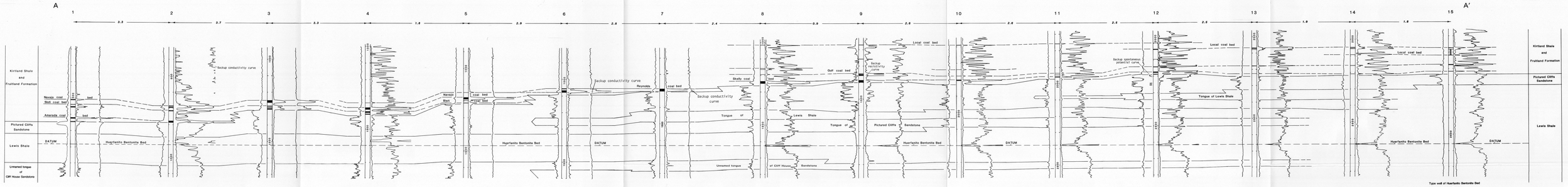

Section A—A′

EXPLANATION

20 — IDENTIFYING NUMBER OF DRILL HOLE—in lines of sections; see table 1

2.9 — DISTANCE BETWEEN HOLES—in miles

DEPTH—in feet, from depth datum (kelly bushing or ground level) of geophysical log

COAL BED

CURVES ON GEOPHYSICAL LOGS—See table 1 for identification

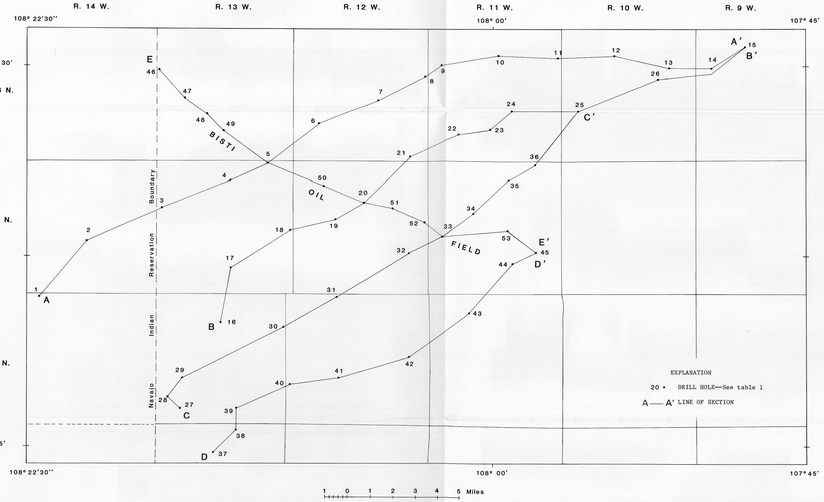

Figure 1.--Location of drill holes and lines of sections of Fruitland Formation coal and associated rocks.

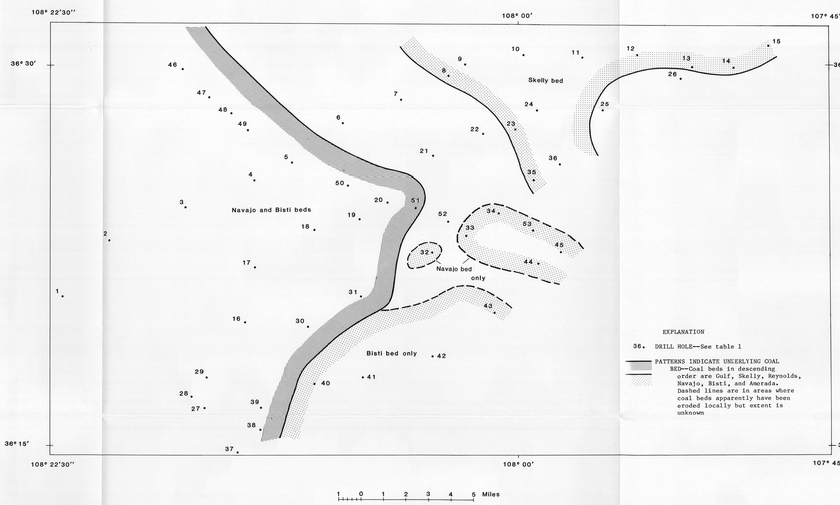

Figure 2.--Distribution of Navajo, Bisti, and Skelly coal beds, as correlated in lines of sections.

