (184-328 ft). Underlying the coal is a partly fossiliferous claystone and sandstone sequence with only thin coal beds down to a total depth of 133 m (430 ft).

The uppermost sandy unit has low values of strength :ndex tests; its clay content is high, and it produces good water under artesian pressure. Schmidt hammer values average about 10 units. Point-load values range from about 0.1 to about 0.2 MN/m^2 (meganewtons per square meter). The anomalously low values of density as shown on the geophysical density log at depths of about 30 m (90 ft) are caused by the tool's response to the badly out of gage borehole (cf. caliper log). For the same reason, values calculated from the other geophysical logs for these depths should be used with caution. The resistivity of the upper sandy unit is low because of its high clay content and ranges from about 8 to 26 ohmmeters. Water from this unit is rated as good by local residents, who use it for domestic purposes. At the site of the borehole, formation pressure was artesian in excess of the height of the standpipe (about 1 m (3.3 ft) above ground level), and flow was measured at about 190 liters (50 gal) per hour.

The coal-bearing sequence occurs in two major zones separated by a shaly and sandy layer. The upper coal (28-45 m thick) is characterized by thin beds of coal in shale and claystone, relatively high clay content, and moderate strength. The short-normal resistivity log shows the most obvious fine-scale correlation to lithology in the upper coal unit. Resistivities range up to about 25 ohmmeters in the coal layers and to less than 10 ohmmeters in the claystone and shale layers. Values of field index tests are significantly different from those of the overlying sandy unit. In the upper coal, Schmidt hammer values range from 10 to 48 units. Of almost equal significance is the increased frequency of occurrence of material suitable for testing. The wider range of values of point-load test in the upper coal shows the strength of the unit to be more variable but, in general, higher than that of the overlying sandy unit. The values range from about 0.2 to 0.7 MN/m^2, with one extreme value of 1.1 MN/m^2.

The claystone and sandstone unit separating the coals is characterized by strength indices lower than those of the upper coal but higher than those of the uppermost sandy unit. They range from less than 10 to about 20 on the Schmidt scale. Point-load values average about 0.12 MN/m^2, with a notable lack of suitable material for testing in the sand unit at around 53 m (175 ft). The resistivity log does not show a good break for this unit, but it can be seen well on the neutron log.

The thick lower coal unit occurs between depths of 56 and 100 m (184-330 ft). It is characterized by more massive bedding, lower clay content, and moderate strength. As in the upper coal, short-normal resistivity provides the best fine-scale correlation to lithology. Thinly interlaminated clays and shales have low resistivities, and hard

coal beds have higher values. Resistivities range from less than 10 to as much as about 120 ohmmeters. Schmidt hammer values average around 30, with ample material suitable for testing. Point-load values range from about 0.9 to 1.75 MN/m^2.

The lowermost barren unit extends from 100 m to the bottom of the hole at 132.9 m (328-430 ft). It is characterized by a nearly complete absence of coal, more massive bedding, and strength lower than that of the coals. The short-normal resistivity log shows the continuous nature of the bedding and a presumed freshwater-bearing sandstone at 110-117 m (360-384 ft). Schmidt hammer values range from less than 10 to 42 units and average about 20. Point-load values range from 0.12 to 1.35 and average about 0.3 MN/m^2.

Results of field strength index tests along with core recovery and p-wave velocities calculated from the sonic logs are presented in graphical form on the geotechnical properties log.

Discussion

Under strip mining conditions, highwalls standing in the upper sandy unit may be unstable, especially if the unit is producing water. Both the Schmidt hammer values and the point-load results indicate the general weakness of the unit. Low values of strength as predicted by index tests were confirmed by the severe caving and washing out of the upper part of the borehole (see caliper log). No coherent samples suitable for laboratory strength tests were available.

The lower coal unit is more continuous and of higher quality and strength than the upper coal. In this location, however, it lies at or below depths presently economic for strip mining.

GEOTECHNICAL PROPERTIES LOG

U.S. GEOLOGICAL SURVEY

DRILL HOLE B-1

COUNTY Johnson STATE Wyoming ELEVATION 1,402 m 4,600 ft

LOCATION NE NW sec. 35, T. 51 N., R. 82 W.

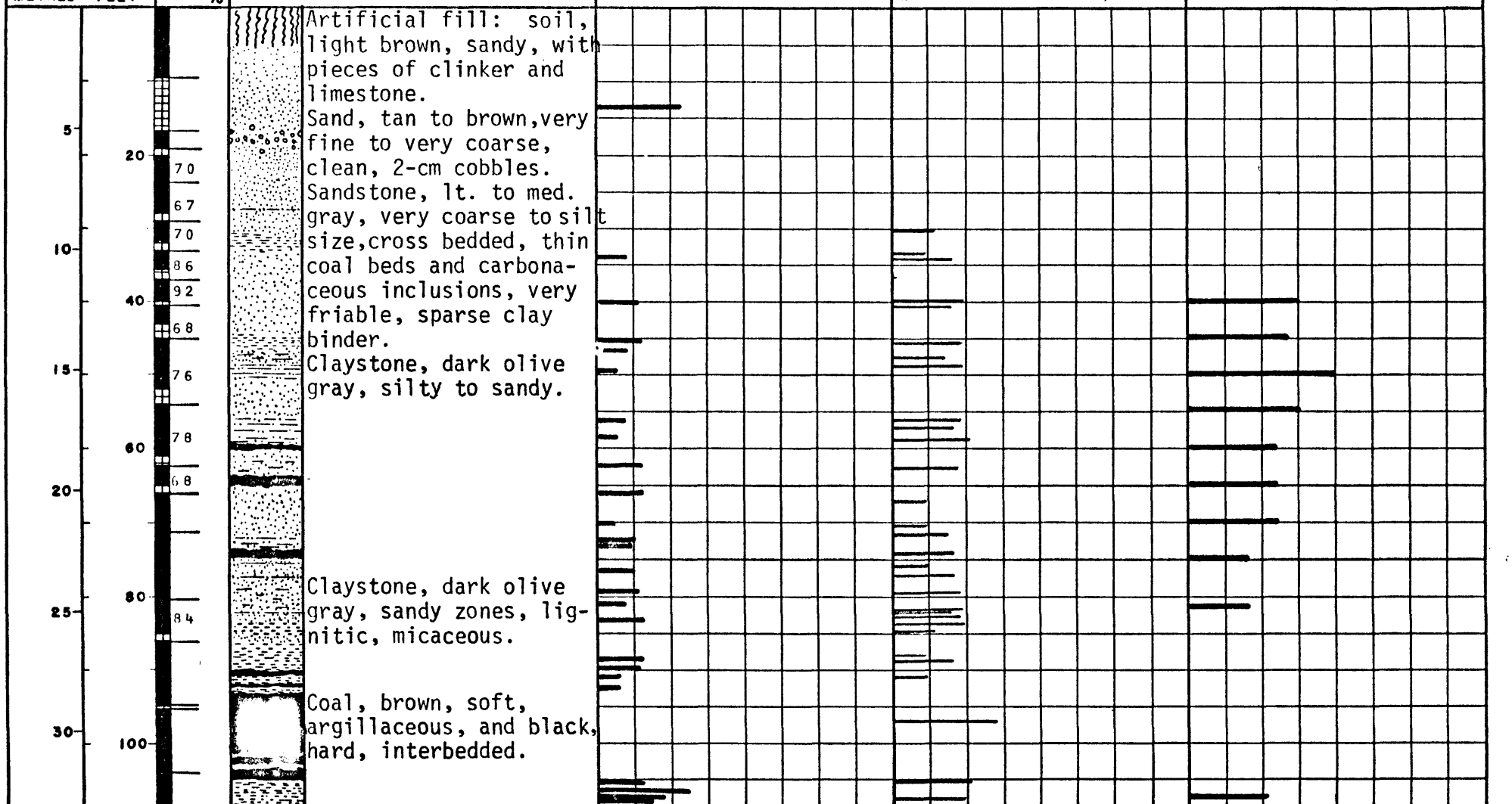
GPO-681-804

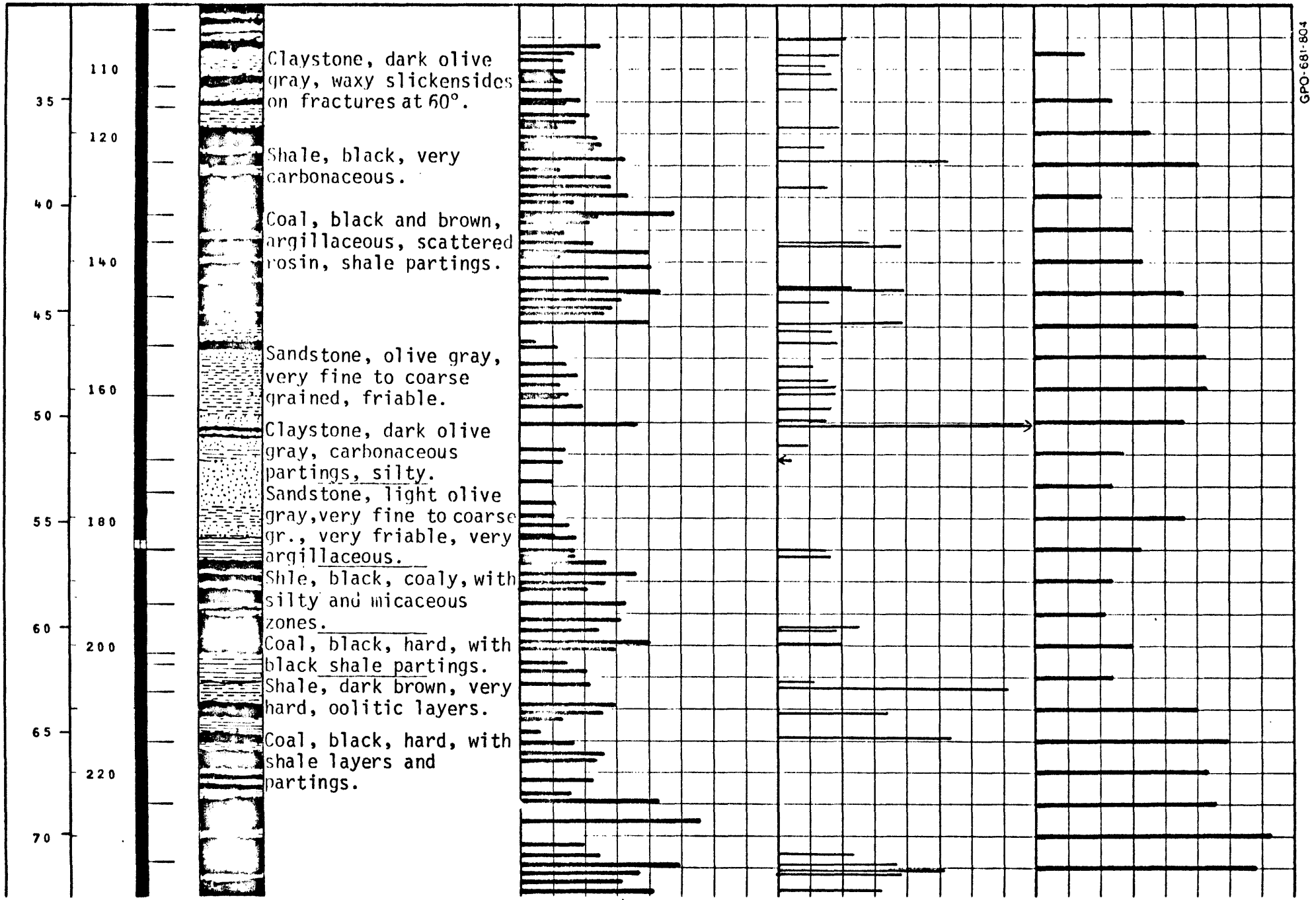
DEPTH METRES	DEPTH FEET	CORE RECOVERY %	LITHOLOGY
5	20	70	Artificial fill: soil, light brown, sandy, with pieces of clinker and limestone.
		67	Sand, tan to brown, very fine to very coarse, clean, 2-cm cobbles.
10		70	Sandstone, lt. to med. gray, very coarse to silt size, cross bedded, thin coal beds and carbonaceous inclusions, very friable, sparse clay binder.
	40	86	
		92	
		68	
15		76	Claystone, dark olive gray, silty to sandy.
	60	78	
20		68	
25	80	84	Claystone, dark olive gray, sandy zones, lignitic, micaceous.
30	100		Coal, brown, soft, argillaceous, and black, hard, interbedded.

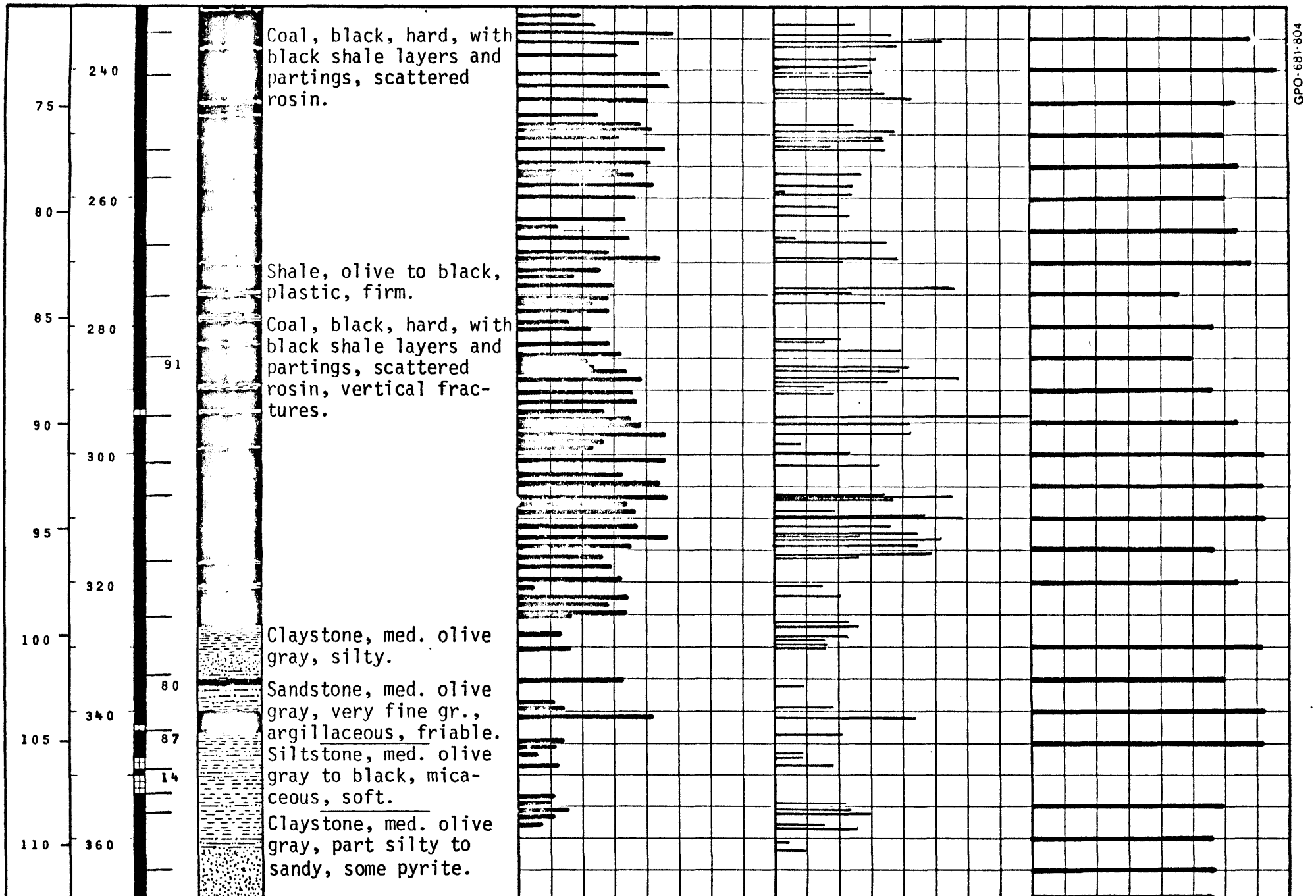
Schmidt Hammer type L: 20 40 60

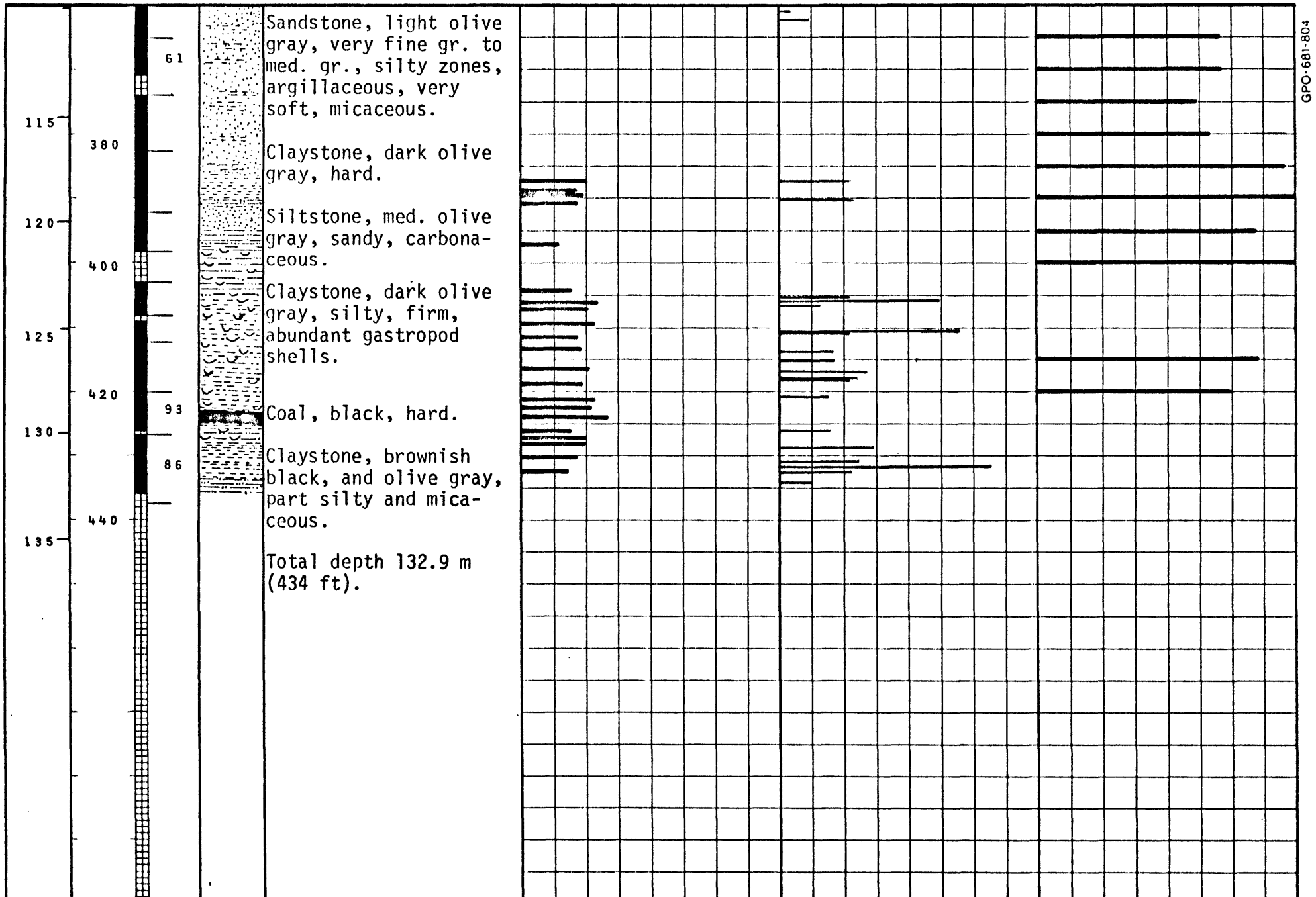
Point load MN/m^2: 0.1 0.5 1.0 1.5

P wave velocity K ft/sec: 6.5 7.0 7.5




110
35
120
40
140
45
160
50
180
55
200
60
220
65
70
Claystone, dark olive gray, waxy slickensides on fractures at 60°.
Shale, black, very carbonaceous.
Coal, black and brown, argillaceous, scattered rosin, shale partings.
Sandstone, olive gray, very fine to coarse grained, friable.
Claystone, dark olive gray, carbonaceous partings, silty.
Sandstone, light olive gray, very fine to coarse gr., very friable, very argillaceous.
Shle, black, coaly, with silty and micaceous zones.
Coal, black, hard, with black shale partings.
Shale, dark brown, very hard, oolitic layers.
Coal, black, hard, with shale layers and partings.
GPO-681-804


