GEOLOGY AND COAL RESOURCES OF CERRO PRIETO AND THE DYKE QUADRANGLES

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INTRODUCTION

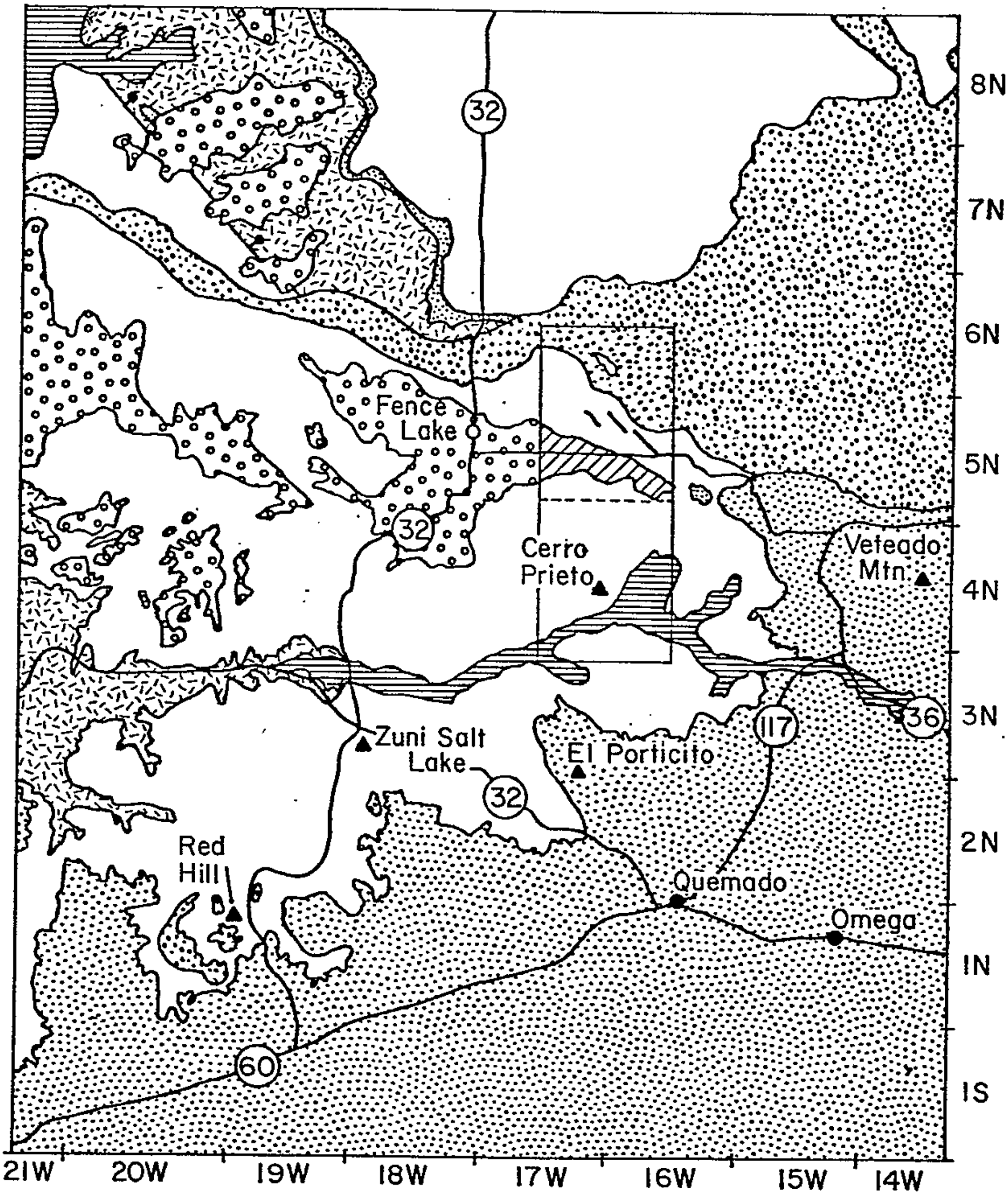
The Cerro Prieto and The Dyke 7.5 minute quadrangles are located on the eastern edge of the Salt Lake coal field. The Dyke quadrangle is the northern most of these two adjacent quadrangles. The area covered includes portions of Townships 3, 4, 5, and 6 N, and Ranges 16 and 17 W. The Salt Lake coal field straddles the Catron-Cibola county lines, and extends from highway 117 west to the Arizona border (fig. 1). The field is roughly U-shaped, with the concave side facing west.

The only paved roads in the area are state highways 117 and 32, which meet at the town Fence Lake (fig. 1). The remaining unpaved roads provide good access to either quadrangle. The nearest large towns are Gallup, 70 mi to the north Quemado, 40 mi to the south and St. Johns 50 miles to the west. No are railroads present in the coal field, however a railroad is being put in on the Arizona side of the border..

SURFACE OWNERSHIP

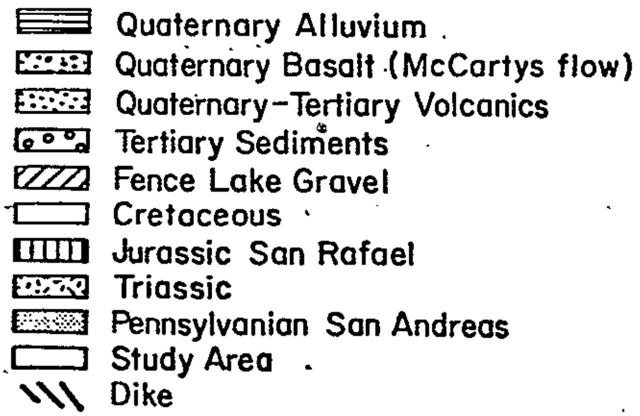
The surface ownership in the study area is private (68.8%), state (27.4%), and federal (3.8%). Figures 2 and 3 show the distribution of surface ownership on The Dyke and Cerro Prieto quadrangles respectfully. Table 1 contains surface ownership of the study area according to township.

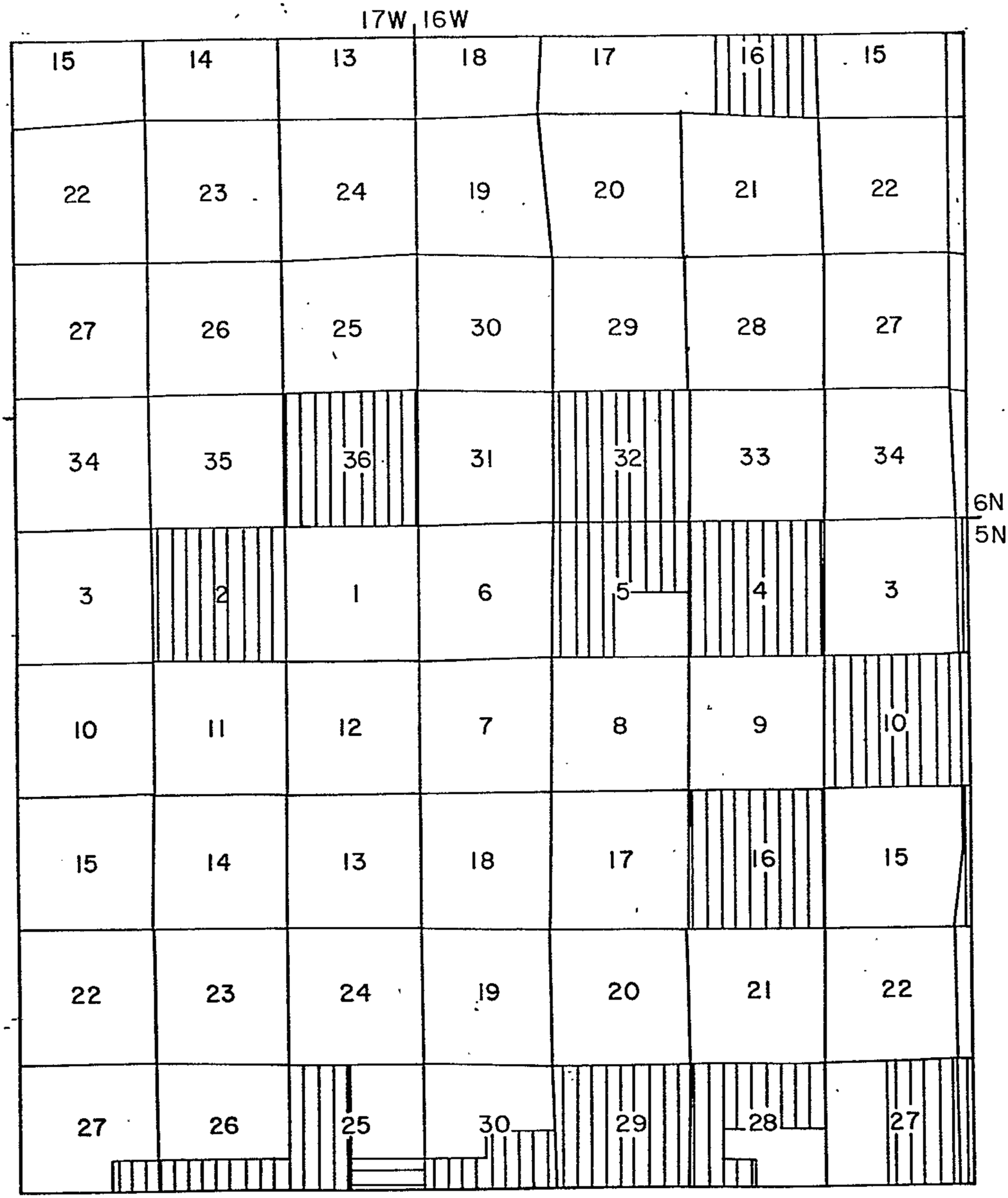
The Cerro Prieto quadrangle has only two residences; however, 54.1% of the surface is owned by nine ranchers. The state owns



GENERALIZED GEOLOGIC MAP OF
SALT LAKE COAL FIELD

FIG. 1

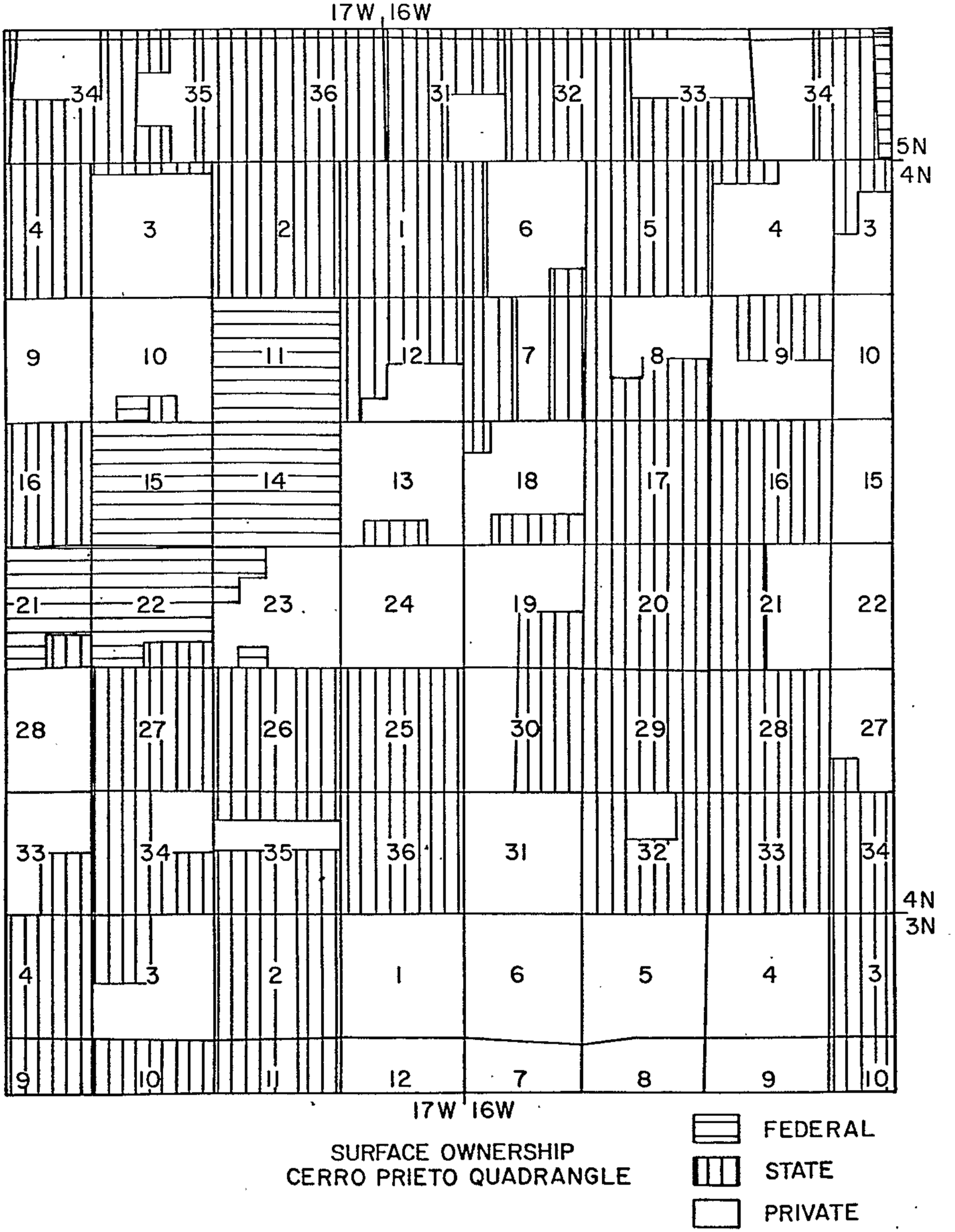




SURFACE OWNERSHIP
THE DYKE QUADRANGLE

FEDERAL
STATE
PRIVATE

FIG. 2



SURFACE OWNERSHIP
CERRO PRIETO QUADRANGLE

FIG. 3

38.8% of the surface and the Federal government owns 7.1%. The 45.9% of the land owned by the state and federal governments is leased to ranchers for grazing.

