



Geology of the Cerrillos coal field, Santa Fe County, New Mexico

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1979, pp. 269-274. <https://doi.org/10.56577/FFC-30.269>

in:

Santa Fe Country, Ingersoll, R. V. ; Woodward, L. A.; James, H. L.; [eds.], New Mexico Geological Society 30th Annual Fall Field Conference Guidebook, 310 p. <https://doi.org/10.56577/FFC-30>

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GEOLOGY OF THE CERRILLOS COAL FIELD, SANTA FE COUNTY, NEW MEXICO

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HISTORY

Still fresh in the minds of oldtimers in Albuquerque and Santa Fe are the spectacular pageants and elaborate displays at Christmas in the once-booming mining town of Madrid. Now occupied by an ever-increasing number of relatively young people who are seeking principally a quieter and simpler life than can be found in the city, Madrid in its heyday was a major center of coal-mining activity.

A part of the Cerrillos coal field, the major Madrid Gulch development came rather late in the history of the greater area. Records indicate (Huber, undated, p. 3) coal having been mined from the Madrid area to operate a gold mill at Dolores in 1835. There are also records (J. Huber, personal commun.) of coal having been mined from the "B" seam at the Government mine to supply military establishments at Santa Fe and Las Vegas during Civil War days.

It wasn't until what is now the Atchison, Topeka and Santa Fe Railway reached Cerrillos (3 mi (4.8 km) north of Madrid) in 1880 that the coal field began to produce on an ongoing commercial basis. The earliest development apart from those mentioned above were in Waldo and Miller gulches which approximately parallel the north-trending Madrid Gulch, and are located about 1.0 mi (1.6 km) and 1.5 mi (2.4 km) west of Madrid Gulch, respectively. These earlier mining localities were closer to the main line of the railroad, and the coal is less involved with igneous intrusions that complicate the geology and hence the mining at Madrid. Also, the dip of the beds is several degrees less than in Madrid Gulch. The coal seams mined at Miller Gulch are lower in the Mesaverde sequence than those in Waldo and Madrid gulches. The Miller Gulch seam is reported (Turnbull and others, 1951, p. 7, 10) to be about three ft (1 m) thick in an abandoned drift, and to thin to unminable thicknesses away from the Miller Gulch mine. The quality of the coal at Miller Gulch is such that it was in great demand for smelting and the manufacture of gas (Lee, 1913, p.311).

Initially, the Santa Fe spur was built from the Waldo switch across Galisteo Creek and up Waldo Gulch about 1.5 mi (2.4 km) to the old village of Waldo. The mines at Waldo operated by the railroad prospered for several years until the demand for anthracite became so great that the Santa Fe extended their spur up Madrid Gulch in 1889, and in 1893, they shifted their entire operation to Madrid (Huber, undated, p. 5). Generally, mining economics favored the Madrid anthracite operations, and the Miller and Waldo gulch operations were closed.

The Colorado Fuel and Iron Company of Pueblo, Colorado leased the Santa Fe's holdings in 1896, and produced bituminous and anthracite coal from Madrid and a superior blending coal that was mixed with their Colorado coking coals. After ten years of difficult mining conditions resulting from steep dips, faults and dikes, Colorado Fuel and Iron relinquished their leases and the properties were leased to Mr.

George Kaseman, a prominent Albuquerque businessman and banker. He operated the Albuquerque and Cerrillos Coal Co. until his tragic death in 1938.

It was during this period that the Huber family, present owners of the property, came on the scene. Mr. Oscar Huber, who had been superintendent of the A&C operations, continued to operate the mines and eventually purchased the property in 1947 (Huber, undated, p. 7). Economic events (e.g., conversion of the railroads to diesel power, and the advent of cheap natural gas and fuel oil) produced a gradual decline in Madrid production until the last mine closed in 1958.

Madrid developed into an archtypical "company town." It was self sufficient in many ways, with the company owning everything, including the company store from which items could be purchased with company scrip. There were many features of this domination of the company over the lives of the employees which were criticized then and would be met with even more vehement criticism in today's world. But there must have been a good side to the sovereignty of the company for Madrid produced an *esprit de corps* and civic pride that would be hard to match anywhere in this nation today. They had a baseball team that was the perennial champion in the Central New Mexico League which included Albuquerque, Santa Fe and Las Vegas. Through the auspices of the Employee's Club, the townspeople put on day-long Fourth of July celebrations, organized elaborate Easter festivities, and from the early '20's, put together a yearly Christmas spectacle which lasted until World War II. Massive Christmas scenes were placed atop the hills and lighted dramatically by power donated by the coal company (Huber, undated, p. 24).