240
260
280
300
320
340
360
75
80
85
90
95
100
105
110
91
80
87
14
Coal, black, hard, with black shale layers and partings, scattered rosin.
Shale, olive to black, plastic, firm.
Coal, black, hard, with black shale layers and partings, scattered rosin, vertical fractures.
Claystone, med. olive gray, silty.
Sandstone, med. olive gray, very fine gr., argillaceous, friable.
Siltstone, med. olive gray to black, micaceous, soft.
Claystone, med. olive gray, part silty to sandy, some pyrite.
GPO-681-804


115
120
125
130
135
380
400
420
440
61
93
86
Sandstone, light olive gray, very fine gr. to med. gr., silty zones, argillaceous, very soft, micaceous.
Claystone, dark olive gray, hard.
Siltstone, med. olive gray, sandy, carbonaceous.
Claystone, dark olive gray, silty, firm, abundant gastropod shells.
Coal, black, hard.
Claystone, brownish black, and olive gray, part silty and micaceous.
Total depth 132.9 m (434 ft).
GPO-681-804

The claystone and sandstone unit separating the upper and lower coals may present fewer stability problems than those of the near-surface sandy unit. The unit is better indurated than the upper barren unit and did not wash out or collapse as did the upper unit. On the basis of seismic velocities calculated from the sonic log and a Seismic Rippability Chart (Caterpillar Tractor Co., 1976, p. 6-14--6-16), all the material encountered is marginal or rippable; however, current mining practice in the eastern Powder River Basin involves blasting of both overburden and coal.

Sampling procedures

The surficial materials were sampled by pushing Shelby tubes ahead of a hollow stem auger. The near-surface clayey soil was recovered in its entirety. As the soil grades progressively downward to sandy alluvium and to coarse gravel, the recovery of samples decreased. The interval from 3 m to 5 m (9.8-16.4 ft) could not be sampled because the Shelby tubes could not be driven into the coarse cobble deposit. At 5.3-m (17.4-ft) depth, the auger hole was filled and abandoned. The drilling rig was moved about 3 m (10 ft) east, and the deep hole was begun. The use of a split tube assembly inside the NX wire-line coring apparatus consistently resulted in nearly complete core recovery. This is remarkable in view of the extremely friable nature of the sandy and silty materials. The claystones and coal beds, however, could possibly be cored with conventional equipment. The use of synthetic drilling mud was discontinued at about 30 m (98.4 ft). After the changeover to bentonite-based mud the hole stayed in gage, with little caving below that depth.

Field test program and procedures

Upon recovery, each core was wiped, scraped or washed, described for lithology and general consistency, subjected to two index tests, and then sealed in glass jars at the drill site in order to preserve natural moisture. The two index tests were the point-load test and the Schmidt hammer test.

The point-load test described in Aufmuth (1974) consists of compressing a segment of core across a diameter between two rounded points to failure in tension. The value of the index is calculated from P/d^2 where P is the force at failure and d is the diameter of the core. Some authors multiply this by the factor $4/\pi$, which then results in the force per unit area on the broken surface; this report does not. The index values in this report differ by that constant from those of other reports which include the factor. Values are reported in meganewtons per square meter (MN/m^2) (1 MN/m^2 = 145 lb/in^2).

The Schmidt hammer test uses a device which propels a spring-loaded hammer against the sample and measures the rebound. The rebound numbers (R) are a dimensionless measure of the amount of rebound against a calibrated spring. The test is a nondestructive index of relative compressive strength for elastic materials (Hall and others, 1974). Most of the rocks and soils in this borehole are near the lower limits of sensitivity of the test; however, relative strengths can be determined in a qualitative sense. The test requires a coherent segment of core whose length exceeds its diameter. If the core failed under impact, the data from that depth were discarded. The plot on the geotechnical properties log shows the arithmetic mean of three Schmidt type L hammer tests for each depth reported.

Laboratory test program and procedures

Subsequent tests in the laboratory were performed to determine properties of the soils and rocks. The less competent materials were tested for grain-size distribution, Atterberg limits, water content, and densities. For the most part, only minimal effort was required to disaggregate the materials so tested. More competent layers were subjected to tests normally associated with rocks. The tests included those for static elastic moduli, unconfined compressive strength, and ultrasonic pulse elastic properties. Preparation of suitable specimens was difficult because of the friable or fissile nature of the material; therefore, only limited numbers of the rock tests were performed.

Preparation of soil samples was performed in accordance with the standard method for dry preparation of soil samples for particle-size analysis and determination of soil constants (ASTM D421-58, reapproved 1972). Particle-size analysis of soils (ASTM D422-63, reapproved 1972) was used in the subject determinations with the exception that disaggregation was accomplished by hand-held mortar and rubber pestle. The results are presented as computer-generated graphs (figs. 1-5). The standard methods of test for liquid limit and for plastic limit and plasticity index of soils (ASTM D423-66 and D424-59, reapproved 1971) were used for those determinations. The water pycnometer method described in the standard method of test for specific gravity of soils (ASTM D854-58, reapproved 1972) was used for determination of grain densities. Bulk densities were determined according to the method described by Chleborad, Powers, and Farrow (1975). (See tables 1 and 2.) Static elastic moduli were determined on the same specimens as were subsequently tested for unconfined compressive strength. Stress-strain curves were

drawn by two X-Y plotters from signals originating from a load cell and from a specimen-mounted deformation jacket containing both radial and longitudinal linear variable differential transformers. The curves, along with specimen dimensions, tolerances, and modes of failure, are shown in figures 6a through 12b and in table 3. The results of ultrasonic pulse velocity tests are shown in table 4.

ENGINEERING GEOLOGY LABORATORY

PARTICLE SIZE DISTRIBUTION CURVE

SAMPLE NUMBER B-1-2.00 #2 (Depth 6.6 feet)

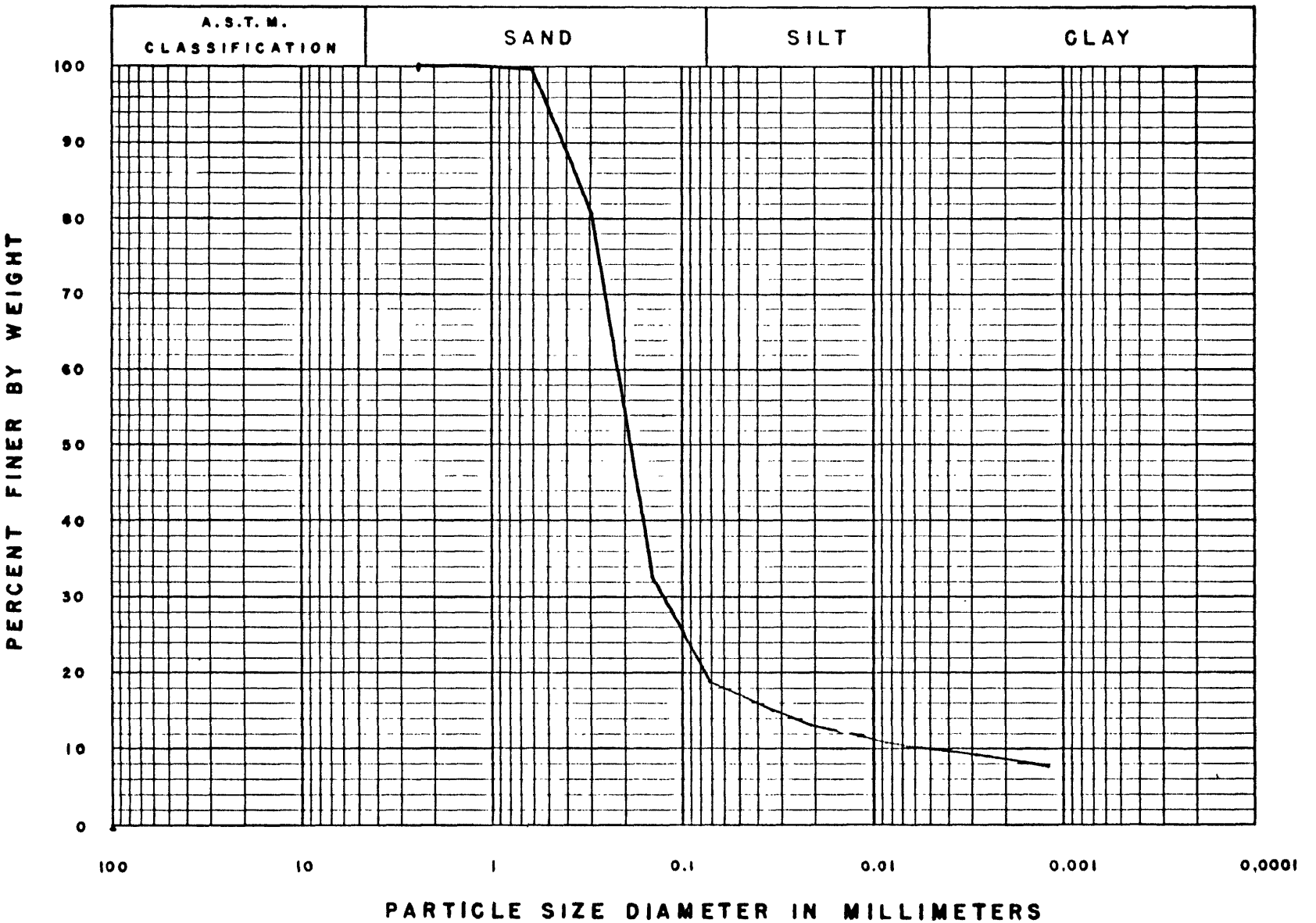


Figure 1

GPO 831-715

ENGINEERING GEOLOGY LABORATORY

PARTICLE SIZE DISTRIBUTION CURVE

SAMPLE NUMBER B-1-2.5C #4 (Depth 8.2 feet)

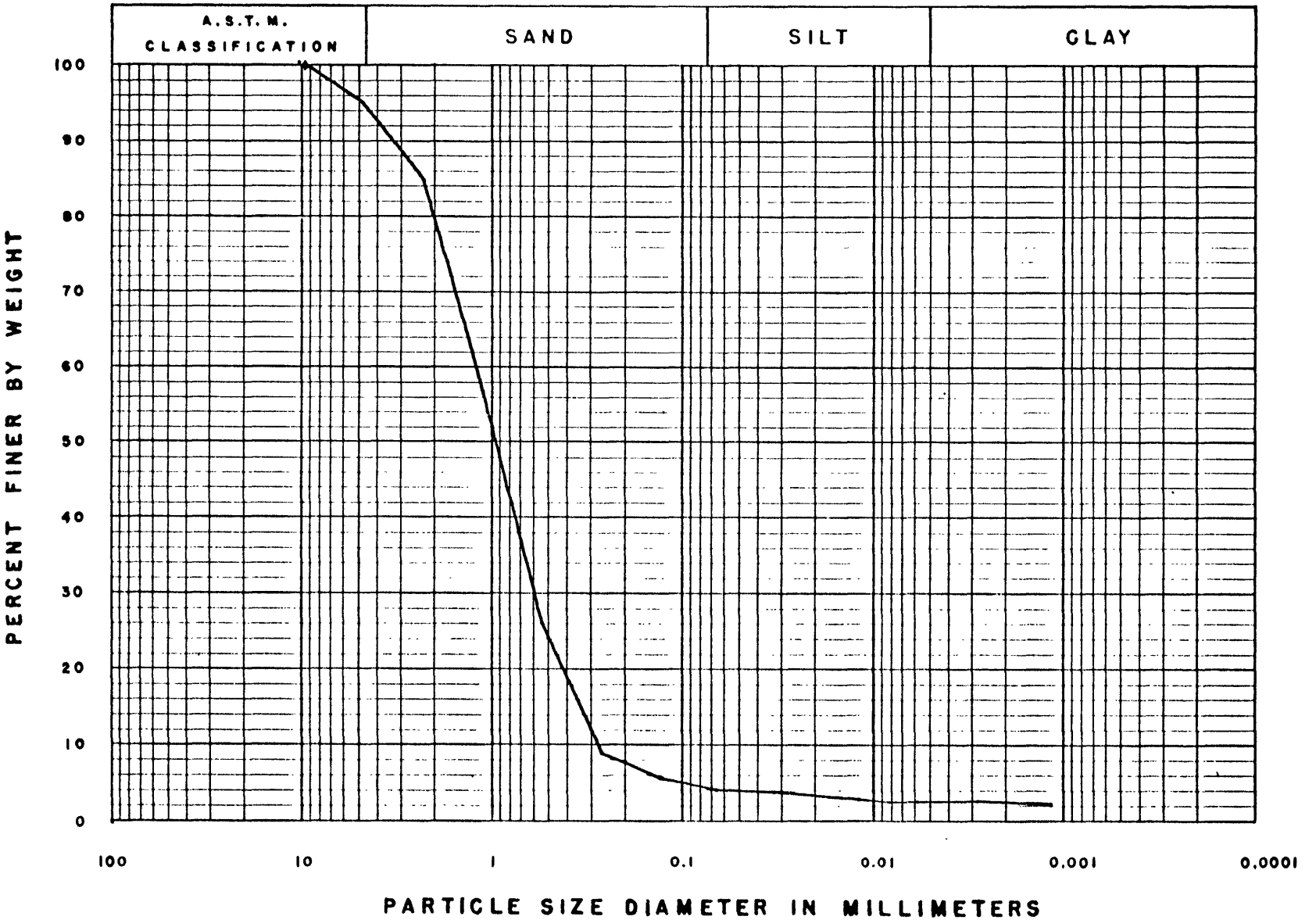


Figure 2

GPO 831-715

ENGINEERING GEOLOGY LABORATORY

PARTICLE SIZE DISTRIBUTION CURVE

SAMPLE NUMBER B-1-46.10 (Depth 151.2 feet)

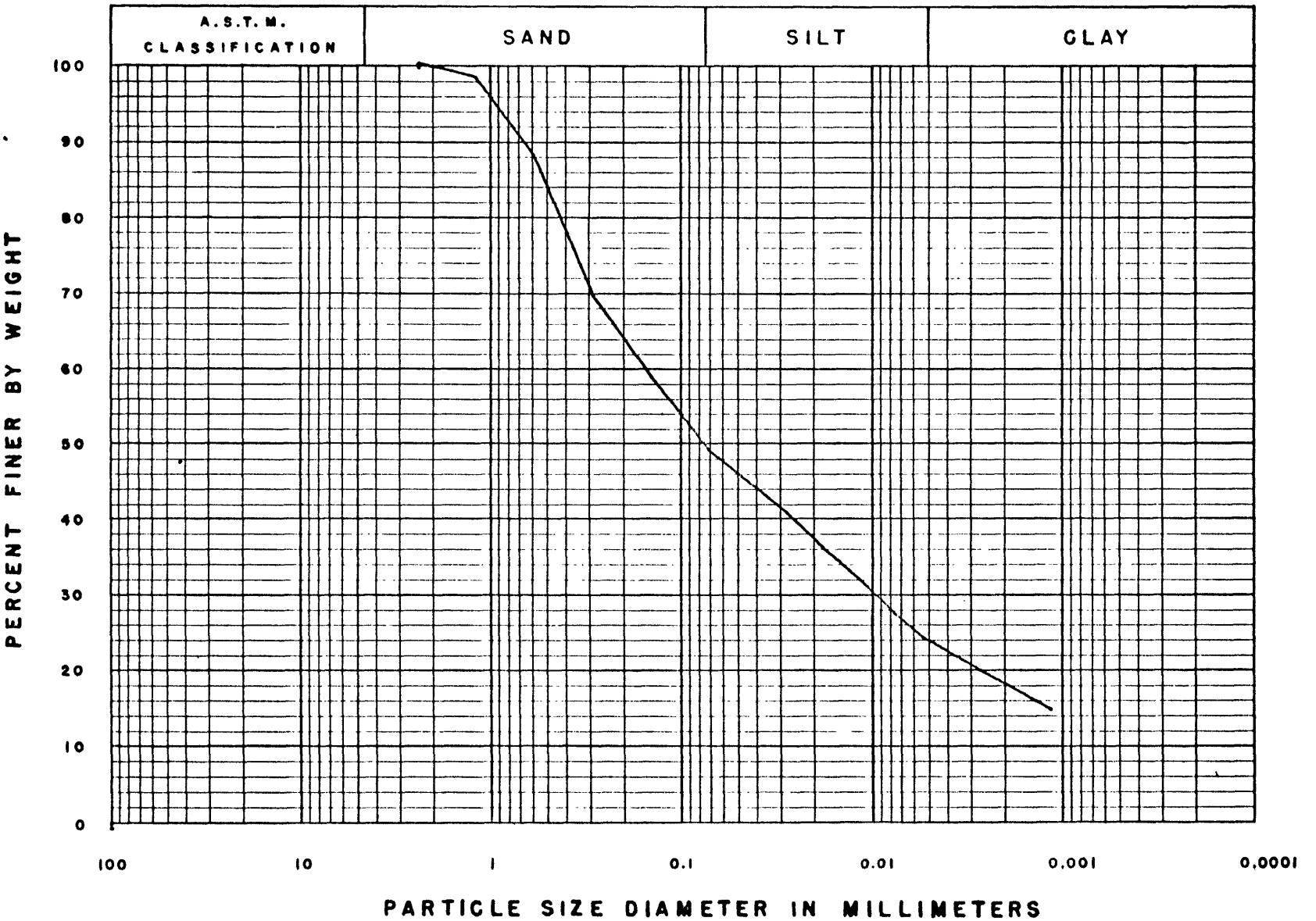


Figure 3

GPO 831-718

ENGINEERING GEOLOGY LABORATORY

PARTICLE SIZE DISTRIBUTION CURVE

SAMPLE NUMBER B-1-115.75 (Depth 379.8 feet)

