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Abstract

The Monero coal field in north-central New Mexico, on the northeastern side of the San Juan Basin, is defined by Mesaverde Group outcrops that form a narrow north–south band cut by several northwest-trending faults. The coal is in the Menefee Formation, the medial unit of the Mesaverde Group.

Monero field coals were mined first to supply fuel to the Denver and Rio Grande Western Railroad built in 1881. Coal mining continued in the Monero field until 1971 although production greatly decreased after 1959. As many as 40 mines were opened during the 90-year period of coal mining in this area, and production from 1882 to 1963 totaled 1.6 million short tons (st). The estimated original coal resource for the Monero field was 17 million st. The remaining demonstrated resource from recent drilling information is 13.5 million st (New Mexico Bureau of Mines and Mineral Resources 1990 coal database). Although the Monero coals are relatively thin, they were valued for their high Btu value and coking properties. The average coal analysis for the Monero field indicates these coals are low moisture (3.0%), moderate ash (11.8%), and a rank of high-volatile A bituminous.

Recent exploration in this field has been minimal. A small exploration program in 1978 by Rochester and Pittsburgh Coal Co. completed 11 holes northeast of the town of Monero and south of Lumberton. In 1987 the U.S. Geological Survey completed a coal-evaluation study of both the Fruitland and Menefee Formations for the Jicarilla Apache Indian Reservation in cooperation with the Bureau of Indian Affairs. In 1988 the New Mexico Bureau of Mines and Mineral Resources drilled seven holes in the northern Monero field as part of a larger coal-quality project funded in part by the New Mexico Research and Development Institute.

Data available from previous work and information from recent drilling are used

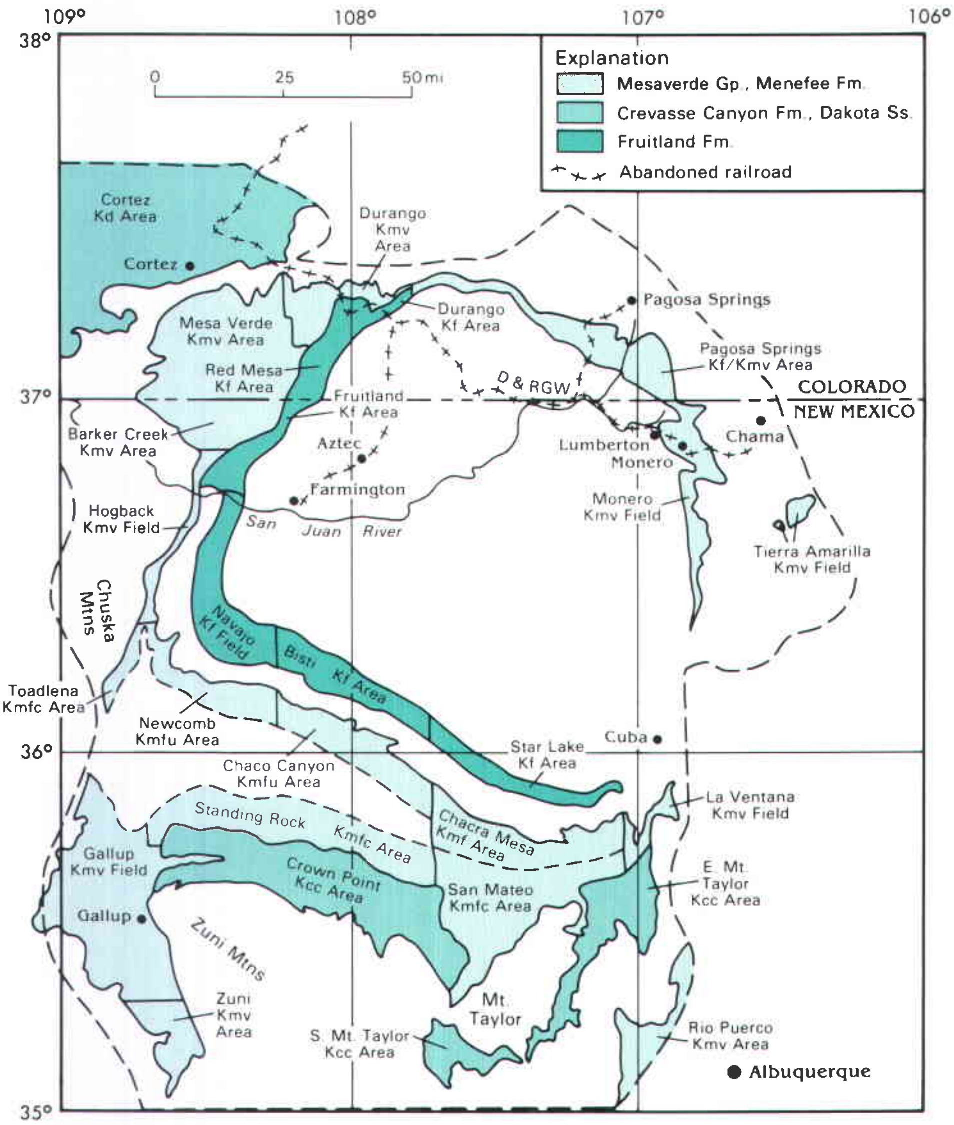

FIGURE 1—Coal fields of the San Juan Basin, New Mexico and railroads in northwestern New Mexico. Dashed line indicates boundary of the San Juan Basin as defined for coal study. Modified from Shomaker, Beaumont, and Kottlowski, 1971.

Also in this issue

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to indicate that coals in the Monero field were deposited in a back-barrier-swamp to lower-coastal-plain environment near the seaward extent of the Menefee Formation. Development of these coals occurred in a short-lived paralic environment associated with the transition from a regressive to a transgressive shoreline. Although these coals are thin, they are of relatively high rank because of subsequent depth of burial and close proximity to the large heat source of the San Juan volcanic complex. Recent studies propose heat advection by groundwater influenced the rank of the Fruitland Formation coals; it is quite possible that advected heat also influenced the Menefee Formation coals.

Introduction

Coal mining in New Mexico was more extensive in the late 1800's and early 1900's than it is today. Most of the smaller coal fields that were active in that early period are located outside the major coal-producing regions of the San Juan or Raton Basins. The Monero coal field is a relatively small, isolated field among the inactive areas, but it is located in a major coal-producing region. The Monero field on the northeastern flank of the San Juan Basin is delineated by outcrops of the Mesaverde Group that extend southward from near the Colorado–New Mexico State Line for about 45 mi (Fig. 1). The purpose of this paper is to combine all available coal data, including recent drilling data, for the northern Monero field and evaluate both general trends of the coal-bearing sequence and characteristics of the coals in the northern Monero field.