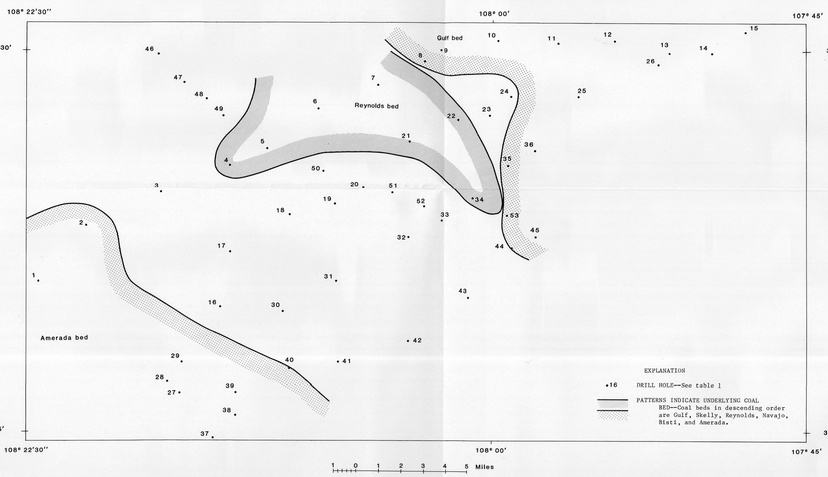

Figure 3.--Distribution of Amerada, Reynolds, and Gulf coal beds, as correlated in lines of sections.

CORRELATION OF COAL BEDS IN THE FRUITLAND FORMATION AS INTERPRETED FROM GEOPHYSICAL LOGS, EAST-CENTRAL SAN JUAN COUNTY, NEW MEXICO

By
Dorothy T. Sandberg

1986

INTRODUCTION

Correlation of coal beds in the Fruitland Formation (Upper Cretaceous) in the subsurface, from interpretation of geophysical logs, is an outgrowth of unpublished studies of deep coal beds in the Fruitland Formation in parts of the Toadlena 30 x 60 minute quadrangle, New Mexico, and by W. J. Nagel in the Farmington 30 x 60 minute quadrangle, New Mexico. The lines of sections of this report extend eastward from the reservation into east-central San Juan County, which is in the western part of the San Juan Basin. In this area, the Fruitland Formation is subbituminous in the central part of the basin. The thick coal is less than 1,500 feet beneath the surface. Of the 53 logs in the sections, 48 are from oil- and gas-test holes, and 5 are from coal-test holes. Previous work by Dane and Bachman (1965) of the Upper Cretaceous Lewis Shale, Pictured Cliffs Sandstone, and Fruitland Formation, shown on the cross sections and briefly reviewed below, have been previously described for this or other parts of the San Juan Basin by Dane and Zapp (1953), Beaumont (1971), Fassett and Hinds (1971), Fassett and Kelley (1972), and Molenaar (1983), among others.

STRATIGRAPHY

The sections include about 900 ft of Upper Cretaceous rocks deposited during a major cycle of transgression-regression of the epicontinental sea that lay mainly to the northeast of this area in the Western Interior of North America. Rocks deposited in the transgressive phase of the cycle is the upper part, or unnamed tongue, of the Cliff House Sandstone; sandstone deposited during the regressive phase of the cycle is the Pictured Cliffs Sandstone. The Huerfanito Bentonite Bed of the Lewis Shale is an easily recognized time marker deposited during the cycle and is used to demonstrate a stratigraphic rise of units above the bentonite as the sea retreated. Sections A-A′, B-B′, C-C′, and D-D′ (fig. 1) trend northeast and show the stratigraphic rise northeastward of units above the Huerfanito marker bed. Section E-E′ which extends southeast through the Bisti oil field, roughly parallels the ancient shoreline of the Pictured Cliffs. It shows few changes in thickness of units.

Unnamed tongue of the Cliff House Sandstone

The upper part of the unnamed tongue of the Cliff House Sandstone is a near-shore marine deposit, and is the lowest interval shown in the sections. It is stratigraphically above the La Ventana Tongue of the Cliff House, as shown in the subsurface by Fassett (1971, p. 194). This unit intertongues with the overlying Lewis Shale.

