UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

SUNDANCE-BISTI-STAR LAKE 1976 DRILLING IN McKINLEY AND SAN JUAN COUNTIES, NORTHWESTERN NEW MEXICO

By

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Authors: R. W. Jentgen and J. E. Fassett

Drill holes BS-8-2 and BS-8-5C were incorrectly located on figure 1 and table 1, pages 5 and 10, respectively.

BS-8-2 should be: SW¼NW¼

BS-8-5C should be: SW¼NE¼

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Sundance-Bisti-Star Lake 1976 drilling in McKinley and San Juan Counties, Northwest New Mexico

By R. W. Jentgen and J. E. Fassett

Introduction

Under Contract No. 14-08-0001-15099, the U.S. Geological Survey drilled 22 test holes in McKinley and San Juan Counties in northwest New Mexico from June 28, 1976 to August 18, 1976. This drilling was done to obtain information on the coal resources and quality of coal in the Sundance, Bisti, and Star Lake areas. The locations of these holes, all of which were rotary drilled with mud, are shown on figures 1-4 of this report. A sample log was kept for all but one of the holes as they were drilled and all but two of the holes were geophysically logged (gamma-ray, density, and resistivity). In addition, selected zones were cored at three drill sites.

The letters in the drill-hole numbers are the first letters of the topographic quadrangle map on which the hole is located. These letters are followed by the number of the section where the hole is located, and finally by a number assigned by the drilling team. The assigned numbers increase from north to south and from west to east. Therefore, drill-hole no. BS-8-1 is located in the Bread Springs quadrangle, section 8, and is the northernmost hole in the section. Holes drilled only for the purpose of obtaining a core were assigned a number as outlined above followed by the letter C. For example, drill-hole TL-7-3C is a core hole in section 7 of the Tanner Lake quadrangle.

Sundance area

Four drill holes and one core hole were drilled in the Sundance area of the Bread Springs quadrangle, sec. 8, T. 14 N., R. 17 W., about 5 mi (8.0 km) southeast of Gallup, N. M. (figure 1). The total depths of the sample logs ranged from 166 ft to 227 ft (50.6 m to 69.2 m) and penetrated the Upper Cretaceous Bartlett Barren Member of the Crevasse Canyon Formation. The depth of the core hole was 106 ft (32.3 m). Two coal zones were selectively cored from 57.9 ft to 75.1 ft (17.6 to (22.9 m) and from 91.2 ft to 99.9 ft (27.8 to 30.4 m) for a total of 26 ft (8.0 m) of core recovered. Estimated depth to the deepest coal was determined from nearby coal outcrops and from the logs of previously drilled holes in the area. All five holes were drilled at least 20 ft (6.1 m) below the estimated depth to assure penetration of the deepest coal.

Bisti area

Fourteen drill holes and one core hole were drilled in the Bisti area near Bisti Trading Post, N. M., which is 32 mi (51.5 km) south of Farmington, N. M. In this report the Bisti area is divided into two parts: the Tanner Lake area south (figure 2) in secs 25-29, T. 23 N., R. 13 W., 10 mi (16.1 km) southeast of Bisti in the Tanner Lake quadrangle; and the Tanner Lake area north (figure 3) in secs. 5-8, T. 23 N., R. 12 W., 6 mi (9.7 km) east of Bisti in the Tanner Lake and Alamo Mesa West quadrangles. Total depths of the sample logs ranged from 60 ft to 182 ft (18.3 to 55.5 m) in the Tanner Lake south area and from 150 ft to 274 ft (45.7 to 83.5 m) in the Tanner Lake north area. At all sites the surface is on the Upper Cretaceous Fruitland Formation and drilling was terminated in the underlying Pictured Cliffs Sandstone in all but two holes. In

hole no. TL-27-1, the drilling continued through the Upper Cretaceous Pictured Cliffs Sandstone and the Lewis Shale and into the Cliff House Sandstone. Drilling was terminated in core-hole TL-7-3C after coring the last thick coal bed in the Fruitland Formation and before penetrating the Pictured Cliffs. A total of 44 ft (13.4 m) of core was recovered from two coal zones--one zone at the 68.0-88.4-ft (21.0-27.0-m) interval and one zone at the 123.0-144.2-ft (37.5-44.0-m) interval. No sample log was kept for this core hole.

Star Lake area

Two holes were drilled in the Star Lake area. One hole is in sec. 10, T. 20 N., R. 6 W., in the Star Lake quadrangle, 5 mi (8.0 km) north of the Star Lake Trading Post (figure 4). The other hole is in sec. 28, T. 20 N., R. 5 W., in the Ojo Encino Mesa quadrangle, 8 mi (13.0 km) northeast of the Star Lake Trading Post (figure 5). Tertiary Ojo Alamo Sandstone is at or near the surface of both sites and both holes penetrated the Kirtland Shale and the Fruitland Formation and ended in or near the Pictured Cliffs Sandstone. The total depth of drill-hole OEM-28-1 was 445 ft (136 m). Drill-hole SL-10-1 went to 651 ft (201 m) and included three cored intervals: 15-35 ft (4.6-10.6 m); 67-96.5 ft (20.4-29.4 m); and 509-515 ft (155-157 m).

Depth drilled and depth logged

In all but one hole (SL-10-1), the depth geophysically logged is less than the total depth drilled. The reason for this is because drill-hole cuttings and rock material settled to the bottom of the holes after drilling had ceased and the drill string had been pulled. Swelling clays bridging the hole sometimes prevented the logging tool

from reaching total depth in several locations and necessitated redrilling. In drill-hole SL-10-1, the logging depth is greater than the recorded drilling depth by 7 ft (2.1 m). This is probably because a 12- or 15-foot joint of drill pipe was not tallied while changing from the drilling bit to the coring bit.

Acknowledgments

The drilling was done by Harlan Drilling Company of Farmington, New Mexico (contract no. 14-08-0001-15099). Geophysical logging was subcontracted by Harlan to Century Geophysical at the Sundance locations and to Nuclear Logging at all other sites. U.S. Geological Survey geologists were responsible for contractor supervision, sample collection, and lithologic logging.

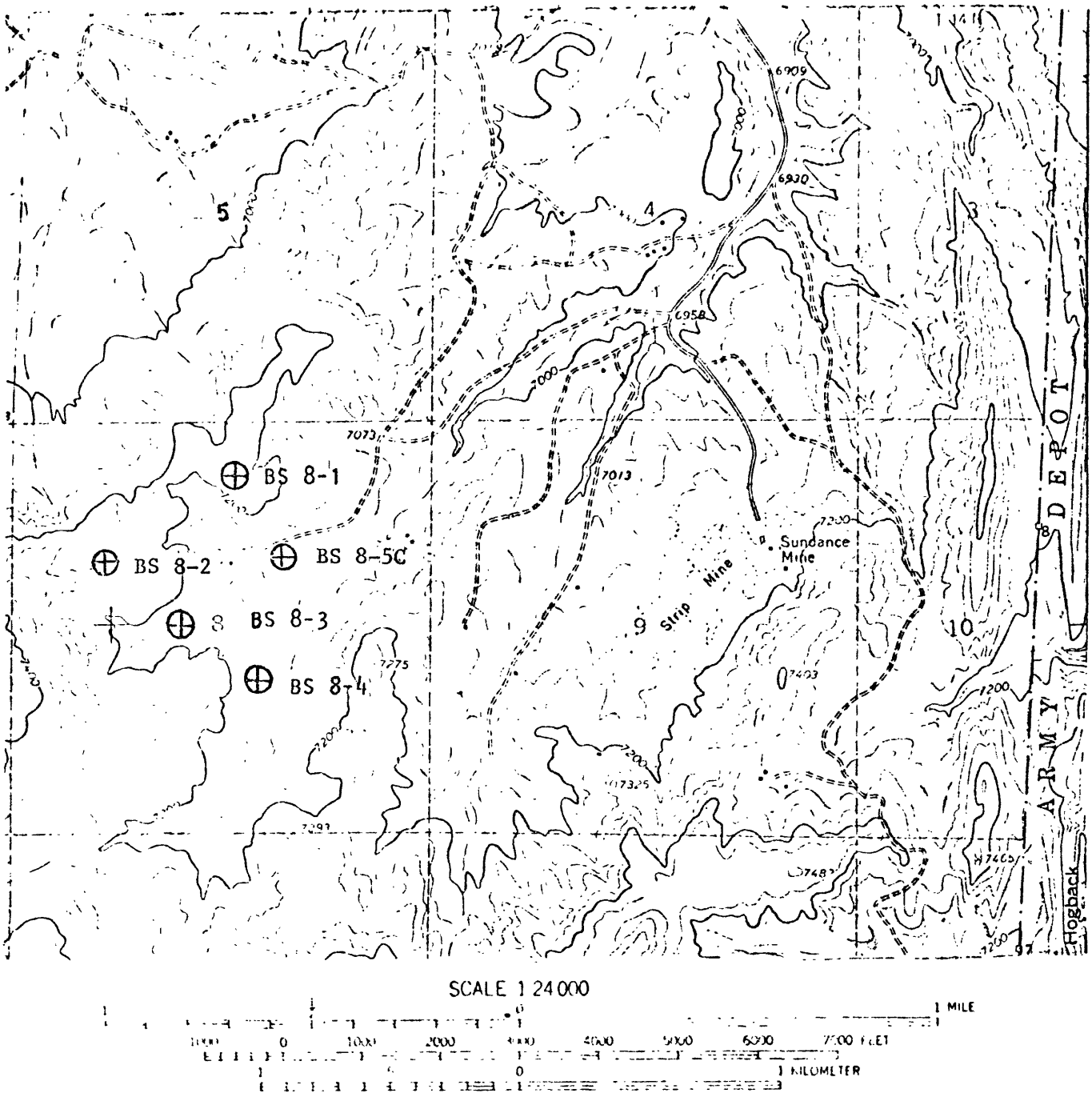

Figure 1.--Drill-hole locations in the Sundance area of the Bread Springs quadrangle, McKinley County, New Mexico.

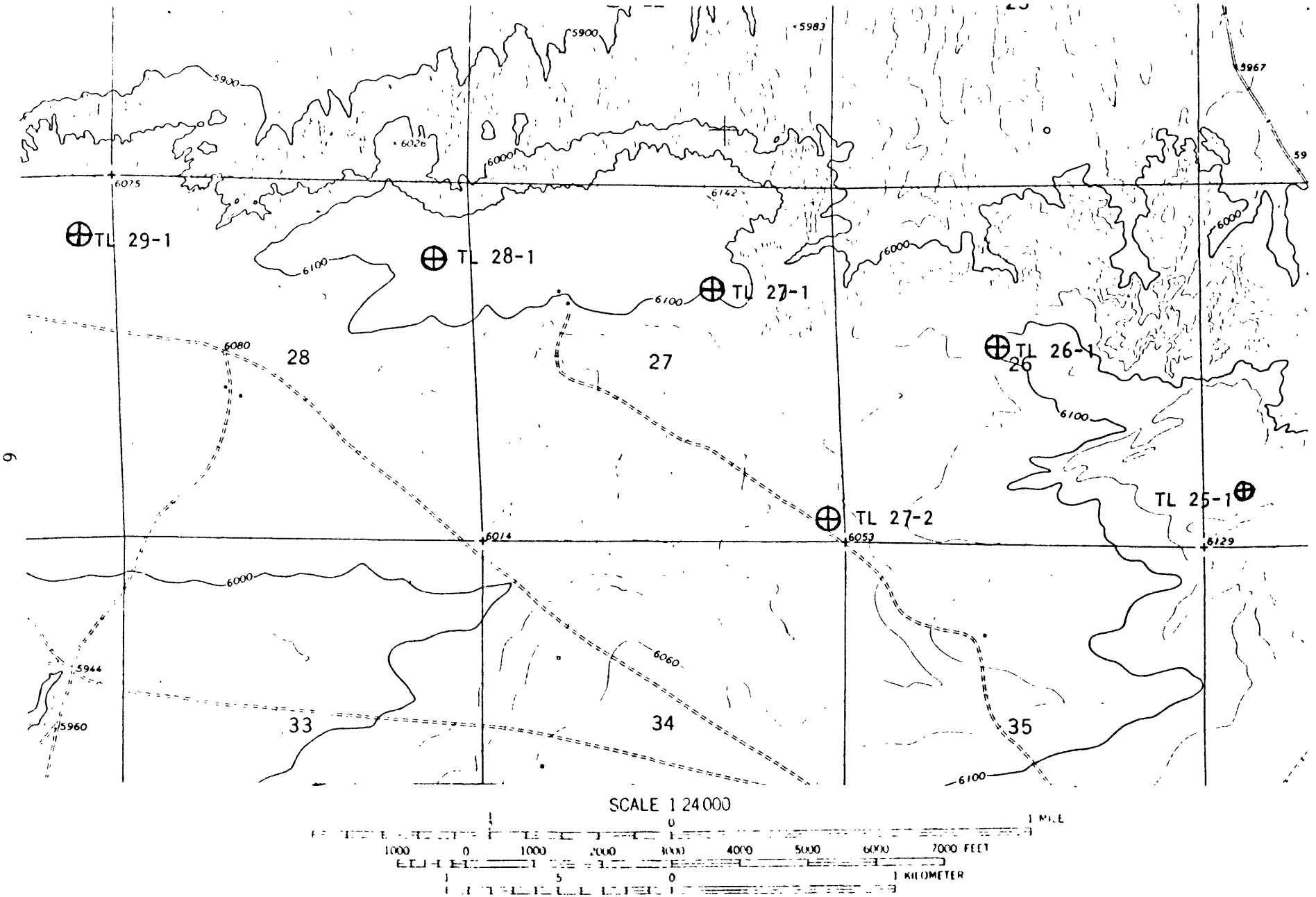

Figure 2.--Drill-hole locations in the Tanner Lake area south, Tanner Lake quadrangle, San Juan County, New Mexico.

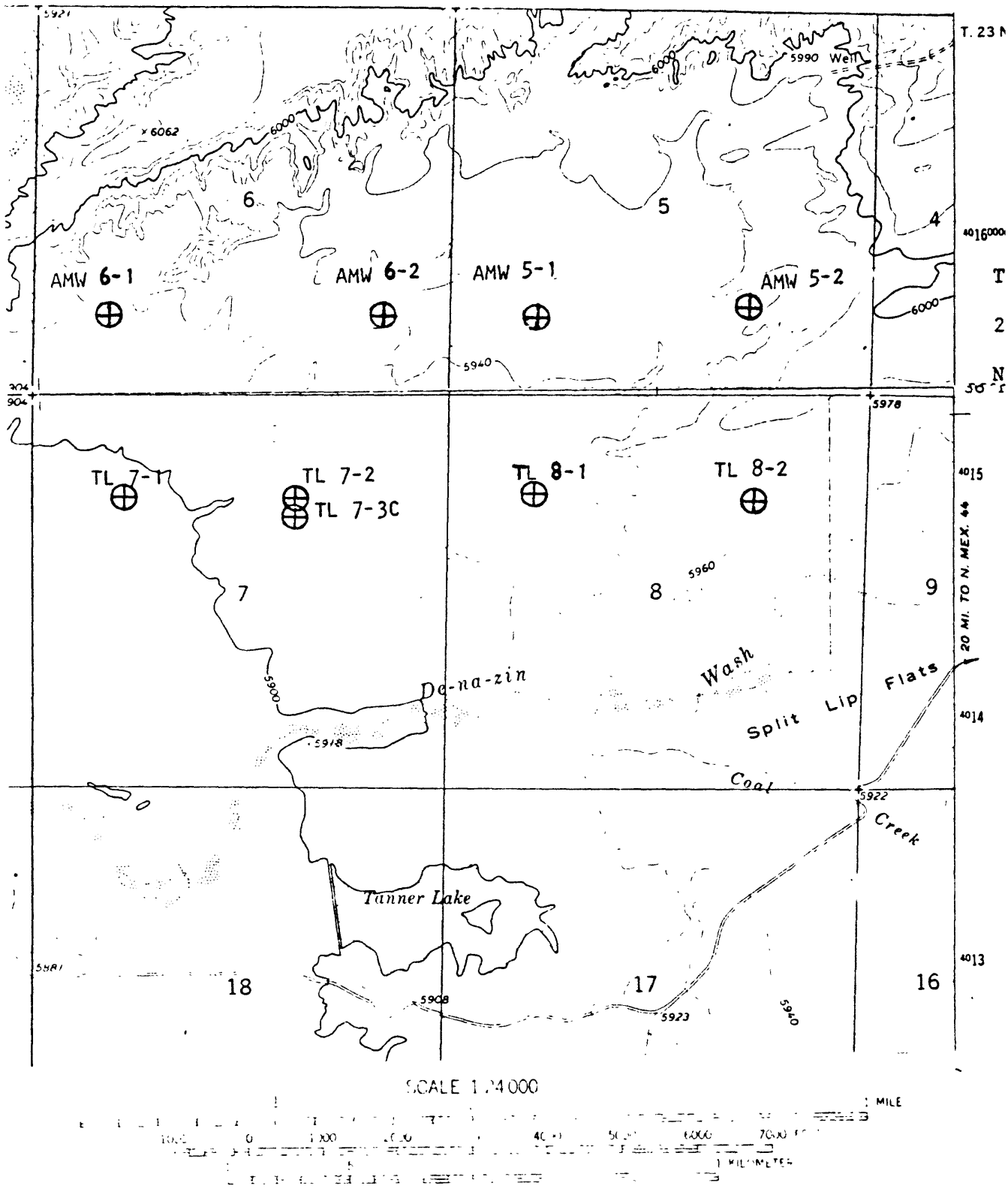

Figure 3.--Drill-hole locations in the Tanner Lake area north, Alamo Mesa West and Tanner Lake quadrangles, San Juan County, New Mexico.

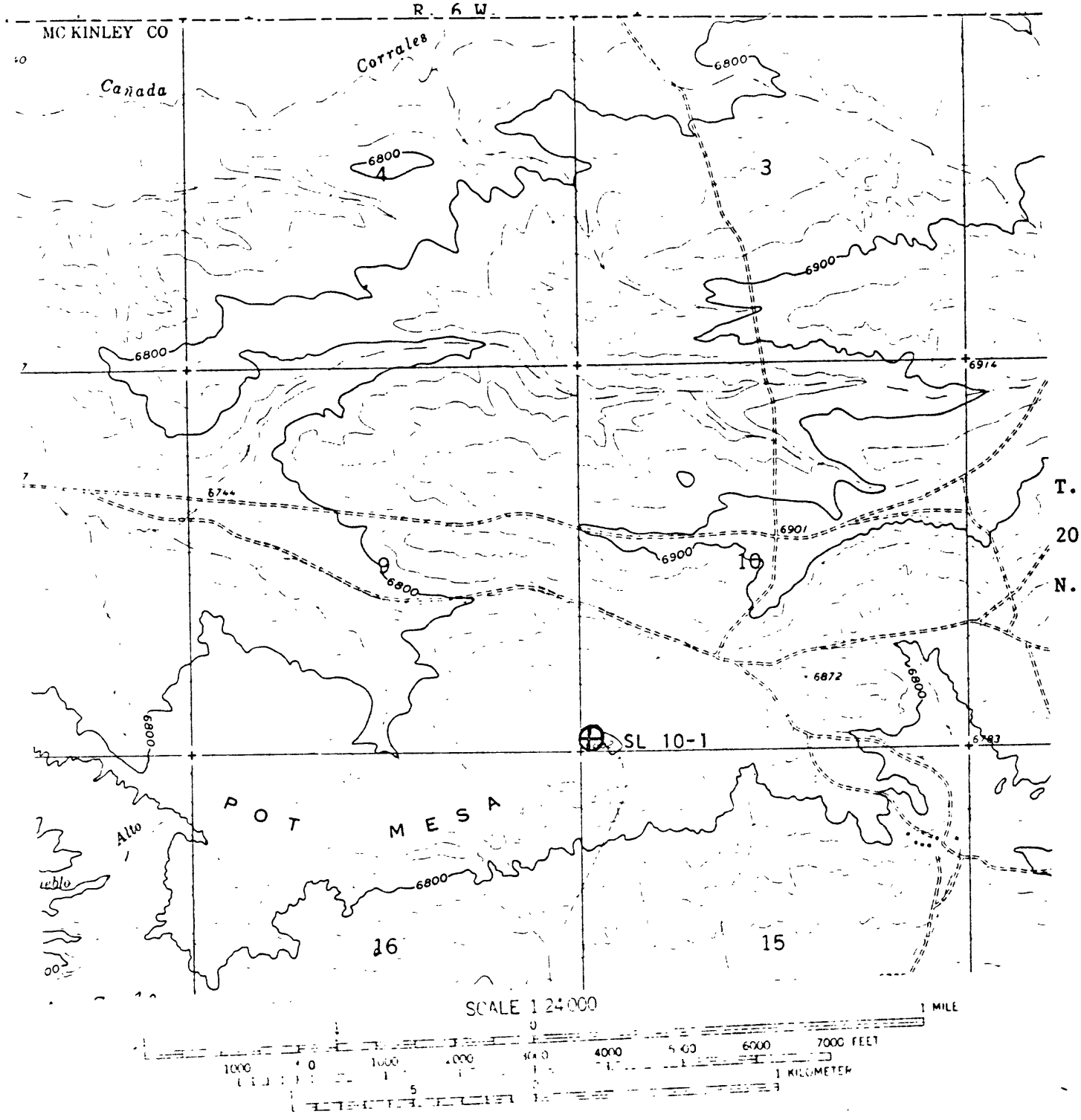

Figure. 4--Drill-hole location in the Star Lake area, Star Lake quadrangle, McKinley County, New Mexico.