GEOLOGIC SETTING

The Cerrillos coal field lies on the northwest flank of the Galisteo basin. The geology of the Madrid sector is shown on Figure 1. The north-south striking Cretaceous strata dip eastward at an average of about 10°. At Madrid, however, the dip is somewhat greater, and in the mine entries, the dip ranges from 14° to 170, decreasing basinward to less than 10° (fig. 2), as determined from elevations taken from mine maps.

Stratigraphy

The Cretaceous units present in the area are, in ascending order: Dakota Sandstone, Mancos Shale and Mesaverde Formation. The Dakota and the Mancos crop out west and east of the area of this investigation, and are of no particular consequence to the geology of the coal deposits. The reader is referred to Bachman (1975) for an overview of the distribution of all of the Cretaceous rocks in the Madrid 15-minute quadrangle, which includes all of the Cerrillos coal field.

The coal-bearing Mesaverde Formation comprises nearly 1,000 ft (305 m) of sandstones, mudstones, shales, siltstones

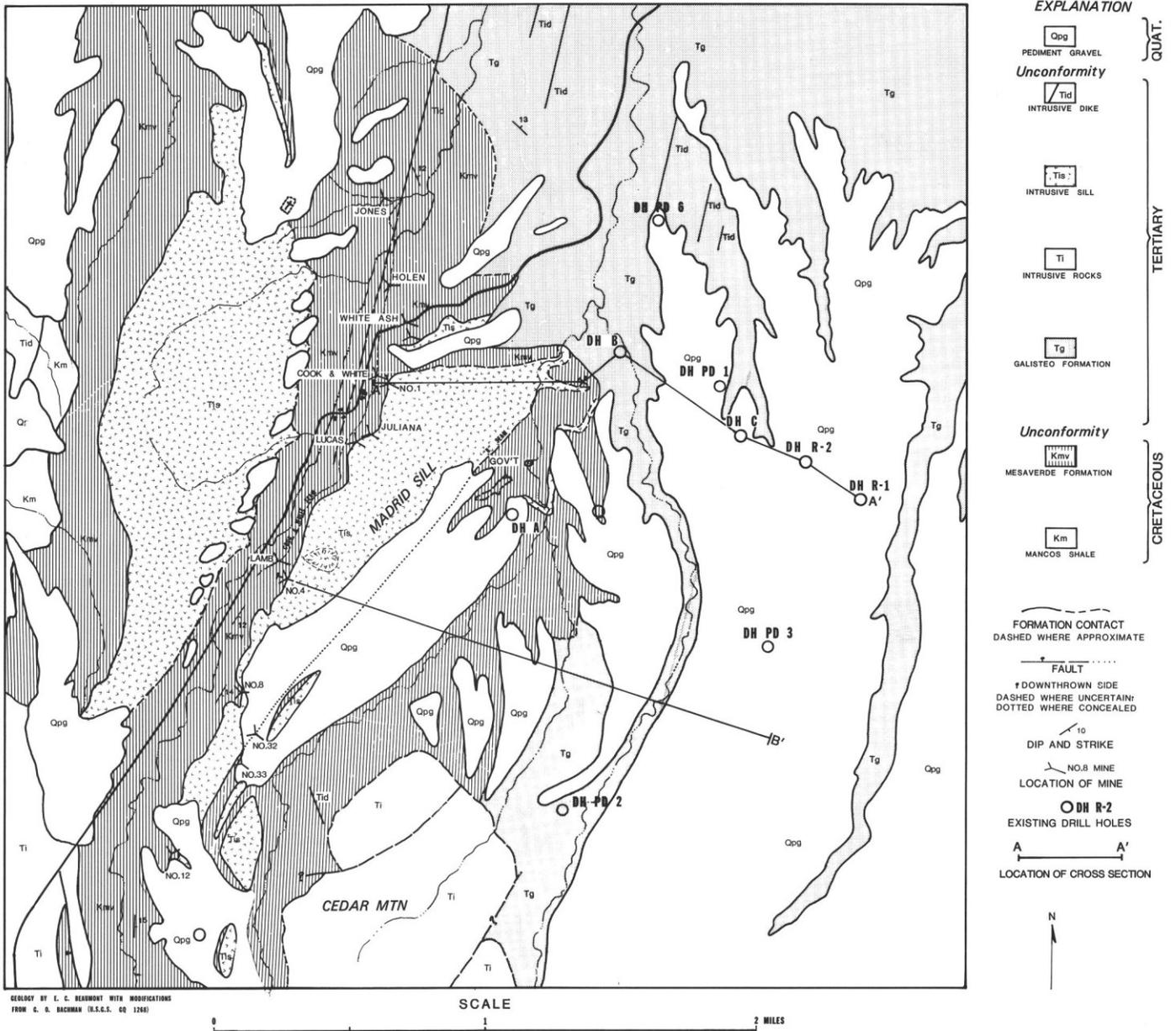


Figure 1. Geologic map of the Madrid area, Santa Fe County, New Mexico. Cross sections (A-A' and B-B') in Figure 2.

and coals, which presumably are of marginal marine origin in the lower predominantly sandstone portion, and of fluvial, paludal and lacustrine origin in the upper coal-bearing portion. Although the exact relationships cannot be established directly, it is likely that the basal sandstone unit corresponds to the Point Lookout Sandstone of the San Juan Basin, and that the coal-bearing sequence is equivalent to the Menefee Formation (see Black, this guidebook).

