Coal resources of the Durango area, Colorado and New Mexico

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base of the tuff is covered in the center of The Amphitheater, it would probably be about 9,000 feet altitude at its lowest point. The minimum exposed relief of the ancient valley is, therefore, about 1,000 feet. Whether the buried valley trended northerly or westerly is not certain.

Southeastern Facade

This view is of a rounded bold ridge south of the Amphitheater. In the foreground is a low ridge of Ouray limestone that rises only a few hundred feet above town. Back of this is a bold somber ridge that is viewed more or less end-on. The lower part is a bold shield consisting mostly of Precambrian quartzite of the Uncompahgre formation; the upper part is San Juan tuff. From the proper vantage point the geologic impression that is gained is one of a Precambrian knob rising in the overlying San Juan tuff. To the right and forming the distant backdrop for the view up Uncompahgre Canyon is the pyramid-shaped Mount Abrams, but this is beyond the Ouray area.

Southern Facade

The southern view is toward the northern end of Hayden Mountain, which is a high ridge between Uncompahgre Canyon to the east and Canyon Creek to the west The view from town is across two geological steps (fig. 7), the first formed by the immediate rise of hills south of town composed of Devonian and Mississippian Ouray limestone. If the view is from Lookout Point, 1.4 miles

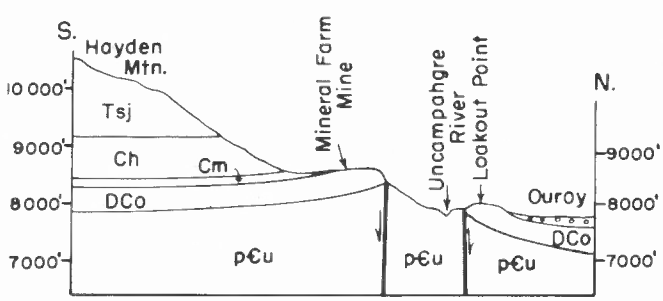

Figure 7. Structure section southward from Ouray.

south of town by the switchback road, then it is from the top of the first step. From this vantage point the second step is more prominent and forms a bold rim rising about ½ mile to the south across the narrow Uncompahgre River gorge. The riser of the second step is largely quartzite that strikes westerly and dips very steeply toward the observer. The cap to the step is formed by a thin interval of Devonian Elbert sandstone and siltstone overlain by massive Ouray limestone. The step is inclined west-northwesterly at about 15° and on its back slope, out of view, lie weak beds of the Pennsylvanian Molas formation, along which erosion has cut the second step or high bench at the base of Hayden Mountain. One may drive to this bench by a side road about two miles south of Ouray along the road up Canyon Creek. The lower slope of Hayden Mountain consists of Pennsylvanian Hermosa beds and the more precipitous upper part is Telluride conglomerate and San Juan tuff.

Perhaps the most striking features of the geology of the southern facade are those along the Ouray fault, which extends from the south side of The Amphitheater about N. 70°W. past Box Canyon and up the western facade into the head of Oak Creek (fig. 1). The fault is nearly vertical and the maximum downthrow on the north side is several hundred feet near the middle. Southeastward along U. S. Highway 550 from Lookout Point the Ouray limestone of the northern, downthrown side stands above the Precambrian quartzite on the south, upthrown side. This situation makes it appear that the limestone is more resistant to erosion than the quartzite, and this may be true especially for the thin-bedded and shattered and sheared quartzite beds near the fault.

At Box Canyon soft Molas and Hermosa beds lie on the north side of the fault while Precambrian diabase (dike) and quartzite lie on the south side; the contrast in resistance of the two blocks is so great as to cause a bold scarp and waterfall. The abrupt descent here, and in the step down from the Ouray limestone ridge at Lookout Point to the valley floor of the town, is largely the result of "plunging" by the Wisconsin glacier as it encountered the soft, nonresistant beds of the Molas that underlie most of Ouray.