Mining history

Small underground coal mines operated in the Monero field from 1881 to 1971. Development of the coal resources in this area began when a market for coal was created by construction of the Denver and Rio Grande Western Railroad (D&RGW) through the coal field. In 1881 a small railroad, lumber, and coal camp was established at Amargo, but the center of coal activity for this field dates from 1884 when a group of Italian miners settled the town of Monero, Italian for money (Nickelson, 1988). The remnants of Amargo are barely visible today, but the town of Monero still exists although it is sparsely populated. Coal mining in this area was difficult because of rugged terrain formed by major northwest-trending faults that cut the area into several fault-block mesas. Generally, two 3–4 ft beds were mined, and in many places the coal is offset by minor secondary faulting perpendicular to the major fault system.

Peak coal production in the Monero field occurred between 1899 and 1908. A total of 391,752 short tons (st) were mined, which essentially depleted the known reserves. After an economic recession in 1908, production dropped to 9,779 st in 1909. It was not until 1922 that coal production again exceeded 16,000 st in the Monero field (Nickelson, 1988). From 1922 to 1953 yearly production remained above 16,000 st with a total for the period of 849,270 st. Production in the Monero field dropped considerably from 15,677 st in 1953 to 3,848 st in 1963 (Nickelson, 1988). The railroad was abandoned in 1963, and demand for coal decreased significantly. In 1970 the last mine in the Monero field closed when the owner was financially unable to comply with the new mine-safety laws (Nickelson, 1988, p. 149).

Most mines in the Monero field were located near the town of Monero and delivered coal to the D&RGW railroad, but several mines were developed after 1921 south of Lumberton. One of these mines (Burns–Biggs) supplied coal to a spur owned jointly by the D&RGW and Burns–Biggs Lumber Company and built to transport lumber from Lumberton south to the company's sawmills at El Vado (Myrick, 1970). Several mines in the Lumberton area supplied coal to the Indian agency at Dulce. From 1881 to 1971 as many as 40 mines were open at various times in the Monero–Lumberton area; they produced a total of 1.6 million st of coal between 1882 and 1963 (Nickelson, 1988).

Previous work

One of the earliest discussions of the Monero field was by Gardner (1909) who mentioned the presence of coal in the vicinity of Monero and noted the displacement of the coal-bearing rocks by the northwest-trending Monero fault. Included in this report were a few measured sections and coal analyses. Campbell (1922) compared coals of several New Mexico coal fields, including Monero, to other areas in the United States. Fieldner et al.'s (1936) compilation of mine-sample analyses for New Mexico incorporated several analyses from the Monero field. Their report included descriptions of the mine locations and the coal sections that were sampled. Dane's field investigations and subsequent map (1948) of the northeastern part of the San Juan Basin encompasses the northern half of the Monero coal field. Dane mapped the coal-bearing Mesaverde Group as one unit but recognized three formations, which he referred to, in ascending order, as the Hosta Sandstone Member of the Point Lookout Sandstone, the Menefee Formation, and La Ventana Sandstone Member of the Cliff House Sandstone. To date Dane's geologic map (1948) is the best available of the Monero field and subsequently was used in the recent compilation of the Aztec 1° × 2° by Manley et al. (1987). Read et al. (1950) estimated the original bituminous resources (at depths less than 1,000 ft) in the Monero field to be 17 million st. Averitt (1966) included a short discussion of the Monero field and the quality of the coals in his report on coking coals in the western United States. The Monero coal field has been described by Kottlowski and Beaumont (1965) and by Shomaker (1971) as part of a coal-resource and coal-quality study of the entire San Juan Basin.

Recent investigations

Recent coal exploration has been limited in the Monero field. In 1978 Rochester and Pittsburgh Coal Company leased several parcels of state-owned coal lands south of Lumberton and north of the town of Monero where they drilled eleven holes. Several of the coal beds encountered were cored and analyzed. Most of the coals were thin and discontinuous so the lease was dropped.

As part of a joint project with the Bureau of Indian Affairs (BIA) in 1986, the U.S. Geological Survey drilled several holes in the Menefee and Fruitland Formations in the northern Jicarilla Apache Indian Reservation. These drill holes and more than 400 available oil and gas logs were used to evaluate the coal resources of both the Menefee and Fruitland Formations in the study area. The interagency report was prepared by Olson and Gardner (1987) for the Jicarilla Tribe and the BIA.

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In 1988 the New Mexico Bureau of Mines and Mineral Resources (NMBMMR) drilled seven holes in the Monero–Lumberton area as part of a larger coal-quality study partially funded by the New Mexico Research and Development Institute (NMRDI). For the larger study drill holes were completed at approximately 150 sites throughout the San Juan Basin. Roybal et al. (1989) discussed the Monero drilling and the coal analyses. The primary objective of the NMRDI study was to obtain coal cores for analysis and to acquire stratigraphic information about the coal-bearing sequences through geophysical logging of the drill holes. To acquire the most stratigraphic information from drilling done in the Monero field and elsewhere in the basin, the entire coal-bearing sequence and at least the upper 40 ft of the underlying stratigraphic unit were penetrated at each location. With depth to the underlying formation known, the coal-bearing sequence can be placed within the stratigraphic framework of the area, and correlation between drill sites is facilitated.

Using the recent drilling data, remaining resources have been estimated (NMBMMR 1990 coal database). Measured (within 1/4-mi radius of the measured coal bed) and indicated (from 1/4- to 3/4-mi radius) resources for coal seams greater than 1.25 ft and within 500 ft of the surface total 13.5 million st of coal in the northern Monero field.

Geologic setting

Structure

The Monero field is structurally complex, relative to other San Juan Basin coal fields. This coal field is located in the eastern part of the Archuleta arch (Fig. 2), which separates the central San Juan Basin from the smaller and shallower Chama Basin to the east. The Chama Basin is generally considered a sub-basin or embayment of the San Juan Basin. The Gallina–Archuleta arch is bounded on the west by a monocline that dips into the San Juan Basin (Woodward, 1987). Much of the northern Monero field is influenced by small domes and northwest-trending synclines, part of the Archuleta arch (Dane, 1948). The structural trend in the southern Monero field parallels the N30°W trend of the Gallina arch. There are several major faults in the Monero field that parallel the eastern edge of the San Juan Basin (Fig. 3). Most, but not all, faulting is believed to be associated with and contemporaneous with this folding (Dane, 1948). Faults in the Monero area tend to be high angle and normal with displacements of less than a hundred feet (Dane, 1948). Manly et al. (1987) indicate that most of the displacement is downdropped to the west. Because of structure and faulting, dip of the beds is quite variable. The structure in the northern Monero field has created a mesa-and-canyon topography, and outcrops of the Mesaverde Group are limited primarily to the steep canyon walls of these fault-block mesas.

