THE CERRILLOS COAL FIELD, SANTA FE COUNTY, NEW MEXICO.

By WILLIS T. LEE.

INTRODUCTION.

Special interest attaches to the Cerrillos coal field, not so much because of its present productiveness as because it is one of the oldest producers of coal in western America. The mines that were worked most extensively have been abandoned, hence a large part of the information desired for an economic report on the field can not now be obtained except as it is gathered from old mine maps, mine inspectors' reports, and the like. This paper is an attempt to bring together data regarding this field gleaned from many different sources. The writer has a general knowledge of the region gained principally from a study of the stratigraphic relations of the coal-bearing rocks. In the course of this study he obtained mine maps and information of a technical nature appropriate only for an economic paper and hence not contained in his paper on the general stratigraphy of the coal fields.[1] J. H. Gardner had previously made a somewhat hasty examination of the coal beds for the purposes of land classification, and his notes have been used by the writer in preparing this paper. Also, at the writer's suggestion, Mr. G. A. Kaseman, a member of the company operating the mining property at the present time, employed Mr. Kirk Bryan to make measurements of the coal beds and obtain various other data in the several mines and prospect entries. Mr. Kaseman has also furnished many details from his records, and both Mr. Gardner and the writer have collected samples of the coal for analysis.

In addition to this first-hand information, there are numerous references in geologic literature to the coals of the Cerrillos field. According to Loew,[2] anthracite coal was mined here as early as 1835, but little was really known of the field until the railroad, which now constitutes a part of the Atchison, Topeka & Santa Fe Railway system, was constructed through Cerrillos and mines were opened to supply coal for the use of the road. The Waldo Gulch and Miller

[1] Lee, W. T., Stratigraphy of the coal fields of northern central New Mexico: Bull. Geol. Soc. America, vol. 23, 1912, pp. 571–686.

[2] Loew, Oscar, Report upon mineralogical, agricultural, and chemical conditions observed in portions of Colorado, New Mexico, and Arizona in 1873: U. S. Geog. Surveys W. 100th Mer., vol. 3, Geology, 1875, p. 635.

Gulch mines northwest of Madrid seem to have been the first ones developed on a commercial scale, but the principal producers of the field were located at Madrid. These are the Lucas or anthracite coal mine, and the White Ash or bituminous coal mine on the upper or White Ash bed, and the Cook & White mine on a lower bed. According to Sheridan,[1] active mining operations on a commercial scale date back to about the year 1888. From that time to the present the production of anthracite has varied from 10,000 to 45,000 tons a year. The production of bituminous coal has been much more irregular. The Waldo Gulch and Miller Gulch coals are of coking quality, and ovens were built at Waldo for the purpose of coking them, but for reasons unknown to the writer very little coke was manufactured. It was soon found that the mines at Madrid were more profitable than those in Waldo and Miller Gulches, and the latter were abandoned. The mines at Madrid were operated under the management of the Atchison, Topeka & Santa Fe Railway Co. and the Colorado Fuel & Iron Co. until 1906, when the Albuquerque & Cerrillos Coal Co. leased the property and began operating in the anthracite coal, gradually extending operations to include the bituminous coals.

LOCATION OF FIELD.

The Cerrillos coal field is located on Galisteo Creek in central New Mexico west of the Rocky Mountain axis. (See index map on Pl. XX.) It derives its name from Cerrillos, a town on the Atchison, Topeka & Santa Fe Railway, situated at the northern extremity of the field. The field is irregular in outline and extends from the town of Galisteo westward about 12 miles to a point about a mile west of Madrid. In a north and south direction its width varies from about 3 miles near Cerrillos to about 8 miles at the eastern end.

GENERAL GEOLOGY.

The coal-bearing rocks occupy the center of a basin, in the eastern part of which they dip toward the west, away from the axis of the Rocky Mountains, and at the western end they dip toward the east, away from the axis of the Sandia Mountains. On the north the rocks were steeply upturned by the intrusion of the igneous rocks of the Cerrillos Mountains and on the south by the Ortiz laccolith.

For a description of the general geology of the Cerrillos region the reader is referred to a work by D. W. Johnson,[2] and for a description of the stratigraphic and age relations of the coal-bearing rocks to a

[1] Sheridan, J. E., Report of the mine inspector for the Territory of New Mexico to the Secretary of the Interior for the fiscal year ended June 30, 1907, p. 34.

[2] Johnson, D. W., Geology of the Cerrillos Hills, N. Mex.: School of Mines Quart., vol. 24, 1903, pp. 173–246, 303–350, 456–500; vol. 25, 1903, pp. 69–98.

recent paper by the present writer.[1] A brief summary of the results presented in the latter paper, in so far as they apply to the Cerrillos field, may be given in tabular form as follows:

Geologic formations outcropping in the Cerrillos coal field.

System.	Series.	Group.	Formation.	Approximate thickness (feet).	Description.
Tertiary (?).			Galisteo sandstone.	(?)	Sandstone, conglomerate, and sandy shale. The conglomerates consist of well-rounded pebbles, mainly of siliceous rocks in the lower part, but are coarser toward the top, where they consist of unsorted material, angular pebbles, and large, slightly worn bowlders of many kinds of rock.
.....			Unconformity.		
Cretaceous.	Upper Cretaceous.	Montana.	Mesaverde formation.	900±	Sandstone and shale, coal-bearing.
		Colorado.	Mancos shale.	2,200	Shale with a prominent sandstone (Tres Hermanos sandstone member) near the base.
			Dakota sandstone.	50	Sandstone, quartzose, locally conglomeratic.

The sandstone at the base of the Cretaceous near Cerrillos is similar lithologically to the Dakota of neighboring localities, but no fossils were found in it. Its reference to the Dakota rests entirely on lithologic character and stratigraphic position. Conformably upon the Dakota lies the Mancos shale. It has yielded a large number of fossils which prove that the lower part of it belongs to the Colorado group and the upper part to the Montana group.

The Mesaverde formation overlies the Mancos and consists of a massive basal sandstone overlain by coal-bearing sandstone and shale. There are three groups of coal beds, the upper two of which are known to contain coal of commercial importance. The highest group is locally known as the Madrid coals in Coal Gulch and as the Waldo Gulch group farther west. The lower group of developed coals is known as the Miller Gulch group because the beds outcrop in that gulch. The coal-bearing rocks of this field have usually been called Laramie. Johnson regarded them as Fox Hills in age, but in the paper just cited the present writer has shown by fossil evidence that they are referable to the Mesaverde.

The Mesaverde is overlain unconformably by rocks consisting of sandstone and shale, more or less highly colored and conglomeratic

[1] Lee, W. T., Stratigraphy of the coal fields of northern central New Mexico: Bull. Geol. Soc. America, vol. 23, 1912, pp. 571–686.

at many horizons. The lowest sandstone is locally conglomeratic and rests with uneven base in some places on coal and in others on shale or sandstone. The lower 300 or 400 feet of rocks consists mainly of shale with a subordinate amount of conglomeratic sandstone, the pebbles of which are relatively small, few having a diameter of more than 1 inch, and are composed mainly of quartz, chert, and other hard siliceous rocks. The upper portions are much coarser, the conglomerates containing a large variety of rocks, some of which are relatively soft and slightly waterworn.

No conclusive evidence of the age of these beds has been obtained farther than that they lie unconformably on Mesaverde. They contain petrified wood, and a few fossil leaves have been found in them, which seem to indicate Tertiary age. This evidence, together with their resemblance both lithologically and stratigraphically to the Tertiary formations farther to the northwest, has induced the writer to believe that they probably belong in that system. It is not certain that all belong to one formation; indeed, it seems probable that they will be subdivided into two or more formations when they are studied in detail. For the purposes of this paper they are grouped together under the name Galisteo sandstone. The stratigraphic limits of the Galisteo have never been clearly defined. Johnson associated the lower part with the underlying coal-bearing rocks in his Madrid group, but the present writer has drawn the line of separation between the Mesaverde and the Galisteo at the unconformity, thus placing all of the coal-bearing rocks in the Mesaverde and all of the conglomeratic rocks in the Galisteo.

THE COAL-BEARING ROCKS.

The principal coals of the Cerrillos field have been developed in the mines at Madrid, where four beds have been opened. The lowest is known as the Cook & White bed, the second as the Peacock, and the third as the White Ash coal bed. The highest, the Ortiz Arroyo bed, is known at only one locality and is of doubtful economic importance. From data obtained in mining and furnished to the writer by Mr. G. A. Kaseman the following section near Madrid has been constructed:

Section of rocks measured near Madrid, N. Mex.

[For graphic section, see fig. 9, p. 302.]