Lewis Shale

The Lewis Shale consists mostly of marine shale, and it ranges in thickness from about 200 ft to more than 500 ft. It includes the Huerfanito Bentonite Bed, identified (12 ft thick) and traced in outcrops and subsurface by Dane and the Turner and Webb Huerfanito 10-4 well, in sec. 4, T. 26 N., R. 9 W. (hole 15 in A-A′ and B-B′). By using its distinctive response on electric logs, Fassett and Hinds were able to trace the bentonite bed throughout the San Juan Basin. Because the bentonite was deposited from fall of volcanic ash, the bed is a time marker used by them to demonstrate that the Pictured Cliffs becomes younger and rises stratigraphically as the Late Cretaceous sea retreated to the northeast.

The Lewis Shale grades upward into, and intertongues with, the overlying Pictured Cliffs Sandstone. Intertonging is prevalent from the Bisti oil field northeastward where the interval between the Huerfanito Bed and the Pictured Cliffs Sandstone has rapid increases (See lines of sections A-A′, B-B′, C-C′, and D-D′, holes 9, 14, and 15). In hole 15, the farthest hole to the northeast, there is virtually no transitional zone at the base of the Pictured Cliffs; only marine shale is in sharp contact with sandstone.

Pictured Cliffs Sandstone

The Pictured Cliffs Sandstone is identified as a nearshore beach deposit (O'Sullivan and others, 1972, p. 5), and Fassett and Hinds, 1971, p. 91). It ranges in thickness, exclusive of tongues of Lewis Shale and other sandstone units or formations, from less than 100 ft to nearly 200 ft. In some of the drill holes it consists entirely of massive sandstone overlying interbedded sandstone and shale, but in many holes the sandstone is thin and shows intertonging and oscillations of the shoreline during deposition.

A coal-bearing interval appears near the middle of the Pictured Cliffs Sandstone in hole 51 of section E-E′, and nonmarine shale possibly extends from hole 51 into hole 52.

The contact with the overlying Fruitland Formation is placed at the base of the lowest part of the Pictured Cliffs and lower part of the Fruitland intertongue, such as in holes 38, 39, and 40 of section D-D′.

Fruitland Formation and Kirtland Shale

The Fruitland Formation and the overlying Kirtland Shale, which are combined on the lines of the sections, have similar lithology except that the Fruitland contains coal beds. Both formations include sandstone, siltstone, shale, and carbonaceous shale. Coal beds occur throughout the Fruitland, but which beds are in the lower part of the Fruitland was deposited adjacent to the Late Cretaceous sea on a swampy coastal plain. The Kirtland Shale was deposited farther from the coast in areas of higher elevation and better drainage (Fassett and Hinds, 1971, fig. 5).

INTERPRETATION OF GEOPHYSICAL LOGS TO IDENTIFY COAL BEDS

Coal beds are identified by a combination of log signatures that are typical for this area. Darker of each log used in the sections are described below, and are shown on the logs from left to right. All the logs used include both both spontaneous potential (left side of log) and resistivity (right side of log) curves. Opposite coal beds, conventional electric logs from oil and gas wells show a resistivity response and show little or no deflection of the spontaneous potential curve and a large deflection of the resistivity curve. For positive identification of coal beds in questionable areas, a density or velocity log is needed to compare with the electric log. Neither of these logs is generally available for this report. Holes 9 (Gulf), 14 (Reynolds), 17, 19, 37, 38, and 39) include in addition to the spontaneous potential and resistivity curves, gamma ray and density curves, which show low radioactivity (gamma ray on extreme left side of log) and low density (extreme right side of log) opposite coal beds.

Many of the logs from oil and gas wells also include a conductivity curve, which is to the right of the resistivity, and is helpful mostly to identify the Huerfanito Bentonite Bed of the Lewis Shale, which was used as datum in the sections.

Dane and Bachman (1965, p. 21-27) discuss at length the use of geophysical logs in their study of coal beds in the San Juan Basin. They state that on conventional logs, partings as thin as 12 inches can be detected, and coal-bed thickness can be determined to the nearest foot.