Stratigraphy

The Upper Cretaceous deposits in the San Juan Basin are a series of transgressive and regressive sequences. The Mesaverde Group consists of barrier-beach and nonmarine units from the base of the Gallup Sandstone to the top of the Cliff House Sandstone (Fig. 4). The lower Mesaverde Group is present in the south-southwestern San Juan Basin, but because of the progression of the shoreline to the northeast with each transgressive–regressive cycle, only the upper Mesaverde Group was deposited in the Monero field. Although the cross section was constructed along the western edge of the San Juan Basin, the northeastern part of the section, near Durango, is considered approximately equivalent to the stratigraphic sequence in the Monero area. The relative positions of the shoreline (Molenaar, 1983) during the deposition of the Mesaverde Group (Fig. 5) support this assumption.

The Mesaverde Group is composed of three formations in the northern San Juan Basin (Fig. 4). The oldest unit, the Point

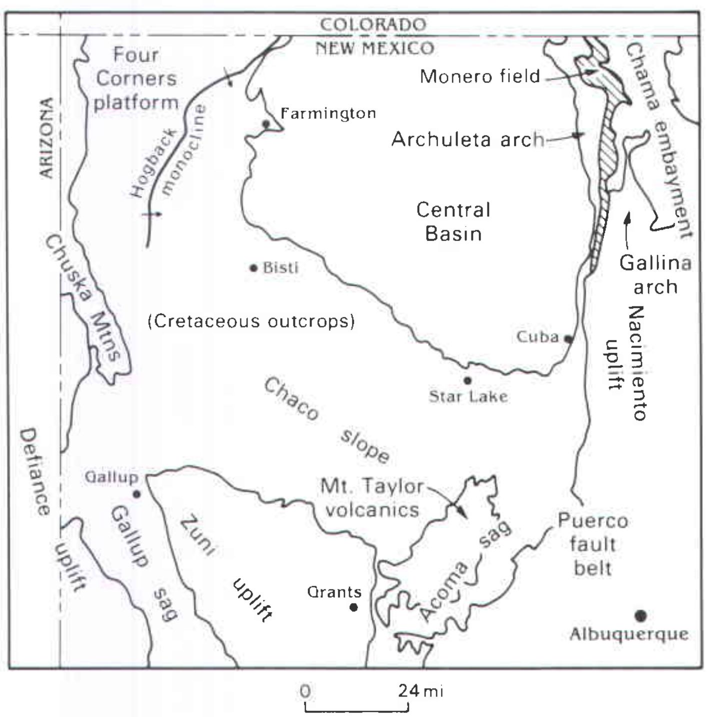


FIGURE 2—Tectonic map of the San Juan Basin, New Mexico. From Beaumont, 1982, printed with permission from American Association of Petroleum Geologists.

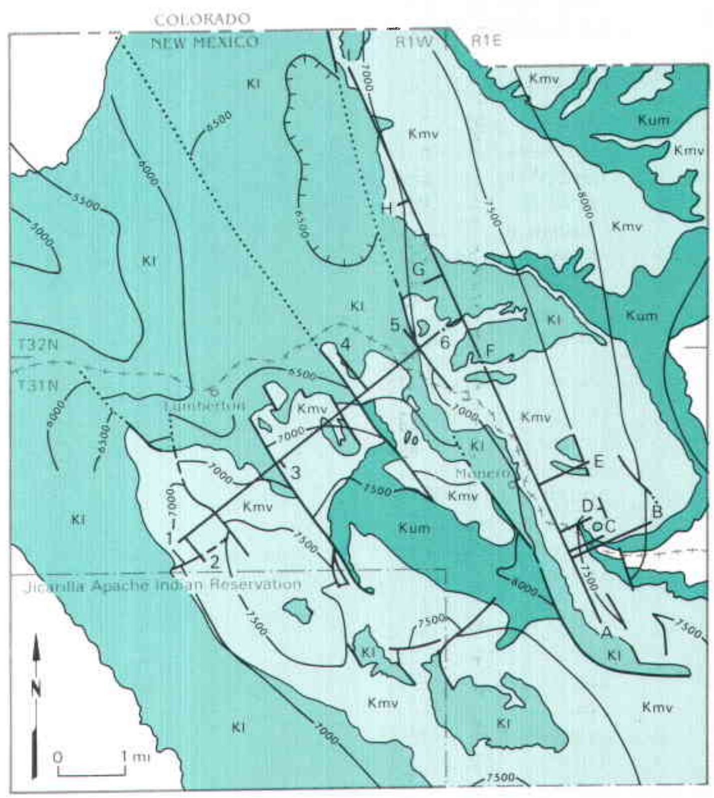


FIGURE 3—Geologic map of northern Monero field, New Mexico. Cross section lines for Figs. 6 and 7 included. From Dane, 1948. **Kl**, Lewis Shale; **Kmv**, Mesaverde Group; **Kum**, upper Mancos Shale.

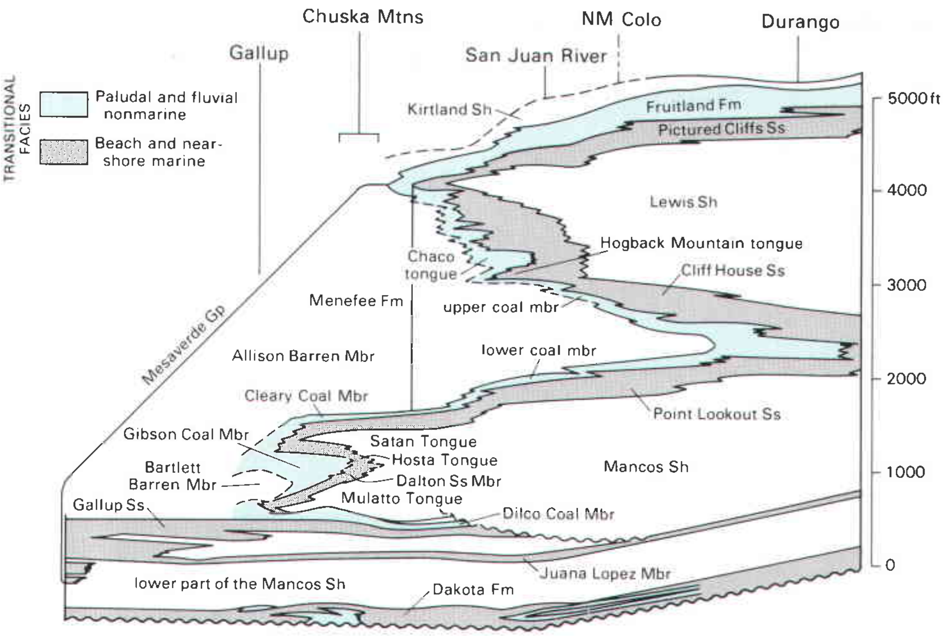


FIGURE 4—Stratigraphic diagram of Cretaceous rocks, San Juan Basin, New Mexico and Colorado. From Beaumont, 1982. Line of section shown in Fig. 5.