The Mesaverde Formation is overlain unconformably by the Galisteo Formation, which consists of a sequence of sandstones, claystones, mudstones and shales ranging from 900 to 4,500 ft (275-1,370 m) in thickness (Stearns, 1953, p. 467) (see Gorham and Ingersoll, this guidebook). The sandstone units within the Galisteo tend to be coarser-grained than those of the Mesaverde, and the Galisteo contains lenses and streaks of pebbles. Galisteo shale beds are reddish-gray or variegated as opposed to the grays and tans of the Mesaverde. Stearns (1953, p. 467) attributes the Galisteo to fluvial deposits flow-

ing "into and through a broad basin, which was deepened and enlarged by warping contemporary to deposition." Both Stearns (1953, p. 467) and Robinson (1957, p. 757) conclude that the Galisteo is mainly, if not entirely, of Eocene age (see Lucas and Kues, this guidebook).

The Galisteo Formation is overlain unconformably by coarse pediment gravels which form an apron around the Ortiz Mountains. These gravels were named the Tuerto Gravel by Stearns (1953), who considered the gravels to be Quaternary in age, but Bachman (1975) considers them to be possibly of late Tertiary age. On the accompanying geologic map (fig. 1), these deposits are shown simply as pediment gravels and are assigned a Quaternary age. The pediment gravels merge with small remnants of possible stream-terrace deposits along the west side of Madrid Gulch, but no distinction is made between these two types of deposits in this report. Small areas of allu-

