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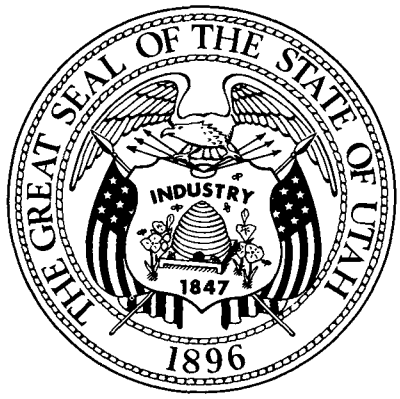
EASTERN AND NORTHERN UTAH COAL FIELDS:

Vernal, Henry Mountains, Sego, La Sal-San Juan, Tabby Mountain, Coalville, Henrys Fork, Goose Creek and Lost Creek

by

H. H. Doelling and R. L. Graham



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PREFACE TO UTAH COAL FIELDS:

SOUTHWESTERN, NORTHERN, EASTERN AND CENTRAL

Coal, first discovered in Utah in 1849, reached an annual production figure of 1 million tons in 1900. Now (1970) between 4 and 5 million tons are produced annually. Coal, widespread and abundant in the state, underlies at least 15,000 square miles amounting to 18 percent of the total area. The Goose Creek-Grouse Creek lignite fields are in addition. These figures, however, project an exaggerated potential worth for Utah. If one excludes areas where the coal is more than 3,000 feet below the surface, the figure drops to 7.8 percent of the land area. If one further eliminates areas where individual coal beds are less than 4 feet thick, the total drops to 4.0 percent of the state's area or less than 3,400 square miles. In this 3,400-square-mile area the average coal bed is 6.21 feet thick. This figure cannot be used to estimate the coal resources of a particular Utah area, but serves to show the true importance of coal in an areal sense. Coal beds greater than 25 feet thick have been discovered in Utah and in many cases more than one such seam is present in a single area. Practically all the operating mines of Utah are extracting coal from beds exceeding 8 feet thick.

The present study began in June 1969 when Dr. A. P. Talboys, National Air Pollution Control Administration, approved a cooperative demonstration grant with the Utah Geological and Mineralogical Survey (UGMS) to accumulate all coal data concerning the quantity, quality and location of Utah coal since 1849. Direct exploration of areas inadequately represented by previous data, as well as for publication of the results, were included in the contract. For every three federal dollars granted, one state dollar was involved.

The work consists of three volumes and divides Utah coal into regions: southwestern Utah, northern and eastern Utah and central Utah. Each of the volumes is subdivided further into coal fields (Preface, figure 1a), areas and quadrangles; geographic data, geology, mines and development, land ownership and control, coal quality and reserves are treated. A bibliography for each field and the principal source of work for each quadrangle are given. The last volume also summarizes, analyzes and compares the data of all three volumes to present Utah's total coal picture, and as highlights, contains a forecast of expected coal activity and a new study of coal palynology.

The magnitude of the work and the short time to complete it increased the possibility of incorporating technical flaws, but the Utah Geological and Mineralogical Survey believes timeliness is paramount and trusts this will be taken into account by the reader.

Hopefully this work will lead to an efficient and productive use of the state's coal resources and, at the same time, provide the data for properly evaluating its environmental and economic impact.

ACKNOWLEDGEMENTS

R. C. Flegal, National Air Pollution Control Administration, guided the study and the U. S. Bureau of Mines, U. S. Geological Survey and the Utah Industrial Commission provided assistance and data exchange. Many coal companies were cooperative in lending maps, analyses and other data. Consultants C. P. Heiner, C. S. Westerberg and L. P. Pearce updated the literature and contacted producers, transporters and users of Utah coal.

Staff members of UGMS who worked on various aspects of the Utah coal project include R. L. Graham, K. C. Thomson, geologists; Fred May, palynologist; R. C. Holland, L. M. Trimble, M. R. Lindgren, R. D. Gray and Edward Dalton, geological field assistants; Steven Rasmussen and Greg McLaughlin, draftsmen. Saffet Doyuran organized and plotted the data on the quadrangle maps and Christine Landward typed the tables and manuscripts. The published version was handled by the editorial staff, Judy McClellan, Mary Horton, Linda Findlay, Judy Allen and Alayne Winegar, under the guidance of Ann Fadel, and the illustrations were supervised by Brent Jones.

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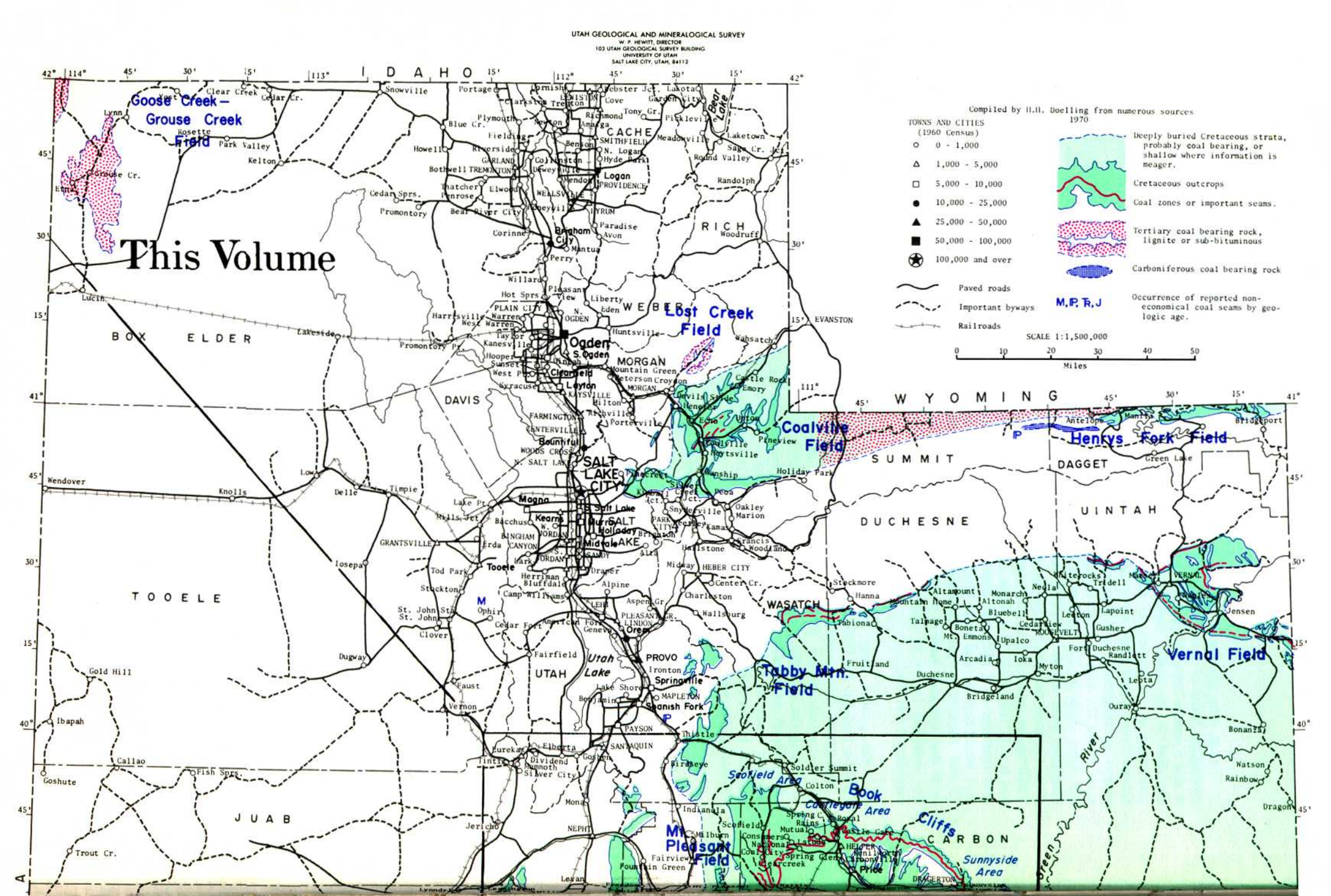

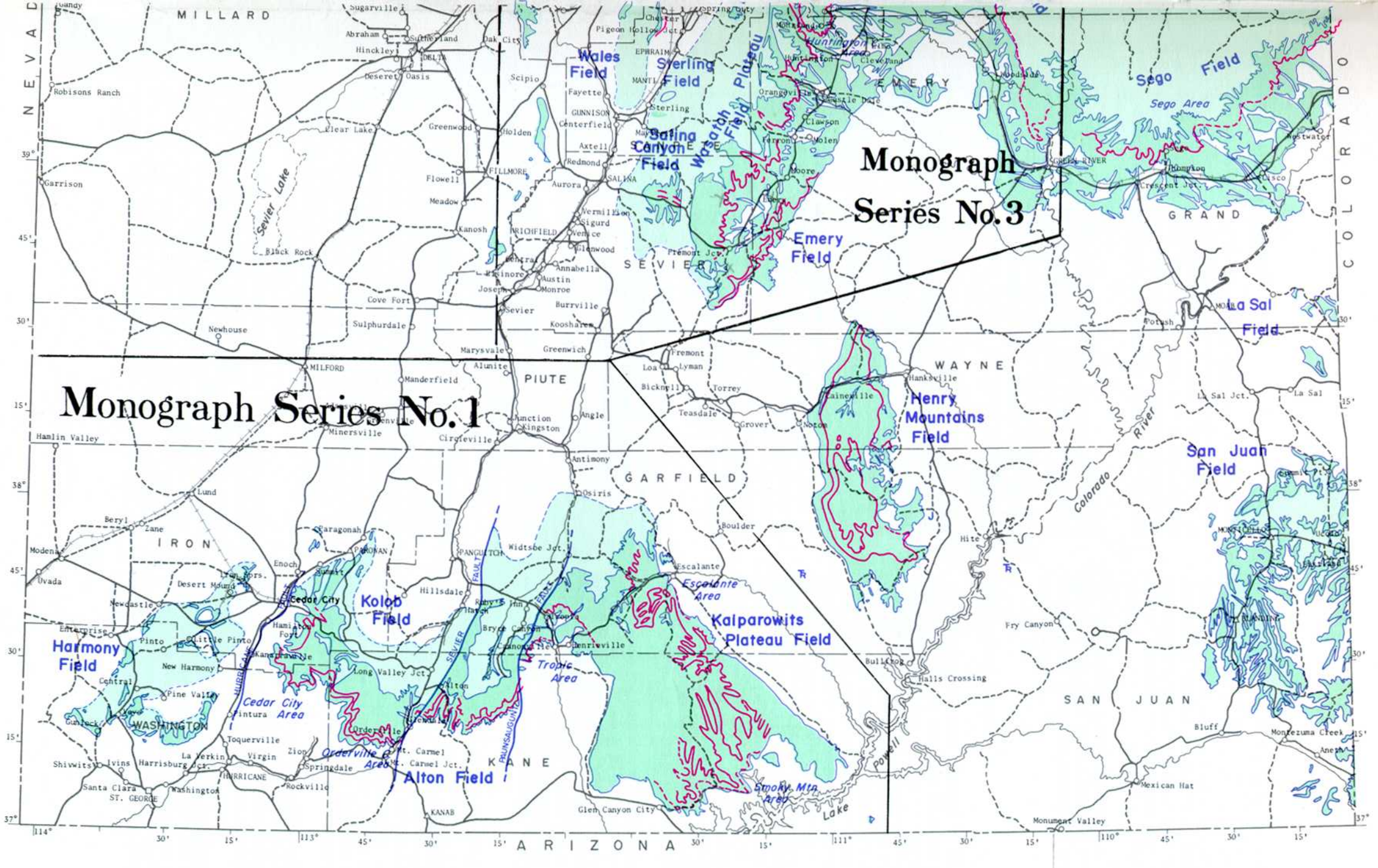

Figure 1a. Map showing area of study.

ABSTRACTS

VERNAL COAL FIELD

Development of the Vernal coal field prior to 1900 served a local market in the Uinta Basin. Increasing costs of mining Vernal coal and reduced transportation rates forced a shutdown of all Vernal mines by 1957. Vernal coal seams are too thin and too badly split to compete with better coal elsewhere. Competition with petroleum, natural gas and electricity aided in the demise of the industry.

The coal in the vicinity of Vernal occurs mainly in two formations, the Frontier Sandstone and Mesaverde Formation, both of Cretaceous age. Most of the 177-million ton reserve is in the Frontier. Frontier coal beds are thin and rarely are more than five feet in thickness. In addition they are badly split. The beds dip moderately to steeply, limiting the reserve considering the 3,000-foot limit.

The 164 million tons of reserve assigned to the Frontier will be difficult to mine and recoverability will be about 33 percent. The rank of the coal is a high-volatile bituminous C. Field averages for dry coal are 39.4 percent volatile matter, 48.5 percent fixed carbon, 12.5 percent ash and 11,509 Btu/lb. The sulfur content is 1.6 percent; the coal is classed a medium-sulfur coal.

Mesaverde coal is a subbituminous C coal, but further testing is necessary to support this. Two available analyses indicate an average of 42.7 percent volatile matter, 39.9 percent fixed carbon, 17.5 percent ash and 8,950 Btu/lb in dry coal. Sulfur content is 0.8 percent; Mesaverde coal is low sulfur. There are several seams in the Mesaverde zone, but they are lenticular and quickly revert to dirty lignite. The steeply dipping beds will make mining of the 12.9-million ton reserve difficult.

The general geologic and structural condition of the coal and the small reserve will discourage near-future use of the resource. Little interest has been displayed by the coal interests in the Vernal coal field and there are no active coal leases or permits.

HENRY MOUNTAINS COAL FIELD

The Henry Mountains coal field lies in a basin 48 miles long averaging 12 miles wide and involving 450 square miles. The location is in a remote part of south central Utah far removed from railroad and important transportation routes.

Three Upper Cretaceous units contain coal seams: the Dakota, Ferron and Emery. The Emery is present in the central part of the basin and is uppermost in the sequence: its coal beds average 2 to 6 feet thick and occasionally occur up to 9 feet. The coal beds in the Ferron are thin, but nearly everywhere present. Only in three small localities does a bed thicken to exceed 4 feet: to the north near Factory Butte, in the southwest part of the field near Swap Mesa and in the southeast part of the field near Mt. Hillers. The lowermost Dakota has thick coal locally, but usually the beds are thin or missing.

Inadequate analyses indicate that the Emery coal contains 9.8 percent moisture, 9.4 percent ash, 0.87 percent sulfur and has a heat value of 11,253 Btu/lb. The Ferron coal has 5.0 percent moisture, 15.3 percent ash, 2.85 percent sulfur with a heat value of 11,575 Btu/lb. The Dakota has 5.8 percent moisture, 1.8 percent ash, 3.10 percent sulfur and a heat value of 14,308 Btu/lb. The Dakota analysis is of jet coal prevalent in a particular part of the basin and may not be representative of Dakota coal as a whole.

Although the field is only partly explored, 230.9 million short tons of reserve are estimated in the field in beds more than 4 feet thick. Of this, 187.4 million tons are assigned to the Emery, 42.0 million tons to the Ferron and only 1.5 million tons are estimated for the Dakota. Activity in the field has been slight and production negligible (9,000 tons). No active mines are active and at least 70 million tons from four separate areas might be strip-mined.

The field has specific disadvantages that will hinder development: (1) thin (4 to 6 feet) coal beds, (2) poor accessibility and (3) high sulfur and ash in some of the coal. No immediate development is anticipated.

SEGO COAL FIELD

The Sego coal field is located in east central Utah along the Book Cliffs between the Green River and the Colorado state line. Along the 65-mile line of cliffs, the important coal beds occur in the Neslen Member of the Price River Formation of Upper Cretaceous age. The member averages 350 feet and contains four coal zones, Palisade, Ballard, Chesterfield and Carbonera, in ascending order. The coal beds are thin over much of the outcrop in all zones and the best development lies between Nash Canyon and Thompsons Canyon in the west central part of the field. There the Palisade zone lies 35 to 60 feet above the base, the Ballard zone 100 to 150 feet above the base, the Chesterfield zone 150 to 175 feet above the base and the Carbonera zone is missing. The Ballard and Chesterfield are separated by a thick cliff-forming sandstone bed. Only the Chesterfield bed has produced significant amounts of coal in the vicinity of Thompson and Sego canyons. The important mining activity occurred from 1912 to 1954 and 2.65 million tons of coal were produced in beds 4 to 6 feet thick.

Outside the main area of development, the coal beds locally thicken, but along much of these outcrops the coal has been adjudged impure. Reserves of thick beds amount to 293.6 million tons; 116 million tons are in the Chesterfield zone, 93 million tons in the Ballard zone and 76 million tons in the Palisade zone. The average coal contains 9.1 percent moisture, 11.1 percent ash, 0.6 percent sulfur and produces 10,940 Btu/lb on an as-received basis.

LA SAL–SAN JUAN COAL FIELDS

The La Sal–San Juan coal fields are located in southeast Utah in Grand and San Juan counties. Both are based on coal occurring in the 30- to 210-foot thick Dakota Formation of Cretaceous age. The outcrops are centered in two general areas: the La Sal field, consisting of scattered patches surrounding the La Sal Mountains, and the San Juan field with the Dakota Formation forming the caprock of a plateau known as the Sage Plain.

Coal exposures occur in a middle member and are rare being covered in most places by colluvium and other surficial material. Where the coal outcrops, it is usually in thin beds and appears to be discontinuous. Only locally does the coal exceed 14 inches.

Neither field has significant past production or reserves. Mining attempts have proved unsuccessful and total production is estimated to be about 300 tons. There are no reserves in beds exceeding 4 feet thick. Limited quality data show coal with 3.5 percent moisture, 21 percent ash, 2.9 percent sulfur and a heat value of 10,890 Btu/lb as-received.

TABBY MOUNTAIN COAL FIELD

Extending 35 miles along the southwest flank of the Uinta Mountains is the Tabby Mountain coal field whose coal beds occur in two steeply dipping formations. These formations include the Frontier and the Mesaverde, both Upper Cretaceous age and both containing thick coal beds. The formations have multiple coal zones and have thick seams along half of the field length. The Mesaverde Formation has more numerous coal beds and hence the greater potential. The coal field has seen only intermittent activity and the total past production probably amounts to a few thousand tons.

Reserves of thick beds under less than 3,000 feet of cover amount to 63 million tons for the Frontier coal and 168 million tons for the Mesaverde. The quality of Mesaverde coal is better than that from the Frontier. Mesaverde coal averages 15 percent moisture, 6.6 percent ash, 1.0 percent sulfur, with 9,895 Btu/lb; Frontier coal averages 19.4 percent moisture, 10.2 percent ash, 0.7 percent sulfur and 8,110 Btu/lb. Since most analyses were obtained from samples collected at outcrop, the quality will be better when mined.

COALVILLE COAL FIELD

Coalville was the first successful coal field in Utah, although it never gained prominence. Discovered in 1859, it achieved steady production after 1870, but Wyoming and central Utah coal proved stiff competition. Only Coalville's proximity to the north Utah market allowed it to continue producing. Maximum production was attained in 1900 when more than 75,000 tons were extracted from a total of at least 3.8 million tons through 1970.

The coal is extracted from the Frontier Formation of Upper Cretaceous age in the Coalville Member, 1,000 to 1,200 feet below the top of the unit. Coal also is known to exist in the Spring Canyon Member, about 200 feet above the base of the 4,800-foot formation and in the basal member of the Wanship Formation lying just above the Frontier. These two other zones are local in extent and have little potential. Coal beds up to 12.5 feet have been found in the Coalville Member and rarely does the main bed diminish to less than 4 feet, averaging 8 to 10 feet thick. The outcrops are distributed around the badly faulted Coalville anticline and the beds dip from 10 degrees to vertical.

The Coalville field has a reserve of about 186 million tons in beds more than 4 feet thick and buried under less than 3,000 feet of cover. The coal is medium sulfur (1.32 percent), low ash (4.5 percent) and subbituminous with 12.0 percent moisture and 10,728 Btu/lb as-received.

HENRYS FORK COAL FIELD

The Henrys Fork coal field is a collection of small coal-bearing areas along the north flank of the Uinta Mountains in north Utah that have yet not produced. The coal occurs in six formations (Mississippian, Cretaceous and Tertiary) with only local potential. The occurrences are mostly in thin and in steeply dipping beds. No reserves of thick beds can be assigned to the field. Not enough is known about the coal quality to make any conclusions, but the few available analyses indicate a high-volatile C bituminous coal, high in ash and sulfur. Some of the coal is probably lower rank.

GOOSE CREEK LIGNITE FIELD

The Goose Creek lignite field lies in the northwest corner of Utah in Box Elder County. The lignite occurs in the Tertiary Salt Lake Formation which underlies two basins in the area: Goose Creek and Grouse Creek. The beds are faulted and dip gently to steeply. The occurrence of lignite is merely a curiosity rather than a deposit of any importance. The beds are thin, impure and discontinuous. There has been no production in Utah from this field and no reserves can be calculated.

LOST CREEK COAL FIELD

The Lost Creek coal field is an unimportant occurrence of coal in Morgan County, north Utah. Intermittent mining activity between 1900 and 1920 produced about 1,000 tons for local use. The coal is found in the Tertiary Knight Formation. The coal beds usually lie above a 700- to 900-foot basal conglomerate in thin discontinuous seams. In one or two localities, however, the coal thickens to 6 feet. The beds dip gently and mining conditions would be good if the coal were extensive. Only 1.1 million tons of coal can be assigned as a reserve for beds thicker than 4 feet. The coal is subbituminous containing 17.9 percent moisture, 18.5 percent ash, 0.53 percent sulfur with a heat value of 8,372 Btu/lb as-received.

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VERNAL COAL FIELD

by

H. H. Doelling[1] *and R. L. Graham*[2]

INTRODUCTION

Location and Extent

The Vernal coal field is located in northeast Utah in the northeast corner of the Uinta Basin in Uintah County (see Preface, figure 1a and figure 1). The field is about 40 miles long in an east-west direction and 24 miles wide north-south. Because of the structural condition of the strata, the resource is available only along thin bands which parallel the outcrops. The important Cretaceous coal-bearing Frontier strata crop out along the south flank of the Uinta Mountains, starting a short distance east of the Uintah County line and extend easterly to Diamond Mountain, a distance of 30 miles. The beds continue southerly from Diamond Mountain to Split Mountain and Blue Mountain, flanking these topographic features on their north, west and south sides. Coal beds of lesser importance lie south of these in the Mesaverde Formation which trends northwesterly from the Colorado state line to the south flank of the Uinta Mountains. The westward extensions of both units are buried under younger Tertiary rocks and little is known about their coal-bearing character in these localities.

Topography and Drainage

The topography of the Vernal field is controlled largely by the structure (figure 2). The Uinta Range trends east-west and rises to elevations exceeding 13,000 feet to the north. To the south toward the basin is a series of hogbacks, lapping on the south flank of the mountain range. The dip of the strata becomes less pronounced in the younger beds and the topography becomes one of plateau features: mesas, buttes and deep canyons. Remnants of former erosion surfaces scattered over the area modify the picture. Split Mountain and Blue Mountain extend into Utah from Colorado along the east margin of the area. These are anticlinal mountains.

The major drainage is the Green River in the southeast corner of the field which flows southwesterly. All other drainages are tributary to it and flow southerly from sources in the mountains.

The Vernal field lies between 4,800 feet above sea level along the Green River to almost 7,500 feet to the north. Most of the minable coal occurs at elevations between 5,200 and 6,500 feet.

Population, Industries and Transportation

The Vernal coal field surrounds the most populated area of Uintah County whose population in 1960 was 11,582 rising slightly to 12,684 in 1970. The largest town and the county seat is Vernal (figure 2), population in 1960 of 3,655 and in 1970 of 3,908. Other communities in the vicinity are Naples (100), Jensen (300), Maeser (1,248), Lapoint (200) and Tridell (40).

Vernal is a center for mineral industry, agriculture and tourism. Thirty-four percent of the Uintah County labor force is employed by mineral industries or construction. There are several oil and gas fields in the county, gilsonite and asphalt mines and a large open-pit phosphate operation. Agriculture employs 18 percent, tourism 17 percent and manufacturing 5 percent of the labor force. The remainder of the working population is employed in various supporting services such as education, government, utilities, finance, real estate, etc. No coal mines are in operation.

The major highway link is an east-west artery joining Denver with Salt Lake City (U. S. Highway 40). All other roads with the exception of Utah Highway 44 join U. S. 40 with smaller communities or tourist areas. Utah Highway 44 leads northerly from Vernal over the crest of the Uinta Mountains to the Flaming Gorge recreational area and points in Wyoming. The nearest railroads to Vernal are north and south, each approximately 100 miles distant.

Vernal is connected with larger communities in Colorado and Utah by regularly scheduled bus and air transportation. Several trucking firms also serve the area.

Climate

Vernal has a mid-latitude steppe climate. Its average annual precipitation is between eight and nine inches. The Uinta Basin is completely surrounded by high mountain ranges that collect much larger amounts of precipitation. This water flows through the basin and makes agriculture possible. Vernal's situation near the bottom of a saucer-shaped basin effects the climate especially in the winter. Temperatures in the winter average 10 degrees lower than other stations at the same latitude and elevation. Snowfall and wind are light during the winter and the basin is often filled with fog. Precipitation is light in all seasons; damaging storms are rare. A statistical summary of climatic information prepared by the U. S. Weather Bureau is presented in figure 3.

HISTORICAL OUTLINE

Possibly the first permanent settlement in the Vernal area and also in Utah was a trading post established near the present site of Whiterocks by Antoine Robidoux in 1832. Trappers and fur traders ventured into the area as early as 1824 when William H. Ashley boated down the Green River. Their influence was confined mainly to the Uinta Mountains where water and game were abundant. Jensen, on the Green River, was established by the Mormons in 1877 to service a ferry crossing the river. Other settlements of historical significance are listed in table 1. West of Vernal the Uintah-Ouray Reservation was established, today the dominant Ute tribe number nearly 2,000.

Uintah County was established in 1880. The Vernal coal field was mined to supply fuel for the earliest of the homesteaders. The Cocklebur mine near the abandoned town of Cocklebur was probably the first to be opened; it supplied coal to communities around Jensen and the Green River. Field evidence indicates that new coal mines were opened in the 1890's just outside the Uintah-Ouray Indian Reservation to supply white settlers sent to govern the Indians. The 1890's saw the opening of many coal mines around Vernal: the Bowen mine in Brush Creek,

[1]Economic geologist, Utah Geological and Mineralogical Survey.
[2]Former field chief, Utah Geological and Mineralogical Survey.

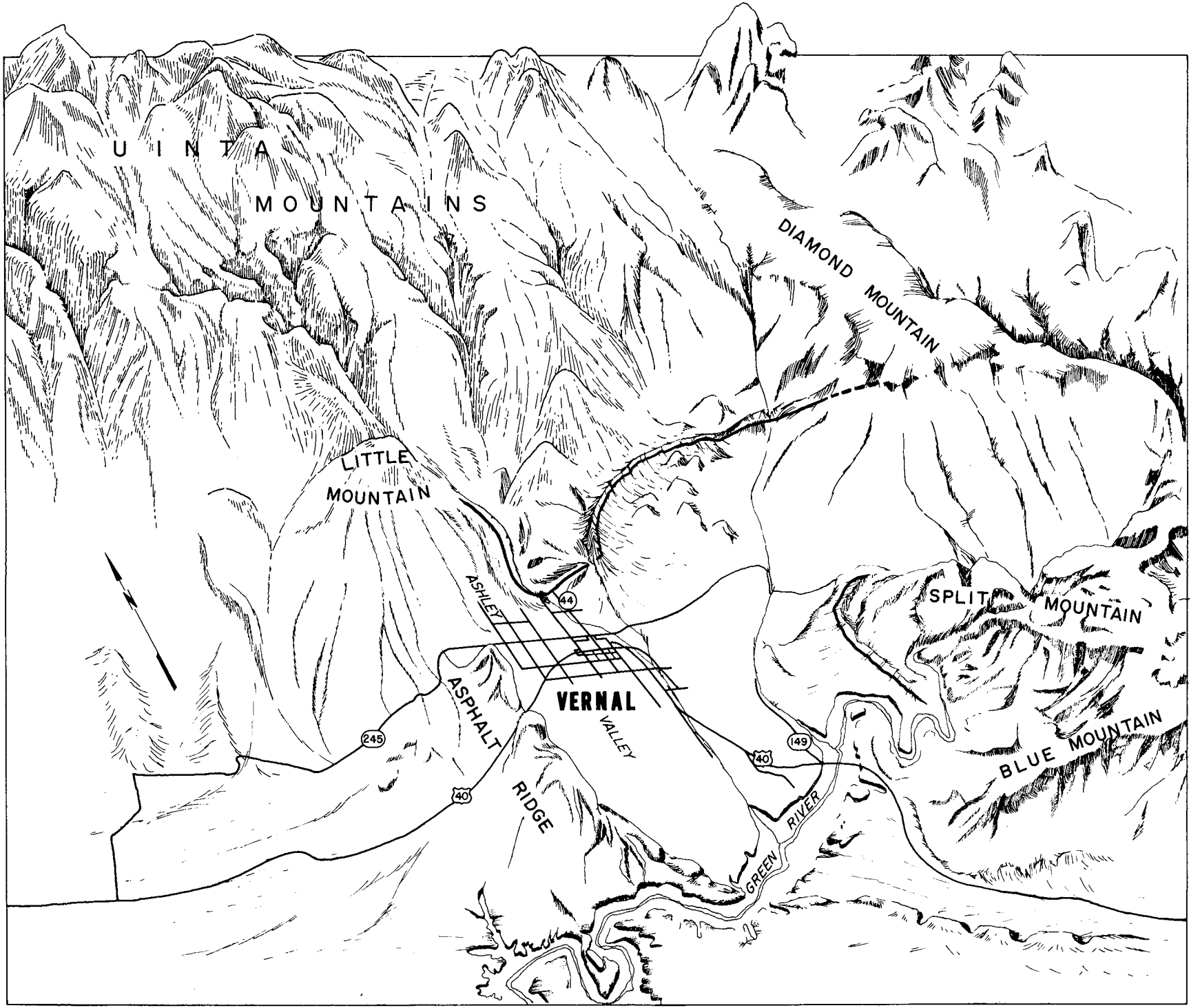


Figure 1. Generalized view of Vernal area.

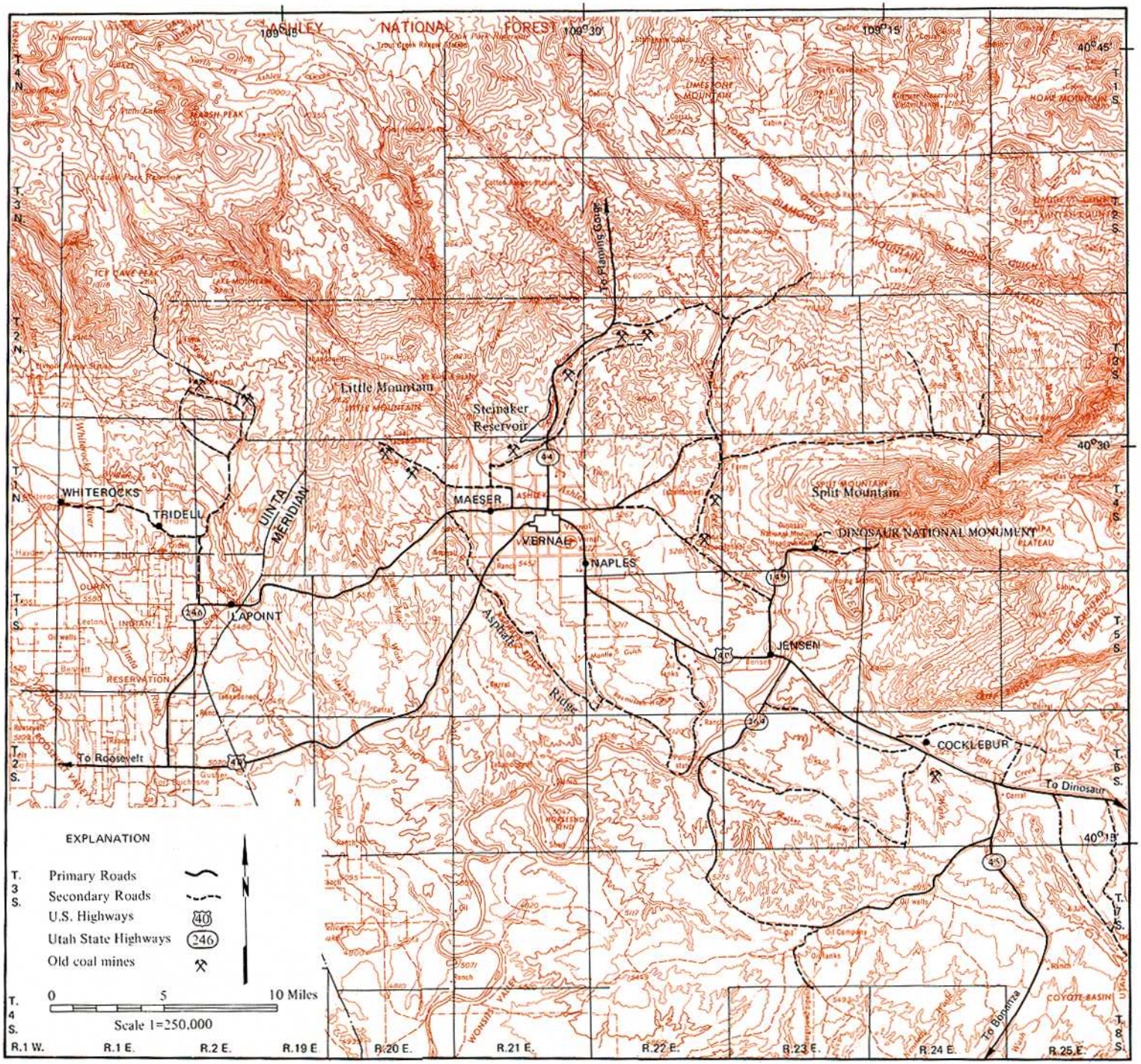


Figure 2. Topography and roads map, Vernal coal field.

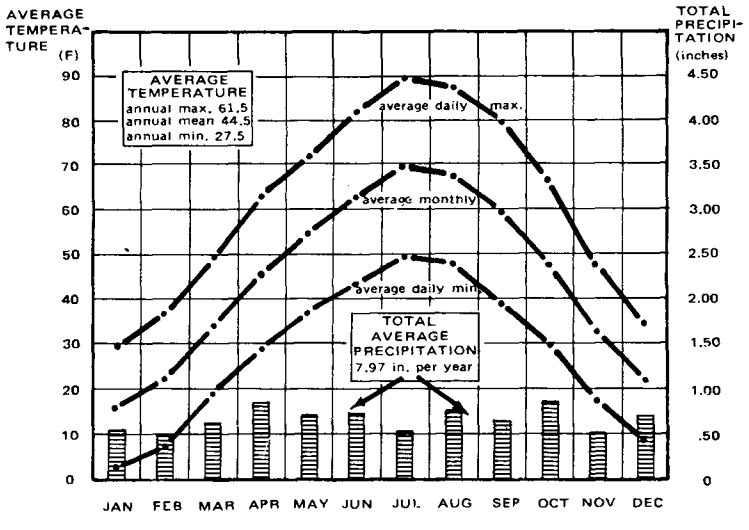


Figure 3. Vernal climatological summary: monthly averages 1931-1960.

the Slaugh mine south of Vernal, the Rich mine at Coal Mine Ridge and the Gibson mine, now covered by the earthfill dam of Steinaker Reservoir.

Just after the turn of the century there were nearly 20 active coal mines in the Vernal field (table 2). Production reached a peak in 1903 to 1905 when nearly 13,000 tons were produced annually. Importing of coal from Colorado and Carbon County, Utah, forced a decline in production of coal. Other sources of fuel soon became available and most of the mines closed. Mining of coal continued until 1957 when the Wardle mine, at the site of one of the first mines in the field, finally closed. The total production from all mines is a little more than 250,000 tons.

GEOLOGIC SETTING

Stratigraphy

The most important coal beds of the Vernal field are confined to Cretaceous rocks. Coal is reported to occur in Mississippian and Tertiary rocks, but the deposits are not commercial. Figure 4 describes the rock formations of the Vernal coal field.

Pre-Jurassic Formations

Precambrian, Cambrian, Mississippian, Pennsylvanian, Permian and Triassic formations are exposed along the south flank of the Uinta Mountains. The Precambrian beds, dominated by reddish quartzites, make up the core of the mountain range and are possibly thicker than 20,000 feet. The remaining pre-Jurassic units aggregate approximately 5,000 feet in thickness and have been subdivided into at least nine divisions including limestone, shale, sandstone, phosphate beds, siltstone and conglomerate.

Coal has been reported in the Manning Canyon Shale near Farm Creek along the Duchesne-Uintah County line (Kinney, 1955, p. 136, 142). No record of the thickness of beds is available but there have been two analyses reporting a heat value of 12,120 Btu/lb and 12,810 Btu/lb on an as-received basis.

Navajo Sandstone

The oldest Jurassic formation, the Navajo Sandstone, is a highly cross-bedded fine- to medium-grained sandstone and usually massive formation which develops picturesque outcrops of sheer walls, domes, rounded backs and sharp turrets. The color is a light tan or light yellow, occasionally red or light brown. The outcrop forms a band flanking the mountains, ranging in thickness from 1,028 feet in the mouth of Whiterocks Canyon to 572 feet at Island Park to the east. This friable unit contains iron and calcareous sandy concretions and at one location (mouth of Whiterocks Canyon) is asphalt-impregnated.

Table 1. Communities of historical significance in the Vernal coal field (1970).

Name	Settled	Population	Comments
Cocklebur	1860's	0	Abandoned
Jensen	1877-	300	Settled by Lars Jensen
Lapoint	1905-	200	Named after spur projecting from Uintas
Maeser	1878-	1,248	Settled by Karl G. Maeser
Naples		100	
Vernal	1879-	3,908	First named Ashley Center, changed to Vernal in 1893
Whiterocks	1868-	300	Indian settlement

Carmel Formation

The Carmel Formation overlies the Navajo Sandstone and consists of soft red sandy shale, thin beds of platy, light gray calcareous mudstone and fine-grained limestone. Most of the limestone occurs at the base of the unit where it makes a sharp contact with the Navajo. The Carmel Formation thins in an easterly direction from 383 feet in west Uintah County to 125 feet at Island Park. It is a soft easily erodable unit that forms a strike valley between the more resistant Navajo and the Entrada sandstones.

Entrada Sandstone

The Entrada Sandstone in Uintah County consists of two types. The first is a light gray, fine- to medium-grained massive sandstone, the second a reddish orange fine-grained silty sandstone. In the west part of the field these lithologies are interbedded but to the east the light gray sandstone dominates or occurs exclusively. This light gray facies is somewhat cross-bedded but not to the extent of the Navajo. The contact with the underlying Carmel is conformable and the contact with the overlying Curtis gradational. The Entrada is more resistant than the underlying Carmel and forms conspicuous strike ridges with the lower part of the Curtis. Like the Carmel and Navajo the unit thins in an easterly direction, 240 feet to the west to 135 feet in the east part of the field.

Curtis Formation

The Curtis can be divided based on lithology and topographic expression into two members. The lower part is a more resistant green-gray, medium- to coarse-grained, thin-bedded and cross-bedded glauconitic sandstone. The upper part is soft green-gray, thin-bedded shale containing thin interbeds of calcareous sandstone or sandy fossiliferous limestone. The upper part also contains much glauconite and the limestone is oolitic. The unit, in contrast to those below, thickens eastwardly from 140 feet in the west half of the county to 270 feet in the east half. The Curtis is usually exposed in the first strike ridge north of another escarpment held up by the coal-bearing Frontier Sandstone. The contact between the Curtis and overlying Morrison is apparently gradational.

Morrison Formation

The Morrison is a heterogeneous unit of sandstone, mudstone and shale. The shales and mudstone beds are variegated and contain brown-weathering concretionary zones. The sandstones are very fine- to medium-grained, with occasional thin lenticular beds of coarse pebble to conglomeratic sandstone. The sandstones are generally light gray to green-gray in color. The formation is easily erodable and crops out in the valleys and lower part of the hogback by the Cretaceous Frontier Sandstone. The thickness ranges from 745 to 930 feet and averages about 850 feet. The Morrison contains a famous reptile fauna in Dinosaur National Monument near the east end of the Vernal coal field. Unlike areas to the south the Morrison cannot be divided into typical Salt Wash-

Table 2. Coal mines and prospects of the Vernal coal field.

Quadrangle	Location	Remarks
Cliff Ridge		
Cocklebur mine	NE.21–6S–24E	1870-1880's?
Prospect	NE.NE.NE.NE.21–6S–24E 4,461,550m.N. 652,000m.E.	
Dinosaur Quarry		
Mine adit	NW.NW.NW.SE.6–4S–23E 4,484,190m.N. 637,875m.E.	
Donkey Flat		
Blue Bell mine (Massey & Winn, Kidd mine)	SE.NE.SE.8–3S–22E 4,491,990m.N. 630,219m.E.	1911-1950? Average 400 tons/yr.
Packard mine	NE.NW.SE.SW.6–3S–23E 4,493,400m.N. 637,350m.E.	Open adit
Pollard mine	NW.NW.NW.SW.18–3S–22E 4,490,530m.N. 627,100m.E.	1907-1910
Taylor mine	SW.NE.NE.18–3S–22E 4,491,240m.N. 628,350m.E.	
Dry Fork–Vernal NW		
C. C. Rich mine (Pack-Allen, Mill mine)	NE.NE.NE.NW.11–4S–20E 4,482,840m.N. 615,050m.E.	1910-1922
Farmers mine	SW.NW.SE.NE.3–4S–20E 4,483,960m.N. 613,835m.E.	
Farmers mine	SE.SW.NE.3–4S–20E 4,484,040m.N. 613,800m.E.	
Fletcher mine (Gray, North Star mines)	NW.NE.NE.SE.3–4S–20E 4,483,620m.N. 614,100m.E.	1908-1924 750 tons/yr.
Helco mine	NE.SW.NE.3–4S–20E 4,484,095m.N. 613,810m.E.	Recent activity
J. E. Rich mine (Hatch)	SW.NW.SW.2–4S–20E 4,483,360m.N. 614,420m.E.	1894-1908 1100 tons
Larson mine	C.NE.NW.NE.30–3S–20E 4,487,570m.N. 608,800m.E.	1910-1921
Mine	SW.SW.NE.11–4S–20E 4,482,440m.N. 615,260m.E.	
Mine adit	E.NW.NW.NE.3–4S–20E 4,484,470m.N. 613,650m.E.	
Mine adit	SE.NW.NE.3–4S–20E 4,484,340m.N. 613,760m.E.	
Mine adit	SE.SE.NW.NE.3–4S–20E 4,484,210m.N. 613,760m.E.	
Timothy mine	NW.SE.SW.2–4S–20E 4,483,170m.N. 614,750m.E.	1910-1921
Wardle mine	C.SW.2–4S–20E 4,483,330m.N. 614,620m.E.	1919-1955
Weeks mine	E.SE.NE.SE.3–4S–20E 4,483,515m.N. 614,300m.E.	
Prospect	NW.NW.NW.NE.SE.3–4S–20E 4,483,719m.N. 613,910m.E.	
Prospect	C.NW.NE.3–4S–20E 4,484,430m.N. 613,690m.E.	
Prospect	SW.NE.SW.NE.3–4S–20E 4,484,025m.N. 613,770m.E.	
Jensen Ridge		
Prospect	SE.SE.SE.NW.5–4S–23E 4,484,600m.N. 639,200m.E.	

Table 2. (continued)

Quadrangle	Location	Remarks
Lake Mountain		
Government mines (Indian mines)	SE.SE.SE.NE.32–2N-2E USM 4,486,640m.N. 603,080m.E.	1919-1921
	NW.NW.SW.33–2N–2E USM 4,486,610m.N. 603,170m.E.	
	C.NW.SW.33–2N–2E USM 4,486,570m.N. 603,260m.E.	
	SW.SE.SE.NE.32–2N–2E USM 4,486,660m.N. 602,840m.E.	
Gross mine	NE.NE.SE.SE.19–3S–19E 4,488,010m.N. 599,470m.E.	Old
Prospects	NW.SE.SE.27–3S–19E 4,486,340m.N. 604,060m.E.	
	NE.SE.SE.27–3S–19E 4,486,280m.N. 604,310m.E.	
	NW.SW.SW.26–3S–19E 4,486,310m.N. 604,450m.E.	
Rasmussen mine	NW.NW.SW.SW.20–3S–19E 4,487,915m.N. 599,685m.E.	1921
Reynolds mines	C.SW.20–3S-19E 4,487,925m.N. 599,920m.E.	1906-1947
	NW.SE.SW.20–3S–19E 4,487,875m.N. 600,040m.E.	
Warburton mine	NW.NW.SE.SE.19–3S–19E 4,487,905m.N. 599,310m.E.	1946-1950
Naples		
Bowen mine	NW.NE.NW.SW.25–4S–22E 4,477,840m.N. 635,650m.E.	1891-1921
Collier mine	NE.NE.NE.SE.NE.26–4S–22E 4,478,240m.N. 635,370m.E.	1921
Dredge mine (Burton)	NE.NE.SE.SE.NE.26–5S–22E 4,478,030m.N. 635,390m.E.	
Dudley mine (Henry)	NE.SW.SE.13–4S–22E 4,480,660m.N. 636,400m.E.	
Green mine	SW.NE.NW.24–4S–22E 4,480,100m.N. 635,900m.E.	Old
Hulinger mine	SW.SW.SE.NE.13–4S–22E 4,481,200m.N. 636,630m.E.	
Prospect	NE.NW.SW.24–4S–22E 4,479,200m.N. 635,600m.E.	
Rasmussen Hollow		
Slaugh mine	NW.NW.NE.31–5S–22E 4,466,950m.N. 628,550m.E.	1893-1904
Steinaker Reservoir–Vernal NE		
Brown mine	W.NE.NW.18–4S–21E 4,481,200m.N. 617,930m.E.	
Gibson mine	NE.NE.NE.NW.2–4S–21E 4,484,710m.N. 624,480m.E.	1890's
Prospects	SW.NE.SW.3–4S–21E 4,483,525m.N. 622,520m.E.	Old
	NE.NE.SW.3–4S–21E 4,483,820m.N. 622,900M.E.	
	C.NW.NW.SW.25–3S–21E 4,487,235m.N. 625,670m.E.	
	C.SW.SW.NW.25–3S–21E 4,487,380m.N. 625,700m.E.	
	NW.NW.SW.NW.25–3S–21E 4,487,625m.N. 625,550m.E.	

(continued on next page)

Table 2. (continued)

Quadrangle	Location	Remarks
	C.NE.NE.NW.25–3S–21E 4,488,025m.N. 626,260m.E.	
	C.SW.NW.36–3S–21E 4,486,025m.N. 625,660m.E.	
	NE.SW.NW.NW.36–3S–21E 4,486,120m.N. 625,710m.E.	
	SE.NW.NW.36–3S–21E 4,486,250m.N. 625,750m.E.	
	SW.SW.NW.36–3S–21E 4,485,840m.N. 625,620m.E.	
Mine	NE.NW.NW.36–3S–21E 4,486,430m.N. 625,870m.E.	
Vernal NE–SE		
Prospect	SE.SE.NE.32–4S–21E	
Uintah County		
Bugham & Keeney	Unknown	1921
Jones mine	Unknown	1949
Miller & Hardy	Unknown (Stringham operator)	1941
Stebb mine	Unknown	1921
Thatcher mine	Unknown	1921

Brushy Basin members in Uintah County. The contact with the overlying Dakota Sandstone is presumed to be unconformable in accordance with fossil evidence elsewhere.

Dakota Sandstone

The Dakota Sandstone in the Vernal area has been subdivided into three individual formations by some authors. Each of these three divisions is thin and described as one for purposes of this report. Kinney (1955, p. 95) describes the Dakota as follows:

> In the area under study, the Dakota Sandstone may consist of a single light-gray to tan, medium- to coarse-grained sandstone, a sandstone underlain by brownish gray shale and interbedded thin sandstone, or a sandstone underlain by brown to greenish-gray shale and a thin, fine-grained light-gray, basal sandstone. The main sandstone, characteristically, is cross-bedded, friable, and noncalcareous. It is composed of angular sand grains and well-rounded chert pebbles. The pebbles consist of dark-gray to black, and reddish-brown chert, which are more abundant near the base of the unit. The brownish-gray shale is interbedded with yellow, platy sandstone or greenish sandstone. It contains thin lignitic layers near Steinaker Draw. The lower sandstone is light gray-to tan, very fine-grained and platy.

G. E. and B. R. Untermann (1964b, p. 42) correlated the lower sandstone with the Buckhorn Conglomerate (Dakota) and note that the unit is but locally conglomeratic in Uintah County. The middle shale unit is correlated with the Cedar Mountain Shale (Fuson) and the upper sandstone is considered the Dakota. According to Hale and Van de Graaff (1964, p. 118-119) an unconformity divides the lower two members from the upper.

The thickness of the total Dakota ranges from 50 to 200 feet but there is no regional trend. The beds are lenticular. Most of the outcrops in the escarpment are supported by the Frontier Sandstone. It is slightly more resistant than the underlying Morrison and is conformably overlain by the Mowry Shale.

The Dakota of the Vernal area is considered to be Lower Cretaceous (Aptian and Albian) by most workers. The Dakota in other coal areas (Kaiparowits, Book Cliffs, Castle Valley) is believed to be Upper Cretaceous or Cenomanian in age. The Dakota is coal bearing in some of the other coal fields, but near Vernal the unit is barren except for the thin lignitic layers in the middle shale near Steinaker Draw and some thin bituminous seams near Mosby Creek in the Deep Creek area. This last coal, however, may belong to the Frontier; the stratigraphic and structural relationships of the area are not too clear.

Mowry Shale

Overlying the Dakota beds is an easily recognizable unit of hard, gray and gray-white weathering siliceous shale. This is the Mowry Shale, sometimes grouped with two overlying units and called the Mancos Shale. It usually occurs in a steep slope immediately below the resistant sandstone units of the Frontier. It weathers into small chips and plates containing abundant fish scales and small teleost bones. The presence of *Neogastroplites wyomingensis* dates the unit as latest Lower Cretaceous. The unit thickness is irregular, ranging from 30 to 123 feet in the Vernal coal field.

Frontier Sandstone

The Frontier is the most important coal-bearing formation of the Vernal coal field (figure 5). The unit varies in thickness from 150 to 300 feet and is composed of clay shale, silty and sandy shale, carbonaceous shale, sandy siltstone, sandstone and coal. The total thickness varies irregularly from place to place within the aforementioned range as individual beds and zones thin and thicken.

Generally the formation can be subdivided into two members. The lower unit is a slope former composed mostly of clay shale, silty and sandy shale and shaley sandstones. The slope is occasionally broken by medium resistant sandstone ledges. The color is usually tan and brown, the sands are fine-grained and the clays are gypsiferous. The lower member varies between 75 and 203 feet in thickness. It is thinnest between Little Mountain and Diamond Mountain and thickens to the southeast and west.

The upper member contains the coal and consists of massive, resistant, medium-grained tan sandstone that weathers gray-white, with lesser amounts of shale, shaley sandstone and carbonaceous shale. It thickens to the north and east and thins to the south and perhaps west. Coal is completely missing in exposures east of the Bonanza road (Utah Highway 45). The member occasionally contains molds and casts of *Inoceramus* and other shellfish, and occasionally poorly preserved cephalopods. These fossils occur throughout the unit. The Frontier is probably Cenomanian and Turonian in age.

The upper part of the Frontier also can be divided into three divisions: a lower thick massive sandstone, a coal zone 10 to 50 feet thick and a capping resistant sandstone. All the coal of the Frontier occurs in the middle zone. The tripartite division disappears to the southeast as the massive sandstones above and below the coal become thin and disappear. They are replaced by thin- and medium-bedded shaley-weathering tan and brown sandstones interbedded with considerable gray shale. The coal disappears as the massive sandstones are replaced.

Mancos Shale

Intermediate between two coal-bearing formations is the marine Mancos Shale. It is a soft clay shale unit of considerable thickness. The lower part weathers to a light gray and the upper part to a yellow-tan. The unit becomes progressively sandier toward the top where abundant thin beds of sandstone occur. Basically it is poorly exposed with a thin soil mantle covering the unit. The silty nonpermeable unit supports little plant life and weathers into badland surfaces and rounded hills. Between Jensen and the Colorado border, measured in two places, the unit is 4,910 and 5,072 feet thick. Fossils, calcite geodes and selenite seams are abundant in many beds. Measurements in Duchesne County indicate that the unit probably thins in that direction. The unit correlates with the members of the Mancos above the Ferron Sandstone in the Book Cliffs, Wasatch Plateau and Henry Mountains areas and is Coniacian, Santonian and Campanian in age. The outcrop lies in the broad area between the Frontier escarpment and the Rim Rock or Asphalt Ridge. East of Little Mountain it is covered by Tertiary rocks and does not reappear for 50 miles farther west. Between the two ridges the formation is covered by

System	Series	Stratigraphic Unit	Thickness (feet)	Description
TERTIARY	Miocene (?)	Browns Park Formation	200- 800	Gray-white or pink sandstone to conglomerate, calcareous, interbedded with tuffaceous sandstone, tuff and bentonitic beds.
				Unconformity
	Oligocene	Duchesne River Formation	0-1,500	Red, tan, brown and varicolored clay shale and siltstone with interbedded reddish-weathering gray to tan sandstone with minor conglomerate.
	Eocene	Uinta Formation	1,650-2,600	Gray, tan, red and brown, medium- to coarse-grained, poorly sorted sandstone interbedded with white, gray, purple and red mudstone.
		Green River Formation: Evacuation Creek Member	500	Gray-brown shale, limestone, mudstone, siltstone, sandstone and tuff.
		Green River Formation: Parachute Creek Member	1,450	Dark gray, brown and black oil shale, green and brown shale, gray limestone and dolomite, siltstone and sandstone.
		Green River Formation: Garden Gulch Member	550	Gray, tan and brown shale intercalated with thin-bedded siltstone, sandstone and limestone.
		Green River Formation: Douglas Creek Member	350- 500	Brown, thick-bedded sandstone and occasional conglomerate with black, gray and brown shale with subordinate limestone.
				Unconformity
	Paleocene	Wasatch Formation	850	Varicolored shale and mudstone interbedded with gray and brown sandstone and local conglomerate.
				Unconformity
CRETACEOUS	Maestrichtian Campanian	Mesaverde Formation: "Upper Member" *COAL SEAMS*	110-1,780	Light gray to brown, fine- to medium-grained, thin-bedded to massive sandstone interbedded with gray to black shale, contains lenticular mostly lignitic coal seams.
		Mesaverde Formation: Rim Rock Member *COAL SEAMS*	260- 530	White, tan and brown sandstone with interbedded minor gray to brown shale with some lenticular coal (includes Asphalt Ridge Member).
	Santonian Coniacian	Mancos Shale	4,900-5,100	Medium to dark gray silty shale interbedded with subordinate thin sandstone and sandy limestone.
	Turonian Cenomanian	Frontier Sandstone *MAJOR COAL ZONE*	150- 300	Gray to tan, fine- to medium-grained sandstone in upper part over light brown to brown-weathering sandy and silty shale in lower part. Upper part contains interbedded coal and carbonaceous shale.
				Unconformity
	Albian	Mowry Shale	30- 123	Dark gray siliceous marine shale, fissile, weathers into silvery white chips and plates.
	Aptian	Dakota Sandstone *MINOR COAL*	50- 200	Light gray to tan, medium- to coarse-grained sandstone interbedded with brown to greenish gray shale and fine-grained thin-bedded sandstone. Contains occasional thin lignitic beds.
				Unconformity
JURASSIC	Upper	Morrison Formation	745- 930	Variegated shale and mudstone with some interbedded fine- to medium-grained sandstone and occasional conglomeratic sandstone. Slope former.
		Curtis Formation	140- 270	Green-gray, glauconitic easily erodable, thin-bedded shale in upper part and green-gray, medium- to coarse-grained, thin-bedded, medium-resistant glauconitic sandstone.
				Unconformity
		Entrada Sandstone	135- 240	Light gray or orange-red, fine-grained resistant silty sandstone.
		Carmel Formation	125- 383	Red sandy shale, light gray, calcareous mudstone and fine-grained limestone. Nonresistant.
	Lower	Navajo Sandstone	572-1,028	Light tan to yellow, cross-bedded, fine- to medium-grained resistant aeolian sandstone.
PRE-JURASSIC	Formations of limestone, shale, sandstone, phosphate, siltstone, quartzite and conglomerate representing Triassic, Permian, Pennsylvanian, Mississippian, Cambrian and Precambrian time with aggregate thickness of at least 25,000 feet. Some lenticular thin COAL beds have been reported from the Mississippian Manning Canyon Shale in the west part of the Vernal coal field.			

Figure 4. Generalized section of rock formations in the Vernal coal field.

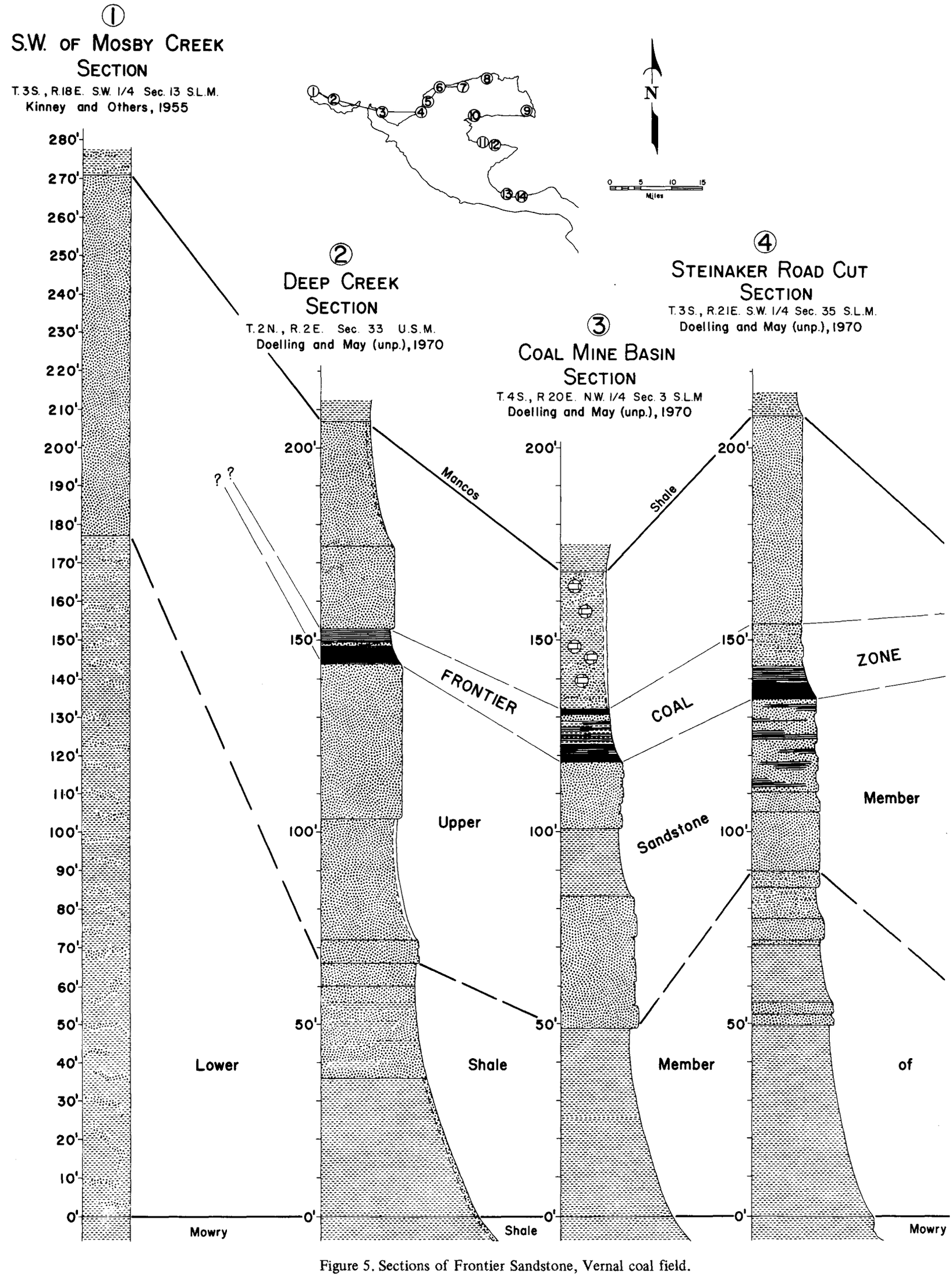
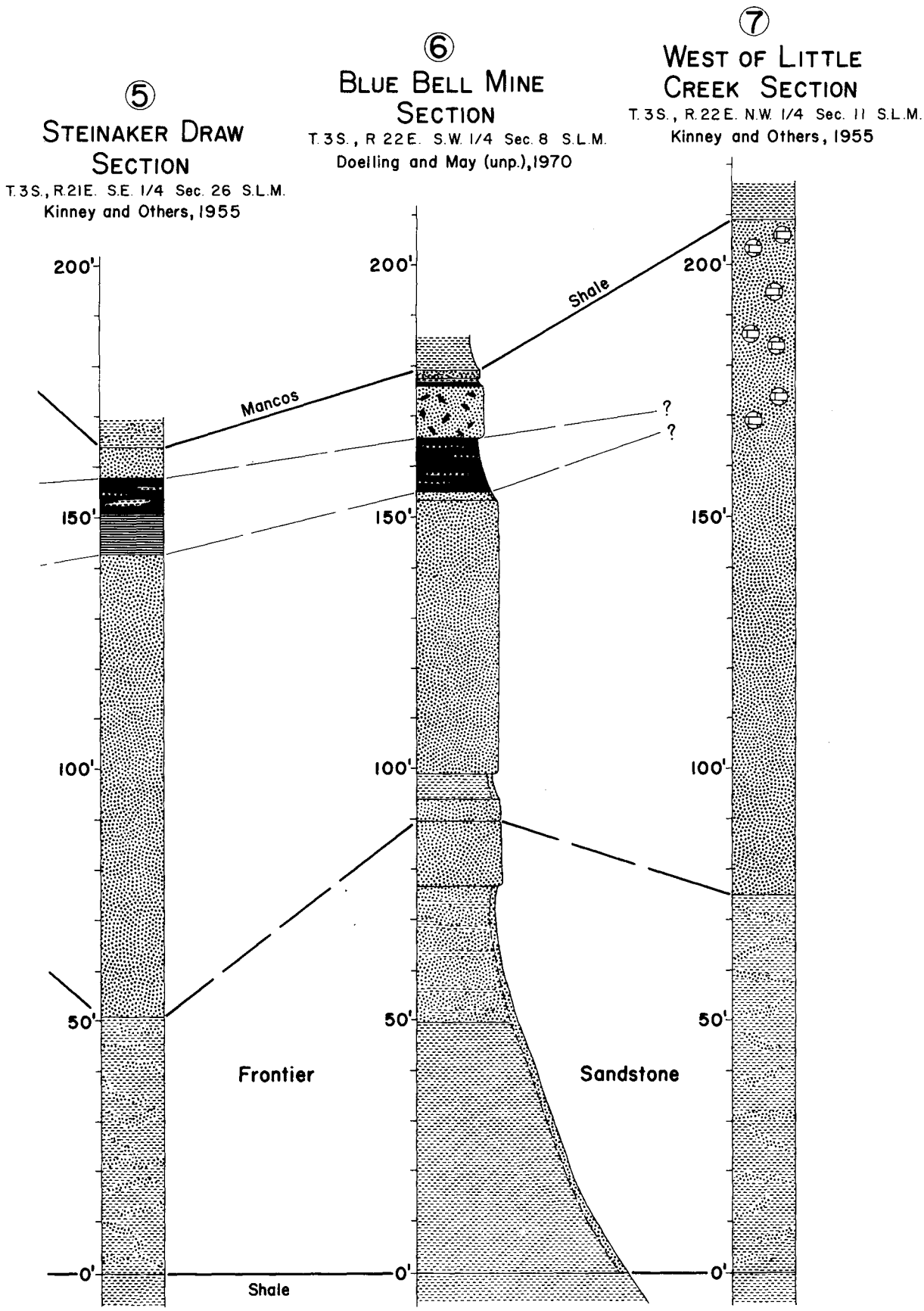


Figure 5. Sections of Frontier Sandstone, Vernal coal field.



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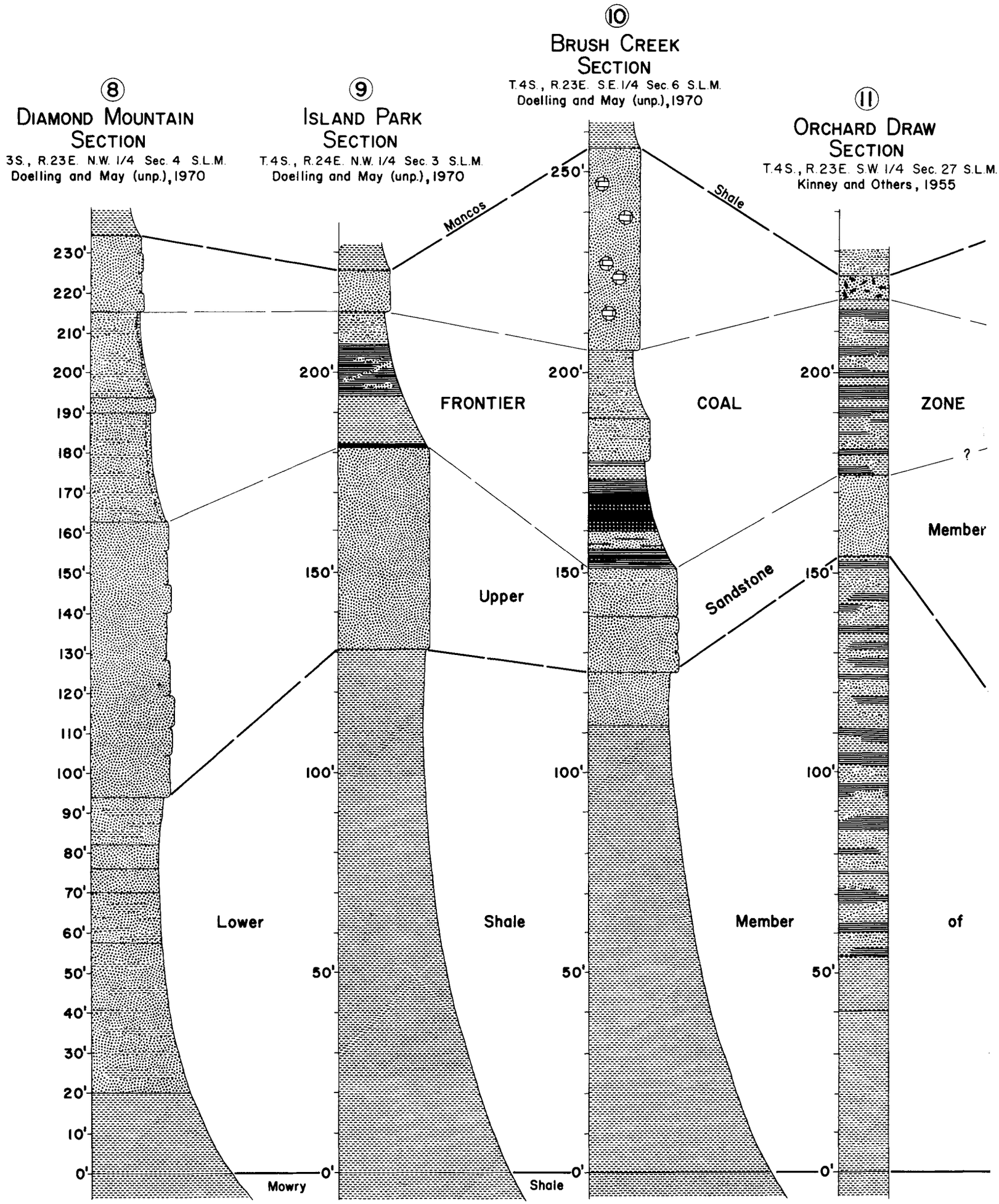


Figure 5. (continued)

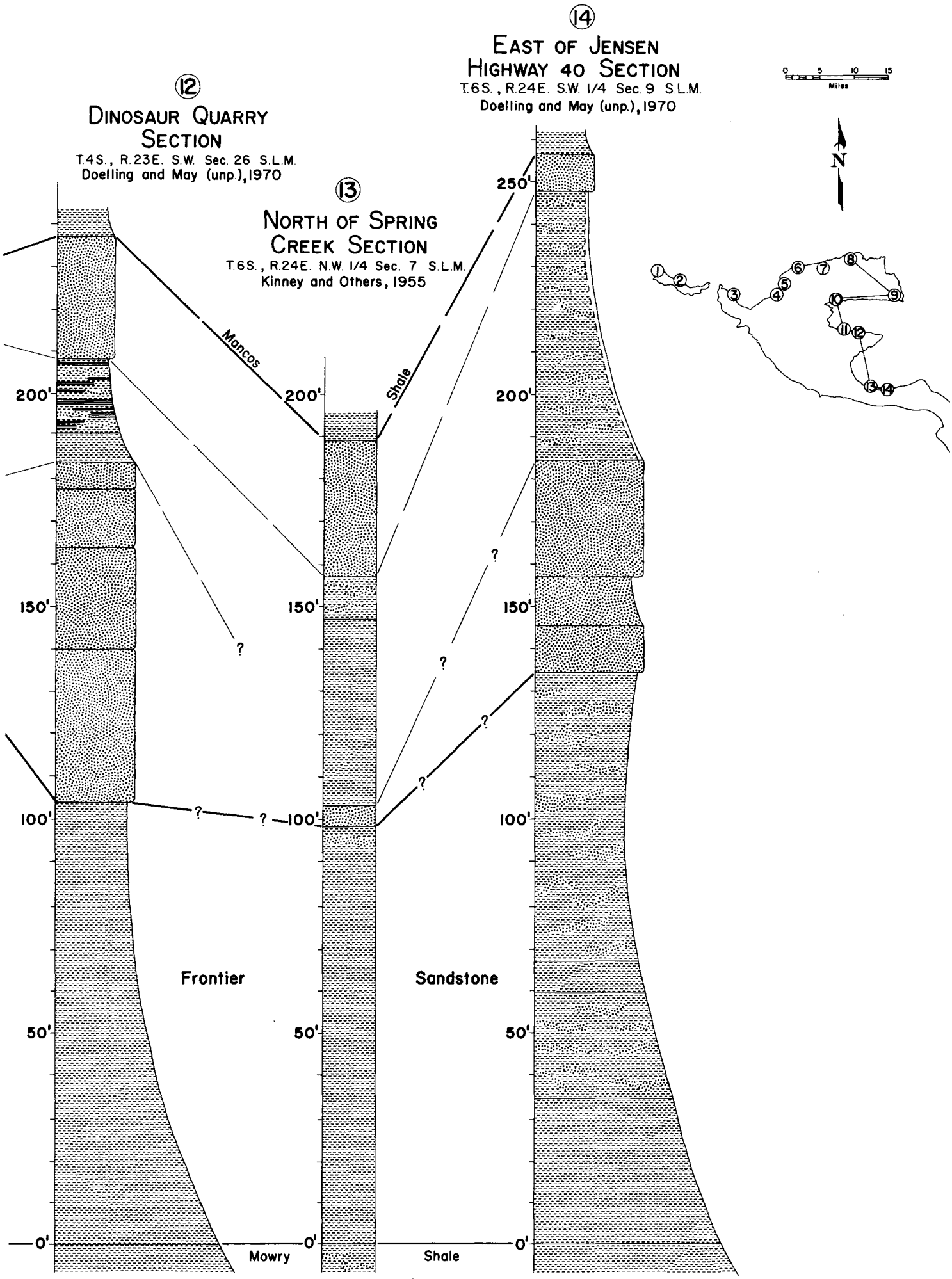
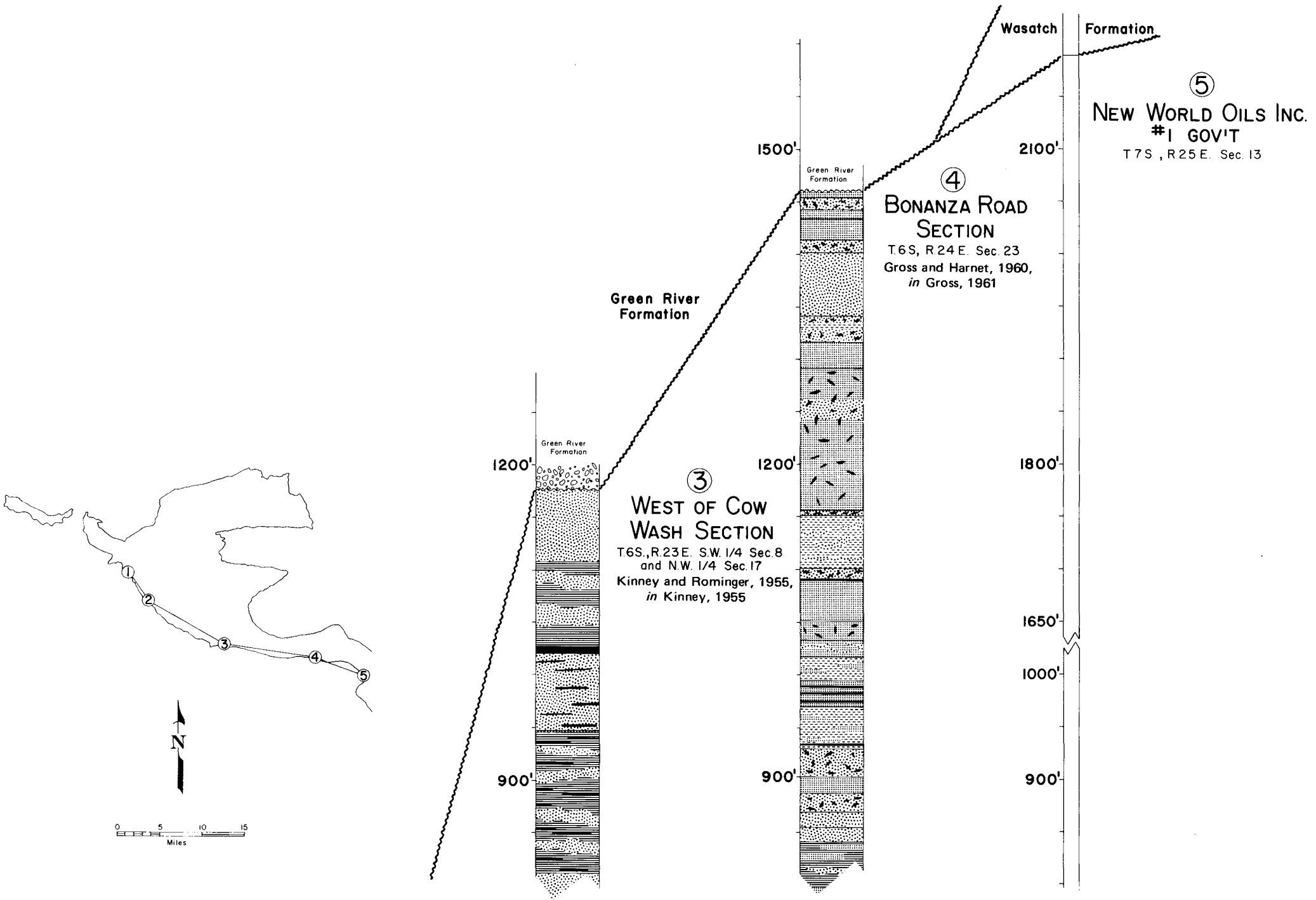


Figure 5. (continued)


Wasatch
Formation
⑤
NEW WORLD OILS INC.
#1 GOV'T
T7S, R25E. Sec. 13
2100'
1800'
1650'
1000'
900'
1500'
Green River
Formation
④
BONANZA ROAD
SECTION
T.6S, R.24E. Sec. 23
Gross and Harnet, 1960,
in Gross, 1961
1200'
900'
Green River
Formation
Green River
Formation
③
WEST OF COW
WASH SECTION
T.6S., R.23E. S.W. 1/4 Sec.8
and N.W. 1/4 Sec.17
Kinney and Rominger, 1955,
in Kinney, 1955
1200'
900'
①
②
③
④
⑤
N
0 5 10 15
Miles

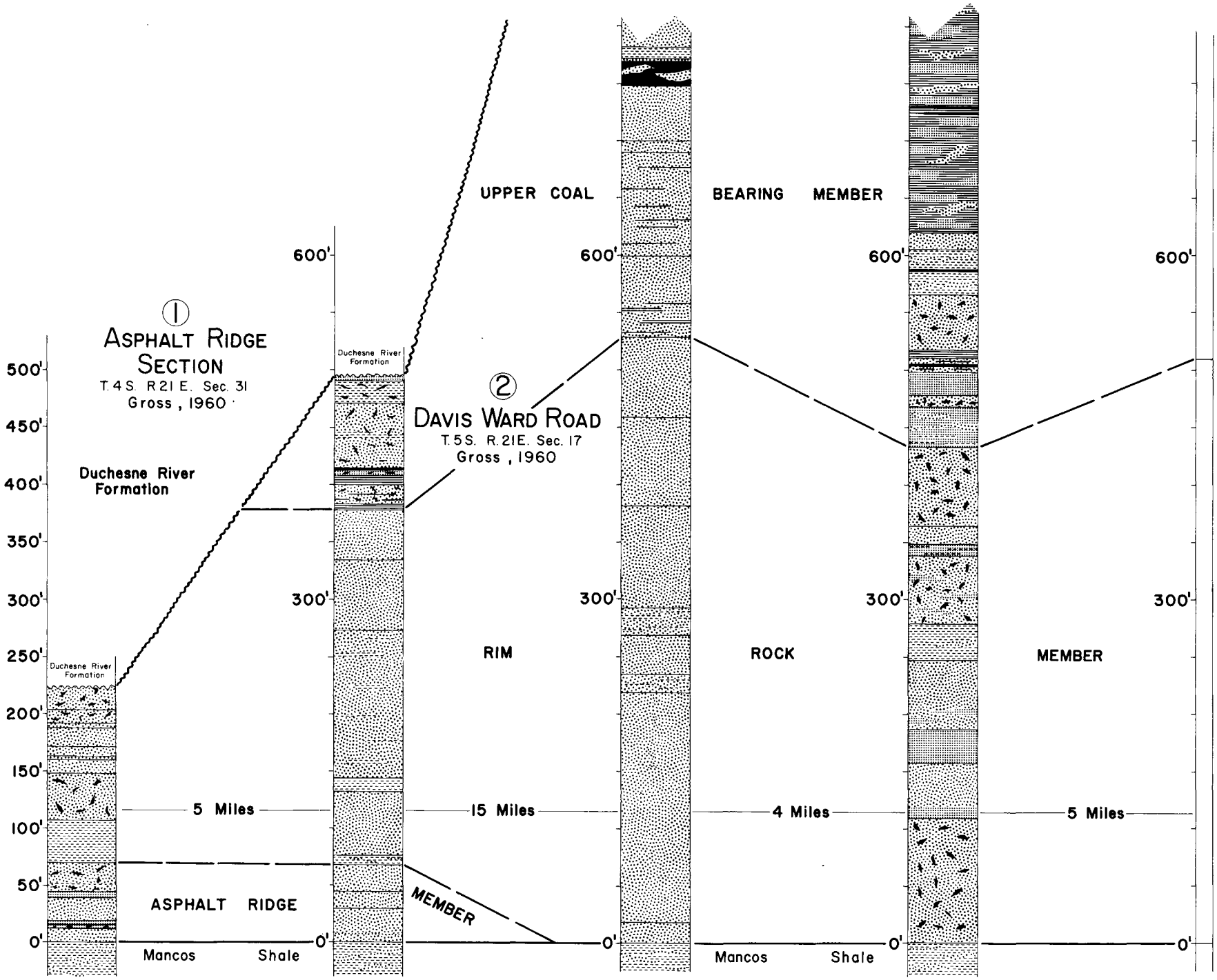


Figure 6. Sections of Mesaverde Formation, Vernal coal field.

much alluvium. These areas are extensively farmed and the towns of Vernal and Jensen are located there.

Mesaverde Formation

The Mesaverde Formation is subdivided by several workers into a number of members. The unit may be divided into four divisions (figure 6) based on weathering characteristics. The lowest member is poorly exposed in the foothills below Asphalt Ridge, southwest of Vernal. To the northwest this Asphalt Ridge Member is buried under Quaternary and Tertiary deposits and to the southeast pinches out approximately where the Green River cuts through the formation. Gross (1961, p. 68) indicates the member is 110 feet thick at Asphalt Ridge. It is a poorly cemented yellow to white gypsiferous sandstone with subordinate siltstone. The grains are predominantly quartz, fine- to medium-grained and subangular. Most of the sandstones are calcareous.

Overlying the Asphalt Ridge Member is the Rim Rock Member. The Rim Rock is a topographic escarpment extending from the Green River eastward into Colorado and is supported by the resistant sandstones of the member. The unit is predominantly sandstone, fine- to coarse-grained. The sand particles consist of smoky quartz, slightly cross-bedded, with limited amounts of interbedded shale, carbonaceous shale and coal. The Rim Rock is about 150 feet thick in the Asphalt Ridge area where it is truncated by overlying Tertiary beds. It thickens on the east side of the Green River to 530 feet where it is overlain by another member of the Mesaverde.

The third unit is a medium resistant group of beds consisting of interbedded sandstone and shale. The fourth unit and youngest part of the Mesaverde has a similar lithology but is so soft that it is difficult to find bedrock outcrops. The sandstones constitute from 50 to 60 percent of the upper two units. These sands are light gray to brown, fine- to medium-grained and thin-bedded to massive, of varying resistance to erosion. The shales are light gray to black, often lignitic, carbonaceous and nonresistant. There are several coal beds in these upper two members but they can only be mapped in the lower half. There is a hint that deposition was cyclical, as indicated by Gross (1961, p. 94):

> The upper Price River Formation (Mesaverde) in the Vernal area is cyclic to a certain extent. The cycles are usually incomplete and without the marine shale and basal littoral sandstone. A typical cycle in the Vernal, Utah area is:
>
> shale and siltstone
> subgraywacke or quartzose sandstone
> shale and siltstone
> lignitic or bone coal
> shale and siltstone
> subgraywacke or quartzose sandstone
> shale and siltstone
> lignite or bone coal
> shale and siltstone
> subgraywacke or quartzose sandstone, etc.

Only two divisions are considered in this writing, as suggested by Kinney (1955, p. 110). The lower half is divided from the upper at the top of the Rim Rock Member. In the remainder of this report the Mesaverde will be subdivided into the Rim Rock Member and an "Upper" Mesaverde Formation. This upper member has been called the Williams Fork by some writers and Upper Price River by others. Still other geologists consider at least part of the sequence to be Tertiary Wasatch in age. The "Upper" Mesaverde ranges in thickness from about 110 feet along the Green River where it is truncated by Tertiary beds to well over 1,780 feet near the Colorado state line where it is also truncated by Tertiary beds.

The Rim Rock Member contains a few extremely thin lenticular coal seams east of the Green River. To the west at Asphalt Ridge the cliff-forming habit of the unit is not well developed and the exposures are poor. Two exposures of coal of considerable thickness have been discovered; these are more fully discussed in the section on coal. An early mine (Slaugh mine) was opened in one of these exposures. It is assumed that these coal exposures are in the Rim Rock, but they could also be in small remnants of the "Upper" Mesaverde.

The "Upper" Mesaverde contains abundant lignitic coal seams and a few bituminous (?) beds. These seams and beds increase in number in the upper portion of the lower medium resistant part of the member. One prospect (the Cocklebur) was opened prior to 1900 near Cow Wash. Quality of the coal beds seems to improve in an easterly direction.

Diagnostic fossils are rare in the Mesaverde Formation. Some shellfish and abundant fossil wood occur in the unit. The Mesaverde is considered to be Campanian in age by most investigators. The Mesaverde of the Vernal area (except perhaps the Asphalt Ridge Member) does not correlate directly with the Mesaverde at Red Creek, Tabby Mountain coal field (Hale and Van de Graaff, 1964, figure 11).

Wasatch Formation

The Wasatch Formation is a fluvial redbed deposit laid down in late Paleocene to early Eocene time. It consists of mudstones and shales, poorly sorted lenticular and massive sandstones and occasional conglomerate. In the Vernal field it is exposed east of Jensen only because of a progressive overlap by the Green River, Uinta and Duchesne River formations. The unit is about 850 feet thick where exposed and thickens westward in subsurface sections to about 4,000 feet in Duchesne County. This overlap is illustrated by figure 7.

Green River Formation

Like the Wasatch, the Green River Formation is exposed only in the east part of the field. In Uintah County the unit can be subdivided into several members, from bottom to top: a black shale facies, Douglas Creek Member, Garden Gulch Member, Parachute Creek Member and Evacuation Creek Member. At Red Wash, a few miles south of the Vernal coal field, the black shale is not present, Douglas Creek is 350 to 500 feet thick, Garden Gulch is 550 feet thick, Parachute Creek is 1,450 feet thick and Evacuation Creek is 500 feet thick.

The Douglas Creek consists mainly of black and brown shales, thick brown sandstone beds and oolitic and algal limestone. It grades eastward into the Delta facies. The Garden Gulch lies conformably above the Douglas Creek and is a green and brown shale unit that weathers to shades of tan and gray. There are smaller amounts of sandstone, siltstone, limestone and oil shale. The unit also grades imperceptibly eastward into the Delta facies. The Parachute Creek Member is mainly oil shale, a dark brown and gray shale with thin tuff beds. It is a resistant cliff former. Uppermost is the Evacuation Creek mudstone, siltstone, sandstone and tuff. It contains small amounts of oil shale. The outcrop area of the Green River is south of the Mesaverde Rim Rock in the east part of the field. To the west it is found only in subsurface sections covered by the Uinta and Duchesne River formations.

Uinta Formation

Beds of the Uinta Formation may not be exposed south of Vernal. They are easily confused with those of the Duchesne River Formation. If present they are exposed above the Green River Formation east of the Green River, not farther west in the coal field. G. E. and B. R. Untermann (1964b, p. 59) describe the unit as a "sequence of interbedded gray, buff, brown, and reddish brown sandstones and gray, white, purple, and red mudstone, siltstones, and clay shales of fluvial origin. The sandstones are medium- to coarse-grained, poorly sorted, cross-bedded and irregularly bedded, frequently representing channel fill."

NORTHEAST SOUTHWEST

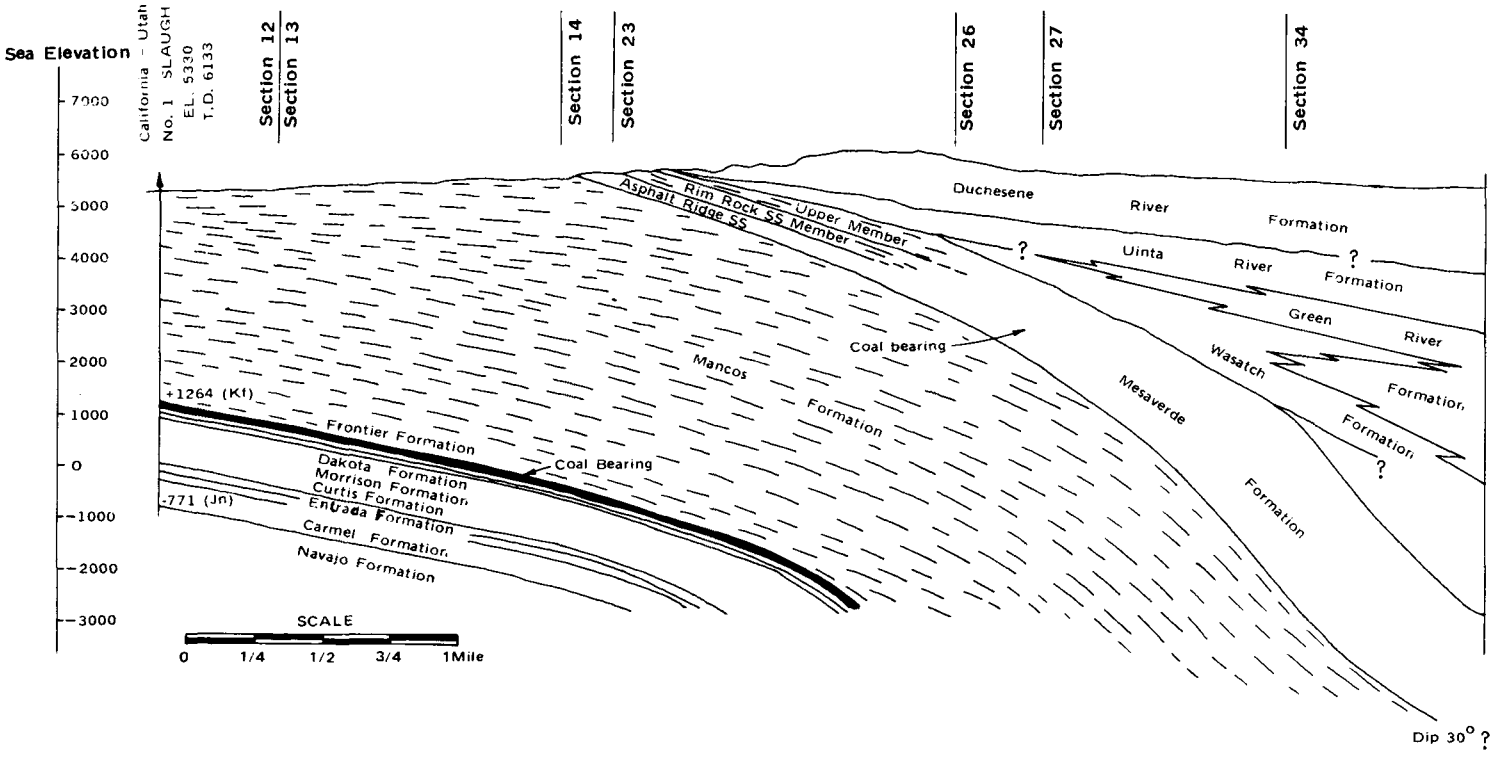


Figure 7. Geologic profile of the Vernal coal field, Asphalt Ridge area, T. 5 S., R. 21 E., Uintah County (geology by Covington, 1963).

The Uinta Formation was subdivided into two or three members (Wagon Hound [A and B] and Myton [C] members) by early workers. The lower unit attains 685 feet in thickness several miles south of the coal area and the Myton Member attains 700 feet 30 miles west of Asphalt Ridge. The Uinta is late Eocene in age.

Duchesne River Formation

Immediately south of the coal-bearing formations in the west part of the field are outcrops of the Duchesne River Formation of Oligocene age. The appearance of the unit is much like that of the Uinta Formation except that it has more sandstone and conglomerate of a dark uniform red color. The red-brown and varicolored shales, red-weathering sandstones and conglomerates were derived mainly from the Uinta Mountains and reach a maximum thickness of 1,500 feet.

Browns Park Formation (Bishop Conglomerate)

The Browns Park Formation is a cap rock on many of the higher mountains located within the area of the Vernal coal field. The largest areas of outcrop are on Little Mountain, Mosby Mountain, Diamond Mountain and the Buckskin Hills. It consists of poorly cemented conglomerate; its maximum thickness is 1,500 feet and it truncates all beds beneath it. The material is composed chiefly of Uinta Mountain Precambrian rock and contains small amounts of sandstone, tuff and bentonite.

Surficial Deposits

The most common varieties of surficial deposits in and around the Vernal coal field are Quaternary-Tertiary terrace gravels, alluvium and landslides. There are also a few areas of blow-sand near such units as the Navajo and Entrada sandstones. Most quadrangles contain terrace gravels; a mixture of boulders, cobbles, pebbles and grit, and sand, silt and clay derived from Precambrian to Tertiary sources. They partially cover the softer consolidated units.

Structure (figure 8)

The Vernal coal field lies on the south flank of the Uinta Mountains and owes its remarkable structure to the tectonics associated with the Uintas. The field is bounded on the north by the Uinta Mountains, on the south by the broad expanse of the Uinta Basin, and on the east by Dinosaur National Monument and the Colorado border. West of the area the associated Cretaceous formations are covered by Tertiary and Quaternary rocks.

Faults

The major faults include the South Flank fault zone, the Deep Creek fault zone, Miners Draw fault and the Island Park fault, all of which have considerable throw. At depth, flanking the Uintas, is a low-angle thrust zone in which the Precambrian rocks of the Uintas are thrust over younger sediments. Of these latter faults little is known, but their existence is confirmed by data from oil wells in the area.

The South Flank fault zone is a series of *en echelon* faults downthrown to the south separating the Precambrian rocks of the Uinta Mountains from the Uinta Basin sediments. The dip of the faults is nearly vertical and the average trend is east-west. The maximum throw is about 350 feet and lessens to the east. The South Flank fault zone is the longest of the many normal faults in the coal field but does not cut the coal-bearing rocks.

A series of northwest-trending faults in the Deep Creek area suggests an interval of severe deformation associated with the Uinta uplift. The Deep Creek fault zone may be the result of movement of the Uinta thrust zone. The throw of the many faults ranges from a few to several hundred feet. The net displacement to the south is small since the number of faults downthrown to the north and south is almost equal. There are twenty-five or more faults in this zone.

On the north side of Split Mountain the Island Park fault displaces an east-west hogback of Frontier Sandstone with several

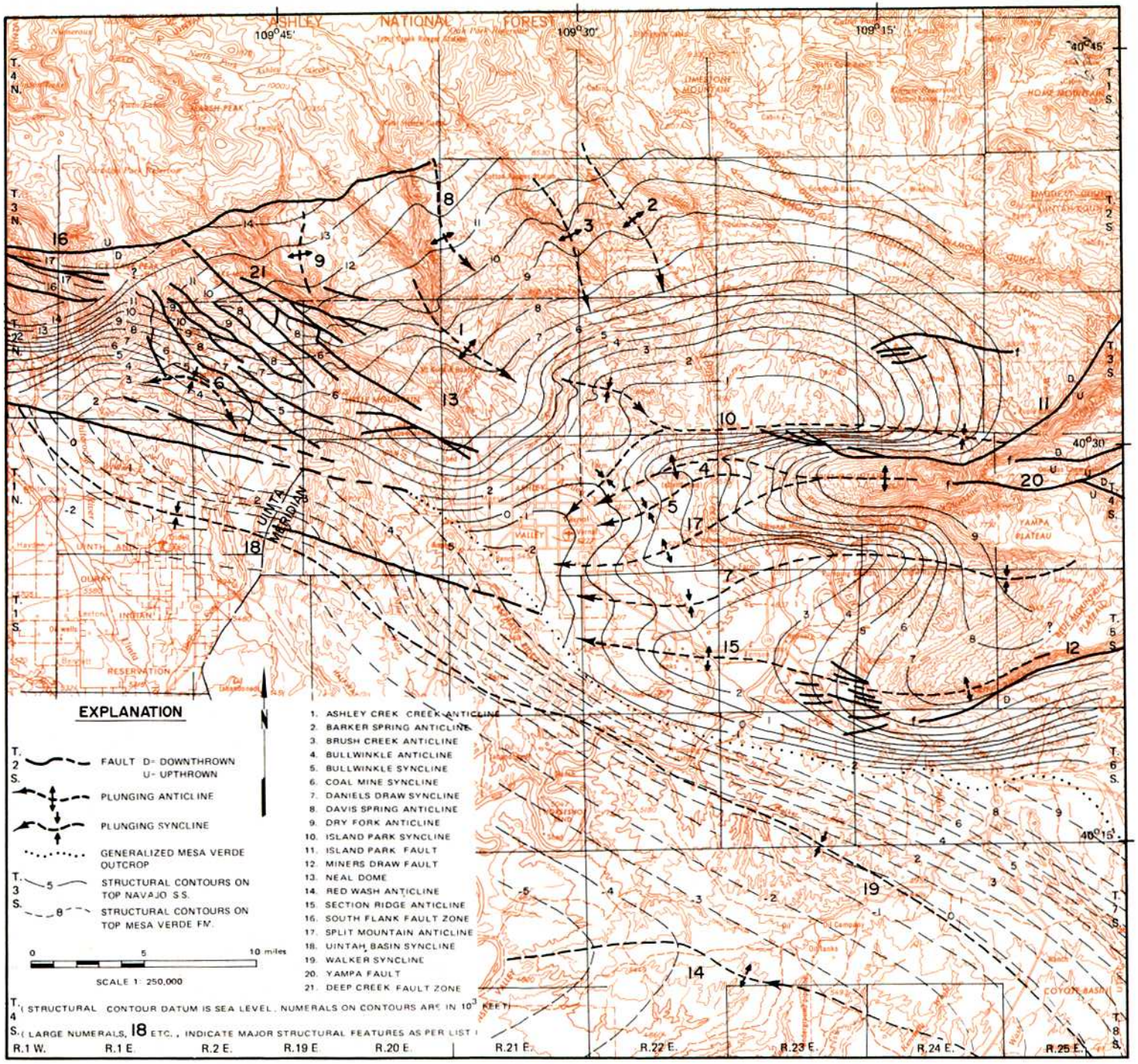


Figure 8. Generalized structure map, Vernal coal field.

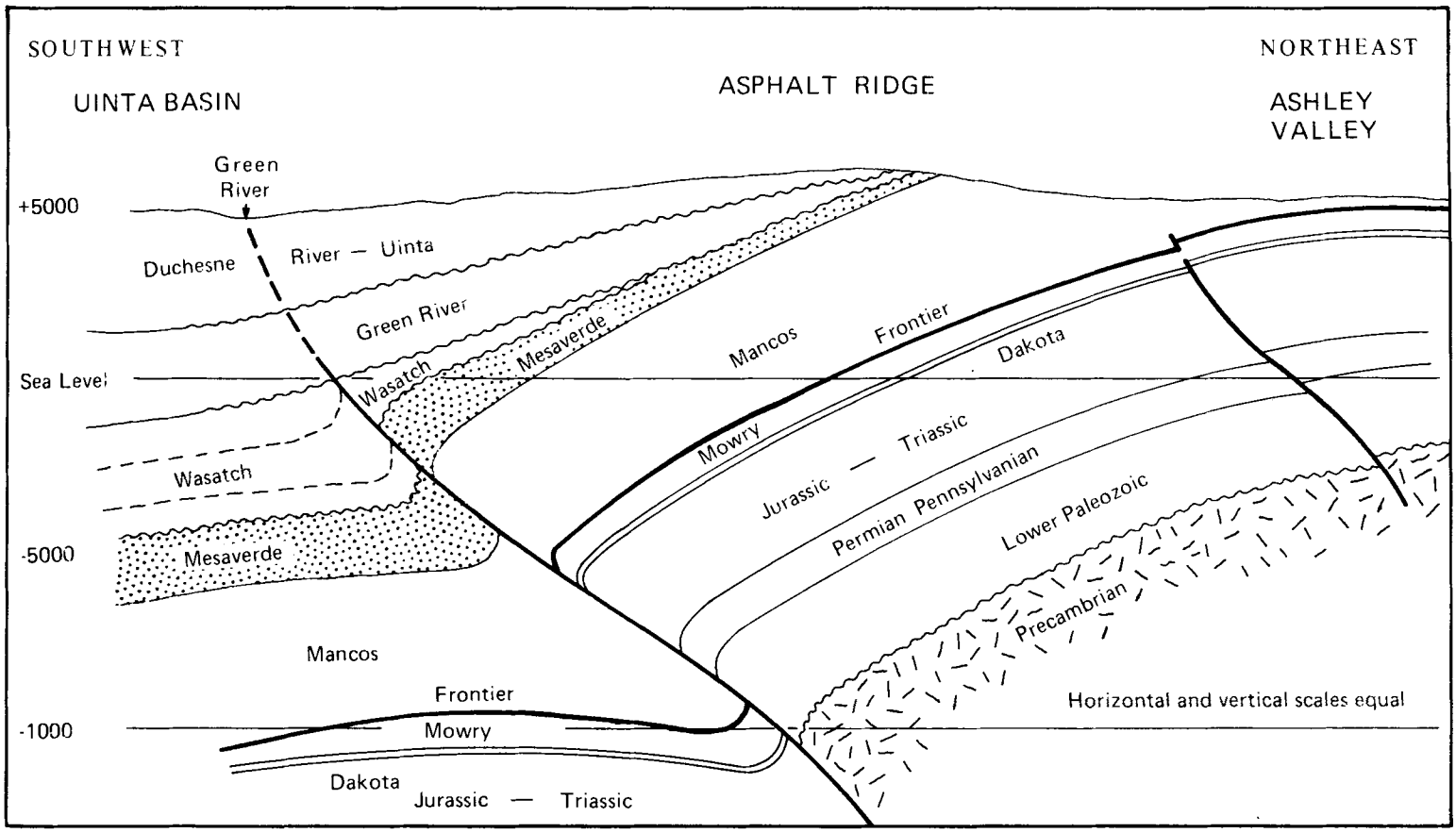


Figure 9. Cross section of southeast Asphalt Ridge, Vernal coal field (based on combination of surface, subsurface and seismic data; after Ritzma, 1970).

of its western branches, but since the Frontier here is barren it is of no concern to this study.

South of Cliff Ridge the Miners Draw fault also cuts Frontier Sandstone, but again there is no coal and a detailed study would be beyond the scope of this summary.

Many small normal faults are found throughout the field but the areas of important coal are not disturbed by them to any great degree. Figure 8 shows the locations of most of the significant faults.

A word concerning the Uinta thrust zone: the previous notion was that the Uinta Uplift simply bowed up the sediments on either side. This is true in general, but a mushrooming effect of the Uinta core has been discovered by wells drilled around Asphalt Ridge (figure 9).

A well on the southeast end of Asphalt Ridge penetrated a highly faulted section including one large normal fault and two small reverse faults. A large concealed overthrust was penetrated at about 9,000 feet and the well bottomed in Mesaverde (?) at 9,350 feet. The well was only 4,000 feet south of outcropping Mesaverde. The indicated vertical displacement on the large thrust is about 8,000 feet (Ritzma, 1970, written communication).

This thrust zone was confirmed by seismic work by the Utah Geological and Mineralogical Survey in 1967.

Folds

Except where interrupted by faults and sharp monoclinal flexures, Mesozoic and Paleozoic rocks on the south flank of the Uinta Mountains dip 20 to 30 degrees southward. Folds of special interest in the field are the Split Mountain anticline, Section Ridge anticline, Daniels Draw syncline, Island Park syncline and several anticlinal noses of the Uinta Mountains (table 3).

The Split Mountain and Section Ridge anticlinal pair are located in the vicinity of Dinosaur National Monument and produce the spectacular topography seen there. The rocks dip from the Uinta Mountains into the Island Park syncline in T. 3 and 4 S., then rise within two miles to the crest of Split Mountain. Split Mountain anticline forms a broad crest making a flat-topped mountain with more than 8,000 feet of structural relief. In the middle of T. 4 S. the rocks dip rapidly into the Daniels Draw syncline. They rise again to Section Ridge anticline and fall steeply at Cliff Ridge into the Uinta Basin syncline. The flexure system trends generally east-west and plunges westwardly into Ashley Valley (figure 8).

Along the nearby flanks of the Uinta Mountains several north-south trending anticlinal noses are located. These include the Ashley Creek, Barker Spring, Brush Creek, Davis Spring and Dry Fork anticlines. The influence of these anticlines on the coal formations is less than that of the flexure system of Split Mountain which has greatly distorted the coal-bearing Frontier Sandstone.

With the exception of the Split Mountain deformation of the Frontier at Brush Creek, the coal-bearing rocks reflect the regional dip from the Uintas to the basin. Frontier hogbacks trend north 50° east and dip generally 30 degrees south in the Steinaker area. In Coal Mine Basin and Deep Creek areas the beds trend northwest and dip 20° southwest. At Asphalt Ridge the Mesaverde Formation shows a regional northwest trend and displays the same steeply dipping situation. In a westward projection beyond Deep Creek under thick cover, the structural situation is expected to remain the same.

Unconformities

Several unconformities have been discovered in the Vernal area. On Diamond Mountain and elsewhere the Tertiary Browns Park Formation disconformably overlies moderately dipping older

Table 3. Major fold flexures in the Vernal coal field.

Island Park syncline	
Plunge:	11°W
Average dip	
North limb:	5°–10°S
South limb:	40°–75°N
Regional trend:	E–W
Location:	Split Mountain
Structural relief:	8,000 feet
Symmetry:	Asymmetrical
Split Mountain anticline	
Plunge:	8–12°W
Average dip	
North limb:	40°–74°N
South limb:	30°–80°S
Regional trend:	NNE, "S" shaped
Location:	T. 4 S., R. 22-25 E.
Structural relief:	8,000 feet
Symmetry:	Symmetric
Bullwinkle anticline	
Plunge:	10°W
Average dip	
North limb:	40°N
South limb:	15°S
Regional trend:	NNE to NNW; arcuate
Location:	NW of Split Mountain anticline
Structural relief:	4,000 feet
Symmetry:	Asymmetric
Bullwinkle syncline	
Plunge:	8–10°W
Average dip	
North limb:	15°S
South limb:	15°–20°N
Regional trend:	Arcuate, mainly NE
Location:	South of Bullwinkle anticline
Structural relief:	2,000 feet
Symmetry:	Symmetric
Daniels Draw syncline	
Plunge:	8–15°W
Average dip	
North limb:	30°–80°S
South limb:	5°–15°N
Regional trend:	E–W to NE, "S" shaped
Location:	Between Split Mountain and Section Ridge anticline
Structural relief:	8,000 feet
Symmetry:	Very symmetric
Barker Spring anticline	
Plunge:	5–8°S
Average dip	
East limb:	10°
West limb:	10°
Regional trend:	NNW
Location:	Center T. 2 S., R. 22 E.
Structural relief:	500 feet
Symmetry:	Symmetric
Brush Creek anticline	
Plunge:	5–6°S
Average dip	
East limb:	15°
West limb:	15°
Regional trend:	NNW
Location:	T. 2 S., between R. 21 & 22 E.
Structural relief:	100 feet
Symmetry:	Symmetric
Davis Spring anticline	
Plunge:	5–6°S
Average dip:	10°
Regional trend:	N–S to NNW
Location:	T. 2 S., between R. 20 & 21 E.
Structural relief:	500 feet
Ashley Creek anticline	
Plunge:	5–7°SE
Average dip:	5–10°
Regional trend:	NW
Location:	T. 3 S., between R. 20 & 21 E.
Structural relief:	2,000 feet
Symmetry:	Asymmetric
Dry Fork anticline	
Plunge:	3–5°S
Average dip:	5°
Regional trend:	N–S
Location:	T. 2 S., between R. 19 & 20 E.
Structural relief:	250 feet
Coal Mine syncline	
Plunge:	Doubly 5–15°
Average dip:	15°–23°
Regional trend:	E–W to NW
Location:	Deep Creek coal area
Structural relief:	250 feet
Symmetry:	Asymmetric
Uinta Basin syncline–Walker syncline	
Plunge:	Undetermined
Average dip:	10–25°
Regional trend:	NW
Location:	Mainly south of field
Structural relief:	10,000 feet
Symmetry:	Asymmetric

rocks, effectively covering them. At Diamond Mountain the buried Frontier Formation is probably barren of coal but at Little Mountain it truncates coal-bearing strata. At Asphalt Ridge and south of the Rim Rock, Tertiary rocks (Green River, Duchesne River) truncate and partially cover the Mesaverde (Covington 1963, p. 233 and Ritzma, 1970, written communication). To the south these same units are conformable and intertongue.

Unconformities also exist below the Frontier Sandstone, Dakota Sandstone and Curtis Formation. The Dakota in the Vernal area may be both Early and Late Cretaceous with concealed unconformities within itself. It lies disconformably on the Morrison.

Geologic and Tectonic History

The geologic history of the Vernal area is complex (figure 10). Most of the rock units are sedimentary, however, and represent marine, continental, geosynclinal and shelf deposition.

During the Precambrian, sedimentation was geosynclinal and immense thicknesses of rock (up to 26,000 feet) were deposited. The strata consist principally of orthoquartzite, argillite, shale and siltstone. Marine and continental rock types have been recognized.

The Precambrian was followed by a period of erosion which was in turn followed by intermittent shelf-type depositions of Cambrian, Mississippian, Pennsylvanian and Permian age. The Cambrian overlies a Precambrian erosion surface with an angular discordance of 5 degrees and probably represents shallow and near-

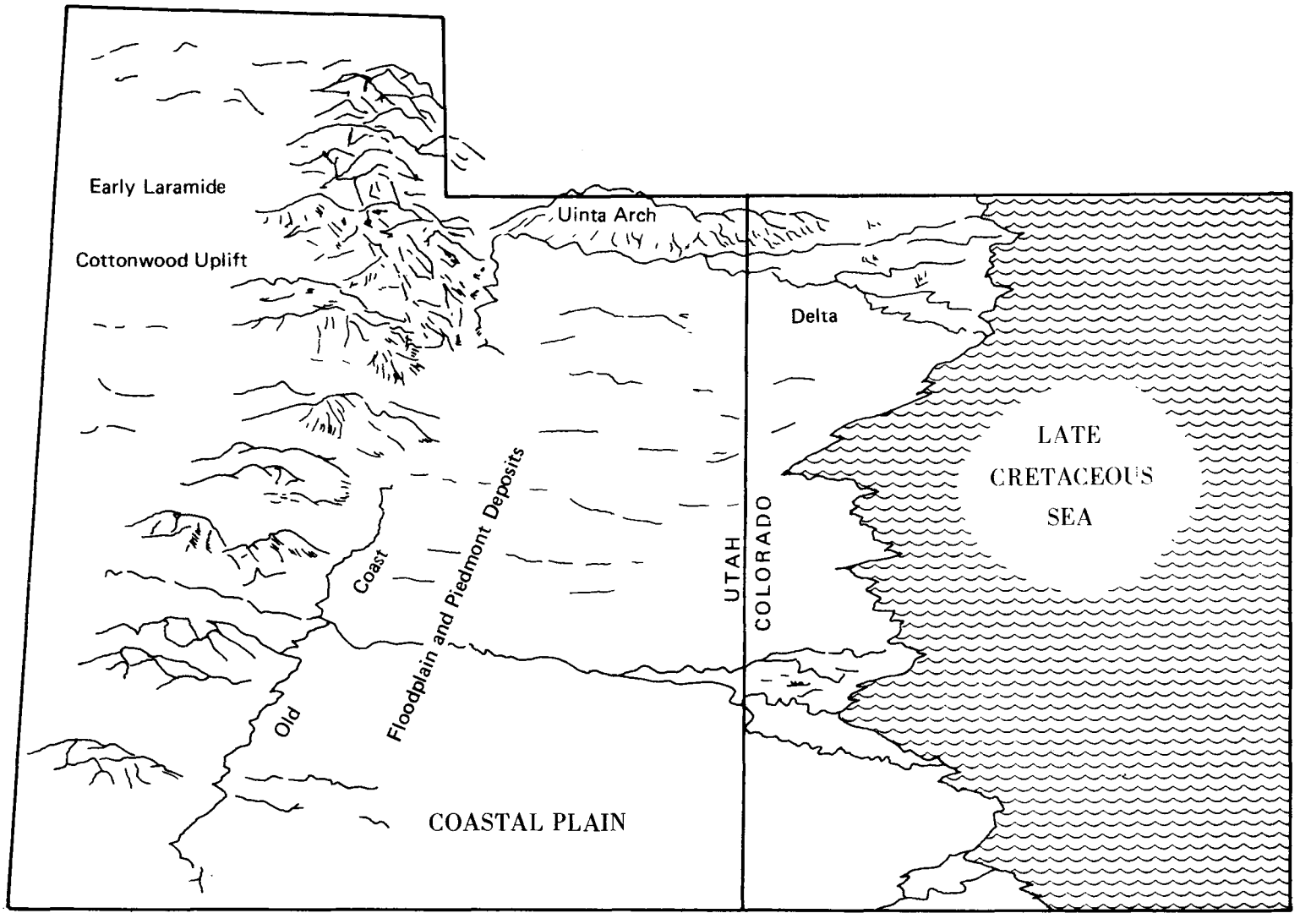


Figure 10. Paleogeographic map of Late Cretaceous (early Laramide) Late Montana time, Vernal coal field.

shore deposition. During Mississippian time the seas returned and a series of limestones was deposited. Thereafter the influence of the ancestral Rockies was felt and during the Pennsylvanian clastic deposition became dominant. A shallow, somewhat restricted sea encroached upon the area during Permian time to complete the Paleozoic. A total of a little more than 4,000 feet of sediments was deposited. The most conspicuous breaks in sedimentation occur between the Precambrian and Cambrian, between the Cambrian and Mississippian, and between the Mississippian and Pennsylvanian.

During Mesozoic time the ancestral Rockies continued to rise and provide a source for Triassic and Jurassic deposition. The nature of these sediments indicates continental deposition either in deserts or in floodplains. Only on rare occasions did marine conditions prevail (Moenkopi, Carmel and Curtis). A total of 3,800 feet of rock was deposited during the Triassic and Jurassic. Thereafter conditions changed and ended the structural quiescence that had prevailed since the end of Precambrian time. During the Cretaceous period mountains arose in the west (Mesocordilleran Highland) and the level of land in the Vernal area subsided, at times forming a marine environment and at times a fluvial, lagoonal or deltaic environment. These alternations have been summarized by Hale and Van de Graaff (1964, p. 316). Notes in brackets are added to clarify:

1. The primary source area [mountain development] of Cretaceous sediments was eastern Nevada and western Utah. It gradually moved eastward across Utah as a series of wave-like folds of imbricate thrusts and reached [the Uinta Basin] in latest Cretaceous.

2. Periodic tectonisms [mountain upheavals] of the provenance [source area] accelerated sedimentation and, along the basinal downwarping, were the principal factors influencing sedimentary facies pattern.

3. Nine principal transgressions and regressions occurred during the Cretaceous.

4. The initial marine transgression occurred in late Mowry with deposition of Mowry Shale. Transgressive marine deposition predominated until middle Niobrara [Coniacian] when the trend reversed to dominantly regressive deposition. [A regression of limited duration after Mowry deposition produced the Frontier Sandstone and its coal beds. The major regression caused deposition of Mesaverde beds].

5. Marine depositions prevailed over the eastern area (eastern Uintah basin) from Early Cretaceous to Pierre [Campanian] and in excess of 5,000 feet of Mancos Shale accumulated. Traced westward and northwestward the Mancos intertongues extensively with continental and associated marine rocks.

6. In middle Montanan [Campanian] time a pronounced uplift of the provenance [source area] shed coarse clastics eastward [into the Vernal area] and accelerated regressive deposition. [During this time a cyclical type of deposition ensued: sandstone immediately after an uplift, followed by finer sediments and finally lagoonal conditions to produce coal].

During early Tertiary time the area continued to subside and receive sediments. These were mainly of fluvial or lacustrine types and the condition persisted until Oligocene time. Periods of uplift within the basin caused some folding and erosion as marked by angular discordance between the early Tertiary units. The Uinta Mountains rose as Tertiary time continued and contributed heavily to the sediments deposited in the Uinta Basin. According to G. E. and B. R. Untermann (1964b, p. 73):

The major uplift of the range and maximum warping of the adjacent synclinal basin may have occurred near the close of the Eocene, at which time the Green River Formation was faulted into contact with Paleozoic sediments. . . Some of these Eocene faults are covered by Browns Park (Miocene?) sediments without disturbance.

Except for development of erosion surfaces and of terrace gravels, deposition ceased in late Tertiary time. Uplift and subsequent erosion produced the present structural and stratigraphic picture.

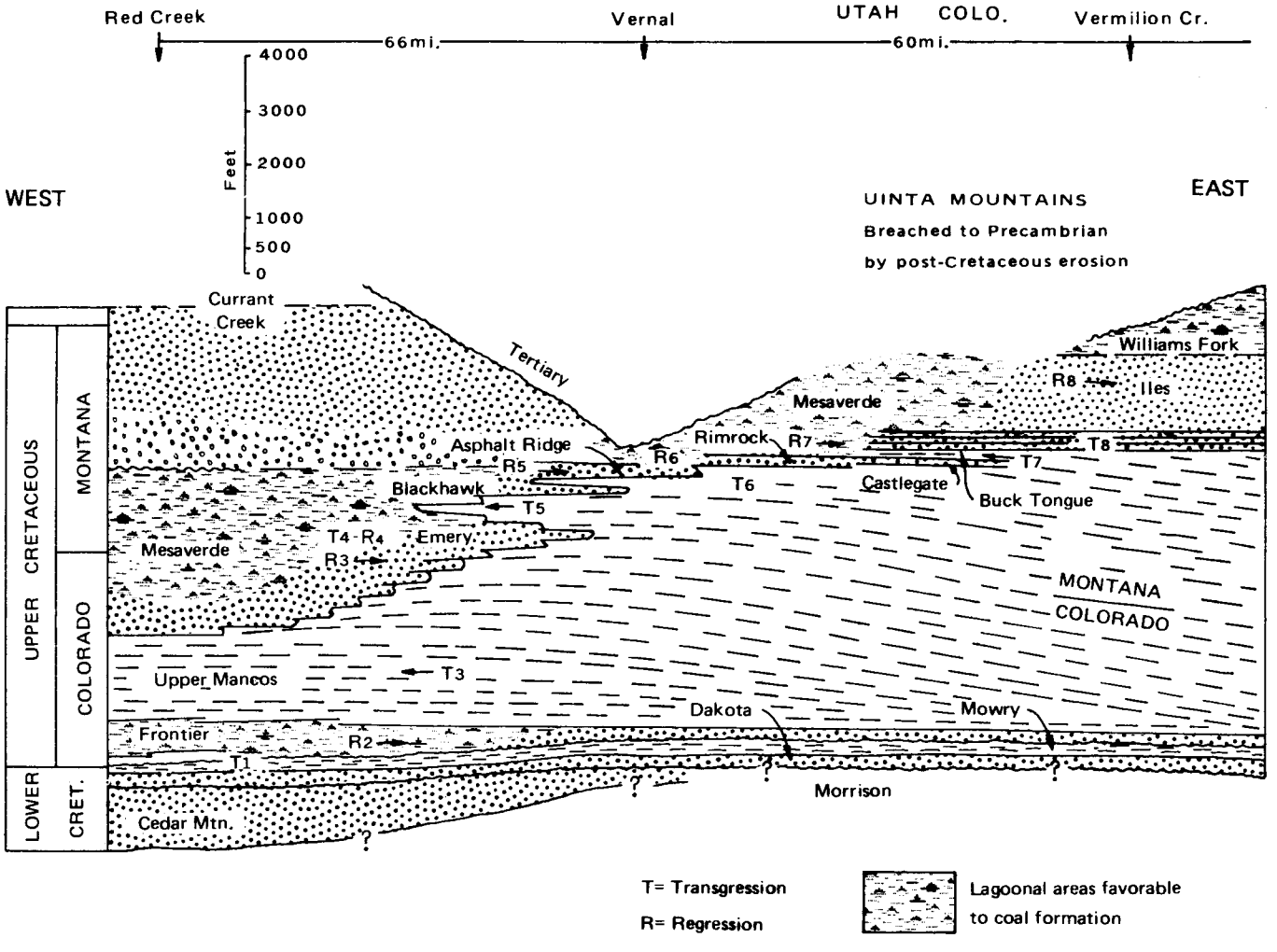


Figure 11. Cross section indicating the environments in the Vernal coal field and surrounding areas during Cretaceous time (from Hale and Van de Graaff, 1964).

Correlation with Surrounding Areas

To fully understand the Cretaceous of northeast Utah it is necessary to understand the geologic events that produced the various facies. Events in the Cretaceous essentially consisted of an ocean encroaching upon Utah from the east and then spasmodically retreating. Mountains and hills on the west supplied sediments for the various environments (figure 11). A piedmont developed at the base of the mountains across which streams originating in the mountains flowed. This was the area of fluvial deposition: gravel, lenticular sandstone, graywackes, siltstone, thin shale beds and perhaps some thin carbonaceous shale or coal beds. The finer sediments were deposited to the east near the sea shore, in deltas, lagoons and beaches. Very few gravels and dark minerals persisted, because of the long transport seaward. In the lagoonal areas the coal beds became thick. Those sediments which did reach the sea produced shale.

Uplift to the west started in Lower Cretaceous time and spread clastics across a subsiding area which had previously undergone a somewhat lengthy period of erosion. We may assume that the land had been leveled. The thicker and coarser sediments were deposited to the west. The subsidence was uneven and the Dakota deposition was interrupted at intervals and varied from place to place. An examination of the correlation chart (figure 12) reveals that the Dakota deposited to the south is younger than that deposited in the Vernal area. Coal swamps developed in some areas but not near Vernal.

Subsidence continued irregularly; in the Vernal area the first inundation by the sea came earlier than in southern Utah. This first inundation was centered north and east and was not experienced to the south. The sea retreated; then followed a period of erosion. In the meantime the Dakota of the south was deposited in the area of the Wasatch Plateau, then was submerged to receive the Tununk Shale.

The sea to the south retreated and the Ferron was deposited to the south and the Frontier to the north. The deposition of these two units was not entirely contemporaneous, however; the Frontier is slightly older. The units are similar, complete with areas of coal deposition.

In the Coalville area, which is very close to the source of sediments, thick conglomerates were deposited while the lands at Vernal and near the Book Cliffs were either being peneplained or receiving the Dakota sediments. The Aspen (?) Shale marks the Mowry transgression. The Frontier Formation is very thick and contains only thin marine or nearshore members. Most of the Mancos Shale and Frontier of the Vernal area are contemporaneous with the Frontier at Coalville. East of Vernal, Frontier equivalents and older units are similar to those at Vernal.

Deposition of the Frontier was followed by a general subsidence which allowed the sea to encroach upon most of eastern Utah. This encroachment gave rise to the thick sequence of the Mancos Shale at Vernal. Along the Book Cliffs these shales are often interrupted by tongues of sand which represent shoreline fluctuations. Lagoonal areas developed behind the beaches and now contain coal beds. None reached the Vernal area or points east.

Toward the end of Late Colorado time (Santonian, near middle of the Upper Cretaceous) the sea began a spasmodic retreat. In the Coalville area renewed uplifts of the source area spread thick conglomerates (Echo Canyon) over the Frontier members. In the Book Cliffs the coal-bearing Mesaverde Formation was deposited. First beach sands were deposited, then lagoonal

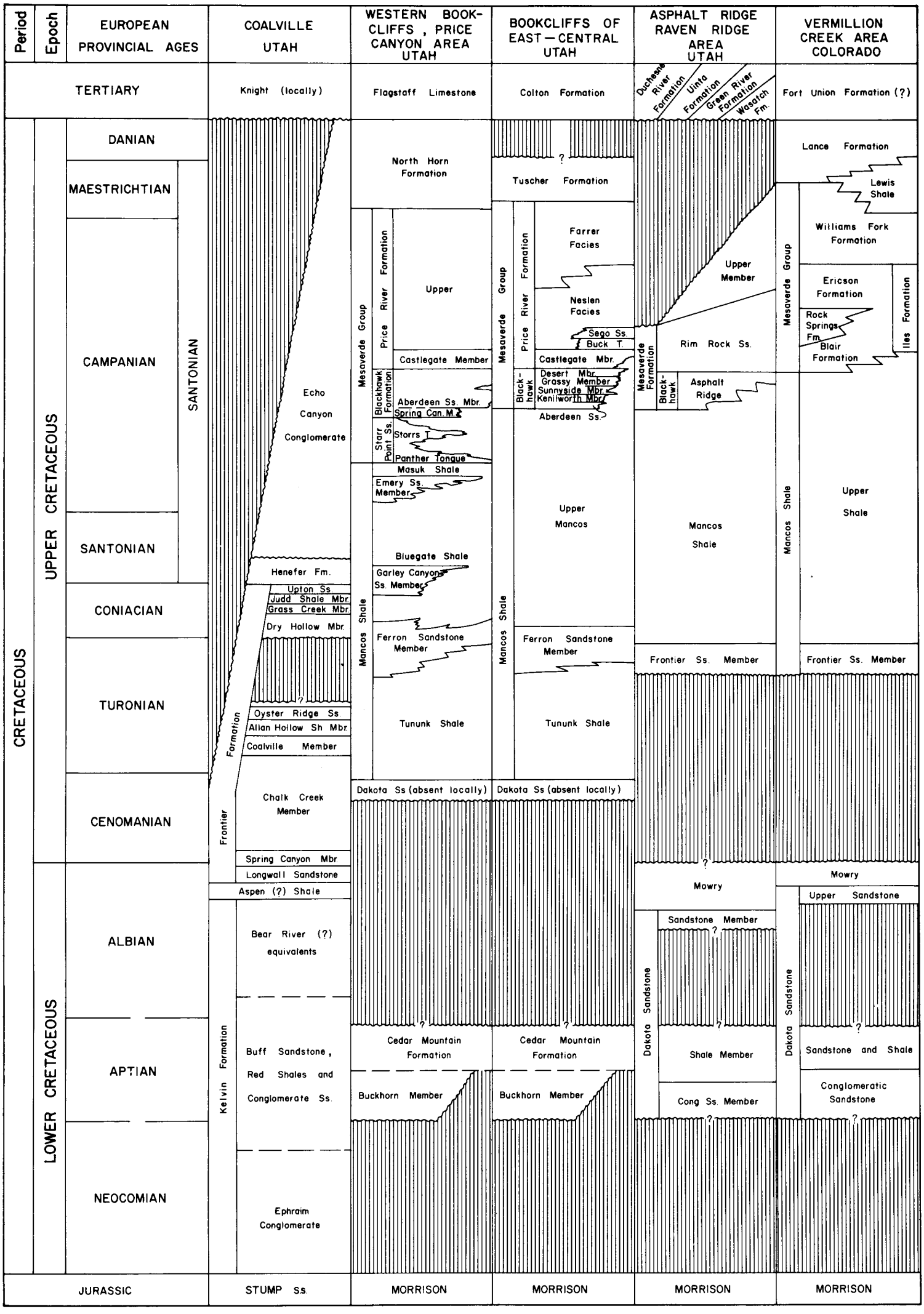


Figure 12. Correlations of Cretaceous formations adjoining Vernal coal field.

beds and then continental fluvial beds. This activity spread east slowly and as a result eastern coal beds including those at Vernal are much younger. Accordingly those to the east in Colorado are younger yet.

Eventually all areas reverted to continental deposition, exemplified by fluvial clastics and occasional thin coals formed in swampy areas near sluggish streams rather than in large lagoonal swamps near the shore. In most areas the transition between Cretaceous and Tertiary was uneventful, but in a few places such as near Vernal, uplifting had spread eastward far enough to interrupt deposition and fold the rocks from time to time.

COAL DEPOSITS

Status of Information

Coal mining in the late 1800's in the Vernal area supplied a local market. Early studies such as those by Gale (1909, 1910), Lupton (1912), Lord (1913) and Fieldner (1914) of the U. S. Geological Survey and Bureau of Mines soon followed. These studies covered such things as quality, mining conditions, coal seam conditions and mines but only slightly touched upon the geology.

The work of U. S. Geological Survey geologist D. M. Kinney (1955) provides an excellent summary of the geology surrounding and including the Frontier coal deposits. He also brought together all the previous data and supplemented it with reserve and production figures.

The Vernal area is interesting not only for coal but for petroleum, oil shale, natural asphalt and phosphate. In recent years much work has been published on the surrounding geology and mineral deposits. Some of the reports are by G. E. and B. R. Untermann (1964a and b), R. G. Pruitt (1961) and Hale and Van de Graaff (1964).

Coal data for the Frontier may be described as adequate. Studies on the Mesaverde have been neglected with respect to coal primarily because of the poor showings. Work by Gross (1961) and Ritzma (1969) aid in understanding the complex geology. More detailed mapping of the coal beds remains to be done.

Principal work and supporting material are listed in the References section. The principal workers have been recognized in the quadrangle reports where applicable and their work can be consulted for more detail.

Mines, Prospects and Production

Mines and prospects that have been opened in the Vernal coal field are listed with the corresponding quadrangle reports, their locations and other pertinent data. The total coal removed from each mine is not known, but a reasonable breakdown with respect to area is possible (table 4). Table 5 gives total production of Uintah County, 1896 to 1955.

Table 4. Estimated coal production by area.

Area	Coal zone	Short tons
Deep Creek	Frontier zone	53,900
Steinaker	Frontier zone	172,900
Brush Creek	Frontier zone	27,300
Asphalt Ridge	Mesaverde zone	less than 1,000
Cocklebur	Mesaverde zone	less than 1,000

Some coal was removed prior to 1896, probably less than 10,000 tons. The last mine reportedly shut down in 1957, but the amount mined after 1955 is thought to have been insignificant.

Table 5. Coal production of Uintah County, 1896-1955 (after Kinney, 1955, p. 143).

Year	Short tons	Source of Information
1896	300	Estimated from combined statistics of Utah and Uintah counties by U. S. Geological Survey.
1897	1,000	Estimated from combined statistics of Iron, Sanpete and Uintah counties by U. S. Geological Survey.
1898	5,000	Utah State Coal Mine Inspector's report.
1899	6,450	Utah State Coal Mine Inspector's report.
1900	6,450	Utah State Coal Mine Inspector's report.
1901	7,750	Utah State Coal Mine Inspector's report.
1902	3,540	U. S. Geological Survey.
1903	10,300	Utah State Coal Mine Inspector's report.
1904	12,200	Utah State Coal Mine Inspector's report.
1905	12,945	Estimated from production of Summit and Uintah counties (U. S. Geological Survey) and Summit County (Utah State Coal Mine Inspector's report).
1906	3,887	Estimated from production of Summit and Uintah counties (U. S. Geological Survey) and Summit County (Utah State Coal Mine Inspector's report).
1907	4,000	Estimated.
1908	5,150	U. S. Geological Survey.
1909	4,480	U. S. Geological Survey.
1910	8,590	U. S. Geological Survey.
1911	4,700	Utah State Coal Mine Inspector's report.
1912	6,800	U. S. Geological Survey.
1913	5,595	Utah State Coal Mine Inspector's report.
1914	4,879	U. S. Geological Survey.
1915	4,341	Utah State Coal Mine Inspector's report.
1916	3,785	Utah State Coal Mine Inspector's report.
1917	3,500	Estimated from combined production statistics of Summit and Uintah counties by U. S. Geological Survey.
1918	6,100	Estimated from combined production statistics of Summit and Uintah counties by U. S. Geological Survey.
1919	9,929	U. S. Geological Survey.
1920	9,228	U. S. Geological Survey.
1921	3,814	U. S. Geological Survey.
1922	3,015	U. S. Geological Survey.
1923	3,500	Estimated from combined statistics of Grand, Iron, San Juan and Uintah counties by U. S. Geological Survey.
1924	4,184	U. S. Geological Survey.
1925	5,214	U. S. Geological Survey.
1926	5,510	U. S. Geological Survey.
1927	6,000	Estimated from combined statistics of Grand, Iron, Summit and Uintah counties by U. S. Bureau of Mines.
1928	7,484	U. S. Bureau of Mines.
1929	5,860	U. S. Bureau of Mines.
1930	3,544	U. S. Bureau of Mines.
1931	2,500	Estimated from combined statistics of Grand, Iron, Kane, Sevier, Summit and Uintah counties.
1932	2,581	U. S. Bureau of Mines.
1933	2,422	U. S. Bureau of Mines.
1934	2,500	Estimated.
1935	2,500	Estimated.
1936	2,500	Estimated.
1937	2,500	Estimated.
1938	2,500	Estimated.
1939	2,500	Estimated.
1940	2,500	Estimated.
1941	2,500	Estimated.
1942	2,880	U. S. Bureau of Mines.
1943	2,000	Estimated.
1944	1,140	U. S. Bureau of Mines.
1945	1,000	Estimated.
1946	599	State of Utah, Industrial Comm. Biennial Report.
1947	2,496	State of Utah, Industrial Comm. Biennial Report.
1948	2,950	State of Utah, Industrial Comm. Biennial Report.
1949	2,400	U. S. Bureau of Mines.
1950	2,500	U. S. Bureau of Mines.
1951	2,400	U. S. Bureau of Mines.
1952	1,000	U. S. Bureau of Mines.
1953	1,000	U. S. Bureau of Mines.
1954	59,482	Estimate from combined statistics of Kane, Sevier, Summit and Uintah counties.
1955	1,050	U. S. Bureau of Mines.
Total	250,992	

Land Ownership (figure 13)

Lands in and around the Vernal coal field are owned by the federal government, state of Utah, Uintah and Ouray Indian Reservation and privately. The federal government owns roughly half the land. A small amount is under jurisdiction of the National Park Service (Dinosaur National Monument) but most is controlled by the Bureau of Land Management. State of Utah lands are scattered throughout areas of BLM lands and make up 10 percent of the area. Indian lands (about 5 percent) are located in the Deep Creek area only.

Most of the farmable lands around Vernal are privately owned. The most favorable coal properties are patented. This includes land in the Deep Creek, Steinaker and Brush Creek areas. A considerable percentage of Mesaverde outcrop in the Asphalt Ridge area is state of Utah land, and a small amount of Frontier coal occurs in the Indian reservation in the Deep Creek area. All of the remaining coal land is controlled by the Bureau of Land Management.

No leases or permits are currently in force. There has been little interest in the Vernal coal field for many years. State leases on Mesaverde coal near the Colorado border were taken up as late as 1968.

Quality of Coal

Thirty-six analyses (table 6) reflect the quality of the coal in the Vernal coal field. Two are from the Mesaverde Formation, one from the Cocklebur area, the others from the Asphalt Ridge area. Table 7 gives the average analyses for the Mesaverde and Frontier coal zones.

Table 6. Quality data for Vernal coal field.

No.	Mine or Prospect-Coal Bed	Township & Range UTM grid		PROXIMATE ANALYSES					ULTIMATE ANALYSES						Btu/lb	OTHER TESTS			Kind of Sample	Ref. Source
				AN	M	VM	FC	Ash	S	H	C	N	O			AST	ADL	HGI		
DONKEY FLAT QUADRANGLE																				
1	Blue Bell mine Frontier bed	SE.NE.SE.8–3S–22E 4491990mN 630219mE	A	9.78	37.19	43.50	9.53	1.49	–	–	–	–	–	2,520	1.8	–		11
			C	–	41.22	48.22	10.56	1.65	–	–	–	–	–	–	–	–		
			D	–	46.09	53.91	–	1.84	–	–	–	–	–	–	–	–		
2	Blue Bell mine		A	11.3	35.6	46.4	6.7	0.95	–	–	–	–	11,280	–	–	–		31
			C	–	40.1	52.3	7.6	1.07	–	–	–	–	12,717	–	–	–		
3	Blue Bell mine		A	5.6	34.3	42.2	17.7	–	–	–	–	–	–	–	–	–		10
			C	–	36.3	44.9	18.8	0.94	–	–	–	–	6,810	–	–	–		
			D	–	44.7	55.3	–	–	–	–	–	–	8,387	–	–	–		
4	Packard mine Frontier zone	NE.NW.SE.SW.6–3S–23E 4493400mN 637350mE	A	5.6	36.2	44.1	14.1	–	–	–	–	–	–	–	–	–		10
			C	–	38.3	46.8	14.9	.57	–	–	–	–	10,590	–	–	–		
			D	–	45.0	55.0	–	–	–	–	–	–	12,444	–	–	–		
5	Outcrop Frontier zone	C.N.W.12–3S–22E 4492640mN 635290mE	A	10.7	33.9	43.7	11.7	–	–	–	–	–	–	–	–	–		10
			C	–	38.0	48.9	13.1	1.24	–	–	–	–	9,530	–	–	–		
			D	–	43.7	56.3	–	–	–	–	–	–	10,967	–	–	–		
DRY FORK QUADRANGLE																				
1	C. C. Rich mine Frontier zone	NE.NE.NE.NW. 11–4S–20E 4482840mN 615050mE	A	8.6	38.6	42.9	9.9	1.8	5.6	63.2	1.1	18.4	11,350	–	2.5	–		23
			C	–	42.2	47.0	10.8	2.0	5.0	69.2	1.2	11.8	12,430	–	–	–		
			D	–	47.3	52.7	–	2.2	5.6	77.6	1.4	13.2	13,390	–	–	–		
2	C. C. Rich mine		A	8.21	34.30	45.70	11.79	1.76	5.39	61.03	.98	19.05	11,074	–	2.5	–		26 & 13
			B	5.9	35.2	46.9	12.1	1.8	5.2	62.6	1.0	17.3	11,358	–	–	–		
			C	–	37.37	49.80	12.83	1.92	4.88	66.49	1.06	12.82	12,065	–	–	–		
			D	–	42.87	57.13	–	2.20	5.60	76.28	1.22	14.70	13,842	–	–	–		
3	C. C. Rich mine		A	8.82	36.60	48.33	6.25	1.66	5.72	65.11	1.09	20.17	11,828	–	2.9	–		26 & 13
			B	6.1	37.7	49.8	6.4	1.7	5.6	67.1	1.1	18.1	12,181	–	–	–		
			C	–	40.14	53.00	6.86	1.82	5.20	71.41	1.19	13.52	12,973	–	–	–		
			D	–	43.10	56.90	–	1.95	5.58	76.67	1.28	14.52	13,919	–	–	–		
4	C. C. Rich mine		A	11.3	33.5	40.1	15.1	–	–	–	–	–	–	–	–	–		10
			C	–	37.8	45.2	17.0	.57	–	–	–	–	8,360	–	–	–		
			D	–	45.5	54.5	–	–	–	–	–	–	10,072	–	–	–		
5	Fletcher mine Frontier zone	E.SE.NE.SE.3–4S–20E 4483515mN 614300mE	A	8.46	34.32	47.17	10.05	1.58	5.33	62.79	1.00	19.25	11,250	–	2.9	–		26 & 13
			B	5.7	35.3	48.6	10.4	1.6	5.2	64.7	1.0	17.2	11,586	–	–	–		
			C	–	37.49	51.53	10.98	1.73	4.80	68.59	1.09	12.81	12,290	–	–	–		
			D	–	42.11	57.89	–	1.94	5.39	77.05	1.22	14.40	13,806	–	–	–		
6	Fletcher mine		A	8.64	36.42	47.62	7.32	1.25	5.57	65.55	1.09	19.22	11,880	–	2.6	–		26 & 13
			B	6.2	37.4	48.9	7.5	1.3	5.4	67.3	1.1	17.4	12,197	–	–	–		
			C	–	39.86	52.13	8.01	1.37	5.05	71.75	1.19	12.63	13,003	–	–	–		
			D	–	43.33	56.67	–	1.49	5.49	78.00	1.29	13.73	14,135	–	–	–		
7	J. E. Rich mine Frontier zone	SW.NW.SW.2–4S–20E 4483360mN 614420mE	A	8.64	36.09	47.21	8.06	1.39	5.57	64.10	1.04	19.84	11,581	–	2.8	–		26 & 13
			B	6.0	37.1	48.6	8.3	1.4	5.4	65.95	1.1	17.9	11,915	–	–	–		
			C	–	39.50	51.68	8.82	1.52	5.05	70.16	1.14	13.31	12,676	–	–	–		
			D	–	43.32	56.68	–	1.67	5.54	76.94	1.25	14.60	13,901	–	–	–		
8	J. E. Rich mine		A	8.65	36.16	48.19	7.00	1.63	5.51	65.10	1.09	19.67	11,639	–	2.6	–		26 & 13
			B	6.2	37.1	49.5	7.2	1.7	5.4	66.8	1.1	17.8	11,950	–	–	–		
			C	–	39.58	52.75	7.67	1.78	4.98	71.26	1.19	13.12	12,740	–	–	–		
			D	–	42.87	57.13	–	1.93	5.39	77.18	1.29	14.21	13,799	–	–	–		
9	Timothy mine Frontier zone	NW.SE.SW.2–4S–20E 4483170mN 614750mE	A	8.23	35.69	45.77	10.31	1.26	5.50	63.52	1.00	18.41	11,422	–	2.3	–		26 & 13
			B	6.1	36.5	46.9	10.6	1.3	5.4	65.0	1.0	16.8	11,692	–	–	–		
			C	–	38.89	49.88	11.23	1.37	5.00	69.22	1.09	12.09	12,447	–	–	–		
			D	–	43.81	56.19	–	1.54	5.63	77.98	1.23	13.62	14,022	–	–	–		

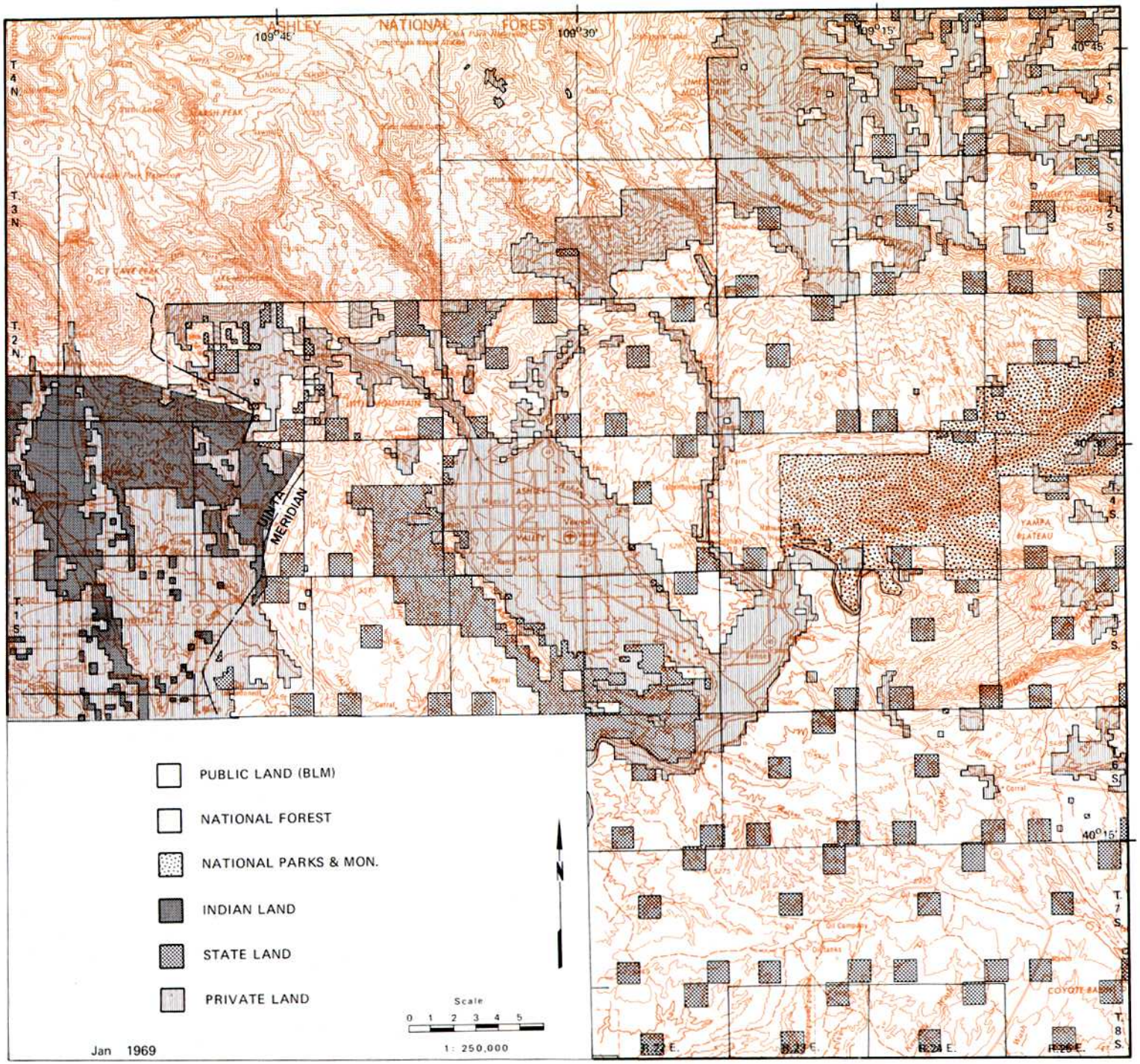


Figure 13. Land ownership map, Vernal coal field.