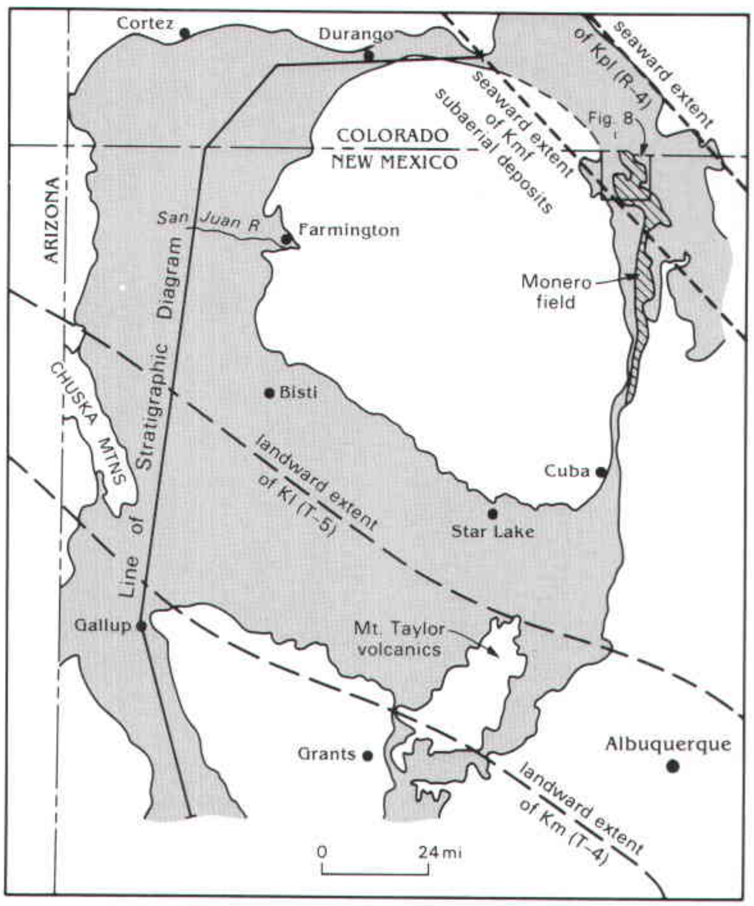


FIGURE 5—Index map of the Cretaceous outcrops, San Juan Basin, New Mexico, (Beaumont, 1982, printed with permission from American Association of Petroleum Geologists) with shoreline positions for the maximum T-4, R-4, and T-5 cycles, and maximum seaward extent of Menefee Formation subaerial deposits. Modified from Molenaar, 1983, printed with permission from Society of Economic Paleontologists and Mineralogists. Cretaceous outcrops are shaded. **Km,** Mancos Shale; **Kmf,** Menefee Formation; **Kpl,** Point Lookout Sandstone; **Kl,** Lewis Shale.

Lookout Sandstone, is a barrier-beach to nearshore sandstone that conformably overlies and intertongues with the marine Mancos Shale. The Point Lookout Sandstone was deposited during a major withdrawal of the Late Cretaceous seaway to the northeast. In the Monero area the formation consists of 50–200 ft of predominantly massive, well-sorted, clean quartz sandstones.

Above the Point Lookout barrier-beach sandstone, the rocks of the lower part of the Menefee Formation represent the regressive back-barrier-paludal to lower-coastal-plain facies. The sequence consists of silty sandstone, siltstone, mudstone, carbonaceous mudstone, and coal. The upper part of the Menefee is composed of the back-barrier-swamp and nearshore deposits developed during the subsequent transgressive cycle, so it is lithologically similar to the lower Menefee Formation. The Menefee Formation is about 2,000 ft thick in the southern San Juan Basin (Fig. 4), but in the Monero field the Menefee is only 50 to 100 ft thick because of the close proximity of this area to the maximum seaward position of the Mesaverde shoreline prior to the reversal of the shoreline movement (Fig. 5).

The overlying Cliff House Sandstone consists of barrier-beach and nearshore sandstones that intertongue with the upper Menefee Formation and the overlying marine Lewis Shale. Although the depositional environment of the Cliff House Sandstone is similar to the Point Lookout, the sandstones are not as massive in the northern Monero field, and the total thickness, 30–80 ft, is less than the Point Lookout (Dane, 1948).

Methodology

Data on stratigraphy and coal thickness and quality were assessed by comparison with published data from Nickelson (1988) and Fieldner et al. (1936), with Dane's (1948) geologic and structural mapping, with new data from NMBMMR, and with unpublished data from Rochester and Pittsburgh Coal Co. Most of these coal data are limited to the northern Monero field, therefore this is the principal area of investigation.

Two cross sections (Figs. 6 and 7) in the northern Monero field were constructed using NMBMMR drill logs and unpublished Rochester and Pittsburgh Coal Co. drill-hole information. Where the base of the Mesaverde Group was not penetrated, Dane's (1948) structure contours (Fig. 3) were used to determine the approximate position of the base of the unit. The accuracy of these structure contours was checked with the holes that did penetrate the underlying Mancos Shale and was found to be reliable. Correlation of units on the cross sections is limited to formation boundaries because of distance between drill sites and variability of the Menefee Formation.