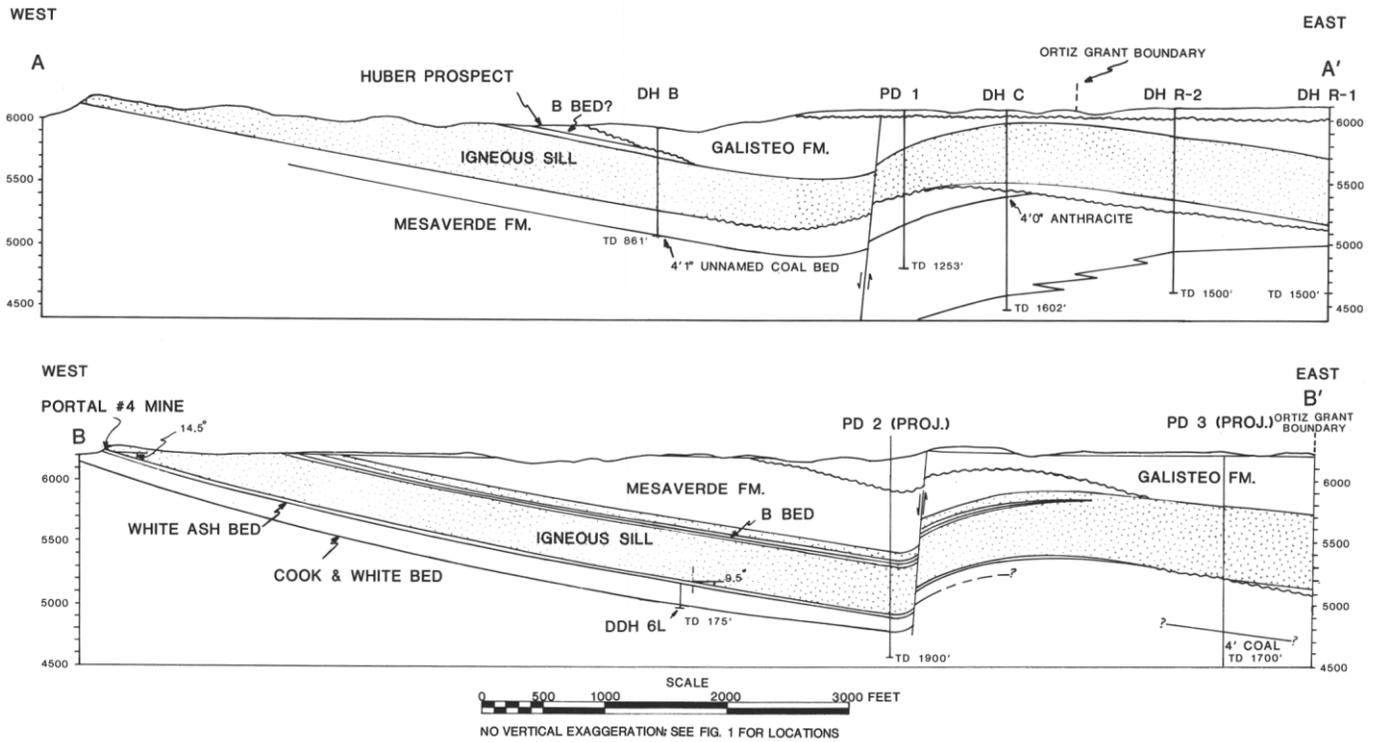


Figure 2. Geologic structure sections drawn along lines A-A' and B-B', as shown on Figure 1.

vium are present in the gulches and canyons, but no effort is made to portray them on the geologic map (fig. 1).

Unconformity

A significant geologic feature with respect to the coal in Madrid Gulch, and to a lesser extent, in Waldo Gulch is the unconformity between the Mesaverde and the Galisteo formations. Prior to deposition of the Galisteo, the slightly westward-dipping Cretaceous strata were leveled so that progressively older rocks are truncated beneath the pre-Galisteo unconformity in a northeasterly direction (fig. 3a). On the east and northeast sides of the Galisteo basin, the Mesaverde is removed entirely by pre-Galisteo erosion, and the Galisteo overlies the Mancos Shale (Stearns, 1953, Pl. 1). The area was tipped eastward into the Galisteo basin during the deposition of the Galisteo Formation (Stearns, 1953, p. 467), resulting in the configuration shown diagrammatically in Figure 3b.

The unconformable relationship between Cretaceous and Tertiary rocks was not recognized by early coal explorers in the area. They assumed that the coal at Madrid extended for many miles beneath the Galisteo basin. The presence of a bed of coal on the southeast side of the basin at the Omera mine lent credence to this view, and it was assumed that the Omera coal bed was equivalent to one of the mined beds at Madrid. In reality, this coal is probably at least as low in the stratigraphic sequence as coal in Miller Gulch, or possibly lower.

Besides truncating the coal beneath the Galisteo basin, the pre-Galisteo erosion surface had the effect of allowing weathering and partial oxidation of the coal for a short distance beneath the surface. This produced a Btu-deficient coal which locally was called "dead coal." In Waldo Gulch, Lee (1913, p. 295) describes a coal bed above the main Waldo seam that is reduced in thickness from three ft (1 m) to a few inches be-