	Ft.	in.
Intrusive igneous rock.		
Shale containing fossil plants	5±	
Coal (White Ash bed)	5	6
Shale and sandstone	22	
Coal (Peacock bed)	1	8
Shale and sandstone	8	
Sandstone	20	

	Ft.	in.
Shale	20	
Sandstone	20	
Shale with thin seams of coal	2	
Shale	6	
Sandstone	20	
Shale	3	
Coal (Cook & White bed)	3	
Sandstone and shale	5	
Sandstone	16	
Shale	8	
Coal		11
Shale	9	
Coal		8
Shale	16	
	191	9

The igneous rock, the base of which is included at the top of the section, was intruded into the coal-bearing rocks just above the White Ash coal and the whole tilted so that the strata now incline about 15° E. Two coal beds, one of them possibly of some commercial importance, lie above the igneous rock and outcrop in Ortiz Arroyo, half a mile east of Madrid. The coal-bearing rocks are overlain unconformably by the Galisteo sandstone. Their relation to other rocks is best shown by the records of two drill holes. The first hole was put down at the point marked B on the accompanying map (Pl. XX), about 4,500 feet east of the outcrop of the White Ash coal bed. The drill was started in the bottom of a gulch and penetrated about 75 feet of rocks that seem to belong to the Galisteo sandstone. It then entered coal-bearing rocks that appear to be the same as those exposed in Ortiz Arroyo east of Madrid. After passing through the igneous rock a group of coal beds was encountered that doubtless are the same as those opened at Madrid. The record of this hole is as follows:

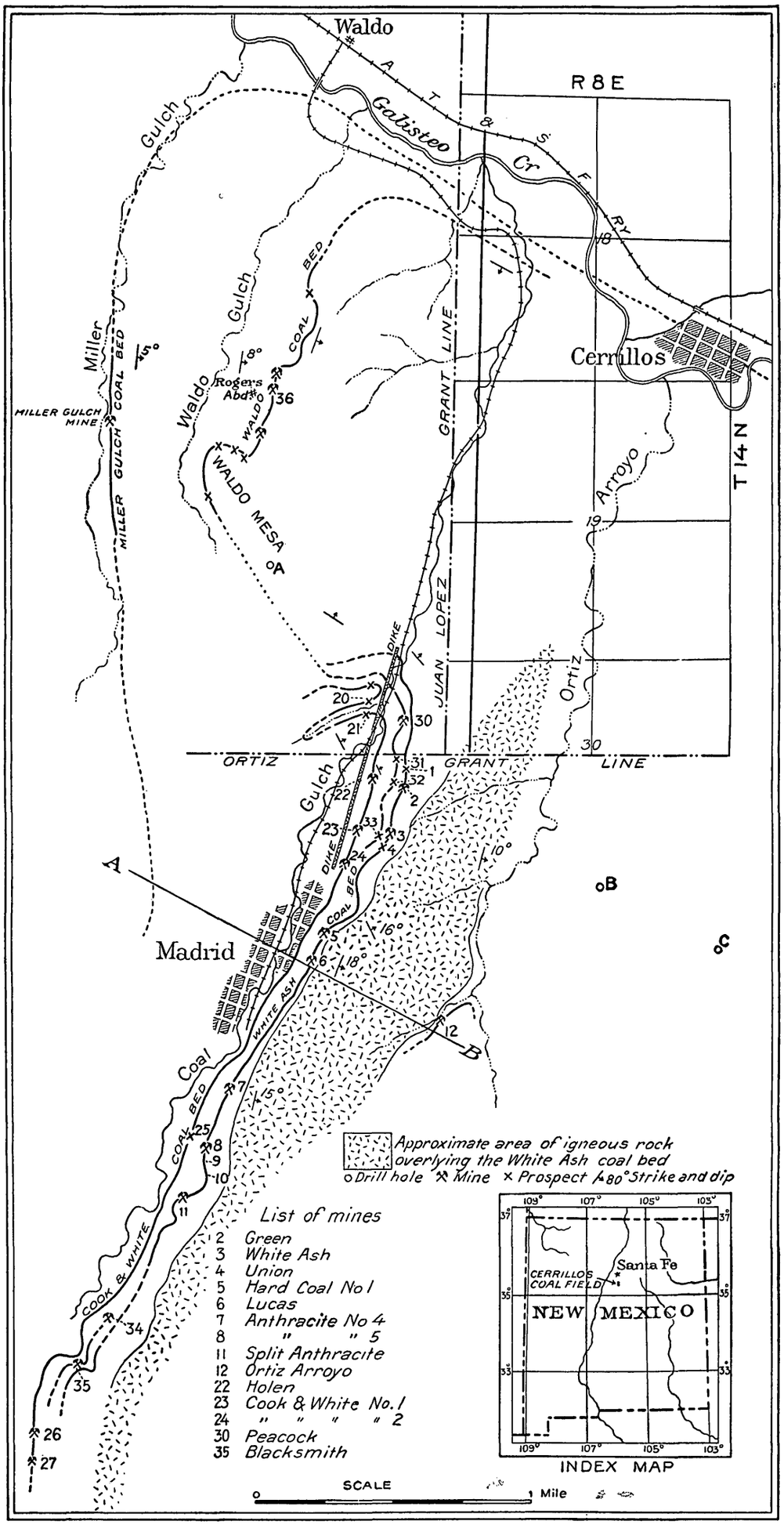
Section of rocks penetrated by diamond drill 4,500 feet east of the line of outcrop of the White Ash coal bed, at Madrid, N. Mex.[1]

[For graphic section, see drill record B, Pl. XXI.]

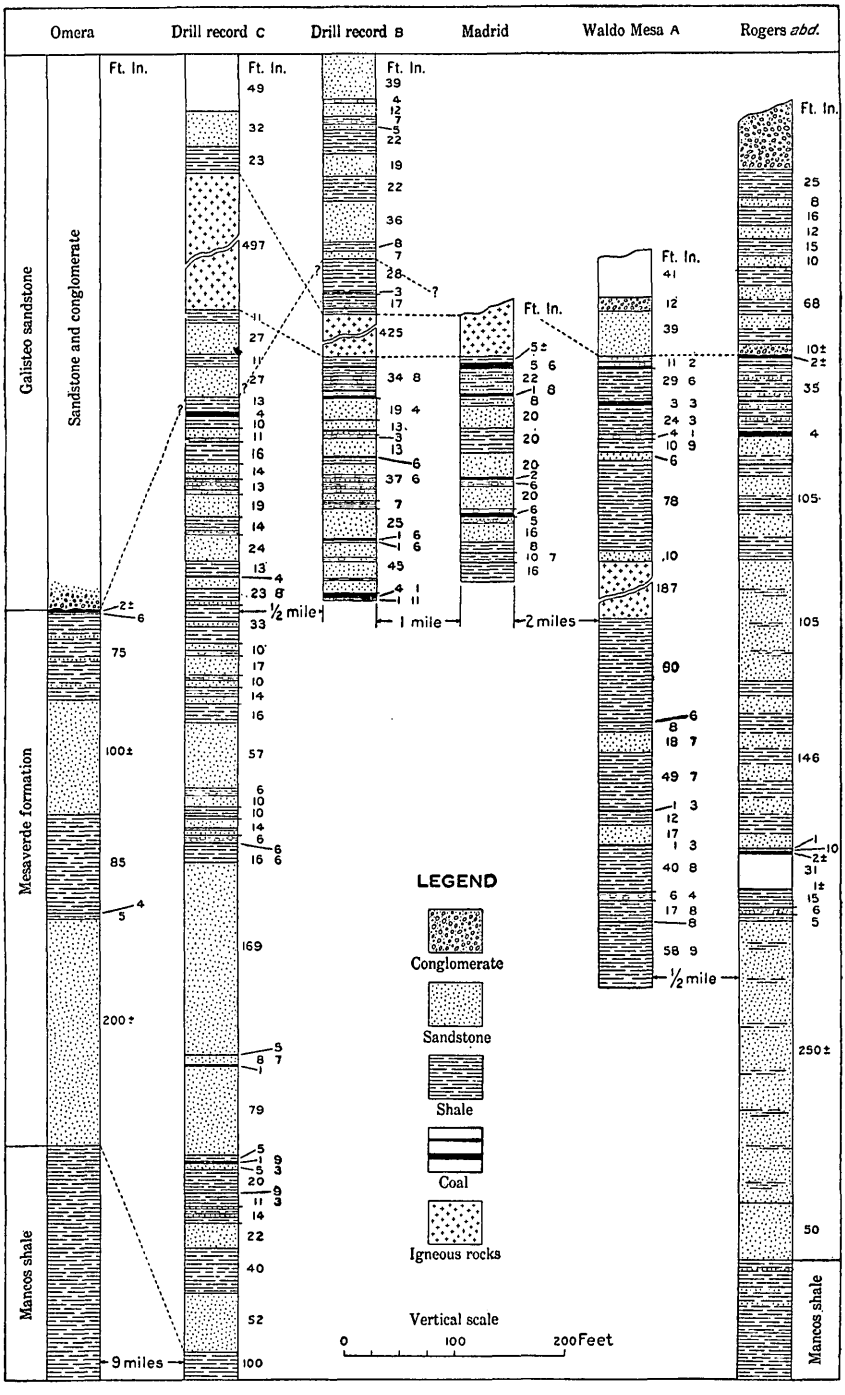
	Ft.	in.
Sandstone, gray to brown	39	
Shale, brown	4	
Sandstone, gray	12	
Shale	7	
Sanstone, gray	5	
Shale, gray to red	22	
Sandstone, gray to red	19	
Shale, gray to red	22	

[1] As the rocks at the outcrop dip 15° E., the measurements of the core taken from the vertical hole are slightly in excess of the true thicknesses of the rocks.

