SPECIAL PUBLICATION NO. 9

1975 SUMMARY

OF

COAL RESOURCES IN COLORADO

BY

A. L. HORNBAKER, RICHARD D. HOLT AND D. KEITH MURRAY

COLORADO GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES
STATE OF COLORADO
DENVER, COLORADO

1976

PRICE $1.00

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DEPARTMENT OF NATURAL RESOURCES
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"Provide technical assistance to local governments concerning designation of and guidelines for matters of State interest in geologic hazard areas and the identification of mineral resource areas."

"To provide other governmental agencies with technical assistance regarding geothermal resources."

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PREFACE

This coal summary initially was prepared for the *1976 Keystone Coal Industry Manual*, where it appears as the Colorado Chapter. It includes descriptive material concerning the geology of the coal fields and regions, together with analyses of the various coal seams or groups of coal seams.

This report precedes much more detailed analyses of historical data, geology of the coal fields and regions, and of the total coal resources of the State, to be published later. This summary report, therefore, should serve a present need in providing information on the coal resources of the State not otherwise available.

D. K. Murray prepared the 1975 summary, which is a fairly extensive revision of Colorado Geological Survey Special Publication No. 3, early in 1976 at the request of the publishers of the *Keystone Manuals*. Although the basic format and data used in the original report generally were adhered to in the present revision, the following changes and additions appear in the 1975 update by Murray:

- Addition of an introductory section
- Minor typographical corrections and editorial changes throughout.
- Updating of production data and related statistics, where possible, as of January 1, 1976, for each of the coal-bearing regions.
- A brief discussion of new coal-related industry activity in each applicable region.
- Expanded and updated list of selected references.

It should be emphasized that no attempt was made to revise the coal resource estimates contained in the original version.

ACKNOWLEDGMENTS

The authors are grateful to Joseph Blake Smith, Colorado Liaison Officer of the U.S. Bureau of Mines, Denver, for many helpful suggestions and review of the original manuscript.

Special thanks are due William G. Park, U.S. Bureau of Mines, Washington D.C., for providing data bank information on coal analyses which were otherwise unavailable.

The Colorado Geological Survey expresses its appreciation to George F. Nielsen, Editor-in-Chief, Mining Informational Services, McGraw Hill, Inc., publishers of the *Keystone Manuals*, for permission to reproduce this article in its entirety.

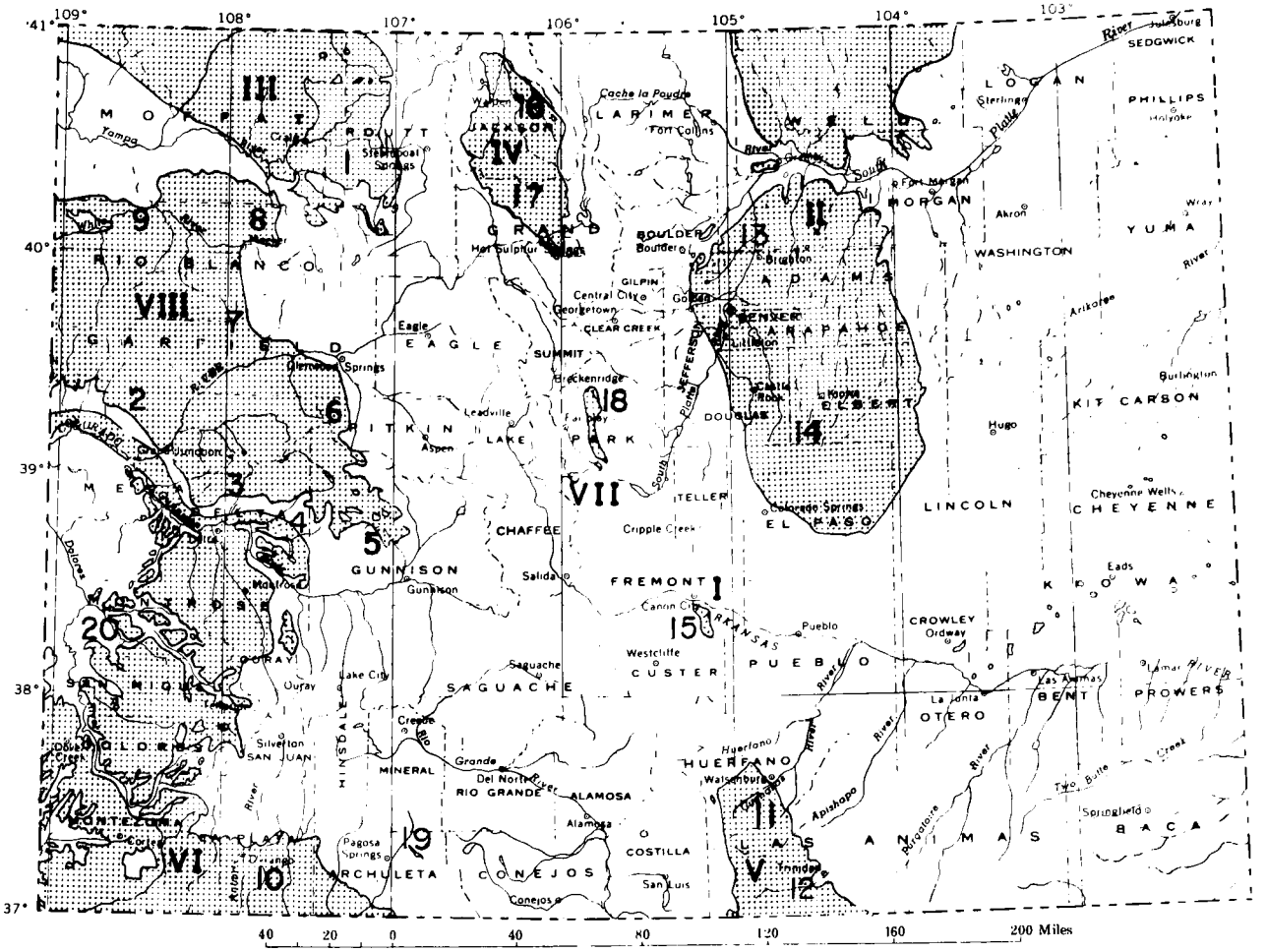
TABLE OF CONTENTS

ABSTRACT

Within the borders of Colorado, and covering approximately 28 percent of the State, occur 8 coal-bearing regions and some 20 coal fields that contain at least 11 percent of the total coal resources of the United States above 6,000 feet. Colorado coals range from early Late Cretaceous to Eocene in age. The higher rank coals, and the largest resources, for the most part are found in the Late Cretaceous sequence (Dakota and Mesaverde Groups) in western Colorado, particularly in the area from Garfield County south to the New Mexico line. The lower rank coals occur in the latest Cretaceous and early Tertiary rocks of the Denver Basin and Green River regions. Colorado coals generally range in rank from high-volatile B bituminous to subbituminous and lignite. In places, igneous intrusions and structural deformation locally have metamorphosed the coal to semianthracite, anthracite, and even to coke. Over 70 percent of the State's coal resources are bituminous in rank, approximately 23 percent are subbituminous, 5 percent lignite, and less than 1 percent anthracite.

Total coal resources of Colorado have been conservatively estimated to be some 230 billion tons at depths to 6,000 feet (over 434 billion tons, according to later figures published in Averitt, 1975 - D.K.M.). In the past 100 years, nearly 600 million tons of coal have been produced in the State. The largest coal resources in Colorado appear to be in the Uinta region (26%), followed by the Green River (25%), Denver Basin (18.5%), North Park (12.5%), and San Juan (11.9%) regions.

1975 SUMMARY OF COAL RESOURCES IN COLORADO



Coal regions and fields in Colorado

COAL REGIONS

I	Canon City
II	Denver Basin
III	Green River
IV	North Park
V	Raton Basin
VI	San Juan
VII	South Park
VIII	Uinta

COAL FIELDS

1.	Yampa
2.	Book Cliffs
3.	Grand Mesa
4.	Somerset
5.	Crested Butte
6.	Carbondale
7.	Grand Hogback
8.	Danforth Hills
9.	Lower White River
10.	Durango
11.	Walsenburg
12.	Trinidad
13.	Boulder-Weld
14.	Colorado Springs
15.	Canon City
16.	North Park
17.	Middle Park
18.	South Park
19.	Pagosa Springs
20.	Nucla-Naturita

Introduction

The largest presently available source of energy in Colorado is its vast deposits of coal, which occur in an area encompassing nearly 30,000 square miles, or approximately 28 percent of the state. Over 434 billion tons of in-place coal resources are believed to remain in Colorado (Paul Averitt, 1975, p. 14) above an overburden thickness of 6,000 feet; this estimate is nearly 11 percent of the total resource for the entire United States and is the fourth largest of all the States. To a depth of 3,000 feet, Colorado's remaining identified coal resources are listed (Averitt, 1975) as nearly 129 billion tons. In terms of remaining identified bituminous coal resources, Colorado ranks second, behind Illinois, but is first in terms of low-sulfur bituminous coal (Averitt, 1975, p. 22). Most (over 80%) of the coal resources of the State are believed to be mineable by underground methods.

Colorado coals range in age from early Late Cretaceous to Eocene, the largest and most widespread resources occurring in the Mesaverde Group (Upper Cretaceous). The marine-influenced (paralic) Cretaceous coals, related to

Revised by D. Keith Murray, Colorado Geological Survey, March 1976. Original text prepared by A.L. Hornbaker and Richard D. Holt.

regressions of the Late Cretaceous seaway, generally are of higher rank and better quality than are the non-marine (limnic) Tertiary coals found in the more restricted Laramide-age structural basins. Of the 8 coal-producing regions in Colorado, the most important from the standpoint both of total in-place resources and present annual production are the Green River-Sand Wash and Uinta-Piceance Creek basins in the northwestern and west-central parts of the state, respectively.

Since 1864, over 596 million tons of coal have been mined in the state, which is less than one year's current output of the entire United States. Colorado's 1975 production was 8,273,515 tons (1.3% of the U.S. total, 9.5% of western U.S. total), which came from 37 mines—22 (or 59%) underground and 15 (or 41%) surface. At the end of 1975, 20 underground and 12 surface mines were operating; one test underground adit was in progress; and 7 underground mines and one surface mine were licensed but produced no coal during the year. Of the 1,975 people employed in Colorado coal mines during 1975 (which was an increase of 365, or 18.5%, over the year before), 442 (or 22.4%) worked in surface mines. Over half (58%) of the State's 1975 production, or 4,807,281 tons, came from surface mines; 3,466,234 tons (42%) was obtained from underground mines. Based on announced new plans by industry, it is reasonable to assume that Colorado's annual coal output will exceed the all-time record of 12.6 million tons, set in 1918, before the end of this decade.

The low sulfur, ash, and moisture content, together with generally high heat values, of the typical coals of this state are resulting in increasing demand for both steam-quality and metallurgical-grade coals. Bituminous coal comprised 94 percent of Colorado's 1975 production; the balance was subbituminous in rank. Over one-third of the coal presently being mined in the State is used for metallurgical purposes. Over two-thirds of the coal now consumed in Colorado is utilized for steam-electric power generation, and the percentage is steadily increasing. Most of the remainder of the coal consumption is for metallurgical and industrial requirements. The rising demand for low-sulfur, high-Btu coal for power-generating and industrial purposes, together with the fact that perhaps 75 percent of our coal resources occur either on private or State-owned land, assure a bright future for the coal industry in Colorado.

Coal-Bearing Areas

Colorado's coal resources occur in diverse physiographic and structural environments. Physiographically they occur in the Great Plains, the Southern Rocky Mountains, the Wyoming Basin, and the Colorado Plateau provinces (Fenneman, 1946). Eight coal regions have been recognized and named by the U. S. Geological Survey and the Colorado Geological Survey.

About 28% of Colorado, roughly 29,600 square miles in 32 counties, is underlain by coal-bearing rocks. These contain approximately 10 percent of the United States original coal resources at depths to 6,000 feet.

The coal regions, alphabetically as shown on the map (Holt; 1972; modified from Landis, 1959), are:

I Canon City	V Raton Basin
II Denver Basin	VI San Juan
III Green River	VII South Park
IV North Park	VIII Uinta

In the major regions the many small coal fields named in early days of development have been grouped into 20 principal coal fields, as in Colorado Geological Survey Bulletin 34-A, and are discussed under the regional headings.

Coal-Bearing Rocks

Colorado's coals occur in rocks of Upper Cretaceous, Paleocene, and Eocene ages. The Cretaceous coals are the most abundant and wide-spread, and are of higher rank than the younger coals. The oldest coals, of Dakota age, occur in the southwest corner of Colorado. Successively younger coals are found northeastward and eastward in formations deposited in coastal swamplands during the irregular withdrawal of the Late Cretaceous interior seas.