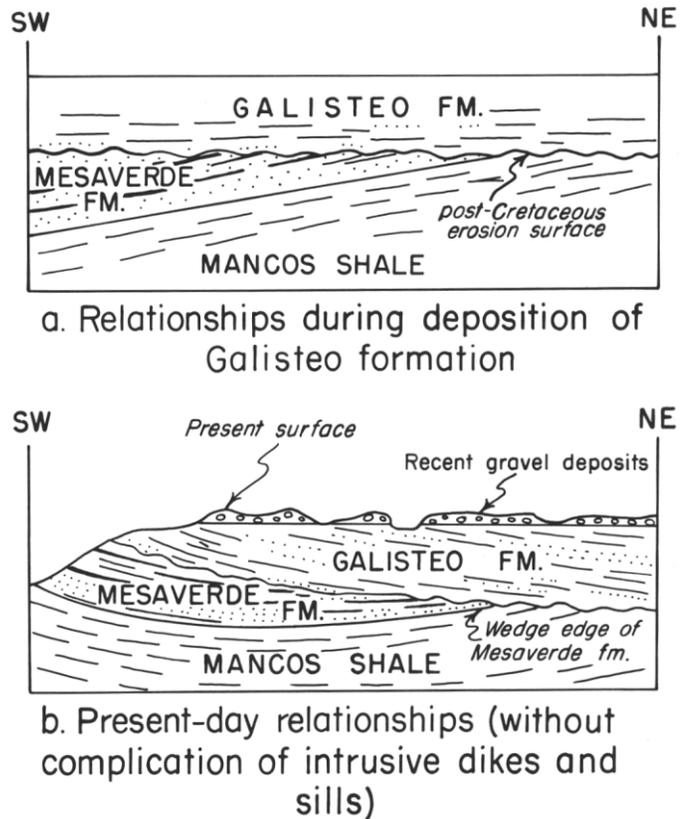


Figure 3. Diagrammatic representation of Mesaverde-Galisteo relationships.

neath the unconformity and is described as "dead." Somewhat further north, the main Waldo seam also was found to be "dead." At the Omera mine, the entry is very close to the Tertiary-Cretaceous unconformity, and similar conditions exist.

Igneous Rocks

Igneous activity associated with the Ortiz Mountains to the south and the Cerrillos Hills to the north has had a significant effect on the coal deposits of the Cerrillos coal field, particularly in the Madrid Gulch portion. Mining of the coal has been complicated by the presence of dikes ranging in thickness from a meter up to more than 24 m. In the northern part of the Madrid Gulch area (fig. 1), there are several parallel dikes that trend slightly east of north. The longest of these extends through the Jones mine workings into the middle of the town of Madrid. These dikes and others to the west and north that were mapped by Bachman (1975) appear to be associated with the Cerrillos Hills and probably are related to the limburgite dikes (Disbrow and Stoll, 1957, Pl. 1). Other dikes encountered in the mine workings farther south have a more random orientation and appear more closely related to the Ortiz Mountain intrusives. At least one of these southern dikes is clearly of post-sill age, as it was mapped in the mines both below and above the 500-ft-thick (150-m-thick) sill.

The coal is relatively unaffected at most places where dikes breach the beds, but at one place, the coal was coked for a distance of about 20 ft (6 m) away from the dike (Turnbull and others, 1951, p. 5).

The major igneous features affecting the coal are the two thick sills that appear to emanate from the Ortiz Mountains area. Each has a maximum thickness of about 500 ft (150 m), and they are separated by about 350 ft (107 m) of Mesaverde strata which include the principal beds that were mined in Waldo Gulch and at Madrid. The Miller Gulch coal lies beneath the lower sill, and the "B" seam which was mined in Ortiz Arroyo lies above the upper sill (Madrid sill), as shown on the geologic map (fig. 1). There is another thinner sill above the Madrid sill and the "B" seam. This intrusive body crops out in the vicinity of No. 32 mine. It may be the same as the sill that crops out in the vicinity of the "B" mine about a mile (1.6 km) to the north, but the presence of thick pediment gravels in the intervening area makes it impossible to prove this relationship. A second sill above the Madrid sill is present west of Cedar Mountain near the southern limit of the Madrid area (fig. 1). Both the Madrid sill and the sill beneath the town terminate rather abruptly northward. Widdecombe (1976) describes these sills as being hornblende monzonite porphyry.

Faulting

Faults having displacements of from 1 to 15 ft (0.3 to 4.5 m) were encountered during mining in the Madrid area, according to mine maps. In some instances, the faults controlled the mining and acted as barriers between operations. Such is the case between the Anthracite No. 4 and No. 8 mines where the records indicate that a shaft was sunk 12 ft (3.7 m) from the No. 8 to the No. 4. This particular fault trends northwest, and was mapped in the mines from near the outcrop to the maximum extent of the mine workings. Surveyed elevation within the adjacent mines indicates a displacement greater than 12 ft (3.7 m) (more nearly 50 ft (15 m)). The discrepancy, however, may lie in the accuracy of the adjacent mine surveys. This same fault appears to have been encountered in

the underlying Cook and White seam in the Lamb mine and to have limited mining to the south.

