

Geology and coal resources of Fence Lake 1:50,000 quadrangle, New Mexico

(SW quadrant of Fence Lake 1:100,000 sheet)

by Frank Campbell, 1989

INTRODUCTION

The Fence Lake 1:50,000 quadrangle (Sheet 1) is the southwest quarter of the Fence Lake 1:100,000 metric-scale quadrangle. The northern part of the Fence Lake coal field lies within the Fence Lake 1:50,000 quadrangle, which covers parts of Townships 3, 4, 5, and 6 north and Ranges 16, 17, 18, 19, 20, and 21 west. The purpose of this report is to determine stratigraphy and structure, as well as to evaluate the quality and quantity of coal in this part of the Salt Lake coal field. Cretaceous rocks extend over an area of approximately 400 mi² in the map area, with coal-bearing strata present over an area of approximately 220 mi². The oldest exposed unit mapped is the Triassic Chinle Formation, while the youngest consolidated unit is a basalt flow dated at 1.41 ± 0.29 m.y. (Laughlin et al., 1979).

Herrick (1900) traversed this area as part of a reconnaissance of Socorro and Cibola (then Valencia) Counties. He noted the presence of a dike, trending to the northwest, in the Dault area and an extensive basalt flow. Coals were reported and designated as the Fox Hills Formation, but no thicknesses were given. Shaler (1907) first designated the coal-bearing strata near Zuni Salt Lake as a separate coal field in a reconnaissance study of the Durango-Gallup coal field. Shaler noted that the coals were less than 4 ft thick and assigned them an early Mesaverde age. He also noted the presence of a basalt flow and an undifferentiated Tertiary unit. Pike (1937), in a paper discussing the major transgressions and regressions of the Cretaceous sea in New Mexico, recognized the Atracque Sandstone as a member of the Mesaverde. His work extended southward to the Atracque Lake area north of the Salt Lake field. Molenar (1973) revised some of Pike's stratigraphy by dropping the Horseshold Tongue of the Mesaverde and designating the Atracque Member as the basal member of the Gallup Sandstone. Molenar also tentatively extended the Torrvio Member of the Gallup Sandstone into the Fence Lake area.

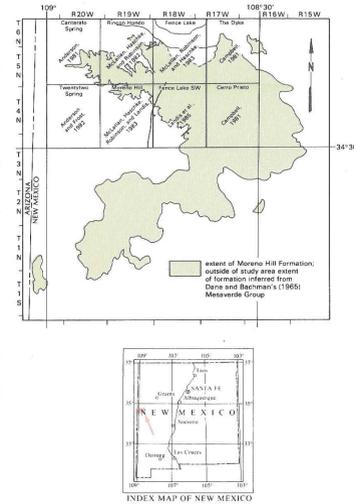


FIGURE 1—Map showing general location of the Salt Lake coal field, the study area, the authority of the eight 7 1/2-min quadrangles used in this compilation, and the areal extent of the coal-bearing Moreno Hill Formation.

The eight quadrangles that compose the central portion of the Salt Lake coal field were mapped jointly by the Coal Resources Branch of the U.S. Geological Survey and the New Mexico Bureau of Mines and Mineral Resources (Fig. 1). In addition to surface geologic data, geophysical logs from 38 drill holes were obtained (Fig. 2, Table 1). Although emphasis was placed on drilling the Moreno Hill Formation, some holes were extended down to the Dakota Sandstone for stratigraphic purposes.

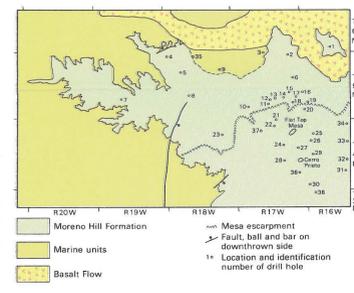


FIGURE 2—Generalized geologic map of the Fence Lake 1:50,000 quadrangle showing locations of drill holes from which geophysical logs were obtained. Drill-hole locations also are given in Table 1.

Acknowledgments

I would like to gratefully acknowledge the Director of the New Mexico Bureau of Mines and Mineral Resources Dr. Frank E. Kottlowski for both the project assignment and his professional review of this manuscript. Also, I thank Dr. William J. Stone, who also reviewed the manuscript. The staff of the U.S. Geological Survey Coal Resources Branch made valuable comments concerning the map compilation. The coal analyses would have been greatly hindered without the help of Cecilia R. McLean and Lynn A. Brandvold. Thanks go to Jane C. Love, editor and Becky J. Titus, draftsman, for their assistance and good humor.

STRATIGRAPHY

The stratigraphic units mapped in the Fence Lake 1:50,000 quadrangle range from Triassic to Quaternary. The outcrops are predominantly Cretaceous marine and nonmarine sediments overlain by Tertiary and Quaternary units. The descriptions of these units and the generalized composite geologic column for the Salt Lake coal field are based on outcrop data with some interpretations from geophysical logs.

Triassic

The Chinle Formation (Tc, Ttr) unconformably underlies the Dakota Sandstone in the southern part of the study area. In the north-central part, the Chinle unconformably underlies the Zuni Sandstone. The Chinle consists of grayish-red to reddish-brown and purple mudstones, siltstones, and claystones, with scattered lenses and conglomerates. As much as 240 ft of this formation are exposed in the study area and are correlated with the Petrified Forest Member of the Chinle Formation (Anderson and Frost, 1982; McLean, Robinson, and Haschke, 1983). Although the top of the north-central part of the study area is the Chinle

is overlain by 20–45 ft of Rock Point Member of the Wingate Sandstone (Rr). The Rock Point Member consists of very fine grained, silty, red to grayish-pink sandstone. The upper part of this member is subdivided and contains quartz pebbles (McLellan, Robinson, and Haschke, 1983).

Jurassic

The Zuni Sandstone (Zs) is present in outcrop only in the north-central part of the study area (McLellan, Robinson, and Haschke, 1983), where it unconformably overlies the Chinle Formation or Wingate Sandstone, but it has been mapped in detail to the north in the Mesita de Yeso quadrangle, north of the study area. The Zuni Sandstone is white to pink, fine- to medium-grained sandstone. Within this sandstone are high-angle crossbeds and a few pebbly conglomerates concentrated along bedding planes. This unit has a maximum thickness of 90 ft. A geophysical log in the eastern portion of the map area indicates the presence of 48 ft of Zuni Sandstone, although no outcrops are present in this area.