COAL RESOURCES OF THE DURANGO AREA, COLORADO AND NEW MEXICO

By

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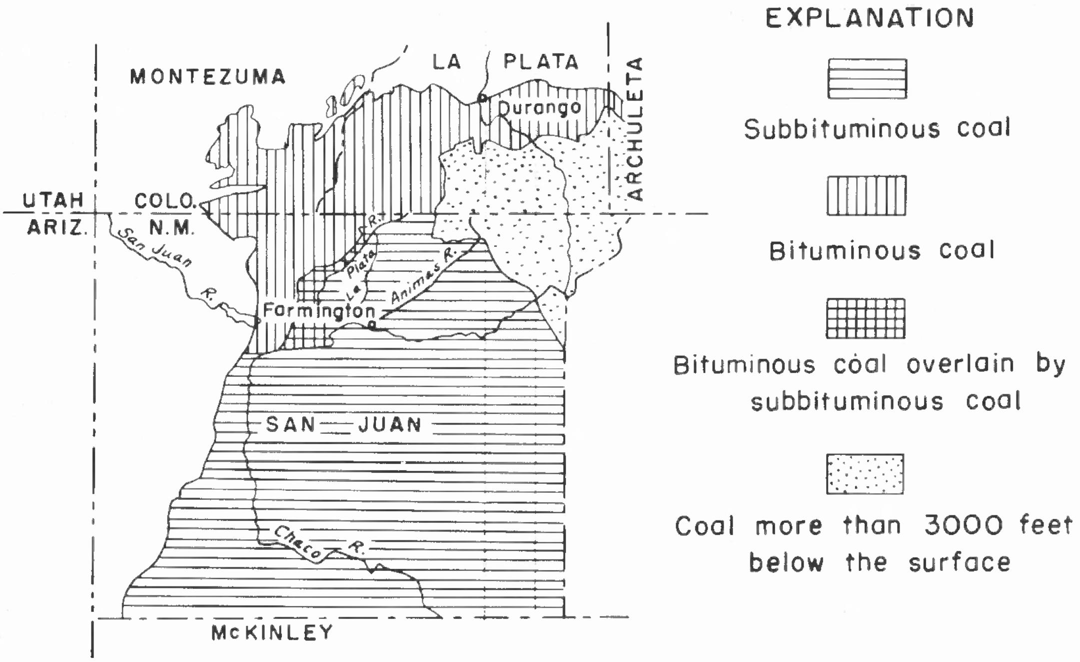
INTRODUCTION

Coal is one of the largest assured sources of energy in both Colorado and New Mexico. Although coal is developed only locally at the present time there may be extensive developments in the future to meet the demands of industry both within and beyond the limits of the two states.

Figure 1.



Index map of the Durango area, Colorado and New Mexico showing areal distribution of coal by rank and overburden.

The Durango area, as defined for purposes of this report, includes San Juan County, New Mexico, the Durango and Red Mesa coal fields in La Plata and Montezuma Counties, Colorado, and the Ignacio coal field in La Plata and Archuleta Counties, Colorado.

All of the coal reserves in the Durango area, a part of the San Juan River region, occur in rocks of Upper Cretaceous age. This region is an area of about 11,000 square miles, includes much of northwestern New Mexico, and extends into southwestern Colorado. The region roughly coincides with the San Juan Basin, a great saucer-shaped structural depression, which includes a narrow southward extension of the Gallup-Zuni Basin in the southwestern part of the region.

The original coal reserves of Colorado are estimated to be 100.4 billion tons (Spencer and Erwin, 1953), of which 7 billion tons are in the Durango area (table 1). Colorado coals range in rank from subbituminous to anthracite: however, a large part of the reserves, including all the Durango area reserves, are classified as bituminous.

Similarly in New Mexico the total original reserves are estimated to be 61.7 billion tons (Read et al., 1950), of which 30 billion tons are in San Juan County (tables 1 and 2). The major reserves in New Mexico are of subbituminous coal.

Some of the coal included in these huge totals is in thin beds and some in thick beds. A large part of the established reserves is near the surface and only a small part is as much as 3,000 feet below the surface. Small amounts of the reserves have been measured accurately by trenching and by drilling. A much larger amount is only inferred to be present on the basis of the known geologic continuity of the coal-bearing rocks.