The drill holes beyond the limits of the mines (fig. 1) suggest that a major fault is present east of the mine workings, and that the coal-bearing sequence is upthrown to the east. The writer's initial interpretation (Beaumont and others, 1976, fig. 11) suggested a pre-Madrid-sill age for the fault, and indicated a throw of more than 450 ft (137 m). This was based on the interpretation of data shown in cross section A-A' with the exception of DH PD 1. The addition of DH PD 2 (Phelps Dodge) has resulted in a modification that combines faulting with folding to achieve the displacement. In this earlier interpretation, the fault was suggested as the conduit whereby the sill shifted to a higher stratigraphic horizon. The present interpretation (fig. 2) does not indicate a pre-sill age for the fault, but this remains a reasonable alternative.

Prior to the Phelps Dodge drilling, there were no data south of cross section A-A' (fig. 2) and east of the mine workings. The writer came upon the remnants of an early drill hole east of the "B" mine (DH A), but no records have been located yet. In 1977, Phelps Dodge drilled a test (PD 3) near the east edge of the Madrid property that allowed, with a certain amount of projection, for the construction of B-B' (fig. 2). The data from DH PD 3 tend to confirm the existence of a fault and folding between this drill hole and the down-dip limit of the No. 4 mine.

The writer has drawn the trace of this implied fault in a south-southwest direction parallel to the dikes in the north part of Madrid Gulch, although this orientation is highly speculative. If such a fault exists, its trend is critical with respect to potential coal development eastward, beyond the limits of the present mine.

COAL BEDS

Miller Gulch

The lowest coal beds in the Mesaverde Formation on the west side of the Galisteo basin are those that occur in Miller Gulch. According to Lee (1913, p. 295), the seam mined at this locality was the "thickest bed of the Miller Gulch group." Lee found the bed to be about three ft (1 m) thick, and was able to follow this coal southward for about three mi (4.8 km) along the outcrop. Turnbull and others (1951, p. 10) concluded on the basis of several drill holes that the Miller Gulch coal is not minable to the south or east of the old Miller Gulch mine. The Miller Gulch coal is of coking quality and has a rank classification of high-volatile B bituminous. The Miller Gulch area had a small resurgence of activity in 1896 when the Colorado Fuel and Iron Co. discovered that the coal from that area was particularly good for blending with their Trinidad, Colorado coal (Huber, undated, p. 5).

Waldo Gulch

The Waldo Gulch area was mined first at the old Waldo mine at the old townsite of Rogers. The Waldo seam, as it was termed in Waldo Gulch, is described by Turnbull and others (1951, p. 6) as averaging three ft (1 m) in thickness and as changing in character in short distances. A second bed occurs in Waldo Gulch 35 ft (11 m) above the Waldo bed, but to the writer's knowledge, was never mined because of its proximity to the Cretaceous-Tertiary unconformity (Lee, 1913, p. 295).

Lee (1913) indicates a possible correlation between the Waldo seam and the Peacock seam of Madrid Gulch. This later proved to be in error, and the Waldo seam was demonstrated through the extensive workings of the Jones mine to be the same as the Cook and White seam, the lowest minable seam in Madrid Gulch. The rather abrupt reduction in the thickness of the coal-bearing sequence by about 500 ft (150 m), brought about by the northward termination of the lower sill, introduces a structural complication that makes the correlation of coal beds difficult in this area.

Madrid Gulch

Cook and White bed

The Cook and White bed is the lowest minable coal in Madrid Gulch. The seam lies about midway between the two major sills and does appear to have been altered by these nearby heat sources. A sample collected by Lee (1913, p. 298) from the Holen mine contained 12,350 Btu's/lb. Lee (1913, p. 307) reported that the Cook and White coal did not coke near the surface, but possessed coking qualities about a half mile (0.8 km) down slope in the Cook and White mine. The thickness of the coal in this seam ranges from about 2.5 ft to 4.5 ft (0.8 to 1.4 m) in the northern part of the Madrid Gulch development. Southward, a thickness of about three ft (1 m) is maintained until the seam splits into two units, each of which is less than two ft (0.6 m) thick.