Cretaceous

Above the Zuni Sandstone is the main body of the Dakota Sandstone (Kdm), which consists of both marine and nonmarine sediments in a 65–85-ft thickness. McLean, Robinson, and Haschke (1983) describe this unit as "the upper 50 to 60 ft . . . [of] largely soft-gray, yellow-weathering claystone and siltstone with a few finely persistent very fine to fine-grained limy sandstone beds from 1 to 5 ft in thickness. The sandstone and siltstone beds are commonly bioturbated and are fossiliferous at some localities." The lower 15–25 ft of the main body Dakota Sandstone are predominantly crossbedded, fine- to coarse-grained sandstone beds as much as 5 ft thick. The lower part of the main body Dakota includes carbonaceous siltstones, shales, and coals, as well as 3 ft thick. Geophysical logs show a slightly coarsening upward, as much as finer sandstones near the top of the unit.

The lower part of the Mancos Shale (Kms) is a 55–75-ft-thick, dark-gray or dusky-yellow marine shale with interbedded claystones and siltstones. There are limestone concretions as large as 2 ft in diameter in this unit; however, no fossils were found. Geophysical logs show a few thin, thin, dense, relatively high gamma responses, which, combined with very low resistivity readings, may be indicative of bentonite beds.

The Pagate Tongue of the Dakota Sandstone (Kip) is a massively to irregularly bedded, fine-grained, yellow to grayish-yellow, poorly sorted, poorly cemented marine sandstone 20–55 ft thick. The contact between the lower part of the Mancos and the overlying Pagate Tongue of the Dakota Sandstone is a gradual change from shales to sandstones. Fossils collected from the Pagate include *Ergonotus* cf. *P. kelhmi*, *Platystrophia* cf. *P. ferris*, *Acrotrochus* sp., *Turritella* sp., and *Cerithium* sp. The Pagate Tongue weathers to pebble-size angular fragments forming sandy slopes above the lower Mancos Shale.

Geophysical logs penetrating this unit show a slight upward coarsening sequence with several interbedded siltstones. The gamma reading is higher at the bottom of the unit than at the top, indicating more clay in the basal Pagate Tongue sandstone and progressively reduced amounts of clay towards the top of the unit, which is a cleaner sand near the top of the unit. The sharp contact with the overlying Whitewater Arroyo Tongue is visible in both outcrops and resistivity logs.

The Whitewater Arroyo Tongue of the Mancos Shale (Kmw) overlies the Pagate Tongue of the Dakota Sandstone. This 65–85-ft-thick unit consists largely of medium dark gray shales with a few siltstones and contains the large oyster *Ergona frantzii*. A persistent 1-ft-thick bentonite layer, which shows up on geophysical logs as high density and high gamma readings, as well as cone-in-cone limestone concretions are mentioned by McLean, Haschke, Robinson, and Landis (1983). The Twowells Tongue of the Dakota Sandstone (Kt) above the marine shales of the Whitewater Arroyo Tongue of the Mancos Shale is a sandstone sequence. The Twowells Tongue is described as an offshore shallow-marine sandstone (Landis et al., 1973). This unit has a measured outcrop thickness of 27 ft to the east (Anderson, 1982); however, geophysical logs indicated 39 ft of Twowells Tongue. This unit coarsens upward from a very fine grained sandstone to a medium-grained, yellow-brown to dark gray sandstone. The upper member of the Moreno Hill Formation (Kmh) contains very few channel sandstones and is dominated by mudstones and claystones with some carbonaceous shales and a few thin coals. This unit is generally greenish yellow to light gray in color. The gamma log shows a blocky member with a high gamma response and is poorly cemented, resulting in a nonresistant sandstone. The upper member of the Moreno Hill Formation is poorly exposed except where it is overlain by the Fence Lake Formation. The upper member of the Moreno Hill Formation has a thickness from 250 ft in the Cerro Prieto quadrangle to less than 30 ft in the Rincon Hondo quadrangle. In the Tejana Mesa quadrangle, south of the Cerro Prieto quadrangle, the thickness of the unit is 761 ft. The low resistivity for the upper member indicates predominantly mudstones, claystones, and siltstones. A few interbedded sandstones have high gamma log readings because of the abundance of clays in the matrix.

TABLE 1—Identification and locations of drill holes from which geophysical logs were obtained. Drill-hole locations also are shown in Fig. 2.

Map no.	Hole no.	Location
1	616-23-1	sec. 33, T6N, R19W
2	517-2-1	sec. 2, T5N, R17W
3	517-4-1	sec. 4, T5N, R17W
4	518-6-1	sec. 6, T5N, R18W
5	518-12-1	sec. 12, T5N, R18W
6	517-13-1	sec. 13, T5N, R17W
7	519-23-1	sec. 23, T5N, R18W
8	518-28-1	sec. 28, T5N, R18W
9	518-13-1	sec. 13, T5N, R18W
10	517-13-1	sec. 13, T5N, R17W
11	517-21-1	sec. 21, T5N, R17W
12	517-22-1	sec. 22, T5N, R17W
13	517-22-1	sec. 22, T5N, R17W
14	517-26-1	sec. 26, T5N, R17W
15	517-26-1	sec. 26, T5N, R17W
16	516-19-1	sec. 19, T5N, R16W
17	517-25-1	sec. 25, T5N, R17W
18	517-25-1	sec. 25, T5N, R17W
19	516-30-1	sec. 30, T5N, R16W
20	516-32-1	sec. 32, T5N, R16W
21	417-3-1	sec. 3, T4N, R17W
22	417-3-1	sec. 3, T4N, R17W
23	417-11-1	sec. 11, T4N, R18W
24	417-11-1	sec. 11, T4N, R18W
25	416-7-1	sec. 7, T4N, R16W
26	417-12-1	sec. 12, T4N, R17W
27	417-12-1	sec. 12, T4N, R17W
28	417-23-1	sec. 23, T4N, R17W
29	416-23-1	sec. 23, T4N, R16W
30	416-31-1	sec. 31, T4N, R16W
31	416-27-1	sec. 27, T4N, R16W
32	416-22-1	sec. 22, T4N, R16W
33	416-10-1	sec. 10, T4N, R16W
34	416-3-1	sec. 3, T4N, R16W
35	318-3-1	sec. 3, T3N, R18W
36	417-36-1	sec. 36, T4N, R17W
37	417-8-1	sec. 8, T4N, R17W
38	318-3-1	sec. 3, T3N, R18W

The overlying Rio Salado Tongue of the Mancos Shale (Kms) varies in thickness in measured sections from 130 ft to 250 ft, with the thicker sections in the northeastern portion of the Salt Lake coal field. Geophysical logs from the 300-ft Rio Salado Tongue unit show a blocky member, predominantly olive-gray to yellow-brown interbedded shales with thin beds of fossiliferous limestone concretions and calcarenite. Anderson (1982) correlates this calcarenite zone with the Bridge Creek Limestone Member of the Greenhorn Formation. The Greenhorn Formation contains fossils, with ammonites in the upper part of the Rio Salado Tongue and *Pycnodonte neuberri* (Anderson, 1981) in the lower part of the unit.