The youngest coals occur in the Fort Union and Wasatch Formations of Paleocene and Eocene ages, which were deposited as non-marine sediments in interior basins.

Structural Geology of Coal Regions

The coal fields of the Denver basin, Green River, Raton basin, San Juan, and Uinta regions occur in broad, structurally simple basins which are locally complex, especially at their rims, because of folds, faults and igneous intrusions.

The Canon City, North Park, and South Park regions are in smaller, more complex structural basins.

These structural conditions afford only small areas of moderately dipping coals with overburden shallow enough to permit strip mining. About 95% of Colorado's coal resources must be mined underground.

Rank

In general, the older coals are of higher rank, ranging from high-volatile B bituminous in the Dakota and Mesaverde strata in the San Juan region to subbituminous C and lignite in the youngest Cretaceous and Tertiary of the Denver basin and Green River regions.

Locally, however, structural deformations and igneous intrusions have caused an increase in rank of some coals to anthracite. About 77% of the coal resources are bituminous, 23% subbituminous and less than 1% semianthracite or anthracite.

Some of the older coals of the San Juan and Raton regions have coking properties. So, also, do some of the up-graded coals in the altered beds at the southeast margins of the Uinta region.

Colorado coals generally are nonweathering and most are nonagglomerating. The few areas of coking coals are discussed separately.

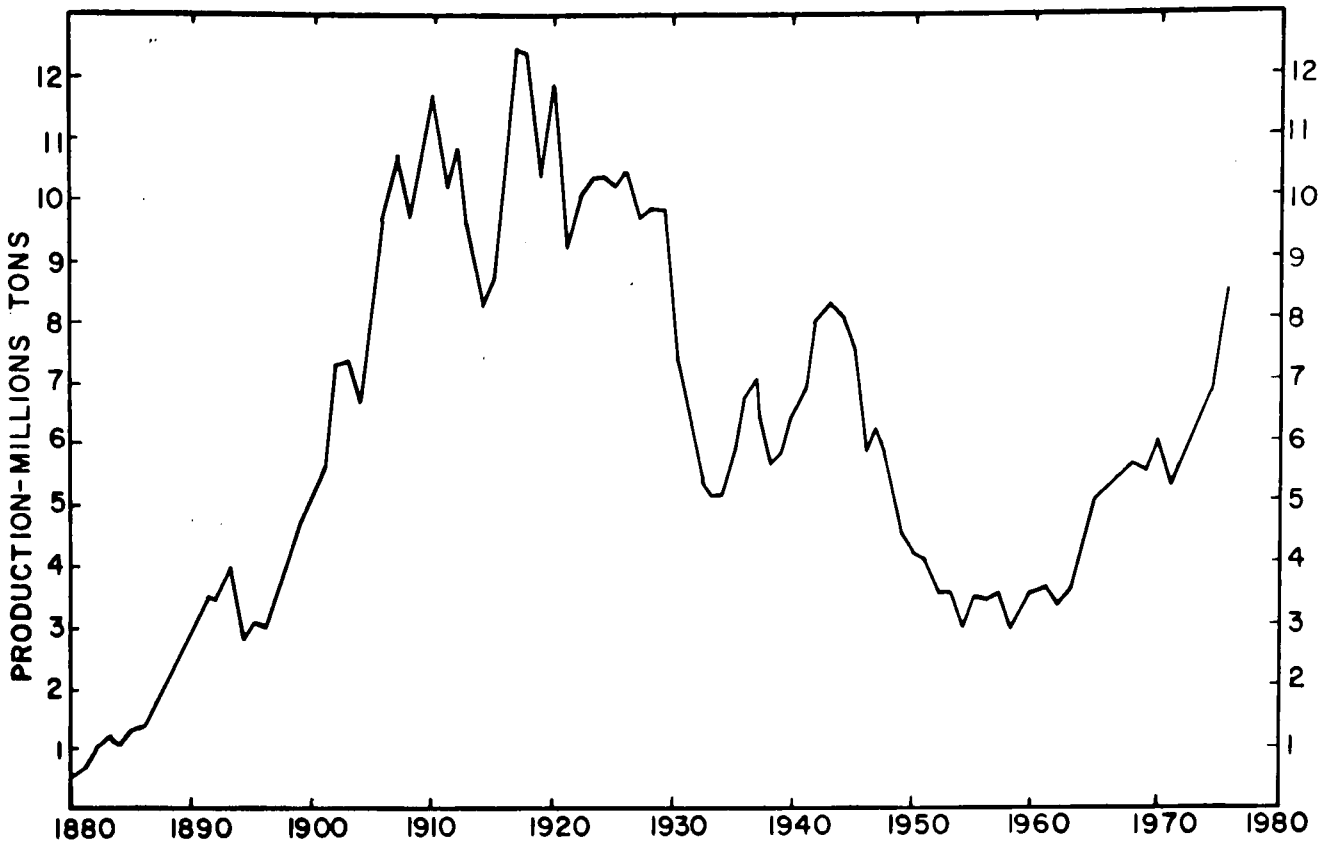
Moisture, Ash, and Sulfur Content

On an as-received basis, the moisture content of most Colorado coals ranges from 1.0% to about 20%; but in a few localities, such as the subbituminous coals near Colorado Springs in the Denver basin, moisture is as high as 35%. From several hundred analyses, an estimated average is about 12%. Ash generally ranges between 2.1% to about 15%, but in a few cases is as high as 29.3%. An estimated average is about 6%.

Colorado coals are mostly low sulfur; more than 99% contain less than 1.0% sulfur, and more than half contain less than 0.7% sulfur. Normal sulfur content varies from 0.2% to about 1.1%, but in some metamorphosed areas, sulfur content locally may be as high as 4.8%. Normal sulfate and organic sulfur content are low. Abnormal pyritic content can be reduced by conventional cleaning or preparation processes. Nearly all can easily be processed to less than 0.5% sulfur.

Washability

Only 14% of Colorado coals were washed in 1974. Most Colorado coals do not require beneficiation other than



COLORADO COAL PRODUCTION, 1880-1975

sizing to meet market demands, usually 2½" x 0". In 13 representative samples, from 0.6% to 3.1% was in 100 mesh to 0 fraction. These fractions showed much higher ash than the whole or any other fraction, from 5.8% to 32.2%, and could easily be eliminated where undesirable. Grindability indices range between 45 and 50.

Heat Values

On a dry, ash-free basis the heat value of most Colorado coals ranges between 14,500 and 13,300 Btu/lb., but some of the subbituminous coals range as low as 11,440 Btu/lb. An estimated average, dry and ash-free, is about 13,950 Btu/lb., or on an as-received basis about 11,370 Btu/lb. Some of the altered coals rank as high as 88% fixed carbon, a true anthracite, but the quantity is insignificant.

Carbonizing Properties

Most Colorado coals are nonagglomerating and may be carbonized in fluidized systems. Chars produced at low temperatures (450°-700°F) contain about 8.5% to 14.4% residual volatile matter and are easily ignited. Char heating values on a moisture-free basis vary from 14,600 to 14,960 Btu/lb. and are suitable for boiler fuel. Lump chars can be produced from most Colorado coals but are relatively weak. Some of the lump chars would be suitable substitutes for coke "breeze" in special uses.

Coking Coal

Good metallurgical coking coals occur in the Durango field in the San Juan region, in the Trinidad field of the Raton region, and in the Crested Butte, Somerset, and Carbondale fields in the southeast Uinta region, and are discussed in the regional descriptions.

Specific Gravity

The lowest specific gravity coal, 1.280, was from the Paonia mine, at Paonia, Delta County, in the southwest Uinta region. The highest, 1.461, was from the Horace mine, at Crested Butte, Gunnison County, in the metamorphosed southeast Uinta region.

Average specific gravity for cleaned bituminous Colorado coal is 1.332, and for subbituminous coal, 1.291. For estimating reserves these values calculate to 1800 T/acre-foot and 1770 T/acre-foot, respectively.

Coal Mining and Production

Recorded production of coal in Colorado, since 1864, totals over 596 million tons. Annual production reached a million tons in 1882 and two million tons in 1888. The peak of 12 million tons in 1910 dropped to 8 million in 1914, but rose to 12½ million tons during the period 1917-1920. The low of 5¼ million tons in 1934 was followed by a peak of more than 8 million tons in the war years of 1942-44. The irregular low production of 3 to 3½ million tons from 1952 to 1963 yielded to mechanization and increased to more than 6 million in 1970, was reduced to 5⅓ million by the strike in 1971, but was over 8.27 million tons in 1975.

Mine prices of coal vary with conditions and quality, from an estimated $5.50 per ton for subbituminous in remote areas to more than $35 per ton for high-grade coking coal, averaging near $7.40 in 1973 and $9.38 per ton in 1974. The 8.27 million tons of coal produced in Colorado in 1975 is valued at $90.2 million (a 28.3% increase over 1974), for an average of $11.00 per ton. This value represents about 10 percent of the value of the State's total mineral production during 1975, the highest on record.

Surface mining of coal began in Colorado around 1909 in the Coalmont area of Jackson County in west central North Park. By 1962, 7 of the State's 117 mines were open pits, which produced 14% of the total from all mines of 3.4 million tons. Since 1962 between 6 and 14 surface mines have been operating in Colorado. During 1975, 15 surface mines (out of a total of 37 mines) were in operation, producing some 4.8 million tons of coal, or 58% of the State's total. Those 15 surface mines employed 442 workers, or 22% of the total. To date, the surface mines in Colorado have produced over 32.77 million tons of coal, or nearly 6% of the state's cumulative production, while temporarily disturbing a total of approximately 4 square miles of land.

The 37 coal mines that were in production during 1975 employed a total of 1,975 workers. At year's end, 20 underground and 12 surface mines were actually in production; 1 underground test adit was licensed; and 7 underground mines and 1 surface mine were licensed but produced no coal during the year. Approximately 94% of the 8,273,515 tons produced in Colorado in 1975 consisted of bituminous coal; the balance was subbituminous in rank. In 1972, according to U.S. Bureau of Mines figures, coal consumption in Colorado was divided up as follows: electric power generation, 65%; industrial usage (steel manufacturing, beet sugar refining, and the like) 31%; and household-commercial usage, 4%.

In 1973, over 1.7 million tons (over 27% of the total production) were shipped out of Colorado; and over 2 million tons of Wyoming coal were transported into Colorado for use in a steam-electric plant in Pueblo. Total daily capacity of all mines in 1973 was 34,316 tons; and daily production per miner averaged 17.5 tons. During 1974, over 2.85 million tons (41% of the production) were exported from Colorado, and 2.68 million tons were imported.

Coal Regions and Fields

For geological considerations, the regions will be discussed in order of the age of the coals, oldest first.

San Juan Region

This region, located in southwest Colorado, includes the north edge of the San Juan basin of New Mexico, the Red Mesa-Mesa Verde platform, and the Cortez saddle and monocline westward toward the Paradox basin in Utah.

During 1975, the San Juan coal region, occupying parts of La Plata and Montrose Counties, Colo., produced 120,770 tons of coal, or 1.5% of the State's total, from one underground and one strip mine employing a total of 30 people.

Dakota Coal Sub-Region

The Dakota Sandstone and associated coals are known to be present in the Colorado portion of the San Juan basin at depths of 3,000 to 8,000 feet and are not presently considered recoverable. In the narrow Dakota outcrop along the Hogback near Durango, a few small areas of coal are mined. These are discussed in the Durango field section.

Coals occur in many places in the Dakota outcrop area west of Mesa Verde National Park and northward from Cortez to the Colorado River near Grand Junction. In some areas the coal is thick enough and clean enough to have been mined. Generally these coals are thin and discontinuous and mostly of poor quality because of high ash content. These Dakota coals have considerable range in rank but generally are high-volatile C and B bituminous.

The range of analyses from uncorrelated Dakota coal seams from 4 mines northeast of Cortez, with thicknesses ranging from 2′8″ to 4′8″, is as follows:

As-received basis	*Range of analyses*
Moisture	1.9-8.1%
Ash	5.0-18.3%
Sulfur	.5-.8%
Btu/lb.	10,440-13,630
Fus. temp., °F.	2,110-2,910+

The New Mexico Bureau of Mines Memoir 25, 1971, reporting on recent exploration and coring in T 36-37 N, R 14-16 W, east and northwest of Cortez, indicates a reserve of 158.8 million tons of Dakota coal in fairly continuous seams 3 to 13 feet thick in a 34-square-mile area. A total of 119 million tons of this coal is considered strippable under less than 150 feet of overburden. This is a non-coking high-volatile C bituminous coal with fairly high ash and 0.7% sulfur.