Table 6. (continued)

No.	Mine or Prospect-Coal Bed	Township & Range UTM grid		PROXIMATE ANALYSES					ULTIMATE ANALYSES						OTHER TESTS			Kind of Sample	Ref. Source
			AN	M	VM	FC	Ash	S	H	C	N	O	Btu/lb	AST	ADL	HGI		
10	Timothy mine		A	8.64	36.74	46.67	7.95	2.09	5.75	65.68	1.01	17.52	11,768	–	2.5	–		26 & 13
			B	6.3	37.7	47.9	8.2	2.1	5.6	67.4	1.01	15.7	12,070	–	–	–		
			C	–	40.21	51.09	8.70	2.29	5.24	71.89	1.11	10.77	12,881	–	–	–		
			D	–	44.04	55.96	–	2.51	5.74	78.74	1.22	11.79	14,108	–	–	–		
11	Wardle mine	C.SW.2–4S–20E	A	8.8	38.2	44.9	8.1	1.5	5.6	65.7	1.1	18.0	11,640	–	–	–		23
	Frontier zone	4483330mN 614620mE	C	–	41.9	49.3	8.8	1.7	5.1	72.1	1.2	11.1	12,770	–	–	–		
			D	–	46.0	54.0	–	1.8	5.6	79.1	1.4	12.1	14,010	–	–	–		
12	Wardle mine		A	9.2	39.2	42.0	9.5	2.2	5.0	69.5	1.3	11.5	11,390	–	–	–	T	2
			C	–	43.2	46.3	10.5	–	–	–	–	–	12,550	–	–	–		
13	Wardle mine		A	8.7	35.6	38.2	17.5	1.9	–	–	–	–	10,180	–	–	–	T	2
			C	–	39.0	41.8	19.2	–	–	–	–	–	11,150	–	–	–		
14	Wardle mine		A	9.2	35.3	38.8	16.7	2.5	–	–	–	–	10,250	–	–	–	T	2
			C	–	38.9	42.7	18.4	–	–	–	–	–	11,290	–	–	–		
15	Wardle mine		A	9.0	36.4	42.6	12.0	1.7	–	–	–	–	11,030	–	–	–	T	3
			C	–	40.0	46.8	13.2	–	–	–	–	–	12,120	–	–	–		
16	Wardle mine		A	8.2	34.2	41.3	16.3	1.9	–	–	–	–	10,450	–	–	–	T	3
			C	–	37.3	45.0	17.7	–	–	–	–	–	11,380	–	–	–		
17	Wardle mine		A	5.5	30.7	37.9	25.9	–	–	–	–	–	–	–	–	–		10
			C	–	32.5	40.1	27.4	.92	–	–	–	–	8,310	–	–	–		
			D	–	45.0	55.2	–	–	–	–	–	–	11,446	–	–	–		
LAKE MOUNTAIN QUADRANGLE																		
1	Gross mine	NE.NE.SE.SE.19–3S–19E	A	8.8	36.8	44.3	10.1	2.4	5.5	63.0	1.1	17.9	11,140	–	2.1	–		23
	Frontier zone	4488010mN 599470mE	C	–	40.3	48.6	11.1	2.6	4.9	69.1	1.2	11.1	12,210	–	–	–		
			D	–	45.3	54.7	–	2.9	5.5	77.7	1.3	12.6	13,730	–	–	–		
2	Rasmussen mine	NW.NW.SW.SW. 20–3S–19E	A	9.6	37.0	46.5	6.9	1.0	–	–	–	–	11,670	2,510	4.0	–		12
	Frontier zone	4487915mN 599685mE	C	–	41.0	51.4	7.6	1.1	–	–	–	–	12,920	–	–	–		
			D	–	44.3	55.6	–	1.1	–	–	–	–	13,980	–	–	–		
3	Reynolds mine	NW.SE.SW.20–3S–19E	A	11.3	35.6	46.4	6.7	.95	–	–	–	–	11,380	2,740	4.5	–		11 & 27
	Frontier zone	4487875mN 600040mE	B	7.1	37.3	48.6	7.0	.99	–	–	–	–	11,920	–	–	–		
			C	–	40.1	52.3	7.6	1.07	–	–	–	–	12,830	–	–	–		
			D	–	43.4	56.6	–	1.16	–	–	–	–	13,880	–	–	–		
NAPLES QUADRANGLE																		
1	Collier mine	NE.NE.NE.SE.NE. 26–4S–22E	A	7.9	39.6	43.8	8.7	2.4	5.6	64.8	1.2	17.3	11,550	2,390	1.9	–		23
	Frontier bed	4478240mN 635370mE	C	–	43.0	47.6	9.4	2.6	5.1	70.4	1.3	11.2	12,540	–	–	–		
			D	–	47.5	52.5	–	2.9	5.7	77.7	1.4	12.3	13,850	–	–	–		
2	Dudley mine	NW.SW.SE.13–4S–22E	A	8.4	38.3	43.8	9.5	1.5	5.5	64.7	1.1	17.7	11,320	2,830	1.8	–		23
	Frontier bed	4480660mN 636290mE	C	–	41.8	47.8	10.4	1.6	4.9	70.6	1.1	11.4	12,360	–	–	–		
			D	–	46.6	53.4	–	1.8	5.5	78.8	1.3	12.6	13,800	–	–	–		
3	Green mine	SE.SW.NE.13–4S–22E	A	8.76	38.84	44.16	8.24	2.36	–	–	–	–	–	2,370	1.1	–		11
	Frontier bed	4481240mN 636530mE	C	–	42.57	48.40	9.03	2.59	–	–	–	–	–	–	–	–		
			D	–	46.80	53.20	–	2.85	–	–	–	–	–	–	–	–		
4	Outcrop	C.SE.13–4S–22E	A	7.2	35.5	50.3	7.0	–	–	–	–	–	–	–	–	–		10
	Frontier zone	4480495mN 636330mE	C	–	38.3	54.2	7.5	1.34	–	–	–	–	11,760	–	–	–		
			D	–	58.6	41.4	–	–	–	–	–	–	12,714	–	–	–		
RASMUSSEN HOLLOW QUADRANGLE																		
1	Outcrop	SE.SW.NE.31–5S–22E	A	12.5	41.0	35.2	11.3	–	–	–	–	–	7096	–	–	–		10
	Mesaverde zone	4466300mN 628510mE	C	–	46.9	40.2	12.9	1.16	–	–	–	–	8,110	–	–	–		
			D	–	53.8	46.2	–	–	–	–	–	–	9,311	–	–	–		
SNAKE JOHN REEF QUADRANGLE																		
1	Outcrop	NE.NE.NE.NE. 35–6S–25E	A	13.1	33.4	34.3	19.2	–	–	–	–	–	–	–	–	–		10
	Mesaverde zone	664889mE 4458990mN	C	–	38.4	39.5	22.1	.30	–	–	–	–	9,790	–	–	–		
			D	–	49.3	50.7	–	–	–	–	–	–	12,567	–	–	–		
STEINAKER RESERVOIR–VERNAL NE QUADRANGLE																		
1	Gibson mine	C.W.NE.NW.2–4S–21E	A	9.43	32.77	44.94	12.86	1.93	5.12	57.81	.90	21.38	10,366	–	3.0	–		26 & 13
	Frontier bed	4484660mN 624380mE	B	6.6	33.8	46.3	13.3	1.99	4.9	59.6	0.90	19.3	10,687	–	–	–		
			C	–	36.18	49.62	14.20	2.13	4.49	63.83	.99	14.36	11,446	–	–	–		
			D	–	42.17	57.83	–	2.48	5.23	74.39	1.15	16.75	13,340	–	–	–		
2	Gibson mine		A	11.66	34.40	44.50	9.44	1.92	5.64	59.16	.92	22.92	10,575	–	4.4	–		26 & 13
			B	7.6	35.98	46.6	9.9	2.0	5.4	61.9	1.0	19.9	11,061	–	–	–		
			C	–	38.94	50.37	10.69	2.17	4.91	66.97	1.04	14.22	11,970	–	–	–		
			D	–	43.60	56.40	–	2.43	5.50	74.99	1.16	15.92	13,403	–	–	–		

Table 6. (continued)

No.	Mine or Prospect-Coal Bed	Township & Range UTM grid		PROXIMATE ANALYSES				ULTIMATE ANALYSES						OTHER TESTS			Kind of Sample	Ref. Source
			AN	M	VM	FC	Ash	S	H	C	N	O	Btu/lb	AST	ADL	HGI		
3	Gibson mine		A	10.22	32.68	44.85	12.25	.77	5.31	60.04	.96	20.67	10,685	–	3.3	–		26 & 13
			B	7.16	33.8	46.4	12.67	.80	5.1	62.1	1.0	18.34	11,050	–	–	–		
			C	–	36.40	49.96	13.64	.86	4.64	66.87	1.07	12.92	11,902	–	–	–		
			D	–	42.15	57.85	–	1.00	5.37	77.43	1.24	14.96	13,781	–	–	–		
4	Mine adit	SW.SW.SW.NW. 36–3S–21E	A	9.8	29.8	36.9	23.5	–	–	–	–	–	–	–	–	–		10
	Frontier zone	4485550mN 625420mE	C	–	33.0	40.9	26.1	.87	–	–	–	–	7,250	–	–	–		
			D	–	44.7	55.3	–	–	–	–	–	–	9,811	–	–	–		
5	Outcrop	NW.NW.NW.SE.3–4S–21E	A	15.3	34.8	39.4	10.3	–	–	–	–	–	–	–	–	–		10
	Frontier zone	4483620mN 623095mE	C	–	41.2	46.6	12.2	.60	–	–	–	–	8,430	–	–	–		
			D	–	46.9	53.1	–	–	–	–	–	–	9,601	–	–	–		

Table 7. Average analyses for the Mesaverde and Frontier coal zones.

Mesaverde Coal Zone	Percent	
	Range	Average
Moisture, as-received	12.5-13.1	12.8
Volatile matter, dry	38.4-46.9	42.7
Fixed carbon, dry	39.5-40.2	39.9
Ash, dry	12.9-22.1	17.5
Sulfur, dry	0.3- 1.2	0.8
Btu/lb, dry	8,110-9,790	8,950

Frontier Coal Zone	Percent	
	Range	Average
Moisture, as-received	5.5-15.3	9.1
Volatile matter, dry	32.5-43.0	39.4
Fixed carbon, dry	40.1-54.2	48.5
Ash, dry	6.9-27.4	12.5
Sulfur, dry	0.6- 2.6	1.6
Btu/lb, dry	6,810-13,003	11,509

Two analyses, of course, are not conclusive as to Mesaverde coal quality, but suggest what might be expected. The analyses indicate a subbituminous C coal. The coal in the Frontier can be classed as high-volatile C bituminous coal.

Kinney (1955, p. 142) analyzed coal found in the Manning Canyon Shale of Mississippian age on Farm Creek in sec. 11, T. 2 N., R. 1 W., USM (table 8). He notes that an abundance of pyrite (FeS_2) in the shale is responsible for the high sulfur content.

Table 8. Average coal analyses of the Manning Canyon Shale (Mississippian age) on Farm Creek.

	Percent			
	Upper Bed Outcrop		Lower Bed Outcrop	
Analysis	A	C	A	C
Moisture	2.2	–	7.4	–
Volatile matter	34.9	35.7	34.2	36.9
Fixed carbon	50.6	51.7	48.0	51.8
Ash	12.3	12.6	10.4	11.3
Sulfur	1.8	1.8	2.4	2.6
ADL	0.4	–	4.9	–
Btu/lb	12,810	13,100	12,120	13,090

Reserves

The coal resources of the Vernal coal field occur in two, possibly four formations: the Mississippian Manning Canyon Shale, and the Cretaceous Dakota, Frontier and Mesaverde formations. No Mississippian coal has been mapped and it is doubtful that the seams are extensive. The known outcrops are located in sec. 11, T. 2 N., R. 1 W., USM along Farm Creek. The Dakota appears to be barren in the Vernal area but may contain thin coal seams in the western part of the Lake Mountain quadrangle in sec. 19, T. 3 S., R. 19 E., SLM. All of the calculable reserves are confined to the Frontier and Mesaverde formations. The combined reserve figure calculated in this study totals 177.2 million short tons. The minable portion of this figure will be limited to between 33 and 50 percent of that amount. Considering the condition of seams the lower figure is probably more accurate.

Most of this coal occurs in the Frontier coal zone (164.3 million short tons). Knowledge of this zone is fairly complete and additional information will probably not change the figure by very much. This figure includes only those seams four feet or more thick (but includes some badly split coal) having less than 3,000 feet of overburden. The remainder (12.9 million short tons) is assigned to the Mesaverde.

Only Class II and Class III reserves were deemed appropriate. Possibly some of the Class II could have been considered Class I reserve in the vicinity of closely spaced mines such as in Coal Mine Basin.

By definition, Class I is the measured reserve, based on adequate exploration and development data, properly correlated. Class II is the indicated reserve, based on geologic measurement supplemented by limited drill-hole information and limited to 1½ miles from a control point. 92,457,800 tons of Class II reserve are found in the Vernal field. Class III is the inferred reserve (84,642,100 tons), based on geologic inference and projection of the habit of the coal beyond 1½ miles from control points. A Class IV reserve is based on geographic and geologic position with little supporting data and includes coal with up to 3,000 feet of cover. No reserves can be assigned now to this category for the following reasons: (1) the coal beds dip too steeply and so most of the reserve falls into Class II and Class III, (2) the coal is too lenticular and unpredictable to be inferred to extend very far into unknown areas and (3) the Frontier, which contains most of the coal, is fairly well known throughout the Vernal coal field. A Class IV reserve classification might be extended to the Frontier in the area west of the Lake Mountain quadrangle and to the Mesaverde if a more detailed study of its outcrops showed better indications of coal than are now thought to exist.

A breakdown of the reserve into quadrangles is given in table 9. Reserve estimates have been made of portions of the field by other workers. Lupton (1914, p. 594) estimated 49.46 million short tons of reserve for the Deep Creek area. He included coal to 14 inches in thickness and to a depth of 3,000 feet. His breakdown is as follows:

Salt Lake Meridian:	Tons
T. 3 S., R. 18 E.	699,000
T. 3 S., R. 19 E.	8,925,000
T. 3 S., R. 20 E.	8,062,000
T. 4 S., R. 19 E.	913,000
Uinta Special Meridian:	
T. 1 N., R. 1 E.	1,901,000
T. 1 N., R. 2 E.	11,293,000
T. 2 N., R. 2 E.	10,128,000
T. 2 N., R. 1 E.	7,540,000
	49,461,000

Table 9. Reserves in Vernal coal field (in thousands of short tons).

Quadrangles Class	Frontier Coal Zone II	Frontier Coal Zone III	Mesaverde Coal Zone II	Mesaverde Coal Zone III	Total X 10^3
Cliff Ridge	–	–	–	3,065.9	3,065.9
Dinosaur Quarry	–	–	–	–	–
Donkey Flat	22,718.5	37.536.3	–	–	60,254.8
Dry Fork–Vernal NW	18,845.0	–	–	–	18,845.0
Island Park	–	–	–	–	–
Jensen	–	–	–	–	–
Jensen Ridge	–	–	–	–	–
Lake Mountain	25,353.2	–	–	–	25,353.2
Naples	5,204.1	30,256.0	–	–	35,460.1
Rasmussen Hollow	–	–	1,568.0	3,136.0	4,704.0
Snake John Reef	–	–	–	5,138.9	5,138.9
Steinaker Reservoir-Vernal NE	18,859.0	5,545.0	–	–	24,404.0
Vernal NE–SE	–	–	–	–	–
Total	90,979.8	73,337.3	1,568.0	11,340.8	177,225.9
Zone Totals	164,317.1		12,908.8		

0–1000 feet of overburden	64,933
1000–2000 feet of overburden	57,483
2000–3000 feet of overburden	54,810

Kinney (1955, p. 143-149) calculated reserves for the Frontier, also including coal to 14 inches and to a depth of 3,000 feet:

Salt Lake Meridian:	Tons
T. 3 S., R. 21 E.	9,450,000
T. 3 S., R. 22 E.	45,340,000
T. 3 S., R. 23 E.	280,000
T. 4 S., R. 20 E.	20,650,000
T. 4 S., R. 21 E.	20,120,000
T. 4 S., R. 22 E.	24,040,000
T. 3 S., R. 19 E.	760,000
T. 3 S., R. 20 E.	200,000
Uinta Special Meridian:	
T. 2 N., R. 1 E.	4,920,000
T. 2 N., R. 2 E.	7,890,000
T. 1 N., R. 1 E.	1,700,000
T. 1 N., R. 2 E.	7,900,000
	143,340,000

Coal Seams:	
Thicker than 42 inches	34,940,000
28 to 42 inches thick	51,620,000
14 to 28 inches thick	56,780,000
0-1,000 feet overburden	60,160,000
1,000-2,000 feet overburden	54,170,000
2,000-3,000 feet overburden	29,010,000

Coal Seams

Deep Creek Area

The Deep Creek area, in the western part of the Vernal coal field, lies in the Lake Mountain and Dry Fork quadrangles (figures 14 and 15). The important coal is located in the Frontier coal zone in the upper third of the formation. The outcrop is from 9 to 10 miles long. The formation is poorly exposed over much of this length and in places is completely covered by terrace gravels. The west edge of the area terminates as the Frontier beds are buried under the Duchesne River onlap. The east edge terminates as the beds are covered by Browns Park conglomerates on Little Mountain.

A coal seam 3 feet 1½ inches thick occurs at the Larsen mine at the east end of the area, but the bed is broken by partings of bone. In the next two miles the Frontier is broken by faults and is poorly exposed; no measurements are available. At Deep Creek the coal is thinner but without partings (1 foot 9 inches). The coal quickly thickens and near the Government mines it is 5 feet 6½ inches thick but broken by boney splits 5 and 3½ inches thick. The Frontier coal zone is then buried by Quaternary gravels for a distance of two miles. In the vicinity of the Reynolds, Gross and Warburton mines the coal averages between four and five feet but is still broken by shaley or boney splits. Exposures are poor west of the Warburton mine and no coal is reported near Cedar Point Spring where the unit is finally buried by the Duchesne River Formation. The coal at the spring may be buried immediately south of the Frontier exposures.

Steinaker Area

This area is the most important of the Frontier coal zone. It extends from where the Frontier emerges from under the Browns Park Formation at Little Mountain to the west to where it disappears under the same formation at Diamond Mountain Plateau to the east. The outcrop is about 24 miles long. Quadrangles involved are Dry Fork-Vernal NW, Steinaker Reservoir-Vernal NE, Donkey Flat and Jensen Ridge. The formation is broken and buried in places under the alluvium of consequent streams such as Ashley Creek, Brush Creek and Little Brush Creek. Coal occurs in the Little Mountain area near the Oaks mine where the following section was measured:

	Ft.	In.
Sandstone ceiling		
Coal, poorly exposed	4	
Gray shale	1	5
Coal		10
Gray shale		6
Carbonaceous shale	1	
Coal		10
Carbonaceous shale		5
Coal		4
Carbonaceous shale		4
Sandstone	10	
Coal	1	6
Gray shale		6
Coal		10
Gray shale	1	6
Coal		4
Gray shale		6
Coal		4
Gray shale		6
Sandstone floor		

The main seam maintains a four- to five-foot average into sec. 11, T. 4 S., R. 20 E., and in places it thickens to as much as six feet. Thin splits of shale and bone are common in the coal. At the southeast end of the ridge flanking Coal Mine Basin the main seam is 2.5 to 3.5 feet thick; the splits are usually missing. Between the Brown mine and Steinaker Reservoir most of the coal is buried. Coal can be observed, however, a mile southwest of the dam in thin seams. It is not known whether the entire zone is exposed. The Gibson mine, now buried under an earth-fill dam, was opened on a seam 6 to 8 feet thick broken by a thin split near the bottom. The coal thins rapidly northeastward and for five miles averages between 2 and 3 feet, broken by splits of bone and shale. Between the Pollard and Blue Bell mines the seam thickens and splits. At the Pollard the seam is reportedly 6 feet 7 inches thick; at a prospect three-quarters of a mile east two seams 2.5 and 3 feet thick are separated by 4 feet of shale. At the Blue Bell the coal seams converge and the splits are much thinner. The coal does not crop out again for 1½ miles; between Brush Creek and Little Brush Creek the coal is split into thin seams, the thickest of which is 3.8 feet. The average is between 1.5 and 2.5 feet. Between Little Brush Creek and Diamond Mountain the coal disappears.

Brush Creek Area

The Brush Creek area, in the east part of the Vernal field, is literally wrapped around the nose of the Split Mountain anticline.

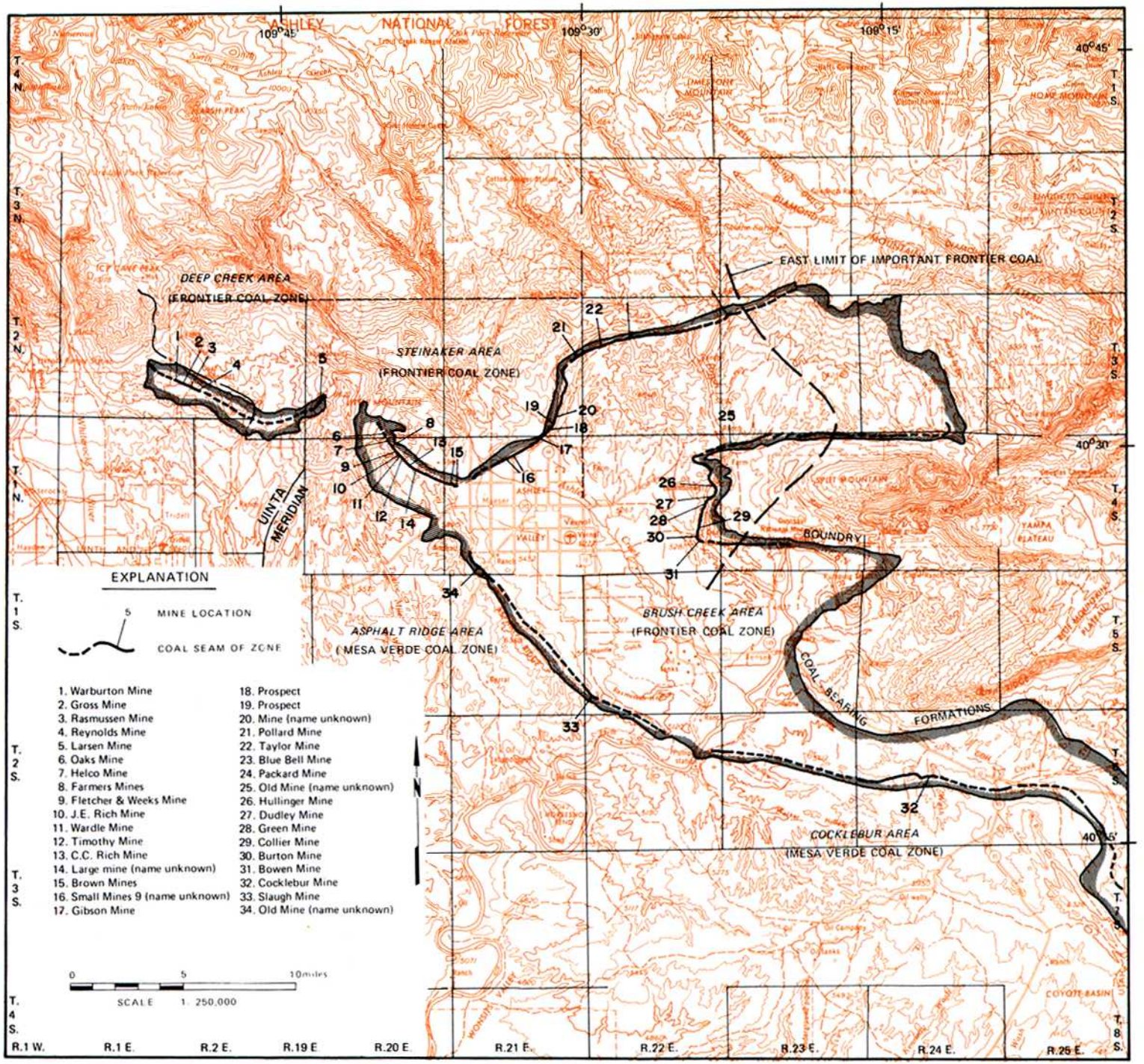


Figure 14. Coal seams and mines map, Vernal coal field.

It involves the Island Park, Jensen Ridge, Naples and Dinosaur Quarry quadrangles. It extends for 20 miles from Island Park to the Dinosaur National Monument headquarters. Frontier Sandstone outcrops between Diamond Mountain Plateau and Island Park, but is essentially barren of coal. At Island Park the coal zone is recognizable, with at least one coal seam one foot thick. Nine miles to the west the coal begins to improve and several coal beds up to 2 feet thick are found. This trend continues around the Bullwinkle anticline into the area around the main nose of Split Mountain. Here the coal thickens to 5 feet, but the coal is broken by splits of shale and bone. All of the important mines of the Brush Creek area are located here. Along the south flank of the mountain the coal quickly thins and the entire zone has almost disappeared at Monument headquarters. The Frontier outcrops continue east and south around Blue Mountain into Colorado but are barren of coal.

Asphalt Ridge Area

This area is contained in the Vernal NE–SE and Rasmussen Hollow quadrangles and involves Mesaverde coal. All the outcrops are located in the foothills below Asphalt Ridge and are poorly exposed. Generally speaking the coal is highly lenticular and reverts rapidly into carbonaceous shale and dirty lignites. It is impossible to trace any seam very far. The seams are observable in sec. 32, T. 4 S., R. 21 E. on the north side of U. S. Highway 40 in the vicinity of the Slaugh mine and in the outcrop along the west bank of the Green River. Coal beds to 5 feet thick were observed, most of them with no splits.

Cocklebur Area

This area in the southeast part of the field contains Mesaverde coal. The area extends from the east bank of the Green River to the Colorado border and derives its name from the only reported mine. This part of the field is the least explored of all the areas. Coal is contained in the "Upper" member of the Mesaverde. Nearly all the outcrops over the entire 20-mile length (except where covered) expose several lignitic seams. Usually one of these contains a thin "black" seam of bituminous coal. In a few areas these thicken, such as at the Cocklebur mine (7 feet) and near the Colorado border (7 feet 9 inches). The latter is broken by several bone and shale splits.

WATER RESOURCES

Barring political and/or judicial processes which would prevent release of water rights for mining and industrial purposes, the supply seems adequate. As previously noted, the Vernal area receives but 9 inches of rain annually, but several perennial streams, Deep Creek, Ashley Creek, Brush Creek and the Green River flow across the field.

ECONOMIC CONSIDERATIONS AND FORECAST

The coal resources of the Vernal coal field must be regarded as marginal in today's (1970) coal market. The seams are generally thin, badly split and steeply dipping. The reserves are small and mining conditions would necessitate a high prohibitive cost-per-ton of coal. Prior to World War II, the Uinta Basin was isolated from other sources of power and fuel and allowed early development of coal mines. Superiority of other coals, both with respect to quality and mining costs, coupled with cheap transportation, closed down most of the mines after the war. Competition with other fuels and electricity caused the final shutdown in 1957.

The geologic condition and low reserves of the field will discourage the use of Vernal coal field for power production. Conversion of coal to liquid and gas might provide a use for the product if an *in situ* method of recovery is developed.

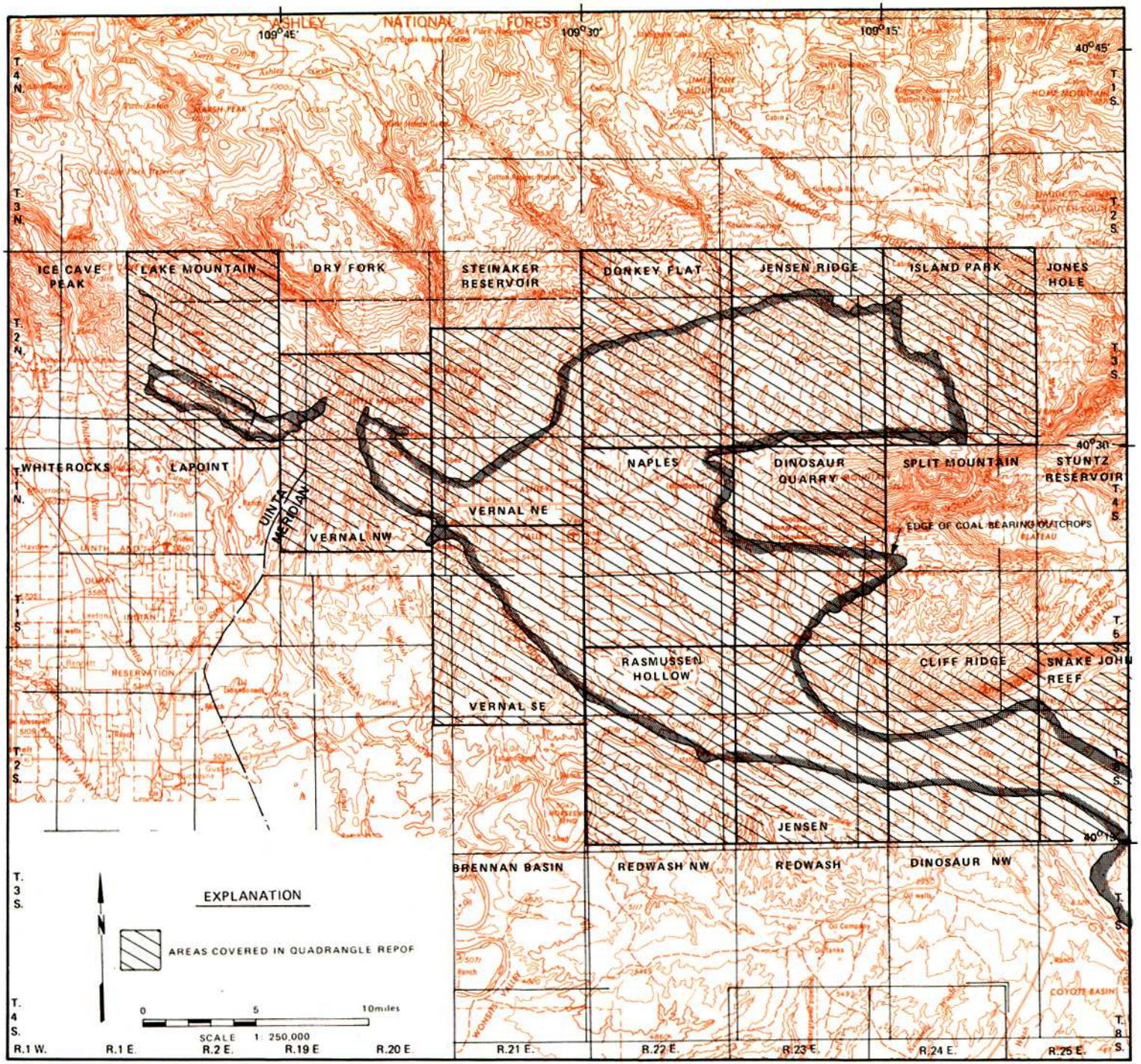


Figure 15. Quadrangle index map, Vernal coal field.

QUADRANGLE REPORTS

CLIFF RIDGE QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Cliff Ridge quadrangle is located in northeast Utah in the east part of the Vernal coal field, approximately 18 miles southwest of Vernal (figures 15 and 16). The surface area is marked by hills, ridges and mountains divided by steep canyons, washes and valleys. The highest areas are in the north (Blue Mountain) with elevations of more than 8,100 feet. Blue Mountain is an anticlinal upwarp (Cliff Ridge). South of Blue Mountain are east-west trending ridges and valleys. Some of these valleys, as the one occupied by Cliff Creek, are very wide. The lowest map elevation is about 5,000 feet and lies along the west central edge a bit north of U. S. Highway 40. The coal seams occur in the lower third of the map, 5,200 to 5,400 feet above sea level. The highway link between Denver and Salt Lake City parallels the outcrops and is connected with them by jeep roads. There are no railroads in the area.

STRATIGRAPHY

Pre-Jurassic units crop out in the north third of the quadrangle on Blue Mountain and the Jurassic units occur as thin outcrops along the mountain's south flank. The Navajo Sandstone is about 700 feet thick, the Carmel Formation 85 feet thick, the Entrada Sandstone 200 feet thick, the Curtis Formation 125 feet thick and the Morrison Formation 500 to 600 feet thick. The description of these units is given in the explanation to the geologic maps (see pages 34 to 35). The Cretaceous rocks crop out in the middle third of the map. The older three Cretaceous units make up a ridge and slope, most of the middle area consists of the marine Mancos Shale and the south outcrops are of the youngest and coal-bearing formation, the Mesaverde.

The three oldest formations consist of the Dakota Sandstone, Mowry Shale and Frontier Sandstone. The 75-foot Dakota Sandstone is a medium resistant unit of yellow, white and gray, medium- to coarse-grained sandstone interbedded with subordinate amounts of gray and carbonaceous shale. The Dakota is barren of coal in the Cliff Ridge quadrangle and forms a slight ridge above the variegated shales of the Morrison Formation. The silvery- and gray-weathering Mowry Shale, 50 to 75 feet thick, lies between the Dakota and Frontier and forms a slope. The fresh shale is dark brown and gray-brown and contains teleost fish scales.

The Frontier Sandstone is barren of coal in the Cliff Ridge quadrangle. The 250-foot formation consists mainly of brownish, thin- to medium-bedded, fine- to medium-grained sandstones and gray-brown shale. To the west a thick-bedded yellow-gray sandstone caps the unit.

A large outcrop of the Mancos Shale covers the central third of the quadrangle. The gray shales often are covered by terrace gravels and exposures are poor. When the unit is well exposed it is usually devoid of vegetation and forms badlands. Its thickness ranges from 4,000 to 5,000 feet.

The coal-bearing unit is the Mesaverde Formation, divided into two members on the basis of topographic expression. The lower Rim Rock Member is a prominent ridge former. According to Gross (1961, p. 85):

> The sandstone and subgraywacke of the Rim Rock consist primarily of fine to coarse quartz grains. Abundant smoky quartz, common coal particles, and minor amounts of biotite produce the speckled appearance of many of the beds. Also there are varying amounts of fine-grained, subangular, and dark gray grains of chert.

Ferruginous concretions and thin interbedded shales are also common in the mostly massive unit. The Rim Rock Sandstone is 433 feet thick along the Bonanza road in sec. 24, T. 6 S., R. 24 E.

The upper member is similar in appearance to the Rim Rock but there is much more shale, including gray and brown carbonaceous shales, lignitic shales, lignite and bituminous coal. Up to 50 percent of the unit are shale and hence are not resistant. The outcrop presents a series of low ridges and intervening swales. There is little to differentiate the unit from the overlying Wasatch and there is controversy as to whether it is all Cretaceous or all Tertiary. Gross (1961) measured both units as one (1,028 feet) on the Bonanza road and correlated it as the top of the Price River Formation. The map (figure 16) divides the unit at the top of the last thick lignite bed. The Wasatch or the upper part of Gross' measurement contains only a small amount of coal in thin seams and is even less well exposed than the lower part of the measured section.

Unconformably overlying the Wasatch and Mesaverde beds with angular discordance is the Green River Formation. The Green River consists largely of shales and sandstone, some of which are oil shales or oil-saturated sandstones. The unit is also occasionally conglomeratic. The Green River is more resistant than the underlying beds and forms the first prominent ridge south of the Rim Rock. The Green River Formation is angularly unconformably overlain by the Duchesne River Formation; a complete section of the unit is therefore not demonstrated on the quadrangle.

The Duchesne River, a unit consisting of interbedded red, brown and varicolored shale, with gray- to tan-weathering sandstone and conglomerate, lies in the southwest part of the area. On top of Blue Mountain, as an erosional remnant, is the Browns Park Formation, a gravelly unit, poorly to well cemented.

STRUCTURE

South of the Section Ridge anticline the beds dip moderately to steeply southward. This involves all the coal-bearing beds (20 to 80 degrees). Except for the Miners Draw fault just south of Blue Mountain (which does not involve coal-bearing strata), faults are inconsequential.

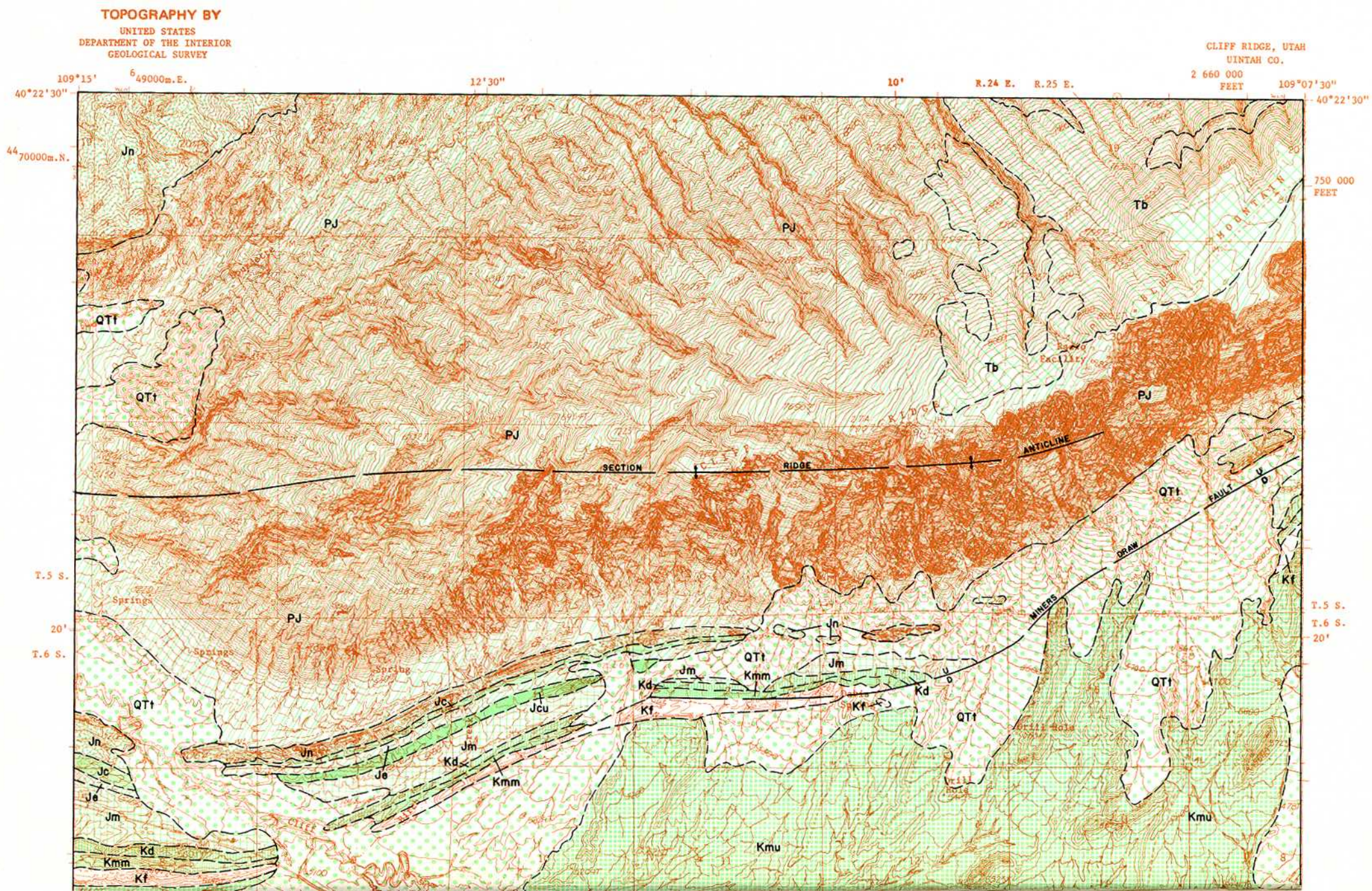
PROPERTY CONTROL

With the exception of a small amount of land along Cliff Creek and U. S. Highway 40 (private) the land is held by the Bureau of Land Management and the state of Utah. No lands are under coal lease or permit.

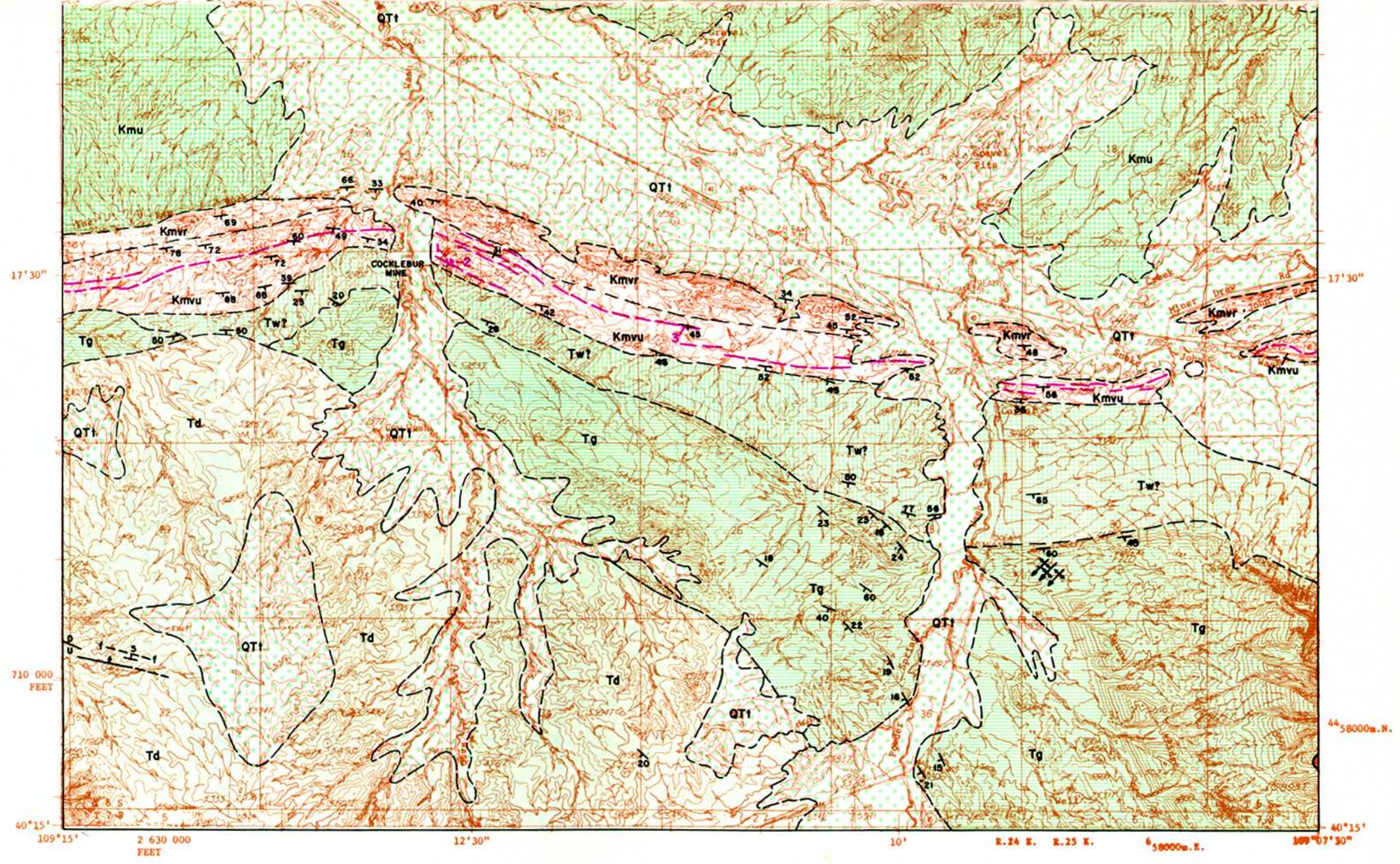
COAL

Surface Information

Coal beds are mainly confined to the upper member of the Mesaverde Formation. Several seams, all lenticular, pinch in and out. Three measured sections (figure 17) show seams ranging to seven feet in thickness. Section 1 was reported by Gale (1910, p. 210) for the Cocklebur mine. Section 2 was measured, presumably near the Cocklebur, which could not be found by the writer, and consisted of a series of coal beds each two feet thick and split by varying amounts of carbonaceous shale. The total coal measured 7.7 feet. Some of the beds were lignitic. The third section contains only thin beds and is located but a few miles east of the other two.



Utah Geological and Mineralogical Survey Monograph Series No. 2, 1972



Geology by G. E. Untermann and B. R. Untermann, 1964, Utah Field House of Natural History at Vernal, modified by H. H. Doelling and R. L. Graham, 1970, UGMS; coal data by H. H. Doelling, 1970, UGMS.

Figure 16. Coal and geology map, Cliff Ridge quadrangle (explanation pages 34-35).

EXPLANATION (figures 16, 18, 20, 22, 24, 26, 27, 29, 31, 33, 35, 37 and 39)

32 1.0 Purple — Coal bed
Dashed where inferred or poorly exposed, dotted where burned. Thickness of coal in feet measured at triangles. Larger numbers refer to location of measured section shown on accompanying sheets.

Prospect

Coal mine

Purple — Burned zone
Area covered with natural clinker or red-burned sandstone.

DH — Coal drill hole

Strike and dip of beds

Apparent dip of beds

Syncline
Axis, dashed where approximately located or where ill defined.

Anticline
Axis, dashed where approximately located or where ill defined.

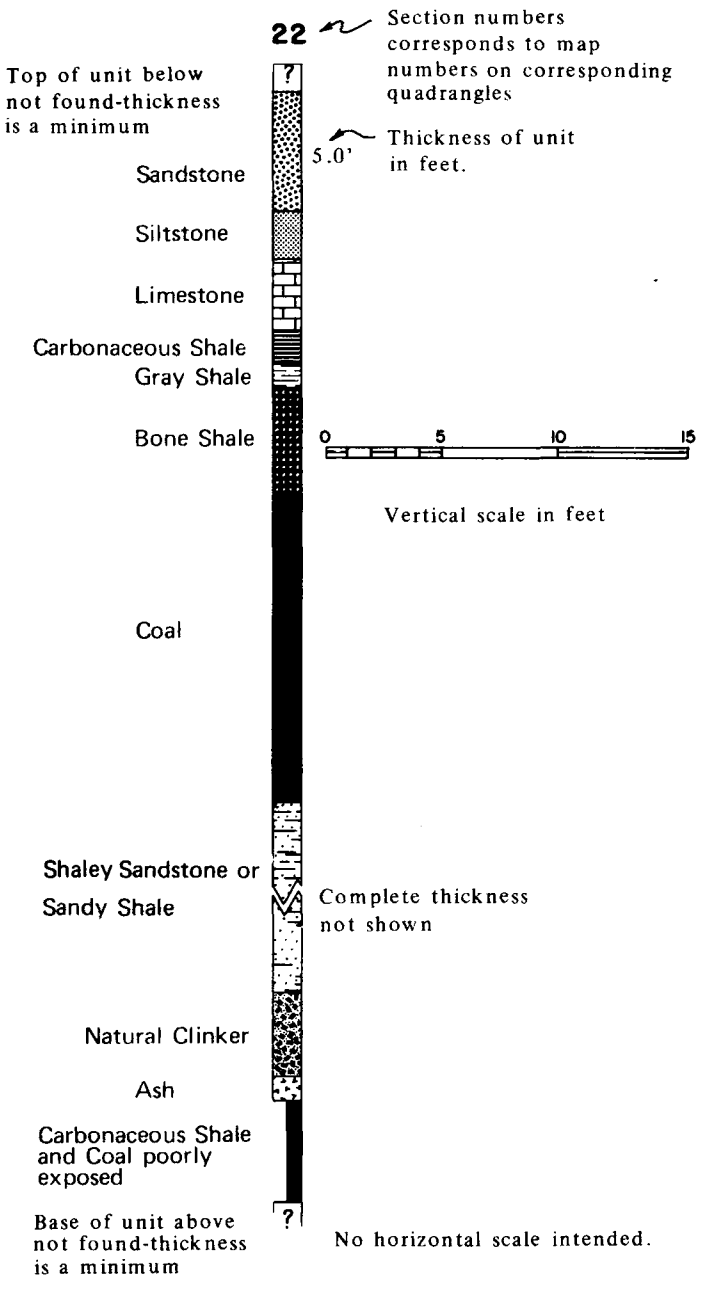
Monocline
Arrow points in direction of dip, dashed where approximately located or where ill defined.

Geologic unit contact
Dashed where location is approximate.

Horizontal strata

D U — Fault
Dashed where inferred or ill defined.

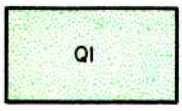
Explanation For Measured Sections



EXPLANATION (continued)

QUATERNARY

Alluvium
Stratified clay, silt, sand, gravel and some unsorted flood deposits.



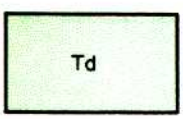
Landslide Deposits
Mixed rubble and blocks of material slumped from formations at higher elevations.

Terrace Gravels
Remnants of terrace deposits of several levels, composed of pebbles, cobbles, sand and gravel. Quaternary and Late Tertiary in age.

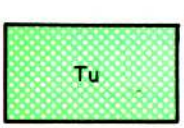
TERTIARY

Browns Park Formation
Gray-white or pink sandstone to conglomerate, calcareous, interbedded with tuffaceous sandstone, tuff, and bentonite beds. 200-800 feet.

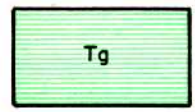
-Unconformity-



Duchesne River Formation
Red, tan, brown and varicolored clay shale, and siltstone with interbedded reddish-weathering gray to tan sandstone with minor conglomerate. 0-1,500 feet.

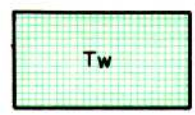


Uinta Formation
Gray, tan, red and brown, medium- to coarse-grained, poorly sorted sandstone interbedded with white, gray, purple and red mudstone. 1,650-2,600 feet.



Green River Formation
Evacuation Creek Member: gray-brown shale, limestone, mudstone, siltstone, sandstone and tuff. 500 feet.
Parachute Creek Member: dark gray, brown and black oil shale, green and brown shale, gray limestone and dolomite, siltstone and sandstone. 1,450 feet.
Garden Gulch Member: gray, tan and brown shale interbedded with thin-bedded siltstone, sandstone and limestone. 550 feet.
Douglas Creek Member: brown, thick-bedded sandstone and occasional conglomerate with black, gray and brown shale with subordinate limestone. 350-500 feet.

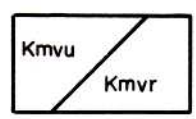
-Unconformity-



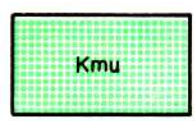
Wasatch Formation
Varicolored shale and mudstone interbedded with gray and brown sandstone and local conglomerate. 850 feet.

-Unconformity-

CRETACEOUS



Mesaverde Formation
Kmvu, Light gray to brown, fine- to medium-grained, thin-bedded to massive sandstone interbedded with gray to black shale, contains lenticular mostly lignitic coal seams. 110-1,780 feet.
Kmvr, white, tan and brown sandstone with interbedded minor gray to brown shale with some lenticular coal (includes Asphalt Ridge Member). 260-530 feet.



Mancos Shale
Medium to dark gray silty shale interbedded with subordinate thin sandstone and sandy limestone. 4,900-5,100 feet.

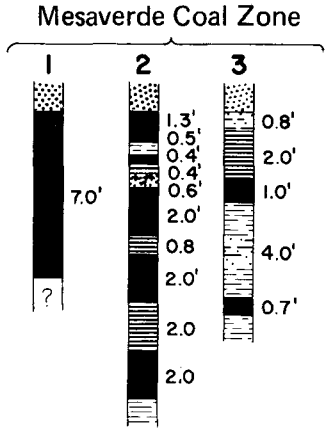


Figure 17. Coal sections of Cliff Ridge quadrangle (vertical scale: 1 inch = 8 feet).

Subsurface Information

There has been no drilling for coal on the quadrangle. Depth to the coal probably increases south of the exposures at a rate of one to one: a thousand feet south of the coal bed would indicate that the depth to the seam is 1,000 feet.

Quality of Coal

There are no analyses available for the quadrangle.

Mines and Development

According to Gale (1910, p. 209):

A single development was noted in a gulch about 2 miles south of Cocklebur. At this place an old mine, from which a considerable amount of coal appears to have been dug at some time in the past, seems not to have been worked recently... The entry runs down the dip, which is 35° S. 85° E. and is accessible for 30 feet or more. The mine has a roof of sandstone, which is apparently sound. The coal bed is at least 7 feet thick; the lower part being concealed so that it could not readily be measured. About 2 feet from the top of the coal there is a streak of bone about 1 inch thick, which is the only visible break in an otherwise solid bed. The mine is about 400 yards south of the rim rock, and if a constant dip of 35° is assumed for the intervening section, this distance gives an estimate of 700 feet for the stratigraphic thickness of the Mesaverde below the coal... The mine is equipped with a wooden track and whim for hauling out the coal... and the coal itself has the appearance of a very satisfactory grade, well suited for domestic use.

A small prospect near the location where the Cocklebur mine was located (table 10) was noted by this writer. The description did not fit and probably represents an additional prospect.

Table 10. Coal mines and prospects, Cliff Ridge quadrangle.

Mine	Location	Remarks
Cocklebur mine	NE.21–6S–24E	1870-1880's?
Prospect	NE.NE.NE.NE.21–6S–24E 4,461,550m.N. 652,000m.E.	

Reserves

Previous writers have not assigned reserves to the quadrangle. Probably only a few seams greater than four feet exist and these are no doubt unreliable and lenticular. Detailed examination of the area would block out at least 3,065,900 short tons of coal here listed as Class III reserve.

PRINCIPAL WORK

The geology of the quadrangle was mapped by G. E. and B. R. Untermann (1964b). Some modification of the geology especially in the area of the Frontier and Mesaverde sandstones was made in connection with this study. H. S. Gale, U. S. Geological Survey, examined the Cocklebur mine (1910), and the remaining coal data were added to this study by the writer.

DINOSAUR QUARRY QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Dinosaur Quarry quadrangle is located in the east part of the Vernal coal field 12 miles east of Vernal (figures 15 and 18). The quadrangle is properly assigned to the Brush Creek area. The north half is mountainous and the south half consists of broad alluvial plains or rolling hills. Split Mountain to the north is part of the Dinosaur National Monument, and much of the south part is privately owned and used for farming. The Frontier coal zone is exposed along the north and south flanks of Split Mountain. The Green River meanders across the south part of the quadrangle.

Elevations range from 4,700 feet where the Green River adjoins the south margin of the map to 7,400 feet on Split Mountain to the northeast. The Frontier coal zone is exposed between 4,800 and 5,200 feet in the last flanking ridge of Split Mountain. Most of the Frontier is easily accessible from paved or well graded roads that join with Vernal or U. S. Highway 40 a few miles to the south.

STRATIGRAPHY

Pennsylvanian to Quaternary strata are exposed on the quadrangle. Pennsylvanian, Permian and Triassic rocks form the core of Split Mountain and strike ridges and valleys surrounding it. Jurassic and Cretaceous beds make up ridges and valleys along the north and south flanks and along the west nose of the anticlinal mountain. The formations involved are the Jurassic Navajo Sandstone (700 feet thick), Carmel Formation (124 feet), Entrada Sandstone (104 feet), Curtis Formation (270 feet) and Morrison Formation (about 900 feet), and the Cretaceous Dakota Sandstone (50 to 200 feet), Mowry Shale (95 feet), Frontier Sandstone (236 feet) and Mancos Shale (approximately 5,000 feet). Brief descriptions of these formations are given in the explanation to the geologic maps (see pages 34 to 35). All of the Mancos Shale is not exposed on the quadrangle in low rolling hills in the south part of the quadrangle; the top of the unit lies several miles south of the area. The Morrison of this area is especially noted for its dinosaur fauna. A large part of the quadrangle is a part of Dinosaur National Monument.

The Frontier Sandstone contains the coal zone. As elsewhere in the Vernal coal field, the Frontier consists of two members. The lower one is barren of coal and consists mainly of brown clay shale that forms a tan slope. At the Dinosaur Quarry road this lower shale is 104 feet thick. The upper member is dominated by yellow-gray, mostly medium-grained, massive sandstone, that forms an impressive cliff. Toward the top of the member, shale, carbonaceous shale, thin coal seams and shaley sandstone occur in a 25-foot zone. This zone is capped by another 35-foot sequence of massive sandstone. The shaley zone marks the position of the coal zone.

Tertiary and Quaternary units are semiconsolidated or unconsolidated gravels or valley alluvium. The gravels have formed surfaces on the Mancos Shale to the south or have formed on high mountain surfaces. The alluvium has accumulated on the floodplain of the Green River and Brush Creek.

STRUCTURE

Several fold axes are concentrated in the north two-thirds of the quadrangle. An offshoot of the main Split Mountain anticline is the east-west trending Bullwinkle anticline forming a secondary nose to Split Mountain near the north flank. Dips are very steep along its north flank (to 60 degrees); the Frontier beds along Split Mountain's north flank are involved. On its south flank the dips range to 20 degrees, becoming steeper to the west.

The Bullwinkle syncline separates the Bullwinkle anticline from the main east-west trending Split Mountain anticline in the nose of Split Mountain. In the vicinity of the Split Mountain anticlinal axis the dips are gentle but steepen rapidly about a mile out, especially to the south, and increase to 40 degrees. This steep dip along the south flank of the mountain again involves the Frontier Sandstone beds. South of the mountain the beds level out to the Daniels Draw syncline south of which the beds dip northerly to 15 degrees.

Faults are remarkably few for an area of steep folding. A few minor faults are found along the south flank of Split Mountain, mostly with small displacements.

PROPERTY CONTROL

Lands on the Dinosaur Quarry quadrangle belong to the Bureau of Land Management, state of Utah, National Park Service and private interests. The Frontier outcrops are mainly controlled by the Bureau of Land Management and the National Park Service. There has been no interest in the coal and there are no current (1970) leases or permits on the quadrangle.

COAL

Surface Information

The single coal section (figure 19, p. 42) was measured in the extreme northwest corner of the quadrangle on the north flank of Split Mountain. The total amount of coal thickness is at least 6.6 feet but there are shale splits. The coal along the south flank of Split Mountain is in thin dirty seams or absent. There is indication of improving beds westward.

Subsurface Information

No drilling for coal on the Dinosaur Quarry quadrangle has been done. Depth to the Frontier increases 1,000 feet each 1,800 to 3,000 feet south of the outcrops.

Quality of Coal

No analyses for the Dinosaur Quarry quadrangle are available.

Mines and Development

One adit, at measured coal section 1, is the only development for coal on the quadrangle (table 11).

Table 11. Mine adit, Dinosaur Quarry quadrangle.

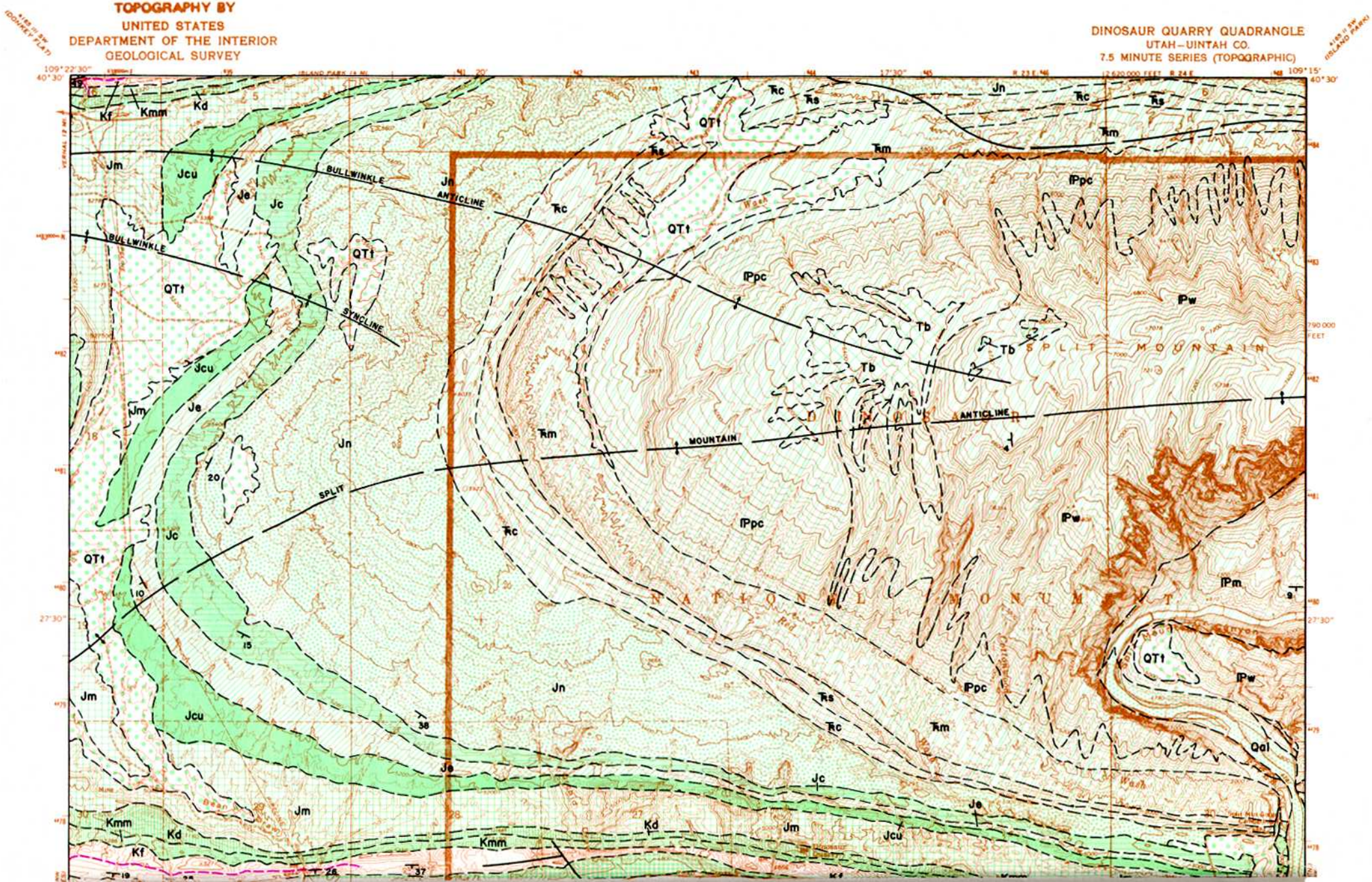
Mine	Location	Remarks
Mine adit	NW.NW.NW.SE.6–4S–23E 4,484,190m.N. 637,875m.E.	

Reserves

The only reserves on the quadrangle are in the extreme northwest corner of the quadrangle. The area is too small for reserve calculation.

PRINCIPAL WORK

Most of the quadrangle was mapped geologically by G. E. and B. R. Untermann, geologists with the Utah Field House of Natural History (1964b). The coal data were compiled by Utah Geological and Mineralogical Survey coal geologist R. L. Graham (1970) for this study.



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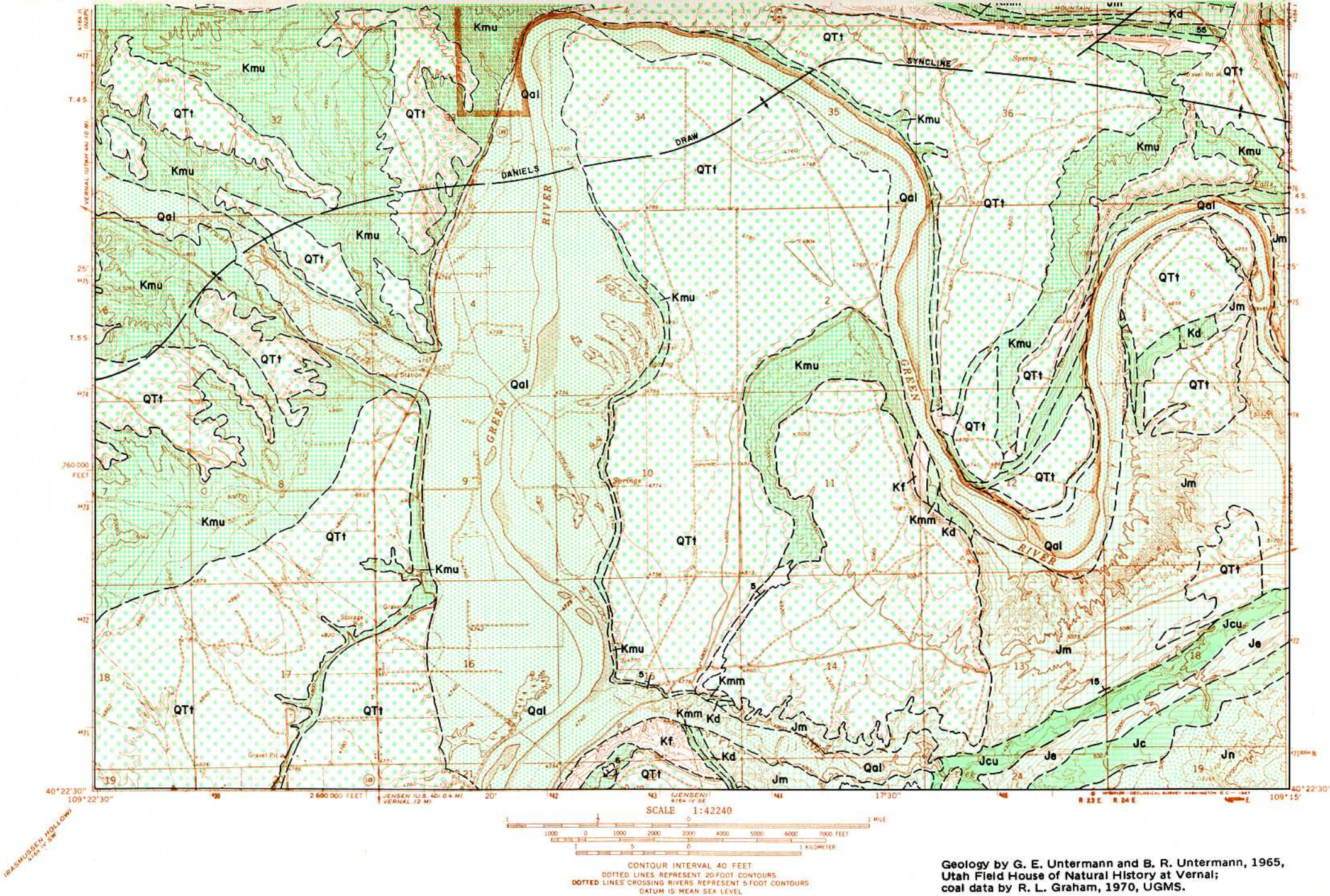


Figure 18. Coal and geology map, Dinosaur Quarry quadrangle (explanation pages 34-35).

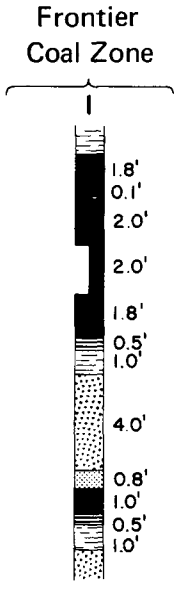


Figure 19. Coal section of Dinosaur Quarry quadrangle (vertical scale: 1 inch = 8 feet).

DONKEY FLAT QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

Donkey Flat is located in the north central part of the Vernal coal field about 8 miles northeast of Vernal in the east part of the Steinaker area (figures 15 and 20). The north half of the quadrangle is a series of east-west trending ridges and swales forming the south flank of the Uinta Mountains. Some deep consequent canyons have cut across the strata. To the south is flat to hilly country which in places is deeply gullied. One of the flatter areas is Donkey Flat. Elevations on the quadrangle range from about 5,300 feet above sea level at the southeast corner of the quadrangle to almost 7,000 feet in the northwest corner. Coal seams are exposed between 5,700 and 6,000 feet.

No towns exist in the quadrangle but Utah Highway 44 between Vernal and Flaming Gorge winds its way up the Uinta Mountains in the northwest map area. Fairly good gravel roads give access to other parts of the quadrangle, including the coal areas.

STRATIGRAPHY

Pennsylvanian to Cretaceous consolidated strata are exposed in the Donkey Flat area. Each produces an east-west band in the north, the width commensurate with its thickness and dip, with the oldest units closer to the crest of the mountains. Involved are quartzites, sandstones, phosphatic rock, limestone, siltstone, shale, conglomerate, redbeds and glauconitic beds. The pre-Cretaceous units are listed below with their thicknesses, and a brief description of each appears in the map explanation (see pages 34 to 35).

	Feet
Jurassic:	
Morrison Formation	926
Curtis Formation	263
Entrada Sandstone	163
Carmel Formation	170
Navajo Sandstone	750-800
Triassic:	
Chinle Formation	234
Shinarump Conglomerate	28
Moenkopi Formation	725
Permian:	
Park City Formation	119
Pennsylvanian:	
Weber Sandstone	1,200

The first three of the four Cretaceous units exposed at Donkey Flat follow the same outcrop pattern as the older formations. The youngest formation is very thick and its outcrops are found over the entire south half of the area.

The Dakota Sandstone unconformably overlies the Jurassic rocks and on the west side of Little Brush Creek it is 50 feet thick. Kinney (1955, p. 96) describes the Dakota as a light gray, coarse-grained sandstone with angular grains and fragments of fossil wood. It usually is found as a not-so-prominent hogback.

The Mowry Shale is 31 feet thick on the west side of Brush Creek, but a few miles west of the quadrangle in Steinaker Draw it is 90 feet. An erosional unconformity marks the upper part of the unit and may be responsible for the variation in thickness. The shale is thin-bedded and dark gray or brown. It is siliceous, fissile and contains common teleost fish scales. It usually forms part of the slope below the prominent hogback formed by the resistant sandstone beds of the overlying Frontier Sandstone.

The Frontier is the coal-bearing unit of the quadrangle. It is divisible into two units; a lower barren shaley unit and an upper unit with massive sandstones and coal. A section measured near the Bluebell mine in sec. 8, T. 3 S., R. 22 E. describes the unit.

Mancos Shale: claystone, dark gray and dark brown with occasional thin beds of brownish fine-grained sandstone and calcareous concretions; slope former.

Frontier Sandstone:	Feet
1. Sandstone, gray to purple-gray, fine-grained, well sorted, single thick bed, resistant, grades into gray shale of overlying Mancos	2.0
2. Shale, gray	0.5
3. Coal, lignitic, brown and black	0.8
4. Sandstone, gray to tan, fine- to medium-grained, well sorted, massive, contains carbonized wood, resistant ledge former, weathers to tabular plates and to shades of yellow and white	10.2
5. Coal, with thin splits	10.8
6. Covered, sandstone rubble float	1.6
7. Sandstone, gray to tan, fine- to medium-grained, well sorted, thick-bedded to massive, ledge former, slightly friable, weathers white with some limonitic staining in fractures, forms caprock to Frontier hogback	54.5
8. Covered, zone with sandstone float and possibly tan claystone	5.1
9. Sandstone, light tan to light brown, fine-grained, well sorted, thick-bedded, weathers light tan to gray, ledge former, medium resistant	4.5
10. Sandstone, tan to brown, medium-grained, fairly sorted, thick-bedded, weathers to shades of brown, ledge former, weathers blocky	12.8
11. Rubble-covered slope, covered with debris from overlying ledges, probably covers interbedded strata of shale and sandstone	27.0
12. Clay and silt shale, tan to brown, massive, slope former	50.0
Total	179.8

Mowry Shale: dark gray to dark brown, siliceous, bedding shaley to fissile, weathers into steel-gray plates, slope forming, contains fragments of fish scales.

Overlying the Frontier is the marine Mancos Shale. The formation is almost 5,000 feet thick in the Cliff Ridge quadrangle and is probably as thick near Donkey Flat. The unit is mainly composed of soft claystone, dark gray, silver-gray or gray-brown, that weathers into badland slopes usually badly gullied. Thin beds of brownish fine-grained, slabby sandstone and zones of calcareous concretions are often interbedded with the shale.

Accumulations of assorted terrace deposits support buttes and flats on the Mancos outcrop area. The Browns Park Formation of Tertiary age caps the Buckskin Hills. The Browns Park is a semiconsolidated conglomerate and sandstone. Quaternary and Tertiary unconsolidated clastics cap Donkey Flat and other areas. Sand, silt and clay alluvium fill the valleys of Brush Creek.

STRUCTURE

The structure of the Donkey Flat quadrangle, already alluded to, is simply south-dipping rocks on the south flank of the Uinta Mountains. The dip changes near the south map edge where the Island Park synclinal axis is found. Dips in the vicinity of the coal seams are moderate to steep and average 20 to 25 degrees. Faulting has been negligible.

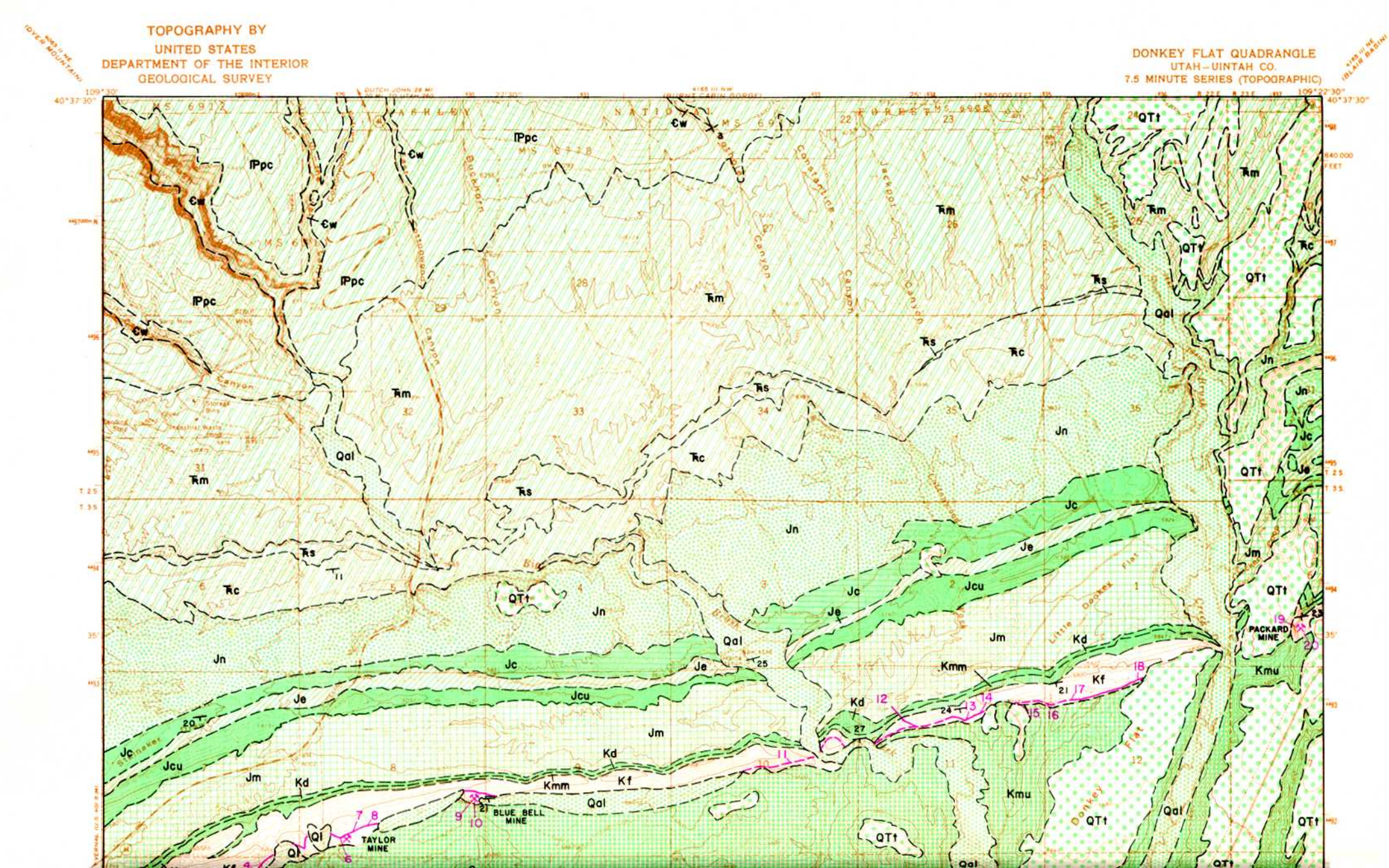
PROPERTY CONTROL

Lands of the Donkey Flat quadrangle are owned (1) privately, (2) by the state of Utah and (3) by the Bureau of Land Management. Alluvial areas around Brush Creek and some coal lands in sec. 8, T. 3 S., R. 22 E. are privately owned. The remainder of the coal outcroppings are in BLM lands. No lands are currently leased or permitted for coal.

COAL

Surface Information

Twenty coal sections have been measured on the quadrangle (figure 21); the coal ranges in thickness to 6.7 feet and becomes thinner and contains more splits toward the east. A strike valley parallels the outcrops to the south and accumulations of alluvium



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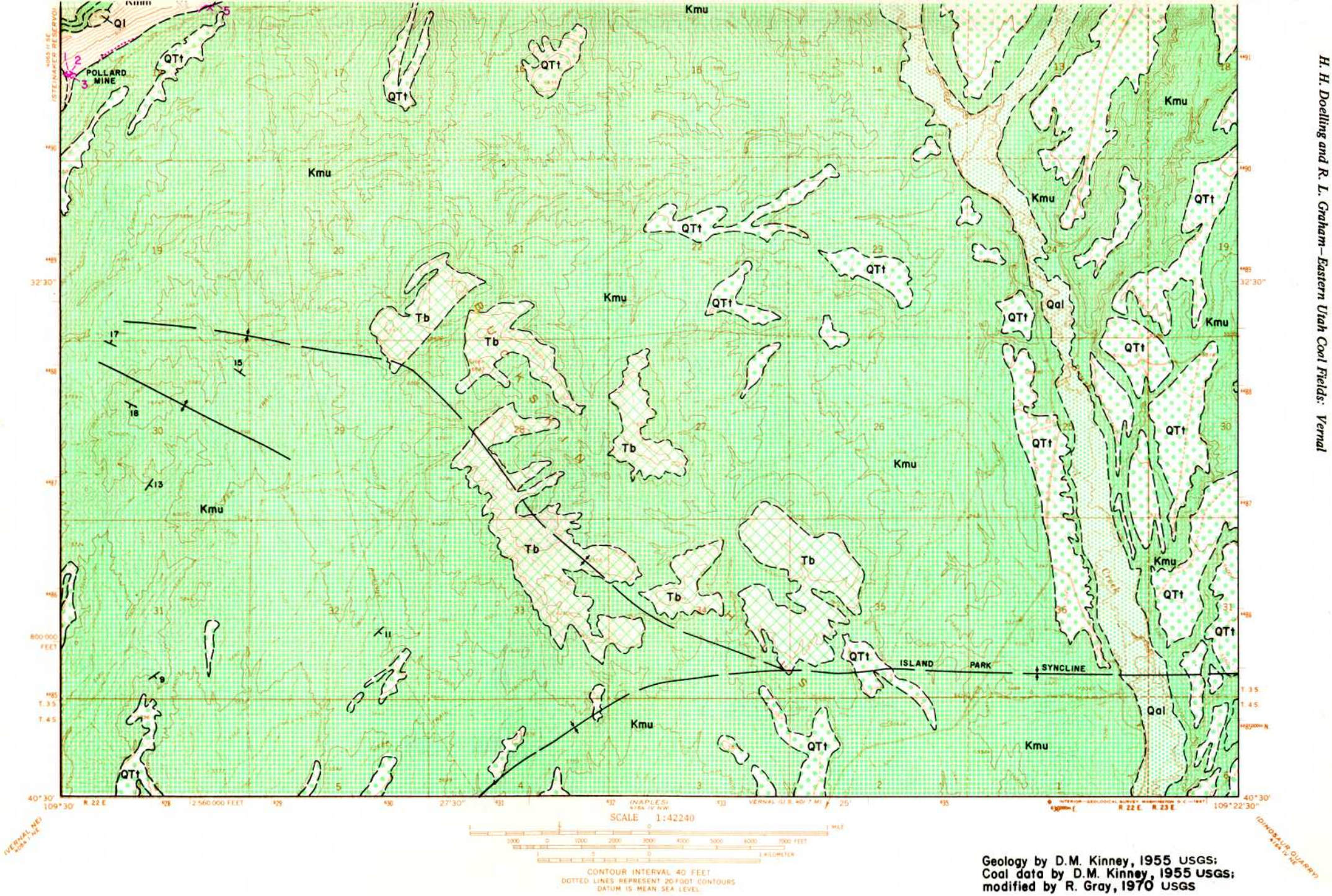


Figure 20. Coal and geology map, Donkey Flat quadrangle (explanation pages 34-35).

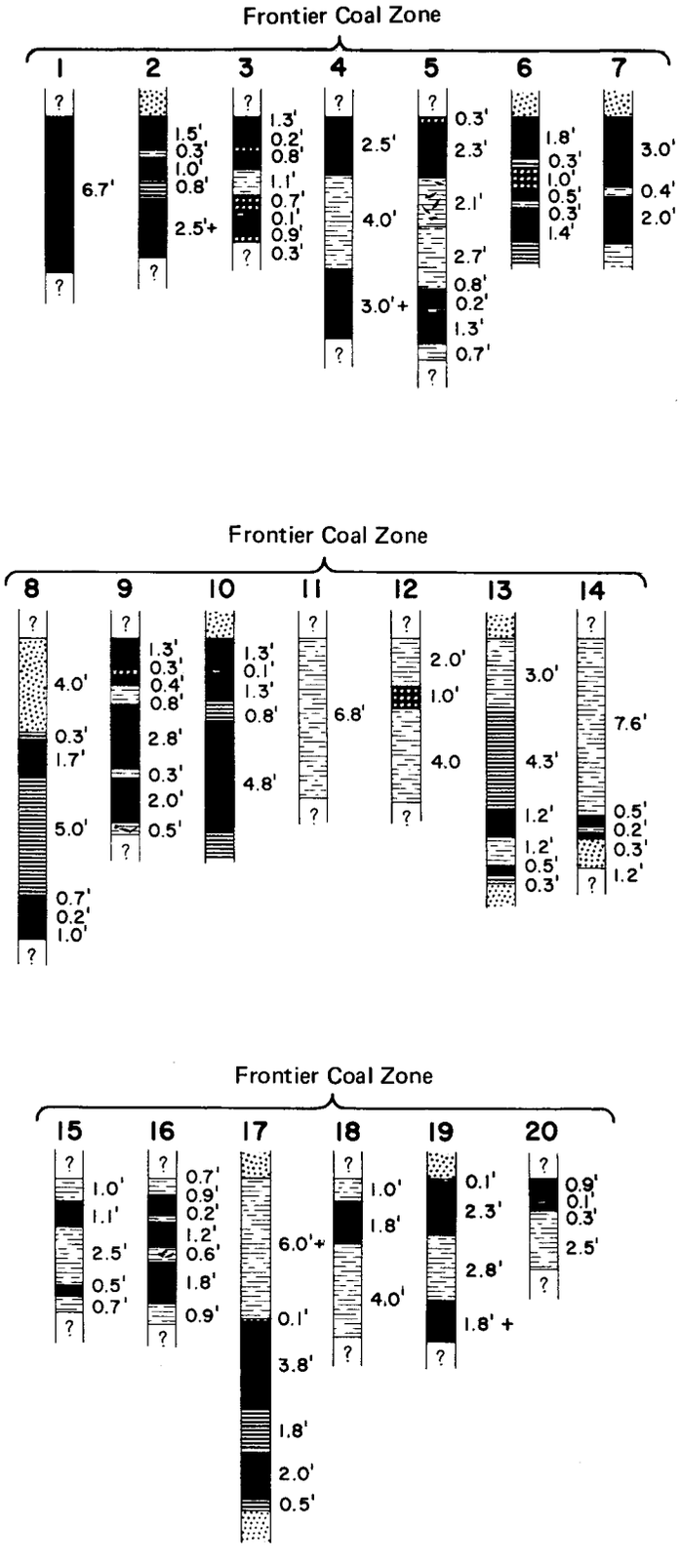


Figure 21. Coal sections of Donkey Flat quadrangle (vertical scale: 1 inch = 8 feet).

often cover the part of the Frontier containing the coal. Coal mines are usually found in the edges of protective landslide debris of overlying Mancos. The condition of the coal in the covered areas is unknown.

Subsurface Information

No drilling for coal on the Donkey Flat quadrangle is known to have taken place. As the beds dip to 25° the coal gains a depth of 400 feet with each 1,000 feet south. Oil well data reveal that dips diminish, broadening the area considerably in the western map area before the 3,000-foot limit is reached.

Quality of Coal

Five analyses establish the quality of the coal in the Donkey Flat quadrangle (table 12). Coal analyses for individual mines or prospects are listed in table 6.

Table 12. Average proximate analysis of coal, Donkey Flat quadrangle.

	Percent As-received	
	Average	Range
Moisture	8.6	5.6-11.3
Ash, dry	13.0	7.6-18.8
Sulfur	1.09	0.57- 1.65
Btu/lb	9,912	6,810-12,717

Mines and Development

Mines and prospects in the Donkey Flat quadrangle are listed in table 13. Pruitt (1961, p. 70) describes three of the mines as follows:

The Packard Mine in the N ½ sec. 12, T. 3 S., R. 23 E., is an old entry near Little Brush Creek. The coal is said to be very boney (Gale, 1910). Nearby the NE ¼ NE ¼ sec. 14 was patented as coal land in 1932.

The Blue Bell Mine (Massey Mine) in the NE ¼ SE ¼ sec. 8, T. 3 S., R. 22 E., was operated for over 40 years and produced low-grade bituminous coal. The coal bed is 9 feet thick and dips 27° south. In 1944 an inclined shaft reached 7 to 10 acres which have been mined out. In 1944 available production was 200 tons per month.

Nearby is the Pollard Mine; the coal bed here is 6 feet 8 inches thick and dips 24° southeast. In 1910 a single entry drift 200 feet long was observed at the mine.

The Taylor mine is located in the SW ¼ sec. 8, T. 3 S., R. 22 E., and consists of at least two entries in at least five feet of coal. A single entry 50 feet long has been dug in the zone in the northeast corner of sec. 18, T. 3 S., R. 22 E. The roof is a thick sandstone lens under which lie more than 2.5 feet of coal, 4 feet of shale and another 3 feet of coal.

Kinney (1955, p. 146) states that 10,000 short tons of coal have been mined out of the area.

Table 13. Mines in the Donkey Flat quadrangle.

Mine	Location	Remarks
Blue Bell mine (Massey & Winn, Kidd mine)	SE.NE.SE.8–3S–22E 4,491,990m.N. 630,219m.E.	1911-1950? Average 400 tons/yr.
Packard mine	NE.NW.SE.SW.6–3S–23E 4,493,400m.N. 637,350m.E.	Open adit
Pollard mine	NW.NW.NW.SW.18–3S–22E 4,490,530m.N. 627,100m.E.	1907-1910
Taylor mine	SW.NE.NE.18–3S–22E 4,491,240m.N. 628,350m.E.	

Reserves

Kinney (1955, p. 146) listed the following reserves for the quadrangle and included all coal 14 inches or thicker (table 14).

In re-evaluating the reserve, coal more than four feet in thickness is considered (table 15), but in some cases where thin splits and partings occur the coal above and below the splits are regarded as a single seam. Oil well data were used to determine the width in which the coal is at depths less than 1,000 feet, 2,000 feet and 3,000 feet. It is assumed that the average quality of the coal persists at depth.

Table. 14. Coal reserves in the Donkey Flat quadrangle (14 inches or thicker).

Frontier coal zone	Class II (all coal)	Class III (coal greater than 4 feet)
0-1000 feet	13,040,000	9,430,000
1000-2000 feet	16,930,000	6,840,000
2000-3000 feet	13,890,000	1,230,000
Total	43,860,000	17,500,000

Table 15. Revised coal reserves in the Donkey Flat quadrangle (includes seams 4 feet or more thick).

Frontier coal zone	Class II	Class III	Total
0-1000 feet	11,848,387	3,177,408	15,025,795
1000-2000 feet	10,870,080	9,274,060	20,144,140
2000-3000 feet	–	25,084,800	25,084,800
Total	22,718,467	37,536,268	60,254,735

(Minable coal will be 33 to 50 percent of the amounts).

PRINCIPAL WORK

The geology was mapped by U. S. Geological Survey geologist D. M. Kinney (1955) except for slight modification near the coal seams. He also supplied much of the coal data, measurements and analyses. The coal outcrop was remapped and additional measurements and analyses supplied by Utah Geological and Mineralogical Survey geologist Robert Gray in 1970.

Portal of Timothy coal mine, Coal Mine Basin.

Remains of loading facilities, Fletcher mine, near Coal Mine Basin.

DRY FORK–VERNAL NW QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

This quadrangle is a composite of the south half of Dry Fork quadrangle and the north half of the Vernal NW quadrangle of the U. S. Geological Survey (figure 22). The area lies in the western part of the Vernal coal field and encompasses part of the Deep Creek area and part of the Steinaker area (figure 15). The two areas are divided by Little Mountain, 8,620 feet above sea level, situated slightly off-center on the map area. Little Mountain is the highest spot; the lowest (about 5,860 feet) is along the south margin of the map.

Topographically the north or Dry Fork portion of the map consists of northwest-trending ridges and valleys interrupted by Little Mountain. The Vernal NW part is a south-dipping slope, incised in many areas by vigorous stream action eroding headward toward Little Mountain.

The coal is held in a ridge whose trend is northwesterly on the east side of the mountain and northeasterly on the west side. The coal outcrops lie at elevations from 6,100 to 6,900 feet above sea level on the east and between 6,800 and 7,800 feet on the west.

A good graded road serves the mine areas from Maeser and Vernal east of Little Mountain and jeep trails provide access to the Deep Creek area. These jeep trails connect with better roads on Little Mountain. The distance to the Steinaker area from Vernal is five or six miles.

STRATIGRAPHY

Permian to Quaternary rocks are exposed on the map area, but only the Cretaceous units are coal bearing. The Permian and Triassic units are exposed along the north margin of the map and consist mainly of phosphatic beds (Permian) and redbeds (Triassic).

The Jurassic Navajo Sandstone is easily recognized and makes a good reference point from which to identify the succeeding formations. The unit is about 750 to 800 feet thick and is marked by aeolian cross-bedding. It is a fine- to medium-grained light gray and tan sandstone that weathers into rounded domes and into sheer walls along canyons. Above the Navajo are about 250 feet of red-brown sandy shale and fine-grained sandstone interbedded with gray calcareous mudstone. This sequence is nonresistant and has limestone or gypsum beds associated with it. This, the Carmel Formation, is the lowest unit of the San Rafael Group. The remainder of this group includes the Entrada Sandstone and the Curtis Formation. The Entrada is a gray to tan, sometimes reddish sandstone about 230 feet thick and the Entrada is a glauconitic, greenish sandstone and shale unit about 150 feet thick.

The Morrison Formation, the uppermost Jurassic unit, is exposed below the cliffy Cretaceous beds. It is usually found in the first important strike valley north of the coal exposures. The unit is dominated by variegated claystone, although thin beds of friable sandstones and conglomerates are common. The unit is soft and forms rounded slopes and badlands. The unit is about 850 feet thick.

The Cretaceous of the Dry Fork-Vernal NW quadrangle is represented by five formations, from oldest to youngest: Dakota, Mowry, Frontier, Mancos and Mesaverde. Of these the Mowry and Mancos are marine shales, the other three mixed continental and marine. The latter three contain coaliferous material. In the Dakota the amount is insignificant. The Mesaverde has thick coal seams to the southeast but not in this quadrangle. Only the Frontier has coal seams here.

The Dakota of this area is a light gray to tan sandstone, often white weathering, interbedded with thin shales that are gray, green and maroon in color. Some are carbonaceous shales. The sandstones are medium- to thick-bedded and friable. The unit is medium resistant and usually crops out in the slope of the more resistant Frontier as an obscure irregularity. The Dakota varies in thickness between 50 and 200 feet.

The Mowry Shale forms a siliceous chip-strewn stripe between the Dakota and Frontier. The thin-bedded shale is easily recognized by this outcrop habit. The chips bear impressions of fish scales and less commonly leaves. The Mowry is approximately 100 feet thick.

The coal-bearing Frontier Sandstone was measured in the vicinity of the Helco mine, NW ¼ sec. 3, T. 4 S., R. 20 E., in Coal Mine Basin:

Mancos Shale: shale, dark gray and brown, massive, bentonitic, sandy and silty, weathers to yellow-gray and yellow-tan slopes.

Frontier Sandstone	Feet
1. Covered slope, probably claystone and thin-bedded sandstone with cannonball concretions (limestone) near the top	35.7
2. Coal	0.4
3. Shale, gray	0.8
4. Sandstone, yellow-tan, medium-grained, thin-bedded	2.0
5. Shale, carbonaceous, gray, with thin coal seams	6.0
6. Coal	1.0
7. Shale, coaley	1.5
8. Coal	2.0
9. Sandstone, light gray, fine- to medium-grained, thin- to thick-bedded, weathers to shades of light tan and fractures into small blocks about 1 foot square	17.3
10. Shale, gray, massive, weathers into gray soil, slope former	17.7
11. Sandstone, tan and brown, medium- to coarse-grained, medium-bedded to massive, ledge former	34.6
12. Claystone, gray-brown, massive, weathers into earthy brown slope	48.9
Total	167.9

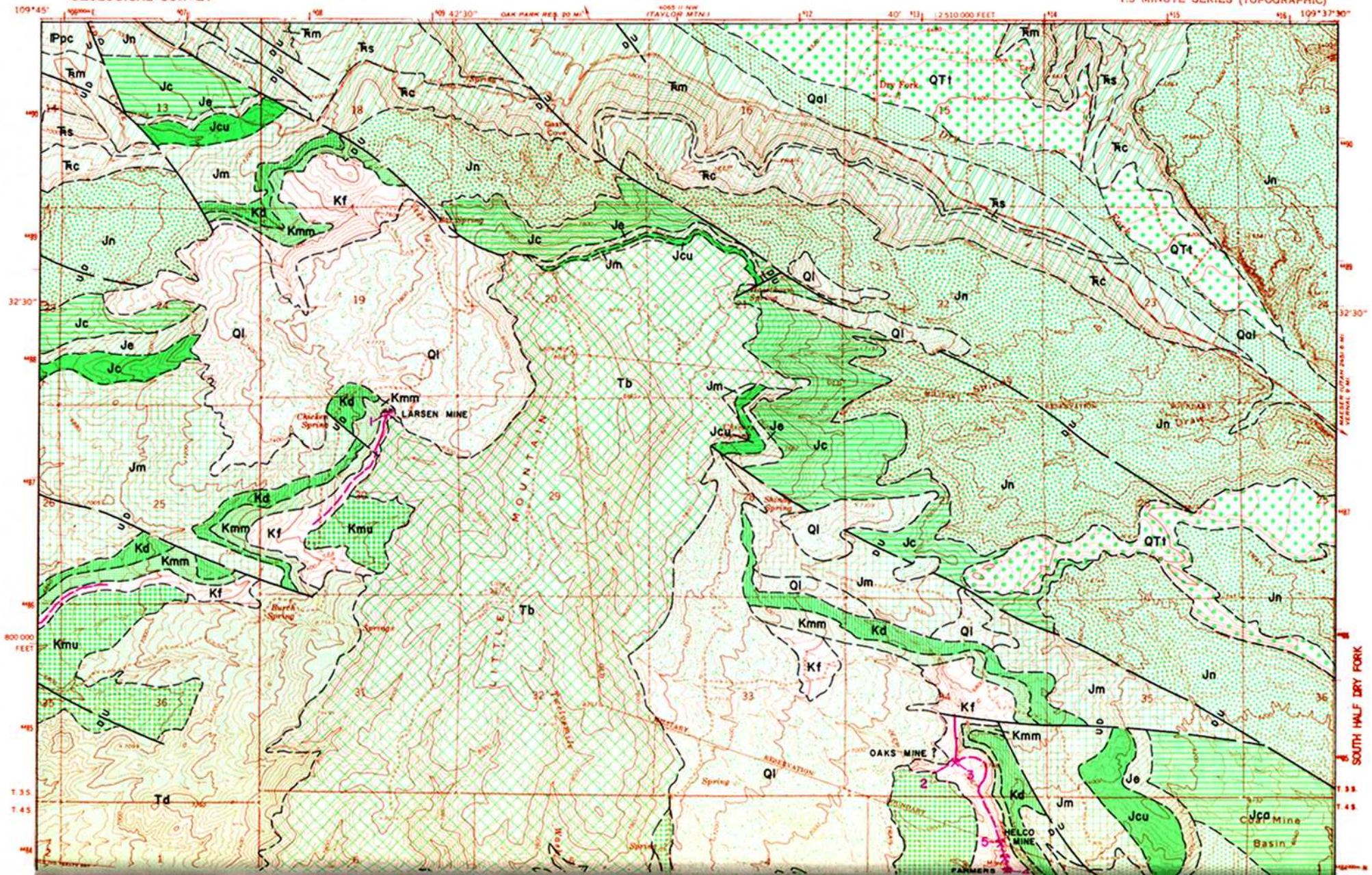
Mowry Shale: shale, gray to black, thinly bedded, weathers to steel-gray, fissile, slope former.

The Frontier may be divided into a lower claystone (here 48.9 feet thick) and an upper massive and cliffy sandstone (119 feet thick). The upper member contains the coal zone. In other areas there is usually a massive sandstone bed below the coal zone and the one above (of varying thicknesses), but in this case the upper sand is missing and replaced by claystone resembling the overlying Mancos. The upper contact lies above a zone of cannonball limestone concretions. These concretions are often found at the top of the upper massive sandstone of other areas.

The Mancos Shale is a marine claystone, mostly massive, gray to brown interbedded with thin sandstone beds or zones of calcareous concretions (some septarian). Toward the top the unit becomes more sandy and silty, imparting a yellow cast to the outcrop. The unit is nonresistant and often covered with unconsolidated deposits. The Mancos is nearly 5,000 feet thick.

Poorly exposed in the south part of the map area is the Mesaverde. The unit consists of thick-bedded to massive friable gray and tan-brown sandstone or graywacke interbedded with lesser amounts of gray or carbonaceous shale. The unit is incompletely exposed and no measurement of its thickness was made.

Overlying the Mesaverde unconformably and with angular discordance is the Tertiary Duchesne River Formation. Its outcrops are evident over most of the southwest part of the map. The beds are of fluvial origin and consist of interbedded red and brown claystones, gray and red sandstones and subordinate conglomerates. The unit has a maximum thickness of 1,500 feet.



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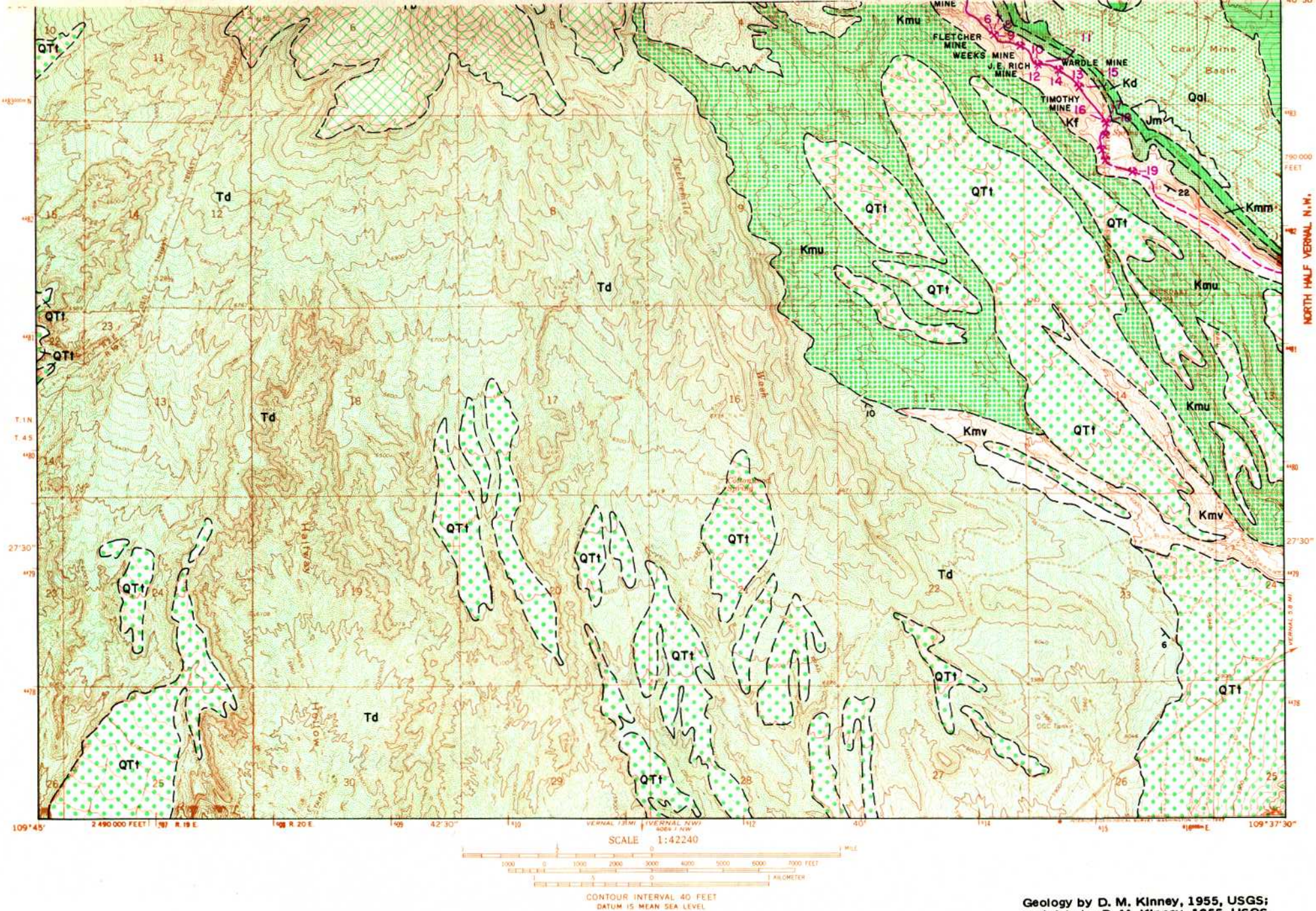


Figure 22. Coal and geology map, Dry Fork-Vernal NW quadrangle (explanation pages **34-35**).

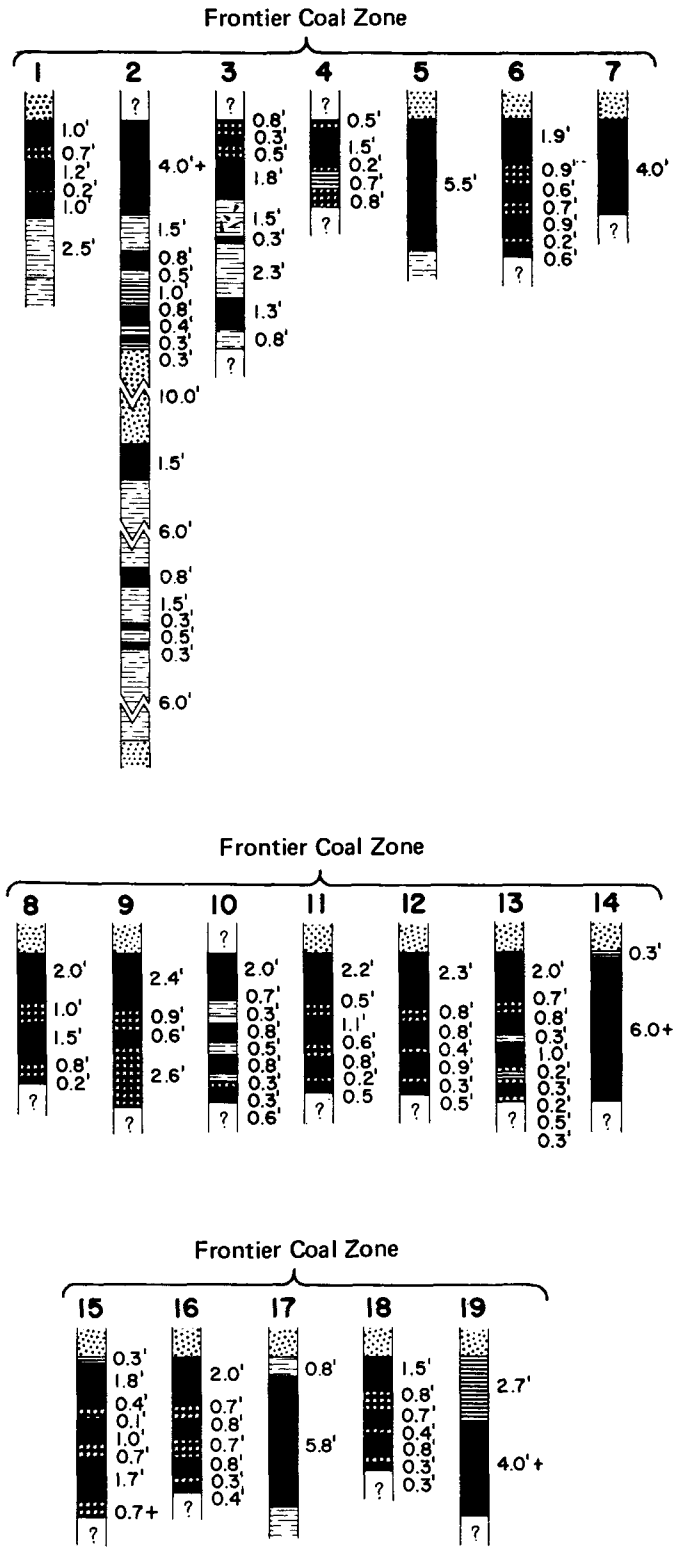


Figure 23. Coal sections of Dry Fork–Vernal NW quadrangle (vertical scale: 1 inch = 8 feet).

Capping Little Mountain is the Browns Park Formation, mostly composed of conglomerate, sandstone and tuffs, poorly to well cemented, perhaps up to 500 feet thick. Unconsolidated terrace gravels lie in scattered patches on the Duchesne River Formation and on some of the Triassic and Jurassic units. Landslides are common in the vicinity of the incompetent shaley units and alluvium fills the more important canyons and valleys including Coal Mine Basin.

STRUCTURE

All the pre-Tertiary beds are exposed as part of the south flank of the Uinta Mountains and form essentially east-west trending, south-dipping outcrops. Local irregularities coupled with differential erosion have produced an irregular line of outcrops. Overlapping Tertiary units have buried some of the hogbacks and strike valleys. To the north several long northwest-trending faults occur, some of which displace the coal strata. The beds in the coal areas dip to 25 degrees, quickly burying the coal behind the outcrops and limiting the area of profitable mining.

PROPERTY CONTROL

The lands of the quadrangle are privately owned or controlled by the Bureau of Land Management and state of Utah. The percentage of private land is small, mostly centered near Dry Fork, a small settlement in the north map area. However, most of the listed mines near Coal Mine Basin are in a small area of coal-patented lands. The remainder of the coal land east of Little Mountain is BLM land; the Deep Creek area lands (west side of Little Mountain) are divided between BLM and the state of Utah. No leases or permits for coal on the quadrangle are in effect.

COAL

Surface Information

Coal in the Dry Fork–Vernal NW area is probably the best of the entire Vernal field. It is here that coal mining persisted until the late 1950's before competition with natural gas and other coal areas forced a shutdown. Nineteen sections were measured, mostly from the Steinaker area (Coal Mine Basin; figure 23). Little is known about the Deep Creek area except what is known about the Larsen mine (section 1). Thicknesses of seams range to at least six feet. Occasionally these seams occur with no splits or irregularities, but usually some bone or shale creeps in.

Subsurface Information

It is not known if any drilling was done to prove coal reserves in the early days. No drilling information is available. Nothing about the coal buried under Little Mountain is known but the assumption is that it remains much the same as in the remainder of the Deep Creek and Steinaker areas of Frontier coal. The steepness of dip causes quick burial of the coal, but locally, as in the vicinity of the Helco mine, the dips are less steep because of structural irregularities and the minable strip may be wider.

Quality of Coal

The 17 analyses of coal in the Dry Fork–Vernal NW quadrangle show few deviations and a narrow range. The characteristics are (in average percent): moisture (as-received) 8.6, sulfur (dry coal) 1.72, ash (dry coal) 12.83 and Btu/lb (dry coal) 12,034. Table 6 gives details of the analyses.

Mines and Development

Gale (1910, p. 215-216) reports:

T. 4 S., R. 20 E. includes most of the working mines near Vernal. These are all on the same bed of coal... They are situated about 7 to 8 miles northwest of Vernal and were known and located as follows: C. C. Rich mine, lots 1 and 2, NW ¼ sec. 11; Alma N. Timothy mine, lot 10, SW ¼ sec. 2; Joseph E. Rich mine, W ½ SW ¼ sec. 2; and George Gray mine, NE ¼ SE ¼ sec. 3.

The C. C. Rich mine consists of several entries situated in a little gulch that intersects the lower Mancos hogback (Frontier). From the gulch bottom, drifts and slopes have been driven in several directions, along the strike of the beds and at various pitches down the dip. The massive white sandstone forming the roof of the coal is well exposed at this mine, the lower stratum lying immediately over the coal and being about 4 feet thick. Above this, other sandstone strata are exposed, as at the Timothy mine... The entry working at the time of examination ran in nearly on a level for about 900 feet toward the northwest, reaching nearly to the workings on the Timothy property. Side headings both above and below the main entry have been driven at intervals. The strike at this place is N. 53° W and the dip 12° SW. (The C. C. Rich mine is also known as the Pack Allan mine and the coal bed averages about four feet in thickness.)

The Alma N. Timothy mine is situated on the property next to that of the C. C. Rich mine on the northwest. The main entry starts in S. 35° W. on a

Table 16. Mines and prospects, Dry Fork–Vernal NW quadrangle.

Mine	Location	Remarks
C.C. Rich mine (Pack-Allen, Mill mine)	NE.NE.NE.NW.11–4S–20E 4,482,840m.N. 615,050m.E.	1910-1922 3100 tons
Farmers mine	SW.NW.SE.NE.3–4S–20E 4,483,960m.N. 613,835m.E.	
Farmers mine	SE.SW.NE.3–4S–20E 4,484,040m.N. 613,800m.E.	
Fletcher mine (Gray, North Star mines)	NW.NE.NE.SE.3–4S–20E 4,483,620m.N. 614,100m.E.	1908-1924 750 tons/yr.
Helco mine	NE.SW.NE.3–4S–20E 4,484,095m.N. 613,810m.E.	Recent
J. E. Rich mine (Hatch)	SW.NW.SW.2–4S–20E 4,483,360m.N. 614,420m.E.	1894-1908 1100 tons
Larson mine	C.NE.NW.NE.30-3S–20E 4,487,570m.N. 608,800m.E.	1910-1921
Mine	SW.SW.NE.11–4S–20E 4,482,440m.N. 615,260m.E.	
Mine adit	E.NW.NW.NE.3–4S–20E 4,484,470m.N. 613,650m.E.	
Mine adit	SE.NW.NE.3–4S–20E 4,484,340m.N. 613,760m.E.	
Mine adit	SE.SE.NW.NE.3–4S–20E 4,484,210m.N. 613,760m.E.	
Timothy mine	NW.SE.SW.2–4S–20E 4,483,170m.N. 614,750m.E.	1910-1921
Wardle mine	C.SW.2–4S–20E 4,483,330m.N. 614,620m.E.	1919-1955
Weeks mine	E.SE.NE.SE.3–4S–20E 4,483,515m.N. 614,300m.E.	
Prospect	NW.NW.NW.NE.SE.3–4S–20E 4,483,719m.N. 613,910m.E.	
Prospect	C.NW.NE.3–4S–20E 4,484,430m.N. 613,690m.E.	
Prospect	SW.NE.SW.NE.3–4S–20E 4,484,025m.N. 613,770m.E.	

slope of 12°. The roof is a large, massive, white sandstone, well exposed at the entrance to the mine. A small bed of coal above the one mined is also exposed, but is not large enough to be of any value. The main entry turns to the south and southeast approaching the workings on the C. C. Rich property. The dip in the mine is 11°. Mr. Timothy says that it increases considerably southeast of his mine, and that this is one reason why coal has not been more extensively opened beyond the C. C. Rich mine. (The coal bed measures 4 feet 3 inches at the Timothy mine.) . . .

. . . The Joseph Rich mine is situated northwest of the Timothy mine . . . The entry worked at the time of visit was a slope and drift, reaching a depth of about 600 feet to the southeast. This starts in due south on a slope of 11½° but soon turns eastward nearly on a level. From this entry a considerable number of side headings or slopes have been run down on the coal, the slopes being worked as far as ground-water level and there abandoned. The longest slope is reported to be about 1,300 feet in length below the main entry. The dip of the coal is 15° . . . (p. 217). . .Another small coal bed about 8 or 10 inches thick crops in the hillside above the main entry but is not considered of value.

In more recent years the Joseph Rich mine became the Wardle mine; it has operated since 1894. It was the last coal mine in the Vernal coal field to cease operations in the late 1950's. Gale (1910, p. 217) continues:

The George Gray mine is north of the Joseph Rich property, and is situated on the east slope of the coal ridge. As in the other mines the roof is solid, massive white sandstone. The main entry runs in S. 40° E. down a short slope, which turns to the northwest on a level, with side headings at intervals running down the dip. . .The strike of the rocks is N. 80° E. and the dip 14° S.

The George Gray mine was later called the Fletcher mine. According to Pruitt (1961, p. 71) the mine opened in 1919, in 1924 produced 2,000 tons of coal and was idle in 1944 when a new entry 400 feet long was driven. The thickness of the coal is about four feet.

The Larsen mine is the only mine in the Deep Creek portion of the mapped area. Here the coal totals 3 feet 1½ inches but is broken by thin splits of bone. The bed is nearly horizontal with possibly a slight dip to the south. The roof is gray massive sandstone and the floor a soft red shale. The main entry is at least 100 feet long.

Kinney (1955, p. 146) estimated that at least 280,000 tons had been mined from the area. Since most of the coal mined in Uintah County after his examination has come from this area it is estimated that an additional 10,000 short tons of coal were mined, bringing the total to 290,000 tons. Between 1896 and 1955 Kinney registers a production of 250,992 tons (table 5) for the entire field. Table 16 lists mines and prospects and their locations.

Reserves

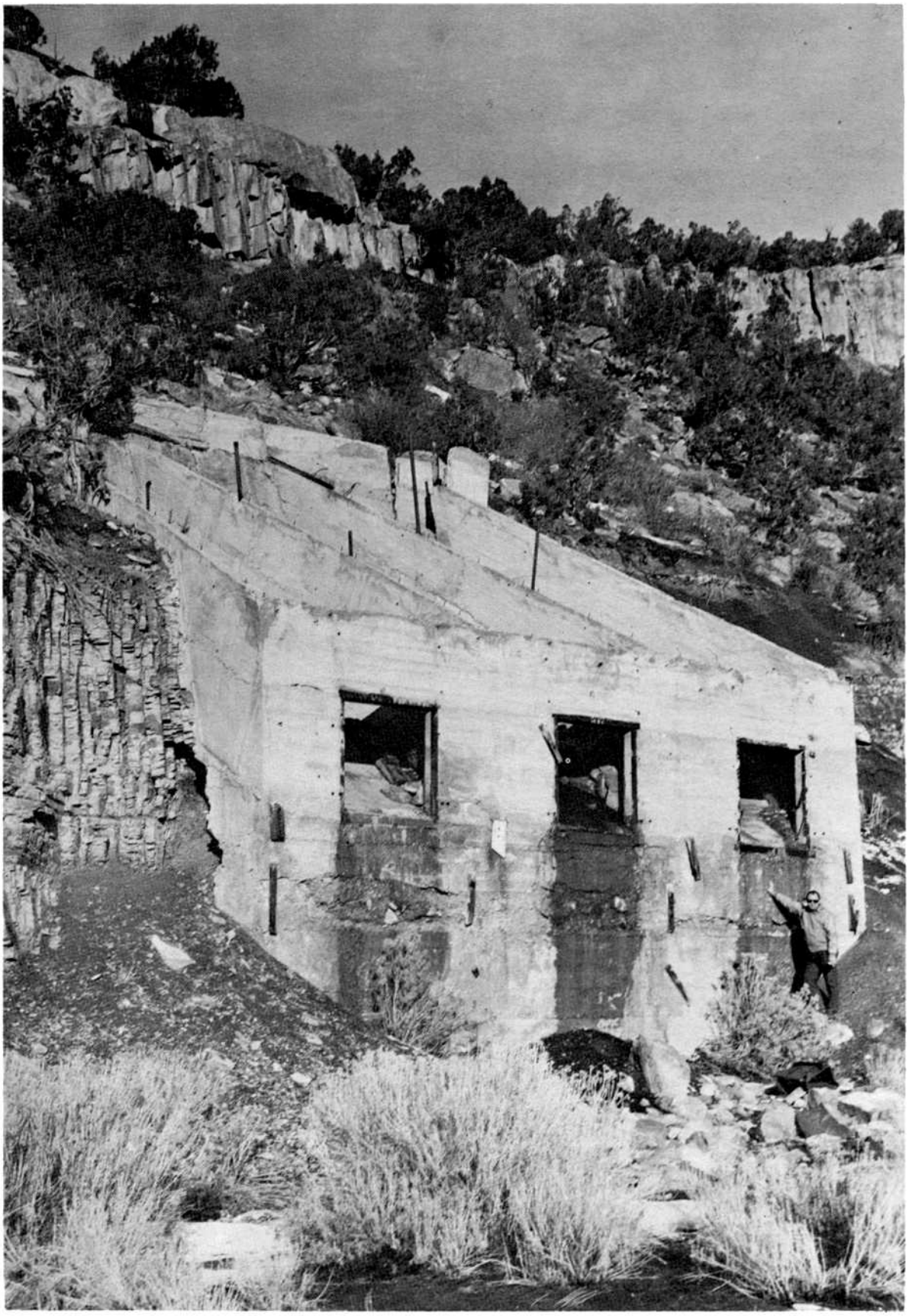
Kinney (1955, p. 146) estimated more than 20 million tons of reserve (table 17), but the coal seams listed average less than four feet in thickness. A re-estimation was made inasmuch as some seams that exceeded four feet were discovered. Seams with thin splits and partings were treated as a single seam.

Table 17. Coal reserves of the Dry Fork–Vernal NW quadrangle.

Frontier coal zone	Kinney (1955)	This report
0-1000 feet	9,940,000	5,904,000
1000-2000 feet	8,260,000	7,133,000
2000-3000 feet	2,360,000	5,808,000
Total	20,560,000	18,845,000
Minable coal will be between 33 and 50 percent of this amount		

PRINCIPAL WORK

The geology was mapped principally by D. M. Kinney (1955), and the data on mines were assembled by Gale (1910), both of the U. S. Geological Survey. Lupton (1912, USGS) and Doelling (1970, Utah Geological and Mineralogical Survey) collected additional information.



Loading chute below Helco mine near Coal Mine Basin.

ISLAND PARK QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Island Park quadrangle is located in the northeast corner of the Vernal coal field north of Split Mountain and south of Diamond Mountain Plateau (figures 15 and 24). The area is hilly to mountainous except where the Green River meanders in the southeast map corner. Grassy floodplain areas in the vicinity of the river give the appearance of a well-kept park.

Elevations range from 4,960 feet above sea level along the Green River to about 7,800 feet on Diamond Mountain. Formations known to contain coal are found between 5,300 and 7,200 feet above sea level. A well maintained gravel road joins Island Park with Vernal and parallels Split Mountain in the southern part of the quadrangle. In addition there are some roads on Diamond Mountain with access to Vernal (20 miles to the west).

STRATIGRAPHY

Rocks Pennsylvanian to Quaternary in age are exposed on the quadrangle. In the north the Tertiary Browns Park Formation (300 feet thick) caps Diamond Mountain. At Diamond Gulch erosion has cut through the Browns Park and exposed the Weber Quartzite of Pennsylvanian age. Between Island Park syncline and Diamond Mountain is a series of northwest-trending outcrops from the Permian Park City on the northeast to the Cretaceous Mancos Shale on the southwest. South of the syncline are east-west trending outcrops on the north flank of Split Mountain ranging from the Jurassic Navajo Sandstone (south) to the Mancos Shale (north).

The approximate thicknesses of pre-Cretaceous rocks on the Island Park quadrangle are as follows:

	Feet
Pennsylvanian:	
Weber Quartzite	100
Permian:	
Park City Formation	40-60
Triassic:	
Moenkopi Formation	950
Shinarump Conglomerate	37-75
Chinle Formation	235
Jurassic:	
Navajo Sandstone	575-600
Carmel Formation	125
Entrada Sandstone	135-165
Curtis Formation	260
Morrison Formation	745

The descriptions of these units appear in the map explanation. Four Cretaceous units occur in the quadrangle but only one is coaliferous. The oldest unit is the Dakota Sandstone. G. E. and B. R. Untermann (1964b, p. 42-43) subdivided the unit into three: the Buckhorn Conglomerate (32 feet), the Cedar Mountain Shale (41 feet) and the Dakota Sandstone (50 feet). The Buckhorn is tan and yellow fine- to coarse-grained sandstone, locally conglomeratic, that weathers to shades of brown. It is overlain by gray-brown, green-gray and maroon claystone (Cedar Mountain). The upper part is yellow to white cavernous weathering cross-bedded sandstone. There are a few thin shale and lignitic partings on the upper part but the entire unit is basically barren of coal. The Mowry Shale (95 feet at Island Park) is an easily recognizable unit of thin-bedded marine shale. The dark brown shales weather into thin plates and cleavages which are hard and siliceous. Imprints of cycloid fish scales are common on the silver gray-weathering plates.

Overlying the Mowry, probably unconformably, is the Frontier Sandstone. In the Vernal coal field the Frontier bears the most important seams although at Island Park they are thin and noncommercial. The Frontier was measured near Rainbow Park at 225 feet. The lower 131 feet consist of tan-brown claystone interbedded with thin sandstone beds. This lower slope former is topped by 50 feet of light tan to brown, fine-grained massive sandstone that forms an impressive ledge. A coal zone 34 feet thick overlies the sandstone:

	Feet
Sandy shale	8
Alternating lignitic coal, carbonaceous shale and shaley sandstone	13
Gray and tan claystone	12
Coal	1
Sandstone	

The remaining 10 feet are a massive resistant ledge of sandstone similar to that below the coal zone.

The youngest Cretaceous unit in the quadrangle is the marine Mancos Shale. It is a gray-brown silt or clay shale, interbedded with occasional thin beds of yellow-brown sandstone, with occasional concretionary zones. It is not known how much of the 4,000- to 5,000-foot formation remains in the quadrangle since the stratigraphic unit (Mesaverde) which overlies it elsewhere is not present.

STRUCTURE

Except for the nearly flat-lying Browns Park Formation on Diamond Mountain, all units north of the Island Park axis dip gently to moderately westward. These dips rarely exceed 15 degrees and average 5 to 7 degrees. Several east-west faults occur in the west central part of the map and in most cases the downthrown block is to the south. The displacements are generally small, less than 100 feet. South of the synclinal axis beds dip steeply north, 50 to 70 degrees.

PROPERTY CONTROL

Except for private lands at Diamond Mountain and Rainbow Park, all of the land is under control of the state of Utah, Bureau of Land Management and the National Park Service. All of the Frontier outcrops are in the lands of the federal agencies. No current leases or permits for coal are in force.

COAL

Surface Information

Coal beds are thin or absent in the Frontier coal zone. Two measured sections show 1.5 feet of boney coal and 1 foot of good coal respectively (figure 25). No coal was seen in outcrops north of 40° 32′ 30″ N. lat.

Subsurface Information

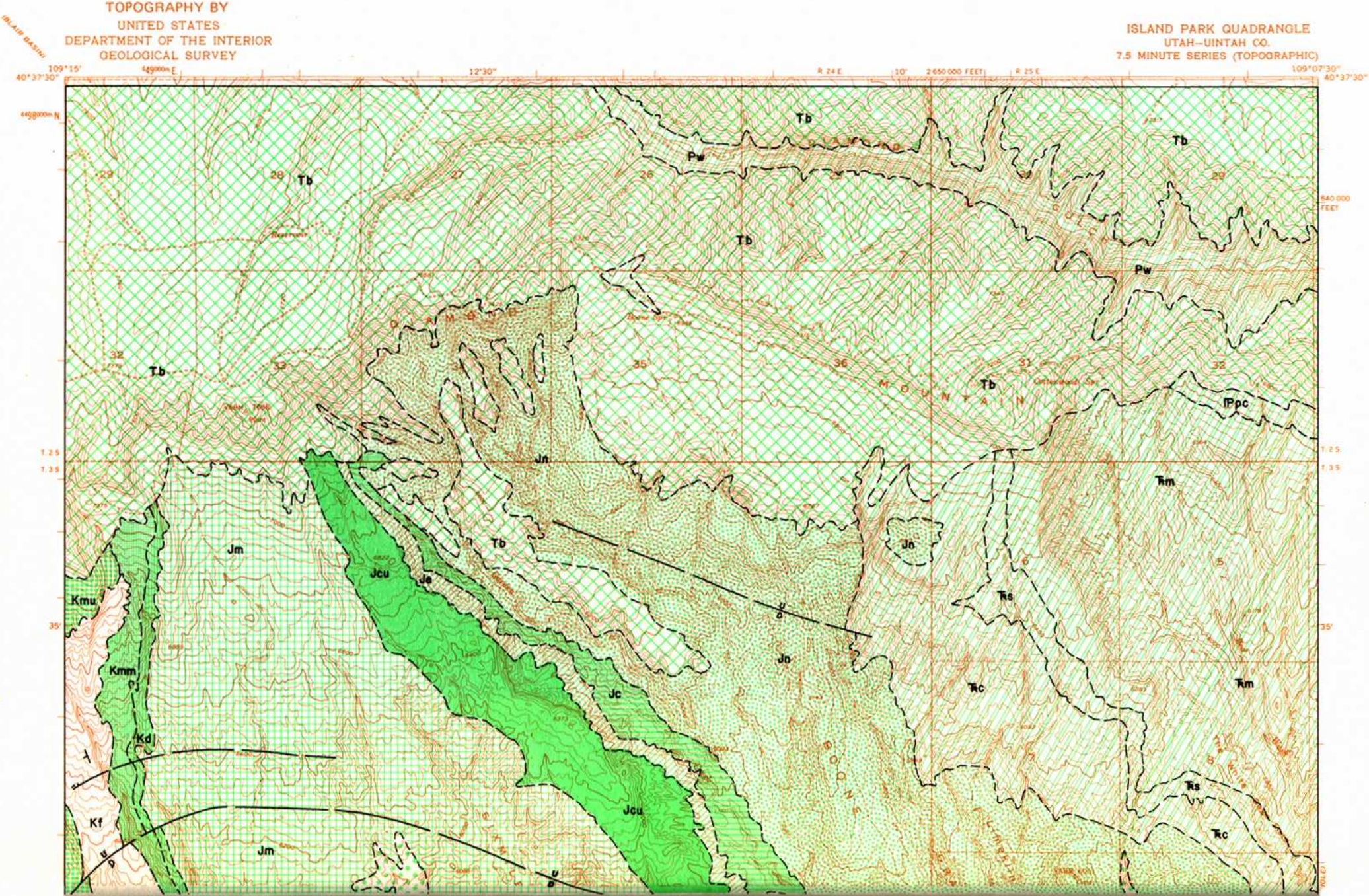
There has been no drilling for coal on the quadrangle. Depth to the coal is irrelevant since surface indications show that the coal is thin.

Quality of Coal

There are no coal analyses available for the Island Park quadrangle.

Mines and Development

No development for coal was noted on the quadrangle.


TOPOGRAPHY BY
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
ISLAND PARK QUADRANGLE
UTAH–UINTAH CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
109°15'
40°37'30"
12'30"
R 24 E
10'
2 650 000 FEET
R 25 E
109°07'30"
40°37'30"
840 000 FEET
T. 2 S.
T. 3 S.
35'
Tb
Pw
Jn
Jm
Jcu
Je
Jc
Kmu
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Ppc
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DIAMOND
MOUNTAIN
BOONE

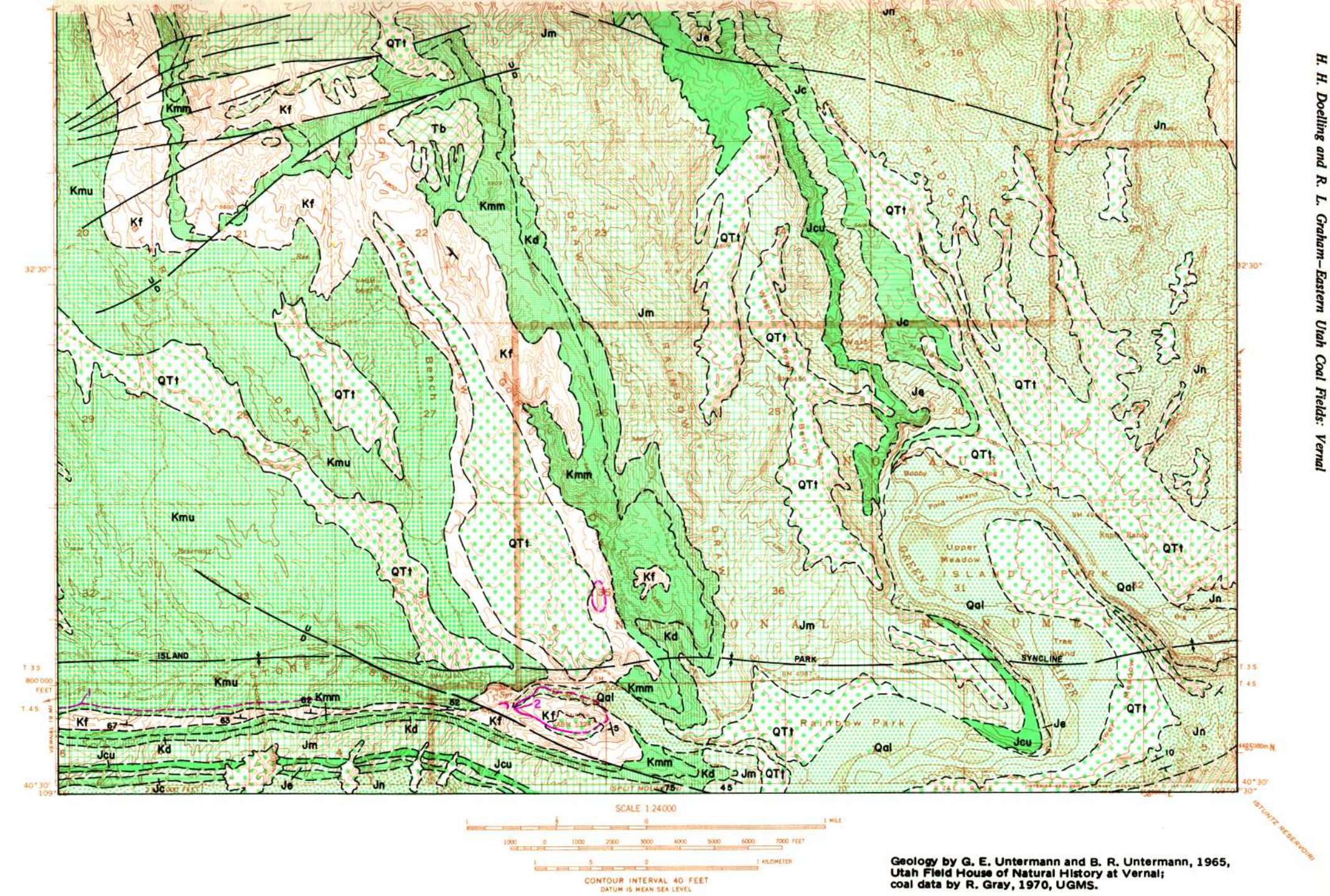


Figure 24. Coal and geology map, Island Park quadrangle (explanation pages 34-35).

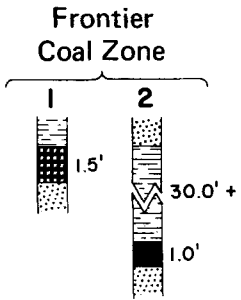


Figure 25. Coal sections of Island Park quadrangle (vertical scale: 1 inch = 8 feet).

Reserves

No reserves can be assigned for the quadrangle.

PRINCIPAL WORK

Geologic mapping was done by G. E. and B. R. Untermann (1965) of the Utah Field House of Natural History at Vernal. The coal data were obtained by Utah Geological and Mineralogical Survey geologist Robert Gray for this study.

JENSEN QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Jensen quadrangle is located in the south central part of the Vernal coal field (figures 15 and 26). The area is hilly, cut by deep gullies and washes along which steep cliffs are located. To the northwest the Green River meanders across its floodplain which adjoins Ashley Valley. The village of Jensen and several farms are located in this flat area. To the northeast is the plunging nose of Blue Mountain; a series of ridges and swales surrounds it. Most of the south half of the quadrangle is covered by east-west trending ridges and swales. Elevations range from 4,700 feet above sea level along the Green River to about 5,400 feet at several locations along the east edge of the map. The coal seams are found between 4,800 and 5,300 feet.

The village of Jensen is on U. S. Highway 40, 11 miles east of Vernal. U. S. 40 lies across the north end of the quadrangle. Another paved road leads south from Jensen along the east bank of the Green River and provides access to the Red Wash oil field, a few miles south of the quadrangle.

STRATIGRAPHY

Quaternary unconsolidated deposits cover most of the Green River floodplain area, Ashley Valley, and fill low areas between ridges elsewhere on the quadrangle. Consolidated units range in age from Triassic to Tertiary, the older outcrops around the nose of Blue Mountain to the northeast and the younger rocks successively to the southwest.

Strata northeast of U. S. Highway 40 include the following:

	Approximate Feet
Jurassic:	
Morrison Formation	860
Curtis Formation	270
Entrada Sandstone	100
Carmel Formation	125
Navajo Sandstone	700
Triassic:	
Chinle Formation	235
Shinarump Conglomerate	35-75
Moenkopi Formation	700

A brief description of each of these units is given in the map explanation (see pages 34 and 35).

Five formations represent the Cretaceous of the Jensen quadrangle. These are the Dakota Sandstone, Mowry Shale, Frontier Formation, Mancos Shale and Mesaverde Formation. Of these units in this quadrangle, only the Mesaverde contains coal seams.