The Atracque Sandstone (Ka) is the basal marine unit in the area. This formation is a regressive marine bed deposit. The thickest section of the Atracque Sandstone is 120 ft (McLellan, Haschke, Robinson et al., 1983), and its thickness is 15 ft. The Atracque Sandstone is not always a single sandstone unit. In places it consists of as many as three sandstones above a 25-ft vertical interval. The Atracque Sandstone is characterized by a sharp upper contact and a gradual lower contact. The lower contact shows a high density reading because of carbonaceous shales in the fossiliferous lower beds. The resistivity readings vary from high in the upper portion to low in the lower portion of this unit. This variation in resistivity indicates a change in the grain size. The gamma log shows a blocky member to low in the upper part of the Atracque Sandstone indicating a lack of clays in the matrix. The lower portion of the Atracque Sandstone has a higher silt and clay content, which is recognized by an increased gamma reading. The Atracque Sandstone is the Cretaceous Moreno Hill Formation, a name proposed for the major coal-bearing continental sediments in the Salt Lake coal field by McLean, Haschke, Robinson et al. (1983). This unit is overlain by the Chinle Formation in the southern part of the study area and is overlain by the Zuni Sandstone in the northern part of the study area. The Chinle consists of grayish-red to reddish-brown and purple mudstones, siltstones, and claystones, with scattered lenses and conglomerates. As much as 240 ft of this formation are exposed in the study area and are correlated with the Petrified Forest Member of the Chinle Formation (Anderson and Frost, 1982; McLean, Robinson, and Haschke, 1983). Although the top of the north-central part of the study area is the Chinle

consists of a sequence of fluvial-channel fills, crevasse splays, and flood-plain deposits, which is divided into three members based on outcrop and subsurface data. The upper member of the Moreno Hill Formation forms an angular unconformity with the overlying Tertiary units; the lower member of the Moreno Hill Formation decreases in thickness to the west. In the eastern portion of the Salt Lake coal field, in the Cerro Prieto quadrangle, Campbell (1981) reported a thickness of 750 ft for the Moreno Hill Formation.

The lower member of the Moreno Hill Formation (Kml) is characterized by fluvial sandstones with siltstones, mudstones, claystones, and coals. The thickest section for this member is in the eastern portion of the Salt Lake coal field. In the Cerro Prieto quadrangle, both geophysical and outcrop data indicate a thickness of 440 ft for this lower member. It thins to the west, where Anderson (1981) mapped 100 ft of undifferentiated Moreno Hill sediments. The sandstone grains in this lower member are supported by a clay and silt matrix, which can amount to as much as 15% of the total rock. Some of these sands have a sharp basal contact, which is indicated by a sudden increase in the resistivity on a geophysical log. The decreasing resistivity upward from the base is indicative of a channel sandstone. The gamma log indicates a greater silt content at the top of the member as would be expected in a channel deposit. Individual channels, although not correlative from hole to hole, are present in nearly all holes that penetrate the lower member of the Moreno Hill Formation, indicating a discontinuous lateral distribution. This type of sandstone-body geometry is suggestive of a meandering-stream deposit. Crevasse splays are also recognizable in this sequence. The resistivity patterns for these crevasse splays have sharp contacts at both the upper and lower boundaries, resulting in a blocky member. The gamma log shows a slightly higher value than for the upper member mudstones and claystones because the lower member mudstones have a greater organic fraction, which silts to concentrate uranium and thorium. There are no limestone dolomites in the lower member, indicating a general absence of lacustrine deposits. The mudstones and claystones probably represent floodplain deposits, and those intervals containing carbonaceous shales and coals probably represent swamps.

The middle member of the Moreno Hill Formation (Kmh) has not been mapped throughout the western part of the Salt Lake coal field. Arkell (1981) mapped this member in the eastern portion of the field, indicating a possible eastern pinchout. To the south, in T1 and 2N, R18–20W, the middle member forms the dominant topographic features. There are limestone concretions as large as 2 ft in diameter in this unit; however, no fossils were found. Geophysical logs show a few thin, thin, dense, relatively high gamma responses, which, combined with very low resistivity readings, may be indicative of bentonite beds.

The geophysical log signatures for the middle member of the Moreno Hill Formation are distinctive and readily identifiable. The resistivity pattern for the middle member is similar to that of the upper member of the upper or lower members of the Moreno Hill Formation. This higher resistivity pattern reflects the coarser-grained nature of this sandstone. The upper and lower contacts show sharp changes, which are reflected in the geophysical logs as high density and high gamma readings, as well as cone-in-cone limestone concretions are mentioned by McLean, Haschke, Robinson, and Landis (1983). The Twowells Tongue of the Dakota Sandstone (Kt) above the marine shales of the Whitewater Arroyo Tongue of the Mancos Shale is a sandstone sequence. The Twowells Tongue is described as an offshore shallow-marine sandstone (Landis et al., 1973). This unit has a measured outcrop thickness of 27 ft to the east (Anderson, 1982); however, geophysical logs indicated 39 ft of Twowells Tongue. This unit coarsens upward from a very fine grained sandstone to a medium-grained, yellow-brown to dark gray sandstone. The upper member of the Moreno Hill Formation (Kmh) contains very few channel sandstones and is dominated by mudstones and claystones with some carbonaceous shales and a few thin coals. This unit is generally greenish yellow to light gray in color. The gamma log shows a blocky member with a high gamma response and is poorly cemented, resulting in a nonresistant sandstone. The upper member of the Moreno Hill Formation is poorly exposed except where it is overlain by the Fence Lake Formation. The upper member of the Moreno Hill Formation has a thickness from 250 ft in the Cerro Prieto quadrangle to less than 30 ft in the Rincon Hondo quadrangle. In the Tejana Mesa quadrangle, south of the Cerro Prieto quadrangle, the thickness of the unit is 761 ft. The low resistivity for the upper member indicates predominantly mudstones, claystones, and siltstones. A few interbedded sandstones have high gamma log readings because of the abundance of clays in the matrix.