The Dyke quadrangle has nine residences, but several sections, mostly in the northern portion of the quadrangle, are being subdivided into 40-acre parcels. Private individuals own 83.6% state of New Mexico owns 16.0% and the federal government owns 0.4% of the surface. All state and federal landholdings on The Dyke quadrangle are leased for grazing.

TABLE 1

SURFACE OWNERSHIP

(in percent)

Township	Private	State	Federal
T. 3 N. R. 16 W.	85.7	14.3	0.0
T. 3 N. R. 17 W.	47.4	52.6	0.0
T. 4 N. R. 16 W.	40.5	59.5	0.0
T. 4 N. R. 17 W.	33.6	44.0	22.4
T. 5 N. R. 16 W.	59.6	40.4	0.0
T. 5 N. R. 17 W.	78.0	20.2	1.7
T. 6 N. R. 16 W.	89.7	10.3	0.0
T. 6 N. R. 17 W.	90.5	9.5	0.0

TOPOGRAPHY

The surface of The Dyke and Cerro Prieto quadrangles are rather flat with a maximum elevation of the study area being 7,484 ft, and the minimum being 6,540 ft, giving a total relief of 944 ft. The Cerro Prieto quadrangle is dominantly contains isolated mesas and valleys. The Nations or Frenches Draw is the largest drainage of the area and flows to the west, disecting the southern part of the Cerro Prieto quadrangle. The area is also roughly divided into northern and southern halves by a steep and continuous escarpment that extends from the eastern to western borders of the Salt Lake field. A volcanic neck called Cerro Prieto, from which the quadrangle gets its name, in the center of the Cerro Prieto quadrangle.

The vegetation of the two quadrangles is of two ecologic types. Present on valley floors and on McCarty's flow are grasslands with few trees. On mesa tops is a pinion-juniper type forest.

PREVIOUS WORK

M.K. Shaler (1907) first designated the Salt Lake field as a separate coal field in a reconnaissance study of the Durango-Gallup coal field. Small coal-bearing sections were measured in the Salt Lake field, several of which are located on the Cerro Prieto quadrangle. Shaler noted coals to be less than 4 ft thick, and assigned them to an early Mesaverde age. He also noted the presence of a basalt flow and an undifferentiated Tertiary unit.

Herrick (1900) traversed this area as a part of a reconnaissance of Socorro and Cibola (then Valencia) counties. He noted the presence of a dike in the Datil area, trending to the northwest, and an extensive basalt flow. Coals were reported and designated as Fox Hills Formation, but no thicknesses were given.

Pike (1947) published a paper discussing the major transgressions and regressions of the Cretaceous sea in New Mexico. His work extended down to the Atarque Lake area north of the Salt Lake field. In this paper he recognized the Atarque Sandstone as member of the Mesaverde.

Molenaar (1973) revised some of the stratigraphy of Pike, by dropping Horsehead Tongue of the Mesaverde and designating the Atarque Member as the basal member of the Gallup Sandstone. He also tentatively extended the Torrivio Member of the Gallup Sandstone into the Fence Lake area.

SCOPE OF PRESENT STUDY

This report is part of a cooperative program with the U.S. Geological Survey, Division of Coal Resources, under grant 20-UG-BI-0-0000. The study is to provide information concerning Cretaceous stratigraphy and the quality and quantity of coal present in the northern portion of the Salt Lake Coal Field, as well as 1:50,000-scale map of the eight 7.5 minute quadrangles covering the northern portion of the field.

This report is based on the data gathered from mapping two 7.5 minute quadrangles, Cerro Prieto and The Dyke, at a scale of 1:24,000. Mapping at this scale provides information concerning both coal geology and general stratigraphic information. Minable coals will be determined from outcrops drilling. Coals were measured and sampled to determine both their quantity and quality. Geophysical logs also provide information concerning the subsurface geology.

STRUCTURE

The two quadrangles constituting the study area are relatively simple structurally. There are no major faults crossing either of the quadrangles, however some minor faulting is present. In the region northwest of the Salt Lake field there is a major northwest trending fault. This fault extends to the northern edge of the western neck of the McCarty's flow (fig. 1). South of this neck there is no indication of faulting. This fault may have created a zone of weakness which extends to the southeast. Such a zone of weakness would provide a good mechanism for the intrusion of the dike. There is no surface evidence of displacement along the dike. The only areas in which Datil Group sediments appear is to the east of the dike, which indicates the possibility of faulting. Subsurface data is required in order to determine whether or not displacement has occurred along the dike. Other minor faulting occurs along the western border of The Dyke quadrangle as well as the southeast quarter of the Cerro Prieto quadrangle.

Dips in the study area are relatively shallow, generally less than 5 degrees. The general direction of dip on the Cerro Prieto quadrangle is to the southeast. Locally there are numerous minor flexures which are especially prevelant in the area around Cerro Prieto. A prominent anticlinal flexure occurs on the Cerro Prieto quadrangle in the north central portion. This flexure has a N-S axis, with the limbs dipping E-W at 5 degrees. A synclincal flexure extends east-west in the central portion of the quadrangle. In the northern portion of The Dyke quadrangle dips tend to flatten out to 1-2 degrees, generally dipping to the northeast.

IGNEOUS ROCK

BASALT FLOW

The northeastern half of The Dyke quadrangle is covered by a 60-70 ft thick andesine basalt flow (fig. 1), termed the McCarty's Basalt flow, (indicated as QB on plate I), the youngest of the Bandera flows. Laughlin and others (1979) dated this flow in Township 6 N. Range 17 W. as being 1.41 +/- 0.29 million years, using K/Ar methods. The surface contains numerous depressions due to collapse structures within the basalt which collect quaternary alluvium.

The McCartys flow was not observed to be in contact with the Fence Lake Gravel. It does overlie an angular unconformity formed on top of the underlying Moreno Hill Formation. A "window" in the flow exposes upper Moreno Hill strata covering sec. 28, 29, 33, and 34.Township 6 N. Range 16 W. which marks the former position of a high knoll formed by the Moreno Hill formation, around which the basalt flowed. No coal was observed to be outcropping in these exposures. However, a drill hole penetrated several coal seams, relatively near the surface.

CERRO PRIETO

Cerro Prieto is a volcanic neck in the center of the Cerro Prieto quadrangle (labeled TV on Plate I, see also fig. 1), composed of olivine basalt. Cerro Prieto was intruded after deposition of the Cretaceous sediments, and probably was the cause of the folding, flexuring and jointing associated with these Cretaceous units. Figure 1 shows several other volcanic necks of similar appearance and composition in the area (Salt Lake, Veteado Mountain, El Porticito, Red Hill). All necks form a roughly northeast-trending line and probably are a result of the same volcanic event. No radiometric age dates have been obtained from Cerro Prieto, based on composition, petrology, and geologic structure, both the dike and Cerro Prieto appear to be related.

DIKE

The northeast corner of the Cerro Prieto quadrangle and the southeast quarter of The Dyke quadrangle contains an en echelon dike (fig. 1), of olivine-basalt composition. The limbs of this dike system trend 60 degrees to the northwest. This is a continuation of the same northwest trending dike system that goes through Pie Town. Each limb is approximately one mile in length, and approximately 15 feet thick, with left lateral offset. This dike cuts the Cretaceous units in the area, but is overlain by the Tertiary Fence Lake Gravel.Laughlin and others (1979) dated this system near Pie Town as being 27.67+/-0.59 m.y., using K/Ar methods, placing this dike within the Oligocene.

GENERAL STRATIGRAPHY

Five major stratigraphic units are exposed in the study area and these range from Quaternary to Cretaceous in age. The Quaternary is represented by a single unit, Quaternary alluvium. The Tertiary is represented by a single unit, the "Fence Lake gravel". The only Cretaceous unit exposed in the study area, the Moreno Hill Formation. Figure 4 is a generalized stratigraphic column for both the Cerro Prieto and The Dyke quadrangles.

TERTIARY STRATIGRAPHY

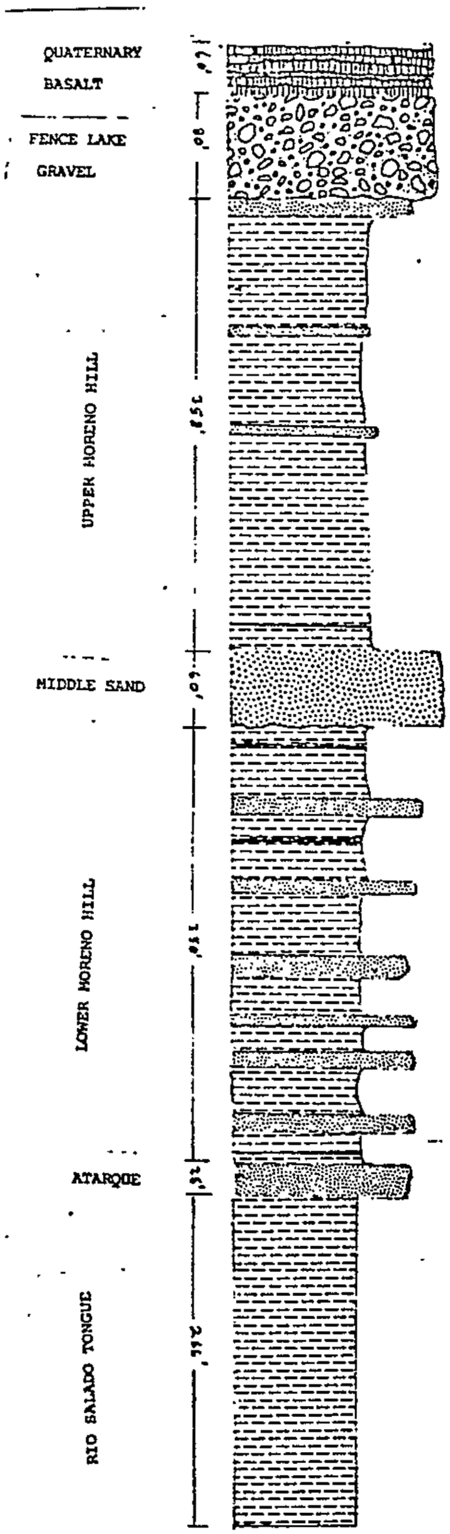
"Fence Lake gravel"

The ""Fence Lake gravel"" is a term informally applied by Marr (1956) to the coarse boulder-conglomerates capping the mesa tops in the Salt Lake field (labeled Tfl on Plate I). The "Fence Lake gravel" unconformably overlies the Moreno Hill Formation and is present in the southeast quarter of The Dyke quadrangle, the northeast quarter of the Cerro Prieto quadrangle, and the top of Flattop Mesa and Hawkins Peak (see Plates I and II). Rubble surfaces that are composed of the Fence Lake Gravel are present in

sec. 21, T. 4 N, R. 17 W and sec. 1, T. 3 N., R. 16 W, and form distinctive northwest trending lineations.

The "Fence Lake gravel" locally attains a thickness of 100 ft, but is commonly about 60 ft. Well-rounded vesicular basalt boulders, up to three feet in diameter are a dominant characteristic of this gravel. Also present, but smaller in size

GENERALIZED STRATIGRAPHIC CO[illegible] FOR
CERRO PRIETO AND THE DYKE QUADRANGLES



Quaternary Basalt.

Large basalt andesite boulders in matrix of $CaCO_3$; cobbles of chert, rhyolite, cretaceous sand and petrified wood.

Green/yellow mudstones and claystones; few tan fluvial channel sands (weak ledge formers) Crevasse splays: coals in lower portion of unit, generally less than 1.5 ft.

Coarse sandstone, arkosic, trough and planar crossbeds grain supported fabric, no fines, weathers pinkish/ orange.

Dominantly channel sands, which are ledge-formers, silty and clay matrix; carbonaceous shales; gray to black mudstones and claystones; coals.

Marine delta deposit

Marine shale sequence, XCO_3, concretions, no sands

FIG. 4

(less than 1 ft) are well rounded clasts of rhyolite, chert, petrified wood, calcite and some sandstones. These large clasts are in a matrix of fine grained calcareous sand.

The clasts in the "Fence Lake gravel" appear to have been derived from three sources. The petrified wood and sandstone are a result of channeling into the underlying Moreno Hill Formation. The most likely source for the basaltic boulders would be McCarty's flow. The remaining clasts are most likely from the Datil sediments. Clasts present in the "Fence Lake gravel" are also present within the Datil Group, with the exception of petrified wood, which is derived from the underlying Cretaceous. A prominent outcrop of Datil Group volcaniclastics is present to the east of the study area, with the "Fence Lake gravel" forming a west-trending apron from the base of these sediments. Based on clast orientation, the direction of flow is apparently to the west. No thinning of the total thickness of the gravels or reduction in grain size was observed in the study area. A similar gravel is also found in the Datil Mountains Field, along with outcrops of the Datil Group. Systematic clast counts of both the "Fence Lake gravel" and the Datil Group, and detailed mapping of the relationship of these two groups are necessary to determine whether or not the "Fence Lake gravel" is actually derived from the Datil Sediments.