The Dakota Sandstone, 100 to 125 feet thick, can be divided into three units. The lowermost is a fine- to coarse-grained subgraywacke, yellow and tan in color, weathering brown. It contains fossil wood. The middle unit is clay shale, gray-green or maroon in color and the upper unit is a yellowish to white, fine- to coarse-grained sandstone that contains silicified wood. At Dinosaur National Monument the lower unit is 18 feet thick, the middle unit 36 feet thick and the upper unit 48 feet thick.

The Dakota is overlain by the Mowry Shale, a dark brown marine shale that typically weathers into gray-white, silvery-white or gray-white platelets. The platelet-strewn outcrop area is easily recognized between the sandstones of the Dakota and the brown shales of the Frontier above. The unit is about 125 feet thick but varies appreciably from place to place because of an erosional unconformity between it and the Frontier Sandstone.

The Frontier, about 250 feet thick a little to the east of the map area and 237 feet thick a little to the north, may be divided into two members. The lower member is dominated by dark gray and brown clay and sandy shale which make the unit a slope-former. It contains thin beds of fine-grained brown and tan sandstone beds. This lower unit varies from 140 feet at Dinosaur National Monument to 157 feet east of the map area. The upper unit is more resistant and is responsible for the hogback that typifies the Frontier exposures. At Dinosaur the upper Frontier, 97 feet thick, consists of two massive yellow to tan-gray sandstone units separated by a carbonaceous shale and gray shale zone. To the east the upper Frontier is mostly sandstone; the lower sandstones are thin-bedded. The shale zone has changed to interbedded fine-grained brown sandstone and fissile black shales and the upper sandstone is a massive unit a little more than eight feet thick. To the west, in the Brush Creek and Steinaker areas, the Frontier contains thick coal seams in the shaley zones in the middle of the upper Frontier.

A great thickness of marine brownish Mancos Shale interbedded with occasional thin sandstone beds lies between the Frontier and Mesaverde formations, estimated to be about 5,000 feet thick in this area. It is marked by badland surfaces, yellow gray-brown in color, upon which little vegetation can grow.

The first continuous ridge south of the Mancos outcrops marks the Rim Rock Sandstone Member of the Mesaverde Formation. It consists of massive gray, gray-yellow, brownish sandstone and subgraywacke interbedded with thin shale beds. Thin lignitic zones are occasionally associated with the shale.

The upper member is of similar lithology but the shale breaks are thicker and more frequent. These shale zones contain several lignitic and coaley beds. The amount of shale increases to 50 percent of the unit, rendering it much less resistant than the sandstone of the Rim Rock Member. The coaley beds occur anywhere within the upper member of the Mesaverde with a greater concentration in the upper part. The Rim Rock varies in thickness between 500 and 550 feet; the upper unit is incomplete inasmuch as the Tertiary rocks overlap and partly cover the unit. At least 1,000 feet are exposed.

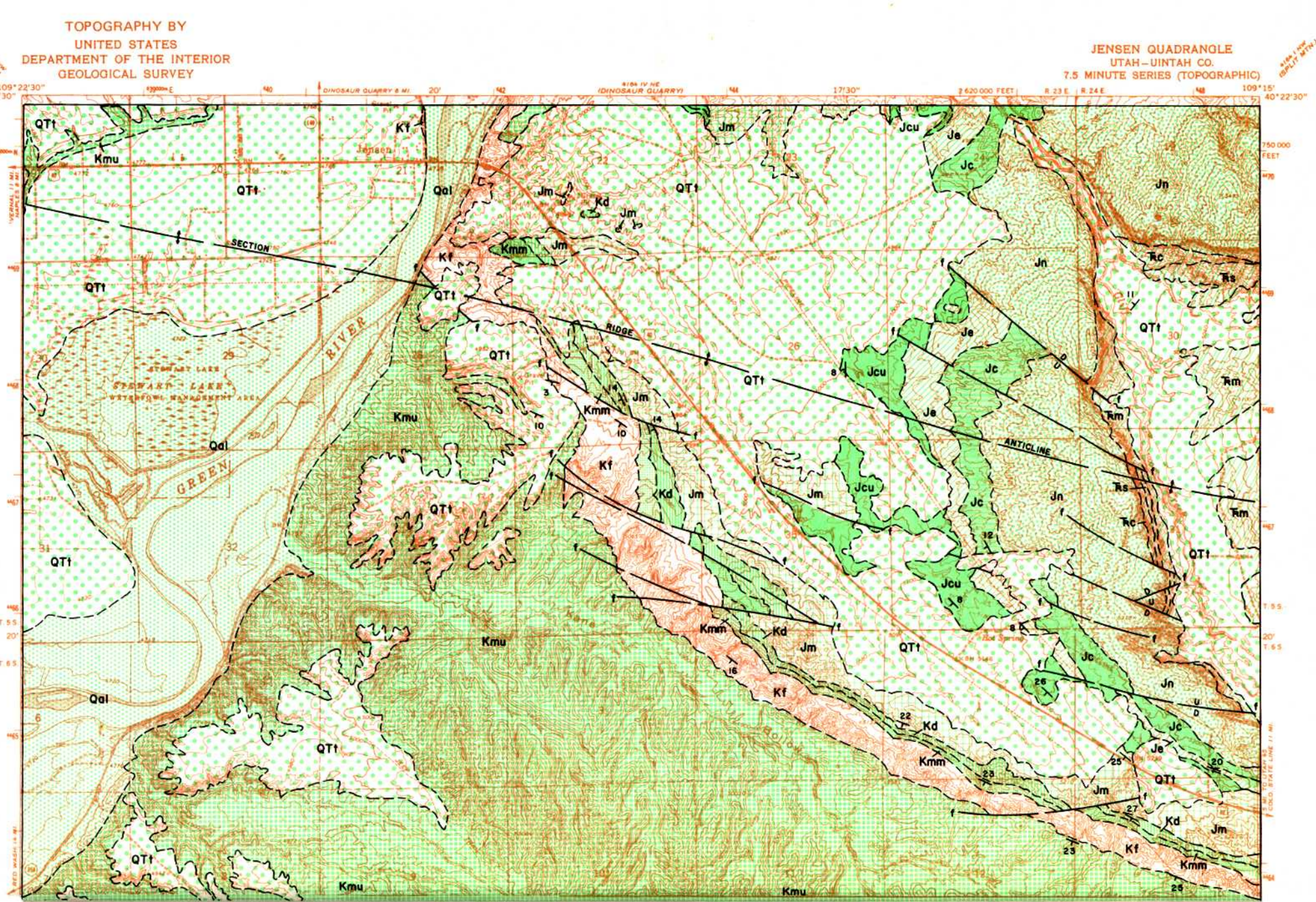
Unconformably overlying the Cretaceous is the Tertiary Green River Formation which in a similar manner is overlain by the Tertiary Duchesne River Formation. The full thickness of either Tertiary unit is not exposed on the quadrangle, but in the Red Wash oil field to the south the Green River is almost 3,000 feet thick. The Duchesne River Formation has a maximum thickness of 1,500 feet in Uintah County. The Green River is marked by a yellowish gray ridge south of the Mesaverde coal-bearing beds and consists of brownish shales (some are oil shale) and yellow-brown sandstone beds that are locally conglomeratic. The Duchesne River beds are reddish intercalated sandstones and shales.

STRUCTURE

Two fold axes trend approximately west-northwest across the quadrangle. The Section Ridge anticline lies in the north part of the map. Dips are moderate to gentle in the vicinity of the axis (to 25 degrees), but father south, in the vicinity of the Mesaverde coal-bearing beds, the dips steepen to as much as 75 degrees. The overlapped Tertiary rocks are marked with pronounced structural irregularities in the vicinity of the Mesaverde. Low displacement faults and closely spaced anticlines and synclines and steeply dipping beds gradually give way to gently south-dipping beds as the Walker syncline is reached. An exception to this trend is a monoclinal flexure in the vicinity of Sage Bench where the beds dip 50 to 60 degrees to the north.

PROPERTY CONTROL

Lands along the Green River are mainly privately owned; the remainder is under the jurisdiction of the Bureau of Land



Utah Geological and Mineralogical Survey Monograph Series No. 2, 1972

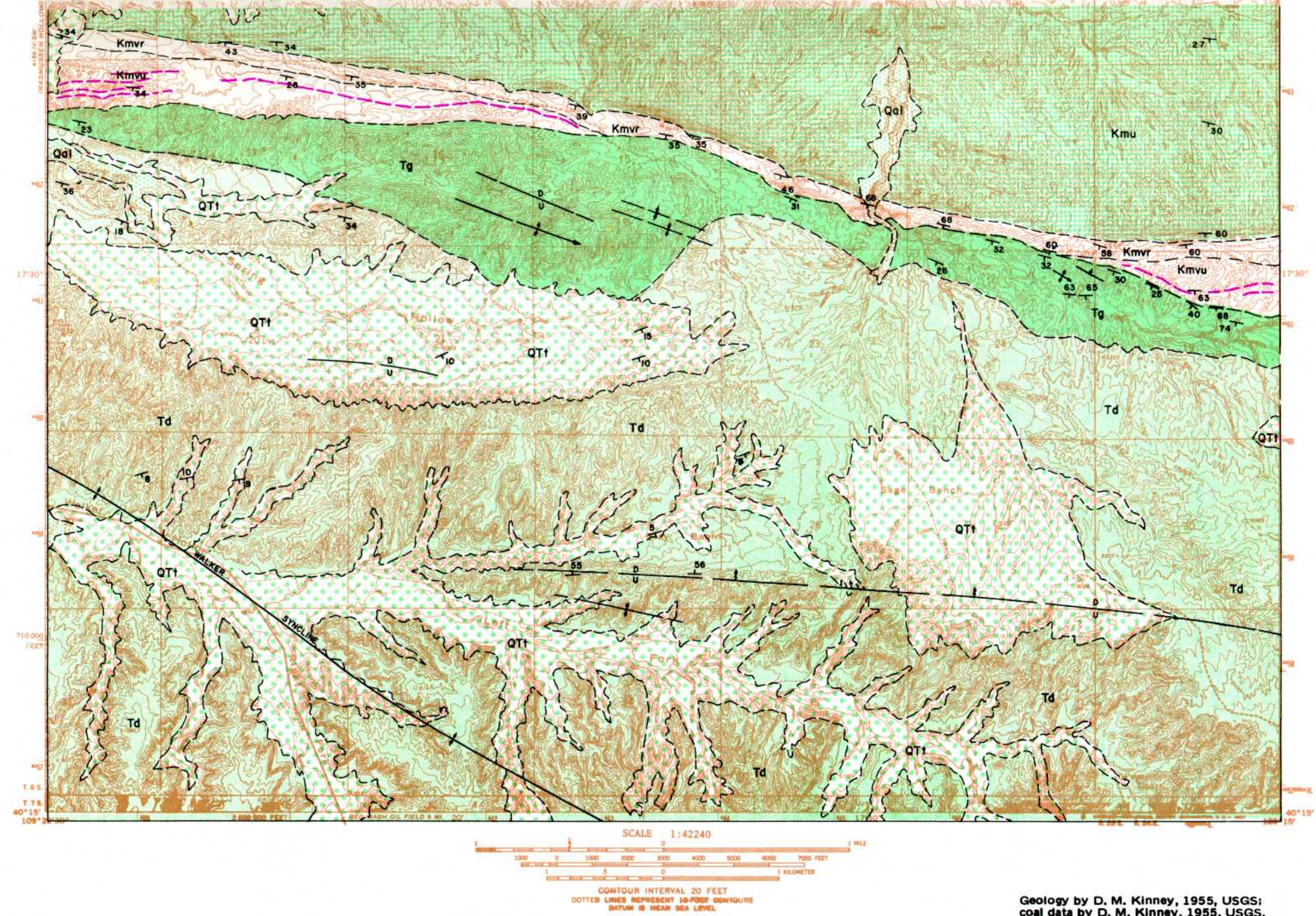


Figure 26. Coal and geology map, Jensen quadrangle (explanation pages 34-35).

Management and the state of Utah. None of the land is held for coal under permits or leases.

COAL

Surface Information

No measured sections are available for the Jensen quadrangle. The coal beds are extremely lenticular, but some attain thicknesses greater than four feet. Thick coal beds are limited to dirty lignite; bituminous coal beds are generally very thin. There are as many as eight seams in the upper Mesaverde.

Subsurface Information

There is no drilling for coal known on the quadrangle.

Quality of Coal

No analyses for the Jensen quadrangle are available.

Mines and Development

Coal in the quadrangle has not been developed.

Reserves

No reserves can be assigned to the quadrangle.

PRINCIPAL WORK

The geologic map is a composite of information drawn from U. S. Geological Survey geologist D. M. Kinney (1955) and G. E. and B. R. Untermann, Utah Field House of Natural History at Vernal (1964a). The coal data and some of the structure data near the upper Mesaverde were supplied by H. R. Ritzma of the Utah Geological and Mineralogical Survey.

JENSEN RIDGE QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Jensen Ridge quadrangle is located in the east central part of the Vernal coal field (figures 15 and 27) just north of Split Mountain, approximately 14 miles northeast of Vernal. The Diamond Mountain Plateau lies in the northeast corner of the map area and is the highest elevation in the quadrangle, 7,700 feet above sea level. The northwest corner of the map is characterized by the strike valleys and ridges of the south flank of the Uinta Mountains. These ridges and valleys are repeated along the south edge of the quadrangle along the north flank of Split Mountain. The large area between the north and south margins of the map consists of a slightly sloping badlands area developed on Mancos Shale. The lowest elevations are along the Island Park syncline to the south, about 5,300 feet in the southwest map corner.

The Frontier Sandstone is exposed in ridges on the north (Steinaker area) between 6,000 and 7,200 feet and on the south (Brush Creek area) between 5,300 and 5,600 feet. Both these areas of outcrop can be reached from Vernal along graded roads.

STRATIGRAPHY

Mesozoic and Cenozoic rocks are exposed on the quadrangle but the largest area exposes Cretaceous units. Triassic fluvial redbeds are exposed in the northwest corner of the map. These beds are overlain by Jurassic Navajo Sandstone, which is exposed on the Jensen Ridge quadrangle on both the south flank of the Uinta Mountains and the north flank of Split Mountain. The Navajo is easy to recognize because of its aeolian cross-bedding. The fine- to medium-grained, light tan to yellow sandstone is resistant, but erosion has carved a variety of rounded domes and turrets on its exposures. The unit ranges in thickness from 700 to 800 feet, thickening slightly westward.

Above the Navajo and appearing as thin ridges and valleys is the San Rafael Group of formations, the Carmel, Entrada and Curtis. The Carmel is a soft reddish sandy shale or fine-grained sandstone and is about 150 feet thick. The Entrada is a medium resistant light gray, fine- to medium-grained sandstone about 130 feet thick. It is poorly cemented, massive and somewhat cross-bedded. The Curtis Formation is a marine unit which can be divided into two members, a lower greenish glauconitic sandstone and an upper greenish glauconitic shale. The lower part is a ridge former and the upper part has low resistance to erosion. The Curtis is about 250 feet thick in the Jensen Ridge quadrangle.

The Morrison is the youngest Jurassic unit exposed; its soft variegated mudstones and light gray sandstones form badland slopes and valleys with occasional conglomeratic beds. The unit is about 900 feet thick in this area.

Cretaceous units exposed are the Dakota, Mowry, Frontier and Mancos formations. The Dakota Sandstone is a medium-resistant interbedded sandstone and shale unit. In other areas the Dakota is coal bearing, but in the Vernal coal field it is barren except for some thin beds in the Deep Creek area and some thin lignitic seams near Steinaker Draw. The thickness ranges from 50 to 200 feet.

The Mowry Shale occurs in the slope below the cliff formed by the overlying Frontier. It is easily recognized because the shale weathers into white or silver-gray platelets. The unweathered color is usually a dark brown and the bedding is fissile to thin-bedded. The unit has not been measured but probably varies between 50 and 100 feet.

The Frontier Sandstone consists of a lower clay shale unit overlain by a unit of thick-bedded to massive sandstone interbedded with clay shale, carbonaceous shale, sandy shale and coal. At Brush Creek on the west the lower member is 139 feet thick; on the east at Island Park it is 131 feet thick. In a section measured near Switchback Spring below Diamond Mountain, the lower shale was 94 feet thick. The upper coal-bearing member also varies in thickness. The unit thins from 117 feet at Brush Creek to 95 feet at Island Park and thickens northward at Switchback Spring to 140 feet. The coal zone is found in the upper part of the upper member but in all parts of the quadrangle the seams are thin. The thinning of the coal is roughly west to east.

The youngest Cretaceous unit is the Mancos Shale whose outcrops are found over a large percentage of the map area. The unit consists of medium to dark gray silt and clay shale, massively bedded, occasionally interrupted by a thin lenticular sandstone bed or layer of calcareous concretions. Near U. S. Highway 40, east of Vernal, the unit is about 5,000 feet thick. Since the overlying Mesaverde Formation is not present in the quadrangle it has been impossible to determine the thickness of the Mancos. Oil wells drilled in secs. 28 and 30, T. 3 S., R. 23 E., have intersected the Frontier at depths of 2,160 and 1,580 feet.

The Browns Park Formation, a conglomeratic unit of Tertiary age, caps the Diamond Mountain Plateau where it is about 300 feet thick. Terrace gravels have developed on some areas of Mancos Shale and Navajo Sandstone outcrops.

STRUCTURE

In the northwest part of the quadrangle the strata dip southerly to 20 degrees. This dip becomes more gentle southward until the Island Park syncline is reached. South of the synclinal axis the beds dip steeply (to 70 degrees) northward. In some places the rocks are shattered and faulted. A group of northwest-trending faults were mapped in the south central map area. In the northeast map corner the nearly horizontal Browns Park Formation has buried the east-west trending ridges (including the Frontier) exposed to the west.

PROPERTY CONTROL

The lands of the Jensen Ridge quadrangle are under control of the Bureau of Land Management, the state of Utah or are privately owned. The Frontier outcrops are exclusively controlled by BLM. There has been no interest in the coal in recent years and no lands are under lease or permit.

COAL

Surface Information

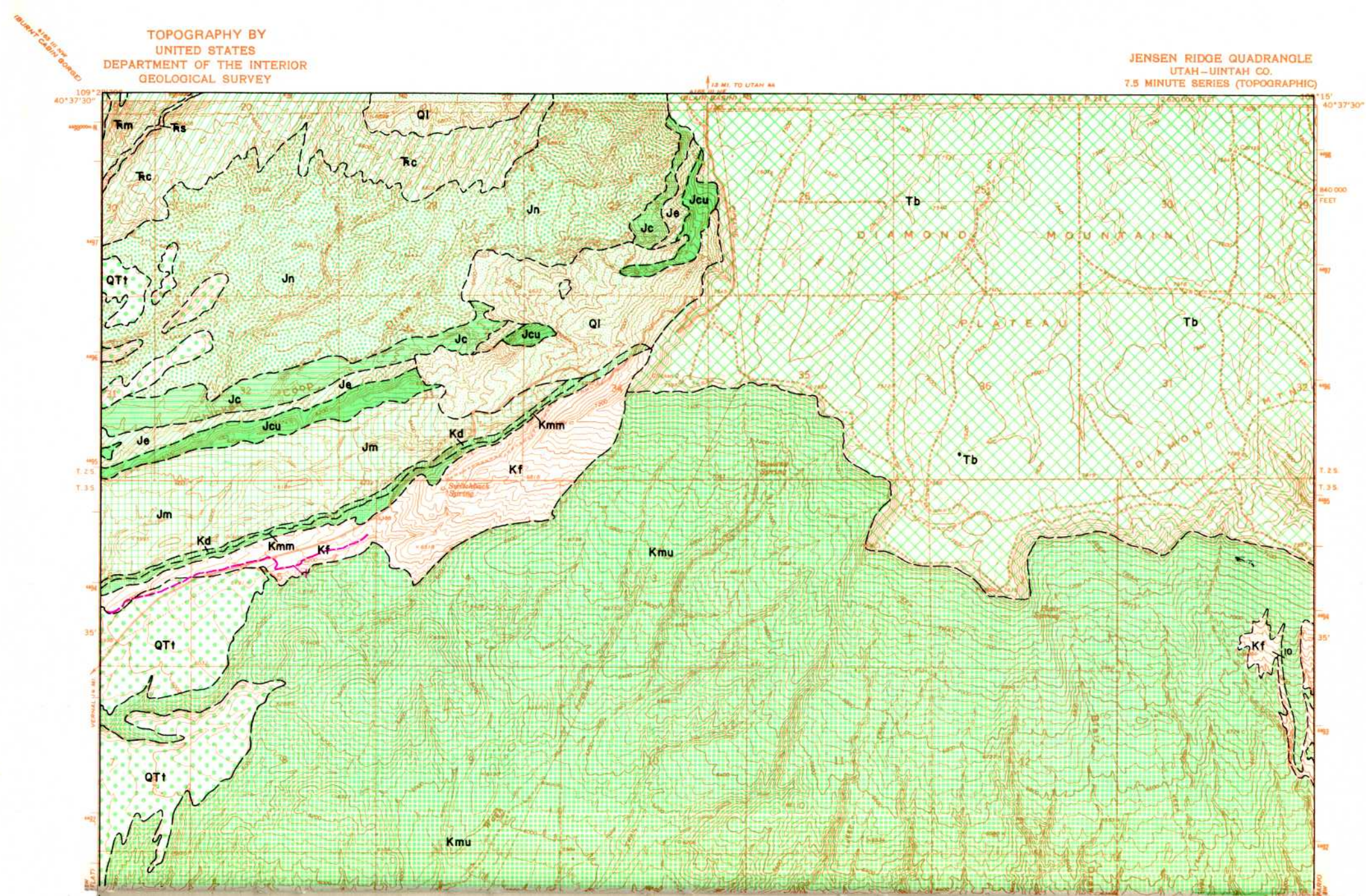
Four coal sections were measured on the Jensen Ridge quadrangle (figure 28). One two-foot section of boney coal was noted in the Steinaker area outcrops; farther east, near Switchback Spring, coal beds are absent. In the south Brush Creek area the coal seams are thin, thickening in a westerly direction, but no seams more than four feet thick were discovered. The best seam is at measurement 4 where there are 2.9 feet of coal, badly split by shale.

Subsurface Information

There has probably been no coal exploration on the quadrangle. No holes are believed to have been drilled. Depth to the formation increases rapidly behind the outcrops but the strata should level out at about a 2,000-foot depth. The Frontier was reached by oil drilling at depths of 2,160 and 1,580 feet in secs. 28 and 30, T. 3 S., R. 23 E.

Quality of Coal

No analyses are available for the Jensen Ridge quadrangle.



Utah Geological and Mineralogical Survey Monograph Series No. 2, 1972

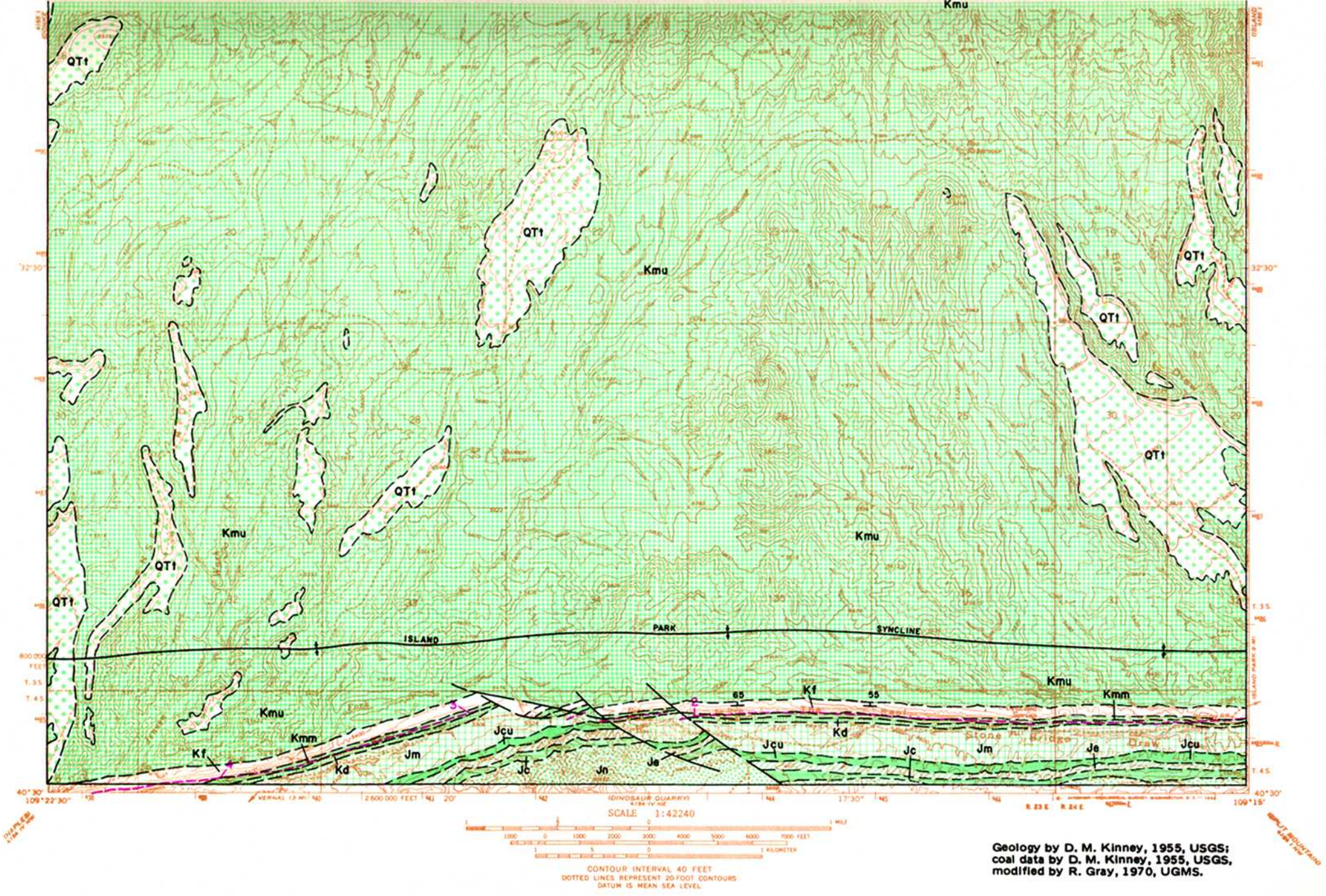


Figure 27. Coal and geology map, Jensen Ridge quadrangle (explanation pages 34-35).

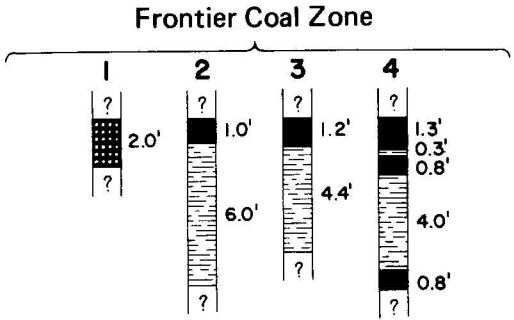


Figure 28. Coal sections of Jensen Ridge quadrangle (vertical scale: 1 inch = 8 feet).

Mines and Development

One small prospect was discovered on the quadrangle in the SE SE SE NW sec. 5, T. 4 S., R. 23 E., in the vicinity of measured coal section 4.

Reserves

Kinney (1955, p. 146) assigned 280,000 short tons of reserve to the quadrangle but notes the average coal bed thickness to be 1.9 feet to a depth of 1,000 feet. Since minimum thicknesses of four feet are considered in this report no reserves are assigned to the quadrangle.

PRINCIPAL WORK

The geologic mapping was performed by U. S. Geological Survey geologist D. M. Kinney (1951). Some of the coal data were supplied by him and the remainder was obtained in the field by R. L. Graham of the Utah Geological and Mineralogical Survey in connection with this study.

LAKE MOUNTAIN QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Lake Mountain quadrangle is located in the west part of the Vernal coal field along the south flank of the Uinta Mountains (figures 15 and 29). The coal outcrops, all in the Frontier Sandstone, lie in the south half of the map area in a narrow west-northwest trending strip. The south flank of the Uintas consists of a series of steeply dipping generally east-west trending ridges that have been cut intermittently by consequent streams or covered by high-level terrace or pediment gravels. The Frontier is one of the southernmost of these ridges. Subsequent valleys have formed in areas of softer rock and are filled with fluvial gravels. The altitude of the quadrangle ranges from about 6,350 feet above sea level in the southwest corner to more than 9,600 feet on Mosby Mountain to the northwest. The coal seams occur in altitudes between 6,600 and 7,000 feet. The coal deposits of the Lake Mountain quadrangle are a part of the Deep Creek area of the Vernal field. Well kept gravel and paved roads serve the area and connect with U. S. Highway 40 to the south.

STRATIGRAPHY

Mississippian to Quaternary rocks are exposed on the Lake Mountain quadrangle. In general the older rocks are exposed to the north and the younger rocks to the south. Pre-Jurassic rocks are Mississippian limestones, Pennsylvanian Morgan and Weber formations, Permian Park City Formation and Triassic Moenkopi, Shinarump and Chinle formations.

Above the Chinle is the Jurassic Navajo Sandstone exemplified by rugged cliffy canyons and rounded erosional forms along its east-west trending ridge. The yellow to tan, fine- to medium-grained aeolian sandstone is easily recognized by its cross-beds one to two miles north of the Frontier exposures. The Navajo in the quadrangle is about 1,000 feet thick.

Overlying the Navajo is the Carmel Formation. It is a unit of interbedded gray mudstone, yellow to reddish fine-grained sandstone with subordinate light gray and greenish gypsum and light gray limestone. The unit is about 375 feet thick, thinning slightly in an easterly direction. It is a soft unit and is usually found with a subsequent stream flowing along its strike forming a valley between the Navajo and Entrada.

The Entrada is a fine- to medium-grained light gray or orange massively bedded sandstone. The unit is about 230 feet thick but is generally poorly exposed. In the Lake Mountain quadrangle it is only slightly more resistant than the underlying Carmel.

The Curtis Formation is a greenish, glauconitic unit between the Entrada and Morrison formations. It can be divided roughly into two members, a lower glauconitic medium- to coarse-grained sandstone and an upper glauconitic shale with thin sandstone and limestone beds near the top. The unit is about 150 feet thick near Lake Mountain and its lower member is resistant enough to produce a strike ridge.

Above the Curtis is the Morrison Formation, a unit consisting of variegated (purplish, greenish and gray) mudstone and shale and gray fine-grained sandstone and beds of conglomeratic sandstone. Along Mosby Creek the formation is 892 feet thick but is poorly exposed. The beds are easily erodable, forming alluvium-filled strike valleys.

Unconformably overlying the Morrison is the Cretaceous Dakota Sandstone. The Dakota was measured by Kinney and others (1955, p. 96) southwest of Mosby Creek in SW¼ sec. 13, T. 3 S., R. 18 E. (unsurveyed):

Dakota Sandstone:	Feet
Sandstone, tan, medium-grained, cross-bedded	61
Sandstone, light gray, weathering tan to buff, medium- to coarse-grained, partly conglomeratic, cross-bedded, massive with pebbles of black chert	34
	95

The formation is medium resistant but is obscured by heavy vegetation. If the mapping is correct two thin coal seams separated by a thin shale unit were seen in the northwest quarter of sec. 19, T. 3 S., R. 19 E., SLM. The lateral extension of these seams has not been explored but is no doubt a local lens. A few thin lignitic seams have been reported in the Dakota in the Vernal field.

The Mowry Shale is a thin dark gray to brown fissile shale that has an easily distinguished outcrop beneath the coal-bearing Frontier Sandstone. The beds are thin and fissile and the weathered area is normally littered with light gray, silvery white or white platelets. The shale is siliceous and imprints of fish scales are common upon the platelets. The medium-resistant unit is about 120 feet thick in the Lake Mountain quadrangle.

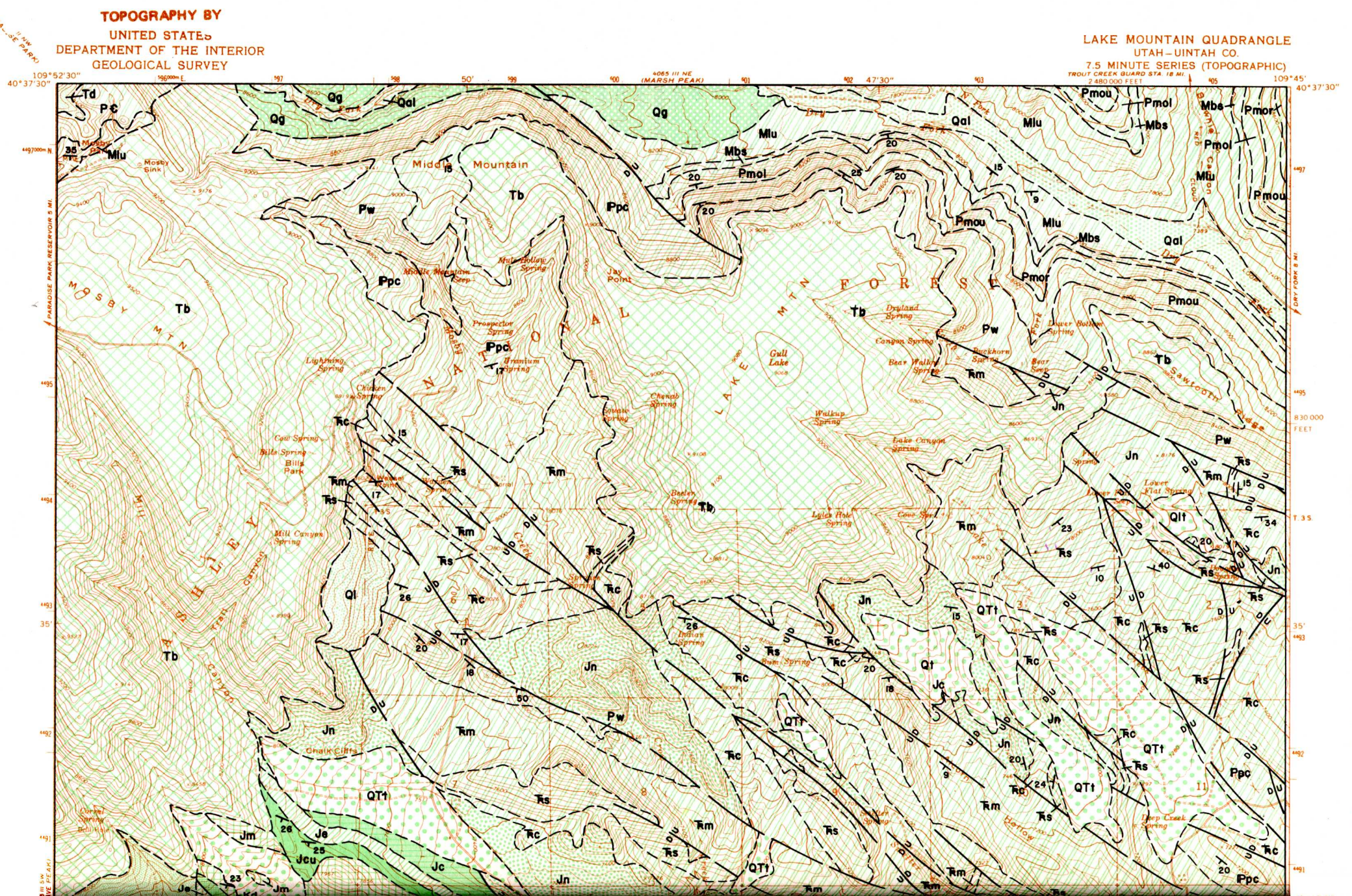
The Frontier Sandstone contains coal seams. The Lake Mountain area is high and close to the Uinta Mountains and therefore receives more rainfall resulting in heavy soil and vegetation cover of most exposures. The more resistant beds are easy to find but the nature of softer units is often lost. Hence coal data are limited to that from a few natural exposures and openings of mines. Basically the formation contains the two members recognized in all parts of the Vernal field: a lower shaley slope-forming unit 99 to 177 feet thick and an upper massive sandstone unit 94 to 108 feet thick. The coal occurs near the top of the upper member. This upper unit may be broken down into three subdivisions: a lower massive sandstone comprising 50 to 75 percent of the upper member, a coal zone and an upper, capping, massive sandstone.

Overlying the Frontier and immediately south of its exposures is the Mancos Shale, composed mainly of medium to dark gray shales of clay and silt with thin lenticular beds of sandstone. The outcrop pattern and lithology are rather uniform in the quadrangle; it is not known how much of the thick unit is exposed south of Lake Mountain. Near Vernal the Mancos Shale is about 5,000 feet thick. The Duchesne River Formation rests upon the Mancos with angular discordance on the Little Water Hills, exposing only part of the Mancos in front of the overlap.

The Tertiary Duchesne River is exposed along the south end of the quadrangle. According to G. E. and B. R. Untermann (1964b, p. 61), "The Duchesne River consists of interbedded red, brown, and varicolored clay shales, gray to buff red-weathering sandstones and some conglomerates of fluviatile origin, derived chiefly from the Uinta Mountain area. It has a maximum thickness of 1,500 feet."

The full thickness is not exposed in the quadrangle. Covering the top of Lake and Mosby mountains is the Browns Park Formation, a capping of conglomerate and sandstone. This caprock is partly cemented and poorly sorted and contains subordinate tuffs and bentonitic beds. The source of the gravel is the Uinta Mountains. The thickness of the Browns Park was not ascertained in the quadrangle but is probably around 600 feet.

The remaining units consist of unconsolidated materials of Quaternary age. The three mapped divisions are glacial debris, alluvium and terrace gravel.


TOPOGRAPHY BY
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
LAKE MOUNTAIN QUADRANGLE
UTAH–UINTAH CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
109°52'30"
40°37'30"
109°45'
40°37'30"
47'30"
50'
35'
4065 III NE
(MARSH PEAK)
TROUT CREEK GUARD STA. 18 MI.
2 480 000 FEET
830 000 FEET
PARADISE PARK RESERVOIR 5 MI.
DRY FORK 8 MI.
T. 3 S.
Middle Mountain
Mosby Sink
Mosby Mtn
Jay Point
Gull Lake
Lake Mtn
Sawtooth Ridge
Bills Park
Chalk Cliffs
Mill Canyon Spring
Lightning Spring
Chicken Spring
Cow Spring
Bills Spring
Prospector Spring
Uranium Spring
Mule Hollow Spring
Middle Mountain Seep
Chenab Spring
Squaw Spring
Beeler Spring
Lyles Hole Spring
Cove Spring
Indian Spring
Bum Spring
Walkup Spring
Lake Canyon Spring
Canyon Spring
Bear Wallow Spring
Buckhorn Spring
Bear Seep
Dryland Spring
Lower Bottom Spring
Flat Spring
Lower Flat Spring
Deep Creek Spring
Corral Spring
Bull Hole
Mill Canyon
Trail Canyon
Dry Fork
Lake Creek
Sawtooth Creek
Hollow
Pmou
Pmol
Mbs
Pmor
Mlu
Qal
Qg
Td
PЄ
Tb
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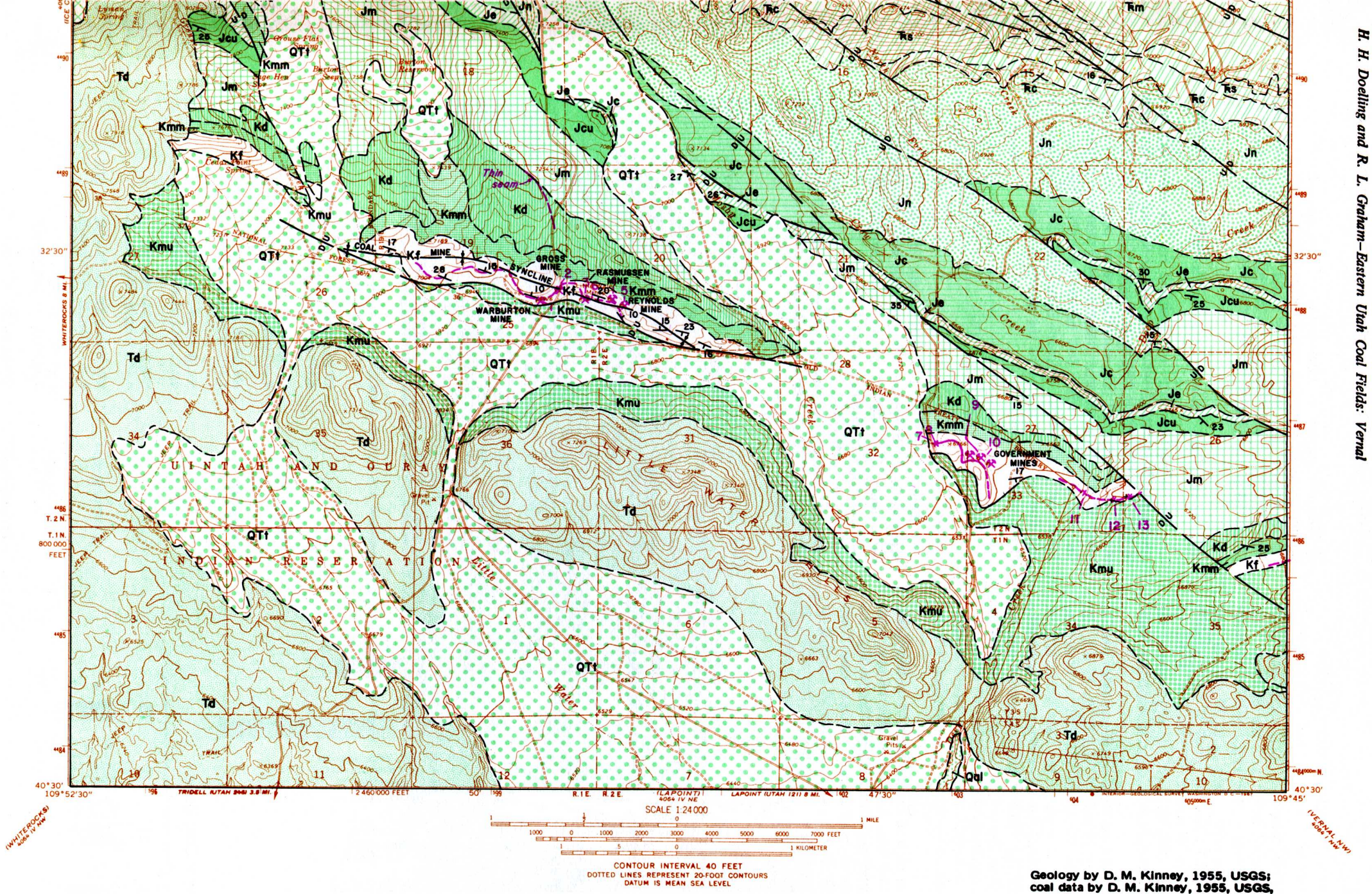


Figure 29. Coal and geology map, Lake Mountain quadrangle (explanation pages 34-35).

STRUCTURE

The strata of the Lake Mountain quadrangle are folded because of the Uinta Mountains uplift and the outcrops form east-west trending ridges and valleys. The major part of the uplift is to the north and dips are southerly ranging to 30 degrees. The folding has been accompanied by faulting which in a few cases is severe. Cutting most of the Mesozoic sequence is a set of northwest-trending faults, the drag of which has often altered the regional dip, in some cases reversing it or creating secondary folds.

One of these folds is the Coal Mine syncline situated parallel to the strike of the beds (secs. 19 and 20, T. 3 S., R. 19 E.). The axis is centered in the Frontier Sandstone and dips to 38 degrees are found on each flank. In a few places the beds are vertical. A fault parallels the folded Frontier on the south and presumably the rocks south of the fault dip in the regional manner. Along the other coal outcrops the beds dip 15 to 22 degrees southwest; depth to the coal increases rapidly in that direction.

PROPERTY CONTROL

Only a narrow ribbon of land on the Lake Mountain quadrangle can be considered coal land. Land along this 1½-mile wide strip is owned by the Uintah and Ouray Indian Reservation, the Bureau of Land Management and private interests (see Land Ownership map, figure 13). There has been no recent leasing or prospecting of the lands. One section of private land was classed as coal land by the Utah State Tax Commission on the quadrangle (sec. 31, T. 2 N., R. 2 E., USM).

COAL

Surface Information

Thirteen measured sections (figure 30) attest to the condition of coal in the Lake Mountain quadrangle. The thickness of coal ranges to 5 feet 7 inches thick, but there are numerous splits of bone or shale. Most of the sections were taken at mine portals because exposures of coal are usually badly weathered or covered by soil and vegetation. Coal section 1, for example, is at the Warburton mine, section 2 at the Gross mine, sections 3 and 6 at the Rasmussen mine and sections 4 and 5 at the Reynolds mine. Sections 7 to 10 were measured at the Government mines and 11, 12 and 13 at prospects.

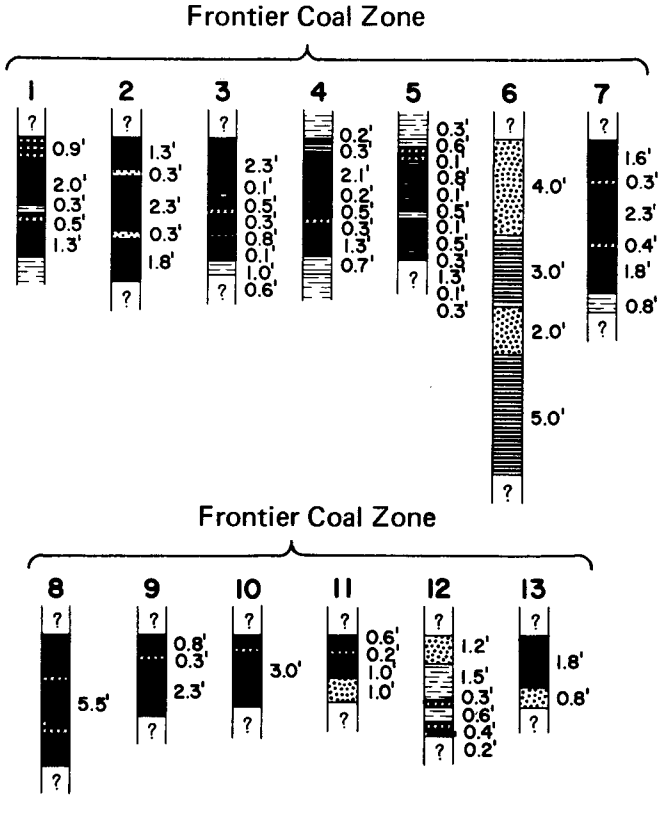


Figure 30. Coal sections of Lake Mountain quadrangle (vertical scale: 1 inch = 8 feet).

Subsurface Information

No subsurface data are available for the Lake Mountain quadrangle. It is not known if any drilling for coal was performed in the past. Subsurface data from inside the mines are difficult to obtain since most of the workings are in poor condition with caved adits and unventilated rooms. Judging from the regional dip, the coal should lie 1,000 feet below the surface no more than 3,000 feet south of the outcrops along level surfaces and the minable limit of 3,000 feet below the surface is about 1½ miles south of the outcrops.

Quality of Coal

Kinney (1955, p. 139) classed the Frontier Sandstone coal high-volatile C bituminous. Three samples were collected from the Gross mine, Rasmussen mine and the Reynolds mine. Calorific value on a dry basis ranges from 12,200 to 12,900 Btu/lb, sulfur content was nearly one percent except at the Gross mine where sulfur content was 2.6 percent. Ash content ranged between 8 and 11 percent. Coal analyses of individual mines or prospects are listed in table 6.

Mines and Development

At least eight mines and three prospects were opened on the Lake Mountain quadrangle in the early days to supply coal to the Indian Agency at Whiterocks and to local inhabitants. Because of adverse mining conditions all the mines were closed down by the early 1930's. Little is known of the extent of the workings. Kinney (1955, p. 147-148) reports that about 105,000 tons were mined from the area. Table 18 lists mines and their locations.

Table 18. Mines and prospects in the Lake Mountain quadrangle.

Mine	Location	Remarks
Government mines (Indian mines)	SE.SE.SE.NE.32–2N–2E USM 4,486,640m.N. 603,080m.E.	1919-1921
	NW.NW.SW.33–2N–2E USM 4,486,610m.N. 603,170m.E.	
	C.NW.SW.33–2N–2E USM 4,486,570m.N. 603,260m.E.	
	SW.SE.SE.NE.32–2N–2E USM 4,486,660m.N. 602,840m.E.	
Gross mine	NE.NE.SE.SE.19–3S–19E 4,488,010m.N. 599,470m.E.	Old
Prospects	NW.SE.SE.27–3S–19E 4,486,340m.N. 604,060m.E.	
	NE.SE.SE.27–3S–19E 4,486,280m.N. 604,310m.E.	
	NW.SW.SW.26–3S–19E 4,486,310m.N. 604,450m.E.	
Rasmussen mine	NW.NW.SW.SW.20–3S–19E 4,487,915m.N. 599,685m.E.	1921
Reynolds mine	C.SW.20–3S–19E 4,487,925m.N. 599,920m.E.	1906-1947
Reynolds mine	NW.SE.SW.20–3S–19E 4,487,875m.N. 600,040m.E.	
Warburton mine	NW.NW.SE.SE.19–3S–19E 4,487,905m.N. 599,310m.E.	1946-1950

Reserves

Kinney (1955, p. 146-148) estimated the reserves for the Vernal coal field. Modification of his data to fit the quadrangle area assigns the following reserves to the quadrangle (table 19).

Table 19. Coal reserves of the Lake Mountain quadrangle (in short tons).

Frontier coal zone	Coal more than four feet thick
Depth to coal	Class II
0-1000 feet	8,030,000
1000-2000 feet	5,520,000
2000-3000 feet	–
Total	13,550,000

Frontier coal zone	Coal less than four feet thick
Depth to coal	Class II
0-1000 feet	2,380,000
1000-2000 feet	4,230,000
2000-3000 feet	2,740,000
Total	9,350,000
Grand Total	22,900,000

Additional data prompted re-evaluation of the reserve data for this report. Since all areas designated for coal reserves calculation fell within 1½ miles of a control point, all reserves fall in the Class II category (table 20). Seams four feet or more thick were the only reserves considered.

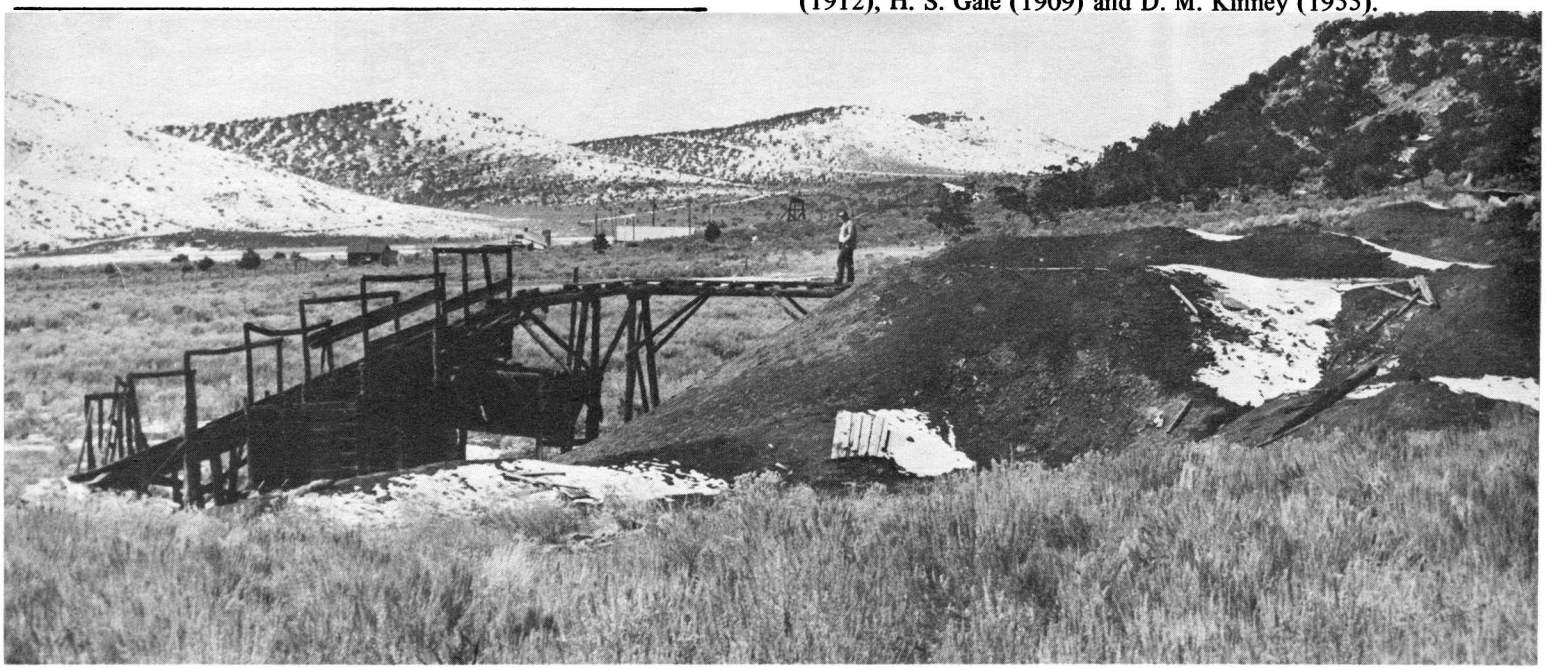
Table 20. Revised coal reserves of the Frontier coal zone, Lake Mountain quadrangle.

Depth to coal	Tons
0-1000 feet	8,269,888
1000-2000 feet	5,564,366
2000-3000 feet	11,518,940
Total	25,353,194
(Minable coal will be between 33 and 50 percent of the amounts)	

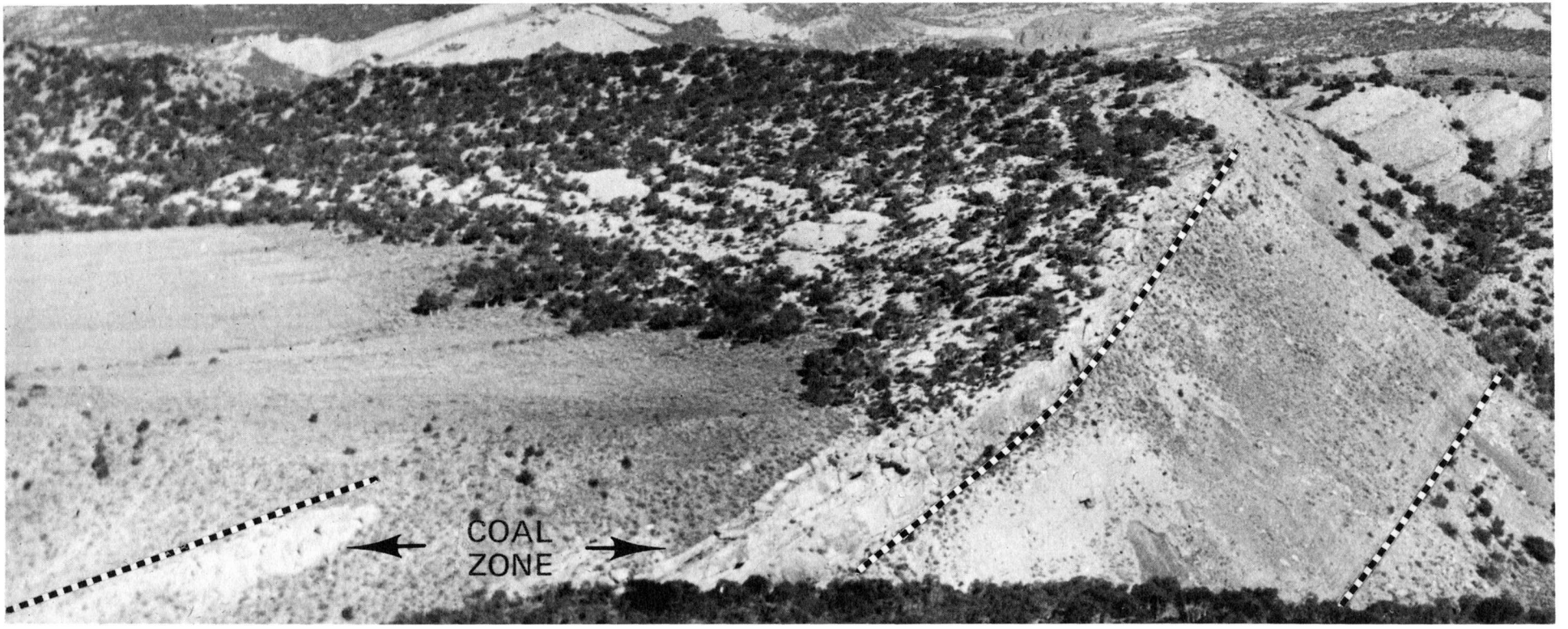
The two reserve figures are very close. The major difference falls in the area of 2,000 to 3,000 feet of cover. About 12 percent of the quadrangle can be classed as coal land.

PRINCIPAL WORK

Most of the geologic mapping and gathering of data was performed by U. S. Geological Survey geologists C. T. Lupton (1912), H. S. Gale (1909) and D. M. Kinney (1955).



Abandoned slack dumps and loading facilities, Rasmussen mine, Deep Creek area.



Hogback of Frontier Sandstone, Brush Creek Canyon. Dashed lines represent lower contact, contact between lower shaley member and upper sandstone member, and the upper contact. The arrows indicate approximate position of coal zone in upper sandstone member.

NAPLES QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

Naples is located three miles southeast of Vernal (figures 15 and 31). U. S. Highway 40 crosses the south part of the quadrangle and provides access to Vernal and Naples and points east. Secondary roads join with Naples and Vernal and provide good access to most parts of the quadrangle.

Most of the quadrangle consists of flat or hilly country; only along the east edge of the map does rugged, mountainous country occur, where the nose of Split Mountain is dissected by Brush Creek Canyon. Ashley Creek flows diagonally across the map, northwest to southeast, and is the principal drainage. The lands on the southwest side of Ashley Creek and along Brush Creek are extensively farmed. The coal outcrops, around the nose of Split Mountain, occur between 4,900 and 5,400 feet above sea level. Elevations on the quadrangle range between 4,800 feet along Ashley Creek to a bit more than 5,500 feet on the nose of Split Mountain.

STRATIGRAPHY

Consolidated units consist of Jurassic and Cretaceous rocks. The oldest unit is the Morrison Formation; its outcrops are located on the nose of the anticlinal mountain along the east edge of the quadrangle. The Morrison consists of variegated mudstone and shale, fine-grained sandstone and thin lenticular beds of conglomeratic sandstone. The outcrops form rounded domes and badland slopes of massive lavender shales. The Morrison is more than 900 feet thick six miles north of the quadrangle, 750 feet thick 10 miles to the east at Island Park, and 860 feet thick at the Dinosaur Quarry, three or four miles to the east on the south side of Split Mountain.

The Cretaceous units include the Dakota, Mowry, Frontier and Mancos formations. All crop out around the Split Mountain nose except the Mancos Shale.

The Dakota Sandstone overlies the Morrison unconformably and consists of gray-white and yellow-gray, fine- to coarse-grained sandstone interbedded with gray, green and maroon shales. Most of the shale occurs near the middle of the unit. The Dakota is medium resistant and usually forms a hogback or cuesta. The Dakota is 50 feet thick north of the quadrangle and 100 feet thick at the Dinosaur Quarry to the east.

The siliceous gray-white outcrop of the Mowry is easily recognized between the Dakota and Frontier. It is a dark gray to brown thin-bedded fissile shale that normally forms a slope. The shale weathers into thin chips and plates that take on a lighter color upon weathering. Fish scales are commonly found on the chips and plates. The marine unit is 31 feet thick on Little Brush Creek a few miles north and 95 feet thick in Orchard Draw a few miles east.

The Frontier Sandstone apparently unconformably overlies the Mowry Shale. The Frontier is coal bearing, and several mines have been opened on its outcrops near Brush Creek. A section measured in the northeast corner of the quadrangle typifies the Frontier of the Brush Creek area.

BRUSH CREEK SECTION
SE ¼ 6-4S-23E SLM

Mancos Shale: gray-brown, yellow-gray weathering shale with occasional brownish, thin-bedded, fine-grained sandstone beds in lower 50 feet.

Frontier Sandstone:	Feet
1. Sandstone, gray to tan, fine- to medium-grained, massive, ledge former, weathers to light tan and yellow, contains "cannonball" concretions up to 15 feet in diameter	50.4
2. Shale, gray with thin interbeds of sandstone, slope forming, weathers white to gray	17.3
3. Sandstone, gray to light tan, fine-grained, medium-bedded, with thin interbeds of gray shale, ledge former, weathers gray to tan with limonitic staining	10.7
4. Shale, carbonaceous	1.0
5. Shale, gray	3.5
6. Shale, carbonaceous	3.5
7. Coal, contains 1-inch shale split 1.7 ft. from base	2.3
8. Coal, lignitic	2.0
9. Coal	2.5
10. Coal, lignitic, brown	2.3
11. Sandstone, tan, medium-grained, with thin streaks of coaley shale	4.5
12. Shale, carbonaceous	1.5
13. Coal	1.0
14. Shale, carbonaceous, dark gray, with black flecks of coal	2.3
15. Sandstone, peppery gray to tan, medium-grained, massive, ledge former, weathers to shades of tan	12.0
16. Sandstone, tan, medium-grained, thick-bedded, weathers shaley	13.9
17. Sandstone, gray to tan, fine-grained, well sorted, thick-bedded, slope former, weathers shaley	13.2
18. Claystone, gray to light tan, massive, slope former	111.8
Total	255.7

Mowry Shale: medium to dark gray, thin-bedded uniform, forms semi-resistant slope, weathers to blue-white to gray-white thin plates.

The two lower units form a uniform slope and are so distinguished from the upper units. The upper part of the Frontier consists essentially of two resistant sandstone units divided by a coal zone.

The Mancos Shale overlies the Frontier Sandstone and its outcrops cover most of the map area. The Mancos is a gray to brown, yellow-gray weathering shale containing occasional interbeds of fine-grained tan and brown sandstone. Small calcareous concretions, some septarian, occur at random levels in the 4,900-foot unit. The outcrops are sparsely vegetated and are weathered into badlands. In many places the unit is covered by a veneer of unconsolidated gravels, sands and silts; in these areas vegetation is more profuse.

Land along the alluvial floodplains of Ashley and Brush creeks is under cultivation. The alluvium consists of sand, silt, clay and conglomerate deposited during the flood stages of the streams.

STRUCTURE

The significant structure of the quadrangle is the west-plunging nose of Split Mountain, an anticlinal feature. It is not a simple nose but contains a medial sag. The north side of Split Mountain is bounded by the Island Park syncline and the first anticlinal projection is marked by the Bullwinkle anticline. The Bullwinkle syncline follows as does the major Split Mountain anticline. The south flank is bounded by the Daniels Draw syncline. Dips on the west end of the nose are moderate (to 20 degrees). No faulting of consequence was discovered in the quadrangle.

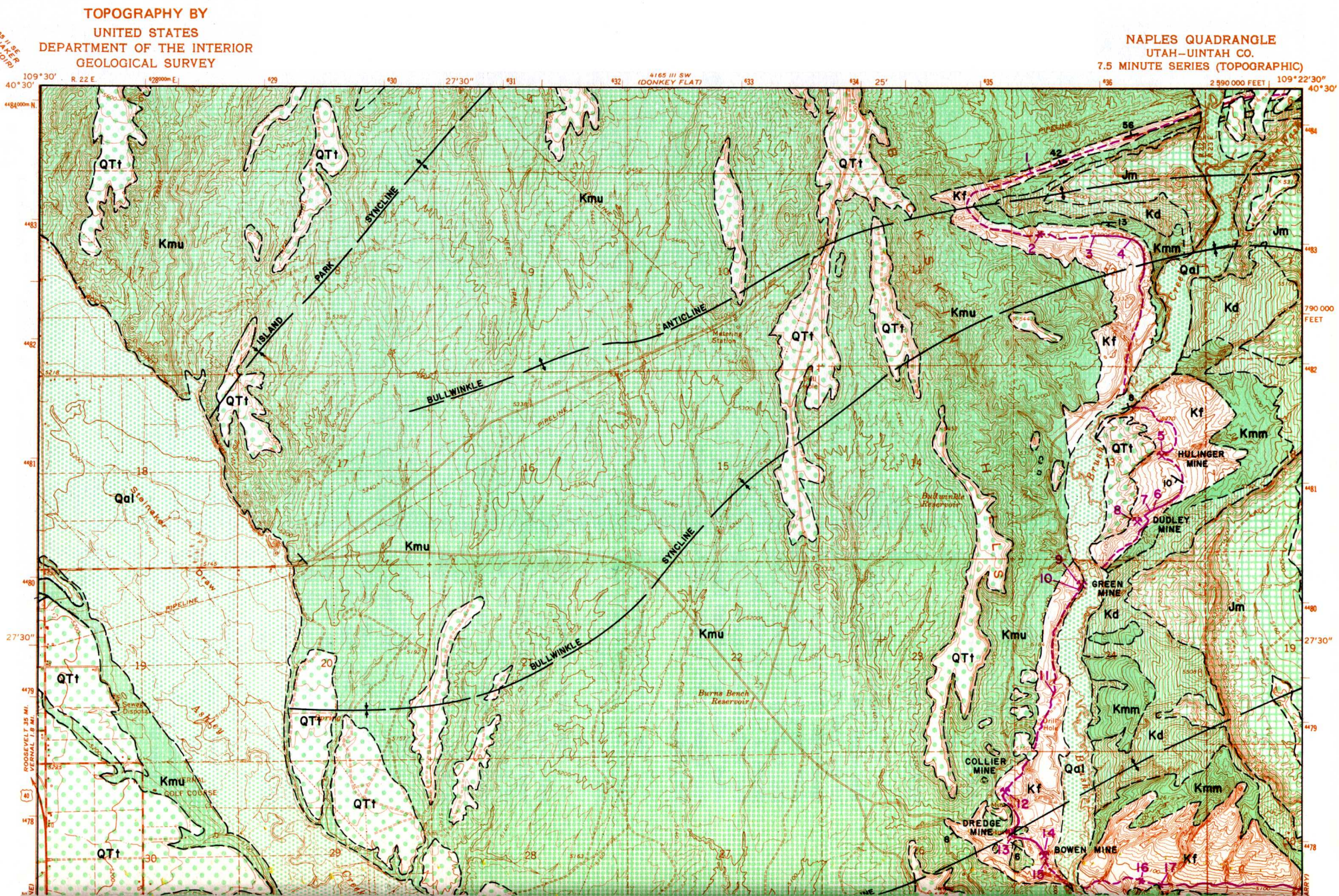
PROPERTY CONTROL

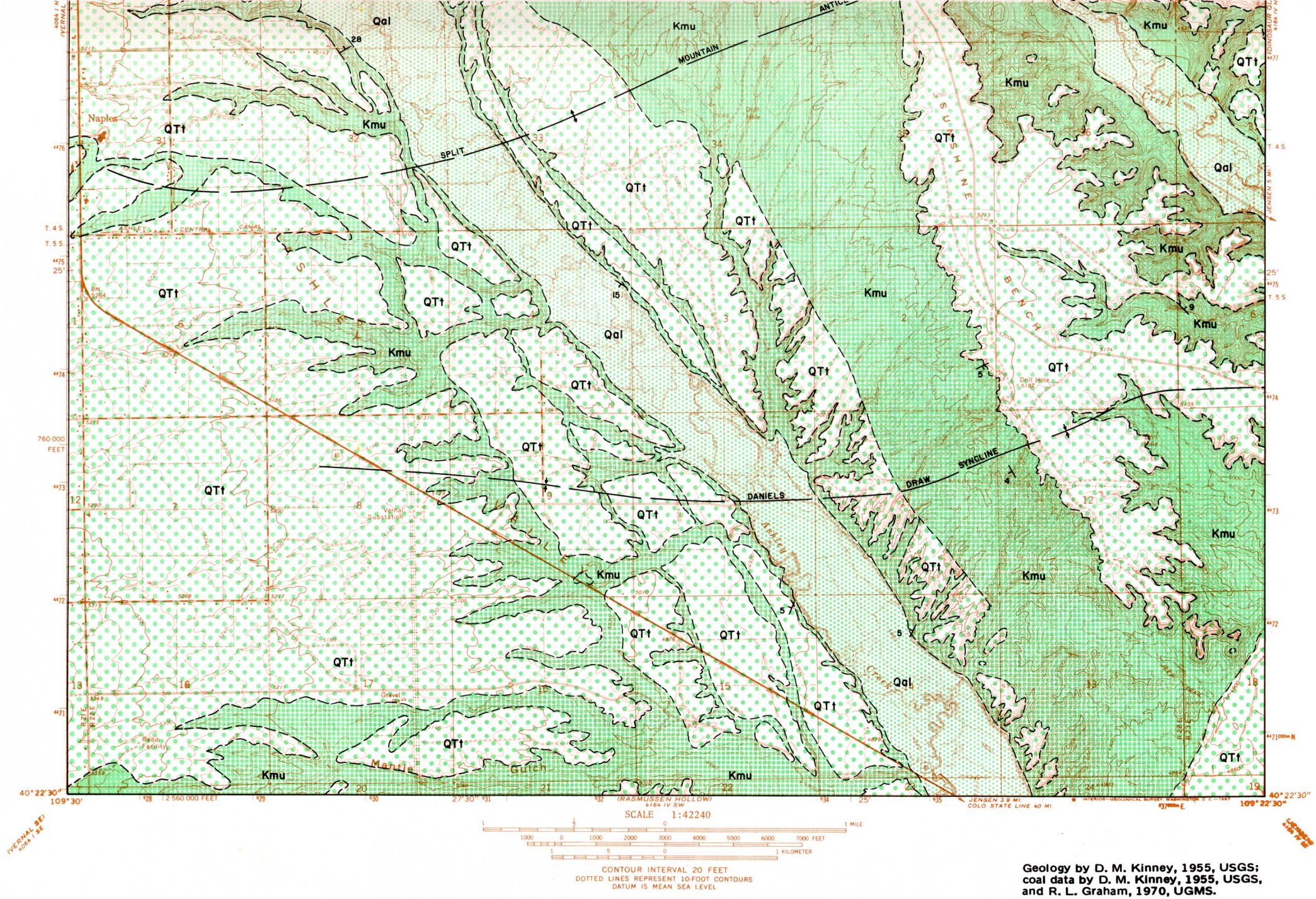
All of the land southwest of Ashley Creek and along Ashley and Brush creeks is privately owned. The remainder of the land is under the jurisdiction of the state of Utah and Bureau of Land Management. Land in the vicinity of the Frontier coal outcrops are all controlled by the Bureau of Land Management except some small areas of private land. These parcels of private land are assessed as coal lands by the state of Utah. None of the federal lands are leased or permitted for coal.

COAL

Surface Information

Seventeen measured sections (figure 32) attest to the condition of the coal in the Naples quadrangle. Thicknesses of indi-


TOPOGRAPHY BY
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
NAPLES QUADRANGLE
UTAH–UINTAH CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
4165 III SW
(DONKEY FLAT)
109°30'
40°30'
109°22'30"
40°30'
27'30"
25'
2 590 000 FEET
790 000 FEET
ISLAND PARK SYNCLINE
BULLWINKLE ANTICLINE
BULLWINKLE SYNCLINE
PIPELINE
Metering Station
Bullwinkle Reservoir
Burns Bench Reservoir
Steinaker Draw
Ashley
Sewage Disposal
GOLF COURSE
HULINGER MINE
DUDLEY MINE
GREEN MINE
COLLIER MINE
DREDGE MINE
BOWEN MINE
Drill Hole
Brush Creek
QTt
Kmu
Kf
Kd
Kmm
Jm
Qal
ROOSEVELT 35 MI.
VERNAL 1.8 MI.



Geology by D. M. Kinney, 1955, USGS;
coal data by D. M. Kinney, 1955, USGS,
and R. L. Graham, 1970, UGMS.

Figure 31. Coal and geology map, Naples quadrangle (explanation pages 34-35).

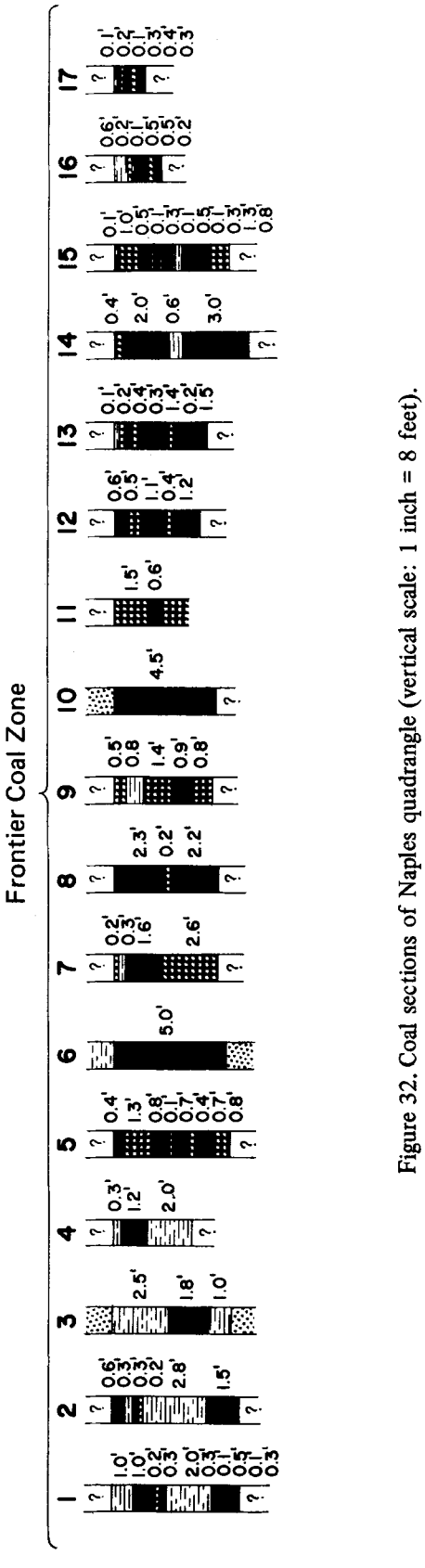


Figure 32. Coal sections of Naples quadrangle (vertical scale: 1 inch = 8 feet).

vidual seams range to five feet; most are split with bone coal. Roofs of seams were not determined in many cases since many measurements are from older published sources from mines whose entries are now collapsed. It is assumed that most roofs are shale or soft shaley sandstone. On the north and south flank of Split Mountain most of the coal is thin and noncommercial.

Subsurface Information

As far as is known no drilling for coal in the Naples quadrangle has been done. The nose of the Split Mountain anticline persists under the Mancos Shale west of Brush Creek. The 1,000-foot depth to the top of the Frontier is 1½ to 2 miles west of the outcrops; coal depths of more than 3,000 feet probably are not attained except along the synclinal axes.

Quality of Coal

Four coal analyses show that moisture content is nearly uniform, from 7.2 to 8.8 percent. Sulfur (dry basis) varies from 1.34 to 2.6 percent. The calorific value (dry coal) averages 12,220 Btu/lb. Coal analyses of individual mines or prospects are listed in table 6.

Mines and Development

Several mines and prospects were operated prior to 1930 in the Brush Creek area. Gale (1910, p. 212-213) reports on two of the mines:

> The Bowen mine presents what is probably the best showing of the lower Mancos coal (Frontier) in the eastern part of the Vernal field. . .The roof consists of 6 feet of bluish to brownish gray shale overlain by massive sandstone 8 feet thick. The coal itself measures approximately 5½ feet in thickness, and owing to its badly weathered condition near the mouth of the old entry it was not possible to distinguish the precise limits of the various benches. A well defined seam of hard white to brownish clay, 2 inches thick, occurs underneath the top 2 feet 8 inches of coal. Mr. John O. Evans, who had worked in the mine states that it was opened sixteen years ago (1891). . . The depth of the entry is reported to be 175 feet.

> A coal bank known as the Eph. Green mine, situated at the northern edge of section 24, near Brush Creek has been worked to a small extent. . . The coal is said to have contained too much dirt to be worked to advantage. Coal exposed near the Brush Creek road just north of this locality is apparently boney and of doubtful value.

No descriptions of the remaining mines are available. Kinney (1955) estimates that about 40,000 tons of coal have been mined from the area. Their names and locations are listed in table 21.

Table 21. Mines and prospects, Naples quadrangle.

Mine	Location	Remarks
Bowen mine	NW.NE.NW.SW.25–4S–22E 4,477,840m.N. 635,650m.E.	1891-1921
Collier mine	NE.NE.NE.SE.NE.26–4S–22E 4,478,240m.N. 635,370m.E.	1921
Dredge mine (Burton)	NE.NE.SE.SE.NE.26–5S–22E 4,478,030m.N. 635,390m.E.	
Dudley mine (Henry)	NE.SW.SE.13–4S–22E 4,480,660m.N. 636,400m.E.	
Green mine	SW.NE.NW.24–4S–22E 4,480,100m.N. 635,900m.E.	Old
Hulinger mine	SW.SW.SE.NE.13–4S–22E 4,481,200m.N. 636,630m.E.	
Prospect	NE.NW.SW.24–4S–22E 4,479,200m.N. 635,600m.E.	

Reserves

Kinney (1955, p. 146) lists the following reserves:

Table 22. Coal reserves of the Naples quadrangle (in short tons).

Frontier Coal Zone	Tons
0-1000 feet	13,950,000
1000-2000 feet	9,420,000
2000-3000 feet	670,000
	24,040,000

Coal reserves in seams four feet or more thick are estimated to be 540,000 tons, all at a depth of less than 1,000 feet.

The Utah Geological and Mineralogical Survey estimated the reserves in table 23.

The reasons for increasing the reserve of four-foot or better coal are: (1) depth to the coal remains shallow (less than 3,000 feet) for 5 or 6 miles west of the outcrops along the nose of the Split Mountain anticline and (2) coal in the Frontier Formation improves westward.

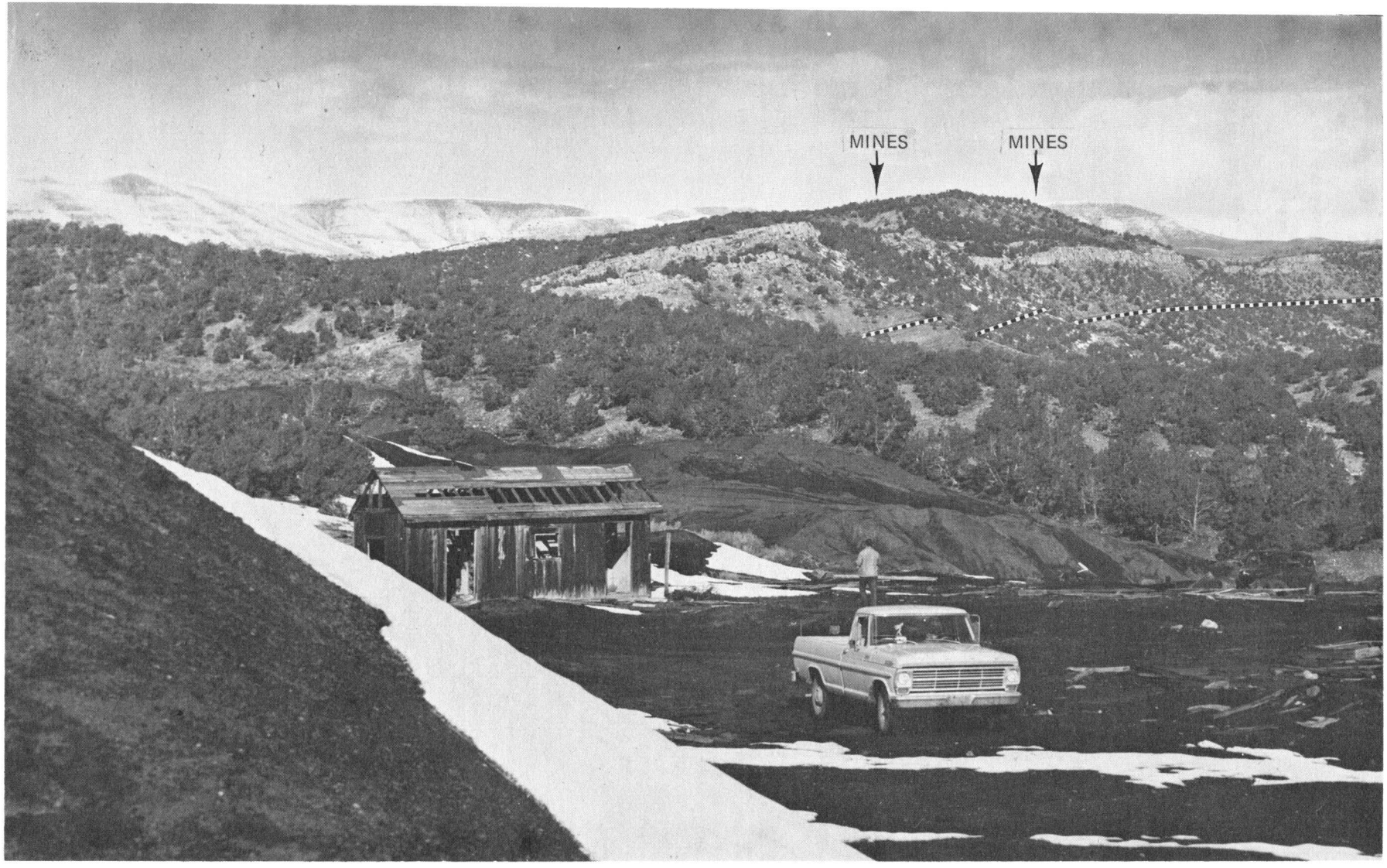
Table 23. Revised coal reserves of the Naples quadrangle (in short tons).

Frontier Coal Zone	Class II	Class III	Total
0-1000 feet	5,204,120	9,504,390	14,708,510
1000-2000 feet	–	15,563,725	15,563,725
2000-3000 feet	–	5,187,888	5,187,888
Total	5,204,120	30,256,003	35,460,123

Minable coal will be between 33 to 50 percent of the above amounts

PRINCIPAL WORK

The geologic map and much of the coal data were published by the U. S. Geological Survey (Kinney, 1955 and Gale, 1910). Additional data were collected by R. L. Graham of the Utah Geological and Mineralogical Survey.



Coal dumps at the abandoned Wardle mine, Steinaker area. Dashed line is the base of the Frontier Sandstone. Coal outcrops occur immediately above the cliff-forming sandstone bed.

RASMUSSEN HOLLOW QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Rasmussen Hollow quadrangle is located in the south central part of the Vernal coal field (figures 15 and 33). Ashley Valley lies in the northeast third of the quadrangle and consists of flat to hilly and gullied badlands. Asphalt Ridge cuts diagonally across the map area northwest to southeast. Its deeply gullied dip slope forms rough terrain to the southwest. The Green River, in early maturity, meanders diagonally across the quadrangle roughly at right angles to Asphalt Ridge.

Elevations range from 4,700 feet above sea level along the Green River to about 5,500 feet on the northwest part of Asphalt Ridge. The coal-bearing beds lie between 5,000 and 5,300 feet. The towns of Vernal and Naples are about 10 miles north of the quadrangle; U. S. Highway 40 runs just inside the northeast corner of the map. Various good gravel roads lead to Asphalt Ridge from Naples and U. S. Highway 40.

STRATIGRAPHY

Only three consolidated units occur in the quadrangle. These are the Cretaceous Mancos Shale and Mesaverde Formation and the Tertiary Duchesne River Formation. Quaternary alluvium covers the Green River floodplain and Quaternary-Tertiary gravels occur in scattered patches, usually at high levels.

The Mancos Shale crops out in Ashley Valley and is thick marine, medium to dark gray, massive clay or silt-shale with thin beds of brownish sandy limestone or calcareous sandstone. The entire unit is nearly 5,000 feet thick.

The Mancos is overlain by the Mesaverde Formation which consists of two members. Both are poorly exposed and relationships are obscure. The lower Rim Rock Member occurs on both sides of the Green River but lacks the resistance which forms the ridge east of the Rasmussen Hollow quadrangle. The unit consists of fine- to coarse-grained massive sandstone beds, light gray to brown and tan in color, interbedded with thin shaley units and perhaps lignite and bituminous coal. The lower massive sandstone bed, the Asphalt Ridge Member of the Mesaverde of some writers, is about 68 feet thick. The remainder of the Rim Rock measures 300 feet. More pronounced on the east side of the river is the upper Mesaverde. As much as 600 feet may be exposed on the east bank of the Green River, but only 100 to 150 feet are exposed on the west bank. The sands of the Rim Rock are duplicated in the upper member but the percentage of shale is much higher. The coal east of Rasmussen Hollow is mainly in the upper Mesaverde. The exact stratigraphic position of the coal on the west side of the river is unknown.

Unconformably overlapping the Cretaceous sediments is the Tertiary Duchesne River Formation. It is exposed on Asphalt Ridge and by its dip slope. The thickness of this unit reaches a maximum of 1,500 feet in Uintah County and consists of fluvial gray to tan sandstone and conglomerate interbedded by red and brown shales. The entire unit weathers to a reddish color.

STRUCTURE

Beds between the Section Ridge anticline along the north margin of the quadrangle and the Walker syncline south of Asphalt Ridge dip gently to moderately southward (figure 33). Mesaverde beds dip to 30 degrees and average 20 to 25 degrees. Faults with moderate displacements occur along Asphalt Ridge near the Green River gap. Dips south of the Walker syncline are gentle.

PROPERTY CONTROL

Most of the Green River floodplain is privately owned. Most of Asphalt Ridge west of the Green River is Utah state land, and most lands on the south and east bank are controlled by the Bureau of Land Management. None of this land is currently leased or permitted for coal.

COAL

Surface Information

The coal beds of the Mesaverde Formation are lenticular and difficult to trace on the quadrangle. Coal beds were reported on the east bank of the river (not shown) by Gale (1910, p. 210). The best beds are located in sec. 31, T. 5 S., R. 22 E. Three coal measurements from this section show the seam ranging from 3.4 to 5 feet in thickness (figure 34).

Subsurface Information

No drilling for coal in the quadrangle is known to have taken place. Depth to the coal increases 400 feet each 1,000 feet south of the outcrop.

Quality of Coal

An analysis from a four-foot seam shows that on an as-received basis the moisture content was 12.5 percent. Dried coal yielded 8,110 Btu/lb and contained 1.16 percent sulfur (table 6).

Mines and Development

Only one mine has been developed on the quadrangle (table 24). Gale (1910, p. 211-212) reports:

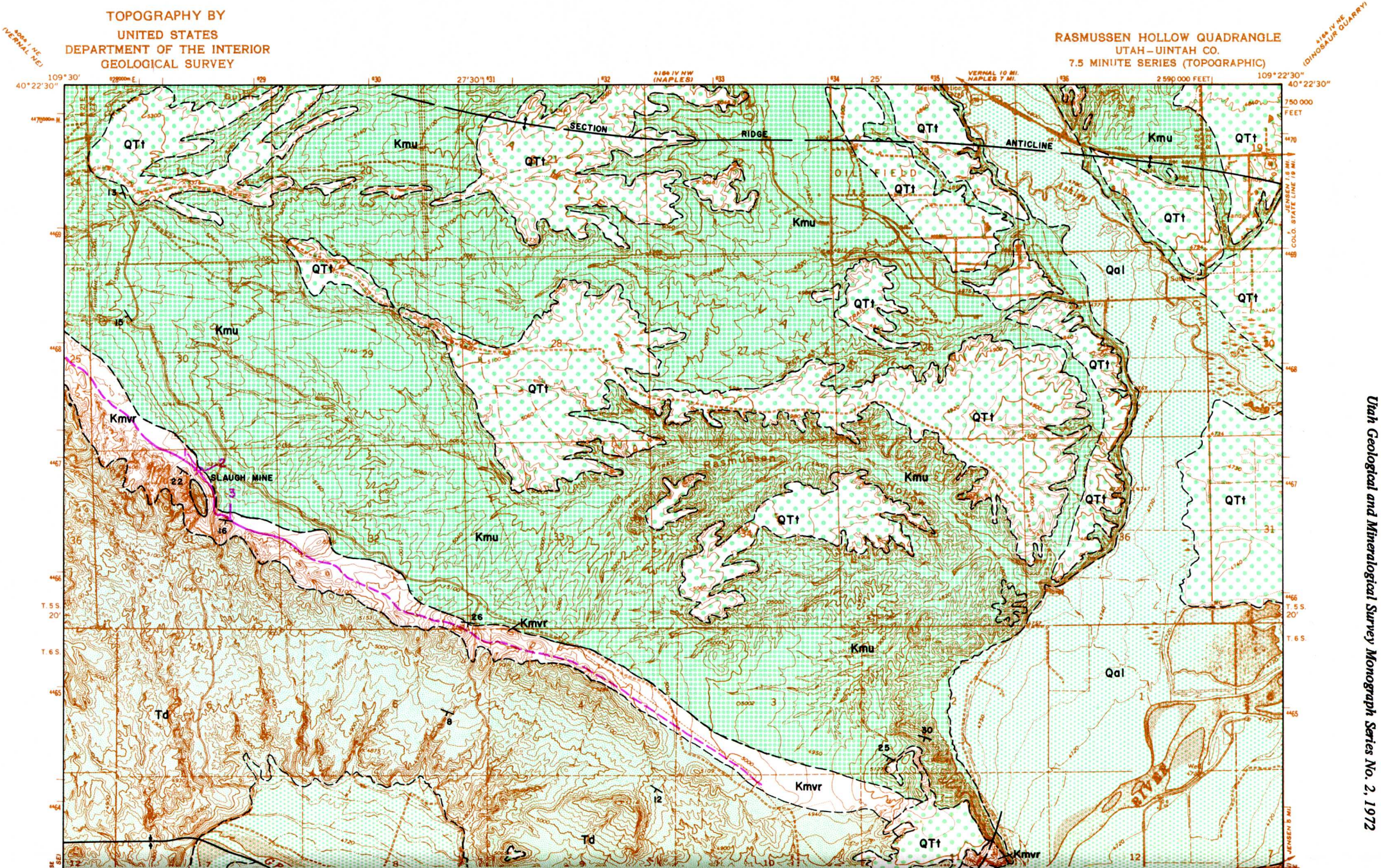
> . . .coal has been mined from these rocks in section 31. This old mine is reported to have been opened by Mr. George A. Slaugh and others of the town of Vernal about fourteen years ago and has been worked at intervals until about 1904. At the depth then reached the bed is said to have broken off abruptly, probably owing to a local fault or slump. The mine is on the northeast side of an isolated hill on the west side of the valley. A slope for mining was driven down the dip a distance of 100 feet or more under a good sandstone roof. The old entry had caved much at the time of visit and did not appear to be in a safe condition. The coal exposed near the entrance was 3 feet 5 inches thick, but the whole bed is reported to have been about 5 feet as worked. The coal has a strong smell of asphaltum or oil, and as it occurs just below the outcrops of the asphaltum deposits that material has very likely saturated the coal as it has much of the neighboring rock. The coal is said to have caked somewhat when burned, spreading over the grates and forming a heavy clinker, a property possibly due to the asphaltum it contains. It is also reported to slack rapidly–within a month after being taken from the mine if left in the open air. The strike of the beds at the mine is N. 42° W. and dip 22° W.

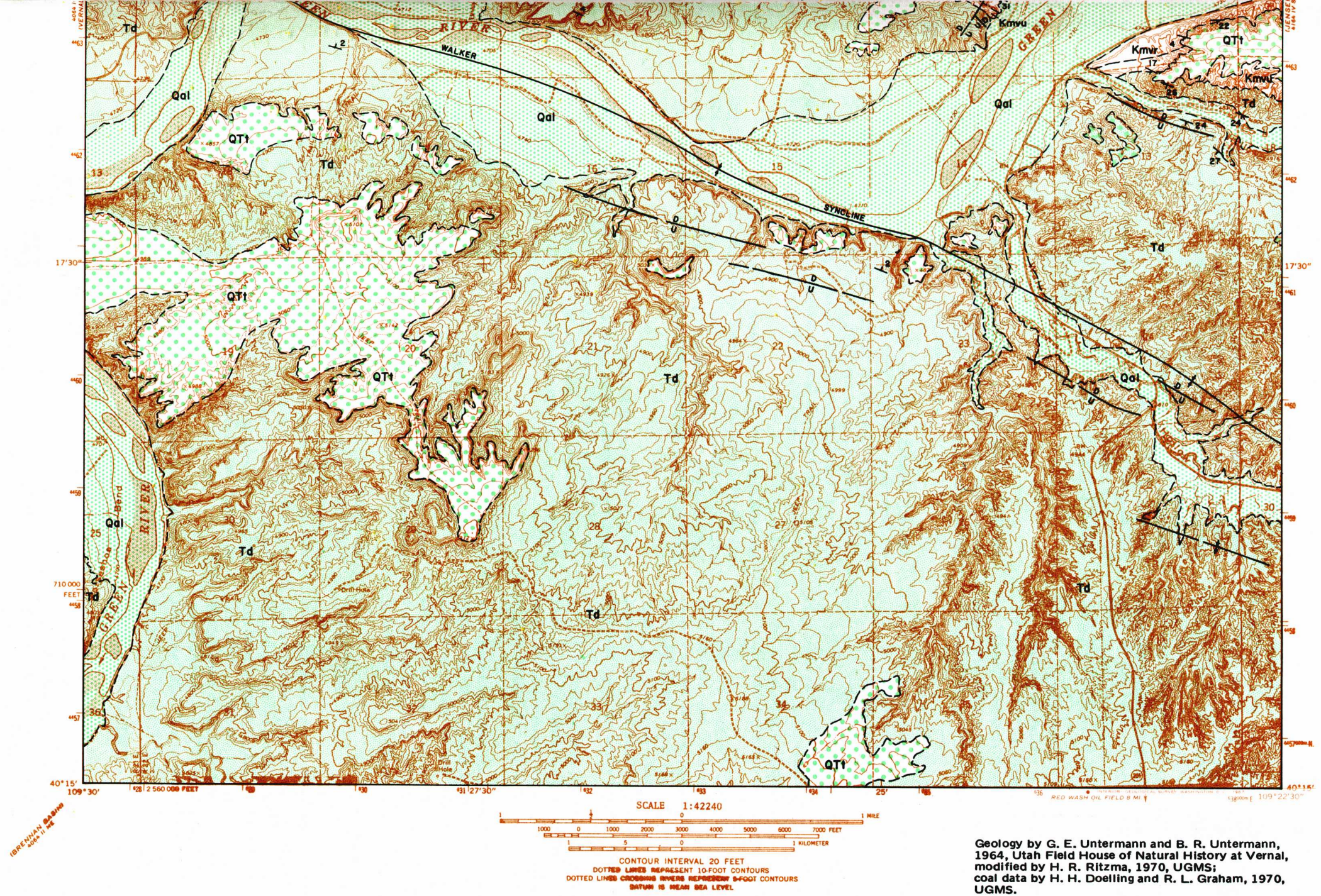
Table 24. Mine in the Rasmussen Hollow quadrangle.

Mine	Location	Remarks
Slaugh mine	NW.NW.NE.31–5S–22E 4,466,950m.N. 628,550m.E.	1893–1904

Reserves

No reserves were assigned the quadrangle by previous workers. Certainly the coal is too lenticular and unreliable in the Mesaverde to expect large quantities of coal to be present. The coal near section 31 is present in thick enough seams to produce 1,568,000 short tons of Class II reserve and 3,136,000 short tons of Class III reserve.


TOPOGRAPHY BY
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
RASMUSSEN HOLLOW QUADRANGLE
UTAH–UINTAH CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
SECTION
RIDGE
ANTICLINE
OIL FIELD
SLAUGH MINE
Rasmussen
Hollow
QTt
Kmu
Kmvr
Qal
Td
T. 5 S.
T. 6 S.
109°30'
40°22'30"
109°22'30"
40°22'30"
27'30"
25'
2 590 000 FEET
750 000 FEET
VERNAL 10 MI.
NAPLES 7 MI.
4164 IV NW
(NAPLES)
4164 IV NE
(DINOSAUR QUARRY)
4064 I NE
(VERNAL NE)
JENSEN 1.6 MI.
COLO. STATE LINE 19 MI.
JENSEN 5 MI.



Geology by G. E. Untermann and B. R. Untermann, 1964, Utah Field House of Natural History at Vernal, modified by H. R. Ritzma, 1970, UGMS; coal data by H. H. Doelling and R. L. Graham, 1970, UGMS.

Figure 33. Coal and geology map, Rasmussen Hollow quadrangle (explanation pages 34-35).

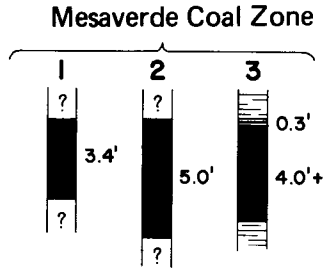


Figure 34. Coal sections of Rasmussen Hollow quadrangle (vertical scale: 1 inch = 8 feet).

PRINCIPAL WORK

The geologic map (figure 33) was enlarged from a small-scale geologic map of Uintah County by G. E. and B. R. Untermann, (1964a) Utah Field House of Natural History geologists. Some changes and refinements, mostly of the geology in and around the Mesaverde outcrops, were supplied by H. R. Ritzma, Utah Geological and Mineralogical Survey. Coal data of Gale (1910) were supplemented by H. H. Doelling and R. L. Graham, UGMS, in this study.

SNAKE JOHN REEF QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Snake John Reef quadrangle straddles the Utah-Colorado line on the east margin of the Vernal coal field (figures 15 and 35). The area is hilly to mountainous. Elevations range from about 5,325 feet above sea level along U. S. Highway 40 along the west edge to 8,400 feet at Shurtz Ridge to the north. The coal zones lie between 5,325 and 5,700 feet. U. S. Highway 40, a major link between Denver and Salt Lake City, traverses the southern third of the quadrangle and any coal beds are found within a few miles of it. The nearest town of any size is Vernal, 25 miles west of the quadrangle.

STRATIGRAPHY

Pennsylvanian to Quaternary rocks are exposed on the Snake John Reef quadrangle. The Pennsylvanian, Permian and Triassic rocks are all exposed north of the Miners Draw fault, never in the vicinity of the Cretaceous coal-bearing rocks.

Jurassic strata are the Navajo Sandstone (about 700 feet thick), Carmel Formation (85 feet thick), Entrada Sandstone (200 feet thick), Curtis Formation (125 feet thick) and Morrison Formation (550 feet thick). Except for the Curtis, most deposits are continental, aeolian or fluvial in nature. The lithologies are dominated by sandstones, mudstones, conglomerates and siltstones. Each unit is briefly described in the map explanation (see pages 34 and 35).

The Cretaceous units contain the coal. The formations are the Dakota Sandstone, Mowry Shale, Frontier Sandstone, Mancos Shale and Mesaverde Formation. In Utah the Dakota, Frontier and Mesaverde all contain coal, but in the Vernal coal field only the last two have significant amounts and in the quadrangle only the last is of importance.

The Dakota Sandstone is a medium-resistant unit of yellow, white and gray, medium- to coarse-grained sandstone interbedded with lesser amounts of brown-gray shale. The unit is about 75 feet thick and contains no coal. The exposures flank the south margin of Blue Mountain (Cliff Ridge) on the north side of the hogback hills of the Frontier Sandstone.

The Mowry Shale lies between the Dakota and Frontier sandstones at the base of the Frontier hogbacks. It typically consists of brownish fissile shale that weathers into gray chips. The thin-bedded marine unit is easily recognizable and is known for its teleost fish scales. The unit has not been measured on the quadrangle but probably ranges between 75 and 100 feet in thickness.

The Frontier Sandstone is typically the most important coal-bearing unit of the Vernal coal field, but at Snake John Reef quadrangle it is barren. It consists mainly of brownish fine- to medium-grained sandstones and gray-brown shale. The formation forms a line of hogbacks north of U. S. Highway 40 but lacks the massive gray-yellow sandstones found to the west in the coal-bearing part of the unit. The formation has not been measured on this quadrangle but is estimated to range from 150 to 200 feet in thickness.

A thick sequence of brown to gray shales and mudstone with occasional interbedded thin-bedded sandstone lenses and concretionary zones overlies the Frontier in a large outcrop area. This is the marine Mancos Shale, nonresistant, supporting only sparse vegetation on its impermeable surface. At Snake John Reef most of this surface is covered by Quaternary or Tertiary gravels. The unit may be more than 4,000 feet thick.

The Mesaverde Formation overlies and probably intertongues with the Mancos Shale. The Mesaverde is a sequence of nearshore marine, lagoonal and nonmarine rocks which have been differentiated into several formations and members. Of consequence in the Snake John Reef quadrangle is the Rim Rock Member (Kmvr) and the Upper Mesaverde (Kmvu; figure 35). These units were correlated by some writers as members of the Price River Formation. The Rim Rock Member is dominated by subgraywacke and quartzose sandstone, in thick-bedded to massive beds interbedded by thin units of black and gray shale, siltstone and coal. Topographically the unit forms an escarpment like a rim on a saucer with the bowl to the south. The rim "snakes" its way east to west across the quadrangle, giving it the name Snake John Reef. The Rim Rock Member is about 500 feet thick.

The upper member is not as resistant as the Rim Rock but the lithology is similar. A greater abundance of shale and lignitic coal accounts for the difference. In fact more than 50 percent of the "Upper" Mesaverde east of Vernal is shale, most of continental origin. The lithology appears cyclic to a certain extent. According to Gross (1961, p. 94) a typical cycle is:

shale and siltstone
subgraywacke or quartzose sandstone
shale and siltstone
lignite or bone coal
shale and siltstone
subgraywacke or quartzose sandstone
shale and siltstone
lignite or bone coal
shale and siltstone
subgraywacke or quartzose sandstone

The outcrops are often covered with Quaternary and Tertiary gravels and relationships in the upper part are usually obscure. The contact with the overlying Wasatch Formation (Tertiary) is not clear and a true thickness cannot be determined. Regionally the upper member thickens eastward. It is estimated, however, that the member is about 1,675 feet thick on the basis of a well log in the Snake John Reef quadrangle.

The Tertiary Wasatch Formation overlies the Mesaverde, its rocks greatly resembling those of the upper member of the Mesaverde. It, too, contains lignitic coal beds, but in thinner beds and in fewer seams. The unit is about 850 feet thick.

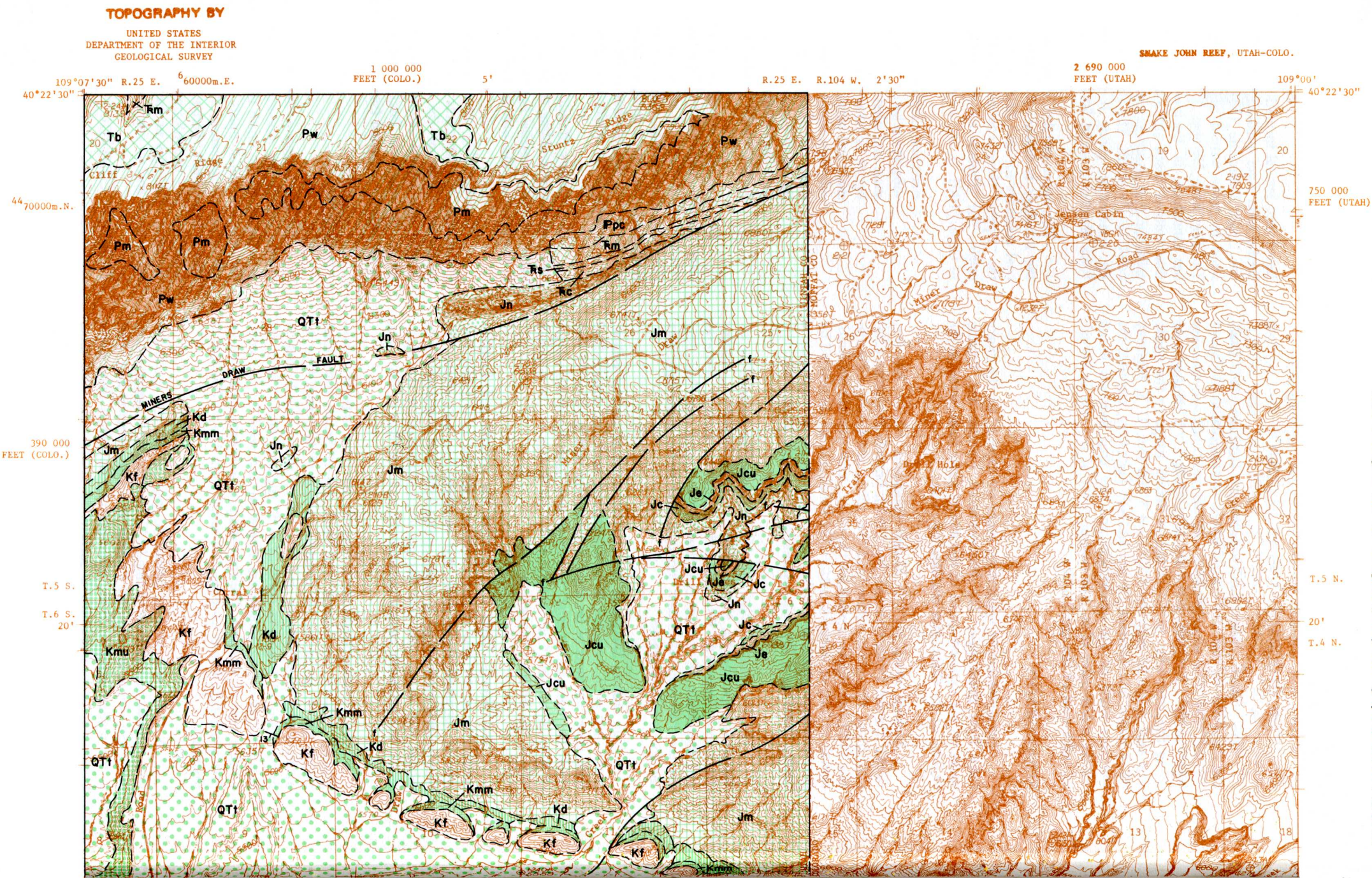
Unconformably overlapping the Wasatch is the Green River Formation. Its exposures occur in cliffs located in the extreme southwest corner of the quadrangle. The Green River was subdivided into several members but only the Douglas Creek is present in the map area. Brief descriptions of each member are given in the map explanation (see pages 34 and 35).

STRUCTURE

All strata except the Tertiary units and the unconsolidated terrace gravels dip moderately to steeply, generally south. Faulting is moderate in the north third of the map area, associated with the east-west anticlinal uplift of Blue Mountain, but these faults do not affect coal-bearing strata. The most important fault is the Miners Draw fault. Tertiary rocks dip less than 20 degrees to the southwest and unconformably overlie older rocks with angular discordance. The dips in the vicinity of the better coal seams range between 20 and 45 degrees.

PROPERTY CONTROL

Snake John Reef quadrangle lands are privately owned, controlled by the Bureau of Land Management or the state of Utah. The area underlain by coal lands is controlled by the governmental agencies. At present there are no leases or permits for coal in the quadrangle, but the land has occasionally been leased for this purpose in the past.


TOPOGRAPHY BY
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
SNAKE JOHN REEF, UTAH-COLO.
109°07'30" R.25 E.
660000m.E.
1 000 000
FEET (COLO.)
5'
R.25 E.
R.104 W.
2'30"
2 690 000
FEET (UTAH)
109°00'
40°22'30"
4470000m.N.
750 000
FEET (UTAH)
390 000
FEET (COLO.)
T.5 S.
T.6 S.
20'
T.5 N.
T.4 N.
MINERS DRAW FAULT
Jensen Cabin
Miner Draw Road
Drill Hole
Stuntz Ridge
Cliff Ridge
Road
Creek
Tb
Pw
Pm
Ppc
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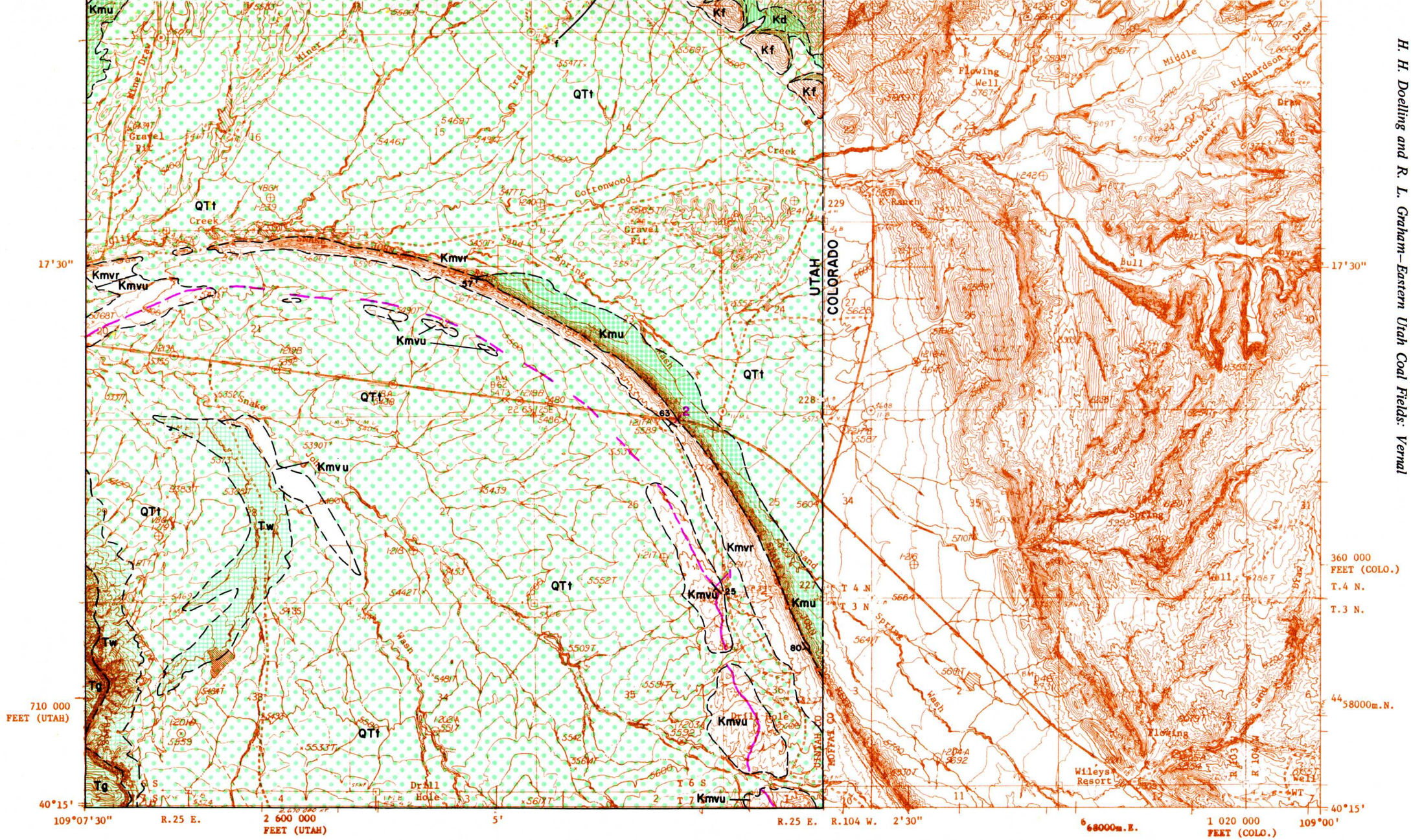


Geology by G. E. Untermann and B. R. Untermann, 1964, Utah Field House of Natural History at Vernal, modified by H. H. Doelling and F. E. May, 1970, UGMS; coal data by H. H. Doelling, 1970, UGMS.

Figure 35. Coal and geology map, Snake John Reef quadrangle (explanation pages 34-35).

COAL

Surface Information

Two sections were measured on the Snake John Reef quadrangle, the first in the upper Mesaverde (figure 36). It showed a total fo 12.7 feet of coal, 9.6 feet in a single seam. About 3.7 feet near the center of the section are boney coal. The second section (not shown) was taken in a road cut in the Rim Rock Member. The coal totaled 0.5 feet.

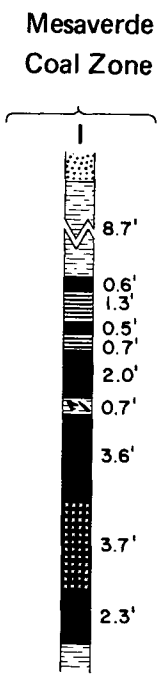


Figure 36. Coal section of Snake John Reef quadrangle (vertical scale: 1 inch = 8 feet).

Subsurface Information

No drilling for coal is known to have been done on the Snake John quadrangle. The steepness of dip would allow a strip 1 to 1½ miles wide behind the outcrop before the 3,000-foot depth limit is reached.

Quality of Coal

Analyses of a channel sample taken at location 1 showed 13.1 percent moisture and 19.2 percent ash on an as-received basis. Only the lower 9.6 feet were channeled. On a dry basis the coal has a calorific value of 9,790 Btu/lb and contains 0.30 percent sulfur (table 6).

Mines and Development

No development work for coal was noted in the map area.

Reserves

Gale (1910) notes that this is an area of limited potential. If the area were better explored some reserves could no doubt be blocked out but they would be small. On the basis of the measured section and examination of the surrounding area, a small Class III reserve of 5,138,900 short tons of low-sulfur coal is assigned to the quadrangle.

PRINCIPAL WORK

The geologic map of the quadrangle was modified from G. E. and B. R. Untermann (1964a) by Utah Geological and Mineralogical Survey geologists H. H. Doelling and F. E. May. The modifications deal with the Frontier and Mesaverde outcrops. The coal outcrop data were collected by Doelling and May.

STEINAKER RESERVOIR–VERNAL NE QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

This quadrangle is a composite of parts of U. S. Geological Survey Steinaker Reservoir and Vernal NE quadrangles (figures 15 and 37). The north third of the Vernal NE quadrangle (north of 40°27'30") and the south two-thirds of the Steinaker Reservoir quadrangle contain all of the coal outcrops in the two quadrangles.

Vernal, on the south edge of the map, marks the center of the Vernal coal field. The town is situated in Ashley Valley. To the north the land consists of sinuous ridges and accompanying strike valleys. One of these strike valleys, Steinaker Draw, has been dammed to form Steinaker Reservoir. Elevations on the composite quadrangle range from 5,260 feet above sea level in the southeast corner to 7,100 feet in the middle of the north margin. Coal outcrops lie between 5,400 to 6,100 feet. Vernal is joined to Salt Lake City and Denver by U. S. Highway 40 and Utah Highway 44 connects Vernal with Flaming Gorge Recreational area and Wyoming to the north. Secondary gravel roads provide access to most of the coal outcrops. There are no railroads in the area.

STRATIGRAPHY

The quadrangle includes the south flank of the Uinta Mountains (or north edge of the Uinta Basin), and the older rocks lie generally to the north and the younger rocks to the south. Because of irregular folding the rocks trend northeast instead of east-west. Pre-Cretaceous rocks exposed in the quadrangle range in age from Pennsylvanian to Jurassic; they are described in the map explanation (see pages 34 and 35) and are listed below with their thicknesses.

	Feet
Pennsylvanian:	
Weber Sandstone	1,250
Permian:	
Park City Formation	100
Triassic:	
Moenkopi Formation	950
Shinarump Conglomerate	66
Chinle Formation	276
Jurassic:	
Navajo Sandstone	750-800
Carmel Formation	231
Entrada Sandstone	215
Curtis Formation	145
Morrison Formation	831

The Cretaceous is represented by five units: Dakota Sandstone, Mowry Shale, Frontier Sandstone, Mancos Shale and Mesaverde Formation. Of these the Frontier contains important coal, the Mesaverde and Dakota insignificant amounts. The other two are marine shales.

Kinney (1955, p. 96) measured the Dakota in SE¼ sec. 25, T. 3 S., R. 21 E. (probably SW¼ sec. 26).

	Feet
Mowry Shale: shale, dark gray.	
Dakota Sandstone:	
Sandstone, light tan, medium- to coarse-grained, with angular grains	33
Shale, gray and interbedded light gray, thin-bedded, fine- to medium-grained sandstone	102
Total	135
Morrison Formation: claystone, light gray, plastic when wet.	

Kinney reported thin lignitic layers near Steinaker Draw. The thickness varies between 50 and 200 feet because of the lenticular nature of the beds. The unit, with exception of the uppermost beds, is poorly cemented and forms semiresistant outcrops, forming ridges and slopes.

The Mowry Shale, immediately above the Dakota, was also measured by Kinney (1955, p. 100) in Steinaker Draw (SE¼ sec. 26, T. 3 S., R. 21 E.).

	Feet
Frontier Sandstone: shale, light gray, sandy, tan weathering.	
Mowry Shale:	
Shale, dark gray, silver-gray weathering, siliceous, fissile, with abundant fish scales	58
Shale, dark gray	32
Total	90
Dakota Sandstone: sandstone, light tan, medium- to coarse-grained, with angular grains.	

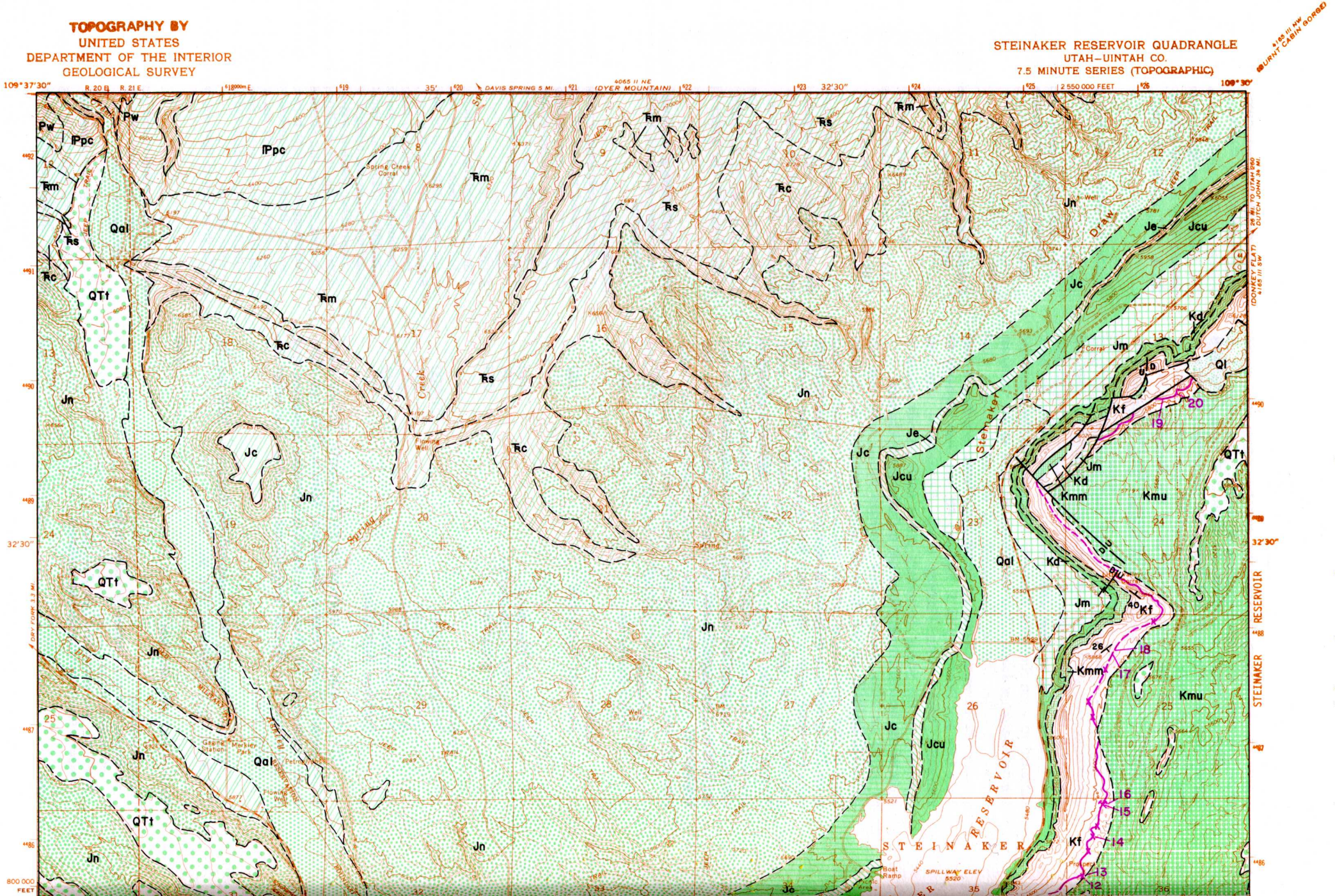
The silver-gray weathering chips and platelets of shale are hard and form a platelet-strewn band or stripe below the Frontier Cliff identifying the outcrop.

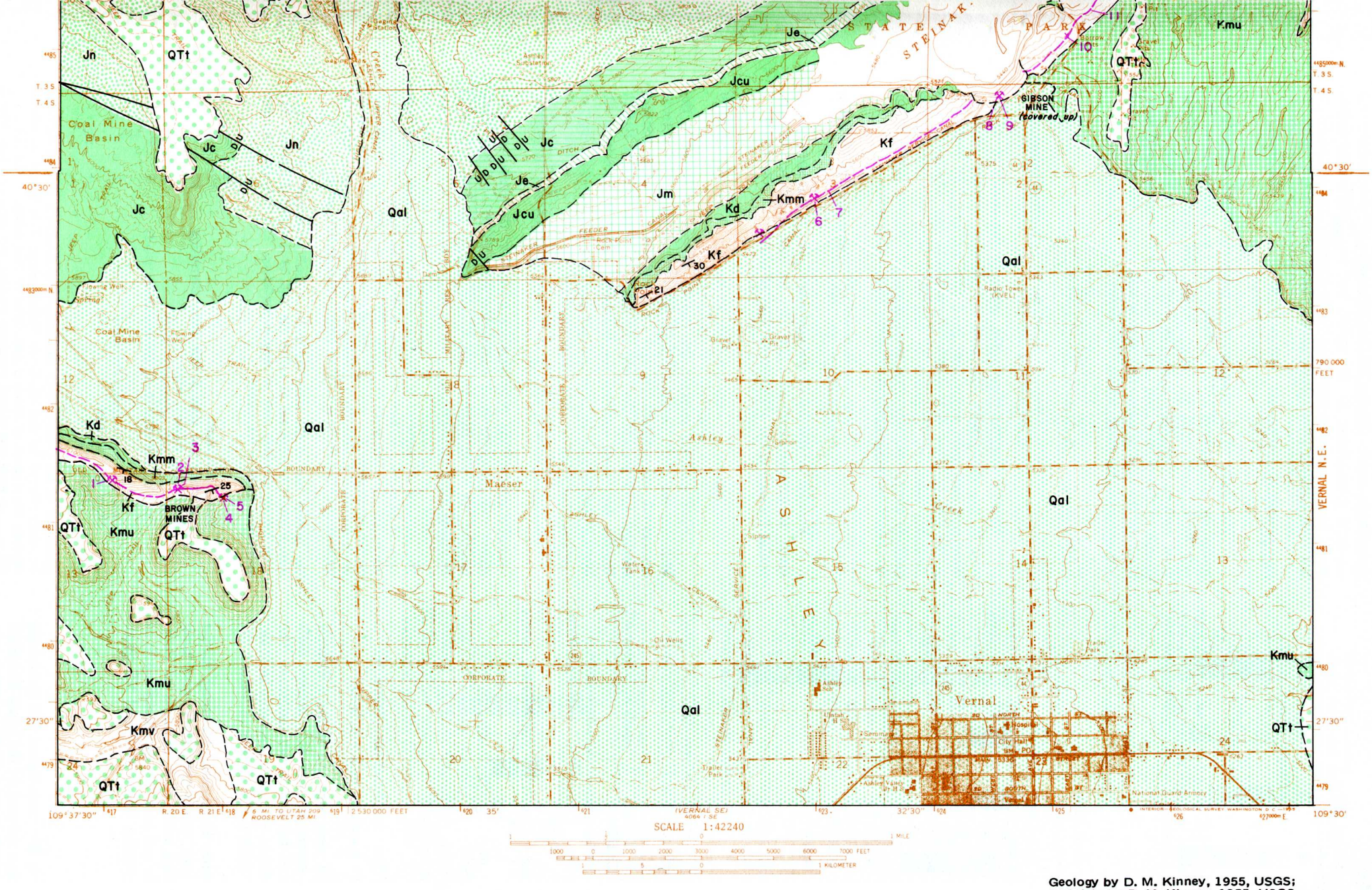
The Frontier Sandstone is the most important formation on the quadrangle with respect to coal. Kinney (1955, p. 104) measured 164 feet of Frontier in SE¼ sec. 26, T. 3 S., R. 21 E., along Steinaker Draw. The writer measured almost 209 feet along the road cut just east of the reservoir (Utah Highway 44) in SE¼ sec. 35, T. 3 S., R. 21 E. Either of these sections gives a good picture of the Frontier. The writer's section is given below.

	Feet
Mancos Shale: shale, gray-brown, yellow-gray, weathering with subordinate sandstone, thin-bedded, medium resistant and fine-grained.	
Frontier Sandstone:	
1. Sandstone, yellow-tan, medium-grained, well sorted, slightly cross-bedded, massive, resistant	54.4
2. Sandstone, light gray, medium-grained, subround to subangular grains, medium-bedded, shaley weathering, contains thin interbeds of gray shale, medium resistant	11.1
3. Shale, carbonaceous, interbedded with gray shale, mudstone and coal	4.0
4. Coal	4.3
5. Sandstone, light tan, medium-grained, well sorted, thin-bedded, medium resistant, alternating with carbonaceous and coaley shale, ratio of sandstone to shale 60:40	24.1
6. Sandstone, tan to yellow-gray, medium- to coarse-grained, fair sorting, subround to subangular grains, thin- to medium-bedded, friable, medium resistant	5.4
7. Sandstone, yellow-gray, medium-grained, well sorted, thick-bedded to massive, resistant ledge former, somewhat cross-bedded, weathers gray-white	15.5
8. Sandstone, light tan, medium-grained, thin- to medium-bedded, contains thin interbeds of gray shale, slope former	13.3
9. Sandstone, tan to light brown, medium-grained, fair sorting, friable, medium-bedded, nonresistant	6.8
10. Claystone, gray to light tan, massive, slope former	13.8
11. Sandstone, tan to brown, fine- to medium-grained, well sorted, thin- to medium-bedded, ledge former, contains worm borrows	6.2
12. Claystone, gray to light tan, massive slope former	49.8
Total	208.7
Mowry Shale: medium to dark gray, weathers into blue-white to gray-white thin plates, siliceous, thin-bedded, forms semiresistant slope.	

The Frontier consists of two units, a lower slope-forming unit about 90 feet thick and an upper resistant coal-bearing unit almost 120 feet thick. The coal is in a slope-forming zone between two resistant sandstone layers. The Frontier Sandstone forms the last significant hogback on the south flank of the Uinta Mountains north of Vernal.

Most of Ashley Valley is covered with alluvium formed of the soft shales of the Mancos. Significant outcrops of the Mancos


TOPOGRAPHY BY
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
STEINAKER RESERVOIR QUADRANGLE
UTAH–UINTAH CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
109°37'30"
109°30'
32'30"
DAVIS SPRING 5 MI.
4065 II NE
(DYER MOUNTAIN)
2 550 000 FEET
STEINAKER RESERVOIR
STEINAKER
SPILLWAY ELEV
5520
Spring Creek Corral
Flowing Well
Gaging Station
Merkley Park
Petroleum
Boat Ramp
Stemaker
Draw
Creek
Spring
Dry Fork
DRY FORK 3.3 MI.
26 MI. TO UTAH 260
DUTCH JOHN 34 MI.
(DONKEY FLAT)
4165 III SW
4165 III NW
(BURNT CABIN GORGE)
800 000
FEET



Geology by D. M. Kinney, 1955, USGS; coal data by D. M. Kinney, 1955, USGS, modified by R. L. Graham and F. E. May, 1970, UGMS.

VERNAL NE, UTAH
N4022.5—W10930/7.5
1964
AMS 4064 I NE—SERIES V897

Figure 37. Coal and geology map, Steinaker Reservoir-Vernal NE quadrangle (explanation pages 34-35).

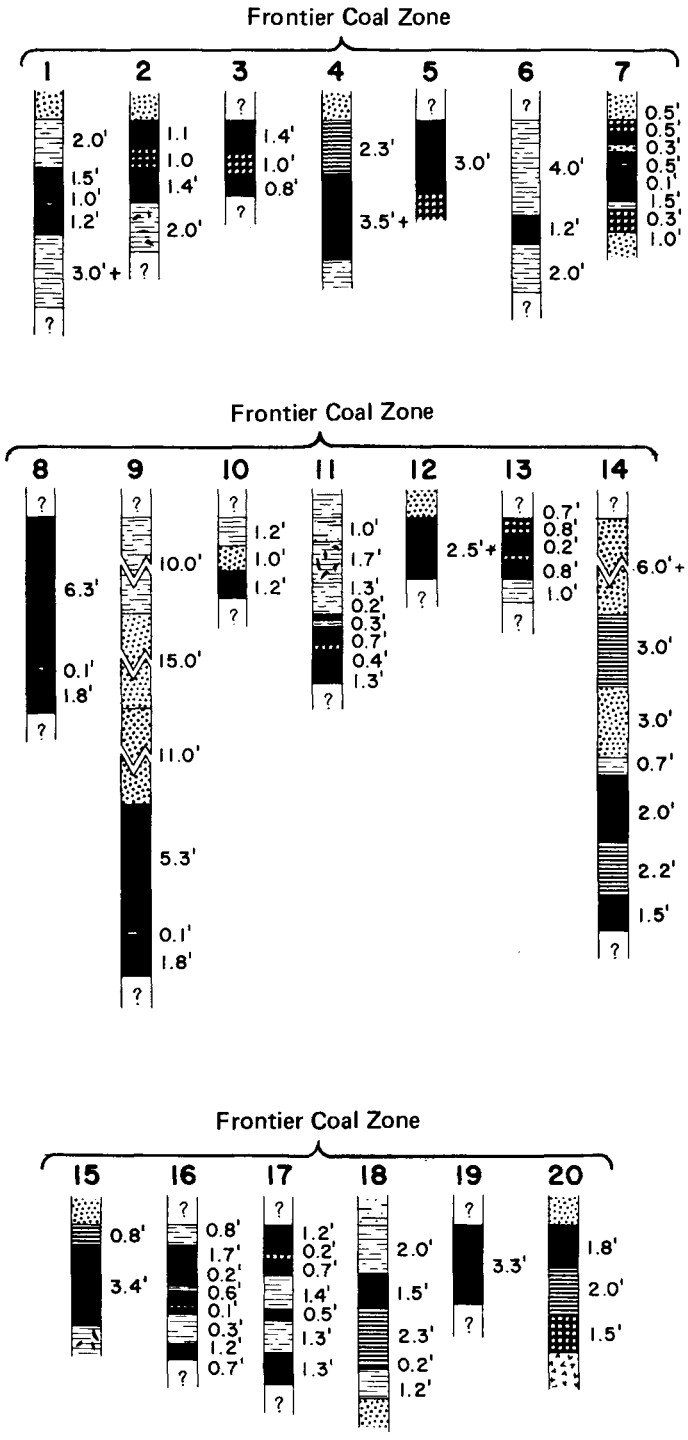


Figure 38. Coal sections of Steinaker Reservoir–Vernal NE quadrangle (vertical scale: 1 inch = 8 feet).

are found along the east central map edge and in the southwest corner. The Mancos is a dark brown to dark gray marine shale containing occasional thin beds of tan and brown sandstone. The outcrops weather into badland slopes, gray to yellow-gray in color. The Mancos is about 5,000 feet thick in the vicinity of Vernal.

Exposures of the Mesaverde Formation, occurring in the southwest map area, consist of gray, yellow-gray, brown-gray sandstones and graywacke interbedded with lesser amounts of shale, carbonaceous shale, lignitic shale and coal. No significant seams of coal were discovered in the Steinaker Reservoir-Vernal NE quadrangle.

STRUCTURE

The strata of the Steinaker Reservoir-Vernal NE quadrangle dip south or southeast. These beds are part of the Uinta Mountain anticlinal uplift and form the south margin of the mapped area. Irregularities in the degree of uplift has caused a sinuous outcrop pattern. The degree of slope on the beds ranges from moderate to steep; beds occur dipping 18 to 40 degrees. Some faulting has occurred sympathetic to the uplift, but most displacements are small. In the northeast exposures of the Frontier toreva landsliding has been significant enough to confuse local relationships.

PROPERTY CONTROL

The lands of the map area are privately owned or are controlled by the state of Utah or Bureau of Land Management. Private lands cover most of Ashley Valley and extend into alluvial areas such as Steinaker Draw, Dry Fork and Ashley Creek. A few parcels of this private land include coal areas as coal-patented land. Most of the coal is under the jurisdiction of the Bureau of Land Management. No current leases or permits for coal are in force.

COAL

Surface Information

Twenty sections (figure 38) attest to the condition of the coal in this quadrangle. The coal is lenticular, quickly picks up bone coal and splits occur near good coal sections. The best coal, at the Gibson mine, is buried by the earth-fill dam which contains Steinaker Reservoir. Location of coal more than four feet thick is unlikely except perhaps near the Gibson and Brown mines. All of the seams dip moderately to steeply, 20 to 40 degrees.

Subsurface Information

Because of the dip of the coal seams, the coal is soon out of reach, an average depth of 1,000 feet for each 2,000 feet of horizontal distance is the approximate rate of burial.

Quality of Coal

Four analyses indicate the quality of coal as found in the Steinaker Reservoir-Vernal NE area. Moisture averages 10.3 percent as-received, ash content averages 15.5 percent dry, sulfur content averages 1.42 percent dry, and the calorific value averages 10,012 Btu/lb dry. Coal analyses for individual mines or prospects are listed in table 6.

Mines and Development

In spite of the poor showing of coal at the surface, several mines and prospects have been opened (table 25). All have been inactive for more than 10 years. Gale (1910, p. 214, 215, 218) describes some of these:

The principal development in this township is a small mine on a 40-acre tract of patented coal land (the NE¼ NW¼ sec. 2) on the William Gibson ranch, 3½ miles due north of Vernal. The entry is close to the public road on the north side. The principal opening consists of a 15° slope running down toward the north for a distance of about 50 feet, beyond which the slope turns northeast along a lighter grade, under shallow cover.

The present face of the mine lies under a small wash gully, from which seepage might be expected to soften the coal, as it is near the surface. The mine has an excellent roof of massive sandstone. The following measurements were made at this place:

	Ft.	In.
Shale, fine, dark	10+	
Sandstone and shale in thin beds, alternating	15	
Sandstone, massive, white	11	
Coal (A), hard, apparently good	1	10
Coal (B), soft (like slack, but apparently good)	3	6½
Clay		1
Coal (C), hard, apparently good	1	9
Floor not exposed		
Total coal	7	1½

Southwest of the Gibson ranch the horizon of the lower Mancos coal may be easily traced to Ashley Creek Valley where it is buried in alluvial deposits for a space of about a mile. West of that valley, in the NW¼ sec. 18, another mine was visited, evidently opening the same coal bed. This is an old mine (Brown mine), and consists of three openings or entries. Two of these are situated at the mouth of a little draw, while another and apparently the last worked is on the side of the rock hill slope about 50

Table 25. Mines and prospects in the Steinaker Reservoir–Vernal NE quadrangle.

Mine	Location	Remarks
Gibson mine	NE.NE.NE.NW.2–4S–21E 4,484,710m.N. 624,480m.E.	1890's
Prospects	C.NW.NW.SW.25–3S–21E 4,487,235m.N. 625,670m.E.	
	C.SW.SW.NW.25–3S–21E 4,487,380m.N. 625,700m.E.	
	NW.NW.SW.NW.25–3S–21E 4,487,625m.N. 625,550m.E.	
	C.NE.NE.NW.25–3S–21E 4,488,025m.N. 626,260m.E.	
	C.SW.NW.36–3S–21E 4,486,025m.N. 625,660m.E.	
	NE.SW.NW.NW.36–3S–21E 4,486,120m.N. 625,710m.E.	
	SE.NW.NW.36–3S–21E 4,486,250m.N. 625,750m.E.	
	SW.SW.NW.36–3S–21E 4,485,840m.N. 625,620m.E.	
Mine	NE.NW.NW.36–3S–21E 4,486,430m.N. 625,870m.E.	
	VERNAL NE	
Brown mine	W.NE.NW.18–4S–21E 4,481,200m.N. 617,930m.E.	
Prospects	SW.NE.SW.3–4S–21E 4,483,525m.N. 622,520m.E.	Old
	NE.NE.SW.3–4S–21E 4,483,820m.N. 622,900m.E.	

feet higher. All open the same coal bed. The strike of the beds is N. 80° E. and the dip 27° S. The coal developed in this entry appeared to be broken into several benches, of which an upper 3 feet or more was the best. The lower part had not been used, probably on account of its bony character.

. . .Numerous prospects were noted in T. 3 S., R. 21 E., along the gulch that follows south of the outcrop of these beds, this being a minor strike valley parallel to and south of Steinaker Draw. In section 36 an entry fitted with a mine car and track had been opened, evidently to supply local demand if the coal proved of sufficiently desirable quality. The bed somewhat resembles that of the Gibson mine, as is shown by the following measurements obtained at this place:

	Ft.	In.
Sandstone, massive	6+	
Shale, dark and carbonaceous	3	
Sandstone (roof of entry)	3	
Shale, brown		8
Coal, quality uncertain	2	9
Shale, brown	2	2
Coal	1	6
Total height in entry	7	

The thickness of the workable coal is doubtful, and it seems very questionable if the coal can be made to pay for mining, on account of the great percentage of shaly and bony material.

Kinney (1955, p. 146) estimated that 15,000 tons of coal have been mined from this area.

Reserves

Kinney (1955, p. 146) lists the following reserves for the area (table 26). None of the coal seams listed is more than 4 feet thick.

Table 26. Coal reserves of the Steinaker Reservoir–Vernal NE quadrangle.