	Ft.	in.
Sandstone, gray	36	
Shale, gray to red	8	
Sandstone	7	
Shale, gray to red	28	
Shale, carbonaceous, with thin seams of coal	3	
Shale, dark	12	
Coal		6
Shale, carbonaceous	4	6
Igneous rock	425	
Shale, dark	8	
Coal	1	2
Shale, dark	6	10
Coal	1	2
Shale, dark	2	
Coal	1	
Shale, dark	2	9
Coal	1	1
Shale, dark	4	
Coal, shaly	1	
Shale, dark	4	
Coal	1	8
Sandstone, shaly	19	4
Sandstone	9	
Coal	1	
Sandstone	3	
Shale, dark	3	
Sandstone	13	
Coal		6
Shale, dark	4	6
Sandstone	9	
Shale, dark	3	
Sandstone	4	
Shale, dark	4	
Sandstone	2	
Shale, dark	4	
Sandstone, brown	7	
Shale, dark	1	
Coal		6
Sandstone	1	6
Shale, dark	4	
Sandstone	25	
Coal	1	6
Shale	1	6
Sandstone	14	
Shale	4	
Sandstone	14	
Shale	2	
Sandstone	11	
Coal	4	1
Shale	1	11
	861	



MAP OF THE DEVELOPED PART OF THE CERRILLOS COAL FIELD, N. MEX.



GEOLOGIC SECTIONS AND DRILL RECORDS IN THE CERRILLOS COAL FIELD, N. MEX.

Showing the correlations of the several beds.

The second hole was drilled at locality C (Pl. XX), about half a mile southeast of locality B or 6,800 feet east of the outcrop of the White Ash coal bed. The thick sheet of intrusive igneous rock encountered by the drill at B was penetrated, but no coal was found above it, and the rocks for a distance of 75 feet below it are of a character that suggests the Galisteo sandstone rather than the Mesaverde formation. Three groups of coal beds were encountered and the drill finally entered a shale that is believed to be the Mancos. The record of this drill hole is as follows:

Section of rocks penetrated by diamond drill 6,800 feet east of the line of outcrop of the White Ash coal bed, near Madrid, N. Mex.[1]

[For graphic section, see drill record C, Pl. XXI.]

	Ft.	in.
Gravel and bowlders	49	
Sandstone	32	
Shale	23	
Igneous rock	497	
Shale, red to gray	11	
Sandstone, variegated in color	27	
Shale, dark-colored	11	
Sandstone, gray	27	
Shale	13	
Coal, anthracite	4	
Shale	10	
Sandstone, dark colored	8	
Shale	2	
Coal	1	
Shale	16	
Sandstone	9	
Sandstone, light colored	5	
Coal		8
Shale	1	4
Sandstone	4	
Shale	3	
Coal		6
Shale	3	6
Sandstone	19	
Shale	11	
Sandstone	2	
Shale	1	
Sandstone, shaly	24	
Shale, sandy	13	
Coal		4
Sandstone	9	8
Shale	10	
Sandstone	4	
Shale	14	
Sandstone	5	

[1] As the rocks at the outcrop dip 15° E., measurements of the core taken from the vertical hole are slightly in excess of the true thicknesses of the rocks.

	Ft.	in.
Shale	14	
Sandstone	6	
Shale	4	
Sandstone	17	
Shale	4	
Sandstone	6	
Shale	8	
Sandstone	6	
Shale	16	
Sandstone	57	
Shale	6	
Sandstone	10	
Shale	8	
Coal		8
Shale	1	4
Sandstone	8	
Coal	1	
Shale	1	
Sandstone	4	
Shale	6	
Coal		6
Shale	16	6
Sandstone, dark	169	
Coal		5
Sandstone, dark	8	7
Coal, shaly	1	
Sandstone, dark	79	
Shale	5	
Coal, shaly	1	9
Sandstone	5	3
Shale, dark	20	
Coal, shaly		9
Shale	11	3
Sandstone	2	
Shale	4	
Sandstone	3	
Shale	5	
Sandstone	22	
Shale, dark	40	
Sandstone	52	
Shale, sandy	100	
	1,602	

The dip of 15° E. at Madrid, if unchanged, would in a short distance carry a given bed to a considerable depth. However, this dip probably becomes less toward the center of the basin, for the coal-bearing rocks reappear with opposite dip at its eastern margin, about 12 miles east of Madrid, where they were observed near the town of Galisteo. The rocks in the eastern part of the field are perhaps best exposed farther south, or about 12 miles southeast of Madrid, near the Omera mine, which has been described by Gard-

ner.[1] Here the Galisteo sandstone rests unconformably on coal which seems to be one of the beds of the middle coal group of the 1,602-foot drill record. A section of the coal-bearing rocks exposed near this mine was measured by pacing across the strike and correcting for dip the distances thus obtained. Although only approximately correct, this section is given in Plate XXI to show the general relations of the formations exposed at the eastern extremity of the field to those of other localities.

The line of outcrop of the coal beds at the southern extremity of the field extends from Omera in a northwesterly direction around the base of the Ortiz Mountains and connects with the coals in the vicinity of Madrid, but in much of the space intervening between these two places the outcrop is obscured by the débris from the mountains.

North of Omera the coal beds are displaced by the intrusion of the igneous rock of Cerro Pelon, a ridge formed by a thick sill which rests on the basal sandstone of the Mesaverde to the south and on Mancos shale farther north. This shale and basal sandstone were observed underlying the Galisteo sandstone north of Cerro Pelon, near the town of Galisteo, but no indication was found that any coal occurs there. It seems probable that during the period of erosion that preceded the deposition of the Galisteo sandstone the rocks were eroded down to the basal sandstone of the Mesaverde formation in the vicinity of Galisteo, just as they were eroded down to the middle group of coals at Omera.

Between Galisteo and Cerrillos little was seen of the rocks that underlie the Galisteo sandstone. They are covered for the most part by younger rocks, although they outcrop in a few places. A coal bed is brought to the surface by faulting south of Ortiz and a few small isolated exposures are known to occur between this town and Cerrillos. From Cerrillos to Waldo the rocks dip steeply toward the south, and although they are well exposed, no coal of commercial importance has been found in them. Coal beds occur at the horizons of prominent coals in other parts of the field, but the beds are thin, possibly on account of crushing at the time the rocks were upturned.

South of Waldo the coals are not well exposed and no openings have been made on them, but several openings were found in Waldo Gulch near the old town site known as Rogers. The Waldo mine, long since abandoned, is located here. There are two groups of developed coal beds in the western part of the field that probably correspond to the upper and middle groups shown in the drill record on page 291. They are locally known as the Waldo Gulch and Miller Gulch beds, and the lowest group indicated by this drill record may

[1] Gardner, J. H., Isolated coal fields in Santa Fe and San Miguel counties, N. Mex.: Bull. U. S. Geol. Survey No. 381, 1910, pp. 447–451.

be represented west of Miller Gulch by carbonaceous shale and thin coal beds. A section measured in an east and west direction across the strike near Rogers is as follows:

Section of rocks near Rogers, 2 miles southwest of Cerrillos, N. Mex.

[For graphic section see Pl. XXII.]