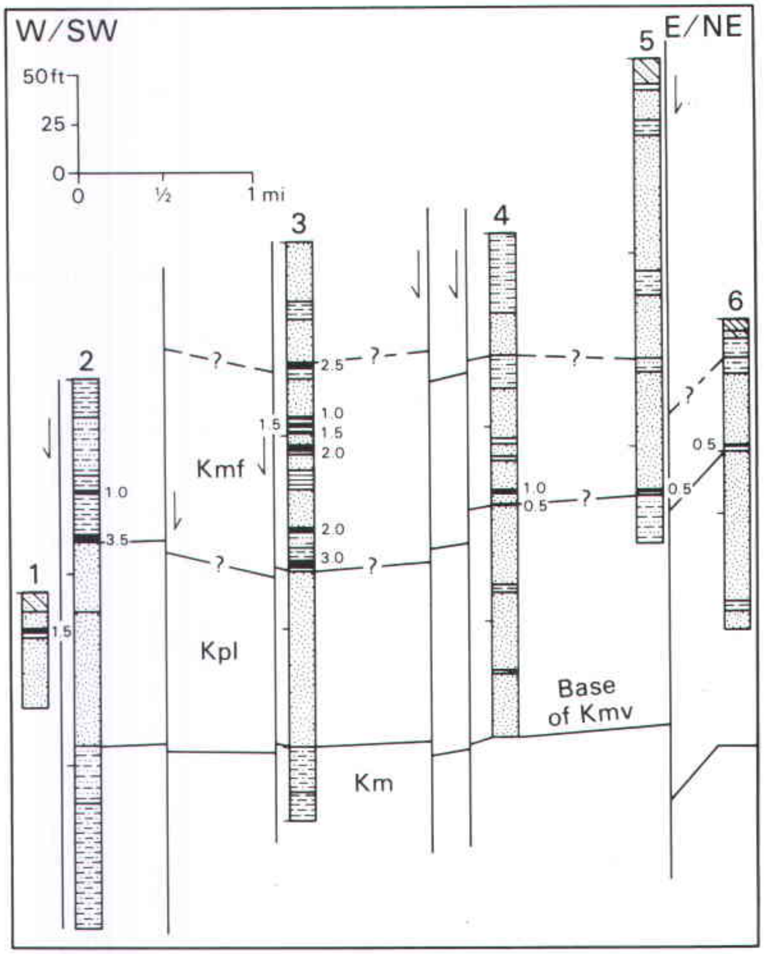


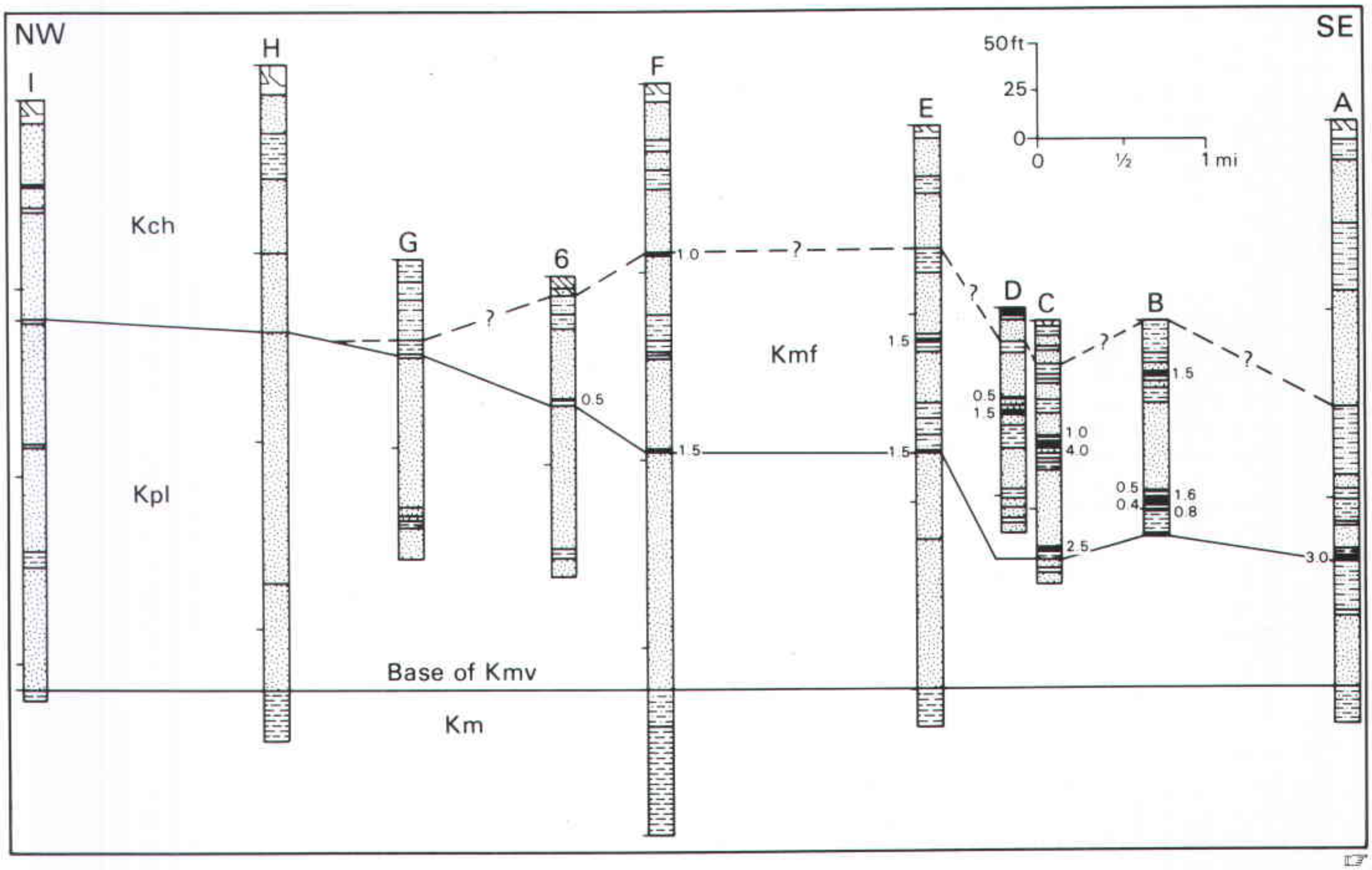
FIGURE 6—Southwest–northeast cross section from drill-hole data in northern Monero field. Line of section shown on Figure 3.

Explanation

- Alluvium
- Sandstone
- Siltstone
- Silty sandstone, silty shale
- Shale
- Claystone
- Carbonaceous shale
- Coal

Kch — Cliff House Ss.
Kmf — Menefee Fm.
Kpl — Point Lookout Ss.
Kmv — Mesaverde Group
Km — Mancos Shale

FIGURE 7—Northwest–southeast cross section from drill-hole data, northern Monero field. Line of section shown on Figure 3.



General trends in the Mesaverde Group

Two cross sections in the northern Monero field were constructed to determine general lithologic trends in the drill-hole data. The southwest–northeast cross section (Fig. 6) shows a decrease in thickness of the Menefee Formation to the northeast. This section, above the Point Lookout (Kpl), has an increase in siltstone and sandstone and a decrease in mudstone, total coal thickness, and coal frequency to the northeast. All the drill holes have coal directly on top or within a few feet of the Point Lookout Sandstone contact. Drill-hole section 3 south of Lumberton (Fig. 3), where many of the old mines were located, has the greatest number of coals and probably the thickest nonmarine sequence (approximately 100 ft) in this cross section.

The northwest–southeast cross section (Fig. 7) has more NMBMMR drill holes and therefore provides more control for the correlation of units. This cross section originates south of the town of Monero and terminates near the Colorado border (Fig. 3), almost parallel to the Late Cretaceous shoreline. The Point Lookout Sandstone thickens to the northwest as the overlying Menefee Formation appears to pinch out. The presence of mudstone and coal in the Menefee Formation is greatest just north of the town of Monero (Fig. 7, sections B–D), and decreases to the northwest. Coal occurs directly on top or within a few feet of the Point Lookout contact, as shown in Figs. 6 and 7. At many localities coal is present at what is considered to be the top of the Menefee Formation (Fig. 7). The position of these coals at the top and base of the Menefee Formation, just above or below a barrier-beach sandstone, tends to substantiate a back-barrier-swamp environment for these coals. The overlying Cliff House Sandstone probably intertongues with the Menefee Formation. Some of the sandstones and siltstones in the upper part of the interval that has been designated Menefee on the cross sections may be sandstone tongues of the Cliff House. Point Lookout Sandstone appears to be directly overlain by Cliff House Sandstone in the two northernmost drill-hole sections (Fig. 7). The Cliff House sandstones are siltier and not as massive as the Point Lookout sandstones in the northern Monero field. These lithologic differences between the Cliff House and the Point Lookout sandstones suggest a fairly rapid rate of shoreline shift to the southwest, eliminating the chance for thicker buildups of sandstone such as those in the Point Lookout Sandstone.