CRETACEOUS STRATIGRAPHY

A single Cretaceous unit is exposed in the study area. This is tentatively assigned to the Moreno Hill Formation, a unit consisting mostly of continental sediments. In the study area, most notably on the Cerro Prieto Quadrangle, the Moreno Hill Formation is readily divided into three members, a lower sandstone/mudstone sequence, a middle sandstone, and an upper mudstone/claystone unit, having a total thickness of 768 ft. These units are labeled Klmh, Kmhs, and Kumh on Plates I and II.

The lower unit is 350 ft thick and consists principally of fluvial channel sandstones with crevasse splay and floodplain deposits and coals. This lower unit rests on the Atarque Formation, a marine beach sand. The Atarque does not have any crop out on either The Dyke or Cerro Prieto quadrangles, however, west of the Cerro Prieto quadrangle the Atarque is found in outcrop.

Channel deposits in this lower unit are 10-20 ft thick, trough cross-bedded, with the scale of crossbedding decreasing upward. Often present on the tops of these fluvial sandstones are assymetrical ripples, linguoid and lunate ripple marks. Lithologically they consist of 95% quartz grains (2.0-4.00) well-sorted and rounded. Feldspars, mostly altered to kaolinite, are the second most abundant grain, but are never greater than 5% of the total. Mica is a common-trace constituent of most of the sandstones, and can be as much as 1% of the total. Mafic and rock fragments are rare, less than 1% of total.

Fossil material associated with these channels is petrified wood, which can occur within the body of the channels, but are mostly found at the upper and lower contacts. The wood has all been transported, since no stumps or large logs are present.

Gray to black mudstones are prevalent within the lower Moreno Hill Formation. The color is due to mudstones rich in organic material, both plant fragments and finely disseminated organic material. The presence of non-oxidized organics indicates that the environment of deposition was anaerobic, and therefore a poorly drained swamp. In many instances mudstones can be seen to grade laterally into crevasse splay deposits, and represent floodplain deposits.

The uniform grain size, roundness, and lack of all but quartz indicate that these streams were mature and of low gradient. The abundance of channels in this lower unit, combined with crevasse splay, floodplain deposits and coal swamps, indicate that the environment of deposition was a low-energy meandering stream system.

Most of the coal present in the study area is found in this lower unit. Two coal zones are present, one directly below the upper contact of the unit, the second approximately 150 ft below the upper contact. The upper coal zone is characterized by one seam that has a single thn kaolinite rich parting, approximately .25 inch thick. Where this upper coal outcrops, the thickness of this parting does not vary significantly. Where the coal does not have a channel sand cutting into the upper portion, this parting is roughly 23" inches from the top of the coal. The lower coal zone is distinguished from the upper by a coal by two kaolinite rich partings, which are separated by 15" of coal. This distance between them is consistent wherever these partings occur. The upper parting is .25 inch thick, while the lower parting is 1.0 inch thick.

The upper coal zone is present only on the southwest portion of The Dyke quadrangle and the northwest portion of the Cerro Prieto quadrangle. The lower coal zone is much more extensive extending from the northern portion of the Cerro Prieto quadrangle southward to the northern edge of the Tejana Mesa 7.5 minute quadrangle.

The lower and upper portions of the Moreno Hill Formation are separated by a thick fluvial sequence. This unit varies in thickness from 40 to 80 ft, averaging 60 ft. The sands are light-tan on fresh surfaces, but weather to a pinkish/orange. These sands are clean, coarse grained, subangular to subrounded and commonly composed of 85% quartz and 15% feldspar. The quartz grains are subangular to subrounded, and vary in size from 1.0--.050. The feldspars are plagioclase, up to 0.5" in diameter and generally subangular. There is no trend in increasing or decreasing grain size. The unit is consists of both trough and planar cross-beds, which decrease in set size upward. The contact with the lower Moreno Hill is erosional. Channels are abundant, offset laterally, and cut into each other. Measurements of current direction on the cross-beds indicate a stream flow to the northwest. Iron concretions are present throughout the unit. These increase in size (0.25-1.0") and frequency upward. The larger concretions are nearly perfect spheres, whereas the smaller ones are irregular. This sandstone sequence is readily distinguished from other sandstones by grain size, pinkish-orange coloration, grain supported fabric, no clay or silt fraction, and large feldspar grains. The presence of clast supported grains, lack of clays and silts, lateral distribution of streams, and the presence of both trough and planar cross beds indicate that deposition was due to a braided stream environment.

The upper unit of the Moreno Hill Formation is 358 ft thick and dominantly claystones and mudstones, (Appendix III). Only a very few channel and crevasse splay deposits are present. The channel deposits are thin, rarely exceeding 4 ft in thickness. They

differ from the lower Moreno Hill channels in that they are much more silty, do not form ledges and do not extend laterally for more than 50-60 yards. The claystones and mudstones are mostly yellow and green in color, with only a few being organic and black in color. Scattered carbonaceous shales are present, as well as a few thin coals. Coalified logs were found, in several locations and usually associated with organic mudstones. An erosional surface with mudstone in contact with mudstone is near the top of this unit. Large fragments (1-2") of fusain marks this surface and appears to be the remnant of an ancient forest fire, followed by flooding and transportation of the burned plant material. No charred logs or stumps were found.

The upper Moreno Hill appears to be deposited during a drier time than the lower Moreno Hill. The fewer channels, with a greater silt fraction, as well as the green and yellow mudstones indicate a drier climate. No organics were found with these green and yellow mudstones. Only a few swamps were present, as indicated by a paucity of organic-rich black mudstones and carbonaceous shales.

The top of this unit is in erosional contact with the Fence Lake Gravel on the Cerro Prieto quadrangle. The upper Moreno Hill Formation is present on The Dyke quadrangle in the northeast quarter, where a "window" in the basalt flow exposes Cretaceous sediments.

COAL GEOLOGY

The major area of outcropping coal in the study area is in the northwest corner of the Cerro Prieto quadrangle, (sec. 1, 2, 3, 4, 9, and 10, T. 4 N., R. 17 W., and sec. 34, 35, and 36 T. 5 N. R. 17 W. 35, and 36) and the southwest border of The Dyke quadrangle, (sec. 25, 26, and 27, T. 5 N. R. 17 W.) mainly along the escarpment. Throughout the remaining area of the two quadrangles outcropping coals are thin and sparsely present. Several exposures of carbonaceous shales and mudstones, but no coals on occur The Dyke quadrangle, at the edge of McCarty's basalt flow.

Two of the thicker coals contain volcanic ash partings, termed tonsteins (Williamson, 1961). These partings appear white on weathered surfaces, making them easily discernable against the black coal outcrop. They have a gray coloration, due to a dark and light banding on a broken surface. These bands are generally less than .1 inch in thickness, and are highly interlaced. X-ray diffraction studies show that these tonsteins are composed primarily of ordered and disordered kaolinite and quartz. Heavy liquid separations did not show any of the heavy minerals that have been found in other tonsteins present in the state (Bohor, 1976). This limited mineral composition, compared to other tonsteins is probably due to the Fence Lake tonsteins being collected from highly weathered outcrops.

There are two coal horizons present based on outcrop information. The upper horizon is exposed mainly along the face of the mesa escarpment. This zone consists of one major coal that has an outcrop thickness of up to 12 ft thick, containing a single tonstein, with several minor, thinner coals above and below. This zone is roughly 20 ft below the middle sandstone.

The lower horizon is located approximately 150 ft below the middle sandstone. This zone is exposed only on the northwest quarter of the Cerro Prieto Quadrangle. The thickest coal in this zone is 7.5 ft in outcrop and 9.5 ft in subsurface. This main seam, like the main seam in the upper zone, has thinner coals, both above and below. The total thickness of this zone is roughly 25 ft. This zone is distinguished from the upper zone by the presence of two tonsteins in the main coal.

Coal outcrops, though abundant, are not traceable as continuous outcrops for any distance; several hundred yards is a maximum. Due to talus cover the coals are best exposed when capped by a sandstone, either channel or crevasse splay, they are best exposed. Where coals are not overlain by sandstone, they are poorly eroded, until another overlying channel sandstone is encountered leaving a flat surface. These topographic features, usually tops of sandstones, are useful in locating coals, which have been eroded and covered by talus.

Several mineral are associated with outcropping coals. Gypsum crystals are found at the contact of coal and finer grained sediments, such as carbonaceous shale, mudstone, or claystone, but never with sandstone. Thicker coal seams have larger crystals associated with them, the largest being up to 15 inches in length and associated with a 12 ft seam. Several minerals are present along cleat surfaces in outcropping coals. These minerals are jarosite, calcite, and gypsum.

Along the boundary of the two quadrangles are extensive outcrops of klinker, or burned coal. In several locations the ash from the burned coal can be seen, the maximum thickness of ash observed is 13 inches. Most of the klinker is due to burning of the main seam in the upper zone. A second klinker layer occurs in a 3 ft coal above this main seam. A klinker deposit was observed in the lower coal zone, just west of the Cerro Prieto quadrangle, on the Fence Lake SW quadrangle. Ranchers report that in Township 4 N. Range 16 W. sec. 31 a coal associated with an abandoned mine is still burning. Core obtained from this section indicate that this would be the main seam of the lower coal zone.

PROXIMATE, ULTIMATE, AND BTU ANALYSES

The proximate, ultimate, BTU and forms of sulfur analyses were done by Hazen Research, Golden, Colorado. Fourteen coal samples were analysed for proximate, ultimate, and BTU values. Table 2 & 3 compares the average proximate, ultimate and BTU values for the Salt Lake coals to those of the lower Mesaverde and nearby

Black Mesa, Arizona. Only three samples (416-31-1, 417-3-1, and 417-14-1) were taken from cores. The remaining samples were taken from cuttings. The three core samples as well as one cutting sample were analysed for forms of sulfur and ash fusion temperature (Appendix 3).

The average as received BTU value for the coals present in the study area is 9920 BTU/lb. The average moist, mineral-matter free BTU value is 12869 BTU/lb. According to ASTM D388-77, this is within the range of high volatile bituminous B rank coals. This moist mineral-matter free value is slightly higher than the average for lower Mesaverde Group (Gallup and Crevasse Canyon) coals, and considerably higher than the average for the coals of Black Mesa, Arizona. The ash content of the Salt Lake coals averages 20.7%, this is considerably higher, than coals of either the other lower Mesaverde Group, which average 8.2% ash, or the 7.3% ash content of Black Mesa coals. The high ash content apparently is not due to samples being collected from cuttings, since some of the higher ash contents are from core samples. This high ash content may be due to a high amount of clays and silt being washed into the coal-forming swamps.

The moisture is low in comparison to both lower Mesaverde Group and Black Mesa coals. This is a result of the proximate analyses being done on cuttings rather than core. The cuttings provide a greater surface area for moisture to be lost. This moisture is as received moisture, rather than capacity moisture and should not be considered as an indicator of rank. Both the

TABLE 2

COMPARISON OF SALT LAKE COALS TO MESAVERDE AND BLACK MESA COALS

	Salt Lake As Received		Black Mesa As Received		Mesaverde As Received	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
No. of samples	12		7		109	
Volatile matter	34.6	3.3	38.5	4.0	36.3	4.3
Fixed carbon	40.1	6.3	42.7	2.0	43.9	6.3
Moisture	4.6	3.5	11.5	4.6	11.6	5.3
Ash	20.7	9.2	7.3	1.8	8.4	4.7
Carbon	56.7	7.8	62.5	3.9	58.1	9.3
Hydrogen	4.4	.4	5.8	.3	4.9	.5
Nitrogen	1.1	.1	1.1	.1	1.2	.2
Oxygen	11.6	1.5	11.5	1.1	14.9	7.1
Sulfur	.9	.3	.4	.1	1.0	.9
As received BTU	9920.0		10890.0		11255.0	

TABLE 3

	Salt Lake		Black Mesa		Mesaverde	
	Dry Ash Free		Dry Ash Free		Dry Ash Free	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
No. of Samples	12		7		94	
Volatile matter	46.5	2.18	47.3	1.86	45.9	2.07
Fixed Carbon	55.3	1.41	53.5	1.88	54.1	2.06
Moisture	----		----		----	
Ash	----		----		----	
Carbon	75.9	1.84	77.0	.25	80.1	1.76
Hydrogen	5.9	.45	5.5	.10	5.8	.11
Nitrogen	1.6	.19	1.4	.08	1.6	.23
Oxygen	15.5	1.72	15.7	.30	11.0	2.81
Sulfur	1.3	.5	.5	.12	1.2	1.00
O/C	.20		.20		.14	
H/C	.08		.07		.07	
Moist, Mineral-Matter Free BTU	12869.0		11847.0		12421.0	

volatile matter and fixed carbon content of the coals in the study area are lower than lower Mesaverde Group coals or the Black Mesa coals.

The total sulfur content of the coals (.87%) is lower than the lower Mesaverde Group coals, but higher than Black Mesa coals. The sulfur of four samples (416-31-1, 417-14-1, 417-3-1, 417-23-1) was broken down into organic, pyritic and sulfate content. In these four samples, the total sulfur averaged .75%. The organic sulfur averages 0.51%, 68% of the total sulfur content of the coals. Pyritic sulfur averages 0.20%, 27% of the total sulfur. One coal sample, 417-3-1 has 0.16% of the total sulfur tied up as sulfate, probably in gypsum.