COAL DEPOSITS

Correlation of coal beds

Correlation of coal beds was made by constructing lines of sections mostly with north-south trends, using the top of the Huerfanito Bentonite Bed of the Lewis Shale as datum. In the coal-test holes, the Lewis Shale was not penetrated, and datum is the top of the Pictured Cliffs Sandstone.

Correlations were begun with hole 44 of section E-E′, in which the Navajo and Bisti coal beds are present. These beds were established in correlation diagrams of the Farmington area on the Navajo Indian Reservation. Correlations of coal beds along this line of section suggest that the upper bed, the Navajo of Nagel, extends for most of the area, and the lower bed, which is the Bisti of Nagel, extends as far as hole 31. From E-E′, correlations were extended to the northeast and southwest along intersecting sections A-A′, B-B′, C-C′, and D-D′ (fig. 1). The study suggests that the Bisti is the most persistent of these three. The approximate extent of these beds is shown in figures 2 and 3.

Where the Pictured Cliffs Sandstone-Fruitland Formation contact rises stratigraphically, progressively younger coal beds appear at the base of the Fruitland. For example, between holes 9 and 14 (fig. 3 and lines of sections 2 and 3), coal beds and abruptly northeastward, and stratigraphically higher ones take their place.

The three highest local coal beds of the Fruitland Formation in the lines of sections are about 60, 100, and 180 ft, respectively, above the highest named bed, the Gulf coal bed. These beds are thin and have limited extent in the area, generally less than 5 ft thick, and at least 1,000 ft beneath the surface.

Names of coal beds

A generalized section of the principal coal beds, the approximate maximum thickness of the coal, and the approximate depth below the surface is given below. Gulf, Skelly, Reynolds, and Amerada are names coined for use in this report. The coal beds are discussed in descending stratigraphic order.

Coal bed	Thickness (in feet)	Interval (in feet)
Gulf bed	13	40*
Skelly bed	12	25
Reynolds bed	20	30
Navajo bed	20	20
Bisti bed (beds)	20	50
Amerada bed	12	--

*Interval between beds

Gulf coal bed

The Gulf coal bed is thickest in hole 9 (A-A′), which is the Gulf Oil Corporation, Western Federal No. 2 well and is located in sec. 9, T. 26 N., R. 11 W. (see fig. 3). The bed is named from this well and includes a lower bench about 8 ft in thickness and an upper bench 3 ft in thickness, separated by 2 feet of shale. The bed is thinner to the northwestern one-third of the area where, in general, it is less than 5 ft thick but the coal horizon is fairly persistent.

Skelly coal bed

The Skelly bed is about 40 ft below the Gulf bed. The Skelly bed is at least 12 ft thick in hole 8 (A-A′), which is the Skelly Oil Company Navajo B No. 1 well and is located in sec. 11, T. 26 N., R. 12 W. This coal bed is named from occurrence in this well. The bed apparently is absent in the northeastern one-third of the area (fig. 2).

Reynolds coal bed

The Reynolds bed is stratigraphically about 25 ft below the Skelly bed and is nearly 15 feet thick in hole 14 (A-A′), the Reynolds Mining Corporation Federal No. 1 well located in sec. 22, T. 26 N., R. 12 W. Although the Reynolds bed appears to extend over only a small area, it is more than 10 ft thick in holes 9, 7, 22, and 23 and has an overburden thickness of less than 1,300 ft.

Navajo coal bed

The Navajo bed is about 30 ft below the Reynolds bed. The name is from the Navajo mine in the Fruitland, described by Dane and Bachman and correlated by W. J. Nagel (written commun.) as the principal coal bed. In hole 46 (E-E′), correlations by Nagel are shown in the British American Oil Producing Company Government Scott No. 1C well located in sec. 17, T. 25 N., R. 13 W. In this well, the Navajo bed is 7 ft thick and lies at a depth of 1,100 ft. The Navajo extends southeastward along E-E′ except in the area around hole 52 where possibly the bed was cut out and replaced by a channel sandstone. The Navajo underlies much of the southern two-thirds of the area and underlies the Bisti and the Pictured Cliffs Sandstone northeast of the Bisti oil field. It is about 10 ft thick in much of the area it underlies (fig. 2 and lines of sections).