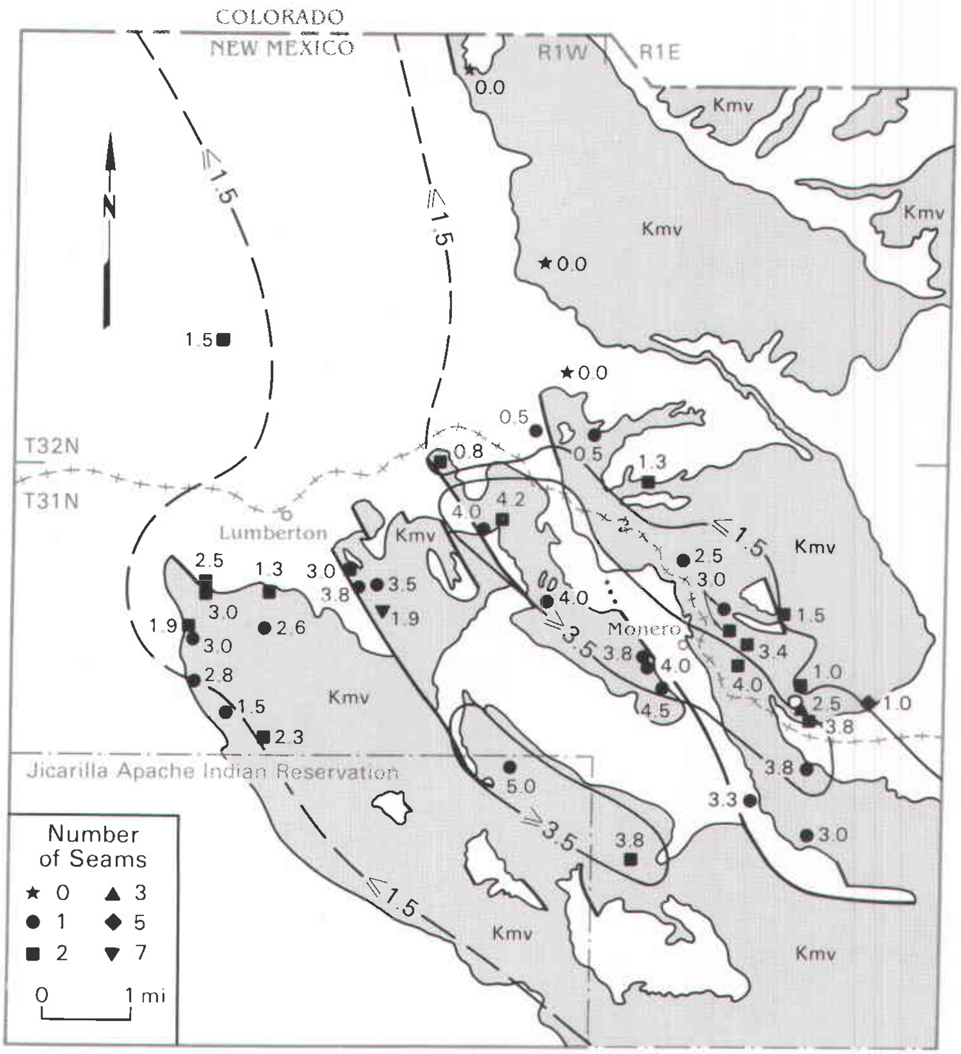


FIGURE 8—Coal thickness and contours in the northern Monero field. Data from Nickelson, 1988; Fieldner et al., 1936; Roybal et al., 1989; and Rochester and Pittsburgh Coal Co. unpublished data. Base map modified from Dane, 1948.

Coal thickness

The cross sections discussed above show the frequency and coal-thickness trends in the northern Monero field. Additional locatable coal-thickness data are available from mine and coal-quality sources (Nickelson, 1988; Fieldner et al., 1936; Roybal, et al., 1989). Fig. 8 shows Menefee coal-bed thickness and number of beds from drill-hole and coal-sampling information. The values in some cases are averages of two or more coal beds at each location, but several values are of individual seams, generally from sections in mines. Although the data is clustered in the southern section of the map, a decrease in the coal thickness to the north–northwest is evident. The average Menefee coal bed is slightly less than 3 ft in the Monero–Lumberton area. The thin and limited extent of the coals shown in the cross sections (Figs. 6 and 7) and in the coal-thickness map (Fig. 8) indicates the swamp environment was restricted and short lived in the northern Monero field. The area of greatest coal thickness (>3.5 ft) is concentrated in a northwest–southeast trend, encompassing the area around the town of Monero and is isolated in two areas southeast of Lumberton (Fig. 8). These areas of thicker coals tend to be elongated parallel to the shoreline, characteristic of back-barrier-beach coals.

Limited data west of the Mesaverde outcrops (Fig. 8) does not allow coal thickness to be determined; it is postulated that Menefee Formation coals would be present in the subsurface and may be as thick or thicker than those in the Monero–Lumberton area. This assumption is made because a thick buildup of Point Lookout Sandstone represents a stillstand of the shoreline in the northernmost Monero field, which would allow for back-barrier and lower-coastal-plain swamps to develop. The total coal-thickness isopachs (Fig. 9) by Crist et al. (1989) tend to support the idea that thicker coals were deposited west of the defined Monero field.

Quality

Coal quality is an indicator of the coal depositional environment as well as the

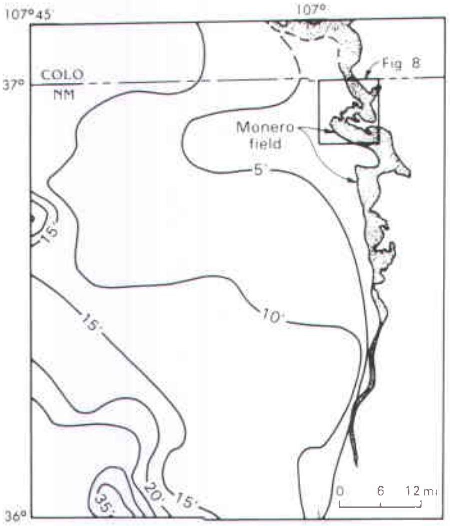


FIGURE 9—Isopach of total coal thickness in the Menefee Formation, northeastern San Juan Basin. Modified from Crist et al., 1989, printed with permission from Society of Petroleum Engineers.

TABLE 1—Available quality analyses for the Monero and other Menefee Formation fields, San Juan Basin, New Mexico (analyses on an as-received basis). Source of data: NMBMMR 1990 coal database.