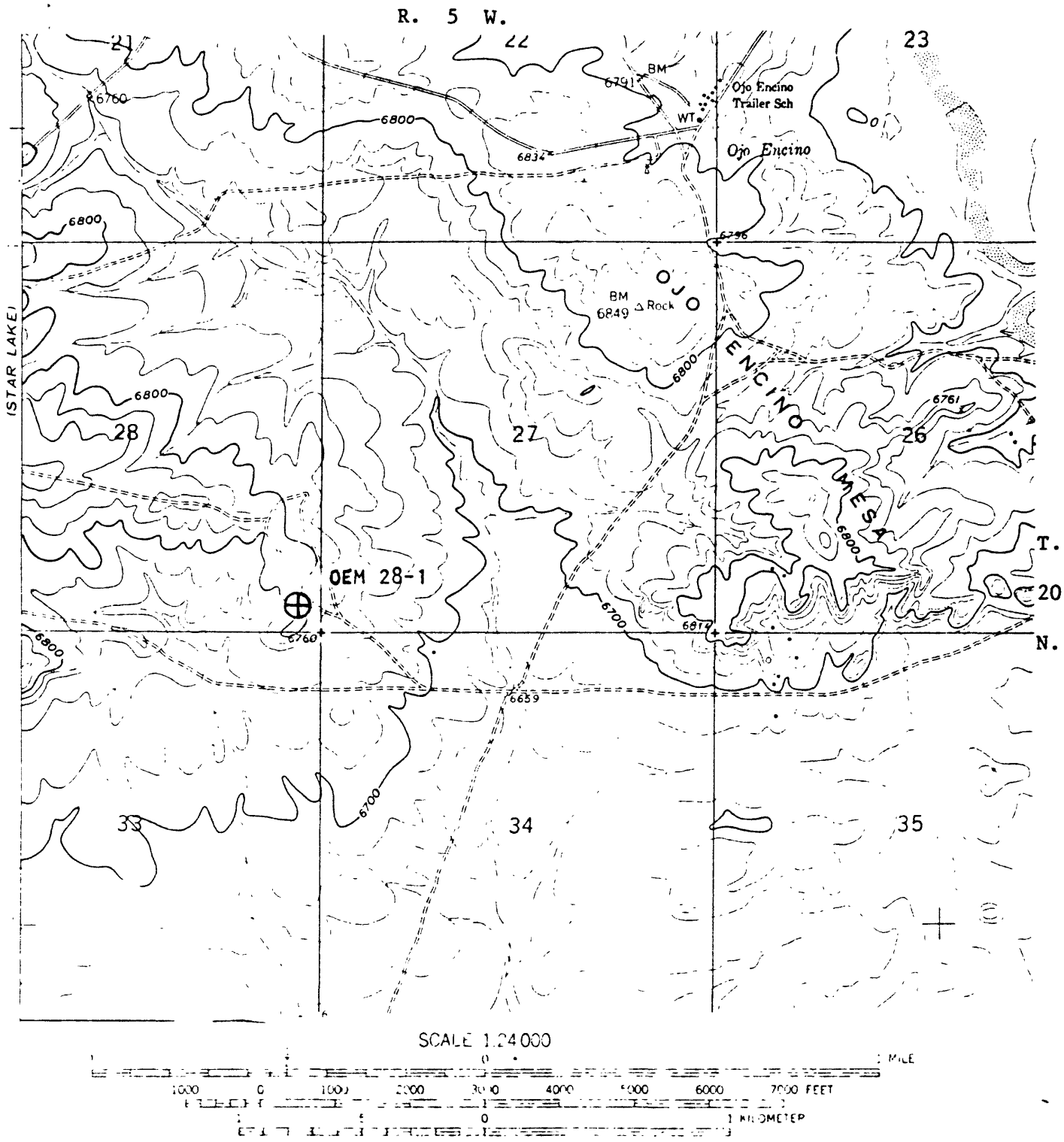

Figure 5.--Drill-hole location in the Star Lake area, Ojo Encino Mesa quadrangle, McKinley County, New Mexico.

Table 1.--Drill-hole locations, elevations, drilling and logging depths, and core recovered

[All measurements are in feet; to convert to meters, multiply by 0.3048]

Drill-hole no.	Location	Surface elevation	Total depth drilled	Total depth logged	Interval cored	Total core recovered
Sundance area, T. 14 N., R. 17 W., N.M.P.M.						
BS-8-1	NW¼NE¼ sec. 8	7,225	227	208	-----	-----
BS-8-2	SW¼NW¼ sec. 8	7,235	179	158	-----	-----
BS-8-3	SE¼NW¼ sec. 8	7,150	193	186	-----	-----
BS-8-4	NW¼SE¼ sec. 8	7,140	166	163	-----	-----
*BS-8-5C	SW¼NE¼ sec. 8	-----	106	---	57.9-75.1 91.2-99.9	26
Bisti area, Tanner Lake south, T. 23 N., R. 13 W., N.M.P.M.						
TL-25-1	SW¼SW¼ sec. 25	6,130	104	100	-----	-----
TL-26-1	SE¼NW¼ sec. 26	6,105	74	71	-----	-----
TL-27-1	SW¼NE¼ sec. 27	6,105	182	166	-----	-----
TL-27-2	SE¼SE¼ sec. 27	6,050	60	57	-----	-----
TL-28-1	NE¼NE¼ sec. 28	6,110	75	70	-----	-----
TL-29-1	NE¼NE¼ sec. 29	6,090	104	99	-----	-----
Bisti area, Tanner Lake north, T. 23 N., R. 12 W., N.M.P.M.						
AMW-5-1	SW¼SW¼ sec. 5	5,146	259	256	-----	-----
AMW-5-2	SW¼SE¼ sec. 5	5,958	274	271	-----	-----
AMW-6-1	SW¼SW¼ sec. 6	5,920	214	212	-----	-----
AMW-6-2	SE¼SE¼ sec. 6	5,933	243	240	-----	-----
TL-7-1	C NW¼ sec. 7	5,958	150	135	-----	-----
TL-7-2	SW¼NE¼ sec. 7	5,925	182	162	-----	-----
*,**TL-7-3C	SW¼NE¼ sec. 7	-----	----	---	68.0- 88.4 123.0-144.2	44
TL-8-1	SW¼NW¼ sec. 8	5,920	228	224	-----	-----
TL-8-2	SW¼NE¼ sec. 8	5,970	254	248	-----	-----
Star Lake area, Star Lake quadrangle, T. 20 N., R. 6 W., N.M.P.M.						
SL-10-1	SW¼SW¼ sec. 10	6,885	651	658	15.0- 35.0 67.0- 96.5 509.0-515.0	48
Star Lake area, Ojo Encino Mesa quadrangle, T. 20 N., R. 5 W., N.M.P.M.						
OEM-28-1	SE¼SE¼ sec. 28	6,820	445	439	-----	-----

* No geophysical logs on these holes.
** No sample log was kept for this hole.

Sample Log of Drill-hole BS-8-1

(SW¼NW¼NE¼, sec. 8, T. 14 N., R. 17 W., New Mexico Principal Meridian, Bread Springs quadrangle, McKinley County, New Mexico; surface elevation 7,225 feet; begun June 28, 1976; logged by J. E. Fassett, R. W. Jentgen, and D. Umshler; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 2 pages)

Lithologic description	Feet From	Feet To
Soil and/or alluvium	0	3
Alternating shale and sandstone	3	53
Coal; carbonaceous shale	53	58
No sample taken	58	71
Coal, impure; carbonaceous shale	71	73.5
No sample taken	73.5	79
Coal	79	79.5
No sample taken	79.5	83
Alternating carbonaceous shale and coal	83	101
No sample taken	101	109
Alternating coal and carbonaceous shale	109	114
No sample taken	114	119
Shale, carbonaceous	119	119.5
Sandstone, hard silty streak	119.5	122
No sample taken	122	132
Shale, carbonaceous	132	133
No sample taken	133	154
Coal	154	154.5
No sample taken	154.5	156
Coal	156	156.5
No sample taken	156.5	164
Coal	164	166
Shale, carbonaceous	166	167

Lithologic description	Feet From	To
Shale, gray	167	171
Coal and some sandstone	171	177
Coal	177	177.5
No sample taken	177.5	180
Shale, soft; sand	180	191
Coal	191	192
No sample taken	192	202
Coal	202	204
Shale, carbonaceous	204	204.5
Coal; shale partings	204.5	207
No sample taken	207	227
Total depth 227 feet		

Sample Log of Drill-Hole BS-8-2

(NW¼SE¼NW¼, sec. 8, T. 14 N., R. 17 W., New Mexico Principal Meridian, Bread Springs quadrangle, McKinley county, New Mexico; surface elevation 7,235; drilling started June 29, 1976; logged by J. E. Fassett, R. W. Jentgen, and D. Umshler; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 3 pages)

Lithologic description	Feet From	Feet To
Alluvium, dark-brown with coal chips	0	8
Sandstone, fine-grained, light-brown	8	12.5
Siltstone, yellow	12.5	14
Shale, slightly carbonaceous, gray	14	17
Shale, silty, yellow	17	20
Shale, gray	20	25
Shale, dark-gray-green; limonite fracture coatings	25	37
Shale, gray, coated with yellow silt	37	38
Shale, dark-gray-green, becoming silty	38	38.5
Sandstone, very fine grained, silty, gray	38.5	39
Siltstone, yellow streak	39	42
Sandstone, fine-grained, yellow-brown	42	43
Siltstone, very fine grained, gray	43	44
Sandstone, fine-grained, yellow-brown	44	47
Shale, gray	47	54
Becoming silty	54	63
Coal streak	63	63.5
Sandstone, very fine grained, gray	63.5	67
Sandstone, medium-grained, gray	67	72
Shale, gray	72	72.5
No sample taken	72.5	81
Coal	81	83
Shale, gray	83	86

Lithologic description	Feet From	To
Sandstone, very fine grained	86	87
Coal	87	87.5
Shale, gray	87.5	95
Shale, carbonaceous	95	96
Siltstone, carbonaceous	96	97
Sandstone, very fine grained, gray	97	99
Siltstone, gray	99	100
Coal (SAMPLE NO. 1)	100	102
Shale, gray	102	105
Shale, carbonaceous	105	106
Shale, dark-gray	106	109
Shale, carbonaceous; some coal	109	110
Shale, gray-green	110	111
Shale, carbonaceous	111	113
Shale, gray	113	114
Siltstone, gray	114	115
Shale, gray	115	118
Coal	118	118.5
Shale, silty, gray	118.5	127
Shale, carbonaceous	127	127.5
Coal	127.5	128
Shale, gray	128	134
Shale, carbonaceous	134	136
Coal (SAMPLE NO. 2)	136	140
Shale, gray	140	143
Coal (SAMPLE NO. 2)	143	146

Lithologic description	Feet From	Feet To
Shale, gray; siltstone	146	147
Sandstone, fine-grained, gray; shale	147	160
Shale streak, carbonaceous	160	161
Sandstone, fine-grained, gray	161	171
Sandstone, fine-grained, gray; gray shale	171	179
Total depth 179 feet		

Sample Log of Drill-Hole BS-8-3

(SE¼SE¼NW¼, sec. 8, T. 14 N., R. 17 W., New Mexico Principal Meridian, Bread Springs quadrangle, McKinley County, New Mexico; surface elevation 7,150; drilling started June 30, 1976; logged by J. E. Fassett, R. W. Jentgen, and D. Umshler; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 3 pages)

Lithologic description	Feet From	Feet To
Alluvium; carbonaceous shale; coal (about 2 ft); shale (only one sample for 10 ft inverval); coal (poorly exposed in gully 30 ft to north) . . .	0	10
Shale, brown	10	12
Shale, carbonaceous; limonite	12	14
Coal	14	15
Shale, dark-brown; limonite	15	28
Sandstone, very fine grained, transitionally darkening, clayey, gray-white	28	36
Sandstone, very fine grained, white	36	42
Sandstone, very fine grained, clayey, light-gray . . .	42	48
Shale, carbonaceous	48	48.5
Sandstone, very fine grained, clayey, light-gray . . .	48.5	54
Sandstone, fine-grained	54	56
Coal	56	57
Shale, black	57	58
Shale, gray	58	60
Shale, very fine grained, sandy	60	61
Shale, black	61	65
Coal	65	66
Shale, carbonaceous, black	66	68
Shale, gray	68	68.5
Sandstone, very fine grained, gray	68.5	71
Shale, silty, dark-gray	71	77
Coal	77	77.5

Lithologic description	Feet From	Feet To
Shale, very fine grained, sandy, gray	77.5	78.5
Sandstone, very fine grained, gray	78.5	81
Sandstone, very fine grained, gray; carbonaceous streaks	81	83
Siltstone, dark-gray	83	84
Shale, carbonaceous; coal streak	84	85
Sandstone, very fine grained, gray	85	88
Siltstone, gray	88	89
Shale, carbonaceous, very dark gray	89	92
Sandstone, very fine grained, silty, light-gray	92	94
Shale, silty, gray	94	102
Sandstone, very fine grained, shal y, light-gray	102	104
Sandstone, very fine grained, light-gray	104	109
Carbonaceous streak	109	110
Sandstone, very fine grained, light-gray	110	112
Sandstone, very fine grained, light-gray	112	115
Sandstone, fine-grained, shaley, light-gray	115	124
Shale, silty, gray	124	125
Sandstone, very fine grained, light-gray	125	126
Clay; carbonaceous streak	126	127
Coal	127	129
Shale parting, carbonaceous	129	129.6
Coal (SAMPLE NO. 1)	129.6	132
Shale, very greasy, gray	132	135
Coal	135	135.6
Shale, gray; coal	135.6	140
Sand, light; clay; coal	140	141

Lithologic description	Feet From	Feet To
Coal	141	141.5
Shale, gray	141.5	143
Coal	143	143.5
Shale, dark-gray	143.5	148
Shale, silty, gray	148	152
Coal	152	152.5
Shale, dark-gray	152.5	154
Coal; abundant clay partings	154	157
Shale, gray	157	158
Sandstone, very fine grained, shaly, light-gray	158	159
Sandstone; carbonaceous shale	159	164
Shale, light-gray	164	165
Shale, carbonaceous; yellow, very fine grained sandstone	165	166
Coal (SAMPLE NO. 2)	166	169
Parting of sandstone and shale	169	170
Coal	170	174
Shale, carbonaceous; coal	174	177
Sandstone, very fine grained, gray; coal chips	177	193
Total depth 193 feet		

Sample Log of Drill-Hole BS-8-4

(NW¼NW¼SE¼, sec. 8, T. 14 N., R. 17 W., New Mexico Principal Meridian, Bread Springs quadrangle, McKinley County, New Mexico; surface elevation 7,140; drilling started June 30, 1976; logged by J. E. Fassett and D. Umshler; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 2 pages)

Lithologic description	Feet From	Feet To
No sample taken	0	11
Coal	11	12
Shale, gray	12	20
Coal	20	22
Shale, carbonaceous	22	24
Shale, gray	24	39
Sandstone; shale	39	43
Shale	43	49
Shale, sandy	49	50
Shale, gray	50	58
Sandstone, very fine grained, white	58	59
Shale, sandy	59	68
Coal	68	68.5
Shale, sandy, gray	68.5	77
Coal	77	78
Shale, carbonaceous	78	79
Shale, gray; very fine grained sandstone	79	80
Shale, dark-gray; siltstone	80	81
Shale, gray	81	82
Coal, carbonaceous shale	82	83
Shale, carbonaceous; coal streaks	83	89
Shale, gray; thin sandy streaks	89	96
Sandstone, very fine grained, gray	96	99

Lithologic description	Feet From	Feet To
Shale, sandy, gray	99	102
Shale, gray	102	105
Shale, sandy, gray	105	130
Coal (SAMPLE NO. 1)	130	133
Shale, gray	133	134
Coal; shale	134	137
Shale, gray	137	139
Shale, gray; coal	139	144
Shale, gray	144	149
Coal	149	151
Shale, gray; siltstone	151	153
Coal	153	154
Shale, gray	154	156
Coal; carbonaceous shale	156	157
Shale, gray	157	160
Coal; carbonaceous shale	160	162
Shale, gray; siltstone	162	166
Total depth 166 feet		

Sample Log of Drill-Hole BS-8-5C

(NE¼SW¼NE¼, sec. 8, T. 14 N., R. 17 W., New Mexico Principal Meridian, Bread Springs quadrangle, McKinley County, New Mexico; surface elevation 7,070; drilling started July 1, 1976; logged by J. E. Fassett and D. Umshler; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 2 pages)

Lithologic description	Feet From	Feet To
Clay, silty, brown	0	13
Sandstone, fine-grained, shaly, light-brown	13	16
Shale, dark-gray	16	20
Sandstone, fine-grained, shaly, dark-gray	20	22
Alternating shale and sandstone	22	32
Coal	32	32.6
No sample taken	32.6	35
Sandstone, fine-grained, light-gray	35	36
Shale, sandy, dark-gray	36	38
Sandstone, shal y	38	44
Shale, brown	44	48
Coal	48	49
Shale, gray	49	50
Sandstone, gray	50	54
Shale, sandy	54	55
Shale, dark-gray	55	57.9
CORE STARTED; shale, carbonaceous, brown	57.9	59.7
Siltstone, gray; dark-gray shale streaks	59.7	62.4
Shale, carbonaceous, gray-brown	62.4	65.1
Shale, carbonaceous, black	65.1	65.3
Coal	65.3	67.65
Siltstone; carbonaceous shale	67.65	68.6
Coal	68.6	70.3

Lithologic description	Feet From	Feet To
Coal; carbonaceous shale	70.3	71
Shale, carbonaceous	71	71.25
Coal	71.25	73.9
Shale, carbonaceous; gray shale	73.9	76
END CORE; cored portion of hole was reamed	76	78
Shale, dark-gray-green	78	80
Shale, fine-grained; gray-green sandstone	80	81
Shale, dark-gray-green	81	88
Coal; dark-gray-green shale; end of sample log	88	91.2
CORE	91.2	99.9
Total depth 99.9 feet		

Description of Core from BS-8-5C

(NE¼SW¼NE¼, sec. 8, T. 14 N., R. 17 W., New Mexico Principal Meridian, Bread Springs quadrangle, McKinley County, New Mexico; surface elevation 7,070; drilling started July, 1976; described by R. W. Jentgen; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 2 pages)