Tertiary

Overlying the Moreno Hill Formation is the Fence Lake Formation (Tf), a Tertiary unit consisting of basaltic boulders. This formation was described first informally by Marr (1956) as the "Fence Lake gravel." McLean, Robinson et al. (1982) renamed this unit the Fence Lake Formation. The following descriptions are from their paper in which they proposed a type section in sec. 1, T4N, R18W, where the Fence Lake Formation is 221 ft thick. This formation consists of two units, a lower conglomeratic unit and an upper sandstone unit. The lower unit is a blocky member that ranges up to 2 ft in diameter and smaller clasts of rhyolite, chert, petrified wood, and Cretaceous sandstone in a calcareous sandstone matrix. At the type section the lower unit is 41 ft thick; however, in other areas this unit may be as thin as 15 ft (Campbell, 1981). The upper unit is 180 ft thick and consists of calcareous, gray-pink sandstone and a 15-ft-thick cap of volcanic-boulder conglomerate. The base of this formation is readily apparent on geophysical logs. Figure 4 shows that where conglomerate layers result in high resistance readings, generally higher than the readings of the sandstones in the underlying Moreno Hill Formation. Densities in these beds are 2.4 to 2.5 g/cc, whereas in the sandstone they are 2.2 to 2.3 g/cc.

The youngest Tertiary sedimentary unit in the Fence Lake 1:50,000 quadrangle, the Bidahocho Formation (Tb, Tw), was mapped by Anderson (1981) and Anderson and Frost (1982) in the Cantarito Spring and Twowells Spring quadrangles, respectively. These two westernmost quadrangles are the only places where the Bidahocho Formation crops out in the map area; maximum thickness there is 300 ft. Anderson and Frost (1982) described the Bidahocho Formation as "highly variable light brown sandstone, light gray sandstones, and pebbly conglomerates, generally poorly to fair cementation, . . . with lenses of calcareous cement and volcanic clasts. The pebble conglomerates within the Bidahocho Formation are matrix supported and consist of basalt and rhyolite pebbles with a minor amount of quartzite pebbles."

In the east-central portion of the study area there is an echelon dike (Td) composed of olive to light-tan dike system. This dike system trends to the northwest. This appears to be a continuation of the same northwest-trending dike system that goes through The Town. Each limb is approximately 1 mi long and 15 ft wide with left-lateral offset. This dike cuts the Cretaceous units in the area but is overlain by the Fence Lake Formation. Using K-Ar methods, Laughlin et al. (1979) reported an age of 27.67 ± 0.59 m.y. for the system near Pie Town, placing it within the Oligocene. The Atracque Sandstone (Ka) is the basal marine unit in the area. This formation is a regressive marine bed deposit. The thickest section of the Atracque Sandstone is 120 ft (McLellan, Haschke, Robinson et al., 1983), and its thickness is 15 ft. The Atracque Sandstone is not always a single sandstone unit. In places it consists of as many as three sandstones above a 25-ft vertical interval. The Atracque Sandstone is characterized by a sharp upper contact and a gradual lower contact. The lower contact shows a high density reading because of carbonaceous shales in the fossiliferous lower beds. The resistivity readings vary from high in the upper portion to low in the lower portion of this unit. This variation in resistivity indicates a change in the grain size. The gamma log shows a blocky member to low in the upper part of the Atracque Sandstone indicating a lack of clays in the matrix. The lower portion of the Atracque Sandstone has a higher silt and clay content, which is recognized by an increased gamma reading. The Atracque Sandstone is the Cretaceous Moreno Hill Formation, a name proposed for the major coal-bearing continental sediments in the Salt Lake coal field by McLean, Haschke, Robinson et al. (1983). This unit is overlain by the Chinle Formation in the southern part of the study area and is overlain by the Zuni Sandstone in the northern part of the study area. The Chinle consists of grayish-red to reddish-brown and purple mudstones, siltstones, and claystones, with scattered lenses and conglomerates. As much as 240 ft of this formation are exposed in the study area and are correlated with the Petrified Forest Member of the Chinle Formation (Anderson and Frost, 1982; McLean, Robinson, and Haschke, 1983). Although the top of the north-central part of the study area is the Chinle

Quaternary

The northernmost portion of the map area is covered by a 60–70-ft-thick andesite-basalt flow, the Jarolosa Draw Lobe of the North Plains lava field (Qb). Laughlin et al. (1979) reported a K-Ar age of 1.41 ± 0.29 m.y. for this flow in T6N, R17W, because of collapse structures within the basalt. Other Quaternary units in the area but are not mapped are the Quaternary alluvium. This flow was not observed to be in contact with the Fence Lake Formation. The underlying Moreno Hill Formation, however, does form an angular unconformity with the overlying Tertiary units. Other Quaternary units in the area but are not mapped are the Quaternary alluvium. This flow was not observed to be in contact with the Fence Lake Formation. The underlying Moreno Hill Formation, however, does form an angular unconformity with the overlying Tertiary units. Other Quaternary units in the area but are not mapped are the Quaternary alluvium. This flow was not observed to be in contact with the Fence Lake Formation. The underlying Moreno Hill Formation, however, does form an angular unconformity with the overlying Tertiary units.

STRUCTURE OF THE SALT LAKE COAL FIELD

The structure of the Salt Lake coal field is relatively simple. A few major faults are present, the most prominent of which is located along NM-52 in the western portion of the field. Extensive faulting is indicated in the Fence Lake and Rincon Hondo quadrangles in the central portion of the field. Displacement on these faults is difficult to determine as no dips are recorded for this area, and outcrops are sparse. Calculation of the dips utilizing subsurface and surface data indicate that the displacements on these faults are only a few feet at maximum. Fig. 3 is a structural contour map of the top of the Atracque Sandstone. In this it is readily apparent that the regional dip of this unit is to the southeast. One prominent structural feature is a broad northeast-trending syncline in the area of Santa Rita Mesa. The northeastern limb, which has the best control, has a dip of approximately 2°. The eastern portion of this area has a southeastern dip of approximately 1°. The regional dip is to the southeast, but Tertiary volcanism has caused local deformation throughout the field, resulting in many small flexures.

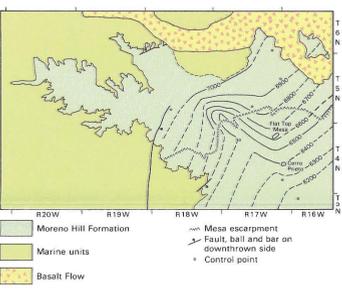


FIGURE 3—Structural contour map of the top of the Atracque Sandstone (elevations in feet).

COAL GEOLOGY

Work by Campbell (1981), Roybal and Campbell (1981), Roybal (1982), Campbell and Roybal (1984), and Campbell (1987) has shown that the coals in the eastern portion of the Salt Lake coal field are bituminous B and C in rank. Coal resources were calculated by projecting this rank for coals in the western portion of the field and by using the minimum thickness of 1.2 ft for bituminous coals in the resource calculations (Wood et al., 1983). Coal resources were calculated by projecting this rank for coals in the western portion of the field and by using the minimum thickness of 1.2 ft for bituminous coals in the resource calculations (Wood et al., 1983). Coal resources were calculated by projecting this rank for coals in the western portion of the field and by using the minimum thickness of 1.2 ft for bituminous coals in the resource calculations (Wood et al., 1983).