Frontier Coal Zone	Class II	Class III	Total
0-1000 feet	9,750,000	2,600,000	12,350,000
1000-2000 feet	6,240,000	3,310,000	9,550,000
2000-3000 feet	4,180,000	3,580,000	7,760,000
Total	20,170,000	9,490,000	29,660,000

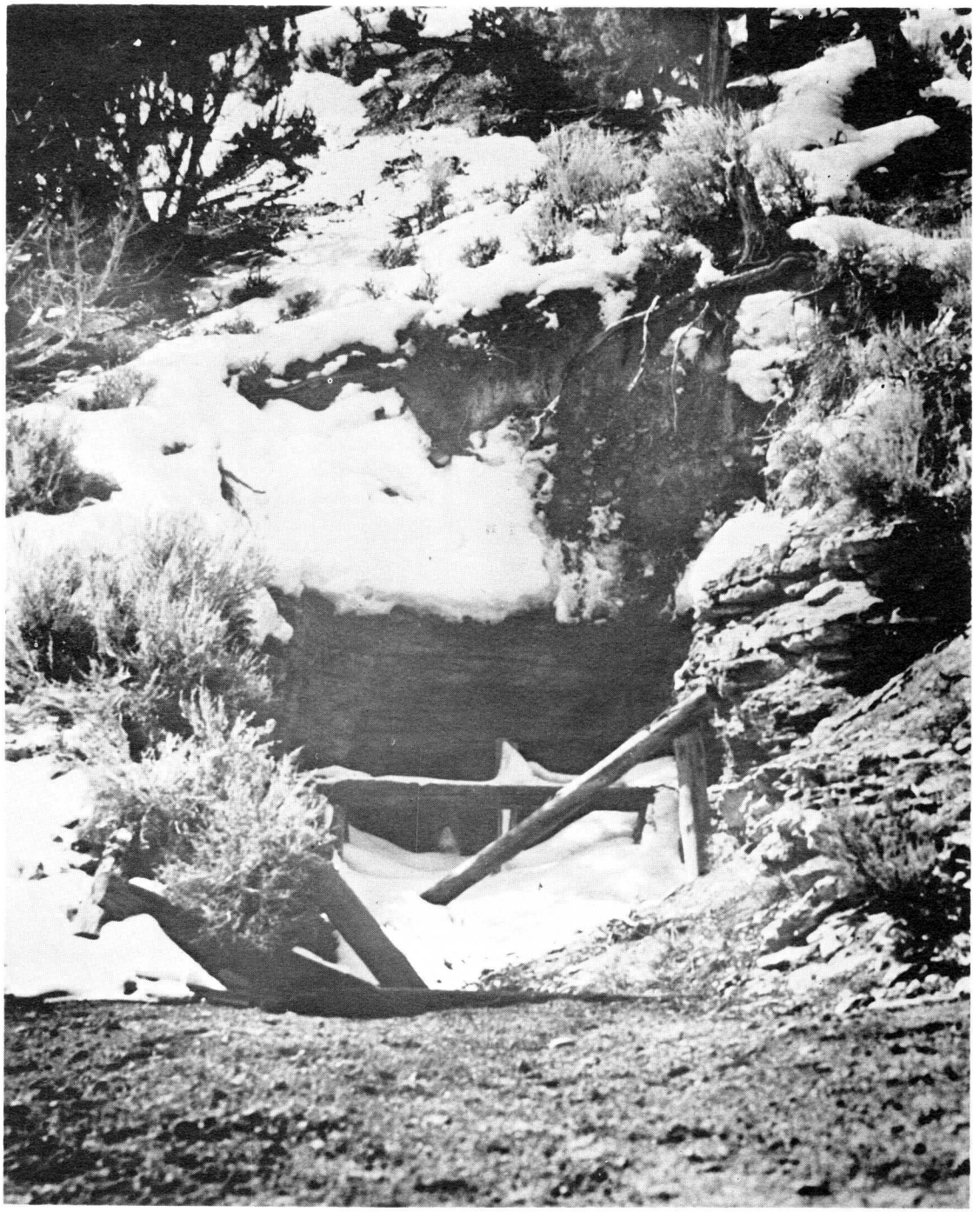
Coal more than four feet thick (table 27) has been found, however. Most of this coal should occur near the vicinity of the Gibson and Brown mines.

Table 27. Coal reserves of the Steinaker Reservoir–Vernal NE quadrangle (more than 4 feet thick; in short tons).

Frontier Coal Zone	Class II	Class III	Total
0-1000 feet	9,064,000	2,051,000	11,115,000
1000-2000 feet			

PRINCIPAL WORK

The geologic mapping on this quadrangle is principally the work of Kinney (1955). Some of the Frontier outcrops were modified by Utah Geological and Mineralogical Survey geologists R. L. Graham and F. E. May. Coal data were collected by Kinney, Graham and Gale (1910).



Abandoned adit, Helco mine.

VERNAL NE–SE QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

This quadrangle is composed of the south two-thirds of the Vernal NE quadrangle and the north third of the Vernal SE quadrangle of the U. S. Geological Survey (figures 15 and 39). Ashley Valley lies in the northwest part of the quadrangle and supports farms and homes surrounding the town of Vernal. The south end of Vernal is on the north edge of the quadrangle. Asphalt Ridge is immediately southwest of Ashley Valley; the ridge's long dip slope extends southwest. The dip slope has been deeply gullied in many places leaving a rough butte-covered surface.

Vernal is the Uintah County seat and is joined with Denver and Salt Lake City by U. S. Highway 40 which crosses the quadrangle. The lowest elevation is in the southwest corner (5,050 feet) and the highest elevation (6,500 feet) is in the north part of Asphalt Ridge. Vernal is a mile-high city, 5,280 feet above sea level. The coal beds lie between 5,400 and 5,700 feet.

STRATIGRAPHY

Three consolidated units, two Cretaceous and one Tertiary, crop out in the quadrangle. Quaternary and Tertiary terrace gravels are scattered in irregular patches on the dip slope and in Ashley Valley. Much of Ashley Valley is covered by alluvium.

The upper part of the Mancos Shale crops out in and around Ashley Valley. The 5,000-foot unit consists of gray-brown marine shales occasionally interbedded with thin tan and brown fine-grained sandstone beds. The outcrops are usually poorly exposed and are yellow-gray in color in the form of badlands. The shales are appreciably sandy and silty in the upper part and lend the yellow-tan color to the weathered slopes.

The Mesaverde Formation, cropping out as a northwest-trending band below Asphalt Ridge, is divided into at least two members. The lowermost, the Asphalt Ridge Member, is the lowermost massive sandstone unit. It consists of sandstone, subgraywacke and small amounts of siltstone. The sand is fine- to medium-grained and calcareously cemented. The unit is about 110 feet thick, thins and disappears a short distance east of the Green River and is the only unit near Asphalt Ridge that is not asphalt-saturated to some degree.

The second member is the Rim Rock Sandstone; its lithology is similar to that of the Asphalt Ridge Member except that the massive beds are not as thick. In addition to quartz in the sandstone there are abundant coal particles. Gross (1961, p. 84-86) describes the unit in some detail and (p. A11-A13) has the Duchesne River Formation unconformably overlying it; the Rim Rock Sandstone at Asphalt Ridge is 147 feet. He makes no mention of coal seams. There is no mention of beds of Cretaceous age exposed above the Rim Rock. Gale (1910, p. 214) mentions the presence of coal. To the east only beds above the Rim Rock in the Mesaverde contain appreciable coal and it is possible that some of these are exposed and not covered under the Tertiary onlap.

Most of Asphalt Ridge and its dip slope exposes Tertiary Duchesne River Formation. It is not known how thick the unit is but a maximum of 1,500 feet has been assigned to it. The unit consists of intercalated varicolored shale and tan and gray-red weathering sandstone. Along Asphalt Ridge the Duchesne River is saturated with tarry bituminous material.

STRUCTURE

No strike and dip data for the rocks of the quadrangle are available, but dips in the Mesaverde are moderate to steep and those of the Duchesne River strata gentle to moderate. These dips are generally southwest and the strike is correspondingly northwest. The Walker syncline crosses Duchesne River beds in the southwest corner of the map. Only a few faults, all with small displacements, were mapped in the northwest part of the area.

PROPERTY CONTROL

Most of Ashley Valley is privately owned; Asphalt Ridge is controlled by the state of Utah and the Bureau of Land Management. None of the land is leased or permitted for coal.

COAL

Surface Information

Gale (1910) reports:

> The Mesaverde coal-bearing rocks outcrop in a continuous narrow strip along the eastern base of Asphalt Ridge which passes diagonally through T. 5 S., R. 21 E., from southeast to northwest. So far as is known to the author no workable coal has ever been opened in this area. . .(p. 212)
>
> . . .The Mesaverde coal is represented by an old entry at or near the quarter corner on the east side of section 32 (T. 4 S., R. 21 E.). No good measurements of the coal could be obtained, but as nearly as the limits of the bed could be ascertained it appeared to be 2 feet 8 inches to 3 feet 4 inches thick. . .(p. 214).

Subsurface Information

No exploration or drilling for coal has been done in recent years. The steep southwesterly dip buries the coal quickly in that direction.

Quality of Coal

No analyses of coal in the quadrangle have been performed.

Mines and Development

Except for the prospect noted by Gale in SE SE NE 32-4S-21E (1910, p. 214), no development of coal in the quadrangle has been done.

Reserves

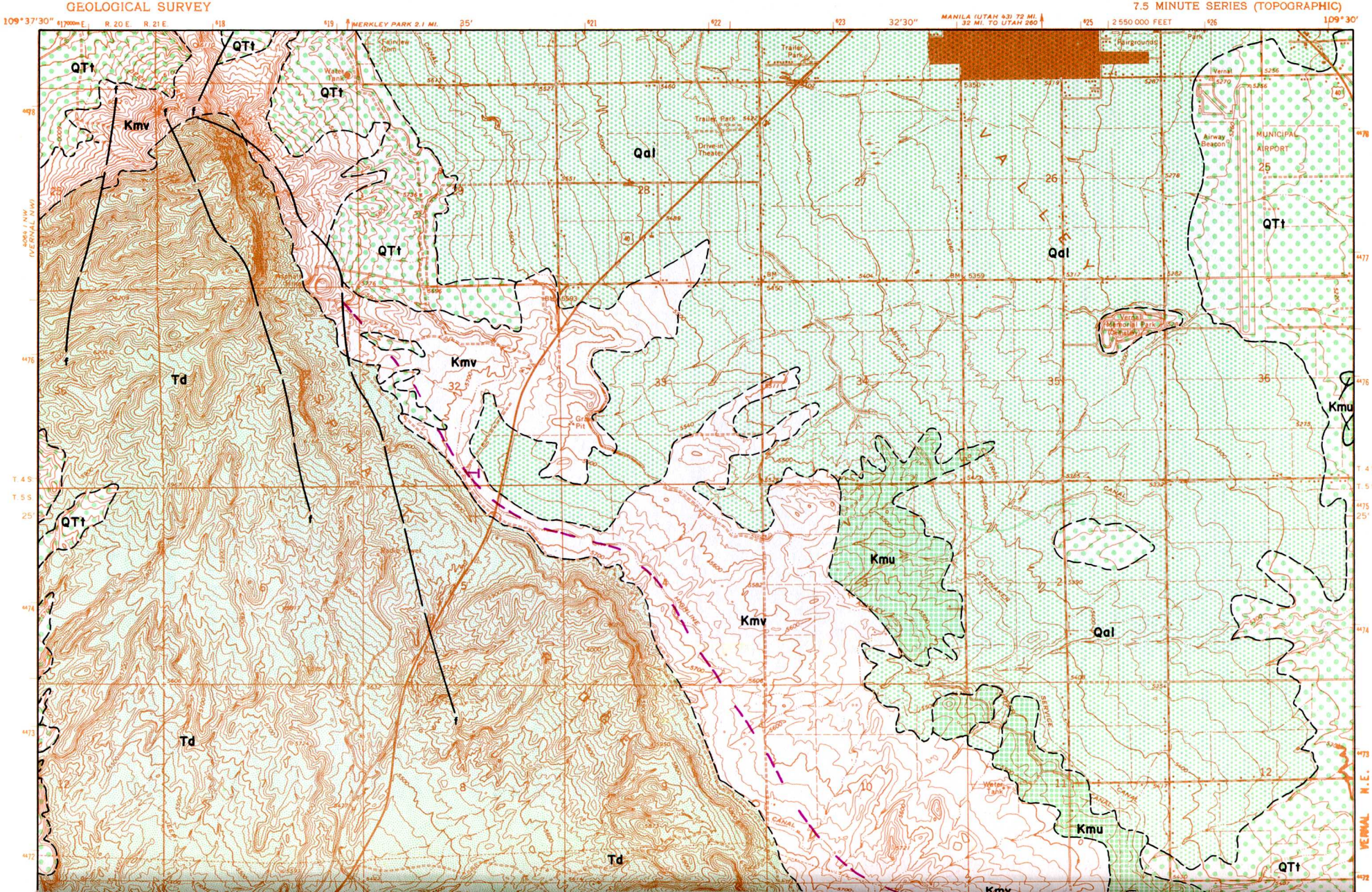
No reserves in the quadrangle have been estimated.

PRINCIPAL WORK

Small-scale geologic maps by G. E. and B. R. Untermann (1964a) were enlarged, and the coal data were mapped in a general manner by Gale (1910).

TOPOGRAPHY BY
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

VERNAL NE QUADRANGLE
UTAH–UINTAH CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



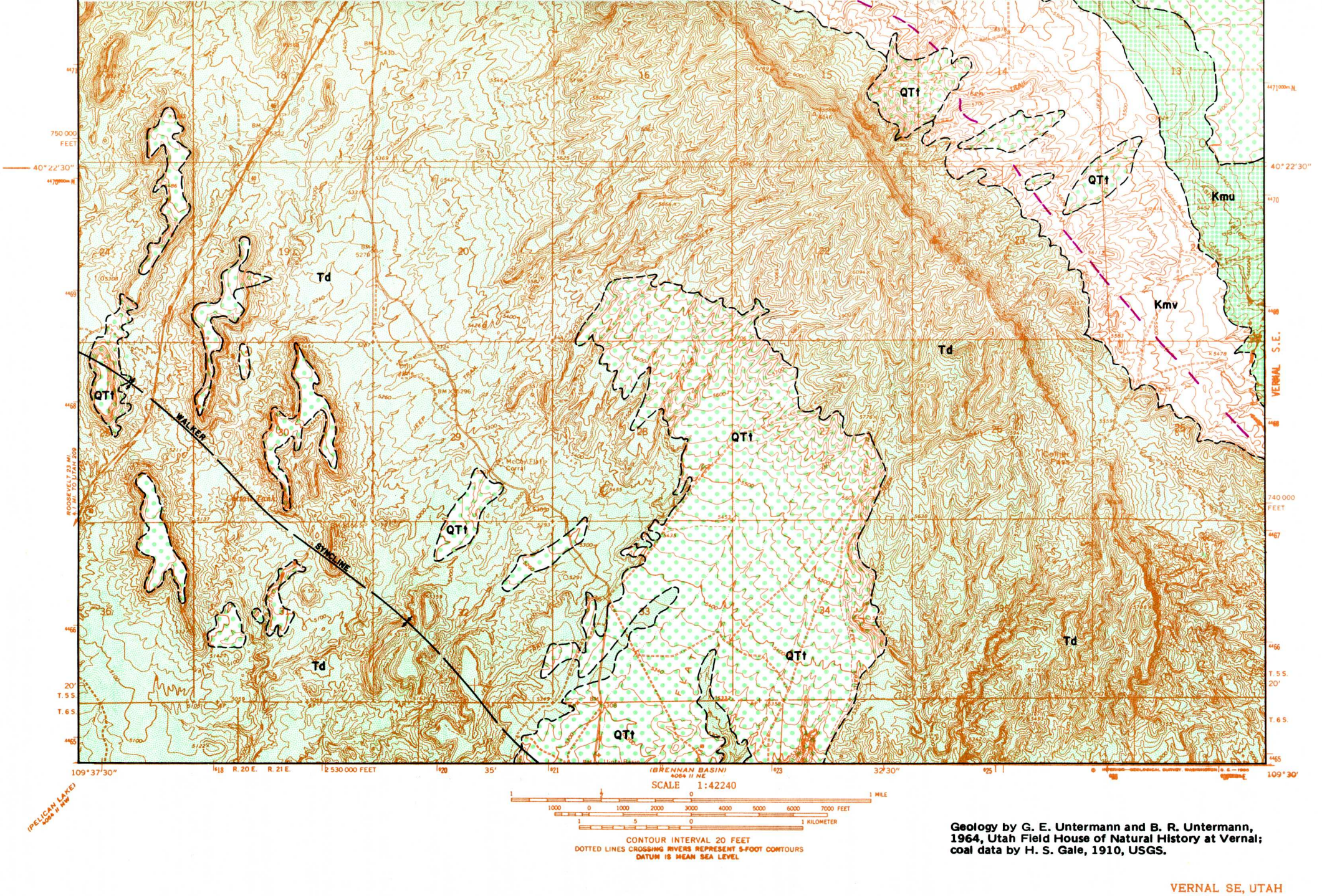


Figure 39. Coal and geology map, Vernal NE-SE quadrangle (explanation pages 34-35).

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HENRY MOUNTAINS COAL FIELD

by

H. H. Doelling[1]

INTRODUCTION

Location and Extent

The Henry Mountains are located in south central Utah (Preface, figure 1a) with coal deposits in a huge island of Cretaceous rock in a basin immediately west of the mountains. The basin is 48 miles long and up to 18 miles wide. The average width of the coal-bearing part is about 12 miles and the area involved includes 450 square miles. The Henry Mountains Basin is a part of the Colorado Plateau and is surrounded by uplifts. The San Rafael Swell outcrops to the north, the Circle Cliffs Upwarp to the west and the Monument Uplift to the east.

Topography (figure 1) and Drainage

The physiography of the Henry Mountains Basin is typically plateau-like. Each resistant stratigraphic unit forms a cliff with a soft unit below it which has been mostly stripped by erosion from the next lower resistant unit. In some places these cliffs have been dissected into mesas and buttes. In the vicinity of the Henry Mountains peaks and along Waterpocket Fold, the strata have been tilted; the soft units form strike valleys and the resistant ones form strike ridges. Even though the area is represented as a stratigraphic basin, it is topographically higher than much of the surrounding land. Atop the highest mesa the elevation is slightly more than 6,950 feet. The lower areas around the basin range from 4,700 to 5,300 feet above sea level. The principal drainages originating in the Henry Mountains flow onto the basin and then parallel the synclinal axis north or south. The principal drainage northward is Sweetwater Creek and southward is Bullfrog Creek. Neither of these streams carries copious amounts of water and during the hot summer months they are intermittent. Along Waterpocket Fold two other drainages also parallel the synclinal axis: Halls Creek flows southward and Sandy Wash northward.

A through-going stream, the Fremont River, crosses the basin from west to east near its north end. Sandy Wash and Sweetwater Creek are tributaries. The Fremont joins with Muddy Creek near Hanksville to form the Dirty Devil River which eventually flows into the Colorado River. Bullfrog and Halls creeks flow directly into the Colorado.

Population, Industries and Transportation

The Henry Mountains coal field in the east part of Wayne and Garfield counties is economically tied to Wayne County. The entire area is sparsely settled; no towns exist in Garfield County and three small ones in Wayne County lie near the field. The three towns are Notom, Caineville and Hanksville. The first two have less than 50 persons and Hanksville has a population of about 100. The 1970 census figures for Wayne County show 1,483 inhabitants and 3,157 for Garfield County. Most of these people live in the west parts 50 miles away.

Hanksville maintains tourist accommodations, such as gas stations, motels and cafes. Except for a few government workers most of the population raises livestock or grows hay and other forage crops. About 10 percent are employed in the uranium mines on the east side of the Henry Mountains or are prospectors.

The principal access route into Hanksville, Utah Highway 24, leaves Interstate 70 five miles west of Green River and extends 53 miles to Hanksille (figure 1). It continues westward across the north end of the Henry Mountains Basin to west Wayne County, essentially paralleling the Fremont River. At Hanksville Utah Highway 95 extends southeastward along the east side of the Henry Mountains and eventually crosses the Colorado River into San Juan County or branches to Bullfrog Basin south of the Henrys. Several graded roads, although rough, provide access into many parts of the basin. The most important of these, Halls Creek road, follows the Waterpocket Fold just west of the basin. There is a federally operated airport at Hanksville, but no regular air, rail or bus service into the area.

Climate

Nearly desert-like conditions prevail in the Henry Mountains Basin. Temperature ranges are great, precipitation and humidity are low. Considerably more moisture precipitates on the peaks because of their greater altitude. The climate is best explained by use of the rainfall map for the area and the climograph of Hanksville (figure 2). Hanksville is a low-elevation station and receives a little more than 5 inches of rain annually. Most comes in late summer as thunder showers. The summer high temperature average is in the high 90's and the winter low temperature average is about 12 or 13 degrees. The diurnal range throughout the year is consistently 30 degrees. At slightly higher elevations, such as at the basin, summer temperature averages drop slightly, about 10 degrees for the first 2,000 feet, but the winter temperatures remain about the same. The precipitation doubles to 10 inches. The highest of the Henry Mountains peaks receives 30 inches of precipitation annually.

The prevailing winds are generally from the southwest. They are not usually violent, but a few gusty days are expected. Summer storms are normally torrential and local. As much as 2 inches has dropped in one hour. Such storms create flash floods that wash out roads and do considerable erosional damage. As in most deserts the annual rainfall is not reliable and annual total precipitation figures fluctuate considerably from year to year. Hanksville has received as little as 2 inches and as much as 9 inches in a year.

HISTORICAL OUTLINE

The first coal mine of the area was opened in the Ferron Sandstone about 1890 at the south end of the basin and called the Stanton mine. The coal was used to power a gold dredge. The gold project failed and the coal mine was closed down. The life of the mine was at most three years, 1888 to 1891.

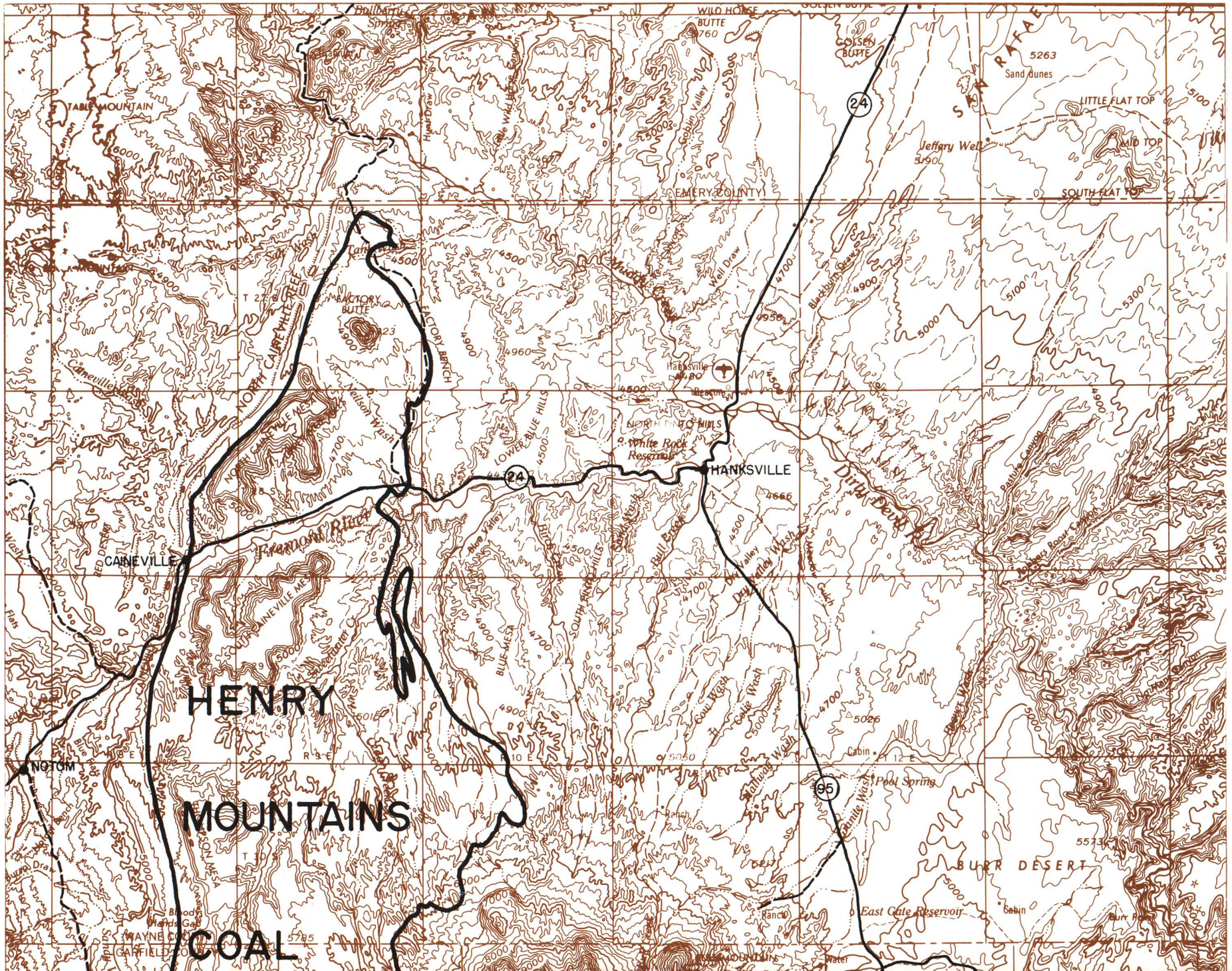
The Factory Butte mine opened on the Ferron coal zone in 1908 to supply domestic needs and coal in the Emery Sandstone was first used about 1914. These mines operated intermittently until at least 1945. No production is reported by the U. S. Bureau of Mines in the Minerals Yearbooks as the production from small wagon mines was omitted prior to 1940. Presently (1970) all mines are abandoned.

GEOLOGIC SETTING

Stratigraphy

Most of the surface of the Henry Mountains Basin exposes Cretaceous rocks; Jurassic rocks are exposed at the edges or where they were pushed upward by the laccolithic intrusions of the Henry Mountains peaks. Three of the Cretaceous units contain coal beds, two in minable proportions. The Jurassic Morrison Formation contains thin seamlets of coal in the proximity of its

[1]Economic geologist, Utah Geological and Mineralogical Survey.


HENRY
MOUNTAINS
COAL
CAINEVILLE
NOTOM
HANKSVILLE
EMERY COUNTY
TABLE MOUNTAIN
WILD HORSE BUTTE
GOLSEN BUTTE
SAN RAFAEL
Sand dunes
LITTLE FLAT TOP
MID TOP
SOUTH FLAT TOP
Jeffery Well
FACTORY BUTTE
FACTORY BENCH
NORTH CAINEVILLE REEF
NORTH CAINEVILLE MESA
SOUTH CAINEVILLE MESA
Fremont River
Neilson Wash
LOWER BLUE HILLS
White Rock Reservoir
Dirty Devil R.
Pool Spring
BURR DESERT
East Gate Reservoir
Blue Valley
Bull Creek
Dry Valley Wash
Cow Wash
Calle Wash
Hanksville
Beacon
Well Draw
Bladburn Draw
Pasture Canyon
Jackpers Roost Canyon
Cabin
Ranch
Water
24
95

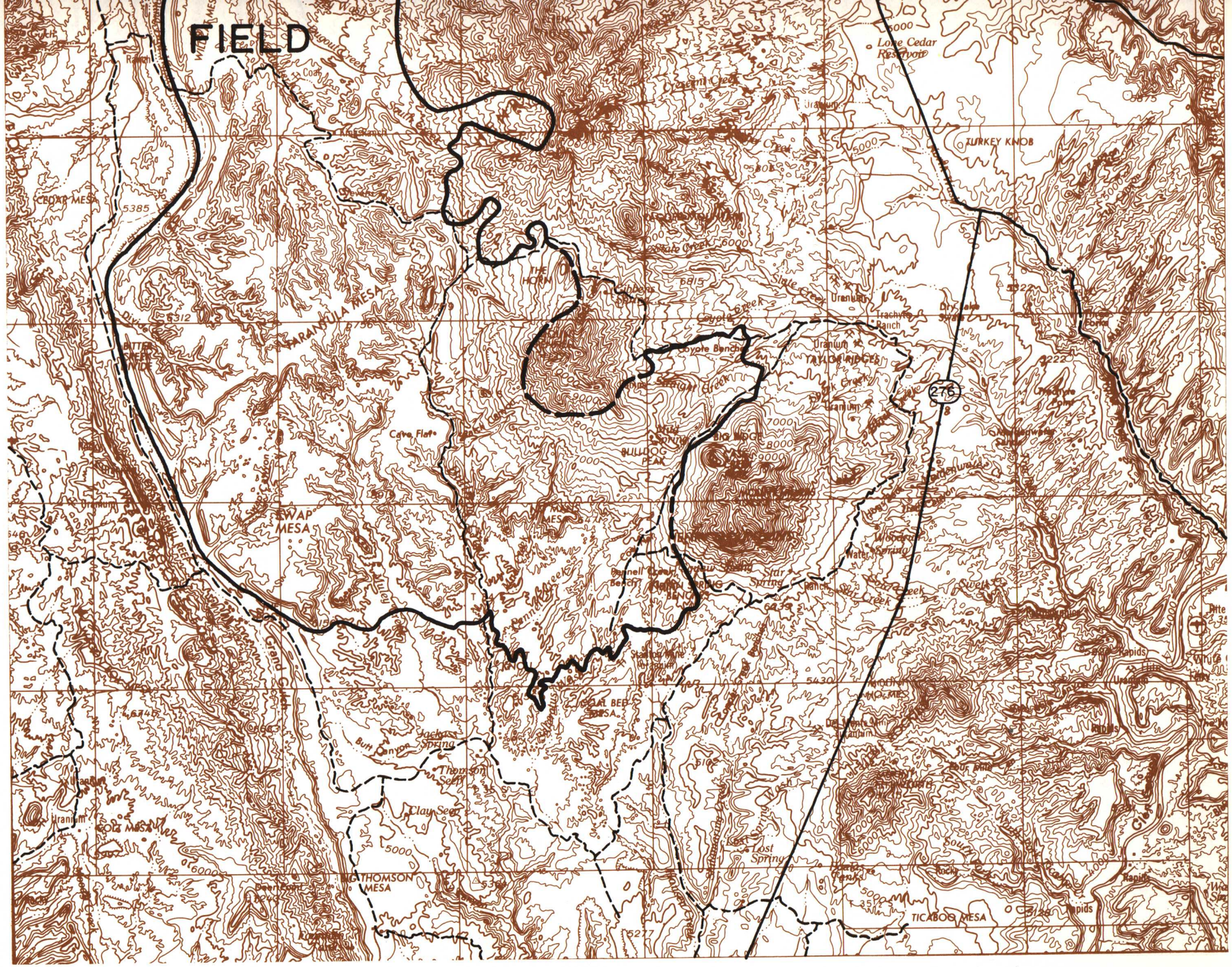
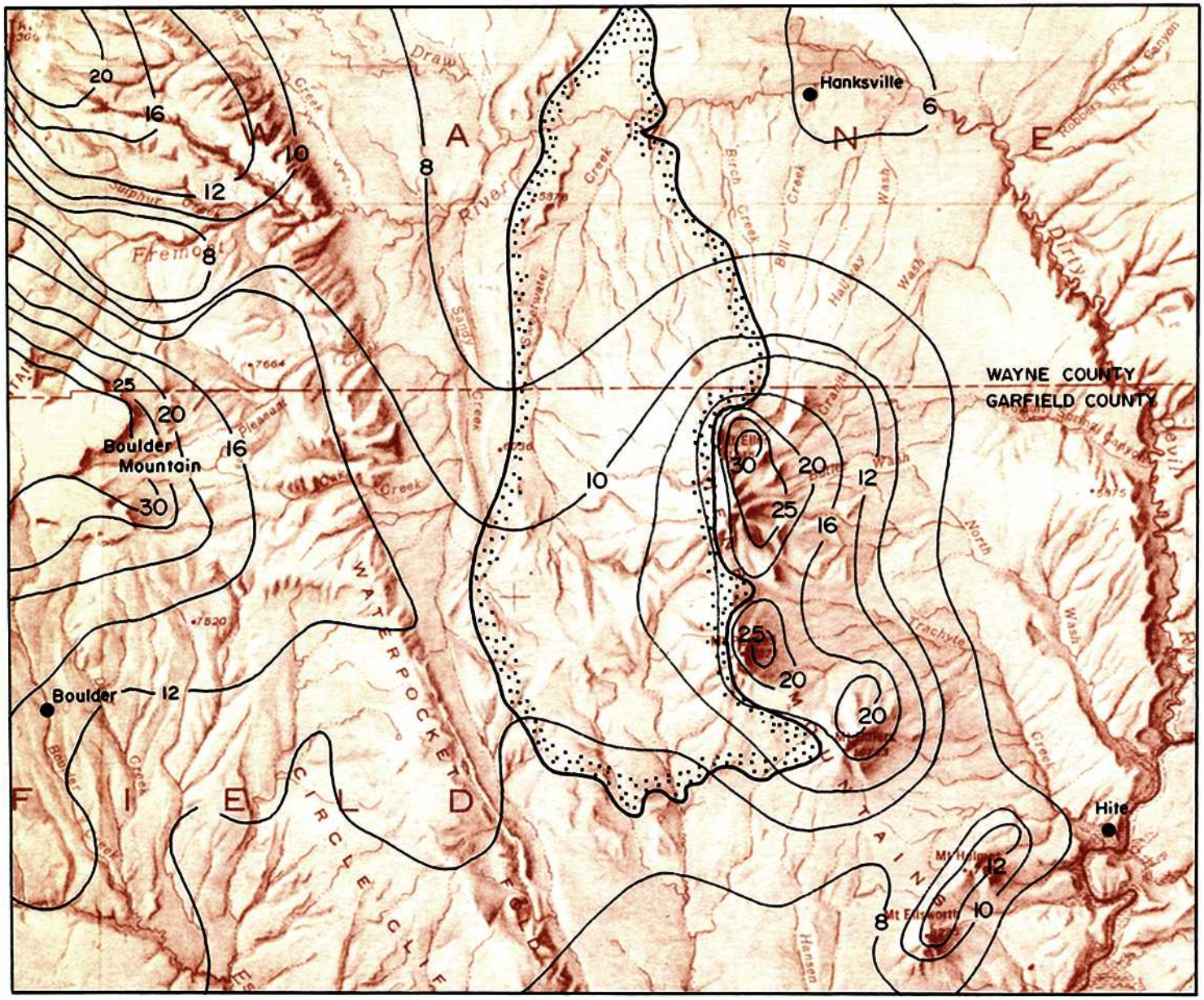
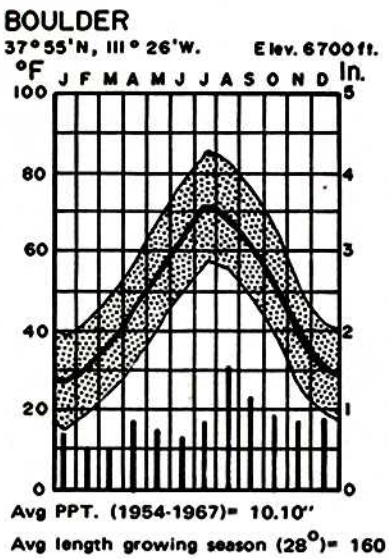


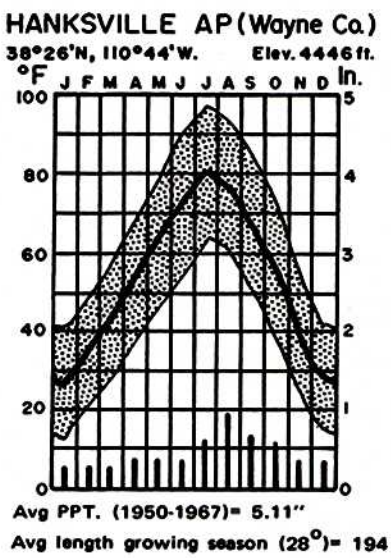
Figure 1. Topography and roads map, Henry Mountains coal field





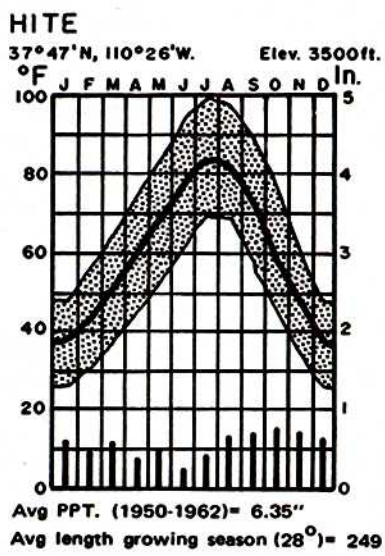
Avg PPT. (1954-1967)= 10.10"

Avg length growing season (28°)= 160 days



Avg PPT. (1950-1967)= 5.11"

Avg length growing season (28°)= 194 days.



Avg PPT. (1950-1962)= 6.35"

Avg length growing season (28°)= 249 days

Figure 2. Rainfall map (isohyetals in inches) and climographs of weather stations in Garfield County and vicinity (based on U. S. Weather Bureau data, 1950-1967), Henry Mountains coal field.

uranium and vanadium deposits. Recognition of formations in the Henry Mountains region best commences with the Navajo Sandstone and ends with the Mesaverde Sandstone when one is investigating the coal deposits. Identification of geologic formations (figures 3 and 4) is especially easy in the Henry Mountains which explains why it is regarded as a classical geologic area.

Navajo Sandstone

The Navajo Sandstone is the most easily recognized formation in south Utah. It is exposed along the Waterpocket Fold just west of the Halls Creek road and along the San Rafael Reef. The Navajo is typically a resistant massive, highly cross-bedded aeolian sandstone, gray to pink or pale red in color. The sand grains are well rounded and frosted. Near the top and bottom of the 800-foot unit are some horizontal bedding planes. Near the top the color is more red and brown, probably the result of staining from overlying units. The upper contact is sharp and unconformable. The Navajo along Waterpocket Fold is steeply folded and highly jointed. These joints form narrow canyons with vertical walls up to 500 feet high. The canyons are dead ends and average 15 feet in width.

Carmel Formation

The Carmel forms flatiron scabs on the Navajo along the Waterpocket Fold. It varies notably in lithology, but its deep red and brown coloration is the most noticeable characteristic. It is made up of nonresistant red sandstone, reddish siltstone and shale, white to light green gypsum and a few beds of gray limestone. A section measured along Waterpocket Fold a quarter mile north of the mouth of Muley Twist Canyon describes the Carmel well:

Section of Carmel Formation measured in 12-35S-8E, Garfield County, by Hunt (1953, p. 67).

Entrada Sandstone Carmel Formation	Feet
5. Sandstone, deep red with white bands at intervals of 5 to 10 feet, fine-grained, irregularly jointed; gradational into unit 4 below and into Entrada above, except Entrada not jointed	28
4. Gypsum, shale and sandy shale, gypsum white and sugary in beds 3 to 5 feet thick; shale and sandy shale, red, and veined with gypsum; gypsum more abundant in lower part	102
3. Shale and sandy shale, red; network of gypsum veinlets especially in upper part	49
2. Limestone and sandy limestone, greenish white, thin-bedded	17
1. Sandstone, shaley, deep red; a few massive sandstone beds 1 to 2 feet thick, ripple marks; contact with Navajo sharp, but only few inches of relief	37
Total Carmel Formation	233

Entrada Sandstone

The Entrada is an easily erodable sandstone unit usually forming wide sandy flat areas. The San Rafael Desert north of Hanksville, the Burr Desert on the east side of the Henrys and the Cane Springs Desert at the south end of the Henry Mountains Basin are all on it. Along Waterpocket Fold it is tilted and its outcrop belt is narrow. Nevertheless it forms the valley of Halls Creek and much of the Waterpocket Fold (Halls Creek) road is built on it. The formation thickens from 300 feet at the south end of the San Rafael Swell to about 700 feet along Halls Creek. The outcrop belt completely surrounds the Henry Mountains Basin and on the west side demonstrates a different facies than on the east side. To the east is a sandy facies and to the west is a red earthy facies. The latter is probably of greater importance because the Entrada is closer to the coal measures there.

Section of Entrada Sandstone measured in 18-35S-9E, Garfield County, Utah, by Hunt and others (1953, p. 67).

Summerville Formation –Unconformity– Entrada Sandstone	Feet
6. Sandstone, white, fine-grained, cross-bedded, massive, no bedding planes, forms vertical cliffs	136
5. Sandstone, orange, massive, bands of white sandstone and bedding planes at intervals of 10 to 30 feet	127
4. Sandstone, white, cross-bedded, poorly cemented; sand grains well frosted	53
3. Sandstone, orange, fine-grained, cross-bedded, massive	46
2. Sandstone, red with thin white bands, earthy; parallel bedding planes at intervals of a few feet; forms flats and gentle slopes in contrast with units 3 to 6 and unit 1	150
1. Sandstone orange, fine-grained, cross-bedded, in layers 3 to 15 feet thick; sand grains well rounded, poorly cemented; weathers brown; erodes into beehive-shaped rocky knobs	181
Total Entrada Sandstone	693

Curtis Formation

The Curtis is present only in the north third of the Henry Mountains region and is completely missing in the Garfield County portion. Along the south end of the San Rafael Swell it is 100 to 175 feet thick and is represented by thin, rather persistent sandstone beds. The sandstone is thinly laminated or shaley. Thin conglomeratic beds also occur. Where present the gray beds contrast with the brownish to reddish units above and below.

Summerville Formation

The next younger unit is the Summerville which is recognized by its chocolate brown color and thin even beds. The unit is mainly fine-grained sandstone. Occasionally individual thin beds are light green with occasional irregular seamlets or nodules of white to pink gypsum in it. Beds of smooth and earthy weathering sandstone alternate. The Summerville is seen often as a vertical escarpment capped by a resistant sandstone or conglomerate of the Morrison Formation. The contact with this overlying unit is unconformable and channels have been cut into the upper Summerville surface. The thickness of the unit varies from 40 to 250 feet.

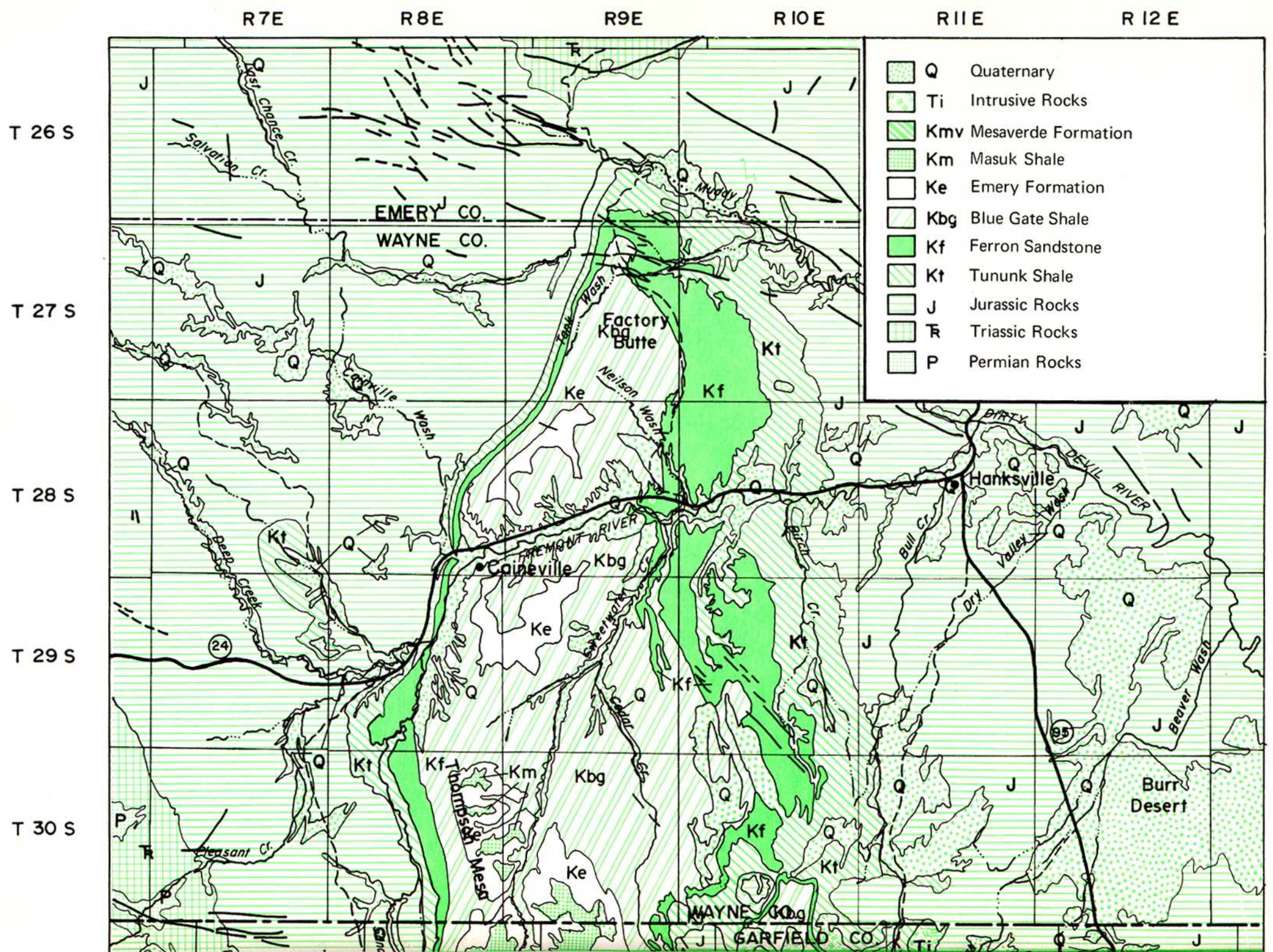
Morrison Formation

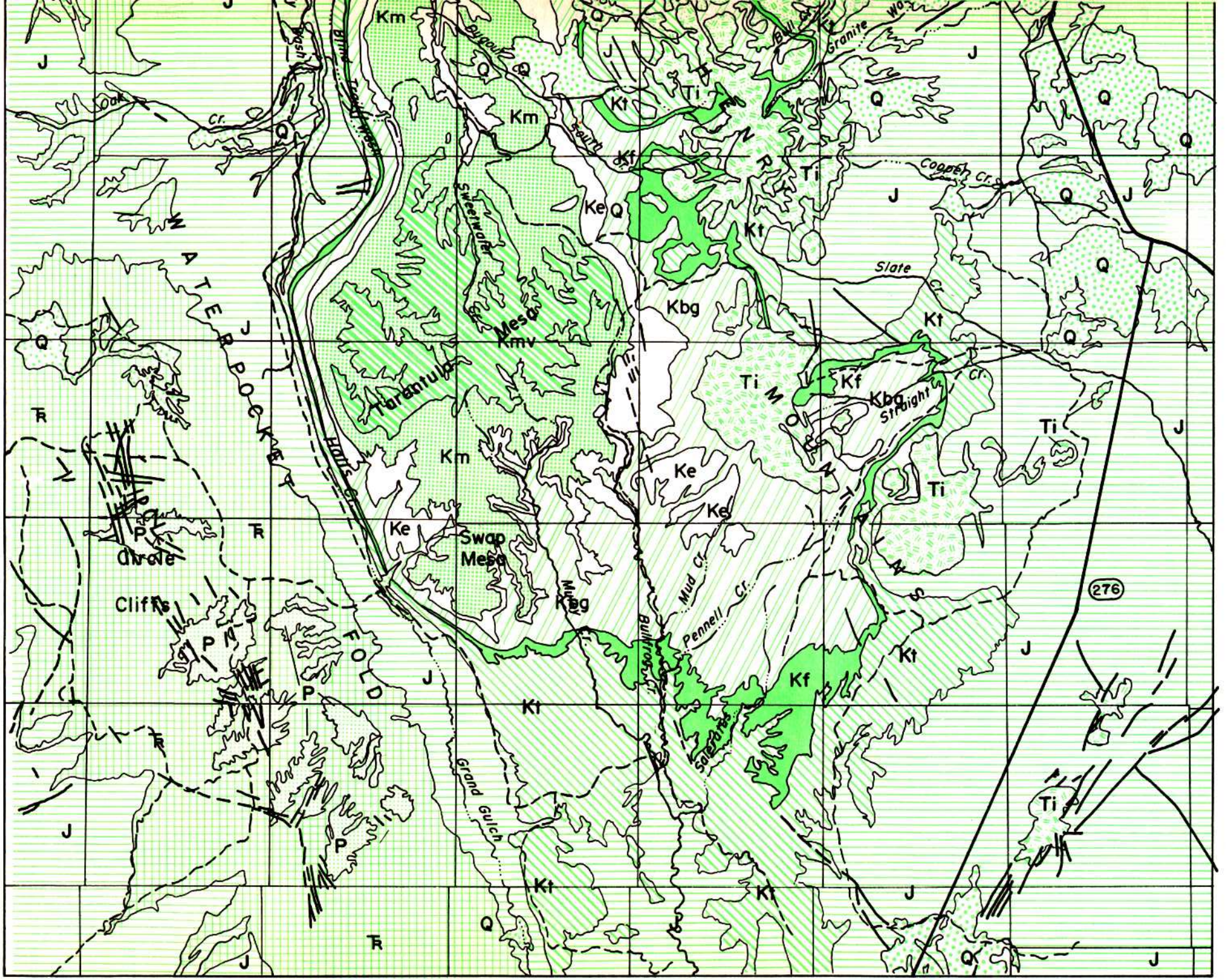
The Morrison is the final Jurassic unit in the Henry Mountains area. The normal thickness ranges from 500 to 600 feet, but thinner and thicker sections have been measured. The Morrison consists of the Salt Wash and Brushy Basin members. The Salt Wash is gray, yellowish gray to yellowish brown, lenticular, quartzose sandstone. It may be thin-bedded to massive, but medium to thick beds dominate. It contains interbeds of conglomeratic sandstone, conglomerate and greenish, grayish and purple mudstones. The thickness ranges from 175 to 500 feet. In several areas the Salt Wash is uraniferous and vanadiferous. The mineralization is localized in intercalated lenses of carbonized vegetal matter. Small seamlets of coal are often recognizable near the uranium minerals.

The upper or Brushy Basin Member consists mostly of clay and mudstone with subordinate limestone, sandstone and conglomerate lenses. Much of the clay is bentonitic and locally silicified wood, "gizzard stones" and bone fragments are abundant. The variegated colors of the Brushy Basin are reminiscent of a rainbow. The thickness of the Brushy Basin varies up to 400 feet.

Dakota Sandstone

Unconformably atop the Brushy Basin is the Dakota Sandstone. It is the first Cretaceous unit and it is coaliferous. The unit is not thick and varies up to 100 feet. It is a heterogeneous unit of yellow-gray to brown lenticular sandstone, gray shale and carbonaceous beds. Along Waterpocket Fold it contains fossil shells in a particular layer of sandstone which is called Oyster Ridge. Some of the sandstone beds are conglomeratic. The


R7E
R8E
R9E
R10E
R11E
R12E
T 26 S
T 27 S
T 28 S
T 29 S
T 30 S
Q Quaternary
Ti Intrusive Rocks
Kmv Mesaverde Formation
Km Masuk Shale
Ke Emery Formation
Kbg Blue Gate Shale
Kf Ferron Sandstone
Kt Tununk Shale
J Jurassic Rocks
TR Triassic Rocks
P Permian Rocks
EMERY CO.
WAYNE CO.
GARFIELD CO.
Factory Butte
Caineville
Hanksville
Burr Desert
Thompson Mesa
FREMONT RIVER
DIRTY DEVIL RIVER
Last Chance Cr.
Salvation Cr.
Muddy Cr.
Tank Wash
Neilson Wash
Cainville Wash
Deep Creek
Sweetwater Cr.
Cedar Cr.
Birch Cr.
Bull Cr.
Dry Valley Wash
Beaver Wash
Pleasant Cr.
24
95


T 31 S
T 32 S
T 33 S
T 34 S
T 35 S
T 36 S
WATERPOCKET FOLD
HENRY MOUNTAINS
Circle Cliffs
Swap Mesa
Tarantula Mesa
Sweetwater
Oak Cr.
Bullfrog Cr.
Mud Cr.
Pennell Cr.
Cooper Cr.
Slate Cr.
Straight Cr.
Granite Wash
Grand Gulch
Salerates
Halls Cr.
Bullfrog Cr.
Bugout Cr.
Km
Kt
Kf
Ke
Kbg
Kmv
Ti
Q
J
P
TR
276

System	Series	Stratigraphic Unit		Thickness (feet)	Description
CRETACEOUS	Campanian	Mesaverde Formation		400	Cliff-forming sandstone containing thin interbeds of shale.
	Santonian	Mancos Shale	Masuk Shale	600- 800	Lenticular sandstone shale, carbonaceous shale and shaley limestone. Mostly continental in origin, but some is marine.
			Emery Sandstone *MAJOR COAL*	240- 450	Lower 150 feet are massive sandstone and shale, carbonaceous shale and *coal* above this unit.
	Coniacian		Blue Gate Shale	1,500	Shale, blue-gray, marine.
	Turonian		Ferron Sandstone *MAJOR COAL*	150- 350	Lenticular sandstone, shale, carbonaceous shale and *coal*, in upper 50 to 100 feet. Sandstone and thin beds of shale in lower 90 to 150 feet.
	Cenomanian		Tununk Shale	525- 650	Shale, blue-gray, marine; numerous thin beds of bentonite.
	Albian	Dakota Sandstone *Minor Coal*		0- 100	Cliff-forming conglomeratic sandstone; locally *coal*-bearing carbonaceous beds lie between two beds of sandstone.
					Unconformity
JURASSIC	Upper	Morrison Formation		350- 750	Upper part mostly clay and shale, variegated, dominantly green gray, maroon and mauve; lower part mostly sandstone and conglomerate, gray, very lenticular, massive, cross-bedded; often impregnated with uranium and vanadium minerals.
					Unconformity
		Summerville Formation		40- 250	Evenly bedded, reddish brown sandstone and sandy shale; minor amounts of greenish white sandstone, gypsum and limestone.
		Curtis Formation		0- 175	Evenly bedded gray sandstone and shaley sandstone, glauconitic, numerous siliceous geodes and concretions at some places. Local thin basal conglomerate; marine.
					Unconformity
		Entrada Sandstone		300- 700	Thick-bedded and cross-bedded buff and brown sandstone; weathers in rounded forms; thinner bedded earthy sandstone to north; forms flat sandy areas.
		Carmel Formation		100- 626	Thin-bedded red sandstone, shaley sandstone and shale; thin limestone and gypsum.
					Unconformity
	Lower	Navajo Sandstone		515- 815	Tan to light gray massive cross-bedded sandstone; thin lenses of limestone.
PRE-JURASSIC ROCKS		Kayenta Formation Wingate Sandstone Chinle Formation Shinarump Conglomerate Moenkopi Formation Kaibab Formation Coconino Sandstone		240- 320 270- 380 200- 855 12- 275 250- 700 0- 100 600+	Formations of various lithologies of Permian and Triassic age exposed along Waterpocket Fold and in the Circle Cliffs and San Rafael Swell.

Figure 4. Generalized section of rock formations, Henry Mountains coal field.

carbonaceous and coaley beds are lenticular and usually thin. They were not measured unless beds were conveniently discovered in road cuts or seen from the road. The thickest reported coal bed is more than 6 feet along the North Caineville Reef. Stratigraphic sections of the Dakota measured at intervals around the basin are presented in figure 5. The Dakota usually forms a resistant ledge.

Tununk Shale

The Tununk is the first of five members that make up the Mancos Shale. The unit ranges from 525 to 650 feet thick and is dominantly a gray marine shale. When supported by the resistant sandstone beds of the Ferron above, it occurs in the first gray cliff east of Waterpocket Fold. Some of the shales are bentonitic with thin brown sandstone beds. The unit grades upward into the Ferron Sandstone Member and the contact is placed normally at the base of the first thick sandstone unit.

Ferron Sandstone (figure 6)

The Ferron is an important coal bearer of the Henry Mountains coal field. It usually consists of three parts, each of varying thickness. In areas the upper and lower parts are thin or missing; at other locations they are equal in thickness to the middle part. The lower unit is a sequence of interbedded shale and sandstone. The shale is gray and typical of that in the Tununk below. The sandstones are thin- to thick-bedded, gray to brown in color and fine- to medium-grained. The base of the Ferron is usually placed at the bottom of the first thick-bedded sandstone. This unit is a transitional zone between the Tununk and Ferron and represents an intertonguing of the two units.

The middle unit is dominated by massive sandstone, yellow-gray to tan and brown in color, fine- to coarse-grained, cliff forming and calcareously cemented. Occasional interbeds and partings of shale, carbonaceous shale and even thin coal occur. Thick and massive beds are somewhat cross-bedded.

The upper beds consist of interbedded sandstone, shale, carbonaceous shale and coal and all beds are lenticular. The sandstone is light colored, frequently yellow, white or brown and often streaked with coaley material. The sandstones often contain petrified wood, are medium-grained and sometimes gritty or conglomeratic. The shales are mainly gray to brown; the latter color prevails when the carbonaceous matter is more abundant. Occasionally purplish siliceous beds outcrop. The coal is present over a narrow interval rarely exceeding 20 feet in one or more beds. In some places the coal is immediately below a very thin (less than 1-foot) sandy layer which in turn is the uppermost bed of the Ferron. In other places this thin friable layer thickens into a reef-like sandstone bed a few tens of feet thick.

The Ferron is thickest in the vicinity of Caineville and thins to 150 feet at the east side of the basin. From Caineville it thins slightly southward along Waterpocket Fold and may be as thin as 122 feet near The Post. Along the south margin of the basin the Ferron appears to average 150 feet. Gregory and Moore (1931, p. 108) measured only 65 feet of the unit along Waterpocket Fold near Burr Trail, but some may have been covered by Blue Gate-like alluvium. Gregory and Moore described the unit as white, calcareous, cross-bedded, grading to yellow flaggy sandstone, soft and massive below with a thin lignite bed 23 feet above the base.

Blue Gate Shale

The Blue Gate nearly duplicates the Tununk, except that it is thicker–an estimated 1,100 to 1,400 feet thick. The lower two-thirds is an almost homogeneous laminated shale. The upper third is intercalated with platy calcareous sandstone beds. The Blue Gate is normally supported in a cliff by the Emery Sandstone. The cliff appears as a huge gray curtain underneath the yellow sandstones of the Emery. The walls of Factory Butte, North and South Caineville mesas and Wildcat and Swap mesas are typical examples.

Emery Sandstone (figure 7)

The Emery Sandstone is exposed in the interior part of the Henry Mountains Basin and is the coal field's most important coal bearer. Like the Ferron the Emery can be subdivided into three

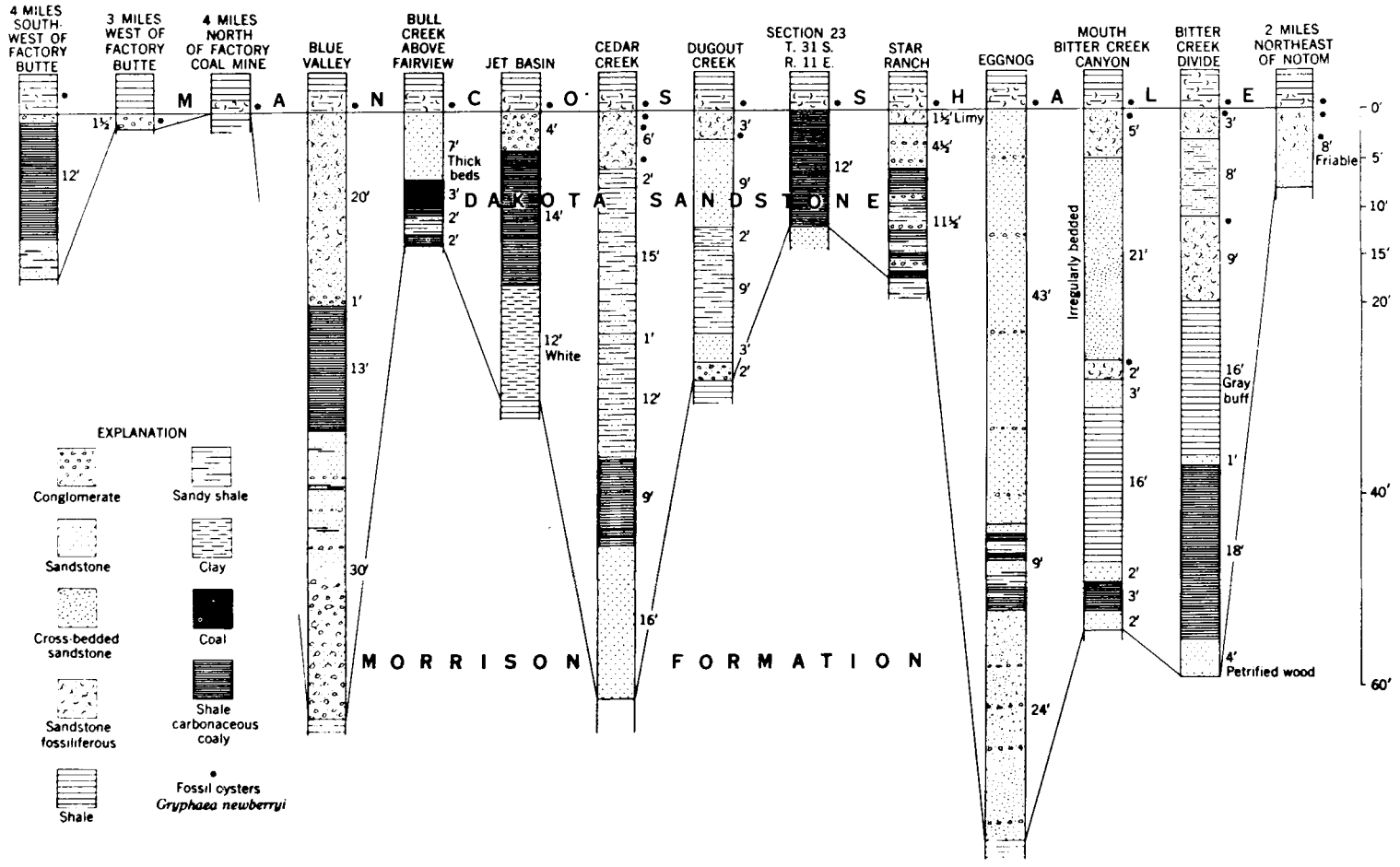


Figure 5. Stratigraphic sections of the Dakota Sandstone (after Hunt, 1953).

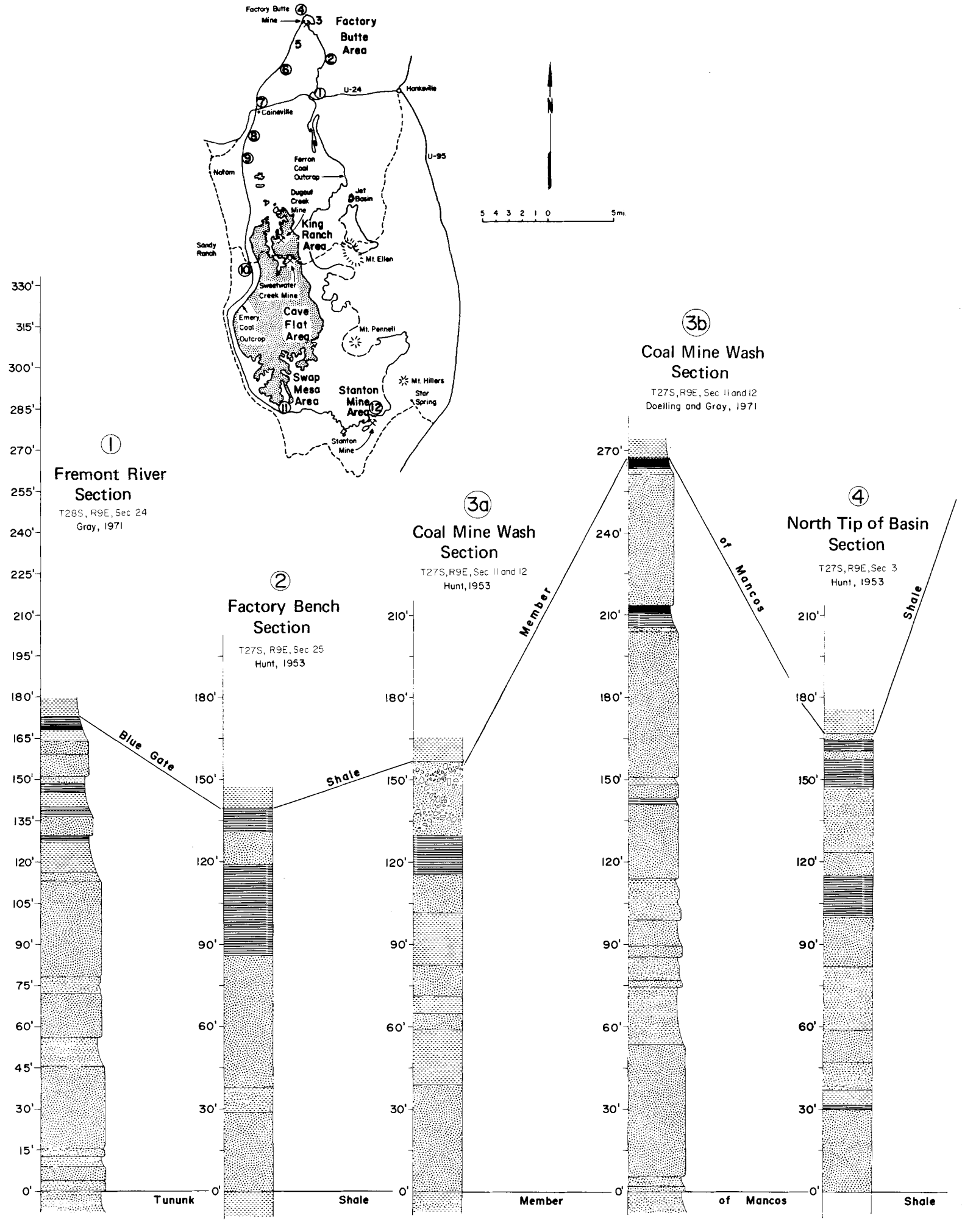
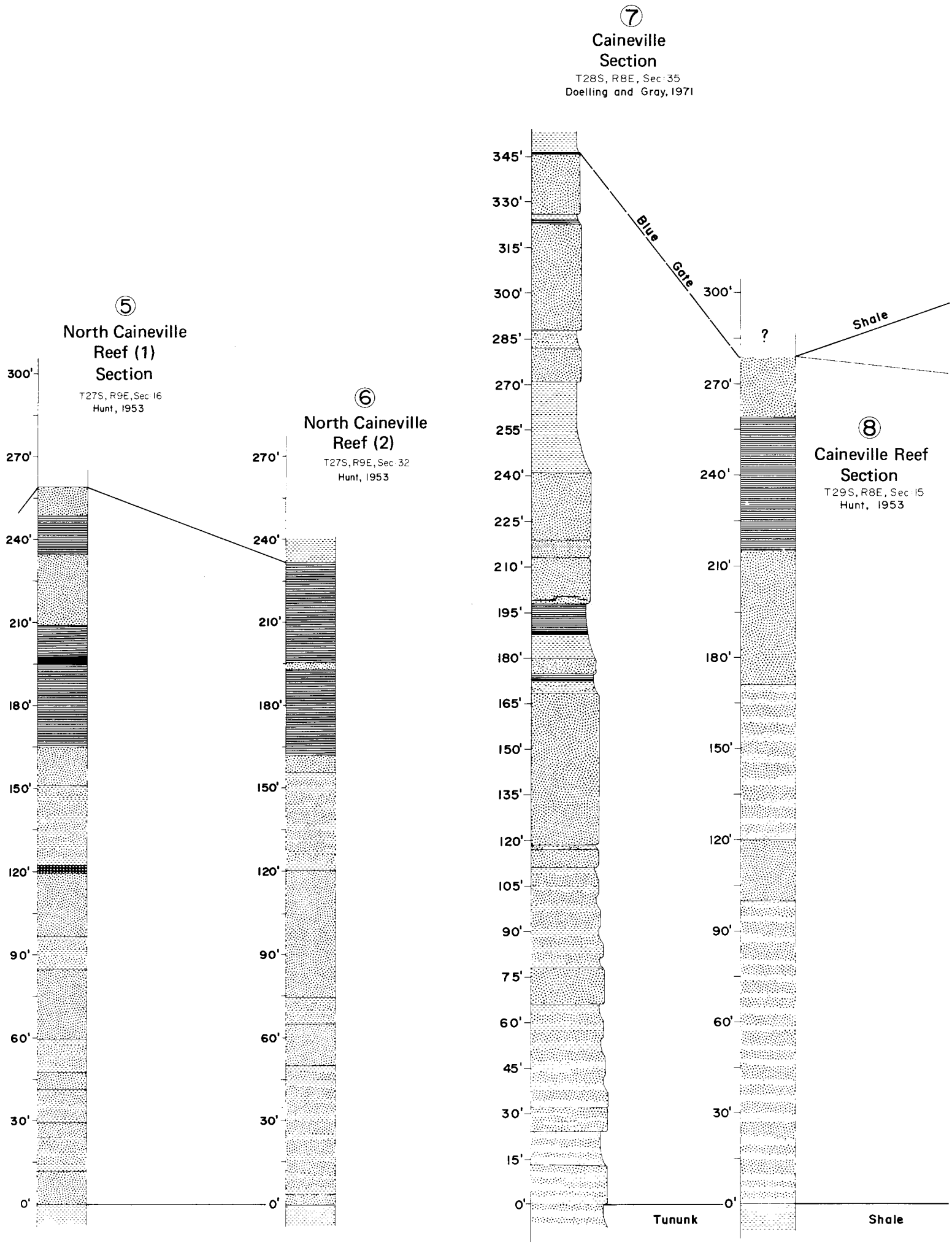


Figure 6. Coal sections of the Ferron Sandstone Member of Mancos Shale, Henry Mountains coal field.



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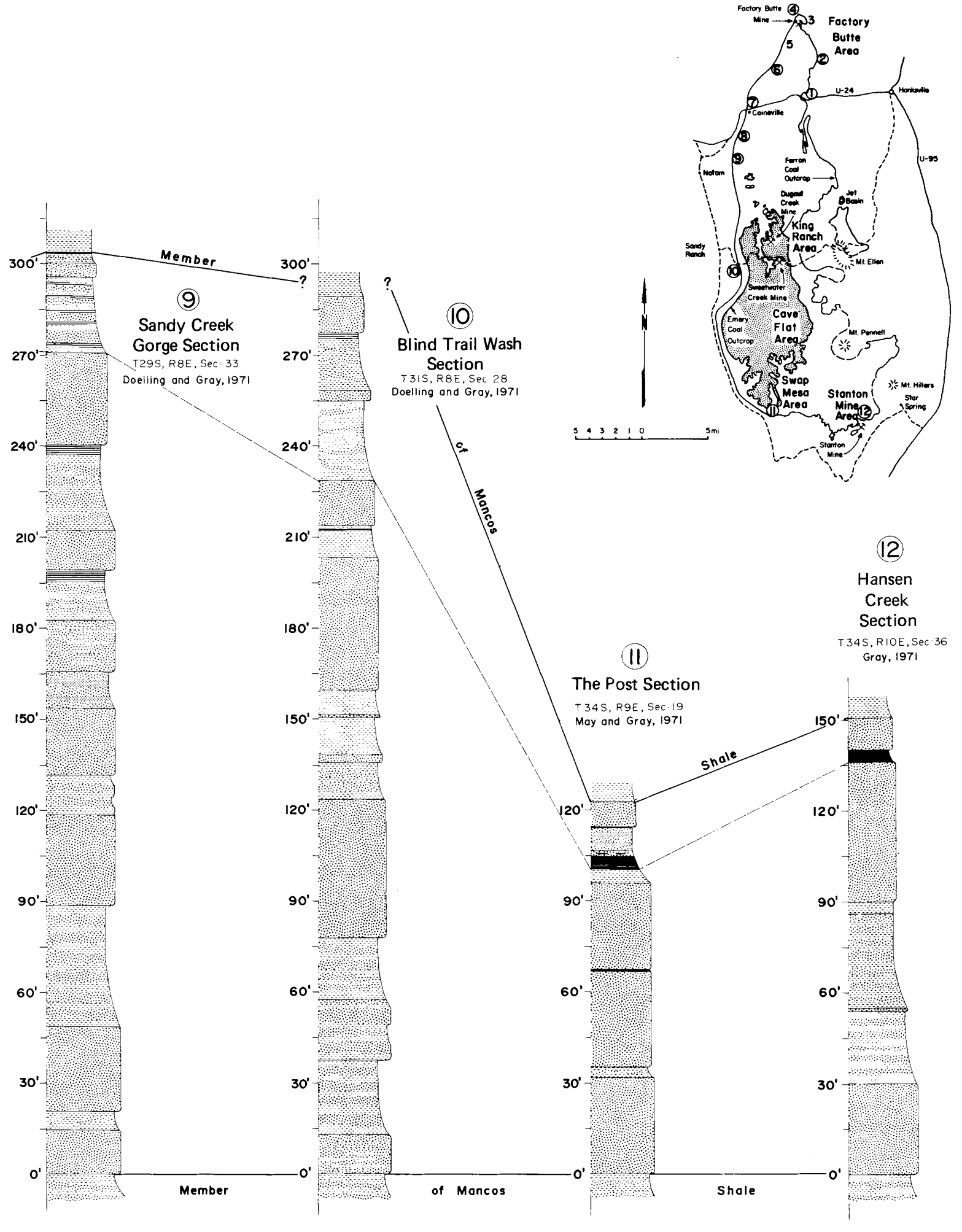

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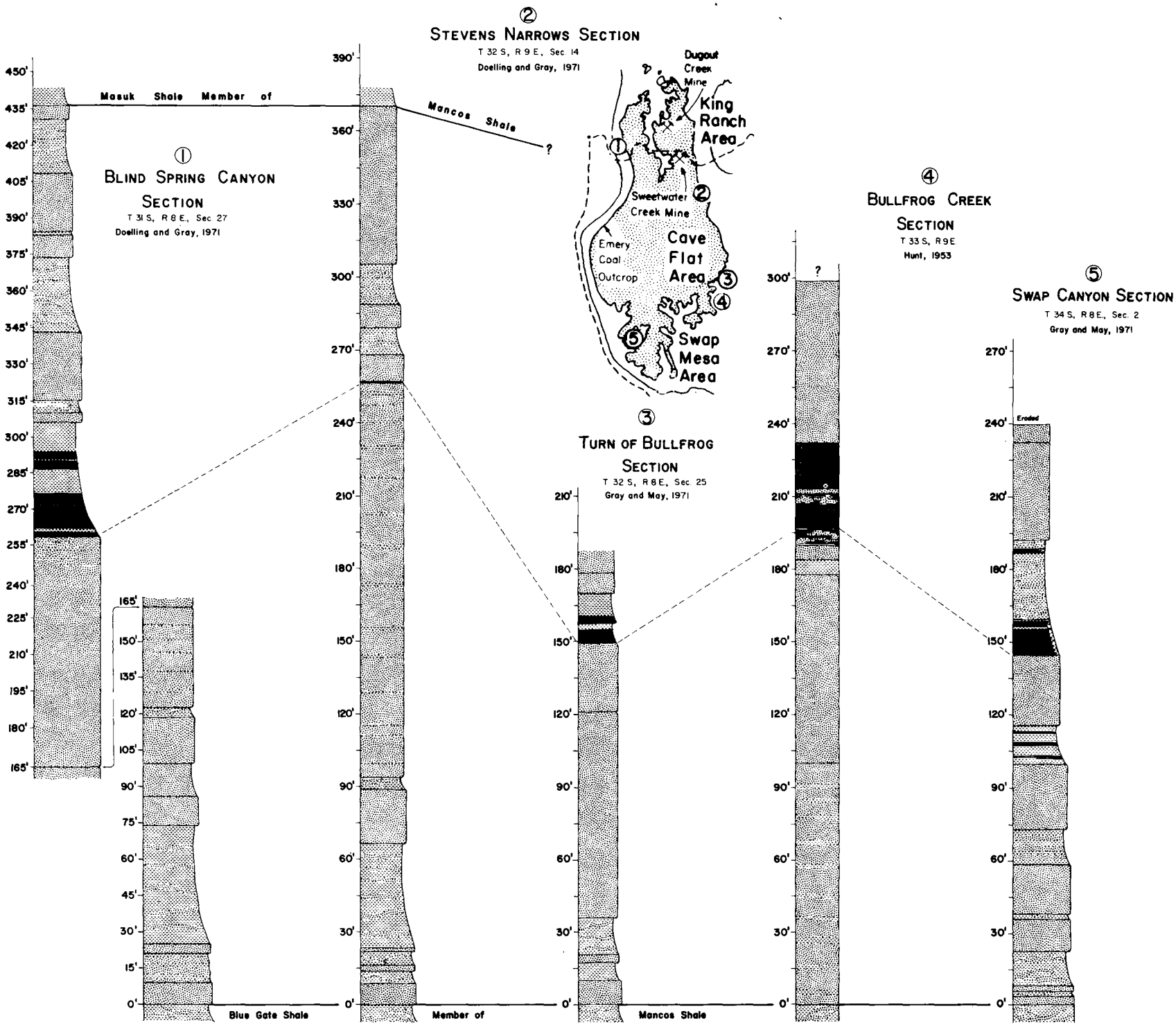


Figure 7. Coal sections of the Emery Sandstone Member of Mancos Shale, Henry Mountains coal field.

units. The lower transitional zone with the Blue Gate is usually thin. The upper Blue Gate Shale is sandy and consists of a rather thick sequence of interbedded shale and thin-bedded sandstone. As for the Ferron the base of the Emery is usually placed at the bottom of the first thick-bedded sandstone.

The middle cliff-forming member quickly follows. It consists of 15- to 40-foot sandstone beds separated by shale partings or thin beds of sandy shale. The sandstone is mostly medium-grained, yellow gray to brown and cliff forming. The Emery coal zone is next, 25 to 50 feet thick consisting mostly of gray shale and coal, but including some thin lenticular sandstone beds. The remainder of the Emery consists of resistant beds with minor amounts of shale and coal. These form a step-like outcrop pattern. Toward the top the sandstone beds thin and sandy shale beds of the overlying Masuk replace them.

Section of Emery Sandstone Member, east side of Bullfrog Creek, half a mile below Cave Camp, modified from Hunt and others (1953, p. 84).

Masuk Shale Emery Sandstone	Feet
1. Sandstone, massive	66
2. Shale, carbonaceous, with thin streaks of coal	19
3. Sandstone, thin-bedded	2
4. Shale, carbonaceous and sandy	5
5. Coal	1
6. Coal, shaley	2
7. Coal	6
8. Shale, carbonaceous and sandy	7
9. Sandstone, thin-bedded	6
10. Shale, carbonaceous	6
11. Sandstone, massive, top 10 feet thinly bedded	78
12. Sandstone, massive, in beds 5 to 10 feet thick separated by shale in beds 2 to 3 feet thick	100
Total Emery Sandstone	298

Blue Gate Shale: interbedded sandstone and shale at top of Blue Gate.

Hunt and others (1953, p. 84) note that a moderately thick, massive sandstone generally is present at the top of the Emery Sandstone. This moderately thick unit is regarded by them as the base of the Masuk, but in this paper all the thick sandstone beds are included with the Emery. A better developed section of the Emery was measured in the Notom quadrangle and appears in that quadrangle report. Coal occurs nearly everywhere along the Henry Mountains Basin Emery outcrops, except between Steele Butte and Stevens Narrows. Coal in single seams up to 9 feet thick is present.

Masuk Shale

The Masuk is 600 to 800 feet thick and limited in outcrop to the central Henry Mountains Basin area beneath Tarantula Mesa. The contact with the underlying Emery Sandstone is gradational and difficult to place. In this report some of the Masuk of other investigators may be included with the Emery. The Masuk is composed of irregularly bedded, sandy gray shale, sandy carbonaceous shale and sandstone. In the Wasatch Plateau region to the west the Masuk is much like the Blue Gate or Tununk, but in the Henry Mountains it includes interbedded littoral and lagoonal beds. In fact shaley sandstones dominate. Physiographically the Masuk acts as the Blue Gate and Tununk.

Section of Masuk Shale near Bitter Creek Divide, T. 33 S., R. 8 E., by Hunt and others (1953, p. 85).

Top massive sandstone of Mesaverde Formation Masuk Shale	Feet
Clay, brown and earthy	8
Sandstone, light tan and yellow, massive bedding, poorly cemented and friable; locally contains small pebbles	16
Sandstone and shale in equal proportion; shale gray, in beds 1 to 8 feet thick; sandstone, light yellow, in beds 1 to 15 feet thick	87
Shale, partly sandy mostly dark, some light colored bands	62
Sandstone, light yellow, mostly shaley	160
Sandstone, light yellow and shaley; some resistant ledges; includes 10 feet of earthy, brown, slightly carbonaceous shale near top	50
Sandstone and shaley sandstone; top feet are hard and form cliff	95
Shale, gray clay, with two thin sandstone beds	45
Sandstone, cross-bedded, some beds hard, others soft and friable; includes minor amounts of shale	122
Shale, gray	8
Sandstone, fine-grained; hard, forms ledge	5
Shale, gray and brown, very shaley coal and coaley streaks 4 feet above base	23
Sandstone, white, fine-grained, cross-bedded	52
Shale, some earthy sandstone	18
Sandstone, massive, poorly cemented, white, fine-grained	36
Total Masuk Shale	787

Mesaverde Formation

Capping Tarantula Mesa are 400 feet of cliff-forming sandstone with thin interbeds of shale. The mostly fine-grained sandstone is locally conglomeratic with no coal. The sandstone probably correlates with the littoral Star Point Sandstone of the Wasatch Plateau and Book Cliffs.

Igneous Rocks

Each of the Henry Mountains peaks exposes stocks or laccoliths composed of diorite or monzonite porphyry. Boulders and cobbles of the rock lie almost everywhere in the higher elevated parts of the basin. The rock is usually light gray and large phenocrysts of feldspar are conspicuous; small phenocrysts of hornblende also are present and large hornblendic inclusions are common.

Surficial Deposits

Of the many varieties of surficial deposits noted in the Henry Mountains region, four are basic: alluvium, colluvium, gravel and boulder deposits. Alluvium consists of stratified sand, silt, clay and some gravel along with some unsorted flood deposits along stream courses or flat valleys. Colluvium usually occurs on sandy formations such as the Entrada in the form of sand dunes and sandy soil. Essentially it is mixed aeolian and fluviatile deposition or accumulation. Gravels occur on pediment surfaces around the foot of the mountains and as terrace deposits along the main streams. They often cover the coal beds and formations in the King Ranch area. The boulder deposits, present only on the flanks of high peaks, consist mostly of broken pieces of diorite or monzonite.

Structure

The Henry Mountains structural basin is the dominant feature of the region; according to Hunt and others (1953, p. 88) it is the counterpart of the Circle Cliffs and the San Rafael Swell upwarps which border it, being the same size and form, only inverted. The structure is elongate and asymmetric. The steep limb to the west is shared with the Circle Cliffs and this monocline is known as the Waterpocket Fold. Along the monocline dips exceeding 45 degrees are locally common, but the average inclination is 20 to 30 degrees. The Waterpocket Fold marks the west boundary of the Henry Mountains coal field. A mile or two east of the fold the beds are nearly horizontal and in an additional 2 miles the major axis of the basin is reached. The east limb of the basin is gentle and beds rarely exceed 10 degrees except in the vicinity of the peaks. The trough of the basin is centered under Tarantula Mesa.

The Henry Mountains intrusions have domed the beds and broken through the rock. Some of the beds are vertical and overturned. These intrusions roughly parallel the basin axis 10 to 15 miles to the east. They effectively delineate the east boundary of the coal field. Some of the Cretaceous coal-bearing beds extend to the east side of the mountains, but the area of outcrop is small and broken by the deformation that was attendant to the intrusive activity.

The beds plunge into the trough at Tarantula Mesa from the north and south. The plunge is gentle, probably not exceeding a degree or two. The coal horizons have been eroded away 12 miles south and 30 miles north of Tarantula Mesa.

In this area of laccolithic doming and steep folding few faults of consequence occur. When present they are of small displacement and extend for only a short distance. Occasionally they displace the coal measures. A generalized structure map (figure 8) and an east-west cross section across the basin (figure 9) are provided.

Geologic and Tectonic History

The geological history during the Mesozoic is similar to that encountered in the coal fields of central Utah and in the Colorado Plateau in general. At the beginning of Jurassic time the area was the site of a large sandy desert which stretched from Colorado to Nevada and from Arizona into Wyoming. About 800 feet of Navajo Sandstone collected near the Waterpocket Fold and 550 feet collected on the east side of the Henry Mountains structural basin. The Navajo continues to thin eastward toward Colorado.

The upper surface of the Navajo was planed flat by a marine incursion which deposited the Carmel. The sea was restricted, probbably very shallow and often dried out. The Henry Mountains area is located near the east shoreline of this sea. The Carmel thins eastward and loses its limestone and gypsum beds somewhere beneath the basin. The Entrada was deposited partly by water and partly by wind. The deposition is believed to have taken place in shallow water land-locked basins marginal to a north sea. The sea which deposited the Carmel encroached into south and central Utah from the north and then retreated from whence it came. The Entrada was undoubtedly deposited during this retreat.

The Curtis marks a brief return to marine conditions. It is present only in the north part of the area. Prior to its deposition the Entrada was planed off by erosion. The Curtis deposition was followed everywhere by Summerville deposition which, in fact, began in the south part of the region while the Curtis was being laid down to the north. The environment appears to have been in quiet water as attested by the even, thin varve-like beds. The presence of gypsum suggests aridity.

Definite fluvial conditions are suggested by the Morrison. Channel sandstone, interbedded shale and fossil logs attest to the floodplain streams that covered the area. The source of the clastics was to the south as the coarseness and thickness of the unit increase in that direction. The energy subsided as time went on and the amount of shale deposition increased. Volcanic-ash-derived bentonite attests that volcanism was prevalent in the latter part of Morrison time. Many dinosaurs roamed the land and their bones often are revealed in the sediments.

Most of the Lower Cretaceous time is represented by a hiatus in the Henry Mountains area. It probably represents a period of no tectonic activity, no subsidence or uplift. Sufficient erosion planed off the surface. Then subsidence resumed and a sheet of fluvial sand and clay covered the area from the southwest. Broad floodplains developed with swamps and lakes. Vegetation flourished and carbonaceous materials collected. In the meantime the Mancos sea began its encroachment from the east as subsidence increased. The sea eventually covered all the Henry Mountains region and extended westward to the present-day High Plateaus area. The shoreline remained there all during the Mancos deposition except for two dramatic regressions which deposited the Ferron and Emery. Orogenic pulses supplied the clastics from the west faster than the area could subside. Shale deposition changed to nearshore sand and finally to lagoonal and fluvial sand and shale. Coal forests flourished and in places thick coal was produced. All of the valuable coal of the Henry Mountains Basin was deposited during these two events.

After deposition of the Mancos the sea retreated permanently eastward. The Mesaverde Cliffs atop Tarantula Mesa represent a littoral environment and finish the sedimentary picture of the area. Deposition undoubtedly continued with marine beds being replaced by continental beds much as they were in the Wasatch Plateau and Book Cliffs areas. These beds were later eroded off.

According to Hunt and others (1953, p. 90) the Waterpocket Fold and presumably the Henry Mountains structural basin were formed between the close of Cretaceous time and the Eocene epoch. Eocene deposits cover the fold near Thousand Lake and Boulder mountains. Probably the tendency to deform the rock strata started much earlier and may have greatly influenced the local variation of the shorelines of the Mancos sea. These variations supposedly influenced the positions of the thicker coal beds.

The intrusion of the Henry Mountains laccoliths may have occurred anytime after Mesaverde deposition; investigators usually date them as early to mid-Tertiary. Thereafter the Colorado Plateau began its uplift and erosion instead of deposition dominated. This activity has continued to the present day.

Correlation with Surrounding Areas

Figure 10 correlates the Henry Mountains formations with those of other areas. The Cretaceous units match directly with those of the Wasatch Plateau-Emery and the Book Cliffs coal fields of central Utah. Probably both the Emery and the Ferron correlate with the Straight Cliffs Formation of the Kaiparowits Plateau and with part of the Mesaverde Formation of the Black Mesa area of north Arizona.

COAL DEPOSITS

Status of Information

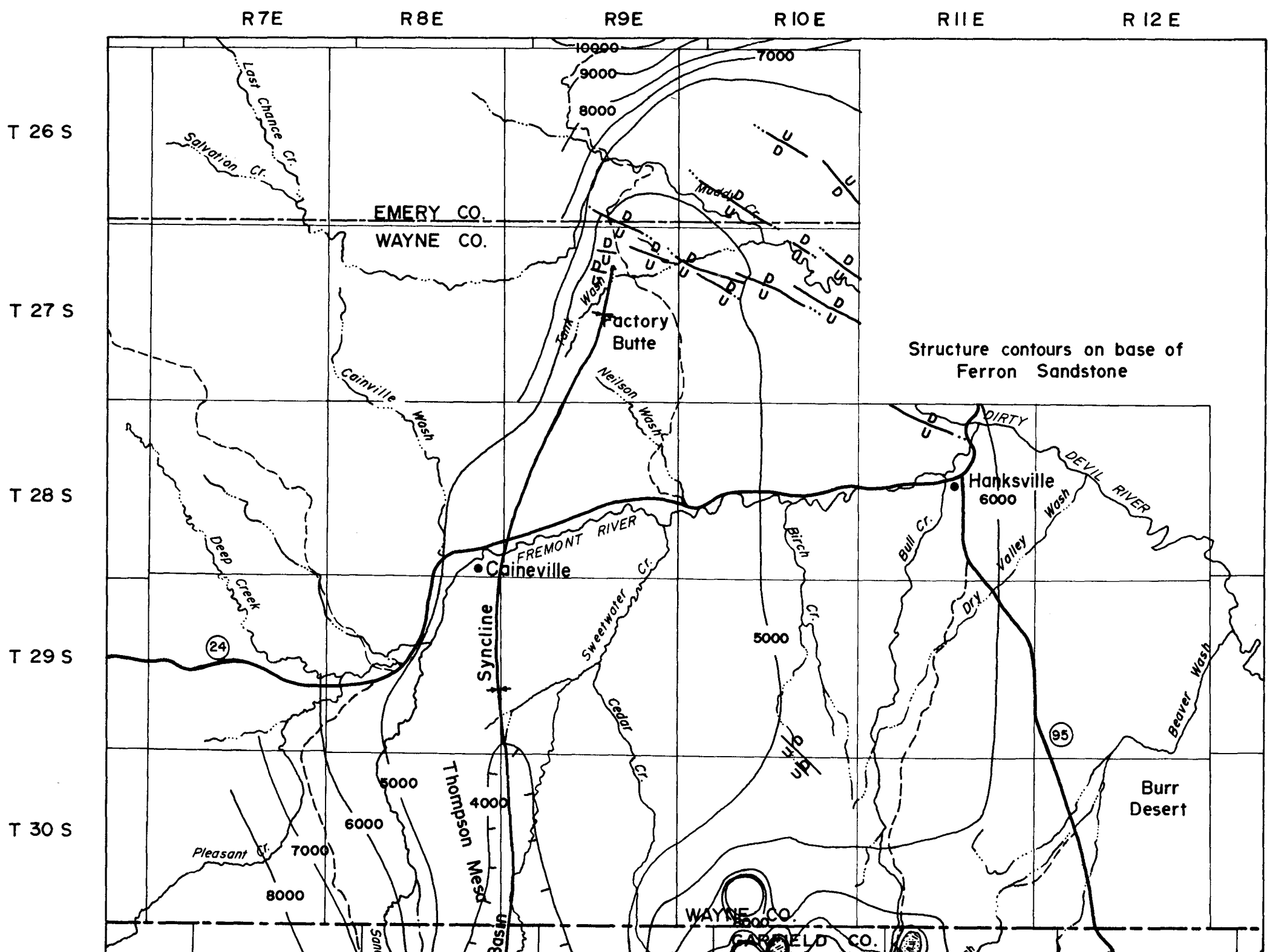
John Wesley Powell, one of the first explorers of the region, named the Henry Mountains in 1869 and made some of the first geologic comments on the region. In 1875 to 1876, G. K. Gilbert studied the Henry Mountains and his report is considered one of the classics of geological literature. Gregory and Moore (1931) and later Smith and others (1963) and Davidson and others (1967) reported on parts of the Waterpocket Fold. But these men only mentioned the presence of coal; the first work was done on the coal deposits when C. B. Hunt and his assistants appeared on the scene. They commenced work in 1935 and finished the field examination in 1939 (U. S. Geological Survey Professional Paper 228, 1953; especially pertinent are p. 216-217 and plate 22). The work provided a good foundation for this study. At present a few areas still need further studies and more coal analyses are necessary. As in most areas of Utah, drill-hole data are either limited or missing; more are necessary to prove the value of the coal.

The References section lists principal and supporting work to the Henry Mountains coal field.

Mines, Prospects and Production (figure 11)

Four groups of mines have operated in the Henry Mountains coal field; all are closed and abandoned at the present time. Total production from all mines is thought to be about 9,000 tons. Two of the mines at opposite ends of the field were opened in the Ferron. To the south the Stanton mine was opened to supply gold dredges on the Colorado River with fuel. Period of operation ended before 1900. At the north end near Factory Butte, coal was mined intermittently from 1908 to the 1950's supplying local ranchers and residents of Wayne County towns.

The two other mines were opened in Emery coal west of Mt. Ellen and operated in the late 1940's. The coal supplied residents of Wayne County. Table 1 lists the mines and their locations.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EMERY CO.
WAYNE CO.
WAYNE CO.
GARFIELD CO.
Structure contours on base of Ferron Sandstone
10000
9000
8000
7000
6000
5000
4000
Last Chance Cr.
Salvation Cr.
Muddy Cr.
Tarm Wash
Factory Butte
Cainville Wash
Neilson Wash
DIRTY DEVIL RIVER
Hanksville
6000
Bull Cr.
Birch Cr.
Dry Valley Wash
Beaver Wash
FREMONT RIVER
Caineville
Deep Creek
Sweetwater Cr.
Cedar Cr.
Syncline
Thompson Mesa
Basin
Pleasant Cr.
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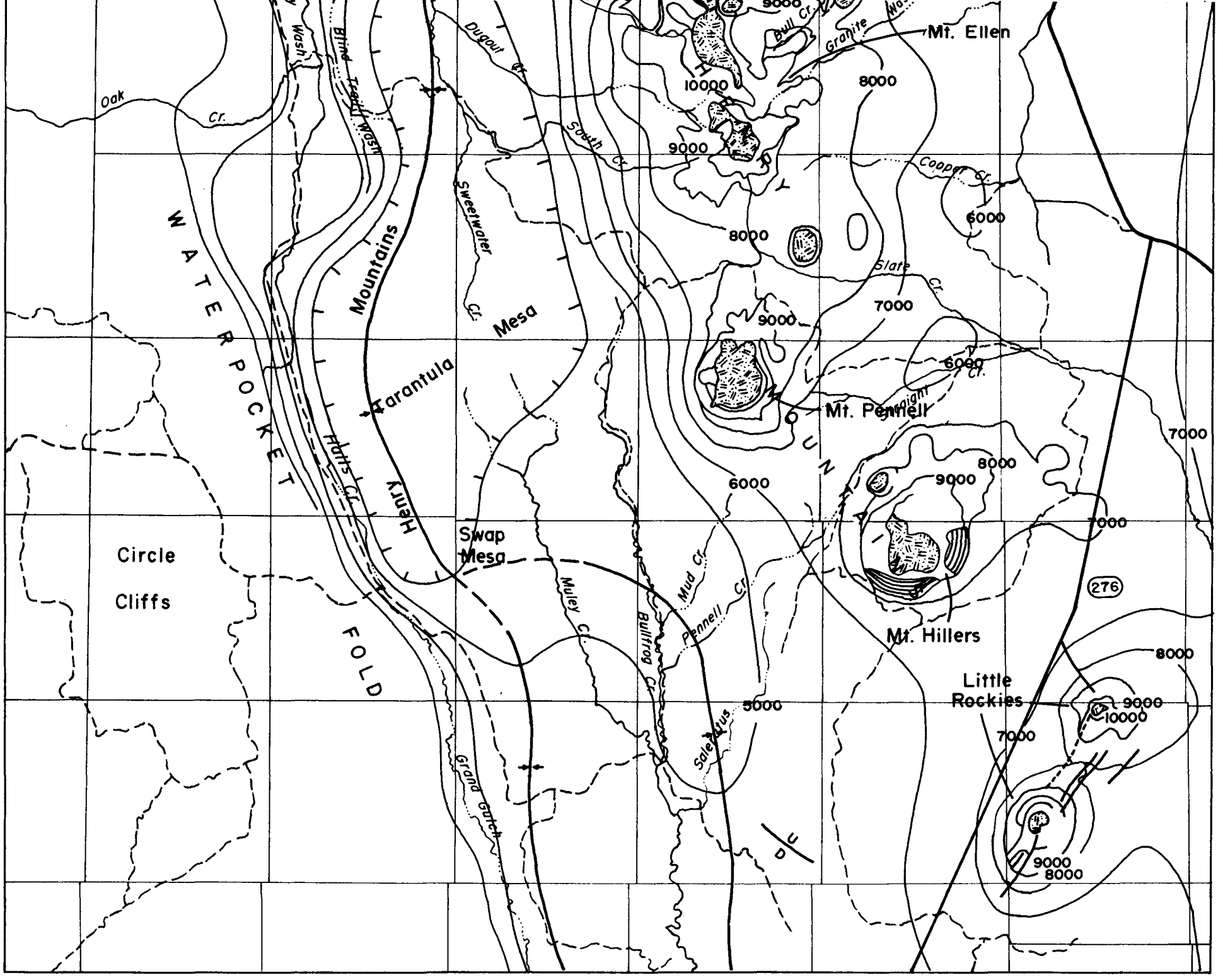
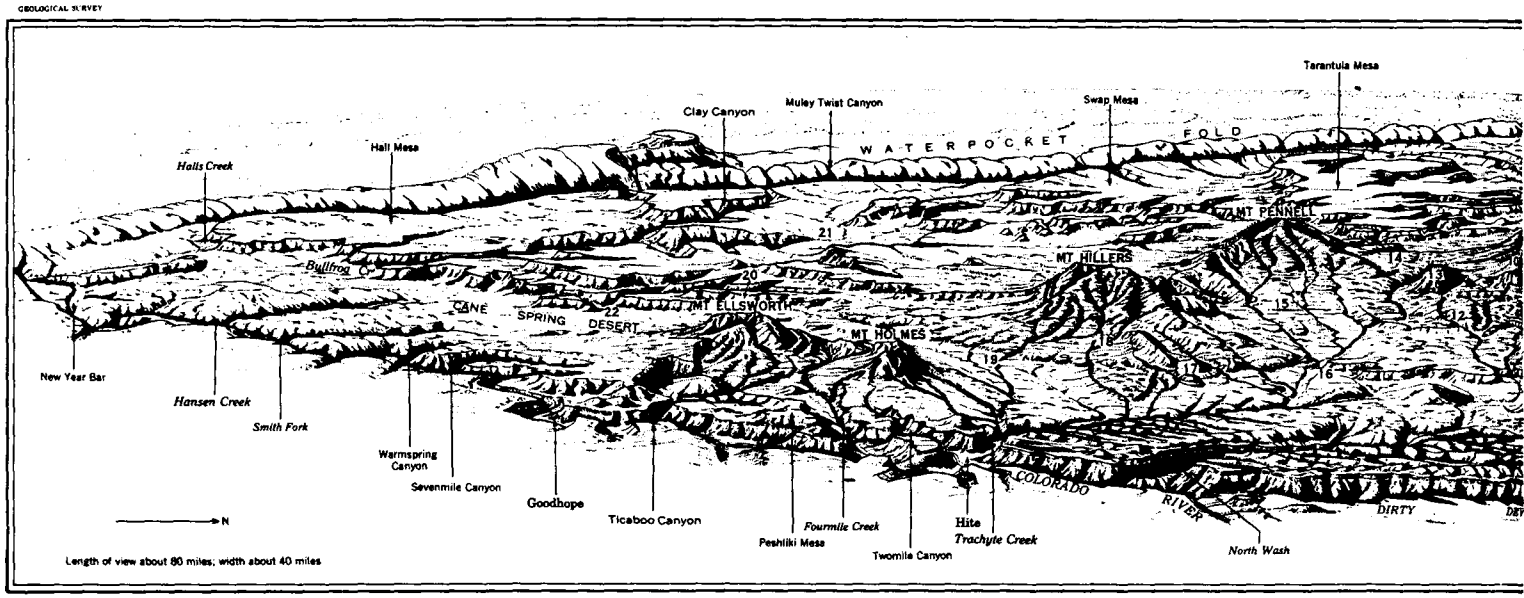


Figure 8. Generalized structure map, Henry Mountains coal field.



DIAGRAMMATIC VIEW OF T

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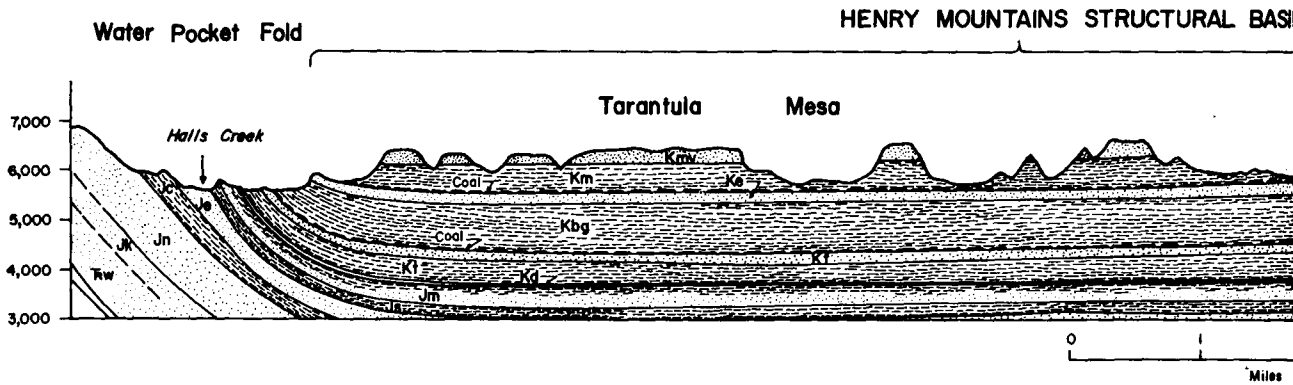
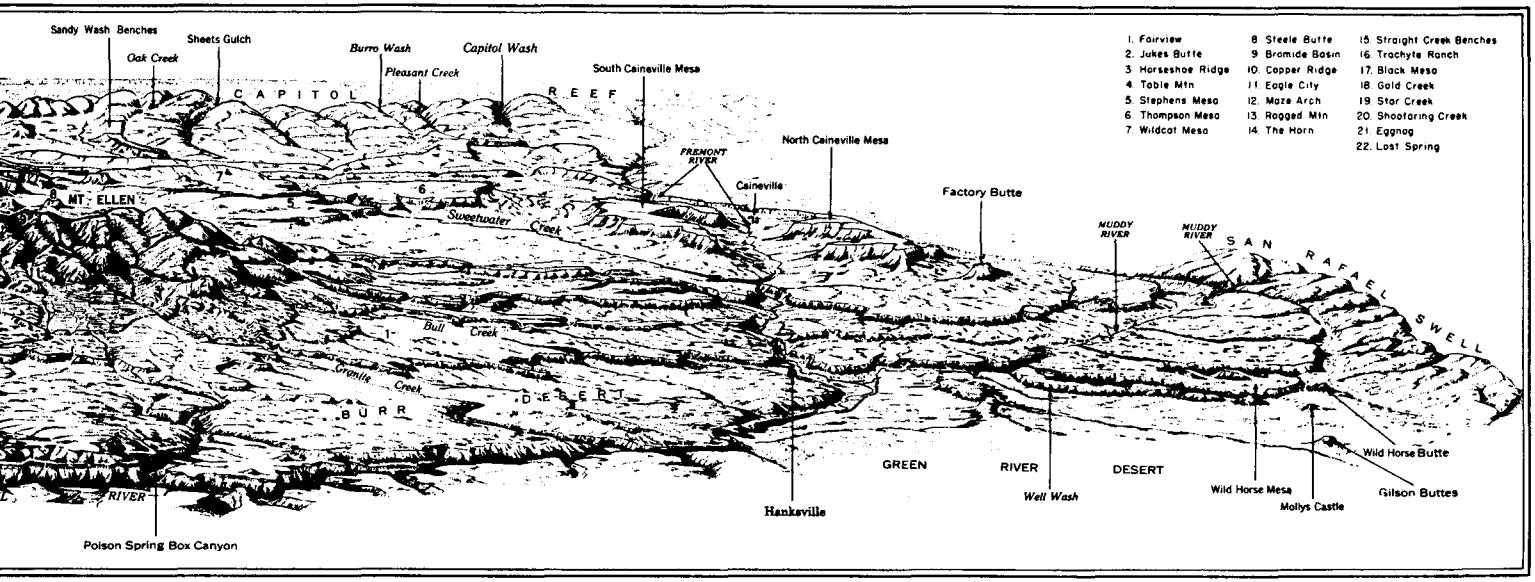
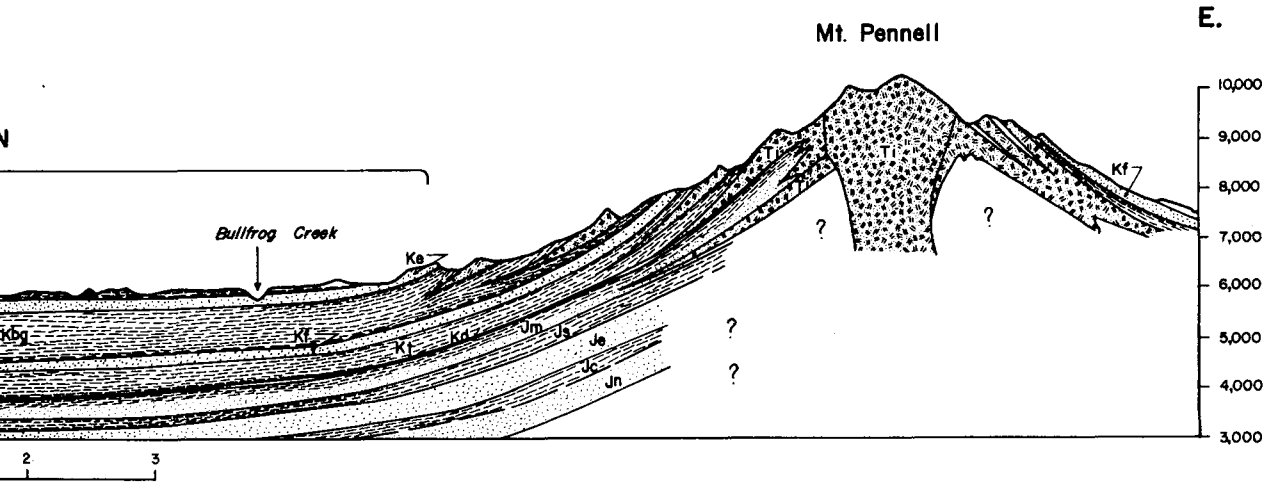


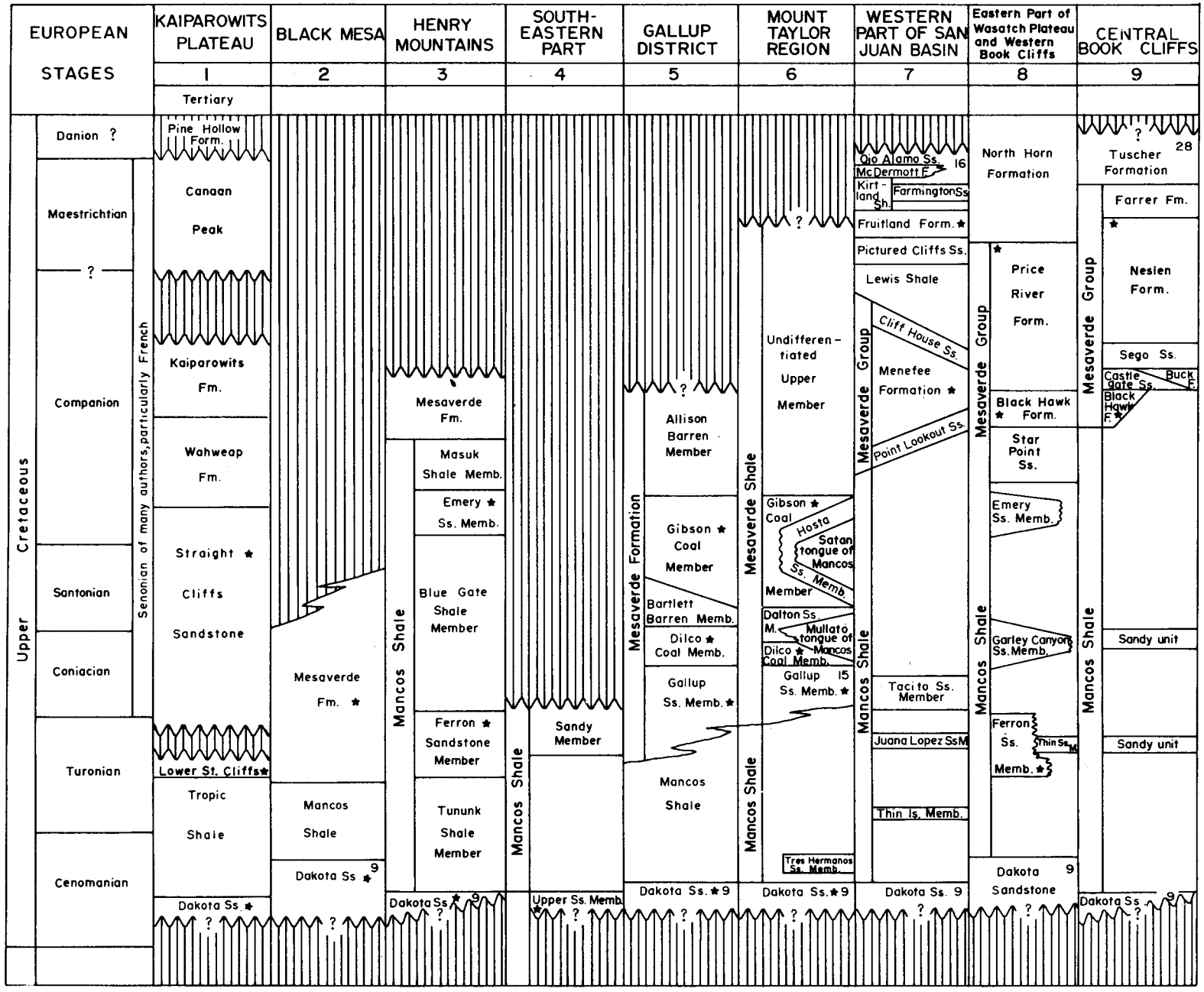
Figure 9. Cross section across T. 33 S., R. 8, 9 and 10 E., Henry



E HENRY MOUNTAINS REGION



Mountains coal field (after Hunt and others, 1935 to 1939).



*Coaliferous units.

Figure 10. Correlation chart of Upper Cretaceous units, south Utah, north Arizona and northwest New Mexico (after Cobban and Reeside, 1952).

Table 1. Coal mines of the Henry Mountains coal field.

Quadrangle	Location	Remarks
Factory Butte NW		
Factory Butte mine Upper Ferron	SW.11-27S-9E 4,258,265m.N. 507,510m.E.	Intermittent 1900-1950s?
Mt. Ellen NW-SW		
Dugout Creek mines Emery coal zone	SW.SW.7-31S-9E 4,218,720m.N. 502,880m.E.	Active 1940's
Stanton mines Ferron coal zone	36-34S-10E 4,184,975m.N. 520,780m.E. 4,184,800m.N. 521,080m.E.	Active 1895-1900
Sweetwater Creek mine Emery coal zone	NW.30-31S-9E 4,215,200m.N. 503,200m.E.	Activity unknown
Cow Flat		
Stanton mines		1888-1891 Int. 1895-1900?

Land Ownership

The lands of the reported quadrangles are owned as follows: Bureau of Land Management 78.2 percent, state of Utah 10.1 percent, National Park Service 9.7 percent and private property 2.0 percent.

The above percentages approximate the distribution ownership of just the coal lands. These properties and their locations are shown on figure 12.

As of January 1, 1970, more than 43,000 acres were held in prospecting permits by the Cayman Corp., more than 17,000 acres were held by G. G. Witter in prospecting permits and almost 5,500 acres were held by Consolidation Coal Co. in the form of state of Utah leases. This amounts to more than 100 square miles held for coal and involves 22 percent of the available coal land of the basin and that portion with the greatest potential (figure 13).

Quality of Coal

Sixteen analyses of coal for the entire Henry Mountains coal field indicate the quality of coal, but many more analyses are necessary to give an accurate picture. Of the sixteen, thirteen are from the Emery coals, two from the Ferron and one from the Dakota. The averages of the proximate analyses are compared below (table 2):

Table 2. Average proximate analyses of coal, Henry Mountains coal field.

	Percent		
	Emery coal	Ferron coal	Dakota coal
Moisture	9.8	5.0	5.8
Volatile matter	36.5	35.3	58.2
Fixed carbon	43.9	42.9	34.2
Ash	9.4	15.3	1.7
Sulfur	0.87	2.85	2.92
Btu/lb	11,253	11,575	13,478

Hunt and others (1953, p. 165) report a proximate analysis of a xenolith of semianthracite coal in a sill along Dugout Creek. It is not included above because of its local nature. Except for moisture the analysis is on a dry basis: moisture 1.13 percent, volatile matter 10.3 percent, fixed carbon 68.6 percent and ash 21.1 percent.

Reserves

Coal in the Henry Mountains in all beds and thicknesses exceeding 1 foot amounts to at least 890 million tons, but the minable portion is a little more than 230 million tons (measured, estimated and inferred reserves over 4 feet thick; table 3).

Table 3. Reserves for Henry Mountains coal field (in millions of short tons).

Quadrangle	Measured and estimated I and II	Inferred reserve III	Potential reserve IV	Total coal	Beds 4 ft. excluding potential reserve
Caineville- Steamboat Point	0.8	–	104.5	105.3	0.8
Cow Flat, Mt. Hillers NW	17.4	–	41.9	59.3	4.2
Factory Butte NE	22.8	–	45.0	67.8	22.8
Mt. Ellen NE-SE	–	–	–	–	–
Mt. Ellen NW-SW	77.4	55.2	50.1	182.7	81.9
Mt. Pennell NE-NW	50.1	63.8	120.4	234.3	45.0
Notom NE-SE	48.8	–	52.2	101.0	48.8
Wagon Box Mesa NE-Cave Point	34.4	–	105.4	139.8	27.4
Totals	251.7	119.0	519.5	890.2	230.9

Of the minable portion the dominant part is found in the Emery coal zone.

	Million short tons
Emery coal zone	187.4
Ferron coal zone	42.0
Dakota coal zone	1.5
Total	230.9

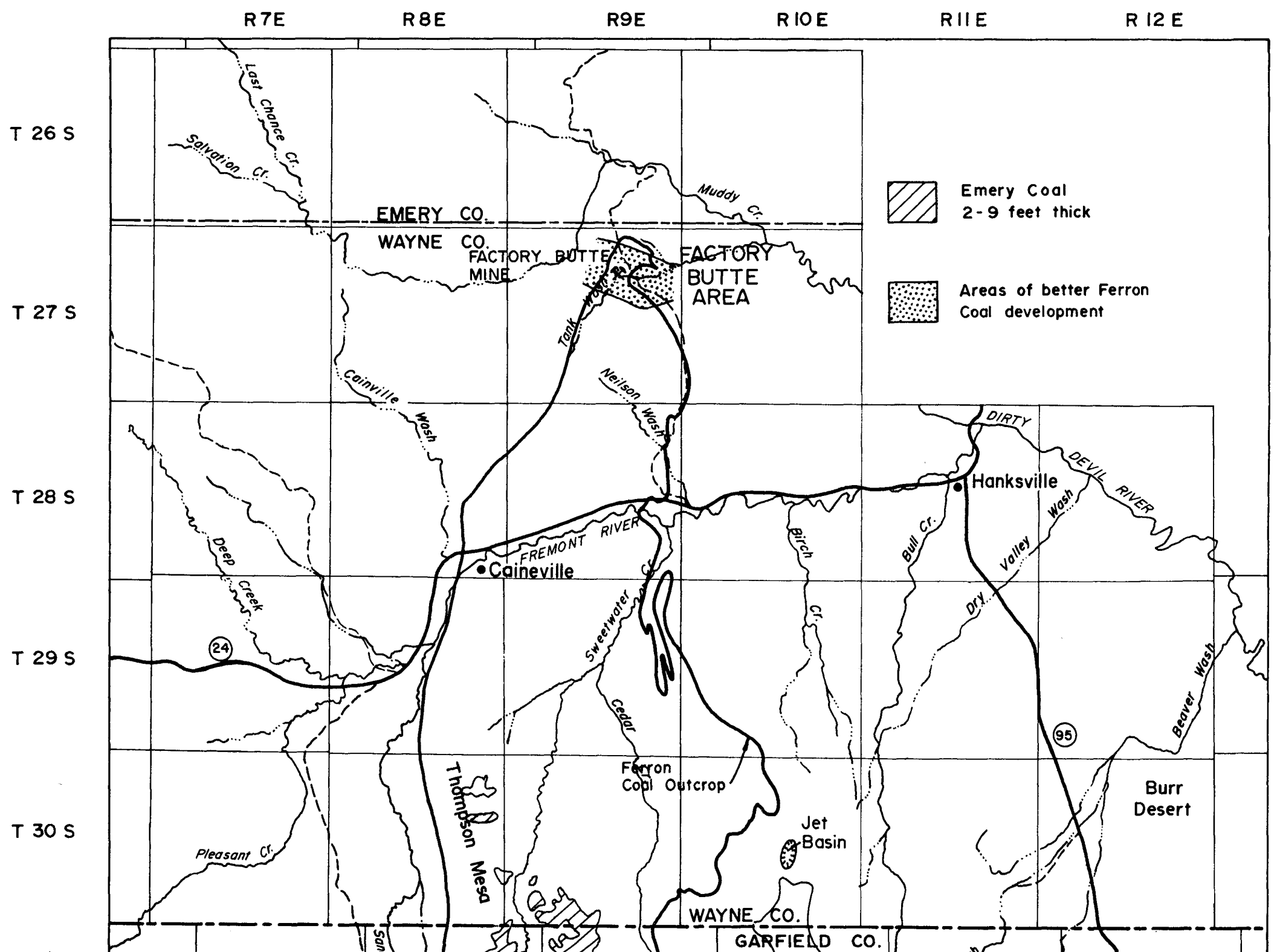
Coal Seams

Five designated areas in the Henry Mountains coal field include: the Factory Butte, King Ranch, Cave Flat, Swap Mesa and the Stanton mine areas. The Factory Butte area is in the north part of the field in which the Ferron coal zone is developed. The King Ranch area is central to the field, located west of Mt. Ellen and involves Emery coal. Cave Flat lies south of Tarantula Mesa and west of Mt. Pennell and involves Emery coal. Swap Mesa is south of Tarantula Mesa and west of Cave Flat. Both the Emery and Ferron are developed here. The Stanton mine area is southwest of Mt. Hillers in the Ferron coal zone.

The Dakota coals are usually thin or missing throughout the field. Locally the beds thicken and for one-quarter mile are thick enough to mine. Such areas have been noted along North Caineville Reef, Waterpocket Fold and around the Henry Mountains peaks. An unusual coal outcrop in the Dakota occurs at Jet Basin north of Mt. Ellen where logs and other woody debris have been coalified and jetified. The jet was once collected to make jewelry.

The Ferron coals are developed in the Factory Butte, Swap Mesa and Stanton mine areas. The important coal beds are near the top of the unit and in many cases appear to be directly under the Blue Gate. In the Factory Butte area the Ferron thickens to minable proportions over an area a little larger than 4 square miles. Except for local areas, as large as those noted for the Dakota, the Ferron remains thin south of Factory Butte except at the south end of the coal field. Over this central interval, however, it remains persistent and in only a few places can it be demonstrated to be completely missing. The average thickness of coal in the Ferron over this central interval is about 1½ feet. In the Swap Mesa area in the southwest corner of the field the Ferron coal bed thickens to more than 4 feet over a 3½-square-mile area. Near the Stanton mine at the southeast end of the field the coal bed is split, but the thickness again develops over a one-square-mile area. Between the Stanton mine area and the Swap Mesa area the coal beds average 2.0 to 3.0 feet thick.

The Emery coals are present in 90 percent of the Emery outcrop areas. The only notable thinning is from Steele Butte to Tarantula Mesa along the east outcrops. The thickest coal beds rarely drop to less than 2 feet thick; most range between 2 to 6 feet. In a few areas beds up to 9 feet thick have been discovered.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EMERY CO.
WAYNE CO.
GARFIELD CO.
Last Chance Cr.
Salvation Cr.
Muddy Cr.
FACTORY BUTTE MINE
FACTORY BUTTE AREA
Tank Wash
Neilson Wash
Cainville Wash
Deep Creek
FREMONT RIVER
Caineville
Sweetwater Cr.
Cedar
Birch Cr.
Bull Cr.
DIRTY DEVIL RIVER
Hanksville
Dry Valley Wash
Beaver Wash
Thompson Mesa
Ferron Coal Outcrop
Jet Basin
Burr Desert
Pleasant Cr.
24
95
Emery Coal
2-9 feet thick
Areas of better Ferron Coal development

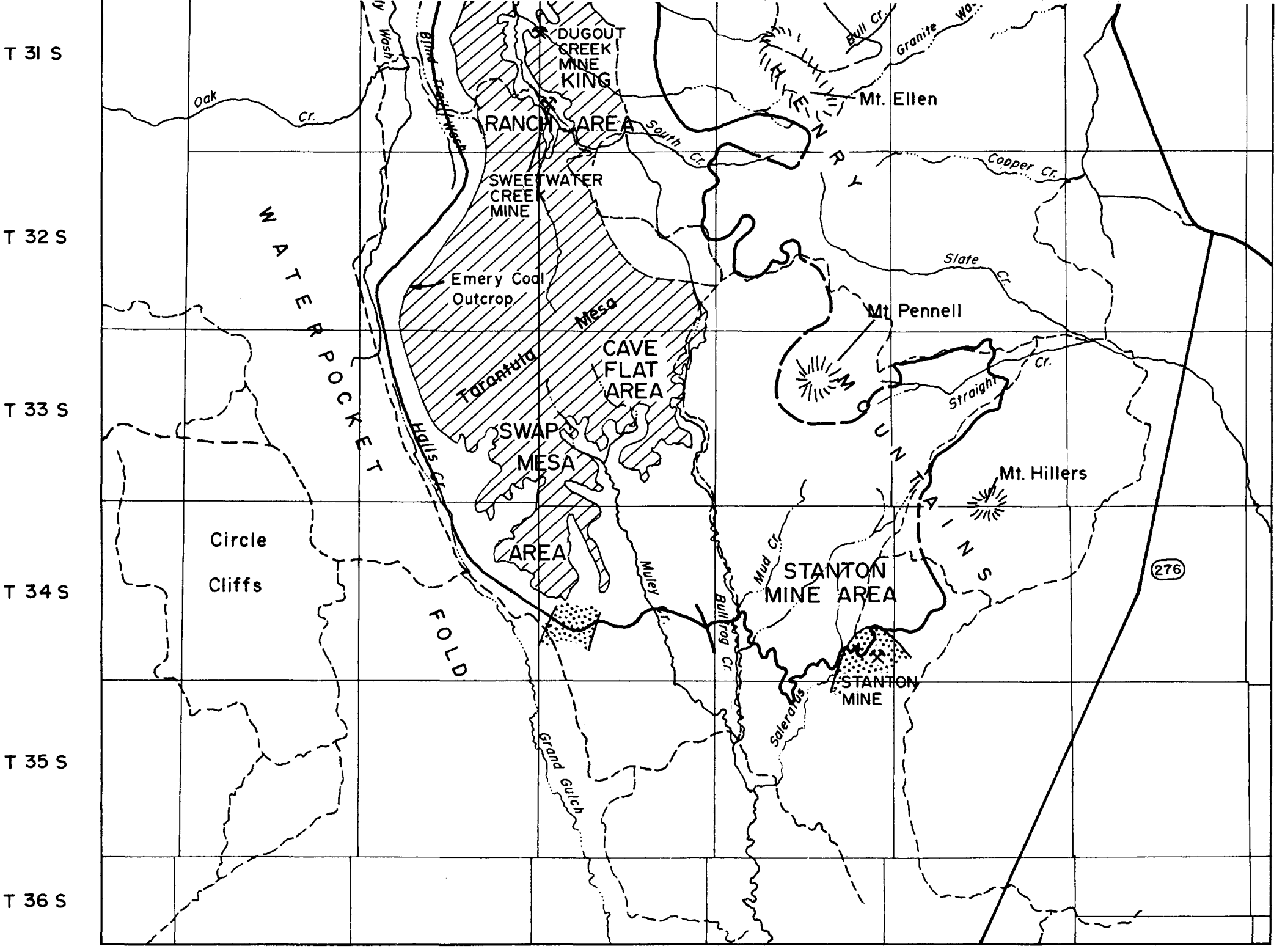
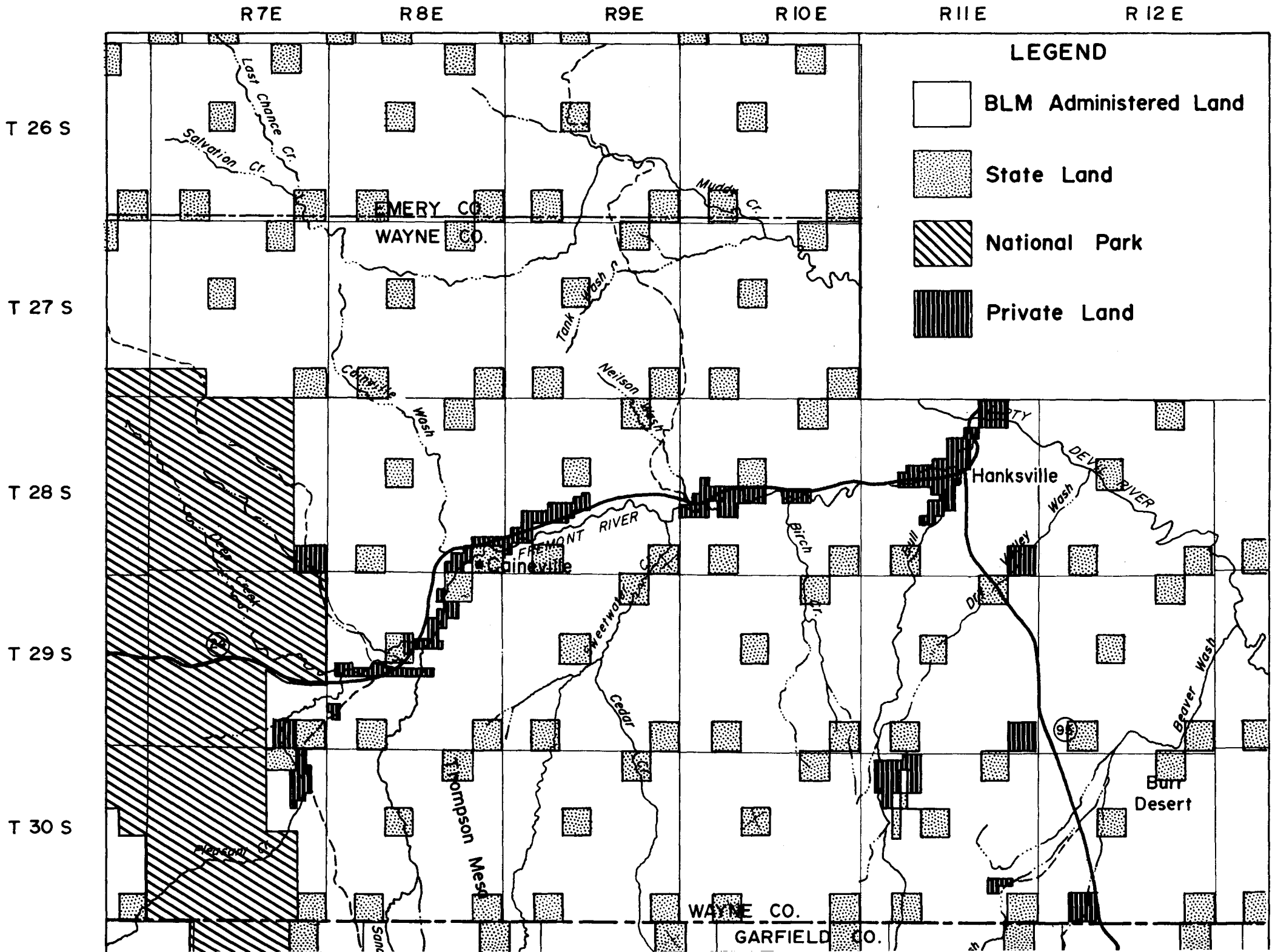


Figure 11. Coal seams and mines map, Henry Mountains coal field.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LEGEND
BLM Administered Land
State Land
National Park
Private Land
Last Chance Cr.
Salvation Cr.
EMERY CO.
WAYNE CO.
Muddy Cr.
Tank Wash
Neilson Wash
Cainville Wash
FREMONT RIVER
Cainville
Birch Cr.
Hanksville
DEVIL RIVER
Valley Wash
Dry
Sweetwater Cr.
Cedar Cr.
Thompson Mesa
Pleasant Cr.
Beaver Wash
Burr Desert
WAYNE CO.
GARFIELD CO.

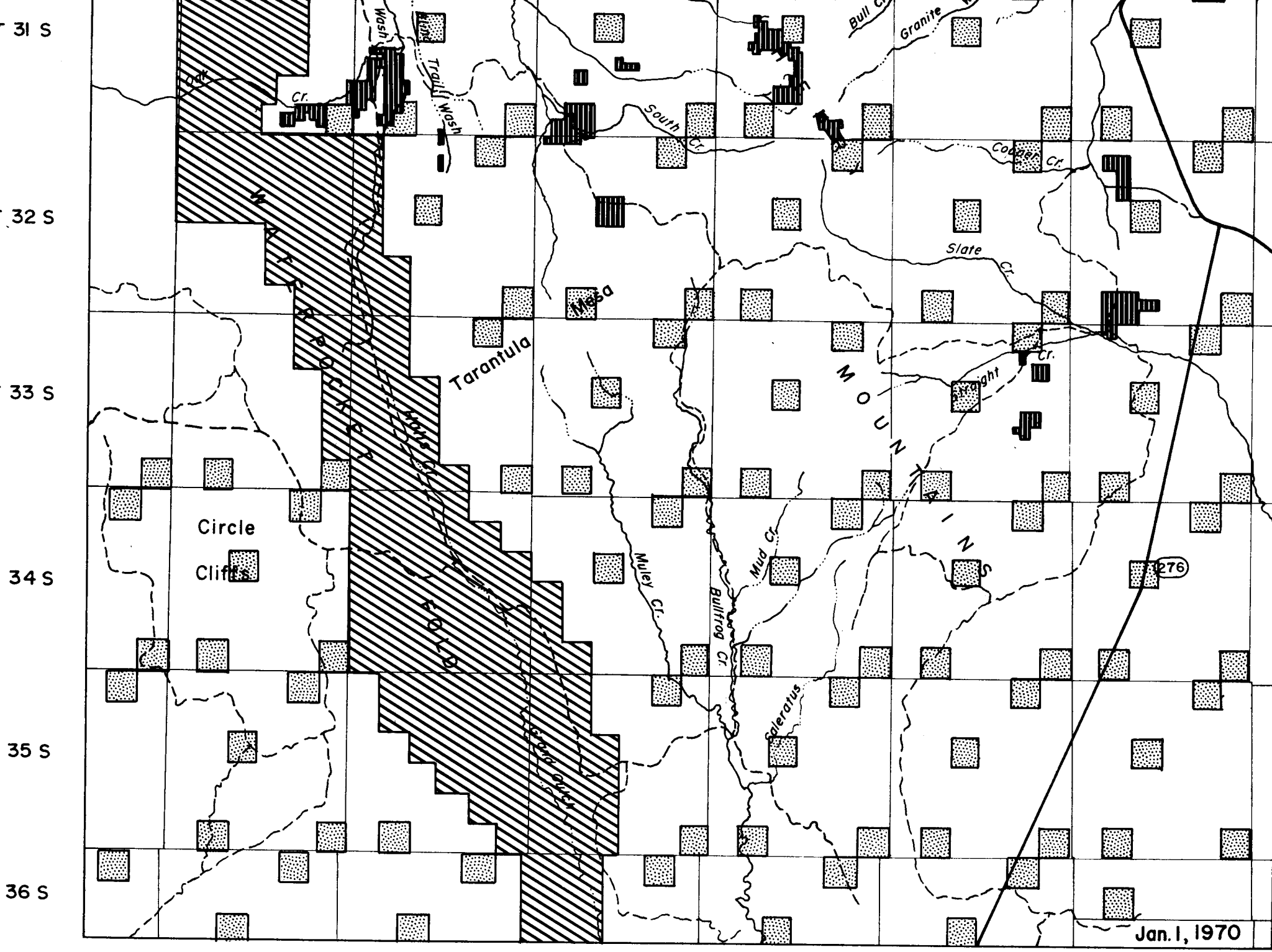
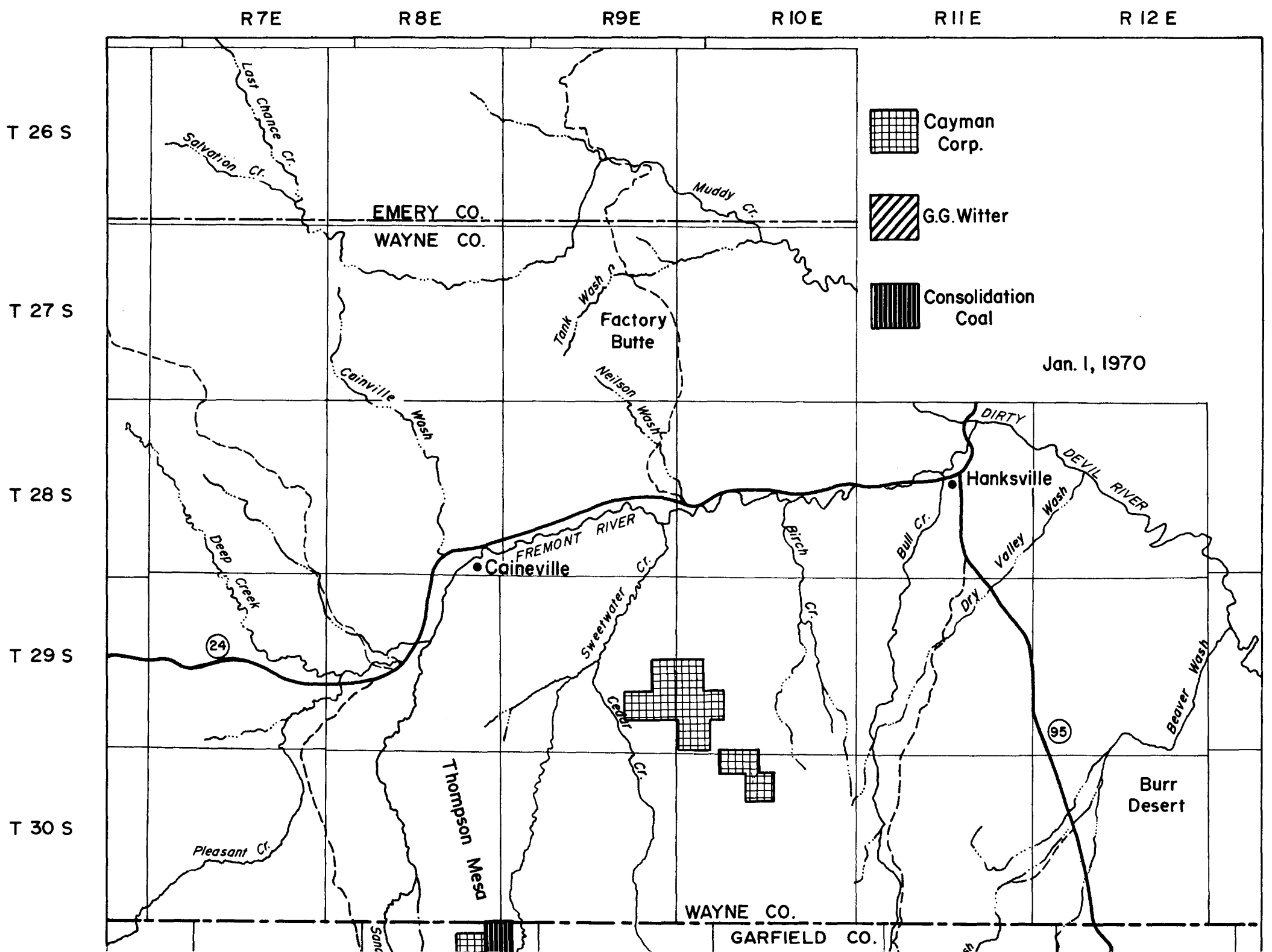


Figure 12. Land ownership map, Henry Mountains coal field.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Cayman Corp.
G.G. Witter
Consolidation Coal
Jan. 1, 1970
EMERY CO.
WAYNE CO.
Last Chance Cr.
Salvation Cr.
Muddy Cr.
Tank Wash
Factory Butte
Neilson Wash
Cainville Wash
DIRTY DEVIL RIVER
Hanksville
FREMONT RIVER
Caineville
Deep Creek
Sweetwater Cr.
Birch Cr.
Bull Cr.
Dry Valley Wash
Cedar Cr.
Beaver Wash
Burr Desert
Thompson Mesa
Pleasant Cr.
24
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WAYNE CO.
GARFIELD CO.

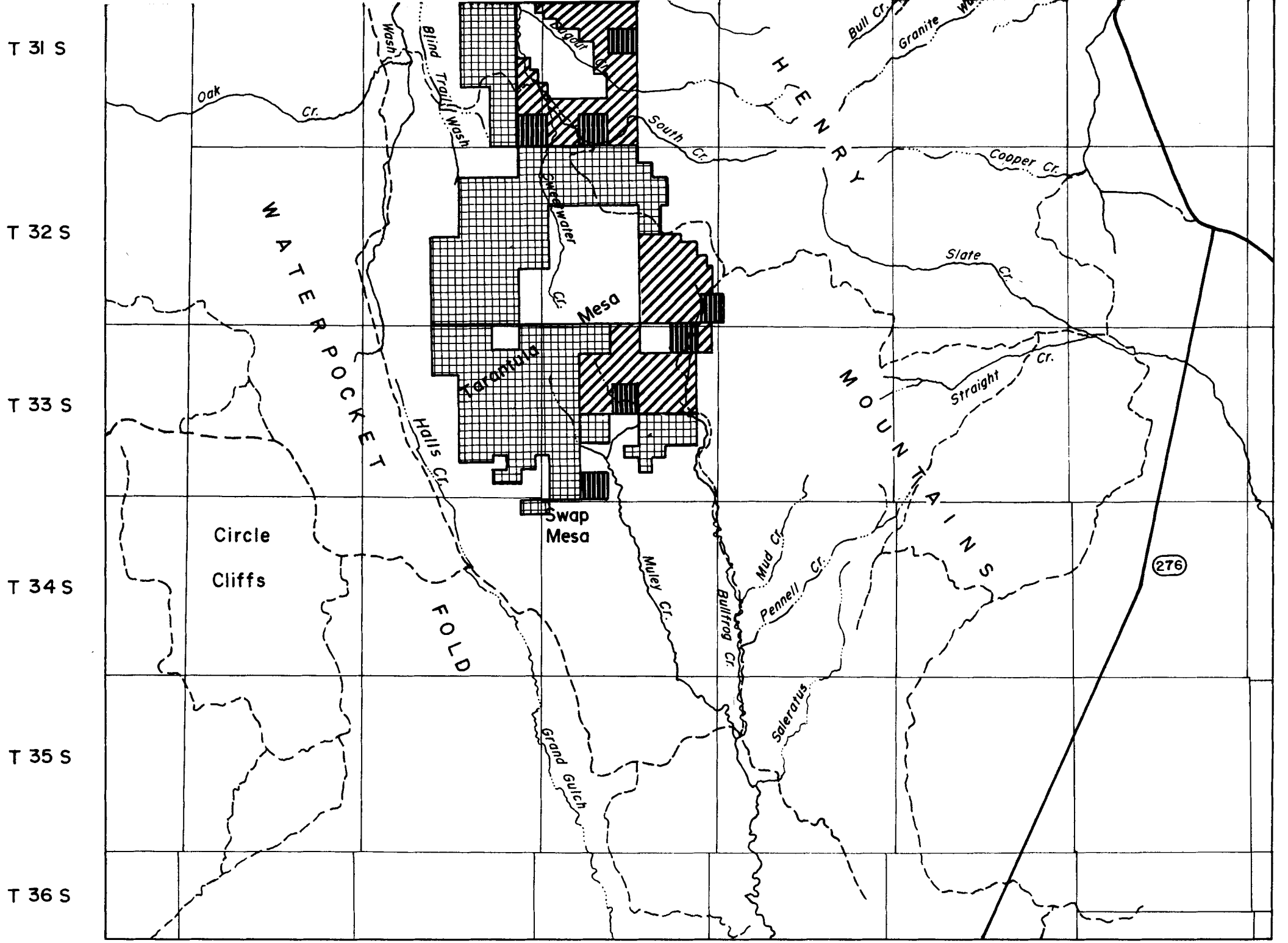


Figure 13. Leases and permits map, Henry Mountains coal field.