In the Nucla-Naturita area of western Montrose County, where the Peabody Nucla multiple-bench strip mine supplies coal to the Nucla power plant south of Uravan, there are three mineable seams 3 to 5 feet thick, with the middle, or "No. 1" seam, the most important. The analyses from three mines in the area average:

As-received basis	*Average of analyses*
Moisture	2.5-13.5%
Ash	6.1-12.8%
Sulfur	.5-1.1%
Btu/lb.	10,010-13,380
Fus. temp., °F.	2,620-2,910+

If 10% of the 5,000 square miles of coal-bearing strata contains coals half as good as the average 5.5 million tons per square mile found in the 50 square miles of explored area, a total of 1,375 million tons of Dakota coal at less than 3,000 feet depth may underlie this sub-region. Exploration for these scattered mineable areas will be difficult.

The Nucla strip produced 104,980 tons of coal in 1975, using 21 workers.

Durango Field

In earlier reports, the Colorado portion of the San Juan region has been divided into the Durango field area, the "hogback", the Red Mesa area (or Hesperus field), and the Mesa Verde area, which includes the National Park and the Mesa area south and west of Durango.

In Colorado Geological Survey Bulletin 34-A (1972), all of these are included in the newly defined "Durango field". This field includes all of the Colorado portion of the San Juan basin and stretches from near Cortez on the west to east of Pagosa Springs on the east.

Coals are included in three horizons of Upper Cretaceous age: the Dakota, the Menefee Formation of the Mesaverde Group, and the younger Upper Cretaceous Fruitland Formation.

The Dakota Formation crops out along the outer rim of the hogback in Archuleta and La Plata Counties. These Dakota coal seams are fewer, thinner, dirtier, and are more discontinuous than those found in areas to the south and west, and constitute about a 5-million-ton resource.

The Menefee coals are best developed from approximately 10 miles east of Durango westward. They occur in three distinct groups, the "middle group" being relatively unimportant. The lower 60 feet of the formation form the "lower group", and the upper 200 feet form the "upper group". The Menefee coals are high-volatile A and B bituminous rank and are of coking quality in structurally complex areas near Durango.

Historically, more than 50 mines have operated in the Durango coal field. However, only 14 mines have operated in recent years, all of them mining Menefee coals in the Hesperus area, west of Durango. During 1975, only one underground mine was in operation in this field, producing 15,790 tons of coal and employing 9 people. This coal is used for electric power generation at the Durango power plant and for domestic purposes. Range-of-analyses of the coals, 3′2″ to 6′7″ thick, from the mines in the Durango

field, 3 in the "Hesperus seam" and 7 "undesignated", are as follows:

As-received basis	*Average of analyses*
Moisture	1.6-10.7%
Ash	3.4-16.6%
Sulfur	.6-1.2%*
Btu/lb.	10,860-14,070
Fus. temp., °F.	2,020-3,000

* Local pyritization in one mine caused up to 4.7% sulfur in one mine-run sample.

In about 40% of the 2,200 square-mile area of the Durango field there are 9,634 million tons of coal identified under less than 3,000 feet of overburden (Landis, 1959). Total additional coal inferred on a zone basis, in the field, is estimated to be about 11,080 million tons. Also, in an area of approximately 400 square miles below the hogback at depths from 3,000 to 6,000 feet, an additional 5,200 million tons are estimated from well-log data.

The Durango field, therefore, is believed to have had approximately 25,914 million tons of coal originally in place to a depth of 6,000 feet. Adding the estimated 1,375 million tons of Dakota coal area to the northwest, the San Juan region coal resources total about 27,300 million tons.

Uinta Region

The coal fields of the Colorado portion of the Uinta Region are found on the moderately to steeply dipping flanks of the Piceance Creek basin, which is a southeastward extension of the Uinta basin of Utah.

This simple synclinal structure is modified by folds, faults, and intrusions along the margins, creating areas of considerable structural complexity. The southeastern part of the Uinta region, in Gunnison County, in which these conditions have increased the rank of some of the coals to anthracite, is considered as a southeastern sub-region for separate discussion. This then separates a Northeastern sub-region and a Southwestern sub-region in which the coals are not metamorphosed.

The Uinta region, which includes parts of Delta, Garfield, Gunnison, Mesa, Pitkin, and Rio Blanco Counties, Colo., produced 2,306,410 tons of coal (27.9% of the state's total) in 1975 from 16 underground mines employing 950 people. Over 95% of this this output is sold as metallurgical-grade coal to steel mills in Provo, Utah and Fontana, California.

Southwest Uinta Sub-Region

This sub-region is an easterly extension of the Book Cliffs field of eastern Utah. It extends to the Colorado River near Grand Junction and continues along the rim of Grand Mesa southeast to about 10 miles west of the Gunnison County line near Paonia. It also includes an outlier 40 miles southeast of Paonia, near Montrose, known as Tongue Mesa coal field.

Book Cliffs Field

On the southwest rim of the Piceance Creek basin the Upper Cretaceous coal-bearing formations generally are nearly flat-lying, but locally are complexly tilted and faulted. Some high-volatile B bituminous coal is found, but most of the coal is high-volatile C bituminous.

These coals occur in three important zones in the Mount Garfield Formation of the Mesaverde Group and in the Anchor tongue of the upper Mancos Shale along the western edge of the basin. Because of the eastward withdrawal of the Upper Cretaceous sea, all of these coals are younger "Mesaverde" than the Menefee Formation coals at Durango, and are roughly time-equivalents of the Fruitland coals of the San Juan region.

The "Anchor seam", the lowest coal, is in a tongue of the Mancos shale. It is 6'2" thick in the Nearing (Farmer's) mine 20 miles northwest of Grand Junction, and has the following analysis:

As-received basis	*Range of analyses*
Moisture	8.2-9.8%
Ash	5.9-9.8%
Sulfur	1.0-1.7%
Btu/lb.	11,910-12,330
Fus. temp., °F.	2,190-2,790

The "Palisade seam", which may be any of several singly occurring seams in the "Palisade zone" at the base of the Mount Garfield Formation, occurs throughout the Book Cliffs field, with increasing importance eastward. Usually only one seam of mineable thickness occurs in this zone in any one locality. A composite of analyses of this coal from several mines in seams from 2'8" to 9'4" thick is as follows:

As-received basis	*Range of analyses*
Moisture	3.3-14.0%
Ash	4.9-17.4%
Sulfur	.5-1.6%
Btu/lb.	10,950-13,560
Fus. temp., °F.	2,130-2,910+

In the western part of the field the **"Carbonera seam"**, which includes any seam in the "Carbonera zone" or "middle zone", has a thickness from 7'6" to 8'6" and a range of analyses as follows:

As-received basis	*Range of analyses*
Moisture	9.3-11.4%
Ash	7.2-14.4%
Sulfur	.4-.6%
Btu/lb.	10,470-11,150
Fus. temp., °F.	2,850

In the eastern part of the field the **"Cameo seam"**, or seams in the "Cameo zone", have accounted for more than two-thirds of the Book Cliffs field production to date. This seam ranges in thickness from 3'6" to 10'5" and has the following range of analyses:

As-received basis	*Range of analyses*
Moisture	5.4-11.5%
Ash	5.2-15.5%
Sulfur	.5-1.3%
Btu/lb.	10,410-12,460
Fus. temp., °F.	2,520-2,960

Coal originally in place, identified in 255 square miles of the Book Cliffs field were estimated to be 2,293 million tons (Landis, 1959). In an additional 145 square miles these coal zones at depths to 3,000 feet are estimated to contain a possible resource of about 1,300 million tons of coal. In an additional area of about 400 square miles, with the coal zones at depths between 3,000' and 6,000', a possible resource of up to 3,600 million tons may be present. This indicates a total resource of coal in place of about 7,193 million tons in the Book Cliffs field to a depth of 6,000 feet.

One mine, near Cameo, 15 miles east of Grand Junction, produced over 75,700 tons of coal in 1975, which provided part of the fuel requirements of the nearby Cameo power plant.

Grand Mesa Field

The Grand Mesa coal field is southeast of Grand Junction. The younger "Mesaverde" coal zones of the Mount Garfield Formation continue southeastward, and the coal seams become more numerous. These coals are of slightly lower rank, grading from high-volatile C bituminous to subbituminous A. Correlation of 6 to 8 fairly persistent seams, all in the Paonia shale member, has been attempted. These letter upward from "A" to "F" in various localities, or locally are numbered "#1 and #2". The lowest seams are the most persistent and productive. There are usually not more than 2 or 3 seams or mineable thickness in any one locality.

These coals are so similar in composition that one composite analysis can represent all of them, ranging from 4'6" to 14'0" in thickness:

As-received basis	*Range of analyses*
Moisture	9.8-20.0%
Ash	2.1-16.1%
Sulfur	.5-1.8%
Btu/lb.	9,360-11,670
Fus. temp., °F.	2,060-2,970

Identified resources originally present in 96 square miles of the Grand Mesa field were 1,569 million tons (Landis, 1959). Only 139 million tons are high-volatile C bituminous, the rest being subbituminous A. These coal zones should be present in an additional 184 square miles at depths to 3,000 feet with possibly 3,086 million tons of coal. Approximately 250 additional square miles could possibly contain as much as 4,000 million tons of coal in seams more than 5 feet thick to depths of 6,000 feet. The Grand Mesa field total coal resources in place to 6,000 feet depth may be as much as 8,655 million tons, with about 9% being high-volatile C bituminous and the rest subbituminous A rank. Two small underground mines in Delta County produced only 642 tons of coal during 1975.

Tongue Mesa Field

Forty miles southeast of the Grand Mesa field, beyond the Black Canyon of the Gunnison, on Cimarron Ridge between the Uncompahgre River and Cimarron Creek, is Tongue Mesa. This physiographic feature is an outlier of Upper Cretaceous age coal-bearing rocks capped and preserved by late Upper Cretaceous volcanics. The coal-bearing rocks correlate with those of the Grand Mesa section to the northwest and with the San Juan basin section to the southeast.

Near the top of the mesa is a 900-foot-thick coal-bearing section that correlates with the Fruitland-Kirtland Formation of the San Juan basin and with the Paonia shale in the Grand Mesa area. Outcrops are badly obscured by landslides and talus, but 3 or more coals occur in the lower half with easterly dips of about 2 degrees.

The principal and most persistent coal, the Cimarron (or Lou Creek) seam, is from 8 to more than 40 feet thick, and has been mined on both sides of the ridge. Several other mines have operated in stratigraphically higher seams 5 to 7 feet thick. The coal is subbituminous B in rank. Some of the coal is considerably oxidized, and much of it is bony. Because of difficult access, this coal does not compete with the better coals of the Somerset field which are used in the Jim Bullock electric power plant at Montrose, only 15 miles away. Range of analyses:

As-received basis	*Range of analyses*
Moisture	14.2-16.0%
Ash	6.7-8.4%
Sulfur	.5-.9%
Btu/lb.	9,350-10,220
Fus. temp., °F.	2,450-2,480

In 58 square miles of the Tongue Mesa field surveyed, Landis (1959) reported an estimated 2,355 million tons of coal originally in place. More recent studies and coring indicate that the original resource could be estimated as high as 4,000 million tons. Since only underground mining is feasible in these thick seams, only about 1/6 to ¼ of the coal is recoverable.

The total coal resources to 6,000-foot depth in the Southwest Uinta sub-region, in the Book Cliffs field, Grand Mesa field, and Tongue Mesa field, can be estimated at about 19,850 million tons, with roughly the west half being high-volatile B and C bituminous coal and the eastern half subbituminous A and B coal. No mines presently are active in Tongue Mesa field. However, some exploratory and evaluation drilling has been carried out by at least two companies in the past year or so.

Southeast Uinta Sub-Region

This sub-region, where the Cretaceous-age coals have been increased in rank by low-order metamorphism caused by structural deformation and igneous intrusion, has had development in three recognized fields: Somerset, Crested Butte and Carbondale.

Somerset Field

The younger "Mesaverde" coals in the Bowie shale member, or "lower group", and the Paonia shale member, or "upper group", are well developed at outcrops along the valley of the North Fork of the Gunnison River and its tributaries near Somerset in western Gunnison and eastern Delta Counties. These are high-volatile C and B bituminous coals. In the eastern half of the field the coals are moderately to strongly coking. Three large mines and one smaller mine along the railroad in the main valley produced nearly 1.3 million tons of coking coal in 1975.