Total coal production to date in the Durango area as defined in this report is probably less than 20 million tons. Assuming that the recoverable reserves are approximately 50 percent of the total original reserves, the total original recoverable reserves amounted to about 18.5 billion tons. The 20 million tons or less that have been mined amount to only about 0.1 percent of that figure.

BASES OF CLASSIFICATION OF COAL

In order to estimate reserves, coal may be classified according to rank, bed thicknesses, thickness of overburden, and reliability of data.

Rank

The ranks assigned to coals of the Durango area accord with the generally accepted classifications established by the American Society for Testing Materials (1939). This classification (table 3) divides all coals

TABLE 1. BITUMINOUS COAL RESERVES IN DURANGO AREA

(Millions of short tons)

	Measured and indicated							Inferred				Additional inferred	
	Coal less than 1,000 ft below surface				Coal 1,000 to 2,000 ft below surface	Coal 2,000 to 3,000 ft below surface	Total	Coal less than 1,000 ft below surface	Coal 1,000 to 2,000 ft below surface	Coal 2,000 to 3,000 ft below surface	Total	Coal less than 3,000 ft below surface computed on zone basis	Total (All reserves, all thicknesses, all depths)
	Beds exceeding 3.5 ft in thickness	Beds 2.3 to 3.5 ft in thickness	Beds 1.2 to 2.3 ft in thickness	Total	Beds exceeding 1.2 ft in thickness			Beds exceeding 1.2 ft in thickness				Beds exceeding 1.2 ft in thickness	
Durango coal field													
Fruitland fm.	22.5	--	--	22.5	--	--	22.5	146.8	137.0	1,269.6	1,553.4	--	1,575.9
Menefee fm.	44.7	--	--	44.7	--	--	44.7	1,117.2	70.6	50.8	1,229.6	--	1,274.3
Red Mesa coal field													
Fruitland fm.	238.2	4.7	7.9	250.8	9.2	--	260.0	140.4	251.4	447.0	838.8	1,762.0	2,860.8
Menefee fm.	4.5	15.8	28.7	49.0	--	--	49.0	17.5	--	--	17.5	500.0	566.5
Ignacio coal field													
Fruitland fm.	11.5	2.4	1.3	15.2	1.7	--	16.9	27.2	30.0	3.0	60.2	603.3	680.4
Colorado total													6,957.9
San Juan Co., N. Mex.													
Menefee fm.	65.5	48.6	84.5	198.6	58.9	4.6	262.1	2.1	19.3	9.6	31.0	1,240.4	1,533.5
Total													8,491.4

TABLE 2. SUBBITUMINOUS COAL RESERVES IN SAN JUAN COUNTY, N. MEX.

(Millions of short tons)

	Measured and indicated							Inferred				Additional inferred	
	Coal less than 1,000 ft below surface				Coal 1,000 to 2,000 ft below surface	Coal 2,000 to 3,000 ft below surface	Total	Coal less than 1,000 ft below surface	Coal 1,000 to 2,000 ft below surface	Coal 2,000 to 3,000 ft below surface	Total	Coal less than 3,000 ft below surface computed on zone basis	Total (All reserves, all thicknesses, all depths)
	Beds exceeding 10 ft in thickness	Beds 5 to 10 ft in thickness	Beds 2.5 to 5 ft in thickness	Total	Beds exceeding 2.5 ft in thickness			Beds exceeding 2.5 ft. in thickness				Beds exceeding 2.5 ft in thickness	
Fruitland fm.	293.8	429.6	782.2	1,505.6	166.5	13.2	1,685.3	2,001.3	1,226.1	1,519.6	4,747.0	9,319.8	15,752.1
Menefee fm.	--	0.8	4.7	5.5	--	--	5.5	--	--	--	--	12,657.2	12,662.7
Total	293.8	430.4	786.9	1,511.1	166.5	13.2	1,690.8	2,001.3	1,226.1	1,519.6	4,747.0	21,977.0	28,414.8

into 13 groups on the basis of the dry mineral-matter-free fixed carbon, the moist mineral-matter-free BTU value, and physical properties. Rank is important in determining the utilization of coal and therefore is used as the prime basis for classification of reserves.