The coal beds, in spite of their persistence, are among the most lenticular in Utah. In a local area on Stevens Mesa, a bed 4 feet thick thins to 6 inches over a 100-foot interval. This is extreme, even for the Emery, but the problem necessitates closely spaced drilling for exact reserve estimation. In the Kings Ranch area coal beds in the Emery appear to exceed 4 feet at least over 15 square miles. In the Cave Flat area the expected area of 4-foot coal is about 6½ square miles. The Swap Mesa area is not thoroughly explored, but indications are that the coal will be thick along much of the Waterpocket Fold side of the field. It is therefore expected that good coal is present under Tarantula Mesa as well.

WATER RESOURCES

High mountainous areas are the only effective water recharge areas in the mid-latitude steppe climate of Utah. The Henry Mountains peaks qualify, but the recharge area is limited in size. Therefore water is scarce; perennial streams are few and their flow is small. Springs and seeps are plentiful but many dry up in the late summer months and in drought years do not flow at all. The structural basin contains deep artesian water, but its quality or quantity is unknown.

Through-going streams contain the largest source of water. These include the Colorado, Fremont and Muddy rivers. Smaller creeks heading on Boulder Mountain include Pleasant and Oak creeks. The largest streams from the Henrys are Bull Creek and Dugout Creek with annual discharges of no more than a few thousand acre-feet.

The aquifers of the artesian Henry Mountains Basin undoubtedly could provide a modest amount of good water. Aquifers include the Ferron, Dakota, some of the sandstone beds in the Morrison and especially the Entrada and Navajo sandstones.

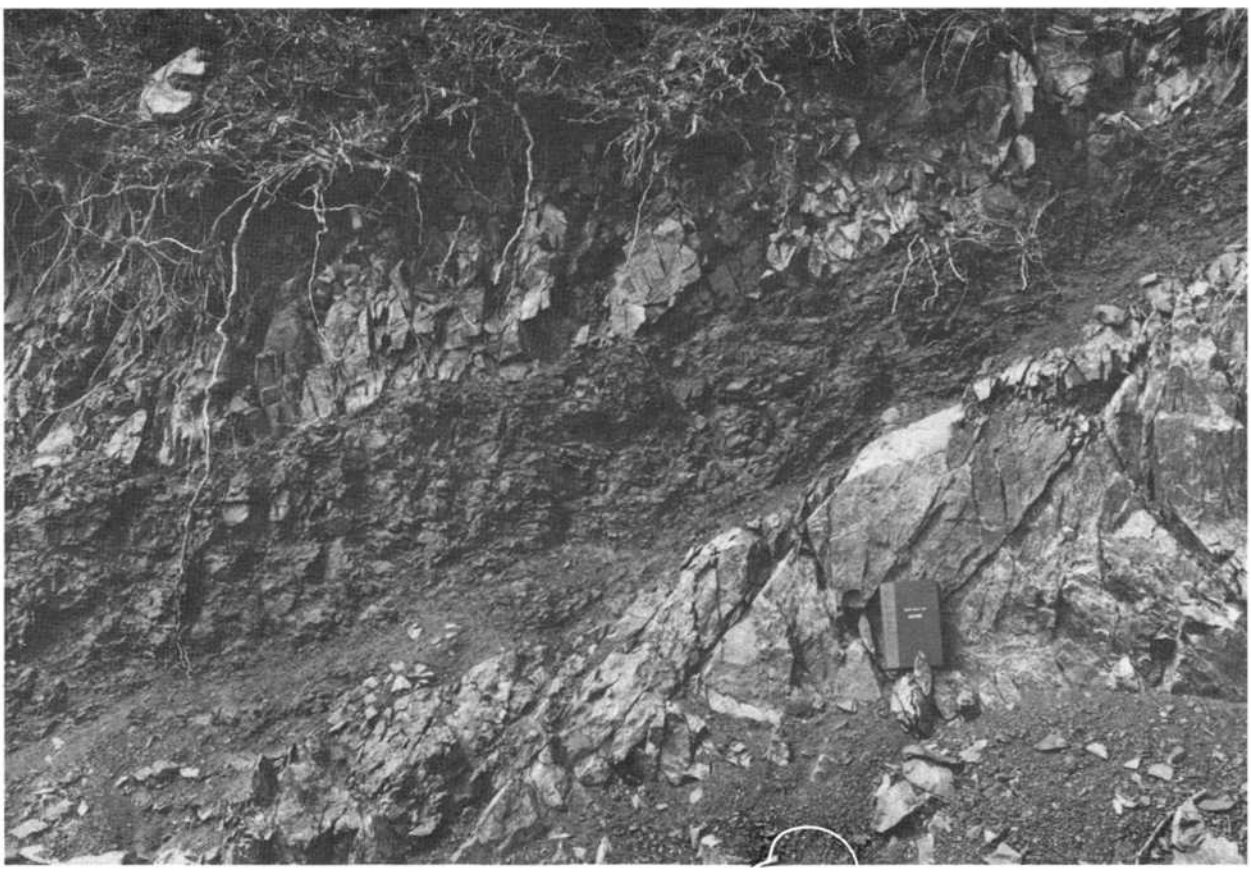
Except for the water of the through-going streams it is doubtful that enough water generated from the Henry Mountains area could be collected to sustain a large power plant.

ECONOMIC CONSIDERATIONS AND FORECAST

Good coal is present in the Henry Mountains coal field, but specific disadvantages will hinder development. First, those areas where the coal is 4 feet or more thick have beds which just barely exceed that figure, notably between 4 and 6 feet. The area of coal-bed development is relatively small and hence the total reserve is relatively small. This is in comparison with competitor fields such as the Book Cliffs, Wasatch Plateau, Emery and Kaiparowits Plateau. In addition the Henry Mountains area is less accessible, farther from market, and is no better and in part of lesser quality than that of the competitor fields. Some of the Henry Mountains coal is badly split, therefore high in ash. This is especially true for the Ferron coal which also appears to be high in sulfur.

The only advantage is the shallow overburden that covers the coal. About one-third of the estimated (Classes I and II) tonnages can be expected to be easily strip-mined with less than 100 feet of overburden.

The Ferron coal reserves are inadequate to supply a larger power plant, but enough might be uncovered in the Emery. The best use for Henry Mountains coal in power generation is in conjunction with another field such as the Emery field. A power plant located between the fields could be supplied by both. Because of the aforementioned disadvantages, development will probably have to wait many years.



Shale and carbonaceous beds, presumably in the Ferron Sandstone, caught between two diorite dikes on Mt. Ellen. The baked zone is less than 1 inch thick. The coal-bearing beds are usually not metamorphosed, but badly broken and twisted in the vicinity of the igneous rocks.

QUADRANGLE REPORTS

CAINEVILLE-STEAMBOAT POINT QUADRANGLES

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Steamboat Point quadrangle is the south central part of the U. S. Geological Survey, Factory Butte topographic quadrangle (figures 14 and 15). Caineville combines portions of the Fruita and Factory Butte quadrangles (figure 16). The area is centered on the Fremont River and Utah Highway 24 which parallels the river. Two towns in the area are Caineville, located near the center of the Caineville quadrangle, and Hanksville, located 6 miles east of the northeast corner of the Steamboat Point quadrangle.

Except for the Caineville Reef the landscape is typically plateau with mesas, buttes, cliffs and large nearly level surfaces. The Caineville Reef trends roughly north-south through the Caineville quadrangle and is a monocline. The highest elevations (5,800 to 6,000 feet) are on top of the North and South Caineville mesas. Most of the area below the mesas and within the Henry Mountains structural basin lies 1,000 to 1,200 feet lower–the area of coal seam exposures. Elevations drop below 4,400 feet in the Fremont River Valley.

Other than Utah Highway 24 few roads provide access. Those present are all high-clearance dirt roads. The Bert Avery Seep road provides access to Blue Mesa and connects with U-24 at Hanksville. The North Caineville Reef road starts at U-24 near Caineville and extends northeastward along the reef.

STRATIGRAPHY

All the Jurassic rocks crop out west of the South Caineville and North Caineville reefs. The oldest unit is the Entrada Sandstone whose reddish orange color gives the name to the Red Desert. The desert is surrounded in turn by a rim of Curtis, Summerville and Morrison formations. The latter crops out just to the west of and along the entire length of the reef. These units have been described adequately in the field report, but attention is focused on the upper member of the Morrison because of its proximity to the reef. The Brushy Basin Member consists primarily of varicolored shale, some of which is bentonitic. The purples, reds and greenish gray colors of the unit are easily identified. At the top of the Brushy Basin is an unconformity above which the Cretaceous coal-bearing deposits occur.

The first Cretaceous unit is thin and sometimes missing or covered entirely by surficial deposits. The Dakota Sandstone is usually less than 50 feet thick and consists of gray shale, ledgy tan sandstone, occasional conglomeratic beds, carbonaceous shales and sometimes coal. Most persistent in the Caineville quadrangle is a carbonaceous zone 3 to 10 feet thick near the top of the unit. Carbonaceous zones lie at other positions within the unit, but are not persistent. Coal up to 6 feet thick is present in this carbonaceous zone, but usually it is too thin to mine. A fossiliferous zone at the upper contact contains abundant *Gryphaea, Exogyra* and *Inoceramus.*

The Tununk is a gray marine shale. Its outcrops make up the lower part of the reef on the Caineville quadrangle; they also make up the lower part of the cliff on the east side of the Henry Mountains structural basin and the surface of Blue Valley on the Steamboat Point quadrangle. The Tununk is about 600 feet thick.

Section of Tununk Shale Member of Mancos Shale, NW ¼, sec. 21, T. 29 S., R. 8 E., by Hunt and others (1953, p. 80):

Ferron Sandstone Member at top. Contact arbitrarily taken at base of a series of interbedded sandstone and shale beds. Contact is sharp with channels eroded 6 feet deep in the top of unit 1.

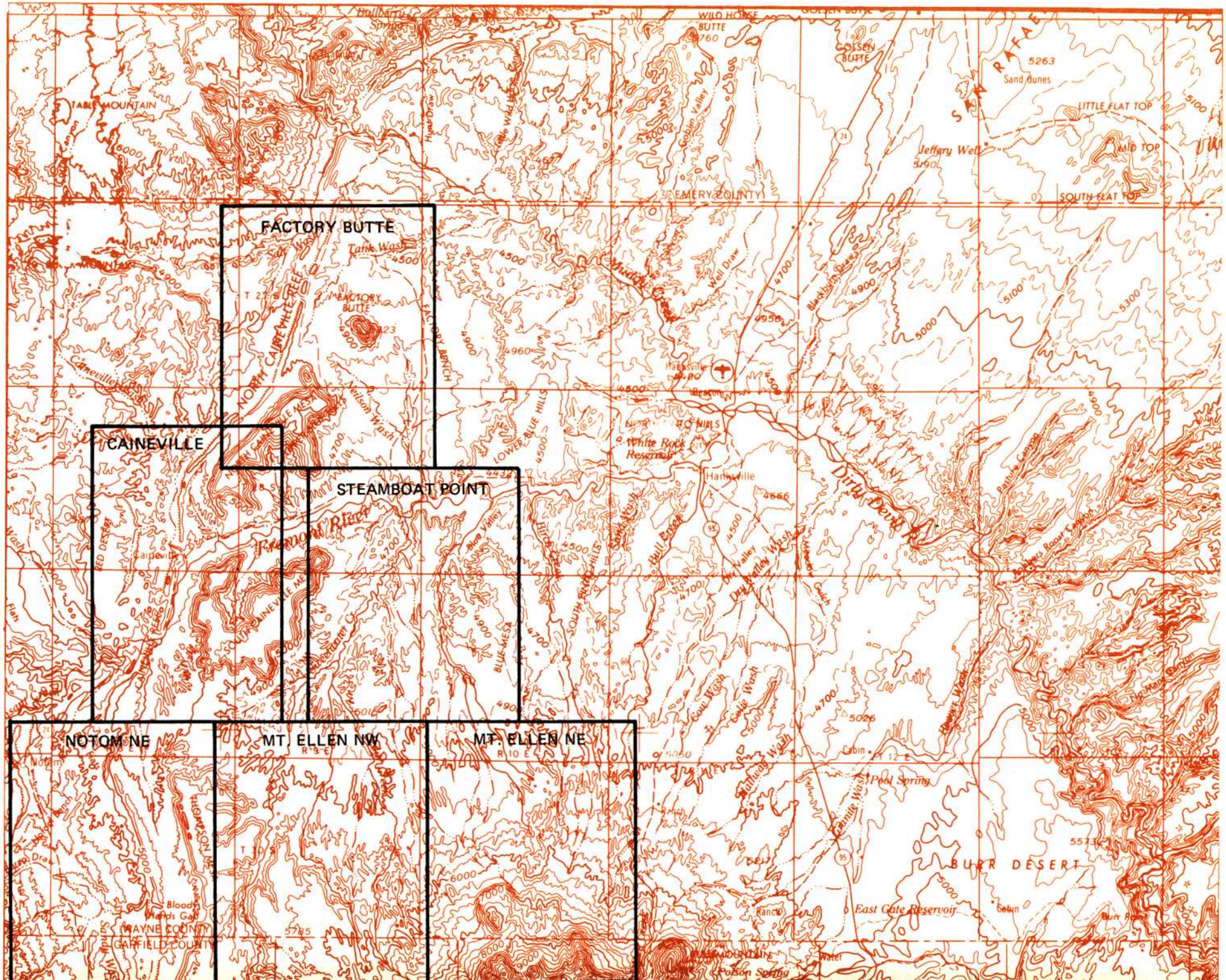
	Feet
Tununk Shale Member	
1. Shale, gray, with very thin sandy shale and sandstone beds in top 60 feet	238.0
2. Bentonite, sandy	0.2
3. Shale, gray	12.0
4. Bentonite, sandy	0.2
5. Shale, gray	6.0
6. Bentonite, sandy	0.2
7. Shale, gray, and thin-bedded sandstone; shale beds 1 foot thick separated by calcareous sandstone in well laminated thin beds. Fossils, poorly preserved, representative of Carlisle fauna in calcareous sandstone near top	31.0
8. Shale, gray	260.0
9. Shale, sandy	1.0
10. Shale, gray	12.0
11. Bentonite, shaley	0.1
12. Shale, gray	34.0
13. Bentonite, shaley and gray	0.3
14. Shale, gray	14.0
15. Bentonite, local lens	0.1
16. Shale, gray	8.0
17. Bentonite	0.1
18. Shale, gray; oyster shells, mostly *Gryphaea newberryi* in lower 2 feet	21.0
19. Bentonite, clean, white	0.7
20. Shale, gray. Base of Mancos	0.3
Total Tununk Shale Member	639.2

Dakota Sandstone at base. Poorly consolidated, abundance of oysters, mostly *Gryphaea newberryi.*

Toward the top of the Tununk thin-bedded gray sandstone becomes abundantly interbedded with the shale. The base of the first thick-bedded to massive sandstone bed marks the base of the Ferron Sandstone. Measurements show the Ferron to be mostly tan, brown, gray or yellow cliff-forming, medium-grained sandstone interbedded with shale. The shale beds are more numerous near the base and near the top. The lower shales are dominantly of marine origin and the upper shales are a mixture, probably lagoonal shales. These upper shales are often carbonaceous and contain coal. The coal in either of the quadrangles appears not to be of minable thickness. The Ferron has been measured to be 165 feet thick along Utah Highway 24 in the Steamboat Point quadrangle and to be almost 350 feet thick at Caineville.

Section of the Ferron Sandstone measured along Utah Highway 24 near Steamboat Point in sec. 24, T. 28 S., R. 9 E., by R. D. Gray in 1971:

Blue Gate Shale Ferron Sandstone	Feet
1. Carbonaceous shale	3.5
2. Coal	1.5
3. Shale, gray	4.0
4. Sandstone, light gray, limonitic staining, friable	5.0
5. Sandstone, red, coarse-grained	8.0
6. Shale, yellow, sandy	2.8
7. Carbonaceous shale	3.3
8. Clay shale, contains gypsum	5.0
9. Carbonaceous shale	1.4
10. Bone coal	0.2
11. Carbonaceous shale	2.0
12. Sandstone, gray, coarse-grained, thin-bedded, cross-bedded, stained with limonite, resistant	7.0
13. Carbonaceous shale	1.0
14. Coal	0.2
15. Carbonaceous shale	1.3
16. Shale, gray with selenite gypsum and partly bentonitic	11.0


FACTORY BUTTE
CAINEVILLE
STEAMBOAT POINT
NOTOM NE
MT. ELLEN NW
MT. ELLEN NE
TABLE MOUNTAIN
WILD HORSE BUTTE
GOLSEN BUTTE
SAN RAFAEL
Sand dunes
LITTLE FLAT TOP
MID TOP
SOUTH FLAT TOP
Jeffery Well
EMERY COUNTY
Tank Wash
FACTORY BUTTE
NORTH CAINEVILLE REEF
Neilson Wash
FACTORY BENCH
LOWER BLUE HILLS
Muddy Creek
Well Draw
Blackburn Draw
Hanksville
White Rock Reservoir
Dirty Devil R.
Fremont River
Caineville
RED DESERT
SOUTH CAINEVILLE MESA
BLUE MESA
Bull Creek
Dry Valley
Dry Valley Wash
Cow Wash
Cottle Wash
Pool Spring
BURR DESERT
East Gate Reservoir
Cabin
Ranch
Water
Polson Spring
WAYNE COUNTY
GARFIELD COUNTY
Bloody Hands Gap
Notom
Pasture Canyon
Jackers Roost Canyon
Burr Point

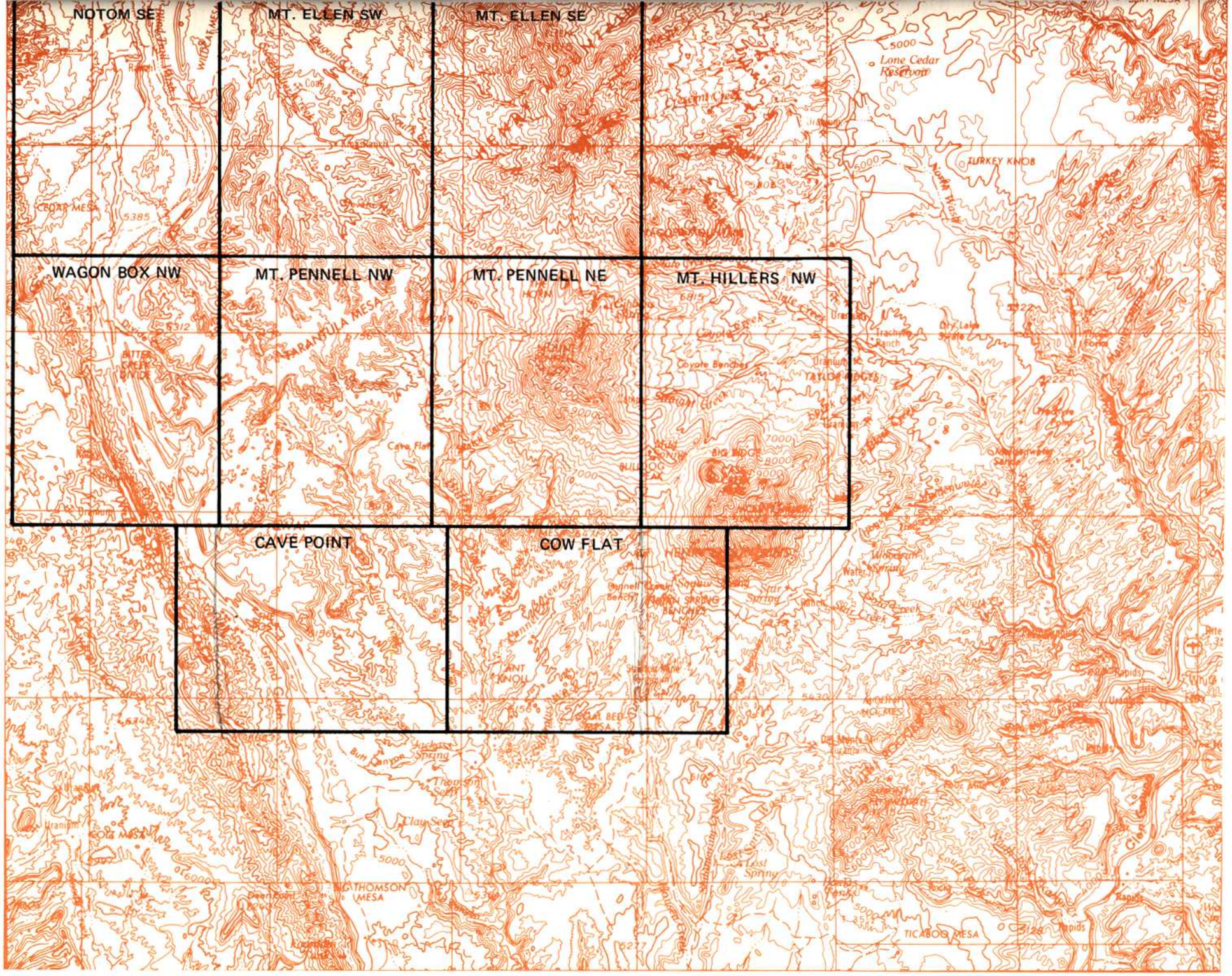


Figure 14. Quadrangle index map, Henry Mountains coal field.

EXPLANATION (figures 15, 16, 19, 20, 22, 24, 25, 27, 28, 31, 32, 35, 36, 39 and 40)

32 1.0 Purple — Coal bed
Dashed where inferred or poorly exposed, dotted where burned. Thickness of coal in feet measured at triangles. Larger numbers refer to location of measured section shown on accompanying sheets.

x — Prospect

⚒ — Coal mine

Purple — Burned zone
Area covered with natural clinker or red-burned sandstone.

DH — Coal drill hole

3 — Strike and dip of beds

1 — Apparent dip of beds

Syncline
Axis, dashed where approximately located or where ill defined.

Anticline
Axis, dashed where approximately located or where ill defined.

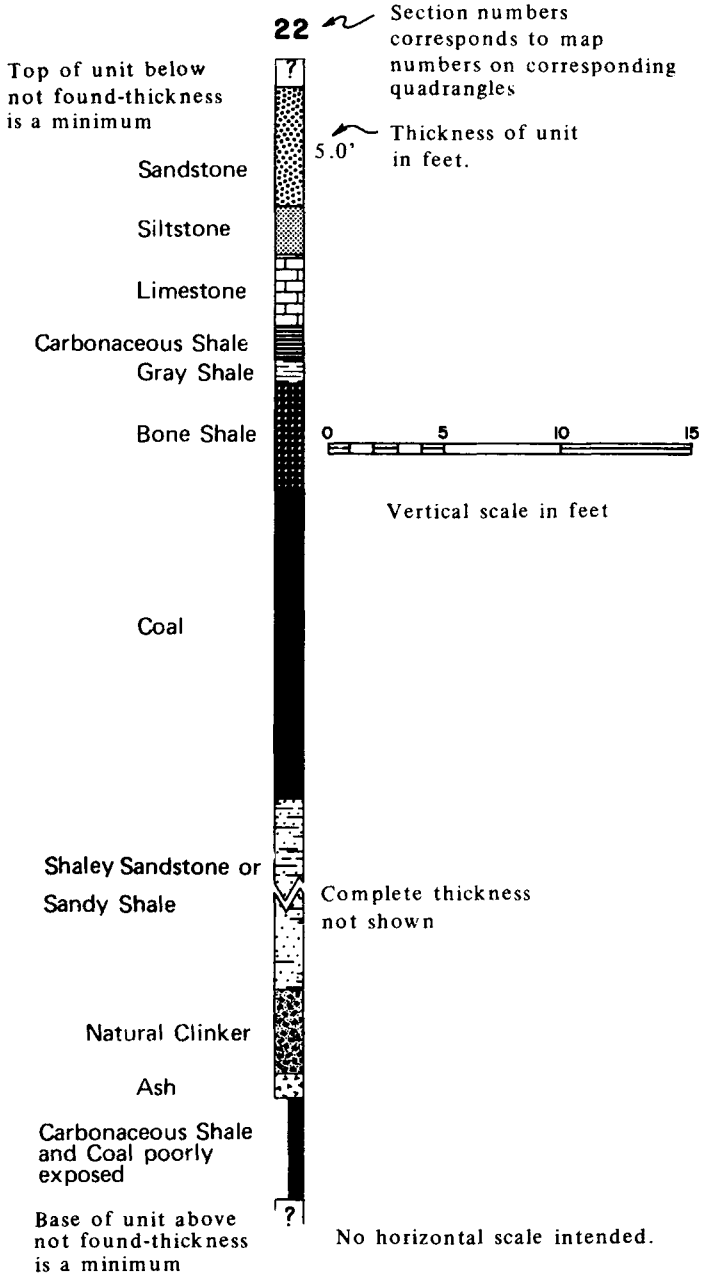
Monocline
Arrow points in direction of dip, dashed where approximately located or where ill defined.

Geologic unit contact
Dashed where location is approximate.

\+ — Horizontal strata

D / U — Fault
Dashed where inferred or ill defined.

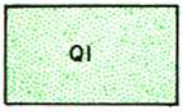
Explanation For Measured Sections



EXPLANATION (continued)

QUATERNARY

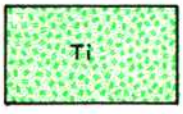
Alluvium
Stratified clay, silt, sand, gravel and some unsorted flood deposits.



Landslide Deposits
Mixed rubble and blocks of material slumped from formations at higher elevations.

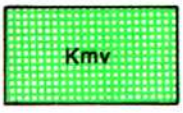
Gravel
Gravel deposits composed of pebbles, cobbles and sand, includes terrace and pediment deposits.

TERTIARY

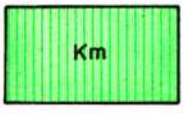


Igneous Rocks
Intrusive igneous rocks of the Henry Mountains stocks and laccoliths, composed mostly of diorite porphyry but with significant amounts of monzonite porphyry.

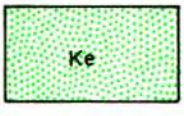
CRETACEOUS



Mesaverde Formation
Cliff-forming sandstone with thin shale interbeds. 400± feet.

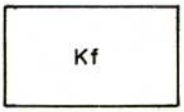


Masuk Shale
Lenticular sandstone, shale, carbonaceous shale and shaley limestone, mostly continental in origin, some marine. 600-800 feet.



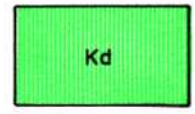
Emery Sandstone
Massive sandstone, shale, carbonaceous shale and coal. *190-450 feet.*

Blue Gate Shale
Shale, blue-gray, marine. 1,500± feet.



Ferron Sandstone
Lenticular cliff-forming sandstone, shale, carbonaceous shale and in upper part coal. *65-330 feet.*

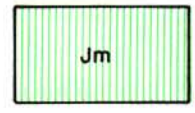
Tununk Shale
Shale, blue-gray, marine with numerous thin beds of bentonite. 525-650 feet.



Dakota Sandstone
Cliff-forming conglomeratic sandstone, locally coal-*bearing. 0-100 feet.*

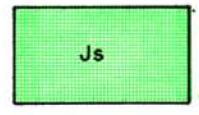
-Unconformity-

JURASSIC

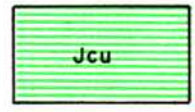


Morrison Formation
Upper part mostly clay and shale, variegated, dominantly green-gray, maroon and massive; lower part mostly sandstone and conglomerate, gray, very lenticular, massive, crossbedded and often impregnated with uranium and vanadium minerals. 35-750 feet.

-Unconformity-

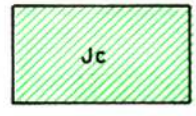


Summerville Formation
Evenly bedded reddish brown sandstone and sandy shale, minor amounts of green-white sandstone, gypsum and limestone. 40-250 feet.



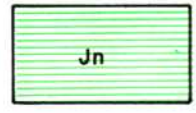
Curtis Formation
Evenly bedded gray sandstone and shaley sandstone, glauconitic, local thin basal conglomerate, marine. 0-175 feet.

Entrada Sandstone
Thickbedded and crossbedded buff and brown sandstone weathering to rounded forms, thinner bedded earth-weathering sandstone to north, forms flat sandy areas. 300-700 feet.



Carmel Formation
Thinbedded red sandstone, shaley sandstone and shale, thin limestone and gypsum. 100-266 feet.

-Unconformity-

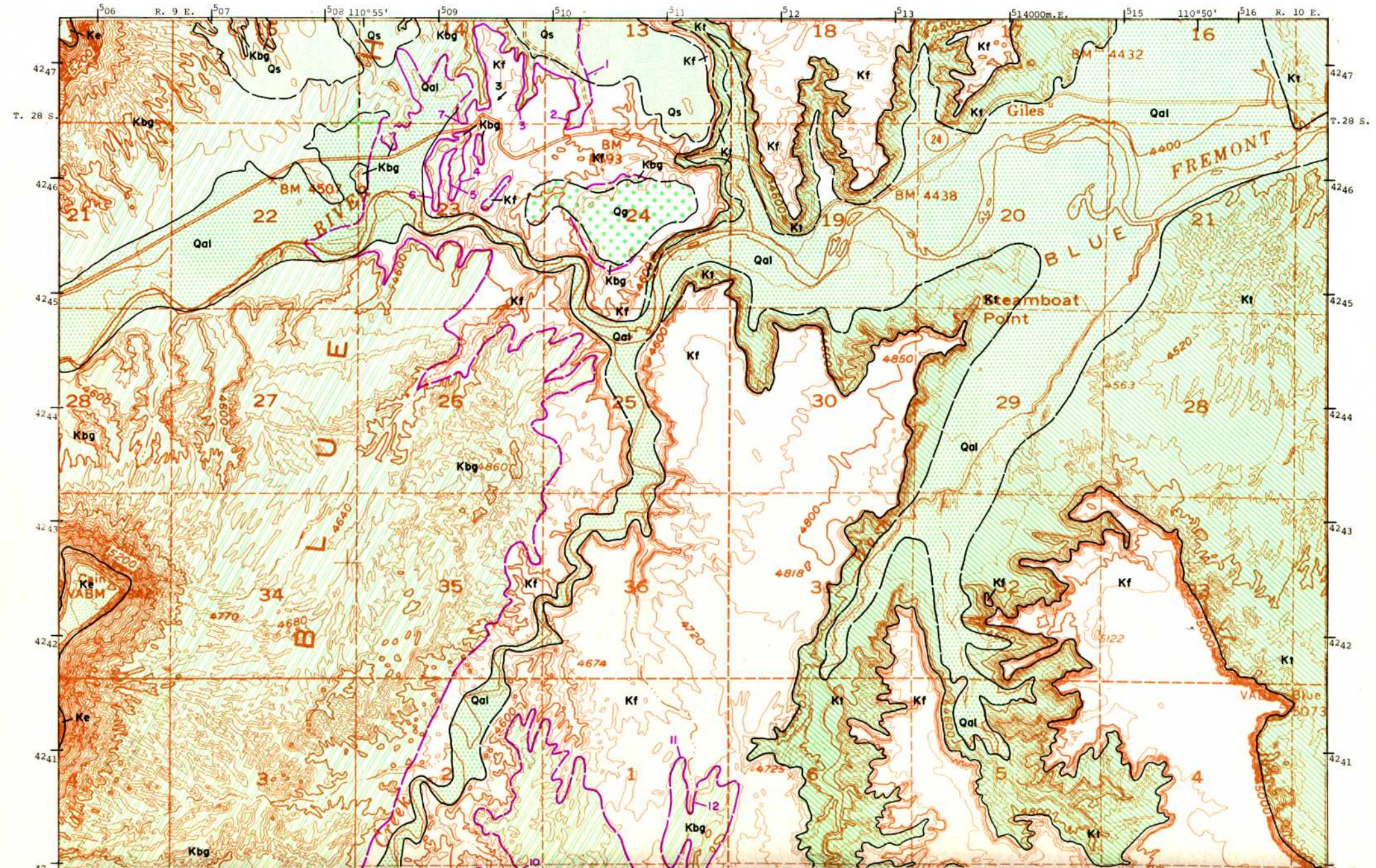


Navajo Sandstone
Tan to light gray massive crossbedded sandstone, thin lenses of limestone. 515-815 feet.

PRE-JURASSIC

Pre-Jurassic Rocks
Formations of various lithologies of Permian and Triassic age exposed along Waterpocket Fold and in the Circle Cliffs and San Rafael Swell.

STEAMBOAT POINT, UTAH



Utah Geological and Mineralogical Survey Monograph Series No. 2, 1972

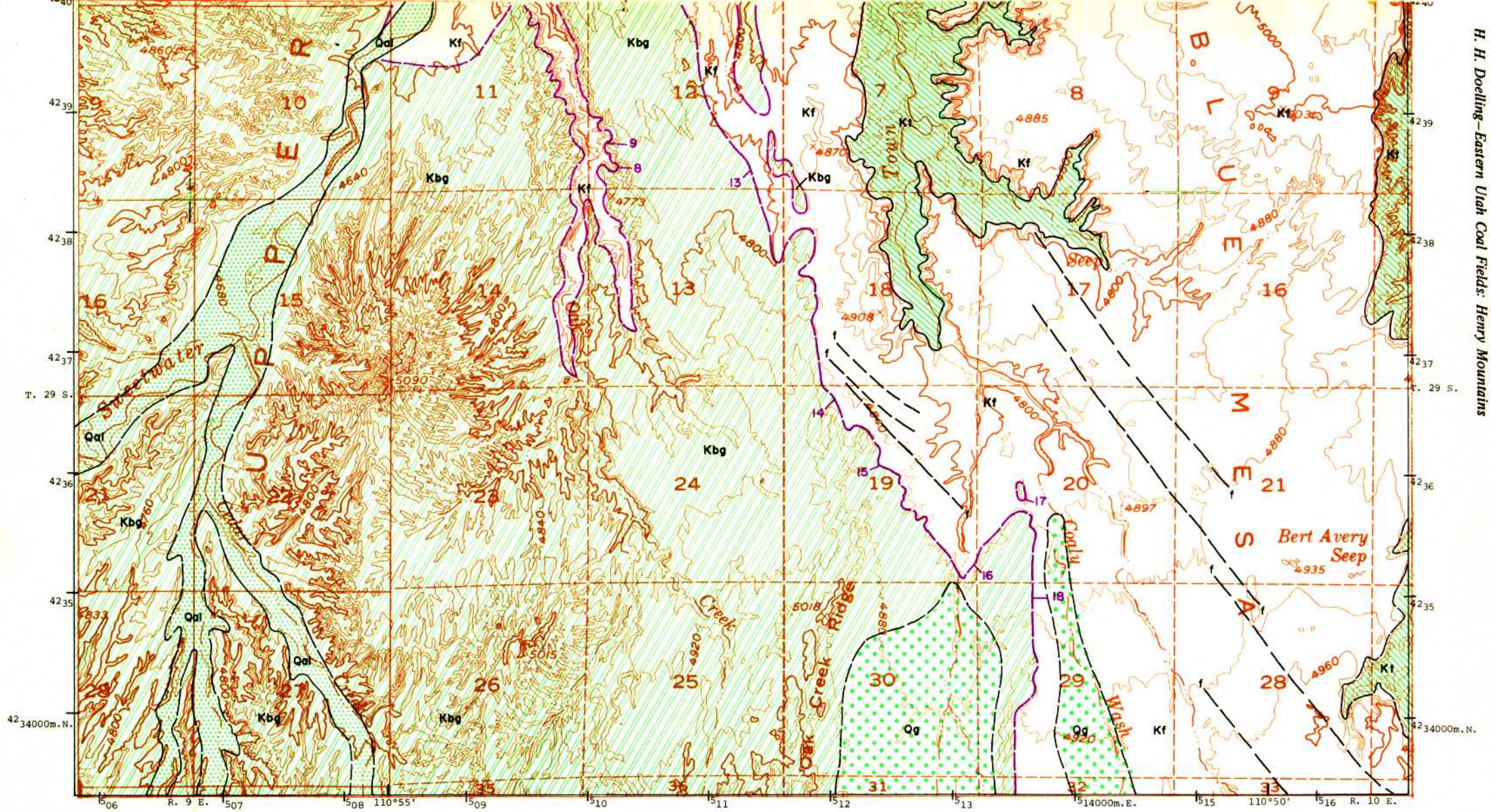
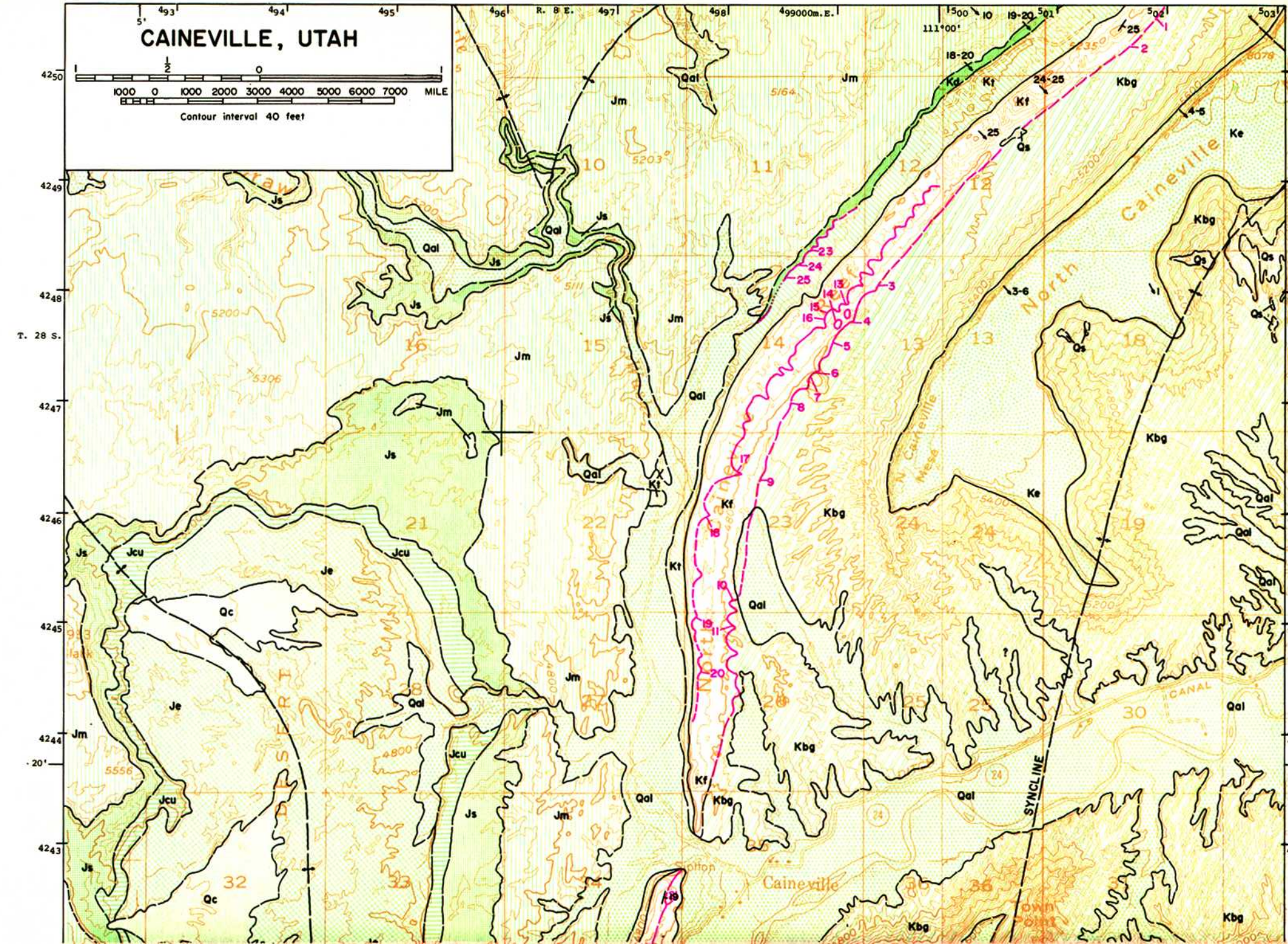
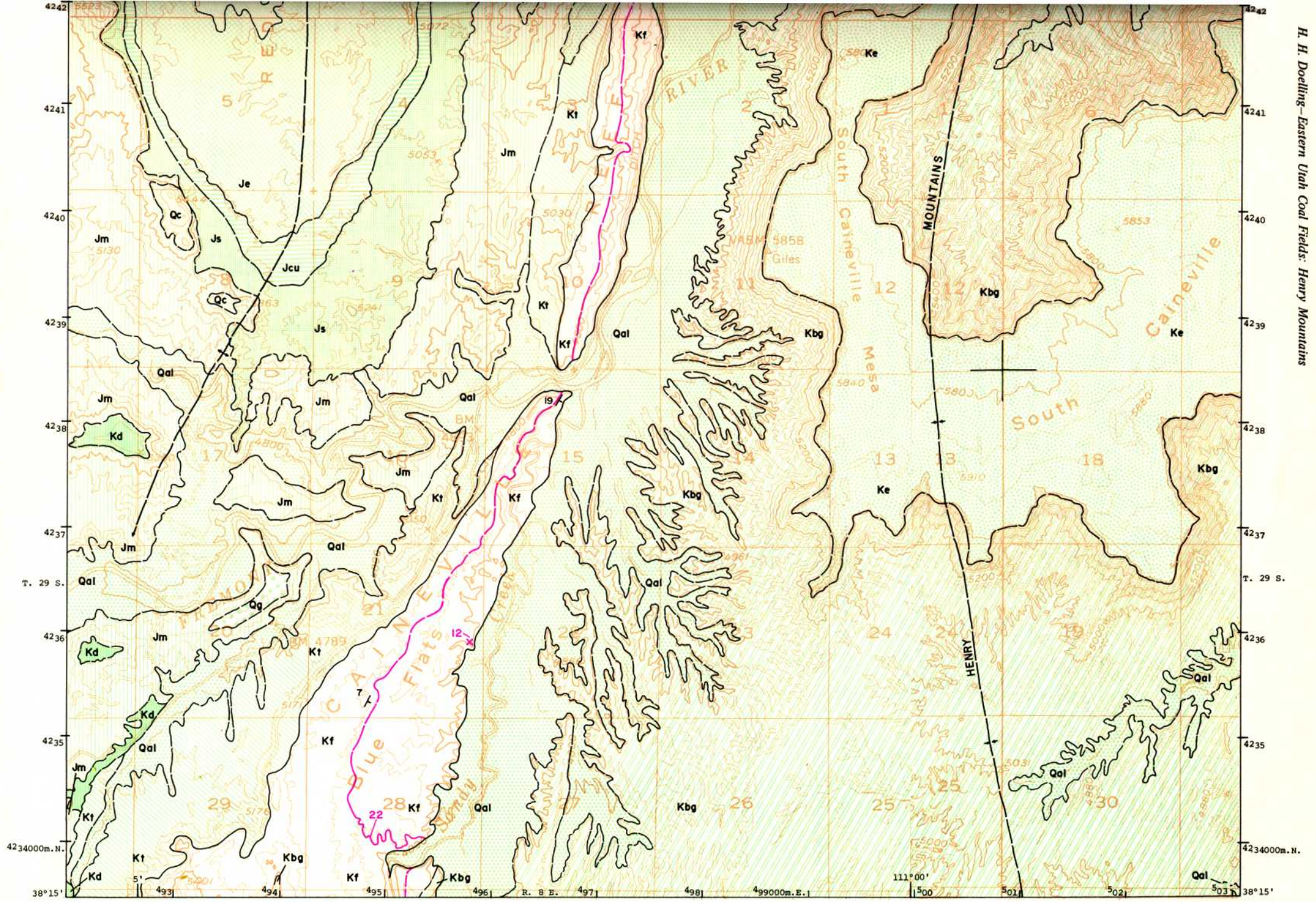


Figure 15. Coal and geology map, Steamboat Point quadrangle (explanation pages 128-129).


CAINEVILLE, UTAH
Contour interval 40 feet
1000 0 1000 2000 3000 4000 5000 6000 7000 MILE
R. 8 E.
T. 28 S.
Caineville
North Caineville Mesa
SYNCLINE
CANAL
Jm
Js
Jcu
Je
Qc
Qal
Kf
Kbg
Ke



Topography by U.S. Geological Survey

Geology by K. C. Thomson, 1964, UGMS; coal data by H. H. Doelling, 1971, UGMS, and L. Trimble, 1970, UGMS.

Figure 16. Coal and geology map, Caineville quadrangle (explanation pages 128-129).

17. Sandstone, brown, medium-grained, friable, thick bed, slope former 3.1
18. Sandstone, yellow-gray to tan, medium-grained, slightly cross-bedded, massive cliff former 35.0
19. Sandstone, tan-gray, medium-grained, shaley weathering 6.0
20. Sandstone, like unit 18 . . . . . .16.0
21. Shale, tan to gray, interbedded with subordinate sandstone, tan-gray, medium-grained, thin- to medium-bedded, nonresistant 10.4
22. Sandstone, like unit 18, but tan-gray 30.0
23. Sandstone, tan-gray, thin- to medium-bedded with thin shale partings 3.0
24. Shale, gray and tan, sandy, nodular weathering, slope former 3.5
25. Sandstone, yellow-tan, medium-grained, cross-bedded, thick bed 5.3
26. Sandstone, yellow gray, medium-grained, blocky with subordinate sandy gray shale 3.8

Total Ferron 173.3

Tununk Shale: gray shale, nodular weathering, sandy, alternating with subordinate thin-bedded sandstone.

Section of Ferron Sandstone, measured along Utah Highway 24 near Caineville, sec. 35, T. 32 S., R. 8 E., by R. D. Gray in 1971:

Blue Gate Shale
Ferron Sandstone

Feet

1. Carbonaceous shale 0.5
2. Sandstone, gray, medium-grained, ledge 20.0
3. Shale, gray 1.5
4. Carbonaceous shale 1.5
5. Sandstone, tan and brown, massive 35.0
6. Shale, gray with subordinate thin sandstone layers 6.0
7. Sandstone, light brown, coarse-grained, ledge 11.0
8. Shale, gray 30.0
9. Sandstone, tan, medium-grained, ledge former 22.0
10. Sandstone and siltstone, tan and gray, alternating 6.0
11. Sandstone, yellow-gray, medium-grained, massive cliff, lower 2 feet contain thin streaks of coal and gypsum 15.0
12. Carbonaceous shale 9.0
13. Coal 1.0
14. Shale, gray 8.0
15. Sandstone, shaley 5.0
16. Carbonaceous shale 1.8
17. Coal 0.8
18. Shale, gray, sandy 4.0
19. Sandstone, gray, medium- to coarse-grained, massive, cliff forming 50.0
20. Shale, gray and brown, sandy 1.5
21. Sandstone, gray, medium-grained, thick bed 6.0
22. Shale, gray, interbedded with tan and gray, thin-bedded, fine-grained sandstone, forms step and slope 33.0
23. Sandstone, yellow, medium-grained, massive cliff former 12.0
24. Shale, gray, like unit 22 . . . . . .34.0
25. Sandstone, yellow tan, medium-grained, medium to thick beds, gray shale in partings, pyritiferous, cliff former 8.0
26. Sandstone, tan, shaley, medium-grained, interbedded with subordinate gray shale, slope former 11.0
27. Sandstone, gray, medium-grained, thin- to thick-bedded, interbedded with subordinate gray shale, cliff former 13.0

Total Ferron Sandstone 346.6

Tununk Shale: sandstone, gray, fine-grained, thin- to medium-bedded, interbedded with gray shale

The Ferron produces the upper part of Caineville and North Caineville reefs in the Caineville quadrangle. To the east near Steamboat Point it forms the top of the cliff known as Blue Mesa. The overlying Blue Gate Shale is soft and has been stripped back from the top of the mesa so that a considerable area of Ferron has been laid bare. Of the two coal zones in the Ferron the one at the top is the most important and another lies as much as 140 feet below the top. The Lower zone occurs anywhere within the interval. In west sections the lower coal is more persistent and lower in the section. In east sections the lower coal is nearer the top and often completely missing. Coal up to 3 feet is known in the Lower zone and coal nearly 4 feet thick has been located in the Upper zone.

The base of the Blue Gate Shale normally lies a few feet above the uppermost coal zone of the Ferron. The Blue Gate has the same description as the Tununk, but is much thicker, estimated to be 1,400 to 1,500 feet. Its outcrop area extends from Blue Mesa on the east to the Caineville Reef on the west.

The uppermost consolidated unit outcrops on top of North and South Caineville mesas and is the Emery Sandstone. Perhaps up to 200 feet of cliff-forming tan and brown sandstones are exposed. The Emery Sandstone bears coal in the Henry Mountains coal field, but the coal-bearing part lies near the top of the unit and is believed to be completely removed by erosion on these two quadrangles.

In addition a few larger areas of unconsolidated deposits occur on the quadrangles. Alluvium covers the valleys of the principal drainages, especially the Fremont River. Gravelly surfaces and colluvium cover terraces and pediments on the Blue Gate and other formations throughout the area. Some gravels formed on older erosion surfaces, such as at or near the top of the Dakota and Ferron, and may have participated in later folding. The pebbles, cobbles and boulders are mainly of Jurassic and Triassic origin and possibly some are of Paleozoic origin. Most noticeable is the petrified wood and agatized material most likely derived from the Triassic Chinle or Jurassic Morrison formations.

STRUCTURE

The two quadrangles form a cross section across the Henry Mountains structural basin. The basin is elongate roughly north-south and its long axis passes underneath the North and South Caineville mesas. The synclinal basin is asymmetrical. Inclinations on either side of the axis are at first gentle, almost unnoticeable, but 3 to 4 miles to the west bend sharply to form the reef. Dips along the reef vary from 10 to 30 degrees. Elsewhere dips exceeding 10 degrees are rare, mostly averaging 1 to 4 degrees.

No faults of consequence occur on either quadrangle. A cluster trending northwesterly mapped by some investigators on Blue Mesa have minor displacements and do not affect the coal. Some faults should be associated with the folding of the reef monocline, but none appears present.

PROPERTY CONTROL

If one discounts the Dakota Formation, perhaps 40 percent of the area of the two quadrangles are underlain with coal. The lands are mostly public, controlled by the Bureau of Land Management (86.8 percent). A scattering of state of Utah land amounts to 8.4 percent of the total. The remaining is privately owned and follows the bottom land along the Fremont River. As of January 1, 1970, about 3,100 acres in the south part of the Steamboat Point quadrangle were held as coal prospecting permits by the Cayman Corp.

COAL

Surface Information

In the Steamboat Point quadrangle 18 sections were measured, all in the Upper Ferron coal zone (figure 17). All measurements are thin, ranging up to 3 feet. The thicker sections are on the north side of the Fremont River. The coal lies immediately below the Blue Gate Shale or within 25 feet of its base. Some coal usually occurs everywhere and the average thickness is 1½ feet.

Along the Caineville and North Caineville reefs two formations are coaliferous. The uppermost unit is the Ferron where two coal zones are developed with the uppermost zone along the Blue Gate contact. This upper carbonaceous zone is present along the entire reef, but the amount of coal is insignificant except in sections 13, 14 and 23 where the coal exceeds 2 feet (figure 18). Here two beds occur, the upper reaching a maximum of 2.8 feet. It is underlain by 3 to 5 feet of shale and a lower bed 0.5 to 1 foot thick.

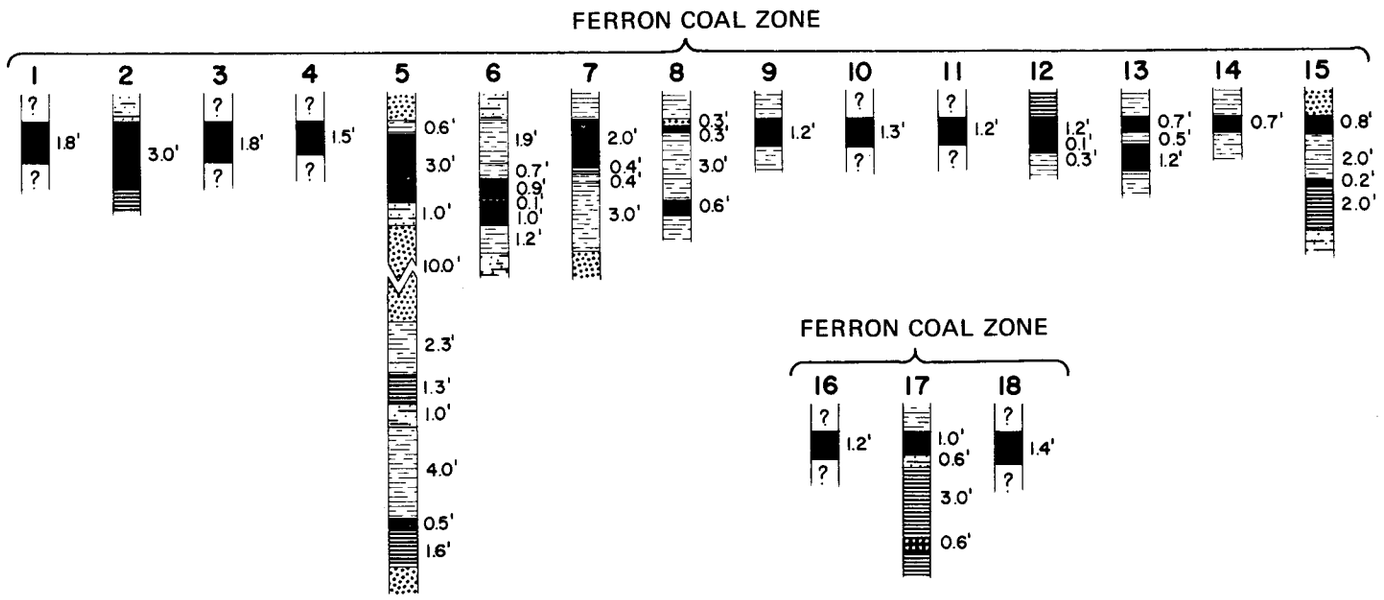


Figure 17. Coal sections of Steamboat Point quadrangle (vertical scale: 1 inch = 8 feet).

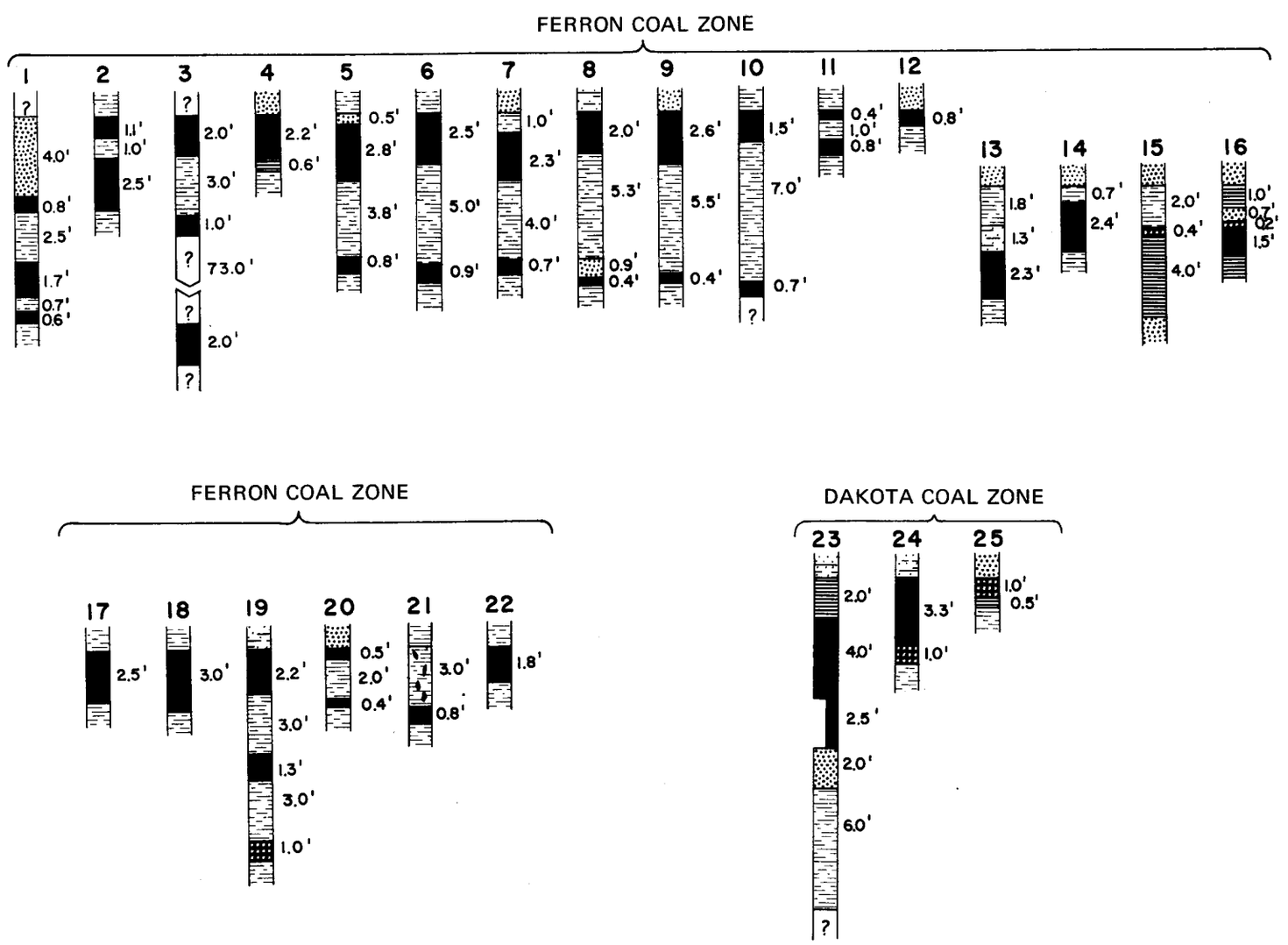


Figure 18. Coal sections of Caineville quadrangle (vertical scale: 1 inch = 8 feet).

The lower coal zone is more persistent along the reef and has coal beds ranging up to 2½ feet, but mostly contains 1 to 1½ feet of coal. This coal occurs up to 150 feet below the Upper zone. The thickest area of development coincides with that of the Upper zone.

The Dakota has been reported as carrying thin coal beds or merely a carbonaceous zone in the Henry Mountains. This is true, but locally a thickening of beds can occur. The area of best development is again along the North Caineville Reef where the Upper and Lower zones of the Ferron are best developed. In the north part of sec. 14, T. 28 S., R. 8 E. the coal reaches 6.4 feet thick. To the north and south the bed is split by the inclusion of coaley carbonaceous shale which worsens away from the favorable area. Hunt and others (1953, p. 216) note that lenticular coal, locally 2 to 3 feet thick, dips steeply southeast at the reef northwest of South Caineville Mesa. The thickness is maintained for about three-quarters of a mile along the outcrop. A thick carbonaceous zone is present in the Dakota east of the Steamboat Point quadrangle, but the maximum coal seam is 12 inches thick and is of shaley poor quality.

Subsurface Information

No drill-hole data are available for either quadrangle. Depth to the Ferron is estimated to be less than 300 feet except under North and South Caineville mesas. There the depth to the coal is expected to be 1,600 to 1,800 feet below the surface.

Quality of Coal

No analyses are available for the Caineville and Steamboat Point quadrangles.

Mines and Development

So far as is known no development for coal on either quadrangle has taken place.

Reserves

Only the Dakota in the north part of sec. 14, T. 28 S., R. 8 E. has coal more than 4 feet thick. About 120 acres are assumed to contain coal averaging 4 feet. This amounts to 835,000 tons. The average dip at this locality is 20 degrees and would present rapidly increasing mining problems with depth.

Ferron coal never reaches 4 feet in the two quadrangles. In several areas the coal maintains a 2-foot thickness over a large acreage. If one were to mine coal beds 1.5 to 3 feet thick there would undoubtedly be 104.5 million tons of coal in the Ferron under the basin (Class I, II, III and IV reserves).

PRINCIPAL WORK

The geologic data and some of the coal data are mostly derived from the work of Hunt and others (1953). Additional investigations were made specifically for this report.

The cliff in the background, Sheer Point, marks the south end of Swap Mesa. The sandstone of Sheer Point is Emery, the cliff in the foreground is Ferron; both units are coaliferous in the Henry Mountains Basin.

COW FLAT-MT. HILLERS NW QUADRANGLES

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Mt. Hillers NW quadrangle corresponds to the U. S. Geological Survey topographic quadrangle, but the Cow Flat is a composite of parts of Mt. Hillers SW and Mt. Pennell SE (figures 14, 19 and 20). The Cow Flat quadrangle better follows the Ferron outcrops and eliminates the necessity of putting the data on two maps. The area involves the southeast end of the Henry Mountains coal field and is situated 30 to 40 miles south of Hanksville and 20 to 30 miles north of Bullfrog Basin (Lake Powell).

The area is remote with few roads traversing the area. The quickest access from Hanksville is on Utah Highway 95 and 276 toward Bullfrog Basin. The paved road passes 5 miles east of the Ferron outcrops. The Star Spring graded road connects the pavement to the coal area. From there a graded road parallels the Ferron cliffs 1 to 2 miles south of them. A branch road circumvents Mt. Hillers. A few other roads, usually in poor condition or washed out, are occasionally found; normally the best access to the coal is on foot.

The land is rugged. Typically the Cow Flat quadrangle consists of large areas of rolling or sloping surfaces deeply indented by dry washes separated on occasion by steep unscalable cliffs. The elevation of Mt. Hillers in the northeast corner exceeds 10,000 feet. Most of the area below the peak ranges between 4,600 and 5,600 feet within which the coal beds lie 5,000 to 5,300 feet above sea level.

Mt. Hillers NW exposes mountains and land wedges between mountains and is very rough. The elevation ranges from 5,200 to 10,723 feet and the creeks and washes have created many canyons and deep ravines. Within the higher mountain areas greater rainfall and corresponding greater vegetation and soil cover make coal exploration difficult.

STRATIGRAPHY

Except for the bowed up beds that surround Mt. Hillers and the north and east two tiers of sections on the Mt. Hillers NW quadrangle, the surface consolidated units are Cretaceous in age. The pre-Cretaceous units are characteristic of their normal habit except where baked or bleached by the intrusives attendant to the mountains. The Morrison Formation in the Mt. Hillers NW quadrangle contains uranium and vanadium. Tunnels and prospects portrayed in the northeast map corner are uranium mines (figure 20).

The Dakota Formation surrounds Mt. Hillers and the Ragged Mountain anticline, the south part of which is exposed in the Mt. Hillers NW northwest map corner (figure 20). The Dakota then extends southward and is exposed 2 to 3 miles south of the Ferron cliffs as shown on the Cow Flat quadrangle. The unit is lenticular in its lithologies and is usually thin, never more than 100 feet thick and rarely exceeding 60 feet. At Eggnog Spring, a half mile south of Cow Flat quadrangle along Bullfrog Creek, the Dakota is 73 feet thick consisting mainly of sandstone with 9 feet of carbonaceous rock and a little conglomerate. At Star Spring 2 miles east of Cow Flat quadrangle the unit is 17½ feet thick with 11 feet of carbonaceous beds. Little coal appears in the Dakota in this area.

The Tununk Shale follows the Dakota and consists mainly of dark gray marine shales. Some are black and carbonaceous, but no coal has been located within them. The unit is at least 700 feet thick. The Tununk is followed by the Ferron Sandstone, easily recognized by the cliff it forms. The Ferron has been measured near the old Stanton coal mine.

Section of Ferron Sandstone adjacent to Hansen Creek, near the Stanton coal mine, center sec. 36, T. 34 S., R. 10 E., measured by R. D. Gray in 1971:

	Feet
1. Sandstone, light tan to white, medium- to coarse-grained, massive	10.5
2. Coal	4.0
3. Sandstone, tan, medium-bedded to massive, cliff former	46.0
4. Shale, gray, slope former	4.0
5. Shale, gray, interbedded with occasional thin-bedded sandstone, fine-grained	31.0
6. Sandstone, dark tan to brown, medium-grained, single resistant bed	1.0
7. Shale, gray, like unit 5	24.0
8. Sandstone, tan, medium-grained, massive cliff former	30.0
Total Ferron Sandstone	150.5

Tununk Shale: gray shale interbedded with subordinate dark gray thin-bedded sandstone.

The coal bed is rather persistent throughout the Cow Flat quadrangle. Usually a thin to thick unit of sandstone lies between the coal and the Blue Gate Shale. The base of the Blue Gate is not identified in the section, but is believed positioned immediately over unit 1. On the Mt. Hillers NW quadrangle the Ferron is less well exposed and has not been explored for coal.

The Blue Gate Shale makes up the surface of most of the north part of the Cow Flat quadrangle and is wedged between Mt. Hillers and Mt. Pennell. The unit is lithologically similar to the Tununk and ranges in thickness from 1,100 to 1,500 feet. At a few scattered localities remnants of the Emery Sandstone form a cliff above it. Coal beds have been reported in the Emery in the Mt. Hillers NW quadrangle, but there are no measurements and the area involved is probably small.

Cow Flat and the Coyote benches are covered by gravel pediment surfaces. The source of the gravel is the diorite and monzonite of the laccolithic intrusions of Mt. Hillers and Mt. Pennell.

STRUCTURE

When intruded the Mt. Pennell and Mt. Hillers stocks domed up the rock around them. The dip is steep adjacent to the peaks, but quickly diminishes. The divide at Stanton Pass is simultaneously a structural divide and the strata dip southwesterly to the west and northeasterly east of the pass. The average dip away from the peaks is 4 to 7 degrees. Locally it is steeper. In the vicinity of Bullfrog Creek the beds are nearly horizontal.

Faults are rare, but in a few cases they displace the coal. The offsets are usually less than 10 feet, but one on the west end of the Cow Flat quadrangle has about 30 feet of displacement.

PROPERTY CONTROL

Ownership of the land is 88.2 percent Bureau of Land Management, 11.0 percent state of Utah and 0.8 percent private property. None is currently held for coal in the form of prospecting permits or leases (January 1, 1970).

COAL

Surface Information

At the head of the large box canyon 1½ miles north-northwest of Thompson Seep, 3 miles west of Eggnog Spring in T. 35 S., R. 9 E., the Dakota carbonaceous zone contains 2½ feet of

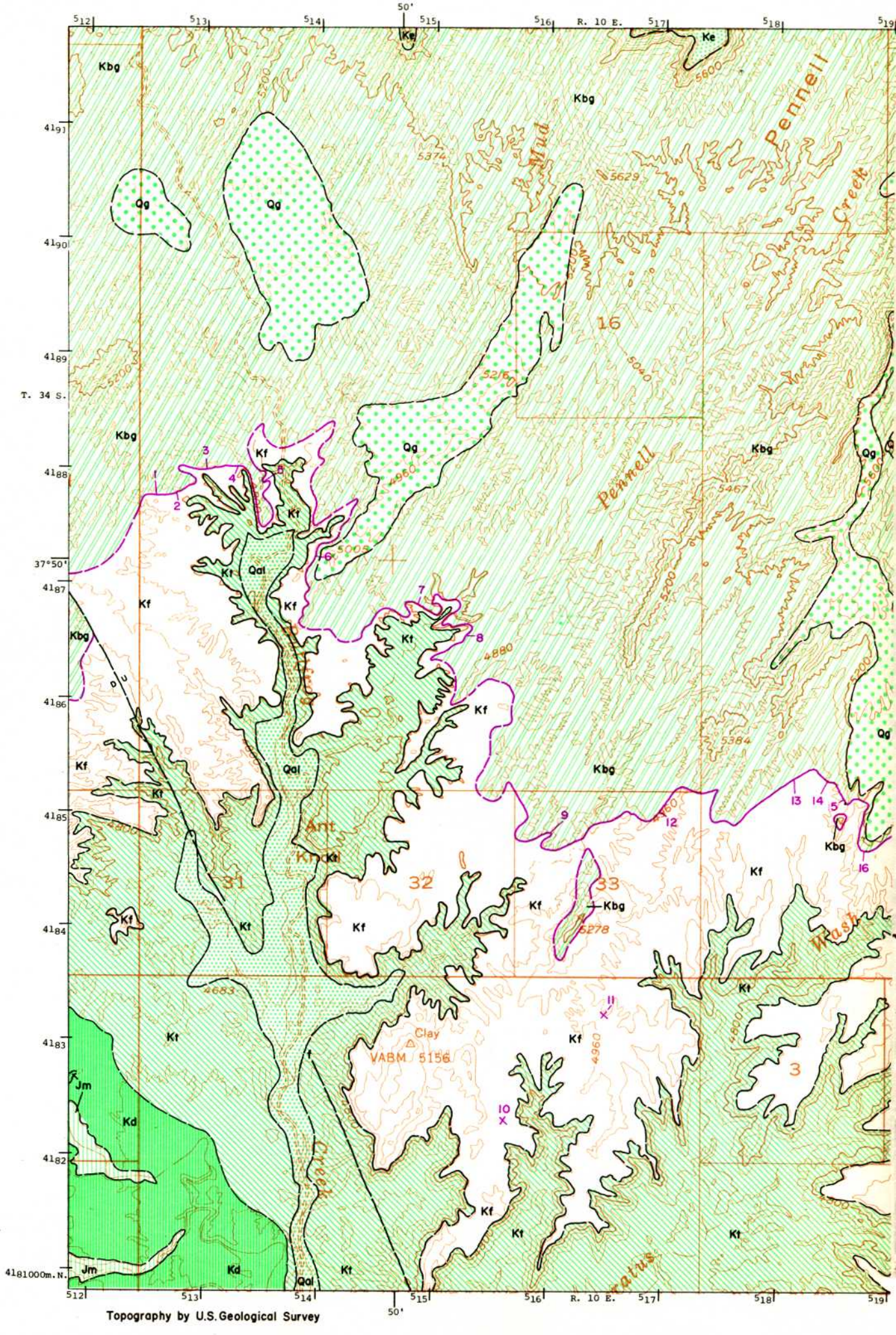
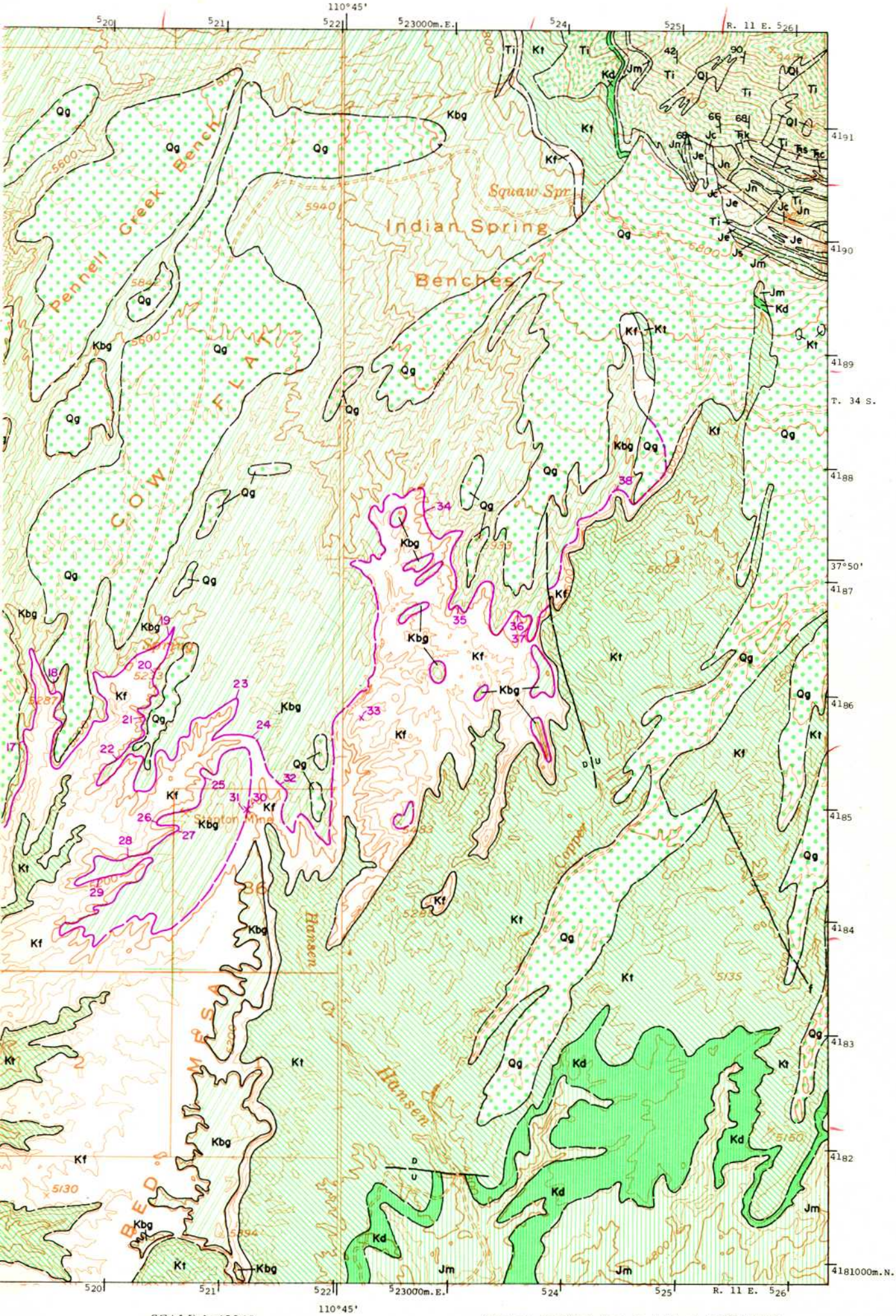
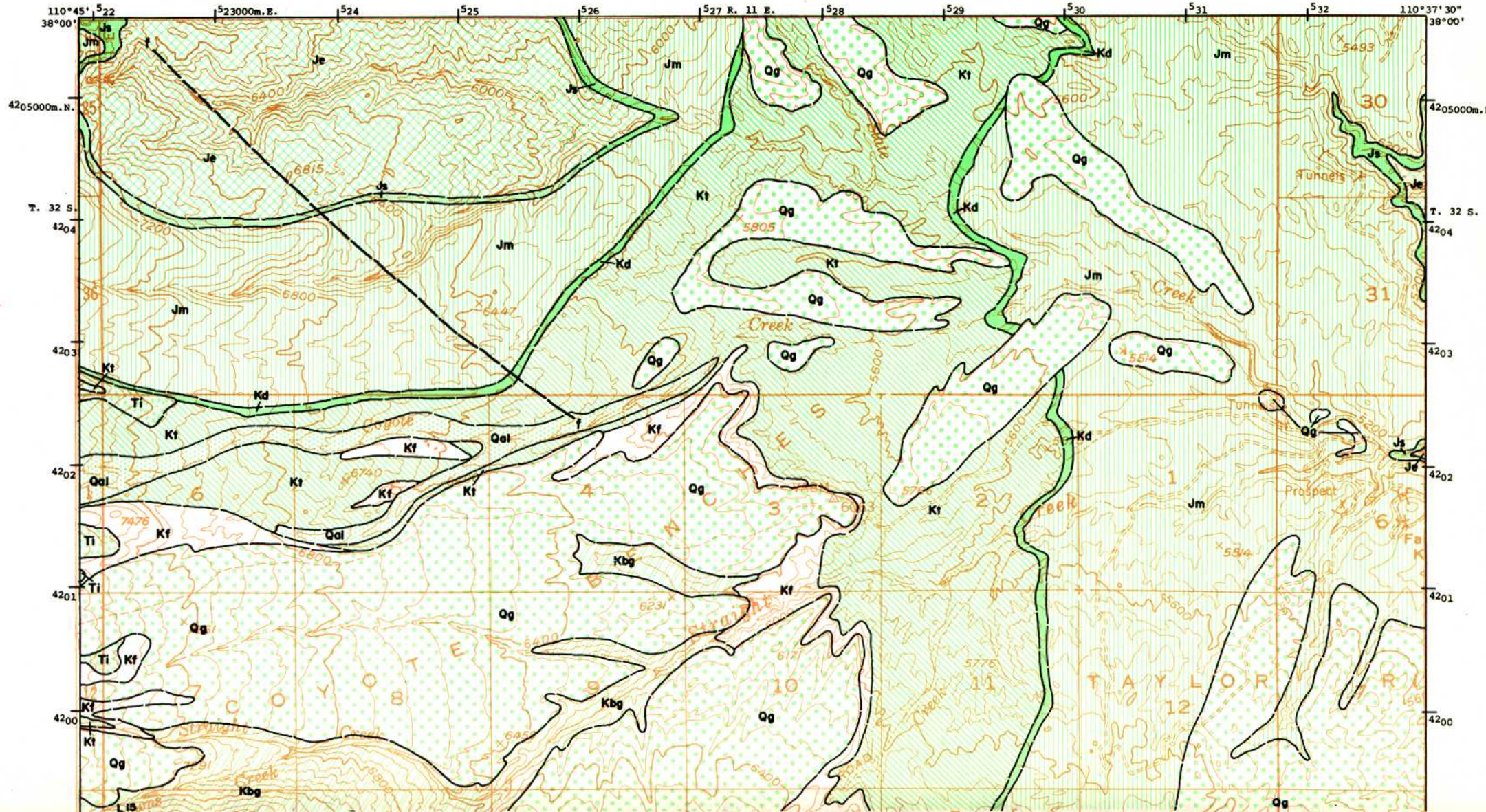


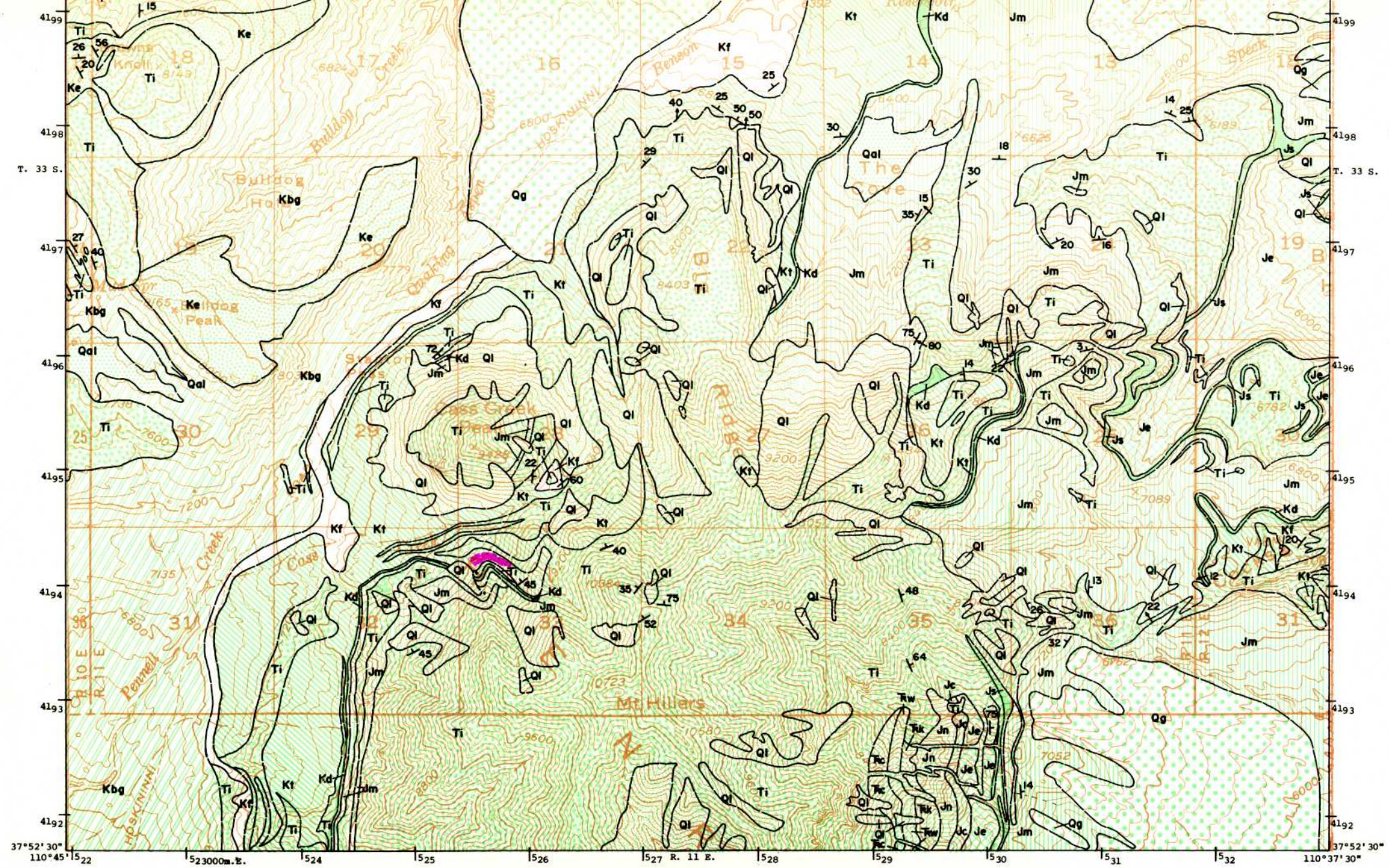
Figure 19. Coal and geology map, Cow Flat quadrangle (explanation pages 128-129).



Geology modified from C. B. Hunt, 1953, USGS; coal data by R. D. Gray and H. H. Doelling, 1970-1971, UGMS, and C. B. Hunt, 1953, USGS.

MT. HILLERS N.W., UTAH





Topography by U.S. Geological Survey

SCALE 1:42240

1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000

Contour interval 40 feet

Geology and coal data by C. B. Hunt, 1953, USGS.

shaley coal which thins eastward. Little is known about the Dakota outcrops and their coal content in either quadrangle. Presumably the coal is either thin or missing, but the unit has not been thoroughly explored.

The Ferron coal zone was traced adequately and checked for coal in the Cow Flat quadrangle (figure 21). In the Mt. Hillers NW quadrangle coal was noted in the Ferron, but poor exposures discouraged exploration. In the Cow Flat quadrangle coal emerges from the Indian Spring benches as a thin seam and quickly thickens and splits. Between Copper and Hansen creeks often 6 feet of coal are divided into two or more benches. The coal is best developed near the Stanton mine where the split coal beds are 4 to 6 feet thick. The splits are thin and the coal may be regarded as one bench. Between the Stanton mine and the west map edge the interval between splits widens; the thicker bed varies between 1½ and 4½ feet thick and probably averages 2 to 2½ feet.

The Emery outcrops in a limited area on either quadrangle. Coal beds in the Emery were reported in the Mt. Hillers NW quadrangle between Mt. Hillers and Mt. Pennell, but no sections are available. Such an occurrence probably would be unimportant because of the expected small area.

Subsurface Information

No drill-hole data are available for either quadrangle. The Ferron beds are expected to be less than 1,000 feet below the surface on the Cow Flat quadrangle and no more than 1,500 feet deep on the Mt. Hillers NW quadrangle.

Quality of Coal

One available analysis of coal (table 4) consists of a composite channel sample from 5.0 feet of coal about 35 feet back from the portal of the abandoned Stanton mine, sec. 36, T. 34 S., R. 10 E. The coal is high in sulfur (3.2 percent) and ash (14.6 percent). Other constituents include moisture (4.5 percent), volatile matter (36.9 percent), fixed carbon (40.8 percent) and a heat value of 12,309 Btu/lb.

Mines and Development

All the development work for coal was performed in sec. 36, T. 34 S., R. 10 E. From several prospects a few thousand tons of coal may have been removed. At present most of the tunnels are collapsed. The location of the original Stanton mine is unknown; the location given in Hunt and others (1953, pl. 22) is different than the one shown on the U. S. Geological Survey topographic base. Field checking proved at least three workings in the vicinity. As reported by Hunt and others (p. 217) the Stanton mine was opened about 1895 to supply placer gold operations along the Colorado River. The mine has not operated since 1900.

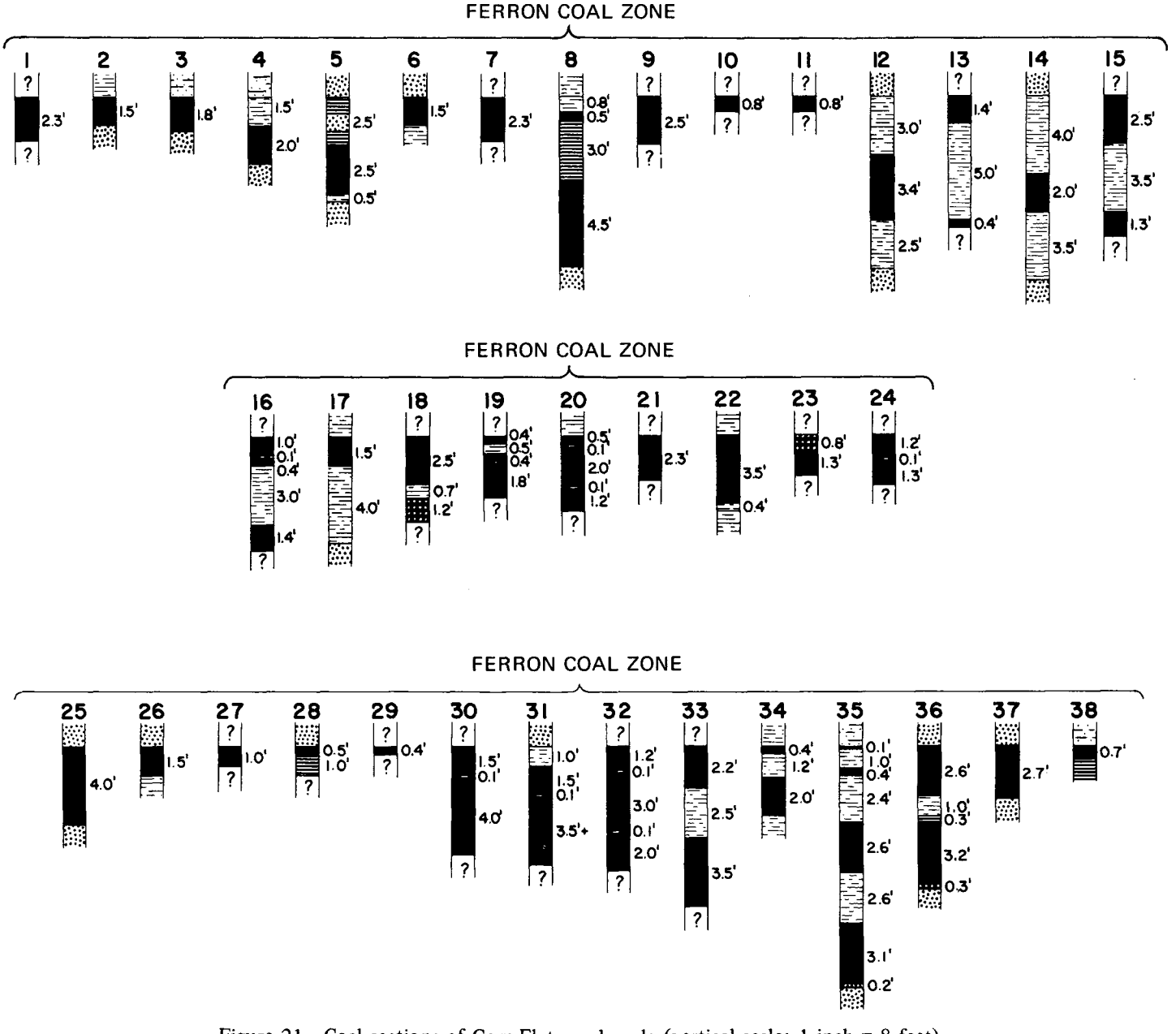


Figure 21. Coal sections of Cow Flat quadrangle (vertical scale: 1 inch = 8 feet).

Table 4. Coal analyses of the Henry Mountains coal field.

No.	Mine or Prospect-Coal bed	Township & Range UTM grid		PROXIMATE ANALYSES					ULTIMATE ANALYSES						OTHER TESTS			Kind of Samples	Ref. Source
			AN	M	VM	FC	Ash	S	H	C	N	O	Btu/lb	AST	ADL	HGI		
								COW FLAT QUADRANGLE										
1	Stanton mine Ferron coal zone composite channel from 5'1"	36–34S–10E 4184975mN 520780mE 4184800mN 521080mE	A	4.50	36.90	40.80	14.60	3.20	–	–	–	–	12,309	–	–	–		15
								MOUNT ELLEN NE QUADRANGLE										
	Outcrop Dakota coal zone	22–30S–10E 4226600mN 516600mE	A	5.9	58.11	34.15	1.74	2.91	–	–	–	–	13,450	–	–	–		18
			C	–	61.82	36.33	1.85	3.10	6.33	76.21	0.63	11.84	14,308					
								MOUNT ELLEN SW QUADRANGLE										
1	Factory Butte mine Ferron coal zone	SW.11–27S–9E 4258265mN 507510mE	A	5.5	33.6	44.9	16.0	2.5	4.9	61.5	1.2	13.9	10,840	2,310	–	–		12
			B	7.5	32.9	44.0	15.6	2.4	5.0	60.2	1.2	15.6	10,620	–	–	–		
			C	–	35.6	47.5	16.9	2.6	4.6	65.1	1.3	9.5	11,470	–	–	–		
			D	–	42.8	57.2	–	3.2	5.5	78.3	1.6	11.4	13,810	–	–	–		
2	Outcrop Emery coal zone	32S–9E	A	9.2	35.4	44.9	10.5	.7	4.7	57.5	1.1	25.5	9,590	2,760	–	–		12
			B	11.8	34.4	43.6	10.2	.7	4.9	55.8	1.1	27.3	9,310	–	–	–		
			C	–	39.0	49.4	11.6	.8	4.1	63.2	1.2	19.0	10,560	–	–	–		
			D	–	44.1	55.9	–	.9	4.6	71.5	1.4	21.6	11,940	–	–	–		
3	Outcrop Emery coal zone	SW.36–31S–8E 4212600mN 502650mE	A	13.51	31.99	35.69	18.81	0.66	–	–	–	–	9,015	–	–	–		1
			C	–	36.99	41.26	21.75	0.76	–	–	–	–	10,423	–	–	–		
			D	–	42.27	52.73	–	–	–	–	–	–	13,320	–	–	–		
4	Outcrop Emery coal zone	NE.36–31S–8E 4213675mN 502700mE	A	13.87	34.37	41.33	10.43	0.53	–	–	–	–	10,204	–	–	–		1
			C	–	39.90	47.99	12.11	0.62	–	–	–	–	11,847	–	–	–		
			D	–	45.40	54.60	–	–	–	–	–	–	13,479	–	–	–		
5	Prospect pit by South Creek Emery coal zone	SW.27–31S–9E 4214100mN 507600mE	A	6.9	38.0	49.1	6.0	.7	5.1	65.3	1.3	21.6	11,130	2,120	–	–		12
			B	7.9	37.5	48.7	5.9	.6	5.1	64.6	1.2	22.6	11,000	–	–	–		
			C	–	40.8	52.8	6.4	.7	4.6	70.2	1.4	16.7	11,950	–	–	–		
			D	–	43.6	56.4	–	.7	5.0	75.0	1.4	17.9	12,770	–	–	–		
6	Prospect pit near Sweet Water Creek Emery coal zone	N.½.NE.30–31S–9E 4215300mN 504000mE	A	9.3	37.2	46.7	6.8	.8	5.3	63.6	1.1	22.4	10,900	2,190	–	–		12
			B	10.9	36.5	45.9	6.8	.8	5.4	62.4	1.1	23.6	10,700	–	–	–		
			C	–	41.0	51.5	7.5	.9	4.7	70.1	1.2	15.6	12,010	–	–	–		
			D	–	44.3	55.7	–	1.0	5.0	75.8	1.3	16.9	12,990	–	–	–		
7	Outcrop near Sweet Water Creek Emery coal zone composite channel of 10'6"	SE.NW.30–31S–9E 4215200mN 503200mE	A	7.70	38.50	40.80	11.50	1.50	–	–	–	–	12,491	–	–	–		15
8	Outcrop near Sweet Water Creek same as no. 7 from upper 4 ft.		A	7.40	36.50	44.90	10.00	1.20	–	–	–	–	12,808	–	–	–		15
9	Outcrop near Sweet Water Creek same as no. 7 from 4 to 6½ ft. above base		A	5.70	36.70	45.50	10.40	1.70	–	–	–	–	12,954	–	–	–		15
10	Outcrop near Sweet Water Creek same as no. 7 from lower 4 ft.		A	6.00	37.10	43.00	12.70	1.20	–	–	–	–	12,604	–	–	–		15
								MOUNT PENNELL NW QUADRANGLE										
1	Outcrop Emery coal bed	SE.2–33S–9E 4201800mN 510850mE	A	10.48	38.29	45.25	5.98	0.78	–	–	–	–	11,468	–	–	–		1
			C	–	42.77	50.55	6.68	0.87	–	–	–	–	12,810	–	–	–		
			D	–	45.83	54.17	–	–	–	–	–	–	13,983	–	–	–		
2	Outcrop Emery coal bed	NW.11–33S–9E 4200800mN 509675mE	A	11.34	36.09	43.86	8.71	0.46	–	–	–	–	10,856	–	–	–		1
			C	–	40.71	49.47	9.82	0.52	–	–	–	–	12,244	–	–	–		
			D	–	45.14	54.86	–	–	–	–	–	–	13,577	–	–	–		
3	Outcrop Emery coal bed	NW.14–33S–9E 4198900mN 509750mE	A	12.29	36.65	45.49	5.57	0.55	–	–	–	–	11,147	–	–	–		1
			C	–	41.79	51.86	6.35	0.63	–	–	–	–	12,709	–	–	–		
			D	–	44.62	55.38	–	–	–	–	–	–	13,571	–	–	–		
4	Outcrop Emery coal bed	SW.11–33S–9E 4199250mN 509820mE	A	13.70	37.20	44.19	4.91	0.47	–	–	–	–	11,121	–	–	–		1
			C	–	43.11	51.20	5.69	0.54	–	–	–	–	12,886	–	–	–		
			D	–	45.71	54.29	–	–	–	–	–	–	13,664	–	–	–		

Reserves

No reserves are calculated for the Mt. Hillers NW quadrangle because no data are available. In the Cow Flat quadrangle only the Ferron Sandstone contains coal (table 5).

The coal areas placed in Class II (estimated) reserves follow the outcrop in a band less than 1 mile wide. Because of the lenticular nature of the coal and because it can disappear quickly, no coal can be inferred beyond that width. A band about 2 miles wide was added for the potential (Class IV) reserve.

PRINCIPAL WORK

The only published work for this area is that of Hunt and others (1953) and the geology and coal data presented in that publication are included here. The analysis was reported by Robison (1963) and additional coal measurements were made in 1970 and 1971 for this report.

Table 5. Coal reserves in the Ferron coal zone, Cow Flat quadrangle.

Location	Acres	Average thickness (feet)	Tonnage	Class Reserve
T.34S. R.9E.	200	2.0	700,000	II
	500	2.0	1,740,000	IV
T.34S. R.10E.	3,300	2.5	14,370,000	II
	600	4.0	4,180,000	II
	7,680	2.5	33,450,000	IV
T.34S. R.11E.	440	3.0	2,300,000	II
	480	3.0	2,510,000	IV
		Total coal	59,250,000	
		Class I and II reserve:	21,550,000	
		Class IV reserve:	37,700,000	
		Coal in beds 4 feet or more:	4,180,000	

Coal bed about 6 to 7 feet thick in Factory Butte area, Henry Mountains coal field. Note shale overburden. Top of Ferron Sandstone is immediately above sandy roof.

FACTORY BUTTE NW QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

Factory Butte is located in the north part of the Henry Mountains structural basin north of the Fremont River (figures 14 and 22). The southeast map corner is about 10 miles west of Hanksville and a mile north of Utah Highway 24. The north edge of Wayne County coincides with the north map margin. The only access road extends north from Utah Highway 24 along the east part of the map to the Factory Butte coal mines and then continues into the San Rafael Swell in Emery County.

The North Caineville Reef marks the west boundary of the Henry Mountains Basin. To the west no coal occurs and the land is rugged. Within the basin area the land is gently rolling and is made up of badlands with two prominent physiographic features: Factory Butte and North Caineville Mesa. The elevation atop these features is about 6,000 feet. The badlands below are 1,000 to 1,200 feet lower and the coal outcrops between 4,800 and 5,200 feet above sea level.

STRATIGRAPHY

The Carmel Formation is the oldest unit exposed on the Factory Butte NW quadrangle and the Emery Sandstone Member of the Mancos Shale is the youngest consolidated unit (figure 22). The Carmel (Jurassic) is exposed at Moroni Slopes to the northwest and between that physiographic feature and the North Caineville Reef the Entrada, Curtis, Summerville, Morrison and Dakota formations each appear in a northeast-trending band the width of which is a function of its thickness. Of these units only the Dakota is coal bearing; the other units are adequately described in the field report.

The Dakota consists of sandstone, conglomerate, gray shale, carbonaceous shale and minor coal. The unit is generally thin, rarely exceeds 50 feet and in many places is missing. The Dakota is not mapped in the north part of the quadrangle where it is either missing or too thin. Either at the top of the Dakota or in the lowermost beds of the Tununk Shale a diagnostic bed of fossils contains *Gryphaea, Exogyra, Inoceramus* and other forms. The coal is generally too thin to mine except locally.

Mancos Shale members fill the basin and contain the thicker coal beds. In the vicinity of Factory Butte four of the five members are present; the uppermost Masuk is completely removed by erosion. The Tununk Shale and the Ferron Sandstone form the North Caineville Reef on the west side of the basin and form a cliff on the east side. The central basin area exposes the Blue Gate Shale which forms rounded hills and badlands. The Blue Gate is held in a cliff by the Emery Sandstone under North Caineville Mesa and Factory Butte.

The Tununk is a gray marine shale with subordinate mostly thin-bedded medium-grained sandstones. These sandstones are gray to yellow-gray on fresh surfaces, but weather to tans and browns. Toward the top they become more abundant giving evidence of the intertonguing relationship between the Tununk and the overlying Ferron. The top is placed underneath the first thick-bedded or massive sandstone ledge. In most places the Tununk appears not to be a true shale and is nodular weathering. The outcrops are usually dark gray slopes or vertically fluted curtain-like cliffs. The Tununk is about 575 feet thick.

The Ferron above is the important coal bearer of the Factory Butte NW quadrangle. In measurements of the unit around the north end of the basin the Ferron thins from west to east. Along the reef the unit is about 300 feet thick and just southeast of the map area it is about 165 feet thick (figure 22). As in most parts of the Henry Mountains region the Ferron consists of three parts: a lower sequence of alternating marine shale and littoral sandstone, a middle massive yellow-gray to brown sandstone and an upper sequence of alternating lagoonal shale, sandstones and coal. A section of the Ferron Sandstone is provided as measured along Coal Mine wash:

Coal Mine Wash measurement of Ferron Sandstone, secs. 11 and 12, T. 27 S., R. 9 E.

Blue Gate Shale
Ferron Sandstone

	Feet
1. Coaley sandstone	0.2
2. Coal	3.0
3. Shale, gray, upper 0.5 feet carbonaceous	2.5
4. Sandstone, tan to brown, medium-grained to coarse-grained, massive cliff, upper part limonite stained	48.0
5. Coal	1.0
6. Carbonaceous shale	0.8
7. Coal	0.8
8. Carbonaceous shale	5.5
9. Sandstone, gray, shaley, medium- to coarse-grained	1.5
10. Sandstone, tan-gray, medium-grained, massive cliff, minor cross-bedding	53.0
11. Shale, gray	2.8
12. Sandstone, yellow-gray, coarse-grained, thick-bedded	5.0
13. Carbonaceous shale	2.3
14. Sandstone, tan, medium-grained, massive resistant cliff former	27.0
15. Shale, gray, interbedded with thin-bedded sandstone, contains occasional gypsum and coal seamlets, step-like ledges and slopes	15.0
16. Sandstone, tan, massive slope former	9.5
17. Sandstone, tan, medium-grained, resistant ledge	4.0
18. Sandstone, tan, shaley weathering	8.5
19. Sandstone, yellow-gray, medium-grained, ledge	2.5
20. Shale, gray interbedded with sandstone, thin-bedded and fine- to medium-grained	21.0
21. Sandstone, tan-gray, medium-grained, thick-bedded to massive, cliff former with ripple marks and numerous worm burrows	48.0
22. Sandstone, shaley and thin-bedded sandstone, medium-grained	3.5
23. Sandstone, yellow-tan, medium-grained, ledge	2.0
Total Ferron Sandstone	267.4

Tununk Shale: shale, brown, sandy, interbedded with subordinate thin-bedded sandstone.

The Blue Gate Shale is almost exactly like the Tununk in its lithology, topographic expression and overall appearance. The lower part on weathered outcrops appears lighter in color than the Tununk and often more yellow. The unit is thicker and estimated to be 1,400 feet thick. The final exposed Emery Sandstone Member is a massive cliff-forming body of rock. Only the lower part is exposed; the coal-bearing portion has been eroded from the top of the mesa.

STRUCTURE

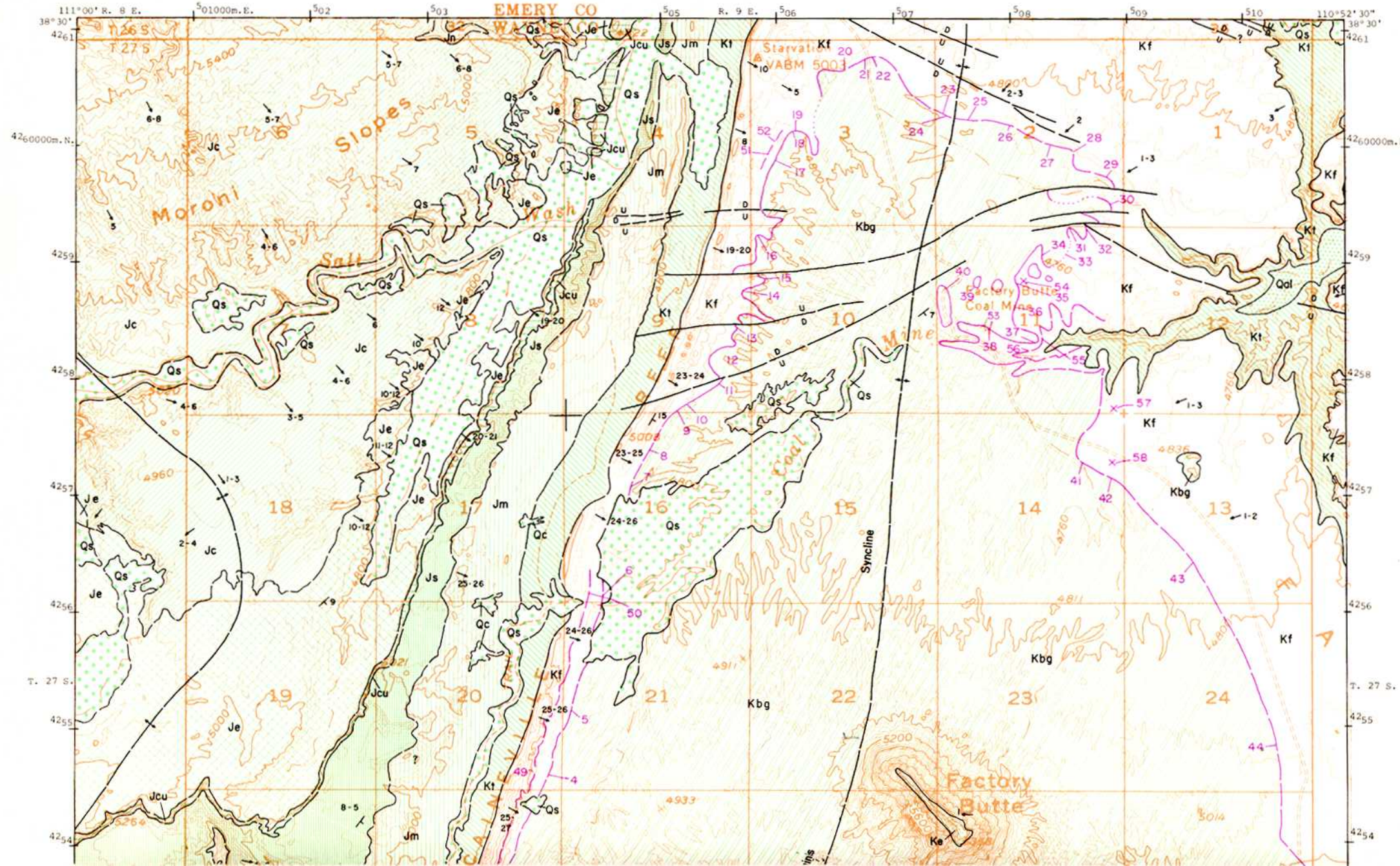
The strata of the Factory Butte NW quadrangle are gently warped (5 degrees or less) except along the North Caineville Reef. There the dips range from 20 to 30 degrees in the sharpest part of the fold. The Henry Mountains synclinal axis parallels the monocline approximately 1½ miles to the west of the reef. The dips immediately west of the axis are gentle although slightly greater than those east of the axis.

Several faults cut strata and coal in the north part of the quadrangle north of the Factory Butte coal mines. They trend roughly east-west and are rather closely spaced. The rocks between them do not appear to be shattered and displacements are usually less than 30 feet.

PROPERTY CONTROL

The lands of the Factory Butte NW quadrangle are public lands with a sprinkling of state of Utah land. The state lands amount to 11.5 percent of the quadrangle and the remainder is

FACTORY BUTTE N. W., UTAH



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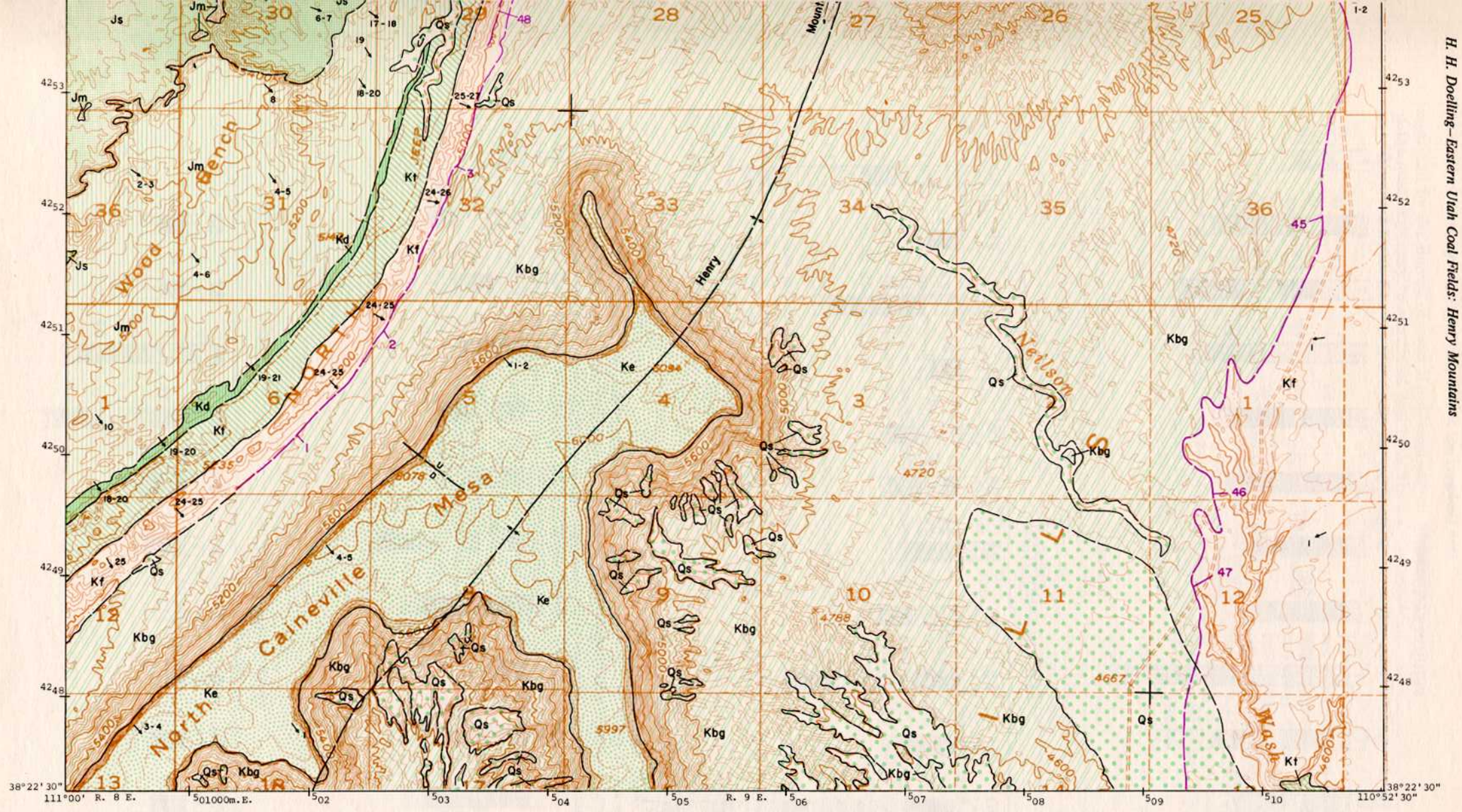


Topography by U.S. Geological Survey

Geology by W. R. Hemphill, 1959, USGS, modified by H. H. Doelling, 1970, UGMS; coal data by C. B. Hunt and others, 1953, USGS, and H. H. Doelling, 1970, UGMS

Figure 22. Coal and geology map, Factory Butte NW quadrangle (explanation pages 128-129).

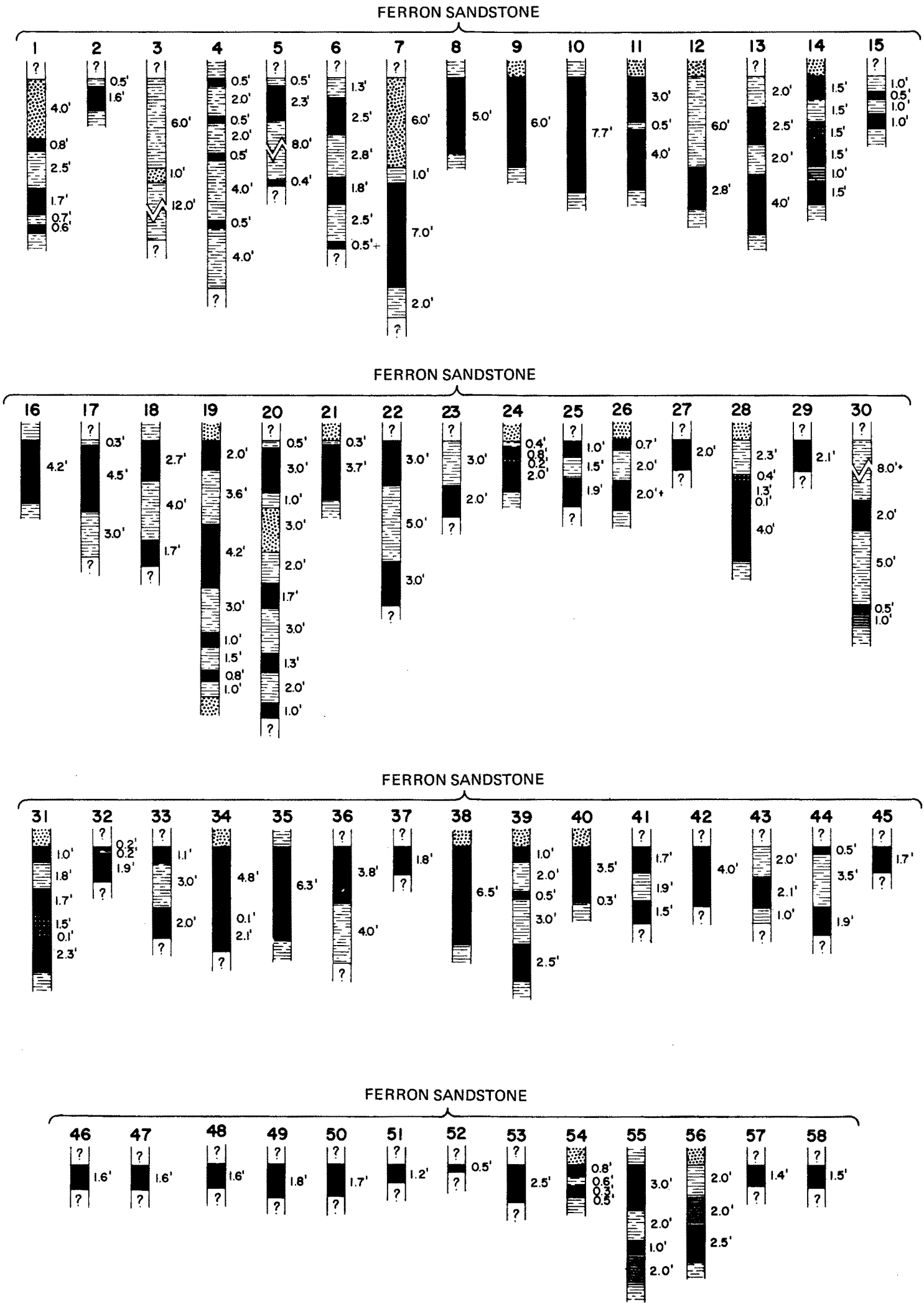


Figure 23. Coal sections of Factory Butte NW quadrangle (vertical scale: 1 inch = 8 feet).

supervised by the Bureau of Land Management. About 57 percent of the quadrangle may be considered coal land. There are no current (January 1, 1970) leases or permits on the quadrangle.

COAL

Surface Information

Fifty-eight surface sections of coal were measured in two coal zones (figure 23). The uppermost zone is near the top of the Ferron; usually only a thin friable sandstone lies above the coal before the gray shale of the Blue Gate is reached. Any seam below the first massive cliff-forming sandstone below the upper zone is designated the Lower Coal zone. There may be several lenticular beds in the Lower zone.

In this quadrangle the Upper zone is the most valuable and it is best developed north of Factory Butte. Along the North Caineville Reef the zone and beds are thin. In 16-27S-9E the main bed thickens up to 7 feet and in sections 9 and 10 it remains thick but splits. In sections 2 and 3 the main bed is lenticular, varying between 2 and 5 feet thick; in section 11 the coal averages 5 to 6 feet thick. Farther south and east of Factory Butte the coal thins and averages 1 to 2 feet.

The Lower zone has no coal bed that thickens to 4 feet. The thickest section measured is at location 55 near the Factory Butte coal mines where the bed is 3 feet. When the bed can be located elsewhere it is usually 1½ feet thick.

Subsurface Information

No drilling data are available for the Factory Butte area. In the Factory Butte coal mines area, the coal lies under shallow cover, mostly under 50 feet of soft shale. In places the depth increases to 100 feet. Only under Factory Butte and North Caineville Mesa does the overburden exceed 400 feet. Under the mesa the depth is assumed 1,600 feet.

Quality of Coal

The one available analysis was collected by the U. S. Geological Survey in connection with Hunt and others' (1953) work on the Henry Mountains and labeled "Factory Butte coal mine, outcrop in upper Bullfrog Creek, center secs. 36." Although the Factory Butte mines are not in sec. 36 nor in upper Bullfrog Creek, the thickness of coal matches well. The analysis presented here is presumably from the Factory Butte mine. The sample was channeled in a 7-foot bed and included 1 inch of sandy shale in a split 2 feet from the base. The coal contains 16 percent ash, 2.5 percent sulfur and has a heat value of 10,840 Btu/lb on an as-received basis.

Mines and Developmen.

The three Factory Butte coal mine entries (table 6) all are located in sec. 11, T. 27 S., R. 9 E. The mines operated intermittently until the 1950's when they were abandoned. It is not exactly known when they initially opened. The mine on the south side of Coal Mine Wash is the largest and it consists of an entry way almost 260 feet long from which two other tunnels have been driven, one 150 and the other 250 feet long. It is estimated that 3,600 tons of coal may have been removed from the mine. Two adits open on the north side of the road, each consisting of a large room. Total production from these two mines is estimated to be 2,300 tons. No other prospects were noted on the quadrangle.

Table 6. Mines of the Factory Butte NW quadrangle.

Mine	Location	Remarks
Factory Butte mine Upper Ferron	SW.11-27S-9E 4,258,265m.N. 507,510m.E.	Intermittent 1900-1950's?

Reserves

All the reserve of coal (table 7) in beds 4 feet or more thick is located at the north end of the Henry Mountains structural basin in secs. 2, 3, 9, 10, 11, 14, 15 and 16 in T. 27 S., R. 9 E. About 2,600 acres are involved with an average of 5 feet of coal. Most of this coal is under shallow cover and may be suited for strip-mining.

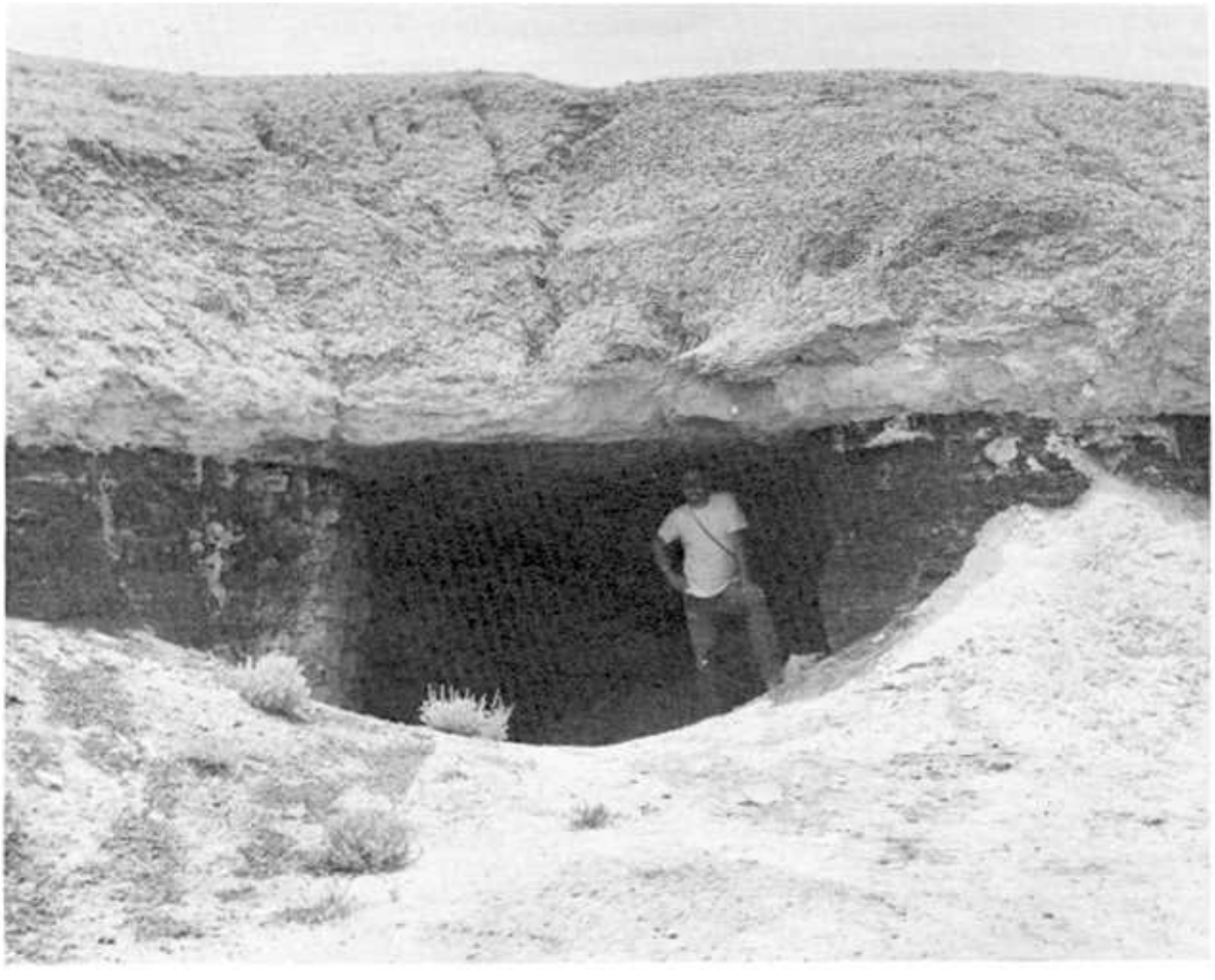
Table 7. Coal reserves for the Factory Butte NW quadrangle.

Location	Average ft. Acres	Class II thickness	Tonnage
T.27S. R.9E.	2,600	5.0	22,750,000

Additional reserve may be located under the synclinal axis. To formulate a Class IV (potential) reserve is risky because the Ferron beds are highly lenticular and because no evidence anywhere supports it. An average of 1½ feet of coal presumably underlie the structural basin everywhere, which, excluding the favorable area, would calculate to be a 45-million ton reserve of thin coal.

PRINCIPAL WORK

The geologic mapping is mostly the work of Hunt and others (1953) and Hemphill (1959). The coal data involve the work of Hunt (1953) and his assistants coupled with new work especially done for this project.



North of the abandoned Factory Butte mine, Henry Mountains coal field. The coal bed is about 7 feet thick here.

Factory Butte with coal in the foreground. The bed is about 7 feet thick and occurs near the top of the Ferron. A 2-foot sandstone followed by the Blue Gate Shale overlies it. The Blue Gate extends upward to the sandstone cliff of Factory Butte which is the lower cliff-forming member of the Emery Sandstone.

MT. ELLEN NE-SE QUADRANGLES

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The east half of the Mt. Ellen quadrangle is located in the east central part of the Henry Mountains coal field (figure 14) in mountainous land. Only the north part of the NE quadrangle has a large area of more level land. The highest prominences of Mt. Ellen rise to more than 11,500 feet. The lowest elevations are below 5,000 feet at the north end of the NE quadrangle. Coal-bearing beds crop out around the margin of Mt. Ellen at any intermediate elevation. Several mountain roads extending from Hanksville or Sandy Ranch provide access to most areas. Hanksville is located 10 to 25 miles north of the quadrangle area.

STRATIGRAPHY

Mt. Ellen is the result of an igneous intrusion. The sedimentary rocks have been domed upward and in many cases irregularly because of attendant emplacement of dikes, sills and laccoliths. Essentially the older rocks are closest to the mountain or stock and the younger ones farthest away (figure 24). Strata of Jurassic and Cretaceous age are present. The two quadrangles are not important with respect to coal resources and are presented only to provide continuity for the Henry Mountains coal field report. The description of units in the field report is adequate except for the following comments.

The Dakota, Ferron and Emery sandstones, all of Cretaceous age, are the coal-bearing formations. The first is considered the least important within the field, but it contains an unusual variety of coal known as jet[1] (Jet Basin is located in the center of the Mt. Ellen NE quadrangle). The Dakota is thin and ranges between 14 and 60 feet on the two quadrangles. Coal zones occur anywhere in the interval and coal up to 3 feet thick has been reported.

The formation with the best developed coal in the two quadrangles is the Ferron Sandstone. The unit is 150 to 250 feet thick and the coal beds are near the top associated with nonresistant shaley units. The major part of the unit builds a resistant cliff or reef from which the upper beds have been stripped back. These upper beds are therefore poorly exposed and it is extremely difficult to trace the coal seams. Nevertheless coal beds up to 5 feet thick have been reported.

The Emery Sandstone is present only in the southwest corner of the Mt. Ellen SE quadrangle (figure 25). A coal zone lies near the top of the 350-foot unit, but the coal is thin.

STRUCTURE

The inclination of strata around Mt. Ellen is moderate to steep (10 to 30 degrees) except locally where it may be much steeper. In the area of the Blue Valley Benches the dips are about 5 degrees to the west. Only a few faults occur on the quadrangle; they are either associated with the igneous intrusion or of minor displacement.

PROPERTY CONTROL

Most of the land is owned by the Bureau of Land Management (86.4 percent); the state of Utah has its usual configuration of lands (each sections 2, 16, 32 and 36) for 11.1 percent and a few parcels of private ranch land total 2.5 percent of the land. About 2.6 percent of the land were held in prospecting permits by the Cayman Corp. as of January 1, 1970. The locations of these holdings are in northwest corner of the Mt. Ellen NE quadrangle as shown on the Leases and Permits Map for the field (figure 13).

[1]A lustrous compact variety of coal that breaks with a glassy conchoidal fracture and takes a high polish.

COAL

Surface Information

The Dakota was studied in detail only in Jet Basin. Here the Dakota coal is under a thin layer of friable sandstone immediately under the Tununk Shale. The shale above the sandstone is highly fossiliferous especially containing *Gryphaea newberryi*. The coal ranges up to 1 foot thick with underlying clay shale. Logs of jetified coal occur in this shale, usually flattened perpendicular to the load.

Hunt and others (1953, p. 216) made the following comments:

T. 30 S., R. 10 E., secs. 15 and 22:
Maximum thickness 14 ft 8 in; thins out in 750 ft; very shaley; much sulfur along bedding planes and in veinlets.

T. 30 S., R. 11 E., secs. 16 and 21:
Maximum thickness in sec. 21 is 6 ft 9 in, but thins north to maximum of 1½ ft in sec. 16. Thins out east and north; in sec. 21 lower half of bed is shaley, upper half is good except for abundant sulfur (this location is east of Mt. Ellen quadrangle).

T. 31 S., R. 11 E., sec. 23: 12 ft coaly carbonaceous shale (this location is east of Mt. Ellen quadrangle).

Hunt also shows (p. 78) 3 feet of coal along Bull Creek. Coal in the Ferron is poorly exposed and available measured sections are few (figure 26). Immediately to the north of Mt. Ellen NE the beds are thin. The bed usually is covered along Blue Valley Benches, but is expected to be thin there as well. In the reef around Table Mountain, Hunt and others (1953, pl. 22) note the presence of a 2½- and a 5-foot seam separated by 7 feet of waste. Along Birch Creek on the north flank of Mt. Ellen they report another 5-foot seam. Another thick section is reported from sec. 36, T. 32 S., R. 9 E. where 5½ feet of coal are present, split in two places. Elsewhere, reported coal is thin, rarely exceeding 2 feet thick. No appreciable exposures of the Emery Sandstone exist on either quadrangle.

Subsurface Information

Two holes were drilled in sec. 32, T. 29 S., R. 10 E. penetrating 1.1 and 1.4 feet of coal respectively in the Ferron Sandstone.

Quality of Coal

One analysis of jet coal from the Dakota Formation is available (table 4) which shows that it is a high-volatile B bituminous coal. It is low in ash, high in volatile matter, sulfur and Btu/lb. The jet is a mixture of vitrinic and resinitic material with macerals of the vitrinite series predominating. It is entirely woody in structure.

Mines and Development

No coal mines open in either quadrangle, but some surface development work was done in early days to mine the jet coal.

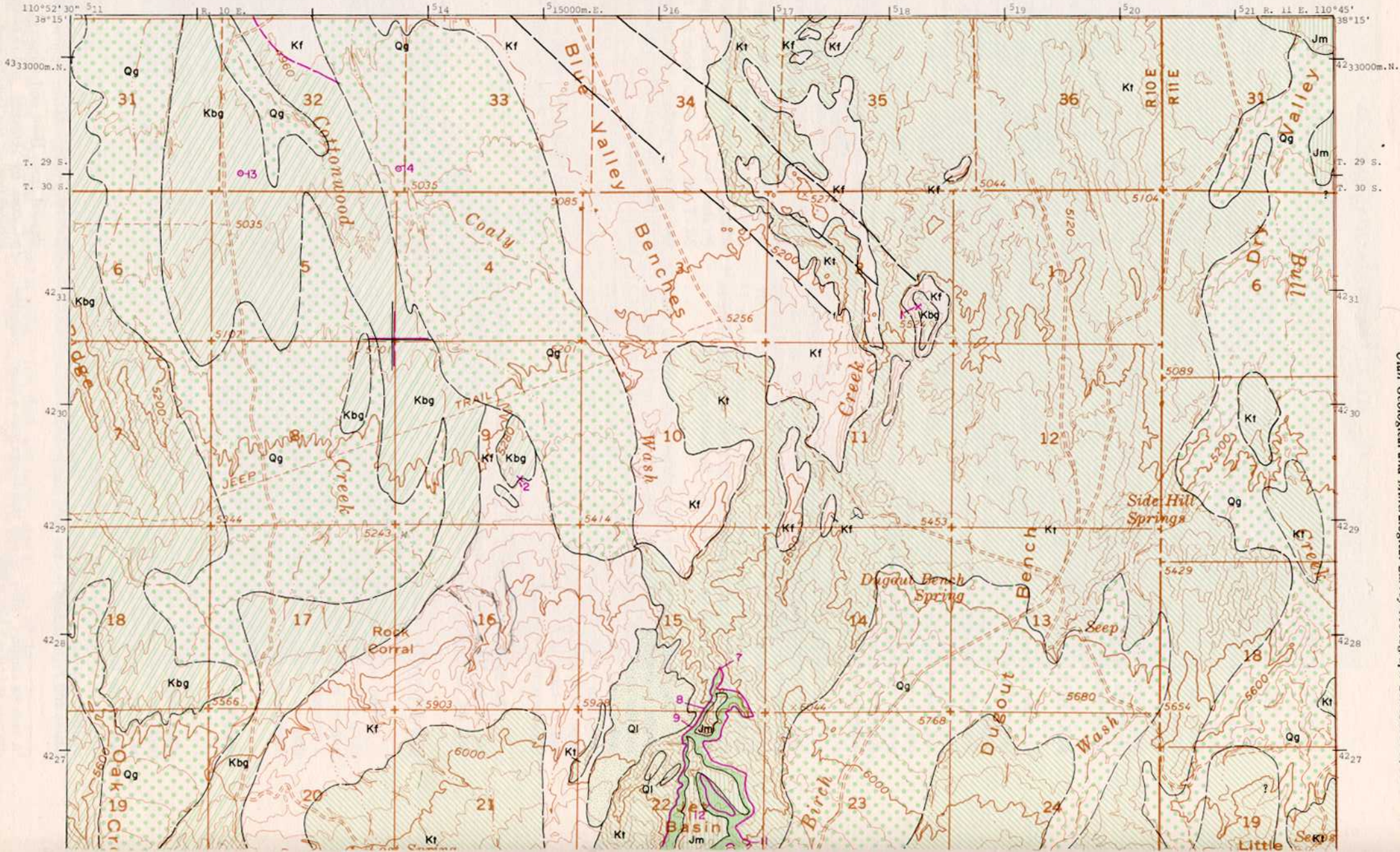
Reserves

In local areas the coal thickens and some reserves may be calculated. Too little supporting evidence at present, however, eliminates adding to the inventory of the Henry Mountains coal field.

PRINCIPAL WORK

Practically all the coal measurements and the geology were gleaned from Hunt and others (1953, pl. 22). A summary of Utah jet coal by Traverse and Kolvoord (1968) supplied additional information on the Dakota coal.

MOUNT ELLEN N.E., UTAH



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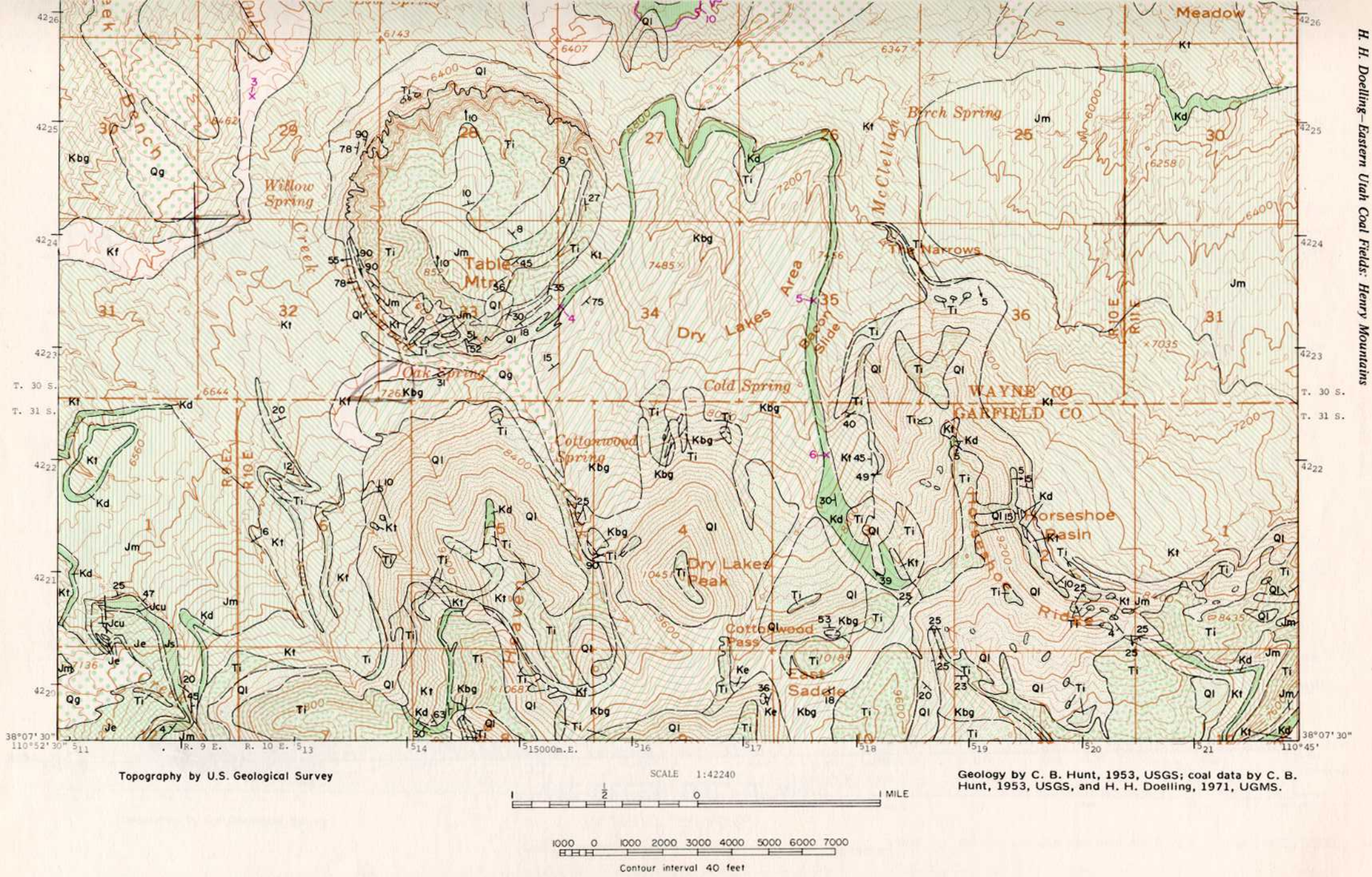
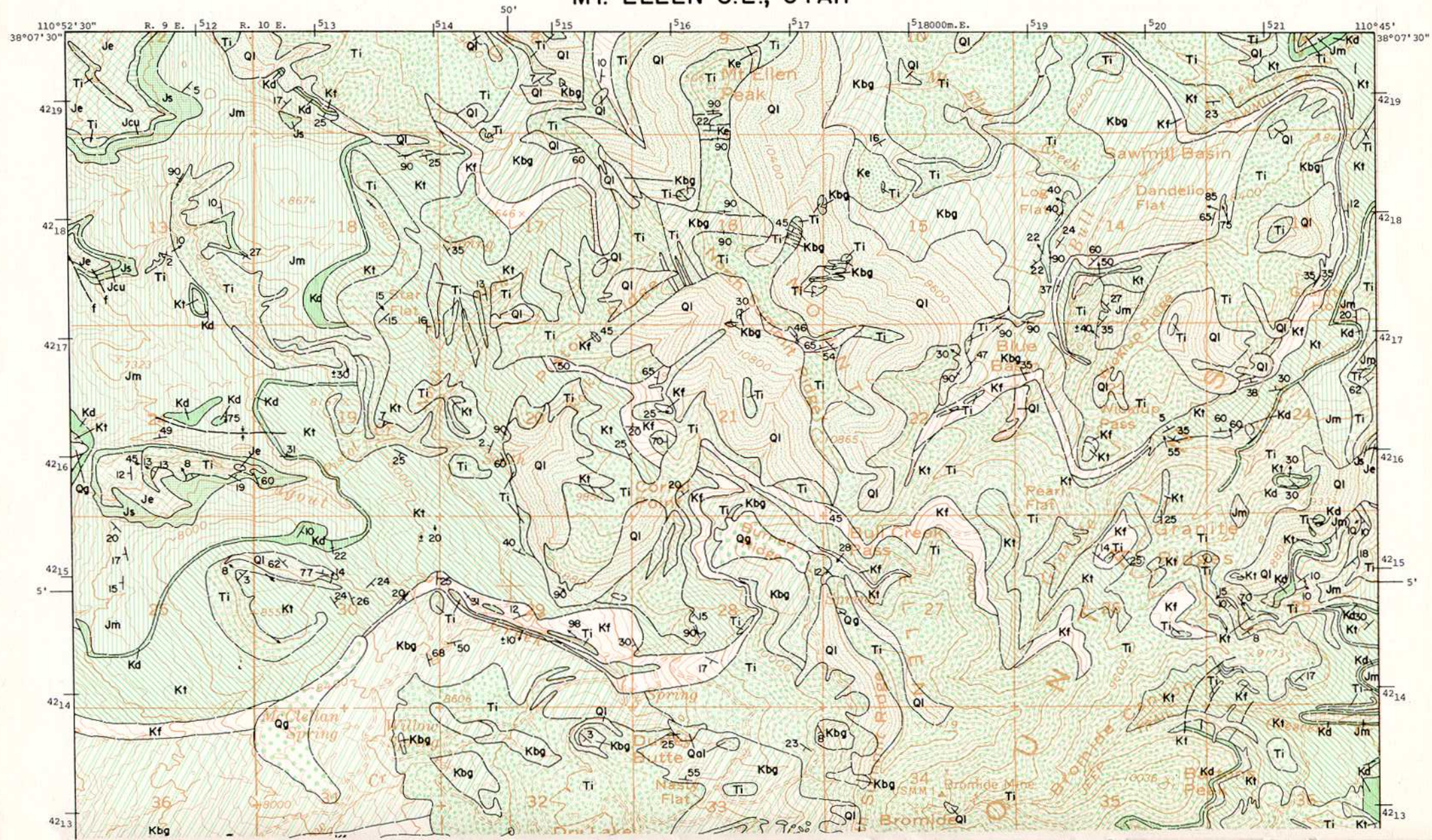


Figure 24. Coal and geology map, Mt. Ellen NE quadrangle (explanation pages 128-129).