Bisti coal bed

The Bisti bed was named by Nagel after the Harrell Bud West Bisti No. 1 well in sec. 7, T. 26 N., R. 14 W. In this well Nagel described (written commun.) the bed as "... 11 feet thick in two benches separated by 2 feet of shale."

The Bisti bed is about 20 ft below the Navajo bed. The two beds underlie much of the same area (fig. 2). The Bisti tends to be thinner or split into benches and beds, but in places it is between 20 and 50 ft thick in holes 16, 17, 38, and 39 (fig. 2). In the extreme southwestern part of the area, holes 38 and 39 "Bisti beds", and includes other beds that may have split from the Bisti and are between the overlying Navajo and underlying Amerada beds.

Amerada coal bed

The Amerada bed is the lowest coal stratigraphically and is about 50 ft below the Bisti coal interval. It underlies only the southwestern part of the area, as shown by the Amerada Petroleum Corporation Navajo 7-1 well in sec. 21, T. 24 N., R. 14 W., in which the Amerada occurs as a bed about 12 ft thick. In most of the wells it generally includes two benches, each about 5 ft thick, or less. It is also in the southwest part of the area of intersecting lines of sections and disappears northeast of holes 2, 29, and 40 where the Pictured Cliffs rises stratigraphically and replaces the Amerada coal interval.

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Table 1.--Drill holes shown in lines of sections in east-central San Juan County, New Mexico

[Depth datum of geophysical logs is kelly bushing, except for five logs, as indicated, that are ground level. Coal beds are identified by letter, as in figure 2, or by name. Curves on geophysical logs: SP, spontaneous potential; R, resistivity; D, density; V, velocity; CD, conductivity; GR, gamma ray. Coal beds are identified by letter or name. Holes are listed in order of sections, from left to right on lines]