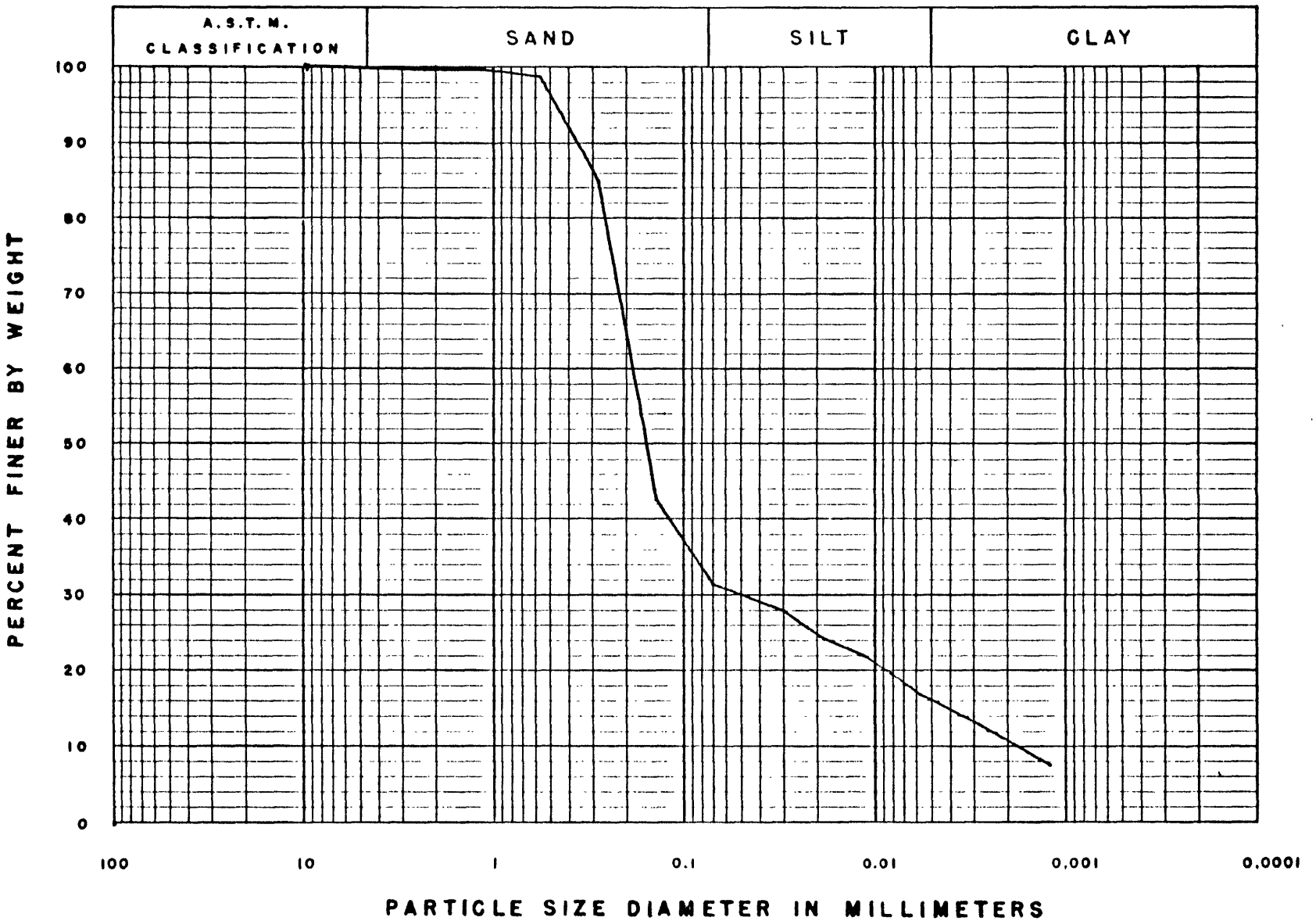


Figure 4

GPO 831-715

ENGINEERING GEOLOGY LABORATORY

PARTICLE SIZE DISTRIBUTION CURVE

SAMPLE NUMBER B-1-12[illegible].95 (Depth 409.9 feet)

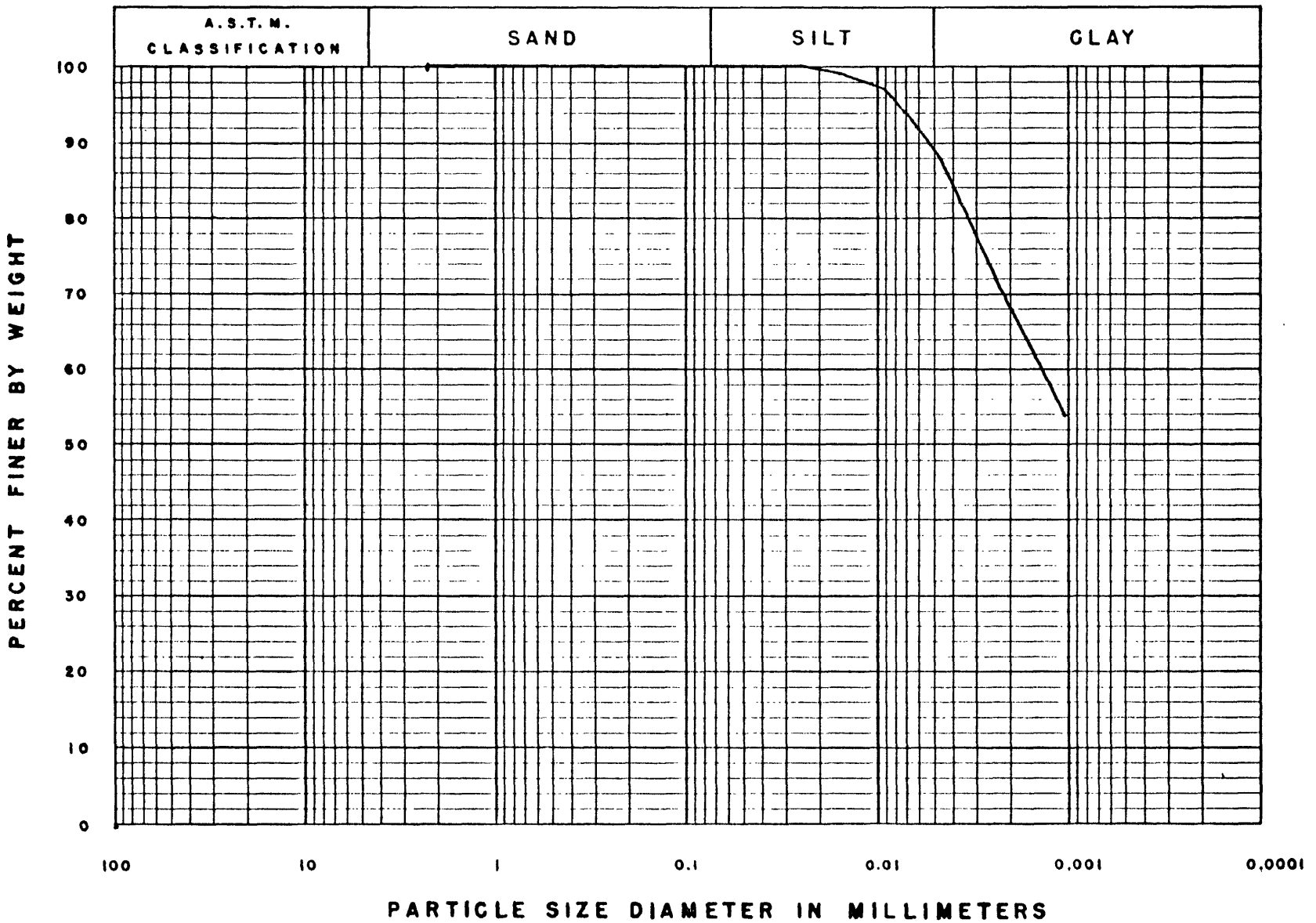


Figure 5

GPO 831-715

Table 1.--Physical properties test results

[Leaders (---) indicate no data]

Depth (meters)	Depth (feet)	Bulk density as received (g/cm^3)	Grain density (g/cm^3)	Void ratio	Porosity (percent)
30.10	98.8	1.23	-------	-----	---------
32.25	105.8	2.04	-------	-----	---------
37.55	123.2	1.40	-------	-----	---------
46.10	151.2	2.24	2.65	0.35	24.8
50.45	165.5	2.73	2.69	-----	---------
61.50	201.8	1.75	-------	-----	---------
68.50	224.7	1.45	-------	-----	---------
80.30	263.5	1.29	-------	-----	---------
91.40	299.9	1.68	-------	-----	---------
106.40	349.1	2.69	2.80	-----	6.1
115.75	379.8	2.08	2.65	-----	34.5
124.95	409.9	2.24	2.72	-----	27.9

Submitter: R. A. Farrow
Location: Buffalo, Wyoming
Project #: 9550-00645

ENGINEERING GEOLOGY LABORATORY
SOIL SAMPLE TEST RESULTS

Date: 10/21/75
Analyst: Eric Smirnow
Reviewed by:

	SAMPLE NUMBER				
	B-1-2.00#2	B-1-2.50#4	B-1-46.10	B-1-115.75	B-1-124.95
Gravel: 76 - 4.76 mm (% by weight)	0	5.5	0	0.5	0
Sand: 4.76 - 0.075 mm (% by weight)	81.5	90.5	51	67.5	0
Silt: 0.075 - 0.005 mm (% by weight)	8.5	1	25	16	11
Clay: <0.005 mm (% by weight)	10	3	24	16	89
Coefficient of uniformity: C_u = D60 ÷ D10	41.8	46.4		100.0	
Coefficient of curvature : C_z = $(D30)^2$ ÷ (D60 x D10)	15.5	0.1		7.7	
Liquid limit [LL] (% of dry soil weight)	NP*	NP	29	NP	65
Plastic limit [PL] (% of dry soil weight)	NP	NP	25	NP	27
Shrinkage limit [SL] (% of dry soil weight)					
Plasticity index [PI] (% of dry soil weight)	NP	NP	4	NP	38
Unified soil classification	SM	SW	SM	SM	CH
As received water content [w] (% of dry soil weight)			14.1	17.6	13.7
Activity: A = PI ÷ % finer than 0.002 mm			0.22		0.55
Liquidity index: I_L = (w - PL) ÷ PI			- 2.7		-0.4
$CaCO_3$	+**	-***	-	-	+

REMARKS: *NP - Non-plastic
**+ - Strong reaction
***- - No reaction
B-1-2.00 #2 - Coal present in hydrometer sieve analysis.
B-1-46.10 - Coal present in hydrometer sieve analysis.