	Ft.	in.
Conglomerate (recent).		
Galisteo sandstone:		
Shale, sandy	25	
Sandstone, yellow	8	
Shale, sandy, yellow	16	
Sandstone, massive	12	
Shale, sandy, light colored	15	
Sandstone, massive, gray	10	
Shale and sandstone in alternating layers	68	
Sandstone, massive, coarse grained, friable, loose textured to quartoze, locally conglomeratic, variable in thickness and character; contains fossil plants	10±	
Unconformity by erosion.		
Mesaverde formation:		
Coal, thickness irregular, due to erosion, absent in some places	2±	
Sandstone, shale, and thin beds of coal in alternating layers, contains fossil plants	35	
Coal (Waldo bed)	4	
Shale and sandstone, the shale carbonaceous in some places, with thin beds of coal	105	
Sandstone in massive layers, separated by thin beds of shale	105	
Sandstone and shale in alternating layers; contains concretions of brown sandstone	146	
Coal	1	
Shale (0 to 10 inches), average		5
Coal	2±	
Not exposed	31	
Coal, impure	1±	
Shale, with yellowish limestone concretions, containing fossil shells	15	
Coal		6
Sandstone and shale	5	
Coal		6
Shale	5	
Sandstone, principally massive, light gray, fossiliferous, friable in some places, with brown flinty concretions; thickness varies from place to place, but the lower 50 feet or more forms a prominent cliff—the basal sandstone of the Mesaverde formation	300±	
Shale (Mancos).		
	922	5

The base of the Mesaverde formation in the Cerrillos field consists of a thick massive sandstone overlain by thinner-bedded and softer sandstones that are somewhat shaly in places. Where the Rogers

section was measured these sandstones form a long dip slope having an irregular surface, and the accuracy of the thickness obtained by measuring across this slope and given in the section is open to question. The 300 feet was obtained by measuring with tape across the strike of the rocks, which here dip 5° to 8°, and computing the thickness from the dip and horizontal distance. It is not certain that the dip is constant nor that no faults occur to vitiate the measurements.

The lowest coal bed that has been developed was opened in Miller Gulch, in the thickest bed of the Miller Gulch group. This coal may be traced continuously southward for about 3 miles. It lies underneath the lower sheet of intrusive igneous rock which outcrops west of Madrid. In other words, the lower sheet (see fig. 8, p. 300) was intruded between the Miller Gulch and the Waldo Gulch groups of coal beds. The Waldo Gulch beds run nearly to the surface, with northeasterly dip, in Waldo Mesa, being covered at the outcrop by surface débris only, and appear again west of Coal Gulch, about half a mile north of Madrid. The lower sheet of igneous rock, which is several hundred feet thick west of Madrid, thins in a short distance to the north and is not known to extend northward beyond Waldo Mesa. It seems to be in the form of a wedge that separated the two groups of coal, so that when they were tilted and eroded those at Madrid outcropped farther east than those of Waldo Mesa, although the two groups are the same.

The unconformable relations between the Galisteo sandstone and the Mesaverde formation are conspicuous in Waldo Gulch because there the sandstone base of the Galisteo rests on a bed of coal that occurs 35 feet above the Waldo bed. This coal ranges in thickness within short distances from 3 feet to a few inches, and in some places is absent. The differences in thickness are due to irregularities in the upper surface of the coal and the presumption that this is due to erosion that occurred previously to the deposition of the Galisteo sandstone is strengthened by the fact that the coal is "dead," resembling in its behavior in the furnace coal that has been weathered. At the northernmost prospect shown in Waldo Gulch on the map (Pl. XX), the opening seems to be in the Waldo bed, but there is no higher coal bed known at that locality, and the coal, although it is as thick as that in the old Waldo mine, was found to be "dead" and worthless. It seems probable that at this locality the upper bed and most of the 35 feet of rock intervening between it and the underlying Waldo coal was eroded previous to the deposition of the Galisteo sandstone and that the Waldo coal was affected by weathering at that time.

A drill was put down in Waldo Mesa at the point marked A on the map (Pl. XX). The drill passed through coal beds that are obviously the same as those outcropping in the sides of the mesa to the north and then encountered the igneous rock referred to above, which,

however, is very much thinner than it is farther south. Several thin coal beds were penetrated below the igneous rock that correspond in position to the Miller Gulch group. The record of this drill hole is as follows:

Section of rocks penetrated by diamond drill in Waldo Mesa, about half a mile south of the old Waldo mine.[1]

[For graphic section see A, Pl. XXI.]

	Ft.	in.
Surface material	41	
Conglomerate	12	
Sandstone, gray	39	
Coal		8
Shale, black	4	2
Coal		10
Shale, sandy, gray	3	
Coal	2	6
Shale, sandy	29	6
Coal	3	3
Shale, sandy, gray	24	3
Coal	1	
Shale	2	8
Coal		5
Shale	10	9
Sandstone	6	
Shale and sandstone	78	
Sandstone, gray	10	
Igneous rock	187	
Shale, sandy	90	
Coal		6
Shale, gray	8	
Sandstone, gray	18	7
Shale, gray	49	7
Coal	1	3
Shale	12	
Sandstone, gray	17	
Coal	1	3
Shale, dark	40	8
Coal		4
Shale, dark	5	2
Coal		10
Shale, dark	17	8
Coal		8
Shale, dark	58	9
	778	3

[1] As the rocks dip 9° E. the measurements of the core taken from the vertical hole are slightly in excess of the true thicknesses of the rocks.

The developed coals near Madrid occur east of Coal Gulch and with a single exception lie between the two great sheets of intrusive igneous rock, as shown in figure 8, p. 300. The beds outcrop through a distance of about 3 miles in the steep east wall of the gulch and strike east of north, but about half a mile north of Madrid the direction of strike changes and the outcrops swing westward across the gulch, where in a short distance they are lost under the surface débris that covers Waldo Mesa.

The sheet of igneous rock which overlies these coal beds does not seem to have been warped in conformity with the underlying sedimentary rocks. In the southern part of the field it lies practically in contact with the principal bed of coal, which is here an anthracite. Farther north, near locality 5 (Pl. XXII), it is said to be 20 to 30 feet above this coal. Still farther north, in the old White Ash mine, it is still farther from the coal and failed here to change the coal to anthracite.

Three of the coal beds outcropping near Madrid have been developed. The lowest one is known as the Cook & White bed, the second one, nearly 100 feet higher, is called the Peacock, and the third, 22 feet above the Peacock, is the White Ash coal bed. All contain bituminous coal except where the igneous rock lies close to the White Ash bed. Here the bituminous coal has been changed to anthracite.

The outcrops of these beds and the principal openings are shown in Plate XX and will be described farther on.

THE COAL.

QUALITY.

Six samples of coal for analysis were taken from the mines near Madrid. All were taken in accordance with the regulations of the United States Geological Survey by making a cut across the bed from roof to floor of the mine. The coal thus obtained, after excluding the partings thrown out in mining, was pulverized and quartered down in the mine and sealed in galvanized-iron cans. The samples were analyzed at the laboratory of the Bureau of Mines in Pittsburgh, Pa. The analyses are as follows:

Analyses of coal samples from the Cerrillos coal field, N. Mex.

[Made at the laboratory of the Bureau of Mines and the United States Geological Survey, F. M. Stanton and A. C. Fieldner, chemists in charge.]

Mine.	Collector.	Laboratory No.	Air-drying loss.	Form of analysis.[a]	Proximate.				Ultimate.					Heating value.	
					Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
Anthracite No. 1	J. H. Gardner	6153	2.9	A	5.7	2.2	86.1	5.99	0.69	2.38	82.87	1.26	6.81	7,370	13,270
				B	2.9	2.2	88.7	6.17	.71	2.12	85.34	1.30	4.36	7,590	13,660
				C	.....	2.3	91.3	6.35	.73	1.86	87.88	1.34	1.84	7,815	14,070
				D	.....	2.5	97.5	.....	.78	1.99	93.84	1.43	1.96	8,345	15,030
Anthracite No. 4	W. T. Lee	14886	2.2	A	7.6	7.2	75.9	9.32	.76	2.10	78.97	1.00	7.85	6,725	12,100
				B	5.5	7.4	77.6	9.53	.78	1.90	80.75	1.02	6.02	6,875	12,370
				C	.....	7.8	82.1	10.08	.82	1.36	85.42	1.08	1.24	7,270	13,090
				D	.....	8.7	91.3	.....	.91	1.51	95.00	1.20	1.38	8,085	14,560
White Ash	J. H. Gardner	6154	1.4	A	3.8	34.4	56.9	4.89	.57	5.70	75.36	1.15	12.33	7,490	13,480
				B	2.4	34.9	57.7	4.96	.58	5.62	76.43	1.16	11.25	7,595	13,670
				C	.....	35.8	59.1	5.08	.59	5.49	78.30	1.19	9.35	7,780	14,010
				D	.....	37.7	62.3	.....	.62	5.78	82.49	1.25	9.86	8,195	14,760
Peacock	W. T. Lee	14887	.9	A	3.2	41.4	44.4	11.01	1.59	5.28	69.71	1.24	11.17	6,920	12,450
				B	2.3	41.7	44.9	11.11	1.60	5.23	70.34	1.25	10.47	6,980	12,570
				C	.....	42.7	45.9	11.37	1.64	5.09	71.98	1.28	8.64	7,145	12,860
				D	.....	48.2	51.8	.....	1.85	5.74	81.22	1.44	9.75	8,060	14,510
Blacksmith	do	14884	3.8	A	4.6	26.4	61.4	7.60	1.27	5.22	75.94	1.38	8.59	7,520	13,530
				B	.8	27.5	63.8	7.90	1.32	4.99	78.94	1.43	5.42	7,815	14,070
				C	.....	27.7	64.3	7.97	1.33	4.94	79.62	1.45	4.69	7,885	14,190
				D	.....	30.1	69.9	.....	1.45	5.37	86.52	1.58	5.08	8,565	15,420
Holen	do	14885	1.6	A	3.6	35.1	49.5	11.83	.96	5.04	69.89	1.29	10.99	6,865	12,350
				B	2.1	35.6	50.3	12.02	.98	4.94	71.03	1.31	9.72	6,975	12,560
				C	.....	36.4	51.3	12.28	1.00	4.81	72.54	1.34	8.03	7,125	12,820
				D	.....	41.5	58.5	.....	1.14	5.48	82.70	1.53	9.15	8,120	14,620

[a] A, Analysis of coal as received; B, analysis of coal air dried; C, analysis of coal moisture free; D, analysis of coal ash and moisture free.