Lithologic description	Feet From	Feet To
Siltstone, dark-gray, with 5 percent white quartz grains, trace pyrite, coal fragments.	57.9	59.4
Coal, arenaceous, dull, black.	59.4	59.8
Sandstone, quartzose, very fine grained, gray (angular to subangular grains), 50 percent large coal fragments .	59.8	59.9
Sandstone, quartzose, very fine grained, white (subangular grains), 10 percent coal fragments, frequent carbonaceous streaks.	59.9	61.8
Coalstone, arenaceous, gray, with 60 percent very coarse grained coal fragments and 40 percent very fine grained quartzose sand, resin nodules, and pyrite traces.	61.8	62.1
Sandstone, quartzose, fine-grained, silty, gray (subrounded grains), with 10 percent fine-grained coal fragments	62.1	62.2
Siltstone, sandy, gray, with 20 percent quartzose sand and 20 percent carbonaceous matter.	62.2	63.6
Siltstone, gray, with 20 percent quartz and 20 percent fine, carbonaceous fragments and large papery coal fragments	63.6	65.3
Coal, shiny, black	65.3	67.7
Shale, black, with 20 percent large coal fragments	67.7	68.4
Coal, shiny, black, with infrequent pyrite traces.	68.4	71.1
Siltstone, gray, with 10 percent fine coal fragments . . .	71.1	71.3
Coal, shiny, black	71.3	73.9
Siltstone, carbonaceous, black, with 5 percent fine coal fragments and 5 percent very fine quartzose sand. . .	73.9	74.2
Siltstone, carbonaceous, dark-gray, with 20 percent large papery coal fragments and 20 percent very fine quartz fragments.	74.2	75.1
No core taken.	75.1	91.2

Lithologic description	Feet From	Feet To
Shale, carbonaceous, vitreous, black	91.2	91.6
Coal, dull, black; very shiny coal fragments	91.6	92.0
Shale, carbonaceous, vitreous, black; large papery coal fragments	92.0	93.3
Siltstone, gray; 10 percent fine coal fragments, highly carbonaceous, moderately brittle	93.3	96.5
Siltstone, black; large papery coal fragments, highly carbonaceous, moderately brittle	96.5	97.0
Shale, silty, gray; large infrequent papery coal fragments, frequency increasing downward; 2 percent very fine coal fragments throughout; crumbly . . .	97.0	99.9
Total core thickness . . . . . 25.9 feet		

Sample Log of Drill-Hole TL-25-1

(NW¼SW¼SW¼, sec. 25, T. 23 N., R. 13 W., New Mexico Principal Meridian, Tanner Lake quadrangle, San Juan County, New Mexico; surface elevation 6,150; drilling started July 13, 1976; logged by J. E. Fassett, R. W. Jentgen, and D. Umshler; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 1 page)

Lithologic description	Feet From	Feet To
Shale, greasy, green; some gypsum	0	9
Alternating shale and yellow, fine-grained sandstone	9	12
Sandstone, very fine grained, gray	12	13
Sandstone, fine-grained, gray, occasionally coarse and white-streaked	13	14
Sandstone, very fine grained, shal y, yellow	14	19
Sandstone, carbonaceous	19	20
Shale, greasy, yellow-coated, gray	20	25
Shale, carbonaceous	25	26
Coal (SAMPLE NO. 1),	26	29
Shale, carbonaceous, black	29	38
Shale, gray	38	41
Shale, sandy, slightly carbonaceous, gray	41	43
Shale, greasy, gray	43	55
Sandstone, very fine grained, carbonaceous, gray	55	67
Coal (SAMPLE NO. 2)	67	70
Shale, carbonaceous	70	71
Siltstone, carbonaceous, brown; sandstone, black	71	72
Sandstone, fine-grained, gray	72	103.93
Total depth 103.93 feet		

Sample Log of Drill-Hole TL-26-1

(SE¼SE¼NW¼, sec. 26, T. 23 N., R. 13 W., New Mexico Principal Meridian, Tanner Lake quadrangle, San Juan County, New Mexico; surface elevation 6,105; drilling started July 13, 1976; logged by J. E. Fassett, R. W. Jentgen, and D. Umshler; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 1 page)

Lithologic description	Feet From	Feet To
Coal; yellow limonite-coated carbonaceous shale	0	7
Shale, gray and yellow	7	21
Shale, silty	21	24
Sandstone, shaly, gray	24	25
Shale, yellowish-gray	25	29
Shale, carbonaceous; very fine grained sandstone . . .	29	32
Shale, silty, gray	32	35
Sandstone, fine-grained, gray; black coal streaks . . .	35	37
Shale, gray, alternating with fine-grained sandstone .	37	38
Coal (SAMPLE NO. 1)	38	42
Coal, shaly	42	43
Sandstone, very fine grained, brown; coal streaks; shale streaks	43	45
Sandstone, fine-grained, light-gray	45	46
Coal streak	46	46.5
Sandstone, fine-grained, light-gray	46.5	62
Hard zone; gray,, very fine grained sandstone	62	65
Sandstone, fine-grained, light-gray	65	74.5
Total depth . . . . . 74.5 feet		

Sample Log of Drill-Hole TL-27-1

(NE¼SW¼NE¼, sec. 27, T. 23 N., R. 13 W., New Mexico Principal Meridian, Tanner Lake quadrangle, San Juan County, New Mexico; surface elevation 6,105; drilling started July 14, 1976; logged by R.W. Jentgen and D. Umshler; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 3 pages)

Lithologic description	Feet From	Feet To
Clay balls; silt	0	10
Clay, white; siderite-cemented sandstone pebbles	10	11
Gravel; clay	11	14
Shale, yellow; siltstone pebbles	14	20
Shale streak, carbonaceous	20	20.5
Shale, gray	20.5	22
Shale, yellow	22	28
Shale, gray	28	29
Sandstone, fine-grained, shaly, yellow-gray	29	33
Sandstone, fine-grained, light-gray	33	34
Sandstone, shaly, yellow-gray	34	35
Shale, yellow	35	37
Concretion chips, hard, yellow	37	37.2
Shale, yellow	37.2	38
Shale, carbonaceous	38	39
Shale, yellow; clay	39	41
Sandstone, soft, yellow	41	44
Shale, yellow	44	48
Shale, carbonaceous	48	49
Shale, silty, dark-gray	49	51
Sandstone, very fine grained, gray	51	65
Sandstone, very fine grained, very hard, gray	65	67
Sandstone, very fine grained, normal, gray	67	69

Lithologic description	Feet From	To
Sandstone, hard, light-gray	69	70
Sandstone, normal, light-gray	70	73
Sandstone, soft, shaly, gray	73	77
Coal	77	78.5
Sandstone, very fine grained, gray	78.5	79
Coal (SAMPLE NO. 1)	79	85
Shale, carbonaceous	85	86
Shale, gray	86	87
Sandstone, very fine grained, gray	87	88
Shale, greasy, gray	88	88.5
Shale, carbonaceous	88.5	91
Shale, greasy, gray	91	93
Shale, fine-grained, sandy, gray	93	96
Sandstone, very fine grained, soft, shaly	96	101
Shale, carbonaceous	101	103
Shale, silty, gray-green	103	106
Clay balls (changed bits)	106	109
Shale, sandy, gray; shaly, very fine grained sandstone	109	113
Sandstone, fine-grained, soft, light-gray	113	113.5
Shale, very fine grained, sandy, gray-brown	113.5	115
Sandstone, fine-grained, soft, with hard streaks; light-gray; carbonaceous streaks	115	118
Sandstone, very fine grained, shaly, dark-gray	118	119
Shale, silty, dark-gray	119	120
Sandstone, shaly, light-gray	120	122
Shale, silty, gray; black carbonaceous streaks	122	137

Lithologic description	Feet From	Feet To
Sandstone, fine-grained, gray, alternating with gray shale	137	139
Sandstone, very fine grained, hard and soft, light-gray.	139	149
Shale, gray; sandy shale	149	154
Sandstone, very fine grained, shaly, gray, alternating with sandy shale	154	158
Sandstone, very fine grained, light-gray; pyrite	158	181.8

Total depth . . . . . 181.8 feet

Sample Log of Drill-Hole TL-27-2

(SE¼SE¼SE¼, sec. 27, T. 23 N., R. 13 W., New Mexico Principal Meridian, Tanner Lake quadrangle, San Juan County, New Mexico; surface elevation 6,050; drilling started July 20, 1976; logged by J. E. Fassett and D. Umshler; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 2 pages)

Lithologic description	Feet From	Feet To
Alluvium	0	2
Sand, fine-grained, yellow-brown	2	5
Sand, fine-grained, gray	5	7
Sand, fine-grained, brown	7	8
Sand, well-cemented, gray	8	8.5
Sand, coarse-grained	8.5	9
Sand, brown	9	11
Sand, poorly cemented, white-gray	11	14
Shale, silty, gray-green	14	16
Shale; sand; carbonaceous siltstone	16	18
Sand, fine-grained, poorly cemented, white-gray	18	22
Sandstone, fine-grained, hard, gray	22	24
Sandstone, fine-grained, brown	24	24.5
Siltstone, carbonaceous	24.5	25
Shale, gray-green; carbonaceous siltstone streaks	25	26
Shale, silty, blue-green	26	27.5
Shale, carbonaceous	27.5	29
Siltstone, carbonaceous; sandy, blue-green shale	29	32
Sandstone, fine-grained, blue-gray; carbonaceous streak	32	33
Sandstone, fine-grained, hard, blue-gray; infrequent carbonaceous streaks	33	38
Carbonaceous streak	38	39
Shale, sandy, blue-green	39	40
Sandstone, fine-grained, blue-green, slightly carbonaceous	40	43.5

Lithologic description	Feet From	Feet To
Siltstone, carbonaceous; blue-green shale	43.5	45
Siltstone; carbonaceous streak	45	46
Sandstone, fine-grained, blue	46	47
Sandstone, hard	47	49
Sandstone, soft	49	52
Shale, greasy, gray	52	55
Sandstone with hard streaks, blue-gray	55	59.72
Total depth . . . . . 59.72 feet		

Sample Log of Drill-Hole TL-28-1

(SE¼NE¼NE¼, sec. 28, T. 23 N., R. 13 W., New Mexico Principal Meridian, Tanner Lake quadrangle, San Juan County; New Mexico; surface elevation 6,110; drilling started July 16, 1976; logged by R. W. Jentgen; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 1 page)

Lithologic description	Feet From	Feet To
Gravel, sandy	0	8
Sandstone, coarse, yellow; gravel	8	14
Shale, greasy, yellow	14	23
Shale, silty, yellow	23	29
Shale, carbonaceous, very greasy	29	30
Shale, greasy, yellow	30	30.5
Shale, carbonaceous	30.5	31
Shale, greasy, yellow coatings, gray	31	42
Coal	42	43
Shale, gray	43	54
Sandstone, very fine grained, light-gray	54	65
Shale, silty, greasy, gray	65	73
Sandstone, very fine grained, light-gray; lost circulation	73	75
Total depth 75 feet		

Sample Log of Drill-Hole TL-29-1

(SE¼NE¼NE¼, sec. 29, T. 23 N., R. 13 W., New Mexico Principal Meridian, Tanner Lake quadrangle, San Juan County, New Mexico; surface elevation 6,090; drilling started July 16, 1976; logged by R.W. Jentgen; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 2 pages)

Lithologic description	Feet From	Feet To
Sand, gravelly; yellow, very sandy shale	0	4
Shale, yellow	4	6
Shale, greasy, yellow-coated, gray	6	8
Shale, carbonaceous	8	9
Shale, greasy, gray	9	11
Shale, very sandy, yellow-gray	11	24
Sandstone, very fine grained, shaly, gray	24	28
Shale, silty, gray; infrequent gypsum	28	33
Shale, very sandy, gray	33	36
Sandstone, fine-grained, shaly, yellow	36	39
Sandstone, very fine grained, light-gray; occasional medium-grained sandstone	39	44
Sandstone, fine-grained, shaly, light-gray	44	54
Coal (SAMPLE NO. 1)	54	58
Shale, gray	58	59
Sandstone, very fine grained, light-gray	59	64
Siltstone, light-gray	64	65
Sandstone, very fine grained, light gray	65	81
Sandstone, shaly, yellow	81	83
Sandstone, very fine grained, pyrite-coated, gray	83	84
Sandstone, very fine grained, very shaly, yellow	84	91
Shale, sandy, yellow	91	93
Sandstone, very fine grained, hard, light-gray	93	94
Shale, yellow	94	95

Lithologic description	Feet From	Feet To
Sandstone, very fine grained, light-gray	95	96
Sandstone, very fine grained, shaly, light-gray . . .	96	104
Total depth . . . . . 104 feet		

Sample Log of Drill-Hole AMW-5-1 (W)

(NE¼SW¼SW¼, sec. 5, T. 23 N., R. 12 W., New Mexico Principal Meridian, Alamo Mesa West quadrangle, San Juan County, New Mexico; surface elevation 5,946; drilling started July 28, 1976; logged by R. Cheeseman and J. Lorenz; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 5 pages)

Lithologic description	Feet From	Feet To
Quaternary alluvium	0	14
No sample taken	14	24
Quaternary alluvium	24	34
Siltstone, green-gray	34	35
Siltstone, green-gray	35	36
Siltstone, green, carbonaceous shale	36	38
Sandstone, buff	38	39
Sandstone	39	41
Siltstone	41	44
Sandstone; siltstone	44	45.3
Sandstone; some silt	45.3	46
Sandstone, slightly carbonaceous, tan	46	48
Shale; micaeous silt	48	49
Sand, salt-and-pepper	49	50
Sandstone	50	51
Sandstone, silt	51	54
Coal; sandstone	54	55
Siltstone	55	56
Coal; silt	56	58
Silt, carbonaceous	58	60
Coal	60	62.5
Coal; silt	62.5	64
Siltstone	64	69

Lithologic description	Feet From	Feet To
Silt, carbonaceous	69	72
Coal; shale	72	73
Silt	73	74
Shale, green-gray	74	75
Shale, carbonaceous	75	76
Silt, shaly	76	77
Sandstone; shale; silt	77	80
Sandstone; gray shale	80	82
Sandstone; silt; shale	82	83
Sandstone; siltstone	83	84
Sandstone, gray	84	88
Sandstone, fine-grained, gray	88	89
Silt, gray; green shale ; sandstone	89	90
Silt; gray sandstone	90	92
Sandstone; silt; coal	92	94
Sandstone; silt	94	95
Sandstone, buff-gray	95	97
Sandstone; coal streak	97	99
Sandstone, salt-and-pepper	99	100
Coal	100	102.5
Silt, carbonaceous	102.5	104
Shale; silt	104	107
Shale; gray silt	107	112
Coal (SAMPLE NO. 1)	112	126
Shale; coal	126	128
Siltstone; coal	128	131

Lithologic description	Feet From	To
Siltstone	131	135
Coal; siltstone	135	136
Silt, carbonaceous	136	139
Sandstone; silt	139	141
Sandstone	141	144
Sandstone, silty, carbonaceous	144	145
Sandstone; coal	145	146
Sandstone, silty	146	147
Sandstone, fine-grained, light-gray	147	148
Sandstone	148	150
Coal; sandstone	150	152
Sandstone, carbonaceous, light-gray	152	155
Sandstone, fine-grained, clayey, light-gray	155	158
Coal	158	160
Sandstone, carbonaceous	160	161
Coal	161	162
Silt, carbonaceous; sandstone	162	172
Coal stringers; silt; sandstone	172	174
Coal; siltstone	174	175
Coal; sandstone	175	176
Coal; siltstone	176	177
Coal	177	179
Coal; silt	179	180
Silt; coal	180	181
Silt, gray	181	182
Silt; coal	182	187

Lithologic description	Feet From	Feet To
Coal, silty	187	188
Coal (SAMPLE NO. 2)	188	196
Coal, silty	196	197
Siltstone; coal	197	198
Coal; silt	198	202
Silt; coal; light-gray sandstone	202	203
Silt; sandstone; gray shale	203	204
Shale; coal	204	206
Coal (SAMPLE NO. 3)	206	212
Silt; coal	212	214
Silt; shale; sandstone	214	215
Coal (SAMPLE NO. 4)	215	219
Silt; shale; sandstone	219	223
Coal; silt	223	224
Shale; coal	224	225
Shale, silty; shale	225	226
Sandstone, brown; silt	226	227
Shale, carbonaceous; coal	227	228
Sandstone, light-gray; shale	228	229
Sandstone, salt-and-pepper, gray	229	230
Coal; sandstone	230	231
Sandstone, gray; shale; coal	231	235
Sandstone; coal	235	238
Sandstone, very fine grained, white	238	241
Sandstone, shale stringers	241	244
Sandstone; silt; shale	244	247

Lithologic description	Feet From	Feet To
Sandstone, white; shale stringers	247	248
Sandstone, white	248	249
Sandstone; silt; shale stringers	249	252
Sandstone, very fine grained, white	252	259
Total depth . . . . . 259 feet		

Sample Log of Drill-Hole AMW-5-2 (E)

(SW¼SE¼, sec. 5, T. 23 N., R. 12 W., New Mexico Principal Meridian, Alamo Mesa West quadrangle, San Juan County, New Mexico; surface elevation 5,958; drilling started August 3, 1976; logged by J. E. Fassett and R. W. Jentgen; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 3 pages)

Lithologic description	Feet From	Feet To
No sample taken	0	14
Shale, silty, green	14	15
Shale, brown	15	16
Shale, green	16	24
Siltstone, gray; fine-grained sand	24	25
Sandstone, very fine grained, light-gray	25	26
Coal	26	26.5
Shale, silty, green-yellow	26.5	29
Shale, silty, green-gray	29	32
Shale, hard, gritty, silty, dark-gray	32	37
Shale, hard, silty, dark-gray with rusty colored coating	37	41
Shale, hard, silty, gray with yellow coatings	41	44
Shale, silty, greasy, gray	44	44.5
Sandstone, very fine grained, shaly, white	44.5	45
Sandstone, fine-grained, hard, gray	45	45.1
Sandstone, fine-grained, gray, becoming shaly; carbonaceous streak	45.1	46
Shale, hard, dark-gray	46	50
Shale, coal	50	51
Coal (SAMPLE NO. 1)	51	53
Shale, silty, gray	53	55
Coal	55	58
Shale, carbonaceous	58	60.5
Shale, sandy, soft, gray	60.5	62

Lithologic description	Feet From	To
Shale, sandy, soft, green	62	69
Shale, sandy, light brown	69	71
Sandstone, fine-grained, soft, shaly, white	71	75
Sandstone, fine-grained, white	75	94
Sandstone, fine-grained, white; clay streaks	94	97
Shale, silty, dark-gray; fine-grained sandstone streaks	97	101
Shale, sandy, gray	101	103
Sandstone, very fine grained, shaly	103	104
Shale, sandy, soft, gray	104	107
Sandstone, very fine grained, shaly, light-gray	107	111
Shale, carbonaceous	111	114
Coal (SAMPLE NO. 2)	114	121
Sandstone, very fine grained, shaly, white	121	127
Sandstone, very fine grained, , shaly, white; dark-gray shale	127	131
Shale, sandy, soft, light-gray; dark-gray hard shale	131	133
Sandstone, very fine grained, soft, shaly, white	133	142
Sandstone, very fine grained, soft, shaly, white; carbonaceous streak	142	161
Shale, carbonaceous	161	163
Coal	163	165
Sandstone, very fine grained, shaly, white	165	166
Shale, carbonaceous	166	169
Sandstone, shaly, white; carbonaceous shale, coal streaks	169	173
Shale, sandy, soft, gray-green	173	181
Sandstone, very fine grained, clayey, soft, white	181	185
Sandstone, very fine grained, clayey, soft, gray	185	189

Lithologic description	Feet From	Feet To
Sandstone, very fine grained, shaly, soft, light-gray . . .	189	191
Shale, sandy, soft, brown	191	193
Sandstone, very fine grained, shaly, soft, light-gray . . .	193	196
Shale, carbonaceous	196	197
Coal (SAMPLE NO. 1)	197	209
Shale, carbonaceous	209	210
Shale, sandy, gray	210	214
Coal (SAMPLE NO. 2)	214	219
Shale, carbonaceous	219	220
Sandstone, very fine grained, light-gray; hard shale . . .	220	222
Shale, carbonaceous; coal	222	223
Coal	223	224
Shale, carbonaceous; coal	224	225
Coal; carbonaceous shale	225	226
Sandstone, clayey, gray-brown; sandy shale	226	227
Sandstone, very fine grained, gray	227	236
Sandstone; gray shale	236	237
Sandstone, fine-grained, light-gray	237	274
Total depth . . . . . 274 feet		