MT. ELLEN S.E., UTAH



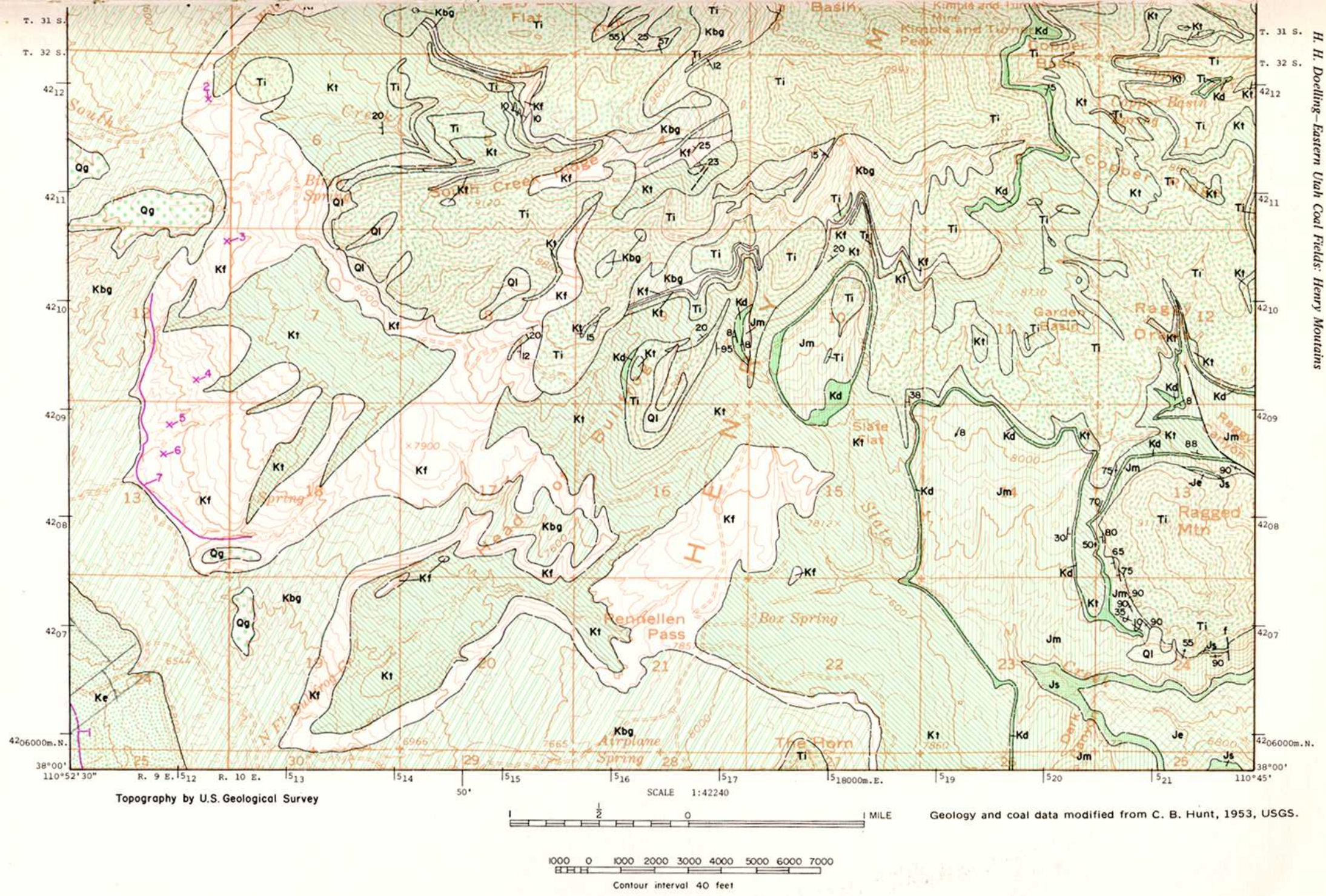
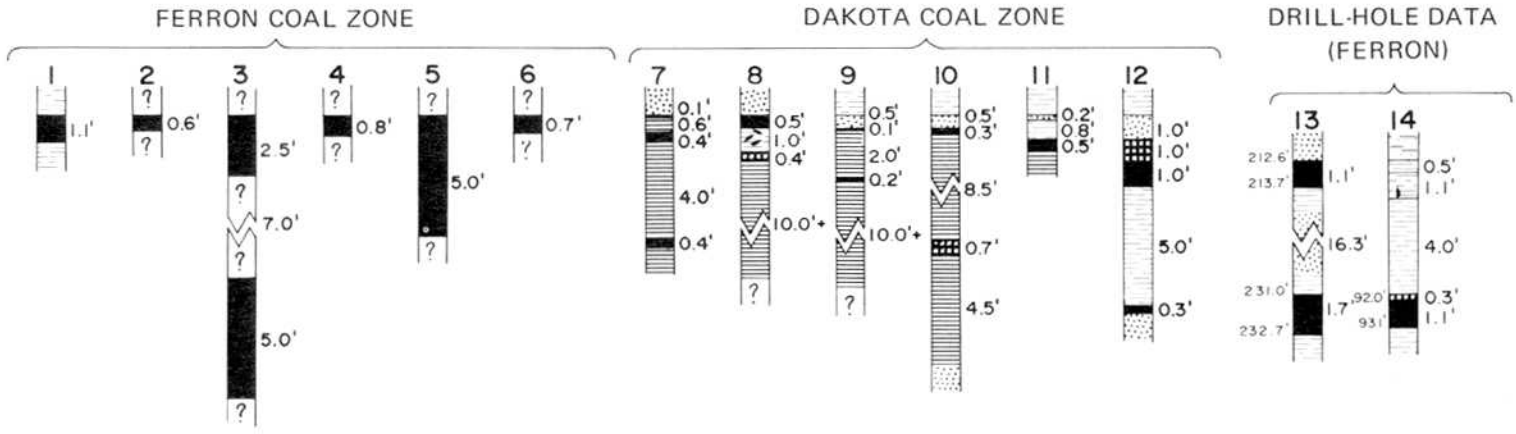
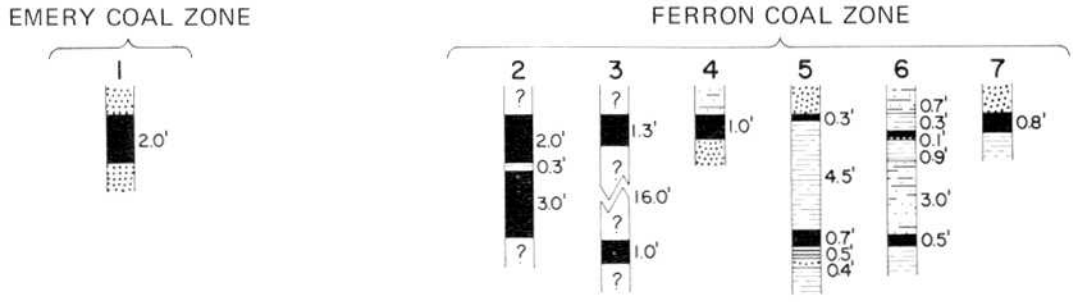


Figure 25. Coal and geology map, Mt. Ellen SE quadrangle (explanation pages 128-129).



Mt. Ellen NE quadrangle



Mt. Ellen SE quadrangle

Figure 26. Coal sections of Mt. Ellen NE-SE quadrangles (vertical scale: 1 inch = 8 feet).

View looking easterly from Burr Trail, Waterpocket across the Swap Mesa area towards the Henry Mountains peaks. The Emery Sandstone, atop the badlands or curtain-like cliffs, contains the more valuable coal deposits of the field. The first slight ridge below the cliffs is the Ferron Sandstone.

MT. ELLEN NW-SW QUADRANGLES

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The west half of the Mt. Ellen U. S. Geological Survey quadrangle lies in the heart of the Henry Mountains coal field (figure 14). The area includes much of the drainage basin of Sweetwater Creek which flows northerly along the west side of both the northwest and southwest quadrangles. The creek approximates the axis of the Henry Mountains structural basin. Most of the area is canyon, mesa and butte country, but to the east, especially in the southwest quadrangle, cuestas and hogbacks parallel the main structural trends.

The lowest elevation is along the Upper Blue Hills at about 4,800 feet with the surface averaging 5,000 feet. Farther south the land rises in a cliff to the Stevens and Thompson Mesa surfaces which lie between 5,600 and 5,800 feet above sea level. Still farther south another cliff occurs above which the Tarantula Mesa surface is located. Its elevation varies between 6,300 and 7,100 feet with the higher areas to the east. The hogbacks along the east map edge of the Mt. Ellen SW quadrangle occasionally rise to 7,300 feet. Most of the important coal beds occur at the elevation of the Stevens Mesa surface.

The roads are dirt or graded and the NW quadrangle is almost without road access. The most important road traverses the SW quadrangle east-west and joins the Halls Creek-Sandy Creek road along the Waterpocket Fold to the west with Mt. Ellen to the east.

STRATIGRAPHY

Most of the area represented by the two quadrangles exposes Cretaceous formations but older units are found east of Apple Brush and Cedar Creek benches (figures 27 and 28). The Entrada Sandstone exposed in the center of a small uplift just west of Mt. Ellen is succeeded by Curtis, Summerville and Morrison. These units are all adequately described in the field report.

The Dakota Sandstone is the first Cretaceous unit; its exposures surround the uplift with a thin narrow band. On the Mt. Ellen NW-SW quadrangles only the west flank outcrops occur. The Dakota is 61 feet thick along Cedar Creek and 28 feet thick along Dugout Creek.

Cedar Creek

Tununk Shale	
Dakota Sandstone	Feet
Fossiliferous sandstone	.6
Sandy shale	.17
Sandstone	.1
Sandy shale	.12
Carbonaceous shale	.9
Sandstone	.16
Morrison Formation	

Dugout Creek

Tununk Shale	
Dakota Sandstone	Feet
Fossiliferous sandstone	.3
Sandstone	.9
Clay	.2
Sandy shale	.9
Sandstone	.3
Conglomerate	.2
Morrison Formation	

In some parts of the Henry Mountains coal field the Dakota contains coal beds, but only an indication in sec. 23, T. 31 S., R. 9 E. is present. Hunt and others (1953, p. 216) report a maximum of 9 feet of very shaley coal at the east edge of section 23 which thins to 8 inches along the north edge. The coaley bed is probably thin or absent in section 14 and is absent in section 11. It is sharply flexed and broken by small faults.

The Tununk Shale overlies the Dakota and similarly surrounds the uplift but with a wider band corresponding to its greater thickness. The Tununk represents a barren marine interlude between two coal-bearing sandstones. The 600-foot unit consists primarily of shale, bentonite and sandstone and is gray to black. Most of its sandstone is near the top in the transition with the Ferron Sandstone.

In the Henry Mountains structural basin the two most important coal bearers are the Ferron and Emery. In these two quadrangles the Emery is of greater importance. The Ferron overlies the Tununk in a hogback east of Apple Brush and Cedar Creek benches. The Ferron was not measured in these two quadrangles because of the poor exposures and because of reported thin coal exposures. The outcrops have not been adequately explored. Generally the Ferron consists of three parts: a lower transitional zone of alternating gray shale and thin- to thick-bedded sandstones, a middle reef-building sandstone member intercalated with subordinate shale and minor coal and an upper series of sandstones, shale, carbonaceous shale and coal. The thickest reported coal seam from this area is 1½ feet.

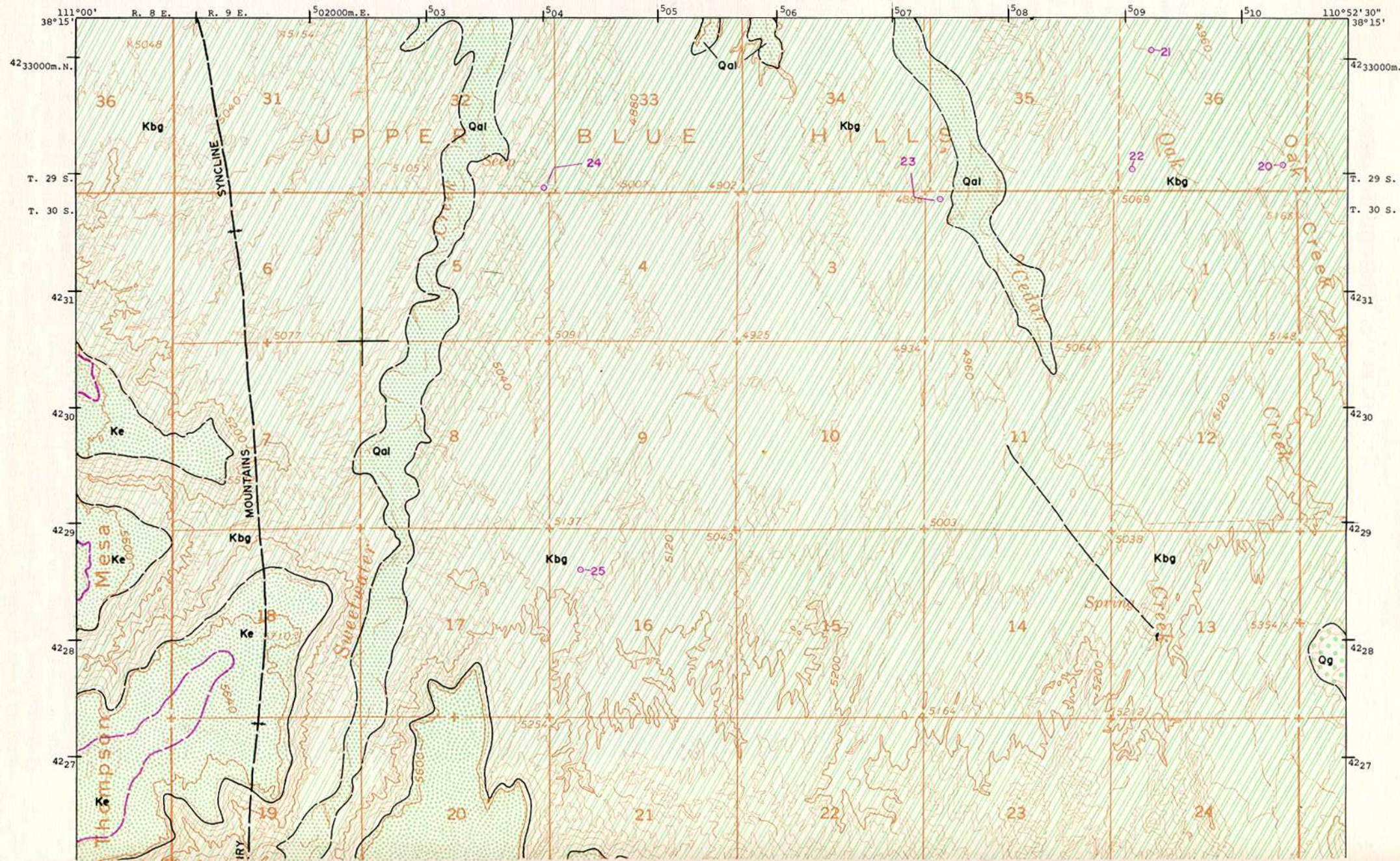
The Ferron is succeeded by the Blue Gate Shale and its main outcrop area is in the Upper Blue Hills in the Mt. Ellen NW quadrangle. Like the Tununk it is dominantly a gray marine shale with subordinate sandstone in a transitional zone with the next overlying unit. The Blue Gate is thicker than the Tununk, however, and is estimated to be 1,500 feet thick.

The Emery Sandstone is the most important coal bearer of either quadrangle. Generally the Emery-Blue Gate transitional zone is about 65 feet thick. In the zone the sandstone beds intercalated into the gray shale thicken and eventually dominate higher in the sections. The lower contact is placed beneath the first thick-bedded sandstone ledge former. It is followed by a rather massive cliff or reef builder 160 to 190 feet thick. The coal zone and an upper succession of 15- to 65-foot sandstone ledges separated by sandy shale, gray shale, carbonaceous shale and coal follows. This upper succession is usually 100 to 150 feet thick. A section was measured at Stevens Narrows in the southeast corner of Mt. Ellen SE where the coal unfortunately was little developed, but it adequately describes the remainder of the unit.

Section of Emery Sandstone measured at Stevens Narrows, sec. 14, T. 32 S., R. 9 E.

Masuk Shale	
Emery Sandstone	Feet
1. Sandstone, tan, medium-grained, friable, cliff former	65.0
2. Shale, gray, sandy with much interbedded thin and blocky sandstone, brown and medium-grained	16.5
3. Sandstone, tan, medium-grained, massive resistant ledge former	9.5
4. Shale, like unit 2	11.2
5. Sandstone, like unit 3	11.0
6. Coal	0.5
7. Sandstone, light tan, medium-grained, forms cliffs, contains occasional thin shale partings	163.0
8. Shale, gray, sandy	5.0
9. Sandstone, tan, medium-grained, massive cliff former	22.0
10. Shale, gray interbedded with subordinate sandstone, medium-grained, thin- to medium-bedded	43.0
11. Sandstone, gray, fine- to medium-grained, thin-bedded and resistant	1.6
12. Shale, gray, interbedded with sandstone, tan, thin-bedded	5.8
13. Sandstone, tan-brown, medium-grained, medium-bedded, resistant	2.3
14. Shale, gray, interbedded with thin-bedded sandstone	5.0
15. Sandstone, yellow-brown, medium-grained, thick-bedded, resistant ledge former, blocky weathering	8.7
Total Emery Sandstone	370.1

MOUNT ELLEN N.W., UTAH



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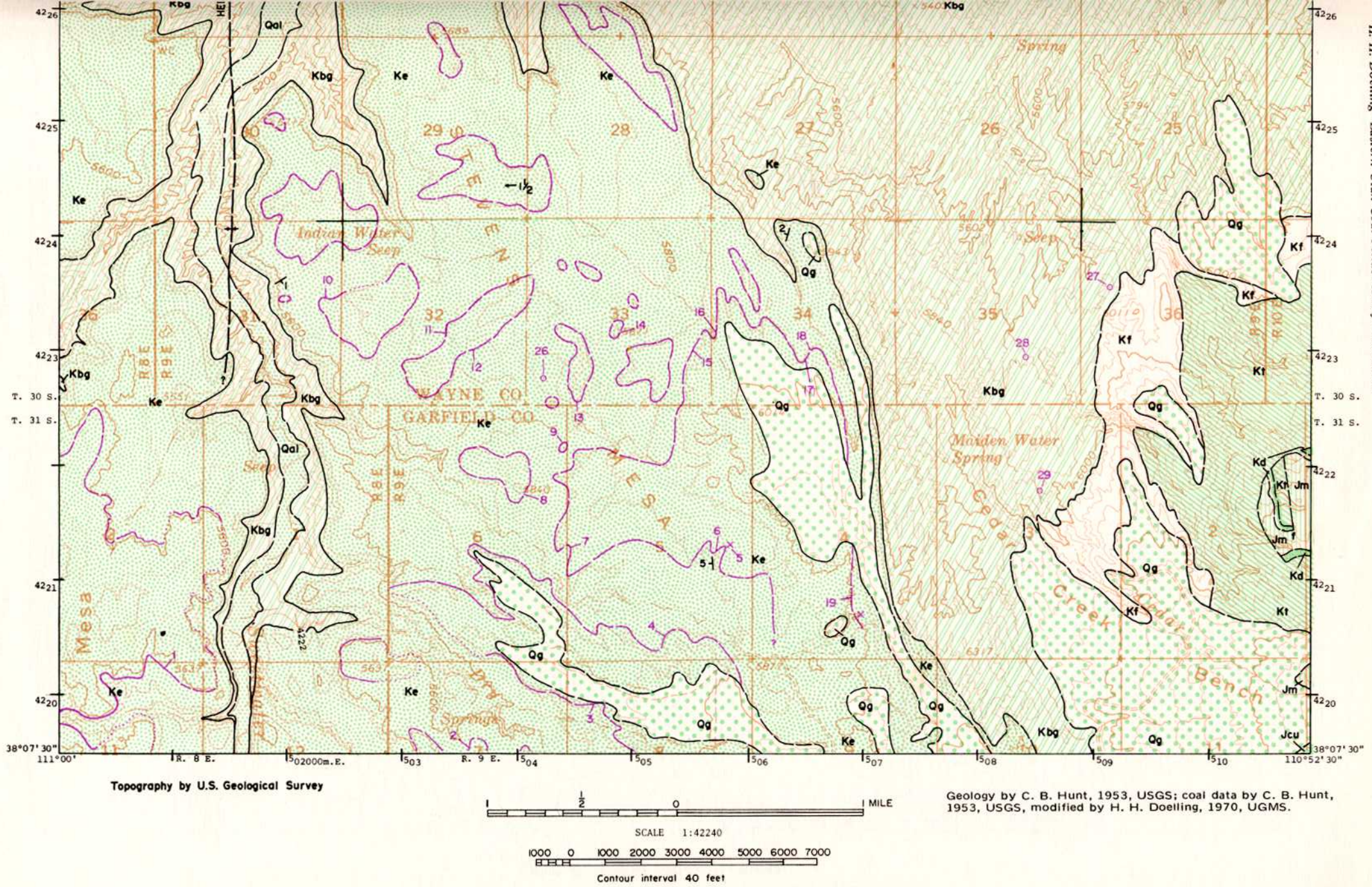
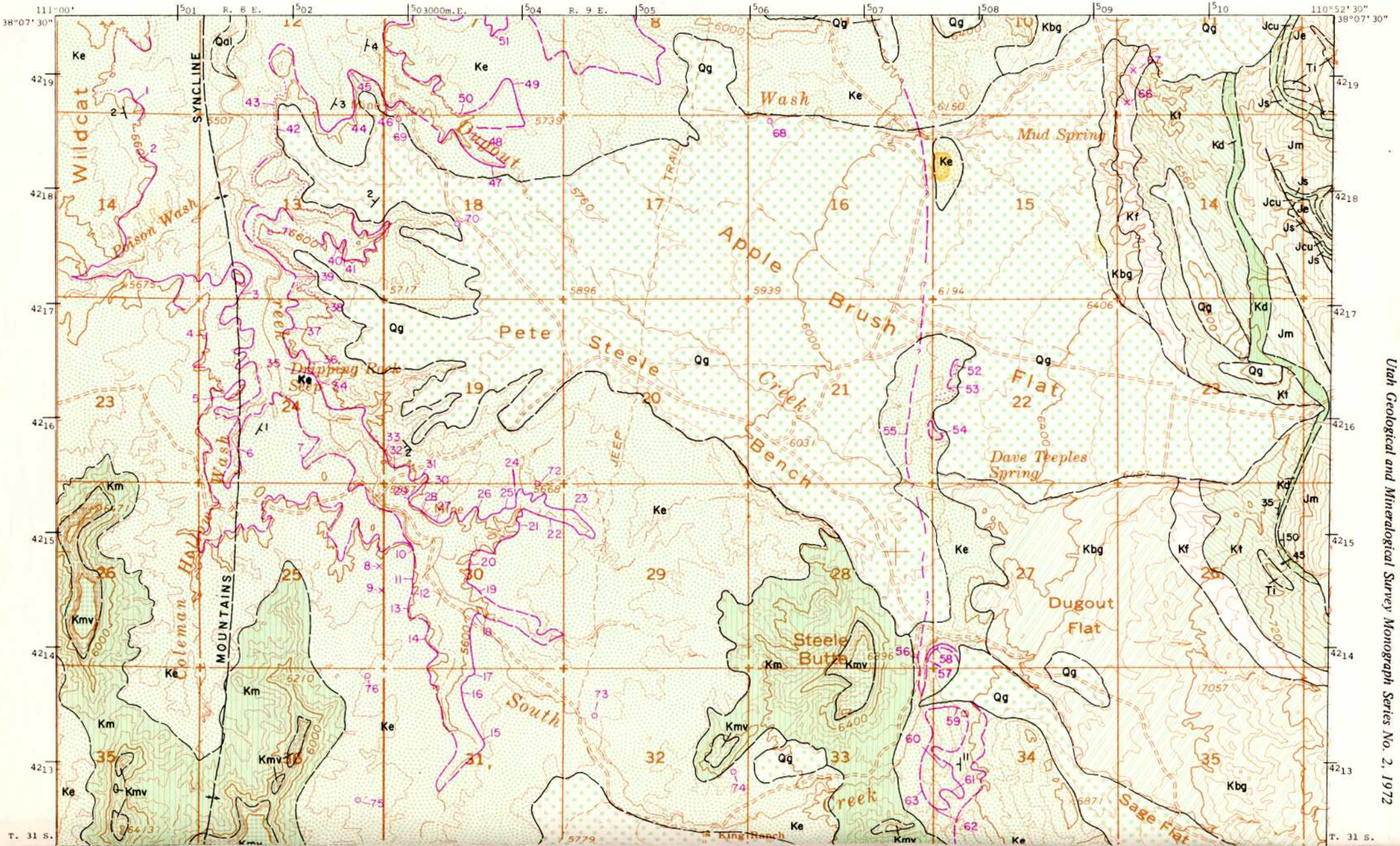


Figure 27. Coal and geology map, Mt. Ellen NW quadrangle (explanation pages 128-129).

MT. ELLEN S.W., UTAH



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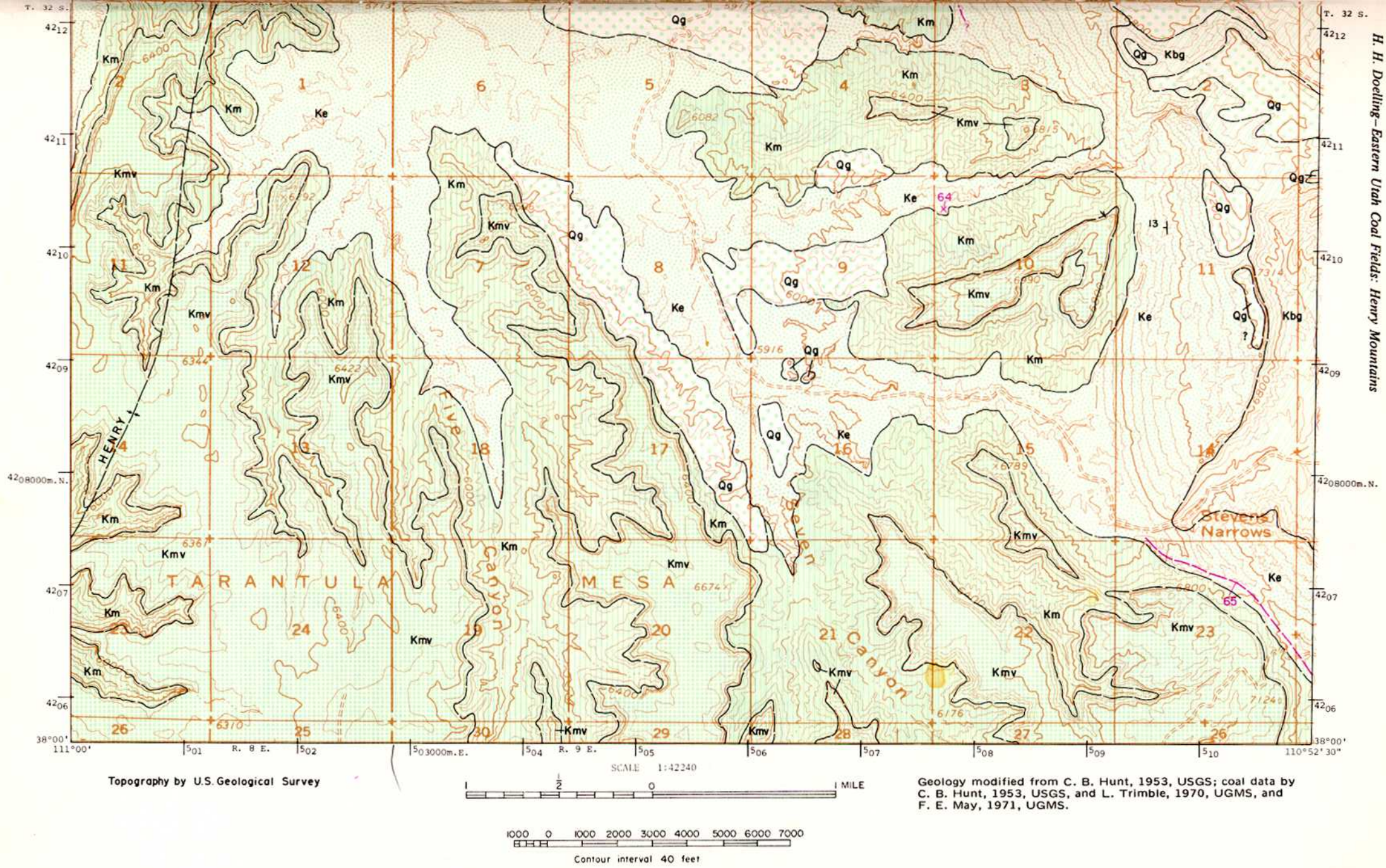


Figure 28. Coal and geology map, Mt. Ellen SW quadrangle (explanation pages 128-129).

Hunt and others (1953) in his geologic map of the Henry Mountains show the Emery much thinner than reported here. For purposes of this report all the thicker ledge-forming sandstones are kept near the top and bottom transitions with the Emery. Exposures of the Emery are located in a hogback along the east parts of the Mt. Ellen SE quadrangle and they form the surfaces of Stevens, Thompson and Wildcat mesas.

The Masuk Shale surrounds Tarantula Mesa to the south and is slightly different in character than the Blue Gate or Tununk. The overall color is more brown because of the greater amount of sand. It is only partly marine and nonmarine beds are present in more than subordinate amounts. Instead of the gray nodular shales, sandy tan shales occur. Some of the shales are carbonaceous and even coaley. The unit forms slopes similar to a shaley unit and is an estimated 600 feet thick.

The final Cretaceous unit, the Mesaverde Formation, caps Tarantula Mesa. Coal bearing in the Wasatch Plateau and Book Cliffs coal fields, the Mesaverde here is barren. Only the lower 400 feet remain and undoubtedly the coal-bearing portion has long been removed by erosion.

Unconsolidated deposits cover large areas of the quadrangles. The most conspicuous are the gravels covering benches and flats. The cobbles and boulders are derived from the laccolithic centers to the east. In addition alluvium fills the valleys of the larger stream courses and a thin sandy covering lies on top of the mesas.

STRUCTURE

The axis of the Henry Mountains structural basin passes north-south near the west map margins of the quadrangles. Eastward to the middle of R. 9 E. the beds are almost flat. Then the beds rise on the flanks of Mt. Ellen and dips of 20° are average. Of the few faults on either quadrangle none seems to affect the coal beds.

PROPERTY CONTROL

Ownership of land in the Mt. Ellen NW-SW quadrangles is 85.4 percent Bureau of Land Management, 11.2 percent state of Utah and 2.4 percent private property. All the private property is located in the SW quadrangle and most of this land is associated with the King Ranch located in the SE 32-31S-9E. The state land is located in its usual pattern within the BLM land, i.e., secs. 2, 16, 32 and 36 of each township. The Land Ownership Map for the coal field indicates exact locations (figure 12).

Three parties maintained coal holdings in the Mt. Ellen NW-SW quadrangles as of January 1, 1970, and held it in the form of federal prospecting permits and state leases: the Cayman Corp., G. Witter and Consolidation Coal Co. The land held amounts to 27.5 percent of the total area. Most of the holdings are for Emery coal. The exact locations of these lands are shown on the fields Leases and Permits Map (figure 13).

Coal lands are officially designated as 93.8 percent of the area and are that part underlain with the Ferron Sandstone. Areas underlain with the thicker coal of the Emery amount to 43.5 percent of the total area.

COAL

Surface Information

Nineteen surface sections are available for the Mt. Ellen NW quadrangle (figure 29) and all are on the Emery Sandstone. Individual coal beds up to 6 feet are present. Coal is probably everywhere present in the Emery where the zone has not been eroded. The thicker seams are located along the Wayne-Garfield County line in secs. 32-34, T. 30 S., R. 9 E. and in sec. 5, T. 31 S., R. 9 E. No sections are available for the Ferron and Dakota coal zones. These remain inadequately explored, but cursory checking indicates the coal beds are either thin or missing.

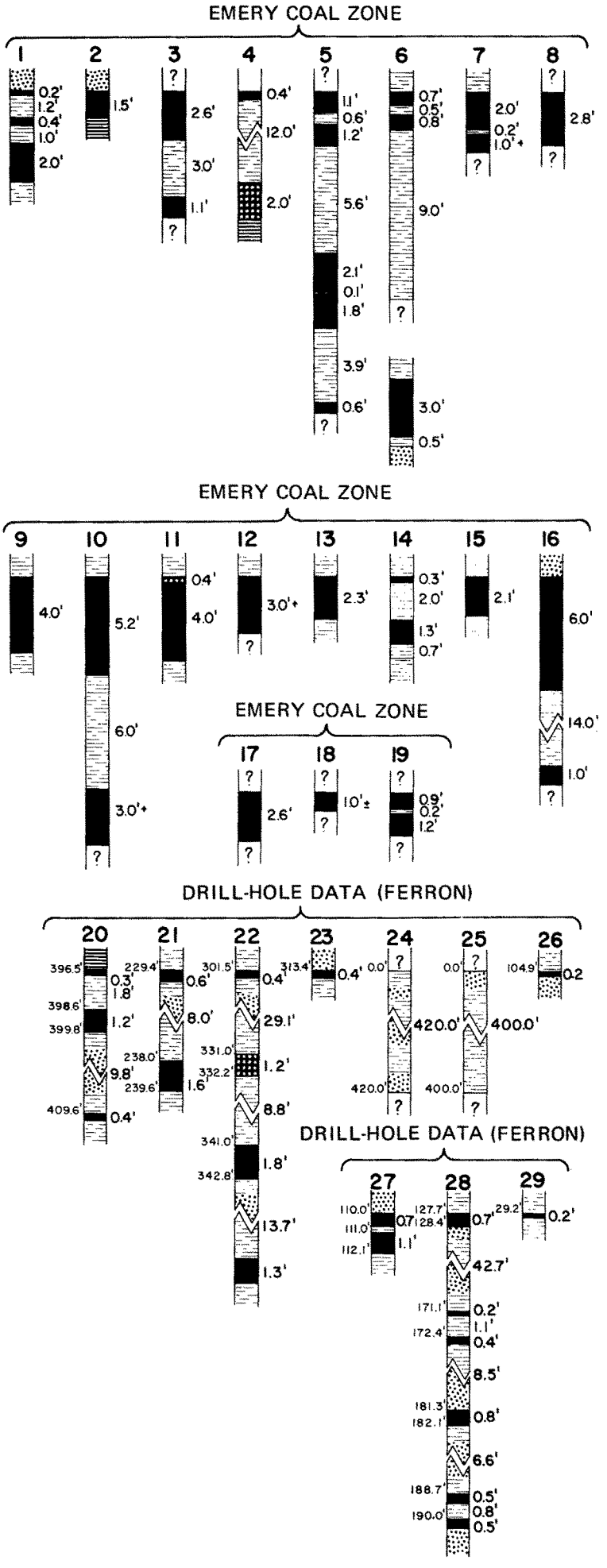


Figure 29. Coal sections of Mt. Ellen NW quadrangle (vertical scale: 1 inch = 8 feet).

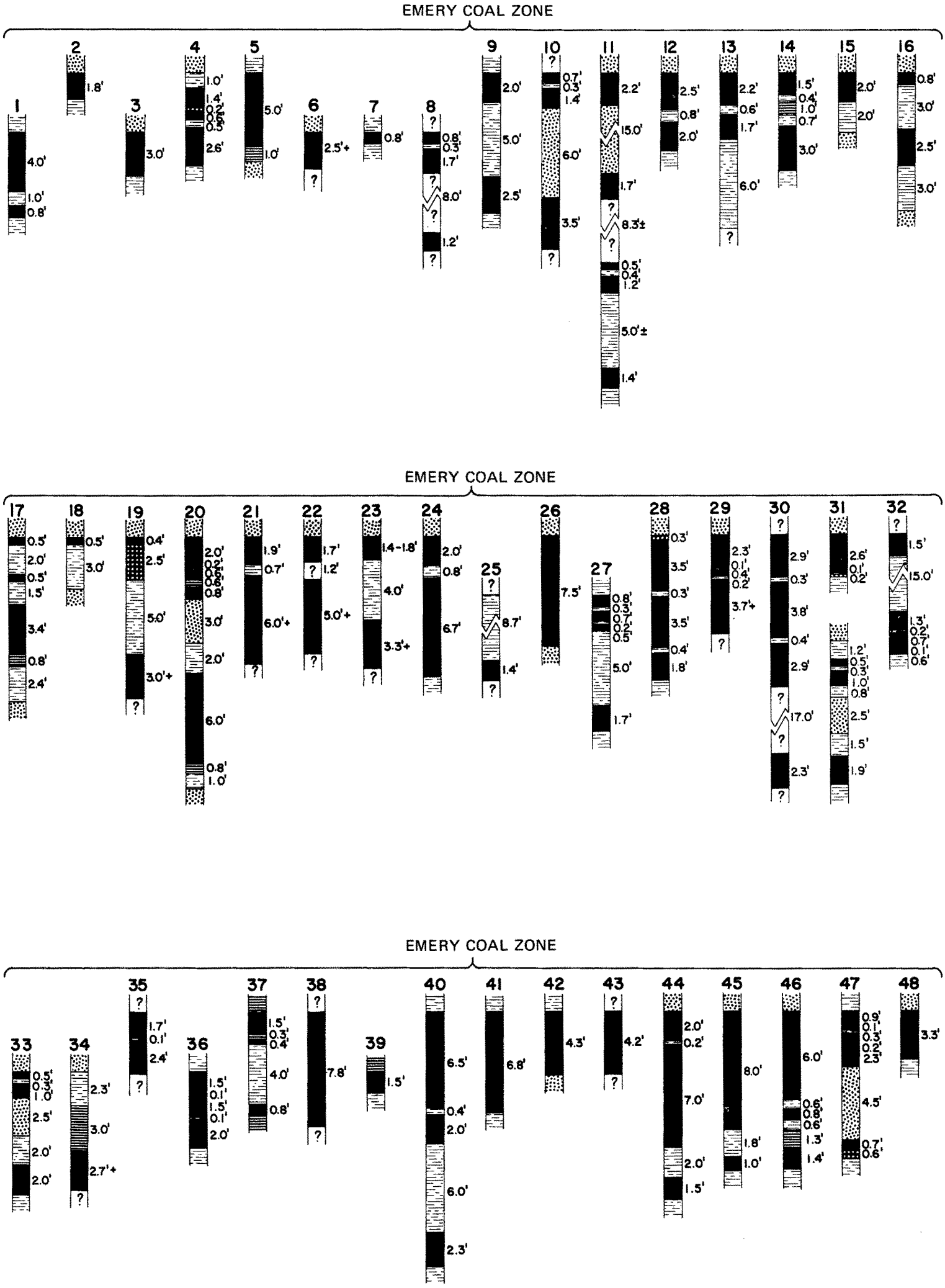


Figure 30. Coal sections of Mt. Ellen SW quadrangle (vertical scale: 1 inch = 8 feet).

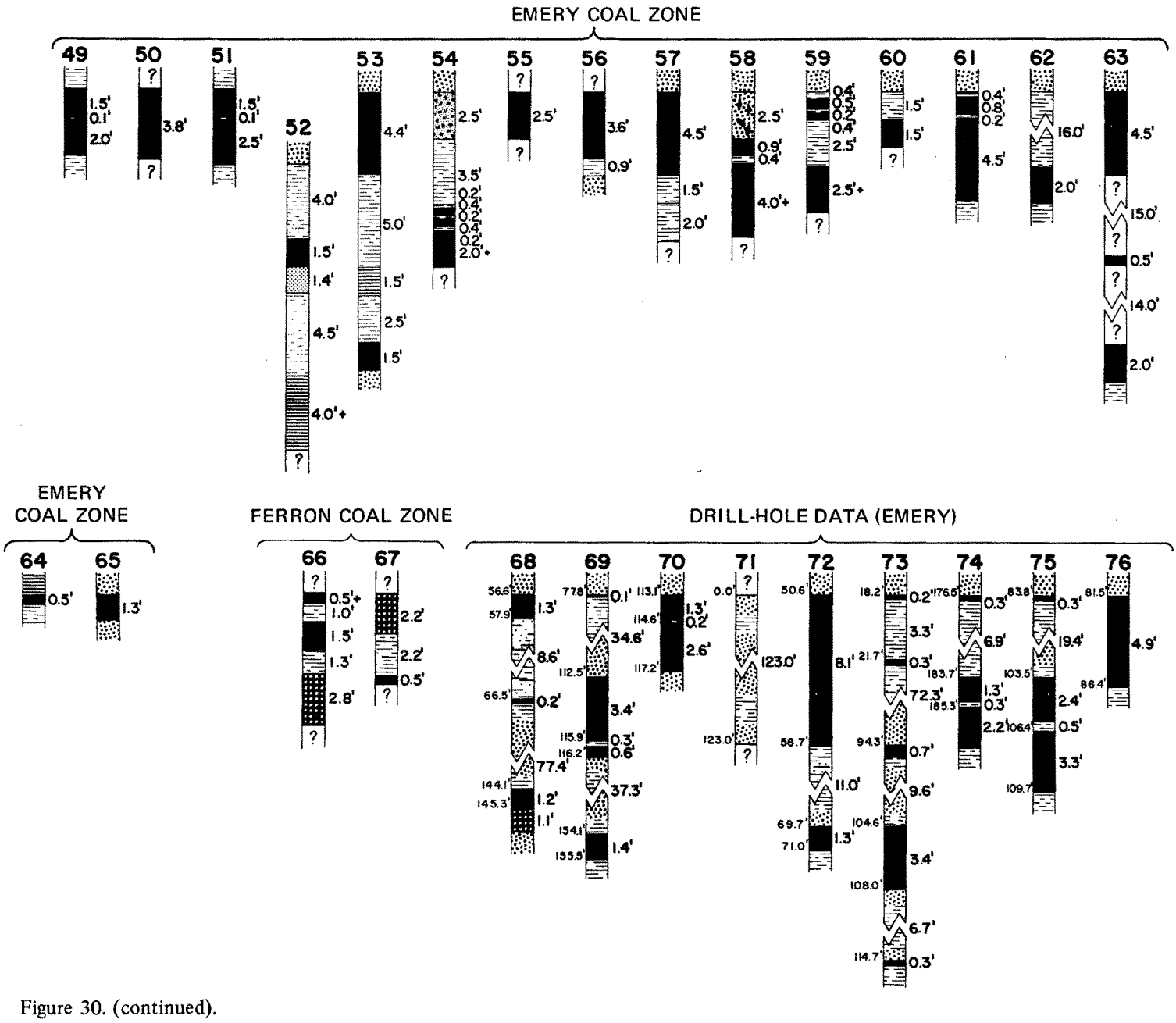


Figure 30. (continued).

In the Mt. Ellen SW quadrangle the coal beds are exposed along Sweetwater Creek along its south extension of South Creek and along the Emery and Ferron hogbacks on the east map edge. Although often poorly exposed, burned and notoriously lenticular, the Emery surrounding Sweetwater Wash maintains a 4.8-foot average in the thickest coal bed. The bed seems to thin where it V's out to the south, but examination anywhere along the remainder of the outcrops shows seams varying from 1½ to 8½ feet in a rather disconcerting and spasmodic manner. Along the east hogback exposures of the Emery, the coal averages 4.0 feet south to the T. 31-32S., township line; thereafter it thins and often cannot be found. At Stevens Narrows only 0.5 feet of coal was detected, but this thickens to 1.3 feet in the southeast map corner.

The Ferron and Dakota beds are not adequately explored but a few measured sections are available (figure 30). The thickest coal seam noted in the Ferron is 1½ feet but 9 feet of shaley coal are reported at the east edge of sec. 23, T. 31 S., R. 9 E. This thins to 8 inches at the north end of the section.

Subsurface Information

Several holes were drilled in the two quadrangles. Most in the north quadrangle intersected the Ferron and most drilled in the south quadrangle intersected the Emery. All the Ferron holes showed thin coal ranging from none to 2.1 feet. The thickest occurrence is in 36-30S-9E. The Emery holes are mostly in the SW quadrangle and the penetrated coal ranges from 0.2 to 7.0 feet of coal. A thinning indicated between Sweetwater Creek and Steele Butte is also borne out in the surface sections. The Ferron coal zone is 350 to 500 feet below the surface in the Upper Blue Hills. Depth to the Emery in the Sweetwater area ranges up to 200 feet and some strip areas can be developed. The coal is deepest under Tarantula Mesa, 2,500 to 2,800 feet for the Ferron and 1,000 to 1,200 feet for the Emery.

Quality of Coal

Nine analyses for coal are available for the Mt. Ellen SW quadrangle (table 4) and all are from the Emery Sandstone. None are available for the north area. The average proximate analysis is as follows (table 8):

Table 8. Average proximate analysis of coal, Mt. Ellen NW-SW quadrangles.

	Percent	
	Average	Range
Moisture	8.8	5.7 -13.9
Volatile matter	36.2	32.0 -38.5
Fixed carbon	43.6	35.7 -49.1
Ash	10.8	6.0 -18.8
Sulfur	1.0	0.53- 1.70
Btu/lb	11,300	9,015-12,954

Some error in the analyses is possible; part is biased to one location. Sources of the analyses come from Hunt and others (1953), Robison (1963) and from an anonymous report with the analyses prepared by Commercial Testing and Engineering Co. of

Chicago. Robison's analyses are all from one locality sampled from different seams in the Emery zone. His analyses are consistently high in sulfur content and the calorific value compared with the other two sources. The moisture content of CT&E Co.'s work is higher than that of the other two sources. Since samples are few and inasmuch as they may be biased either by analytical method or by localized sampling, caution must be taken in evaluating the data. The author feels that the sulfur content and the calorific value may be slightly high.

Mines and Development

Other than the aforementioned drilling, at least two mines or prospects have been opened on the Mt. Ellen SW quadrangle (table 9):

Table 9. Mines in the Mt. Ellen NW-SW quadrangles.

Mines	Location	Remarks
Dugout Creek mines Emery coal zone	SW.SW.7-31S-9E 4,218,720m.N. 502,880m.E.	Active 1940's
Sweetwater Creek Emery coal zone	NW.30-31S-9E 4,215,200m.N. 503,200m.E.	Activity unknown

Little is known about either mine. The first is a straight tunnel 190 feet long with an average interior width of 20 feet. The tunnel trends southwest in 6 feet of clear coal. The wreckage of a loading platform is all that remains at the mine mouth. The production has been about 900 tons considering the volume removed.

The Sweetwater Creek mine adit also is open, but appears partly caved and dangerous at the entrance. No attempt was made to examine the mine's interior. A spring issues a small stream of water from the mine's interior. From outward appearances the mine's production was small, less than that from the Dugout Creek mine.

Reserves

No reserves of coal from the Ferron or Dakota zones are thought to exist on either quadrangle. If one is interested in coal beds 1.5 to 2.0 feet thick a few local areas of reserve can be found. Table 10 lists reserves for the Emery coal zone.

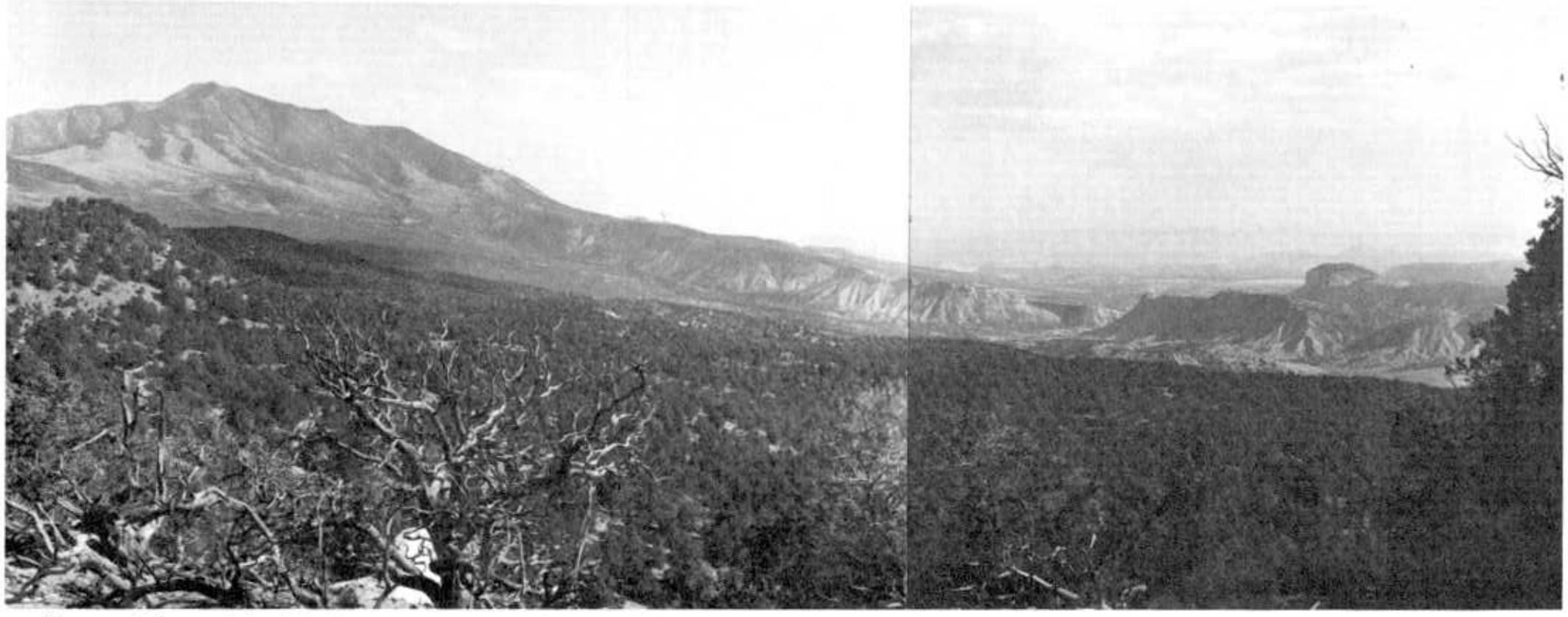
Table 10. Original coal reserves, Emery coal zone, Mt. Ellen NW-SW quadrangles.

Location	Acres	Average thickness (feet)	Tonnage	Class Reserve
T.30S. R.9E.	780	3.0	4,080,000	II
T.31S. R.8E.	4,030	4.8	33,700,000	II
T.31S. R.9E. secs. 18, 19, 30, 31, and parts of 7, 8, 17, 20, 29 and 32	3,488	4.8	29,170,000	II
secs. 4-6, parts of 7, 8, 9, 22, 27, 34	1,997	3.0	10,440,000	II
Remainder of Twp.	3,840	2.2	14,720,000	III
T.32S. R.8E. northern 2 tiers of sections	2,278	4.8	19,050,000	III
Remainder of Twp.	2,496	5.0	21,740,000	IV
T.32S. R.9E. secs. 5-8	2,560	3.5	15,610,000	III
secs. 16-21, 28-30	4,064	4.0	28,320,000	IV
Remainder of Twp.	2,240	1.5	5,850,000	III
		Total	182,680,000	
		Class I and II reserve:	77,390,000	
		Class III reserve:	55,230,000	
		Class IV reserve:	50,060,000	
Coal reserve in beds 4 feet or more thick excluding Class IV reserve:			81,920,000	

PRINCIPAL WORK

Most of the surface data including coal measurements and geology are from Hunt and others (1953, pl. 22). Supplemental coal measurements were collected specifically for this report.

Caineville Reef crossed by Utah Highway 24. Coal beds in the Ferron in this area range from 1 to 2 feet thick.



Panorama of the east flank of the Henry Mountains Basin looking south. The coal-bearing Emery Sandstone dips away from Mt. Pennell, whose intrusion bowed up the rocks. Bullfrog Creek passes through the gap where the rocks begin to level. Behind this gap, "Turn of the Bullfrog," is the Cave Flat area.

MT. PENNELL NE-NW QUADRANGLES

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The north half of the U. S. Geological Survey Mt. Pennell 15-minute topographic quadrangle is entirely within Garfield County, located 30 miles north of Bullfrog Basin, Lake Powell and 30 miles south of Hanksville. Mt. Pennell is in the south part of the Henry Mountains coal field (figure 14).

The land is rugged. Mt. Pennell NW is dominated by dissected mesas and cliffs. The highest elevation is on Tarantula Mesa, nearly 6,900 feet and the lowest is 5,000 feet in Muley Creek Canyon. The principal coal seams are exposed along the edges of Swap Mesa and Cave Flat at about 5,600 feet. Mt. Pennell NE is dominated by Mt. Pennell which reaches a maximum of 11,371 feet above sea level. The land around the peak is a rough slope beset with canyons and cliffs. The lowest elevation is approximately 5,000 feet in the canyon of Bullfrog Creek. The coal is mostly located along the west fringe of the map between 5,700 and 6,200 feet above sea level.

. The area is difficult of access. A dirt road traverses Tarantula Mesa and one parallels Bullfrog Creek on its west bank about halfway onto Cave Flat from the north. A rocky four-wheel drive road climbs nearly to the top of Mt. Pennell to a group of copper claims from the east. The area is otherwise roadless and access must be on foot or horseback. Presently an airstrip lies on Cave Flat near the end of the road.

STRATIGRAPHY

Jurassic to Cretaceous sedimentary units are exposed on the two quadrangles (figures 31 and 32). The Jurassic, Entrada, Summerville and Morrison crop out in the northeast corner of Mt. Pennell NE in the vicinity of Black Canyon; they are described in the coal field report.

The Cretaceous consists of seven units; four are cliff-forming sandstones with subordinate shale and coal and three are gray shales. The sandstones alternate with the shales. The Dakota is at the bottom and is a thin unit rarely exceeding 60 feet and often disappearing entirely. It is mapped as occurring northeast of Mt. Pennell, but nothing is known of its coal-bearing characteristics there. The nearest examined locality is 6 to 7 miles to the north where the Dakota contains 12 feet of coaley carbonaceous shale.

The Dakota is overlain by the 525- to 650-foot Tununk Shale which in turn is overlain by the Ferron Sandstone. Both crop out roughly circularly around Mt. Pennell. Igneous dikes and sills often occur above, below and between these beds. Nothing is known about the coal-bearing properties of the Ferron in this area.

The 1,500-foot Blue Gate Shale nearly surrounds Mt. Pennell in a wide band. To the northeast it is intricately interbedded with the sills, dikes and intrusions of the mountain. Toward the top of the formation the gray shales are interbedded with thin fine- to medium-grained sandstone beds. The most important coal bearer of the Mt. Pennell NE-NW area is the Emery Sandstone. The lower contact is placed below the first thick-bedded sandstone in the transition zone between the Blue Gate and Emery. The Emery is described by the following incomplete section:

Section of Emery Sandstone in 25-32S-9E at the Turn of Bullfrog, by R. D. Gray and F. E. May in June 1971.

Emery Sandstone	Feet
1. Sandstone, dark tan, medium-grained, thick-bedded, ledge former	8.5
2. Shale, gray	9.5
3. Coal	1.8
4. Shale, brown and carbonaceous	0.4
5. Sandstone	0.6
6. Shale, gray	2.5
7. Coal	5.5
8. Sandstone, light gray, medium-grained, somewhat cross-bedded, massive cliff former	28.5
9. Sandstone, tan, medium-grained, massive cliff former	85.0
10. Shale, gray, with subordinate thin-bedded sandstone, tan and medium-grained, slope former	15.0
11. Sandstone, light tan, medium-grained, thin- to medium-bedded, ledge former	3.5
12. Shale, gray	7.0
13. Sandstone, light tan, thick-bedded and ledge former	9.7
Total Emery	177.5

Blue Gate Shale: gray shale interbedded with thin to medium beds or gray to tan fine- to medium-grained sandstone.

The above section is incomplete; the top was not located. At least 100 feet of ledgy medium-grained sandstone beds lie above the coal near Cave Flat. Another incomplete section was measured in Swap Canyon.

Section of Emery Sandstone in a tributary of Swap Canyon, sec. 2–34S–8E, by R. D. Gray and F. E. May in 1971.

Emery Sandstone	Feet
1. Sandstone, brown, medium-grained, medium- to thick-bedded, weathers into plates, top of unit at this location, overlying beds removed by erosion.	7.5
2. Sandstone, white to tan, medium-grained, massive cliff former.	40.0
3. Shale, gray with thin- to medium-bedded sandstone, burned red, slope former; represents coal zone, mostly burned at outcrop, coal bed near top is 1.8 feet thick.	47.5

NOTE: Unburned section from across canyon revealed the following in the lower portion.

Sandstone	Feet
Shale	1.0
Coal	1.8
Shale	1.5
Coal	9.0
Shale	0.5
Coal	1.0
Sandstone	(unit 4)

4. Sandstone, gray to light tan, medium-grained, well sorted, cliff former.	29.0
5. Shale, gray, slope former, partly carbonaceous.	16.0
6. Sandstone, tan to light brown, medium-grained, massive cliff former.	27.0
7. Sandstone, gray to tan, shaley, very fine- to medium-grained, grain size differentiated by bed with subordinate gray shale, thin- to medium-bedded, slope former or forms undercut in cliff.	14.5
8. Sandstone, light tan, medium-grained, massive cliff former.	20.5
9. Shale, light tan, sandy, nonresistant.	2.1
10. Sandstone, like unit 8.	13.5
11. Shale, gray, sandy with subordinate thin-bedded sandstone.	14.0
12. Sandstone, light brown, medium-grained, medium-bedded	2.4
13. Shale, light brown, sandy, nonresistant.	2.0
14. Sandstone, light brown, medium-grained, medium- to thick-bedded, ledge former.	3.5
Total Emery	239.5

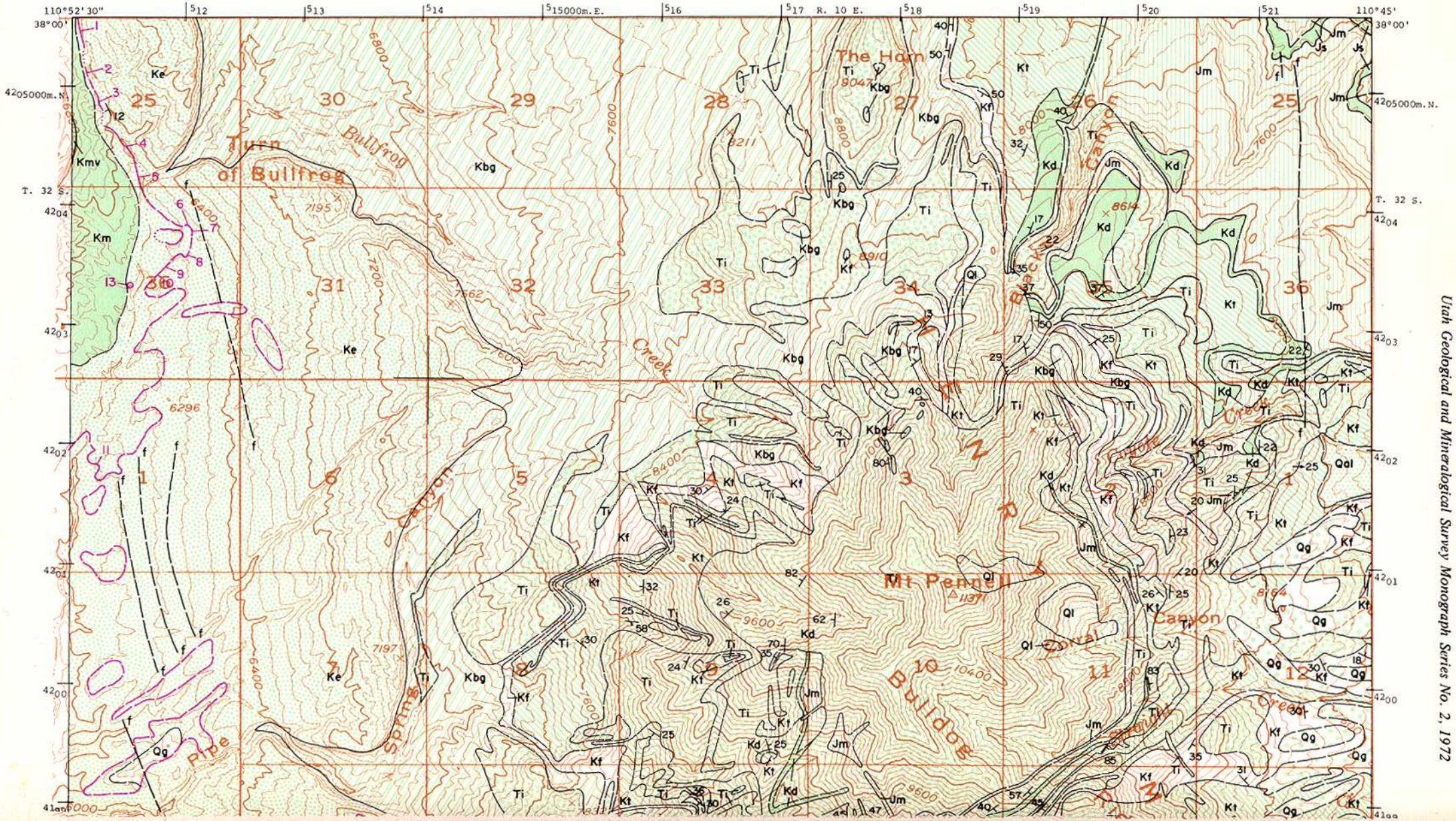
Blue Gate: sandstone, light brown, silty, fine-grained, thin-bedded with subordinate gray shale, mostly slope forming but stands in cliff when supported by cliff-forming sandstone.

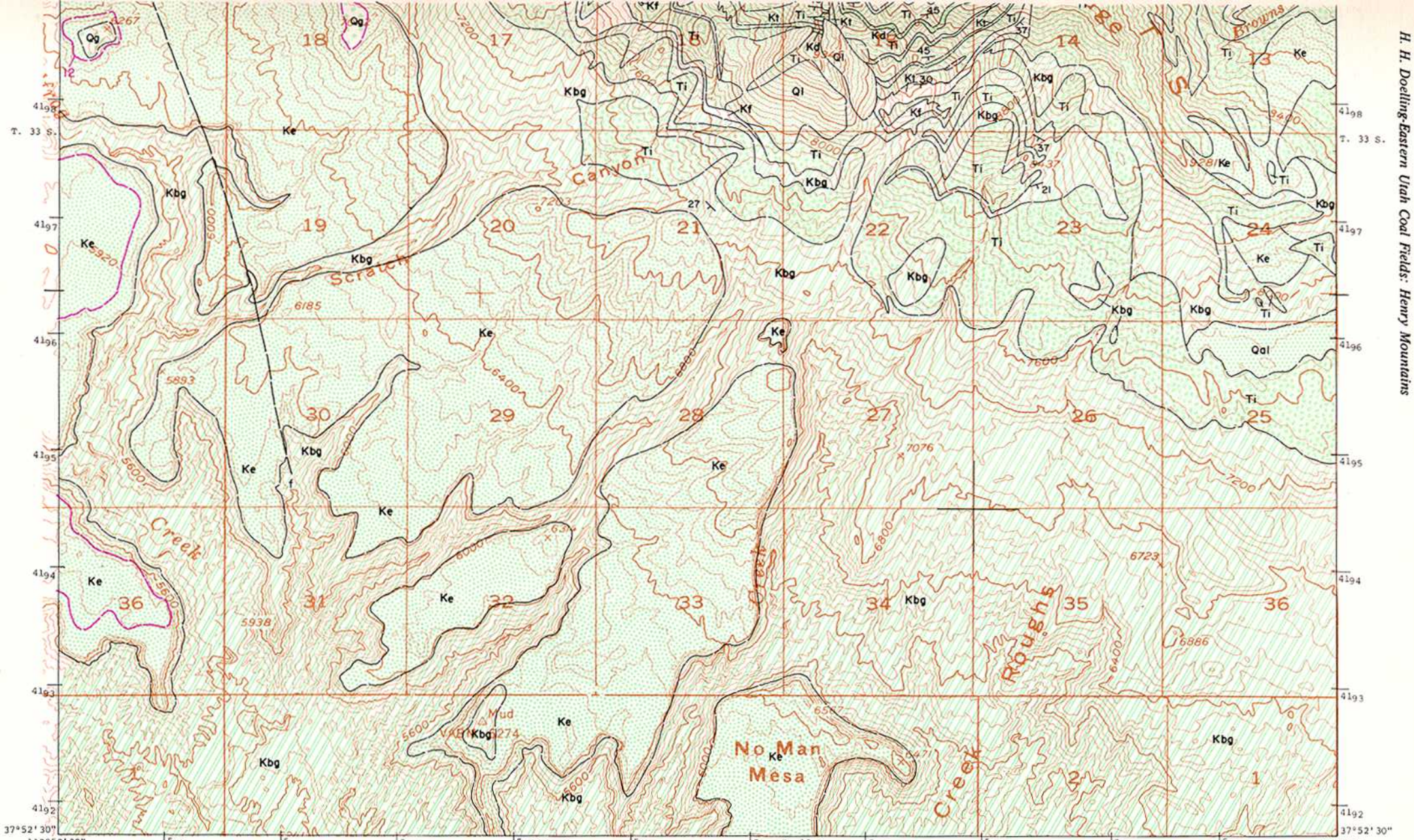
The coal zone is 140 to 160 feet above the base of the Emery. The sandstones below the coal usually occur as a reef or a massive cliff. The coal zone usually forms a wide bench or slope. For the remainder of the formation, 15- to 30-foot cliffs are separated by 5- to 20-foot slopes consisting of shale, carbonaceous shale and often thin coal beds. The Emery outcrop area covers the Swap Mesa and Cave Flat areas of Mt. Pennell NW and the lower cliffy part is exposed on the west slopes of Mt. Pennell in the east quadrangle.

Upward in the section, the lithology becomes dominantly shaley and slope forming. This is the Masuk Shale. Hunt and others (1953, p. 85) describe the Masuk:

The Masuk Member differs from the Tununk and Blue Gate Shale members of the Mancos in being composed of irregularly bedded, sandy gray shale,

MT. PENNELL N.E., UTAH





Topography by U.S. Geological Survey

SCALE 1:42240

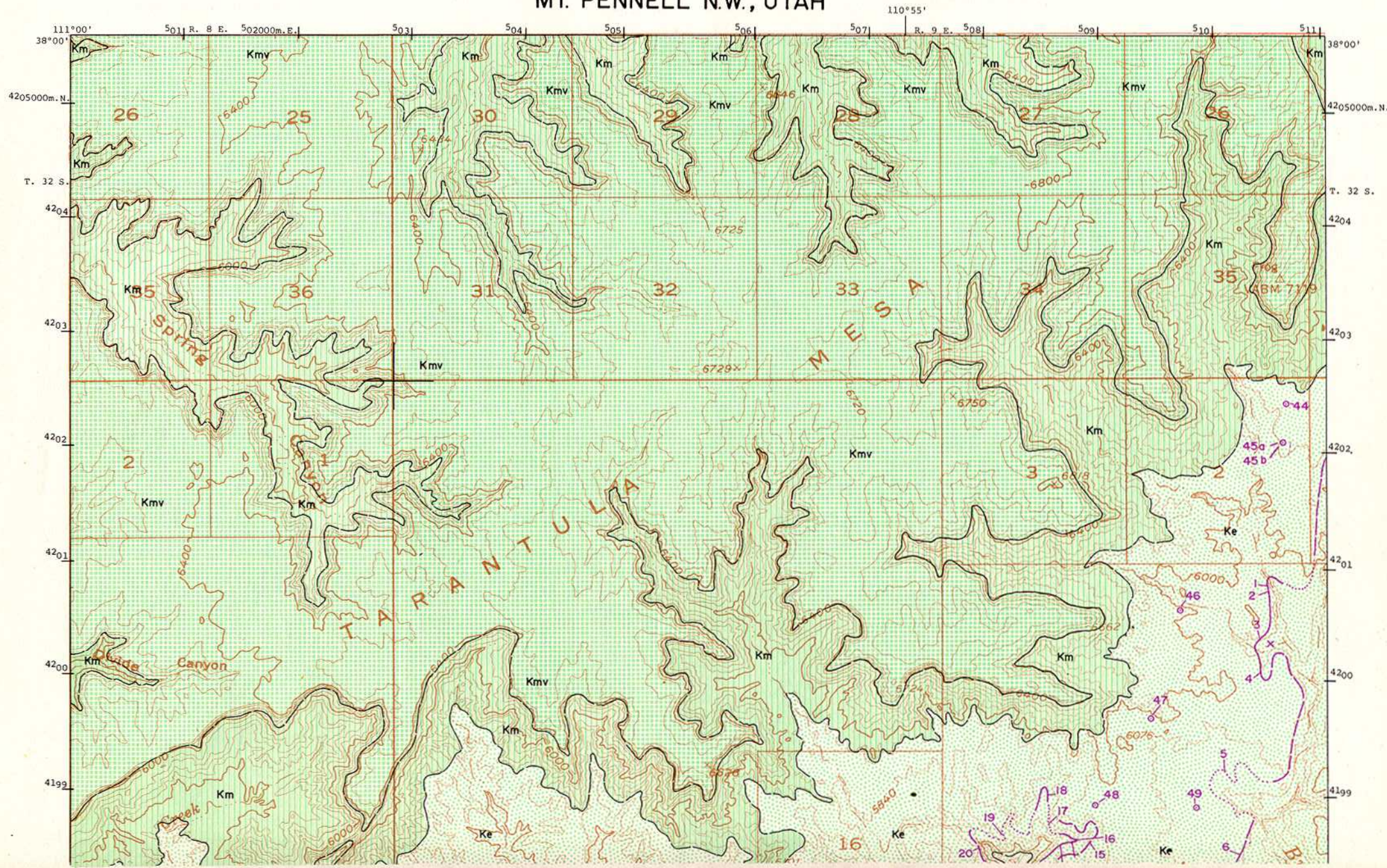
1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000

Contour interval 40 feet

Geology modified from C. B. Hunt, 1953, USGS; coal data by C. B. Hunt, 1953, USGS, and R. D. Gray, 1971, UGMS.

MT. PENNELL N.W., UTAH



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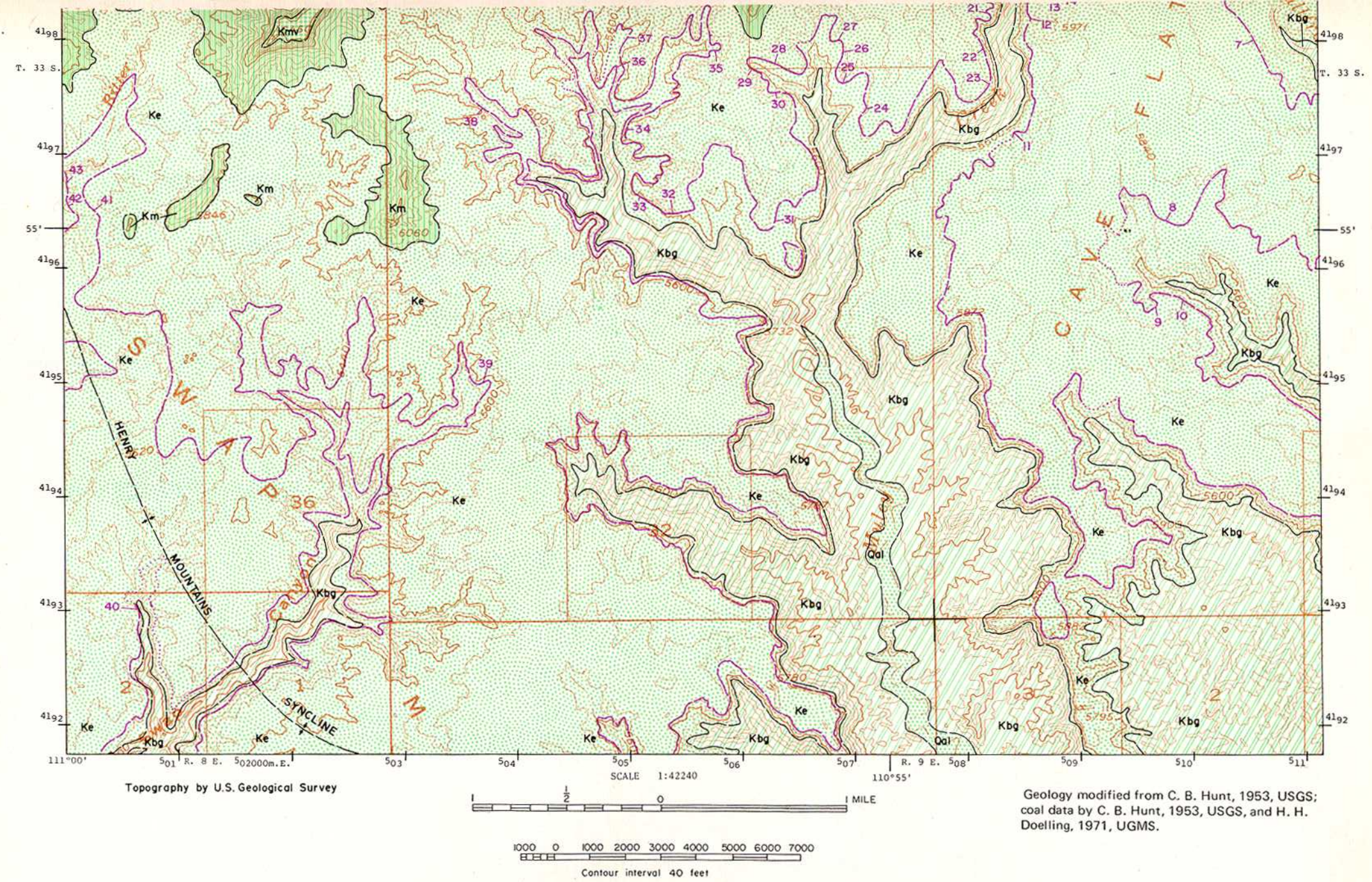


Figure 32. Coal and geology map, Mt. Pennell NW quadrangle (explanation pages 128-129).

sandy carbonaceous shale, and sandstone. It differs from the upper part of the Ferron and Emery Sandstone members in having much less carbonaceous material, several marine zones and more regular bedding. The number and thickness of the sandstone beds increases upward and provides a nearly perfect transition into the massive sandstone of the overlying Mesaverde. The Masuk Member is easily eroded and forms a long slope below the cliffs of Mesaverde Sandstone.

In this report the thicker sandstone beds near the top and bottom of the Masuk are included with the sandstone units above and below. Thus the outcrop area of the Masuk is confined to the cliff and immediate slopes below Tarantula Mesa and an occasional remnant bluff on the stripped mesas supported by the Emery.

The light tan Mesaverde Sandstone is the final Cretaceous unit and forms the caprock of Tarantula Mesa. The cliff-forming sandstone is mostly fine-grained, but locally may be conglomeratic. The unit is incomplete; the upper part has been removed by erosion. A minor amount of shale and carbonaceous material occurs near the upper portion of the unit. About 400 feet are exposed. According to Hunt and others (1953, p. 86) the Mesaverde is a clean beach deposit and presumably the sandstone was formerly overlain by carbonaceous and coal-bearing sandstone and shale as it is in the Wasatch Plateau or Book Cliffs areas.

The core of Mt. Pennell is an intrusive stock of diorite and monzonite. Dioritic laccoliths and sills are intruded between the sedimentary units along its flanks. The gravel from the mountain is found nearly everywhere in the area.

STRUCTURE

In the Mt. Pennell NW quadrangle the strata are nearly horizontal and dips are generally less than 3°. The axis of the Henry Mountains structural basin trends northerly and is near the west map edge. No faults of consequence were discovered on the quadrangle. The dominant structural feature of the Mt. Pennell NE quadrangle is the Mt. Pennell intrusion with the accompanying doming of surrounding rock. Along Bullfrog Creek the rocks dip gently westward, but immediately east of the drainage, dips increase rapidly. The strata incline up to 80 degrees; the average dip on the Mt. Pennell slope is 30 degrees. Formations on the peak are intercalated with laccolithic sills or cut by dikes and the stock itself. There are no faults of consequence in spite of deformation produced by the intrusion.

PROPERTY CONTROL

The lands of both quadrangles are public, controlled by the Bureau of Land Management and the state of Utah. The latter controls 13.9 percent of the acreage in the normal pattern, i.e., sections 2, 16, 32 and 36 of each township.

As of January 1, 1970, prospecting permits were held mainly on the Mt. Pennell NW quadrangle by the Cayman Corp. and G. Witter. In addition state leases were held by the Consolidation Coal Co. Of the total acreage of both quadrangles, 31.3 percent were held for coal. Since most of the permits and leases were on the west quadrangle, more than 60 percent of that area were involved.

All but the 21.2 percent of the land which are involved in the Mt. Pennell intrusion is coal land. The most important coal bearer here is the Emery Sandstone; Mt. Pennell NW is 82.5 percent underlain with Emery coal. Only in the re-entrant canyons of Muley and Bullfrog creeks has it been removed. The deeper Ferron coal underlies the entire quadrangle. The little Emery coal on the east quadrangle is mostly confined to the northwest corner. The Ferron underlies all but Mt. Pennell and northeast corner area of this quadrangle.

COAL

Surface Information

No coal sections were measured for the Dakota and Ferron sandstones on these quadrangles. Exposures of these formations occur on the flanks of Mt. Pennell, but the outcrops are poorly exposed. The major coal zone of the Emery crops out 140 to 160 feet above the base of the formation. Near the heads of Muley and Swap canyons, Hunt and others (1953, pl. 22) show beds in the upper part of the Emery which are 50 feet above the lower zone. The coal beds between the west map margin and Muley Creek have not been adequately explored. The south end of Cave Flat also needs more attention.

From available information (figures 33 and 34) it appears that coal under the north part of Cave Flat is thick, averaging 6½ feet. Toward the south the beds thin to about 1½ feet. In the upper branches of Muley Creek the coal zone is persistent and breaks up into several beds with from 3 to 7 feet of coal in two thicker seams. In many places the thicker seam is 4 feet thick. The separation, usually in shale, is 3 to 7 feet thick. A single measurement in a tributary of Swap Canyon showed 9.0 feet of clear coal in an area of heavy outcrop burning.

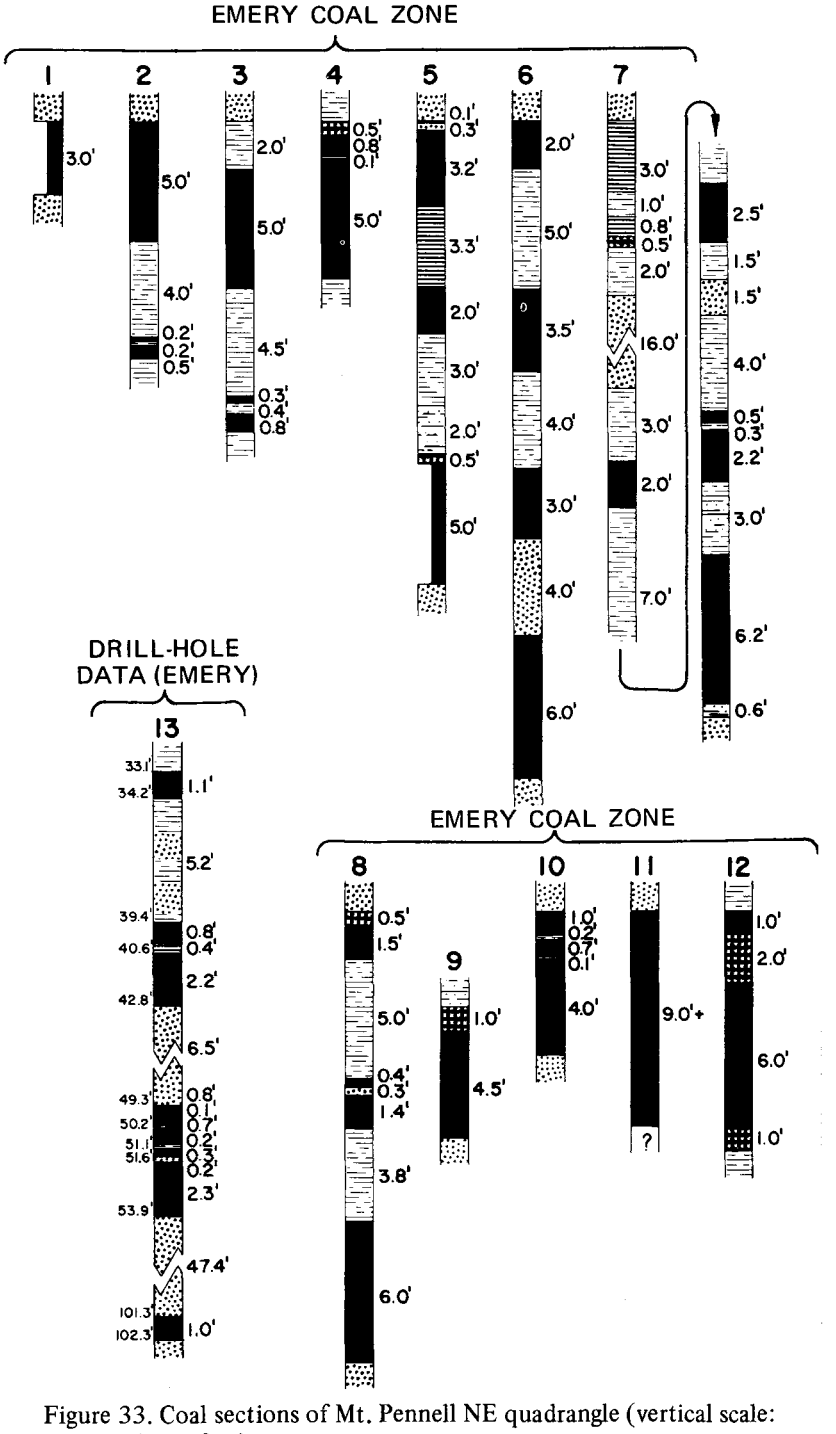


Figure 33. Coal sections of Mt. Pennell NE quadrangle (vertical scale: 1 inch = 8 feet).

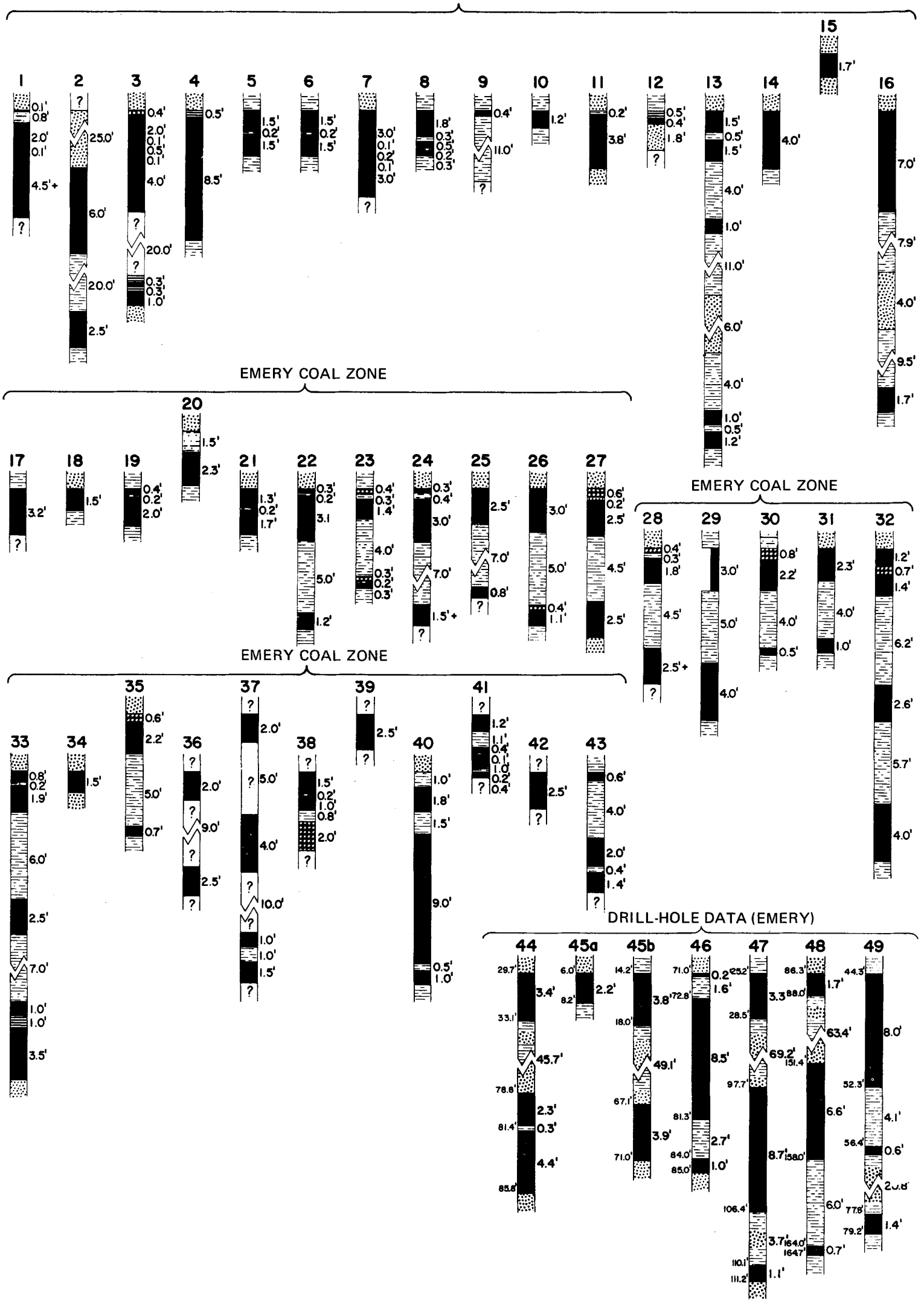


Figure 34. Coal sections of Mt. Pennell NW quadrangle (vertical scale: 1 inch = 8 feet).

Subsurface Information

Seven drill holes have penetrated the Emery coal zone in the north Cave Flat area. Coal, 6.6 to 9.1 feet thick, was encountered. Six of the seven holes encountered the coal at depths less than 100 feet and a considerable area of potentially strippable coal is present. The cover, except under Tarantula Mesa, rarely exceeds 200 feet and in many other areas outside of Cave Flat the overburden drops to less than 100 feet. Under Tarantula Mesa the overburden will be 800 to 1,000 feet thick.

In Muley Creek Canyon and in Bullfrog Canyon below the Emery the Ferron should lie at depths of 500 feet or less. On the mesas supported by the Emery the depth to the Ferron will increase to about 1,700 to 1,900 feet. Under Tarantula Mesa the depth to the Ferron should be between 2,500 and 3,000 feet.

Quality of Coal

Four analyses are available from the Mt. Pennell NW quadrangle, all from Emery drill holes (table 4). The following is an arithmetic average proximate analysis for the coal (table 11):

Table 11. Average proximate analysis of coal, Mt. Pennell NE-NW quadrangles.

	Percent	
	Average	Range
Moisture	12.0	10.5 -13.7
Volatile matter	37.1	36.1 -38.3
Fixed carbon	44.7	43.9 -45.5
Ash	6.3	4.9 - 8.7
Sulfur	0.57	0.46- 0.78
Btu/lb	11,148	10,856-11,468

Mines and Development

No mines or prospects have opened on the Mt. Pennell NW-NE quadrangles. The only development work known is the drilling of the seven holes in the Cave Flat area.

Reserves

Evaluation of the reserves is difficult because only limited data are available. Reserves are here estimated, however, according to class–indicated, inferred or potential (table 12).

Table 12. Coal reserves of the Emery coal zone, Mt. Pennell NE-NW quadrangles (in short tons).

Location	Acres	Average thickness (feet)	Tonnage	Class Reserve
T.32S. R.8E.	2,169	5.0	18,890,000	IV
T.32S. R.9E.	6,381	5.0	55,580,000	IV
T.33S. R.8E.	3,198	3.0	16,710,000	IV
Upper half of Twp.				
Lower half of Twp.	3,360	5,0	29,270,000	IV
T.33S. R.9E.				
Lower two tiers of secs. and parts of secs. 19 to 22 and 15 to 21	5,488	2.5	23,900,000	III
parts of secs. 17 and 20	2,393	3.5	14,590,000	II
secs. 3 to 10	662	4.0	4,610,000	II
secs. 1, 2, 11, 12, 14 and parts of 10, 15 and 23	4,400	3.5	26,830,000	III
T.34S. R.8E.	2,726	6.5	30,870,000	II
T.34S. R.9E.	800	6.8	9,480,000	III
	820	2.5	3,570,000	III
		Total	234,300,000	
		Class I and II reserve (estimated and measured)	50,070,000	
		Class III reserve (inferred)	63,780,000	
		Class IV reserve (potential)	120,450,000	
Measured, estimated and inferred reserve in beds more than 4 feet thick:			44,960,000	

The latter figure of almost 45 million tons is the only reserve that can be mined today economically. The figure might be enlarged by additional surface and subsurface exploration.

PRINCIPAL WORK

Geological and coal data were first collected by Hunt and others (1953) and presented on a preliminary coal map of the Henry Mountains coal field. Drill-hole data were contributed by an anonymous source and supplemental coal measurements were made in the more accessible portions of the quadrangles by the author specifically for this report.

NOTOM NE-SE QUADRANGLES

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Notom quadrangles are located on the west central flank of the Henry Mountains structural basin (figure 14). The coal beds crop out in the south extension of the Caineville Reef which parallels Sandy Creek. The town of Notom located in the northwest corner of the Notom NE quadrangle has no available services. The nearest services are at Hanksville 29 miles to the northeast or at Capitol Reef National Monument 10 miles northwest. Notom is located about 4 miles south of Utah Highway 24. The principal access road extends south along Sandy Creek from Notom and parallels the reef over the entire length of the two quadrangles. At Sandy Ranch, another road extends eastward at a junction and provides access across the reef and onto the mesas which make up the basin.

The lowest elevation is less than 4,800 feet along Sandy Creek. To the west the elevations rise gradually onto the Waterpocket Fold (about 7,000 feet). To the east of Sandy Creek the elevation rises in step-like fashion. Elevations on top of the Ferron Reef are about 5,300 to 5,600 feet. The top of Thompson and Wildcat mesas is about 5,900 to 6,000 feet and the top of Tarantula Mesa is about 6,400 feet.

STRATIGRAPHY

Triassic to Cretaceous consolidated units crop out on the quadrangles (figures 35 and 36). The outcrops are in roughly north-south trending bands with widths commensurate with the thickness, resistance to erosion and dip. The older rocks are exposed along the west map margin and the strata become progressively younger eastward.

Triassic strata exposed include the Chinle, Wingate and Kayenta formations. The exposure area is small in the southwest corner of the Notom SE quadrangle. The Chinle consists of irregularly bedded sandstone, sandy shale, conglomerate and limestone. The Wingate and Kayenta are massive or thick-bedded sandstone units with a typical reddish color. The Jurassic units are all below the coal and include the Navajo, Carmel, Entrada, Curtis, Summerville and Morrison formations. The descriptions of these units given in the field report are adequate with the following notations. The Curtis Formation becomes exceedingly thin in the north part of the Notom NE quadrangle. South of Cottonwood Wash the unit disappears completely. The Notom road is mostly built on the Entrada Sandstone, sometimes on the Summerville. The Entrada is mainly a reddish orange, earthy weathering unit producing a low area covered with sand and sandy soil. The Summerville is more brown and often stands vertically in bluffs east of the road. It is recognized easily by its even bedding. The uppermost Jurassic unit is the varicolored Brushy Basin Shale Member of the Morrison Formation. The first Cretaceous coal-bearing unit lies immediately above these greenish, purplish and gray shales.

Of greatest importance with respect to coal are the seven Cretaceous units; four are resistant sandstone units supporting reefs, tops of mesas or ledges and three are gray marine shales.

	Feet
Mesaverde Formation	400±
Masuk Shale	700-800
Emery Sandstone	300-500
Blue Gate Shale	1,400±
Ferron Sandstone	280-310
Tununk Shale	575±
Dakota Sandstone	0-60

The marine shale units, the Tununk, Blue Gate and Masuk, are similar in appearance, but the Masuk contains more intervening sandstone ledges than the others. Sandstone beds mostly lie near the top where they intertongue with the overlying sandstone units. The dominant lithology is a gray shale, nodular and earthy weathering, forming the gray and bluish appearing slopes under the cliffs.

In Utah all the other units contain coal. The Dakota usually contains some lenticular coal and the Henry Mountains area is no exception. The Dakota is a thin unit, sometimes missing, consisting of sandstone, claystone, sandy shale, gray shale, carbonaceous shale, coal and conglomerate. In the Notom quadrangles a fossiliferous zone usually occurs at the top. The continuity of coal has not been checked closely along the outcrop, but in all observed areas the coal has been thin, less than 1½ feet.

The next coal-bearing formation, the Ferron Sandstone, forms the basis of the Emery coal field to the west and contains thick coal seams in parts of the Henry Mountains field. In the Notom quadrangles coal is present, but thin. The character of the Ferron is well described by two measured sections:

Section of the Ferron Sandstone measured in sec. 28, T. 31 S., R. 8 E., along Blind Trail Wash, by R. D. Gray in 1971:

Bluegate-Ferron upper contact unexposed

Ferron Sandstone	Feet
1. Shale, purple-gray	—
2. Sandstone, light gray, medium-grained, ledge former	12.0
3. Carbonaceous shale, brown	2.0
4. Shale, gray, contains lenticular coarse- to medium-grained sandstone, thin-bedded, weathers to red, purple or brown	17.0
5. Sandstone, light gray, medium-grained, ledge former	3.5
6. Shale, gray and yellow, sandy	26.0
7. Sandstone, tan, medium-grained, ledge former	15.0
8. Shale, gray	1.0
9. Coal	0.2
10. Shale, gray	9.0
11. Sandstone, like unit 7	44.0
12. Shale, gray and brown	8.0
13. Sandstone, brown bed	1.0
14. Shale, gray	12.0
15. Sandstone, tan and yellow-gray, medium-grained, thick bed	3.0
16. Shale, sandy	12.0
17. Sandstone, like unit 7, but light gray	46.0
18. Shale, gray alternating with thin-bedded sandstone	20.0
19. Sandstone, light gray, medium-grained, interbedded with subordinate shale, medium- to thick-bedded ledge and slope	20.0
20. Shale, gray interbedded with thin beds of sandstone	24.5
21. Sandstone, tan to gray, medium-grained, medium- to thick-bedded, shale partings, cliff former	13.0
Total Ferron	289.2

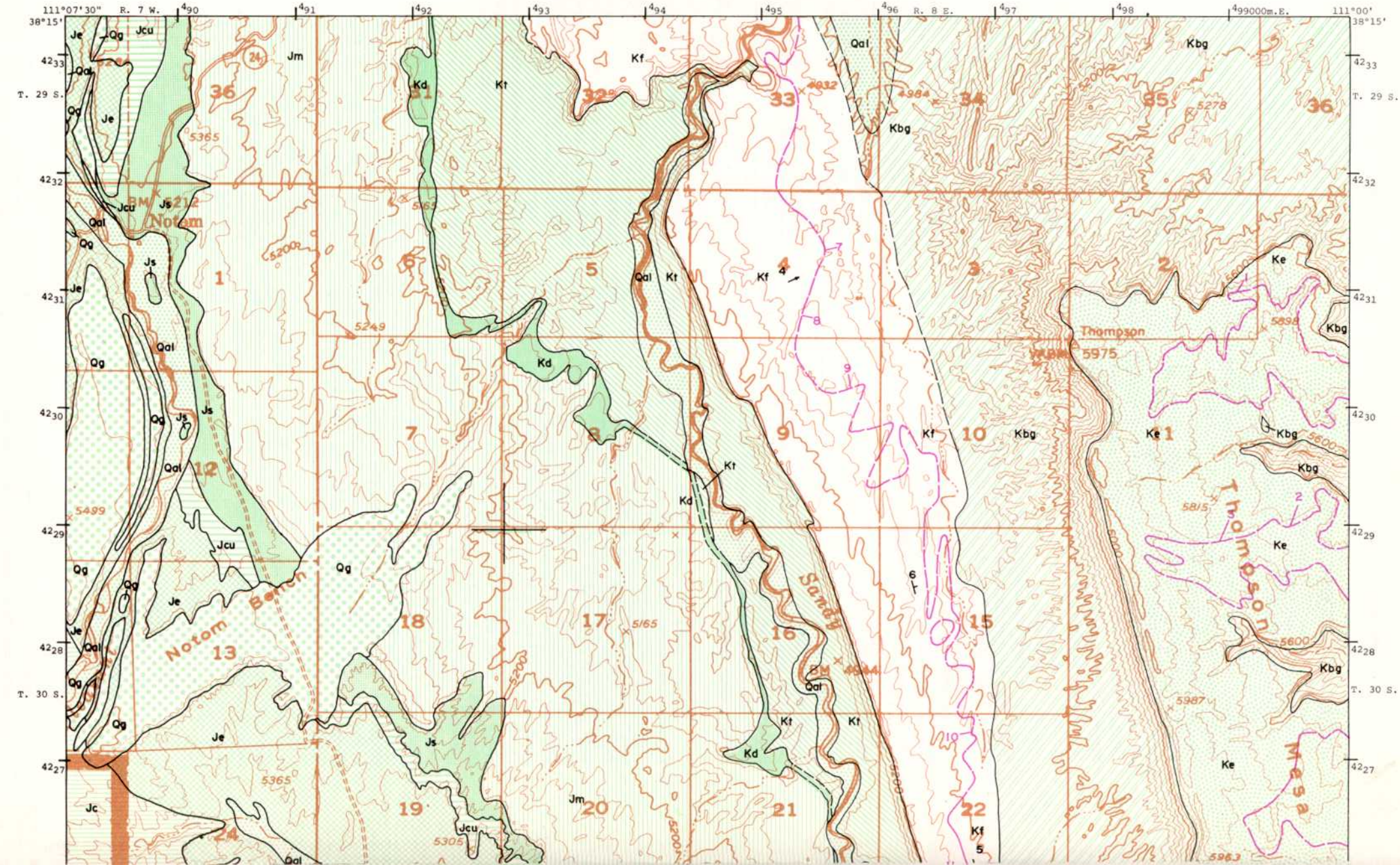
Tununk Shale: gray shale interbedded with subordinate light gray sandstone.

Section of the Ferron Sandstone in Sandy Creek Gorge, sec. 33, T. 29 S., R. 8 E., measured by R. D. Gray in 1971:

Blue Gate Shale

Ferron Sandstone	Feet
1. Coal	0.4
2. Shale, sandy	3.2
3. Sandstone, shaley	3.5
4. Interbedded friable sandy shale, carbonaceous shale and gray shale	25.0
5. Sandstone, white to gray, coarse-grained, massive, cliff forming	31.0
6. Carbonaceous shale, sandy	3.0
7. Shale and sandy shale, gray	25.0
8. Sandstone, tan, medium-grained, ledge	13.0
9. Carbonaceous shale	3.6
10. Shale and shaley sandstone	13.0
11. Sandstone, tan, coarse-grained, thick-bedded to massive, interbedded with minor amounts of gray shale, ledge former	17.0
12. Siltstone interbedded with thin-bedded sandstone, slope former	12.0
13. Sandstone, tan-gray, medium-grained, massive cliff former	22.0
14. Sandstone, light tan-gray, interbedded with gray shale	13.0

NOTOM N.E., UTAH



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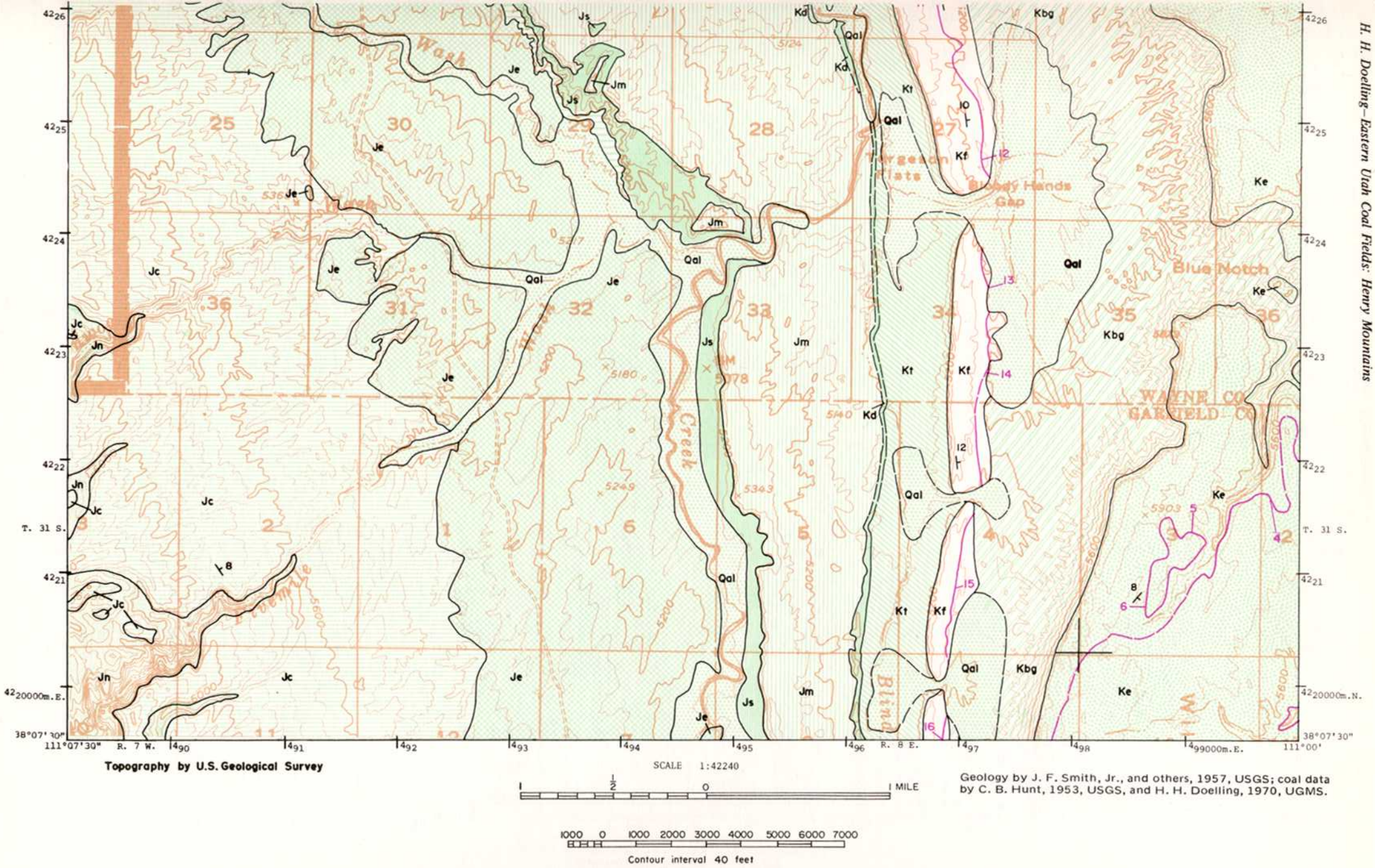
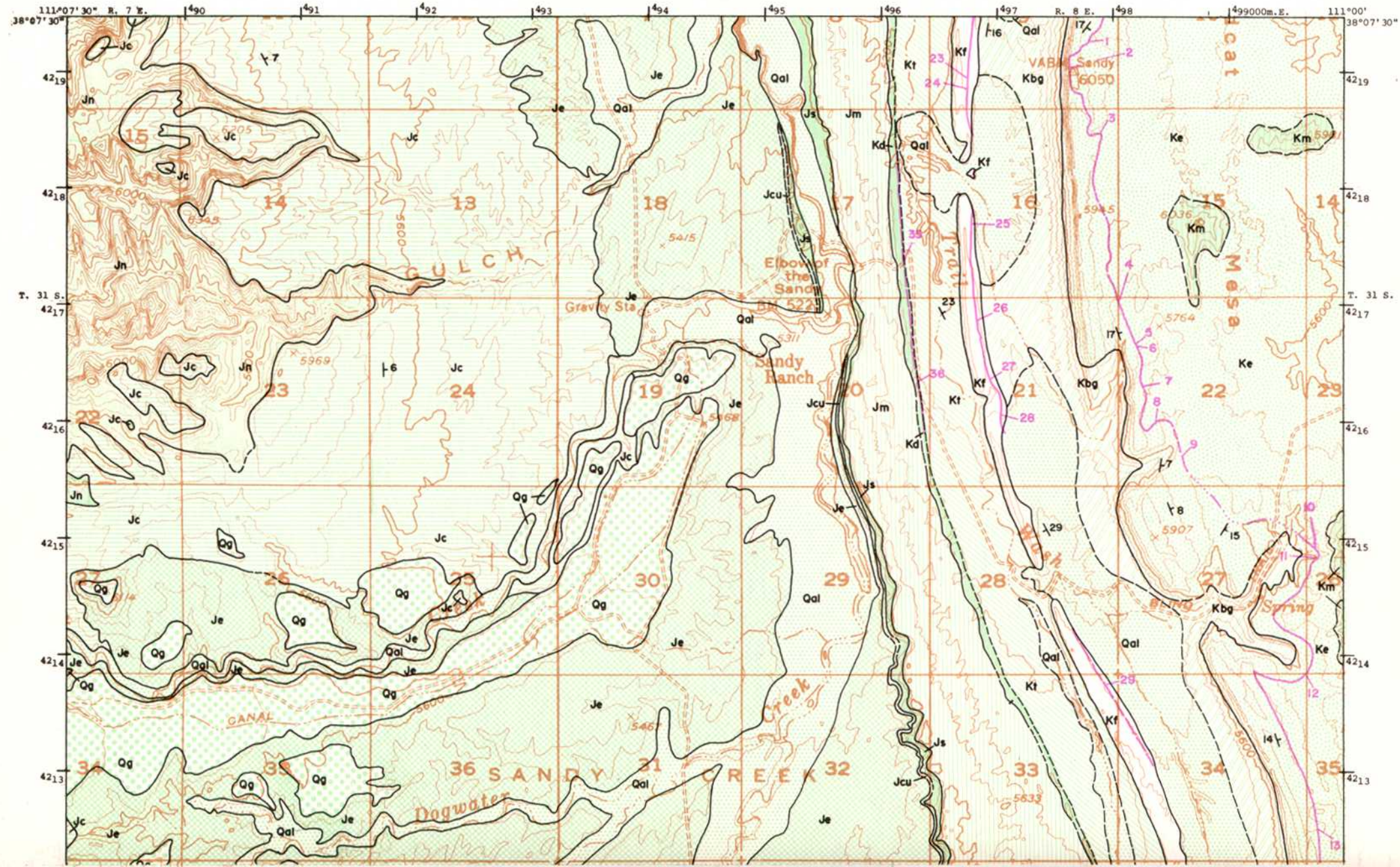


Figure 35. Coal and geology map, Notom NE quadrangle (explanation pages 128-129).

NOTOM S.E., UTAH



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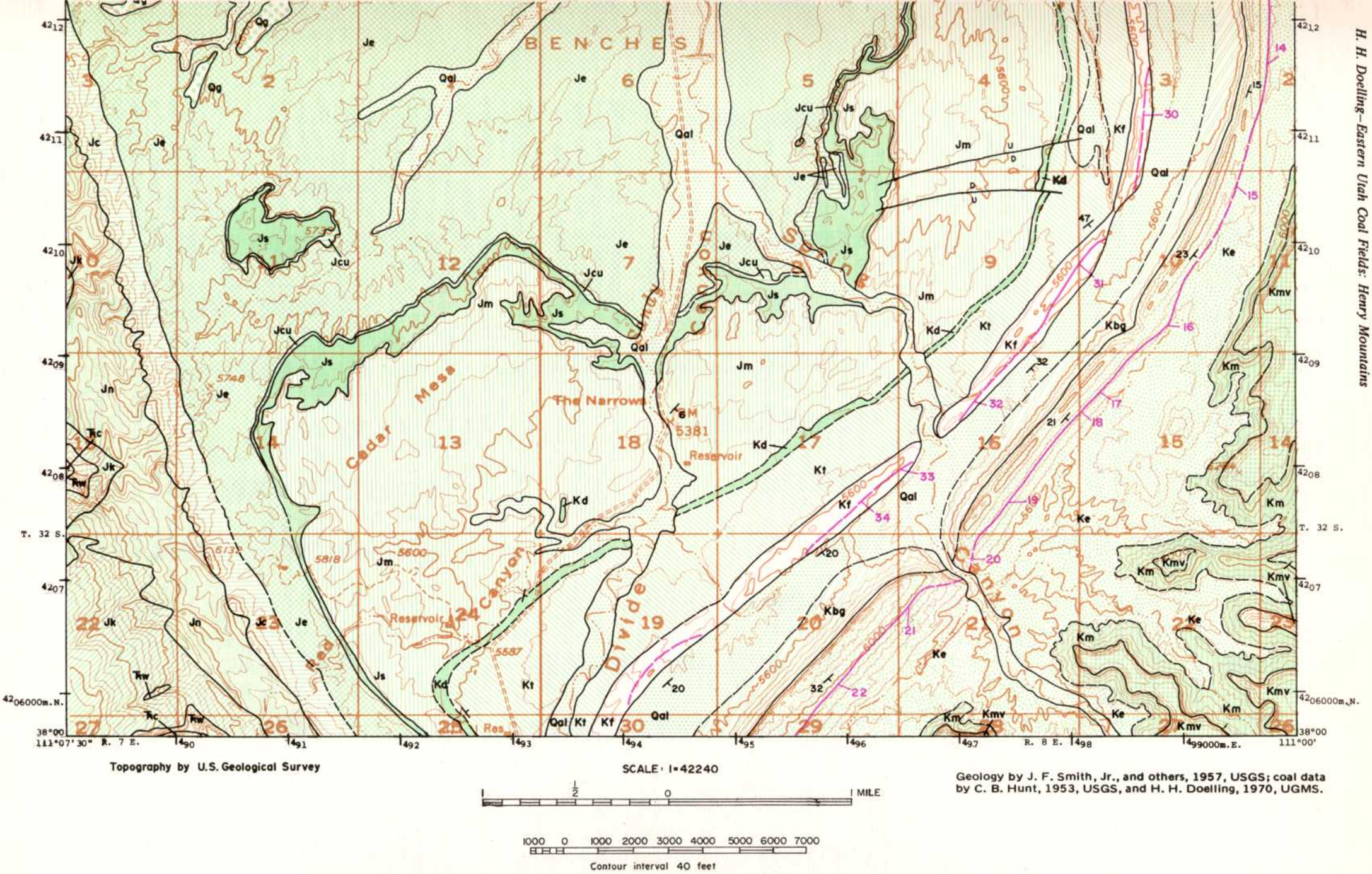


Figure 36. Coal and geology map, Notom SE quadrangle (explanation pages 128-129).

15. Sandstone, like unit 13	30.0
16. Shale, gray interbedded with thin sandstone beds	40.0
17. Sandstone, like unit 13	28.0
18. Shale, gray like unit 16	6.0
19. Sandstone, like unit 13	14.5
Total Ferron	303.2

Tununk Shale: shale, tan and gray interbedded with thin-bedded sandstone.

The Emery is the more important coal bearer of the Henry Mountains coal field. In other parts of Utah, the Emery is usually barren, but in the Henry Mountains field it contains beds known to contain minable coal. The following measured section adequately describes the Emery in the Notom SE quadrangle. It contains more than 19 feet of coal:

Section of the Emery Sandstone measured in Blind Spring Canyon in sec. 27, T. 31 S., R. 8 E.

Masuk Shale

Emery Sandstone	Feet
1. Sandstone, brown, medium-grained, blocky weathering	6.0
2. Shale, gray, sandy	22.0
3. Sandstone, tan, medium-grained, ledge former	24.0
4. Shale, gray	1.5
5. Sandstone, tan to brown, medium-grained, ledge former	9.0
6. Shale, tan, very sandy, contains subordinate thin beds of sandstone	31.0
7. Sandstone, tan, medium-grained, massive cliff former	28.0
8. Shale, tan, sandy	5.0
9. Sandstone, tan to brown, medium-grained, thick bed	4.0
10. Shale, gray	12.0
11. Coal	2.8
12. Shale, gray	0.8
13. Coal	3.8
14. Shale, gray	10.0
15. Coal	4.5
16. Shale, gray	0.5
17. Coal	3.5
18. Shale, gray	0.4
19. Coal	5.2
20. Shale, gray	1.5
21. Coal	1.3
22. Shale, coaley	0.7
23. Sandstone, tan, brown and red, medium- to coarse-grained, massive cliff former with a few shaley and coaley partings near the top	95.0
24. Sandstone, tan, coarse-grained, medium- to thick-bedded, occasional shale partings, cliff former	42.0
25. Shale, gray, nodular weathering, sandy in part, slope former	4.3
26. Sandstone, light brown, medium-grained, massive, lower one foot contains seamlets of gypsum, cliff former	19.0
27. Sandstone, gray, medium-grained, friable and massive slope former, contains lenses and lentils of isolated bodies of more resistant brown weathering sandstone	13.4
28. Sandstone, like unit 26 with no gypsum seamlets	12.0
29. Shale and sandstone, alternating	54.3
30. Sandstone, tan, medium-grained, massive, resistant cliff former	9.0
Total Emery	436.5

Blue Gate Shale: gray shale alternating with thin-bedded sandstone.

The transition between the Emery and Masuk is thick. In this report the transitional beds are included with the Emery and the mapping reflects this. Most of the upper surface of Wildcat and Thompson mesas is, therefore, included with the Emery.

The Mesaverde contains the most important coal in Utah. In the Henry Mountains, however, only the lower cliffy sandstones remain; the coal-bearing portion has been removed by erosion. The Mesaverde is exposed only on Tarantula Mesa in the southeast corner of Notom SE quadrangle.

STRUCTURE

The structure of the Notom NE-SE quadrangles is dominated by eastward-dipping beds participating in the Waterpocket Fold. The monocline separates the Henry Mountains structural basin to the east from the Circle Cliffs upwarp to the west. The dip ranges from 4 to 35 degrees along the coal-bearing beds. Along the Ferron they average 15 to 20 degrees and along the Emery, 7 to 15 degrees. The dips rapidly become more gentle eastward.

Faults are rare along the Waterpocket Fold. Two appear at right angles to strike in T. 32 S., R. 8 E. in the Notom SE quadrangle. The displacements are small.

PROPERTY CONTROL

The lands of the Notom NE-SE quadrangles are owned as follows: Bureau of Land Management 66.3 percent, National Park Service 18.7 percent, state of Utah 10.6 percent and private property 4.4 percent.

The private property is concentrated around the Sandy Creek benches and around Notom; none of it includes the coal measures. Capitol Reef National Monument is located along the west map margins and only a small acreage is superimposed on coal land (and the coal is thin in this area). Most of the coal lands, therefore, are the property of the BLM and the state of Utah.

Of the approximately 6,800 acres of coal land, some are held as leases or coal prospecting permits; 96.9 percent are prospecting permits of the Cayman Corp. and the remaining land is state leases of Consolidation Coal Co. The land so held (January 1, 1970) amounts to 30 percent of the available coal lands, but includes the entire area of coal seams more than 4 feet thick. The coal lands are located along the east map margins of the Notom NE-SE quadrangles and involve 28.6 percent of the total area.

COAL

Surface Information

Notom NE Quadrangle

Sixteen measured sections are available for the Notom NE quadrangle (figure 37) including six from the Emery and ten from the Ferron Sandstone. The Dakota has coal as well, but its presence is lenticular and the beds are mostly under 1 foot thick.

Coal in the Ferron appears to continue along the length of the reef in the Notom NE quadrangle. The maximum thickness discovered is 2½ feet. The coal beds lie within 150 feet of the top of the Ferron, underneath a resistant sandstone ledge; they correspond to the Lower zone as defined in the Caineville quadrangle to the north. The Upper zone is present only as a carbonaceous zone which is poorly exposed and usually covered by Blue Gate Shale derived alluvium. The coal of the Lower zone averages 1.3 feet thick.

Remnants of coal in the Emery Sandstone appear on Thompson Mesa and on the north end of the Wildcat Mesa. The coal appears to thicken southward and in the southernmost section thickens to more than 4 feet of coal. Location 6 has three beds of coal 3.5, 4.8 and 3.5 feet thick, respectively.

Notom SE Quadrangle

The thin character of coal in the Dakota and Ferron sandstones appears to continue into the Notom SE quadrangle. Two sections were measured in the Dakota, less than a mile apart. One section had 2.3 feet of coal with a 1-inch sandstone split; the other revealed 1.3 feet of boney coal. The Dakota, which has not been thoroughly investigated along its entire length of outcrop, may contain thicker coal.

The Lower coal zone in the Ferron Sandstone continues southward along the reef and the carbonaceous zone bearing the coal beds thickens. The number of beds within the zone occasionally increases, but the beds remain thin. The thickest measured

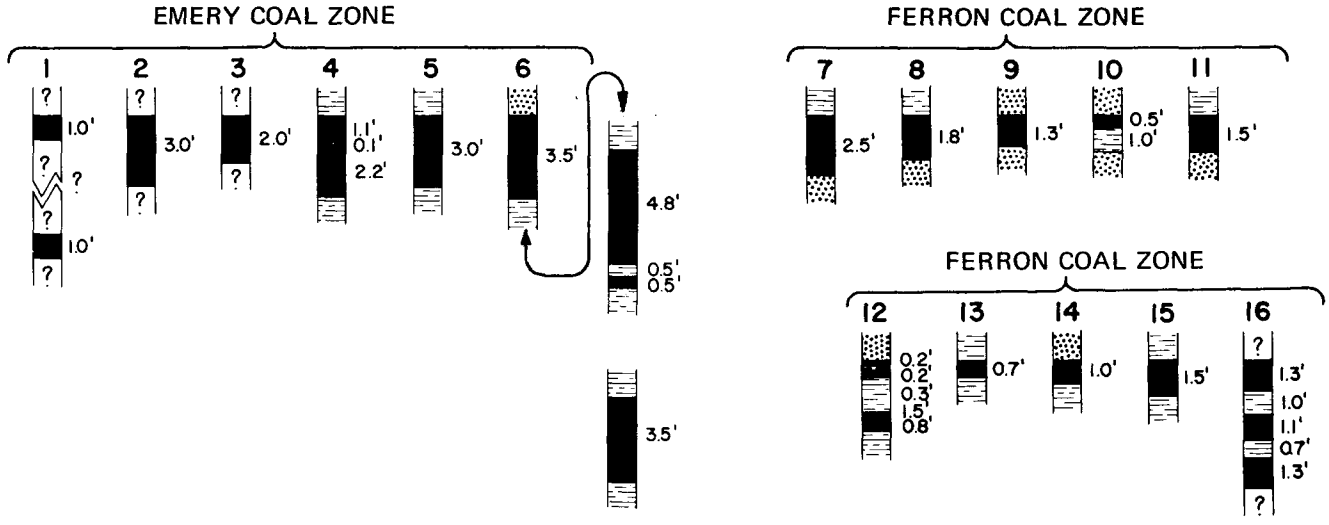


Figure 37. Coal sections of Notom NE quadrangle (vertical scale: 1 inch = 8 feet).

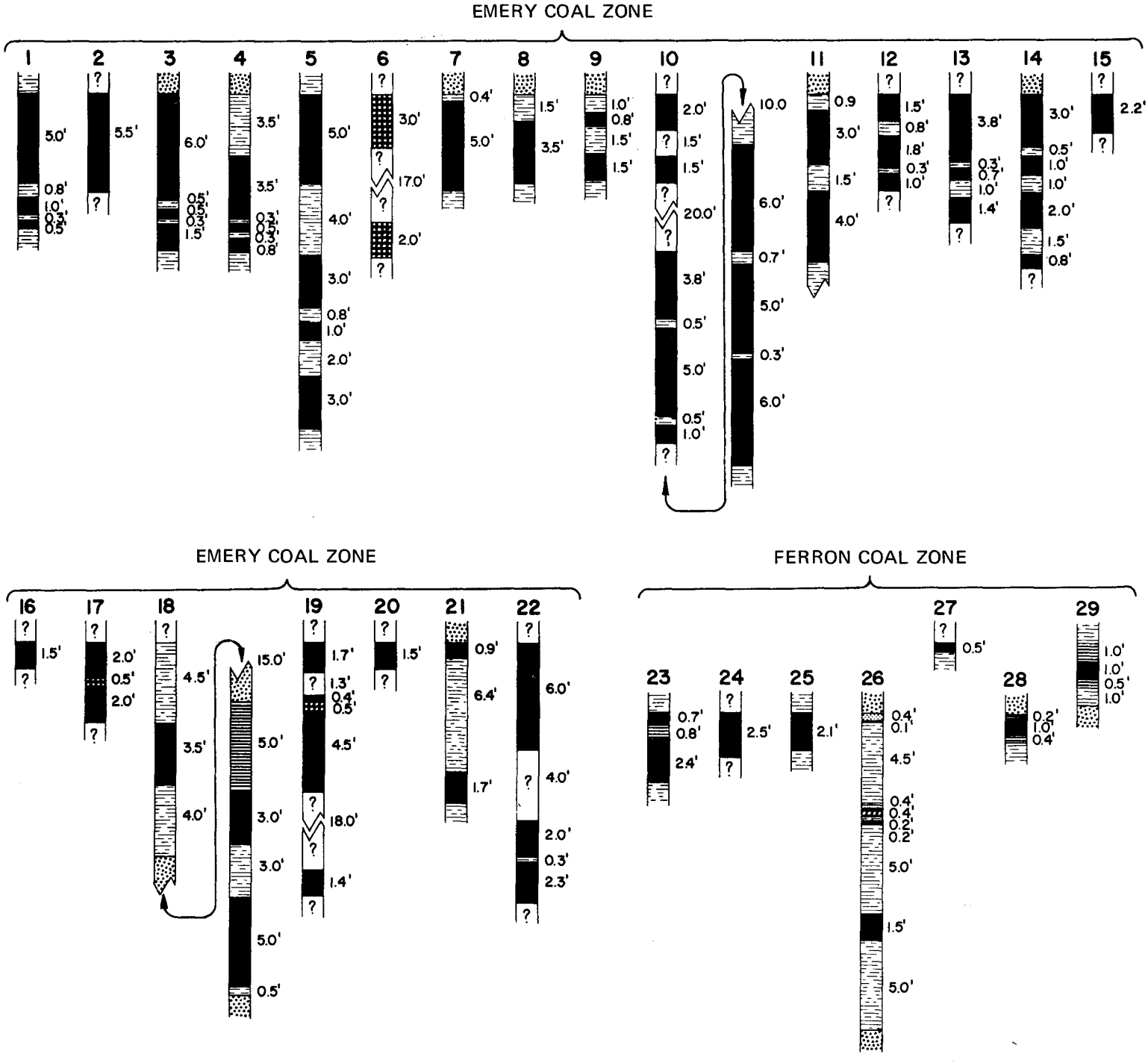


Figure 38. Coal sections of Notom SE quadrangle (vertical scale: 1 inch = 8 feet).

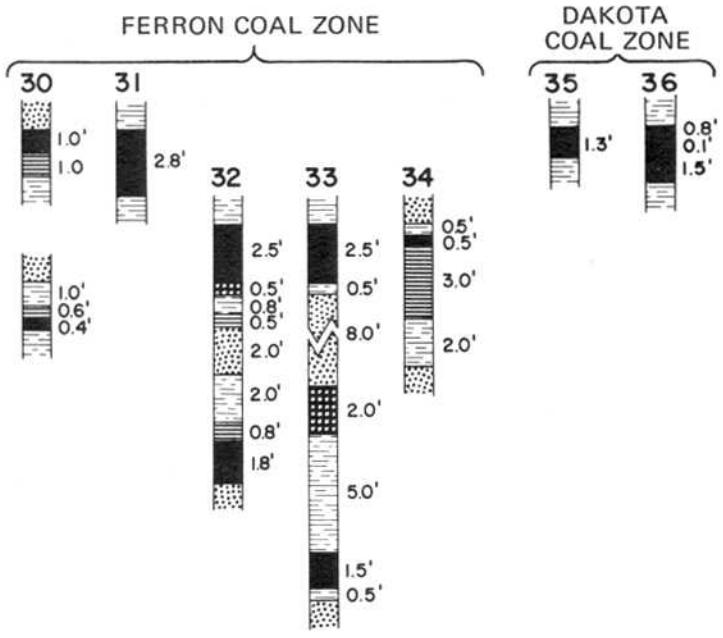


Figure 38. (continued)

section is 2.8 feet and the average thickness of the thickest coal bed along the outcrop is 1.7 feet.

The best coal beds are in the Emery Sandstone. Twenty-two coal sections were measured along Wildcat Mesa and under Tarantula Mesa (figure 38). The coal zone is near the top of the formation above the cliff rim. The thickest individual seam is 6 feet and at location 11, three seams total 17 feet of coal split by a total of 1 foot of rock. An additional 7 feet in two seams are located above a 10-foot interval of shale. The coal beds are very lenticular and pinch in and out but, except for a few local areas, coal is continuous in thick seams along the outcrop. An average of at least 5 feet of coal may be expected.

Subsurface Information

No drill-hole data are available for the Notom quadrangles. Depth to the Ferron coal horizons increases rapidly eastward and is expected to be 1,800 feet under Wildcat and Thompson mesas. Emery coal is found at shallow depths and only under Tarantula Mesa does the depth approach 1,000 feet.

Quality of Coal

No analyses for the coal of the Notom NE-SE quadrangles are available.

Mines and Development

As far as is known, no mines or prospects have opened for coal in either quadrangle.

Reserves

Only the Emery Sandstone contains coal beds exceeding 4 feet thick in the Notom NE-SE quadrangles (table 13):

Table 13. Original coal reserves in Emery Sandstone exceeding 4 feet thick, Notom NE-SE quadrangles.

Location	Acres	Average thickness (feet)	Tonnage
T.31S., R.8E.	2,816	5.0	24,500,000
T.32S., R.8E.	2,797	5.0	24,300,000
		Total	48,800,000

If coal 1½ feet thick were mined in the Ferron, there would be 20,000 acres containing 52.2 million tons of coal in the two quadrangles.

PRINCIPAL WORK

The geologic mapping is primarily the work of Smith and others (1963) as a part of their work on the Capitol Reef area for the U. S. Geological Survey. Their work was modified for this presentation. Coal data were collected by Hunt and others (1953) and augmented by the Utah Geological and Mineralogical Survey for this report.

Compressed log of jet coal from the Dakota Formation at Jet Basin north of Mt. Ellen, Henry Mountains coal field.

WAGON BOX MESA NE–CAVE POINT QUADRANGLES

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Wagon Box Mesa NW quadrangle corresponds to the northwest corner of the U. S. Geological Survey Wagon Box Mesa quadrangle. The Cave Point quadrangle is made up of parts of the Survey's Wagon Box Mesa and Mt. Pennell 15-minute quadrangles. The area lies in the southwest corner of the Henry Mountains coal field and portrays the Waterpocket Fold for a distance of 17 miles (figure 14).

Generally the higher elevations are to the north in Wagon Box Mesa NW and gradually decrease from the Bitter Creek Divide southward. The highest elevation is along the Waterpocket Fold on the reef west of the road (7,300+ feet) and the highest elevation in the Henry Mountains structural basin is on Tarantula Mesa (almost 6,400 feet). The elevation along the road at Bitter Creek Divide is 5,650. At the south end of Cave Point quadrangle, the elevation on Waterpocket Fold has decreased to about 6,600 feet; the elevation in the basin has dropped to about 5,000 feet and Halls Creek is at less than 4,800 feet. Coal beds occur at two average elevations, that in the Ferron about 5,000 feet and that in the Emery at about 5,600 to 5,800 feet above sea level.

A well graded road paralleling Waterpocket Fold along Halls Creek is the only accessway into either quadrangle. The north edge of Wagon Box Mesa NW quadrangle is 18 miles south of Utah Highway 24 pavement. The south extension of the road eventually reaches Bullfrog Basin on the Colorado River.

STRATIGRAPHY (figures 39 and 40)

As seen from the Halls Creek road, the Waterpocket Fold to the west is a reef made up of the Navajo Sandstone. Below and exposed to the west of the Navajo are mostly Triassic redbeds and the few exposures of Permian rock within the Circle Cliffs area. The Carmel, which overlies the Navajo, is usually seen as dark reddish brown triangular flatirons lapping onto the Navajo Reef. The orange sandstones of the Entrada form low hills in the valley of Halls Creek and occasional low Entrada derived sand dunes can be seen on the valley surface. The next two Jurassic formations, the Summerville and Morrison, form a hogback.

The Summerville is a reddish brown, evenly bedded silty sandstone; the lower member of the Morrison is gray, yellowish gray to yellowish brown lenticular quartzose sandstone interbedded with conglomeratic sandstone, conglomerate and greenish, grayish and purple mudstones. The upper member of the Morrison consists mostly of clay and mudstone with subordinate limestone, sandstone and conglomerate lenses. The mudstones are variegated in color; especially notable are the purple, green and white hues. Some of the conglomeratic beds of the upper member are resistant, but generally the unit is seen in rounded colorful hills.

The Cretaceous coal-bearing beds lie atop the Morrison. The Dakota, when present, forms an insignificant ridge on the Morrison clays. This ridge is made more significant by the presence of fossil beds. Along the Waterpocket Fold the ridge is generally known as Oyster Shell Reef.

Section of Dakota Sandstone near Burr Trail on the Waterpocket Fold, a few miles north of mouth of Muley Twist Creek, approx. sec. 15, T. 34 S., R. 8 E., measured by Gregory and Moore (1931).

Cretaceous
Mancos Shale; includes "oyster bed" 92 feet above the base.
(Tununk Shale)
Dakota (?) Sandstone:

	Feet
5. Conglomerate, brown; contains three thin lenses of sandstone; subangular pebbles, mainly chert, quartzite, and quartz, which average three-fourths inch in diameter	10
4. Shale, arenaceous, and thin sandstone, yellow-brown, cross-bedded, lenticular; contains impressions of plants	15
3. Sandstone, coarse, in overlapping lenses; quartz and chert grains well worn but not round; contains scattered pebbles one-half inch or less in diameter and a few iron concretions	14
2. Shale, sandy, and thin sandstone, red-brown; foliation surfaces sun cracked and ripple marked; some worm tracks; abundant iron in grains and black patches	15
1. Conglomerate (75 percent) and very coarse sandstone 25 percent), a series of short thick lenses and thin irregular beds, all strongly cross-bedded; pebbles one-eighth inch to 2 inches in diameter of white, red, and black chert, lesser amount of quartzite, quartz, and jasper, some igneous (?); some petrified wood; chunks and balls of compact green-white clay and of calcareous sand, irregularly distributed, weathering of which gives rock a porous appearance; iron concretions in form of pancakes, lozenges and bolt heads	38
Total Dakota (?) Sandstone	92

Unconformity
Shale and sandstone, red and green-gray. (Morrison)

The Dakota contains very lenticular coal, sometimes surpassing 4 feet thick. The coal is usually associated with the shaley beds. The unit is generally less than 60 feet thick. The coal thickens locally a mile south of Bitter Creek Divide and at a few other localities. The Dakota has not fully been explored for coal.

The drab gray marine shales of the Tununk divide the coal-bearing Ferron Sandstone from the Dakota Sandstone. The Tununk is a dark shale on fresh surfaces and is usually 700 to 800 feet thick. At the Burr Trail the following section was measured and described by Moore (Gregory and Moore, 1931):

Shale, dark bluish to greenish drab, sandy, contains selenite crystals; two thin sandstone [beds?], 8 inches to 1 foot thick, dark brown, hard, flaggy, separated by 5 feet of shale, occur 300 feet below top; near middle part occurs thin soft sandstone that contains hard dark-brown concretions; at base lies 6 to 8 feet of soft brown calcareous sandstone with abundant marine invertebrates . . . 950 feet.

The upper part of the Tununk is gray silty sandstone, nodular weathering and massive. It is interbedded with minor shale. As the first thick-bedded to massive sandstone is reached, it is assigned to the Ferron Sandstone. The Ferron varies from 100 to 250 feet thick within the two quadrangles. The formation along much of the south end of the Henry Mountains Basin is thin, 100 to 175 feet. The formation usually consists of three parts: a lower transitional zone with the Tununk containing gray marine shale, a middle cliff-forming beach or nearshore sandstone and an upper coal-bearing part. The following section measured near The Post does not have a well developed lower transitional zone, but the upper two units are easily differentiated.

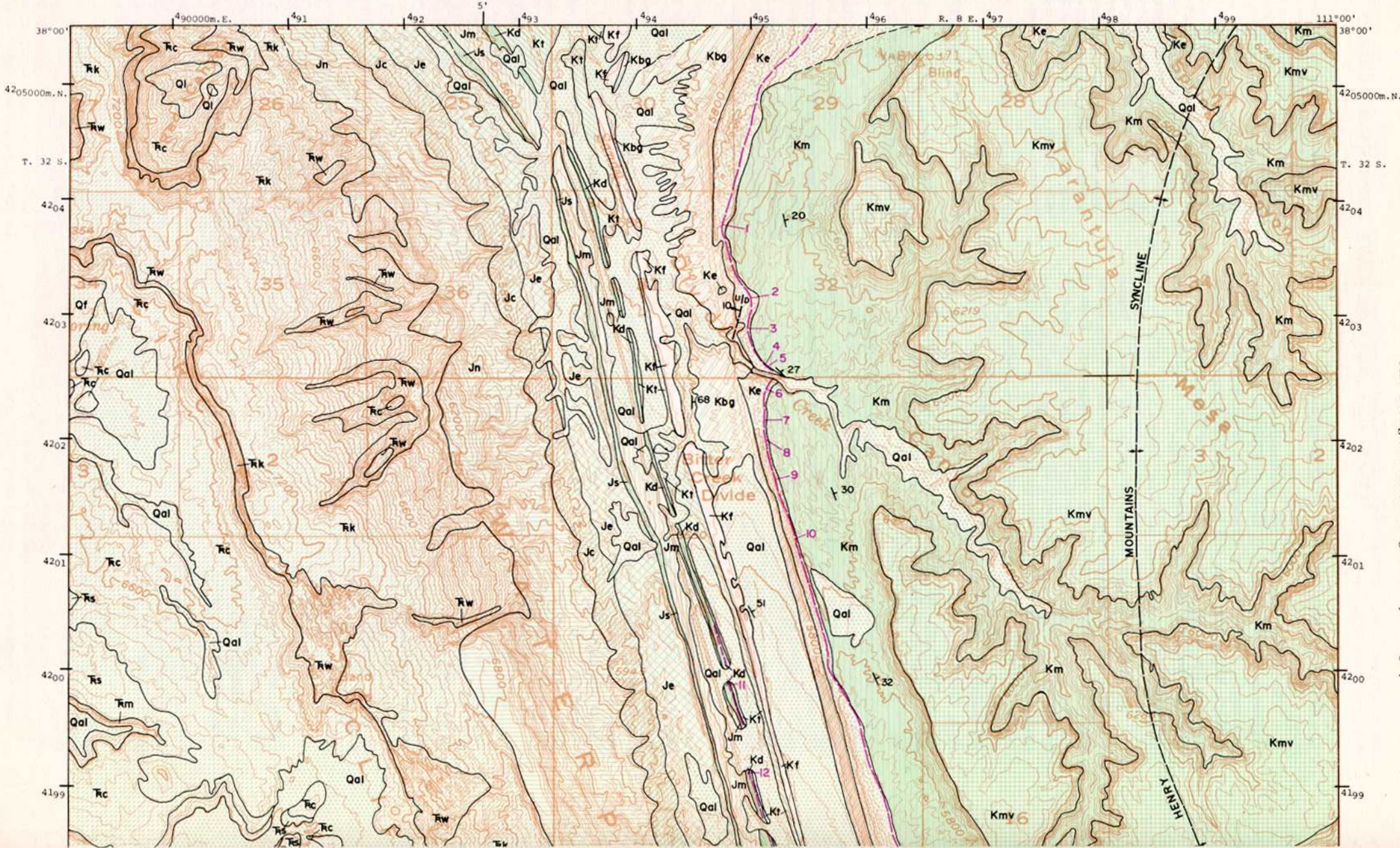
Section of Ferron Sandstone measured near The Post, sec. 19, T. 34 S., R. 9 E.

Blue Gate Shale
Ferron Sandstone

Coal Zone

	Feet
1. Sandstone, white to light gray, medium-grained, massive cliff former	8.5
2. Coal	0.3
3. Siltstone, gray with rusty colored bands, sandy, massive slope former	7.5
4. Sandstone, white to light brown, silty with thin seamlets of coal, slope former	1.8
5. Coal	2.8
6. Shale, dark brown, coaley	0.7
7. Coal	0.8
8. Shale, gray to black, nonresistant	4.5
Middle Unit	
9. Sandstone, tan, medium-grained, massive cliff former	28.5
10. Shale, brown, coaley, fissile	0.5
11. Sandstone, brown, medium-grained, massive cliff former	31.4

WAGON BOX MESA N.E., UTAH



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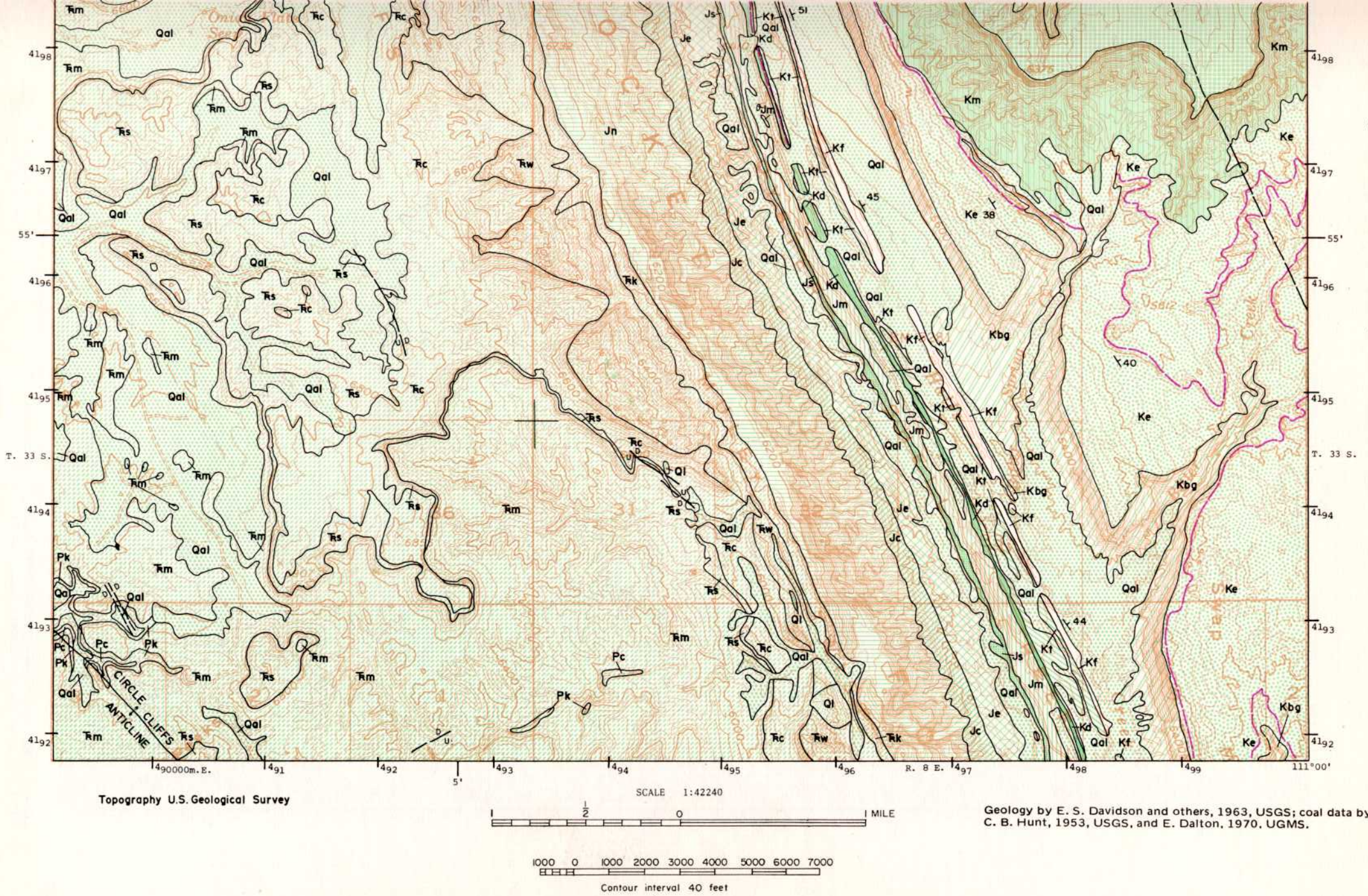


Figure 39. Coal and geology map, Wagon Box Mesa NE quadrangle (explanation pages 128-129).