No. 6153.—Sample of the White Ash coal, taken April 10, 1908, by James H. Gardner, from a working face in the main entry of Anthracite mine No. 1 (locality 5, Pl. XXII), 200 feet from its mouth, representing a thickness of 2 feet 10 inches of dry coal.

No. 14886.—Sample of the White Ash coal, taken October 10, 1912, by W. T. Lee, from a working face in Anthractie mine No. 4 (No. 6 in Anthracite mine No. 4, Pl. XXII), 1,500 feet S. 80° E. from the mouth of the mine, representing a thickness of 2 feet 9 inches of coal.

No. 6154.—Sample of the White Ash coal, taken April 10, 1908, by James H. Gardner, from a working face in the main entry of the White Ash mine (locality 3, Pl. XX), 120 feet from its mouth, representing a thickness of 4 feet 6 inches of dry coal.

No. 14887.—Sample of the Peacock coal, taken October 10, 1912, by W. T. Lee, from a newly cleared face of coal, 400 feet northeast of the opening of the Peacock mine (locality 30,Pl. XX), representing a thickness of 2 feet 4 inches of dry coal.

No. 14884.—Sample of the Peacock(?) coal, taken October 10, 1912, by W. T. Lee, rom a working face 310 feet south of the mouth of the Blacksmith mine (locality 35, Pl. XX), representing a thickness of 2 feet 4 inches of damp coal from which a 3-inch parting of shale was thrown out.

No. 14885.—Sample of the Cook & White coal, taken October 9, 1912, by W. T. Lee, from a working face 1,300 feet N. 80° E. from the mouth of the Holen mine (locality 22, Pl. XX), representing a thickness of 3 feet 3 inches of dry coal. Two inches of bony coal at the top of the bed was thrown out.

Three grades of coal are found in the Cerrillos field, namely, anthracite, coking bituminous, and noncoking bituminous. The White Ash bed, where it is least affected by the intrusive igneous rock, contains coking bituminous coal, which in former years was produced from the White Ash mine. The igneous rock is reported as lying 30 to 50 feet or more above the coal in this mine. Farther south it approaches the bed, until in some parts of Anthracite mine No. 4 it rests practically on the coal. (See section in Pl. XXII.) Between the White Ash mine, in which the coal averages 5 feet 6 inches in thickness, and Anthracite mine No. 1 the change from bituminous to anthracite takes place, and the bed is little more than half as thick as it is where the coal is bituminous. Not enough is known at present to state whether the change takes place gradually or whether there is a relatively sharp line of demarcation between the two kinds of coal. There is a somewhat widespread belief that the nearer a large body of intrusive igneous rock approaches a bed of coal the greater will be its degree of anthracitization. Although this may be true in general, the analyses of the Cerrillos coals do not seem to bear it out. In Anthracite mine No. 1, where the igneous rock is several feet above the coal, there is relatively little volatile matter in the coal (see analysis No. 6153), but in Anthracite mine No. 4, where the igneous rock is separated from the coal by only a few inches of shale, as it was where sample No. 14886 was taken, there is more than three times as much volatile matter. In the latter mine it was noted that the shale in direct contact with the igneous rock was not notably metamorphosed. It has the same general appearance as the shale overlying the coal elsewhere and is not notably harder. Its laminæ are not contorted nor otherwise

disturbed, and there is little indication in its physical appearance that a sheet of igneous rock nearly 500 feet thick was forced into the sedimentary rocks over it. The anthracitization of the coal has been very generally attributed to the heat from the igneous rock. It seems possible that the influence of the heat may have been overestimated and that other causes, as, for example, pressure due to lateral thrust during the mountain-making epochs that warped and tilted the rocks, may have contributed toward the change. However, this pressure was not the only cause, as is shown by the fact that the coals below the White Ash, although subjected to the same movements, were not changed to anthracite.

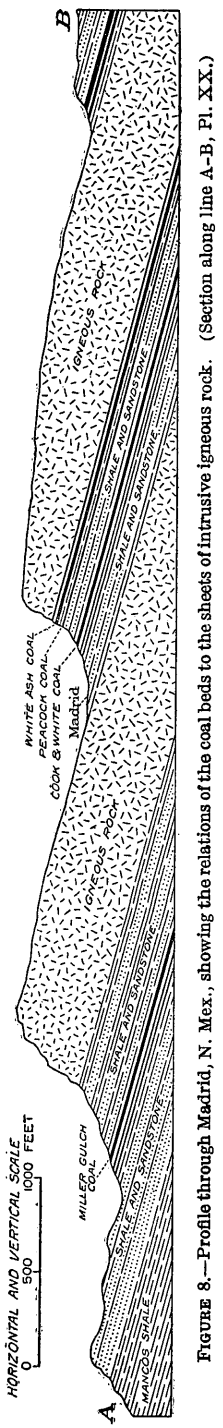


FIGURE 8.—Profile through Madrid, N. Mex., showing the relations of the coal beds to the sheets of intrusive igneous rock. (Section along line A-B, Pl. XX.)

The Peacock coal, 22 feet below the White Ash bed, gives little evidence of the proximity of a great body of igneous rock. As its percentage of volatile matter is much higher than that of the coal in the White Ash mine there might seem to be a gradual decrease of metamorphism away from the igneous rock. However, the coal of the Holen mine, which is nearly 100 feet below the Peacock bed, and therefore farther from the upper sheet of igneous rock, contains notably less volatile matter than the Peacock coal. But on the other hand the coal of the Holen mine may be affected by the sill that lies below it. (See fig. 8.) Also, the coal of the Blacksmith mine, which appears to be nearly as far from the igneous rock as that of the Holen mine, has lost a large part of its volatile matter.

The Cerrillos field affords an excellent opportunity for a study of the influence of intrusive igneous rock on the character of coal, but extended and detailed observation is necessary before the subject can be adequately discussed.

THE COAL BEDS.

In presenting the details of the coal the more extensively developed areas are described first. Thus in Madrid Gulch the most valuable coal, both bituminous and anthracite, is in the White Ash bed. The next coal in value is in the Cook & White bed. The intervening (Peacock) bed is not yet proved to be of great commercial importance. The less extensively developed coals are described later.

Thus the coals of Ortiz Arroyo, Waldo Gulch, and Miller Gulch have all been mined to some extent, but the mines are now abandoned.

MADRID GULCH.

WHITE ASH COAL BED.

The northernmost opening in which the White Ash coal bed was observed is at locality 1 (Pl. XX), 225 feet north of the Old Green mine (locality 2, Pl. XX). A prospect opening at this point shows a thickness of 4 feet 6 inches of coal underlain by shale. (See fig. 9, p. 302.)

The Green mine is one of the old openings in the White Ash coal bed, but is now inaccessible because of caving and a mine fire, which burned for several years. At a good exposure near the mouth of the mine, at locality 2, the following section was measured:

Section of rocks near the mouth of the Old Green mine.

	Ft.	in.
Sandstone, white to yellow	15	
Shale, light gray	6	
Sandstone	4	
Shale, dark	7	
Shale, iron stained	8	
Shale, sandy, light	2	5
Shale, dark	2	4
Coal, bituminous	2	
Shale, dark, carbonaceous	1	6
Coal, bituminous		6
Shale, dark	3	10
Shale, light gray	3	
Coal, bituminous, White Ash bed	3+	
Shale.		
	58+	7

At this point the White Ash bed is more than 3 feet thick (the lower part is not exposed), and above it occur two beds of coal 6 inches and 2 feet thick. These three beds seem to be persistent for some distance to the south.