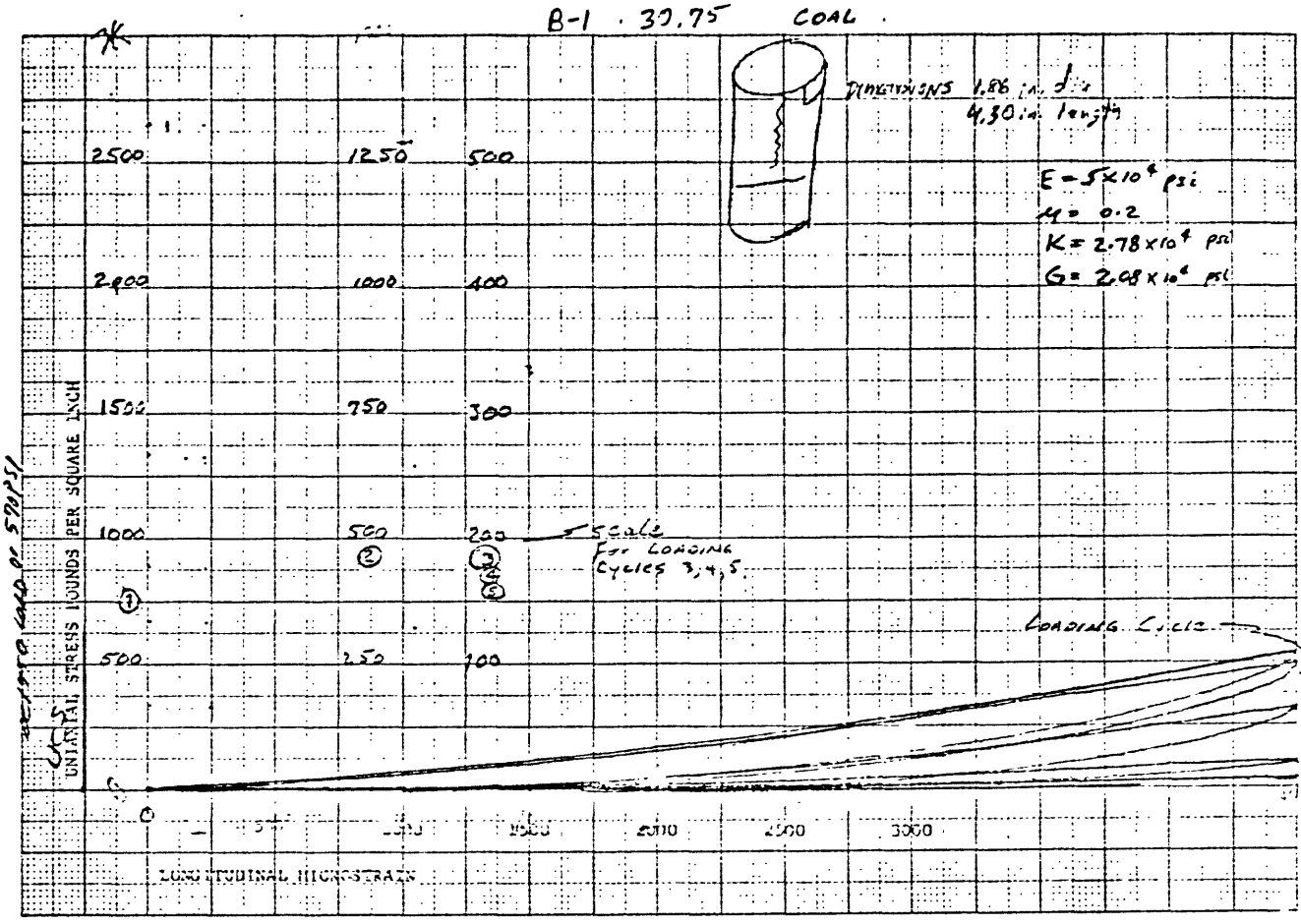


Figure 6a

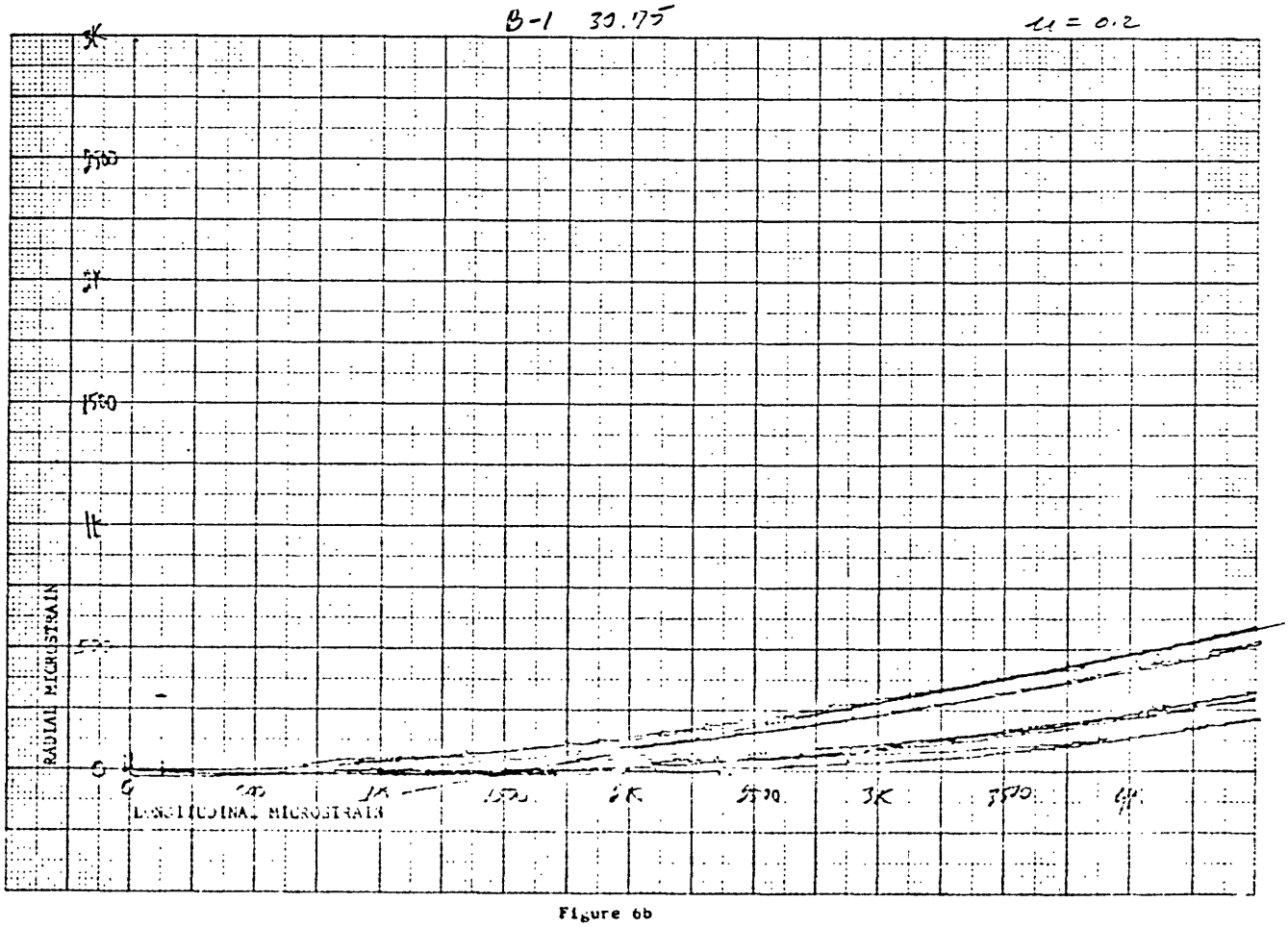


Figure 6b

B-1 45.95 – claystone, very sandy

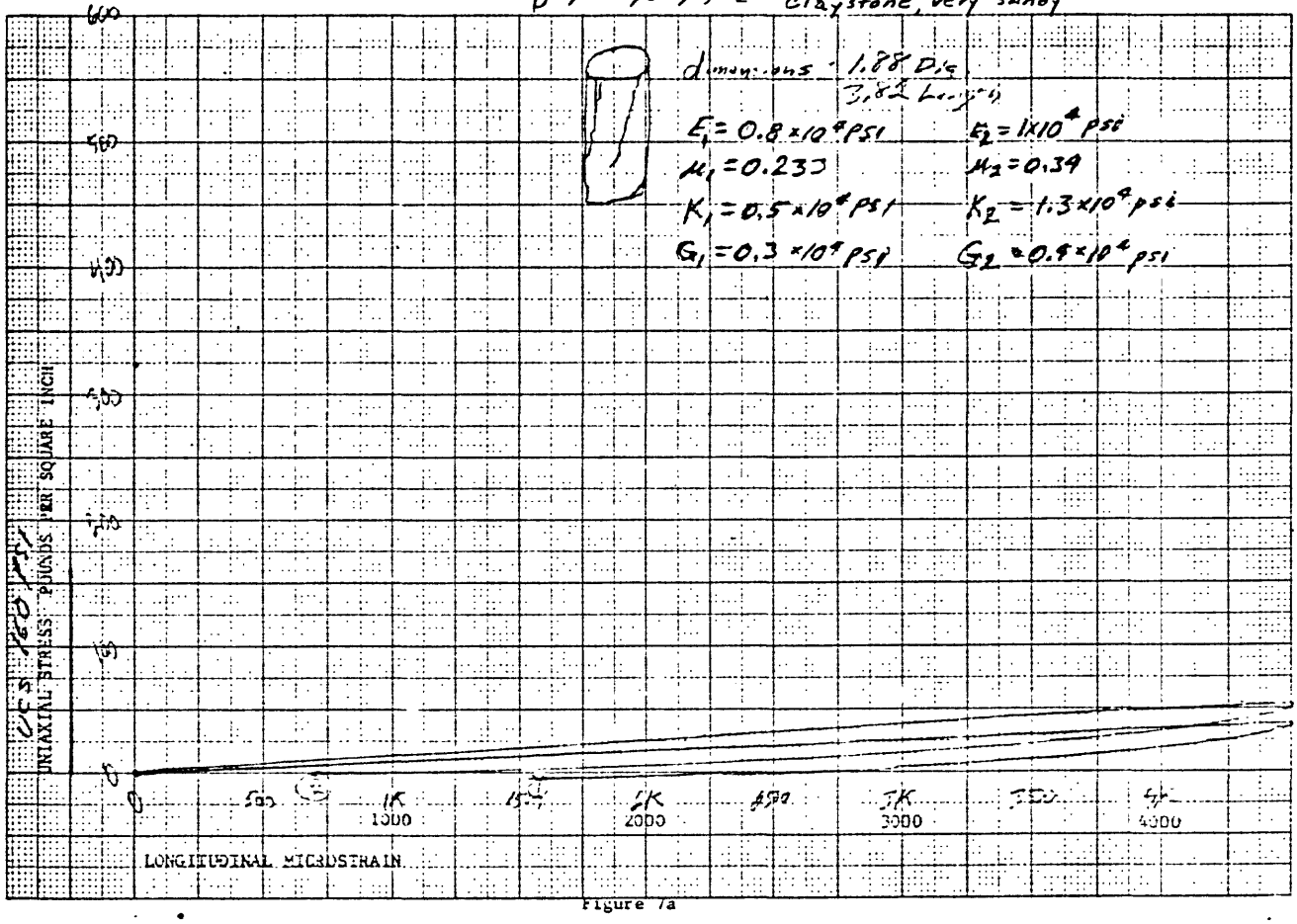


Figure 7a

B-1 45.95

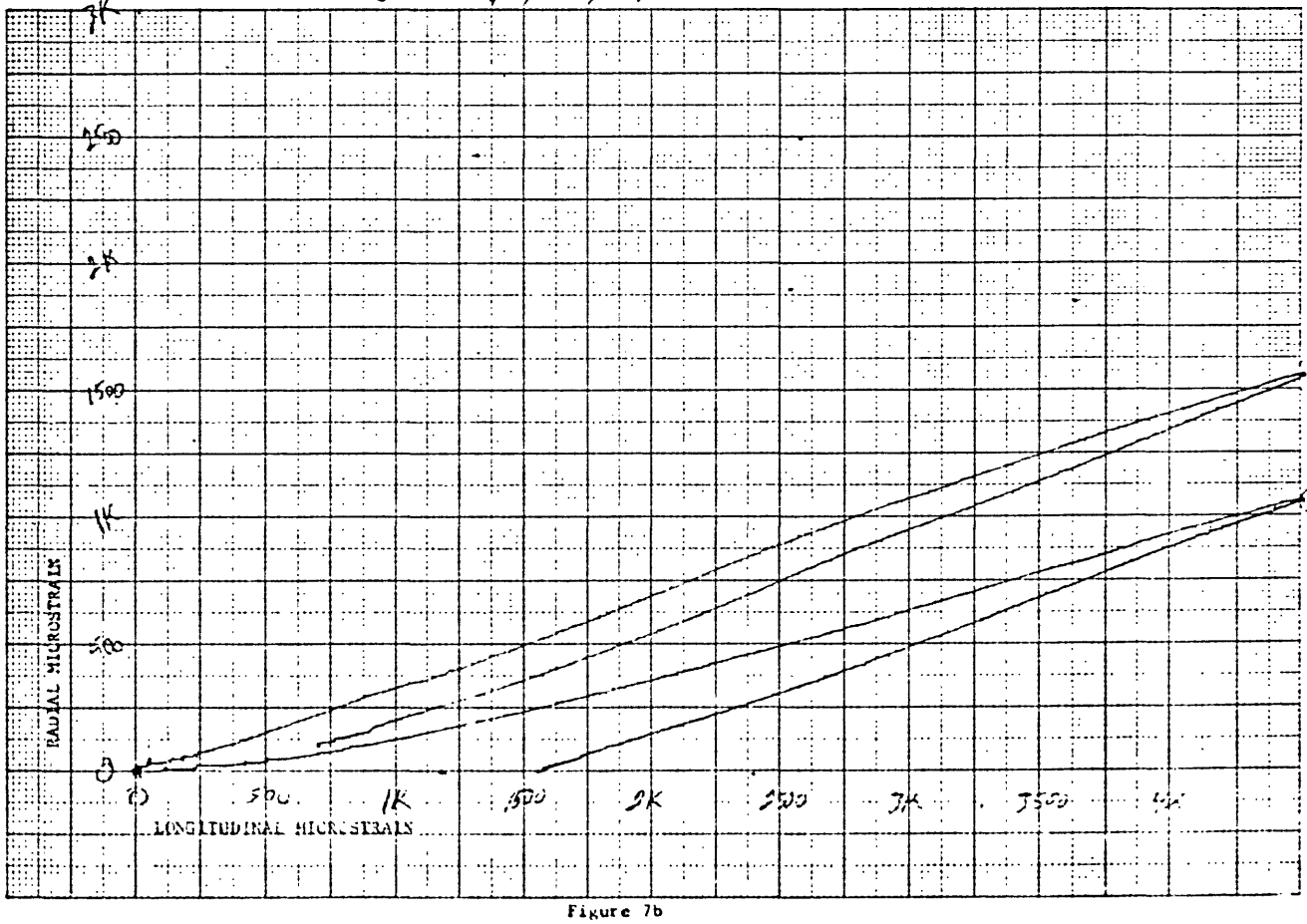


Figure 7b

Claystone, silty B-1 49.55 Sample cased in condom and allowed to free stand for five minutes. No significant shrinking recorded.

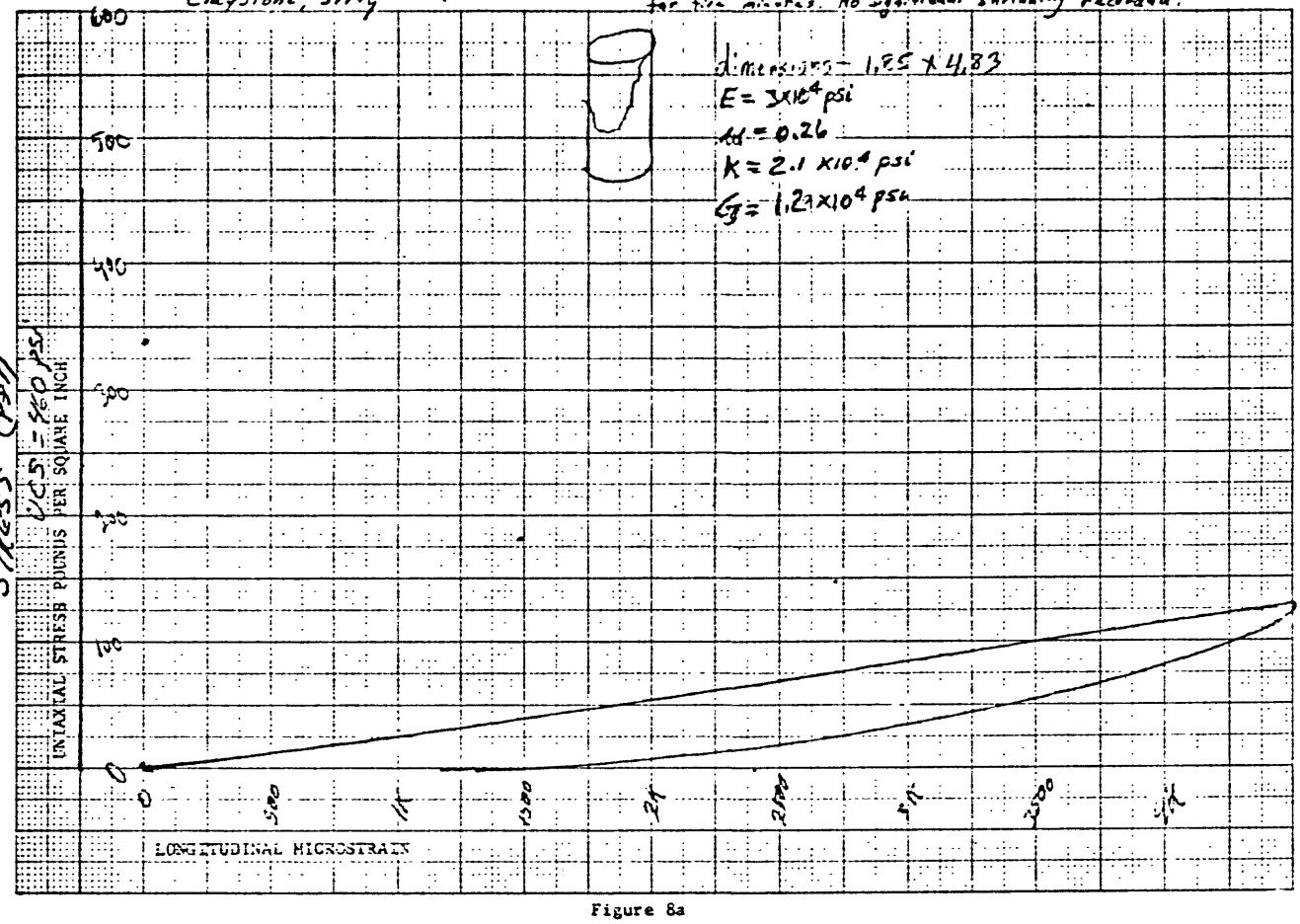


Figure 8a

B-1 49.55

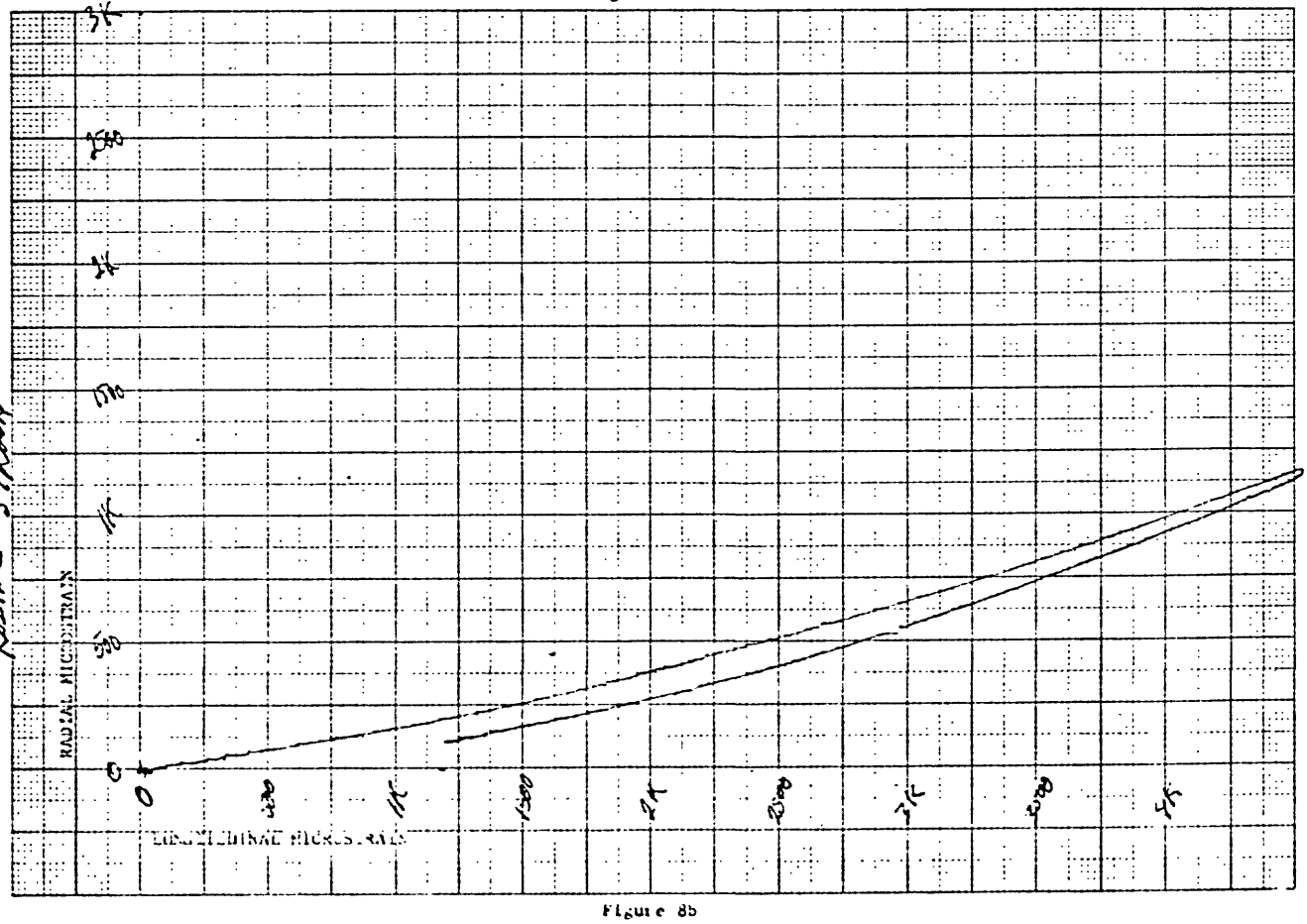
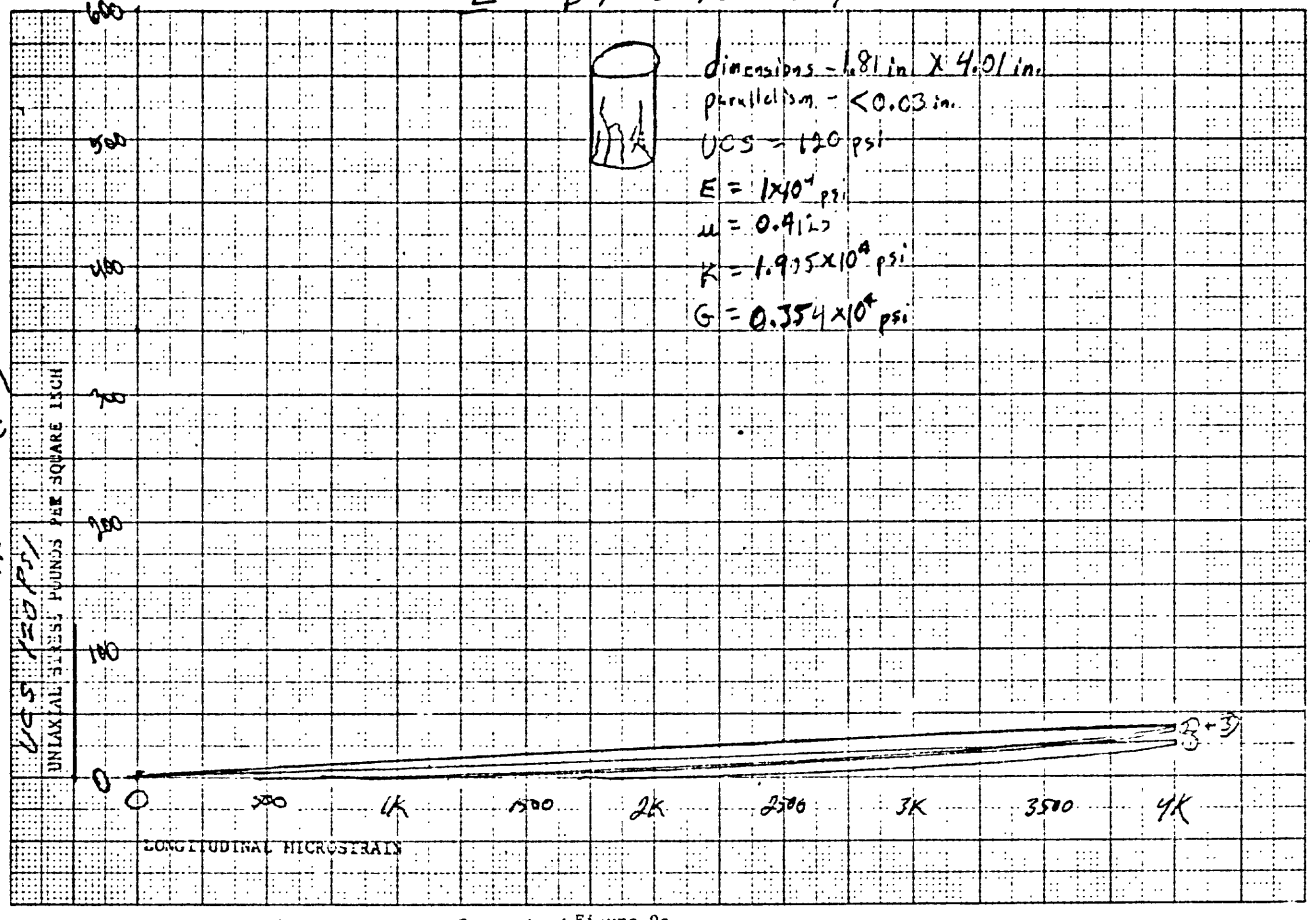