Sample Log of Drill-Hole AMW-6-1 (W)

(SW¼SW¼, sec. 6, T. 23 N., R. 12 W., New Mexico Principal Meridian, Alamo Mesa West quadrangle, San Juan County, New Mexico; surface elevation 5,920; drilling started July 23, 1976; logged by R. W. Jentgen and D. Umshler; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 4 pages)

Lithologic description	Feet From	Feet To
Shale	0	1
Siltstone, dark-brown	1	5
Shale, very hard, dark-gray	5	7
Shale, hard, black	7	8
Sandstone, very hard, shaly, dark-gray	8	9
Sandstone, very fine grained, soft, light-gray; clay; several very hard dark-brown and dark-gray shale streaks at 11, 13, and 15 ft	9	15.5
Sandstone, very fine grained, hard, dark-gray	15.5	16
Sandstone, very fine grained, soft, gray	16	17
Shale, hard, dark-gray with yellow coating; possibly cemented with siderite	17	25
Shale, carbonaceous	25	25.5
Coal	25.5	26
Shale, carbonaceous, very soft	26	27
Shale, hard, dark-gray with yellow coating; very thin bentonite partings	27	30.7
Shale, coaly, black	30.7	34.5
Shale, greasy, gray; clay streaks	34.5	39.5
Coal	39.5	40.5
Sandstone, hard, gray	40.5	41
Coal; carbonaceous shale, partings	41	42
Shale, carbonaceous	42	43
Shale, silty, gray-green; sandstreaks; clay streaks	43	43.5
Shale, gray; less than 30 percent clay	43.5	49

Lithologic description	Feet From	Feet To
Shale, carbonaceous	49	51.7
Shale, hard, gray-green	51.7	53.7
Shale, carbonaceous	53.7	56
Shale, hard, greasy, dark-gray	56	57
Shale, carbonaceous; coal streak	57	58.5
Shale, gray-green; clay	58.5	71
Coal; carbonaceous shale streak	71	71.5
Shale, gray-green; clay	71.5	77
Shale; siderite streaks	77	80
Sandstone, light-gray; greasy, very fine grained shale	80	83.5
Shale, hard, dark-gray, carbonaceous; siderite streaks; clay	83.5	94
Sandstone, very fine grained, soft, light-gray; dark-gray, hard, very fine grained sandstone	94	100
Vogesite, biotite-rich	100	101
Shale, dark-gray; light-gray clay	101	102
Shale, silty; sandstone streak	102	104.4
Shale, carbonaceous; coal streak	104.4	105
Coal (SAMPLE NO. 1)	105	112
Clay, greasy, brown	112	112.5
Shale, brown-gray	112.5	113
Shale, dark-gray; light-gray clay	113	115.5
Shale, carbonaceous; black shale	115.5	116.5
Coal (SAMPLE NO. 2)	116.5	123
Clay, slightly silty, light-gray	123	126
Shale, dark-gray; clay	126	129
Shale, carbonaceous; coal; siderite	129	130

Lithologic description	Feet From	Feet To
Coal (SAMPLE NO. 3)	130	133.5
Sandstone, fine-grained, shaly, light-gray	133.5	134
Coal (SAMPLE NO. 3)	134	135
Coal; carbonaceous shale; underclay	135	136
Shale, dark-gray; light-gray sandy clay	136	140.5
Shale, dark-gray; light-gray clay; sandstone	140.5	143
Shale, dark-gray; sandy clayey shale	143	144
Coal	144	145
Shale, carbonaceous; silt	145	146
Coal	146	147.5
Shale, dark-gray; light-gray clayey shale	147.5	149
Shale, carbonaceous	149	150
Coal	150	150.5
Shale, carbonaceous	150.5	151
Shale, dark-gray; clay	151	158
Shale, carbonaceous	158	158.5
Coal	158.5	161
Shale, carbonaceous	161	161.5
Shale, dark-gray; clay	161.5	164
Clay, sandy; dark-gray shale	164	165.5
Sandstone, very fine grained, light-gray	165.5	168
Shale, dark-gray; light-gray clay; sand	168	170
Sandstone, very fine grained, light-gray	170	173
Coal (SAMPLE NO. 4)	173	179.5
Shale, carbonaceous	179.5	180
Clay, sandy, light-gray	180	180.5

Lithologic description	Feet From	Feet To
Sandstone, very fine grained, light-gray; carbonaceous shale; clay streaks	180.5	182
Shale, dark-gray; clay	182	183
Shale, carbonaceous	183	183.5
Coal	183.5	184.5
Shale, carbonaceous	184.5	186
Sandstone, carbonaceous	186	187
Sandstone, very fine grained, soft, light-gray; probably Pictured Cliffs	187	214.2
Total depth 214.2 feet		

Sample Log of Drill-Hole AMW-6-2 (E)

(SE¼SE¼, sec. 6, T. 23 N., R. 12 W., New Mexico Principal Meridian, Alamo Mesa West quadrangle, San Juan County, New Mexico; surface elevation 5,933; drilling started July 26, 1976; logged by J. E. Fassett, R. Cheeseman, and J. Lorenz; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 4 pages)

Lithologic description	Feet From	Feet To
No sample taken	0	12
Sandstone, medium-grained, yellow-brown	12	13
Shale, green-gray; sandstone	13	14
Sandstone, fine-grained, yellow-brown	14	16
Shale, fine-grained, gray-green	16	17
Sandstone, very fine grained, white; siltstone	17	20
Shale, gray-green; sandstone	20	23
Shale, gray-green	23	23.5
Coal; shale	23.5	25
Shale, gray; yellow-brown sandstone	25	26
Sandstone, fine-grained, yellow-brown	26	27
Sandstone; gray-green shale	27	34
Sandstone, fine-grained, hard, white; limy siltstone	34	37
Shale, gray; fine-grained sandstone	37	38
Siltstone, carbonaceous; shale, gray	38	39
Sandstone, fine-grained, gray; shale	39	41
Siltstone, hard, gray	41	44
Coal; interbedded shale	44	46
Shale, silty, blue-gray; grading to friable gray sandstone	46	47
Coal	47	48
Sandstone, gray-brown	48	49
Shale, gray; sandstone; coal	49	51
Shale, blue-gray	51	52

Lithologic description	Feet From	To
Coal; blue-gray shale	52	55
Shale, blue-gray	55	57
Coal; gray shale	57	58
Shale, gray	58	60
Siltstone, gray	60	61
Shale, gray	61	62
Coal	62	65
Shale, gray; white sandstone	65	68
Shale, carbonaceous; sandstone	68	70
Shale, gray; carbonaceous sandstone; gray siltstone	70	73
Shale, gray; gray siltstone	73	81
Sandstone, medium-grained, gray; thin gray shale beds	81	89
Sandstone, fine-grained, friable, gray	89	92
Sandstone, fine-grained, hard, gray	92	94
Sandstone, fine-grained, gray; gray shale	94	99
Sandstone, fine-grained, white; interbedded coaly carbonaceous shale	99	109
Shale, gray; thin, hard, fine-grained sandstone layers	109	114
Sandstone, fine-grained, gray; gray shale	114	116
Coal; gray sandstone	116	118
Coal (SAMPLE NO. 1)	118	132
Coal; white fine-grained sandstone	132	134
Sandstone, fine-grained, light-gray; coal	134	135
Coal (SAMPLE NO. 2)	135	142
Shale, gray; coal; fine-grained sandstone	142	144
Sandstone, fine-grained, white; coal	144	145
Sandstone, fine-grained, white; carbonaceous shale	145	146
Shale, gray; gray sandstone	146	151

Lithologic description	From	To
Sandstone, fine-grained, white; gray shale	151	165.5
Coal streak	165.5	166
Sand, white; shale	166	172
Sand, white	172	174
Sand, white; gray shale	174	177
Sandstone, white; gray shale; clay pellets	177	180
Sandstone, white; gray shale	180	181
Sandstone, white; siltstone	181	182
Sandstone, white; silt; shale	182	183
Coal; gray shale	183	184
Sand; coal	184	185
Coal (SAMPLE NO. 3)	185	192.5
Sandstone; shale	192.5	193
Shale, gray	193	197.5
Shale; sandstone; silt	197.5	198
Shale; coal; sandstone	198	199
Coal (SAMPLE NO. 4)	199	205.2
Sandstone; silt; shale	205.2	207
Shale; coal	207	208
Shale, carbonaceous; brown siltstone	208	210
Sandstone; carbonaceous shale; thin coal streak	210	211
Coal; sandstone	211	212
Coal	212	214
Sandstone; carbonacoeus shale	214	217
Pictured Cliffs sandstone, fine-grained, gray	217	218
Sandstone, fine-grained, gray	218	224

Lithologic description	Feet From	Feet To
Sandstone, fine-grained, white	224	233
Sandstone, fine-grained, gray; gray shale	233	235
Sandstone; gray shale	235	240
Sandstone; gray silt	240	243
Total depth . . . . . 243 feet		

Sample Log of Drill-Hole TL-7-1 (W)

(NW¼, sec. 7, T. 23 N., R. 12 W., New Mexico Principal Meridian, Tanner Lake Quadrangle, San Juan County, New Mexico; surface elevation 5,895; logged by J. E. Fassett and D. Umshler; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 2 pages)

Lithologic description	Feet From	Feet To
Quaternary alluvium; sand; small gravel; clay fragments	0	7
Shale, dark-gray with yellow-brown coating	7	12
Shale, greasy, yellow-brown	12	18
Shale, slightly carbonaceous, dark-gray	18	21
Shale, sandy, gray; siltstone	21	22
Sandstone, fine-grained, hard, gray; dark-gray siltstone (SAMPLE NO. 1)	22	24
Shale, carbonaceous, black	24	25
Shale, carbonaceous, gray	25	26
Shale, brown; siderite fragments	26	28
Shale, sandy, light-gray	28	29
Shale, dark-gray	29	30
Shale, sandy, light-gray	30	37
Coal; thin shale parting (SAMPLE NO. 2)	37	40.5
Shale, gray	40.5	46
Siltstone, hard, dark-gray	46	47
Siderite, hard	47	48
Shale, dark-gray	48	59
Shale, carbonaceous, dark-gray-black	59	60
Coal (SAMPLE NO. 3)	60	65
Shale, carbonaceous, brown; coal	65	67
Coal, interbedded with carbonaceous shale	67	71
Shale, carbonaceous; brown-gray shale	71	74
Shale, blue-gray	74	83

Lithologic description	Feet From	Feet To
Coal	83	86
Coal; gray carbonaceous shale	86	87
Shale, blue-gray	87	90
Coal (SAMPLE NO. 4)	90	94
Shale, gray	94	96
Shale, black	96	100
Shale, gray	100	102
Shale, silty, light-gray	102	103
Sandstone, carbonaceous, gray	103	103.5
Sandstone, fine-grained, light-gray, salt-and-pepper	103.5	105
Shale, blue-gray	105	110
Coal; green-gray shale (SAMPLE NO. 5)	110	115
Shale, carbonaceous, brown	115	116
Sandstone, fine-grained, gray	116	117
Shale, brown-gray; carbonaceous streaks	117	119
Shale, carbonaceous, brown	119	119.5
Coal; brown carbonaceous shale	119.5	121
Shale, carbonaceous, brown	121	122
Pictured Cliffs sandstone, fine-grained, gray	122	150
Total depth	150 feet	

Sample Log of Drill-Hole TL-7-2 (E)

(NE¼, sec. 7, T. 23 N., R. 12 W., New Mexico Principal Meridian, Tanner Lake quadrangle, San Juan County, New Mexico; surface elevation 5,925; logged by J. E. Fassett and R. W. Jentgen; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 3 pages)

Lithologic description	Feet From	Feet To
Shale, gray-green	0	4
Sandstone, fine-grained, light-gray	4	7
Sandstone, yellow-brown	7	8
Coal	8	11
Shale, dark-gray with yellow coating	11	15
Sandstone, fine-grained, yellow; clay	15	19
Coal	19	21
Shale, silty, blue-gray	21	24
Shale, gray	24	28
Coal; carbonaceous shale streak	28	28.5
Shale, gray	28.5	32
Shale, sandy, gray	32	33
Shale, sandy, brown	33	34
Shale, dark-gray	34	35
Shale, carbonaceous	35	36
Shale, dark-gray	36	38
Coal	38	40
Shale, carbonaceous	40	40.5
Shale, dark-gray	40.5	44
Shale, carbonaceous, light-brown	44	49
Shale, carbonaceous	49	50
Shale, gray	50	51
Coal	51	51.3
Shale, gray	51.3	54

Lithologic description	Feet From	Feet To
Shale, blue-gray; white clay	54	57
Shale, sandy, gray	57	64
Coal (SAMPLE NO. 1)	64	66
Coal, gray shale	66	69
Coal	69	72
Shale, carbonaceous	72	72.5
Coal	72.5	75
Shale, gray	75	78
Coal (SAMPLE NO. 2)	78	88
Shale, gray	88	89
Sandstone, fine-grained, gray; shale	89	93
Shale, gray	93	99
Shale, dark-gray; gray fine-grained sandstone	99	104
Coal; sandstone (SAMPLE NO. 3)	104	109
Sandstone, fine-grained, salt and pepper, gray	109	110
Coal	110	112
Sandstone, carbonaceous; shale	112	115
Shale, carbonaceous	115	116
Sandstone, carbonaceous; shale	116	117
Shale, gray; sandstone streaks	117	120
Shale, carbonaceous; siderite streak; scattered coal	120	121.5
Coal (SAMPLE NO. 4)	121.5	130
Sandstone; shale	130	134
Coal	134	134.5
Shale, gray	134.5	136
Coal	136	145

Lithologic description	Feet From	Feet To
Shale, gray; sandstone	145	146
Sandstone, fine-grained, salt-and-pepper, light-gray	146	147
Shale, sandy, gray	147	148
Shale, carbonaceous, dark-gray; coal	148	149
Coal; shale	149	150
Coal	150	151
Shale, carbonaceous, brown; siltstone	151	157
Pictured Cliffs sandstone, hard, light-gray	157	158
Sandstone, light-gray; interbedded with thin green-gray shale	158	165
Sandstone, fine-grained, light-gray	165	166
Sandstone, light-gray; interbedded with thin green-gray shale	166	167
Sandstone, light-gray	167	168
Shale, silty, dark-gray	168	169
Sandstone, light-gray	169	176
Sandstone, light-gray; interbedded with blue-gray shale	176	177
Sandstone, light-gray	177	182
Total depth	182 feet	

Description of Core from TL-7-3C

(SW¼NE¼, sec. 7, T. 23 N., R. 12 W., New Mexico Principal Meridian, Tanner Lake quadrangle, San Juan County, New Mexico; surface elevation 5,925; drilling started August 5, 1976; described R. W. Jentgen; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 2 pages)

Lithologic description	Feet From	Feet To
Coal	68.0	74.4
Shale, black; coal fragments	74.4	74.6
Shale, gray, silty; scattered coal fragments	74.6	79.4
Shale, carbonaceous, black	79.4	79.7
Shale, silty, gray; scattered coal fragments	79.7	79.9
Coal	79.9	80.4
Tonstein (possibly), carbonaceous, sandy, white	80.4	80.5
Coal	80.5	83.57
Tonstein-like streak	83.57	83.6
Coal	83.6	88.4
Shale, carbonaceous, black	88.4	88.7
Shale, silty, dark-gray; medium to small coal fragments.	88.7	89
No core taken	89	123.0
Coal	123.0	130.9
Shale, silty, dark-gray; medium-sized coal fragments	130.9	135.2
Shale, carbonaceous, black	135.2	135.5
Shale, silty, light-gray; medium coal fragments	135.5	135.8
Sandstone, very fine grained, silty, white; medium-sized coal fragments	135.8	136.0
Shale, silty, light-gray; medium-sized coal fragments	136.0	136.4
Shale, black; medium- to large-sized coal fragments	136.4	137.4
Shale, carbonaceous, black	137.4	137.6
Shale, sandy, coaly, light-gray	137.6	138.1
Coal	138.1	138.3

Lithologic description	Feet From	Feet To
Shale, carbonaceous, black	138.3	138.6
Coal	138.6	144.2
Shale, carbonaceous, sandy, black	144.2	144.6
Sandstone, very fine grained, coaly, light-brown	144.6	145.2
Sandstone, very fine grained, white; coaly streaks	145.2	146.0
Total core thickness . . . . . 44.4 feet		

Sample Log of Drill-Hole TL-8-1 (W)

(NE¼SW¼NW¼, sec. 8, T. 23 N., R. 12 W., New Mexico Principal Meridian, Tanner Lake quadrangle, San Juan County, New Mexico; surface elevation 5,920; drilling started July 29, 1976; logged by R. Cheeseman and J. Lorenz; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 4 pages)

Lithologic description	Feet From	Feet To
Quaternary alluvium	0	11
Sandstone, medium-grained, yellow-brown	11	12
Shale, gray-brown	12	13
Coal; shale	13	14
Shale, gray-brown	14	19
Shale, carbonaceous	19	20
Coal; shale	20	22
Shale; siltstone	22	24
Shale, carbonaceous, gray; sand	24	26
Shale, gray	26	29
Mudstone, silty, light-gray	29	30
Mudstone, light-gray; carbonaceous shale	30	34
Mudstone, light-gray	34	36
Mudstone, light-gray; silty shale	36	37
Shale, carbonaceous	37	38
Coal; shale	38	39
Coal; mudstone	39	40
Shale; mudstone	40	41
Shale, gray	41	43
Shale, gray, carbonaceous	43	44
Shale, gray	44	45
Shale, gray; mudstone	45	46
Shale, gray; mud; sandstone	46	47

Lithologic description	Feet From	Feet To
Shale, gray; mudstone	47	48
Shale, green	48	49
Mudstone, gray	49	55
Mudstone, gray; gray, silty sandstone	55	56.5
Sandstone, very fine grained, gray	56.5	57.5
Shale; gray mudstone	57.5	58
Siltstone, gray	58	61
Mudstone, gray	61	67
Sandstone, silty; shale; mudstone	67	68
Siltstone; shale	68	69
Shale, gray-green	69	70.5
Shale; very fine grained sandstone	70.5	73
Siltstone, gray	73	74
Siltstone, brown-gray	74	75
Shale, carbonaceous	75	76
Mudstone, silty; white sandstone	76	78
Sandstone; coal	78	79
Coal; shale	79	81
Coal (SAMPLE NO. 1)	81	85
Coal; sandstone	85	87
Coal; sandstone; mudstone	87	89
Coal	89	95
Shale, carbonaceous; mudstone	95	97
Shale, carbonaceous	97	99
Coal; shale	99	100
Shale, carbonaceous	100	101

Lithologic description	Feet From	To
Shale; sandstone	101	102
Shale, carbonaceous, dark-gray	102	103
Coal; gray sandstone	103	104
Coal	104	107
Coal; carbonaceous shale	107	108
Coal; shale; mudstone	108	109
Mudstone, sandy	109	116
Sandstone; mudstone	116	120
Coal; sandstone; mudstone	120	124
Shale; mudstone	124	133
Shale; very fine grained sandstone	133	134
Sandstone, white; shale	134	135
Mudstone, sandy	135	136
Sandstone; coal	136	137
Sandstone, medium- to fine-grained, light-gray	137	138
Coal (SAMPLE NO. 2)	138	142
Shale, carbonaceous; sandy mudstone	142	146
Siltstone; silty shale	146	148
Siltstone, sandy	148	150
Siltstone, light-gray; white sandstone	150	154
Mudstone, silty, gray	154	156
Siltstone, brown	156	158
Sandstone; siltstone; mudstone	158	160
Coal; siltstone	160	161
Coal (SAMPLE NO. 3)	161	167
Coal; siltstone	167	168