The next place to the south at which observations were made is at the White Ash mine (locality 3, Pl. XX). Although reports do not all agree, this mine seems to have been opened about 1888, being operated actively until 1897, and then with decreasing activity until 1900, when, according to the mine inspector's report, it was worked out. The coal from this mine is said to have been of superior quality and much in demand. Although this seems to have been the most valuable mine in the Cerrillos field, few details have been obtained regarding it. The coal is reported to average 5 feet 6 inches in thickness in the old workings. The mine yielded a maximum of about 150,000 tons a year of coking bituminous coal. The main entry was driven down the dip about 3,600 feet but there encountered a dike, which

was erroneously regarded as terminating the coal in that direction. This dike is evidently unimportant, as it does not appear at the surface, nor is there any surface indication of a fault or other dis-

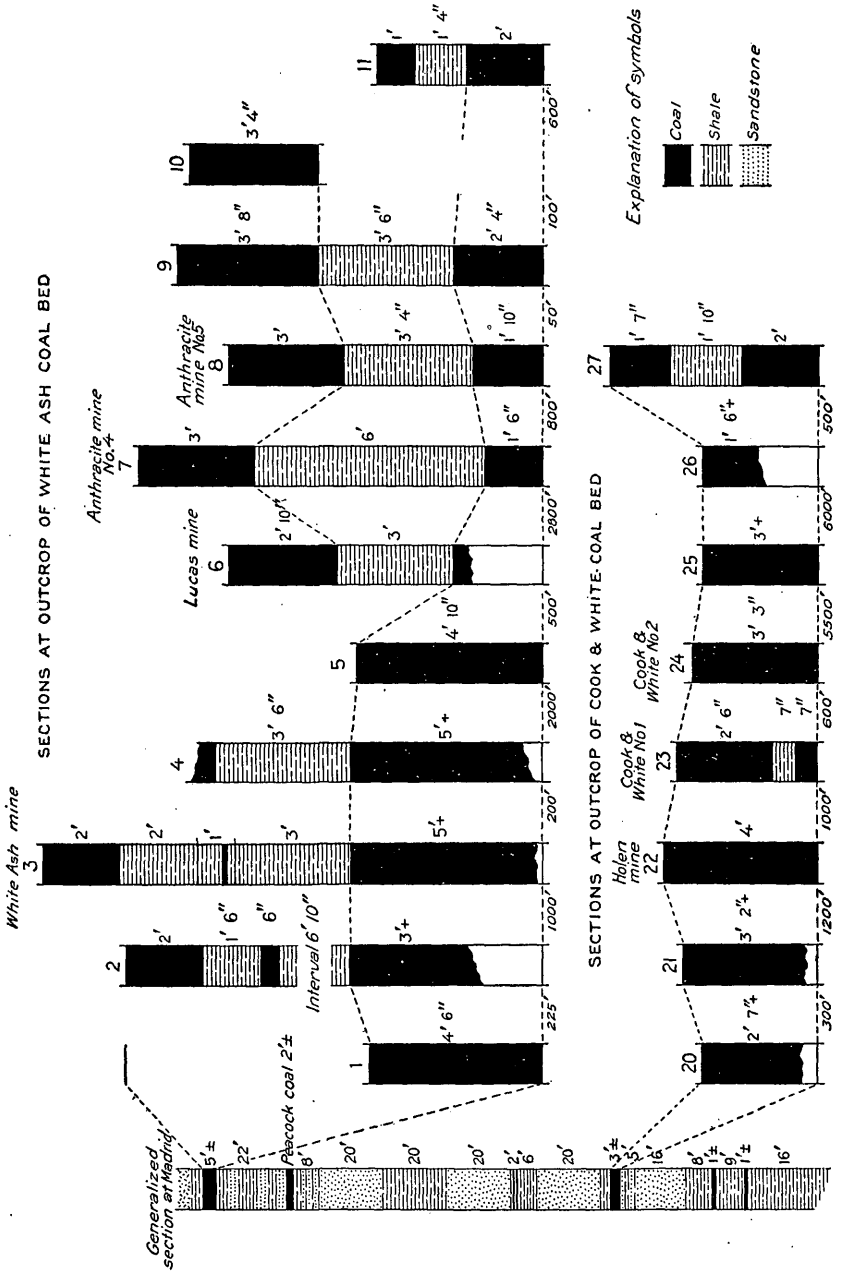


FIGURE 9.—Sections of coal beds near Madrid, N. Mex.

turbance that would seriously interfere with mining operations. Furthermore, a drill record, given on page 289, shows the presence at locality B (Pl. XX), about 1,000 feet east of the dike, of the same

group of coal beds that outcrop near the mouth of the mine. The mine inspector states that the mine yielded large quantities of gas, and there was an explosion in 1895.

In 1908 a part of the White Ash mine was reopened for the purpose of drawing some of the pillars and in April of that year J. H. Gardner took a sample of coal for analysis in the main entry, 120 feet from the mouth of the opening, where the coal is 4 feet 6 inches thick. The results of the analysis are given in the table on page 298, under No. 6154.

Three beds of coal, presumably the same three that were found at the old Green mine, were observed at this locality. The full thickness of the lowest or White Ash coal was not exposed, but the highest maintains its thickness of 2 feet. At the mouth of this mine the following section was measured:

Section at the mouth of the old White Ash mine, north of Madrid, N. Mex.

	Ft.	in.
Shale, brown	2	
Shale, light gray	1	6
Coal, bituminous	2	
Shale, light gray	2	
Shale, dark, containing 2 inches of coal	1	
Shale, light gray	3	
Coal, bituminous, White Ash bed	5+	
	16+	6

The next locality toward the south at which the White Ash coal was observed is the old Union mine at locality 4, which has long since been abandoned. The entries have caved, but the bed was measured at the surface, as follows:

Section of bed at the old Union mine.

	Ft.	in.
Coal	(?)	
Shale, dark	1	6
Shale, light gray	2	
Coal, bituminous, White Ash bed	5+	
	8+	6

The highest coal bed observed at the Green and White Ash mines occurs here, but is not well enough exposed to include in the section, nor was the full thickness of the White Ash bed seen. No measurements were made by the writer between the old Union mine and the Lucas or old Anthracite mine, but from measurements made in two openings by the present operators the bed is known to be somewhat more than 4 feet thick. At the Lucas mine (locality 6) the igneous rock that overlies the anthracite is close to the coal, and within the space between the two mines the change takes place in the character of the coal from bituminous in the Union mine to anthracite in the Lucas mine. The coal bed developed in this mine seems to be the

upper bench of the White Ash bed, or, in other words, the 2-foot bed of coal 6 feet above the bed exploited in the White Ash mine. The bench developed in the White Ash mine is present here 3 feet below the floor of the Lucas mine, but was not mined, and its thickness is not known to the writer. Two of the old entries to the Lucas mine were accessible at the time of investigation and the relation of the beds observed in them is shown in the following section:

Section of the White Ash coal bed in an abandoned entry of the Lucas mine.

	Ft.	in.
Igneous rock, base irregular.		
Shale, carbonaceous	5	3
Shale, light, "fire clay"	3	6
Coal, anthracite of Lucas mine	2	10
Shale, light gray	3	
Coal, anthracite, thickness not determined, lower bench of White Ash bed.		
	14	7

Anthracite coal has been mined from the White Ash bed in the vicinity of Madrid for many years. According to Loew's report, previously quoted, anthracite, obviously from this bed, was used as early as 1835. Its first production on a commercial scale is not known to the writer, but from such records as are available it appears to date back at least to 1882. From that time to the present the production of anthracite at Madrid has been continuous, the output varying from a few tons to 45,000 tons a year. The Lucas mine was opened on a commercial basis about 1893. Descriptions of the mine written during the years of its operation indicate that the coal in the developed area, where it occurred in three benches, ranged in thickness from 2 feet 8 inches to 4 feet 2 inches. In some places the benches were close together and were all worked, but generally only the middle one, reported as ranging from 3 feet to 3 feet 6 inches, was worked. Development work was discontinued in 1902 because of the poor quality of coal encountered at the bottom of the slope, somewhat more than 3,000 feet from the outcrop, and in 1905 the mine was abandoned.

North of the opening of the old Lucas mine a small mine has recently been opened at locality 5 for the purpose of extracting the coal lying between the outcrop of the bed and the old workings of the Lucas mine. The coal bed was measured in the main entry as follows:

Section of coal bed in Hard Coal mine No. 1, near Madrid, N. Mex.

	Ft.	in.
Shale, dark	1	
Coal, anthracite	4	10
Shale	1	
	6	10

A sample of this coal was collected for analysis by J. H. Gardner in 1908 in the main entry, 200 feet from the mouth of the mine, where the part of the bed sampled is 2 feet 10 inches thick. The results are given under No. 6153 of the table of analyses on page 298.

About 2,800 feet south of the opening of the Lucas mine a mine known as Anthracite No. 4 has been opened at locality 7 (Pl. XX). Here the upper bench of the White Ash coal bed seems to be about double the thickness of the lower bench and is the coal which is developed in the mine. It is 3 feet thick at the mouth of the mine and is separated by 6 feet of shale from the lower bench, which is here 1 foot 6 inches thick. The anthracite of the upper bench is reported to have an average thickness of about 3 feet, but this thickness varies considerably within short distances, as shown in Plate XXII.