TABLE 2—Coal resources for the four coal zones in the Moreno Hill Formation, Salt Lake coal field, in million tons. A minimum thickness of 1.2 ft was used in the resource calculation.

Coal zone	Shalying ratio		0-180 ft		Depth category		200+ ft	
	Measured	Indicated	Measured	Indicated	Measured	Indicated	Measured	Indicated
Antelope	4.1	30.2	5.5	39.4	4.7	33.5	2.4	17.3
Cerro Prieto	11.7	64.7	4.5	31.3	11.8	46.8	9.3	61.3
Twilight	0.0	0.0	0.0	0.0	1.5	10.0	1.7	13.6
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The northwest portion of the Cerro Prieto quadrangle contains numerous thin beds of coal. These coals, although laterally continuous, rarely exceed 3 ft in thickness. Coals in this area are interbedded with channel sandstones, which, in many cases, cut into the coals. The vertical intervals between sandstone beds are generally less than 15 ft. This high frequency of thinner coals with numerous channels indicates a greater degree of channeling, restricting coal-swamp development. In the area south of Flat Top Mesa, the channel sandstones occur less frequently and at vertical intervals of 30–40 ft, and the coals are generally 5–6 ft thick. Where the thickest coals occur, sec. 31, T4N, R16W, there are only three sandstones within a 260-ft vertical interval. These thicker coals associated with thicker and stratigraphically less frequent sandstones are indicative of a more stable environment with less fluctuation of stream channels, which allowed for thicker coal development. A drill hole located in sec. 31, T5N, R17W penetrates the entire lower Moreno Hill Formation, and the Cerro Prieto zone is represented by three thin coal beds and only 1-ft-thick sandstone over a 40-ft interval. This is the western boundary for the Cerro Prieto zone.

The average total coal thickness for the Cerro Prieto zone in the Fence Lake 1:50,000 quadrangle is 5.2 ± 3.2 ft, and the average individual bed thickness is 3.6 ± 1.9 ft. Coals from this zone have an ash content of 18.44 ± 7.77%, an average moisture content of 13.89 ± 2.33%, an average sulfur content of 0.67 ± 0.25%, and a pyritic sulfur content of 0.19 ± 0.15% (Table 3). The Double T bed does not vary significantly from the other Cerro Prieto zone coals except in ash content, which averages 13.94 ± 6.71%. Coals from this zone have an average as-received heating value of 9,047 ± 1,201 BTU/lb and an average moist, mineral-free heating value of 11,549 ± 560 BTU/lb, indicating a rank of high-volatile C bituminous. The estimated measured and indicated resources for the Cerro Prieto zone are 247 million tons, of which 76 million tons has a stripping ratio of less than 20:1 (Table 2).

Rabbit zone

The next coal zone in the Moreno Hill Formation is the Rabbit zone. The base of this zone is located approximately 290 ft above the top of the Atracque Sandstone and approximately 60 ft below the base of the middle member of the Moreno Hill Formation in the eastern part of the Salt Lake coal field. Like the Cerro Prieto zone, the Rabbit zone thins from west to east, being 30 ft thick at its westernmost extent and 70 ft thick in the east. The Rabbit zone has as many as four coal beds; generally the second bed from the bottom is the thickest. This bed, referred to as the Lagus bed, has a single kaolinitic parting, which distinguishes this zone from the lower Cerro Prieto zone. The kaolinitic parting has a uniform thickness of 0.5 inch and is found near the top of the bed. The Lagus bed has a maximum outcrop thickness of 12.0 ft in sec. 27, T5N, R17W. In a drill hole, this zone is 12.0 ft thick and is 7.5 ft thick; however, in sec. 23, T5N, R16W, it is absent, indicating a rapid eastward thinning. Coal in sec. 33, T6N, R16W also contains a single tonstein, indicating a northeast trend for the Rabbit zone. In this drill hole, 11 ft of coal are present in three beds over a 60-ft vertical interval. Drilling farther north showed no continuation of this coal.

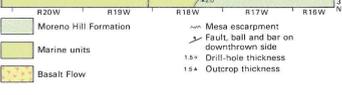


FIGURE 4—Map showing distribution and thicknesses in feet of Antelope zone coals in the Fence Lake 1:50,000 quadrangle.

carbonaceous shales as indicated by drill-hole and outcrop data. The Antelope zone coals are as much as 5.8 ft thick in outcrop in sec. 31, T5N, R16W, but this thickness does not continue for any distance laterally. In some outcrops these coal beds have thin kaolinitic layers, which often extend throughout the entire bed. The few analyses available for these coals (Table 3) show an ash content as high as 21.01 ± 9.64% and show an as-received heating value as low as 8,827 ± 1,891 BTU/lb. The moist, mineral-matter-free heating value is 11,496 ± 2,742 BTU/lb; this coal is agglomerating; a rank of high-volatile C bituminous for these coals is indicated. MBMTBU values for resource calculations for all four coals are based on nonvolatile-bearing coals (Campbell, 1987). Sulfur content for these coals is 0.88 ± 0.57%, and pyritic sulfur content is 0.35 ± 0.34%. The estimated measured and indicated resources in the Antelope zone are 103 million tons, of which 34 million tons has a stripping ratio of less than 20:1 (Table 2).

TABLE 3—Combustion analyses on an as-received basis for the four coal zones in the Moreno Hill Formation, Salt Lake coal field.

	Antelope zone			Cerro Prieto zone			Rabbit zone			Twilight zone (outcrop)		
	No. of samples analyzed	Mean %	S.D.	No. of samples analyzed	Mean %	S.D.	No. of samples analyzed	Mean %				

TABLE 6—Vertical distribution of the major oxides, chlorine, fluorine, and water-soluble alkalis in the Moreno Hill Formation coals, Salt Lake coal field. All elemental analyses reported on a whole-coal basis. – indicates analysis not run.