In the western edge of the field 3 or 4 uncorrelated seams in the Bowie shale member have been mined. Also, 2 or 3 uncorrelated seams in the Paonia shale section have been mined and are of lower rank than the Bowie coals, as indicated in the following range of analyses:

Bowie shale, "lower group" coals: Mined seams range in thickness from 8'6" to 17'8".

As-received basis	*Range of analyses*
Moisture	7.4-13.6%
Ash	2.4-11.4%
Sulfur	.5-.8%
Btu/lb.	10,040-12,600
Fus. temp., °F.	2,470-2,810

Paonia shale, "upper group" coals: Mined seams range in thickness from 12'0" to 13'0".

As-received basis	*Range of analyses*
Moisture	10.6-22.4%
Ash	4.3-13.9%
Sulfur	.3-.8%
Btu/lb.	8,160-10,610
Fus. temp., °F.	2,910+

In the center of the field, at Somerset, two main seams are mined from the Bowie group, the "lower" or "B" seam (also called Somerset, Juanita, and King) and the "upper" or "C" seam. These seams range in thickness from 5'8" to 25'0", and are of fair to good coking quality. A range of analyses can apply to both "B" and "C" seams of the Bowie group:

As-received basis	*Range of analyses*
Moisture	2.3-8.2%
Ash	2.8-12.0%
Sulfur	.4-.7%
Btu/lb.	12,070-13,900
Fus. temp., °F.	2,220-2,910+

In the eastern part of the field, the "D" or Oliver seam and the "E" or "Hawks Nest" seam are identified in the Paonia or "upper" group. Mined seams range in thickness from 7'0" to 10'0". These, too, are of coking quality, and a range of analyses representative of both seams is as follows:

As-received basis	*Range of analyses*
Moisture	4.2-8.1%
Ash	2.8-10.4%
Sulfur	.4-.9%
Btu/lb.	12,090-13,400
Fus. temp., °F.	2,150-2,910+

Estimated resources identified in 133 square miles of the Somerset field are 3,348 million tons of bituminous coal (Landis, 1959), about one half of which is high-volatile B bituminous and of coking quality. To a 3,000-foot depth, an additional area of about 87 square miles could add as much as 2,190 million tons to the resources.

The complex structural nature of the field and the uncertainties of the stratigraphic section dictate a conservative estimate of additional resources to a 6,000 foot depth. It is possible that in another 100 square miles in the Somerset

field, 2,000 to 2,500 million tons of good bituminous coal could be present at depths to 6,000 feet. Field total then could be as much as 8,038 million tons originally in place to this depth.

Crested Butte Field

This field is in the southeast end of the Piceance Creek basin, where the coal-bearing "Mesaverde" strata have been folded, faulted, and intruded by ingeous rocks. South of the town of Crested Butte, the coals are increased in rank through metamorphism to high-volatile C and B bituminous and are of good coking quality. North and west of town, the coals are metamorphosed to semi-anthracite and anthracite.

Six correlated coal seams are all in the Paonia shale (upper) group. Analyses of the coal seams, numbered upward stratigraphically, are recorded from 4 mines in the "#1" seam, 9 mines in the "#2" or "Kubler" seam, 6 mines in the "#3" seam, and one each identified as "#4", "#5", and "#6" seams. Some "#1" and "#2" seams, where altered to anthracite, were worked in thicknesses as low as 2'3" to 3'2". Most other seams were mined in 4'0" to 8'8" thicknesses, and "#3" seam had a maximum thickness of 13'10". A representative range of analyses for the six seams is:

As-received basis	*Range of analyses*
Moisture	2.5-13.3%
Ash	3.2-9.1%
Sulfur	.4-1.9%
Btu/lb.	11,400-14,170
Fus. temp., °F.	2,130-2,480

About 15% of the measured and indicated coal reserves are semianthracite or anthracite. An estimated 244 million tons of coal were present in 35 square miles surveyed (Landis, 1959). In the remaining 155 square miles of the field, with coal seams occurring to a depth of 3,000', an additional 1,000 million tons may be present. Probably not more than 50 additional square miles contain an estimated 320 million tons of coal to depths of 6,000', making a field total of approximately 1,564 million tons. One small mine operated in the "#2" seam in this field in 1975, producing less than 3,000 tons.

Carbondale Field

This field is transitional from the highly faulted, folded, and intruded coal sections of the Crested Butte field northward to the steeply west-dipping monocline on the southeast rim of the Piceance Creek basin near Glenwood Springs.

These younger "Meseverde" coal-bearing rocks seem to correlate roughly with the upper part of the Iles Formation, and the lower part of the Williams Fork Formation of the Grand Hogback and the Meeker area to the north.

In the southern half of the field the coals are metamorphosed to high-volatile A and medium-volatile bituminous and, locally, to semianthracite and anthracite. The bituminous coals are moderately to strongly coking. In the northern part of the field most of the coals are high-volatile B bituminous and non-coking.

The lowest coal, the "Black Diamond" seam, occurs in the Glenwood Springs area and may be equivalent to the Black Diamond group at the top of the Iles Formation in the Meeker area. Seam thickness ranges from 4'0" to 16'0". Range of analyses of "Black Diamond" coal is:

As-received basis	*Range of analyses*
Moisture	11.1-14.1%
Ash	2.1-9.2%
Sulfur	.5-1.4%
Btu/lb.	10,360-12,310
Fus. temp., °F.	2,210-2,470

The 6 Williams Fork coals, correlative with the "Fairfield group" in the Meeker area, are lettered and named upward, "A", "B", "C", "D", "Allen", and "Anderson". The "D", "Allen", and "Anderson" seams, the most persistent and the highest in quality, have been mined the most. Thickness of mined seams ranges from 4'0" to 11'6". The following range of analyses applies to the 3 seams where they are relatively little affected by metamorphism:

As-received basis	*Range of analyses*
Moisture	3.8-7.5%
Ash	1.9-10.5%
Sulfur	.4-1.5%
Btu/lb.	11,840-13,530
Fus. temp., °F.	2,160-2,840

Mined seams are from 4'0" to 11'5" thick. Range of analyses of the "A", "B", and "C" seams in the same area is:

As-received basis	*Range of analyses*
Moisture	5.1-8.9%
Ash	3.5-16.2%
Sulfur	.6-2.1%
Btu/lb.	10,160-12,820
Fus. temp., °F.	2,690-2,790

In the area of Coal Basin and southward, the upper group of coals is altered to semianthracite and anthracite. The seams mined in this area are the "Allen" ("Sunshine"), the "B" or coalesced "A" and "B" seams, the "Placita" seam and the "Coal Basin" seam, which may correlate with the "D" or the "Anderson" seam. The mined seams range in thickness from 3'2" to 11'6". A range of analyses for these metamorphosed seams is as follows:

As-received basis	*Range of analyses*
Moisture	1.0-3.4%
Ash	3.4-10.0%
Sulfur	.5-.7%
Btu/lb.	12,470-15,190
Fus. temp., °F.	2,150-2,370

Only 7% of the coal in the Carbondale field is anthracite. At least 50% of the bituminous coal is of coking quality. In 34 square miles of the field, "measured and indicated" coal in place was estimated at 1,136 million tons (Landis, 1959; and Donnell, 1962). The same coal strata occur in an additional 56 square miles to depths of 3,000' containing an estimated 1,870 million tons of coal. Similar coals at depths from 3,000' to 6,000' may underlie an additional 75 square miles, with a potential of 2,200 million tons.

Total resources originally in place in the Carbondale field area to a depth of 6,000', therefore, may be as much as 5,206 million tons of coal. Five relatively large underground mines in the Coal Basin field near Redstone, in Pitkin County, produced 926,546 tons of coking coal in 1975. Two old underground mines are being rehabilitated in the Thompson Creek area west of Carbondale. The new mines are expected to be producing metallurgical-grade coal sometime during 1976. One small underground mine in Garfield County, southwest of Glenwood Springs, produced less than 1,300 tons of coal in 1975.

The combined total resources for the Southeast Uinta sub-region, including the possible 1,564 million tons in the Crested Butte field and 8,038 million tons in the Somerset field, may originally have been as much as 14,800 million tons of Cretaceous-age coal.

Northeast Uinta Sub-Region

This sub-region includes the Cretaceous-age coal-bearing rocks along the Grand Hogback on the east edge of the Piceance Creek basin northward from Glenwood Springs to Meeker, and along the north rim of the basin westward to the Rangely area. Although folding and some faulting have tilted the strata to near-vertical in part of the area, the coals have not been metamorphosed to higher rank.

Grand Hogback Field

The "Mesaverde" coal-bearing rocks are exposed, with some very steep dips in the monoclinal fold forming the east rim of the Piceance Creek basin. In the southern part

of the field, the coals are mostly high-volatile B bituminous; but in the northern part, mostly high-volatile C bituminous. All are non-coking.

The coals of the "lower group" or "Black Diamond" group, at the top of the Iles Formation, are too thin and discontinuous to be of much importance. The "Black Diamond" coal, locally 8'10" thick where mined in the Rifle area, has the following analysis:

As-received basis	*Range of analyses*
Moisture	9.2%
Ash	3.7%
Sulfur	.6%
Btu/lb.	11,970
Fus. temp., °F.	2,210

Most of the coal in the Grand Hogbank field has been mined from nine seams in the "middle group" in the lower 2,500 feet of the Williams Fork Formation. These seams correlate with the "Fairfield group" in the Meeker area. In this area, they are identified in ascending order as the "A", "B", "C", "D", "Allen", "Anderson", "Wheeler", "E", and "F" seams.

The "Wheeler seam", 14'0" to 18'0" thick, is of major importance, with the range of analyses as follows:

As-received basis	*Range of analyses*
Moisture	3.4-8.3%
Ash	4.9-11.3%
Sulfur	.3-.8%
Btu/lb.	11,220-13,120
Fus. temp., °F.	2,130-2,620

The "Allen seam", where thickness ranges from 5'6" to 15'6", was a major producer. Average analyses are as follows:

As-received basis	*Range of analyses*
Moisture	3.5-10.7%
Ash	3.9-7.9%
Sulfur	.4-.5%
Btu/lb.	11,600-13,270
Fus. temp., °F.	2,060-2,370

The other seven identified seams in various mines range from 4'3" to 9'0" in thickness and are quite similar, with the following range of analyses:

As-received basis	*Range of analyses*
Moisture	2.9-10.5%
Ash	2.3-11.0%
Sulfur	.4-1.1%*
Btu/lb.	11,100-13,060
Fus. temp., °F.	2,090-2,910+

* In one mine, along a fault zone at Harvey Gap, ash was as high as 16.3% and sulfur as high as 2.6%.

An "upper zone", the "Keystone zone", about 1,000 feet higher in the Williams Fork Formation, probably correlates with the "Goff group" or the "Twenty mile zone" in some of the areas to the north. Four seams recognized in this zone are named in ascending order, "Keystone #4", "Keystone #3", "Keystone #2," and "Keystone #1". All are thin seams with a range of thickness from 3'6" to 4'6". Coals from these seams are quite similar, and a range of analyses is as follows:

As-received basis	*Range of analyses*
Moisture	3.7-10.3%
Ash	5.4-9.2%
Sulfur	.3-.4%
Btu/lb.	11,020-13,120
Fus. temp., °F.	—

In the 43 square miles of the field surveyed, 885 million tons of coal were identified (Landis, 1959). These same coals underlie another 37 square miles at depths to 3,000 feet, with possible resources of about 760 million tons. At depths from 3,000 to 6,000 feet, under an additional 80 square miles, as much as 1,450 million tons of coal may be present. Total coal in the field originally in place to a depth of 6,000 feet is estimated at 3,095 million tons. One small mine, 7 miles west of New Castle, produced only 540 tons of coal during all of 1975 with one miner.

Danforth Hills Field

This field stretches for nearly 30 miles along the northeast side of the Piceance Creek basin northwest of Meeker. The strata dip to the southwest, but the regional dip is interrupted by several local, gentle anticlinal structures.

The lower part of the "Mesaverde" is the Iles Formation and the upper part is the Williams Fork Formation.

A "lower coal group" is present near the base of the Iles Formation. The "Black Diamond group" occurs near the top of the Iles. The "Fairfield" coal group is near the base of the Williams Fork Formation. The "Goff group" occurs roughly 1,000 feet above the "Fairfield group". The "Lion Canyon group" occurs about 1,000 feet still higher in the section. Seams are quite discontinuous in all groups, so they are not generally correlated.

No analyses were available for any coals in either the "lower group" of the Iles Formation, or for the "Goff group" of the Williams Fork Formation.