The as received values for the ultimate analyses of the Salt Lake coals are lower than the ultimate analyses for either the lower Mesaverde or Black Mesa coals. The oxygen/carbon and oxygen/hydrogen ratios (table 3) on a dry ash free basis are very similar for the Salt Lake and Black Mesa coals. The oxygen/carbon ratio for the Salt Lake and lower Mesaverde coals are somewhat different, reflecting a higher carbon content for the Salt Lake coals.

The mean proximate, ultimate and BTU values for the coals present in the study area can be compared to lower Mesaverde Group and Black Mesa coals by use of the Student "t" test. In making these comparisons the analyses were converted to a dry ash free basis. The moisture and ash contents are highly variable, due both to sampling techniques and sample location in the coal swamp. Coals from these three areas are similar in rank, so differences in the proximate and ultimate analyses would not be what is expected from coals of different ranks. The t test shows that the means of of the proximate and ultimate analyses for the Salt Lake coals have a greater similarity to the Black Mesa coals than to the lower Mesaverde coals. The only values the had acceptable t values for the Salt Lake/Mesaverde comparison were the fixed carbon, hydrogen and nitrogen. However comparison of the Salt Lake/Black Mesa coals resulted in all values except volatile matter and oxygen being accepted as being from the same population.

COAL CHEMISTRY

Three coal cores were analysed for concentrations of chemical elements. All analyses were done by Chemical Testing and Engineering in Denver, Colorado. Mercury was analysed using flameless atomic absorption. The oxides were done by x-ray fluoresence, on ashed coal, and figured in percentage. All other elements were analysed by spark source mass spectrometry, figured in parts per million and on a whole coal basis. Table 4 is the average of these three coals converted to an ashed coal basis, compared to the average for lower Mesaverde (Gallup and Crevasse Canyon) coals and Black Mesa coals. Since only three coals were analysed, neither standard deviations or statistical comparisons would have any significance. The standard deviation for lower Mesaverde coals is given for rough comparisons.

TABLE 4

COMPARISON OF CONCENTRATION OF CHEMICAL ELEMENTS PRESENT IN SALT LAKE COALS TO MESAVERDE AND BLACK MESA COALS

(on whole coal basis)

	Salt Lake		Mesaverde		Black Mesa	
No. of Samples	3		25		16	
Ash	20.70		9.1		7.63	
SiO2	7.89	4.04	8.94	6.46	3.18	1.97
Al2O3	3.40	1.59	3.27	1.96	1.16	.63
CaO	.51	.32	.79	1.02	.98	.48
MgO	.10	.08	.20	.24	.17	.05
Na2O	.07	.05	.09	.08	.11	.06
K2O	.07	.10	.11	.13	.06	.05
Fe2O3	1.34	.71	.87	1.18	.46	.10
TiO2	.19	.08	.20	.12	.07	.03
SO3	.51	.20	.55	.28	.86	.10
As	1.20	.83	4.88	10.89	1.94	2.24
Be	.50	.53	2.02	1.62	.53	.37
Cu	18.00	13.08	11.94	7.01	5.42	1.76
F	73.33	59.70	21.31	41.49	35.00	14.94
Hg	.08	.09	.21	.34	.03	.01
Li	4.33	2.31	10.50	5.76	3.41	1.92
Mn	210.00	87.18	56.57	175.76	9.59	3.65
Pb	6.33	.58	7.93	4.94	2.43	1.12
Sb	15.33	11.15	2.93	3.81	.29	.15
Se	1.10	.85	2.80	1.26	1.59	.30
Th	9.67	8.33	5.60	3.79	3.04	.18
U	5.00	1.73	2.16	1.14	.53	.35
Zn	69.67	43.66	11.79	9.94	15.81	8.45

Those elements marked with an L occur below the detection limit of the analytical technique used. These detection limits are found in those coals analysed by x-ray fluoresence, in most cases. As a result care should be used when drawing conclusions from Table 4. As an example, the phosphorus content of the Fence Lake coals is considerably lower than either the lower Mesaverde or the Black Mesa coals, which would indicate that these coals would have less of a tendency to foul steam plant machinery. However, the spark source mass spectrometry is capable of detecting smaller quantities of P2O5 than is x-ray fluoresence.

X-ray diffraction data on the Salt Lake coals indicate a mineral matter of kaolinite, quartz and pyrite. Using the forms of sulfur data, pyritic sulfur averages .2% of the total sulfur This indicates that 1.69% of the mineral matter is pyrite. SEM scans of whole coal indicate that no finely disseminated pyrite is present. Work by Gluskoter and others (1975) on Illinois coals, has demonstrated which elements are tied up in the organic and inorganic fractions. Their work indicates that nearly all of the silica and potassium are associated with the mineral matter. Since the only potassium bearing mineral found in these coals is kaolinite, all the potassium can be assumed to be in kaolinite. By using the percentages of potassium and silica present, the amount of kaolinite and quartz can be obtained. This indicates that there is 65% kaolinite and 28% quartz. SEM scans on the residue of macerated and whole coals show that quartz occurs both as discrete grains and finely disseminated material and that all the kaolinite is finely disseminated within the coal. The finely disseminated quarts is most likely due to the breakdown of silica rich minerals (feldspars and micas) that were probably present in the original coal swamp into kaolinite. These three minerals make up 94.7% of the ash of the coal. The remaining 5.3% of the ash can be attributed to the ash formed formed by burning the plant material. The high ash fusion temperatures of these coals is due to the high kaolinite content. The low alkali content of the Salt Lake coals would also indicate a high ash fusion temperature.

The volatiles present in the Salt Lake coals are generally in lower concentrations than the volatiles of either Black Mesa or lower Mesaverde coals. The arsenic concentration is considerably lower than what is present in the coals of the lower Mesaverde but is similar to Black Mesa coals. Antimony has an anomalously high concentration, compared to the other two populations. This is partially due to one sample, 417-14-1, which has a concentration of 28 ppm. Ruch (1974) demonstrates that antimony is concentrated in the mineral fraction of Illinois coals. Both arsenic and antimony can substitute for iron, so pyrite would be the most likely place to find these elements in the Salt Lake coals. The uranium, thorium, and vanadium concentrations are considerably higher than what is found in either Mesaverde or Black Mesa coals. Both the Datil Group and Baca Formation would serve as a source for these three elements. As these two overlying units were stripped away, the uranium, thorium and vanadium were leached out and concentrated in the coals.

COAL RESERVES

A total of 24 holes were drilled in conjunction with this study. In addition nine water wells were logged. These holes are numbered according to township, range, section and number of holes drilled on the section. The numbering is the same for the water wells except that those wells cased with steel are indicated Fe and those cased with PVC pipe are so indicated. These drill holes, as well as several water-wells that were logged are summarized in appendix II. Figures 7 and 8 show the locations of all drill holes and logged water wells in the study area. Table 7 identifies these locations to quarter/quarter section and well number. Minable coals were penetrated in 21 of the 24 holes drilled. Whenever possible, drilling was done on private land with federal minerals. All holes were geophysically logged and had cuttings collected at five foot intervals.

The coals present in the Salt Lake field are bituminous in rank and have a minimum strippable thickness of 1.2 ft. The reserve figures for this report, therefore, are based on coals of 1.2 ft or greater thickness. Reserve calculations were done according to U.S.G.S Bull. 1450-B, for measured and indicated categories. The weight of bituminous coal is estimated to be 1800 tons/acre-foot, which agrees with the value derived from the density of the coal in the Salt Lake Field.

Mineral ownership of the coal in the study area is split into federal, state and private categories. Table 5 gives a breakdown of these categories, in percentages, according to the portions of the townships present in the study area. The largest owner of mineral rights in the study area is the federal government with 40.5%, followed by the state government with 38.4% and only 21.1% of the minerals are privately owned. These percentages are not equally distributed over the two quadrangles. The 38.4% of the minerals on The Dyke quadrangle are owned by the federal government, 8.6% by the state and 53.0% are privately owned. On the Cerro Prieto quadrangle 43.3% of the minerals are owned by the federal government, 35.2% by the state and 22.1% are privately owned.

TABLE 5

MINERAL OWNERSHIP BASED ON TOWNSHIP AND RANGE

Township	% Federal	% State	% Private
T. 6 N. R. 16 W.	34.4	16.4	49.2
T. 6 N. R. 17 W.	38.1	9.1	52.7
T. 5 N. R. 16 W.	72.1	18.5	9.4
T. 5 N. R. 17 W.	5.9	17.5	76.6
T. 4 N. R. 16 W.	30.1	65.3	4.6
T. 4 N. R. 17 W.	58.0	47.7	10.3
T. 3 N. R. 16 W.	75.8	24.2	0.0
T. 3 N. R. 17 W.	40.3	51.3	8.4

The two quadrangles involved in this study contain measured coal reserves based on both outcrop and drill data of 53.6 million tons of coal. Indicated reserves are based on drill data only and consist of 202.9 million tons. The demonstrated coal reserves for the study area are 256.4 million tons. The average depth of this coal is 116 ft, ranging from surface outcrop to 252 ft. Separating the coals into depth categories shows that 200.3 million tons of demonstrated coal are within 150 ft of the surface and 49.04 million tons have overburden of between 150-250 ft. Only 6.13 million tons of coal are greater than 250 ft in depth. The average seam thickness, for minable coal is, 3.1 ft, ranging from 1.2 ft to 12 ft. Table 6a shows the demonstrated tonnages in the three depth categories based on township and range. Separating the demonstrated reserves based on stripping ratios results in 82.5 million tons being less than 10:1; 27.7 million tons being between 10 and 20:1; and between 20-30:1 there are 43.1 million tons. The remaining 102.6 million tons have a stripping ratio of greater than 30:1.

Table 6b gives a breakdown of the measured and indicated reserves according to township and range, as well as the demonstrated tonnages under the various mineral ownership categories. All but two holes were drilled on land that had federal mineral ownership. The Federal government owns the largest amount of coal in the area, with a demonstrated reserve of 184.68 million tons. State owned coal reserves amount to 40.91 million tons. Privately owned coal amounts to only 9.52 million tons.

Several townships (Township 3 and 6 N. Range 17 W. and Township 6 N. Range 16 W.) show no measured coal reserves, this is due to a lack of drill data. Township 6 N. Range 17 W. probably has no coal present, based on projections of the

TABLE 6

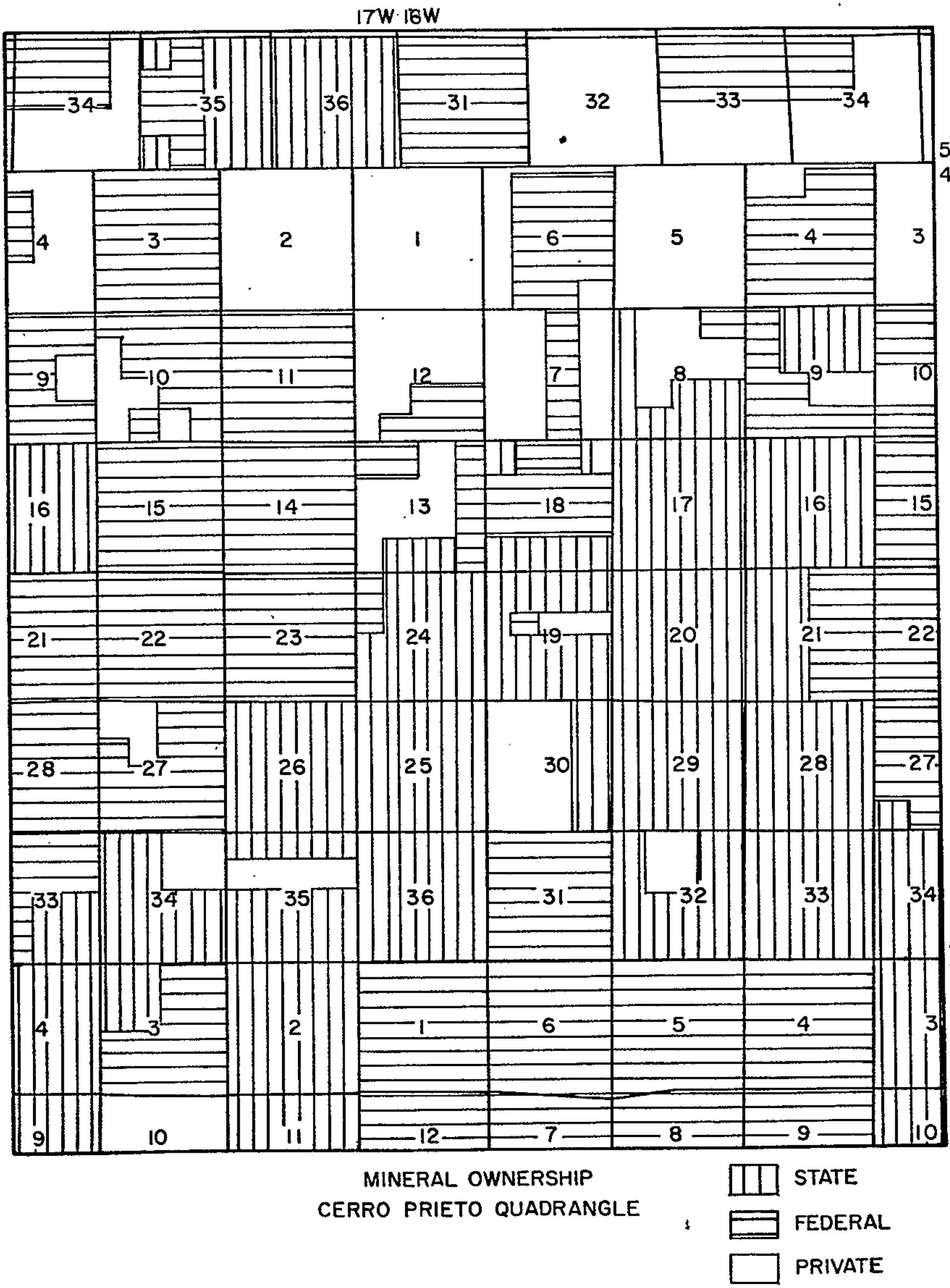
a) DEMONSTRATED RESERVES IN DEPTH CATEGORIES OF CERRO PRIETO AND THE DYKE QUADRANGLES