Lithologic description	Feet From	Feet To
Silt; sandstone; coal	168	170
Shale, carbonaceous; sandstone; siltstone	170	171
Coal	171	173
Coal; siltstone; mudstone	173	174
Silt, carbonaceous; shale	174	176
Shale, gray-green	176	179
Siltstone, white-gray; shale	179	182
Siltstone; mudstone	182	184
Mudstone; sandstone; siltstone	184	190
Shale, carbonaceous	190	192
Siltstone	192	193
Shale, sandy	193	194
Sandstone, silty; carbonaceous shale	194	195
Siltstone, sandy, light-gray; shale	195	200
Siltstone, sandy, light-gray	200	203
Pictured Cliffs sandstone, silty, white	203	205
Sandstone, siliceous, white	205	218
Sandstone, siliceous, white; shale	218	221
Sandstone, white	221	226
Sandstone, white; siltstone, brown	226	227.5
Sandstone, siliceous, white	227.5	228
Total depth	228 feet	

Sample Log of Drill-Hole TL-8-2 (E)

(NE¼SW¼NE¼, sec. 8, T. 23 N., R. 12 W., New Mexico Principal Meridian, Tanner Lake quadrangle, San Juan County, New Mexico; surface elevation 5970; drilling started July 29, 1976; logged by J. E. Fassett, R. Cheeseman, and J. Lorenz; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 7 pages)

Lithologic description	Feet From	Feet To
Quaternary alluvium	0	9
Shale, gray-green; Quaternary alluvium	9	15
Shale, silty, greenish-tan	15	16
Siltstone, muddy	16	19
Sandstone, very fine grained, white; shale	19	20
Coal	20	23
Coal; siltstone; shale	23	24
Siltstone; shale	24	25
Shale, gray; white sandstone	25	25.5
Coal; shale	25.5	26
Coal	26	27.5
Mudstone	27.5	30
Shale; mudstone	30	32
Mudstone	32	36
Shale, greenish-brown	36	39
Shale, gray-green	39	40
Shale, gray	40	41
Shale, gray	41	42
Shale, carbonaceous	42	42.5
Shale, gray; coal	42.5	43
Shale, carbonaceous; gray shale	43	44
Shale, gray	44	46
Mudstone; brown siltstone; gray shale	46	49

Lithologic description	Feet From	To
Shale, carbonaceous; gray siltstone; mudstone	49	53
Mudstone, gray	53	57
Shale, gray	57	69
Shale, gray; brown silty mudstone	69	70
Mudstone, gray	70	71
Mudstone, sandy	71	72
Shale, carbonaceous; mudstone	72	74
Sandstone; silt; mudstone	74	75
Mudstone, silty	75	76
Sandstone, silty; mudstone	76	77
Sandstone, very fine grained, gray	77	78
Sandstone, fine-grained; clay	78	80
Sandstone; petrified wood; clay matrix	80	81
Clay; sandstone; organics	81	82
Sandstone; carbonaceous shale	82	83
Sandstone, fine-grained, well-cemented	83	84
Sandstone, clear gray-to-white; organics	84	85
Coal (SAMPLE NO. 1)	85	98.5
Coal; mudstone	98.5	99
Mudstone; brown, silty shale	99	100
Shale, gray	100	101
Siltstone, sandy	101	102
Shale, gray; coal	102	103
Sandstone, fine-grained, light-gray; shale	103	104
Sandstone; shale	104	107
Coal; sandstone; shale	107	109

Lithologic description	Feet From	Feet To
Shale; mudstone	109	110
Shale, dark-gray	110	110.5
Sandstone, very fine grained, white; shale	110.5	111
Sandstone, very fine grained, clayey, white; carbonaceous shale	111	112
Shale, gray; carbonaceous shale; sandstone; coal	112	114
Sandstone, fine-grained, white; clay matrix	114	114.5
Shale, gray	114.5	115
Sandstone, very fine grained	115	116
Sandstone, very fine grained; clay matrix	116	117
Sandstone, fine-grained	117	118
Sandstone, medium- to fine-grained, white	118	119
Sandstone, medium- to fine-grained, brown	119	120
Sandstone, medium- to fine-grained sandstone, light-gray	120	121
Sandstone, medium- to fine-grained, white	121	121.5
Sandstone, medium-grained, well-cemented, white	121.5	122
Sandstone, medium- to fine-grained, white; clay matrix	122	123
Shale, gray	123	124
Shale, carbonaceous, black	124	125
Sandstone; black, carbonaceous shale	125	126.5
Sandstone, very fine grained; coal	126.5	127
Siltstone, gray-green	127	128
Shale, gray; white, very fine grained sandstone	128	129
Shale, gray	129	130
Shale; sandstone	130	131
Shale, carbonaceous	131	132

Lithologic description	Feet From	To
Coal; gray shale; sandstone	132	133
Shale	133	135
Siltstone, gray; sandstone	135	136
Shale, green	136	140
Mudstone	140	140.5
Shale, brown-black; silty mudstone	140.5	141
Sandstone, very fine grained; light-gray mudstone	141	143
Mudstone	143	144
Shale	144	145
Siltstone, gray	145	146
Mudstone	146	146.5
Shale, black	146.5	147
Mudstone	147	147.5
Mudstone, sandy	147.5	148
Siltstone	148	148.5
Mudstone; siltstone	148.5	149
Sandstone; siltstone	149	150
Mudstone; sandstone; shale	150	150.5
Siltstone; mudstone	150.5	151
Siltstone, sandy	151	152
Shale, gray; mudstone	152	154
Shale, gray; mudstone; sandstone	154	155
Shale, gray-green	155	155.5
Sandstone, very fine grained; shale	155.5	156
Mudstone, silty	156	157.5
Siltstone, sandy	157.5	159

Lithologic description	Feet From	Feet To
Sandstone, fine-grained; mudstone	159	160
Sandstone, medium-fine-grained; mudstone; shale	160	161
Shale, carbonaceous; white sandstone; siltstone	161	162
Shale, carbonaceous	162	163
Coal	163	164
Coal; carbonaceous shale; siltstone (SAMPLE NO. 2)	164	165
Coal; hard sandstone (SAMPLE NO. 2)	165	166
Coal, sandy	166	167
Mudstone; siltstone	167	169
Coal; shale; siltstone	169	170
Siltstone, sandy; shale	170	171
Shale, black; brown siltstone; sandstone	171	172
Siltstone, sandy; white medium-grained sandstone; shale	172	173
Sandstone, medium-fine-grained, white	173	175
Shale, carbonaceous; sandstone	175	176
Siltstone, friable, sandy, brown	176	177
Sandstone, silty, medium-grained, white	177	178
Sandstone, fine-grained, clean, white	178	179
Sandstone, white; brown siltstone; green shale	179	180
Sandstone, shaly	180	181
Shale; sandstone	181	183
Siltstone; sandstone; carbonaceous shale	183	184
Sandstone, shaly; siltstone	184	185
Sandstone, very fine grained, light-gray	185	187
Shale, carbonaceous	187	188
Coal; sandy shale	188	190

Lithologic description	Feet From	To
Coal (SAMPLE NO. 3)	190	195
Shale, carbonaceous; coal	195	196
Shale; sandstone; coal; red quartz conglomerate pebbles 1-inch diameter	196	197
Shale, sandy; sandstone	197	198
Shale, sandy; siltstone; coal; petrified wood	198	200
Sandstone, fine-grained; shale	200	202
Shale; petrified wood; carbonaceous shale	202	203
Shale; sandstone	203	204
Coal; shale; sandstone	204	205
Coal	205	206
Sandstone, shaly	206	209
Coal; siltstone; shaly sandstone	209	211
Coal; siltstone	211	212
Shale; coal; siltstone; very fine grained sandstone	212	212.5
Coal; silt	212.5	213
Shale; coal; white sandstone	213	214
Coal; sandstone; siltstone; conglomerate cobble 2-inch diameter	214	215
Shale; sandstone	215	216
Coal; sandy shale	216	218
Sandstone, very fine grained, silty, white ; coal	218	221
Sandstone, silty, white; brown mudstone	221	223
Pictured Cliffs sandstone, very fine grained, white	223	224
Sandstone, very fine grained, white; shale	224	228
Sandstone, very fine grained, white	228	230
Sandstone, very fine grained, white; shale stringers	230	242

Lithologic description	Feet From	Feet To
Sandstone, fine-grained, clean, white	242	254
Total depth . . . . . 254 feet		

Sample Log of Drill-Hole SL-10-1

(SW¼SW¼SW¼, sec. 10, T. 20 N., R. 6 W., New Mexico Principal Meridian, Star Lake quadrangle, McKinley County, New Mexico; surface elevation 6,885; drilling started August 12, 1976; logged by J. E. Fassett, R. W. Jentgen, and D. Umshler; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 5 pages)

Lithologic description	Feet From	Feet To
Quaternary alluvium; clayey, fine-grained sandstone	0	4
Sandstone, slightly carbonaceous, medium-grained, brown	4	10
No sample taken	10	15
CORE	15	31.4
Shale, gray (SAMPLE NO. 1)	31.4	32
Shale, gray	32	42
Shale, sandy, light-gray (SAMPLE NO. 2)	42	45
Do. (SAMPLE NO. 3)	45	49
Shale, sandy, blue-gray	49	50
Do. (SAMPLE NO. 4)	50	52
Do.	52	61
Do. (SAMPLE NO. 5)	61	65
Do. (SAMPLE NO. 6)	65	67
CORE	67	96.6
No sample taken	96.6	111
Shale, silty, black; blue, sandy shale; clay	111	121
Shale, sandy, blue-gray; carbonaceous streaks; white, silty shale streaks	121	124
Sandstone, light-gray; shale	124	125
Sandstone, light-gray	125	130
Shale, carbaonceous, silty	130	133
Shale, blue-gray; hard siltstone	133	148
Siltstone, black-dark-gray	148	161
Sandstone, light-gray; interbedded blue-gray siltstone	161	171

Lithologic description	Feet From	Feet To
Sandstone, fine- to medium-grained, light- to dark-gray	171	178
Sandstone; blue-gray siltstone	178	185
Sandstone, fine- to medium-grained, salt-and-pepper, dark-gray	185	190
Sandstone, well-cemented, carbonaceous, dark-gray	190	195
Siltstone, carbonaceous, blue-gray	195	202
Sandstone, fine-grained, friable, white	202	205
Siltstone, dark-gray	205	208
Coal	208	210
Coal; carbonaceous shale	210	211
Sandstone, fine- to medium-grained, white; blue-gray siltstone	211	218
Coal; carbonaceous shale; sandstone; siltstone	218	221
Coal; carbonaceous shale	221	233
Shale, dark-gray	233	234
Sandstone, fine- to medium-grained, white; carbonaceous siltstone streaks	234	240
Shale, carbonanaceous; sandstone; blue siltstone	240	255
Siltstone, carbonaceous; clay	255	256
Sandstone, fine- to medium-grained, white	256	261
Coal	261	264
Siltstone, blue; white soft sandstone	264	267
Coal; carbonaceous shale	267	268
Sandstone, fine- to medium-grained, white	268	269
Siltstone, carbonaceous; coal	269	270
Coal	270	271
Siltstone, blue; white sandstone	271	272

Lithologic description	Feet From	To
Coal; carbonaceous shale	272	274
Siltstone, blue; sandstone	274	275
Siltstone, hard, blue	275	285
Siltstone, carbonaceous; clay	285	289
Coal; siltstone	289	299
Shale, hard, dark-gray; gray, sandy soft shale	299	300
Shale, hard, brittle, silty, dark-brown	300	302
Shale, sandy, dark-gray and light-gray	302	312
Shale, carbonaceous	312	315
Shale, hard, dark-gray; soft, light-gray silty shale	315	319
Sandstone, soft, shaly, light-gray	319	322
Shale, carbonaceous	322	323
Shale, brittle, dark-gray; light-gray, soft sandy shale	323	330
Sandstone, very fine grained, soft, white	330	335
Sandstone, very fine grained, brittle, white and gray	335	338
Shale, sandy, brown	338	339
Shale, brittle, dark-gray; light-gray, soft sandy shale	339	348
Sandstone, very fine grained, shaly, hard, brittle, light-gray	348	361
Sandstone, very fine grained, shaly, white, alternating soft and hard	361	365
Sandstone, very fine grained, gray; coaly streaks; brown shaly streaks	365	367
Shale, brittle, dark-gray; light-gray soft sandy shale	367	371
Shale, carbonaceous, brittle, dark-gray	371	374
Shale, brittle, dark-gray; light-gray soft sandy shale	374	376
Sandstone, very fine grained, shaly, dark-gray and light-gray	376	394

Lithologic description	Feet From	To
Sandstone, very fine grained, very shaly, light-gray; blue, very fine grained sandstone	394	397
Shale, hard, dark-gray; white, soft shaly, very fine grained sandstone	397	401
Sandstone, very fine grained, shaly, gray and white	401	413
Shale, soft, sandy, very light-gray	413	417
Shale, brittle, dark-gray; light-gray, sandy, soft shale	417	424
Sandstone, soft, shaly, light-gray	424	431
Sandstone; light-gray shale	431	432
Sandstone, blue; light-gray, sandy, soft shale	432	433
Shale, soft, sandy, light-gray	433	438
Sandstone, soft, shaly, light-gray	438	456
Siltstone, dark-blue-gray	456	457
Siltstone, dark-gray; dark-gray shale	457	459
Sandstone, soft, blue-green	459	464
Sandstone, fine- to medium-grained, white; carbonaceous shale	464	466
Sandstone, fine- to medium-grained, white; carbonaceous shale; blue siltstone	466	468
Siltstone, blue	468	471
Shale, dark-gray; blue siltstone	471	473
Shale, green	473	476
Sandstone, fine- to medium-grained, white; green shale	476	477
Shale, carbonaceous; coal streak	477	478
Siltstone, blue; white, shaly sandstone	478	485
Shale, dark-gray	485	489
Shale, silty, dark-green	489	490
Shale, dark-gray; white, fine- to medium-grained sandstone	490	494

Lithologic description	Feet From	Feet To
Shale, dark-gray	494	499
Shale, sandy, light-gray	499	503
Coal; very fine grained sandstone	503	505
Shale, brittle, dark-gray; light-gray, sandy, soft shale	505	505.5
Shale, dark-gray; coal	505.5	507
Coal	507	509
CORE	509	515
No sample taken	515	522
Sandstone, fine-grained, soft, gray	522	533
Shale, carbonaceous, greasy	533	538
Sandstone, shaly, gray	538	552
Sandstone, fine-grained, salt-and-pepper, light-gray	552	568
Shale, carbonaceous	568	569
Sandstone, light-gray	569	571
Coal	571	574
Sandstone, light-gray	574	595
Shale, dark-gray	595	596
Coal; carbonaceous shale	596	598
Shale, carbonaceous; dark-gray shale; brown carbonaceous siltstone	598	611
Sandstone, fine-grained, light-gray	611	651
Total depth 651 feet		

Description of Core from SL-10-1

(SW¼SW¼SW¼, sec. 10, T. 20 N., R. 6 W., New Mexico Principal Meridian, Star Lake quadrangle, McKinley County, New Mexico; surface elevation 6,885; drilling started August 12, 1976; described by R. W. Jentgen; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 2 pages)

Lithologic description	Feet From	Feet To
Sandstone, fine-grained, light-yellow; sub-angular quartz grains with zones containing clay balls becoming more frequent near bottom of sand	15.0	21.0
Clay-ball conglomerate, ½-cm to 1½-cm diameter, sandstone-cemented	21.0	21.5
Shale, silty, yellow-gray	21.5	21.9
Shale, silty, dark-gray with yellow splotches	21.9	25.0
Sandstone, light-yellow; sub-angular, fine-grained quartz	25.0	26.1
Shale, silty, gray-green with yellow splotches	26.1	27.0
Shale, gray-green; white sand streaks	27.0	28.8
Shale, gray-green with yellow splotches	28.8	31.4
No core taken	31.4	67.0
Sandstone, very fine grained, white	67.0	68.9
Sandstone, medium-grained, sub-angular, gray	68.9	70.0
Sandstone, medium-grained, sub-angular, clayey, light-gray to white	70.0	77.6
Sandstone, coarse- to medium-grained, sub-rounded, quartzitic, gray	77.6	78.0
Sandstone, medium-grained, sub-rounded, clayey, light-gray to white, some dark streaks	78.0	78.8
Sandstone, medium- to coarse-grained, sub-rounded, gray, some dark streaks	78.8	80.4
Sandstone, medium- to fine-grained, sub-angular, clayey, light-gray	80.4	80.8
Sandstone, medium- to coarse-grained, sub-rounded, zones of 2-cm clay balls and lenses, light-gray	80.8	82.8
Sandstone, medium-grained, sub-angular, clayey, light-gray	82.8	84.8

Lithologic description	Feet From	Feet To
Sandstone, fine-grained, light-gray; sub-rounded 1.5-cm clay balls	84.8	85.3
Sandstone, medium-grained, sub-angular, light-gray to white, clayey	85.3	86.9
Sandstone, fine-grained, sub-angular, silty, clayey, gray	86.9	88.0
Sandstone, fine-grained, light-gray; sub-angular 1.5-cm dark clay balls; long clay streaks and swirls . . .	88.0	92.7
Sandstone, coarse-grained, light-gray to white; 3- to 5-cm, 10 percent pyritic, dark clay balls	92.7	93.8
Shale, silty, gray-green	93.8	96.6
No core taken	96.6	509
Coal	509	511.6
Sandstone, very fine grained, clayey, gray; small coal fragments	511.6	513.1
Shale, carbonaceous, black	513.1	515

Total core thickness . . . . . 51.0 feet

Sample Log of Drill-Hole OEM-28-1

(SE¼SE¼, sec. 18, T. 20 N., R. 5 W., New Mexico Principal Meridian, Ojo Encino Mesa quadrangle, McKinley County, New Mexico; surface elevation 6,820; drilling started August 17, 1976; logged by R. W. Jentgen and D. Umshler; all measurements are in feet; to convert to meters, multiply by 0.3048; page 1 of 5 pages)

Lithologic description	From	To
Shale	0	2
Shale, limonite-coated, brown to dark-yellow to light-gray	2	9
Sandstone, fine- to medium-grained, dark-brown; gray-green-brown, sandy shale	9	11
Sandstone, fine-grained, well-cemented, white with red-brown stains	11	25
Sandstone; gypsum	25	26
Shale, limonite-coated, light-gray	26	27
Shale, sky-blue	27	27.5
Shale, navy-gray	27.5	28
Sandstone, fine-grained, well-cemented, yellow coated, white	28	36
Sandstone, medium-grained, coarse	36	44
Sandstone, very fine grained, white; yellow-coated, gray shale	44	47
Shale, light-blue-gray	47	48
Shale, silty, dark-gray	48	51
Shale, silty, black and dark-blue mixed	51	55
Shale, silty, dark-gray-green	55	57
Sandstone, fine-grained, dark-gray-green; shale	57	62
Shale, silty, hard, dark-gray-green	62	67
Sandstone, fine-grained, hard, white to gray	67	72.5
Shale, carbonaceous	72.5	73
Shale, silty, dark-gray-green	73	74

Lithologic description	Feet From	Feet To
Shale, silty, dark-gray	74	75
Shale, silty, dark-gray-green	75	78
Shale, carbonaceous, silty, dark-gray	78	84
Shale, silty, dark-gray	84	85
Shale, carbonaceous, silty	85	86
Shale, silty, gray-green	86	88.5
Shale, carbonaceous, silty, black	88.5	90
Sandstone, fine-grained, hard, white-gray; gray, silty, carbonaceous shale	90	93
Shale, silty, dark-gray-green	93	100
Shale, carbonaceous, silty, dark-gray-green	100	111
Sandstone, fine-grained, white to dark-gray-green	111	114
Sandstone, fine-grained, hard, white	114	118
Shale, carbonaceous	118	119
Sandstone, fine-grained, white; dark-gray-green, silty shale	119	120
Shale, carbonaceous, silty, gray-green	120	124
Shale, very silty, gray	124	125
Sandstone, fine-grained, shaly, white-gray	125	129
Shale, carbonaceous, white-gray-green; fine-grained sandstone	129	131
Shale, carbonaceous	131	133
Shale, dark-gray	133	135
Shale, carbonaceous	135	137
Shale, black	137	140
Shale, silty, dark-gray-green	140	142
Sandstone, fine-grained, hard, shaly, white-gray	142	149
Shale, carbonaceous, silty; gray shale streaks	149	154