Range of analyses for coal seams in the "Black Diamond" group, from 5'1" to 18'1", which have been mined is as follows:

As-received basis	*Range of analyses*
Moisture	9.2-13.4%
Ash	3.7-10.0%
Sulfur	.4-.6%
Btu/lb.	11,220-11,970
Fus. temp., °F.	2,210-2,990

In the Williams Fork Formation, seams in the "Fairfield group" from 6'8" to 22'3" thick have been mined, with the following range of analyses:

As-received basis	*Range of analyses*
Moisture	9.4-14.4%
Ash	2.2-9.6%
Sulfur	.3-.9%
Btu/lb.	10,600-11,370
Fus. temp., °F.	2,310-2,730

Seams from 4'2" to 34'0" thick were mined in the "Lion Canyon" group, with the following range of analyses:

As-received basis	*Range of analyses*
Moisture	8.9%-15.5%
Ash	2.2-9.6%
Sulfur	.5-1.4%
Btu/lb.	10,690-11,790
Fus. temp., °F.	2,210-2,910+

Mines at the north edge of the field, near Axial, have mined the "Collum seam", which may correlate with the "Goff group" or the "Lion Canyon group". These coals ranged in thickness from 6'0" to 28'9", with the following range of analyses:

As-received basis	*Range of analyses*
Moisture	11.4-15.4%
Ash	2.2-6.3%
Sulfur	.3-1.0%
Btu/lb.	10,140-11,770
Fus. temp., °F.	2,220-2,480

These coals are generally high-volatile C bituminous in rank, but some of the younger coals in the northern part may be subbituminous. All are non-coking.

Original identified reserves of bituminous coal amounted to 7,854 million tons in 252 square miles of the field (Landis, 1959). To a depth of 3,000' in an additional 18 square miles, another 560 million tons may be present. Basinward, in an additional 140 square miles, as much as 2,100 million tons of these coals may be present to depths between 3,000' and 6,000'. Total coal originally in place 10,514 million tons.

No railroad service reaches this area and development has been limited. One small mine, now idle, located 7 miles northeast of Meeker, produced 2,871 tons in 1975.

Lower White River Field

The Lower White River field embraces an area from T 5 N, R 97 W, to the Utah state line, around Rangely oil field and southward to T 3 S in the Douglas Creek drainage area. The coal-bearing "Mesaverde" Formation crops out along the north rim of the Piceance Creek basin west of the Danforth Hills.

All coals investigated in this field are in the Williams Fork (upper) member of the "Mesaverde", but some Iles (lower) coals may be present. Mines operated southeast of Rangely in seams from 8′0″ to 12′3″ thick mined high-volatile C bituminous coal with the following range of analyses:

As-received basis	*Range of analyses*
Moisture	11.2-14.1%
Ash	4.4-8.5%
Sulfur	.4-.5%
Btu/lb.	10,800-11,230
Fus. temp., °F.	2,280-2,900

About 7,013 million tons of coal were estimated to have been originally present in 553 square miles of this coal field (Landis, 1959). In an additional 177 square miles as much as 2,250 million tons may be present at depths to 3,000′. Under an additional 200 square miles, at depths between 3,000′ and 6,000′, possible resources of 2,500 million tons may be present. The coal originally in place in this field to a depth of 6,000 feet may total as much as 11,763 million tons.

In the Northeast Uinta sub-region, from Glenwood Springs north and west to the Colorado-Utah state line, a total of about 25,370 million tons of coal are estimated to have been originally in place to a depth of 6,000′, by fields as follows:

Grand Hogback	3,095 million T.
Danforth Hills	10,514 million T.
Lower White River	11,762 million T.
Total	25,371 million T.

Green River Region

The Colorado part of the Green River region of northwest Colorado is the southeast-trending extension of the Washakie basin of Wyoming. That part of this structural basin lying south of the Cherokee Ridge, along the Colorado-Wyoming line, is termed the Sand Wash basin.

The Green River coal region, in Moffat and Routt Counties, produced 4,583,100 tons of coal in 1975, which amounts to 55.4% of Colorado's total. This production came from 7 surface and 2 underground mines employing 421 people.

Yampa Field

Coal-bearing Cretaceous, Paleocene, and Eocene formations which crop out along the Yampa River drainage area constitute the Yampa coal field, the only one in the Colorado portion of the region. The Denver and Rio Grande Railroad probably was largely responsible for development of the field.

Relatively gentle local folding along the south edge of the basin grades into more complicated structures eastward. On the southeast and east rims of the basin, local folding is complex and complicated by faulting and minor intrusives. Locally, the intrusives and structural deformation have increased the rank of the coals to anthracite.

The "Mesaverde" coals occur in the Iles and Williams Fork Formations. Coals in the lower Iles are rare, but a few occurrences in the western part of the Yampa coal field indicates possible maximum development of that zone under deep cover in a southwesterly direction.

Coals in the upper Iles, correlated with the "Black Diamond group" of the Danforth Hills, are of major importance in the extreme southeast area near Oak Creek. "Seams" or "zones" number "1", "2", and "3" were correlated in the Oak Creek area. In later studies, "2" and "3" were correlated with "A" and "B" seams of a master lettered correlation which extends from "A" to "S" for the entire Yampa field. The "1" seam also is called "Brooks" and "Curtis". The "2" or "A" also is called "Pinnacle seam" in this area. Higher "seams" or "zones" "C", "D", and "E", also in the Black Diamond group, occur with increasing importance westward and to the north. In those directions "B" or "3" is also "Bear River seam" and "Sun mine seam", and "C" is also "Webber", "Butcher Knife", and "Rice mine" seam. These "Black Diamond group" coals generally are absent in the west half of the field. Mined seams range from 3′8″ to 12′4″ in thickness, with the following range of analyses:

As-received basis	*Range of analyses*
Moisture	6.3-12.2%
Ash	4.3-11.3%
Sulfur	.3-.9%
Btu/lb.	11,090-12,560
Fus. temp., °F.	2,250-2,780

Most of this group, where not metamorphosed, is non-coking high-volatile C bituminous coal.

Coals in the lower part of the Williams Fork Formation constitute the "middle group", with seams "F" through "J", correlating with the "Fairfield group" in the Meeker area. Here the "H" is also called the "Wolf Creek seam", "I" the "Wadge", and "J" the "Lennox seam", with these names more common than the letters. The "F" and "G" zones, 10 to 16 feet thick locally, include multiple seams in the western part of the field. These named seams are generally the most important seams throughout the field.

Where mined east of Hayden, ranges in thickness for the same are: "Wolf Creek", 8′7″ to 18′7″; "Wadge", 4′6 to 11′9″; "Lennox", 3′0″ to 6′0″. South of Craig and east of Hamilton, in the Williams Fork Mountains area, the "J" or "Lennox zone is composed of multiple seams with thickness ranging from 3′6″ to 21′8″ and with local names such as "Searcy Gulch seam" and "Kellogg seam". The "Wadge" is a single 4 to 7 foot seam or is absent. The "Wolf Creek" zone has multiple seams of 3′ to 15′ which in one locality coalesce to a thickness of 42 feet with only minor partings.

Range of analyses is similar for all coals of this "middle" or "Fairfield" group, and is as follows:

As-received basis	*Range of analyses*
Moisture	7.7-11.8%
Ash	3.4-11.5%
Sulfur	.3-.6%*
Btu/lb.	10,740-12,260
Fus. temp., °F.	2,410-2,910*

* Local exceptions in the "Lennox" seams, where altered, show sulfur as high as 2.4%. This group of coals, where not metamorphosed, generally are high-volatile C bituminous non-coking coals.

Coals in the upper part of the Williams Fork Formation are in the "upper group" or "Twenty Mile group" (lying above the Twenty Mile Sandstone marker), and may correlate with the "Goff group" and/or the "Lion Canyon group" of the Danforth Hills field to the south. Correlation letters are from "K" through "S", with "L" also called the "Crawford seam" and "Sleepy Cat seam"; "M" also is called the "Carey seam"; and "Q" also called the "Dry Creek seam". These three are the most important in the "upper group" in the eastern half of the field. From Craig westward, in as much as 900 feet of section, as many as 8 seams from 3′ to 10′ thick may be present, with 8 or more thinner interspersed beds. Correlations, even by the letter system, are difficult, and perhaps relatively unimportant until mining development is farther advanced. The mined seams range in thickness from 4′4″ to 10′4″. Most of these "upper group" coals are subbituminous A, and the range of analyses of the several seams mined is quite similar, as follows:

As-received basis	*Range of analyses*
Moisture	14.2-16.9%
Ash	4.1-5.4%
Sulfur	.4-.9%
Btu/lb.	10,360-11,040
Fus. temp., °F.	2,070-2,480

Above the "Mesaverde" is about 2,000′ of Lewis Shale. Overlying this is the late Upper Cretaceous Lance Formation, with coal-bearing rocks in the lower part. These beds dip gently toward the northwest-trending center of the basin, where they are covered by younger non-marine Ter-

tiary-age formations. In this gentler topography the coal seams usually are concealed at the surface.

Along the north edge of the Yampa Valley, 3 miles north of Hayden, the "Lorella seam", 3′ to 10′ thick, has been mined. Also, in 4 mines east-northeast of Craig, a higher seam, the "Kimberly", 7′8″ to 11′8″ thick, has been mined. Two other mines about, 9 and 16 miles northwest of Craig, are probably in the "Kimberly seam", 7′6″ to 11′9″ thick.

These Lance coals generally are subbituminous B or C, and have not been competitive with the better "Mesaverde" coals in the eastern part of the field. The range of analyses is quite similar for all of the "Lorella" and "Kimberly seams", as follows:

As-received basis	*Range of analyses*
Moisture	19.6-21.8%
Ash	4.1-6.5%
Sulfur	.5-.7%
Btu/lb.	9,660-9,720
Fus. temp., °F.	2,010-2,260

The Paleocene Fort Union, a non-marine coal-bearing formation, overlies the Upper Cretaceous Lance Formation.

The "Campbell seams", two 6-foot beds 3 feet apart near the base of the Fort Union, were mined 10 miles northwest of Hayden. Four mines about 11 miles northeast of Craig were operated in the "Seymour seam, a 9′6″ to 17′0″-thick coal near the top of the Fort Union Formation.

These are subbituminous B or C coals and are not competitive with the better Cretaceous coals to the east unless they might be developed in a strippable area. The range of analyses of the "Campbell" and the "Seymour" seams are similar, and are as follows:

As-received basis	*Range of analyses*
Moisture	17.1-20.5%
Ash	3.9-7.8%
Sulfur	.2-.4%
Btu/lb.	9,500-10,080
Fus. temp., °F.	2,050-2,420

In the basin above the Fort Union is a considerable thickness of the continental Eocene Wasatch Formation, which contains several coal-bearing zones that are approximately correlative with beds to the north in Carbon County, Wyoming. The outcrop of the Wasatch in the Sand Wash basin is remotely located. The coals have been mined only from ranch mines and from the Sparks mine at West Hiawatha oil field, less than 20 miles from the northwest corner of Colorado. No data are available on the Sparks coal, but generally the Wasatch coals are subbituminous B and C, and probably have the same range of analyses as the "Battle", "Creston", and "Hadsell" seams just to the north in Wyoming, as follows:

As-received basis	*Range of analyses*
Moisture	20.7-23.0%
Ash	11.2-13.8%
Sulfur	1.8-2.7%
Btu/lb.	8,250-8,710
Fus. temp., °F.	——

Although the Wasatch coals are lenticular, they would be expected to range from 6′ to 20′ in thickness in mineable areas, some of which could be strippable. None of these Wasatch coals has been included in the resource estimates.

In 828 square miles of the Yampa field where the coal resources were measured or indicated (Landis, 1959), 23,607 million tons of coal were estimated as originally in place, ¾ of which was bituminous and ¼ subbituminous. In an additional 852 square miles, to depths of 3,000′, 21,300 million tons may be present. From 3,000′ to 6,000′ depths, in the deeper part of the Sand Wash basin to the northwest, a smaller resource of 5,000 to 8,000 million tons could be present. Also, in the Wasatch beds in that area, as much as 5,000 million tons of mineable coal may be found.

Total possible resources of coal in place in the Colorado part of the Green River region may be as much as 57,907 million tons. Approximately two-thirds of this coal is believed to be high-volatile C bituminous and the remaining third A, B or C subbituminous.

Historically, more than 70 coal mines have been in operation at various times in the Yampa field. During 1975, 9 mines—of which 7 were surface—were active. The 2 underground mines currently are producing a total of about 1,300 tons per day. The 7 surface mines, which include the largest mines in the state, together produced nearly 20,000 tons per day in December 1975.