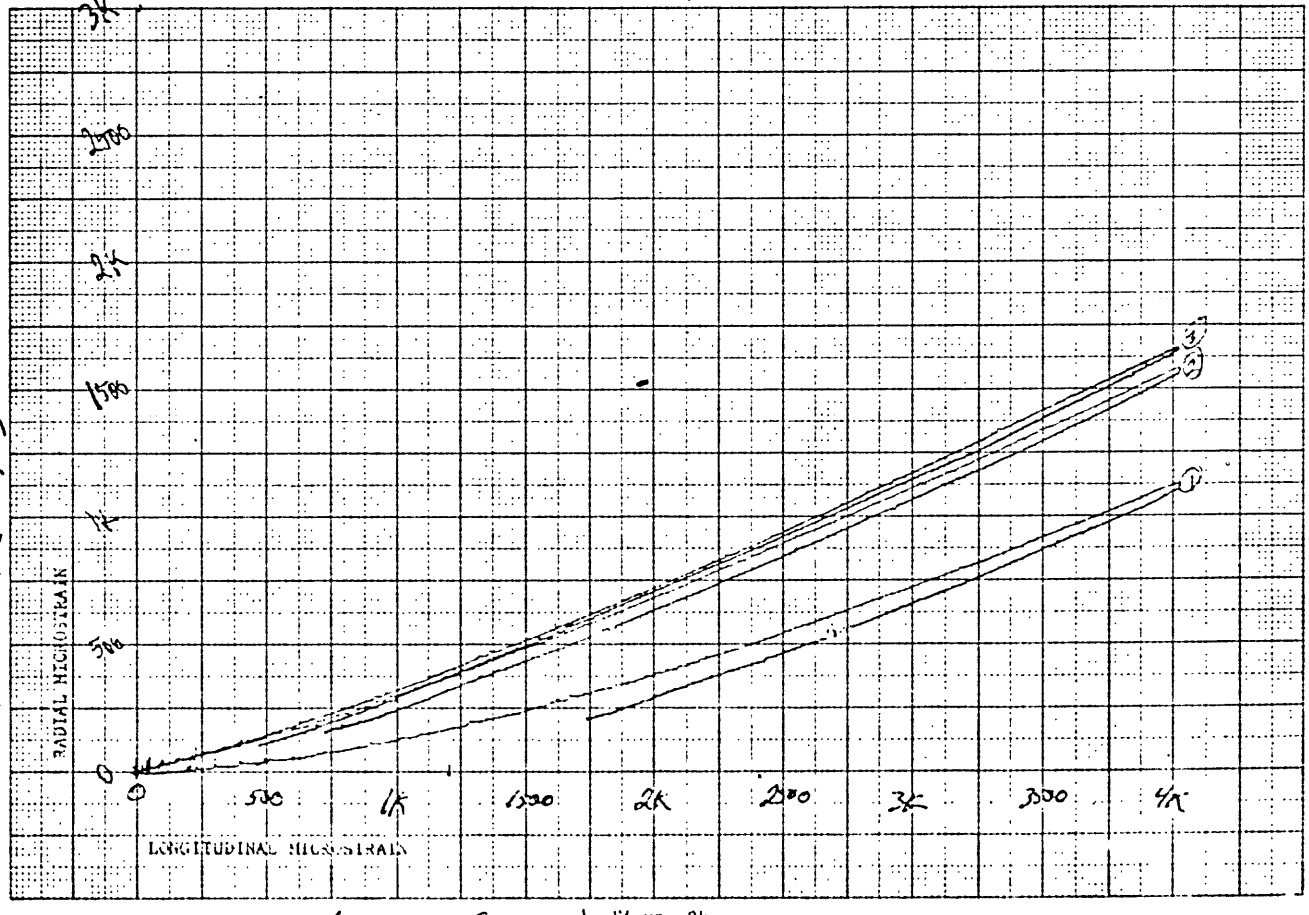
Figure 8b

E B-1 61.90 - claystone



Longitudinal Strain (μin/in) Figure 9a

μ B-1 61.90



Longitudinal Strain (μin/in) Figure 9b

B1 62.05' - claystone

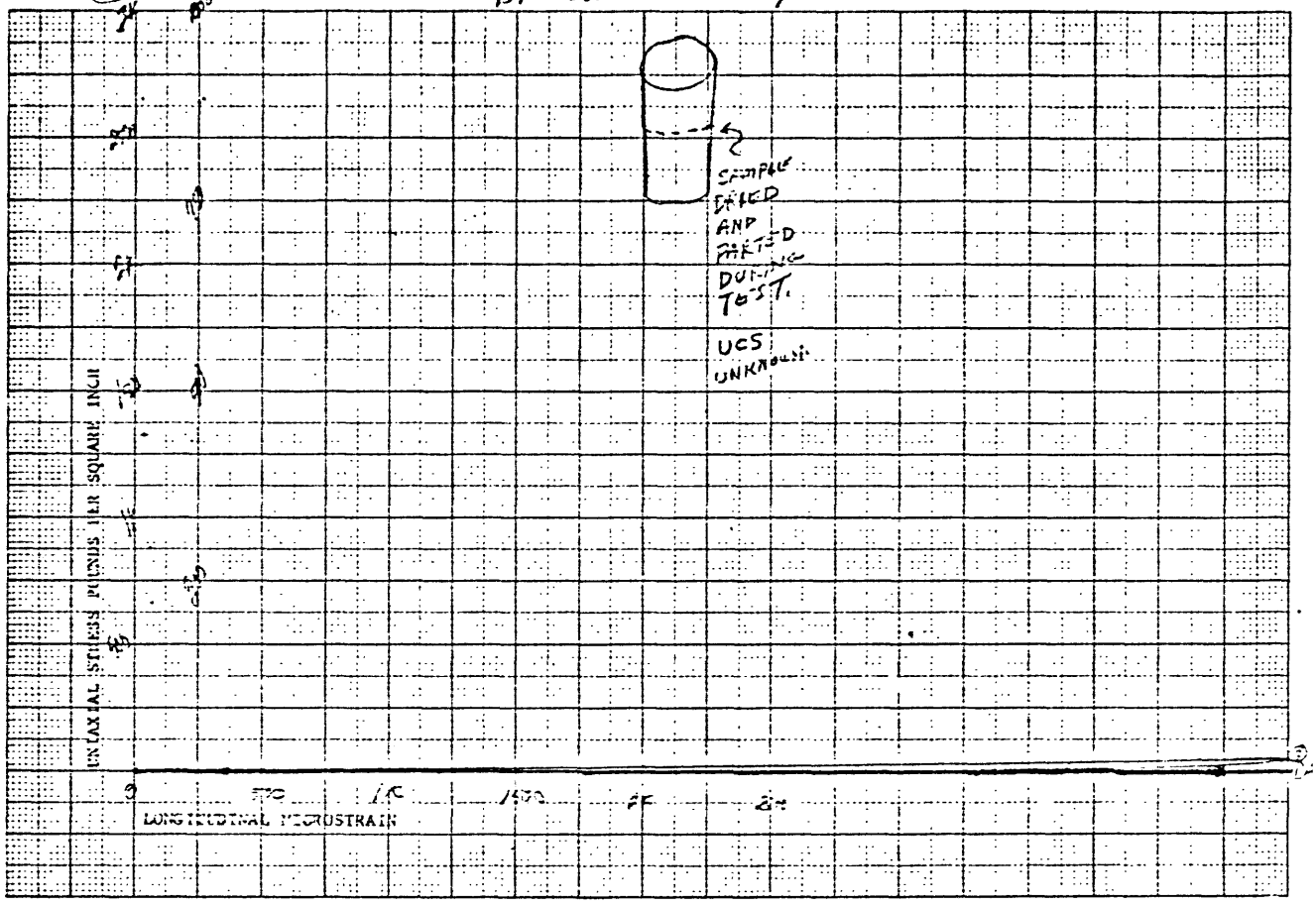


Figure 10a

B1 62.05

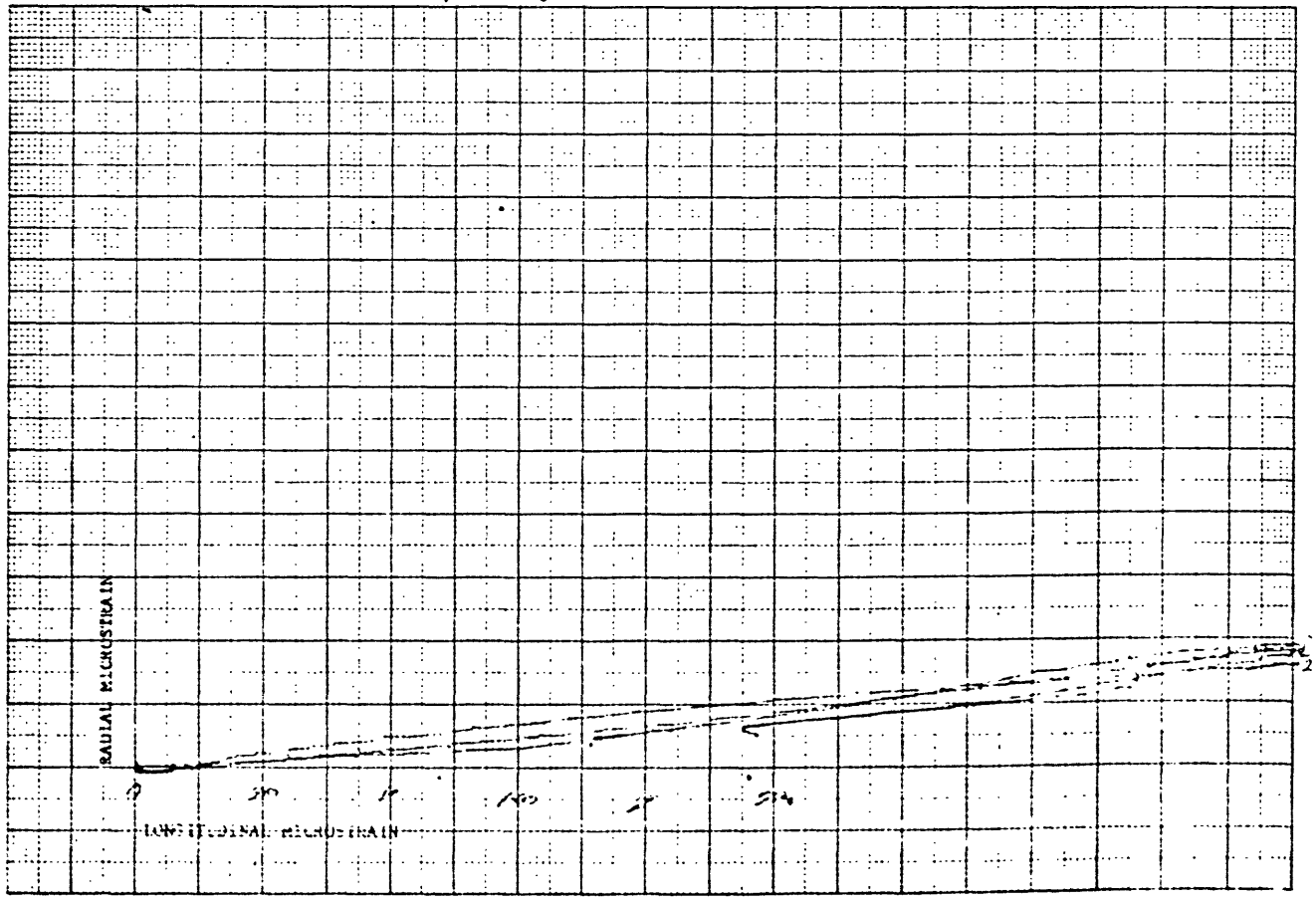
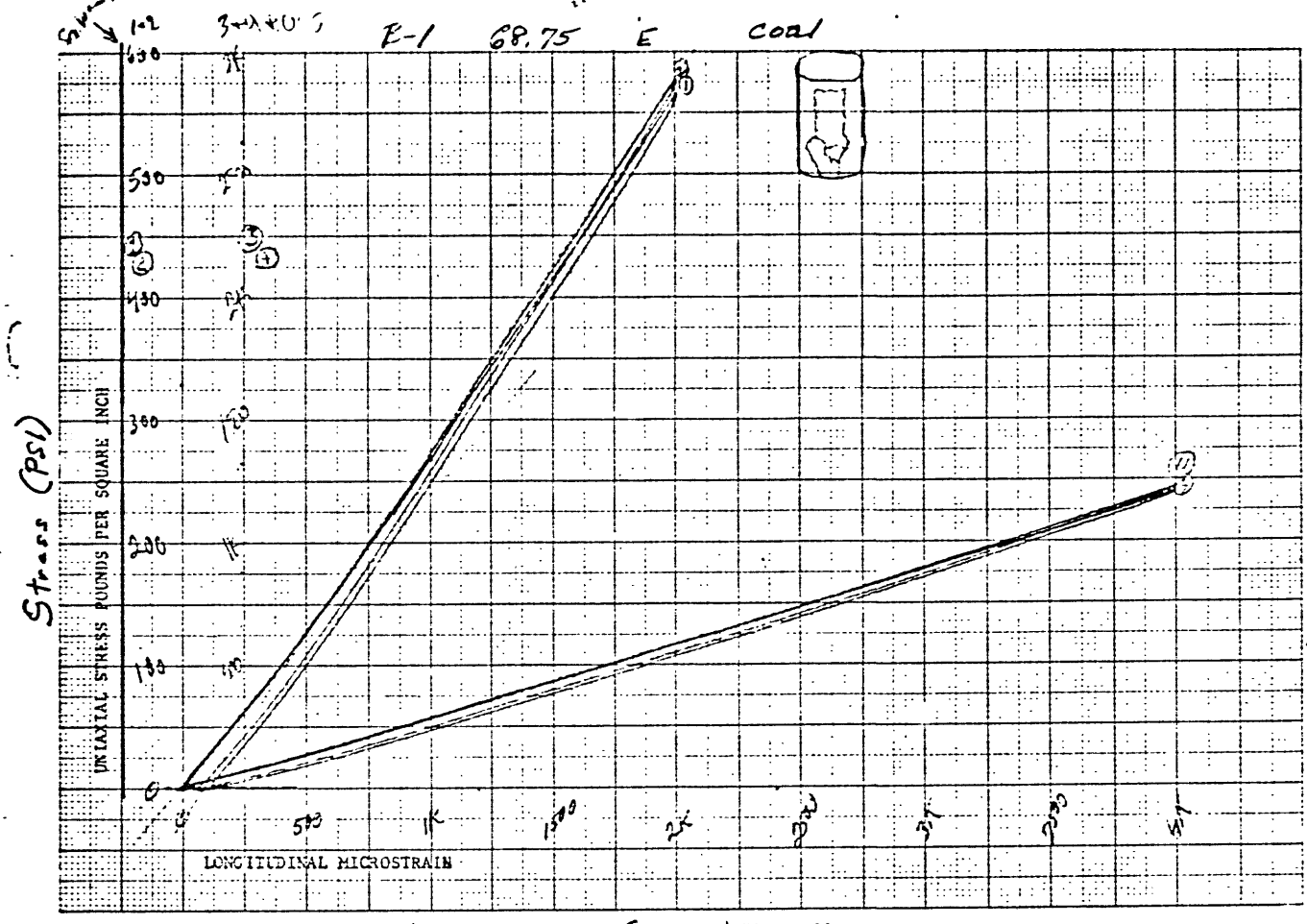