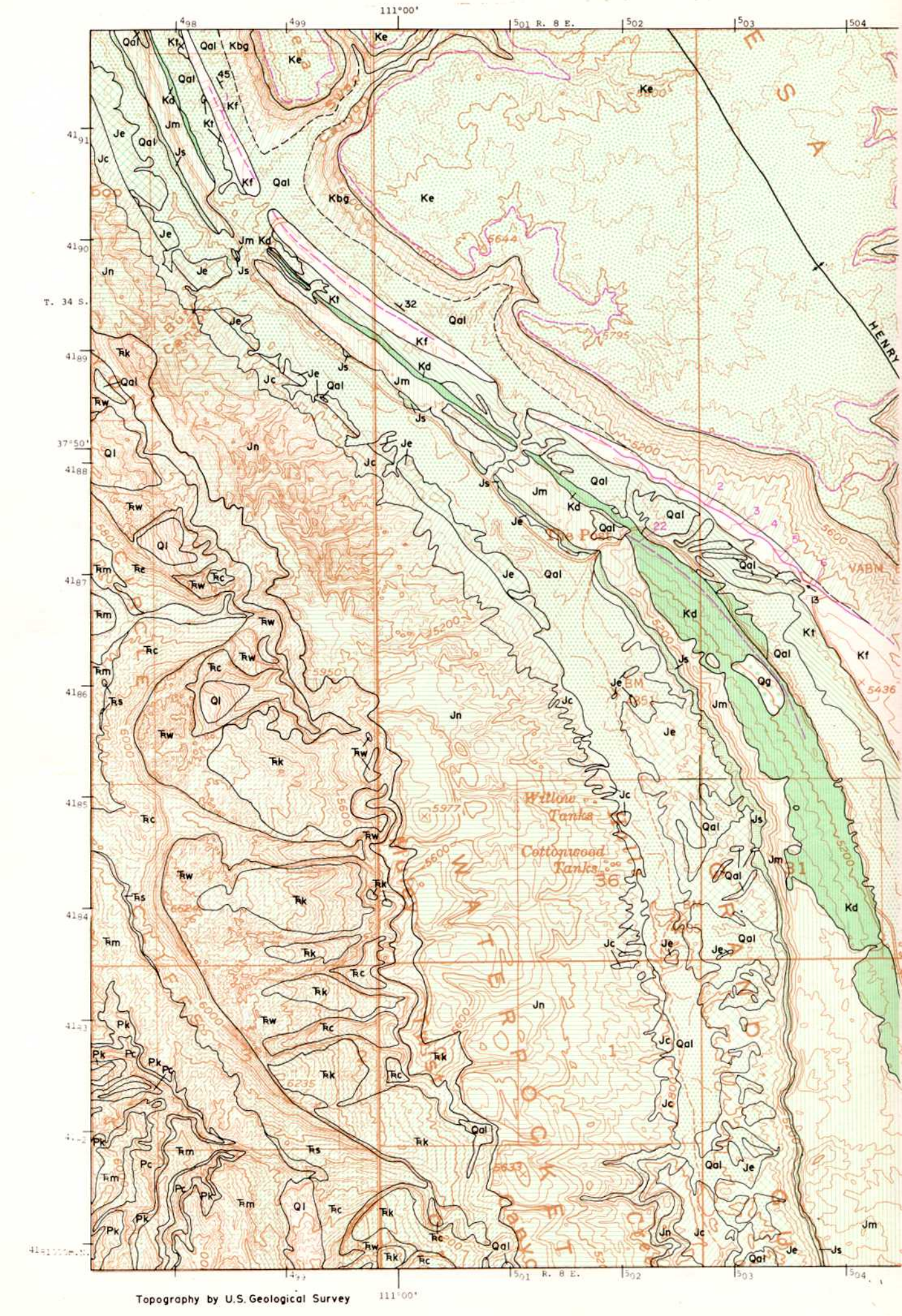
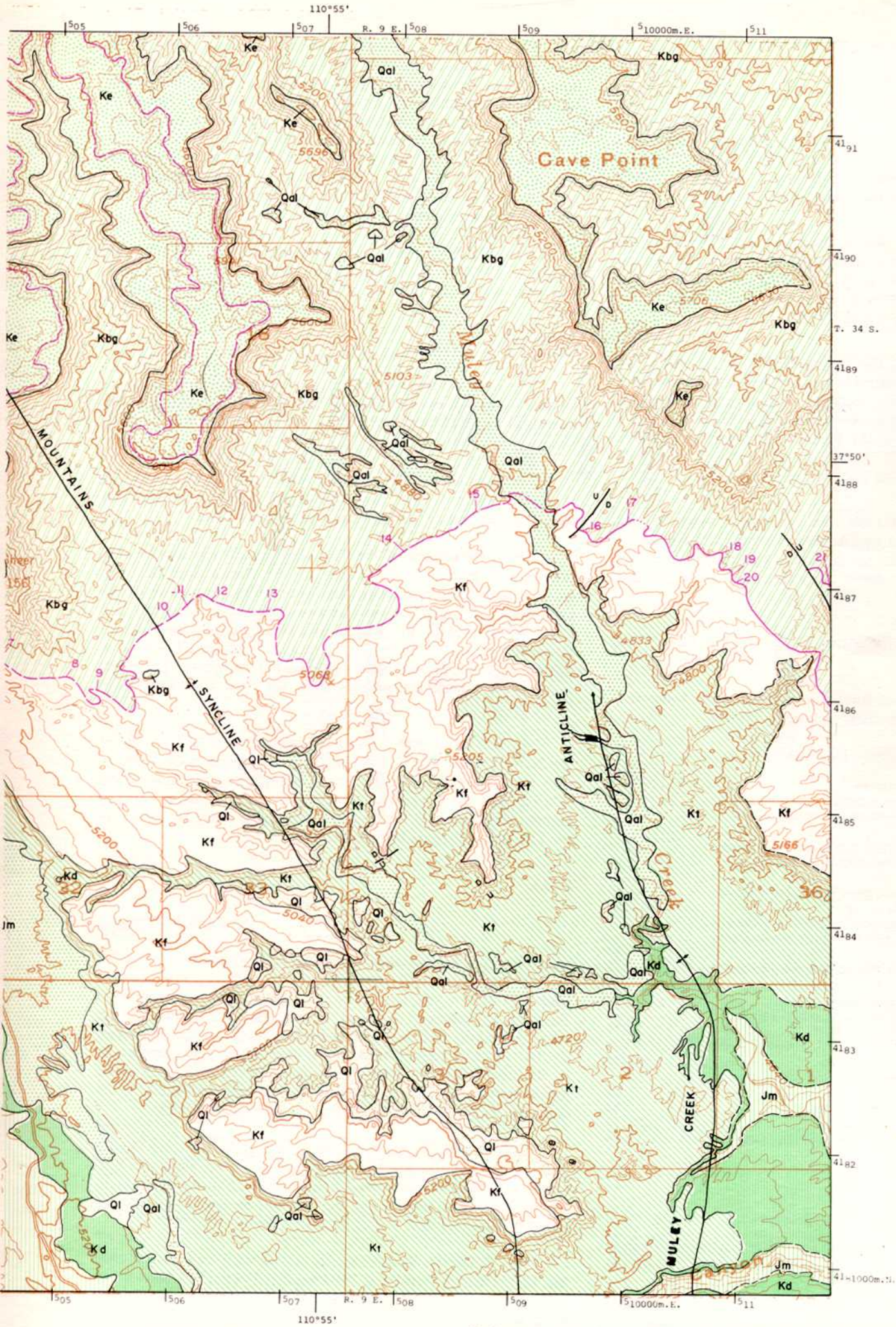


Figure 40. Coal and geology map, Cave Point quadrangle (explanation pages 128-129).



SCALE 1=42240

1 ½ 0 1 Mile

1000 0 1000 2000 3000 4000 5000 6000 7000

Contour interval 40 feet

Datum mean sea level

Geology by E. S. Davidson and others, 1967, USGS; coal data by H. H. Doelling, 1971, UGMS, and C. B. Hunt, 1953, USGS.

12. Shale, gray interbedded with thin-bedded sandstone, light brown, fine-grained	3.4
13. Sandstone, gray to tan, medium-grained, massive cliff former	31.7
Total Ferron	122.4

Tununk Shale

In outcrop, the Ferron either forms a ridge or cliff. Along Waterpocket Fold the ridge is often very slight, but can be traced easily. The softer coal member at the top is mostly covered by slumping clays derived from the overlying Blue Gate Shale.

The Blue Gate Shale overlies the Ferron and, were it not for the Ferron, would be almost indistinguishable from the Tununk. At Burr Trail the shale is 1,100 feet thick and weathers into curtain-like badlands. The Ferron was measured to be only 65 feet thick at this locality (Gregory and Moore, 1931, p. 108).

The next sandstone, the Emery Sandstone, is also a coal bearer and much like the Ferron in description. Like the Ferron, it can be subdivided into three members. The upper member, however, differs in that several massive sandstone beds are included in it. An incomplete section of the Emery Sandstone has been measured in sec. 2, T. 34 S., R. 8 E. about a mile east of the southeast corner of the Wagon Box Mesa NE quadrangle.

A little more than 200 feet were recorded in which 95+ feet were assigned to the upper coal-bearing member, 122 feet to the cliffy member and 22 feet to the lower transitional zone. The better coal beds occur just above the middle and upper unit contact.

Above the Emery is the Masuk Shale, which at Bitter Creek Divide measures 787 feet.

Section of Masuk Member at Bitter Creek Divide, secs. 4 and 5, T. 33 S., R. 8 E., measured by Hunt and others (1953).

Top: massive sandstone of Mesaverde Formation

Masuk Member:	Feet
Clay, brown and earthy	8
Sandstone, light tan and yellow; about 0.1 mm sand grains, massive bedding; poorly cemented and friable; locally contains small pebbles	16
Sandstone and shale in about equal proportion; shale, gray, in beds 1 to 8 feet thick; sandstone, light yellow, in beds 1 to 15 feet thick	87
Shale, partly sandy, mostly dark, some light colored bands	62
Sandstone, light yellow, mostly shaley	160
Sandstone, light yellow and shaley; some resistant ledges; includes 10 feet of earthy, brown, slightly carbonaceous shale near top	50
Sandstone and shaley sandstone; top 20 feet are hard and form cliff	95
Shale, gray clay, with two thin sandstone beds	45
Sandstone, cross-bedded; some beds hard, others soft and friable; includes minor amount of shale	122
Shale, gray	8
Sandstone, fine-grained; hard; forms ledge	5
Shale, gray and brown, very shaley coal and coaley streaks 4 feet above base	23
Sandstone, white, fine-grained, cross-bedded	52
Shale, some earthy sandstone	18
Sandstone, massive, poorly cemented, white, fine-grained	36
Total Masuk Member	787

Base: Emery Sandstone Member

In present mapping, some of the lower sandstone members are included with the Emery. The contact was placed where the unit becomes dominantly shaley or slope forming in habit. The Masuk is exposed only in the Wagon Box Mesa NE quadrangle below Tarantula Mesa. The final stratigraphic unit is the Mesaverde Sandstone. The 400 exposed feet are almost exclusively sandstone. Near the top are a few thin shaley beds. The sandstone is tan-gray to brown in color, fine- to medium-grained and cliff forming.

STRUCTURE

The dominant structural feature of each quadrangle is the Waterpocket Fold. Dips up to 40 degrees or more are not uncommon in beds up to and including the Dakota Sandstone. Farther east the dips diminish and inclinations greater than 20 degrees in the Ferron and greater than 10 degrees in the Emery are uncommon. The average inclination of the Ferron along the Waterpocket Fold is about 12 degrees and that for the Emery about 6 degrees. An exception to this rule is near Divide Canyon where the beds are considerably steeper. The strata are nearly horizontal east of the fold in both quadrangles.

The only fault discovered of consequence is near the east margin of the Cave Point quadrangle which cuts the Ferron coal. The west side is downthrown and the displacement is at least 30 feet.

PROPERTY CONTROL

The lands of the Cave Point and Wagon Box Mesa NE quadrangles are owned by the National Park Service (53.2 percent), the Bureau of Land Management (43.3 percent) and the state of Utah (3.5 percent).

The National Park Service land follows the Waterpocket Fold in a wide (about 4 miles) band. About two-thirds of the BLM and state lands lie east of Waterpocket Fold on coal lands.

Thirty-six percent of the Cave Point quadrangle may be considered coal land and 39 percent of the Wagon Box Mesa NE quadrangle may be considered coal land. About 14 percent of the Cave Point coal land are on National Park Service property and about 40 percent of the Wagon Box Mesa NE coal land are on National Park land. The latter quadrangle has almost all of its coal outcrops on the Capitol Reef National Park property. The exact locations of boundaries are shown on the field Land Ownership Map (figure 12).

All but about 400 acres of the available coal land outside of the National Park area is held in prospecting permits by the Cayman Corp. on the Wagon Box Mesa NE quadrangle. None of the coal lands of the Cave Point quadrangle is held either as leases or permits. The land held for coal as of January 1, 1971, is shown on the Leases and Permits Map (figure 13).

COAL

Surface Information

Most of the available coal sections in Wagon Box Mesa NE are for the Emery coal zone (figure 41), with one measurement from the Ferron and two from the Dakota. The Dakota, which was only spot-checked for coal, shows a local thickening in sec. 17, T. 33 S., R. 8 E. Several bulldozer scars across the coal reveal a split section of more than 8 feet of coal. About one-quarter mile to the north, the total coal amounts to less than 4 feet as the former seams are replaced by shale. Other local thickening of the coal may be expected along the Dakota Waterpocket Fold.

The Ferron is represented by one section with less than a foot of coal. It was checked at one mile intervals along the outcrop in the Wagon Box Mesa NE quadrangle, but the upper beds, where the coal is expected to be exposed, are usually poorly exposed or have less than 1 foot of coal in them.

The Emery Sandstone has the best showing of coal, but only the Divide Canyon area has been explored. Coal has been measured ranging in thickness from 1.5 to 9.0 feet. The smaller measurement is believed a partial measurement of the coal zone. The thickest seam is about 4 feet thick, but the splitting intervals between beds are often less than 1 foot. In Bitter Creek Canyon 2.5 to 3.5 feet of coal have been measured.

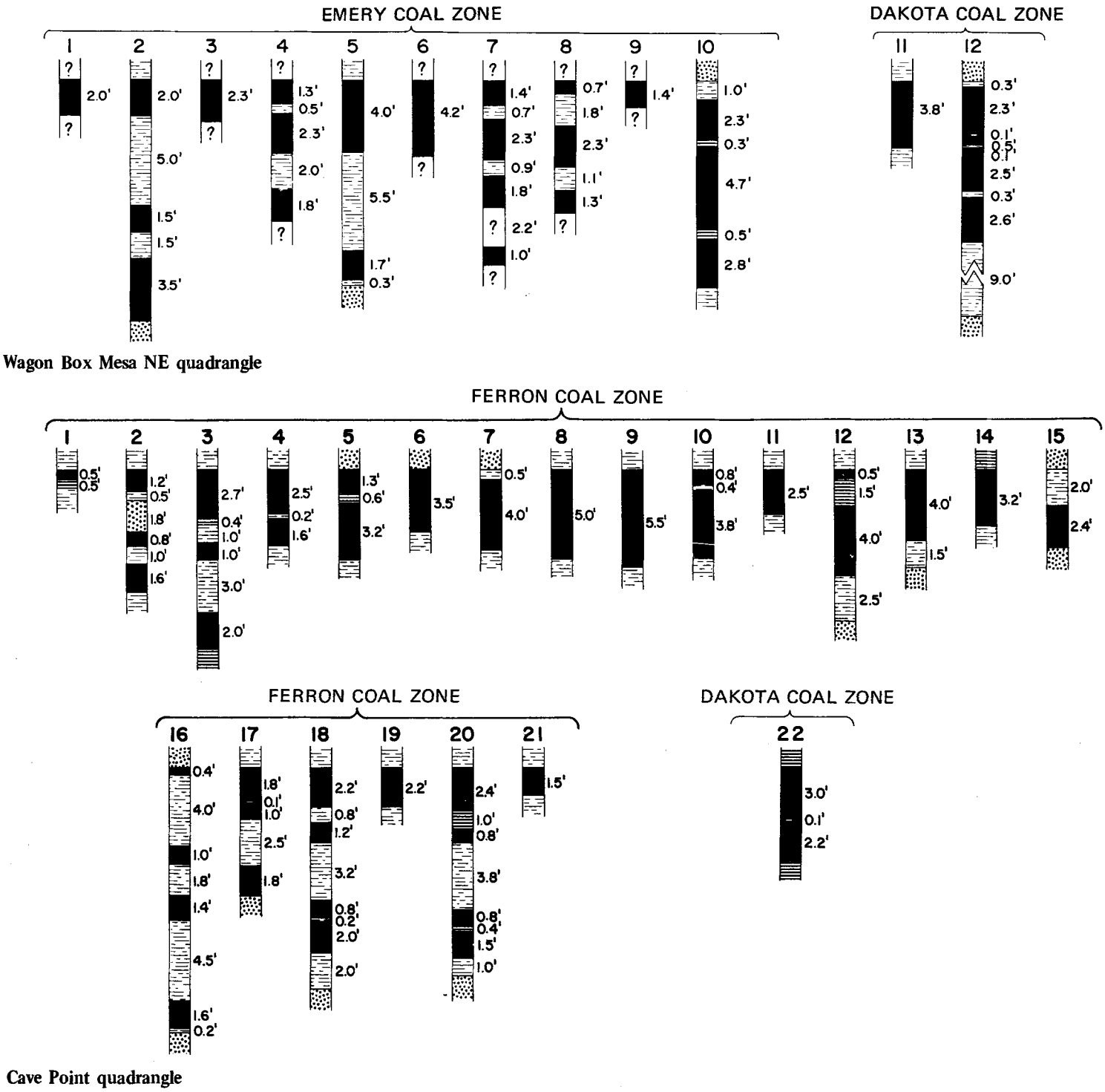


Figure 41. Coal sections of Wagon Box Mesa NE-Cave Point quadrangles (vertical scale: 1 inch = 8 feet).

The Dakota contains 1.5 to 3.0 feet of coal near The Post and is the only measurement of the unit available on the Cave Point quadrangle. The Ferron has been checked adequately from the vicinity of Sheer Point at the south end of Swap Mesa eastward. At the mouth of Swap Canyon insignificant coal appears to be in the Ferron. In sec. 19., T. 34 S., R. 9 E. the coal develops and exceeds 4 feet thick. It remains between 4 and 5 feet into sections 29 and 28. In section 22 eastward the coal persists with the thickest seam in the zone averaging 2.5 feet and the total coal ranging between 3 and 6 feet. The overburden behind the coal does not increase rapidly until the cliffs are reached; part of the coal could be removed by stripping.

Undoubtedly coal beds in the Emery Sandstone extend onto Swap Mesa. These beds may be of appreciable thickness as determined by a check into Swap Canyon. Heavy outcrop burning and a remnant with 9 feet of clean coal were discovered less than one-half mile north of Cave Point quadrangle.

Subsurface Information

No drill-hole information is available for either quadrangle. Only under Tarantula Mesa would the Emery coal be under 1,000 feet of overburden. The Ferron would be buried under 2,500 to 3,000 feet at the same locality. The Ferron will lie at a depth of about 1,500 feet under the mesas supported by the Emery Sandstone.

Quality of Coal

No analyses of coal are available for either quadrangle.

Mines and Development

The only development work for coal has been in the Dakota coal zone along the Waterpocket Fold in sec. 17, T. 33 S., R. 8 E., where two to three bulldozer excavations have bared the coal seam.

Reserves

To estimate reserves is hazardous when the data are incomplete and where the coal is lenticular. Apparently modest reserves do exist, however, and generalizations can be made (table 14).

Table 14. Coal reserves of the Wagon Box Mesa NE-Cave Point quadrangles.

Location	Acres	Average thickness (feet)	Tonnage	Class Reserve	Coal Zone
T.33S. R.8E. parts of sec. 29, 32	1,000	4.0	6,970,000	II	Emery
remainder of Twp.	2,440	4.0	17,000,000	IV	Emery
T.34S. R.8E. part of sec. 17	100	4.0	700,000	II	Dakota
parts of sec. 5 and 8	600	4.5	4,700,000	II	Emery
remainder of Twp.	5,855	5.0	50,100,000	IV	Emery
T.35S. R.9E. parts of secs. 19, 20, 21, 28, 29	1,920	4.5	15,050,000	II	Ferron
parts of sec. 22 to 24	1,600	2.5	6,970,000	II	Ferron
13 to 15	2.300	5,0	20,030,000	IV	Emery
T.35S. R.8E	2,100	5.0	18,290,000	IV	Emery
Total reserve all classes:			139,810,000		
Class I and II reserve:			34,390,000		
Class III reserves:					
Class IV reserve:			105,420,000		
Coal reserve in beds 4 feet or more thick excluding Class IV reserve:			27,420,000		

The writer feels that some of the Class IV reserve should be Class III (inferred) since the Emery coal, even though highly lenticular, is usually everywhere present. The average of 5 feet for the entire Emery coal zone is used and is the weakest point in the calculation. Additional outcrop exploration in the vicinity of Swap Mesa will undoubtedly carry part of the Class IV reserve into the Class II bracket.

PRINCIPAL WORK

The geology presented on the Cave Point and Wagon Box Mesa NE quadrangles is primarily the work of Davidson and others (1967) with modifications based on Hunt and others (1953) and field investigations made specifically for this report. The coal measurements presented by Hunt and others (1953, pl. 22) were augmented by additional data collected for this report.

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SEGO COAL FIELD

by

H. H. Doelling[1]

INTRODUCTION

Location and Extent

The Sego coal field lies in east central Utah along the Book Cliffs between the Green River and the Colorado state line (Preface, figure 1a). The field is about 65 miles long and the effective width should not exceed 6 miles producing an area of 390 square miles.

The Sego coal field previously was associated with the Book Cliffs field which extends from Grand Junction, Colorado, to beyond the Price River. A suggested division of the Utah portion is along the Green River. West of the river the coal occurs in the Blackhawk Formation and, east of the river, it occurs in the Neslen Member of the Price River Formation. The area west of the river retains the name Book Cliffs field and the area east of the river is herein called the Sego coal field.

Topography and Drainage (figure 1)

The coal field is situated at the south rim of the Uinta Basin and the rim is marked by the Book Cliffs. The area below the cliffs stands at an elevation of approximately 5,000 feet and the drainage divide at the top of the rim ranges between 8,000 and 9,000 feet. The distance between the base of the cliff and the divide is 6 to 16 miles. In this belt numerous canyons indent the cliffs; a major canyon can be expected every 4 to 10 miles. North of the divide all drainages flow to the north and basinward and cut gradually into the dip slope. The principal creeks flowing south with canyons cut into the Book Cliffs include San Arroyo Wash, West Bitter Creek, Westwater Creek, Cottonwood Creek, Nash Wash, Thompson-Sego Wash, Crescent Wash and Saleratus (Floy) Wash. The Green River cuts through the Book Cliffs as well, but it is a through-going stream originating in Wyoming and crossing the Uinta Mountains and Basin before reaching the area.

The cliff front is built of alternating hard and soft rock; if the hard rock is thick, a steep cliff occurs. Elsewhere the cliff rises in steps. The coal seams are found one-third of the cliff height from the base.

Population, Industries and Transportation

Two major transportation routes cross the shale desert below the Book Cliffs. The first is the Denver and Rio Grande Western Railroad's main line, Denver to Salt Lake. The second is Interstate Highway 70 and U. S. 50-6 joining Denver with Salt Lake and Los Angeles (figure 2).

Four settlements lie below the cliffs along the railroad between the Green River and the Colorado line: Crescent Junction, Thompson, Cisco and Westwater. The total population, including the few isolated ranchers, is less than 100. The nearest settlements of size are Green River and Moab. Green River is on I-70 and the D&RGW main line on the west side of the Green River. The town is the center of a small missile base, provides tourist and trade services and is a farm community specializing in melons. The permanent residents number 1,033 (1970). Moab is located 30 miles south of Crescent Junction and connected to it by U. S. Highway 163 and a spur line of the D&RGW Railroad. The highway continues southward and serves the Four Corners area of Utah-Colorado-New Mexico-Arizona. The rail line terminates at a potash mine not far from the town. The chief industries of the town are mining and milling of potash, uranium, vanadium, tourism, trade and agriculture. Moab is the county seat and governmental services are available. It has a population of 4,793 (1970).

Climate

Mid-latitude steppe and desert climates prevail in the Sego coal field area. The amount of rain or snow fall is a function of altitude (figure 3). The area below the cliffs is a desert, receiving an average of 6 to 8 inches annually. The drainage divide or crest of the cliffs receives 16 to 20 inches. The reliability of precipitation is poor; some years less than half the average falls and other years, half again as much as expected falls. Two seasons normally produce the most moisture. The first comes in late winter to early spring and is the result of the eastward passage of cold fronts and associated cyclones. The second arrives in late summer and is the result of convection. These summer thunderstorms are often violent and of short duration, producing damaging floods. The average potential evapotranspiration rate is 30 to 33 inches below the cliffs and less than 18 inches at the crest.

At Green River the January minimum daily temperature is about 11° F and in July the maximum daily temperature is expected to be 97° F. Summer nights cool the area 35 to 40° F and

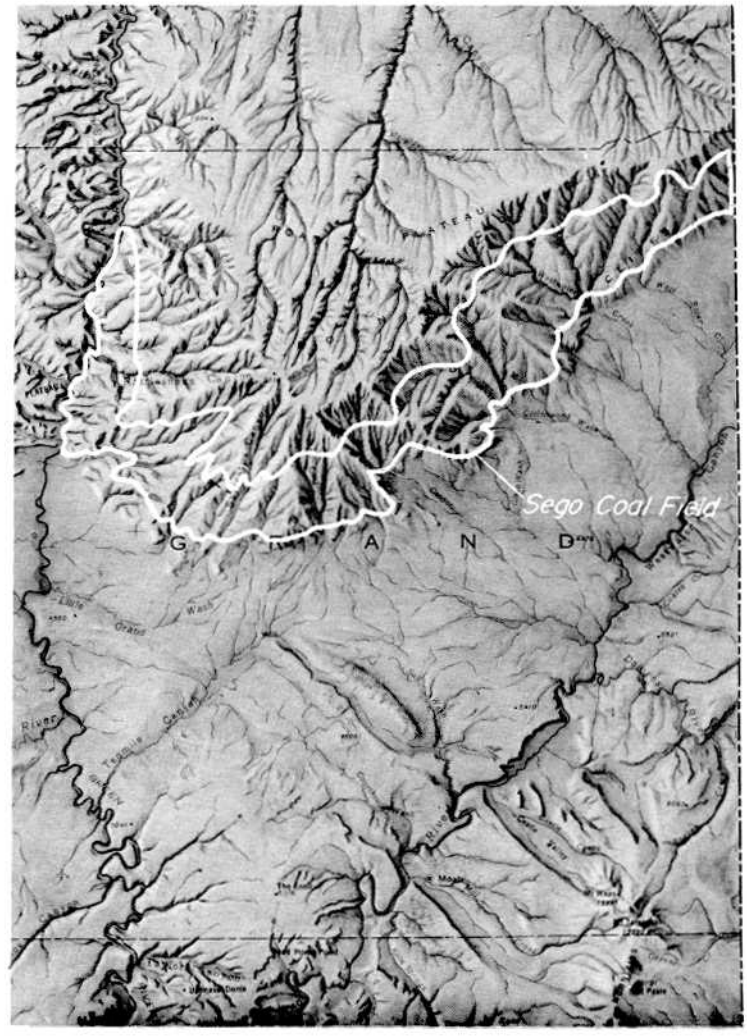
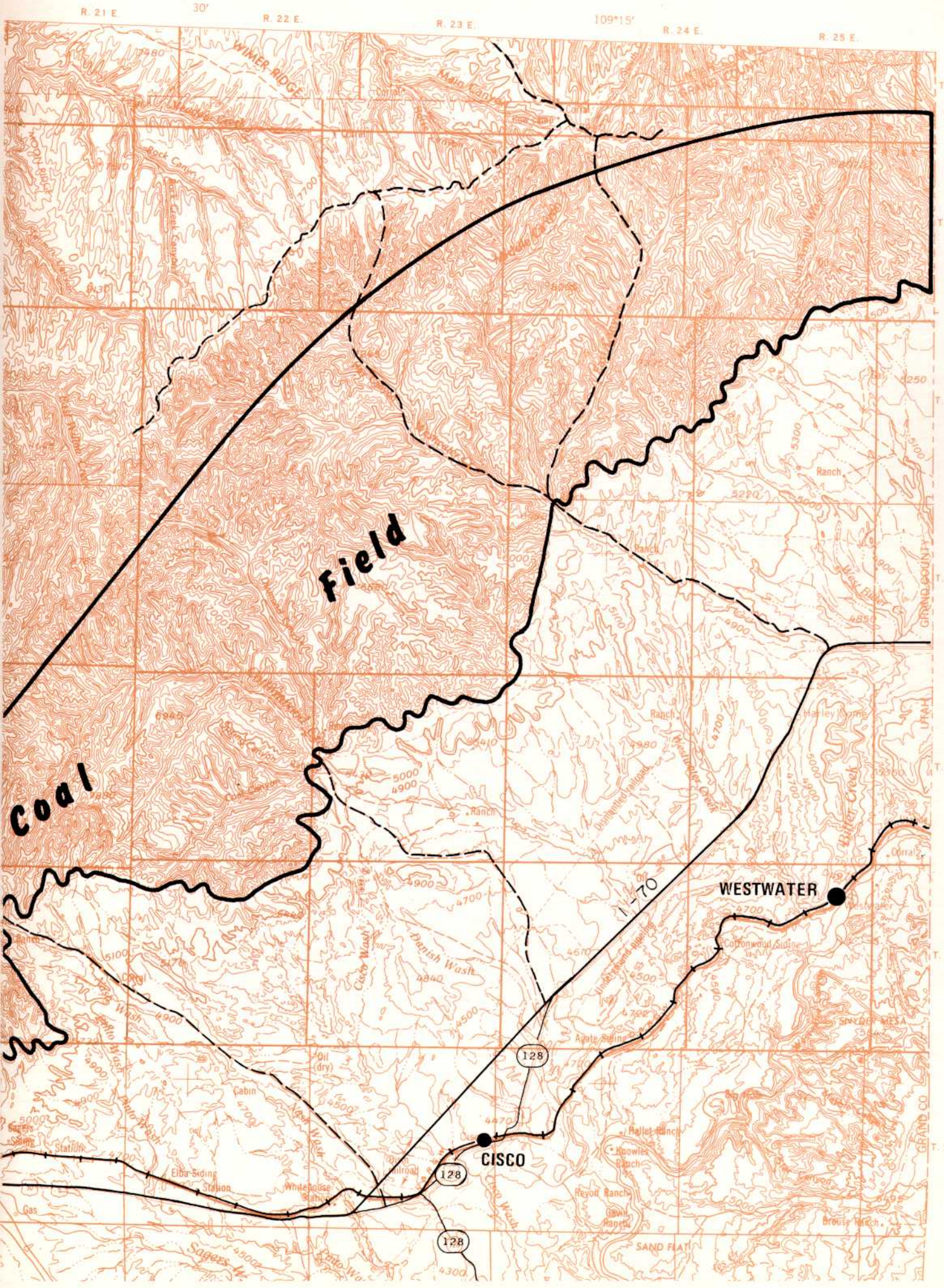


Figure 1. Relief map of east central Utah showing the approximate location of the Sego coal field.

[1]Economic geologist, Utah Geological and Mineralogical Survey.

Figure 2. Topography and roads map, Sego coal field.


R. 21 E.
30'
R. 22 E.
R. 23 E.
109°15'
R. 24 E.
R. 25 E.
T. 15 S.
T. 16 S.
T. 17 S.
T. 18 S.
T. 19 S.
T. 20 S.
T. 21 S.
WIMER RIDGE
Coal
Field
WESTWATER
CISCO
I-70
128
Ranch
Cottonwood Siding
Agate Siding
Danish Wash
Cisco Wash
Nash Wash
Elba Siding
Station
Whitehouse Station
Cabin
Oil (dry)
Hallet Ranch
Knowles Ranch
Revoil Ranch
Gavin Ranch
Brouse Ranch
SAND FLAT
SNYDER MESA
Harley Dome
Westwater Creek
Bitter Creek
West Bitter Cr.
Disintegrated railroad
Underground pipeline
Sagers Siding
Gas
GRAND COUNTY
UTAH
GRAND CO

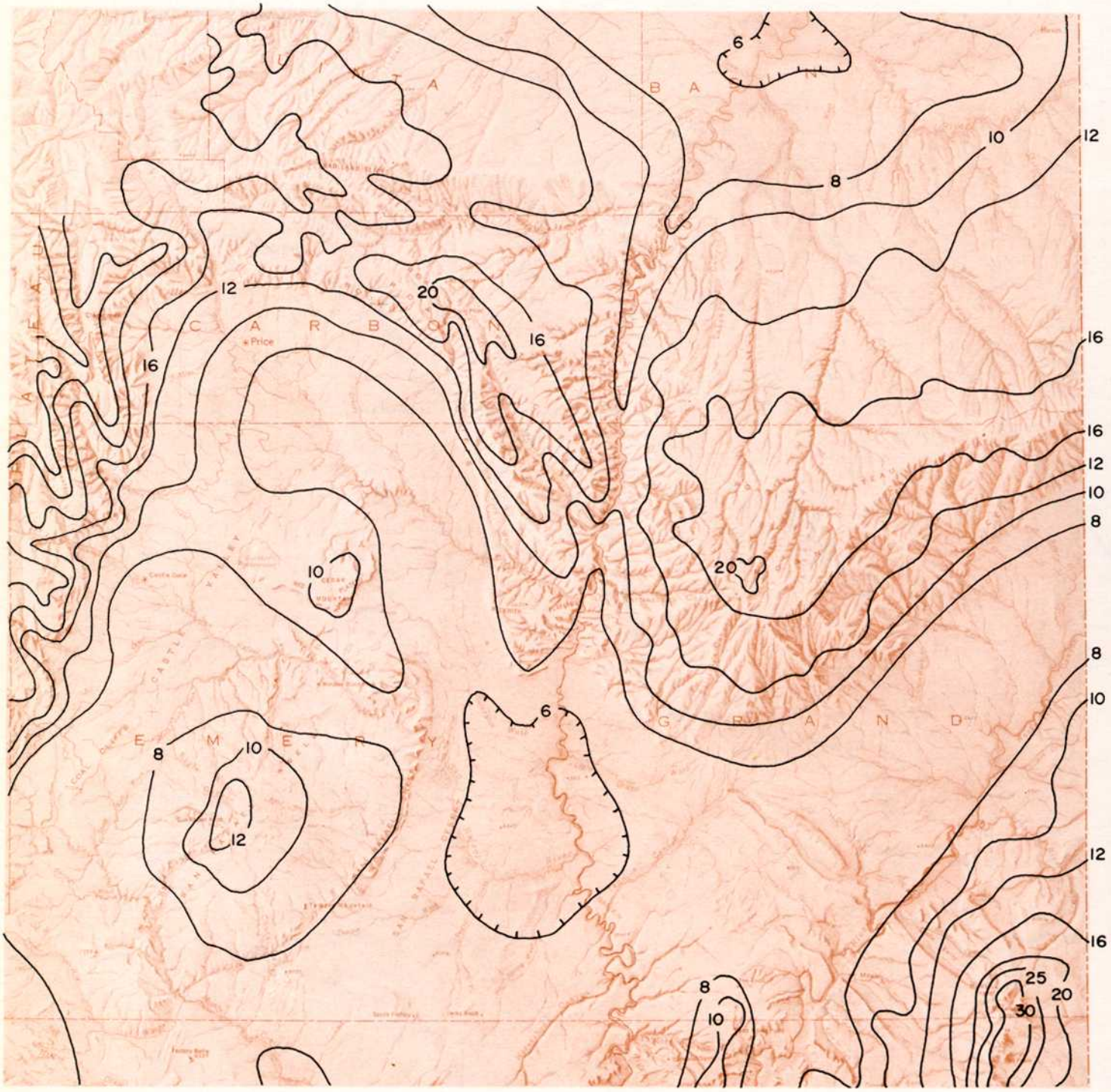


Figure 3. Rainfall map of the Sego coal field (isohyetals in inches).

winter days raise the temperature 25 to 30° F. No measurements were made at the higher elevations, but summer highs are expected to be 10 to 15° F cooler on the mountain tops and winter lows about 5 to 10° F cooler. The diurnal range is expected to be about the same.

HISTORICAL OUTLINE

Coal was discovered in the Wasatch Plateau and the Book Cliffs in 1874 and prospecting activity probably quickly spread along the outcrops. The coal from the Green River eastward received less attention because of the thinner coal seams discovered there. Nevertheless in 1900 the first mine was opened by Mr. Ballard in Sego Canyon in the middle or Ballard bed. The coal was initially hauled to Thompson and the Denver & Rio Grande Western Railroad by wagon, a distance of 5 to 6 miles. Activity was slow and production was small. In March 1912, the property came under the ownership of the American Fuel Co. of Utah. The company built a town, first known as Neslen, for their employees which included a company store, post office, office building, clubhouse, hotel and barns for mine stock. A connecting rail spur was constructed from Thompson. According to Clark (1914, p. 475):

> This company gave the name of "Bear Coal" to the coal which they contemplated mining in this region, and named the beds lower, middle and upper. . .They first started development on the middle bed on both the east and west sides of the Right Fork of Thompson Creek (Sego Canyon) in the NE ¼, SE ¼, NW ¼ sec. 27. The company shipped their first coal to the market in October 1912, but did not reach their average daily output of 150 tons until the beginning of January 1913. From the time the mines were opened in October 1912, to November 1913, they mined approximately 47,500 tons of coal.

The middle bed contains a great deal of impurity in the form of shale and bone. Clark describes the company's difficulties entwined with the cleaning process. After the coal was shot from the face, the coal was cleaned loose from the bone and shale by pick. The larger pieces of waste were then hand picked from the pile and washed by a jig to remove the smaller particles. In 1913 the company attempted to develop the lower bed (Palisade) a little west of the old Ballard mine. The coal was impure and the endeavor was abandoned in 1915. The upper bed was explored in 1914 and a mine started on the west side of Sego Canyon. By 1915 it was the only mine working. The upper bed became the most important seam.

During the years 1900 to 1915 other mines were opened in different parts of the field, but none gained the importance of the mines of Sego Canyon; even their combined production was small. These smaller mines supplied local markets, mainly ranchers and townspeople. Sego coal was used by the railroad, locally in Moab and shipped to the Midwest and to the Pacific Northwest. From 1914 to 1930 production averaged 100,000 tons a year at Sego. 1930 to 1944 coal production dropped to 50,000 tons in response to the economic depression. 1944 to 1953 saw a steady decline and in 1954 the mine was shut down. Diesilization of the D&RGW Railroad was probably the leading cause of the mine abandonment. All mines are now shut down. Total production from the field is an estimated 2,650,000 short tons of coal.

GEOLOGIC SETTING (figure 4)

Stratigraphy

The important coal beds of the Sego coal field are contained in the Neslen Member of the Price River Formation of Upper Cretaceous age. This unit and the other formations that appear on the associated quadrangle maps are discussed here. These units extend through the entire Upper Cretaceous and into the early Tertiary (figure 5).

Dakota Formation

The Dakota appears on none of the quadrangle maps, but is discussed because the unit is coal bearing in several areas of Utah. It is the lowest Upper Cretaceous unit and is exposed south of Interstate Highway 70. The formation is a sandstone unit, often conglomeratic with minor gray shales. It forms a cuesta and is a thin unit thickening easterly from 2 to 126 feet. The Dakota south of the Book Cliffs and east of the Green River has not been investigated thoroughly for the presence of coal seams. Fisher (1936, p. 11) did not find any, and no positive reports have come from other investigators. The nearest coal is reported from the La Sal Mountains about 20 miles to the south.

Mancos Shale

In this report all beds between the Dakota Formation and Castlegate Sandstone are assigned to the Mancos Shale. Its outcrops form a wide band below the Book Cliffs that are sparsely vegetated and light gray appearing. The Mancos is dominantly a gray marine shale, nonresistant, limy, without a pronounced fissility. Interstate Highway 70 and the D&RGW Railroad tracks have been built on it. In addition to the shale occasional sandstone beds occur within it. The Ferron Sandstone Member is present in its lower part where the Ferron forms a slight cuesta. In central Utah the Ferron is coal bearing, but here it is barren. Fisher (1936, p. 14) traced vestiges of the Blackhawk Formation as far east as Nash Canyon. The Blackhawk appears as a massive cliff of sandstone difficult to separate from the overlying Castlegate. The Blackhawk forms the basis of the Book Cliffs coal field to the west of the Green River and contains all of the important beds of coal of that field. Some thin beds of coal occasionally may be observed on the cliffs between Green River and Thompson. The entire Mancos is thick, estimated to be 3,500 to 4,500 feet. Fisher (1936, p. 29) measured the Blackhawk 3 miles north of Thompson in T. 21 S., R. 20 E.

Blackhawk Formation	Feet
Shale and very thin-bedded sandstone, intercalated	2 1/2
Bone and coal	1 1/3
Shale	1 2/3
Sandstone and shale, sandstone is light buff, cross-bedded; shale, which is in small part carbonaceous, constitutes about one-third of the unit	20
Sandstone, fine-grained, light gray, weathering buff, carbonaceous	1/2
Sandstone, buff to reddish brown, medium-grained, massive, cross-bedded, cliff maker	95
Total Blackhawk Formation	121

Gradational contact

Mancos Shale:

Shale, bluish gray, limy, gypsiferous; thin beds of fine-grained sandstone in upper part.

Castlegate Sandstone

The Castlegate Sandstone forms the first cliff above the Mancos along the Book Cliffs. The softer units immediately above the unit are usually stripped back so that a bench is formed ½ to 2 miles wide. The Castlegate Sandstone is the lowest member of the Price River Formation. The Price River coupled with the Blackhawk remnant makes up the Mesaverde Group in this sector of the Book Cliffs.

The Castlegate is mainly a massive cliff-forming sandstone, light gray or yellow gray in color that weathers to shades of brown. Some beds of sandstone are very fine-grained, others are coarse. Locally shale and thin coal beds appear. Fisher (1936, p. 30) describes the unit in a measured section (NW.32-20S-21E).

Castlegate Sandstone Member:	Feet
Sandstone, thin-bedded, cross-bedded, medium gray, except basal stratum 8 inches thick, which is hard, blocky and brown; locally carries limy lenses full of *Corbula subtrigonalis*	6
Sandstone, shaley, locally grading laterally into shale, in part carbonaceous, with an inch or so of dirty coal	16
Sandstone, massive, cross-bedded, buff	40
Total Castlegate Sandstone Member	62

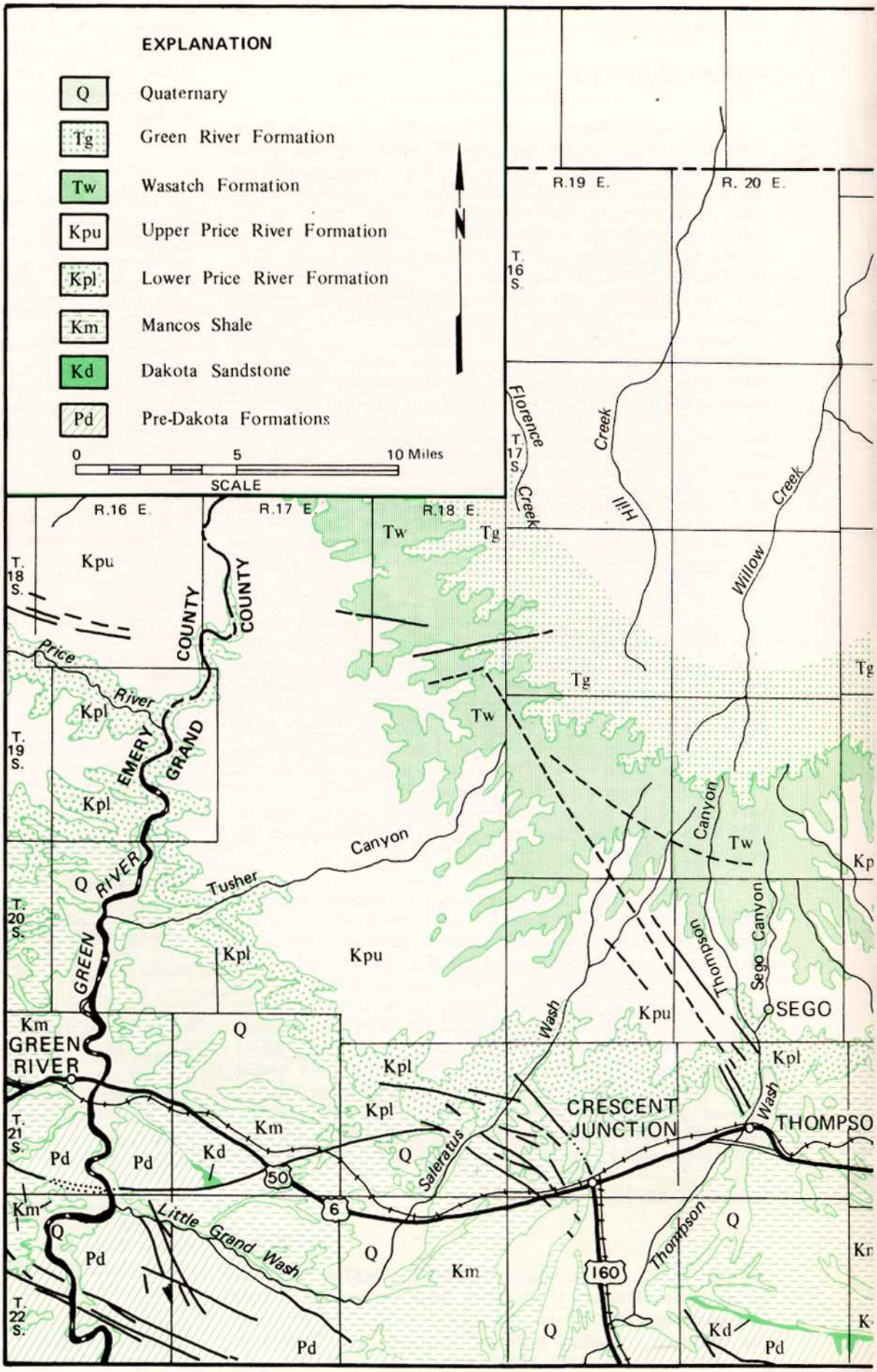
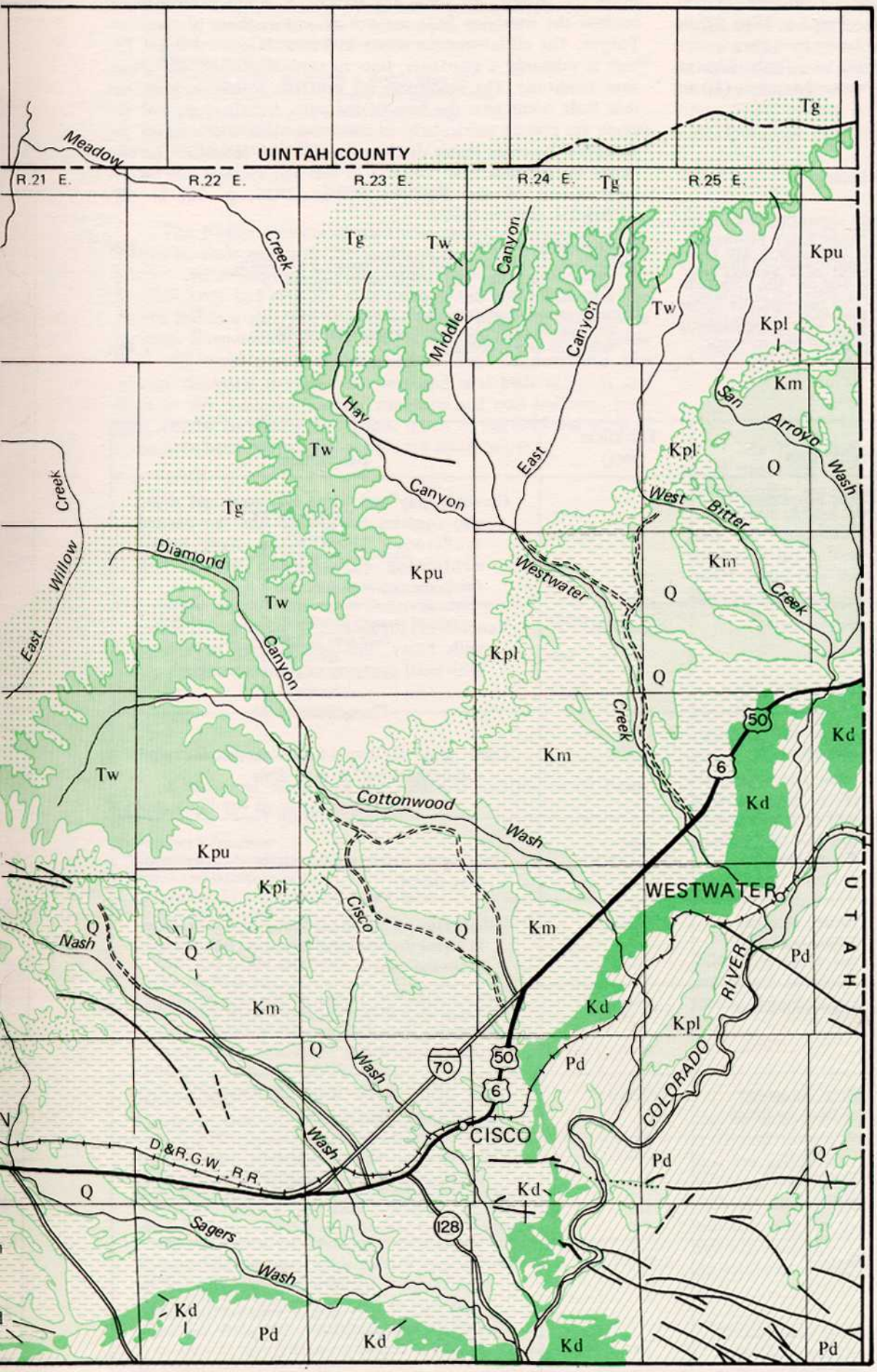


Figure 4. Generalized geology map, Sego coal field.


UINTAH COUNTY
R.21 E.
R.22 E.
R.23 E.
R.24 E.
R.25 E.
Meadow Creek
Middle Canyon
Canyon
Hay Canyon
East Canyon
San Arroyo Wash
West Bitter Creek
Westwater Creek
Diamond Canyon
East Willow Creek
Cottonwood Wash
Nash Wash
Cisco Wash
Sagers Wash
Tg
Tw
Kpu
Kpl
Km
Q
Kd
Pd
WESTWATER
CISCO
COLORADO RIVER
UTAH
D&R.G.W. R.R.
50
6
70
128

Gross (1961, p. 75) notes that thin lagoonal deposits are present near the top of the unit west of Thompson Canyon. Carbonaceous streaks and coal particles in the sandstones are abundant with an increase in carbonaceous shale and siltstone. In contradiction to Gross, the present writer discovered a 2- to 3-inch seam of coal in Sagers Canyon, but the bed may have been a part of the Blackhawk beds. The Castlegate thins to a featheredge at the Colorado state line and is thickest in western sections (10 to 190 feet).

Buck Tongue of Mancos Shale

The Buck Tongue, a gray marine shale separating the Castlegate and Sego Sandstone members of the Price River Formation, looks exactly like the Mancos Shale. It is much thinner than the Mancos and becomes a part of that body east of the Colorado state line. It thickens easterly from 100 to 350 feet and the upper part grades into the Sego Sandstone. It is a soft slope-forming unit, but the upper part stands in a cliff supported by the Sego.

Sego Sandstone

The Sego Sandstone Member of the Price River Formation forms the second cliff above the Mancos. It is not as pronounced because the overlying beds are not as soft as those of the Buck Tongue. The cliffs continue above it, but with reduced slope. The unit is primarily a quartzose, fine- to medium-grained and calcareous sandstone. The sandstones are generally massive-bedded, but thin beds occur near the base of the unit. A little shale and siltstone are present particularly in eastern sections and some of the sandstone becomes shaley dividing the cliff into subcliffs. The unit ranges in thickness from 140 to 215 feet and averages 200 feet. A measurement of the Sego by Fisher (1936, p. 30) in NW. 32-20S-21E is given below:

Sego Sandstone Member	Feet
Sandstone, very massive cliff maker; mostly buff brown, but near top is buff gray; ripple marks (current) with amplitude of slightly over 1 inch	43
Sandstone and shale slope, shale, limy, nodular in part; lithology like lower unit except that all the sandstone is thin-bedded	49½

System	Series	Stratigraphic Unit		Thickness (feet)	Description
TERTIARY	Eocene	Green River Formation		–	Greenish gray and white claystone and shale, also contains fine-grained and thin-bedded sandstone. Shale often dark brown containing carbonaceous matter. Full thickness not exposed.
		Wasatch Formation		250-3,000	Varicolored, predominantly purplish red shales with heavy cliff-forming gray sandstones with basal conglomerate, thins eastward.
	Paleocene	—Unconformity ?—			
		Tuscher Formation		130-600	Light gray to cream-white sandstones with subordinate buff to gray shale.
		—Unconformity ?—			
CRETACEOUS	Maestrichthian	Price River Formation	Farrer Member	410-1,095	Yellow-gray to brown sandstones with greenish gray shales.
	Campanian		Neslen Member *Major coal seams*	250-410	Yellow gray to brown sandstone and gray shales in equal proportions, contains carbonaceous shale and coal.
			Sego Sandstone	140-215	Mostly yellow-gray sandstone, massive and cliff forming, in a few places thin-bedded, makes one to four cliffs.
			Buck Tongue of Mancos Shale	100-350	Gray marine shale with subordinate littoral sandstone, thins westward.
			Castlegate Sandstone *Minor coal*	10-190	Yellow-gray to brown sandstone, very fine to very coarse-grained, massive-to thin-bedded cliff former, occasional thin shale beds and coal.
		Mancos Shale		3,500-4,500	Mostly gray marine shale, contains remnants of Blackhawk Formation in upper 200 feet in west part of field, consisting of yellow gray cliff-forming sandstone, may carry thin beds of coal in this upper part.
	Santonian				
	Coniacian				
	Turonian				
	Cenomanian	Dakota Sandstone		2-126	Sandstone and conglomerate with interbedded gray shales, often forms hogback.

Figure 5. Generalized section of rock formations, Sego coal field (after Fisher, 1936).

Sandstone, massive, buff to gray; cliff maker; semi-rounded weathering surfaces in upper part	24
Sandstone, shaley, cross-bedded, thin-bedded, buff; forms a slope with a few minor ledges of more massive sandstone; probably a little shale is present	54
Sandstone, massive, cross-bedded, buff, capping first cliff above the Castlegate Sandstone; semirounded weathering surfaces	10
Sandstone and shale; sandstone is shaley thin- to medium-bedded, buff, with some interbedded shale in upper part, lower part is sandstone, locally massive, elsewhere medium-bedded	32½
Total Sego Sandstone Member	213

Neslen Member

The Neslen consists of quartzose sandstone, subgraywackes, siltstones, shale and coal. The grains of sand are fine- to medium-grained and subangular. Bedding ranges from thin to massive. The outcrop habit is a step-like alternation of soft and hard units. The Neslen builds a cliff, not as steep as that of the Sego, but difficult to scale. Examination of coal beds is difficult except where softer units ride above a hard sandstone and a bench has developed. The average thickness is about 350 feet and coal beds occur at any level in this sequence. Certain sandstone and coal horizons, however, can be correlated throughout much of the field and some of these have been named. These beds are listed below:

	Farrer Member	Feet
Neslen Member	Interval	100-150
	Carbonera coal zone	
	Interval	50±
	Chesterfield coal zone	
	Thompson Canyon Sandstone-Sulphur Canyon Sandstone	10-50
	Ballard coal zone	
	Interval	100±
	Palisade coal zone	
	Interval	30-50
	Sego Sandstone	

A measured section of the Neslen is contributed by Fisher (1936, p. 27-28) from SE.32-20S-20E.

Price River Formation	Feet
Farrer noncoal-bearing member	
Neslen coal-bearing member	
Sandstone, light gray to buff, minor ledge	2
Shale, medium gray	17
Sandstone, with shaley zone in upper part, sandstone carries thin slabs (pebbles) of shale; lower 20 feet form a light gray ledge	45
Shale, medium gray	17
Sandstone, light gray to buff, cross-bedded, friable	14
Shale, with minor sandstone, light gray to buff, shale medium gray above, partly dark gray below; slope-forming unit, largely concealed	90¾
Sandstone, light gray to buff	2
Coal, bone and shale (Chesterfield coal zone)	6¼
Shale, brown	8
Sandstone, buff yellow; massive ledge with rounded surface (Thompson Canyon sandstone bed)	18
Coal and shale (Ballard coal zone)	5
Shale, buff to medium gray	7
Sandstone, buff, massive, cross-bedded, blocky ledge; lenticular, giving way laterally to shale	32
Shale, buff to medium gray, with four thin coal seams	29
Sandstone, buff to gray, forming a rather blocky minor ledge	19
Shale, sandy, medium to light gray	1
Coal (Palisade zone)	1
Sandstone and shale, making a slope; lower third is thin-bedded light gray sandstone; upper part is medium to light gray sandy shale	45
Total Neslen coal-bearing member	359

A series of east to west measured sections at convenient locations is given in figure 6. The Neslen is overlain by the Farrer Member of the Price River Formation. The contact is irregular and gradational, transgressing upward to the east.

Farrer Member

The Farrer Member of the Price River Formation is similar to the Neslen lithologically—primarily sandstone beds interbedded with shale and siltstone. The overall appearance is somewhat more brown than the Neslen and the resistant sandstones appear to be thicker and more closely spaced. The shales are dark gray, some with a greenish tint. The shale is usually silty and coal beds are rare. Those present are very thin and lenticular. The unit averages 690 feet thick, but ranges from 410 to 1,095 feet.

Tuscher Formation

The Tuscher beds conformably overlie the Farrer Member and are a sequence of sandstones. They are often conglomeratic and coarser than those of the unit below. The sandstone beds are separated by thin shaley beds. The Tuscher ranges in thickness from 130 to 600 feet and is sometimes impossible to differentiate from the Farrer beds below. The age of the Tuscher is very late Cretaceous and early Tertiary.

Wasatch Formation

The Wasatch Formation lies near the top of the Book Cliffs with one other unit above it. The base of the unit consists of cliff-forming sandstones and conglomerates and gray freshwater limestones. Above the basal cliff-forming sequence for the most part are varicolored shales with occasional limestone beds and sandstone beds. Near the Green River the Wasatch Formation is about 3,000 feet thick and thins eastward to 250 feet just east of the Colorado-Utah line.

Green River Formation

The thick sequence of rocks above the Wasatch is assigned to the Green River Formation. The unit is divisible into several members, the discussion of which is beyond the scope of this report. The unit is generally composed of greenish gray and white claystones and shale with sandstones, marlstones, algal reefs and oolites within it. The Green River is commonly rich in organic material such as kerogen shales and tar sands. The Green River is about 2,400 feet thick at the Utah-Colorado line.

Surficial Deposits

Several types of unconsolidated rocks occur in the Sego coal field. The shale flat below the cliffs often is decked with low mesas and benches capped by gravel. Landslides have developed around the edges of the steeper cliffs.

Structure (figure 7)

The Book Cliffs lie at the south edge of a tremendous stratigraphic basin known as the Uinta Basin. All strata generally dip northward toward the center of the basin. For the most part the dips are gentle but in a few cases, related to smaller structures impinging the basin from the south, they become moderate. The cliffs are scalloped deeply in places where anticlinal noses extend into the edge of the basin. The axes of these folds trend northwesterly in sympathy with the Uncompahgre Highland centered to the southeast. These folds from west to east include:

Court House syncline	Harley dome or anticline
Salt Valley anticline and graben	Bryson Canyon syncline
Crescent Wash syncline	Westwater anticline
Thompson anticline	Bar X syncline
Sagers Wash syncline	Bar X anticline
Cisco anticline and dome	Unnamed syncline
Cottonwood Creek anticline	San Arroyo anticline
Danish Flat syncline	

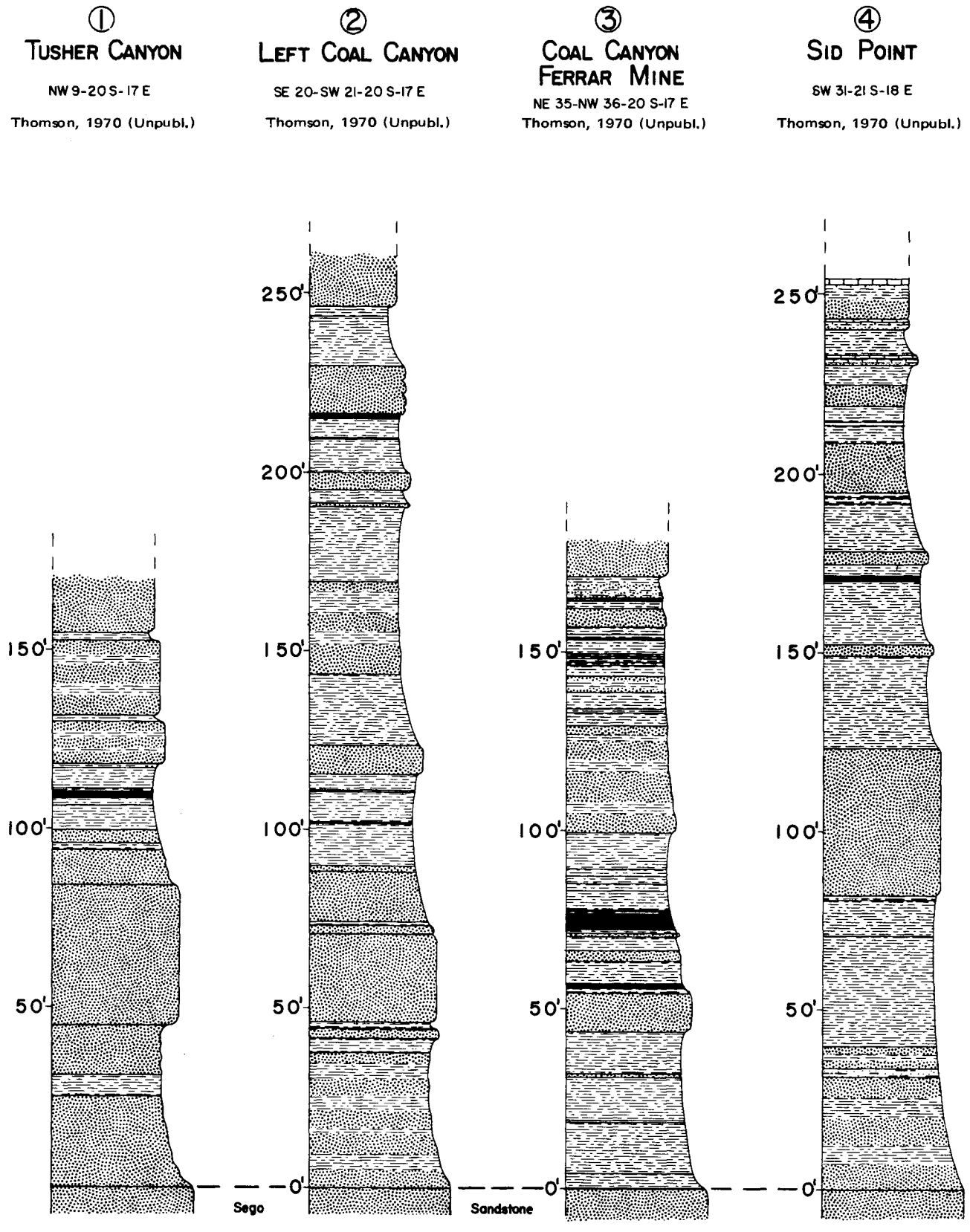
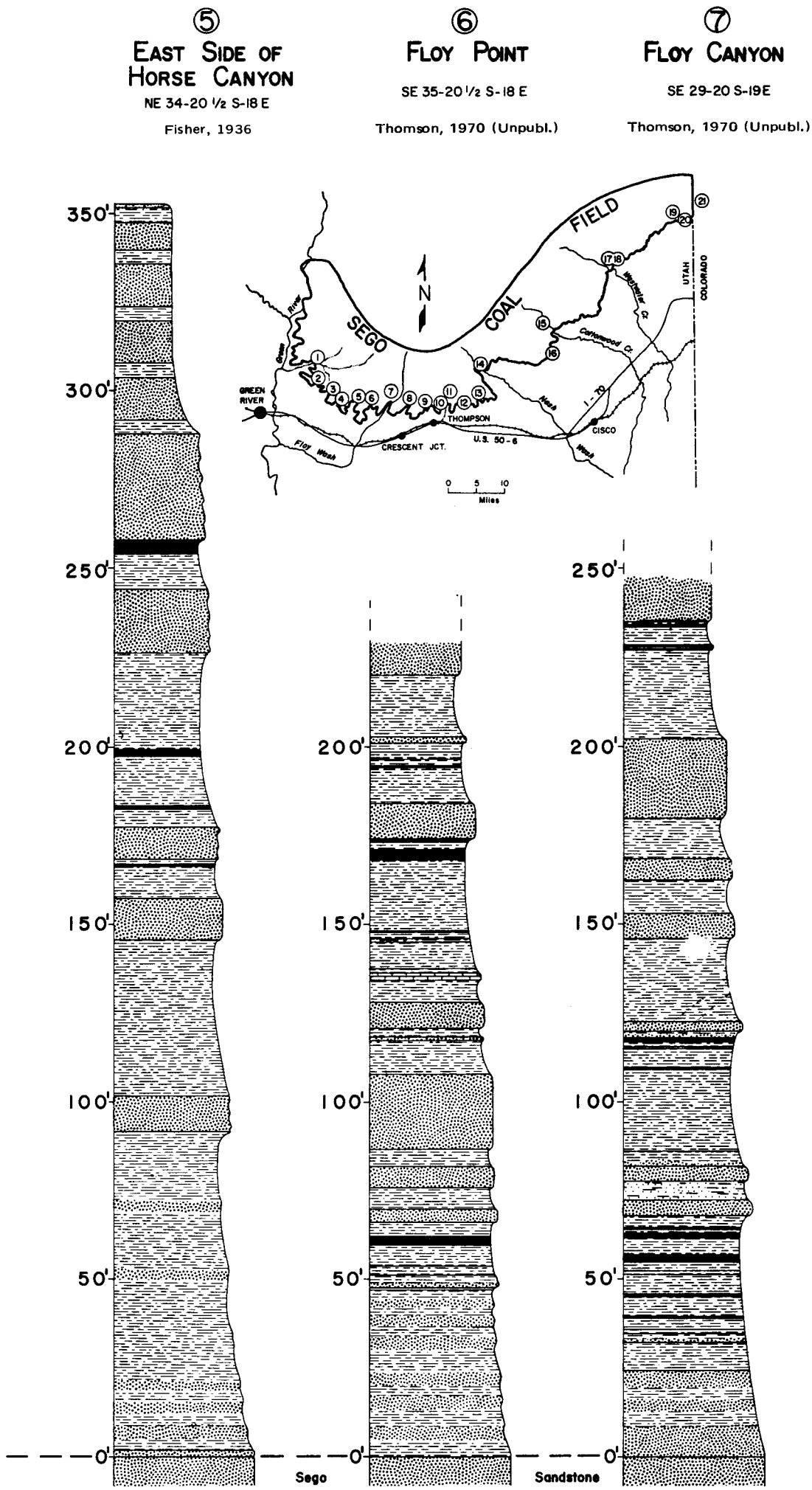


Figure 6. Coal sections of the Neslen Member, Price River Formation, Sego coal field (vertical scale: 1 inch = 8 feet).



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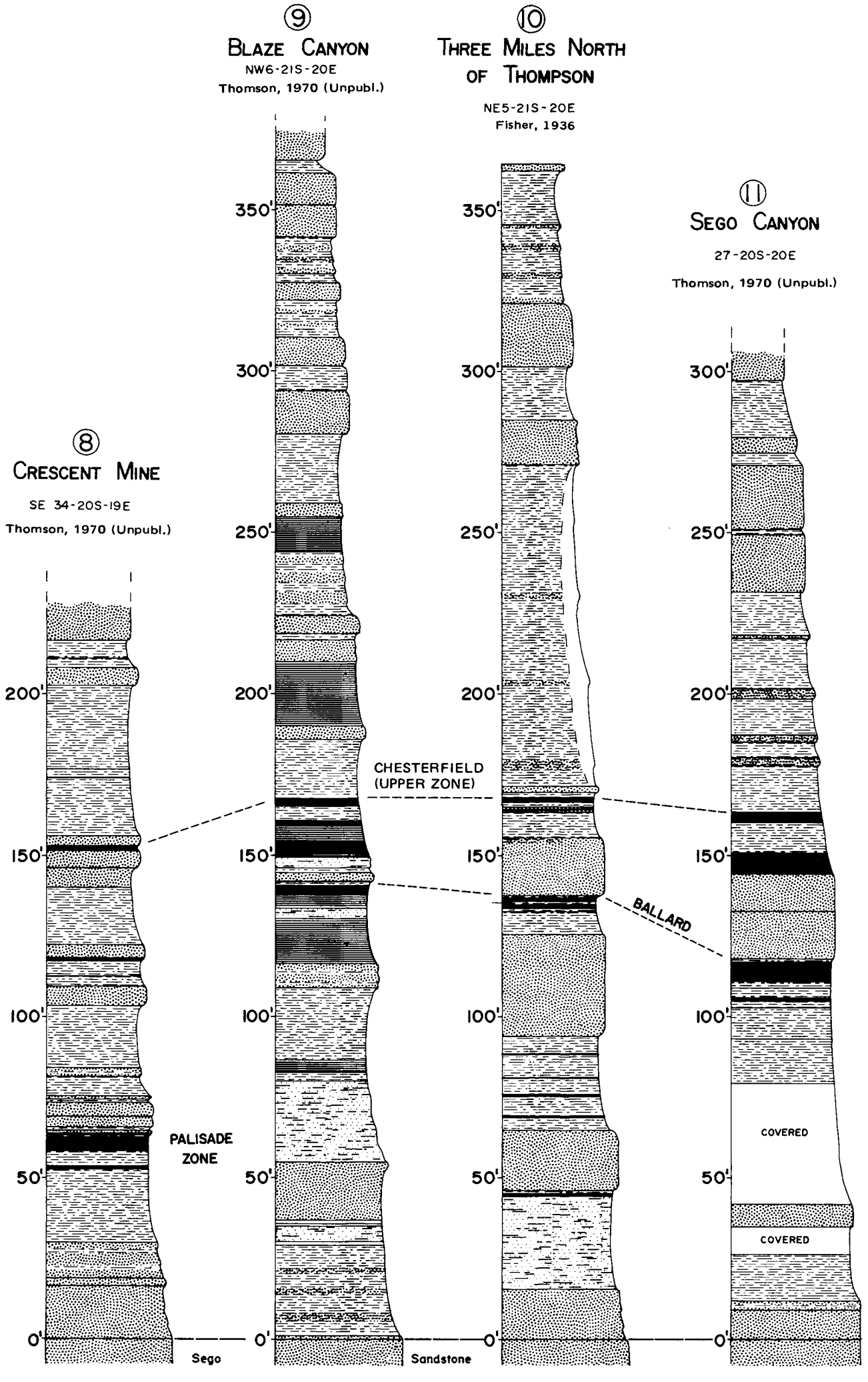

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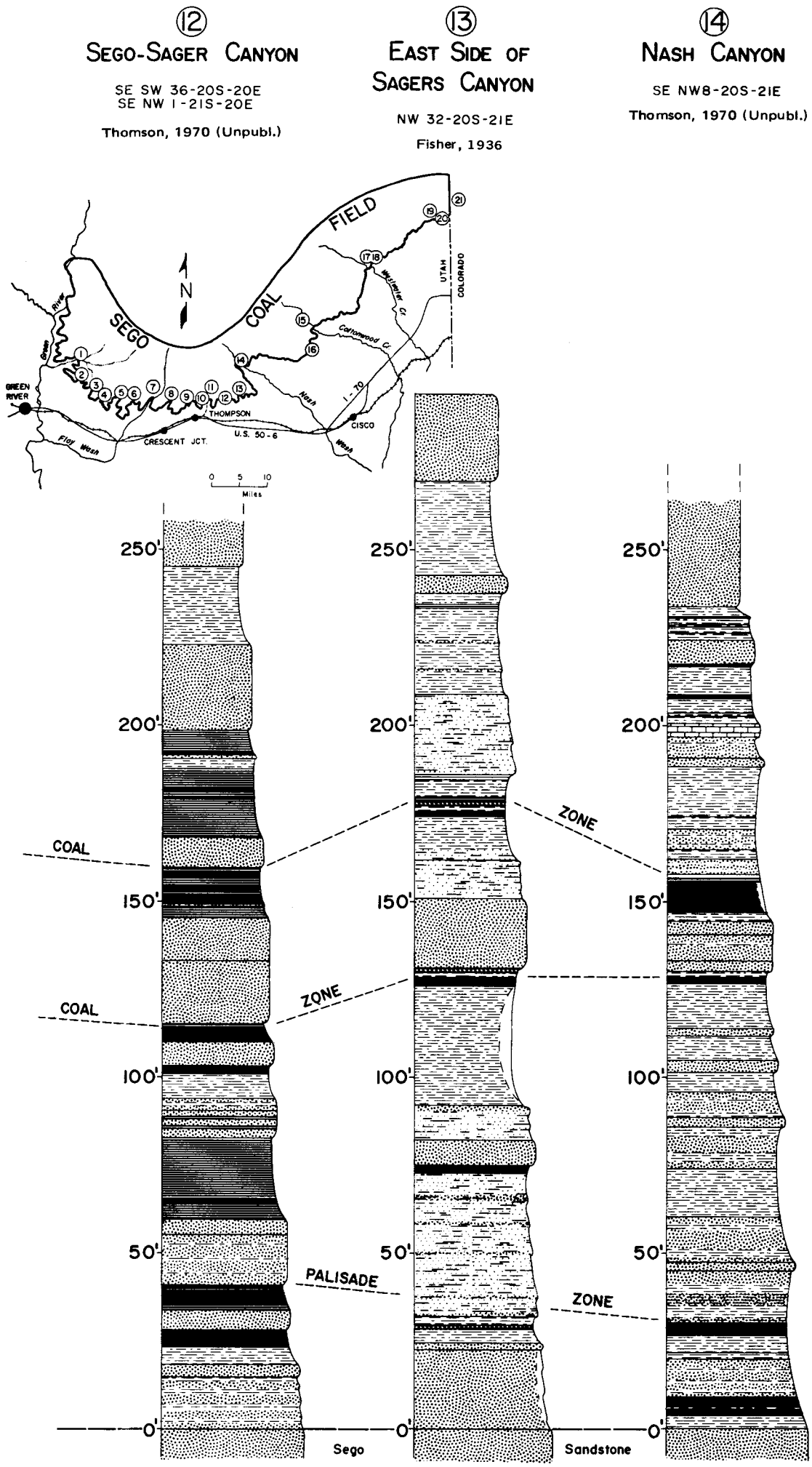

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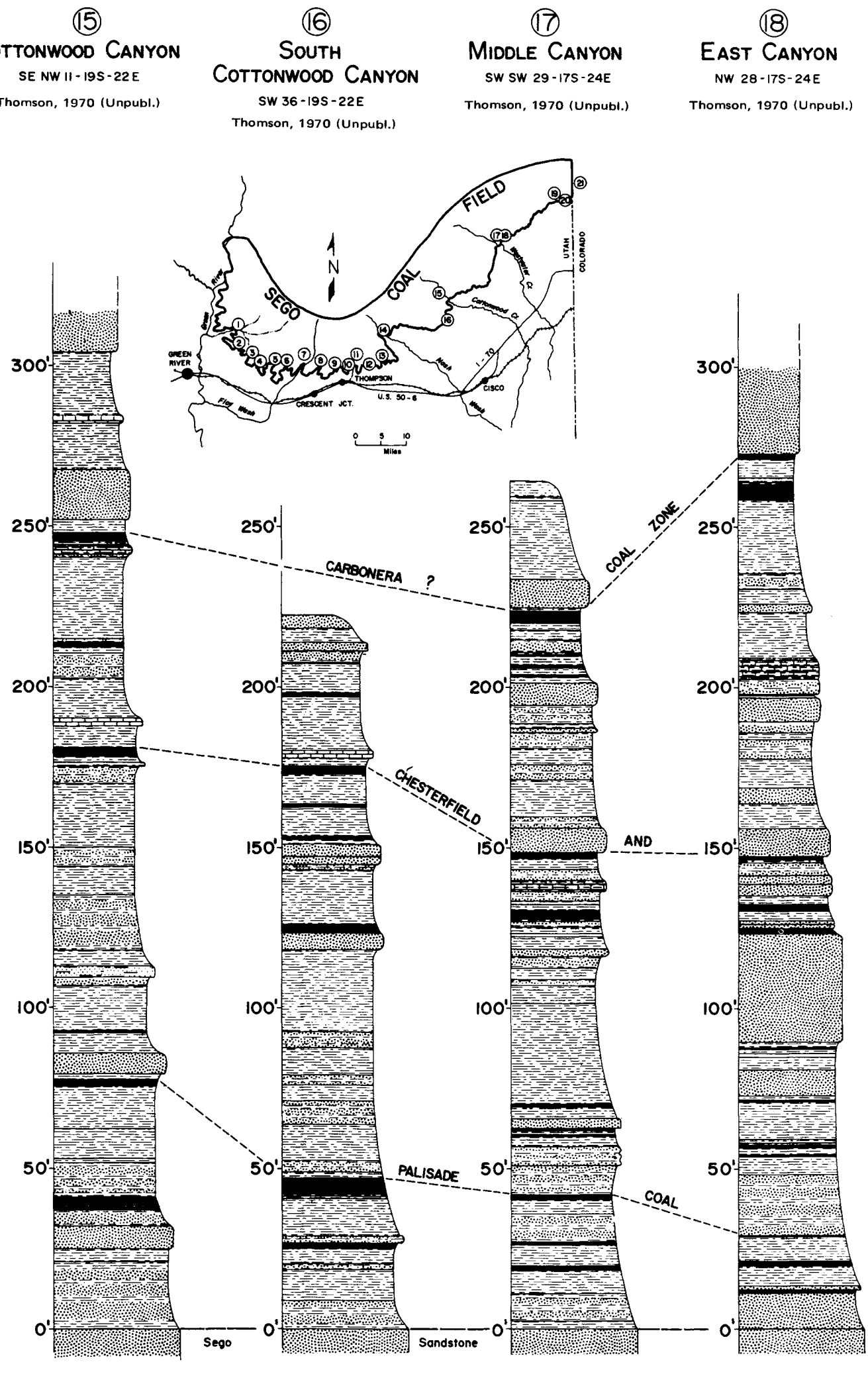

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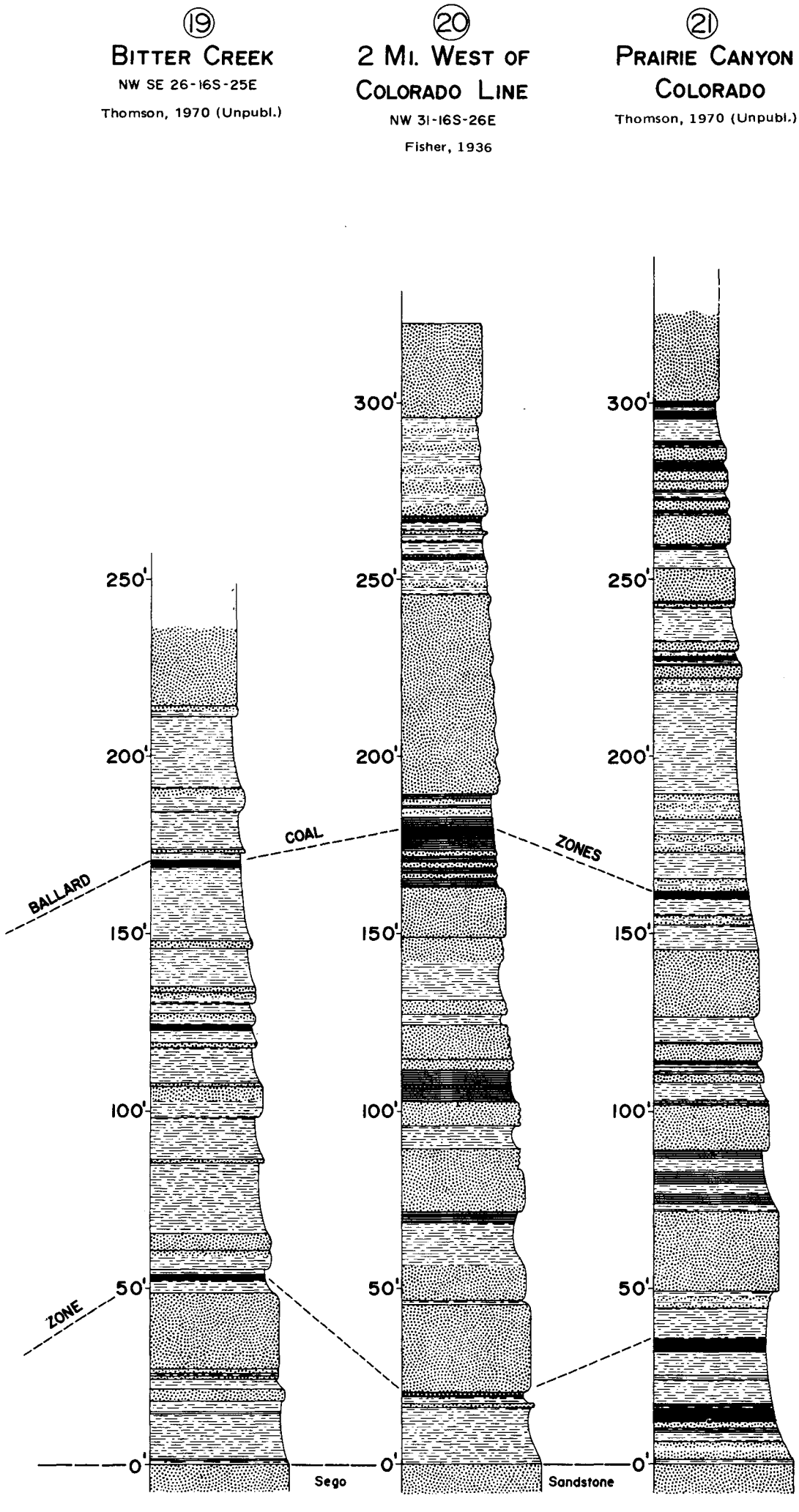

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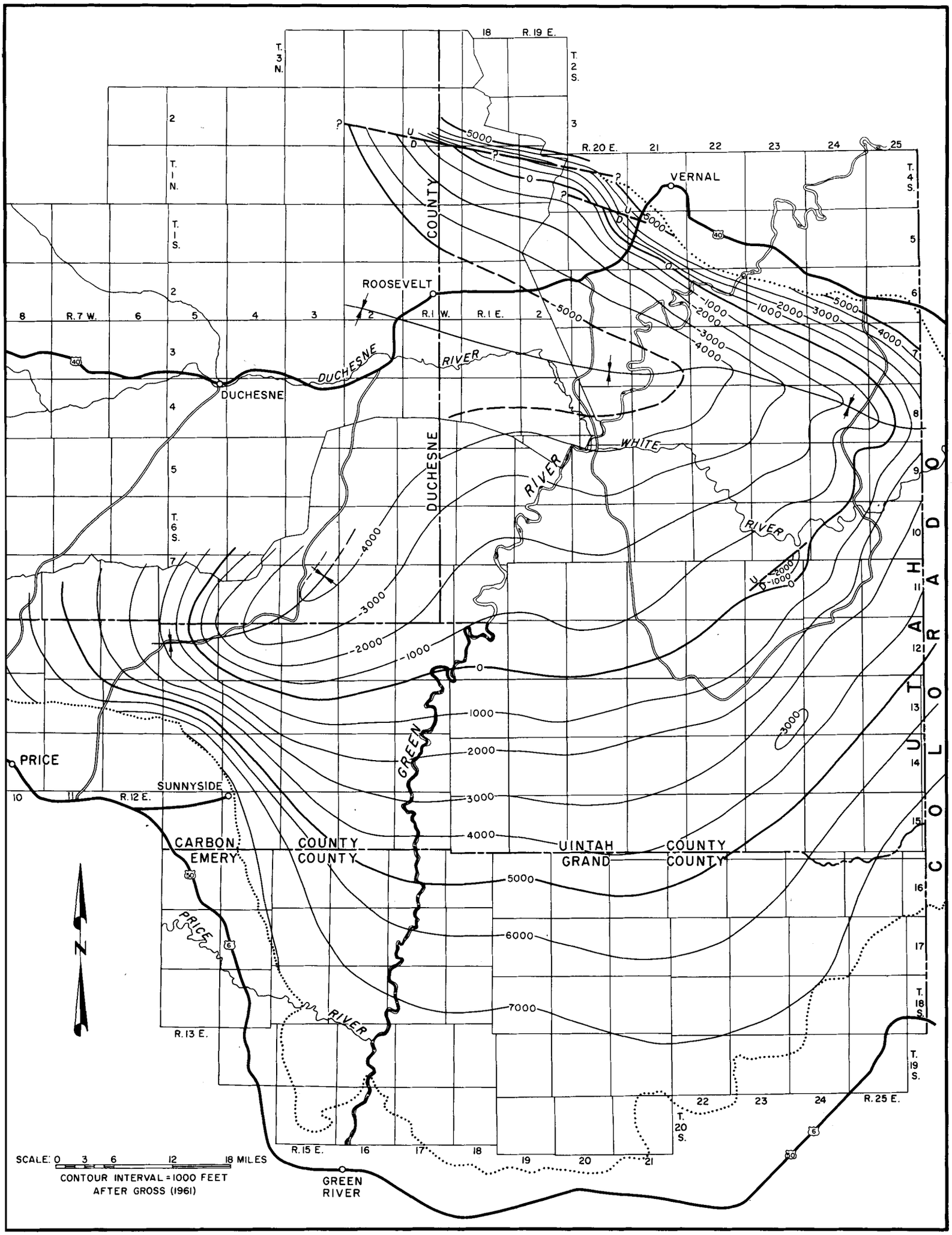


Figure 7. Structure contour on top of the Mesaverde Group, Uinta Basin, Sego coal field.

Some of these features have been drilled for natural gas. All plunge into the basin and eventually die out. Figure 8 shows many of the above named axes from R. 18 E. to Cisco along the base of the Book Cliffs.

Faults are rare in the Book Cliffs between the Green River and the Colorado border. The rocks northwest of Crescent Junction in T. 21 S., R 18 and 19 E. are cut by several normal faults. The faults do not extend northward far enough to disturb the coal beds. The next group of faults also trends northwesterly commencing south of Sego, extending west of Thompson Canyon across Crescent and Saleratus washes. These faults have displacements up to 200 feet and displace the coal beds.

A few faults occur on either side of the Cisco dome around Nash Wash. The displacement is up to 165 feet, but the faults do not appear to cut coal. From Nash Canyon eastward are at least eight minor faults. Most of these displace coal and most have throws less than 100 feet, but one near the Colorado state line in Jims Canyon is downthrown 225 feet to the south.

The Uinta Basin itself is about 100 miles wide along a line extending from Sego to Vernal and about 120 miles long along its east-west axis. The coal-bearing Mesaverde Group is buried within the basin and the structural contour map (figure 7) indicates the elevations at which the top of the Mesaverde may be found. Along its east-west axis the surface elevations near the basin center are about 5,000 feet below sea level. These gradually rise to 8,000 feet along the Book Cliffs rim. Therefore the top of the Mesaverde is 10,000 feet below the surface at the axis.

Geologic and Tectonic History

Geologic history for the east Book Cliffs region in Utah commences at the time of the encroachment of the Mancos sea in Upper Cretaceous time. Several earlier events, however, undoubtedly affected the area with lasting results. The most important of these is the formation of the Ancestral Rocky Mountains during the Pennsylvanian. The Uncompahgre Highlands, one body of the ancient mountain chain, consisted of an elongate range most active to the southeast of the Book Cliffs along the Colorado line and extending in Colorado. Perhaps the north nose of the positive feature extended into the area between Nash Canyon and the Colorado line. Immediately southwest of the Uncompahgre a deep basin developed which collected erosional debris from the highland. It was also a basin of evaporite deposition. Great thicknesses of salt accumulated in this Paradox basin. From Pennsylvanian time on, spasmodic activity has marked the Uncompahgre and Paradox areas in the form of renewed uplift and salt deformation. This has had the affect of local thinning of formations and local nondeposition. At the time of the arrival of the Upper Cretaceous sea, most of this activity had subsided, but later renewed activity along the old lines of weakness produced the series of folds that projects into the Book Cliffs.

The Cretaceous sea extended into central Utah and 3,000 to 5,000 feet of Mancos Shale were deposited. The thinner deposit is along the Utah-Colorado line and may reflect a positive influence of the Uncompahgre uplift. Thereafter the sea began its steady retreat and the marine-continental transitional environments moved eastward. In the west Book Cliffs lagoonal conditions arrived earlier and the important Blackhawk coal seams were laid down. Later these conditions shifted eastward into the Sego area and the Neslen Member of the Price River Formation contains the coal. Gradually lagoonal conditions were replaced by continental environments and coal accumulation ceased.

Subsidence continued and the area received more sediment. The rate was greater to the north as the Uncompahgre and Paradox elements that had been positive in the past continued to resist the subsidence. Accumulation in the basin continued at least through Oligocene time under fluvial and lacustrine conditions. To the south sedimentation was slight and uplift probably occurred earlier. Erosional activities then were activated to carve the canyons and cliffs present today.

Correlation with Surrounding Areas

The Mesaverde Group in Utah involves many formations and facies changes. The group usually involves all units stratigraphically above the Mancos Shale and below the unit containing the Cretaceous and Tertiary boundary. This transitional unit is represented by the Tuscher Formation at Sego, but the North Horn in the Wasatch Plateau and Book Cliffs. The exception is in southwest Utah in the Kolob-Harmony, Alton and Kaiparowits fields where the Straight Cliffs, Wahweap and Kaiparowits formations are not regarded as Mesaverde units although they correlate in time with such units in adjacent states. The Mesaverde was deposited following the retreat of the Mancos sea.

The sea retreated slowly with a series of minor regressions and transgressions. The oldest units, therefore, are in the central part of the state in the Wasatch Plateau field. These include the Star Point Sandstone and Blackhawk Formation. The Blackhawk Formation is 700 to 1,100 feet thick in that field and contains its important coal beds. It gradually thins eastward supplanted by the Mancos shales. The Book Cliffs coal field, intermediate to the Wasatch Plateau and Sego, is also in Blackhawk coal, but in the east part of the field the seams are located a smaller interval from the top of the unit and the formation is generally thinner. The Mesaverde formations above the Blackhawk include the Castlegate Sandstone and the Price River Formation, mostly fluvial sandstones and minor intermediate shales. Thin noncommercial coal beds are locally present. At the Green River the Blackhawk is undergoing a facies change from lagoonal to marine; the coal is in thin stringers and is noncommercial. The Price River also is undergoing facies changes, fluvial to lagoonal. At Sego the important coal beds are in the Neslen Member of the Price River Formation and this condition persists into Colorado.

Northward, under the Uinta Basin, the Mesaverde persists until it crops out near Vernal. The Mesaverde contains coal seams near Vernal, but they are lignitic and only locally thick enough to mine. The Rim Rock Member near Vernal is thought to correlate with the Castlegate, at least in part, and the Upper Mesaverde is thought to be the same as the Upper Price River at Sego. The Asphalt Ridge Member of the Mesaverde thins out near Vernal and is thought to be the last remnant of the Blackhawk.

These relationships are illustrated in figure 9.

COAL DEPOSITS

Status of Information

Serious mining commenced in the Sego coal field in 1912 simultaneously with the first detailed geological investigation carried out by Clark (1914) in the Sego and Thompson Canyon areas. The remainder of the field was explored later and mapped by Fisher (1936) and his assistants during the summers of 1925 and 1926. These two works represent the only comprehensive coal investigations of the area; a few stratigraphic papers augment the bibliography along with brief reports about the field. Many of the coal measurements are widely spaced and large areas are without coal analyses. A bibliography of principal and supporting work is at the end of the report.

Mines, Prospects and Production

All mines of the Sego coal field were closed in 1970 (table 1). Past principal activity was in the Thompson-Sego canyons area during the years 1912 to 1954. Practically all of the 2,650,000 tons produced to date from the field came from this area.

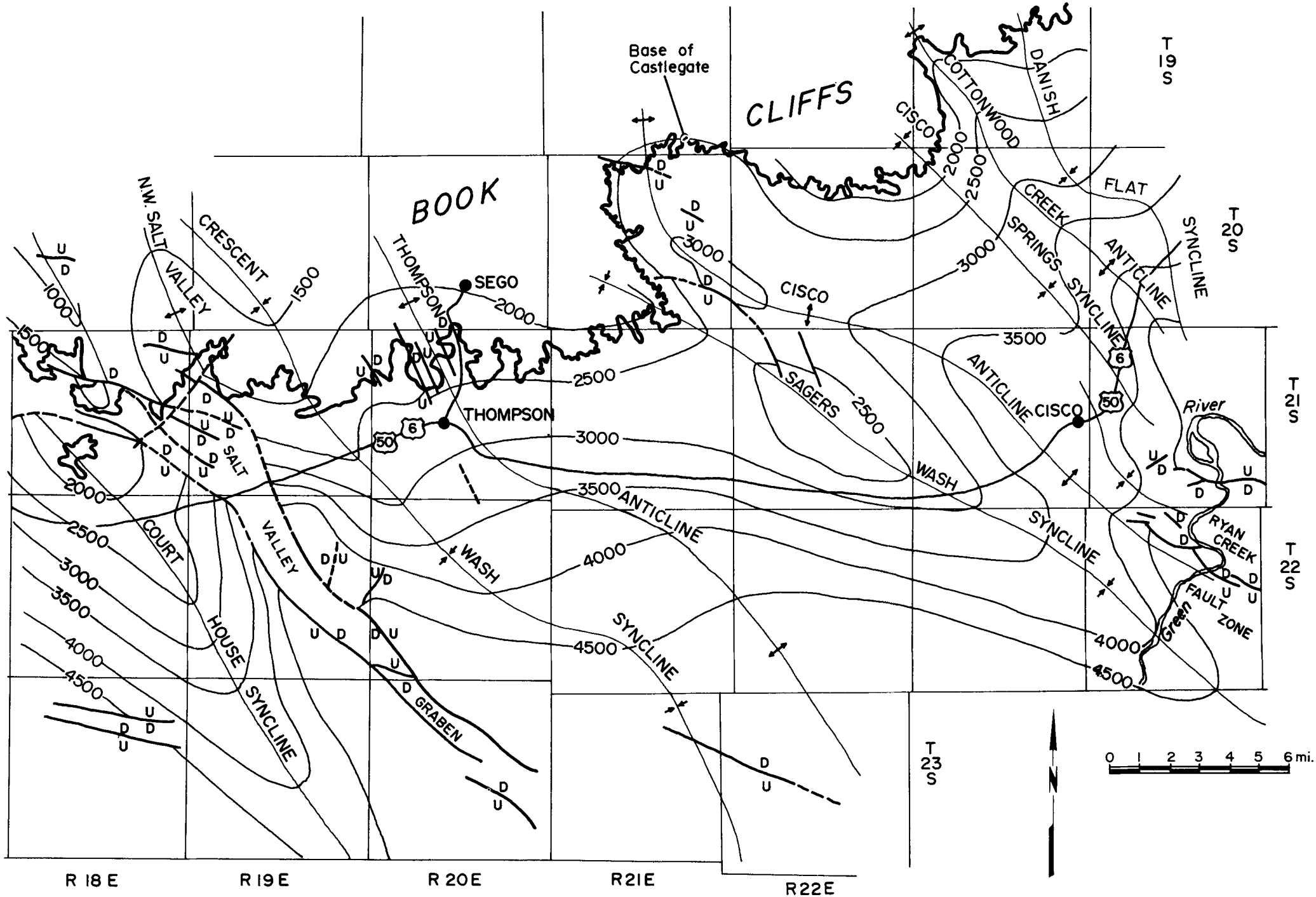


Figure 8. Structures along Book Cliffs, north Salt Valley to Cisco; contours on top of the Dakota Sandstone (after Walton, 1956).

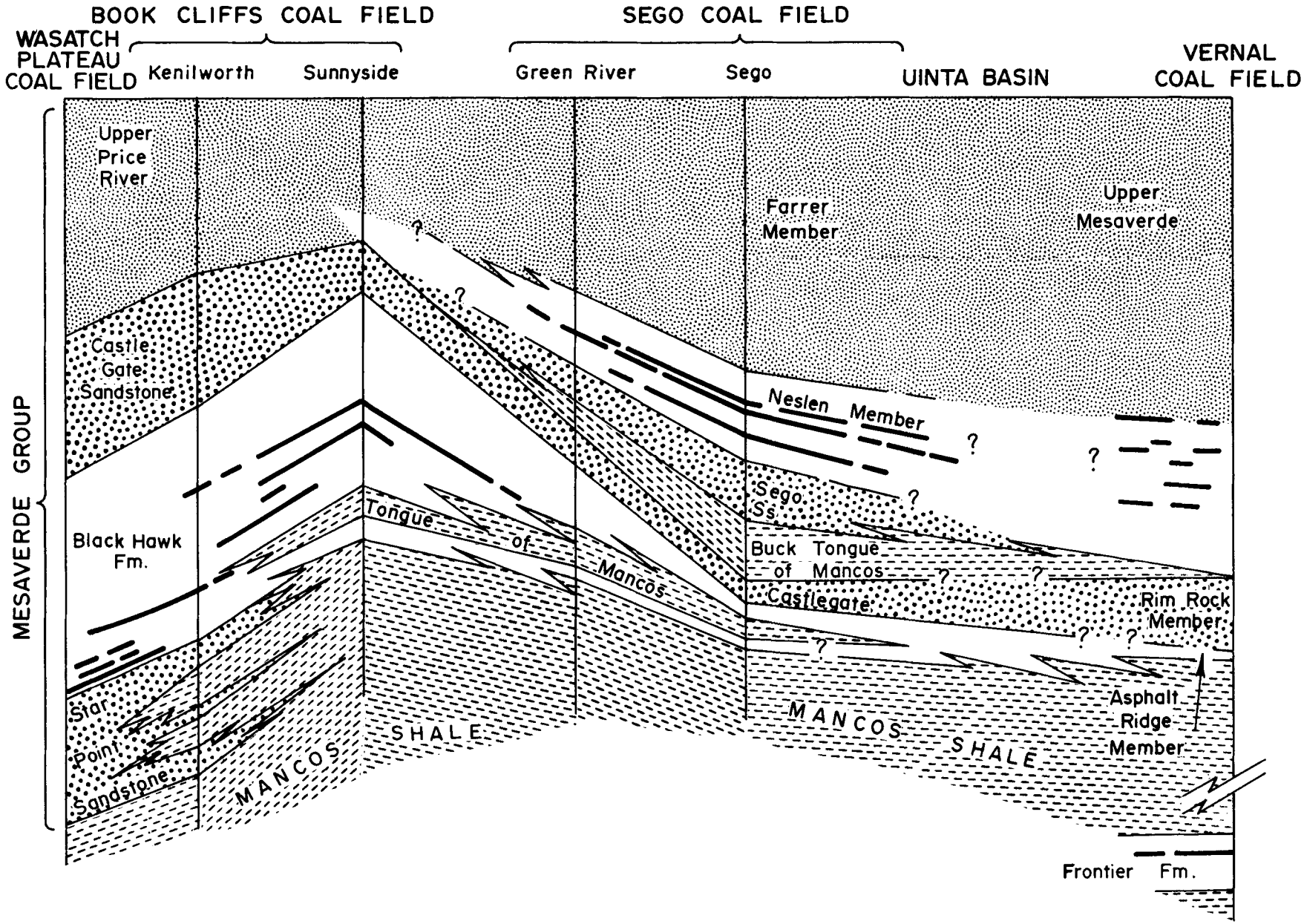


Figure 9. Correlation of Mesaverde Group along Book Cliffs and across Uinta Basin to Vernal.

Table 1. Coal mines and prospects of the Sego coal field.

Quadrangle	Location	Remarks
Floy Canyon SE-SW		
Black Baby mine (Farrer)	NW.35-20S-17E 4,321,500m.N. 588,940m.E.	1898-1925 Int. activity
Crescent mine	SW.SE.34-20S-19E 4,319,320m.N. 603,400m.E.	1920-1948 Int. activity
Crescent Junction prospects No. 1	SE.29-20S-19E 4,321,080m.N. 600,840m.E.	Activity unknown
No. 2	NE.10-21S-19E 4,317,770m.N. 603,520m.E.	Activity unknown
No. 3	SW.2-21S-19E 4,318,340m.N. 604,360m.E.	Activity unknown
Sego Canyon SW		
American Fuel mine (Ballard, Sego, Chesterfield, Neslen)	NW.27-20S-20E 4,322,000m.N. 612,400m.E. (center of map)	Activity 1900-1953 10 portals
Knight mine	NW.NW.SE.29-20S-20E 4,321,300m.N. 610,300m.E.	Activity unknown
Nash Canyon prospect	NE.NW.7-20S-21E 4,327,200m.N. 617,500m.E.	Activity unknown
Thompson Canyon mine (Clark)	NE.29-20S-20E 4,321,880m.N. 610,150m.E.	Activity 1946-1953

Land Ownership

The lands of the reported quadrangles of the Sego coal field are owned as follows (figure 10): Bureau of Land Management 85.6 percent, state of Utah 11.5 percent and private property 2.9 percent.

The private property in most instances lies below the Book Cliffs. A partial exception is in the Thompson and Sego canyons area. The BLM and state of Utah hold the coal land nearly in the proportions shown above. As of January 1, 1970, 800 acres were held for coal, all in the Sego Canyon SW quadrangle.

Quality of Coal

Twenty-seven analyses of coal are available for the Sego coal field of which two-thirds are from one quadrangle; five of the ten quadrangles are not represented. Fisher (1936) indicates that much of the coal in the east half of the field is impure and degraded by bone coal. The one sample collected in this vast area does not verify this assumption and additional data remain to be collected. With these inadequacies, however, the field averages are as follows (table 2):

Table 2. Average proximate coal analysis for the Sego coal field, as-received.

	Samples	Percent	
		Average	Range
Moisture	27	9.1	5.2 -20.0
Volatile matter	23	34.7	28.7 -42.2
Fixed carbon	23	46.8	38.4 -52.6
Ash	27	11.1	4.2 -19.0
Sulfur	27	0.60	0.37- 1.00
Btu/lb	18	10,940	9,000-12,150

Reserves

A total of 505.1 million tons of coal in all beds (greater than 1.5 feet) throughout the entire field is calculated as original reserve (table 3). This includes measured, estimated and inferred categories and of this figure 293.6 million tons are in beds 4 feet or more thick. Most of the reserve is in the west part of the field, particularly in the Sego Canyon SW quadrangle.

Table 3. Original (in millions of short tons) coal reserves for the Sego coal field.

Quadrangle	Measured and Estimated I and II	Inferred Reserve III	Total Coal	Beds 4 feet or more
Colorado line	–	–	–	–
Cottonwood Creek	–	–	–	–
Floy Canyon SE-SW	16.9	17.9	34.8	17.9
Gunnison Butte East	–	–	–	–
Sego Canyon SE	15.8	52.9	68.7	61.9
Sego Canyon SW	238.4	155.3	393.7	205.9
West Bitter Creek	–	–	–	–
Westwater Creek North	–	7.9	7.9	7.9
Westwater Creek South	–	–	–	–
Totals	271.1	234.0	505.1	293.6

The distribution of the reserve to zones is given in table 4.

Table 4. Distribution of reserve to zones in the Sego coal field.

	>4-foot seams	<4-foot seams
Carbonera zone	7.9	–
Chesterfield zone	116.3	69.3
Ballard zone	93.3	89.4
Palisade zone	76.1	44.8
Other beds	–	8.0
Totals	293.6	211.5

Coal Seams

Coal beds have been located in the Blackhawk Formation, Castlegate Sandstone, Neslen Member, Farrer Member and perhaps the Wasatch Formation. Of these the Neslen Member of the Price River Formation contains valuable coal resources. Coal beds have been found in all positions within the 250- to 410-foot interval; four zones, however, contain most of the reserve (in descending order): the Carbonera, Chesterfield, Ballard and Palisade zones. A more exact positioning within the stratigraphic column is given in the Stratigraphy section.

The Carbonera zone has not been mapped and where checked does not appear to have thick valuable beds except perhaps in the east part of the field where more work is needed.

The Chesterfield zone is the most valuable in terms of reserve. The beds are considered thin or impure in the east half of the field and thicken between Nash and Thompson canyons. In several blocks of this sector the zone contains beds 4 feet or more thick. Only rarely, however, are beds greater than 6 feet encountered. In various local areas within the sector the beds are split. Farther west the zone appears to remain continuous, but only in local areas do beds exceed 4 feet. Again splitting of the beds by bone and shale is common.

The Ballard zone like the Chesterfield is of little value east of Nash Canyon; it, too, is best developed between Nash and Thompson canyons where the coal is usually 4 to 5 feet thick. It is normally in two benches which may be split by as much as 5.0 feet of waste. The zone is identifiable west of Thompson Canyon, but is generally thin or badly split.

The Palisade zone is usually identifiable throughout the field and local thickening of beds may be expected anywhere. Known areas are near the Crescent mine and in Thompson and Sego can-

yons. Further examination of the Palisade in the east sector of the field also may prove the existence of beds exceeding 4 feet thick.

WATER RESOURCES

Water resources draining from the crest of the Book Cliffs southward are almost negligible. The major canyons, of which Nash is the largest, contain a small flow much less than that required by a large power plant. Almost all of this water is consumed by the local ranches.

The large through-going rivers such as the Colorado and Green normally carry relatively large quantities of water. The Colorado parallels the Book Cliffs 18 miles to the south in the east part of the field. The weighted-average discharge for the Colorado River at Cisco, Utah, over a 40-year period is 7,639 cfs.

The Green River marks the west field boundary. At the town of Green River the weighted-average discharge over a 40-year period is 6,292 cfs which calculates to be 5.5 and 4.6 million acre-feet annually for the Colorado and Green rivers.

ECONOMIC CONSIDERATIONS AND FORECAST

The coal in the Sego coal field is in thin beds compared with other Utah coal areas. In addition much of the field is considered to contain impure coal. Most of the reserve is concentrated between Nash and Thompson canyons.

If future prospecting determined the workability of the coal beds of this sector, the total mine cost, including amortization, reasonably could be expected to be $3.50 to $4.00 per ton (Pearce, 1970, p. 8). Hopefully washing will be unnecessary.

The Sego coal field does have a few advantages: (1) closeness to the railroad and (2) closeness to an adequate water supply for a future coal-fired electric power plant. The total rail haul from the favorable sector to the Green river is only 30 miles. The mines are 5 miles from the existing rail line.

Conventional mining or more likely long-wall mining will prove to be the most satisfactory method to mine the coal, both as to cost and as to greatest recovery. Mining of coal in a 4-foot bed would spread rapidly and a maximum recovery would be of paramount importance.

Further drilling may show that the Ballard bed is minable to the north of the Sego mine. The massive sandstone lying between the Chesterfield and Ballard beds is a big advantage considering the narrow interval between the two zones.

But the disadvantages may outweigh the advantages and all that is expected for the Sego coal field for the next 10 years is exploration work. The results of that work will determine the field's extended future.

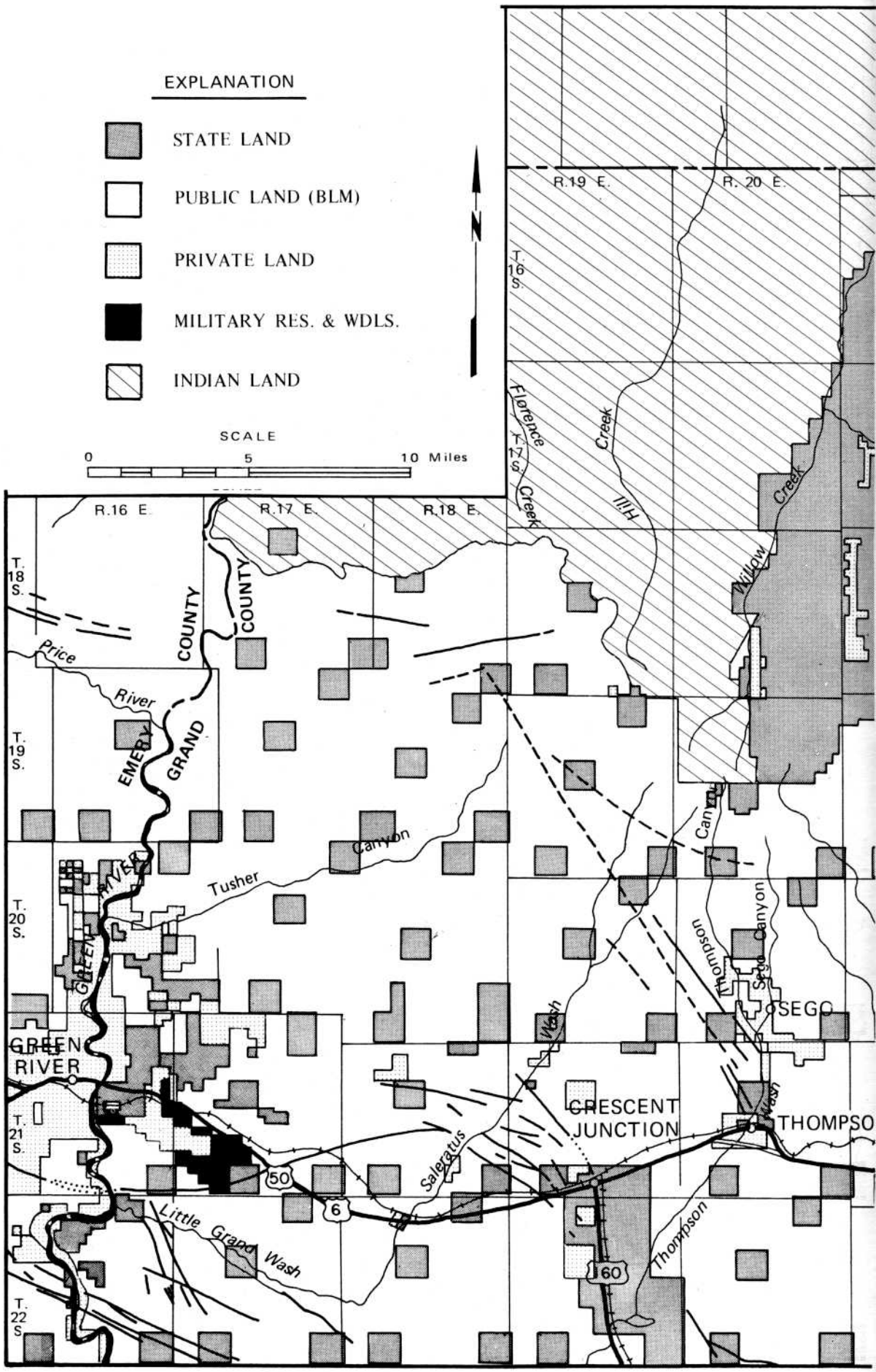
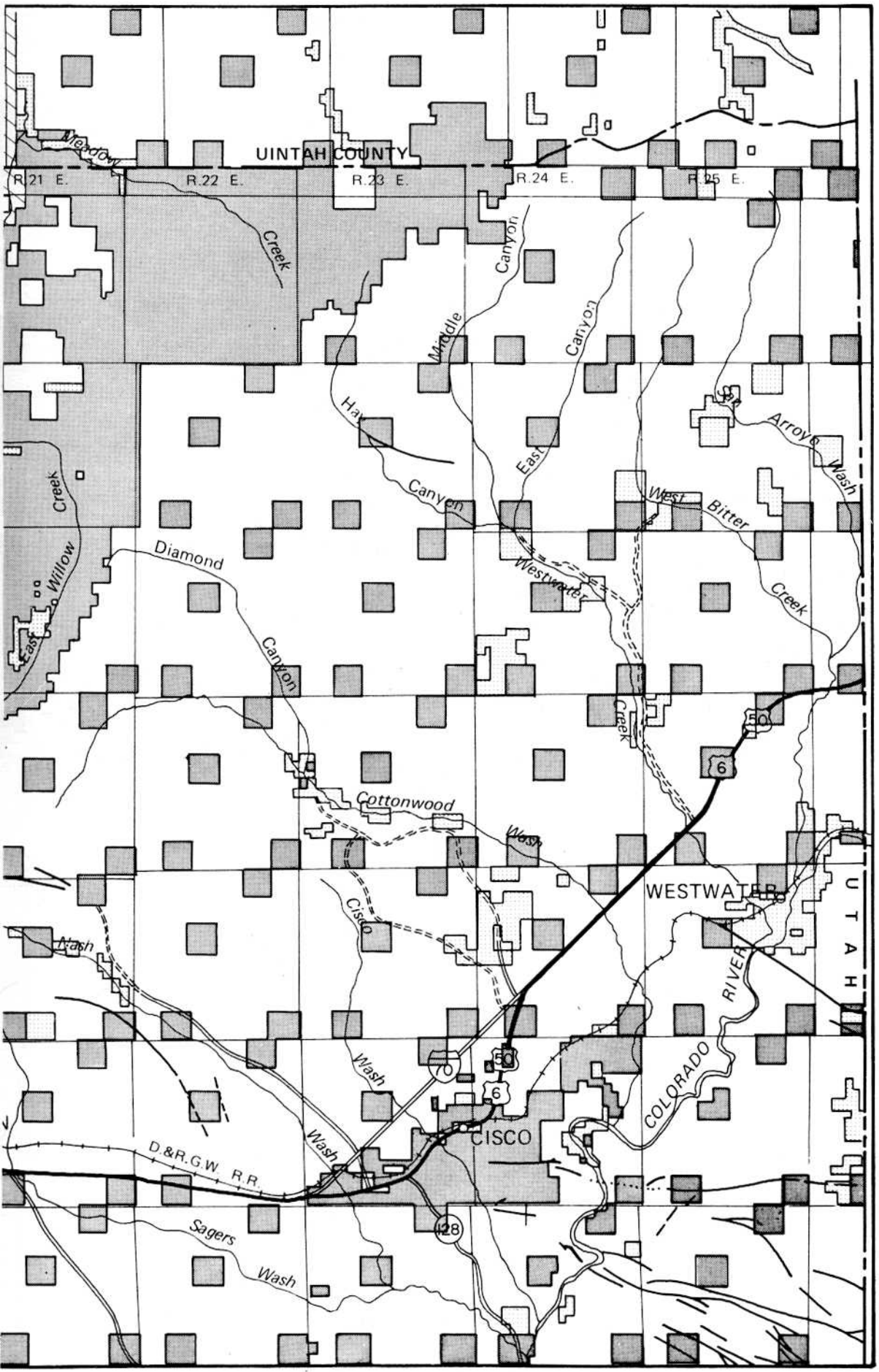
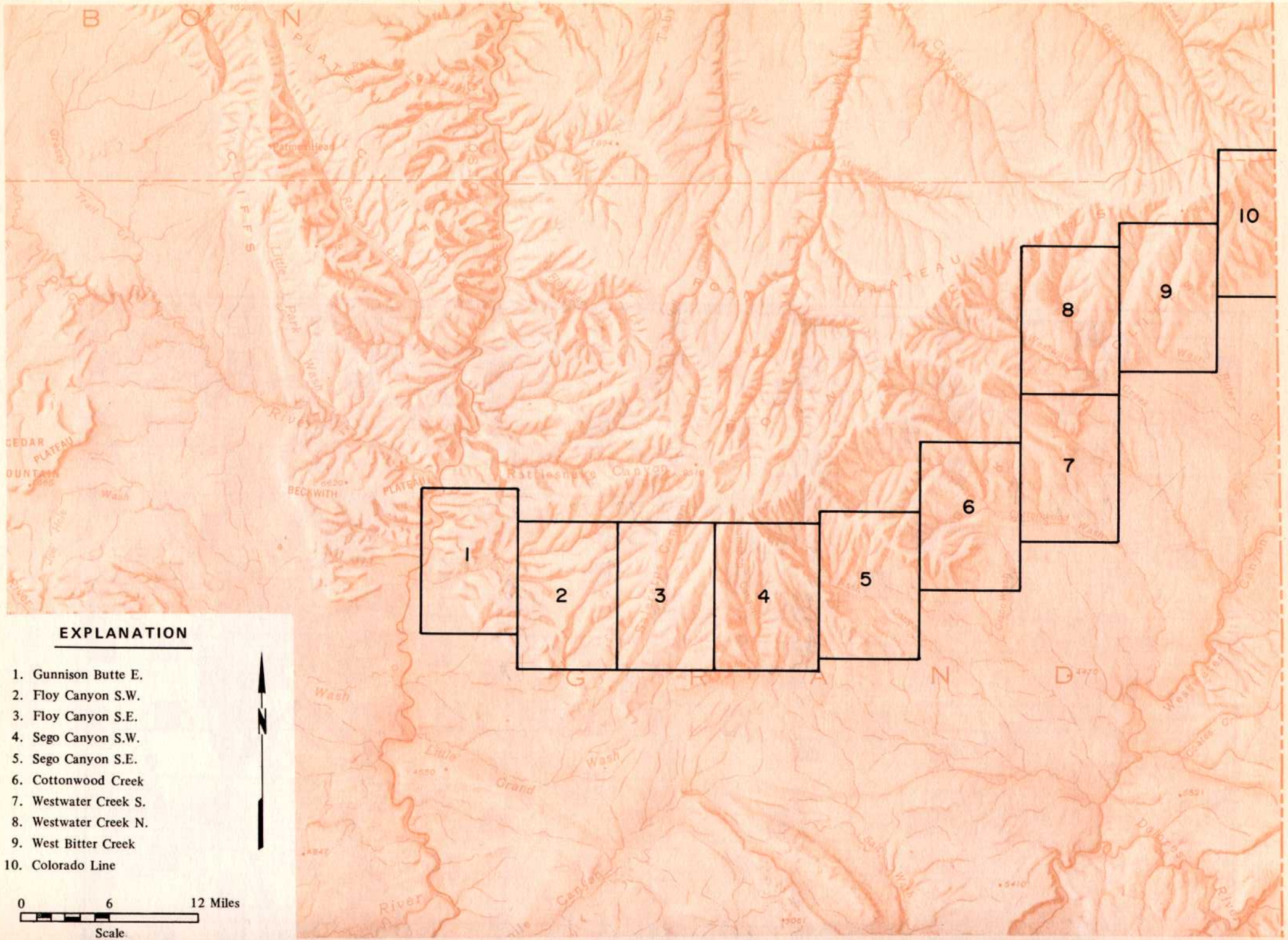


Figure 10. Land ownership map, Sego coal field.


UINTAH COUNTY
R.21 E.
R.22 E.
R.23 E.
R.24 E.
R.25 E.
Meadow Creek
Middle Canyon
East Canyon
Hay Canyon
Arroyo Wash
West Bitter Creek
Willow Creek
East Willow Creek
Diamond Canyon
Westwater Creek
Cottonwood Wash
Cisco Wash
WESTWATER
UTAH
COLORADO RIVER
CISCO
D.&R.G.W. R.R.
Sagers Wash
6
50
70
128


1
2
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10
EXPLANATION
1. Gunnison Butte E.
2. Floy Canyon S.W.
3. Floy Canyon S.E.
4. Sego Canyon S.W.
5. Sego Canyon S.E.
6. Cottonwood Creek
7. Westwater Creek S.
8. Westwater Creek N.
9. West Bitter Creek
10. Colorado Line
N
0
6
12 Miles
Scale

QUADRANGLE REPORTS

GUNNISON BUTTE EAST QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Gunnison Butte East quadrangle is a portion of the east half of the U. S. Geological Survey 15-minute Gunnison Butte topographic quadrangle (figure 11). It is located at the west end of the Sego coal field 4 miles northeast of the town of Green River. Represented is a portion of Gray Canyon where the Green River cuts through the Book Cliffs. Other than Gray Canyon, Tusher Canyon is the most important physical feature.

The altitude of Gunnison Valley below the cliffs is approximately 4,200 feet. The elevation rises in step-like fashion to a maximum of about 6,400 feet. The coal is at 5,200 feet in the south part of the map area and gradually lowers northward as it V's into Gray Canyon.

Graded roads or jeep trails give access to the railroad and highway at Green River. These roads parallel the Green River and extend into Tusher Canyon.

STRATIGRAPHY

Bedrock units exposed on the Gunnison Butte East quadrangle range from the Mancos Shale to the Tuscher Formation (figure 12). These are adequately described in the field report and on the Generalized Section of Rock Formations, Sego coal field, Utah (figure 5). Two sections of the coal-bearing Neslen were measured to describe its condition:

Partial section of Neslen Member of Price River Formation, north side of Coal Canyon in 18-20S-17E, by Thomson (1970).

Neslen Member	Feet
1. Sandstone, gray weathering orange-brown, medium- to coarse-grained, massive cliff former, may be lowermost Farrer Member	10+
2. Mudstone and shale, gray	16.3
3. Sandstone, brown, fine-grained, thin- to medium-bedded, some interbeds of shale, forms ledges	12.8
4. Shale, gray and carbonaceous	0.8
5. Coal	0.5
6. Shale, gray	5.3
7. Coal	0.5
8. Shale, gray	9.9
9. Sandstone, light brown, fine-grained, thin-bedded ledge former	4.9
10. Shale, gray	3.8
11. Sandstone, like unit 9	0.8
12. Shale, gray	21.0
13. Interbedded sandstone and shale, slope former	26.1
14. Shale, gray and brown	19.9
15. Sandstone, like unit 9	8.3
16. Shale, gray	4.5
17. Coal	0.5
18. Shale, gray	8.0
19. Sandstone, brown, fine-grained, thin-bedded, slope former	0.5
20. Shale, gray	9.9
21. Sandstone, like 19, but gray, becomes medium-grained in lower part	15.6
22. Coquina, sandy lime matrix, thin-bedded	1.0
23. Sandstone, brown gray, fine- to medium-grained, single bed, weathers blocky	2.3
24. Sandstone, brown, medium-grained, thin-bedded, ledge former	24.7
25. Shale, gray	1.9
26. Sandstone, like unit 24	3.1
27. Shale, gray	3.9
28. Sandstone, gray-brown, fine- to medium-grained, thin-bedded with thin interbeds of shale	36.9
Sego Sandstone	253.7+

Partial section of Neslen Member of Price River Formation, near junction of Left Hand and Right Hand Tusher canyons, 9-20S-17E, by Thomson (1970).

Neslen Member	Feet
1. Sandstone, light brown, fine- to medium-grained, massive cliff former	?
2. Shale, gray	2.0
3. Interbedded sandstone and mudstone	38.5
4. Shale, gray	1.0
5. Mudstone, red and gray, fossiliferous (gastropods)	6.7
6. Coal	1.7
7. Mudstone and shale, gray	8.8
8. Sandstone, light brown to brown, fine-grained, thin-bedded, slope former	3.6
9. Shale, gray	1.6
10. Coquina in sandy limy matrix, thin- to medium-bedded, small ledges	9.8
11. Sandstone, light to orange-brown, medium-grained, thick-bedded, cliff former	53.2
12. Shale, gray	5.8
13. Sandstone, gray weathering brown, fine-grained, slope former	25.1
Sego Sandstone	157.8+

STRUCTURE

The structure contour lines trend northwesterly and the strata dip 1 to 4 degrees northeasterly. No faults of consequence occur.

PROPERTY CONTROL

Approximately 11 percent of the quadrangle is state of Utah land and the remainder belongs to the Bureau of Land Management (figure 10). None is leased or permitted for coal.

COAL

Surface Information

The coal has been mapped only in the southeast map corner, but thick coal seams are not expected farther north and west. All the coal measurements in the mapped portion indicate thin uncommercial beds (figure 13). The Gunnison Butte East quadrangle marks the west edge of the Sego coal field. Five miles north of the mapped area Coal Creek runs tributary to Green River. Its canyon is inaccessible at present and exploration of its coal-bearing possibilities could not be carried out.

Subsurface Information

There has been no drilling for coal on the Gunnison Butte East quadrangle.

Quality of Coal

No analyses are available of coal for the quadrangle.

Mines and Development

No mines have opened and no development for coal has occurred.

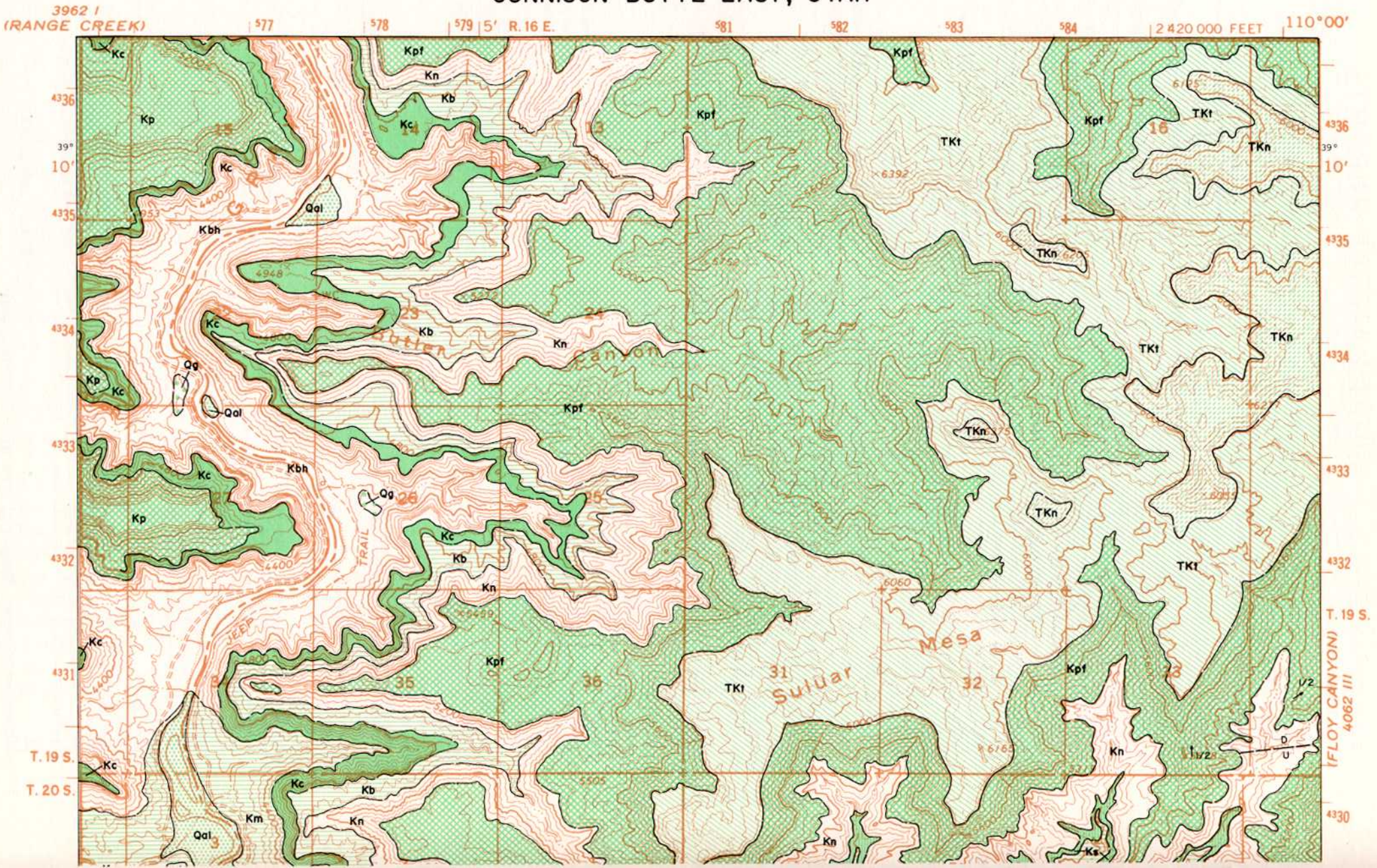
Reserves

No reserves can be assigned to this quadrangle on the basis of known data. Future exploration might locate pockets of thick coal, but large blocks are not expected.

PRINCIPAL WORK

The principal coal and geologic data were collected by Fisher (1936) and Thomson (1970).

GUNNISON BUTTE EAST, UTAH



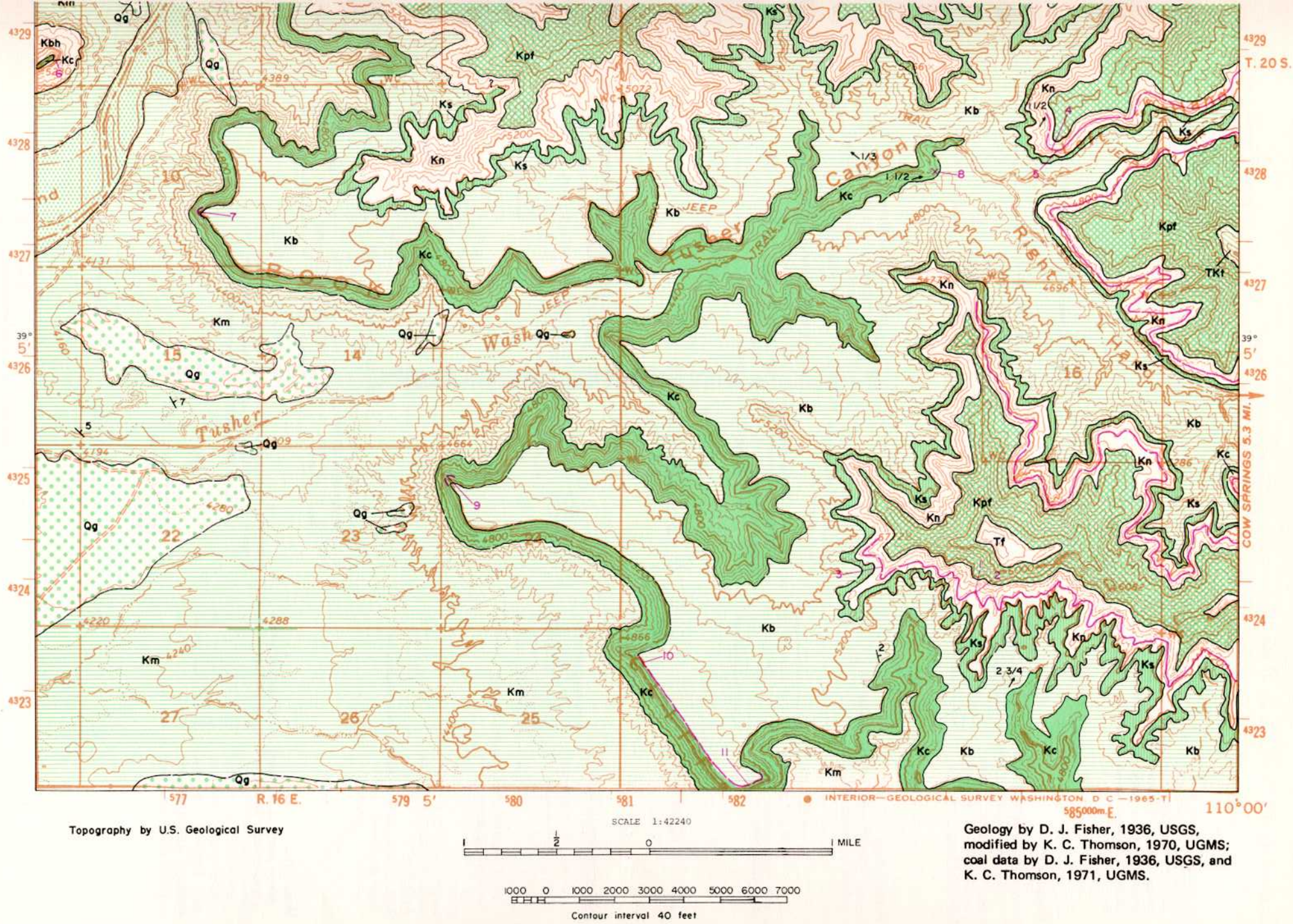


Figure 12. Coal and geology map, Gunnison Butte East quadrangle (explanation pages 218-219).

EXPLANATION (figures 12, 14, 15, 18, 20, 22, 23, 26, 27 and 28)

32 10 — Coal bed
Purple
Dashed where inferred or poorly exposed, dotted where burned. Thickness of coal in feet measured at triangles. Larger numbers refer to location of measured section shown on accompanying sheets.

Prospect

Coal mine

Purple
Burned zone
Area covered with natural clinker or red-burned sandstone.

DH — Coal drill hole

Strike and dip of beds

Apparent dip of beds

Syncline
Axis, dashed where approximately located or where ill defined.

Anticline
Axis, dashed where approximately located or where ill defined.

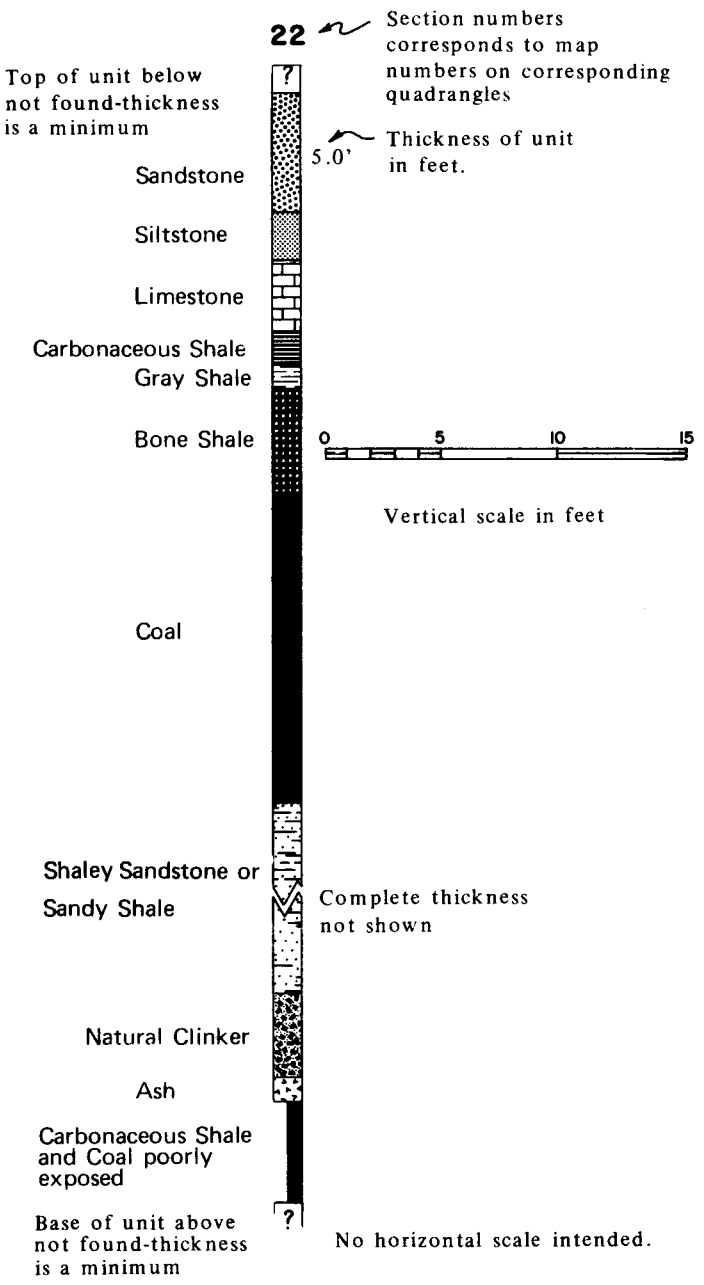
Monocline
Arrow points in direction of dip, dashed where approximately located or where ill defined.

Geologic unit contact
Dashed where location is approximate.

Horizontal strata

D U — Fault
Dashed where inferred or ill defined.

Explanation For Measured Sections



Explanation (continued)

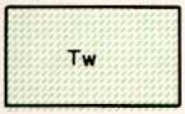
QUATERNARY

Alluvium
Stratified clay, silt, sand, gravel and some unsorted flood deposits.

Gravel Deposits
Partly consolidated, poorly sorted and stratified deposits of rock fragments of local origin, pediments or terrace.

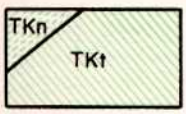
TERTIARY

Green River Formation
Greenish gray and white claystone and shale, also contains fine-grained and thinbedded sandstone. Shales often dark brown containing carbonaceous matter. Full thickness not exposed.



Wasatch Formation
Varicolored, predominantly purplish red shales with heavy cliff-forming gray sandstones, with basal conglomerate, thins eastward. 3,000-250 feet.

TERTIARY
CRETACEOUS

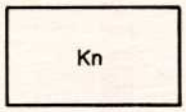


North Horn Formation
Gray to gray green calcareous and silty shale, tan to yellow-gray fine-grained sandstone and minor conglomerate. Present only in western part of field. (TKn) Thickness unknown.

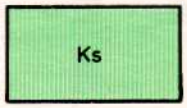
Tuscher Formation
Light gray to cream-white friable massive sandstone and subordinate buff to gray shale that exhibits light greenish cast. (KTt) 130-600 feet thick.