	0-150	150-250	>250
T. 6 N. R. 17 W.	5.43	0.00	0.00
T. 6 N. R. 16 W.	.63	.84	0.00
T. 5 N. R. 17 W.	46.81	14.99	0.00
T. 5 N. R. 16 W.	10.90	13.37	3.37
T. 4 N. R. 17 W.	66.53	14.92	0.00
T. 4 N. R. 16 W.	39.11	7.82	2.76
T. 3 N. R. 17 W.	3.86	0.00	0.00
T. 3 N. R. 16 W.	3.60	0.00	0.00
TOTAL	176.87	51.94	6.13

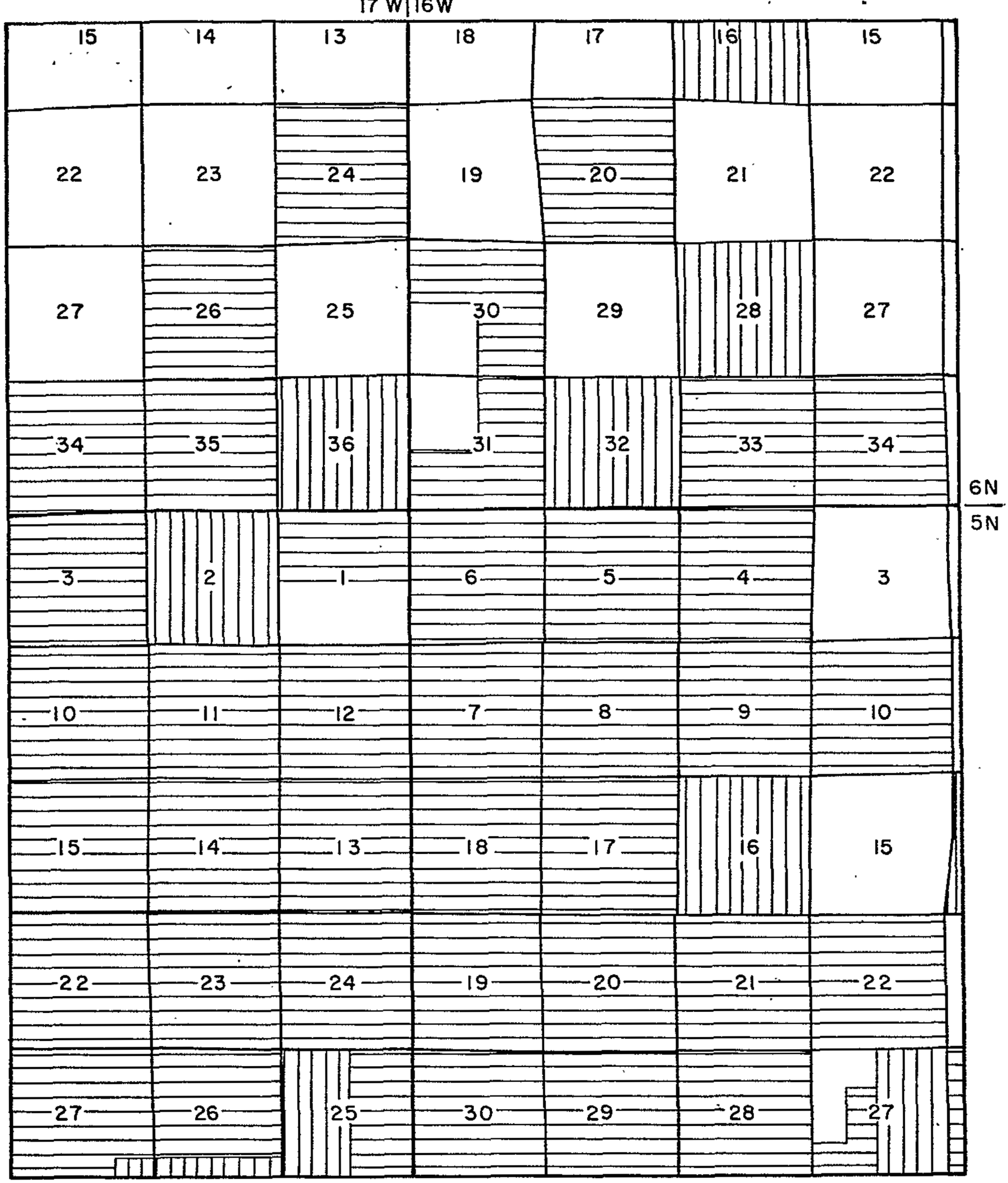
b) COAL RESERVES OF CERRO PRIETO AND THE DYKE QUADRANGLES

(in millions of short tons)

	Measured	Indicated	Federal	State	Private
T 6 N. R 17 W.	0.00	5.43	3.76	1.67	0.00
T 6 N. R 16 W.	2.33	19.28	21.61	0.00	0.00
T 5 N. R 17 W.	17.17	44.64	50.64	8.76	2.81
T 5 N. R 16 W.	6.74	20.89	27.72	.67	0.00
T 4 N. R 17 W.	17.03	64.41	67.43	9.86	3.69
T 4 N. R 16 W.	8.32	42.68	27.51	19.59	3.03
T 3 N. R 17 W.	0.00	3.86	3.39	.48	0.00
T 3 N. R 16 W.	2.04	1.56	3.60	0.00	0.00



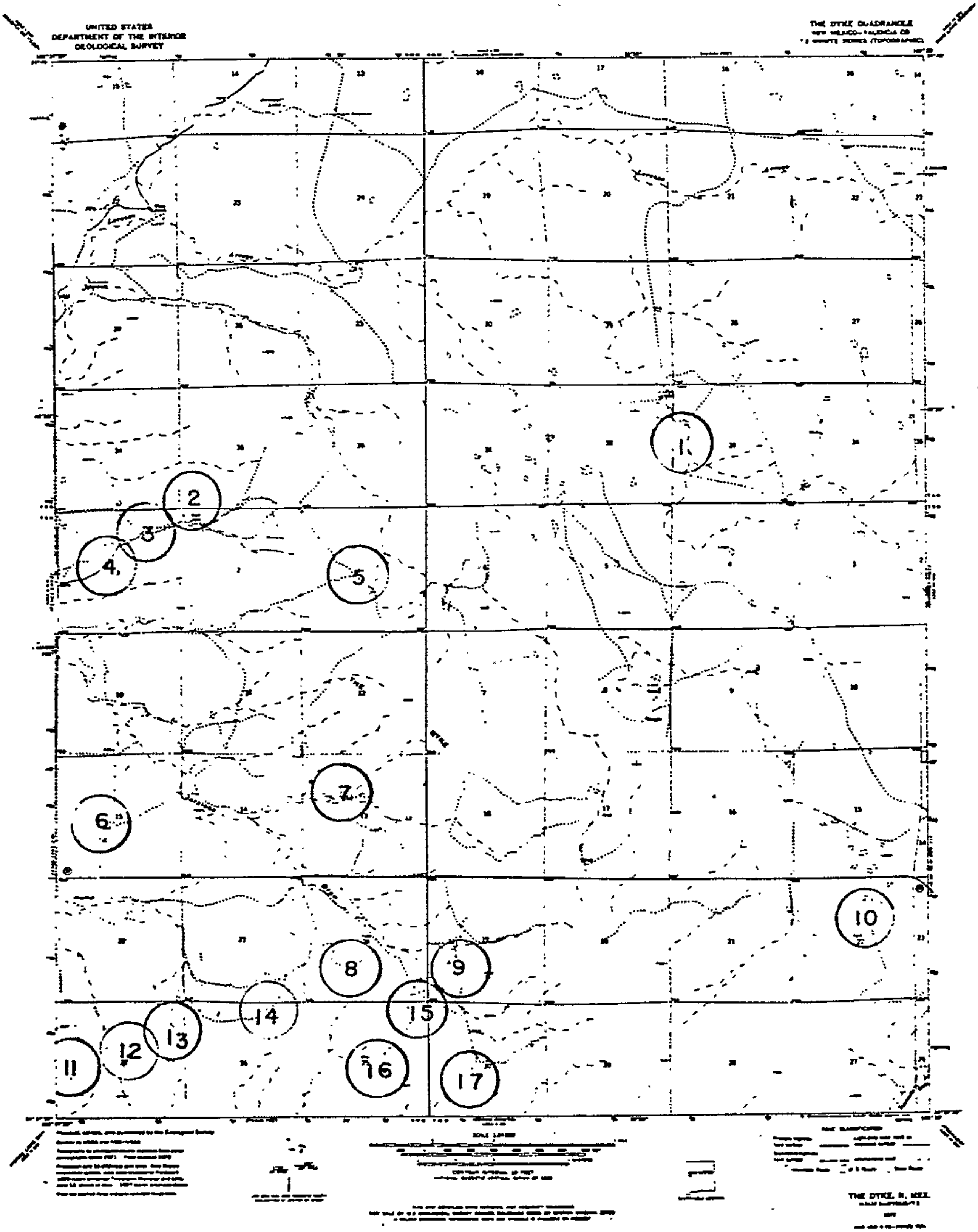
MINERAL OWNERSHIP
CERRO PRIETO QUADRANGLE