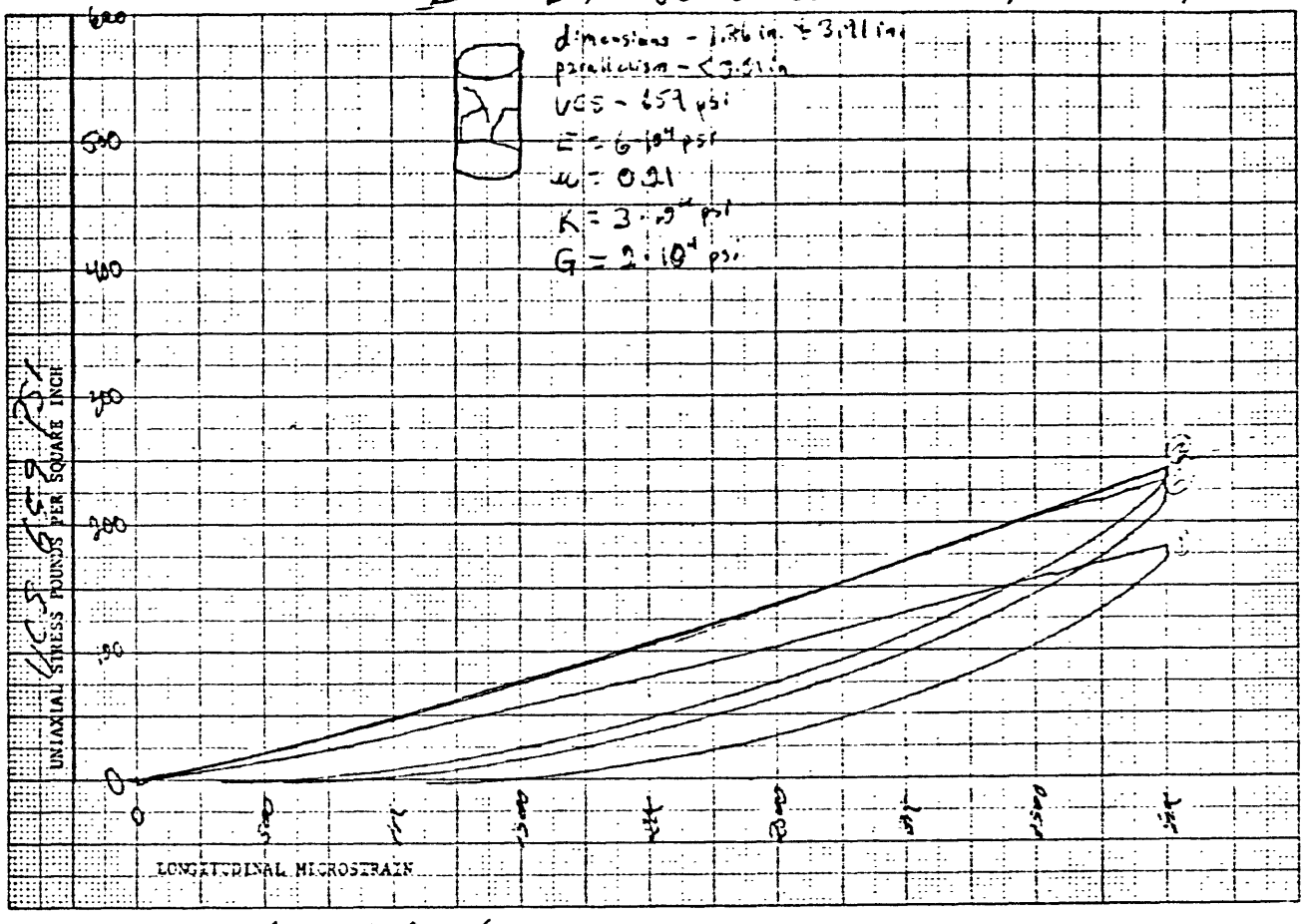
Figure 10b



Longitudinal Strain (u in/in) Figure 11a

Longitudinal Strain (u in/in) Figure 11b

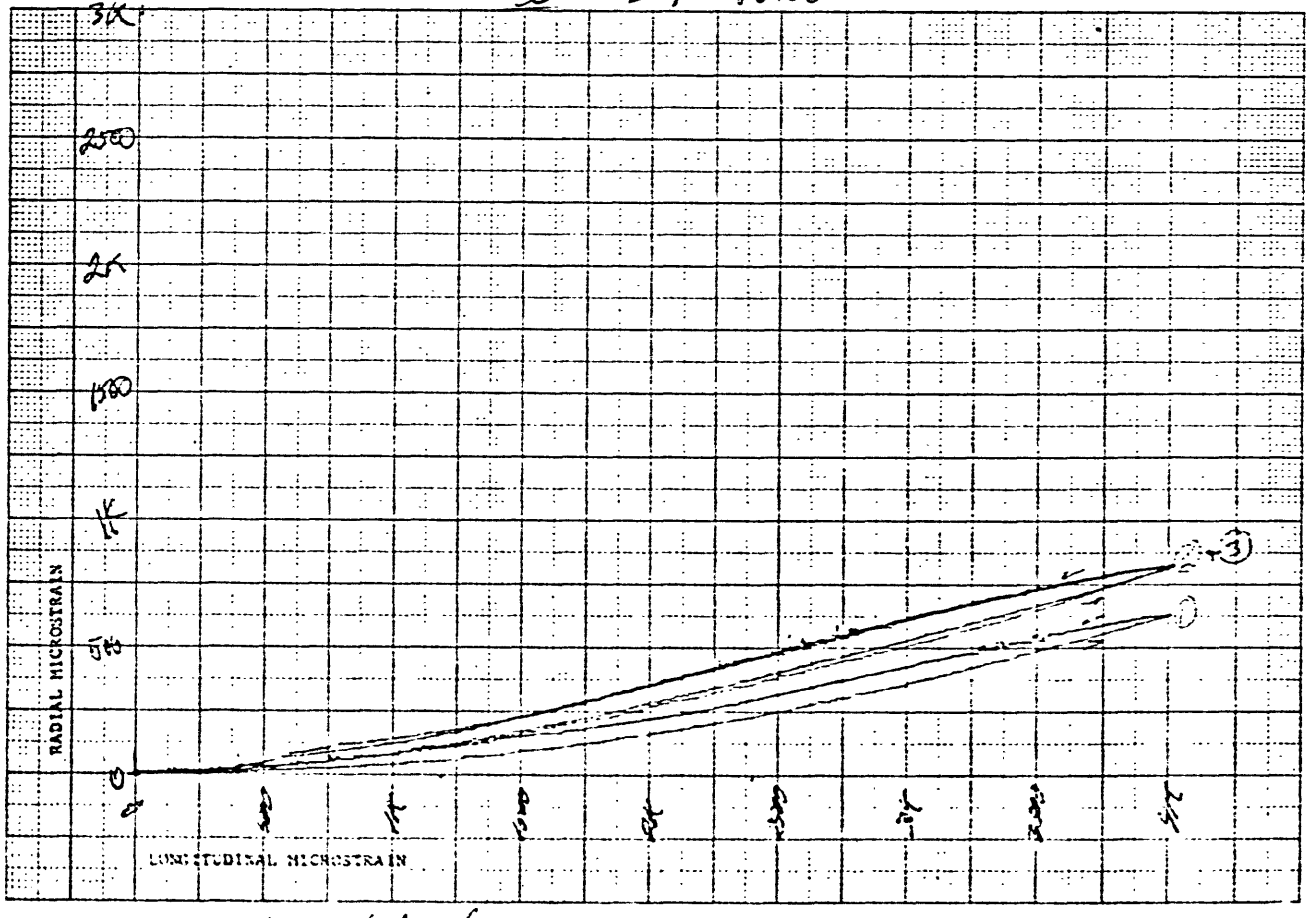
E B-1 80.00 coal with claystone, silty



Stress

Longitudinal Strain Figure 12a

u B-1 80.00



Lateral Strain

Longitudinal Strain Figure 12b

Table 3.--Physical properties results

Requester: R. A. FARROW

Location: Buffalo, Wyoming

Date: January 1976

Project No.: B-1

Method: Unconfined uniaxial compression

Analyst: D. Worley

Depth (m)	Depth (ft)	Rock type	Core diameter (in.)	Core length (in.)	End parallelism (in.)	Unconfined compressive strength (psi)	Young's Modulus (psiX10^6) (E)	Poisson's ratio (μ)	Tangent range (psi)	Bulk modulus (psiX10^6) (K)	Shear modulus (psiX10^6) (G)
30.75	100.9	Coal	1.86	4.30	0.01	570	0.05	0.20	60-110	0.03	0.021
45.95	150.8	Clay-	1.88	3.82	.01	160	.01	.23	0-35	.01	.003
		stone					.01	.34	0-50	.01	.004
49.55	162.6	--do---	1.85	4.83	.01	460	.03	.26	0-115	.02	.012
61.90	203.1	--do---	1.81	4.01	.03	120	.01	.41	0-40	.01	.004
68.75	225.6	Coal			.01	3,050	.28	.40	0-565	.47	.100
							.29	.39	0-575	.43	.100
							.30	.41	0-1,200	.57	.110
							.31	.42	0-1,225	.63	.110
80.00	262.5	--do---	1.86	3.91	.01	659	.06	.21	100-240	.03	.020

TABLE 4
PHYSICAL PROPERTIES RESULTS

Requester: R. A. Farrow

Date : January 20, 1976

Method : Sonic Velocity, ULTRASONIC PULSE

Analysts : D. M. Worley

Location : Buffalo,Johnson County,Wyoming

Project No:

DEPTH METRES	DEPTH FEET	Bulk Density as rec'd g/cm^3		VP Compressional velocity (FT/sec)	VS Shear velocity (FT/sec)	σ Poisson's ratio	E Young's modulus (10^6psi)	G Shear modulus (10^6psi)	K Bulk modulus (10^6psi)	Sample condition and remarks
29.80	97.8	1.27		3,490	1,710	.34	.13	.05	.14	good
30.75	100.9	1.63		3,265	975	.45	.06	.02	.21	very good
45.95	150.8	2.18		5,430	1,460	.46	.18	.06	.78	good
49.55	162.6	2.07		5,690	2,120	.42	.36	.13	.74	very good
61.65	202.3	1.85		5,230	1,800	.43	.23	.08	.57	good
80.00	262.5	1.36		6,260	2,765	.38	.39	.14	.53	very good
91.80	301.2	1.31		6,740	2,715	.40	.36	.13	.63	poor

Lithology

Depth (metres)	Description
	Shelby tube samples
0-1.5	Artificial fill consisting of soil, sandy, light brown,with occasional pieces of clinker and limestone
1.5-2.0	Sand, brown to tan, fine grained with some coarse grains, clayey and silty
2.0-2.5	Sand, brown, very fine to medium grained, clean, moist
2.5-3.0	Sand, as above, very fine to very coarse grained, clean, wet, with cobbles to 2 cm
3.0-5.0	No sample - sand as above with coarse gravel
5.0-5.30	Sand, and coarse gravel, quartz and granite to 4 cm
	NX core samples
5.70-6.30	Sandstone, light to medium gray, subangular, wet, very friable, sparse clay binder
6.30-6.50	Sandstone, as above, with 5-cm pebbles, cavings?
6.50-6.60	Sandstone, becomes medium gray, very argillaceous, carbonaceous
6.60-6.70	Sandstone, as above
6.70-6.85	----do----------
6.85-7.75	No sample - sandstone, as above, with clay, reddish brown, coaly

Depth (metres)	Description
	NX core samples--Continued
7.75-7.90	Sandstone, as above, becomes slightly more competent
7.90-8.10	----do----------
8.10-8.25	Sandstone, as above, becomes slightly more competent, with dark-gray carbonaceous stringers
8.25-8.40	Sandstone, as above, becomes slightly more competent, grades downward to claystone, dark brown, silty to nonsilty, plastic, carbonaceous
8.40-8.55	Sandstone, light to medium gray, medium to coarse grained, subangular to subrounded, very friable
8.55-9.00	----do----------
9.00-9.15	----do----------
9.15-9.30	Sandstone, light to medium gray, medium to coarse grained, subangular to subrounded, very friable, fine grained, with carbonaceous flecks
9.30-9.40	----do----------
9.40-9.55	----do----------
9.55-10.00	Siltstone, medium gray, sandy (very fine grained), carbonaceous, argillaceous, friable
10.00-10.15	Sandstone, medium gray, silty, carbonaceous, argillaceous, friable, interlaminated with siltstone as above
10.15-10.40	Siltstone, as above

Depth (metres)	Description
	NX core samples--Continued
10.40-10.50	Sandstone, medium gray, very fine grained to very coarse, interbedded, carbonaceous inclusions of sticks, chunks, and laminae, very friable
10.50-10.80	----do----------
10.80-11.10	Sandstone, medium gray, very fine grained to very coarse, interbedded, carbonaceous inclusions of sticks, chunks, and laminae, very friable, with crossbedding about 30°
11.10-11.25	----do----------
11.25-11.35	Sandstone, medium gray, very fine grained to very coarse, interbedded, carbonaceous inclusions of sticks, chunks, and laminae, very friable, becomes predominately fine to medium grained
11.35-11.50	----do----------
11.50-11.65	----do----------
11.65-11.75	----do----------
11.75-11.90	Sandstone, medium gray, very fine grained to very coarse, interbedded, carbonaceous inclusions of sticks, chunks, and laminae, very friable, becomes very fine grained and interlaminated with dark-gray carbonaceous layers
11.90-12.00	Sandstone, medium gray, very fine grained to very coarse, interbedded, carbonaceous inclusions of sticks, chunks, and laminae, very friable, with very coarse grained layers

Depth (metres)	Description
	NX core samples--Continued
12.00-12.15	Sandstone, medium gray, very fine grained to very coarse, interbedded, carbonaceous inclusions of sticks, chunks, and laminae, very friable, becomes brown, silty, carbonaceous
12.15-12.40	----do----------
12.40-12.55	Sandstone, medium gray, very fine to medium grained, with carbonaceous stringers, very friable
12.55-12.65	Sandstone, medium gray, very fine to medium grained, with carbonaceous stringers, very friable, becomes coarse grained
12.65-12.75	----do----------
12.75-12.90	----do----------
12.90-13.00	----do----------
13.00-13.15	----do----------
13.15-13.35	Sandstone, medium gray, very fine to medium grained, with carbonaceous stringers, very friable with claystone, medium gray, silty, carbonaceous
13.35-13.80	No sample - sandstone, as above
13.80-13.95	Claystone dark olive gray, silty, with medium-grained sandy inclusions
13.95-14.10	----do----------
14.10-14.25	Sandstone, medium gray, as above
14.25-14.30	----do----------

Depth (metres)	Description
	NX core samples--Continued
14.30-14.45	Sandstone, medium gray, as above, with darker gray carbonaceous clayey layers
14.45-14.60	Sandstone, medium gray, as above, becomes more argillaceous
14.60-14.75	----do----------
14.75-14.90	Siltstone, olive gray, very argillaceous, carbonaceous stringers
14.90-15.05	Sandstone, olive gray and dark gray, crossbedded, fine to very coarse grained, argillaceous
15.05-15.10	----do----------
15.10-15.25	Siltstone, dark gray, argillaceous, with scattered very coarse sand grains
15.25-15.40	Sandstone, medium gray, very fine to very coarse grained, carbonaceous stringers, friable
15.40-15.50	----do----------
15.50-15.65	----do----------
15.65-15.75	----do----------
15.75-15.85	----do----------
15.85-16.50	No sample - sandstone, as above
16.50-16.60	Sandstone, as above, becomes darker gray
16.60-16.75	Sandstone, as above, becomes medium gray
16.75-16.85	----do----------
16.85-16.95	----do----------

Depth (metres)	Description
	NX core samples--Continued
16.95-17.10	Siltstone, medium to dark gray, sandy (very fine grained), carbonaceous
17.10-17.25	Siltstone, medium to dark gray, sandy (very fine grained), carbonaceous, with sandstone as above
17.25-17.40	Sandstone, as above
17.40-17.55	----do----------
17.55-17.65	Siltstone as above with medium-grained sand lenses
17.65-17.80	Siltstone as above with medium-grained sand lenses, carbonaceous
17.80-17.90	Siltstone as above with medium grained sand lenses, with medium to coarse sand grains
17.90-18.05	----do----------
18.05-18.20	----do----------
18.20-18.25	Coal, black, hard
18.25-18.40	Siltstone, olive gray and medium brown, carbonaceous, sandy lenses
18.40-18.45	Sandstone, medium gray, medium to coarse grained, friable
18.45-19.00	No sample - sandstone as above
19.00-19.15	Siltstone, medium to dark grayish brown, sandy, very argillaceous
19.15-19.20	----do----------

Depth (metres)	Description
	NX core samples--Continued
19.20-19.35	Sandstone, medium to dark gray, very fine to very coarse grained, carbonaceous
19.35-19.50	Coal, black, hard, with mudstone, olive gray
19.50-19.65	Coal and mudstone as above
19.65-19.75	Sandstone, medium gray, very fine to coarse grained, very argillaceous, friable, occasional lignite seams
19.75-20.10	No sample, sandstone as above
20.10-20.20	Sandstone, as above
20.20-20.30	----do----------
20.30-20.45	----do----------
20.45-20.50	----do----------
20.50-20.65	Sandstone, as above, with thin (1-cm) clay seams
20.65-20.75	Sandstone, as above, mostly very fine grained
20.75-20.90	Sandstone, as above, becomes coarse grained, very argillaceous
20.90-21.05	----do----------
21.05-21.20	----do----------
21.20-21.30	----do----------
21.30-21.40	----do----------
21.40-21.55	----do----------
21.55-21.70	----do----------
21.70-21.90	Sandstone, as above, with thin clay seam

Depth (metres)	Description
	NX core samples--Continued
21.90-22.05	Siltstone, light olive gray and light brown, carbonaceous inclusions
22.05-22.20	----do----------
22.20-22.30	Siltstone, light olive gray and light brown, carbonaceous inclusions, with claystone, brown, silty, and carbonaceous, 1/2-cm coal
22.30-22.45	Claystone, black, very carbonaceous, micaceous
22.45-22.50	Coal, black
22.50-22.65	Siltstone, medium olive gray, sandy, micaceous, with carbonaceous inclusions
22.65-22.80	----do----------
22.80-23.00	Sandstone, medium gray, very fine to very coarse grained, very argillaceous, very friable
23.00-23.10	----do----------
23.10-23.25	Siltstone, light olive gray, very argillaceous, friable
23.25-23.35	----do----------
23.35-23.50	Sandstone, as above
23.50-23.65	Siltstone, as above
23.65-23.75	Claystone, dark olive gray, sandy lenses
23.75-23.90	Siltstone, as above
23.90-24.00	----do----------

Depth (metres)	Description
	NX core samples--Continued
24.00-24.15	Sandstone, medium gray, fine to medium grained, very argillaceous
24.15-24.30	Siltstone, as above
24.30-24.35	----do----------
24.35-24.50	Sandstone, as above
24.50-24.60	Siltstone, as above
24.60-24.70	----do----------
24.70-24.85	Siltstone, as above, becomes very sandy
24.85-24.95	----do----------
24.95-25.10	----do----------
25.10-25.25	----do----------
25.25-25.30	----do----------
25.30-25.45	Claystone, medium olive gray, silty, micaceous
25.45-25.60	----do----------
25.60-25.75	----do----------
25.75-25.90	Claystone, medium olive gray, silty, micaceous, with fine- to medium-grained sandy inclusions
25.90-26.10	No sample - sandstone as above
26.10-26.25	Sandstone, light to medium gray, very fine to very coarse grained, very argillaceous, micaceous, friable
26.25-26.40	----do----------

Depth (metres)	Description
	NX core samples--Continued
26.40-26.65	Claystone, brown, lignitic, with carbonaceous streaks, medium- to coarse-grained sandy inclusions
26.65-26.80	Claystone, brown, lignitic, with carbonaceous streaks, medium- to coarse-grained sandy inclusions, becomes dark olive gray, micaceous, silty
26.80-26.95	----do----------
26.95-27.05	Claystone, brown, lignitic, with carbonaceous streaks, medium- to coarse-grained sandy inclusions, with fracture at 60°
27.05-27.20	----do----------
27.20-27.35	Claystone, dark olive gray, silty, carbonaceous, micaceous
27.35-27.45	Claystone, dark olive gray, silty, carbonaceous, micaceous, with hard waxy slickensides at 60°
27.45-27.60	Coal, brown and black, interlaminated, hard
27.60-27.70	Claystone, dark olive gray
27.70-27.85	----do----------
27.85-28.00	Claystone, dark olive gray, with 10-cm coal, black, hard
28.00-28.05	Coal, black, hard
28.05-28.20	Claystone, brown to olive gray, carbonaceous

Depth (metres)	Description
	NX core samples--Continued
28.20-28.30	Claystone, brown to olive gray, carbonaceous, becomes dark gray, carbonaceous
28.30-28.45	Coal, brown, lignitic, soft, argillaceous
28.45-28.60	Coal, brown and black, soft
28.60-28.75	Coal, brown and black, soft, becomes black, harder
28.75-28.90	Shale, black, coaly
28.90-29.10	Claystone, blackish brown, carbonaceous
29.10-29.25	Coal, black, hard
29.25-29.40	Coal, black, hard, and coal, brown, low density
29.40-29.55	----do----------
29.55-29.65	----do----------
29.65-29.80	----do----------
29.80-29.95	----do----------
29.95-30.10	----do----------
30.10-30.20	----do----------
30.20-30.30	----do----------
30.30-30.40	----do----------
30.40-30.50	----do----------
30.50-30.60	----do----------
30.60-30.75	----do----------
30.75-30.90	----do----------
30.90-31.05	Claystone, dark grayish black, silty, carbonaceous
31.05-31.20	Claystone, dark grayish black, silty, carbonaceous, with coal