In the Cook and White mine, the Cook and White bed yielded considerable quantities of methane and was closed several times by fire. Following a particularly disastrous fire in 1905, the mine was closed and allowed to fill with water from natural seepage (Lee, 1913, p. 308). It was this major setback that finally caused the CF and I Co. to close their operations and relinquish their leases in 1906 (Huber, undated, p. 5).

Peacock bed

The Peacock bed lies about 80 to 100 ft (24 to 31 m) above the Cook and White bed and about 20 ft (6 m) below the White Ash bed. It is thinner than either of the other two seams in the gulch, the maximum thickness observed by Lee (1913, p. 309) being 2.3 ft (0.7 m) near the Peacock mine. Southward, the Peacock is not observable at the surface through the central part of the Madrid workings, but a thin seam in about the same position was worked on a small scale in the southern part of the gulch. It is presumed to be the Peacock, although it is closer to the Cook and White bed (20 ft (6 m)) than it is farther north. In the southern area, the Peacock is closely cleated and fragile, and despite its thinness, it was in demand as a blacksmith coal. The name is derived from an iridescence that is commonly present in broken fragments.

White Ash bed

By far the most valuable coal in the district, the White Ash bed is the uppermost coal in the Madrid Gulch sequence. The White Ash is a compound unit consisting of two or three individual beds, the two principal ones being separated by a shale unit known as the "middle band." In the northern part of Madrid Gulch, the lower coal is designated the "White Ash" and is the minable portion. Farther south, in the anthracite area, the upper split is the thicker, mined portion. The upper split maintains thicknesses of 4.5 to 5.5 ft (1.4 to 1.7 m) over a considerable area, but to the south, the anthracite is less than 4 ft (1.2 m) thick; Lee (1913, Pl. XXII) reported one measurement of the Anthracite No. 4 mine of 6.6 ft (2 m) of nearly

continuous coal. This seam is reported (Lee, 1913, p. 305) to have averaged three ft (1 m) in thickness in the mines.

The upper White Ash split is close to the underside of the Madrid sill for about two mi (3.2 km) along Madrid Gulch. Where this phenomenon occurs, the coal has been anthracitized. Where it would otherwise be a high-volatile bituminous coal with 55 to 65 percent fixed carbon, the coal is elevated several categories in the rank scale to a fixed carbon content ranging from 91 to nearly 98 percent (dry, mineral-matter-free basis). The anthracite possesses a conchoidal fracture, as opposed to the cubic cleat of its bituminous counterpart, has a submetallic luster, and is practically nonweathering.

From the heart of the anthracite production in Madrid Gulch northward, the Madrid sill and the White Ash seam probably diverge (Lee, 1913, Pl. XXII). Here, the thermal effect of the sill appears to have decreased below the critical level needed for anthracitization. The northward limit of anthracite occurrence at Madrid is approximately the main entry of the Anthracite No. 1 mine in which coal of anthracite rank was encountered to the south, and coal of bituminous rank was found north of the main entry (Huber, undated, p. 3).

Ortiz Arroyo

"B" or Ortiz Arroyo bed

Lying above but close to the Madrid sill, the "B" coal seam was mined at several localities over a long period. Even though the coal is of anthracite rank, the mining was never on a scale with Madrid Gulch owing to its irregular and unpredictable distribution. It is assumed that the injection of the molten sill did little to depress the compacted sediments below it, but rather it acted to lift the overlying strata. If this is true, it is probable that the rocks above the sill are more disturbed than those below it, and irregularities in the top surface of the Madrid sill such as those that can be observed in the bottom of Ortiz Arroyo near the "B" and Government mines are to be anticipated. The delicate relationship between coal and sill that produced anthracite is more tenuous above the sill, and mining in the "B" bed proved to be somewhat unpredictable. Where the coal lies within about 30 ft (9 m) of the sill but is not in direct contact with it, it is anthracitized; where it is either in contact with it or very close to being so, it is likely to be converted to natural coke or consumed; and where the coal is more than about 30 ft (9 m) from the sill it is unlikely to exhibit significant alteration.

The "B" bed is overlain by a higher but much thinner sill which crops out near the Nos. 32 and 33 mines (fig. 1). Because the upper igneous unit is present in DH PD 2 but absent in PD 3, and also because the Madrid sill is thicker in PD 3, the writer has chosen to illustrate the upper sill as merging eastward with the main Madrid sill. In the Nos. 32 and 33 mines, the "B" seam is variable in thickness but generally maintains a thickness in excess of three ft (1 m) (Beaumont, 1964, p. 8).