In October, 1912, the writer took a sample for analysis of the anthracite in mine No. 4, from a working face 1,500 feet S. 80° E. from the mouth of the main entry, at a point where the coal is 2 feet 9 inches thick with shale above and below it. The results of the analysis are given under No. 14886 of the table of analyses on page 16.

In the southern portion of Anthracite mine No. 4, near the area supposed to be faulted, the coal thickens toward the disturbed area, the main bench attaining a thickness of 3 feet or more, and in one place there are two beds 2 feet 5 inches and 4 feet thick, separated by 2 inches of shale. It is not known, however, whether these benches represent the two benches that are normally separated by about 6 feet of shale or whether the occurrence is due to some other cause, such as thrust faulting. Similar conditions were observed in Anthracite mine No. 5, which has been opened just south of the area supposed to be faulted, but development had not gone far enough in this mine at the time of investigation for comparison with the more extensively developed areas farther north.

At locality 8 (Pl. XX) a mine known as Anthracite mine No. 5 has been opened. The coal ranges in thickness from 1 foot 6 inches to 5 feet and occurs in two benches similar to those just described. A section measured at the mouth of this mine is as follows:

Section of rocks at the mouth of Anthracite mine No. 5, near Madrid, N. Mex.

	Ft.	in.
Coal, anthracite	1+	
Shale, sandy, gray	6	
Coal (Anthracite mine No. 5)	3	
Shale, gray	3	4
Coal, anthracite	1	10
Shale, gray	3	6
	18+	8

At locality 9, about 50 feet south of the opening of Anthracite mine No. 5, two benches of coal occur in the relations observed at several localities farther north. A section measured at this locality is as follows:

Section of the anthracite coal beds 50 feet south of the opening of Anthracite mine No. 5.

	Ft.	in.
Coal, anthracite	3	8
Shale, gray	3	6
Coal, anthracite	2	4
Shale, gray	2	
	11	6

At locality 10, about 100 feet farther south, one of the benches of the anthracite coal bed, presumably the upper bench, is exposed. It is 3 feet 4 inches thick and 8 feet of overlying shale is exposed.

At locality 11, about 1,350 feet south of Anthracite mine No. 5, is the opening of the old Boyle mine. This mine has recently been reopened and is now known as the "Split Anthracite." Little active mining has been done here, but both benches of the anthracite bed have been exposed and the following section was measured near the mouth of the mine.

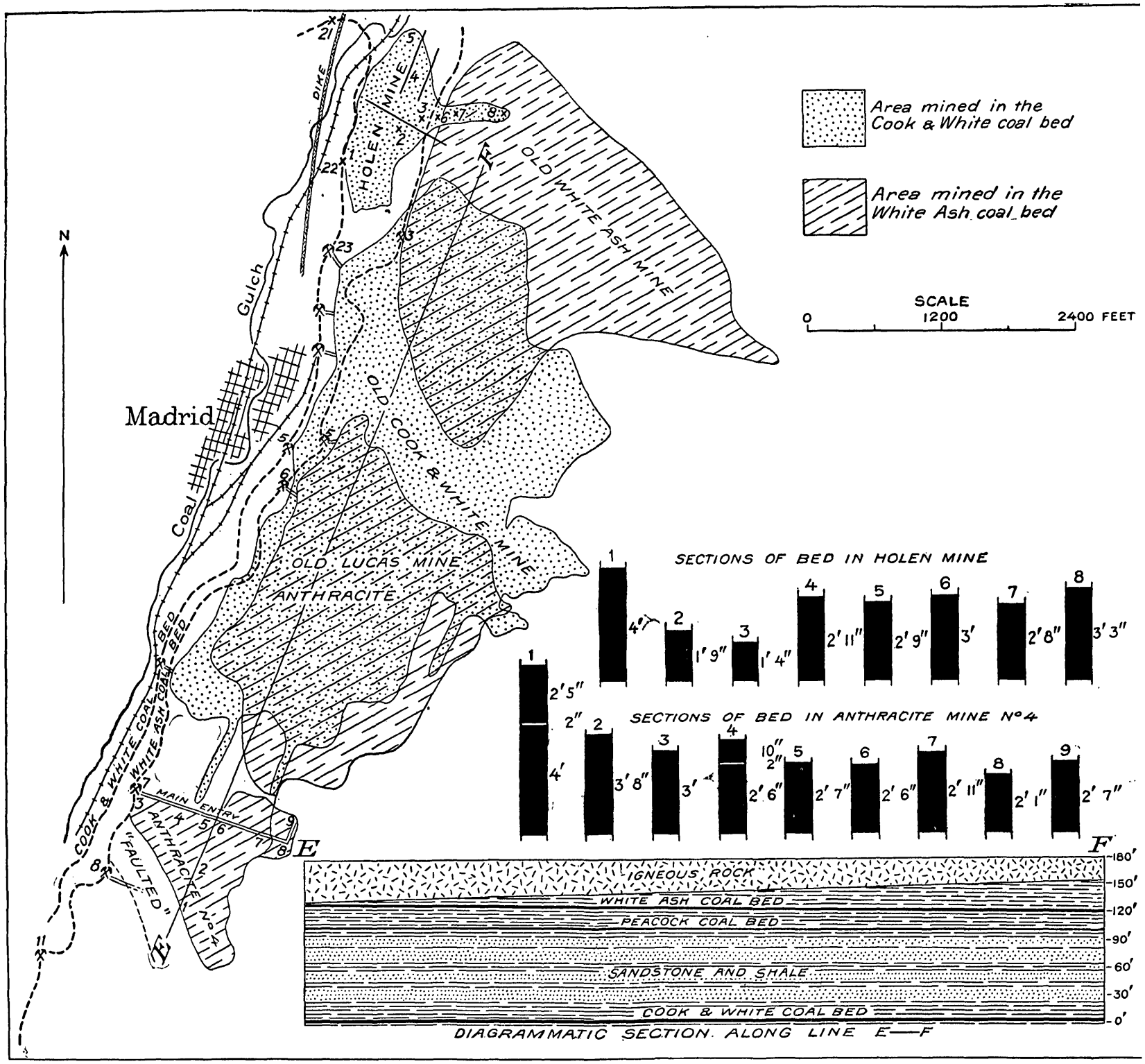
Section of rocks at the "Split Anthracite" mine.

Igneous rock.	Ft.	in.
Covered	10	
Sandstone	10	
Shale with nodules	11	2
Coal, anthracite	1	
Shale, dark gray	1	4
Coal, anthracite	2	
Shale, gray	3	
	38	6

COOK & WHITE COAL BED.

The northernmost opening on the Cook & White coal bed at which a measurement was obtained is north of Madrid and west of Coal Gulch, at locality 20. The old opening at this point shows 2 feet 7 inches of bituminous coal with shale above it, but the bottom of the bed was not exposed. At another opening, locality 21, on the same bed, about 300 feet farther south, the coal is more than 3 feet 2 inches thick. From locality 21 the outcrop of the bed trends eastward, crosses the creek, and then turns southward. The northernmost opening on this bed east of the creek is at the Holen mine, locality 22, at the mouth of which the coal is 4 feet thick, with shale above and below it.

Several measurements of the coal bed were made in the Holen mine for the purpose of showing the variations encountered by the miners,



MAP SHOWING LOCATION OF OPERATING AND ABANDONED MINES NEAR MADRID, N. MEX.

With a diagrammatic section showing the relation of the igneous rock to the coal beds and sections of the coal beds showing their variation in thickness.

The thickness of the bed at several localities is shown graphically in Plate XXII and need not be repeated here. There are two sets of normal faults in this mine, having a maximum measured displacement of 20 feet. One set trends a few degrees east of north, with downthrow toward the west, and the other trends nearly east-west, with downthrow toward the north.

A sample of this coal was taken for analysis from a working face in the mine 1,300 feet N. 80° E. from its mouth. The results of the analysis are given under No. 14885 of the table on page 298. At this point the following section of the coal bed was measured:

Section of Cook & White coal bed in Holen mine.

	Ft.	in.
Shale.		
Coal		2
Coal (analysis No. 14885)	3	3
Shale.		
	3	5

At locality 23, about 800 feet farther south, at one of the openings to the old Cook & White mine, the coal bed is 3 feet 8 inches thick, but contains impurity near the base, as shown in the following section:

Section of the Cook & White coal bed near the tipple at Madrid, N. Mex.