Depth (metres)	Description
	NX core samples--Continued
31.20-31.35	Coal, very argillaceous to shaly
31.35-31.45	----do----------
31.45-31.60	Claystone, black, carbonaceous, coaly
31.60-31.70	----do----------
31.70-31.80	Siltstone, medium gray and coal, black, hard
31.80-31.95	Coal, black, hard
31.95-32.10	Claystone, medium olive gray, silty
32.10-32.25	Claystone, medium olive gray, silty, with fracture at 50°
32.25-32.40	Claystone, medium olive gray, silty, with dark waxy slickensides
32.40-32.55	Coal, black
32.55-32.65	----do----------
32.65-32.80	Claystone, olive gray, and siltstone, yellowish olive gray, very dense, hard
32.80-32.90	Claystone, olive gray, silty, fractures at 20° and 70°
32.90-33.05	Claystone, olive gray, silty, fractures at 20° and 70°, carbonaceous, micaceous
33.05-33.20	----do----------
33.20-33.35	----do----------
33.35-33.45	----do----------
33.45-33.55	----do----------

Depth (metres)	Description
	NX core samples--Continued
33.55-33.65	Claystone, olive gray, silty, fractures at 20° and 70°, with waxy slickensides at 75°
33.65-33.75	----do----------
33.75-33.85	----do----------
33.85-34.00	----do----------
34.00-34.15	Coal, black, shaly
34.15-34.30	----do----------
34.30-34.45	Claystone, dark grayish brown, carbonaceous to coaly
34.45-34.60	----do----------
34.60-34.75	Claystone, dark grayish brown, carbonaceous to coaly, black, coaly, micaceous
34.75-34.85	----do----------
34.85-34.95	----do----------
34.95-35.10	----do----------
35.10-35.20	Coal, black, hard
35.20-35.35	Claystone, brown, carbonaceous laminae, silty lenses
35.35-35.50	Claystone, brown, carbonaceous laminae, silty lenses, medium olive gray, sandy lenses
35.50-35.65	----do----------
35.65-35.75	----do----------
35.75-35.85	Claystone, brown, carbonaceous laminae, silty lenses, dark gray to black, coaly

Depth (metres)	Description
	NX core samples--Continued
35.85-36.00	Claystone, brown, carbonaceous laminae, silty lenses, dark gray to black, coaly
36.00-36.10	----do----------
36.10-36.25	Claystone, brown, carbonaceous laminae, silty lenses, becomes dark olive gray
36.25-36.35	Claystone, brown, carbonaceous laminae, silty lenses, with waxy slickensides at 60°
36.35-36.45	Claystone, brown, carbonaceous laminae, silty lenses, coaly
36.45-36.55	Coal, black, hard
36.55-36.70	----do----------
36.70-36.85	----do----------
36.85-37.00	----do----------
37.00-37.15	Coal, black, hard, shaly partings, softer
37.15-37.25	Shale, black, very carbonaceous, to coal, very shaly
37.25-37.40	----do----------
37.40-37.55	Coal, black, with shale partings
37.55-37.65	Coal, black, hard
37.65-37.75	----do----------
37.75-37.85	----do----------
37.85-38.00	----do----------
38.00-38.10	Coal, black, hard, with shale partings
38.10-38.20	----do----------

Depth (metres)	Description
	NX core samples--Continued
38.20-38.30	Shale, olive black, carbonaceous
38.30-38.40	Claystone, olive gray, with carbonaceous shale partings to 3 mm, with sandy lenses
38.40-38.55	----do----------
38.55-38.70	Coal, black, hard and soft, interbedded
38.70-38.80	----do----------
38.80-39.05	Coal, black, hard and soft, interbedded, part shaly, soft
39.05-39.15	Coal, black, hard and soft, interbedded, shaly
39.15-39.30	----do----------
39.30-39.40	Coal, black, hard and soft, interbedded, with silty shale partings, micaceous
39.40-39.50	Coal, black, hard and soft, interbedded, shaly, soft
39.50-39.60	----do----------
39.60-39.75	Coal, black, hard and soft, interbedded, rosin inclusions
39.75-39.90	Coal, black, hard and soft, interbedded, black, hard, with shale partings, dip 10°
39.90-40.00	Coal, black, hard and soft, interbedded, with 10-mm clay seam, olive gray
40.00-40.15	----do----------
40.15-40.25	Coal, black, shaly partings

Depth (metres)	Description
	NX core samples--Continued
40.25-40.40	Coal, black, shaly partings,with waxy slickensides
40.40-40.50	Coal, black, shaly
40.50-40.60	----do----------
40.60-40.70	----do----------
40.70-40.75	----do----------
40.75-40.90	Coal, black, shaly, becomes very argillaceous
40.90-41.05	----do----------
41.05-41.20	----do----------
41.20-41.35	Coal, black, shaly, with claystone, olive gray
41.35-41.50	Claystone, olive gray, carbonaceous partings
41.50-41.60	Claystone, olive gray, carbonaceous partings, with coal, black, hard
41.60-41.75	Coal, black, hard, shaly
41.75-41.90	----do----------
41.90-41.95	----do----------
41.95-42.10	Coal, black, hard, shaly, with vertical fracture
42.10-42.25	----do----------
42.25-42.40	Coal, black, hard, shaly, with 10-cm claystone, olive black, carbonaceous
42.40-42.50	Claystone, olive gray, soft
42.50-42.65	----do----------
42.65-42.80	Claystone, olive gray, soft, blackish, carbonaceous, slickensides at 25°

Depth (metres)	Description
	NX core samples--Continued
42.80-42.95	Coal, brown and black, interbedded
42.95-43.10	Coal, black, hard
43.10-43.25	----do----------
43.25-43.35	----do----------
43.35-43.50	----do----------
43.50-43.60	Coal, black, hard, with 5-cm claystone, black
43.60-43.75	Claystone, black, with 10-cm coal, black, hard
43.75-43.85	Coal, black
43.85-44.00	Coal, black and brown
44.00-44.10	Coal, black, hard
44.10-44.15	----do----------
44.15-44.30	----do----------
44.30-44.40	Shale, black, carbonaceous
44.40-44.55	Coal, black, hard
44.55-44.70	----do----------
44.70-44.85	Coal, black, hard, shaly
44.85-45.00	Coal, black, hard, becomes soft
45.00-45.15	Shale, black, coaly
45.15-45.30	Coal, black, hard
45.30-45.45	----do----------
45.45-45.50	----do----------
45.50-45.65	Coal, black, hard, with coal, brown, and shale partings

Depth (metres)	Description
	NX core samples--Continued
45.65-45.80	Claystone, dark olive gray, soft
45.80-45.95	----do----------
45.95-46.10	Claystone, dark olive gray, soft, with claystone, very sandy, fine to very coarse grains
46.10-46.20	Claystone, dark olive gray, soft, with carbonaceous inclusions
46.20-46.35	Sandstone, olive gray, very argillaceous, soft
46.35-46.50	----do----------
46.50-46.60	Claystone, dark olive gray, waxy slickensides at 70°
46.60-46.70	Coal, black, hard
46.70-46.80	Coal, black, hard, with 10-cm claystone, olive black
46.80-46.90	Coal, black, hard, with sandstone, very dark gray, friable
46.90-47.00	Sandstone, olive gray, very fine to coarse grained, friable
47.00-47.15	----do----------
47.15-47.30	----do----------
47.30-47.40	----do----------

Depth (metres)	Description
	NX core samples--Continued
47.40-47.55	Claystone, dark olive gray
47.55-47.70	----do----------
47.70-47.85	----do----------
47.85-48.00	Claystone, dark olive gray, with carbonaceous shale partings
48.00-48.15	----do----------
48.15-48.30	Claystone, dark olive gray, part very silty
48.30-48.45	Claystone, dark olive black
48.45-48.60	Claystone, dark olive black, dark olive gray
48.60-48.80	Claystone, dark olive black, with silty zones
48.80-48.90	Siltstone, olive gray, micaceous, carbonaceous layers
48.90-49.00	Claystone, dark olive gray, carbonaceous partings, silty
49.00-49.15	Claystone, dark olive gray, carbonaceous partings, silty, with waxy slickensides at 70°
49.15-49.30	----do----------
49.30-49.40	----do----------
49.40-49.55	Claystone, dark olive gray, carbonaceous partings, silty, with black carbonaceous shale partings

Depth (metres)	Description
	NX core samples--Continued
49.55-49.70	Claystone, dark olive gray, carbonaceous partings, silty, becomes silty, micaceous
49.70-49.80	Claystone, dark olive gray, carbonaceous partings, silty, very silty
49.80-49.90	----do----------
49.90-50.00	Claystone, dark olive gray, carbonaceous partings, silty, carbonaceous shale partings, very sandy
50.00-50.15	Sandstone, light olive gray, very fine to coarse grained,very angular, very argillaceous, friable
50.15-50.30	----do----------
50.30-50.45	Sandstone, light olive gray, very fine to coarse grained,very angular, very argillaceous, friable, light gray, hard, calcareous concretion?
50.45-50.60	Sandstone, light olive gray, very fine to coarse grained,very angular, very argillaceous, friable, becomes shaly
50.60-50.75	Siltstone, yellowish gray and dark gray, noncalcareous, hard
50.75-50.90	Claystone, dark gray
50.90-51.00	Coal, black, hard

Depth (metres)	Description
	NX core samples--Continued
51.00-51.10	Claystone, dark olive gray, hard, coaly
51.10-51.25	Coal seam 5 cm, sandstone, dary gray, carboniferous
51.25-51.40	Sandstone, dark olive gray, very fine grained, carboniferous shale partings
51.40-51.55	Coal, black, 3 cm, with siltstone, black, carboniferous
51.55-51.65	Siltstone, olive gray, soft, shaly partings
51.65-51.80	Sandstone, light and dark gray, silty, coaly
51.80-51.90	Sandstone, light and dark gray, silty, coaly, light olive gray, very argillaceous
51.90-52.05	Sandstone, light and dark gray, silty, coaly, very fine to very coarse grained, very friable
52.05-52.20	----do----------
52.20-52.30	----do----------
52.30-52.45	----do----------
52.45-52.60	----do----------
52.60-52.75	----do----------
52.75-52.90	Sandstone, light and dark gray, silty, coaly, becomes very fine to fine grained
52.90-53.05	----do----------

Depth (metres)	Description
	NX core samples--Continued
53.05-53.20	Sandstone, light and dark gray, silty, coaly, becomes olive gray
53.20-53.35	----do----------
53.35-53.50	----do----------
53.50-53.70	----do----------
53.70-53.80	----do----------
53.80-53.90	----do----------
53.90-54.05	----do----------
54.05-54.20	----do----------
54.20-54.30	Siltstone, medium olive gray, very friable
54.30-54.40	Sandstone, as above
54.40-54.50	----do----------
54.50-54.60	Sandstone, as above, with claystone, olive gray
54.60-54.80	Claystone, olive gray, very sandy, firm
54.80-54.90	Sandstone, as above, very friable
54.90-55.00	Sandstone, as above, very friable, very argillaceous
55.00-55.15	Sandstone, as above, very friable, becomes silty and firmer
55.15-55.30	Siltstone, light gray and olive gray, firm
55.30-55.40	Sandstone, as above, poorly sorted, very friable

Depth (metres)	Description
	NX core samples--Continued
55.40-55.55	Sandstone, as above, poorly sorted, very friable, very fine grained to silty
55.55-55.70	----do----------
55.70-55.85	Siltstone, light gray, with darker shale layers
55.85-55.90	Shale, dark gray, silty, micaceous, carboniferous
55.90-56.05	Coal, black, very argillaceous, soft
56.05-56.25	No sample
56.25-56.40	Shale, dark gray, carboniferous
56.40-56.55	Shale, dark gray, carboniferous, with silty stringers
56.55-56.70	Shale, dark gray, carboniferous, hard, silty
56.70-56.80	Shale, dark gray, carboniferous, waxy texture
56.80-56.90	----do----------
56.90-57.05	----do----------
57.05-57.10	Coal, black, hard
57.10-57.25	----do----------
57.25-57.35	Coal, black, soft, argillaceous
57.35-57.50	Shale, black, coaly, silty and micaceous layers
57.50-57.65	----do----------
57.65-57.80	----do----------

Depth (metres)	Description
	NX core samples-Continued
57.80-57.90	Coal, with waxy slickensides
57.90-58.05	----do----------
58.05-58.15	Shale, black, carbonaceous, soft, waxy slickensides
58.15-58.30	----do----------
58.30-58.40	----do----------
58.40-58.50	Coal, black, shaly
58.50-58.65	----do----------
58.65-58.75	----do----------
58.75-58.90	----do----------
58.90-59.00	----do----------
59.00-59.15	Claystone, black, soft
59.15-59.30	----do----------
59.30-59.40	Coal, black, firm
59.40-59.50	Shale, black, carbonaceous, micaceous
59.50-59.65	----do----------
59.65-59.75	Coal, black
59.75-59.90	----do----------
59.90-60.00	Shale, black, coaly
60.00-60.15	Coal, black and brown, interlaminated, hard
60.15-60.30	Coal, black and brown, interlaminated, hard, becomes shaly

Depth (metres)	Description
	NX core samples--Continued
60.30-60.45	Coal, as above
60.45-60.55	----do----------
60.55-60.70	Coal, as above, with hard siltstone inclusions
60.70-60.85	----do----------
60.85-60.95	----do----------
60.95-61.10	----do----------
61.10-61.20	----do----------
61.20-61.35	Coal, as above, with shale stringers
61.35-61.40	----do----------
61.40-61.50	Shale, black, coaly, waxy partings
61.50-61.60	----do----------
61.60-61.65	Shale, black, coaly, waxy partings, micaceous
61.65-61.80	----do----------
61.80-61.90	----do----------
61.90-62.05	Claystone, olive black, soft, plastic
62.05-62.20	----do----------
62.20-62.40	----do----------
62.40-62.55	Shale, black, coaly, waxy slickensides
62.55-62.70	----do----------
62.70-62.75	----do----------
62.75-62.85	Coal, black, hard, with brown layers

Depth (metres)	Description
	NX core samples--Continued
62.85-62.95	Shale, dark brown, very hard, oolitic layers
62.95-63.10	----do----------
63.10-63.20	Coal, dark brown to black, hard
63.20-63.35	----do----------
63.35-63.50	Shale, dark olive brown, coaly
63.50-63.65	Coal, soft, shaly
63.65-63.80	----do----------
63.80-63.90	Shale, black, coaly, soft
63.90-64.00	Coal, black and brown, interlaminated
64.00-64.10	Coal, black
64.10-64.25	Coal, black, part shaly
64.25-64.40	----do----------
64.40-64.50	Claystone, black, soft, silty
64.50-64.60	Shale, dark gray
64.60-64.65	Shale, dark gray, waxy
64.65-64.85	Shale, dark gray, slickensides at 60°
64.85-65.00	Shale, dark gray, silty inclusions
65.00-65.15	Claystone, black, soft, very sandy
65.15-65.25	Claystone, black, soft, very sandy, interlaminated with very fine sand
65.25-65.40	----do----------
65.40-65.60	Coal, black, hard

Depth (metres)	Description
	NX core samples--Continued
65.60-65.70	Shale, black, carbonaceous
65.70-65.85	Shale, dark olive gray, waxy
65.85-65.95	----do----------
65.95-66.10	Coal, black, hard
66.10-66.20	----do----------
66.20-66.30	----do----------
66.30-66.40	----do----------
66.40-66.55	----do----------
66.55-66.70	----do----------
66.70-66.85	Coal, black, hard, shaly
66.85-67.00	----do----------
67.00-67.10	Shale, black, coaly
67.10-67.25	----do----------
67.25-67.40	Coal, black, shaly
67.40-67.55	Shale, black
67.55-67.65	----do----------
67.65-67.80	Coal, black
67.80-67.95	Coal, black, shaly
67.95-68.10	Shale, black, coaly
68.10-68.25	----do----------
68.25-68.35	----do----------
68.35-68.50	Coal, black
68.50-68.60	----do----------

Depth (metres)	Description
	NX core samples--Continued
68.60-68.75	Coal, black
68.75-68.90	----do----------
68.90-69.00	----do----------
69.00-69.15	----do----------
69.15-69.30	----do----------
69.30-69.40	----do----------
69.40-69.55	----do----------
69.55-69.70	Coal, black, with 5-cm siltstone, olive gray
69.70-69.80	----do----------
69.80-69.90	Coal, black, becomes shaly
69.90-70.00	Shale, black, coaly
70.00-70.15	----do----------
70.15-70.30	Shale, black, coaly, with waxy slickensides
70.30-70.45	Coal
70.45-70.60	Coal, shaly
70.60-70.70	----do----------
70.70-70.75	----do----------
70.75-70.90	----do----------
70.90-71.05	----do----------
71.05-71.15	----do----------
71.15-71.30	----do----------
71.30-71.45	----do----------
71.45-71.60	----do----------

Depth (metres)	Description
	NX core samples--Continued
71.60-71.75	Coal, shaly
71.75-71.90	----do----------
71.90-72.00	----do----------
72.00-72.10	Coal, with rosin
72.10-72.25	Shale, black, coaly
72.25-72.35	Coal, black, hard
72.35-72.50	----do----------
72.50-72.60	----do----------
72.60-72.75	Coal, black, hard, with shale, black, coaly
72.75-72.90	Coal, black, hard
72.90-73.05	----do----------
73.05-73.20	----do----------
73.20-73.35	----do----------
73.35-73.50	----do----------
73.50-73.65	----do----------
73.65-73.75	----do----------
73.75-73.90	----do----------
73.90-74.05	----do----------
74.05-74.20	----do----------
74.20-74.35	----do----------
74.35-74.50	----do----------
74.50-74.60	----do----------
74.60-74.75	Coal, black, brecciated, with silty claystone

Depth (metres)	Description
	NX core samples--Continued
74.75-74.90	Shale, black, coaly
74.90-75.05	Coal, with waxy slickensides
75.05-75.20	Coal
75.20-75.35	----do----------
75.35-75.50	----do----------
75.50-75.65	Shale, black, coaly
75.65-75.80	Coal, black, hard
75.80-75.95	----do----------
75.95-76.10	Coal, black, hard, very shaly
76.10-76.25	Coal, black, hard
76.25-76.40	----do----------
76.40-76.55	----do----------
76.55-76.70	----do----------
76.70-76.85	----do----------
76.85-76.95	----do----------
76.95-77.10	----do----------
77.10-77.25	----do----------
77.25-77.35	----do----------
77.35-77.50	Coal, black, hard, with much rosin
77.50-77.60	Coal, black, hard
77.60-77.75	----do----------
77.75-77.85	----do----------
77.85-77.95	----do----------
77.95-78.05	----do----------