MINERAL OWNERSHIP
THE DYKE QUADRANGLE

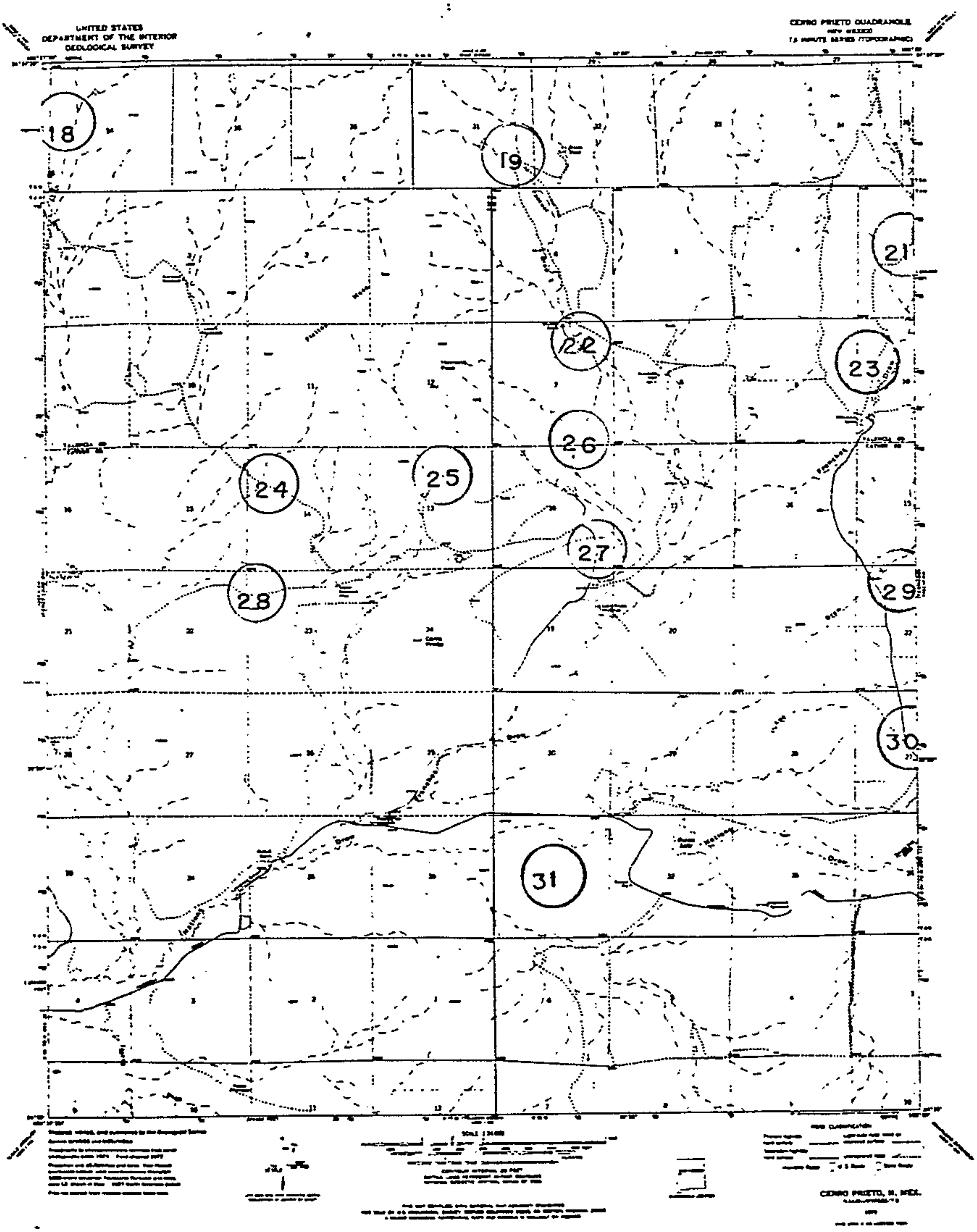
FIG. 6

STATE
FEDERAL
PRIVATE



LOCATION OF DRILL HOLES THE DYKE QUADRANGLE

FIG. 7



LOCATION OF DRILL HOLES CERRO PRIETO QUADRANGLE

FIG. 8

TABLE 7

LOCATION OF DRILL HOLES

1.	616-33-1	swl/4	nwl/4	sec.	33	T.	6	N.	R.	16	W.
2.	617-35-1pvc	swl/4	swl/4	sec.	35	T.	6	N.	R.	17	W.
3.	517-3-1pvc	nwl/4	sel/4	sec.	3	T.	5	N.	R.	17	W.
4.	517-3-1fe	sel/4	nel/4	sec.	3	T.	5	N.	R.	17	W.
5.	517-1-1fe	nwl/4	sel/4	sec.	1	T.	5	N.	R.	17	W.
6.	517-15-1fe	nel/4	swl/4	sec.	15	T.	5	N.	R.	17	W.
7.	517-13-1	nwl/4	nwl/4	sec.	13	T.	5	N.	R.	17	W.
8.	517-24-1	nwl/4	swl/4	sec.	24	T.	5	N.	R.	17	W.
9.	516-19-1	nel/4	swl/4	sec.	19	T.	5	N.	R.	16	W.
10.	516-22-1pvc	nwl/4	nel/4	sec.	22	T.	5	N.	R.	16	W.
11.	517-27-2	nwl/4	swl/4	sec.	27	T.	5	N.	R.	17	W.
12.	517-27-3	swl/4	nel/4	sec.	27	T.	5	N.	R.	17	W.
13.	517-27-1	nel/4	nel/4	sec.	27	T.	5	N.	R.	17	W.
14.	517-26-1	nwl/4	nel/4	sec.	26	T.	5	N.	R.	17	W.
15.	517-25-3	nel/4	nel/4	sec.	25	T.	5	N.	R.	17	W.
16.	517-25-1	nwl/4	sel/4	sec.	25	T.	5	N.	R.	17	W.
17.	516-30-1	sel/4	nwl/4	sec.	30	T.	5	N.	R.	16	W.
18.	517-34-1	swl/4	nwl/4	sec.	34	T.	5	N.	R.	17	W.
19.	516-31-1	nwl/4	sel/4	sec.	31	T.	5	N.	R.	16	W.
20.	417-3-1			sec.	3	T.	4	N.	R.	17	W.
21.	416-3-1	nel/4	swl/4	sec.	3	T.	4	N.	R.	16	W.
22.	416-7-1	nel/4	swl/4	sec.	7	T.	4	N.	R.	16	W.
23.	416-10-1	swl/4	nwl/4	sec.	10	T.	4	N.	R.	16	W.
24.	417-14-1	sel/4	nwl/4	sec.	14	T.	4	N.	R.	17	W.
25.	417-13-1	nwl/4	nel/4	sec.	13	T.	4	N.	R.	17	W.
26.	416-7-2	swl/4	sel/4	sec.	7	T.	4	N.	R.	16	W.
27.	416-18-1	nwl/4	sel/4	sec.	18	T.	4	N.	R.	16	W.
28.	417-23-1	nwl/4	nwl/4	sec.	23	T.	4	N.	R.	17	W.
29.	416-22-1	nwl/4	nwl/4	sec.	22	T.	4	N.	R.	16	W.
30.	416-27-1	sel/4	nwl/4	sec.	27	T.	4	N.	R.	16	W.
31.	416-31-1	swl/4	nel/4	sec.	31	T.	4	N.	R.	16	W.
32.	316-6-1fe			sec.	6	T.	3	N.	R.	16	W.
33.	317-12-1fe			sec.	12	T.	3	N.	R.	17	W.

stratigraphy present in holes drilled to the south of this township (see fig. 4). Township 6 N. Range 16 W. probably does have some coal, based on reports of ranchers who have drilled water wells and the presence of upper Moreno Hill sediments. The few geophysical logs available indicate that Townships 3 N., Range 16 and 17 W both probably contain extensive coal reserves.

SUBSURFACE GEOLOGY

All holes were collared in the Moreno Hill Formation. The upper, middle and lower coal zones were penetrated in drilling. The logs and cuttings indicate that most of the holes were drilled through crevasse splay, fluvial channels, and siltstones and mudstones (Allen, 1975). In some holes (517-13-1, 517-27-3, 516-31-1 and 417-3-1) marine shales, calcite concretions and thin limestones can be identified (Century, 1979). Above these shale sequences are sandstones that coarsen upward, have flat upper surfaces and crossbedding, indicative of a beach deposit (ALLEN, 1975). These units do not outcrop in the study area but are believed to represent the Rio Salado Tongue of the Mancos shale and the Atarque Formation respectfully.

Three coal zones are present in the drilling data. The two outcropping zones, with their tonsteins are readily identified. A third deeper zone is present in hole 517-34-1, 270 ft below the middle sandstone. What is probably the middle coal zone was penetrated along the eastern edge of the Cerro Prieto quadrangle at a depth of 252'. Figure 4 demonstrates the structure along an east-west line through the center of the quadrangle, showing how the strata dip to the east. The middle coal zone extends in subsurface to the southern border of the Cerro Prieto quadrangle. The major seam is increasing in thickness to the south.

Water was frequenty encountered in drilling. In most cases aquifers only produce 2-6 gpm. Based on information from established water wells, these rates are fairly consistent. Two aquifers seem prominent, an upper one at about 6600 ft and a lower aquifer at 6400 ft, both in the lower Moreno Hill Formation. The upper aquifer produces 6 gpm, the water is highly corrosive, since stock tanks and well pumps corrode within a relatively short period of time. No data is available on the quality of the upper aquifer. The lower aquifer has had some analyses done by the New Mexico Bureau of Mines. Table 8 lists the results of these analyses. This well is located in Township 5 N., Range 16 W. sec. 22, is cased in PVC, with the depth of the water at 840′. This lower aquifer produces at least 20 gpm, ranchers report higher rates at a slightly greater depth.

TABLE 8

WATER QUALITY DATA

Dissolved Salts	365	ppm	Umhos	700	ppm
CO3	0	ppm	Na	116	ppm
HCO3	244	ppm	K	20.8	ppm
SO4	85	ppm	Mg	1.14	ppm
Cl	4	ppm	Ca	7	ppm

Geophysical logs indicate a few anomalously high gamma counts in mudstones. Background is roughly 60 cps, mudstones show up to 120 cps. Holes 416-31-1 and 417-14-1 have zones of mudstone with up to 300 cps. This is not approaching mineralization, but appear to be correlatable.

CONCLUSIONS

The coals present in the study area are high volatile bituminous C in rank. Their apparent high ash and volatile matter content as well as low fixed carbon content would indicate their best usage as steam coal. Mining of these coals is feasible, due to their shallow depth, however transportation would be a problem, due to the remoteness of the area. One possible destination for this coal would be the generating plants presently under construction at Showlow and St. Johns, Arizona.

Based on the information gathered from the drilling program, further drilling is indicated. The best areas are in the Tejana Mesa quadrangle to the south, and the Techado quadrangle to the east. Logs from the southern portion of the Cerro Prieto quadrangle show a 9-ft seam that apparently extends south into the Tejana Mesa quadrangle. This seam is generally within 100 ft of the surface, and could be valuable as a strippable unit. The area east of Cerro Prieto, in the Techado quadrangle, is also a likely area to show extensive coal resources. The middle coal zone present on the Cerro Prieto quadrangle dips down at about five degrees to the east. This coal, if present as projected, would be deeper than 250 ft, the limit for stripping under present economic conditions. A third area that should be considered is in the northeast quarter of The Dyke quadrangle, where Moreno Hill sediments crop out in McCarty's Basalt flow. This coal would not be minable, since it would be deeper than 250 ft, also the presence of the flow would seriously restrict strip mining this coal.

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DRILL HOLE SUMMARY SHEET

Hole no. 316-6-Fe

Township 3 N. Range 16 W. sec. 6

Location: 2000´ E. of W. line

4500´ N. of S. line

Elevation: 6670´

Mineral Ownership: Federal

County: Catron

Total Depth: 64´

Quadrangle: Cerro Prieto

Formation: Moreno Hill

Water: water well

Data: geophysical logs - gamma(api), density(g/cc)

Coal Depth Thickness Elevation

CONFIDENTIAL

Hole no. 317-12-1fe

Township 3 N. Range 17 W. Sec.12

Location: 1000´ E. of W. line

1900´ N. of S. line

Elevation: 6680´

Mineral Ownership: Federal

County: Catron

Total Depth: 101´

Quadrangle: Tejana Mesa

Formation: Moreno Hill

Water: 54´ ?gpm (6606)

Data: geophysical logs - gamma, density, neutron

Coal Depth Thickness Elevation

CONFIDENTIAL

Hole no. 416-3-1 Township 4 N. Range 16 W. Sec. 3

Location: 1650′ E. of W. line Elevation: 6980′

2400′ N. of S. line Mineral Ownership: Private

County: Valencia Total Depth: 260′

Quadrangle: Cerro Prieto Formation: Moreno Hill

Water: 136′ 4 gpm (6844′)

Data: cuttings; geophysical logs: gamma(cps), density(cps), resistance

Coal Depth	Thickness	Elevation
45′	1.2′	6935′
106′	2.4′	6874′

Hole no. 416-7-1 Township 4 N. Range 16 W. Sec 7

Location: 4000′ E. of W. line Elevation: 6870′

4300′ N. of S. line Mineral Ownership: Federal

County: Valencia Total Depth: 180′

Quadrangle: Cerro Prieto Formation: Moreno Hill

Water: no water

Data: cuttings; geophysical logs - gamma(cps), caliper, density(g/cc)

Coal Depth	Thickness	Elevation
53′	2.4′	6827′

Hole no. 416-7-2

Township 4 N. Range 16 W. Sec. 7

Location: 3800´ E. of W. line

500´ N. of S. line

Elevation: 6845´

Mineral Ownership: Federal

County: Catron

Total Depth: 245´

Quadrangle: Cerro Prieto

Formation: Moreno Hill

Water: 83´ 6gpm (6762´)

Data: cuttings; geophysical logs - gamma(api), caliper, density(g/cc), resistivity

Coal Depth	Thickness	Elevation
106´	2.8´	6739´
127´	1.2´	6718´

Hole no. 416-10-1

Township 4 N. Range 16 W. Sec. 10

Location: 200´ E. of W. line

3800´ N. of S. line

Elevation: 6920´

Mineral Ownership: Federal

County: Valencia

Total Depth: 272´

Quadrangle: Cerro Prieto

Formation: Moreno Hill

Water: 143´ 4 gpm (6777´)

Data: cuttings; geophysical logs - gamma(cps), density(cps) resistance

Coal Depth	Thickness	Elevation
252´	2.1	6668´

Hole no. 416-18-1 Township 4 N. Range 16 W. Sec. 18

Location: 4000´ E. of W. line Elevation: 6790´

2400´ N. of S. line Mineral Ownership: Federal

County: Catron Total Depth: 115´

Quadrangle: Cerro Prieto Formation: Moreno Hill

Water: no water

Data: cuttings; geophysical logs - gamma(cps), density(cps), resistance

Coal Depth	Thickness	Elevation
38´	3.0´	6752´

Hole no. 416-22-1 Township 4 N. Range 16 W. Sec. 22

Location: 1550´ E. of W. line Elevation: 6810´

4700´ N. of S. line Mineral Ownership: Federal

County: Catron Total Depth: 280´

Quadrangle: Cerro Prieto Formation: Moreno Hill

Water: no water

Data: cuttings; geophysical logs - gamma(cps), density(cps), resistance

Coal Depth	Thickness	Elevation
212´	3.0´	6598´
217´	2.2´	6593´
244´	2.0´	6566´

Hole no. 416-27-1 Township 4 N. Range 16 W. sec. 27

Location: 2200´ E. of W. line Elevation: 6810´

3000´ N. of S. line Mineral Ownership: Federal

County: Catron Total Depth: 280´

Quadrangle: Cerro Prieto Formation: Moreno Hill

Water: 200´ 6 gpm (6610´)

Data: cuttings; geophysical logs - gamma(cps), density(cps), resistivity

Coal Depth Thickness

No coal

Hole no. 416-31-1 Township 4 N Range 16 W Sec. 31

Location: 2600´ E. of W. Line Elevation: 6790´

2600´ N. of S. Line Mineral Ownership: Federal

County: Catron Total Depth: 262´

Quadrangle: Cerro Prieto Formation: Moreno Hill

Water: 20 GPM @ 255´, minor seeps starting at 92´ (6535´)

Data: cuttings; geophysical logs - gamma(API), caliper, density, resistivi

core - 45-70.5´

Coal	Depth	Thickness	Elevation
	48´	8.5´	6742´
	67´	1.2´	6723´

Core Description (cored interval 45-70.5´)

32" Sandstone, lt. tan, 2.0-3.00, round, clay matrix (kaolinite), grains in contact, very friable, some coal grains present, 95%

quartz, grains coated with clay and stained tan, carbonaceous laminations increase in frequency to 17" from top where abruptly terminate

14" Sandstone, lt. gray, less matrix than above, 2.0-3.00, carbonaceous laminations common in upper 6" of interval, not present in lower 8"

77" Coal, pyrite and gypsum along cleats, 10% vitrain, 10% durain, 80% clarain; pyrite exists as vein filling as well as irregular masses (<.1") along cleat surfaces; two kaolinitic partings, upper 26" from top of coal, second 41" from top of coal; at 56" from top of coal, coal blocky, with brownish hue on surface, on broken surface is vitrain, approximately 25% of this lower interval lost.