Location	Cored interval (in feet)	Ash %	SiO ₂ %	Al ₂ O ₃ %	TiO ₂ %	Fe ₂ O ₃ %	MgO %	CaO %	K ₂ O %	Na ₂ O %	P ₂ O ₅ %	Cl ppm	F ppm	HNa ppm	HK ppm
Cerro Prieto coal zone sec. 31, T4N, R16W	48.0– 49.0	10.73	5.59	2.29	0.16	0.62	0.08	0.50	0.02	0.04	0.05	101	156	423	50
	49.0– 50.0	8.39	4.32	1.55	0.14	0.18	0.08	0.49	0.01	0.04	0.02	41	136	531	89
	50.0– 51.0	12.71	6.83	2.61	0.21	0.53	0.07	0.53	0.02	0.05	0.06	159	159	273	23
	51.0– 52.0	9.44	4.46	2.43	0.17	0.15	0.04	0.56	0.01	0.05	0.12	–	–	980	130
	52.0– 53.0	15.67	9.60	2.89	0.20	0.71	0.06	0.46	0.01	0.07	0.17	175	152	506	39
53.0– 54.0	12.36	6.93	2.81	0.37	0.19	0.04	0.12	0.01	0.08	–	134	110	342	20	
Cerro Prieto coal zone sec. 6, T3N, R16W	48.2– 48.9	33.61	17.68	5.65	0.46	1.79	0.44	3.43	0.13	2.73	–	123	113	848	48
	48.9– 49.8	37.31	19.41	5.90	0.31	2.06	0.45	4.21	0.11	0.29	–	201	100	555	36
	49.8– 50.7	10.46	5.31	1.95	0.18	0.78	0.08	0.78	0.03	0.06	–	164	115	478	57
	50.7– 51.6	13.25	6.23	3.31	0.17	1.46	0.08	0.52	0.08	0.10	–	117	177	353	55
Cerro Prieto coal zone sec. 23, T4N, R17W	31.0– 32.0	14.63	4.51	2.93	0.25	0.82	0.10	2.70	0.13	2.13	0.03	375	149	867	85
	32.0– 33.0	36.72	19.20	12.30	0.30	0.68	0.08	0.97	0.07	0.10	0.04	63	98	853	103
	33.0– 34.0	7.34	4.02	1.17	0.08	0.15	0.05	0.48	0.01	0.04	–	93	73	540	74
	34.0– 35.0	14.47	7.66	3.88	0.46	0.26	0.05	0.61	0.12	0.03	–	299	165	437	62
	35.0– 36.0	11.31	4.47	1.59	0.03	1.37	0.11	1.21	0.08	0.03	0.06	168	150	548	48
No. of samples analyzed	15	15	15	15	15	15	15	15	15	15	8	14	14	15	15
Mean	16.56	8.41	3.55	0.23	0.78	0.12	1.17	0.06	0.39	0.07	0.07	158	132	569	61
S.D.	10.39	5.57	2.78	0.13	0.62	0.13	1.24	0.05	0.84	0.06	0.06	89	31	216	30
Rabbit coal zone sec. 14, T4N, R17W	138.0–139.0	37.97	19.50	6.35	0.32	1.07	0.21	4.55	0.43	0.14	0.06	266	298	576	94
	139.0–140.0	7.93	3.35	1.43	0.01	0.62	0.05	0.54	0.02	0.05	–	115	139	444	22
	140.0–141.0	24.25	12.27	7.66	0.20	0.62	0.06	0.93	0.04	0.07	–	138	143	560	62
	141.0–142.0	6.34	2.84	1.35	0.06	0.32	0.05	0.57	0.01	0.05	0.06	145	151	417	43
	142.0–143.0	10.00	4.79	2.22	0.24	0.43	0.04	0.60	0.02	0.05	0.06	102	155	481	55
Rabbit coal zone sec. 30, T5N, R16W	180.0–181.0	12.78	7.93	3.51	0.18	0.21	0.09	0.64	0.02	0.02	–	–	–	–	–
	181.0–182.0	31.45	20.21	7.48	0.38	1.69	0.02	0.84	0.25	0.03	0.01	115	94	593	39
	182.0–183.0	13.73	8.05	3.93	0.26	0.42	0.08	0.68	0.02	0.01	–	156	155	462	51
	183.0–184.0	8.93	4.89	1.46	0.15	0.33	0.07	0.54	0.00	0.02	0.17	132	145	405	38
	184.0–185.0	12.42	7.18	3.56	0.27	0.54	0.09	0.61	0.01	0.02	0.04	121	163	356	55
	185.0–186.0	7.69	3.75	1.78	0.10	0.47	0.07	0.79	0.01	0.03	0.05	159	105	318	39
186.0–186.5	12.39	7.13	3.22	0.19	0.78	0.12	0.67	0.06	0.02	0.02	135	149	–	–	
Rabbit coal zone sec. 33, T6N, R16W	42.8– 43.7	18.39	11.61	3.04	0.28	0.54	0.08	0.48	0.01	0.02	0.34	123	87	192	26
	44.1– 45.0	13.49	–	2.23	0.21	0.40	0.06	0.35	0.01	0.02	–	–	97	276	48
	89.0– 90.0	19.13	11.71	5.69	0.30	1.14	0.09	1.12	0.03	0.03	0.05	106	83	248	35
	96.6– 97.4	18.53	9.71	4.82	0.32	0.49	0.05	0.43	0.03	0.02	0.02	248	100	276	60
	97.4– 98.7	9.48	–	2.46	0.16	0.25	0.02	0.22	0.02	0.01	–	–	–	147	14
	98.7– 99.8	4.66	1.99	0.92	0.04	0.19	0.06	0.50	0.01	0.02	–	284	91	213	26
No. of samples analyzed	18	16	18	18	18	18	18	18	18	18	11	15	15	16	16
Mean	15.22	8.56	3.51	0.20	0.58	0.07	0.84	0.06	0.04	0.08	0.08	156	138	373	44
S.D.	9.02	5.47	2.10	0.10	0.38	0.04	0.95	0.11	0.03	0.10	0.10	59	53	141	19

TABLE 7—Vertical distribution of the trace-element compositions of the Moreno Hill Formation coals, Salt Lake coal field. All analyses reported on a whole-coal basis. – indicates analysis not run.