Depth (metres)	Description
	NX core samples--Continued
78.05-78.20	Coal, black, hard
78.20-78.30	----do----------
78.30-78.45	----do----------
78.45-78.60	Coal, black, hard, becomes very shaly
78.60-78.70	Coal, black, hard, with shale layers
78.70-78.85	----do----------
78.85-78.90	----do----------
78.90-79.05	Coal, black, hard, shaly
79.05-79.20	Coal, black, hard
79.20-79.35	----do----------
79.35-79.50	----do----------
79.50-79.65	----do----------
79.65-79.80	Coal, black, hard, with rosin
79.80-79.95	Coal, black, hard, shaly, with waxy slickensides at 60°
79.95-80.00	----do----------
80.00-80.15	Coal, black, hard, with silty claystone
80.15-80.30	Coal, black, hard, shaly
80.30-80.40	----do----------
80.40-80.55	Coal, black, firm
80.55-80.65	Coal, black, firm, with shale
80.65-80.75	Coal, black, firm
80.75-80.90	----do----------

Depth (metres)	Description
	NX core samples--Continued
80.90-81.05	Coal, black, firm
81.05-81.20	----do----------
81.20-81.30	----do----------
81.30-81.40	Coal, black, firm, becomes silty and shaly
81.40-81.55	Coal, black, firm
81.55-81.70	Coal, black, firm, shaly
81.70-81.85	----do----------
81.85-82.00	----do----------
82.00-82.15	Coal, black, firm
82.15-82.25	----do----------
82.25-82.40	----do----------
82.40-82.50	Shale, black, coaly
82.50-82.65	Coal, black, shaly
82.65-82.75	----do----------
82.75-82.90	----do----------
82.90-83.00	----do----------
83.00-83.15	Coal, black, firm
83.15-83.30	----do----------
83.30-83.45	----do----------
83.45-83.60	----do----------
83.60-83.75	Shale, olive black, plastic, firm
83.75-83.90	----do----------
83.90-84.00	Shale, olive black, plastic, firm, becomes coaly

Depth (metres)	Description
	NX core samples--Continued
84.00-84.10	Coal, black, firm
84.10-84.25	----do----------
84.25-84.30	----do----------
84.30-84.45	----do----------
84.45-84.55	----do----------
84.55-84.65	----do----------
84.65-84.80	----do----------
84.80-84.90	----do----------
84.90-85.05	Coal, black, firm, becomes shaly
85.05-85.20	Shale, olive black, firm, plastic
85.20-85.35	Coal, black, firm
85.35-85.45	----do----------
85.45-85.60	----do----------
85.60-85.75	----do----------
85.75-85.85	----do----------
85.85-86.00	----do----------
86.00-86.05	----do----------
86.05-86.20	----do----------
86.20-86.35	Shale, black, coaly
86.35-86.50	Coal, black, hard
86.50-86.65	----do----------
86.65-86.80	----do----------
86.80-86.90	----do----------

Depth (metres)	Description
	NX core samples--Continued
86.90-87.00	Coal, black, hard
87.00-87.15	Coal, black, hard, with 10-cm shale, olive black
87.15-87.30	Coal, black, hard
87.30-87.45	----do----------
87.45-87.60	----do----------
87.60-87.65	----do----------
87.65-87.80	Coal, black, hard, becomes shaly
87.80-87.90	Coal, black, hard, with rosin
87.90-88.05	----do----------
88.05-88.20	Claystone, olive gray
88.20-88.35	----do----------
88.35-88.40	Coal, black, hard
88.40-88.55	----do----------
88.55-88.70	Coal, black, shaly
88.70-88.80	Coal, black, hard
88.80-88.95	Coal, black, hard, with rosin
88.95-89.00	----do----------
89.00-89.40	Coal, black, hard, very shaly
89.40-89.50	Shale, black, coaly
89.50-89.60	----do----------
89.60-89.70	Coal, black, hard
89.70-89.90	----do----------
89.90-90.05	Coal, black, hard, with shale layers

Depth (metres)	Description
	NX core samples--Continued
90.05-90.20	Coal, black
90.20-90.35	----do----------
90.35-90.50	----do----------
90.50-90.55	----do----------
90.55-90.70	----do----------
90.70-90.85	Coal, black, part shaly
90.85-91.00	----do----------
91.00-91.10	----do----------
91.10-91.25	Shale, black, coaly
91.25-91.40	Coal, black
91.40-91.55	Coal, black, vertical fracture
91.55-91.65	----do----------
91.65-91.80	----do----------
91.80-91.95	Coal, black, fracture at 80°
91.95-92.15	Coal, black, and clay, olive gray, separated by fracture at 80°
92.15-92.30	Coal, black, vertical fracture
92.30-92.45	----do----------
92.45-92.55	----do----------
92.55-92.65	Coal, black, vertical fracture, becomes very shaly
92.65-92.80	Coal, black, hard
92.80-92.95	Coal, black, hard, with shaly layers

Depth (metres)	Description
	NX core samples--Continued
92.95-93.10	Coal, black, hard, vertical fracture
93.10-93.25	----do----------
93.25-93.40	Coal, black, hard
93.40-93.55	----do----------
93.55-93.65	----do----------
93.65-93.80	----do----------
93.80-93.90	----do----------
93.90-94.05	----do----------
94.05-94.20	----do----------
94.20-94.40	----do----------
94.40-94.50	Coal, black, hard, with shale partings
94.50-94.60	Coal, black, hard
94.60-94.75	----do----------
94.75-94.90	----do----------
94.90-95.05	----do----------
95.05-95.20	----do----------
95.20-95.35	----do----------
95.35-95.45	----do----------
95.45-95.55	Coal, black, hard, becomes shaly
95.55-95.65	Coal, black, hard, part shaly, vertical fractures
95.65-95.80	Coal, black, hard
95.80-95.90	----do----------
95.90-96.00	----do----------

Depth (metres)	Description
	NX core samples--Continued
96.00-96.15	Coal, black, hard
96.15-96.30	----do----------
96.30-96.40	Coal, black, hard, part shaly
96.40-96.55	----do----------
96.55-96.65	----do----------
96.65-96.80	Shale, olive black, rosin
96.80-96.90	----do----------
96.90-97.05	Coal, black, hard
97.05-97.20	----do----------
97.20-97.30	----do----------
97.30-97.40	----do----------
97.40-97.50	Coal, black, hard, very shaly
97.50-97.65	Coal, black, hard, vertical fractures
97.65-97.80	Shale, olive black
97.80-97.95	----do----------
97.95-98.10	Coal, black, hard
98.10-98.25	----do----------
98.25-98.40	Coal, black, hard, part shaly
98.40-98.55	Coal, black, hard, waxy slickensides at 10°-30°
98.55-98.65	----do----------
98.65-98.75	----do----------
98.75-98.90	----do----------

Depth (metres)	Description
	NX core samples--Continued
98.90-99.00	Coal, black, hard
99.00-99.10	----do----------
99.10-99.25	Coal, black, hard, with waxy slickensides at 60°
99.25-99.35	----do----------
99.35-99.50	----do----------
99.50-99.65	Claystone, medium olive gray
99.65-99.80	----do----------
99.80-99.95	----do----------
99.95-100.10	----do----------
100.10-100.20	Claystone, medium olive gray, with hard yellowish concretion
100.20-100.35	----do----------
100.35-100.50	Claystone, medium olive gray, with some silty lenses
100.50-100.65	----do----------
100.65-100.75	Claystone, medium olive gray, abundant pyrite
100.75-100.90	Claystone, light olive gray, very silty
100.90-101.05	Sandstone, olive gray, very fine grained, friable
101.05-101.15	Sandstone, olive gray, very fine grained, friable, argillaceous
101.15-101.25	----do----------
101.25-101.40	----do----------
101.40-101.55	----do----------

Depth (metres)	Description
	NX core samples--Continued
101.55-101.70	Sandstone, olive gray, very fine grained, friable, argillaceous
101.70-101.85	----do----------
101.85-101.95	Siltstone, olive gray, argillaceous, micaceous
101.95-102.05	----do----------
102.05-102.25	Siltstone, olive gray, argillaceous, micaceous, few black carbonaceous layers
102.25-102.40	Coal, black, hard
102.40-102.55	Siltstone, dark olive gray, carbonaceous, hard
102.55-102.60	Siltstone, dark olive gray, carbonaceous, hard, becomes soft, micaceous
102.60-102.75	----do----------
102.75-102.95	Siltstone, dark olive gray, carbonaceous, hard, olive gray and black, finely interlaminated
102.95-103.10	Siltstone, dark olive gray, carbonaceous, hard, high-angle carbonaceous shale stringers
103.10-103.25	----do----------
103.25-103.40	Siltstone, dark olive gray, carbonaceous, hard, firmer
103.40-103.55	Claystone, dark olive gray and black, coaly partings
103.55-103.65	----do----------
103.65-103.70	Siltstone, dark gray, carbonaceous

Depth (metres)	Description
	NX core samples--Continued
103.70-103.85	Coal, black
103.85-104.00	----do----------
104.00-104.15	----do----------
104.15-104.70	----do----------
104.70-104.85	Coal, black, with claystone, medium olive gray
104.85-104.90	Claystone, medium olive gray
104.90-105.05	----do----------
105.05-105.20	----do----------
105.20-105.30	----do----------
105.30-105.40	Claystone, medium olive gray, becomes silty
105.40-105.55	----do----------
105.55-105.70	Siltstone, medium olive gray, micaceous, firm
105.70-105.85	----do----------
105.85-106.10	----do----------
106.10-106.25	Claystone, medium olive gray
106.25-106.40	----do----------
106.40-106.70	Siltstone, medium olive gray, carbonaceous flecks
106.70-107.70	Core lost
107.70-107.80	Claystone, medium olive gray
107.80-107.95	Claystone, medium olive gray, becomes silty
107.95-108.10	----do----------
108.10-108.25	Siltstone, olive yellow, argillaceous, friable
108.25-108.40	Claystone, medium olive gray

Depth (metres)	Description
	NX core samples--Continued
108.40-108.50	Claystone, medium olive gray
108.50-108.60	Claystone, medium olive gray, silty
108.60-108.75	----do----------
108.75-108.85	Claystone, medium olive gray, with waxy slickensides and partings
108.85-109.00	Claystone, medium olive gray, abundant pyrite
109.00-109.10	Claystone, medium olive gray, becomes black, abundant pyrite
109.10-109.25	Claystone, medium olive gray, becomes very silty
109.25-109.35	Claystone, medium olive gray, with carbonaceous partings
109.35-109.50	----do----------
109.50-109.65	Siltstone, medium olive gray, very argillaceous, very soft
109.65-109.85	----do----------
109.85-110.10	Siltstone, medium olive gray, very argillaceous, very soft, few carbonaceous partings
110.10-110.20	Siltstone, medium olive gray, very argillaceous, very soft, becomes sandy
110.20-110.35	Sandstone, medium olive gray, very fine grained
110.35-110.50	Sandstone, medium olive gray, very fine grained, very argillaceous, soft
110.50-110.65	Sandstone, medium olive gray, very fine grained, stringers black sandstone

Depth (metres)	Description
	NX core samples--Continued
110.65-110.80	Sandstone, medium olive gray, very fine grained, with carbonaceous sandy beds
110.80-110.90	----do----------
110.90-111.05	Sandstone, light olive gray, very fine grained to silty
111.05-111.20	Sandstone, light olive gray, very fine grained to silty, very argillaceous, soft
111.20-111.30	----do----------
111.30-111.50	Sandstone, light olive gray, very fine grained to silty, becomes fine grained, micaceous, friable
111.50-111.70	----do----------
111.70-111.85	----do----------
111.85-112.00	----do----------
112.00-112.05	----do----------
112.05-112.20	----do----------
112.20-112.35	----do----------
112.35-112.50	----do----------
112.50-112.65	----do----------
112.65-112.75	Sandstone, light olive gray, fine grained, micaceous
112.75-113.05	Sandstone, light olive gray, fine grained, micaceous, argillaceous, friable
113.05-113.15	----do----------

Depth (metres)	Description
	NX core samples--Continued
113.15-114.20	No core - sandstone as above
114.20-114.30	Sandstone, as above
114.30-114.45	----do----------
114.45-114.60	Sandstone, as above, with carbon-rich layers
114.60-114.75	----do----------
114.75-114.80	Sandstone, as above, becomes very fine grained to silt size
114.80-114.95	Sandstone, as above, becomes fine to medium grained
114.95-115.10	----do----------
115.10-115.25	----do----------
115.25-115.40	----do----------
115.40-115.55	----do----------
115.55-115.65	----do----------
115.65-115.75	----do----------
115.75-115.90	----do----------
115.90-116.05	----do----------
116.05-116.20	Sandstone, as above, with carbonaceous pieces and coaly layers
116.20-116.30	Sandstone, as above, micaceous
116.30-116.45	----do----------
116.45-116.60	----do----------
116.60-116.75	----do----------
116.75-116.85	----do----------

Depth (metres)	Description
	NX core samples--Continued
116.85-116.90	Sandstone, as above, micaceous
116.90-117.05	----do----------
117.05-117.20	----do----------
117.20-117.30	----do----------
117.30-117.45	Sandstone, as above, becomes very silty
117.45-117.60	Sandstone, as above, very silty
117.60-117.70	----do----------
117.70-117.85	----do----------
117.85-118.00	----do----------
118.00-118.15	Claystone, dark olive gray, hard
118.15-118.25	----do----------
118.25-118.40	----do----------
118.40-118.50	----do----------
118.50-118.65	----do----------
118.65-118.75	Claystone, dark olive gray, hard, silty lenses, and micaceous
118.75-118.90	Siltstone, olive gray, micaceous, argillaceous
118.90-119.05	----do----------
119.05-119.20	----do----------
119.20-119.25	Siltstone, olive gray, micaceous, argillaceous, with olive-gray claystone
119.25-119.40	Siltstone, olive gray, micaceous, argillaceous, becomes sandy

Depth (metres)	Description
	NX core samples--Continued
119.40-119.55	Sandstone, medium olive gray, very fine grained, friable
119.55-119.70	Sandstone, medium olive gray, very fine grained, friable, very argillaceous
119.70-119.85	Sandstone, medium olive gray, very fine grained, friable, very soft, carbonaceous laminae
119.85-120.00	Siltstone, medium olive gray, with sandy layers
120.00-120.15	Siltstone, medium olive gray, with sandy layers, with thin claystone layers
120.15-120.30	Siltstone, medium olive gray, with sandy layers, very argillaceous
120.30-120.45	----do----------
120.45-120.60	----do----------
120.60-120.75	----do----------
120.75-120.85	----do----------
120.85-121.00	----do----------
121.00-121.15	Siltstone, medium olive gray, with sandy layers, very argillaceous, micaceous
121.15-121.30	----do----------
121.30-121.35	----do----------
121.35-123.05	Core lost, siltstone and sandstone as above
123.05-123.10	Claystone, olive gray, silty
123.10-123.25	Claystone, dark olive gray, silty, firm

Depth (metres)	Description
	NX core samples--Continued
123.25-123.40	Claystone, dark olive gray, silty, firm
123.40-123.55	Claystone, dark olive gray, silty, firm, nonsilty, waxy texture
123.55-123.70	----do----------
123.70-123.85	----do----------
123.85-124.00	----do----------
124.00-124.10	----do----------
124.10-124.20	----do----------
124.20-124.25	----do----------
124.25-124.40	----do----------
124.40-124.80	No core
124.80-124.95	Claystone, dark olive gray, waxy, firm
124.95-125.10	----do----------
125.10-125.20	----do----------
125.20-125.30	----do----------
125.30-125.40	Claystone, dark olive gray, waxy, firm, fossil gastropods
125.40-125.55	----do----------
125.55-125.60	Claystone, dark olive gray, waxy, firm, fossiliferous pelecypods
125.60-125.70	----do----------
125.70-125.85	----do----------
125.85-126.00	----do----------

Depth (metres)	Description
	NX core samples--Continued
126.00-126.05	Claystone, dark olive gray, waxy, firm, fossiliferous pelecypods
126.05-126.15	----do----------
126.15-126.25	Claystone, as above, gastropods
126.25-126.35	----do----------
126.35-126.50	----do----------
126.50-126.70	----do----------
126.70-126.85	----do----------
126.85-126.90	----do----------
126.90-127.05	----do----------
127.05-127.15	----do----------
127.15-127.30	----do----------
127.30-127.45	----do----------
127.45-127.60	----do----------
127.60-127.75	----do----------
127.75-127.85	----do----------
127.85-128.00	----do----------
128.00-128.10	----do----------
128.10-128.20	----do----------
128.20-128.30	----do----------
128.30-128.45	----do----------
128.45-128.60	----do----------
128.60-128.75	----do----------

Depth (metres)	Description
	NX core samples--Continued
128.75-128.85	Claystone, as above, gastropods
128.85-129.00	----do----------
129.00-129.15	----do----------
129.15-129.25	Coal, black, hard
129.25-129.40	Coal, black, shaly, vertical fracture
129.40-129.55	Coal, black, shaly, vertical fracture, with sandy, silty, and shaly layers
129.55-129.70	Claystone, dark gray, coaly, part sandy
129.70-129.85	Siltstone, dark gray, carboniferous, sandy layers
129.85-130.00	----do----------
130.00-130.10	----do----------
130.10-130.20	Siltstone, dark gray, carboniferous, sandy layers, fossiliferous
130.20-130.35	Siltstone, dark gray, carboniferous, sandy layers, micaceous
130.35-130.50	Claystone, dark brownish black, pelecypods
130.50-130.65	Claystone, dark brownish black, pelecypods, olive gray
130.65-130.80	----do----------
130.80-130.90	----do----------
130.90-131.00	----do----------
131.00-131.10	----do----------

Depth (metres)	Description
	NX core samples--Continued
131.10-131.35	Claystone, dark brownish black, pelecypods, silty
131.35-131.50	Claystone, dark brownish black, pelecypods, very hard
131.50-131.65	----do----------
131.65-131.70	----do----------
131.70-131.80	Siltstone, olive gray, soft, micaceous
131.80-131.95	Siltstone, olive gray, soft, micaceous, with light-gray layers
131.95-132.10	----do----------
132.10-132.20	----do----------
132.20-132.35	----do----------
132.35-132.50	----do----------
132.50-132.90	No sample - total depth: 132.90 m

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