Thickness of Beds

Inasmuch as the thickness of a coal bed is an important factor in mining economy, the reserves are commonly classed in three groups, which range in bed thickness for each rank as indicated in Table 4.

Table 4. **Classification of coal beds in thickness groups**

Coal rank	**Thickness groups**		
	Thin	**Intermediate**	**Thick**
Anthracite	14-28 inches	28-42 inches	More than 42 inches
Semianthracite	14-28 inches	28-42 inches	More than 42 inches
Bituminous	14-28 inches	28-42 inches	More than 42 inches
Subbituminous	2½-5 feet	5-10 feet	More than 10 feet
Lignite	2½-5 feet	5-10 feet	More than 10 feet

TABLE 3 —CLASSIFICATION OF COALS BY RANK.[a]

Legend: F.C. = Fixed Carbon. V.M. = Volatile Matter. Btu. = British thermal units.

Class	Group	Limits of Fixed Carbon or Btu. Mineral-Matter-Free Basis	Requisite Physical Properties
I. Anthracitic	1. Meta-anthracite	Dry F.C., 98 per cent or more (Dry V.M., 2 per cent or less)	
	2. Anthracite	Dry F.C., 92 per cent or more and less than 98 per cent (Dry V.M., 8 per cent or less and more than 2 per cent)	
	3. Semianthracite	Dry F.C., 86 per cent or more and less than 92 per cent (Dry V.M., 14 per cent or less and more than 8 per cent)	Nonagglomerating[b]
II. Bituminous[d]	1. Low volatile bituminous coal	Dry F.C., 78 per cent or more and less than 86 per cent (Dry V.M., 22 per cent or less and more than 14 per cent)	
	2. Medium volatile bituminous coal	Dry F.C., 69 per cent or more and less than 78 per cent (Dry V.M., 31 per cent or less and more than 22 per cent)	
	3. High volatile *A* bituminous coal	Dry F.C., less than 69 per cent (Dry V.M., more than 31 per cent); and moist[c] Btu., 14,000[e] or more	
	4. High volatile *B* bituminous coal	Moist[c] Btu., 13,000 or more and less than 14,000[e]	
	5. High volatile *C* bituminous coal	Moist Btu., 11,000 or more and less than 13,000[e]	Either agglomerating or nonweathering[f]
III. Subbituminous	1. Subbituminous *A* coal	Moist Btu., 11,000 or more and less than 13,000[e]	Both weathering and nonagglomerating
	2. Subbituminous *B* coal	Moist Btu., 9500 or more and less than 11,000[e]	
	3. Subbituminous *C* coal	Moist Btu., 8300 or more and less than 9500[e]	
IV. Lignitic	1. Lignite	Moist Btu., less than 8300	Consolidated
	2. Brown coal	Moist Btu., less than 8300	Unconsolidated

[a] This classification does not include a few coals which have unusual physical and chemical properties and which come within the limits of fixed carbon or Btu. of the high-volatile bituminous and subbituminous ranks. All of these coals either contain less than 48 per cent dry, mineral-matter-free fixed carbon or have more than 15,500 moist, mineral-matter-free Btu.

[b] If agglomerating, classify in low-volatile group of the bituminous class.

[c] Moist Btu. refers to coal containing its natural bed moisture but not including visible water on the surface of the coal.

[d] It is recognized that there may be noncaking varieties in each group of the bituminous class.

[e] Coals having 69 per cent or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of Btu.

[f] There are three varieties of coal in the high-volatile C bituminous coal group, namely, Variety 1, agglomerating and nonweathering; Variety 2, agglomerating and weathering; Variety 3, nonagglomerating and nonweathering.