7" mudstone, dark gray/black, carbonaceous streaks

58" claystone, lt gray/green, horizontal fractures with CO3 along surface

46" Claystone, black, crumbly, waxy texture, 50% recovery

18" claystone, gray/brown, crumbled, soft, greasy lustre

2" Coal, 70% vitrain, 30% clarain

4" Claystone, gray/brown, greasy lustre

54" Sandstone, very light gray, 3.0-4.00, round, grains float in clay matrix, friable

Hole no. 417-3-1 Township 4 N Range 17 W Sec. 3

Location: 1300´ E. of W. Line Elevation: 6880´

2800´ N. of S. Line Mineral Ownership: Federal

County: Valencia Total Depth: 250´

Quadrangle: Cerro Prieto Formation: Moreno Hill

Water: 227´, 4 gpm (6653´)

Data: Cuttings; geophysical logs - gamma(API), caliper, density, resistivity

core(35-45´)

Coal Depth	Thickness	Elevation
CONFIDENTIAL		

Hole no. 417-13-1 Township 4 N Range 17 W Sec. 13

Location: 2750´ E. of W. Line Elevation: 6875´

4000´ N. of S. Line Mineral Ownership: Private

County: Valencia Total Depth: 250´

Quadrangle: Cerro Prieto Formation: Moreno Hill

Water: no water

Data: cuttings; geophysical logs - gamma(cps), density(cps), resistance

Coal Depth	Thickness	Elevation
76´	2.5´	6799´
168´	4.5´	6709´

Hole no. 417-14-1

Township 4 N Range 17 W Sec. 14

Location: 1950′ E. of W. Line
3000′ N. of S. Line

Elevation: 6810′

Mineral Ownership: Federal

County: Catron

Total Depth: 250′

Quadrangle: Cerro Prieto

Formation: Moreno Hill

Water: 169′ 4 gpm (6641)

Data: cuttings; geophysical logs - gamma(cps), SP, resistance, gamma-gamma, core(134-154′)

Coal Depth	Thickness	Elevation
53′	2.0′	6757′
135′	6.2′	6675′
213′	2.0′	6597′

Core description (core interval; 134-154)

35" mudstone, gray, soapy, elongate claystone clasts, carbonaceous plant remains

12" silty mudstone, dark gray, waxy, soft, organic fragments

11" coal, 75% durain, 5% vitrain, 20% clarain, no visible pyrite

4" organic mudstone, black, thin (.1") coaly bands

50" coal, visible pyrite veins and irregular masses along cleats (<.1" dia), 80% clarain, 20% durain CO3 along cleats

13" coal, pyrite along cleats, 80% clarain, 10% vitrain, 10% durain

6" organic mudstone, well indurated, greasy

39" mudstone, dark gray, indurated , carbonaceous plant remains

47" siltstone, micaceous, gray/green

Hole no. 417-23-1 Township 4 N Range 17 W Sec. 23

Location: 1000′ E. of W. Line
4150′ N. of S. Line

Elevation: 6740′

Mineral Ownership: Federal

County: Catron

Total Depth: 250′

Quadrangle: Cerro Prieto

Formation: Moreno Hill

Water: 150′ 6 gpm (6590′)

Data: cuttings, geophysical logs - gamma(cps), SP, resistance, gamma-gamma, gamma(api), caliper, density(g/cc)

Coal Depth	Thickness	Elevation
31′	5.8′	6709′
41′	4.5′	6699′
107′	3.0′	6633′

Hole no. 516-19-1 Township 5 N Range 16 W Sec. 19

Location: 1300′ E. of W. Line
500′ N. of S. Line

Elevation: 7300′

Mineral Ownership: Federal

County: Valencia

Total Depth: 250′

Quadrangle: The Dyke

Formation: Moreno Hill

Water: no water

Data: cuttings; geophysical logs - gamma(cps), density(cps), resistance

Coal Depth	Thickness	Elevation
89′	4.3′	7211′
172′	3.4′	7128′

Hole no. 516-22-1pvc

Township 5 N. Range 16 W. Sec. 22

Location: 3100′ E. of W. line
4300′ N. of S. line

Elevation: 7310′

Mineral Ownership: Federal

County: Valencia

Total Depth: 254′

Quadrangle: The Dyke

Formation: Moreno Hill

Water: none

Data: Geophysical logs - gamma, density

Coal Depth	Thickness	Elevation
115′	1.5′	7195′
126′	1.2′	7184′
175′	2.8′	7135′

Hole no. 516-30-1

Township 5N Range 16 W Sec. 30

Location: 1950′ E. of W. Line
1900′ N. of S. Line

Elevation: 7300′

Mineral Ownership: Federal

County: Valencia

Total Depth: 250′

Quadrangle: The Dyke

Formation: Moreno Hill

Water: no water

Data: cuttings; geophysical logs - gamma(cps), density(cps), resistance

Coal Depth	Thickness	Elevation
121′	2.0′	7179′
181′	6.5′	7119′
268′	2.4′	7032′

Hole no. 516-31-1 Township 5 N. Range 16 W. sec. 31

Location: 2700′ E. of W. line Elevation: 7020′

1700′ N. of S. line Mineral Ownership: Federal

County: Valencia Total Depth: 253′

Quadrangle: Cerro Prieto Formation: Moreno Hill

Water: no water

Data: cuttings, geophysical logs - gamma(api), density(g/cc), caliper, resistance

Coal	Depth	Thickness	Elevation
	104′	1.5′	6916′

Hole no. 517-1-Fe Township 5 N. Range 17 W. sec. 1

Location: 2000′ E. of W. line Elevation: 7200′

3650′ N. of S. line Mineral Ownership: Federal

County: Valencia Total Depth: 294′

Quadrangle: The Dyke Formation: Moreno Hill

Water: Water well

Data: geophysical logs - gamma(api and cps), density(g/cc), neutron

Coal	Depth	Thickness	Elevation
	61′	3.8′	7139′
	247′	1.4′	7053′

Hole no. 517-3-Fe | Township 5 N. Range 17 W. sec. 3

Location: 4000′ E. of W. line | Elevation: 7020′

4500′ N. of S. line | Mineral Ownership: Federal

County: Valencia | Total Depth: 108′

Quadrangle: The Dyke | Formation: Moreno Hill

Water: water well

Data: geophysical logs - gamma(cps and api), neutron, density(g/cc)

Coal	Depth	Thickness	Elevation
	35′	2.1′	6985′
	70′	2.1′	6950′

Hole no. 517-13-1 | Township 5 N. Range 17 W. sec. 3

Location: 1200′ E. of W. line | Elevation: 7120′

3900′ N. of S. line | Mineral Ownership: Federal

County: Valencia | Total Depth: 516′

Quadrangle: The Dyke | Formation: Moreno Hill

Water: no water

Data: cuttings; geophysical logs - gamma(cps and api), density(g/cc), resistivity, resistance, caliper, SP, gamma-gamma

Coal Depth Thickness Elevation

no coal

Hole no. 517-15-1fe

Township 5 N. Range 17 W. Sec. 15

Location: 2100´ E. of W. Line
1650´ N. of S. Line

Elevation: 7060´

Mineral Ownership: Federal

County: Valencia

Total Depth: 234´

Quadrangle: The Dyke

Formation: Moreno Hill

Water: 232´ 2gpm (6828´)

Data: Geophysical logs - gamma, density, neutron

No Coal

Hole no. 517-24-1

Township 5 N Range 17 W Sec. 24

Location: 2000´ E. of W. Line
1500´ N. of S. Line

Elevation: 7225´

Mineral Ownership: Federal

County: Valencia

Total Depth: 250´

Quadrangle: The Dyke

Formation: Moreno Hill

Water: no water

Data: cuttings; geophysical logs - gamma(cps), density(cps), resistance

Coal	Depth	Thickness	Elevation
	31´	3.5´	7194´
	90´	2.2´	7135´
	101´	3.3´	7124´

Hole no. 517-25-3 Township 5 N Range 17 W Sec. 25

Location: 3250´ E. of W. Line Elevation: 7340´

2000´ N. of S. Line Mineral Ownership: Federal

County: Valencia Total Depth: 250´

Quadrangle: The Dyke Formation: Moreno Hill

Water: no water

Data: cuttings; geophysical logs - gamma(cps), density(cps), resistance

Coal Depth	Thickness	Elevation
44´	1.4´	7286´
117´	7.5´	7223´
194´	3.8´	7146´

Hole no. 517-25-1 Township 5 N Range 17 W Sec. 25

Location: 4700´ E. of W. Line Elevation: 7250´

4100´ N. of S. Line Mineral Ownership: Federal

County: Valencia Total Depth: 250´

Quadrangle: The Dyke Formation: Moreno Hill

Water: no water

Data: cuttings; geophysical logs - gamma(cps), density(cps), resistance

Coal Depth	Thickness	Elevation
70´	3.6´	7180´
75´	1.2´	7175´
154´	3.1´	7096´

Hole. no. 517-27-1 | Township 5 N Range 17 W Sec. 27

Location: 4300′ E. of W. Line | Elevation: 7150′

4900′ N. of S. Line | Mineral Ownership: Federal

County: Valencia | Total Depth: 250′

Quadrangle: The Dyke | Formation: Moreno Hill

Water: no water

Data: cuttings; geophysical logs - gamma(cps), density(cps), resistance

Coal	Depth	Thickness	Elevation
	33′	3.5′	7117′
	99′	2.2′	7051′

Hole no. 517-27-2 | Township 5 N. Range 17 W Sec. 27

Location: 600′ E. of W. Line | Elevation: 7150′

2000′ N. of S. Line | Mineral Ownership: Federal

County: Valencia | Total Depth: 250′

Quadrangle: The Dyke | Formation: Moreno Hill

Water: no water

Data: cuttings; geophysical logs - gamma(cps), density(cps), resistance

Coal	Depth	Thickness	Elevation
	137′	2.2′	7013′

Hole no. 616-33-1 | Township 6 N. Range 16 W. Sec. 33

Location: 3650′ E. of W. line | Elevation: 7220′

3300′ N. of S. line | Mineral Ownership: Federal

County: Cibola | Total Depth: 280′

Quadrangle: The Dyke | Formation: Moreno Hill

Water: seep at 140′

Data: cuttings; Geophysical logs - Gamma, Denisty

Coal	Depth	Thickness	Elevation
	40′	2.5′	7180′
	82′	2.4′	7138′
	96′	3.8′	7124′
	111′	1.6′	7109′

Hole no. 617-35-lpvc | Township 6 N. Range 17 W. Sec. 35

Location: 200′ E. of W. line | Elevation: 7060′

400′ N. of S. line | Mineral Ownership: Federal

County: Catron | Total Depth: 160′

Quadrangle: The Dyke | Formation: Moreno Hill

Water: none

Data: Geophysical logs - gamma, density

No coal

PROXIMATE AND ULTIMATE ANALYSES OF COALS OF SALT LAKE FIELD

(on as received basis)

sample	V.M.	F.C.	H2O	ash	C	H	N	S	O
416-31-1 (48´-56.5´)	33.39	44.28	10.86	11.47	61.64	4.39	1.12	.91	9.61
417-3-1	30.81	31.04	10.24	27.91	46.02	3.65	.97	.78	10.43
417-13-1 (168´-172.5´)	36.15	40.15	3.36	20.34	57.89	4.42	1.08	.89	12.02
417-14-1 (135´-142.2´)	36.61	44.90	8.62	9.87	63.78	4.78	1.35	.73	10.87
417-23-1 (31´-36.8´)	29.86	31.11	6.67	32.36	46.27	4.41	.93	.58	8.78
516-19-1 (89´-93.3´)	36.10	44.90	2.72	16.28	61.10	4.62	1.14	1.10	13.04
516-30-1 (181´-187.5´)	35.61	43.15	2.35	18.89	60.27	4.52	1.24	.75	11.98
517-24-1 (31´-34.5´)	39.50	47.52	2.38	10.60	66.10	4.95	1.26	1.04	13.67
517-25-1 (70´-73.6´)	36.29	42.48	1.80	19.43	59.59	4.47	1.00	.81	12.90
517-25-3 (117´-124.5´)	36.73	40.71	2.45	20.11	57.48	4.53	1.14	1.56	12.73
517-34-1 (170´-175´)	35.65	42 45	2.14	19.76	58.98	4.48	1.15	.68	12.81
517-34-1 (190´-195´)	28.57	28.73	1.56	41.14	41.34	3.59	.76	.62	10.99

BTU VALUES AND RANK

	As Received	Moist, Mineral-matter Free	
416-31-1	10739	12308	high volatile bituminous C
417-3-1	8228	11891	high volatile bituminous C
417-13-1	10101	13037	high volatile bituminous B
417-14-1	11303	12696	high volatile bituminous C
417-23-1	8174	12710	high volatile bituminous C
516-19-1	10624	12970	high volatile bituminous C
517-24-1	11574	13128	high volatile bituminous B
516-30-1	10445	13206	high volatile bituminous B
517-25-1	10339	13173	high volatile bituminous B
517-25-3	10127	13128	high volatile bituminous B
517-34-1 170-175	10223	13206	high volatile bituminous B
517-34-1 190-195	7168	13173	high volatile bituminous B