The Yampa coal field is estimated to contain some 950 million short tons of identifield plus undiscovered strippable coal resources (approximately 5% of the state's total strippable resource), according to data released by the U.S. Bureau of Mines (Speltz, 1974). Statewide, however, only about 10% of the total coal resources is believed to be mineable by surface methods.

The Colorado-Ute Electric Association's Hayden plant, located several miles east of the town of Hayden, consumes the entire output of the nearby Seneca surface mine, which amounted to over 650,700 tons in 1975. A second generating unit is under construction at the Hayden plant. Most of the coal now produced in the Yampa field is shipped by Denver & Rio Grande Western Railroad to power generating plants in eastern Colorado. In addition, some coal is being shipped to the Cameo plant east of Grand Junction.

Raton Basin Region

The Colorado portion of the Raton basin region extends northward from the Colorado-New Mexico state line to just north of Walsenburg, and from the Sangre de Cristo Range eastward to Trinidad. Structurally, it is a portion of the Raton basin, an asymmetric syncline with its axis near the western margin. Dips are gentle on the east side and steep on the west flank, where the strata are sharply up-turned along the mountain front. The center of the basin is penetrated by the Spanish Peaks, which are Tertiary igneous stocks with many associated dikes, sills and laccoliths.

Coals occur in the Vermejo Formation of late Upper Cretaceous age, and in the Raton Formation of Upper Cretaceous and Paleocene ages. Three crude coal "groups" are recognized, and some attempts have been made to correlate coal seams in various localities.

The "lower" coal group is in the lower part of the Vermejo, and contains from 1 to 14 seams of coal throughout the region. The "middle" coal group, with 1 to 5 seams, is about 300 feet above the base of the Raton Formation; and the "upper" group, 700 to 1,000 feet higher, has only a few thin seams. All of the Raton Formation is missing in the northwest part of the region near La Veta.

More than 230 mines have operated in this region, mostly along the escarpment on the eastern edge of the region and along the drainage of the Purgatoire River that dissects the area west of Trinidad. Most of these mines were in thicker, more persistent, and higher quality Vermejo coal seams.

Coals in the southern part of the region generally are coking, while those in the northern part are non-coking. This division occurs approximately at the Hurefano County line; and the "Walsenburg field" includes the coals in that county, while those in Las Animas County constitute the "Trinidad field".

The Raton basin coal region produced 632,207 tons (or 7.6% of the State's total) during 1975 from one large underground mine and one newly opened strip mine, both located in the Trinidad field, Las Animas County. These mines employed 445 workers in 1975, all but 3 in the underground mine.

Walsenburg Field

Principal production has been from the Vermejo "lower" coal group. Named seams of this group, upwards, and their maximum mined thicknesses, are: Cameron-6'9", Lennox-6'4", Walsen-7'3", Pryor-5'5", Lower Robinson-5'0", (Rider-3'0"), and Upper Robinson-6'0". Other names have been used in certain localities or mines which might correlate with some of these seams.

Vermejo coals in this field are high-volatile B and C bituminous, non-coking, and the range of analyses from all seams is quite similar, as follows:

As-received basis	*Range of analyses*
Moisture	5.3-10.2 (19.2)%*
Ash	7.2-14.4 (19.3)%*
Sulfur	.4-1.3 (1.8)%*
Btu/lb.	11,050-12,880
Fus. temp., °F.	2,210-2,840

* The high moisture, ash, and sulfur entries in parentheses are from exceptional local conditions, notably in the La Veta area.

Limited mining of the "middle" group, in the Raton Formation in the area of Walsenburg and southward, used local names for some seams, such as Lower Rugby-to 3'10", Upper Rugby-4'0" (also called Primrose), Mutual seam-6'0", and in some cases "A" seam and "B" seam where split. Also, some nearby local seam names from the Trinidad field, such as "Cass", "Delagua", and "Boncarbo", were used rather loosely. The Raton Formation coals generally are high-volatile B or C bituminous, non-coking, with a common range of analyses as follows:

As-received basis	*Range of analyses*
Moisture	2.5-4.2%
Ash	5.3-13.5%
Sulfur	.4-1.0%
Btu/lb.	12,660-13,340
Fus. temp., °F.	2,230-2,730

Survey of 172 square miles of the field (Landis, 1959) indicated an estimated 1,190 million tons of coal originally in place. In an additional 48 square miles to total depth of the basin, which would not exceed 3,000', an estimated additional 330 million tons may be present, making a field total of 1,490 million tons.

Total production from the approximately 90 mines that have operated through the years is 75,520,000 tons. Twelve mines operated in 1956 with production of 63,680 tons of coal. Eight mines were in operation in 1962 and produced 44,644 tons. Only 1 small mine operated in 1972, producing 5,234 tons before shutting down. No mines presently are operating in the Walsenburg field.

Trinidad Field

More than 140 mines have operated in this field through the years in the three groups of coals. In the "lower" group, in the Vermejo Formation, as many as 14 mineable seams have been recognized. The principal seams, upward, with their range of mined thicknesses—and possible equivalent and/or intervening locally named seams—are as follows: Berwind, 4'0"-7'0" (Rainbow?); Cameron, 3'7"-7'8" (Empire?); Walsen, 4'0"-5'0"; Hastings "A" and "B" (Lower and Upper Bunker Hill) (Majestic), 5'4"-8'8" (Pryor); Rapson, 3'8"-5'0"; Ludlow, Lower and Upper?, 4'0"-5'3" (Thomas); and Gem (Robinson) (Peerless), 4'0"-7'5".

From Morley, in the southeast corner of the Trinidad field, westward to Weston, Tercio, and Stonewall, the common seams in this "lower" group, in ascending order, are: Piedmont; Morley (Lower Starkville) (Engleville), 4'11"-7'10"; Upper Starkville (Upper Morley) (Engle-Starkville, 3'1"-6'6"; Cokedale, 6'0"-7'7"; Lower Sopris, 3'0"-4'0"; and Sopris, 4'0". These and other locally named, numbered, or lettered seams have not been correlated with those above.

Most of these coals are high-volatile A bituminous, with some B, and all are coking coals. Ranges of analyses in most of these seams, under normal circumstances, are quite similar, and can be represented as follows:

As-received basis	*Range of analyses*
Moisture	1.6-5.8%
Ash	7.7-21.8%
Sulfur	.5-1.0%
Btu/lb.	11,430-13,510
Fus. temp., °F.	2,290-2,910

Locally some of these coals are affected by intrusions of igneous dikes and sills, some being increased in rank, and a few becoming natural coke.

Coal seams occur throughout the 1,000' to 1,600' of the Raton Formation, but most of the thicker and more persistent coals are in the "middle" group 300' to 500' above the base. The "upper" group, with fewer, thinner, and less extensive seams occurs in the upper one-third of the formation. Principal seams along the eastern escarpment, in ascending order, with ranges of mined thicknesses, are: Bear Canyon (#6), 3'2"-4'0", (Alfreda); Cass, 5'9"-7'8"; Lower Rugby, 4'4"; Upper Rugby, 3'0"; Delagua, 3'6"-8'0"; and Boncarbo, 4'0"-5'8". Westward, up the Purgatoire Valley from Starkville to Weston and Stonewall, the principal named seams are Frederick (Zone E), 3'2"-5'10"; Primero (Zone I), 4'9"-7'11"; and Ciruela (Zone R) (Allen), 5'0". All of these are in the "middle" group. The ranges of Frederick and Primero analyses are quite similar, all of these coals being high-volatile A bituminous or high-volatile B bituminous, coking coals:

As-received basis	*Range of analyses*
Moisture	1.0-4.5%
Ash	5.3-16.4%
Sulfur	.4-1.1%
Btu/lb.	12,200-13,970
Fus. temp., °F.	2,230-2,910+

Recorded cumulative production from 141 mines in the Trinidad coal field is nearly 168.8 million tons. In 1956, 22 mines produced a total of about one million tons. During 1975, only one mine was in operation—CF&I Steel's captive Allen mine, located west of Trinidad near Stonewall (in T. 33 N., R. 68 W.). Production for 1975 amounted to 632,047 tons of coking coal, mined from the Ciruela (Allen) bed and utilized in the company's steel mill in Pueblo. Analyses of this coal have not been made available.

In the 872 square miles of the Trinidad field surveyed (Landis, 1959), an estimated 11,484 million tons of coal were originally present at depths of less than 3,000 feet. Only an additional 18 square miles were thought to contain resources at depths below 3,000 feet, and could hold a resource of as much as 237 million tons. Total for the field may be over 11,720 million tons of high-volatile A and B bituminous coking coal.

Total for the Raton basin region could be more than 13,211 million tons, with almost 90% of coking quality.

Canon City Region

Canon City Field

In an asymmetric synclinal fold just east of the Wet Mountains in the Colorado Piedmont section of the Great Plains is another outcrop of coal-bearing rocks of the Cretaceous-age Vermejo Formation. This is a northward continuation of the "lower" coal zone of the Raton basin region. Dips on the east side of the field are gentle, but on the west side are moderate to steep and involve some locally important faulting. Surface mining is operated on the east side, but is limited because of massive sandstones found just above the coal section.

As many as 16 coal seams have been recognized, but only 7 have any importance commercially. In ascending order, with ranges of mined thickness, these seams are: Rockvale, 3'0"-3'8"; Canon City, 3'0"-7'4"; Magnet, 4'6"; Radiant (Jack-O-Lantern), 3'4"-4'6"; Royal Gorge

(Bassick), 4'0"; Chandler (Littel), 2'0"-4'6"; and Brookside, 4'6"-6'7" (10'0"). The general ranges of analyses for these seams under average conditions are:

As-received basis	*Range of analyses*
Moisture	5.4-15.0 (23.3)%
Ash	4.6-17.7 (22.6)%
Sulfur	.3-1.1 (2.4; 3.4)%
Btu/lb.	10,110-12,010 (9,630)
Fus. temp., °F.	2,030-2,720 (1,990-2,910+)

The figures in parentheses are local exceptions under special conditions, and some indicate cause-and-effect relationships in certain individual mines.

Most of this coal is high-volatile C bituminous, nonweathering, non-agglomerating, and non-coking.

The field has produced over 39.44 million tons from more than 70 mines. In 1962, 25 mines, including 2 strip, produced 334,559 tons. However, in 1975 the 2 operating underground and 3 surface mines produced less than one-half of that amount, or 147,619 tons (1.8% of the State's total), employing 31 persons.

Most of the coal produced from the Canon City field is used in steam-electric plants in Canon City and Colorado Springs, and in institutions such as the State Prison at Canon City.

Accurate surveys (Landis, 1959) have indicated an estimated 295 million tons of coal originally in place in the 36 square-mile-area of the field. Present resources are estimated at 217 million tons, with over 100 million tons recoverable from depths of probably less than 2,000 feet.

South Park Region

South Park Field

Coal-bearing formations crop out around the rim of a twenty-mile-long syncline about 15 miles east of Fairplay at elevations of about 9,900 feet in the South Park intermontane basin in Park County.

These strata are similar to part of the Vermejo Formation of the Raton basin and Canon City regions. They areLate Cretaceous in age and correlate with the Laramie Formation of the Denver basin area. Much of the section is missing around the south end of the syncline near Hartsel, and only thin coal seams have been found. At the north end, near Jefferson, about 250 feet of section contains one or more seams which may attain mineable thickness under cover. Most of the east side is covered by a granitic thrust block.

On the west side, near Como, a "lower seam"-5' to 12', a "middle seam"-2'9", and an "upper seam"-4'0", with intervals of about 200', were mined from 1870 to 1905 for railroad and local use. Deep weathering and dips to 45° made mining difficult. The seven or eight old mines have long been closed and flooded.

Recent analyses of a sample recovered from one of the old Como mines indicate subbituminous A or B coal, with the following analyses:

As-received basis	*Range of analyses*
Moisture	6.3-15.5%
Ash	1.3-6.4%
Sulfur	.47-.53%
Btu/lb.	9,780
Fus. temp., °F.	2,700

A total area of about 8 square miles, mostly down dip east of the Como mines, was estimated (Landis, 1959) to have had about 92 million tons of coal originally present. Down to a depth of 3,000 feet, an additional 12 square miles could hold resources of about 135 million tons. No conjectures are made here concerning resources below that depth. Possible original total for the field could be as much as 227 million tons, but prospecting and mining will be difficult.