Lithologic description	Feet From	Feet To
Shale, carbonaceous, silty, dark-gray	154	160
Shale, silty, slightly carbonaceous, gray	160	168
Shale, silty, dark-gray	168	170
Shale, carbonaceous, silty; coal streak	170	172
Shale, carbonaceous, silty, gray	172	178
Shale, very silty, gray	178	182
Shale, carbonaceous, silty, dark-gray	182	185
Shale, carbonaceous, silty	185	188
Shale, silty, slightly carbonaceous, dark-gray; clay	188	193
Shale, carbonaceous, silty, black	193	195
Shale, silty, black	195	197.5
Sandstone, fine-grained, soft, shaly, white	197.5	198
Shale, carbonaceous	198	203
Shale, silty, dark-gray	203	206
Shale, silty, dark-gray; clay	206	207
Shale, carbonaceous, silty; clay	207	210
Shale, silty, dark-gray-green	210	215
Shale, hard, silty, blue-gray	215	217
Sandstone, fine-grained, shaly, white-gray	217	229
Shale, silty, gray	229	235
Shale, carbonaceous; coal	235	238
Shale, silty, gray; clay	238	244
Shale, carbonaceous, silty, black; clay	244	249
Shale, silty, gray; clay	249	254
Shale, sandy, gray; clay	254	255
Sandstone, fine-grained, white to gray	255	261

Lithologic description	Feet From	Feet To
Sandstone, fine-grained, soft, shaly, white	261	262
Sandstone, fine-grained, hard, gray	262	265
Sandstone, fine-grained, soft, shaly, white	265	270
Shale, silty, dark-gray; white, soft, shaly, fine-grained sandstone	270	271
Sandstone, fine-grained, soft, shaly, white	271	297
Shale, silty, dark-gray	297	310
Coal	310	311.5
Shale, carbonaceous	311.5	312
Shale, brittle, silty, dark-gray	312	315
Sandstone, soft, shaly, light-gray	315	316
Shale, brittle, silty, dark-gray	316	321
Sandstone, very fine grained, shaly, hard, light-blue	321	324
Shale, brittle, silty, dark-gray	324	326
Sandstone, fine-grained, soft, shaly, white	326	329
Sandstone, fine-grained, soft, shaly, white- and dark-streaked	329	331
Shale, brittle, silty, dark-gray	331	340
Shale, silty, soft, light-gray	340	341
Shale, silty, brittle, dark-gray; streaks of white soft sandy shale	341	351
Sandstone, very fine grained, shaly, soft, gray	351	352
Shale, silty, brittle, dark-gray; soft white shale	352	355
Coal	355	356
Shale, silty, brittle, dark-gray; soft white shale	356	357
Coal	357	357.5
Shale, brittle, dark-gray; soft white shale	357.5	360
Sandstone, very fine grained, shaly, soft, white	360	362

Lithologic description	Feet From	Feet To
Coal; carbonaceous shale	362	363
Shale, silty, soft, white	363	365
Shale, silty, brittle, dark-gray; soft white shale	365	371
Sandstone, very fine grained, shaly, soft, white	371	373
Shale, silty, brittle, dark-gray; soft white shale	373	374
Sandstone, very fine grained, white and gray	374	379
Sandstone, very fine grained, soft, shaly, white	379	393
Coal (SAMPLE NO. 1)	393	401
Do. (SAMPLE NO. 2)	401	409
Sandstone, very fine grained, shaly, soft, white	409	414
Coal	414	416
Sandstone, very fine grained, shaly, soft, light-gray	416	420
Shale, soft, sandy, gray	420	425
Sandstone, shaly, soft, gray	425	430
Shale, soft, sandy, gray	430	431
Sandstone, shaly, soft, gray	431	435
Sandstone, very fine grained, shaly, soft, white	435	445
Total depth	445 feet	

Figure 10. Geophysical logs of drill-hole TL 25-1

Hole location: SW SW, sec. 25, T. 23 N., R. 13 W. N.M.P.M., San Juan County, N.M.

Ground elevation: 6130 ft.

Drill-bit size (diameter): 4-0 in.

Drilling medium: mud

Total depth: 104 ft.

Logged depth: 100 ft.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Time constant: 2 sec.

Logged by: K. Luttrell

Observed by: Jentgen
Umshier

Date logged: July 21, 1976

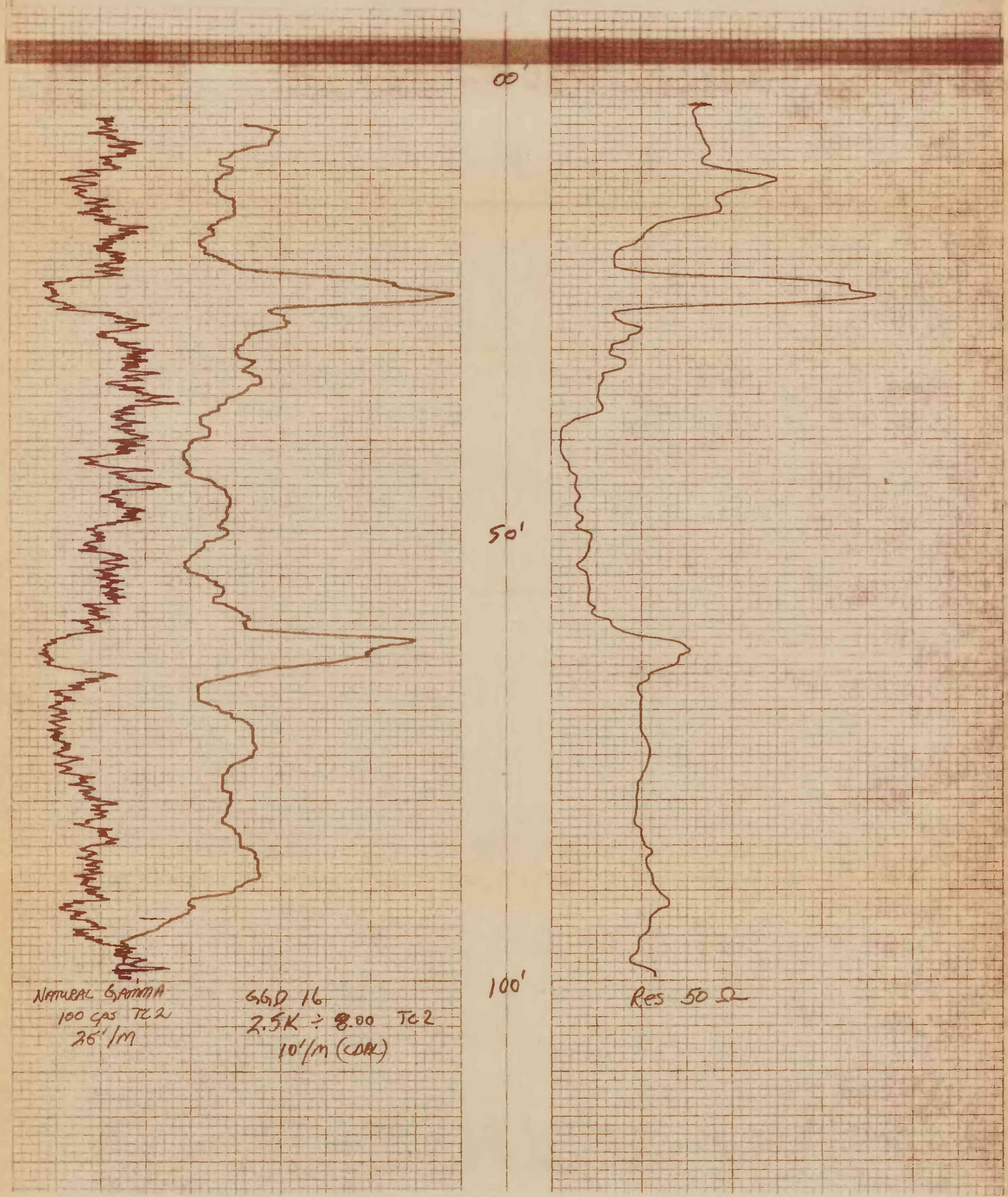

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Figure 11. Geophysical logs of drill-hole TL 26-1

Hole location: SE NW, sec. 26, T. 23 N., R. 13 W. N.M.P.M., San Juan County, N.M.

Ground elevation: 6105 ft.

Drill-bit size (diameter): 4-0 in.

Drilling medium: mud

Total depth: 74 ft.

Logged depth: 71 ft.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Time constant: 2 sec.

Logged by: K. Luttrell

Observed by: Jentgen
Umshler

Date logged: July 21, 1976

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Figure 12. Geophysical logs of drill-hole TL 27-1

Hole location: SE NE, sec. 27, T. 23 N., R. 13 W. N.M.P.M., San Juan County, N.M.

Ground elevation: 6105 ft.

Drill-bit size (diameter): 4-6 in.

Drilling medium: mud

Total depth: 182 ft.

Logged depth: 166 ft.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Time constant: 2 sec.

Logged by: K. Luttrell

Observed by: Jentgen
Umshler

Date logged: July 21, 1976

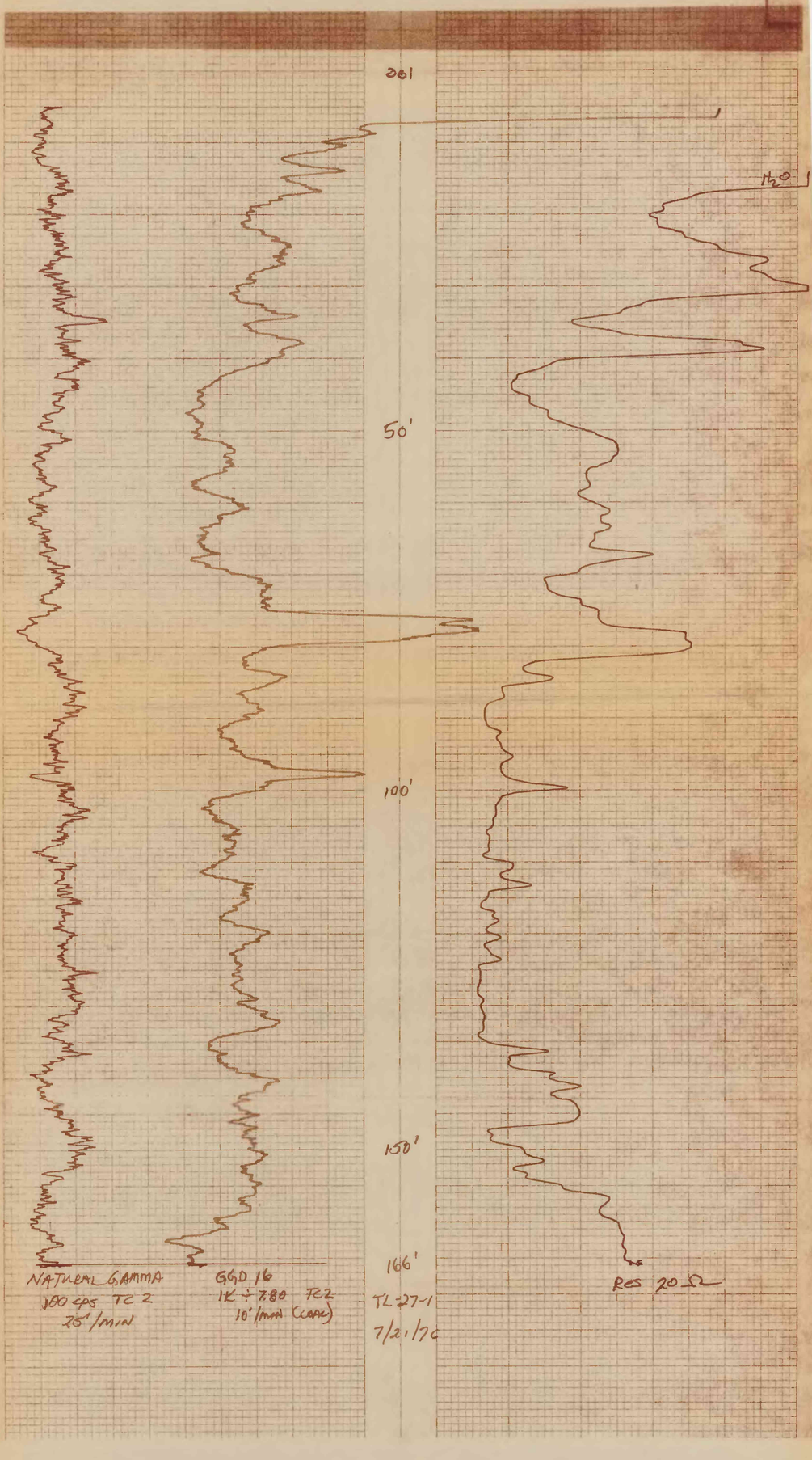

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Figure 13. Geophysical logs of drill-hole TL 27-2

Hole location: SE SE, sec. 27, T. 23 N., R. 13 W. N.M.P.M., San Juan County, N.M.

Ground elevation: 6,050 ft.

Drill-bit size (diameter): 4-0 in.

Drilling medium: mud

Total depth: 60 ft.

Logged depth: 57 ft.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Time constant: 2 sec.

Logged by: E. Luttrell

Observed by: Jentgen
Umshier

Date logged: July 21, 1976

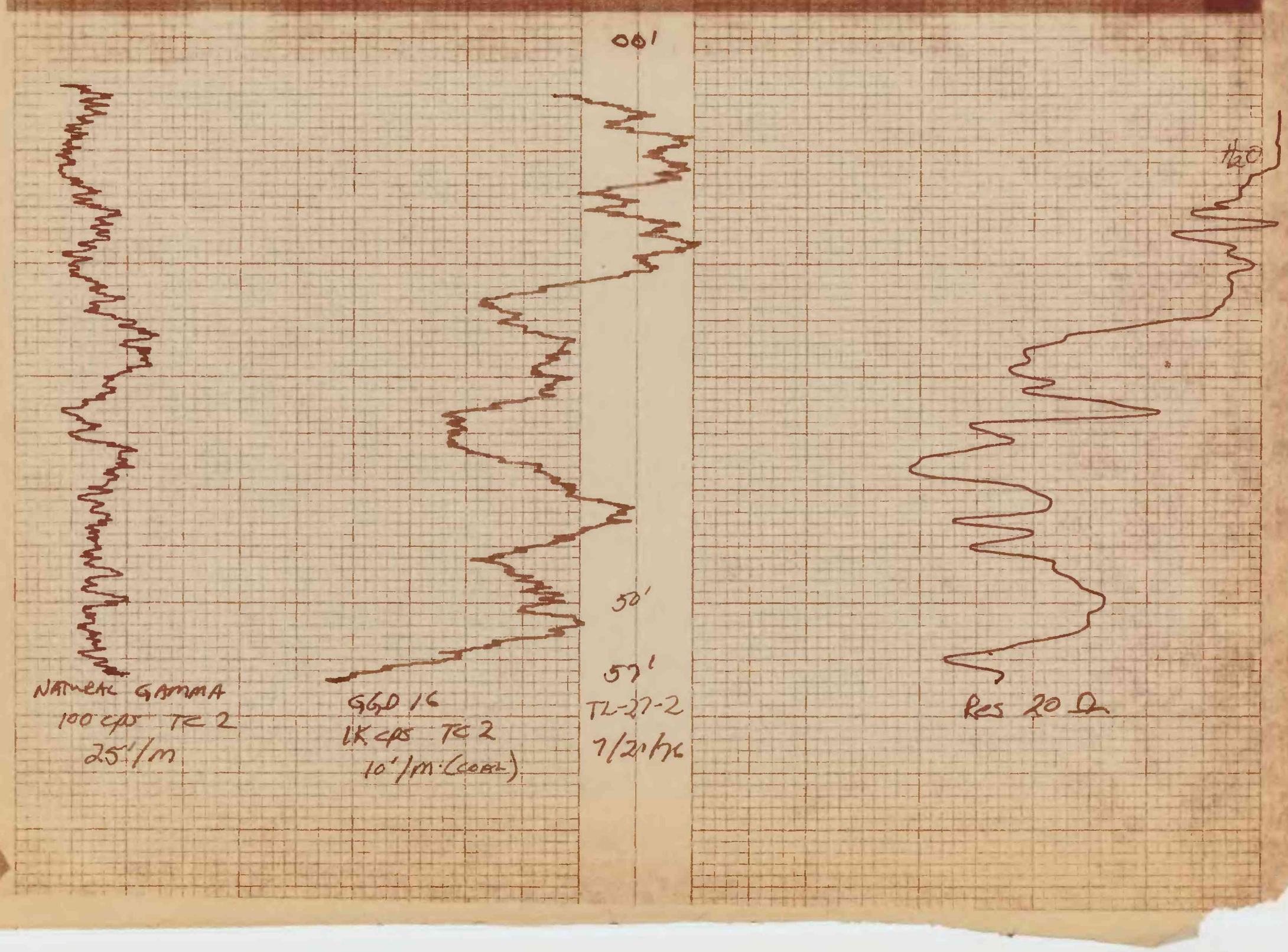

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Figure 17. Geophysical logs of drill-hole AMW 5-2

Hole location: SW SE, sec. 5, T. 23 N., R. 12 W. N.M.P.M., San Juan County, N.M.	Logger speed: 25 ft/min gamma & resistivity 10 ft/min density
Ground elevation: 5,938 ft.	Time constant: 2 sec.
Drill-bit size (diameter): 4-0 in.	Logged by: K. Luttrell
Drilling medium: mud	Observed by: Fassett Jentgen
Total depth: 259 ft.	
Logged depth: 256 ft.	Date logged: August 4, 1976

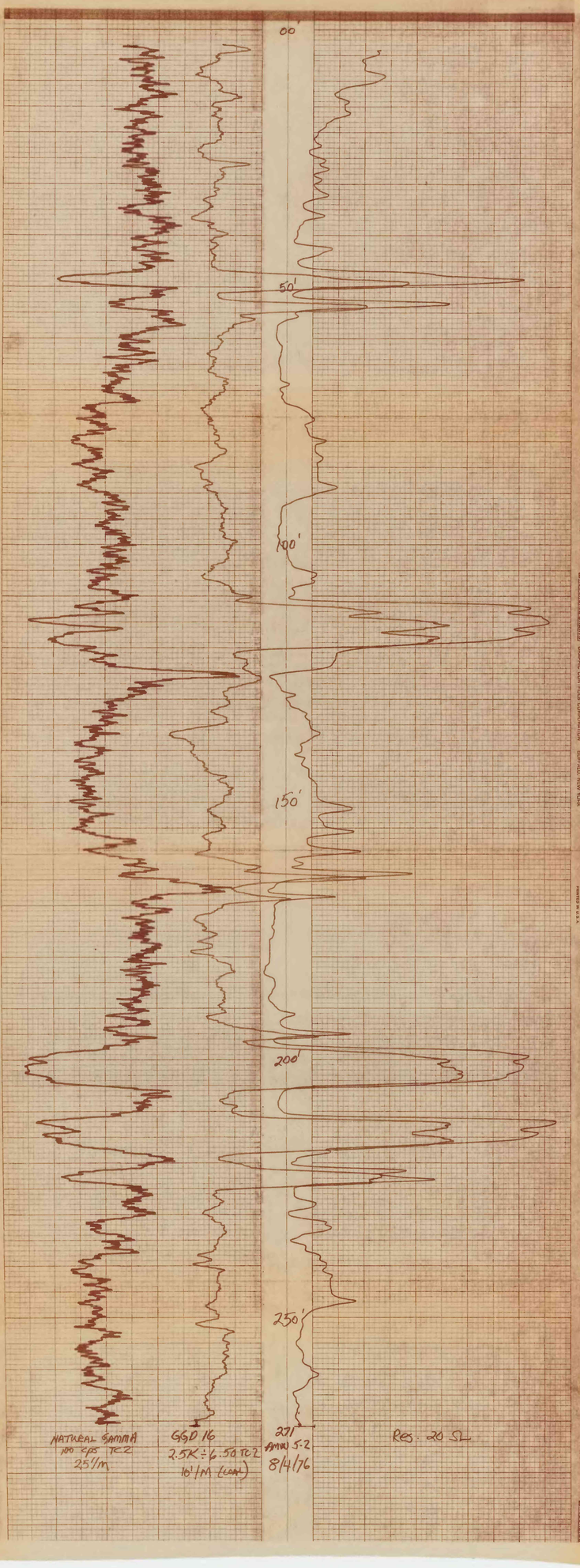

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Figure 18. Geophysical logs of drill-hole AMW 6-1

Hole location: SW SW, sec. 6, T. 23 N., R. 12 W. N.M.P.M., San Juan County, N.M.