Location	Cored interval (in feet)	Ash %	As	Be	Cr	Cu	Hg	Li	Mn	Mo	Nb	Ni	Pb	Sb	Sr	V	Zn
Cerro Prieto coal zone sec. 31, T4N, R16W	48.0– 49.0	10.73	–	2.0	5	7	–	4	23	24	5	2	7	–	12	12	4
	49.0– 50.0	8.39	0.8	6.0	10	19	0.33	3	76	–	–	3	12	0.40	155	25	5
	50.0– 51.0	12.71	1.1	0.3	6	11	0.18	4	36	30	3	1	5	0.27	35	10	3
	51.0– 52.0	9.44	–	0.2	3	7	0.03	3	63	24	2	1	2	–	6	3	2
	52.0– 53.0	15.67	1.1	0.4	8	15	0.20	4	41	34	2	1	3	0.47	29	5	1
Cerro Prieto coal zone sec. 6, T3N, R16W	48.2– 48.9	33.61	1.9	0.7	1	7	0.09	11	168	57	7	6	9	0.31	132	11	11
	48.9– 49.8	37.31	2.3	1.0	17	29	0.02	11	209	70	9	11	11	0.27	173	19	22
	49.8– 50.7	10.46	1.5	1.0	8	9	0.11	5	104	24	2	5	6	0.70	39	8	8
	50.7– 51.6	13.25	1.8	4.0	8	9	–	3	60	32	4	6	4	1.87	28	8	8
Cerro Prieto coal zone sec. 23, T4N, R17W	31.0– 32.0	14.63	1.8	1.0	23	16	0.26	1	439	55	–	1	5	0.18	89	5	2
	32.0– 33.0	36.72	0.5	0.2	4	16	0.14	2	104	122	10	0.0	1	–	3	1	1
	33.0– 34.0	7.34	1.0	2.0	6	24	0.60	11	14	5	2	5	1	0.51	17	9	–
	34.0– 35.0	14.47	0.8	0.7	9	15	–	2	123	33	–	2	6	0.54	41	13	3
	35.0– 36.0	11.31	0.9	4.0	3	8	0.20	2	249	23	3	3	1	0.39	25	4	5
No. of samples analyzed	14	12	14	14	14	11	14	14	13	11	14	14	14	11	14	14	13
Mean	16.86	1.3	1.7	8	14	0.14	5	122	41	4	3	5	0.5	56	10	6	
S.D.	10.61	0.6	1.8	6	7	0.10	4	115	30	3	3	4	0.5	57	6	6	
Rabbit coal zone sec. 14, T4N, R17W	138.0–139.0	37.97	1.2	0.1	26	14	0.12	1	106	74	–	1	–	0.27	16	3	–
	139.0–140.0	7.93	1.0	0.8	2	5	0.10	6	18	9	–	4	–	0.21	45	59	–
	140.0–141.0	24.25	0.7	0.2	4	15	0.18	3	70	74	6	3	2	0.61	6	3	2
	141.0–142.0	6.34	1.2	2.0	3	6	0.04	11	14	16	1	8	0.0	0.49	93	9	5
	142.0–143.0	10.00	7.0	3.0	11	9	0.19	3	160	24	5	5	26	0.82	38	21	4
Rabbit coal zone sec. 30, T5N, R16W	181.0–182.0	31.45	1.1	0.3	22	8	–	7	42	63	10	3	8	0.55	47	18	14
	182.0–183.0	13.73	1.4	1.0	3	9	0.19	4	91	–	–	3	10	0.26	93	27	4
	183.0–184.0	8.93	1.0	0.6	9	11	0.23	4	89	–	–	3	6	0.35	89	22	3
	184.0–185.0	12.42	–	0.8	12	12	0.18	6	75	–	–	3	10	0.23	89	36	3
	185.0–186.0	7.69	0.8	0.6	7	3	0.16	2	45	20	1	3	2	0.24	27	6	2
	186.0–186.5	12.39	1.1	2.0	11	10	0.26	2	99	–	–	7	7	0.70	88	30	5
Rabbit coal zone sec. 33, T6N, R16W	42.8– 43.7	18.39	1.8	3.0	6	18	0.11	12	19	42	2	6	5	1.41	34	11	4
	44.1– 45.0	13.49	0.9	4.0	11	12	0.10	7	40	36	3	9	5	1.50	36	11	4
	89.0– 90.0	19.13	1.0	2.0	9	24	–	8	39	22	6	4	23	–	42	28	15
	96.6– 97.4	18.53	0.8	5.0	6	9	0.28	12	66	55	7	4	9	1.10	20	21	10
	97.4– 98.7	9.48	1.8	2.0	1	8	–	5	25	16	1	2	2	0.45	41	6	3
	No. of samples analyzed	16	15	16	16	16	13	16	16	12	12	16	16	16	15	16	16
Mean	15.76	1.5	1.7	9	11	0.16	6	62	38	4	4	8	0.61	50	19	5	
S.D.																	

The chlorine content of these two coals is similar, the Cerro Prieto zone coals being slightly higher (158 ± 89 ppm) than those from the Rabbit zone (156 ± 59 ppm). Fluorine values are essentially the same; the Cerro Prieto zone coals average 132 ± 31 ppm, and the Rabbit zone coals average 138 ± 53 ppm.

Ash-fusion temperatures based on base/acid ratio calculations (Sage and McIlroy, 1960) were calculated from the core presented in Table 6 and are similar for the Cerro Prieto and Rabbit coal zones. The greater range of base/acid ratios for coals from the Cerro Prieto zone, averaging 0.21 ± 0.18 , is reflected in a greater range of fusion temperatures. The temperatures needed for the ash of these coals to reach a viscosity of 250 poise range from 2800°F to 2200°F . Coals from the Rabbit zone with an average base/acid ratio of 0.15 ± 0.07 have much more uniform ash-fusion temperatures, ranging from 2800°F to 2650°F . These base/acid ratios differ from those presented in Table 5 because they represent the fluctuations within a few seams and not over the entire field.

The vertical distribution of the trace-element compositions in the Cerro Prieto and Rabbit coal zones is presented in Table 7. These two coal zones do not differ in the average whole-coal concentrations of trace elements except in manganese and vanadium. The Cerro Prieto zone has a notably higher average (122 ± 115 ppm) of manganese than the Rabbit zone (62 ± 40 ppm). However, the Rabbit zone is significantly higher in vanadium (19 ± 15 ppm) than the Cerro Prieto zone (10 ± 6 ppm). Barium was run on all 1-ft intervals but was not detected.

The relationships of the trace elements within each zone show some interesting differences. In the Rabbit zone strontium, manganese, and nickel have a negative association with the ash content of the coal, indicating an organic affinity. Whereas the Cerro Prieto zone coals have only manganese and beryllium associated with the organic fraction of the coal.

Carbon tetrachloride was used to separate the minerals from the organic fraction of these samples. The mineral content of the Moreno Hill Formation coals, as determined by x-ray diffraction, consists of carbonates, sulfides, kaolinite, quartz, and sulfates. The kaolinite and quartz occur as finely disseminated grains within the coals. The diffraction patterns did not show any clay minerals except kaolinite. The absence of other silicates would then indicate that the silica present after removal of what is needed for kaolinite essentially represents the quartz in the sample. No vertical trends were observed for the nonkaolinitic silica. The iron presented in these tables reflects the nonsulfide iron in the coal. Pyrite, calcite, and gypsum are found largely as sheetlike growths along cleat surfaces. Gypsum is present on coal outcrops and in shallow cores, probably the result of weathering (Campbell, 1987). At present, none of the zones can be characterized based on mineral content.

A statistical summary of the major-oxide and trace-element contents of the Salt Lake coals is presented in Table 8. Averages for both the Cleary Member coals of the Menefee Formation and the Gibson/Cleary Member coals in the Gallup coal field are provided for comparison. The Gibson/Cleary Member was chosen because there are no marine influences from either an overlying or underlying marine unit. The Cleary Member of the Menefee Formation is a regressive sequence, which is underlain by the Point Lookout Sandstone. The only coal zone in the Moreno Hill Formation that has been influenced by marine deposition is the Antelope coal zone, which rests on top of the regressive Atarque Sandstone.