North Park Region

North Park Field

Coals have been mined in two areas of the North Park intermontane basin in Jackson County. The coals occur in about 3,500 feet of fresh-water clastics of the Coalmont Formation of Paleocene age, which is correlated with the Fort Union Formation of the Green River region, and with the Denver Formation of the Denver basin.

On the flanks of McCallum anticline, in the northeast part of the basin southeast of Walden, the "Sudduth seam", 10' to 58' thick, occurs at or near the base of the Coalmont; and the "Lower and Upper Winscom" (or "Lower and Upper Capron") seams, 8' to 12' thick, occur about 2,000' and 2,300' higher in the section. Dips range from 20° to 85°.

In the southwest part of the basin, near Coalmont and northward, 5 seams occur in this formation and have been prospected or mined. Dips range from less than 10° to about 20° easterly, but the area is complexly block-faulted. In ascending order, the lower four unnamed seams are: (1) an 8'6" seam an unknown distance above the base of the Coalmont; (2), an 18' seam an unknown distance (100'-200'?) above 1; (3) a 12' seam about 1,250' above 2; (4) a 5' seam about 1,000' above 3. About 360' above these is the "Riach seam", 22' to 77' thick, in which most of the mining has been done.

In two small areas north of Coalmont, mines were operated in two thinner seams. The Mitchell seam, which possibly might be correlated with 3 or 4 above, is from 7'0" to 11'0" thick. The "Monahan seam" is about 4'6" thick and is thought to occur in a zone that interfingers with the top of the Pierre Shale (Upper Cretaceous). Analyses of all mined seams fall in the same range, as follows:

As-received basis	*Range of analyses*
Moisture	13.6-(22.8)%
Ash	2.8-13.4%
Sulfur	.1-.9%
Btu/lb.	(8,840)-10,870
Fus. temp., °F.	2,100-2,680

All of the North Park field coals generally are of subbituminous B rank.

In 102 square miles surveyed, an estimated 3,735 million tons were originally in place (Landis, 1959). It is believed that an additional 748 square miles are underlain by similar coal-bearing strata, some of which may be at depths of greater than 3,000 feet. In those strata another 25,000 to 27,000 million tons of reserves may be present, making a possible total for the field of about 28,735 million tons of coal originally in place.

The North Park coal field lies at elevations of 8,000 feet or more and is completely encircled by high mountain ranges. All-weather State highways provide access both from the north (Albany and Carbon Counties, Wyo) and from the south (Grand Co., Colo.). A light-duty railroad operated by Union Pacific extends from the Coalmont field to the U.P.R.R. main line at Laramie, Wyoming.

During 1975, 320,677 tons of coal were produced by 3 surface mines, employing a total of 43 workers, in Jackson County. This represents 3.9% of the total State production. Two of these mines, the Marr and Canadian, are located on the steeply dipping east flank of McCallum anticline, where they are mining high-quality subbituminous coal from the Sudduth bed which is approximately 50' to 60' thick, with virtually no partings, in this particular area. (The Canadian strip did not produce any coal during the last 6 months or so of 1975 and is presently in a "maintenance" category).The third strip mine in North Park, the Grizzly Creek, located near Coalmont, mined 65,000 tons of coal during the first half of the year to be used for a test burn at the Drake Power Plant in Colorado Springs. This

mine currently is idle, pending further plans by the operator. The Grizzly Creek strip mined a 25-ft.-thick bed ("Riach Seam") in the upper Coalmont Formation, where it occurs just below the surface in an old gravel pit. All of these three surface mines commenced operations in late 1974—early 1975.

Middle Park Field

Just south of North Park, in Grand County, is the intermontane basin called Middle Park, where the Colorado River heads. Some thin, impure lenticular coals occur in this basin in Paleocene strata of the same age and characteristics as the Coalmont Formation of North Park. These strata are called the Middle Park Formation, but are thought to be continuous with the Coalmont to the north.

Limited exploration has revealed no mineable seams of coal, but the possibility of appreciable resources exists in an area covering about 270 square miles. There is no satisfactory basis for an estimate of resources. No coal ever has been mined in Grand Country; however, it is believed that some exploratory work now is underway in the northern part of Middle Park, north of Kremmling.

Denver Basin Region

The Denver basin region covers an area of about 8,000 square miles in eastern Colorado east of the Front Range, which extends from near Colorado Springs north to near the Wyoming State line. Physiographically, this is in the dissected Piedmont section of the Great Plains.

Structurally, it is a broad, gentle basin, steeper on the west flank along the uplifted mountain front. The margins of the Denver basin region are defined by the outcrop of the coal-bearing basal part of the Laramie Formation. These beds are well-exposed along the foothills hogbacks extending from near Colorado Springs to Boulder, where dips may be near-vertical but flatten rapidly to 5° or less eastward into the basin. They are less well-exposed northeastward to Greeley; and poorly exposed on the north, east, and south edges of the region. They occur at depths of probably less than 1,000 feet throughout most of the basin.

The coals occur throughout the area in the Laramie Formation of late Upper Cretaceous age, which correlates with the Vermejo Formation of the Raton basin region. In the southern part of the basin, a few lenticular coal seams also occur in the Dawson arkose, which is more coarsely clastic than, but roughly the time equivalent of, part of the Raton Formation.

In the northern part of the basin, beds above the Laramie Formation contain lenticular coals. These are called the Arapahoe Formation, of Upper Cretaceous-Paleocene age, and the Paleocene Denver Formation. These formations correlate in part with the Coalmont Formation of the North Park region and the Fort Union of the Green River region.

Colorado Springs Field

In this report, the Colorado Springs field is not restricted to the mined area immediately north and east of the city, but is applied to all of the southern part of the region in El Paso, Elbert, and Douglas Counties. This includes formerly mined areas in northeast El Paso County, and in central and eastern Elbert County known as Ramah-Fondis area and Buick-Matheson area.

At Colorado Springs, three seams, A, B, and C, are recognized in the basal Laramie. Only the lowest, "A" seam, is of mineable thickness, varying from 4′7″ to 17′1″. Range of analyses of the "A" seam is as follows:

As-received basis	*Range of analyses*
Moisture	19.2-(26.9)%
Ash	3.9-10.2%
Sulfur	.2-.5%
Btu/lb.	(8,000)-9,270 (10,140)*
Fus. temp., °F.	2,150-2,470

* Rank increased by metamorphism at Franceville.

The Laramie coals in the Buick-Matheson area at the east edge of the field are lenticular and have not been correlated. They were mined from the middle and upper part of the section at the south end of the area, and range from 8′0″ to 15′0″ thick. These are subbituminous C coals, with high moisture and ash, and with the following range of analyses, some bordering on lignite:

As-received basis	*Range of analyses*
Moisture	33.1-35.0%
Ash	7.8-15.7%
Sulfur	.4-1.1%
Btu/lb.	6,150-7,340
Fus. temp., °F.	2,140-2,400

The younger Paleocene coals in the Dawson (arkose) Formation crop out in the Ramah-Fondis area nearer the center of the basin and are of low-grade subbituminous rank, bordering on lignite. These are very lenticular and generally have many thin partings of shale and sandstone. Mined thicknesses vary from 4′8″ to 7′4″,but one "pod" was estimated at 18′9″ including partings. Range of analyses of the Dawson seams is as follows:

As-received basis	*Range of analyses*
Moisture	33.1-34.4%
Ash	13.9-18.2%
Sulfur	.1-.5%
Btu/lb.	5,510-6,700
Fus. temp., °F.	2,480-2,530

In the 147 square-mile-area of Laramie coals surveyed, resources of about 885 million tons were estimated to have been originally present (Landis, 1959). In the three-county area of the field, perhaps two-thirds of the remaining 2,733 square miles may have comparable coals. This could add an additional 9,900 million tons of resources to the region, bringing the total in-place resources of Laramie-age coals originally present in the Denver basin, all of which probably occur at depths of less than 1,000 feet, to an estimated 10,785 million tons.

In the 128 square miles of Dawson coals surveyed (Landis, 1959), 474 million tons of resources were estimated to have been originally present. Perhaps half of the remaining 1,600 square miles of Dawson Formation in the three-county area may have comparable coals. This could add as much as 5,600 million tons of resources, for a total of about 6,074 million tons of Dawson coals originally present.

Total resource for the Colorado Springs field, in Douglas, Elbert, and El Paso Counties, is about 16,860 million tons. As much as two-thirds of this, or about 10,000 million tons, is subbituminous C rank coal bording on lignite. No mines presently are operating in the Colorado Springs field.

Boulder-Weld Field

In this report, the Boulder-Weld field is redefined to include all of Weld County to the eastern limits of the region. It also includes the area of exposed and mined seams along the foothills from Boulder south through Jefferson County, and eastward into the basin through Denver, Adams and Arapahoe Counties to the eastern limits of the region.

These limits are defined by the outcrop of coal-bearing beds in the lower 225 feet of the Laramie Formation. A lesser area of overlying coal-bearing strata of the Paleocene Arapahoe and Denver Formations, correlated with the Dawson arkose to the south, lies within the field.

The "Scranton district", an area 15 miles east of Denver, was active between 1860 and 1910. The Scranton seam in the Paleocene Arapahoe-Denver Formation, where mined, was 6′0″ to 10′0″ thick with many small partings. A 3-foot-thick seam of coal 30′ below the Scranton, and a 7′6″

seam 85″ below that, were never mined. The Laramie coal zone is approximately 1,050 feet below the Scranton seam.

Survey data on 59 square miles of Paleocene coals indicate an estimated in-place resource of 489 million tons originally present (Landis, 1959). Perhaps as much as one-half of the additional 1,525 square miles underlain by the Arapahoe-Denver section may have comparable coals. This could add estimated resources of about 6,100 million tons, making total estimated Paleocene coal resources in this field of 6,600 million tons.

The better quality, more extensive coals of the Laramie Formation were produced from an over 150-square-mile area along the northwest edge of the field northeast from Boulder toward Greeley. Also, about 20 mines have been operated in the upturned beds along the foothills south of Boulder, through the Golden area in Jefferson County, to the Douglas County line. Scattered mining in the area north of Greeley took place near Briggsdale, near Eaton, and at the edge of Larimer County near Wellington. Seven seams, all in the lower 275 feet of the Laramie Formation, are recognized in the mines near Boulder, and are numbered upward. Seams 1 and 2 generally are thin and discontinuous and were seldom mined. Seam 3, known as the "Main Seam", is the most persistent and productive seam, and ranges from 4′0″ to 14′0″ thick. Seam 4, lenticular and discontinuous, ranging from 2′6″ to 11′0″, occurs mostly in the western part of the field. Seam 4 lies from 35 feet above Seam 3 to directly upon it. Where they coalesce, they all have been mined together.

Although Seam 5 is lenticular, varying from 4′11″ to 10′1″, it is quite extensive, and is known in the field as the "Middle Seam". Seam 6, known as the "Upper Seam", is more lenticular and less persistent, with mined thicknesses of 7′0″ to 8′11″. Seam 7 occurs sporadically, having limited lateral extent, and is of minor importance, ranging from 2′6″ to 5′0″ in thickness.

Ranges of many analyses of Seams 3, 5, and 6 were quite similar and may be grouped as follows:

As-received basis	*Range of analyses*
Moisture	15.5-25.8%
Ash	3.3-10.1%
Sulfur	.2-.9%
Btu/lb.	8,890-10.660
Fus. temp., °F.	1,990-2,470

These coals generally are subbituminous B in rank, with slightly higher rank in the western part of the field and along the hogbacks in the foothills. However, these Laramie coals are subbituminous C in the eastern and northern parts of the field. Usually not more than 1 to 3 of the seams are of mineable thickness in any one area.

This is the one coal region in Colorado where shaft mining predominated over drifts or slopes. Depths of the shafts range from 250 to approximately 500 feet.

Of historical interest is the fact that one of the machines which enabled underground coal mining to remain competitive with other fuels, the ripper-type continuous-mining machine, was developed in this field. The prototype was placed in the field in 1943 and was on the market in 1946.

In spite of mechanization, production in the field has declined since 1962 because of competition with lower cost surface-mined coal, as indicated here:

Year	*Mines in Operation*	*Production*
1956	8	643,812
1962	6	786,457
1972	3	574,707

During 1975, the lone mine operating in the Denver basin (Imperial Coal's underground Eagle mine) produced 162,732 tons (2.0% of the State's total) and employed 55 workers. All of this coal is used for electric power generation in the Denver area.. The remaining reserves of this mine should be exhausted sometime during 1976.

With the exception of the relatively small Zuni plant, all of the generating plants of Public Service Company of Colorado located in the Front Range corridor utilize coal as their predominant fuel source.