	Moisture	Ash	Fixed carbon	Vol. mat.	Sulfur	Btu	MMFBtu	Thickness
Monero field								
Average	3.00	11.80	49.24	37.81	1.89	12,562	14,466	2.86
Maximum	8.37	30.40	55.10	40.56	5.92	13,798	14,993	6.40
Minimum	1.50	5.30	41.68	34.00	0.40	9,114	10,694	0.44
Number of samples	44	44	38	38	44	44	44	21
All other Menefee Formation fields								
Average	15.38	11.27	37.85	35.48	0.96	10,171	11,602	4.44
Maximum	26.13	33.80	61.73	56.17	5.17	12,385	14,344	23.80
Minimum	4.60	1.30	21.99	22.22	0.10	8,132	9,240	0.90
Number of samples	345	345	325	325	325	343	345	345

degree of coalification. The average, maximum, and minimum values of the available quality data for Monero and other Menefee Formation fields are presented in Table 1 on an as-received basis, except for moist, mineral-matter-free Btu (MMFBtu) values. Locatable quality data from the Monero field were plotted to determine geographic trends; none were evident so these diagrams have not been included.

Point-source data for the northern Monero field do not reveal any distinct geographic trends in the sulfur content of Menefee coals; however, the sulfur content itself is variable (Table 1). Average sulfur content for the northern Monero field (1.89%) is the highest of all Menefee Formation fields; average for Menefee coals in other parts of the San Juan Basin is closer to 1%. The higher sulfur content of the Monero coals and the stratigraphic position of many of these coals (just above or below the Point Lookout and Cliff House barrier-beach sandstones, respectively) are indicative of back-barrier-swamp environments where the swamp deposits were subject to periodic invasions by the sea.

Locatable ash-content values of Monero coals do not show any definite geographic trends, and the average (11.80%) is approximately the same as that for other Menefee coal fields (11.27%). These values are moderately low for San Juan Basin coals, many of which have ash contents of 15–20%. The source of ash in Monero coals could be attributed to sediment brought into the swamp environment during occasional storms or shifts in the fluvial-drainage pattern.

Although the majority of Monero coals are bituminous, the moist, mineral-matter-free Btu values (MMFBtu) that determine rank (Table 1) vary greatly from high-volatile C bituminous to high-volatile A bituminous. Monero coals have the highest rank and heating value (Btu) of all Menefee Formation coals (Table 1). The remaining Menefee coals in the San Juan Basin range from subbituminous C to high-volatile A bituminous rank.

Comparison of coal rank

Indicators of coal maturity or rank are calorific value (Btu/lb, moist, mineral-matter-free basis), moisture content (ash-free basis), percent volatile matter (dry, ash-free), fixed-carbon content (dry, ash-free basis), and vitrinite reflectance (American Society of Testing Materials, 1985; Rightmire, 1984). Different indicators are used to determine the degree of coalification in lower rank coals than those used for the higher rank coals. Moist, mineral-matter-free Btu values (MMFBtu) and agglomerating properties determine the rank of coals in the lignite to high-volatile B bituminous range. Rightmire (1984) also indicated ash-free moisture as an important indicator of coalification in the lower coals. In the higher rank coals, high-volatile A bituminous to meta-anthracite, fixed carbon (dry, ash-free), and volatile matter (dry, ash-free) are important in calculating rank.

Most of the Menefee Formation coals are of a subbituminous to high-volatile bituminous rank, therefore ash-free moisture content and MMFBtu values were plotted within surface-minable Menefee coal areas in the San Juan Basin to determine any apparent coalification trends. Data points (Figs. 10, 11) represent individual sites, but values may be averages for several analyses from the same location. The moisture content (ash-free basis) (Fig. 10) generally increases from northeast to southwest. Northern Monero coals have the lowest moisture content (2–5%) while Chaco Canyon, Standing Rock, San Mateo, and La Ventana fields have the highest moisture content (15–20%). Chacra Mesa, Hogback, and northern San Mateo coals have lower moisture values (ash-free) (10–15%). Menefee coal MMFBtu values range from approximately 8,000 Btu/lb to greater than 12,000 Btu/lb. The MMFBtu values (Fig. 11) increase from southwest to northeast. The northern Monero coals have the highest MMFBtu values (>13,000 Btu/lb). Most of the Standing Rock, Chaco Canyon, and Newcomb coals have the lowest MMFBtu values (9,000–11,000 Btu/lb).

Moisture and MMFBtu values illustrate the increase in rank or degree of coalification in Menefee Formation coals from south–southwest to northeast in the San Juan Basin. Northern Monero coals have the highest rank of the fields with analyses. Northern Hogback and Barker coals may be of equivalent rank to Monero coals, but supporting data is lacking.

Other studies (Shomaker and Whyte, 1977; Crist et al., 1989) that have dealt with deep Menefee Formation coals have noted the increased rank in the northern San Juan Basin. This increase is attributed in part to close proximity of the San Juan volcanic complex. Several studies (Reiter and Clarkson, 1983; Choate and Rightmire, 1982) using heat-flow and hydrocarbon vitrinite-reflectance data found the geothermal gradient increased toward the northern San Juan Basin. Some of these studies attribute the increased hydrocarbon rank in the northern part of the basin to the close proximity of the San Juan volcanic complex, a massive heat source. Clarkson and Reiter (1987) believe conductive heat flow from Oligocene magmatism and depth of burial before Eocene erosion are not sufficient to account for the observed maturation pattern in the northern San Juan Basin. They suggest heat advection by ground-water flow also may be a significant influence. Regional ground-water flow in the northeastern part of the basin is from the San Juan Mountains toward the north-central part of the basin (Stone et al., 1983). This theory, especially with reference to the Menefee Formation, needs further study. ☞

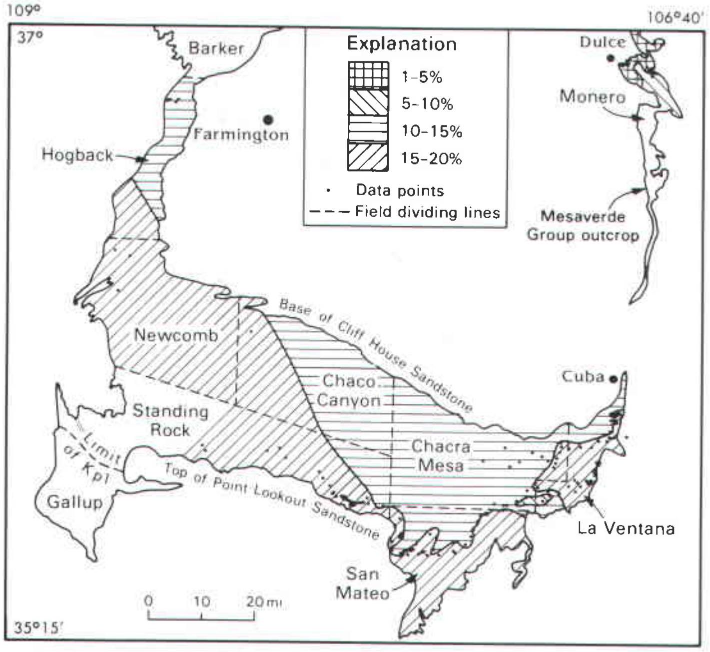


FIGURE 10—Moisture content (ash-free basis) of Menefee Formation coals in designated coal fields of the San Juan Basin. Base map modified from Clemons et al., 1982, printed with permission from New Mexico Geological Society.