Number on map	Location and name of hole	Source	Curves on geophysical log	Elevation of kelly bushing, or ground level (in feet)	Year
		T 23 N., R. 15 W.			
37	NE 5	Wilson and Jentgen, 1980 DN-O	R, D, V, SP	5,948 (gl)	1979
38	NE 5	Wilson and Jentgen, 1980 DN-G-01	R, D, V, SP	6,047 (gl)	1979
		T. 24 N., R. 15 W.			
43	SE 5	Sandia Oil Co. Bisti Federal No. 1	R, SP	6,280 ±	1960
		T. 24 N., R. 12 W.			
31	NW 4	W. Hutchison Mesa Canyon No. 1	R, D, C	6,050	1956
42	SW 13	R. L. Fowler, Jr., Vandenfield No. 1	R, SP	6,008 ±	1958
41	SW 23	Sunoco Oil and Refining Co. Turner Unit No. 1	R, D, C	6,288	1967
40	NW 30	Texaco Petroleum Corp. Bertz Federal No. 1	R, D, C	6,039	1976
		T. 24 N., R. 13 W.			
19	NW 25	Shell Oil Co. Hilditch No. 1	R, D, C	6,259	1960
20	SE 12	R. G. Lauritsen Southern Union-Federal No. 1-12	R, D, C	6,255	1962
29	NW 30	Monsanto Chemical Co. Chaco No. 1	R, D*, C	6,079 ±	1966
30	SE 30	Wilson and Jentgen, 1980 DN-N-4	R, D, V, SP	5,972 (gl)	1979
27	NW 30	Wilson and Jentgen, 1980 DN-A-5	R, D, V, SP	5,772 (gl)	1979
28	SW 30	Wilson and Jentgen, 1980 DN-B-02	R, D, V, SP	5,858 (gl)	1979
		T. 24 N., R. 14 W.			
1	NE 6	Sarto Oil Co. Verty Navajo No. 1	R, D*, C	6,976	1957
		T. 25 N., R. 11 W.			
16	NE 2	Jarman M. Waugh Erin No. 1	R, D, C	6,260	1977
15	SE 3	Inexco Oil Co. Cooper No. 1	R, D, C	6,292	1973
14	NW 10	Shell Oil Co. Government No. 12-10 X	R, D*, C	6,299	1960
13	NE 10	Shell Oil Co. Carson Unit No. 20-10	R, D*, C	6,240	1960
12	NE 22	Sun Oil Co. Native of Ka Pah No. 2	R, D*, C	6,217 ±	1967
11	NW 26	Mapco-Trio Petroleum Co. Kerr-McGee No. 1	R, D, C	6,250 ±	1967
44	NW 27	Shell Oil Co. Carson No. 5	R, D*, C	6,231	1960
		T. 25 N., R. 12 W.			
53	NW 5	Sunray Mid-Continent Oil Co. Federal C No. 21	R, D*, C	6,207	1956
52	SW 15	Shell Oil Co. Government No. 14-15	R, D*, C	6,240	1958
51	SE 15	Shell Oil Co. Bisti Gasket Well No. 1	R, D*, C	6,257	1958
50	SW 22	Shell Oil Co. Carson Unit No. 21-14	R, D*, C	6,277	1967
49	SE 27	Sunray Mid-Continent Oil Co. Federal K No. 3	R, D*, C	6,271	1956
48	NW 35	Shell Oil Co. Carson No. 2	R, D*, C	6,218	1960
		T. 25 N., R. 13 W.			
6	NE 12	El Paso Natural Gas Co. Kelly State No. 1	R, D, C	6,245 ±	1958
4	SW 3	British-American Oil Producing Co. Dalton No. 1-C	R, D, C	6,283	1963
3	SW 10	F. A. Anderson Federal No. 21-10	R, D, C	6,404	1958
2	NW 24	British-American Oil Producing Co. Navajo No. 2	R, D*, C	6,266	1959
47	SW 27	Texaco Petroleum Corp. Lee Gas Federal No. 1	R, D, C	6,258	1976
		T. 25 N., R. 14 W.			
7	SE 25	Amerada Petroleum Corp., Navajo T.C. No. 39-L	R, D, C	5,708	1965
		T. 24 N., R. 14 W.			
15	SW 4	Turner-Webb Huerfanito 10-4	R, D, C	6,456	1965
14	SE 9	El Paso Natural Gas Co. Hawkins No. 206	R, D, C	6,263	1973
		T. 23 N., R. 12 W.			
17	NW 9	El Paso Natural Gas Co. Hawkins No. 201	R, D, C	6,450	1971
13	SE 11	El Paso Natural Gas Co. Hawkins No. 203	R, D, C	6,480 ±	1973
18	NW 14	El Paso Natural Gas Co. Hawkins No. 199	R, D, C	6,471	1969
25	NW 19	El Paso Natural Gas Co. Hawkins No. 202	R, D, C	6,416	1974
		T. 23 N., R. 11 W.			
9	SE 7	Gulf Oil Corp. Western Federal No. 2	R, D, C	6,210 ±	1967
10	NW 20	The American Petroleum Corp. Kirk Gasbuggy No. 1	R, D, C	6,450	1968
11	NE 22	El Paso Natural Gas Co. Hawkins No. 204	R, D, C	6,203	1974
26	SE 22	Tenneco Gas Transmission Co. Kirk Navajo No. 1	R, D, C	6,280	1969
23	SW 28	El Paso Natural Gas Products Co. Nelson-Taylor No. 1-A	R, D, C	6,253 ±	1967
22	SW 29	Tenneco Oil Co. Gallegos Well No. 2	R, D, C	6,404	1973
		T. 23 N., R. 10 W.			
8	NE 15	Shell Oil Co. Navajo M No. 1	R, D, C	6,258	1958
7	NE 22	Reynolds Mining Corp. Federal M No. 1	R, D, C	6,246	1965
6	NW 25	El Paso Natural Gas Co. Sullivan No. 2-R	R, D*, C	6,089	1967
21	SW 26	El Paso Natural Gas Co. Ute No. 1-A	R, D*, C	6,242	1965
		T. 23 N., R. 11 W.			
46	SW 7	British-American Oil Producing Co. Government Scott No. 1-C	R, D*, C	6,282	1960
47	NW 25	Shell Oil Co. Ute No. 1	R, D, C	6,320	1958
48	SW 25	Benson-Montin-Greer Drilling Corp. Fletcher No. 3	R, D, C	6,240	1967
49	SE 28	British-American Oil Producing Co. Navajo M No. 4-C	R, D, C	6,245	1960

*Where three curves are present, right curve is short-normal resistivity
and fourth curve is long-normal resistivity

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