SULFUR ANALYSES

sample	total	pyritic	organic	sulfate
416-31-1	0.91	0.38	0.53	0.00
417-3-1	0.78	0.05	0.57	0.16
417-14-1	0.73	0.19	0.54	0.00
417-23-1	0.58	0.18	0.40	0.00

ASH FUSION TEMPERATURE

SAMPLE NO.	DEFORMATION	SOFTENING	HEMISPHERICAL	FLUID
416-31-1	2300 F	2380 F	2430 F	2620 F
417-3-1	>2700 F	>2700 F	>2700 F	>2700 F
417-14-1	2380 F	2560 F	2610 F	2700 F
417-23-1	>2700 F	>2700 F	>2700 F	>2700 F

MEASURED SECTION

UPPER MORENO HILL

14.0	Sandstone, tan, 2.00, clay supported, well indurated
1.2	Sandstone, tan, friable, 2.00, clay rip-up clasts at base, trough bedded
.8	Sandstone, white, dark brown on weathered surface, 2.50, calcareous cement, massive, clay matrix
22.4	Talus
4.2	Sandstone, tan, cross-bedded, friable, clay matrix
28.0	Claystone, gray/green, no organics
4.7	Sandstone, tan, 4.0-2.00, sily matrix, thin claystone layers
11.8	Claystone, gray/green, no organics
2.0	Mudstone, carbonaceous, upper 8" well indurated, some coalified plant material
25.5	Claystone, gray/green
13.7	Sandstone, tan, 2.0-1.00, clay matrix, upper 1.5 ft cross-bedded, lower 3.0 ft massive well indurated, ledge former; .5 ft gray claystone separates upper and lower sands
67.3	Claystones and mudstones, gray/green, no organics
4.5	Sandstone, tan, some clay, 4.0-2.00
6.7	Claystone, tan/gray, no organics
3.1	Sandstone, silty, 4.0-3.00, no bedding
8.1	Claystone, tan/gray, no organics
3.1	Sandstone, tan, friable, clay matrix, massive, 2.00
3.9	Claystone, gray, with carbonaceous mudstone, coalified plant remains

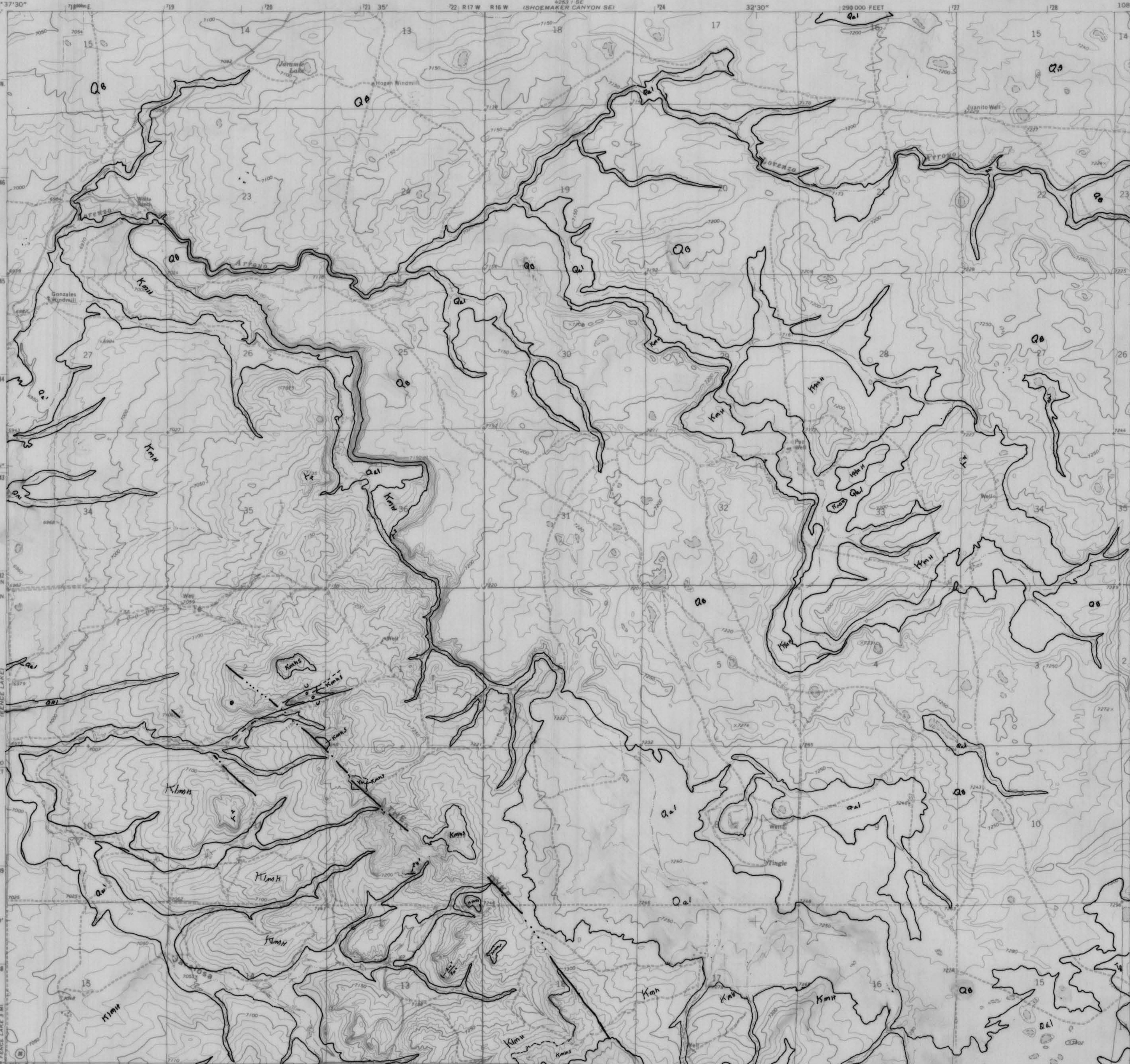
1.7	Sandstone, tan, 3.0-2.00, poorly indurated, clay matrix
6.0	Mudstone, gray
4.7	Sandstone, light tan, 1.5-2.50, trough cross-bedded, friable, clay matrix
1.1	Carbonaceous mudstone, coalified limb
5.6	Mudstone, dark gray
2.6	Sandstone, tan, 2.50, friable, trough cross-bedded, silty
.3	Claystone, gray
.6	Coal, 90% durain, 10% vitrain
6.1	Mudstone, gray
1.5	Sandstone, tan, 4.0-1.50, graded downward to mudstone
2.5	Claystone, dark gray
7.3	Sandstone, tan, 2.00, upper 2 ft Fe-stained, clay cement trough cross-bedded
2.5	Claystone, dark gray, minor plant impressions (stems)
1.3	Mudstone, fusain fragments near base with subparallel orientation, clasts of underlying claystone
11.2	Claystone, gray/green, some organics
2.2	Siltstone, sandy, green, well indurated, massive
10.2	Mudstone, gray, some organis, coalified logs
.8	Sandstone, white, loose, friable, 2.00, massive
10.0	Sandstone, tan, 2.0-3.00, clay matrix trough cross-bedded, increas in Fe-staining upward, current direction N.W.
13.0	Claystone, dark gray to gray/green
2.1	Sandstone, tan, 3.00, clay matrix, massive, poorly indurated
17.2	Claystone, gray and gray/green layers, gypsum at upper contact

.8	Siltstone, sandy, gray/green well, indurated
1.3	Mudstone, green/gray, some organics
.5	Mudstone, brown/gray, coalified plant material
7.2	Claystone, gray/green to dark gray
.7	Coal, 70% vitrain, 30% durain
.8	Mudstone, dark brown
1.1	Claystone, gray/brown, coalified plant material

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Plate 1

THE DYKE QUADRANGLE
NEW MEXICO—VALENCIA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1971. Field checked 1972

Projection and 10,000-foot grid ticks: New Mexico coordinate system, west zone (transverse Mercator) 1000-metre Universal Transverse Mercator grid ticks, zone 12, shown in blue. 1927 North American datum

Fine red dashed lines indicate selected fence lines

UTM GRID AND 1972 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, hard surface — Light-duty road, hard or improved surface

Secondary highway, hard surface — Unimproved road

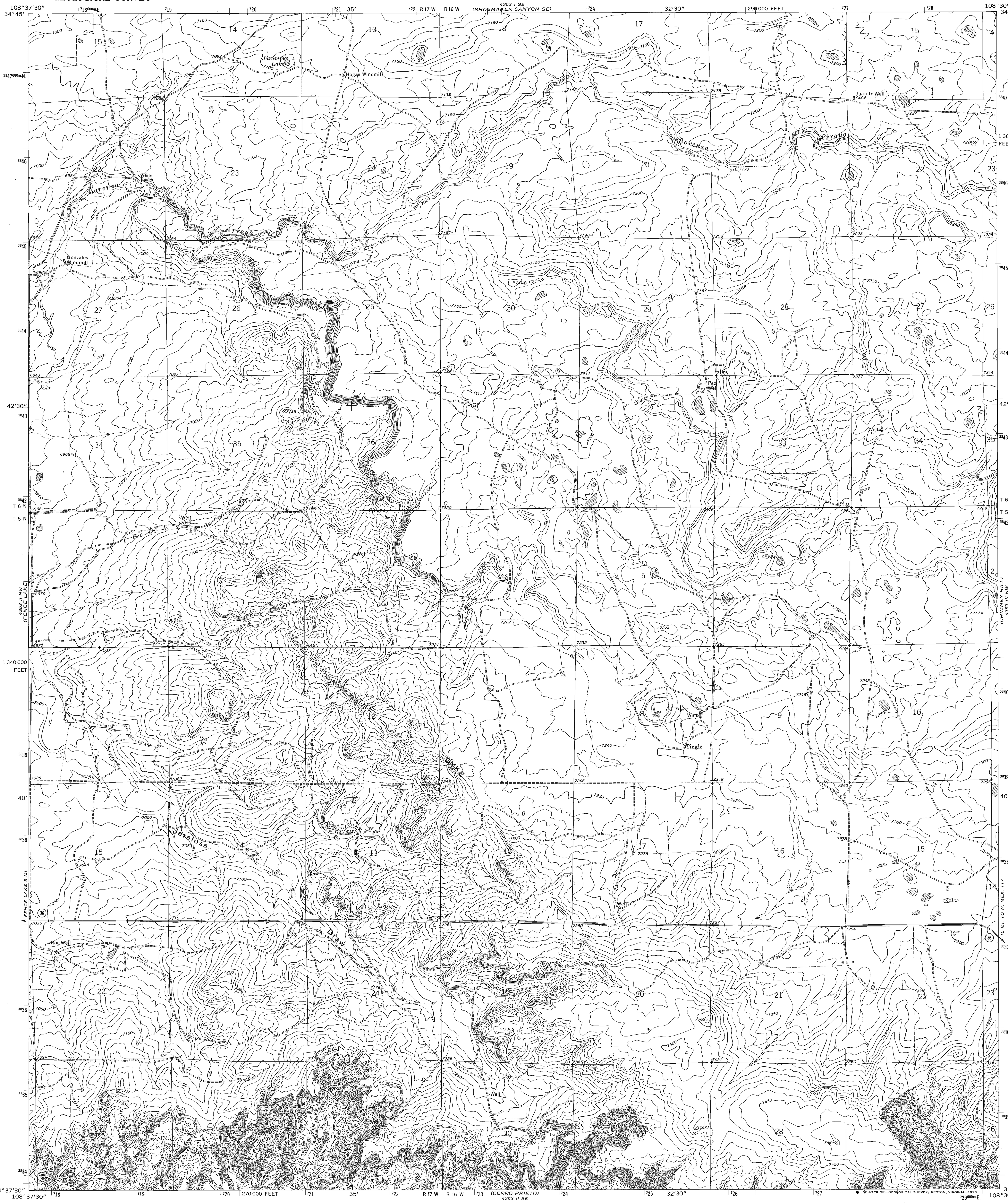
Interstate Route — U. S. Route — State Route

Qal	-	Quaternary Alluvium
Qb	-	Quaternary Basalt (McCarty' Flow)
Tfl	-	Tertiary Fence Lake Gravels
Kumh	-	Cretaceous: upper Moreno Hill
Kmhs	-	Cretaceous: Moreno Hill, middle sand
Klmh	-	Cretaceous: lower Moreno Hill
	-	Coal outcrop and measured thickness in inches
	-	Fault
Δ	-	Talus

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Plate 2

THE DYKE QUADRANGLE
NEW MEXICO–VALENCIA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



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Topography by photogrammetric methods from aerial photographs taken 1971. Field checked 1972

Projection and 10,000-foot grid ticks: New Mexico coordinate system, west zone (transverse Mercator) 1000-metre Universal Transverse Mercator grid ticks, zone 12, shown in blue. 1927 North American datum

Fine red dashed lines indicate selected fence lines

1°23′ 25 MILS — 12½° 222 MILS

UTM GRID AND 1972 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, hard surface — Light-duty road, hard or improved surface

Secondary highway, hard surface — Unimproved road

Interstate Route — U. S. Route — State Route

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THE DYKE, N. MEX.
N3437.5—W10830/7.5

1972

AMS 4253 II NE—SERIES V881