Ground elevation: 5,920 ft.

Drill-bit size (diameter): 4-0 in.

Drilling medium: mud

Total depth: 214 ft.

Logged depth: 212 ft.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Time constant: 2 sec.

Logged by: K. Luttrell

Observed by: Jentgen

Date logged: August 4, 1976

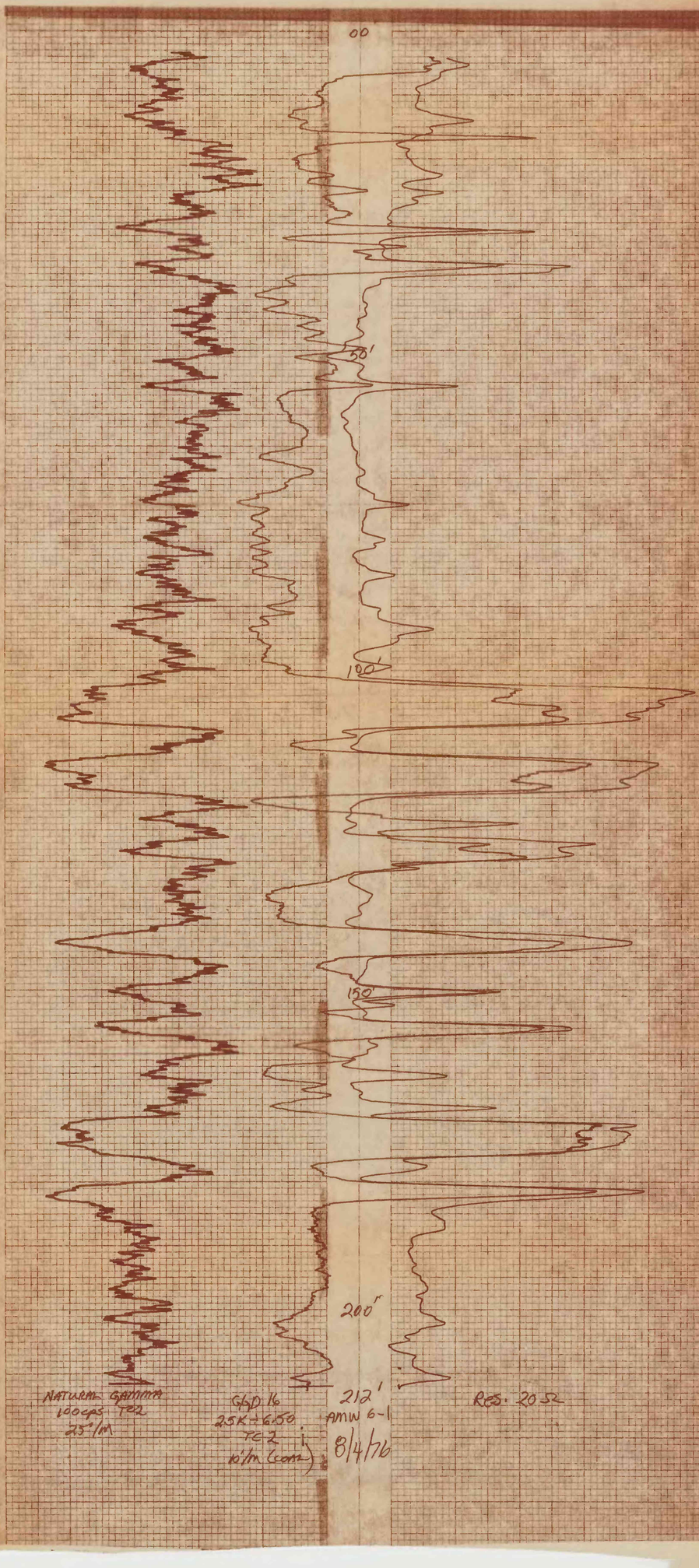

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Figure 19. Geophysical logs of drill-hole AMW 6-2

Hole location: SE SE, sec. 6, T. 23 N., R.12 W. N.M.P.M., San Juan County, N.M.

Ground elevation: 5,933 ft.

Drill-bit size (diameter): 4-0 in.

Drilling medium: mud

Total depth: 243 ft.

Logged depth: 240 ft.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Time constant: 2 sec.

Logged by: K. Luttrell

Observed by: Jentgen

Date logged: August 4, 1976

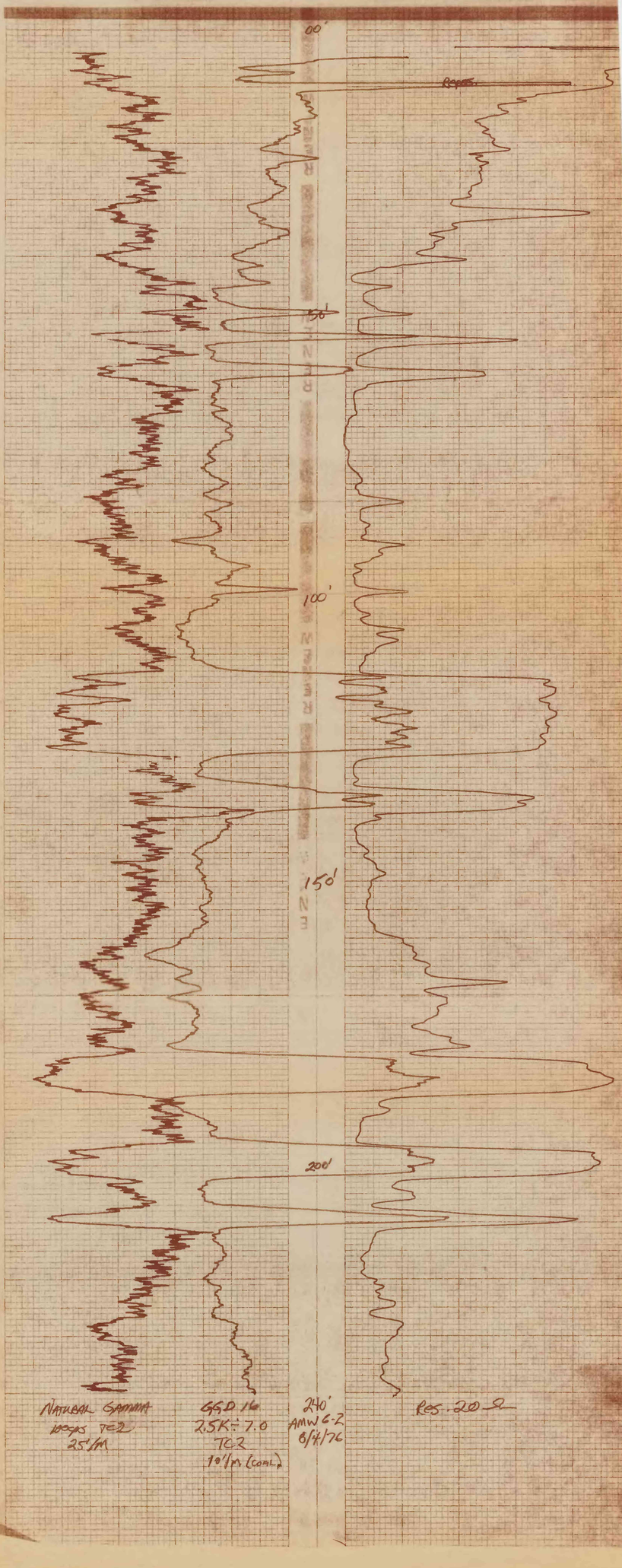

Figure 20. Geophysical logs of drill-hole TL 7-1

Hole location: C NW¼, sec. 7, T. 23 N., R. 12 W. N.M.P.M., San Juan County, N.M.

Ground elevation: 5,958 ft.

Drill-bit size (diameter): 4-0 in.

Drilling medium: mud

Total depth: 150 ft.

Logged depth: 135 ft.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Time constant: 2 sec.

Logged by: K. Luttrell

Observed by: Fassett

Date logged: August 3, 1976

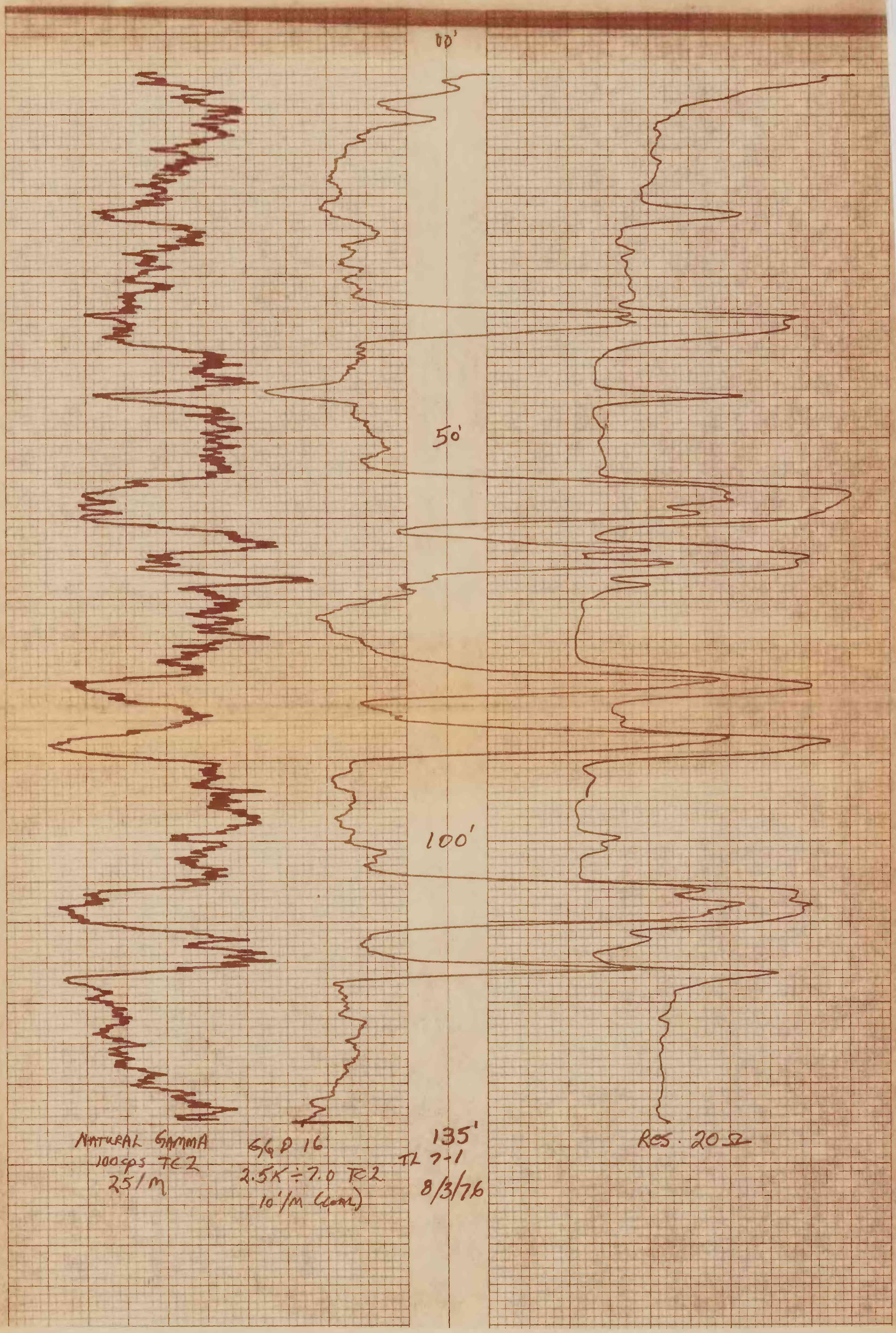

Figure 21. Geophysical logs of drill-hole TL 7-2

Hole location: SW NE, sec. 7, T. 23 N., R. 12 W. N.M.P.M., San Juan County, N.M.

Ground elevation: 5,925 ft.

Drill-bit size (diameter): 4-0 in.

Drilling medium: mud

Total depth: 182 ft.

Logged depth: 162 ft.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Time constant: 2 sec.

Logged by: K. Luttrell

Observed by: Fassett

Date logged: August 3, 1976

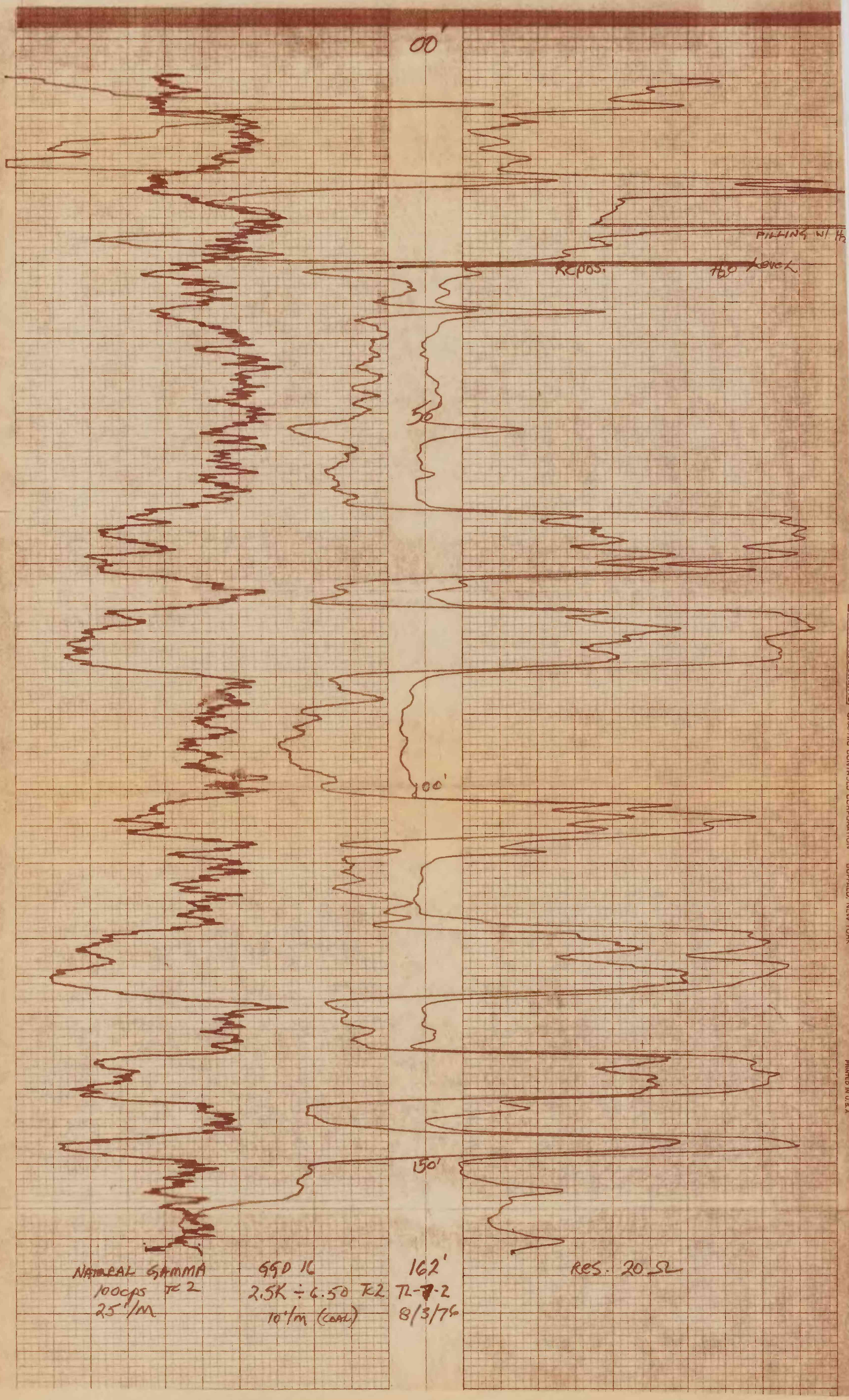

Figure 22.—Geophysical logs of drill-hole TL 8-1

Hole location: SW NW, sec. 8, T. 23 N., R. 12 W. N.M.P.M., San Juan County, N.M.

Ground elevation: 5,920 ft.

Drill-bit size (diameter): 4-0 in.

Drilling medium: mud

Total depth: 228 ft.

Logged depth: 224 ft.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Time constant: 2 sec.

Logged by: K. Luttrell

Observed by: Fassett

Date logged: August 3, 1976

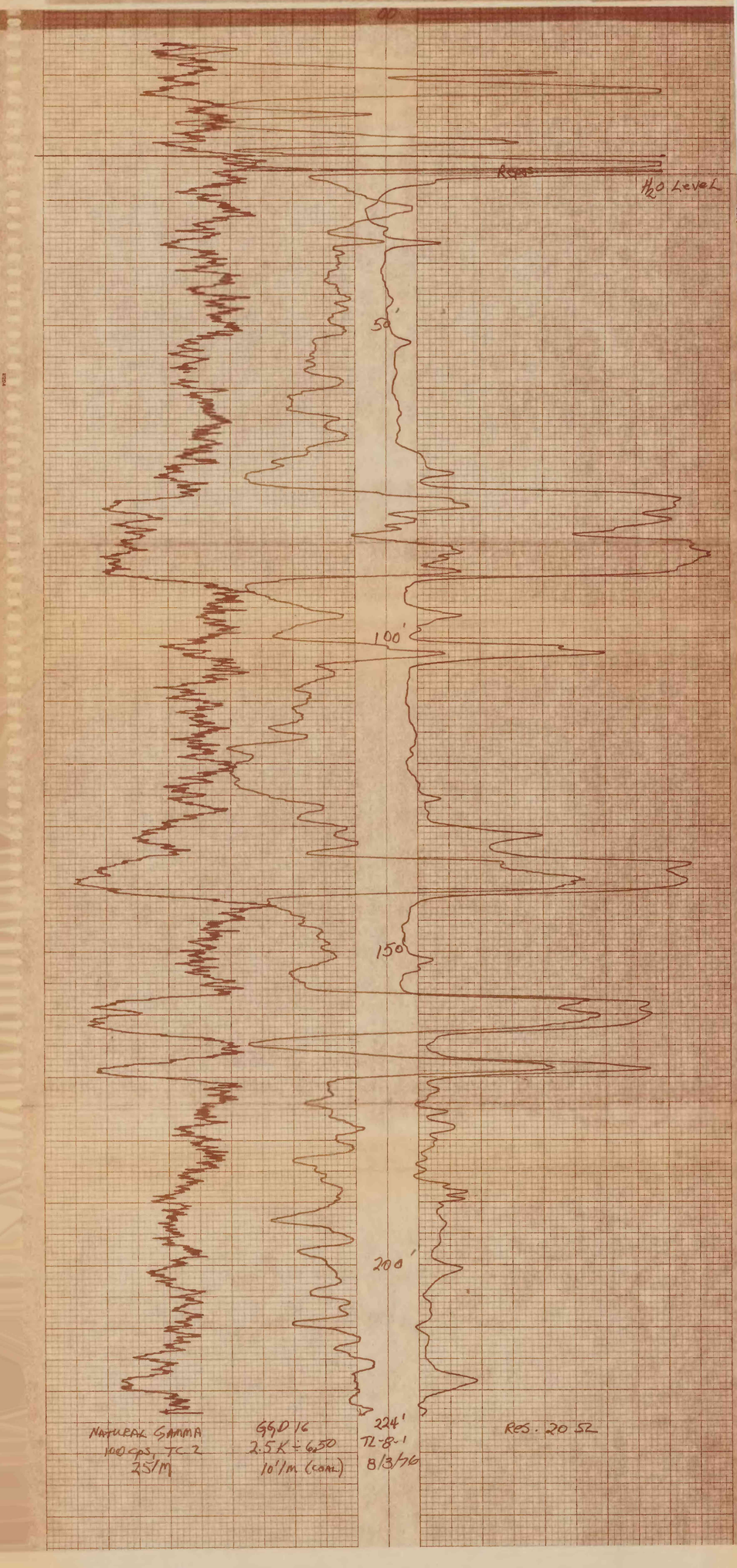

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Figure 23. Geophysical logs of drill-hole TL 8-2

Hole location: SW NE, sec. 8, T. 23 N., R. 12 W. N.M.P.M., San Juan County, N.M.