	Ft.	in.
Shale.		
Coal	2	6
Coal, shaly		7
Coal		7
Shale.		
	3	8

At locality 24, about 800 feet still farther south, is the main entry to the old Cook & White workings. At the mouth of this mine the coal is 3 feet 3 inches thick, with shale above and below. This mine seems to have been opened about 24 years ago and supplied coal somewhat irregularly for about 17 years, with a maximum yearly output of approximately 145,000 tons. The coal in the developed area was found to range in thickness from 1 foot 6 inches to 4 feet 6 inches. An average of 3 feet 6 inches is reported. The main entry was driven down the slope of the bed through the best part of the coal, but the bed thins both north and south of the main entry. At the eastern extremity of the old workings the coal is 4 feet 2 inches thick. As this point is less than 3,000 feet from the outcrop of the bed, it would seem that a large body of valuable coal is still within easy reach from the present opening, and resumption of mining operations was being planned at the time of investigation. The coal near the surface did not coke, but about 2,600 feet down the slope it changed in character to a coking coal. It yields considerable quantities of gas (CH_4), and according to the mine inspector's statement this mine was one of the few dangerously gaseous mines in New Mexico and was

closed several times because of fire. The scarcity of water rendered it impossible to drown the fires, and after a disastrous fire in December, 1905, the mine was permanently closed and allowed to fill with water from natural seepage. The fire has long since been extinguished and in 1912 the water was being pumped out preparatory to reopening the mine.

One of the small beds known to occur below the Cook & White coal is exposed at this locality. About 20 feet below the opening just described the following section was measured:

Section of a coal bed 20 feet stratigraphically below the Cook & White coal in a prospec entry.

	Ft.	in.
Shale	1	2
Coal		6
Shale		11
Coal		6
Shale	3	6
	6	7

No measurements were made on the Cook & White bed south of locality 24 for a distance of more than a mile, but at locality 25 a prospect entry has been run on the bed, showing 3 feet of coal overlain by shale. The bottom of the coal bed was not seen. About half a mile farther south another prospect entry was run in on a bed supposed to be the Cook & White bed, but less than 1 foot of coal was found. However, 200 feet farther south this coal is 1 foot 8 inches thick, but the rocks at these localities seem to be disturbed and the coal beds probably have not their normal thickness.

At locality 26, about 1 mile south of locality 25, a bed has been opened at the horizon of the Cook & White bed, where 1 foot 6 inches of coal was overlain by shale. The bottom of the bed was not seen. This opening is known as the "Shick coke bank." About 400 feet farther south a small mine known as the Gallagher mine has been opened at locality 27 on the Cook & White bed. Here the following section of the bed was measured:

Section of the Cook & White coal bed measured at the Gallagher mine.

Shale.	Ft.	in.
Coal	1	7
Shale	1	10
Coal	2	
Shale	3	3
	8	8

PEACOCK COAL BED.

The Peacock coal bed is a relatively thin bed lying between the Cook & White and the White Ash beds. It has been opened north of Madrid in the east wall of Coal Gulch, at locality 30. (See Pl. XX.)

The bed is not exposed at the surface, but about 400 feet from the mouth of the opening the coal is 2 feet 4 inches thick, with bony coal and shale both above and below. A sample of the 2 feet 4 inches of good coal was taken for analysis at this point, and the results are given under No. 14887 of the table of analyses on page 298.

The Peacock mine is above the Holen mine, and the faults noted in the latter were encountered in the Peacock.

At locality 31, about 400 feet farther south, the Peacock and associated beds were measured at the outcrop as follows:

Section of rocks 400 feet south of the Peacock mine.

	Ft.	in.
Shale	5	
Sandstone	1	6
Shale, brown		8
Coal		3
Shale, brown		11
Coal	1	
Shale, brown		11
Coal	1	3
Shale.		
	11	6

At locality 32, about 200 feet farther south, a trench at the horizon of the Peacock coal exposed the following beds:

Section of coal beds at locality 32.

	Ft.	in.
Shale	3	
Sandstone	1	
Coal	1	3
Shale, brown	1	6
Coal		8+
	7	5+

At locality 33, the next point to the south at which a measurement of the Peacock coal was obtained, is located an opening known as the Upper Peacock mine, where a thickness of 1 foot 5 inches of coal is exposed. This, however, is probably not the full thickness of the bed, as the coal is here overlain by surface material.

Little is known of the Peacock bed for a distance of about 2 miles south of locality 33. At locality 34 a small mine has recently been opened on a coal bed that intervenes between the White Ash and the Cook & White beds. This may be the Peacock coal, but as it is only 20 feet stratigraphically above the Cook & White coal it seems more probable that it represents one of the thin beds shown in the section in figure 9, page 302, about 25 feet above the Cook & White bed. The Blacksmith mine, at locality 35, was opened in 1910 on this coal bed and has been operated since that time. At the mouth of this mine the coal is 2 feet 2 inches thick with shale above and below. Within

the mine, about 300 feet from the mouth, the following section was measured:

Section of coal bed in the Blacksmith mine.

	Ft.	in.
Shale.		
Coal		6
Shale	2	2
Coal (analysis No. 14884)		9
Shale		3
Coal (analysis No. 14884)	1	7
Shale.		
	5	3

A sample of the coal was taken for analysis at this point and includes the coal of the lower two benches. The results of the analysis are given under No. 14884 of the table of analyses on page 298.

The coal bed varies considerably in thickness, is warped and undulating, and the coal is crushed to such an extent that the product of the mine resembles slacked coal. It is in demand for smithing, and the entire product of the mine is sold as blacksmith coal.

ORTIZ ARROYO.

About 1900 a mine was opened in Ortiz Arroyo, at locality 12, half a mile east of Madrid, on the bed of anthracite coal lying a few feet above the intrusive sheet of igneous rock that outcrops east of Madrid. The mine was operated for three or four years, yielding, according to the published figures of the mine inspector, a total of about 23,000 tons of coal. Although long since abandoned, the entry is still accessible, and at its mouth the following section of the coal bed was measured:

Section of coal bed at the old anthracite mine in Ortiz Arroyo, near Madrid, N. Mex.

	Ft.	in.
Shale.		
Coal	4	
Shale	1	3
Coal		6
Shale.		
	5	9

The coal averaged about 4 feet 2 inches in thickness, but the area of good coal was small. When the entries ran into coal destroyed by the intrusive igneous rock the mine was abandoned.

WALDO GULCH.

Two coal beds have been opened in Waldo Gulch, but only one, the Waldo or second bed from the top, is commercially valuable. The upper bed is irregular in thickness, due to erosion previous to the deposition of the Galisteo sandstone. The coal is "dead" and worthless, probably because of weathering during this time of erosion.

At locality 36 a mine was opened in 1912 on the Waldo bed in coal 3 feet 9 inches thick, with shale above and below. A few hundred feet farther north, in the opening of an old abandoned mine, this same bed is 3 feet 6 inches thick. To the south of this mine is the old Waldo mine, which was one of the first to be operated in the Cerrillos field. The bed seems to consist normally of two benches of coal with a thin bed of shale between. The principal or upper bench is 3 feet 6 inches thick and is separated from the lower one, which is here 1 foot thick, by 6 inches of shale. About 100 feet still farther south the following section was measured:

Section of the Waldo coal and associated beds in Waldo Gulch.

	Ft.	in.
Sandstone	4	
Shale		9
Coal		6
Shale	10	
Coal	3	6
Shale	1	
Coal	1	2
Shale.		
	20	11

The bed was opened in many places years ago in the side of Waldo Mesa, but most of the old openings have caved, so that few satisfactory observations could be made. However, enough could be seen to show that the coal has been disturbed by rock movements, and in some places destroyed by intrusions of igneous rock. This seems to be the northern limit of the intrusive sheet that is so prominent farther south and that, in the drill prospect A, half a mile to the southeast, is 187 feet thick. (See Pl. XXI.)

The northernmost opening on this bed has already been described as yielding coal that is "dead" and worthless. For this reason, although the coal bed is thick and free from bedded impurities, the opening was abandoned.

MILLER GULCH.

The principal coal bed of the Miller Gulch group was opened about 1892 and from that time to 1897, according to mining records, yielded a maximum of about 15,000 tons a year of coking bituminous coal. The entries were driven in on the bed about 900 feet and the average thickness of the coal is reported as 3 feet. The coal was so well adapted for smithing and the manufacture of gas that it was found profitable to mine even though it had to be hauled by wagon from the mine to the railway, a distance of over 2 miles. At the mouth of the old mine the following section was measured:

Section of coal in old Miller Gulch mine.

	Ft.	in.
Sandstone, yellow, with ironstone concretions.		
Shale		4
Coal	1	
Shale	1	4
Coal	2+	
	4+	8

QUANTITY OF COAL AVAILABLE.

The coals of the Cerrillos field have been developed in so few places, and so little is known of the continuity of the beds that no useful estimate of available tonnage can be made. The area of coal-bearing rocks is about 30 square miles, but the grave uncertainty as to the occurrence of commercially important coal beds in many places renders almost worthless any estimate that might be made. However, as the mines in the very small area developed have furnished, according to the statistics of the United States Geological Survey, about 2,330,000 tons of coal, large bodies of valuable coal may yet be found in the Cerrillos field.