Thickness of Overburden

Inasmuch as the thickness of overburden resting on the coal bed is important in mining economy, it is customary to classify reserves estimates according to three overburden-thickness groups, which are established as follows: 0 to 1,000 feet; 1,000 to 2,000 feet; and 2,000 to 3,000 feet. Coal beds at depths greater than 3,000 feet are not considered usable reserves at the present time.

Reliability of Data

Three categories of coal reserves are recognized ac-

TABLE 5. AVERAGED ANALYSES OF COAL IN DURANGO AREA

Coal Field	Formation	No. Spls. Averaged	Moisture	Volatile Matter	Fixed Carbon	Ash	As Received B.T.U.
Durango	Fruitland	1	3.1	32.7	47.4	16.8	11,900
Durango	Menefee	10	3.9	37.1	52.2	6.8	13,220
Red Mesa	Fruitland	6	6.1	35.9	45.4	12.6	11,520
Red Mesa	Menefee	5	6.7	38.2	49.2	5.9	12,760
Ignacio	Fruitland	3	3.5	34.0	46.0	16.5	11,700
San Juan Co.	Fruitland	10	8.1	38.6	42.9	10.4	11,600
San Juan Co.	Menefee	5	10.5	38.7	47.0	3.8	11,840

cording to the relative abundance of reliable data concerning their thicknesses and distribution. The categories are as follows:

Measured reserves – Measured reserves are those for which tonnage is computed from measurements at the trenches, mine workings, and drill holes, with points of observation so closely spaced that the estimates are considered accurate to within 20 percent of the tonnage that will be proved by mining development.

Indicated reserves – Indicated reserves are those for which tonnage is computed partly from direct measurements and partly from a reasonable interpretation of such data on geologic evidence.

Inferred reserves – Inferred reserves are those for which tonnage estimates are based largely on geologic information concerning the character and continuity of the beds; the estimates are supported by few and widely spaced points of observation or control.

COAL-BEARING FORMATIONS

Menefee formation

Coal beds are found throughout the Menefee formation, but beds in excess of 1 foot in thickness are generally confined to the upper and lower parts of the formation in the Mesa Verde region (Barnes, Baltz, and Hayes, 1954). Toward the east, as the Menefee formation becomes thinner in the Durango area, these upper and lower coal-bearing zones converge (Zapp, 1949). Farther to the east, in the vicinity of Los Pinos River in eastern La Plata County, the Menefee formation tongues out into the underlying regressive Point Lookout sandstone and into the overlying transgressive Cliff House sandstone (Barnes, 1953). In Colorado the maximum observed thickness of any coal bed in the Menefee is 9 feet (Zapp, 1949), and most beds are less than 5 feet thick.

Coal of commercial thickness but somewhat lower quality (table 5) is present in both the lower and upper parts of the Menefee formation southward in San Juan and McKinley Counties, New Mexico, the lower zone generally being important (Beaumont and O'Sullivan, 1955; O'Sullivan, 1955; Hayes and Zapp, 1955).

Fruitland Formation

The Fruitland formation coal occurs in several zones of decreasing importance upward. The basal zone overlies the regressive Pictured Cliffs sandstone and contains the important "Carbonero" bed, which consists of nearly 80 feet of coal and partings in the vicinity of Durango (Zapp, 1949). Although this is a spectacular maximum thickness, it is not at all unusual to find beds over 20 feet thick in the basal zone (Zapp, 1949; Barnes, Baltz, and Hayes, 1954). The most important coal beds in the Fruitland formation are in La Plata County, but beds up to 15 feet in thickness occur to the east in Archuleta County (Wood, Kelley, and MacAlpin, 1948).

The overall quality of Fruitland coal tends to decrease slightly to the southwest in New Mexico (table 5), but beds of subbituminous coal in excess of 15 feet are common as far south as the San Juan River near Fruitland (Hayes and Zapp, 1955). Although the individual beds tend to be thinner (Beaumont and O'Sullivan, 1955), there are large tonnages of strippable coal in the lower part of the Fruitland formation over a broad area to the south of the San Juan River in San Juan County, New Mexico.