Ground elevation: 5,970 ft.

Drill-bit size (diameter): 4-0 in.

Drilling medium: mud

Total depth: 254 ft.

Logged depth: 248 ft.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Time constant: 2 sec.

Logged by: K. Luttrell

Observed by: Fassett

Date logged: August 3, 1976

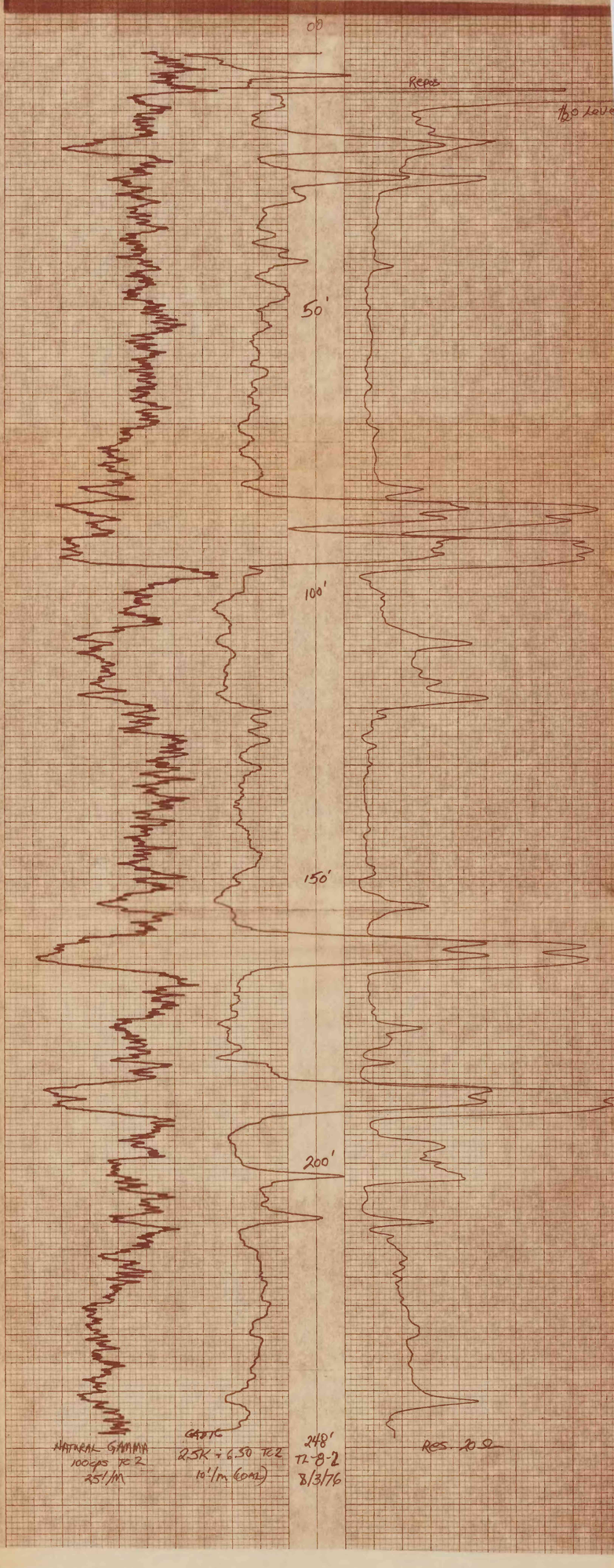

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Figure 24.

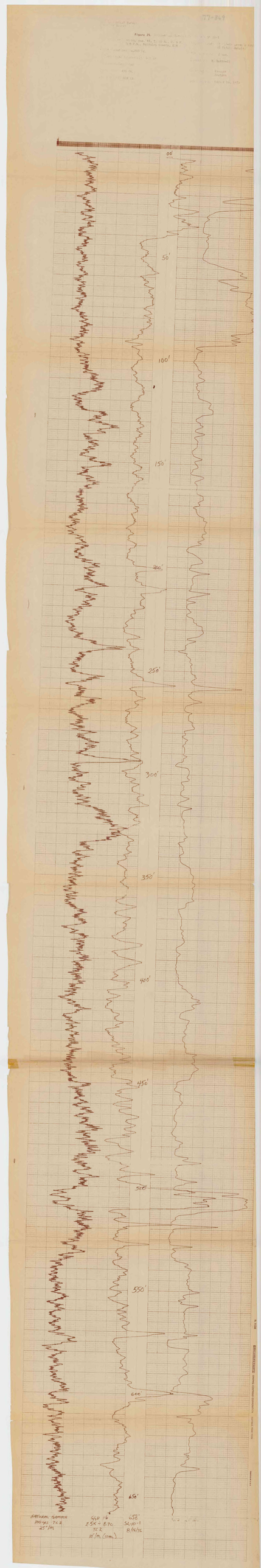

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Figure 25. Geophysical logs of drill-hole DEM 28-1

Hole location: SE SE, sec. 28, T. 20 N., R. 3 W., N.M.P.M., McKinley County, N.M.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Ground elevation: 6,810 ft.

Time constant: 2 sec.

Drill-bit size (diameter): 4-0 in.

Logged by: K. Luttrell

Drilling medium: mud

Observed by: Jeargen

Total depth: 465 ft.

Logged depth: 439 ft.

Date logged: August 18, 1976

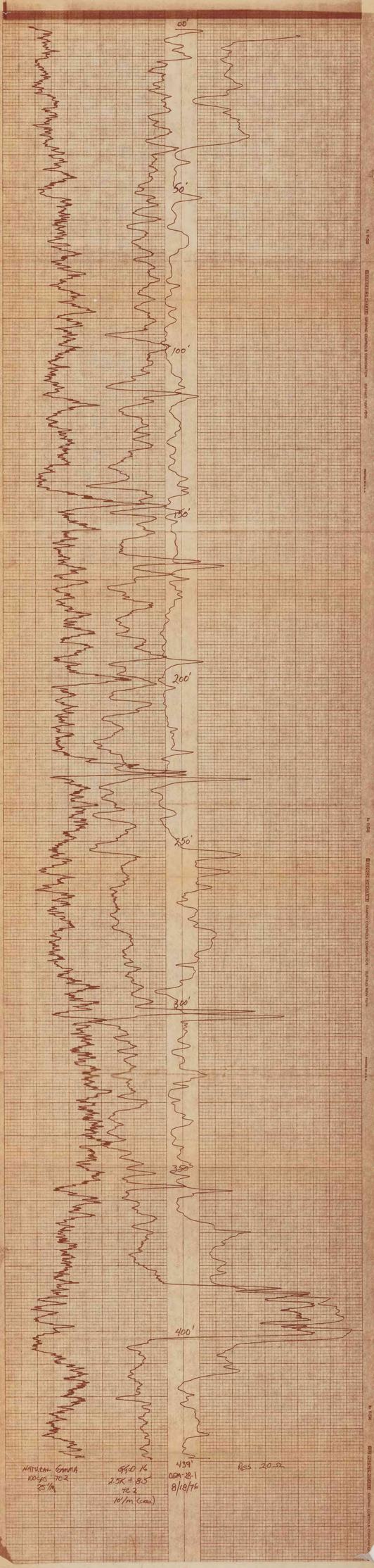

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Figure 6. Geophysical logs of drill-hole BS 8-1

Hole location: NW NE, sec. 8, T. 14 N., R. 17 W. N.M.P.M., McKinley County, N.M.

Ground elevation: 7,225 ft.

Drill-bit size (diameter): 4-0 in.

Drilling medium: mud

Total depth: 227 ft.

Logged depth: 208 ft.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Time constant: 2 sec.

Logged by: Lutkens
Shriner

Observed by: Fassett
Jentgen
Umshler

Date logged: June 29, 1976

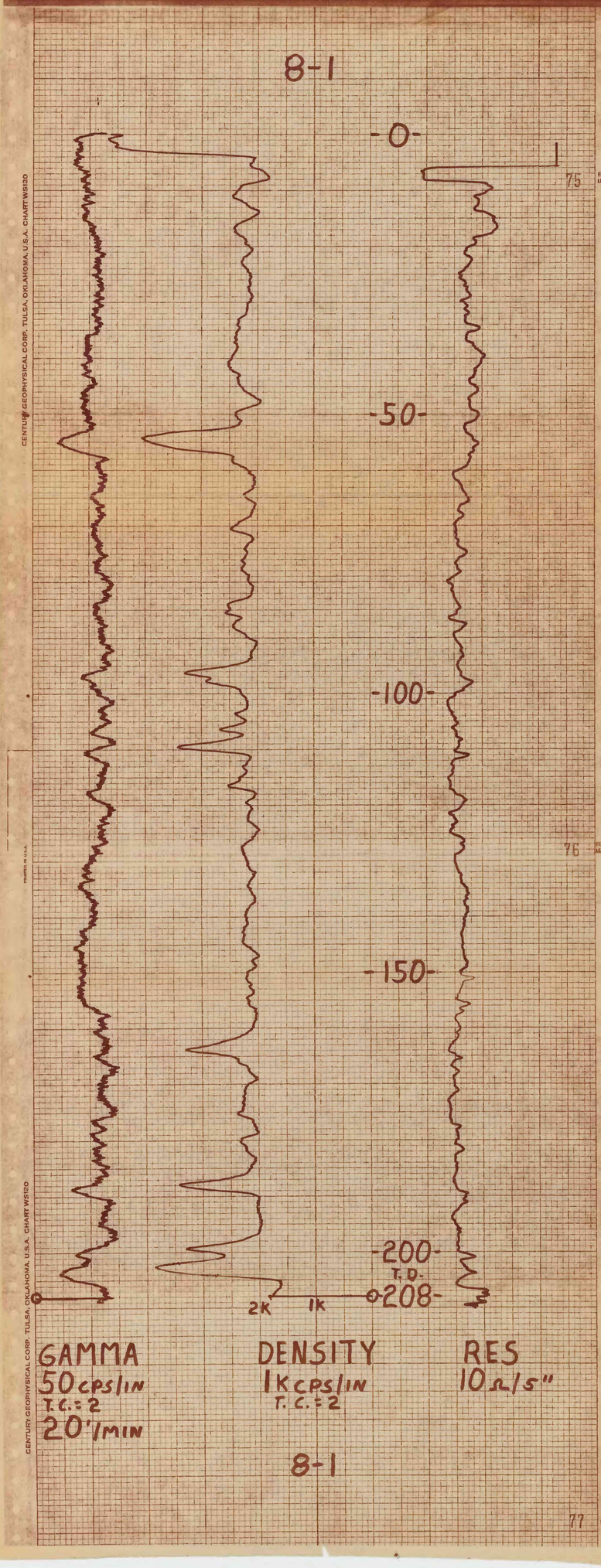

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Figure 7. Geophysical logs of drill-hole BS 8-2

Hole location: NE NW, sec. 8, T. 14 N., R. 17 W. N.M.P.M., McKinley County, N.M.

Ground elevation: 7,235 ft.

Drill-bit size (diameter): 4-0 in.

Drilling medium: mud

Total depth: 179 ft.

Logged depth: 158 ft.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Time constant: 2 sec.

Logged by: Luikens
Shriner

Observed by: Fassett
Jentgen
Umshler

Date logged: June 29, 1976

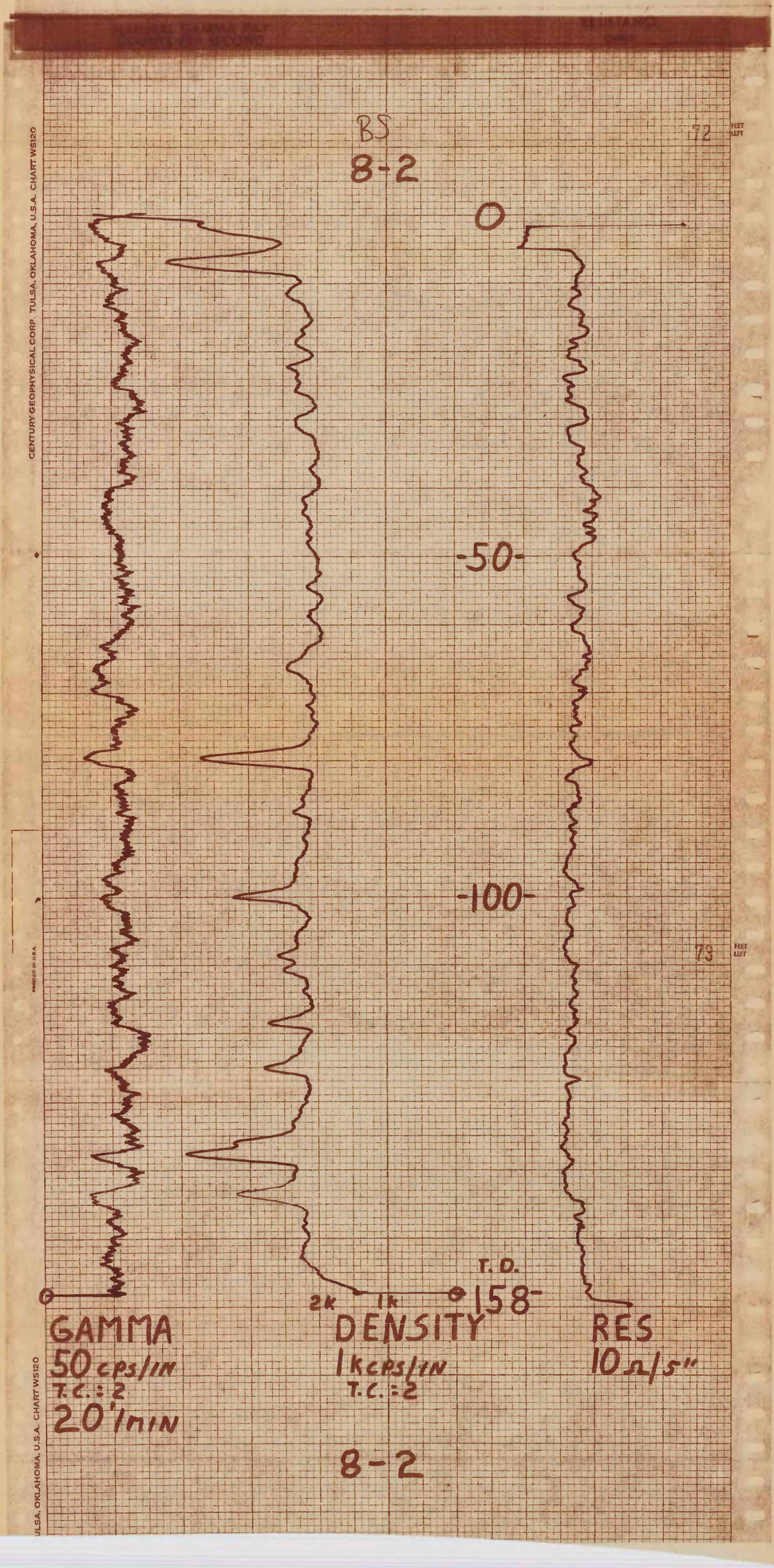

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Figure 8. Geophysical logs of drill-hole BS 8-3

Hole location: SE NW, sec. 8, T. 14 N., R. 17 W. N.M.P.M., McKinley County, N.M.

Ground elevation: 7,150 ft.

Drill-bit size (diameter): 4-0 in.

Drilling medium: mud

Total depth: 193 ft.

Logged depth: 186 ft.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Time constant: 2 sec.

Logged by: Suny M.
Jim L.

Observed by: Fassett
Umshler

Date logged: July 1, 1976

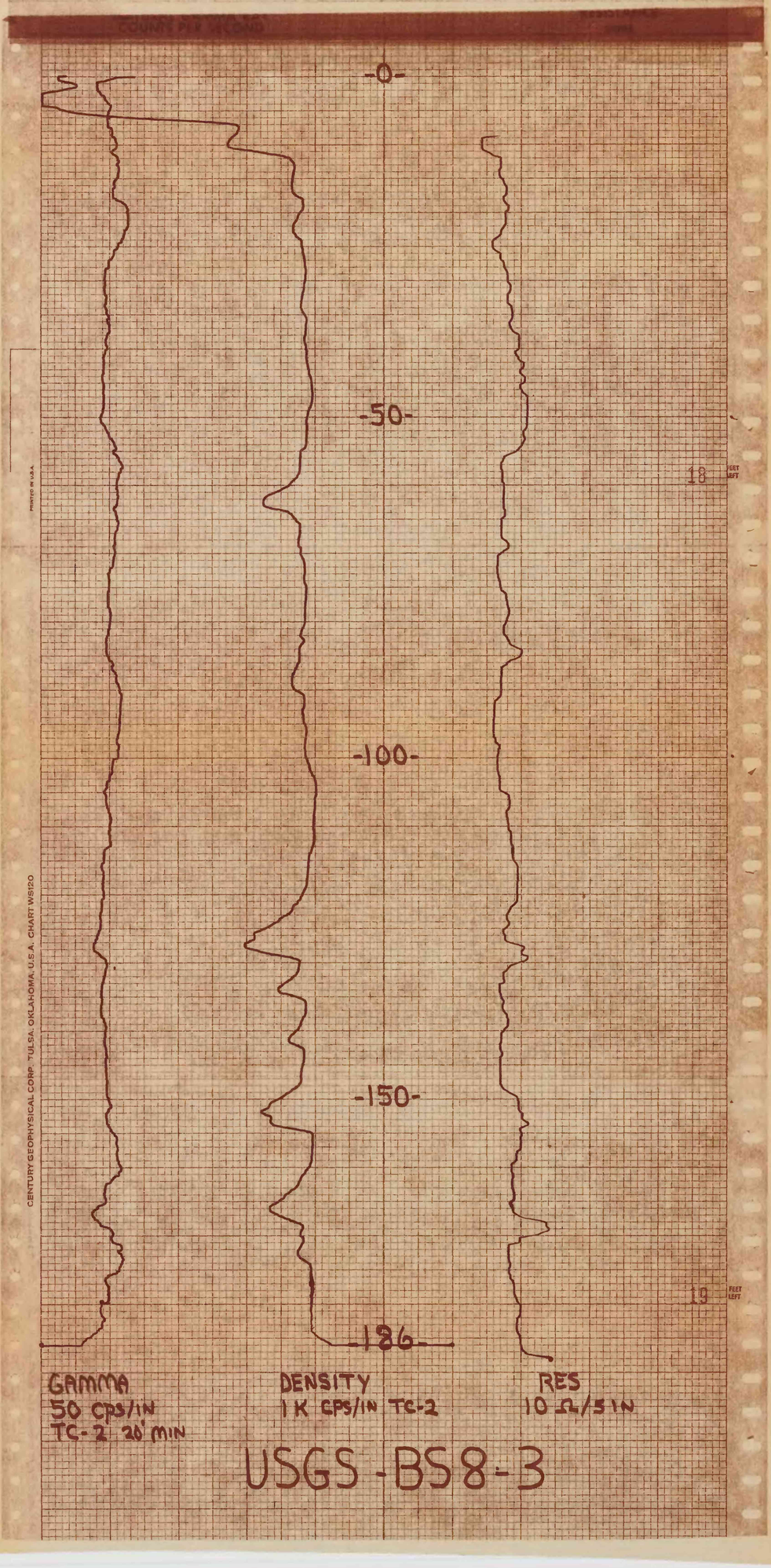

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Figure 9. Geophysical logs of drill-hole BS 8-4

Hole location: NW SE, sec. 8, T. 14 N., R. 17 W. N.M.P.M., McKinley County, N.M.

Ground elevation: 7,140 ft.

Drillbit size (diameter): 4-0 in.

Drilling medium: mud

Total depth: 168 ft.

Logged depth: 163 ft.

Logged speed: 25 ft/min gamma & resistivity
10 ft/min density

Time constant: 2 sec.

Logged by: Suny M.
Jim L.

Observed by: Fassett
Umshler

Date logged: July 1, 1976