Total SiO_2 and Al_2O_3 content for the Moreno Hill Formation coals of the Salt Lake field is much higher than that found in the coals of the Cleary Member or the Gibson/Cleary Member. However, the ratio of Al_2O_3 to SiO_2 is similar for all three groups of coals, indicating similar amounts of free quartz. The total iron content for these three groups of coals is similar, but the proportion of the different components is not the same. Removal of the iron in pyritic sulfur does not reduce the amount of iron significantly in the coals from the Salt Lake coal field, and this nonpyritic iron is similar to the amount of nonpyritic iron present in the Gibson/Cleary Member coals. Coals from the Cleary Member of the Menefee Formation have a much greater percentage of the total iron in the pyritic form. The concentration of titanium is significantly higher in coals from the Salt Lake coal field than what is found in coals from either the Cleary Member or the Gibson/Cleary Member. Like titanium, calcium and phosphorus are more abundant in coals from the Salt Lake coal field than they are in coals from the other two populations. Total sodium and potassium, however, are lower in the Salt Lake coals than they are in the other two coal-bearing areas. Water-soluble sodium in the Salt Lake coals is significantly lower than what is found in either the Cleary Member coals or the Gibson/Cleary Member coals (Table 8). Even though the total amount of water-soluble

TABLE 8—Major-oxide and trace-element analyses for the Moreno Hill Formation coals of the Salt Lake coal field, coals from the Cleary Member of the Menefee Formation, and Gibson/Cleary Member coals of the Gallup coal field.

	Moreno Hill Formation (Salt Lake coal field)			Cleary Member Menefee Formation			Gibson/Cleary Member of Crevasse Canyon/Menefee (Gallup coal field)		
	No. of samples analyzed	Mean %	S.D. %	No. of samples analyzed	Mean %	S.D. %	No. of samples analyzed	Mean %	S.D. %
Major-oxide composition (whole-coal basis)									
SiO_2	76	9.06	3.96	73	7.25	3.99	17	6.59	4.62
Al_2O_3	76	4.02	1.94	73	2.65	1.88	17	2.63	1.84
Fe_2O_3	76	0.69	0.43	73	0.77	0.57	17	0.59	0.33
$\text{Fe}_2\text{O}_3 - \text{S}_2$	76	0.67	0.46	73	0.58	0.40	17	0.48	0.26
TiO_2	76	0.23	0.12	73	0.13	0.06	17	0.15	0.09
CaO	76	0.73	0.44	73	0.45	0.40	17	0.39	0.25
MgO	76	0.10	0.05	73	0.12	0.08	17	0.12	0.06
Na_2O	76	0.13	0.39	73	0.21	0.08	17	0.27	0.10
K_2O	76	0.05	0.05	73	0.10	0.10	17	0.07	0.09
P_2O_5	76	0.02	0.01	73	0.004	0.002	17	0.003	0.002
HNa_2O	44	0.04	0.02	47	0.12	0.05	17	0.09	0.03
HK_2O	44	0.003	0.003	47	0.005	0.003	17	0.004	0.001
Trace-element composition (ashed-coal basis; all values in ppm)									
Be	30	14	12	89	25	27	38	17	10
Cu	30	81	39	89	59	32	38	61	30
Cr	30	58	37	88	156	101	38	45	14
Li	30	42	18	89	36	15	38	39	18
Mn	30	745	647	89	276	324	35	210	446
Mo	13	229	69	39	151	71	24	14	10
Ni	30	32	19	79	71	48	34	43	20
Pb	30	58	48	89	65	40	38	30	19
Sr	30	455	307	84	826	465	34	800	508
V	26	137	99	80	181	66	33	119	27
Zn	30	41	17	77	125	110	33	138	100

sodium is different, the percentage of the total sodium in the Salt Lake coals attributable to the water-soluble form is similar to that of the Gibson/Cleary Member coals, approximately one-third of the total sodium value. Coals from the Cleary Member have nearly half their total sodium in the water-soluble form. The water-soluble potassium, as well as the water-soluble component of the total potassium is similar for all three coal groups. The amounts of beryllium and vanadium in the Salt Lake coals are similar to the amounts found in the Gibson/Cleary Member coals but significantly lower than the amounts found in the Cleary Member coals of the Menefee Formation. Copper, manganese, and molybdenum, on the other hand, are in notably higher concentrations than for either of the other two populations. Nickel, strontium, and zinc are lower in the samples from the Salt Lake field than what is present in either of the other two populations. Lead concentrations are comparable to those found in the coals of the Cleary Member of the Menefee Formation but higher than what is present in the Gibson/Cleary Member coals.

CONCLUSIONS

Stratigraphic units in the Salt Lake coal field range from the Triassic Chinle Formation to a Quaternary basalt flow. Some of the oldest Cretaceous coals in New Mexico are found in two of these units. While the oldest coal is a zone in the Dakota Sandstone, the Moreno Hill Formation contains four coal zones. The regional dip for the Salt Lake field is approximately 5° to the southeast. Only a few major faults are present in the western portion of the field, and they have little effect on the coal-bearing areas. Minor flexures because of Tertiary volcanism, however, do affect the coals.

The Moreno Hill Formation is the major coal-bearing unit in the Salt Lake coal field. It is a sequence of continental sediments containing fluviually deposited coals. In the northern portion of the Salt Lake coal field, Moreno Hill sediments may be as much as 700 ft thick. The Moreno Hill Formation can be broken down into three members; three coal zones are in the lower member, and one is in the upper member.

The ash content is among the highest for New Mexico coals, and this mineral matter is finely disseminated, making it difficult to remove by conventional coal-cleaning methods. The rank of these coals is high-volatile C bituminous. Both the total sulfur and pyritic-sulfur contents are low for coals in the two major coal-bearing zones, the Cerro Prieto and Rabbit zones, and resemble those values found in the Gibson/Cleary coals in the Gallup field. Only in the Antelope zone are these two values significantly higher, resembling the values for the regressive Cleary Member coals of the Menefee Formation. The chemical and mineralogical characteristics of these coals are uniform, indicating a consistent behavior of the ash in a power plant.

The northern half of the Salt Lake coal field contains an estimated 480 million tons of coal. These resources are present in three of the four coal zones. The Antelope zone has only 103 million tons of coal with a high stripping ratio of 66:1. The Cerro Prieto zone has a resource of 247 million tons with an average stripping ratio of 23:1. The Rabbit zone has a resource of 130 million tons with an average stripping ratio of 21:1.

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