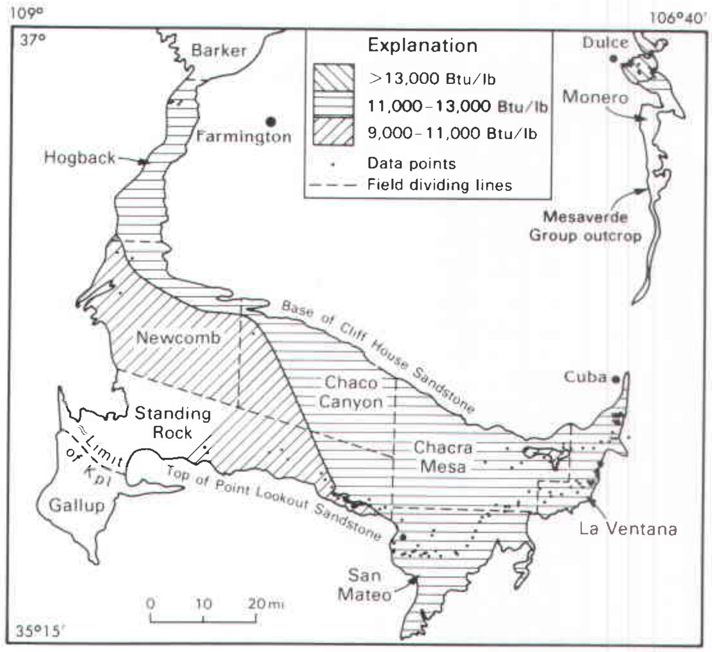


FIGURE 11—Btu values (moist, mineral-matter-free basis) of Menefee Formation coals in designated coal fields of the San Juan Basin. Base map modified from Clemons et al., 1982, printed with permission from New Mexico Geological Society.

Summary and conclusions

The Monero field was an area of coal mining from the 1880's into the early 1970's. The impetus for this activity was the building of the Denver and Rio Grande Western Railroad through the area. Although the coals in the Monero area are relatively thin and the terrain is rugged, these are high-quality coals that proved to be a valuable resource for the railroad as well as domestic use for almost 90 years. The Monero coal field probably does not have a significant economic-resource base (13.5 million st, remaining demonstrated resources) for coal mining today because of the remoteness and structural complexity of this area, but data from the Monero field may be useful in determining what the coal characteristics are in the Menefee Formation at greater depths just west of this area in the San Juan Basin.

Early geologic investigations in this area were limited. Dane's (1948) investigations and subsequent geologic map including the Monero coal field are based on outcrop data and a few oil and gas wells available at that time. With this information, Dane mapped the Mesaverde Group as one unit, although he recognized the Point Lookout Sandstone, Menefee Formation, and Cliff House Sandstone. Dane felt that the entire Mesaverde Group section became sandier to the north and the individual units were not discernable.

Recent drilling in the Monero field supplies further evidence about the Mesaverde Group and indicates the nonmarine Menefee Formation thins and may pinch out in the northern Monero field. Molenaar's (1983) projections of maximum extent of the shoreline of the Point Lookout Sandstone and Menefee Formation (Fig. 5) are supported by available point-source data; the Menefee probably was not deposited in the northernmost Monero field, and the Point Lookout Sandstone is directly overlain by the Cliff House Sandstone. Thinness of the Menefee Formation and the coals in the Monero field indicate these nonmarine sediments and the coals in particular were deposited in short-lived, unstable back-barrier-swamp to lower-coastal-plain environments behind the regressive and subsequent transgressive barrier-beach environments. High-sulfur content of these coals and thickness trends parallel to the shoreline support the hypothesis of deposition in a back-barrier-swamp environment subjected to occasional seawater flooding. Increased thickness of the Point Lookout Sandstone in the northernmost Monero field may be indicative of a minor stillstand in this section of the shoreline. This buildup of shore-margin sandstones may indicate the presence of a correspondingly thicker coal sequence in the back-barrier environment west of the Monero field.

The rank of Monero Menefee Formation coals is significantly higher than similar Menefee coals in the southern San Juan Basin. The moisture content and Btu values in particular indicate these coals have undergone a greater degree of coalification. Studies by Reiter and Clarkson (1983) show the northern San Juan Basin hydrocarbons have been influenced by depth of burial and heat from the San Juan volcanic complex. Clarkson and Reiter (1987) suggest heat advection by ground-water flow may have contributed significantly to maturation of the coals in the San Juan Basin.

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(References on p. 21)

square miles (75.8 square km) of the southern San Mateo Mountains in south-central Socorro County. Thick sequences of Tertiary lavas, ignimbrites, and associated volcaniclastic and sedimentary rock units are grouped from oldest to youngest as the Red Rock Ranch formation (up to 1200 m thick), Rock Spring formation (up to 1200 m thick), Nogal Canyon cauldron sequence (300–1600 m thick), and the Turkey Springs volcanic sequence (60–320 m thick). Several regional ash-flow tuff units of the Mogollon–Datil volcanic field are included in the stratigraphic section. Repeated volcanotectonic activity related to cauldron development has produced complex stratigraphic and structural relationships in the area. Gold and silver deposits of the San Jose and San Mateo Mountains mining districts occur along a broad northeast-trending fault system within cross-cutting fracture zones, breccia pipes, and veins. Mineralization is associated with late-phase intrusive rocks. Hydrothermal alteration that surrounds mineralized zones is discernible in enhanced satellite imagery. □

Upcoming geologic meetings

Conference title	Dates	Location	Contact for more information
22nd Annual Gem and Mineral Show	March 16-17	UNM Continuing Education Conference Center Albuquerque, NM	Albuquerque Gem and Mineral Club P.O. Box 13718 Albuquerque, NM 87192
New Mexico Geological Society annual spring meeting	April 5	Macey Center Socorro, NM	Richard M. Chamberlin NMBMMR Socorro, NM 87801 (505) 835–5310
AAPG annual meeting (with SEPM, EMD, and DPA)	April 7–10	Dallas, TX	Charles F. Dodge 607 Meadows Bldg. Dallas, TX 75106 (214) 363–2937
9th Annual Oil & Gas Conference for Industry & Government	May 7–8	Albuquerque, NM	Diana Escudero Public Affairs, BLM P.O. Box 1449 Santa Fe, NM 87504-1449 (505) 988–6316
Grand Junction Geological Society dinosaur quarries field trip	June 6–8	Colorado and Utah	Bill Chenoweth 707 Brassie Drive Grand Junction, CO 81506 (303) 242–9062

(*Continued from p. 8*)

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