The Arapahoe plant in 1975 consumed 654,000 tons of coal (which comprised 65% of the total fuel burned), obtained from the Eagle mine in Weld County, and from mines in Routt County, Colo. and the Hanna basin in Carbon County, Wyo. The Cherokee plant burned 2,159,-000 tons of coal (78% of the fuel required) from the same two fields that supplied the Arapahoe plant. The Commanche plant, near Pueblo, used 1,220,000 tons of coal (98.8% of its fuel requirements), all of which is shipped by unit train from AMAX Coal's Belle Ayr mine near Gillette, Wyoming (in the Powder River basin). The Commanche power plant is expected to require 2.5 million tons of coal annually when its second generating unit comes on line sometime in 1976. The small Valmont plant, near Boulder, used 180,000 tons of coal (33% of its fuel needs) in 1975, obtained from mines in Routt County, Colo. and Carbon County, Wyo.

Steam-electric plants operated by other utilities in eastern Colorado, such as the Martin Drake plant at Colorado Springs, are for the most partdependingupon coal as their prime source of fuel.

In addition to power plants, a number of industrial and public facilities in eastern Colorado are rapidly converting to coal as their main fuel supply.

In the 502 square miles surveyed in the several mined areas, resources of about 3,410 million tons were estimated to have been originally in place. In the additional 3,890 square miles of the field, perhaps two thirds may be underlain by comparable coals. This could add as much as 15,-600 million tons of resources, making a possible total for the field of about 19,010 million tons.

With the Paleocene lower-rank coals previously discussed, total resources for the Boulder-Weld field as here defined may be as much as 25,610 million tons.

Totals for the Denver basin region would be:

Laramie coals	29,795 million T
Paleocene coals	12,469 million T
Total	42,469 million T

Approximately one third of the Laramie coals, or about 10,000 million tons in the western part of the region, are subbituminous B rank. All of the rest are subbituminous C rank, with some on the eastern margin bordering on lignite.

Grand Total Coal Resources in Colorado

Total coal resources originally in place in Colorado at depths to 6,000 feet are estimated as follows:

Region	Millions of tons	% of total
San Juan	27,300	11.90
Uinta	60,020	26.00
Green River	57,907	25.00
Raton Basin	13,210	5.70
Canon City	295	0.13
South Park	227	0.09
North Park	28,735	12.50
Denver Basin	42,470	18.50
GRAND TOTAL	230,164	

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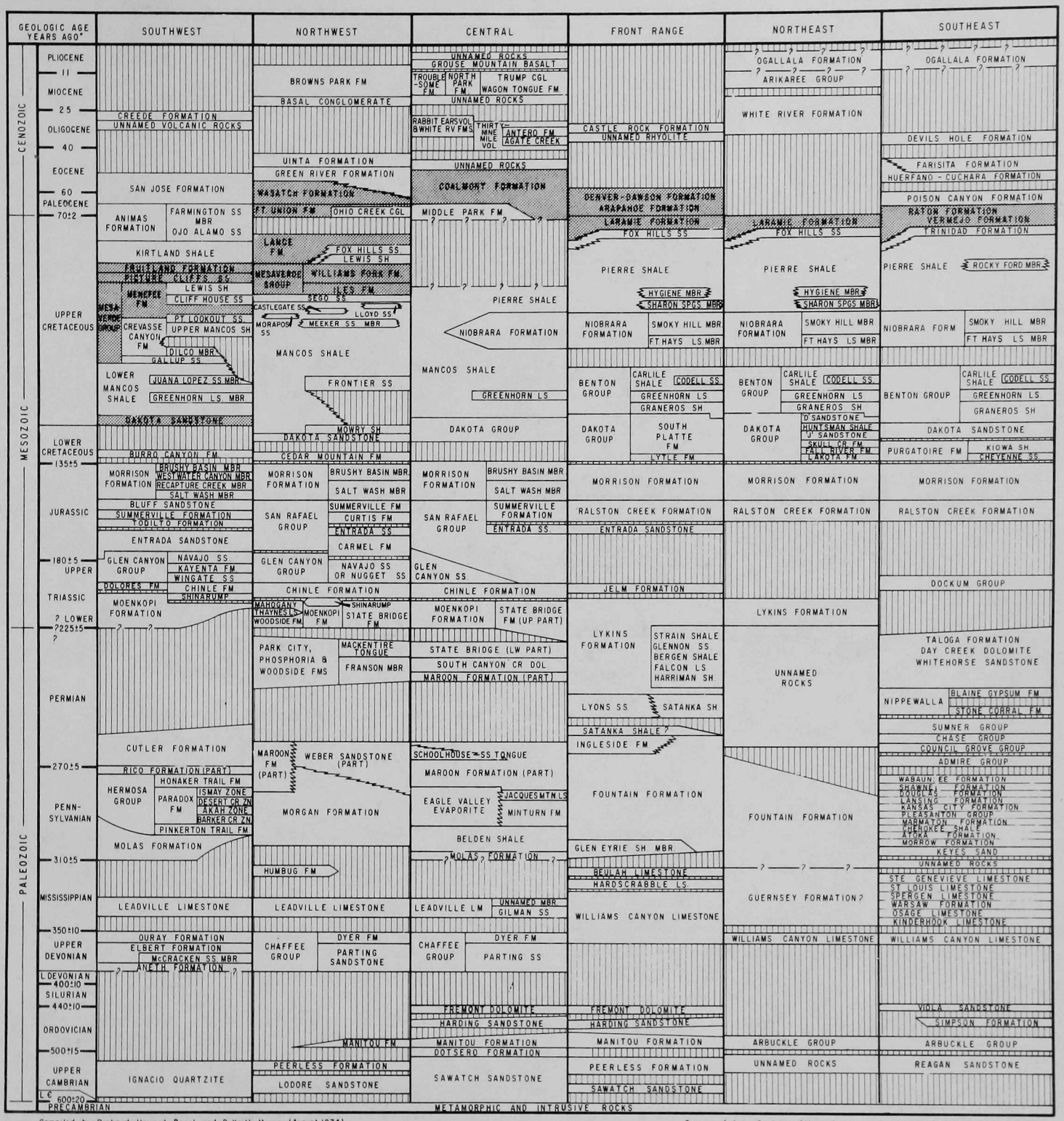
RANGE OF ANALYSES OF COLORADO COALS ON AN "AS-RECEIVED" BASIS

Regions, fields & coals	% Moisture	% Ash	Sulfur	Btu/lb	Ash ^{o}F. fusion
San Juan Region					
Dakota coals NE of Cortez	1.9- 8.1	5.0-18.3	.5- .8	10,440-13,630	2,110-2,910+
Nucla-Naturita area	2.5-13.5	6.1-12.8	.5-1.1	10,010-13,380	2,620-2,910+
Durango field	1.6-10.7	3.4-16.6	.6-1.2	10,860-14,070	2,020-3,000
Uinta Region					
Southwest Uinta Sub-region					
Book Cliffs field					
"Anchor seam"	8.2- 9.8	5.9- 9.8	1.0-1.7	11,910-12,330	2,190-2,790
"Palisade seam"	3.3-14.0	4.9-17.4	.5-1.6	10,950-13,560	2,130-2,910+
"Carbonera seam"	9.3-11.4	7.2-14.4	.4- .6	10,470-11,150	2,850
"Cameo seam"	5.4-11.5	5.2-15.5	.5-1.3	10,410-12,460	2,520-2,960
Grand Mesa field					
Coals in Paonia sh.	9.8-20.0	2.1-16.1	.5-1.8	9,360-11,670	2,060-2,970
Tongue Mesa field					
Several seams	14.2-16.0	6.7- 8.4	.5- .9	9,350-10,220	2,450-2,480
Southeast Uinta Sub-region					
Somerset field					
Bowie sh. coals	7.4-13.6	2.4-11.4	.5- .8	10,040-12,600	2,470-2,810
Paonia sh. coals	10.6-22.4	4.3-13.9	.3- .8	8,160-10,610	2,910+
Near center of field					
Bowie gp. "B" & "C"	2.3- 8.2	2.8-12.0	.4- .7	12,070-13,900	2,220-2,910+
Eastern part of field					
Paonia gp. "D" & "E"	4.2- 8.1	2.8-10.4	.4- .9	12,090-13,400	2,150-2,910+
Crested Butte field					
Six Paonia sh. seams	2.5-13.3	3.2- 9.1	.4-1.9	11,400-14,170	2,130-2,480
Carbondale field					
"Black Diamond" seam	11.1-14.1	2.1- 9.2	.5-1.4	10,360-12,310	2,210-2,470
"D", "Allen" & "Anderson"	3.8- 7.5	1.9-10.5	.4-1.5	11,840-13,530	2,160-2,840
"A", "B", & "C"	5.1- 8.9	3.5-16.2	.6-2.1	10,160-12,820	2,690-2,790
"Allen", "B", "Placita" &"Coal Basin"	1.0- 3.4	3.4-10.0	.5- .7	12,470-15,190	2,150-2,370
Northeast Uinta Sub-region					
Grand Hogback field					
"Black Diamond"	9.2	3.7	.6	11,970	2,210
"Wheeler seam"	3.4- 8.3	4.9-11.3	.3- .8	11,220-13,120	2,130-2,620
"Allen seam"	3.5-10.7	3.9- 7.9	.4- .5	11,600-13,270	2,060-2,370
Seven other seams	2.9-10.5	2.3-11.0	.4-1.1	11,100-13,060	2,090-2,910+
Keystone zone coals	3.7-10.3	5.4- 9.2	.3- .4	11,020-13,120	------
Danforth Hills field					
"Black Diamond" gp.	9.2-13.4	3.7-10.0	.4- .6	11,220-11,970	2,210-2,990
"Fairfield" gp.	9.4-14.4	2.2- 9.6	.3- .9	10,600-11,370	2,310-2,730
"Lion Canyon" gp	8.9-15.5	2.2- 9.6	.5-1.4	10,690-11,790	2,210-2,910+
"Collum seam"	11.4-15.4	2.2- 6.3	.3-1.0	10,140-11,770	2,220-2,480
Lower White River field					
Williams Fork coals	11.2-14.1	4.4- 8.5	.4- .5	10,800-11,230	2,280-2,900
Green River Region					
Yampa field					
"Black Diamond gp."	6.3-12.2	4.3-11.3	.3- .9	11,090-12,560	2,250-2,780
"Fairfield gp."-"Wolf Ck","Wadge","Lennox	7.7-11.8	3.4-11.5	.3- .6	10,740-12,260	2,410-2,910
"Upper or Twenty Mile gp."	14.2-16.9	4.1- 5.4	.4- .9	10,360-11,040	2,070-2,480
"Lorella" & "Kimberly"	19.6-21.8	4.1- 6.5	.5- .7	9,660- 9,720	2,010-2,260
"Campbell" & "Seymour"	17.1-20.5	3.9- 7.8	.2- .4	9,500-10,080	2,050-2,420
Fort Union "Sparks"	20.7-23.0	11.2-13.8	1.8-2.7	8,250- 8,710	------
Raton Basin Region					
Walsenburg field					
Vermejo coals	5.3-10.2	7.2-14.4	.4-1.3	11,050-12,880	2,210-2,840
Raton coals	2.5- 4.2	5.3-13.5	.4-1.0	12,660-13,340	2,230-2,730
Trinidad field					
Vermejo coals	1.6- 5.8	7.7-21.8	.5-1.0	11,430-13,510	2,290-2,910
Raton coals--"Frederick","Primero" et al	1.0- 4.5	5.3-16.4	.4-1.1	12,200-13,970	2,230-2,910+
Canon City Region					
Canon City field					
Seven Vermejo coals	5.4-15.0	4.6-17.7	.3-1.1	10,110-12,010	2,030-2,720
South Park Region					
South Park field					
Como area mines	6.3-15.5	1.3-6.4	.4- .5	9,780	2,700
North Park field					
Coals in Coalmont fm.	13.6-22.8	2.8-13.4	.1- .9	8,840-10,870	2,100-2,680
Denver Basin Region					
Colorado Springs field					
"A" seam	19.2-26.9	3.9-10.2	.2- .5	9,270-10,140	2,150-2,470
Buick-Matheson area	33.1-35.0	7.8-15.7	.4-1.1	6,150- 7,340	2,140-2,400
Dawson lignite	33.1-34.4	13.9-18.2	.1- .5	5,510- 6,700	2,480-2,530
Boulder-Weld field					
Seams "3", "5" & "6"	15.5-25.8	3.3-10.1	.2- .9	8,890-10,660	1,990-2,470

COLORADO STRATIGRAPHIC CORRELATION CHART

COLORADO GEOLOGICAL SURVEY



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