The "B" bed is concealed northward from the Nos. 32 and 33 mines beneath pediment gravels, but recent drilling has indicated the bed to be present. In the interval between the Nos. 32 and 33 mines on the south and the "B" and Government mines on the north, small tonnages of anthracite might be won by surface-mining methods. The distance in which this might occur is about 1.5 mi (2.4 km), but the steep dip should put the coal out of range of any surface-mining method a short distance to the east. Also, irregularities in the "B" seam similar

to those that were encountered in the mines should be expected in this area.

The thickness of the coal in the Government mine was reported by a single notation on an ancient map to be 2.57 ft (0.8 m), and I measured 3.5 ft (1.1 m) of coal in an opening associated with this operation. The thickness observed in the "B" mine ranged from 2.1 to 4.0 ft (0.6 to 1.2 m).

PRODUCTION AND RESERVES

It is difficult to pin down coal production from the Cerrillos coal field either by year, by mine or by type of coal. There is a scattering of information in each category, but not enough to put together a complete record.

Read and others (1950, Table 15) reported the following production for Santa Fe County (Cerrillos field):

| Years | Short Tons |
|-----------|------------|
| 1882-1890 | 408,568 |
| 1931-1940 | 1,325,315 |
| 1940-1948 | 577,700 |

The intervening years were not reported by county, and thus, some extrapolation and generalizations are necessary in order to arrive at an approximate production figure. Huber (undated, p. 27) reports that production at Madrid reached its peak in 1928 when nearly 185,000 tons of both bituminous and anthracite were produced. Lee (1913, p. 286) states that anthracite production from 1888 to the time of writing (c. 1910?) ranged from 10,000 to 45,000 tons per year, but that bituminous production was more erratic. It would seem reasonable to assume that production for the unreported decades averaged something in excess of a million tons/decade and that production from 1948 until the closing of the mine in 1953 probably added another 150,000 tons. Thus, the estimated total production for Madrid in 1882 to 1954 is about 6 million tons of both anthracite and bituminous coals.

Original reserves in the ground have been estimated to a depth of 3,000 ft (915 m) by Read and others (1950) as follows:

| | |
|--------------------------|-------------------|
| Bituminous | |
| Measured | 5.6 million tons |
| Indicated | 14.6 million tons |
| Inferred | 26.3 million tons |
| Sub-total | 46.5 million tons |
| Anthracite | |
| Measured | 2.8 million tons |
| Indicated | 2.9 million tons |
| Inferred | 5.7 million tons |
| Sub-total | 11.4 million tons |
| TOTAL | 57.9 million tons |
| Less amount mined | 6.0 million tons |
| Total remaining reserves | 51.9 million tons |

The above figures are, in the opinion of the writer, excessive. It should be pointed out that they are based on minimum bed thicknesses of 14 in (36 cm), thinner than it is possible to mine profitably under present economic conditions. Also, mining below a depth of 2,000 ft (610 m) probably would be impractical because of unstable rock conditions. The 51.9 million-ton figure should be viewed in the sense of a resource base figure with the actual recoverable reserve figure being only a fraction thereof, perhaps on the order of a tenth.

A much better estimate of the bituminous and anthracite reserves could be obtained through drilling of a few thoughtfully placed exploration core-holes. The difficulty of drilling the Madrid sill so far has discouraged the drilling of more than the handful of holes shown on Figure 1.

CONCLUSIONS

Madrid, the heart of the Cerrillos field, was, in its day, a purely "company" town. If you lived in Madrid in those days, you worked for the company. By virtue of this unanimity of experience and employment, the town possessed a corporate soul. There was a community sharing of the sorrows of mine disasters and a corresponding sharing in the celebration of holidays. The town survives, in fact it is in a sense reborn, but not as a mining town. The mines may reopen at Madrid, but the technology of coal mining assures that it will never be the labor-intensive operation it was at its zenith when the mines employed over 700 miners and the average productive capacity was around 4.5-5.0 tons per man-day as compared with more than 15 tons per man-day in 1970. It is also improbable that those few who might be employed in the mines would choose to live in Madrid. Modern transportation and good highways bring Madrid within easy commuting range of either Santa Fe or Albuquerque. This mobility which brings discount shopping within everyone's range and which destroyed the singular position of the Indian trading post, also assures that there never will be another "company store."

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