Unconformity ?

Farrer Member of
Price River Formation
Yellow-gray to brown sandstone with greenish gray shales. 410-1,095 feet thick.

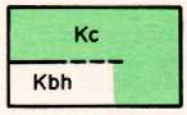


Neslen Member of
Price River Formation
Yellow gray to brown sandstone and gray shales in equal proportions, contains carbonaceous shale and coal. 250-410 feet thick.



Sego Sandstone Member of
Price River Formation
Mostly yellow-gray sandstone, massive and cliff-forming, in a few places thinbedded, makes one to four cliffs. 140-215 feet thick.

Buck Tongue of
Mancos Shale
Gray marine shale with subordinate littoral sandstone. Thins westward. 100-350 feet thick.



Castlegate Sandstone Member of
Price River Formation and
Blackhawk Formation
Castlegate yellow-gray to brown sandstone, very fine- to very coarse-grained, massive to thin-bedded cliff former, occasional thin shale beds and coal, thins eastward. 10-190 feet thick. Includes remnant of Blackhawk west of Nash Canyon. Blackhawk yellow-gray cliff-forming sandstone with interbedded gray shale, may carry thin beds of coal, thins eastward. 0-600 feet thick.

Mancos Shale
Gray marine shale, locally heavily charged with carbonaceous material, slightly calcareous and gypsiferous, nonresistant forming flat desert surfaces and low rounded hills and badlands, contains occasional thin beds of brown sandstone. 3,500-4,500 feet thick.

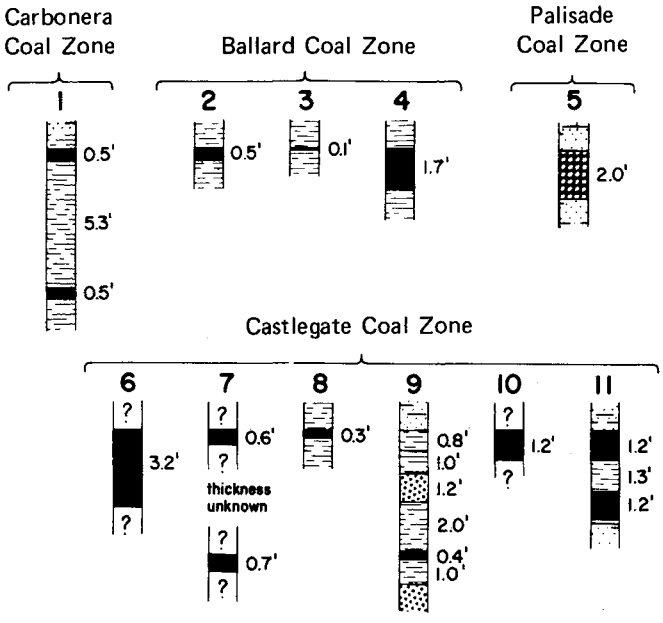


Figure 13. Coal sections of Gunnison Butte East quadrangle (vertical scale: 1 inch = 8 feet).

FLOY CANYON SE–SW QUADRANGLES

LOCATION, GEOGRAPHY AND ACCESSIBILITY

Crescent Junction on U. S. Highway 50-6 is about 5 miles directly south of the south edge of the maps (figures 11, 14 and 15). Thompson is 3 miles southeast of the southeast map corner. This portion of the Book Cliffs is in the west third of the Sego coal field. The land is cliffy and the elevation rises in steps from a low of 4,800 feet in the southwest corner of the Floy Canyon SW quadrangle to almost 7,800 feet in the northwest corner of the Floy Canyon SE quadrangle. The cliffs are cut by many long and deep canyons and the drainage is to the southwest. The coal beds generally lie 5,600 to 6,000 feet above sea level.

STRATIGRAPHY

Stratigraphic units on the Floy Canyon quadrangles with their approximate thicknesses are listed as follows:

Unit	Feet
Wasatch Formation	2,200
Tuscher Formation	380
Price River Formation	
Farrer Member	975
Neslen Member	350
Sego Sandstone	175
Buck Tongue	137
Castlegate Sandstone (includes remainder of Blackhawk)	465
Mancos Shale	3,500-4,500

The Castlegate and what remains of the Blackhawk Formation often contain local thin coal seams, mostly not more than a few inches thick. The next coal is in the Neslen Member of the Price River Formation. These are the important seams and form the basis for the Sego coal field. The following sections illustrate the Neslen Member:

Partial section of Neslen Member measured near Crescent mine 34-20S-19E, by Thomson (1970).

Neslen Member	Feet
1. Shale, gray-green	8.4
2. Sandstone, gray brown weathers rusty, thick-bedded ledge former	5.5
3. Shale, gray	28.9
4. Coal	0.3
5. Shale, gray	18.0
6. Sandstone, medium brown, medium-grained, forms ledge	3.1
7. Coal	1.5
8. Sandstone, like unit 6	5.4
9. Sandstone, light brown, fine-grained, slope former	6.0
10. Shale, gray	17.9
11. Sandstone, gray, medium-grained, medium-bedded	4.0
12. Sandstone, brown weathering to orange, fine-grained, thin-bedded	0.6
13. Coal	0.5
14. Shale and mudstone, gray	7.9
15. Sandstone, light brown weathering white, fine-grained, medium-bedded	6.0
16. Shale, gray	19.2
17. Sandstone, medium brown, fine-grained, with some interbedded shale	2.7
18. Shale, gray	6.0
19. Sandstone, like 15, single bed	1.0
20. Shale, gray	1.0
21. Sandstone, white, medium- to fine-grained, thin-bedded	4.4
22. Sandstone, like 15	3.4
23. Shale, brown and gray	1.0
24. Sandstone, light brown, weathering white, fine-grained, single bed	0.7
25. Shale with thin limestone lens	1.3
26. Coal	0.5
27. Shale, carbonaceous	0.7
28. Coal	3.1
29. Shale, gray	4.7
30. Coal	1.0
31. Shale, gray	22.7
32. Interbedded sandstone and shale, sandstone light brown, fine- to medium-grained and thin-bedded, shale gray to light brown	11.0
33. Sandstone, mottled brown and white, weathers rusty, medium-grained, ledge former with leaf impressions	2.3
34. Interbedded sandstone and shale, like unit 32	16.4
Total measured Neslen Member	217.1
Sego Sandstone	

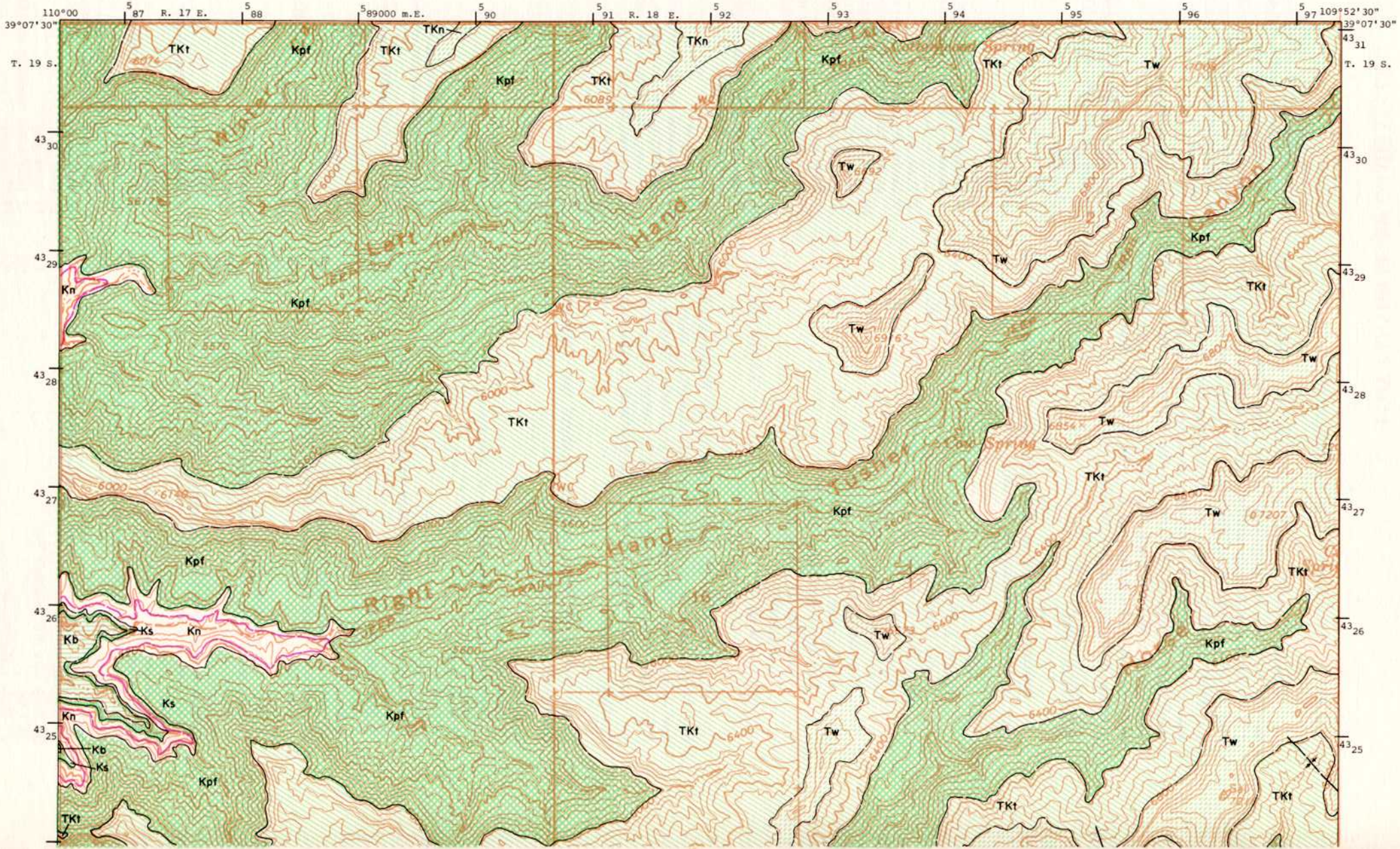
Partial Section of Neslen Member measured on west side of Floy Canyon SE-29-20S-19E, by Thomson (1970).

Neslen Member	Feet
1. Mudstone, gray	0.7
2. Coal	0.8
3. Shale, gray	5.0
4. Limestone, gray	1.0
5. Coal	0.3
6. Shale, gray	25.0
7. Sandstone, light tan, medium-grained, medium- to thick-bedded, ledge former	22.4
8. Shale, gray	11.4
9. Sandstone, yellow brown, weathers tan, medium-grained, thin-bedded, ledge former	5.9
10. Shale with lenses of limestone, gray	9.2
11. Sandstone, light tan, weathers brown, fine- to medium-grained, medium-bedded, ledge former	7.1
12. Shale, gray	23.4
13. Sandstone, like unit 11, but thin-bedded	2.7
14. Interbedded sandstone and shale	1.6
15. Coal	1.0
16. Shale, gray	9.2
17. Sandstone, gray, weathers light brown, fine- to medium-grained, thin-bedded	0.4
18. Coal	0.3
19. Shale, gray	22.9
20. Interbedded sandstone and shale	4.2
21. Sandstone, light tan weathers darker, fine- to medium-grained, thick bed forms ledge	4.0
22. Mudstone, light gray, sandy	5.3
23. Sandstone, like unit 21	4.5
24. Shale, gray	3.1
25. Coal	0.5
26. Clay, white	1.1
27. Coal	1.3
28. Shale, gray	4.7
29. Coal	2.0
30. Shale, gray	8.7
31. Limestone, gray	0.8
32. Shale, gray	7.5
33. Coal	0.5
34. Shale and mudstone, gray	4.4
35. Interbedded sandstone and shale	2.4
36. Shale, gray	7.9
37. Interbedded sandstone and shale	24.4
Total measured Neslen Member	237.6
Sego Sandstone	

Partial section of Neslen Member near Farrer mine, 35-20S-17E, by Thomson (1970).

Neslen Member	Feet
1. Shale, gray	0.3
2. Coal	2.5
3. Shale, gray	4.0
4. Siltstone, light brown to gray	13.8
5. Coal	0.8
6. Shale, gray	12.2
7. Sandstone, light tan, fine-grained, thin-bedded	1.0
8. Shale, gray	11.6
9. Sandstone, light brown, fine- to medium-grained, medium- to thick-bedded, ledge former	11.0
10. Shale, gray	1.5
11. Coal	1.0
12. Shale, gray	6.8
13. Interbedded sandstone and shale	3.0
14. Shale, gray	3.5
15. Sandstone, gray, weathering rust brown, fine- to medium-grained, single bed	1.0

FLOY CANYON S.W., UTAH



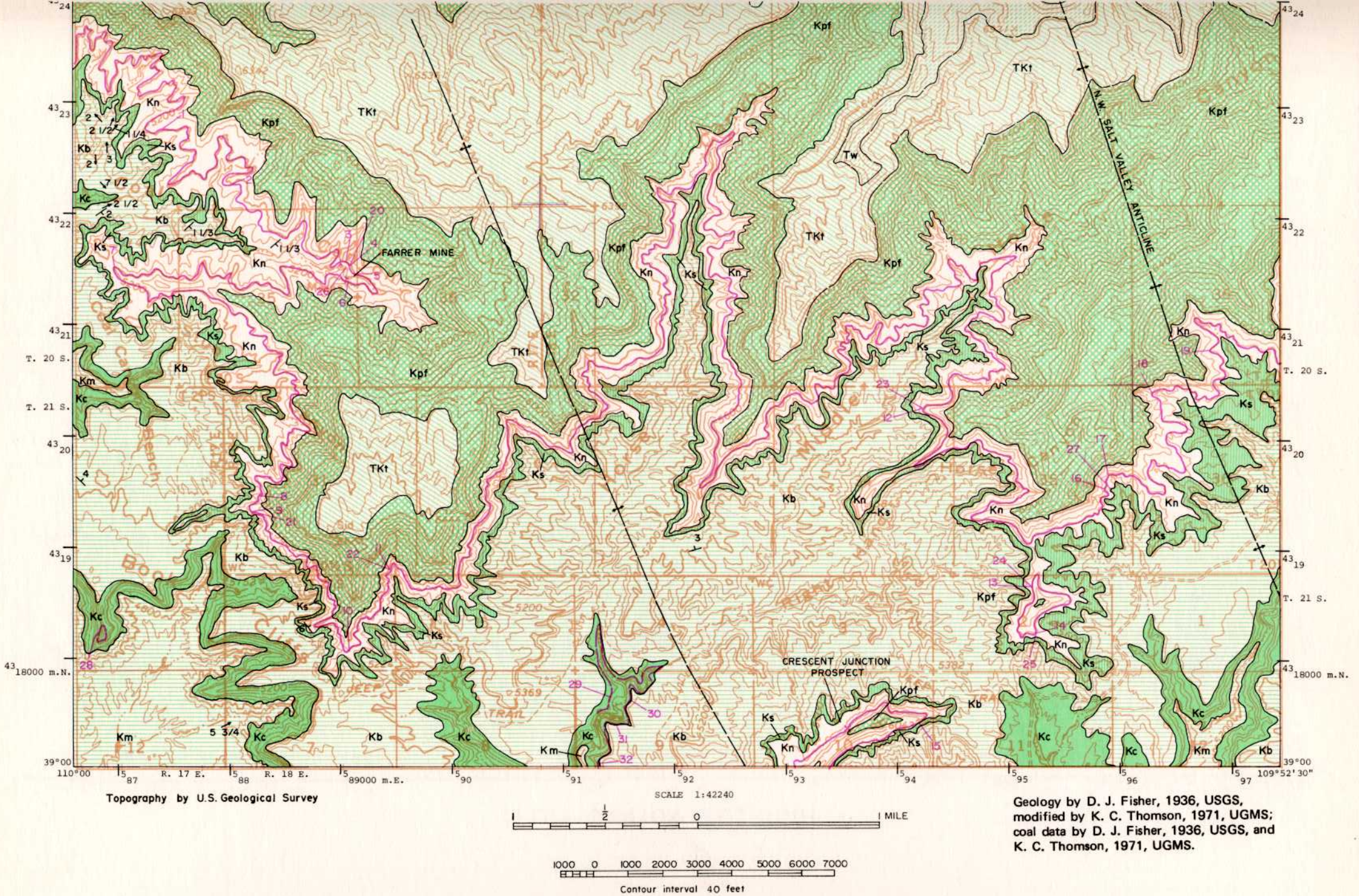
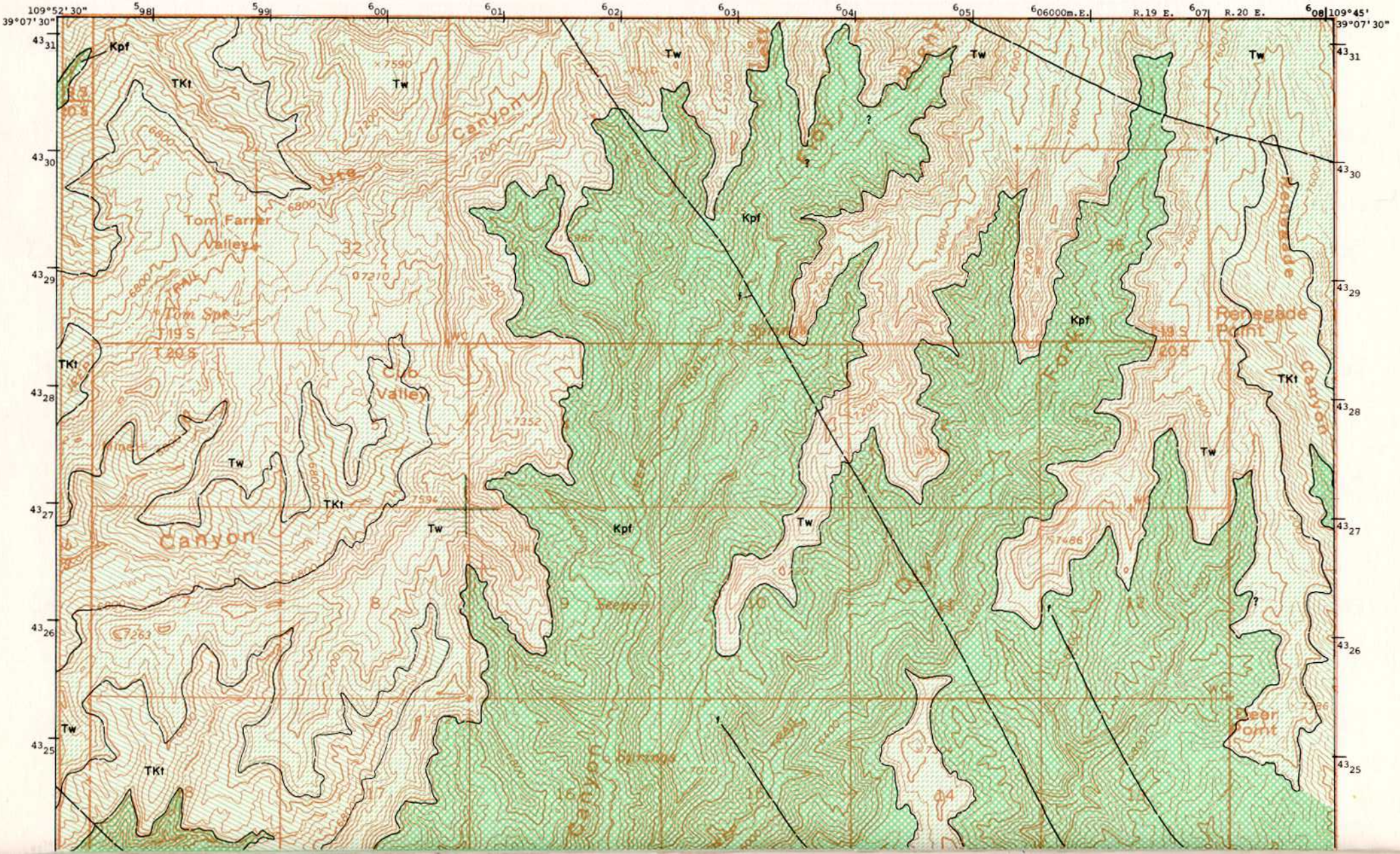


Figure 14. Coal and geology map, Floy Canyon SW quadrangle (explanation pages 218-219).

FLOY CANYON S.E., UTAH



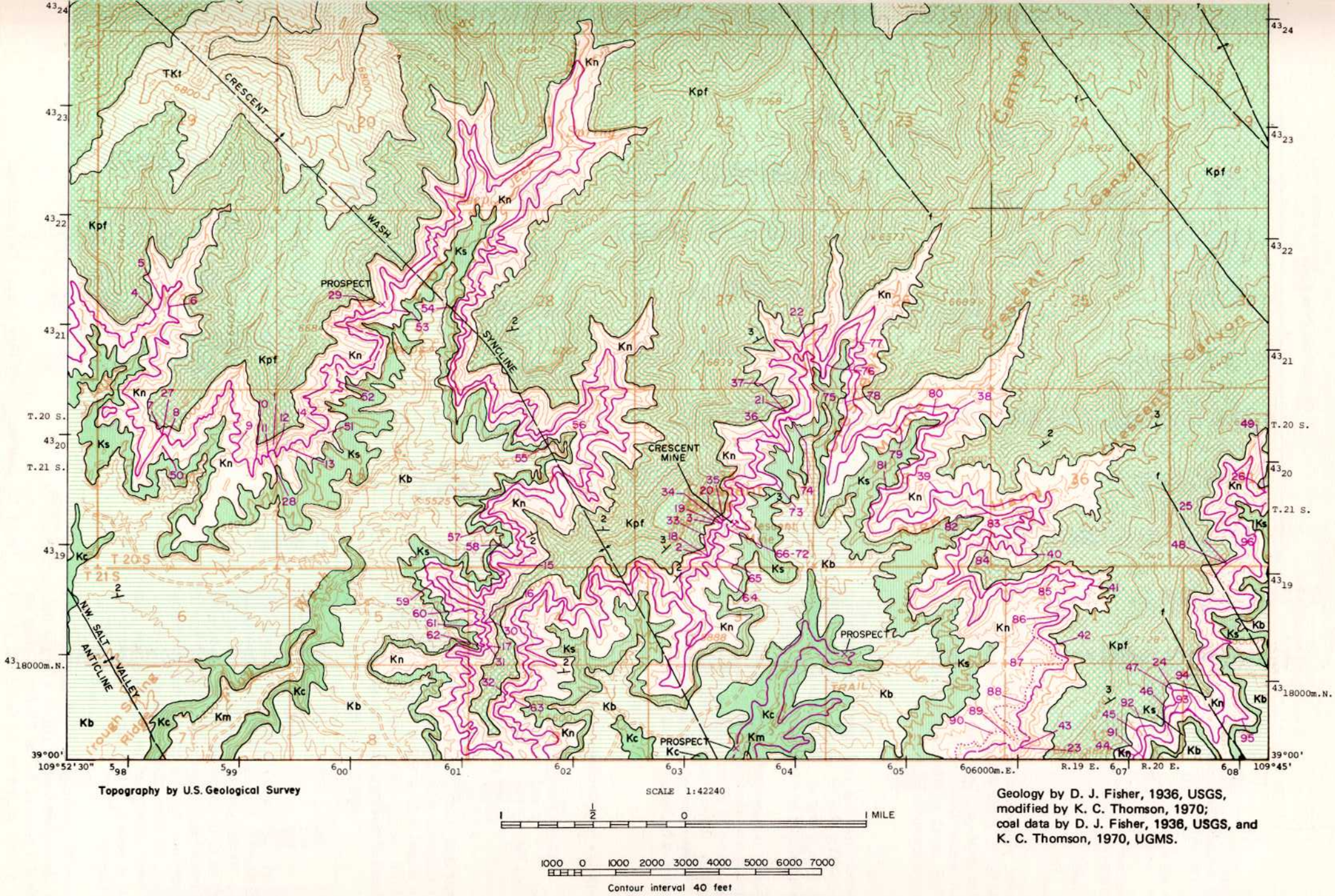


Figure 15. Coal and geology map, Floy Canyon SE quadrangle (explanation pages 218-219).

16. Shale, gray	1.0
17. Coal	3.0
18. Shale, carbonaceous	0.5
19. Coal	1.0
20. Shale, gray	0.8
21. Coal	0.4
22. Shale and mudstone, gray	21.4
23. Sandstone, light brown, medium-grained, thin- to thick-bedded with minor interbedded shale	30.0
24. Shale, gray and brown	9.0
25. Interbedded sandstone and shale	4.6
26. Shale, gray and brown	10.0
27. Coal	0.5
28. Shale and mudstone, gray and brown	3.0
29. Interbedded sandstone and shale, slope former	5.0
30. Shale, gray	1.5
31. Interbedded sandstone and shale	6.8
Total measured Neslen Member	172.5
Sego Sandstone	

The Farrer Member, although termed noncoal bearing, has occasional thin beds within it. Little is known of the Tuscher and Wasatch sequence. Thin local coal beds may be found in these formations as well but mines shown on the topographic maps (especially in 15-19S-18E) north of the south two Floy Canyon quadrangles are abandoned uranium prospects.

STRUCTURE

Several northwesterly trending fold axes affect the south edges of the cliffs in the Floy Canyon area. The folds are gentle with dips ranging from 3 to 6 degrees. All the axes plunge northward. None of the folding should be a serious deterrant to mining.

Faulting, also trending northwesterly, affects the east part of the Floy Canyon SE quadrangle. The faults continue into the Sego Canyon SW area and according to Fisher (1936, p. 87) a total of 11 faults occur; two have throws exceeding 30 feet and the maximum is 85 feet. The separation of faults is adequate so that mining could be accomplished between the fault planes.

PROPERTY CONTROL

Ownership of properties is approximated as follows:

	Floy Canyon SW	Floy Canyon SE
Bureau of Land Management	85.9	87.1
State of Utah	12.6	11.4
Private Property	1.5	1.5

Little of the private land, mostly located in the south fringes of the quadrangles, is underlain with coal. The state lands are mostly scattered in the normal fashion within each township (sections 2, 16, 32 and 36 are normally state land). Currently (January 1, 1970) no leases or permits for coal are active.

COAL

Surface Information

Four coal zones are represented in the Floy Canyon SW quadrangle (figure 16). Nineteen locations attest to the condition of the Chesterfield zone. At all locations the beds are thin. At the Farrer mine, locations 3 to 6, the seams are thickest. At location 6, 2.3 feet of coal, 0.7 feet of impure coal followed by 2.0 feet of coal occur. In the Ballard zone, location 20, also near the Farrer mine, is a bed 3 feet thick. All other locations indicate thin seams. The Palisade zone is either missing or has coal beds less than 1 foot thick. Coal also is present in thin beds in the Castlegate Sandstone along Horse Canyon.

In the Floy Canyon SE quadrangle the first three locations are for beds above the Chesterfield horizon (figure 17). The beds are thin but at location 2 a range of 0.7 to 4.0 feet is given for the thickest seam and a range of 0.8 to 3.0 feet for a second seam. This probably indicates only a local thickening and any

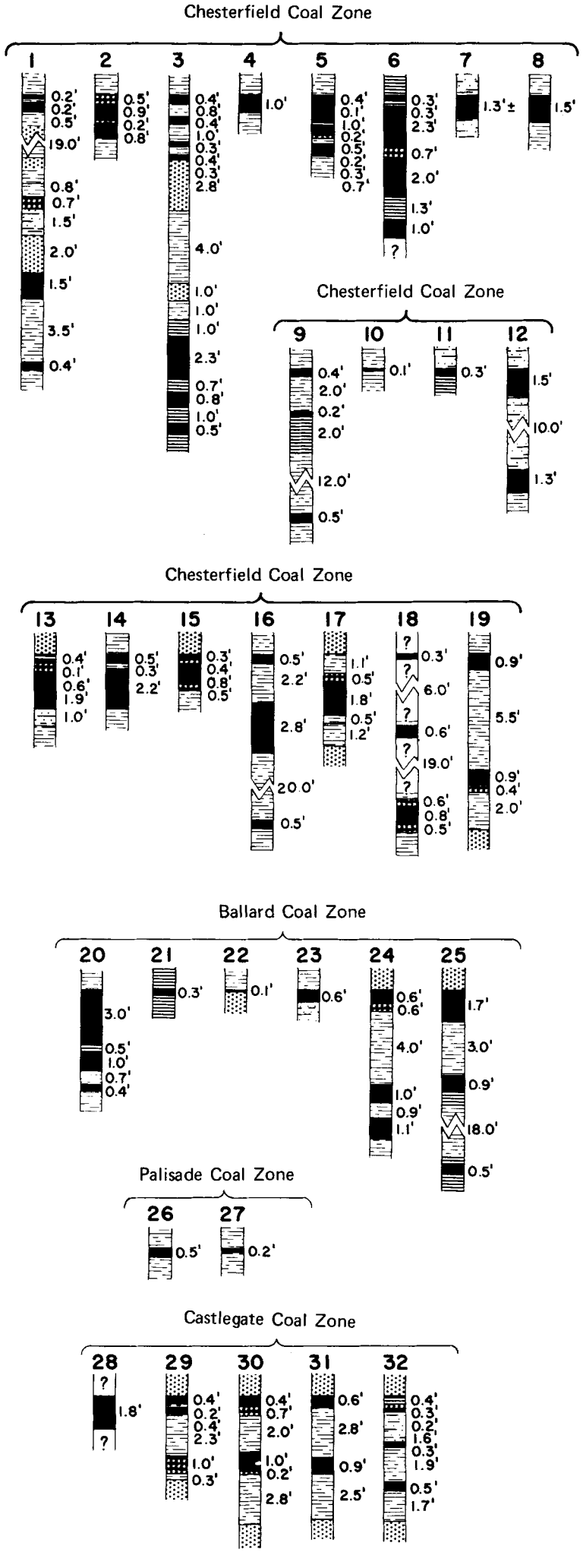


Figure 16. Coal sections of Floy Canyon SW quadrangle (vertical scale: 1 inch = 8 feet).

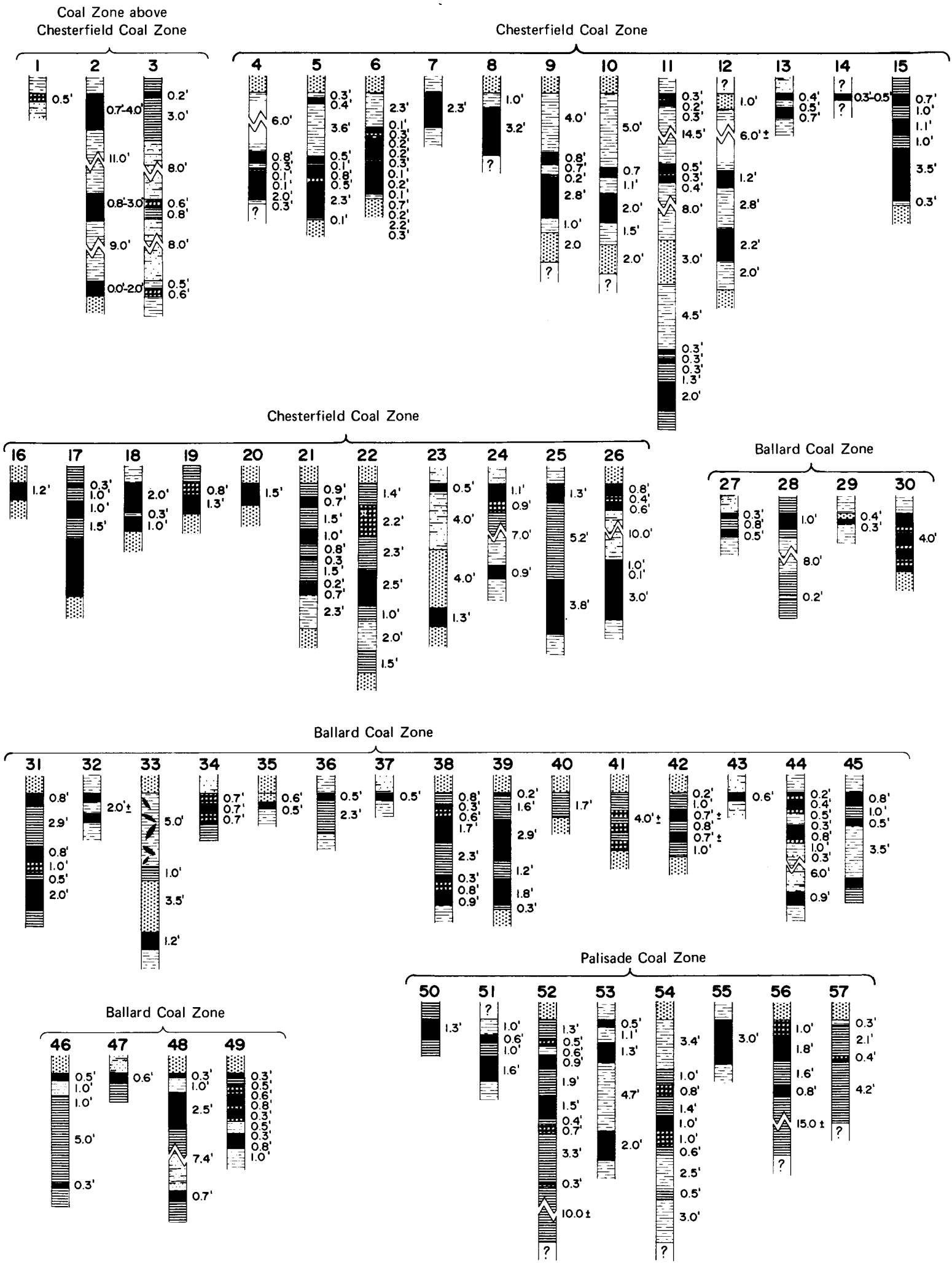
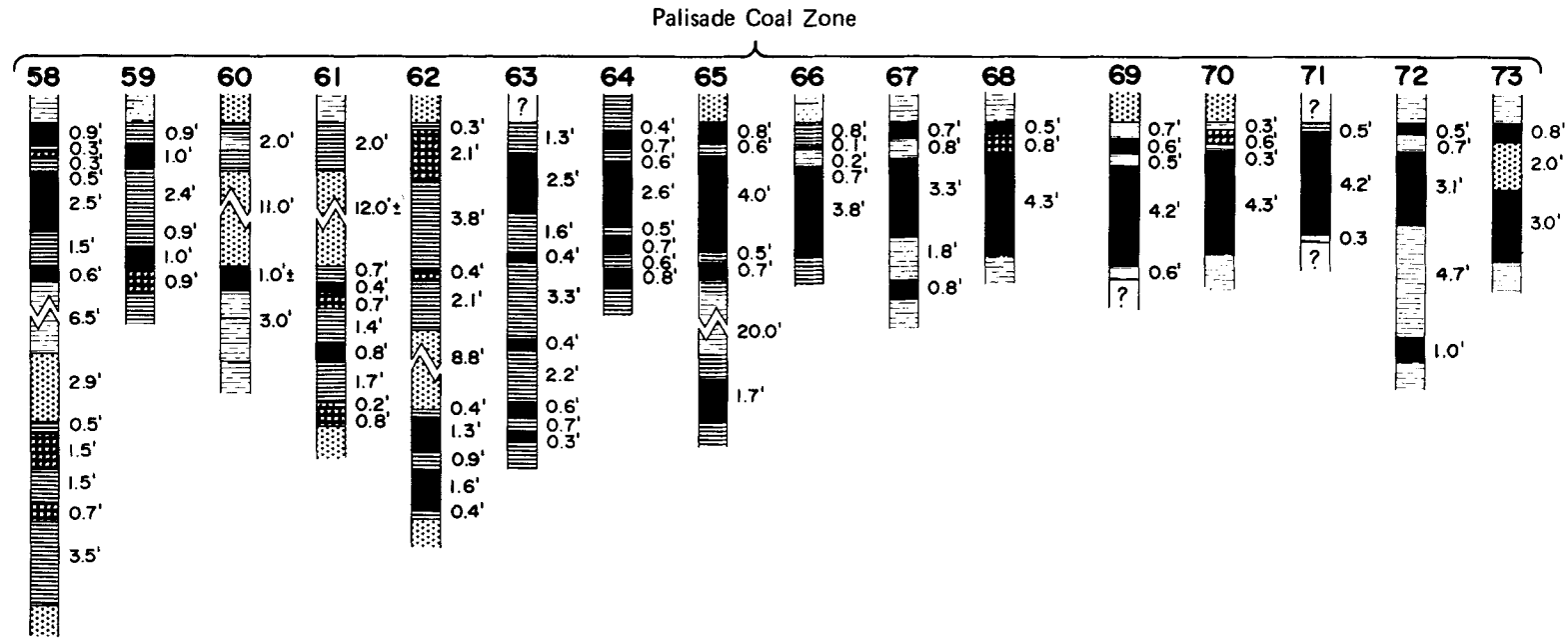
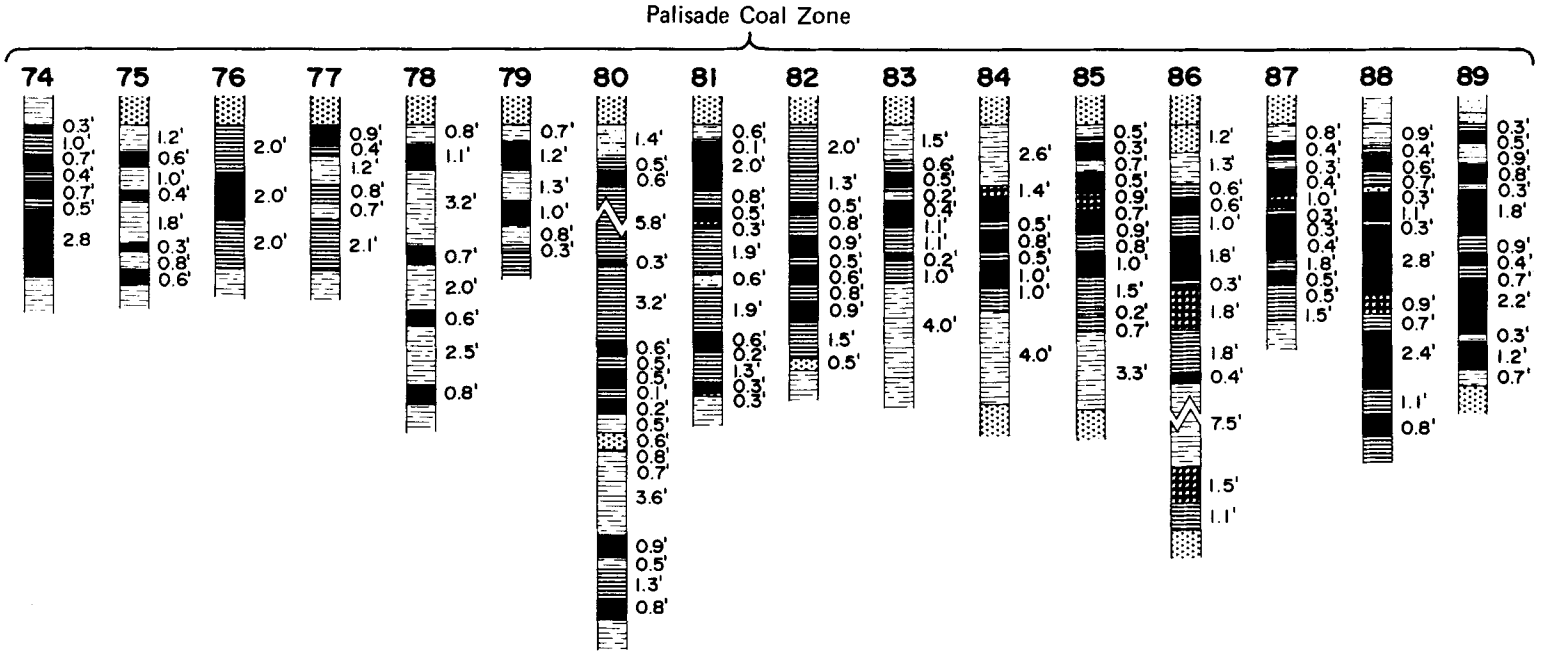


Figure 17. Coal sections of Floy Canyon SE quadrangle (vertical scale: 1 inch = 8 feet).





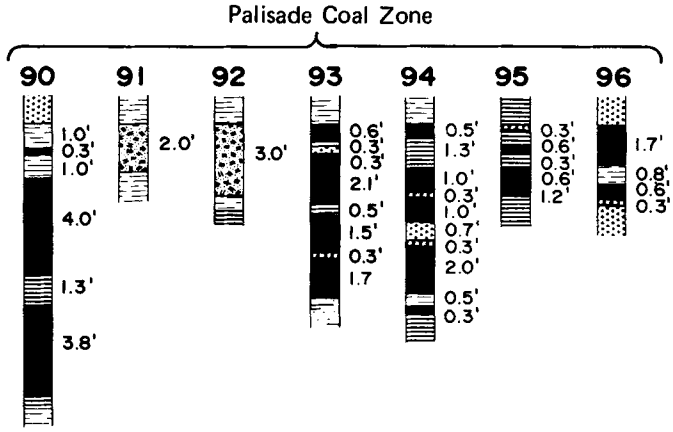


Figure 17. (continued)

appreciable extent of the beds is not expected. Locations 4 to 26 are for the Chesterfield zone. The primary bed ranges in thickness between 1 and 4 feet. Some of the locations indicate thinner coal, but surface exposures are thought to be poor. The primary bed of the zone across the quadrangle is 2.5 feet thick.

Ballard zone locations are numbered 27 to 49. Eighteen of these measured sections show coal 1 foot or less thick. The best showing of the coal is at locations 38 and 39 in the Crescent Canyon area. At location 39, 2.9 feet of coal are followed by a 1.2-foot shale layer followed by 1.8 feet of coal.

The remaining locations are for the lowermost Palisade zone. The best coal bed undulates between 1 and 3 feet thick from locations 50 to 62. The coal thickens to greater proportions on the west side of Crescent Canyon; at locations 63 to 75 the best seams average 3.5 feet. From location 75 to the east map edge the zone breaks up into as many as eight thin seams with each bed 0.3 to 2.0 feet thick. At locations 88 to 90 there is a thickening of at least two seams, an upper one averaging 3.5 feet and a lower one averaging 3.2 feet.

Several adits and prospects shown on the topographic map in the north part of the quadrangles and north of the presented maps are in the Wasatch or North Horn formations and are assumed to be in coal. Nothing is known of these beds and they remain to be explored.

Subsurface Information

None of the area of either quadrangle has lands where the coal is buried under more than 3,000 feet of overburden. The deepest burial is in the northeast corner of Floy Canyon SE quadrangle where overburden may exceed 2,000 feet. Although no drilling to intercept coal has occurred Shamrock Oil and Gas Corp. Well No. 1 Tusher Creek penetrated the entire Neslen in the southeast corner of sec. 36, T. 19 S., R. 18 E. Analysis of logs indicates the presence of coal as follows:

	Feet
Chesterfield zone	2.0
Interval	approx. 30
Ballard zone	
Upper bed	4.0
Interval	4.0
Lower bed	3.0
Interval	150
Palisade zone	5-6
Interval	32
Sego Sandstone	

Quality of Coal

Of the seven analyses of coal for the combined quadrangles, three are from the Chesterfield zone in the Floy Canyon SW quadrangle and four are from the Palisade zone in the Floy Canyon SE quadrangle (table 5). Table 6 lists individual analyses for the zones.

Table 5. Average proximate analysis of coal for the Floy Canyon SE-SW quadrangles.

	Samples	Percent	
		Average	Range
PALISADE			
Moisture	4	8.7	6.5 -13.8
Volatile matter	3	34.9	33.1 -35.8
Fixed carbon	3	43.2	41.7 -44.5
Ash	4	11.2	8.2 -12.6
Sulfur	4	0.6	0.52- 0.70
Btu/lb	2	11,265	11,230-11,300
CHESTERFIELD			
Moisture	3	6.3	5.3 - 7.9
Volatile matter	3	34.2	32.8 -36.2
Fixed carbon	3	44.8	43.1 -47.7
Ash	3	14.8	12.8 -18.0
Sulfur	3	0.7	0.45- 1.0
Btu/lb	1	11,050	11,050

Table 6. Quality data for coal of the Sego coal field.

No.	Mine or Prospect-Coal bed	Township & Range UTM grid		PROXIMATE ANALYSES					ULTIMATE ANALYSES						OTHER TESTS			Kind of Sample	Ref. Source
			AN	M	VM	FC	Ash	S	H	C	N	O	Btu/lb	AST	ADL	HGI		
FLOY CANYON SE QUADRANGLE																			
1	Crescent mine Palisade bed	SE.SE.34–20S–19E 4319320mN 603400mE	A	7.4	35.8	43.3	12.6	.7	5.2	63.4	1.5	16.6	11,230	2,600	1.8	–		7
			B	5.7	37.4	44.1	12.8	.7	5.1	64.5	1.5	15.4	11,440	–	–	–		
			C	–	39.6	46.8	13.6	.8	4.7	68.5	1.6	10.8	12,130	–	–	–		
			D	–	45.9	54.1	–	.9	5.5	79.2	1.9	12.5	14,040	–	–	–		
2	Crescent mine Palisade bed		A	7.1	35.8	44.5	12.6	.6	5.2	64.3	1.4	15.9	11,300	2,580	2.0	–		11
			B	5.2	36.5	45.4	12.9	.7	5.1	65.6	1.4	14.3	11,530	–	–	–		
			C	–	38.5	47.9	13.6	.7	4.7	69.2	1.5	10.3	12,160	–	–	–		
			D	–	44.6	55.4	–	.8	5.5	80.0	1.7	12.0	14,080	–	–	–		
3	Crescent mine Palisade bed		A	6.5	–	–	8.2	.62	–	–	–	–	–	–	–	–		22
4	Crescent mine Palisade bed		A	13.8	33.1	41.7	11.4	0.52	–	–	–	–	–	–	–	–		2
			C	–	38.4	48.4	13.2	0.60	–	–	–	–	–	–	–	–		
FLOY CANYON SW QUADRANGLE																			
1	Black Baby mine Chesterfield bed	NE.35–20S–17E 4321500mN 588940mE	A	5.6	32.8	43.6	18.0	.7	–	–	–	–	–	–	1.9	–		17
			B	3.75	33.41	44.45	18.39	.74	–	–	–	–	–	–	–	–		
			C	–	34.7	46.2	19.1	.8	–	–	–	–	–	–	–	–		
			D	–	42.9	57.1	–	.9	–	–	–	–	–	–	–	–		
2	Black Baby mine Chesterfield bed		A	7.9	36.2	43.1	12.8	1.0	5.2	62.4	1.4	17.2	11,050	2,570	4.9	–		7
			B	3.1	38.0	45.5	13.4	1.0	4.9	64.7	1.5	13.5	11,620	–	–	–		
			C	–	39.3	46.8	13.9	1.1	4.7	67.8	1.5	11.0	11,990	–	–	–		
			D	–	45.6	54.5	–	1.2	5.5	78.7	1.8	12.8	13,920	–	–	–		
3	Black Baby mine Chesterfield bed		A	5.3	33.5	47.7	13.7	0.45	–	–	–	–	–	–	–	–		2
			C	–	35.4	50.3	14.3	0.48	–	–	–	–	–	–	–	–		

Table 6. (continued)

No.	Mine or Prospect-Coal bed	Township & Range UTM grid		PROXIMATE ANALYSES					ULTIMATE ANALYSES						OTHER TESTS			Kind of	Ref.
				AN	M	VM	FC	Ash	S	H	C	N	O	Btu/lb	AST	ADL	HGI	Sample	Source
									SEGO CANYON SW QUADRANGLE										
1	American Fuel mine Ballard zone	SE.NW.27–20S–20E 4322000mN 612800mE	A	6.4	31.9	42.7	19.0	.6	5.0	59.1	1.3	15.0	10,600	–	2.3	–		11
			B	4.1	32.6	43.8	19.5	.6	4.9	60.5	1.4	13.1	10,850	–	–	–		
			C	–	34.1	45.6	20.3	.6	4.6	63.1	1.4	10.0	11,320	–	–	–		
			D	–	42.7	57.3	–	.8	5.8	79.2	1.8	12.4	14,210	–	–	–		
2	American Fuel mine Ballard zone		A	20.0	28.7	38.4	12.9	.5	–	–	–	–	9,300	2,910	18.1	–		11
			B	1.9	35.0	46.8	15.7	.6	–	–	–	–	11,350	–	–	–		
			C	–	35.9	48.0	16.1	.7	–	–	–	–	11,620	–	–	–		
			D	–	42.4	56.8	–	.8	–	–	–	–	13,850	–	–	–		
3	American Fuel mine Chesterfield zone	NW.27–20S–20E 4322200mN 612150mE	A	8.0	33.6	47.1	11.3	.7	–	–	–	–	11,480	2,800	5.6	–		11
			B	8.5	35.6	49.9	12.0	.7	–	–	–	–	12,160	–	–	–		
			C	–	36.5	54.2	12.3	.7	–	–	–	–	12,480	–	–	–		
			D	–	41.6	58.4	–	.8	–	–	–	–	14,510	–	–	–		
4	American Fuel mine Chesterfield zone		A	7.6	–	–	8.2	.57	–	–	–	–	–	–	–	–		22
5	American Fuel mine Chesterfield zone		A	6.4	–	–	8.9	.63	–	–	–	–	–	–	–	–		22
6	American Fuel mine Chesterfield zone		A	8.1	35.3	46.2	10.4	.6	–	–	–	–	11,570	2,910	5.6	–		11
			B	2.5	37.2	48.7	11.0	.6	–	–	–	–	12,260	–	–	–		
			C	–	38.2	50.0	11.2	.6	–	–	–	–	12,800	–	–	–		
			D	–	43.0	56.3	–	.7	–	–	–	–	14,410	–	–	–		
7	American Fuel mine Chesterfield zone	NW.NW.27–20S–20E 4322200mN 612900mE	A	9.6	32.4	47.0	11.0	.5	–	–	–	–	–	–	2.5	–		11
			B	7.3	33.2	48.3	11.3	.5	–	–	–	–	–	–	–	–		
			C	–	35.8	52.1	12.1	.5	–	–	–	–	–	–	–	–		
			D	–	40.7	59.3	–	.6	–	–	–	–	–	–	–	–		
8	American Fuel No. 1 Chesterfield zone	NW.27–20S–20E 4322200mN 612150mE	A	8.0	35.7	45.9	10.4	.7	5.6	65.4	1.4	16.5	11,550	–	5.5	–		11
			B	2.3	37.6	48.4	11.0	.7	5.3	69.2	1.5	12.3	12,220	–	–	–		
			C	–	38.8	49.9	11.3	.7	5.1	71.1	1.6	10.2	12,550	–	–	–		
			D	–	43.7	56.3	–	.8	5.7	80.1	1.8	11.6	14,150	–	–	–		
9	American Fuel No. 1 Chesterfield zone		A	8.0	36.1	46.8	9.1	.6	–	–	–	–	11,790	2,450	5.2	–		11
			B	2.8	37.9	49.2	9.5	.6	–	–	–	–	12,440	–	–	–		
			C	–	39.0	50.5	9.8	.7	–	–	–	–	12,800	–	–	–		
			D	–	43.3	56.0	–	.7	–	–	–	–	14,410	–	–	–		
10	American Fuel No. 1 Chesterfield zone		A	7.4	–	–	7.9	.60	–	–	–	–	–	–	–	–		22
11	American Fuel No. 1 Chesterfield zone		A	7.4	–	–	–	.6	5.1	73.8	1.6	10.4	12,150	–	–	–	T	3
			C	–	38.9	52.6	8.5	–	–	–	–	–	13,120	–	–	–		
12	American Fuel No. 1 Chesterfield zone		A	6.1	37.7	47.8	14.5	.7	–	–	–	–	11,420	–	–	–	T	3
			C	–	–	–	–	–	–	–	–	–	12,170	–	–	–		
13	American Fuel No. 1A Ballard zone	NW.27–20S–20E 4322200mN 612150mE	A	7.1	37.1	45.4	10.4	.66	5.59	65.98	1.45	15.88	11,720	2,960	2.0	–		6
			B	5.3	37.8	46.3	10.6	.67	5.48	67.29	1.48	14.43	11,950	–	–	–		
			C	–	39.9	48.9	11.2	.71	5.17	71.05	1.56	10.27	12,620	–	–	–		
			D	–	44.9	55.1	–	.80	5.82	80.04	1.76	11.58	14,210	–	–	–		
14	American Fuel No. 1A Palisade zone	NW.27–20S–20E 4321250mN 612800mE	A	6.4	37.8	45.2	10.6	.6	–	–	–	–	11,860	2,670	1.3	–		8
			B	5.1	38.3	45.9	10.7	.62	–	–	–	–	12,020	–	–	–		
			C	–	40.4	48.3	11.3	.7	–	–	–	–	12,670	–	–	–		
			D	–	45.5	54.5	–	.73	–	–	–	–	14,280	–	–	–		
15	American Fuel No. 2 Ballard zone	NW.27–20S–20E 4321800mN 612600mE	A	20.0	28.7	38.4	12.9	.5	–	–	–	–	9,300	2,910	18.1	–		9
			C	–	35.9	48.0	16.1	.7	–	–	–	–	11,620	–	–	–		
16	American Fuel No. 3 Palisade zone		A	5.2	37.2	48.1	9.5	.7	–	–	–	–	12,050	2,510	3.2	–		9
			B	2.0	38.2	49.4	9.7	.7	–	–	–	–	12,450	–	–	–		
			C	–	39.2	50.7	10.1	.8	–	–	–	–	12,720	–	–	–		
			D	–	43.2	55.9	–	.9	–	–	–	–	14,150	–	–	–		
17	Nash Canyon outcrop Chesterfield zone	NE.7–20S–21E 4327100mN 618200mE	A	12.7	33.0	50.1	4.2	.5	–	–	–	–	–	–	4.5	–		11
			B	8.6	34.6	52.4	4.4	.5	–	–	–	–	–	–	–	–		
			C	–	37.9	57.3	4.8	.5	–	–	–	–	–	–	–	–		
			D	–	39.8	60.2	–	.6	–	–	–	–	–	–	–	–		
18	Nash Canyon Chesterfield zone	8–20S–21E 4326660mN 619790mE	A	19.4	30.4	39.5	10.7	.37	–	–	–	–	–	–	–	–		2
			C	–	37.7	49.0	13.3	.46	–	–	–	–	9,380	–	–	–		
19	Sego-Sager Ballard zone	36–20S–20E 4319650mN 616150mE	A	10.2	31.0	44.3	14.5	.54	–	–	–	–	–	–	–	–		2
			C	–	34.5	49.4	16.1	.60	–	–	–	–	9,540	–	–	–		
									SEGO CANYON SE QUADRANGLE										
1	Nash Canyon	8–20S–21E 4326660mN 619790mE	A	19.4	30.4	39.5	10.7	0.37	–	–	–	–	9,380	–	–	–		2
			C	–	37.7	49.0	13.3	0.46	–	–	–	–	–	–	–	–		
									WESTWATER CREEK NORTH QUADRANGLE										
1	Outcrop Carbonera zone	SE.30–17S–23E 4350900mN 640710mE	A	10.0	42.2	41.2	6.6	0.61	–	–	–	–	10,270	–	–	–		2
			C	–	46.9	45.8	7.3	0.68	–	–	–	–	11,410	–	–	–		

Walker and Hartner (1966, p. 38) considered one analysis from the Crescent mine in the Palisade zone with respect to kinds of sulfur: sulfate 0.01 percent, pyritic 0.25 percent and organic 0.36 percent for a total of 0.62 percent.

Calculated carbonization product yields for two samples from the Crescent mine (Gomez and others, 1967, p. 13) are as follows (table 7):

Table 7. Carbonization product yields, weight percent maf coal at 500°C, Floy Canyon SE-SW quadrangles.

Char	Water of decomposition	Tar plus light oil	Gas	Gas vol. scf/lb maf coal	Heat val. Btu/scf
70.8	5.6	17.2	5.9	1.023	747
73.7	5.2	15.5	5.4	0.982	773

Mines and Development

Fisher (1936, p. 75) reports the following for the Farrer or Black Baby mine:

The Farrer mine is a local wagon mine 14 miles northeast of the city of Green River. . .It was opened in 1904, and 300 tons were produced that year. Since then the production has varied. It was operated in the late fall and winter of 1924-25 and 400 tons were reported to have been mined. . .In 1925 there were four short entries. Entry 3, which had been abandoned for some time, is more of a circular room with a bulge to the west than it is a tunnel. Many props were used to support the roof, much of which has now fallen in. Entries 1, 2 and 4 are recent; entry 1 leads in 220 feet; entry 2, 110 feet; and entry 4, 45 feet. These resemble tunnels, there having been little attempt to get out extra coal by cutting laterally.

Little is known about any activity since 1925, but reports of production at the mine prior to 1904 are available. The mines presently (1970; table 8) appear to be long abandoned. A minimum of 1,480 tons was reported and perhaps as much as 2,000 tons may have actually been removed during the full life of the Farrer mine.

Table 8. Mines and prospects of the Floy Canyon SE-SW quadrangles.

Mine	Location	Remarks
Black Baby mine (Farrer)	NW.35-20S-17E 4,321,500m.N. 588,940m.E.	1898-1925 intermittent activity
Crescent mine	SW.SE.34-20S-19E 4,319,320m.N. 603,400m.E.	1920-1948 intermittent activity
Crescent Junction prospects		
No. 1	SE.29-20S-19E 4,321,080m.N. 600,840m.E.	Activity unknown
No. 2	NE.10-21S-19E 4,317,770m.N. 603,520m.E.	Activity unknown
No. 3	SW.2-21S-19E 4,318,340m.N. 604,360m.E.	Activity unknown

The Crescent mine also is reported by Fisher (1936, p. 81):

The Crescent mine in section 34 was opened several years prior to 1925. . .From 1925 to 1927 it produced several hundred tons of coal. In 1926 it consisted of a single entry heading northwest about 260 feet in length, with branches at 45 feet in, 85 feet to the northeast; at 110 feet in, 115 feet to the northeast, and at 160 feet in, 165 feet to the southwest. The entries are about 20 feet wide and 5½ feet high. The coal has a notable amount of resin in it, and thin veinlets filled with paper-like sheets of a mineral, probably marcasite or pyrite (FeS_2) are common. Films of calcite ($CaCO_3$) are also present along the joint planes. About half the coal is bright, and it is well jointed in one direction. From the appearance of lumps that had presumably been dumped at the portal for some time, the weathering and shipping qualities would seem to be good.

Little is known about the activity of the mine after 1925. The last available production report is from 1948. The mine probably operated intermittently during the interval with long periods of no activity. Minimum production is 3,000 tons and as much as 5,000 tons may have been extracted. Nothing is known about the Crescent Junction prospects except that if any production were achieved, the figures would be expected to be negligible.

Reserves

Tonnage estimates evaluated by Fisher (1936, p. 56) are repeated here (table 9). He based his measurements on an area extending along the cliff not more than 2 miles behind the generalized outcrop.

Table 9. Coal reserve estimates of the Floy Canyon SE-SW quadrangles.

	Average thickness (feet)	Area in acres	Tons x 10^6
T. 20 S., R. 17 E.			
Chesterfield	1.5	2.45	4.0
T. 21S., R. 18 E.			
Chesterfield	2.0	0.68	2.0
Ballard	1.5	0.07	0.1
T. 21 S., R. 19 E.			
Palisade	2.0	0.30	0.7
Upper Blackhawk, high[1]	2.0	1.90	4.0
Upper Blackhawk, low[1]	2.0	0.02	0.1
T. 20 S., R. 19 E.			
Chesterfield	2.5	0.65	2.0
Palisade	2.5	1.35	4.0
Total coal			16.9

[1]Mapped with Castlegate Sandstone.

The present author cursorily examined the area and does not dispute the calculation. The basic data (coal sections measured and average seam thickness) agree except when considering local areas. The Palisade zone is probably the best developed in the SE quadrangle and for a short distance near the Crescent mine averages 4 feet. The drill hole in 36-19S-18E infers the presence of a 4-foot bed in the Ballard and a 5- to 6-foot bed in the Palisade zone. A 1½-square mile area afforded the drill hole and a 1-square mile allowed the Crescent mine area would total 11.2 million tons for the Palisade zone and 6.7 million tons for the Ballard zone in beds 4 feet or more thick. The degree of reliability is not good so that the reserve is best placed in the inferred or Class III category. The best potential area is in the east part of the SE quadrangle and other local blocks might be located in the future by the drill bit.

PRINCIPAL WORK

Data are primarily from Fisher (1936) supplemented by Thomson (1970).

View in Sego Canyon in area of old Ballard mine (in gulch to right) and the Chesterfield mines (both sides of main canyon). Prominent sandstone in the middle ridge is the Thompson Canyon Sandstone bed; the Ballard coal lies below and the Chesterfield coal lies above. The coal is in the Neslen Member and the uppermost sandstone beds in the photo are in the Farrer Member of the Price River Formation.

SEGO CANYON SW QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Sego Canyon SW quadrangle is located immediately north of Thompson (figure 11), a small settlement along the main line of the Denver and Rio Grande Western Railroad and along U. S. Highway 50-6. The south edge of the quadrangle lies 3 miles north of Thompson. About 1½ miles north of the south map edge (figure 18) the graded road from Thompson forks and provides access to Thompson Canyon and Sego Canyon. These roads soon deteriorate a few miles up the canyons. The abandoned ghost town of Sego is reached 1 mile north of the junction in Sego Canyon.

The area is rugged and cliffy. Elevations range from about 5,400 feet to nearly 8,000 feet. The coal crops out between 5,800 and 6,400 feet above sea level along the cliff faces and canyon walls.

STRATIGRAPHY

The Mancos Shale is exposed at the mouths of a few canyons along the south map margin. The unit consists of medium to dark gray shales which weather to slightly lighter shades. It is limy and carries veinlets of gypsum and calcite. Efflorescences of alkali salts are often seen on its surface. At irregular intervals thin beds of sandstone or siltstone weather gray or brown. The Mancos forms a rolling plain or badland-type hills. In the Sego Canyon SW quadrangle it is best seen in the lower part of the Castlegate cliff, being supported by the overlying formation and appearing like a gray curtain. The unit is an estimated 4,000 feet thick.

The initial cliff is formed by the Castlegate Sandstone and what remains of the Blackhawk Formation which thins and disappears eastward. The two units together are about 200 feet thick. The dominant lithology is cliff-forming medium- to massive-bedded sandstone, yellow-gray to tan in color. The individual sandstone beds are separated by various thicknesses of gray shale. A prominent bench has developed on the Castlegate from which the Buck Tongue of the Mancos has been eroded. This bench or dip slope is up to 2 miles wide.

The Buck Tongue is the same as the Mancos in appearance, lithology and weathering characteristics. It lies at the base of the second and major line of cliffs and is about 200 feet thick.

The Buck Tongue is overlain by a cliffy sandstone similar to the Castlegate known as the Sego Sandstone. A section measured by Fisher (1936, p. 28) in the west half of 5-21S-20E describes the unit:

Sego Sandstone	Feet
Sandstone, massive, cross-bedded, buff to light gray, cliff maker	58
Sandstone and shale (20 percent); forms a slope with minor sandstone ledges; carries poorly preserved fossil plants; sandstone like unit below and Mancos-like shale	86
Sandstone, fairly massive, buff to light gray	49
Total	193

The Neslen Member of the Price River Formation overlies the Sego and is the most important unit because of the coal it bears. The Neslen is a heterogeneous unit of sandstone and shale. The sandstone is like that of the Sego, although thinner, less persistent and forming less pronounced cliffs. The Neslen consists of an equal amount of shale, much of which is carbonaceous. Here and there a coal bed may be observed as well. A rather persistent middle sandstone bed may be noted in the Sego Canyon SW quadrangle and was named by Fisher (1936, p. 18) the Thompson Canyon sandstone bed. It is an important marker inasmuch as the Chesterfield coal bed lies a short stratigraphic interval above it and the Ballard coal bed immediately below it. At least three important coal zones occur in the Neslen in this quadrangle. The average thickness is believed to be 350 feet for the entire interval. Measured sections follow which describe the Neslen in more detail:

Section of Neslen Member measured by Fisher (1936, p. 27, 28) SE.32-20S-20E.

Price River Formation
Farrer noncoal-bearing member (not measured)

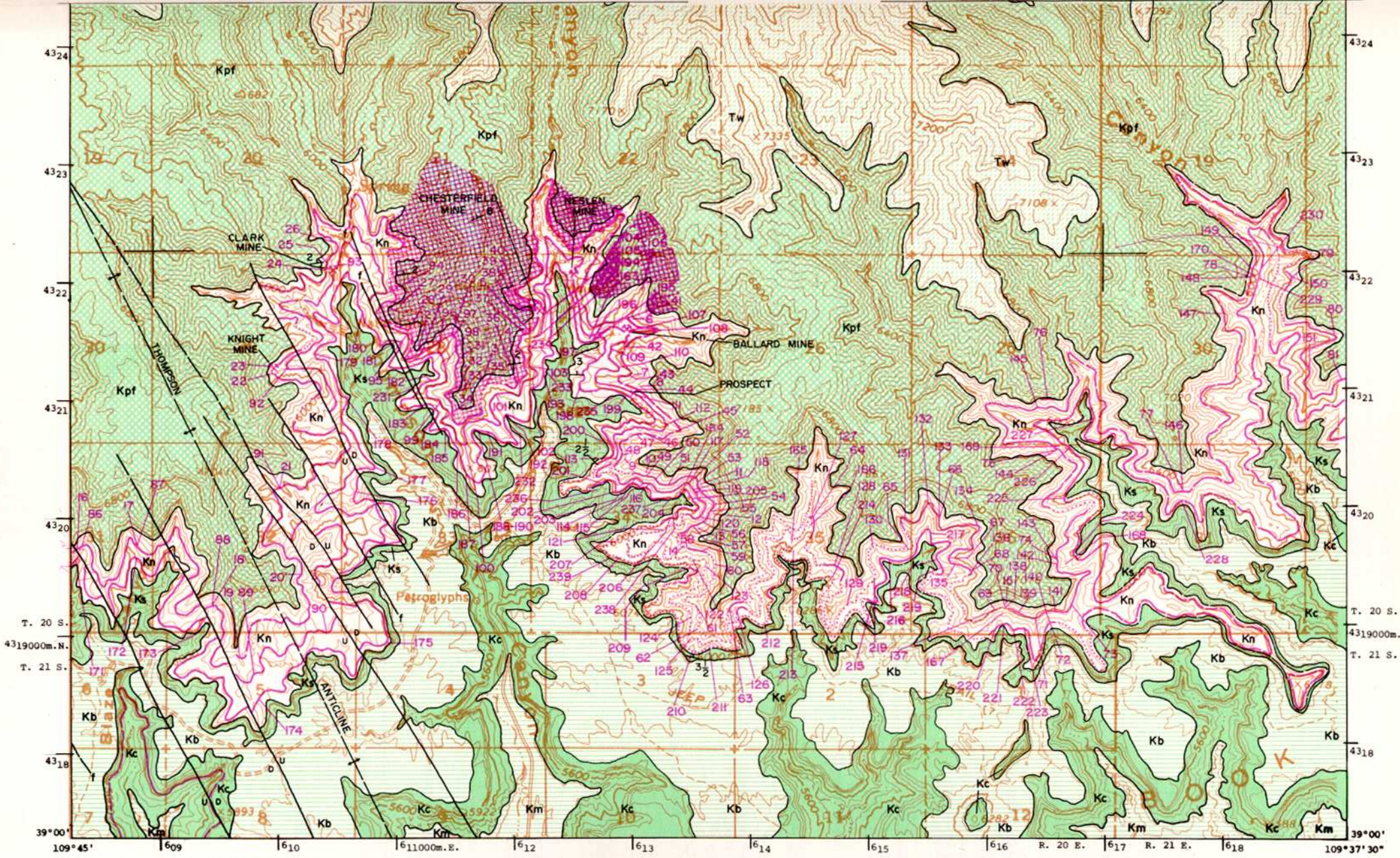
Neslen coal-bearing member	Feet
Sandstone, light gray to buff; minor ledge	2
Shale, medium gray	17
Sandstone, with shaley zone in upper part, sandstone carries thin slabs (pebbles) of shale; lower 20 feet form a light gray ledge	45
Shale, medium gray	17
Sandstone, light gray to buff, cross-bedded, friable	14
Shale, with minor sandstone, light gray to buff, shale medium gray above, partly dark gray below; slope-forming unit, largely concealed	90¾
Sandstone, light gray to buff	2
Coal, bone and shale (Chesterfield coal zone)	6¼
Shale, brown	8
Sandstone, buff yellow; massive ledge with rounded surface (Thompson Canyon sandstone bed)	18
Coal and shale (Ballard coal zone)	5
Shale, buff to medium gray	7
Sandstone, buff, massive, cross-bedded, blocky ledge, lenticular, giving way laterally to shale	32
Shale, buff to medium gray, with four thin coal seams	29
Sandstone, buff to gray, forming a rather blocky minor ledge	19
Shale, sandy, medium to light gray	1
Coal (Palisade zone)	1
Sandstone and shale, making a slope; lower third is thin-bedded light gray sandstone; upper part is medium- to light-gray sandy shale	45
Total Neslen coal-bearing member	359

Section of Neslen Member measured in Sego Canyon, sec. 27-20S-20E, by Thomson (1970).

Farrer Member: (lowermost bed) sandstone, brown, medium-grained, poorly sorted, massive, cliff former, weathers to light brown.

Sego Member	Feet
1. Shale, gray	17.9
2. Sandstone, brown and white, medium-grained, medium-bedded, ledge former	5.1
3. Shale, gray	3.9
4. Sandstone, light brown, medium-grained, massive cliff former, cross-bedded	20.0
5. Mudstone	1.5
6. Sandstone, like unit 20, but not cross-bedded	18.0
7. Shale, gray	13.6
8. Sandstone, light brown, medium-grained, single bed	0.9
9. Shale, gray	15.8
10. Sandstone, brown, medium-grained, thick bed and ledge former, weathers orange and is cross-bedded	3.1
11. Shale, gray	11.3
12. Sandstone, like unit 10, fossil leaves	2.4
13. Shale, gray with interbedded light brown mudstone	4.7
14. Sandstone, like unit 10, without cross-bedding	2.9
15. Shale, gray	14.2
16. Coal	3.5
17. Shale, gray	9.5
18. Coal (Chesterfield zone)	6.5
19. Interbedded sandstone and shale, sandstone fine-grained and thin-bedded, shale brown and gray	11.8
20. Sandstone, light brown-gray, medium-grained, massive cliff former	15.0
21. Shale, brown-gray	1.0
22. Coal (Ballard zone)	6.0
23. Shale, gray	2.0
24. Mudstone	3.0
25. Shale, gray and carbonaceous	1.0
26. Mudstone, brown	12.0
27. Shale, gray	14.0
28. Covered	37.7
29. Sandstone, light brown, fine-grained, medium-bedded, ledge former	7.2
30. Covered, probably interbedded sandstone, shale and coal	8.7
31. Shale, gray black with some thin coal	14.4

SEGO CANYON S.W., UTAH



Topography by U.S. Geological Survey

SCALE 1:42240

1 0 1/2 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000

Contour interval 40 feet

Geology by D. J. Fisher, 1936, USGS, modified by K. C. Thomson, 1970, UGMS; coal data by F. R. Clark, 1914, USGS, D. J. Fisher, 1936, USGS, and H. H. Doelling, 1971, UGMS.

32. Interbedded sandstone and shale, like unit 19 ..... 2.9
33. Sandstone, brown-gray, fine-grained, thin-bedded 9.4
Total Neslen Member 300.9
Sego Sandstone

Partial section of Neslen Member, measured by Fisher (1936, p. 29, 30). East side of Sagers Canyon in NW ¼ sec. 32-20S-21E.

Price River Formation
Neslen coal-bearing member — Feet
Sandstone, massive, cross-bedded, buff gray, friable 25
Shale, weathers medium gray, slope 27
Sandstone, buff-gray, minor ledge 5
Shale, brown, weathering medium light gray, carries a few thin layers of sandstone and nodules of brownish silty clay ironstone, 1 foot of coal and boney shale 3 feet below top 29
Sandstone, shaley, thin-bedded, buff to gray; lower part contains some shale and a lens of fine-textured limestone 23
Bone and coal 1¼
Shale, brown 5
Coal, bone and shale, carbonaceous (Chesterfield zone) 5½
Shale, sandy in lower part 12½
Sandstone, buff, thin-bedded, and shaley except for upper 1½ feet, which make a minor ledge 11
Sandstone (Thompson Canyon sandstone bed); lower 11 feet are buff-brown, blocky; upper 9 feet are buff yellow, massive, weathering to semirounded surfaces 20
Coal, bone and shale (Ballard zone) 5¼
Concealed, probably shale, more or less sandy 34¼
Sandstone, shale, thin-bedded, buff 10
Sandstone, fairly massive, cross-bedded, buff to gray; minor ledge 9½
Coal, boney, and carbonaceous shale (higher Palisade) 2¼
Sandstone, thin-bedded, shaley, buff 41
Shale, brown to medium gray 2½
Coal, boney, with a 1-inch brown-shale parting (lower Palisade) 1¼
Shale 3¾
Sandstone, thin-bedded, light gray-buff, minor ledge 2
Sandstone, thin-bedded, shaley, buff; mostly concealed 23
Total measured Neslen coal-bearing member 299

Partial section of Neslen Member measured in sec. 36-20S-20E, by Thomson (1970).

Feet
1. Shale, gray-black, carbonaceous 33.6
2. Sandstone, brown, fine-grained, calcareous, massive, cliff former 24.8
3. Shale, carbonaceous 5.8
4. Coal 1.2
5. Sandstone, brown, fine-grained, ledge former 1.1
6. Mudstone, gray 2.8
7. Shale, carbonaceous 5.4
8. Coal 1.0
9. Shale, carbonaceous 1.9
10. Coal 0.6
11. Shale, carbonaceous 11.2
12. Sandstone, tan, medium-grained, friable, but massive cliff former 8.6
13. Shale, carbonaceous 1.4
14. Coal 1.5
15. Shale, carbonaceous 2.7
16. Coal 1.1
17. Shale, carbonaceous 1.1
18. Coal 2.6
19. Sandstone, light brown, fine-grained, ledge 0.8
20. Shale, gray to black and carbonaceous 3.2
21. Interbedded sandstone and shale 12.5
22. Sandstone, like unit 19, thin-bedded 18.0
23. Shale, carbonaceous 1.0
24. Coal 4.0
25. Sandstone, like unit 22, but medium-grained 7.0
26. Shale, carbonaceous 1.0
27. Coal 1.5
28. Shale and mudstone, brown and gray 7.0
29. Interbedded mudstone and sandstone, brown and red brown 3.5
30. Interbedded sandstone and shale, sandstone fine-grained and thin-bedded, shale gray to black 8.0
31. Shale, gray, black and carbonaceous 17.6
32. Coal 1.1
33. Shale, gray 5.0
34. Sandstone, gray-brown, fine- to medium-grained, massive ledge former 4.2
35. Interbedded sandstone and shale, like unit 30, but some medium beds 14.5
36. Coal 1.2
37. Bone 0.4
38. Coal 4.3
39. Shale, carbonaceous 1.6
40. Interbedded sandstone and shale, like unit 30 ..... 5.8
41. Coal 1.5
42. Shale, carbonaceous 1.0
43. Coal 0.7
44. Shale, carbonaceous 0.5
45. Coal 1.4
46. Shale, gray 4.1
47. Sandstone, light gray-brown, fine-grained, ledge former, speckled with carbonaceous matter 3.5
48. Interbedded sandstone and shale, like unit 30 ..... 15.0
Total measured Neslen Member 259.3
Sego Sandstone

The Neslen Member is succeeded by the Farrer Member, which is similar to the Neslen except for a larger percentage of sandstone and a paucity of coal beds. Generally the Farrer consists of fine- to medium-grained sandstone interbedded with siltstone and shale with a few coarse-grained beds and the bedding is thin to massive. The shales are normally dark gray, some with a greenish tint, and silty. The Farrer Member was measured in Thompson Canyon by Gross (1961, p. A 34-35) as 974 feet thick. The Farrer is the uppermost member of the Price River Formation and the Mesaverde Group.

The following Tuscher Formation is difficult to distinguish from the underlying Farrer. The sandstones of the Tuscher are often conglomeratic and coarser-grained. The Tuscher probably straddles the Cretaceous-Tertiary time line. The unit is variable in thickness, ranging from 250 to 450 feet and is incompletely differentiated on the map.

The uppermost Wasatch beds are exposed on the cliff tops and are a fluvial deposit of lenticular sandstones, shales and siltstone. The color of the beds is red-brown with some yellow. The thickness of the unit is unknown in the Sego Canyon SW quadrangle.

STRUCTURE

Clark (1914, p. 457) notes that the structure in the Thompson and Sego Canyon areas is simple and regular. The beds dip gently 2 to 3 degrees northward. Locally in Sego Canyon the dip increases to 5 degrees. A synclinal axis parallels Sagers Wash and an anticlinal axis is located just east of Nash Canyon along the east map edge. Between the axes dips range 3 to 5 degrees, but locally increase to 7 degrees. East of Thompson Canyon the structure becomes more complex. Dips surrounding the Thompson Canyon anticline are gentle but a series of northwest-trending faults occurs. According to Fisher (1936, p. 87) the area is cut by eleven faults. Two of these have throws exceeding 30 feet with a maximum of 85 feet. Four small grabens and a horst are formed between the normal faults.

PROPERTY CONTROL

The lands of the Sego Canyon SW quadrangle are owned by the Bureau of Land Management (80.6 percent), the state of Utah (12.4 percent) and privately (7.0 percent). As of January 1, 1970, one section (640 acres) was held as a state lease by T. J. Peterson. One hundred and sixty acres of private land are being taxed as coal land and are owned by Glenn & D. H. Lile. Essentially state-owned property follows the standard school land pattern, sections 2, 16, 32 and 36 of a township. Private lands are concentrated in the lower parts of Thompson and Sego canyons. Some of the private lands originally were secured as coal land. About 20 percent of the quadrangle, located along the south map margin, are noncoal land.

COAL

Surface Information

Clark (1914, p. 458) lists three important seams in the Thompson Canyon area which he designates beds A, B, C with A

the lowest. Fisher (1936, p. 86) agrees and named the zones: the lower bed (A) is the Palisade coal zone, located approximately 30 feet above the Sego Sandstone; bed B is the Ballard coal zone, 130 feet above the Sego and the highest bed (C) is the Chesterfield coal zone, 150 feet above the base of the Neslen. A prominent sandstone bed, the Thompson Canyon sandstone bed, lies between the Ballard and the Chesterfield zones.

Two hundred and thirty-nine measured coal sections document the condition of the seams throughout the quadrangle (figure 19). Some thin beds occur above the Chesterfield zone which are represented by locations 1 to 15. The thickest bed is 2.3 feet and its extent at that thickness is local. The Chesterfield zone is represented by locations 16 to 85. West of Thompson Canyon the zone is split into several seams and the individual seams often are split again by boney coal. The thickest measured single seam is 3.6 feet and the average thickest bed is 2.6 feet.

In the mined-out area between Thompson and Sego canyons (locations 27 to 40) the thickest bed measured is 7.7 feet with a 0.1-foot boney split. The main bed is more consistent and splitting is minor. The average thickness is 4.9 feet. Locations 41 to 62 are measured on the east side of Sego Canyon where the main bed continues, but is thinner. In part of the area two seams of nearly equal thickness separated by 2 to 10 feet of shale are common. The average thickness of the thickest bed across the interval is 3.8 feet. Locations 63 to 81 extend to Sagers Canyon. Between Sego and Sagers canyons the individual beds thin markedly or are badly split. In Sagers Canyon the bed averages 4 to 6 feet. On the west side of Nash Canyon the Chesterfield zone beds again exceed 4 feet thick. Farther east the Chesterfield thins.

The Ballard zone is represented by sections 86 to 162. It is the most easily observed zone and often can be discerned from the canyons below. Locations 86 to 93 are west of Thompson Canyon and all indicate badly split seams. The average coal thickness is 2.6 feet. The trend continues to Sego Canyon (locations 94 to 105), but the average coal thickness is up to 3 feet. On the east side of Sego Canyon (locations 106 to 125) the coal still is split, usually with two to three partings involving 0.2 to 2.3 feet of waste. The average thickness of the Ballard coal here is 4.3 feet. Locations 126 to 151 cover the area to Sagers Wash. At most locations two seams have a total coal averaging 4.5 feet. The beds combine into a single bed on the east side of Sagers Canyon. The remaining locations (152 to 162) are in Nash Canyon where an apparent northward-thickening of beds occurs. Locations 152 to 154 indicate coal 1.5 to 2.0 feet thick and sections 161 and 162 across the canyon show 2.5 feet of coal. The remaining sections average 5.1 feet of coal.

Locations 163 to 170 are beds between the Ballard and Palisade zones. Between Thompson and Sagers canyons these beds occur up to 4.3 feet thick. Locations 171 to 230 are on the Palisade zone. West of Thompson Canyon the beds are thin (through location 179) with individual beds rarely exceeding 2 feet. Between Thompson and Sego canyons (through location 194) one to three beds at each location average 3.5 feet. The Palisade zone is best developed on the east side of Sego Canyon from locations 195 to 208. A single seam persists in this interval ranging in thickness from 3.5 feet to 5.8 feet and averaging 4.4 feet. Farther east the Palisade zone breaks into many individual seams each separated from the other by an average of 1 foot of waste. The average thickness of 2.3 feet is registered for the most important bed at each location. The Palisade seems little developed in Nash Canyon and is either absent or represented by coal seamlets (less than 1 foot thick).

A few beds are located below the Palisade zone, but all beds are thin, the thickest discovered being 1.7 feet. Thin coal beds also are present in the Castlegate Sandstone west of Thompson Canyon.

Subsurface Information

No drill holes are available for the Sego Canyon SW quadrangle. Approximately 80 percent of the quadrangle are underlain with coal; by extrapolating the dip and considering the surface rise in elevation, little if any of the quadrangle area has more than 3,000 feet of overburden above the coal.

Quality of Coal

A summary of proximate analyses is given in table 10. Table 6 gives individual analyses for the quadrangle. Not enough samples are available to adequately test the Palisade zone. The Ballard is higher in ash and subsequently lower in Btu/lb because of the necessity of mining splits. Walker and Hartner (1966, p. 38) subdivided the sulfur content into components (table 11).

Table 10. Average proximate analysis of coal, Sego Canyon SW quadrangle.

	Samples	Percent	
		Average	Range
CHESTERFIELD ZONE			
Moisture	12	9.1	6.1 -19.4
Volatile matter	9	34.8	30.4 -38.9
Fixed carbon	9	47.0	39.5 -52.6
Ash	12	9.6	4.2 -14.5
Sulfur	12	0.59	0.37- 0.7
Btu/lb	7	11,280	~ 9,000-12,150
BALLARD ZONE			
Moisture	4	10.9	6.4 -20.0
Volatile matter	4	32.2	28.7 -37.1
Fixed carbon	4	42.7	38.4 -45.4
Ash	4	14.2	10.4 -19.0
Sulfur	4	0.6	0.5 - 0.66
Btu/lb	4	10,230	9,300-11,720
PALISADE ZONE			
Moisture	2	5.8	5.2 - 6.4
Volatile matter	2	37.5	37.2 -37.8
Fixed carbon	2	46.7	45.2 -48.1
Ash	2	10.1	9.5 -10.6
Sulfur	2	0.65	0.6 - 0.7
Btu/lb	2	11,955	11,860-12,050
ALL ZONES COMBINED			
Moisture	18	9.1	5.2 -20.0
Volatile matter	15	34.5	28.7 -38.9
Fixed carbon	15	45.8	38.4 -52.6
Ash	18	10.7	4.2 -19.0
Sulfur	18	0.59	0.37- 0.7
Btu/lb	13	11,053	~ 9,000-12,150

Table 11. Sulfur content of samples from Sego Canyon SW quadrangle.

Mine	Percent			
	Sulfate	Pyritic	Organic	Total Sulfur
Chesterfield	0.02	0.12	0.43	0.57
Sego No. 1	0.01	0.25	0.37	0.63
Utah Grand	0.04	0.10	0.46	0.60

Calculated carbonization yields (Gomez and others, 1967, p. 13) show the following results (table 12):

Table 12. Carbonization product yields, weight percent maf coal at 500°C, Sego Canyon SW quadrangle.

Mine	Char	Water of Decomposition	Tar plus light oil	Gas	Gas vol. scf/lb maf coal	Btu/scf
Sego No. 1	73.2	5.4	15.8	5.3	0.989	772
Utah Grand	74.3	5.2	15.1	5.2	0.976	779

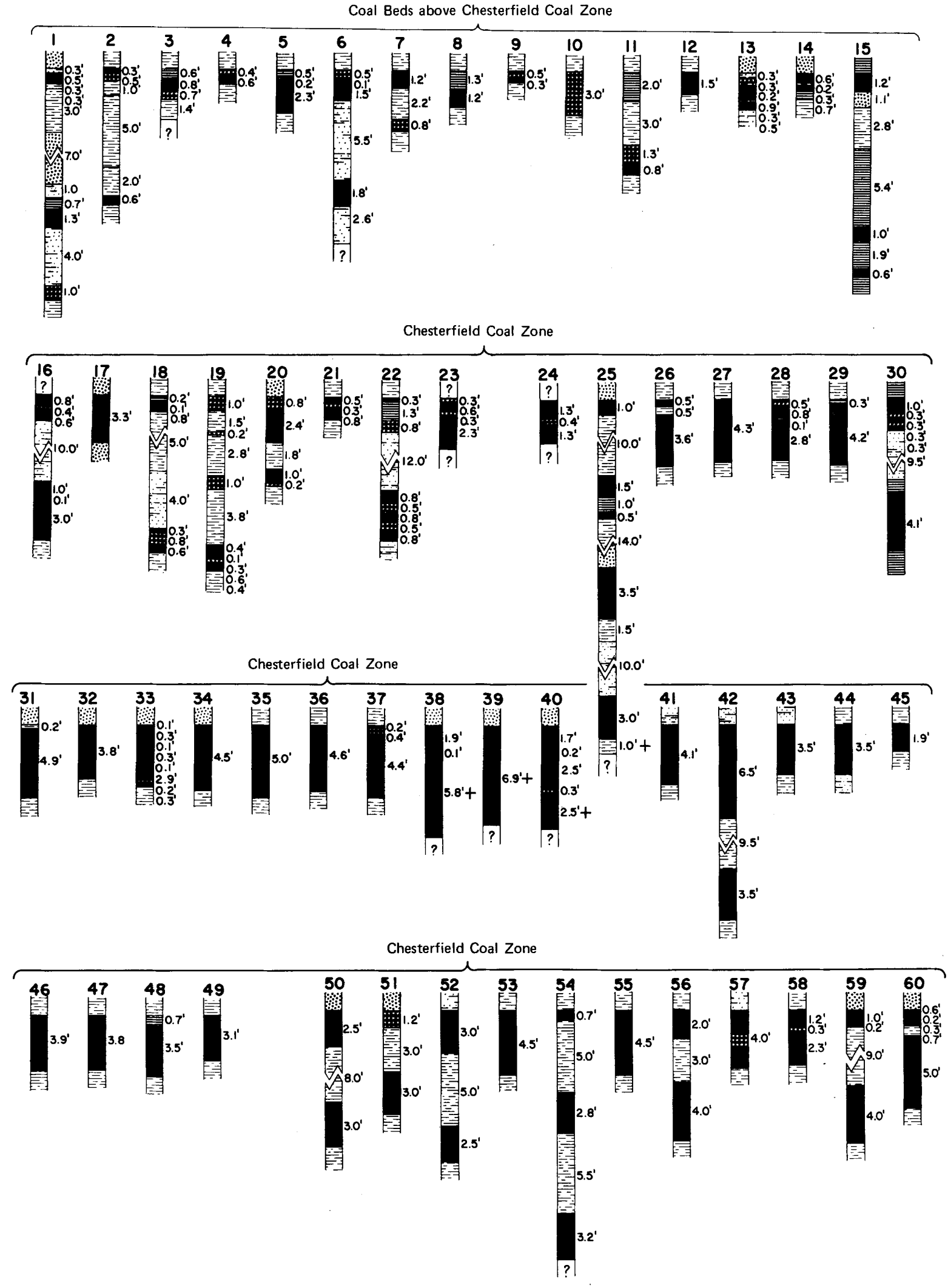


Figure 19. Coal sections of Sego Canyon SW quadrangle (vertical scale: 1 inch = 8 feet).

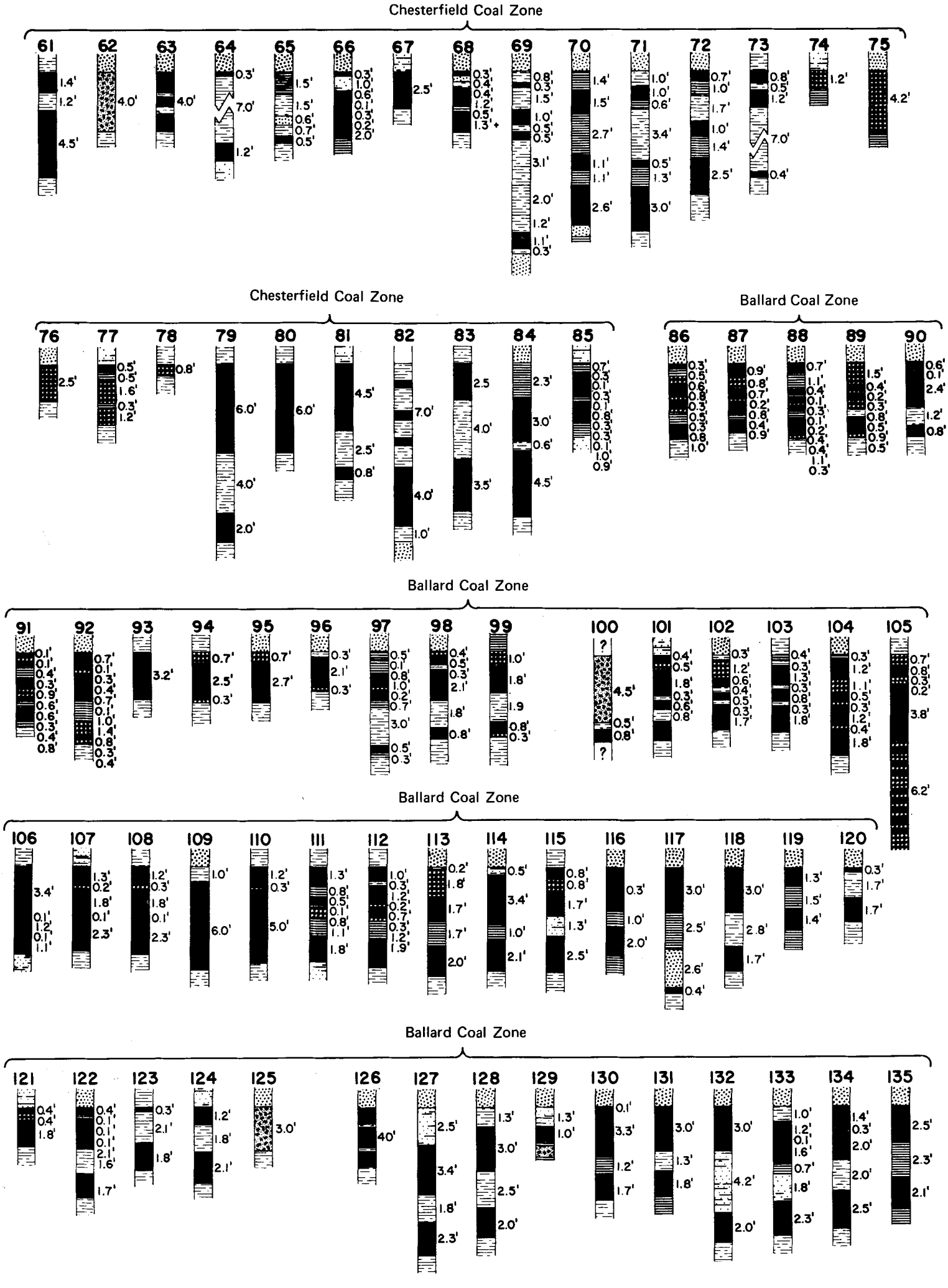


Figure 19. (continued)

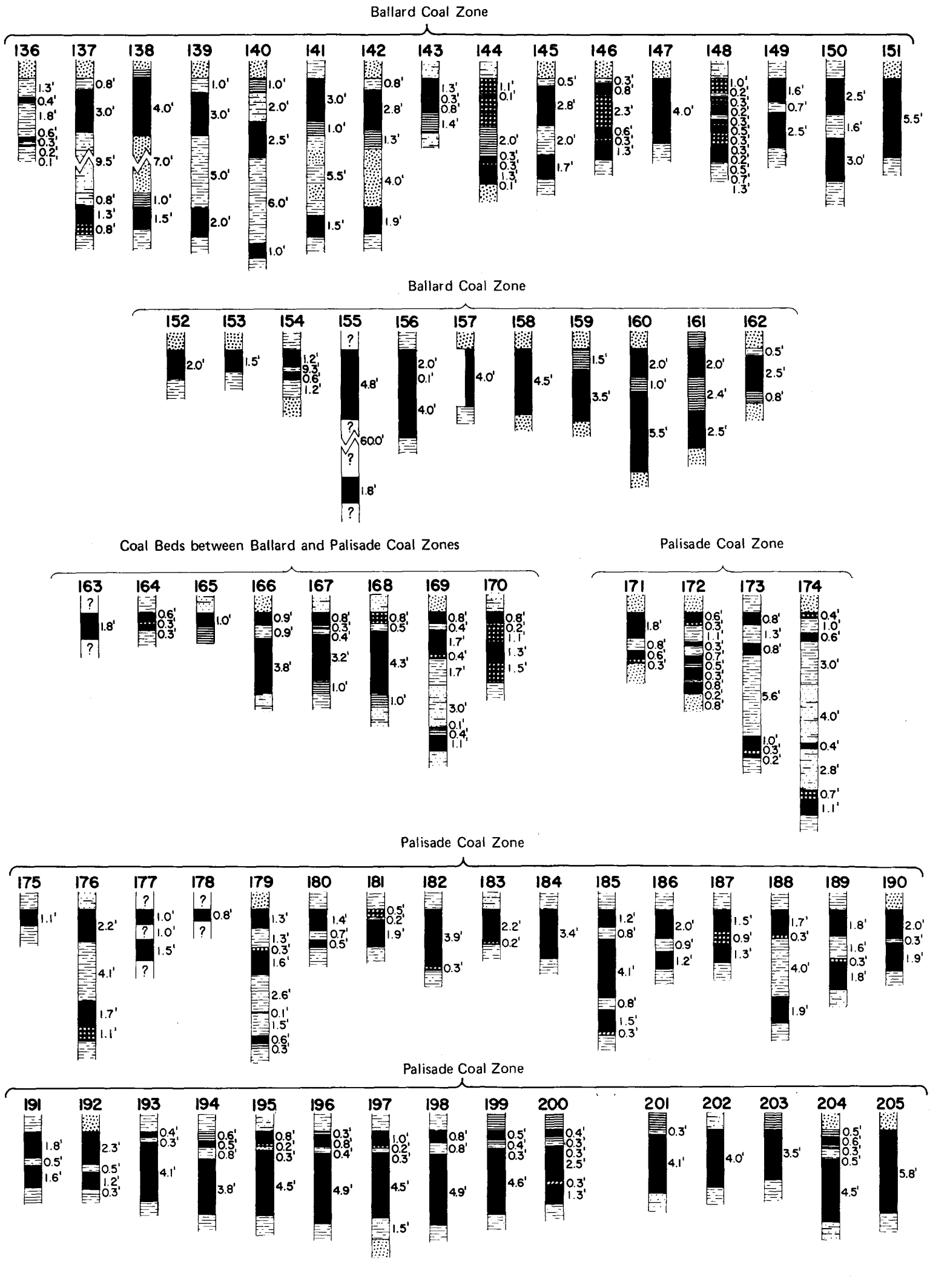


Figure 19. (continued)

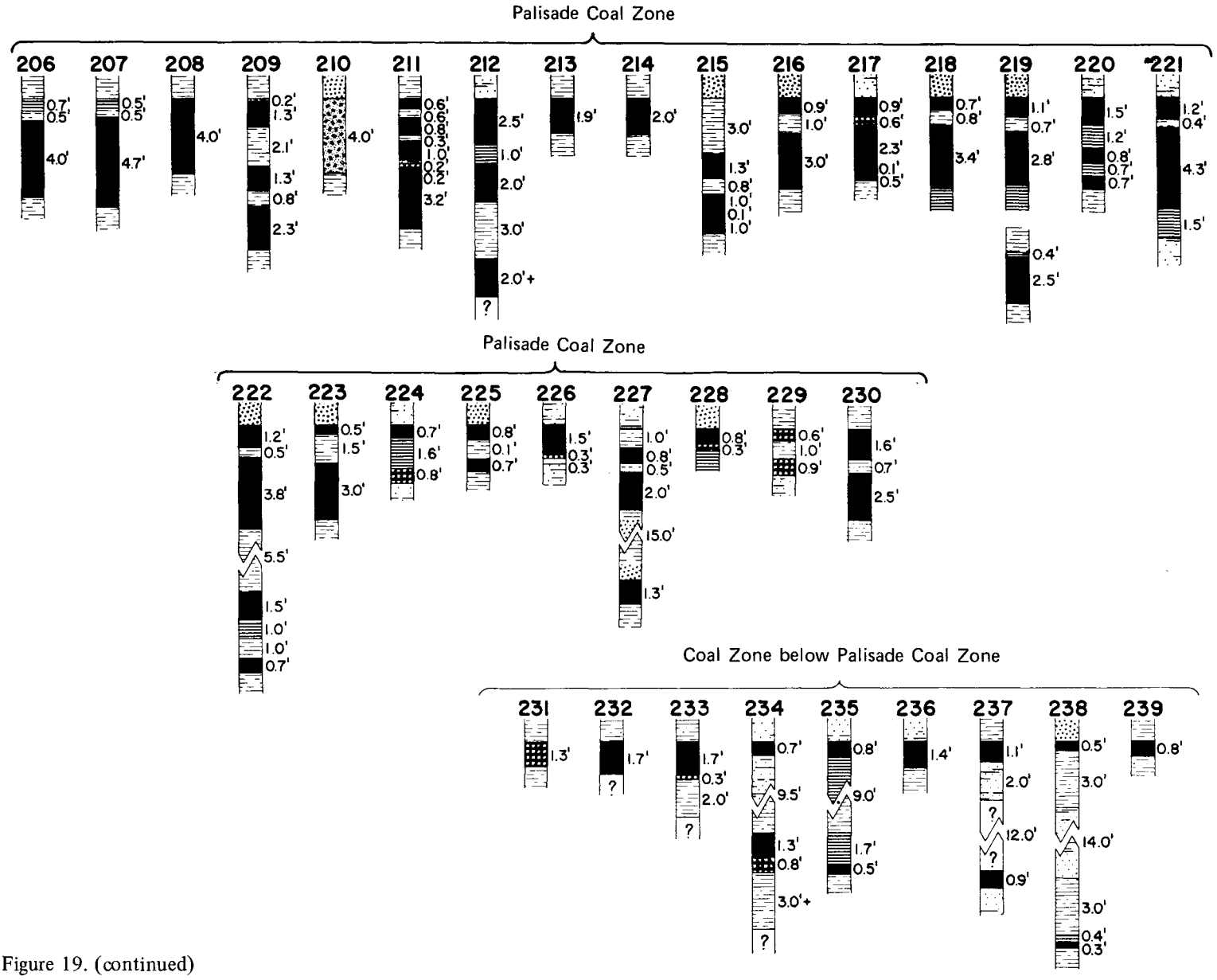


Figure 19. (continued)

Mines and Development (table 13)

Coal mining was begun in Sego Canyon 5 miles north of Thompson, a station on the D&RGW Railroad, in 1900 by Mr. Ballard. Coal sold under the name of the Ballard Coal Co. was hauled by wagon to Thompson until 1912 and little was accomplished in the way of developing a strong operation.

Table 13. Mines and prospect of the Sego Canyon SW quadrangle.

Mine	Location	Remarks
American Fuel mine (Ballard, Sego, Chesterfield, Neslen)	NW.27-20S-20E 4,322,000m.N. 612,400m.E. (center of camp)	Active 1900-1953 10 portals
Knight mine	NW.NW.SE.29-20S-20E 4,321,300m.N. 610,300m.E.	Activity unknown
Nash Canyon prospect	NE.NW.7-20S-21E 4,327,200m.N. 617,500m.E.	Activity unknown
Thompson Canyon mine (Clark)	NE.29-20S-20E 4,321,880m.N. 610,150m.E.	Active 1946-1953

In 1912 the American Fuel Co. took over the Ballard mines. They built a branch railroad line from Thompson to the mine and constructed surface facilities for mine employees and production of coal. Clark (1914) reports that mining began on the "B" bed (Ballard zone) on both the east and west sides of Sego Canyon and that the company shipped its first coal in October 1912. From October 1912 to November 1913 about 47,500 tons of coal were extracted. Subsequently the mines on the Ballard coal zone were abandoned because of thinning and the appearance of bone and shale bands in the coal. In July 1913 an attempt was made to mine the Palisade zone and operation of this mine lasted until 1915. The Chesterfield bed was opened in 1914 and became the major source of supply. In 1925 the mines became the property of the Chesterfield Coal Co. The company's outlet for coal was in the domestic coal market and the D&RGW Railroad. When the former market declined and the D&RGW converted to diesel locomotives, the company was forced to shut down and the mines were sold to Utah Grand Coal Co. Production ceased entirely in 1953 and the railroad was pulled up shortly thereafter. When operations ceased 2,606,000 tons had been removed. Two other small mines have operated as well, one in Thompson Canyon and the other in Nash Canyon. The Thompson Canyon mine produced intermittently from 1946 to 1953 producing 3,482 tons. The period of activity of the Nash Canyon mine is unknown. The mine now is abandoned, but the adit still is open and consists of a single room, 20 by 30 feet in a 4.5-foot coal bed in the Ballard coal zone from which no more than 108 tons could have been removed.

Reserves

Fisher (1936, p. 56) calculated coal reserves by township (table 14). Most of T. 20 S., R. 20 E. and about two-thirds of T. 20 S., R. 21 E. are a part of the Sego Canyon SW quadrangle.

Table 14. Calculated coal reserves by township, Sego Canyon SW quadrangle (within two miles of the outcrop).

	Average thickness (feet)	Estimated area (sq. mi.)	Tons x 10^6
T. 20 S., R. 20 E.			
Highest coal	1.5	0.12	0.2
Chesterfield	2-4	8.87	30
Ballard	2-4	10.23	35
Palisade	1.5-4	8.21	30
Lowest coal	1.5	0.50	1
T. 20 S., R. 21 E.	(part estimated to appear on quadrangle)		
Chesterfield	1.8-2	1.6	3.3
Ballard	1.5	2.2	4
Palisade	1.5-2	2.3	4
Total coal			107.5

The above calculations do not include the entire townships, only that part which is within 2 miles of the outcrop. In addition they include coal 1.5 to 4 feet thick which is below the limits set for minable reserve in this report. A recalculation is therefore made (table 15):

Table 15. Recalculated coal reserves, Sego Canyon SW quadrangle (1.5 to 4 feet thick, in short tons).

	Res.	Avg. thickness (ft.)	Area (acres)	Tons x 10^6	Location
T.19S. R.20E.					
Chesterfield zone	II	4.0	595	4.2	Part of sec. 36
	III	2.6	1,446	6.6	Head of Thompson Canyon
	III	4.1	3,674	26.4	Heads of Sego and Left Hand canyons
Ballard zone	II	5.1	595	5.3	Part of sec. 36
	III	2.6	1,446	6.6	Head of Thompson Canyon
	III	3.5	3,674	22.5	Head of Sego and Left Hand canyons
Palisade zone	III	2.6	3,674	16.7	Heads of Sego and Left Hand canyons
			Total coal	88.3	
T.20S. R.20E.					
Chesterfield zone	II	2.6	3,104	14.1	Secs. 17,19,20,29, 30,31,32
	II	4.9	1,645	12.9	Secs. 16,21,28
	II	3.8	2,682	17.8	Secs. 15,22,27,34 and parts of 14,23,26,35
	II	5.0	979	8.6	Secs. 19,20,29
	II	4.0	960	6.7	Sec. 12, part of 13
	III	2.6	2,112	9.6	Upper Thompson Canyon
	III	4.1	3,584	25.7	Upper Sego and Sagers canyons
Ballard zone	II	2.6	3,104	14.1	Secs. 17,19,20,29, 30,31,32
	II	3.0	1,645	8.6	Secs. 16,21,28
	II	4.3	2,682	20.2	Secs. 15,22,27,34 and parts of 14,23,26,35
	II	4.5	3,571	28.1	Secs. 24,25,36 and parts of 13,14,23,26,35
	II	1.5	640	1.7	Parts of secs. 12,13
	II	5.1	800	7.1	Sec. 1, part of 12
	III	2.6	2,112	9.6	Upper Thompson Canyon
	III	3.5	3,584	22.0	Upper Sego and Sagers canyons
Beds between Ballard and Palisade zones					
	II	3.7	600	3.9	Parts of secs. 35,36
Palisade zone	II	4.4	1,500	12.0	Secs. 15,22,27
	II	2.3	3,571	14.4	Secs. 24,25,36, parts of 13,14,23,26,35
			Total coal	237.1	
T.19S. R.21E.					
Chesterfield zone	II	3.5	858	5.3	Secs. 31,32
	III	3.5	640	3.9	Secs. 29,30
Ballard zone	II	5.1	858	7.7	Secs. 31,32
	III	5.1	640	5.7	Secs. 29,30
			Total coal	22.6	
T.20S. R.21E.					
Chesterfield zone	II	4.0	2,022	14.2	Secs. 5-8,17,18
	II	5.0	979	8.6	Secs. 19,20,29
	II	3.8	602	4.0	Parts of secs. 30,31
Ballard zone	II	4.5	1,581	12.5	Secs. 19,20,29,30,31
Palisade zone	II	2.3	1,581	6.4	Secs. 19,20,29,30,31
			Total coal	45.7	
			Quadrangle grand total	393.7	

	Feet	II	III	Total
Coal	4.0	148.1	57.8	205.9
Coal	3.0-4.0	39.6	48.4	88.0
Coal	2.0-3.0	49.0	49.1	98.1
Coal	1.5-2.0	1.7	–	1.7
	Total	238.4	155.3	393.7

Recoverability on some beds may be low because of their tendency to split. In prime areas 50 percent of the coal might be retrieved, in others only 30 percent.

PRINCIPAL WORK

The bulk of data is credited to Fisher (1936), but much was gleaned from Clark (1914), Thomson (1970) and Pearce (1970). Stratigraphic data came from the listed authors and Gross (1961). Additional measurements were made specifically for this report.

SEGO CANYON SE QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Sego Canyon SE quadrangle is located at the Nash Canyon embayment of the Book Cliffs, the center of which is 10 miles northeast of Thompson (figure 11). It lies about halfway between the Green River and the Colorado line. Except for the north and west fringes of the map the quadrangle consists of the rolling and gently sloping badlands below the Book Cliffs. The coal-bearing cliffs partly surround the embayment in half-moon fashion. The elevation of the embayment ranges from 4,800 to 5,600 feet. The cliffs rise rapidly and along the north map edge (figure 20) elevations exceeding 8,000 feet are noted. The coal crops out between 6,000 and 6,600 feet.

The principal access route parallels Nash Wash and extends from U. S. Highway 6 and 50, 10 miles to the southeast. The Denver and Rio Grande Western Railroad is 4 miles south of the south map edge. No road provides access into the cliffs.

STRATIGRAPHY

Formations and members of formations present and exposed on the quadrangle include the Mancos Shale, Castlegate Sandstone, Buck Tongue, Sego Sandstone, Neslen coal-bearing member of the Price River Formation, Farrer Member and Wasatch Formation. All are Upper Cretaceous in age except for the Wasatch, which is Tertiary.

These units are described adequately in the coal field Stratigraphy section and only a discussion pertinent to the coal is presented here. The coal seams are in the Neslen Member, basically in three zones. The first is 30 to 60 feet above the base of the unit; the next two lie above and below a medial sandstone bed. In addition coal beds occur between and above the major zones, but these are usually thin and inconsequential.

Partial section of Neslen coal-bearing member of Price River Formation at north side of entrance to Nash Canyon, sec. 8-20S-21E, by Thomson (1970).

Neslen Member	Feet
1. Shale, gray	3.0
2. Sandstone	0.6
3. Shale, gray	2.0
4. Mudstone, brown	0.6
5. Shale, gray	1.8
6. Mudstone, dark brown	2.0
7. Sandstone, light brown, medium-grained, massive, cliff former	7.0
8. Coal	0.8
9. Mudstone, blue-gray	8.0
10. Coal	0.6
11. Shale, carbonaceous	0.6
12. Shale, gray	4.0
13. Mudstone, gray and dark brown	3.0
14. Limestone, gray-brown, silty, fissile, weathers orange-brown	3.8
15. Interbedded sandstone and shale, sandstone fine-grained and thin-bedded, slope former	6.0
16. Sandstone, light brown, medium-grained, single ledge-forming bed	2.7
17. Shale, gray, brown and carbonaceous	26.7
18. Interbedded sandstone and shale, like unit 15	4.4
19. Shale, gray and carbonaceous	2.2
20. Coal, partly impure (Chesterfield)	8.7
21. Shale, gray-black	2.5
22. Sandstone, brown, fine-grained, ledge	3.9
23. Interbedded sandstone and shale, like unit 15	7.5
24. Sandstone, like unit 22	2.8
25. Shale, brown	1.8
26. Coal	1.1
27. Shale, brown and carbonaceous	12.8
28. Sandstone, brown, fine- to medium-grained, ledge former	2.1
29. Shale, gray	7.1
30. Sandstone, like unit 30	3.5
31. Shale, gray	5.7
32. Interbedded sandstone and shale, like unit 15	22.8
33. Shale, gray	13.7
34. Interbedded sandstone and shale, like unit 15	30.5
35. Coal	0.9
36. Shale, gray and white	0.8
37. Coal	1.9
38. Shale, gray	6.9
39. Interbedded sandstone and shale, like unit 15	11.0
40. Coal	0.9
41. Shale, gray	0.6
42. Coal	1.0
43. Shale, gray	0.6
44. Coal	1.3
45. Shale, gray and carbonaceous	3.8
Total measured Neslen Member	236.0
Sego Sandstone	

STRUCTURE

The large re-entrant or embayment in the Book Cliffs is the topographic expression of the Cisco anticline which trends northwesterly; dips on the southwest flank average 5 to 8 degrees and locally steepen to 10 degrees. Maximum dips on the northeast flank rarely exceed 5 degrees. The Sagers Wash syncline transects the southwest map corner. According to Fisher (1936, p. 39):

> Two parallel normal dip faults are present in the northwestern part of T. 20 S., R. 21 E., on the northwest end of the Cisco dome. The north fault has a downthrow on the south of 65 feet. The other fault extends farther to the northwest. In the eastern part of section 4 it has a downthrow of 165 feet to the north, and the fault surface dips 60°N.

These faults do not appear to influence the coal.

PROPERTY CONTROL

Most of the area of the quadrangle belongs to the Bureau of Land Management (84.4 percent). The normal sprinkling of four sections per township is Utah state land (14.1 percent) and small privately owned acreage extends along Nash Wash (1.3 percent). As of January 1, 1970, no land was held for the purpose of extracting coal.

COAL

Surface Information

Seventy-nine coal sections have been measured on the Sego Canyon SE quadrangle (figure 21). Locations 1 to 7 are for coal above the Chesterfield zone; all show thin coal, the thickest at location 4 with 5.2 feet of impure coal split by 0.3 feet of shale.

Locations 8 to 29 are for the Chesterfield zone. Seams varying in thickness from 1.5 to 8.7 feet occur along the west map edge and these average 4.3 feet. To the east they thin out rapidly and are usually 1 foot or less.

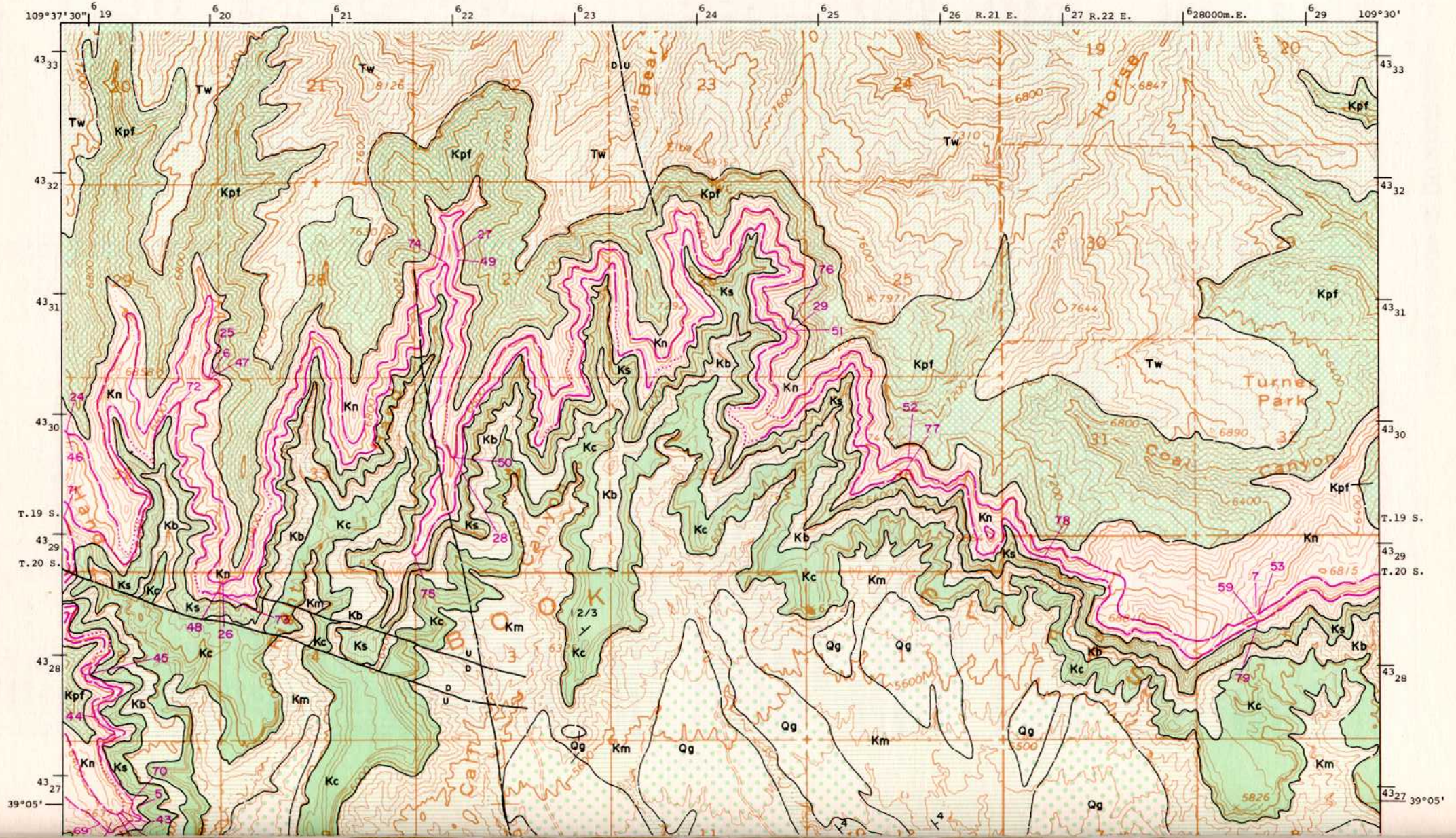
The Ballard zone is represented by locations 30 to 53. Through location 40 the zone is represented by two beds of coal, the thickest averaging 2.3 feet and the thinnest averaging 1.5 feet. Elsewhere the beds are thin, except locally, but even then the coal has been adjudged impure.

Thin coals are situated between the Ballard and Palisade coal zones; the thickest, at location 56, is 1.8 feet. From 67 to 73 the coal is thin. Some thick beds, up to 8.2 feet with 1 foot of waste in two splits, have been measured between location 74 and the east map edge. This coal has been adjudged mostly impure, but averages 4.1 feet thick.

Subsurface Information

There has been no drilling for coal on this quadrangle.

SEGO CANYON S.E., UTAH



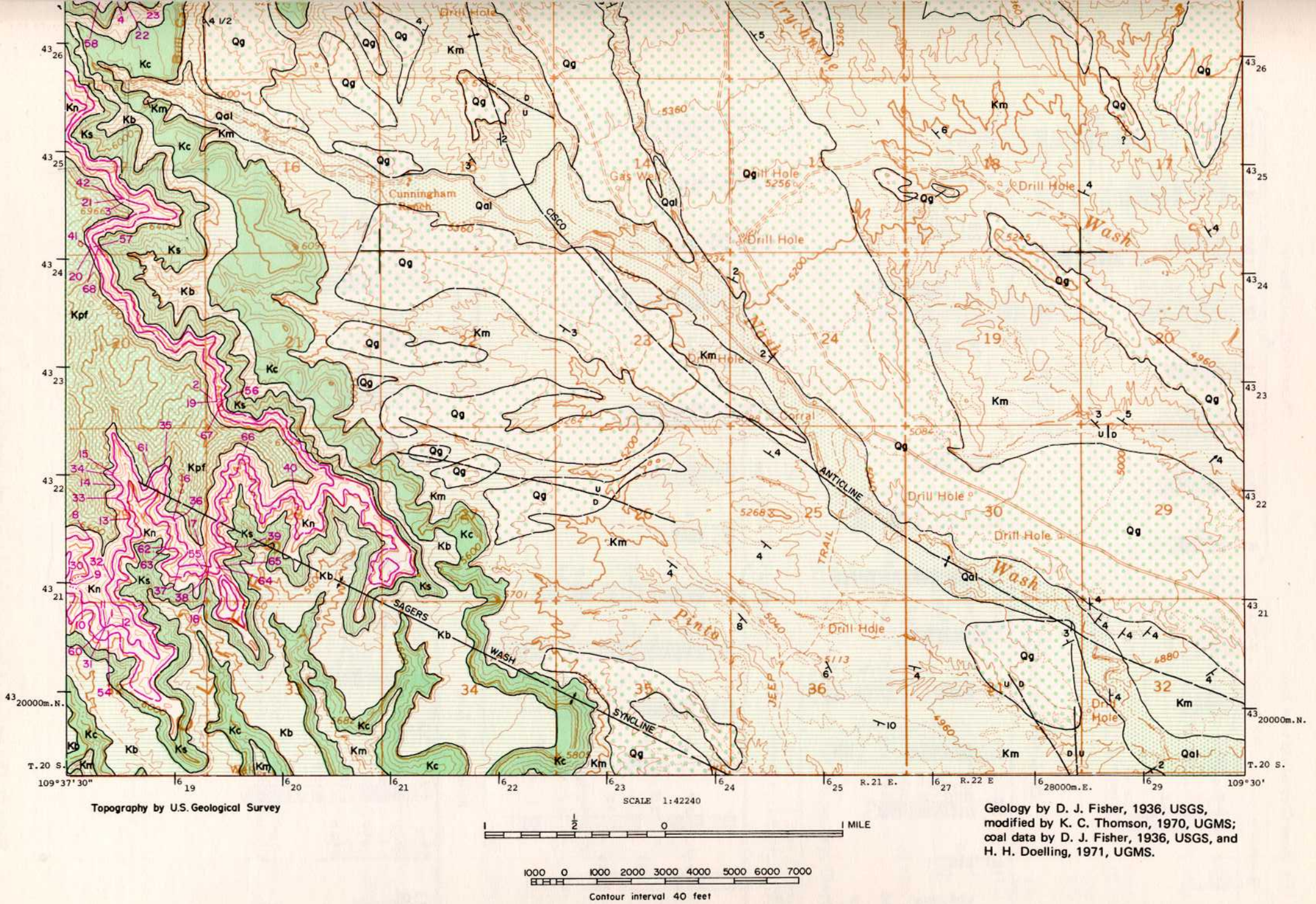


Figure 20. Coal and geology map, Sego Canyon SE quadrangle (explanation pages 218-219).

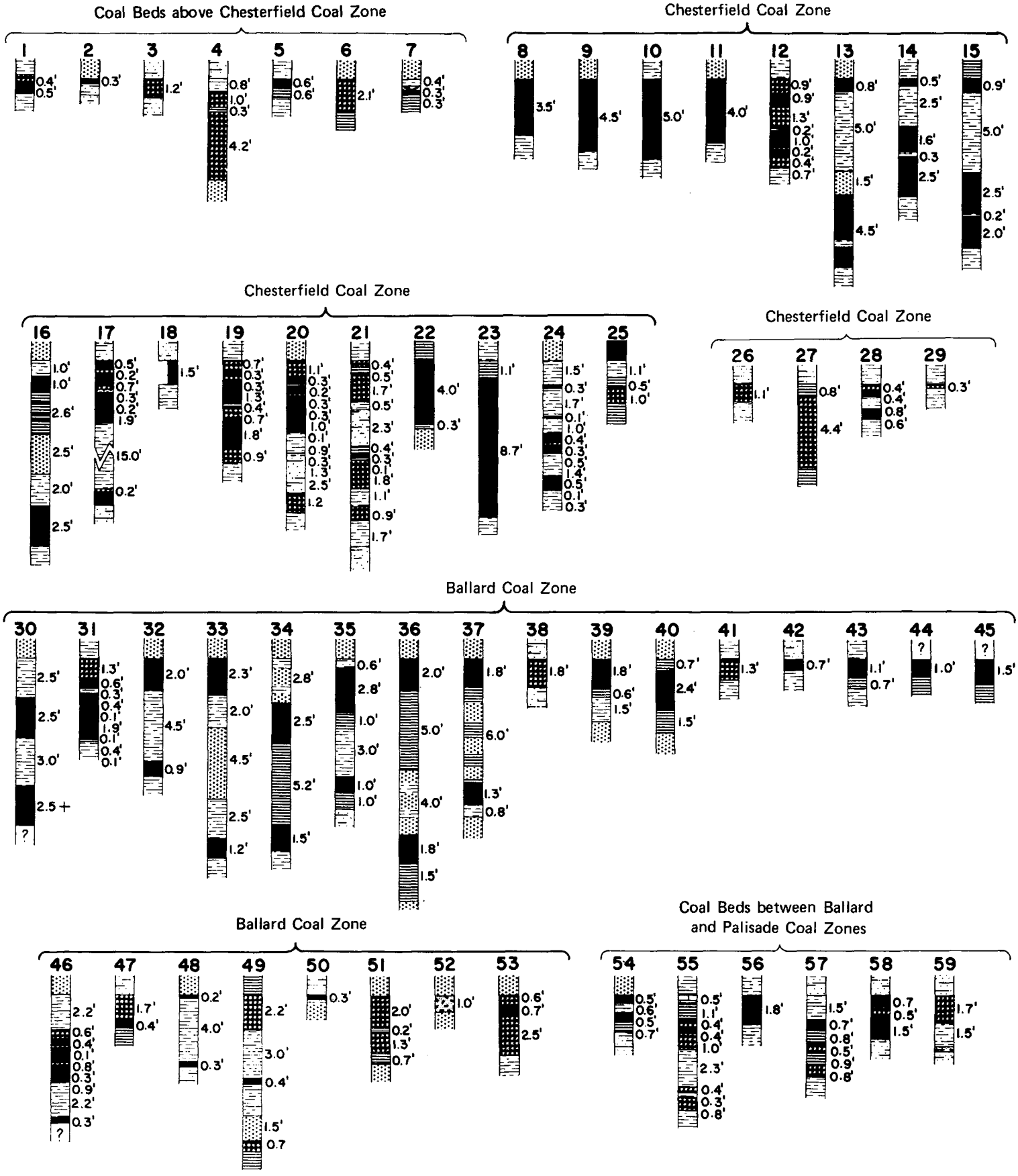


Figure 21. Coal sections of Sego Canyon SE quadrangle (vertical scale: 1 inch = 8 feet).

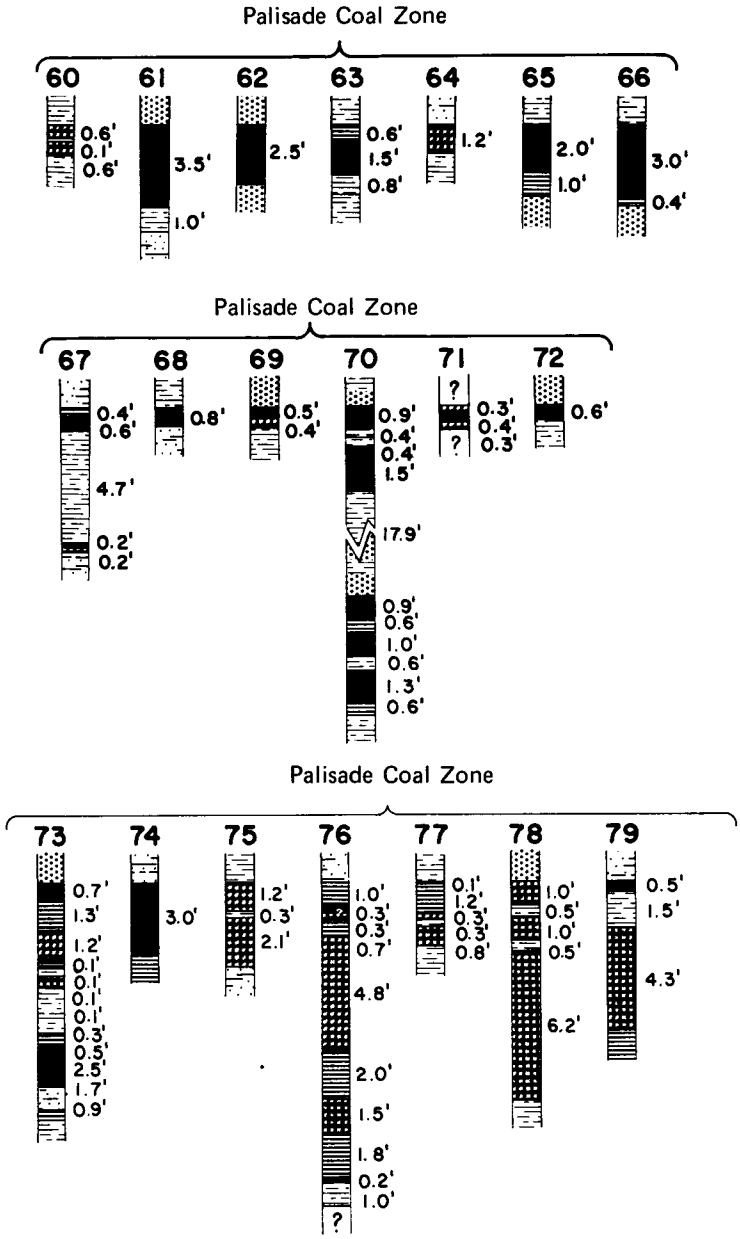


Figure 21. (continued)

Quality of Coal

One analysis is available (table 6) and believed collected from the Chesterfield zone, sec. 8, T. 20 S., R. 21 E. The sulfur content is 0.37 percent with 19.4 percent moisture of a sample from highly weathered outcrop. Btu/lb value as-received is 9,380, probably a low determination. The sample corresponds to location 23.

Mines and Development

No mines have opened with no development for coal on the quadrangle.

Reserves

Fisher (1936, p. 56) estimated reserves for the quadrangle by township extending no farther than 2 miles behind the outcrop. His results are repeated here (table 16).

Table 16. Calculated coal reserves by township, Sego Canyon SE quadrangle.

	Average thickness (ft.)	Est. area (sq. mi.)	Tons x 10^6
T.19S. R.21E.			
Ballard	1.5	0.57	1
Palisade	2.0	0.99	2
T.20S. R.21E.			
Chesterfield	1.8-2	2.40	5
Ballard	1.5	3.35	6
Palisade	1.5-2	3.51	6
T.19&20S. R.22E.	No reserve		
Total			20

A recalculation extending to all coal areas of the quadrangle is given in table 17.

Table 17. Recalculated coal reserves, Sego Canyon SE quadrangle.

	Res.	Average thickness (ft.)	Area (acres)	Tons x 10^6	Location
T.19S. R.21E.					
Palisade zone	III	4.1	3,565	25.5	E. ½ of Twp.
T.20S. R.21E.					
Chesterfield	II	4.3	1,197	9.0	SW of Nash Wash
Ballard zone	II	3.8	640	4.2	Secs. 28, 29, 32
Palisade zone	II	2.3	640	2.6	Secs. 28, 29, 32
T.19S. R.22E.					
Palisade zone	III	4.1	3,840	27.4	
		Quadrangle grand total		68.7	

	Feet	II	III	Total
Coal	4.0	9.0	52.9	61.9
Coal	3.0-4.0	4.2	–	4.2
Coal	2.0-3.0	2.6	–	2.6
Total		15.8	52.9	68.7

The wide separation between the two calculations is only partly resolved by the difference in area. Fisher undoubtedly eliminated much area because of his opinion of coal quality at the outcrop. This was not considered in the latter evaluation. Much of the coal, however, is split which does not enhance the desirability of the coal.

PRINCIPAL WORK

The major work for this quadrangle was performed by Fisher (1936) and Thomson (1970). Additional checking was done by the present author.

View easterly from near the bottom of Sego Canyon. Two abandoned buildings of the former town of Sego are in foreground. Massive sandstone behind the buildings is the Sego Sandstone of the Price River Formation. This is succeeded by the Neslen coal bearer and the Farrer barren member.

COTTONWOOD CREEK AND WESTWATER CREEK SOUTH QUADRANGLES

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Cottonwood Creek and Westwater Creek South quadrangles lie in the east central part of the Sego coal field and immediately north (approximately 10 miles) of Cisco, U. S. Highway 50–6 (Interstate 70), and the Denver and Rio Grande Western Railroad (figure 11). They represent a sector of the Book Cliffs and the land is rugged and beset with cliffs and canyons. The portion in front of the cliffs presents a rolling surface.

Access to the foot of the cliffs is generally good, but only in the major canyon (Cottonwood Creek Canyon) does road access continue inward. After a few miles even this road becomes a jeep trail.

STRATIGRAPHY

Formations ranging from the Cretaceous Mancos Shale to the Tertiary Wasatch Formation are present on the quadrangles (figures 22 and 23). The Mancos exposed below the cliffs is the oldest and is approximately 3,300 to 3,500 feet thick. It is primarily a gray marine shale. The first cliff former lies immediately above the Mancos and is the Castlegate Sandstone Member of the Price River Formation. No remnants of the Blackhawk Formation occur this far east in the Sego coal field. The Castlegate thins west to east across the field and in these quadrangles averages about 50 feet thick. The cliff-building sandstone is highly resistant and a wide bench has formed in most places on its upper surface where the softer overlying rock has been eroded off. This bench is up to a mile wide.

The Buck Tongue of the Mancos overlies the Castlegate. It has the same description as the Mancos, thickens eastward and ranges between 250 and 350 feet on the quadrangles. The next cliff former is the Sego Sandstone Member of the Price River Formation. It is similar in appearance to the Castlegate and is about 200 feet thick. The Neslen Member, which overlies the Sego, is also cliff forming with more numerous shale splits so that a steep step and slope regimen is set up. The Neslen is the coal bearer and some detailed measurements have been made of the sequence.

Partial section of Neslen Member of Price River Formation, sec. 11-19S-22E in Cottonwood Creek Canyon, by Thomson (1970).

Neslen Member	Feet
1. Sandstone, light brown, medium-grained, massive	?
2. Shale, gray	19.4
3. Limestone, gray, ledge former	2.5
4. Shale, gray	14.4
5. Sandstone, like unit 1	11.5
6. Shale, gray	4.2
7. Coal	2.7
8. Shale, gray	1.0
9. Coal	0.5
10. Limestone, red-gray, silty, thick bed, ledge	2.4
11. Interbedded sandstone and shale	1.0
12. Shale, gray	25.6
13. Interbedded sandstone and shale	1.2
14. Coal	1.5
15. Shale, gray	2.1
16. Interbedded sandstone and shale	7.9
17. Shale, gray	12.6
18. Limestone, gray, thick ledge	2.7
19. Shale, gray	6.8
20. Coal	2.7
21. Shale, gray	1.8
22. Siltstone, gray white, ledge	1.4
23. Interbedded sandstone and shale	5.4
24. Shale, gray	20.0
25. Interbedded sandstone and shale with a few thick shale sequences	36.6
26. Sandstone, gray weathers to brown, silty, thin-bedded ledge former	3.5
27. Interbedded sandstone and shale	2.9
28. Shale, gray	14.0
29. Coal	1.5
30. Shale, gray	6.4
31. Sandstone, light brown, medium-grained, thin- to medium-bedded, ledge former	6.4
32. Shale, gray	1.8
33. Coal	2.0
34. Shale, gray and brown	24.1
35. Interbedded sandstone and shale	11.2
36. Coal	1.1
37. Shale, carbonaceous	2.7
38. Interbedded sandstone and shale	4.8
39. Sandstone, gray-white, weathers brown, medium-grained, medium-bedded, ledge former	7.2
40. Shale, gray	4.2
41. Interbedded sandstone and shale	21.0
Measured interval	302.7+
Sego Sandstone	

Partial section of Neslen Member of Price River Formation, sec. 36-19S-22E, by Thomson (1970).

Neslen Member	Feet
1. Shale, gray	8.6
2. Sandstone, brown to red-brown, medium-grained, ledge former	2.7
3. Interbedded sandstone and shale	3.2
4. Coal	0.5
5. Shale, gray	9.2
6. Coal	1.0
7. Shale, gray	17.1
8. Limestone, gray, ledge	2.5
9. Shale, gray	2.5
10. Coal	2.7
11. Shale, gray	9.4
12. Coal	1.0
13. Shale, gray	9.2
14. Coal	1.0
15. Shale, gray	1.5
16. Sandstone, gray brown, fine-grained, medium-bedded, ledge former	6.2
17. Interbedded sandstone and shale	1.7
18. Shale, gray	17.1
19. Coal	2.5
20. Sandstone, medium brown, medium-grained, ledge	6.3
21. Shale, gray	25.7
22. Interbedded sandstone and shale, sandstone thin-bedded, brown and fine-grained	47.0
23. Coal	2.5
24. Shale, gray	0.4
25. Coal	3.0
26. Shale, gray	0.8
27. Coal	0.7
28. Shale, gray	11.7
29. Interbedded sandstone and shale	2.3
30. Coal	1.0
31. Shale, gray with a few thin beds of sandstone	16.4
32. Interbedded sandstone and shale	9.2
Measured interval	226.6
Sego Sandstone	

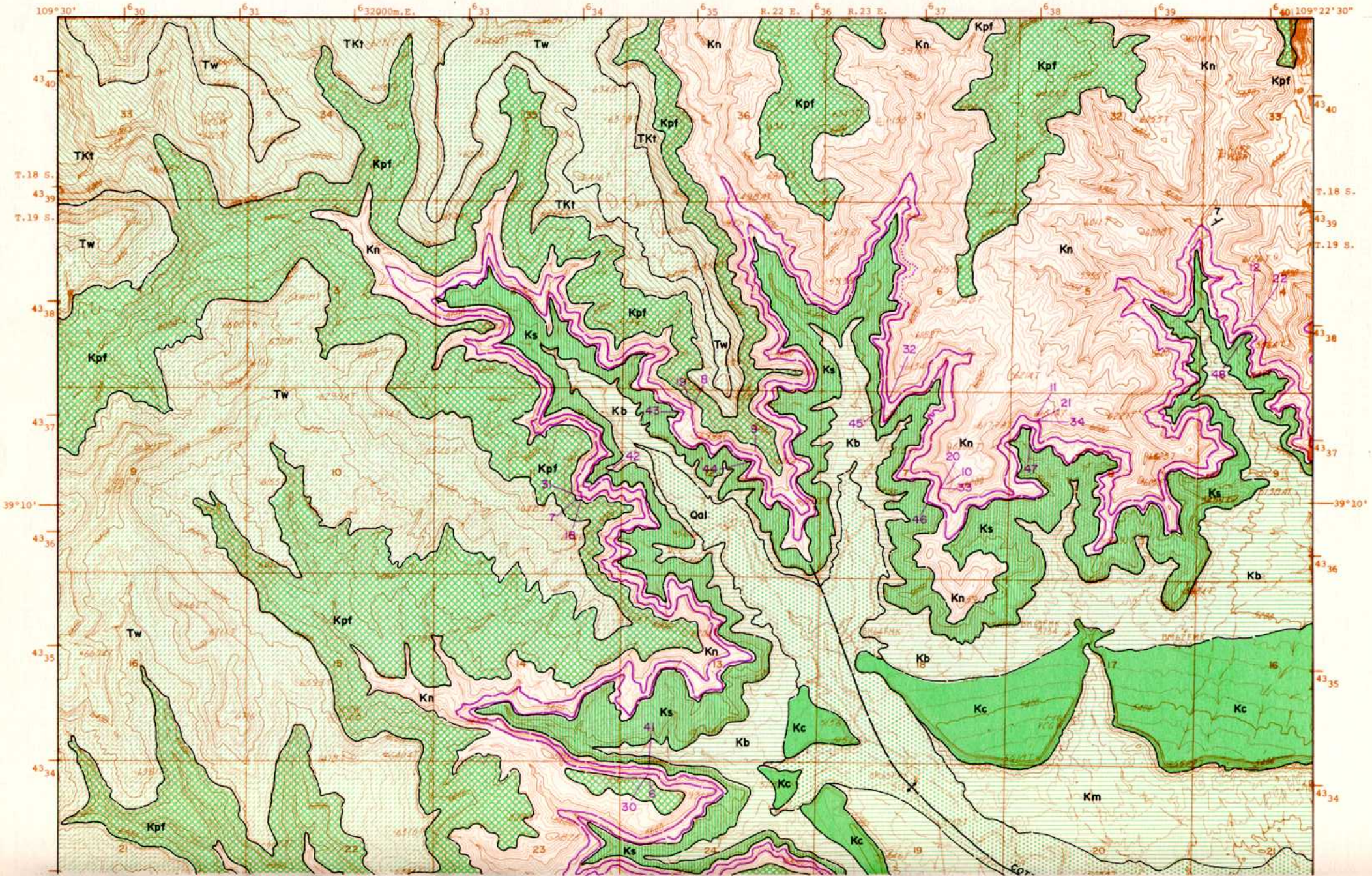
The Neslen is succeeded by the Farrer Member of the Price River Formation. The Farrer has a lithology similar to that of the Neslen but with less shale and coal. Thin coal lenses of little economic importance occur at several horizons. The Farrer is estimated to be about 600 to 750 feet thick. The remaining formations, the Tuscher and Wasatch, are not well known in the area and the descriptions in the field report give the general information.

STRUCTURE

The structure contours roughly parallel the cliff front. The canyon embayments generally represent anticlines and cliff front projections indicate synclinal axes. The fold axes all trend and plunge northwesterly. These folds are gentle with dips of 2 to 5 degrees, except on the south side of Cottonwood Creek where the dips steepen to 10 degrees locally.

No faulting was noted on the Cottonwood Creek quadrangle and a small fault cuts the coal-bearing strata at the north edge of the Westwater Creek South quadrangle.

COTTONWOOD CREEK, UTAH



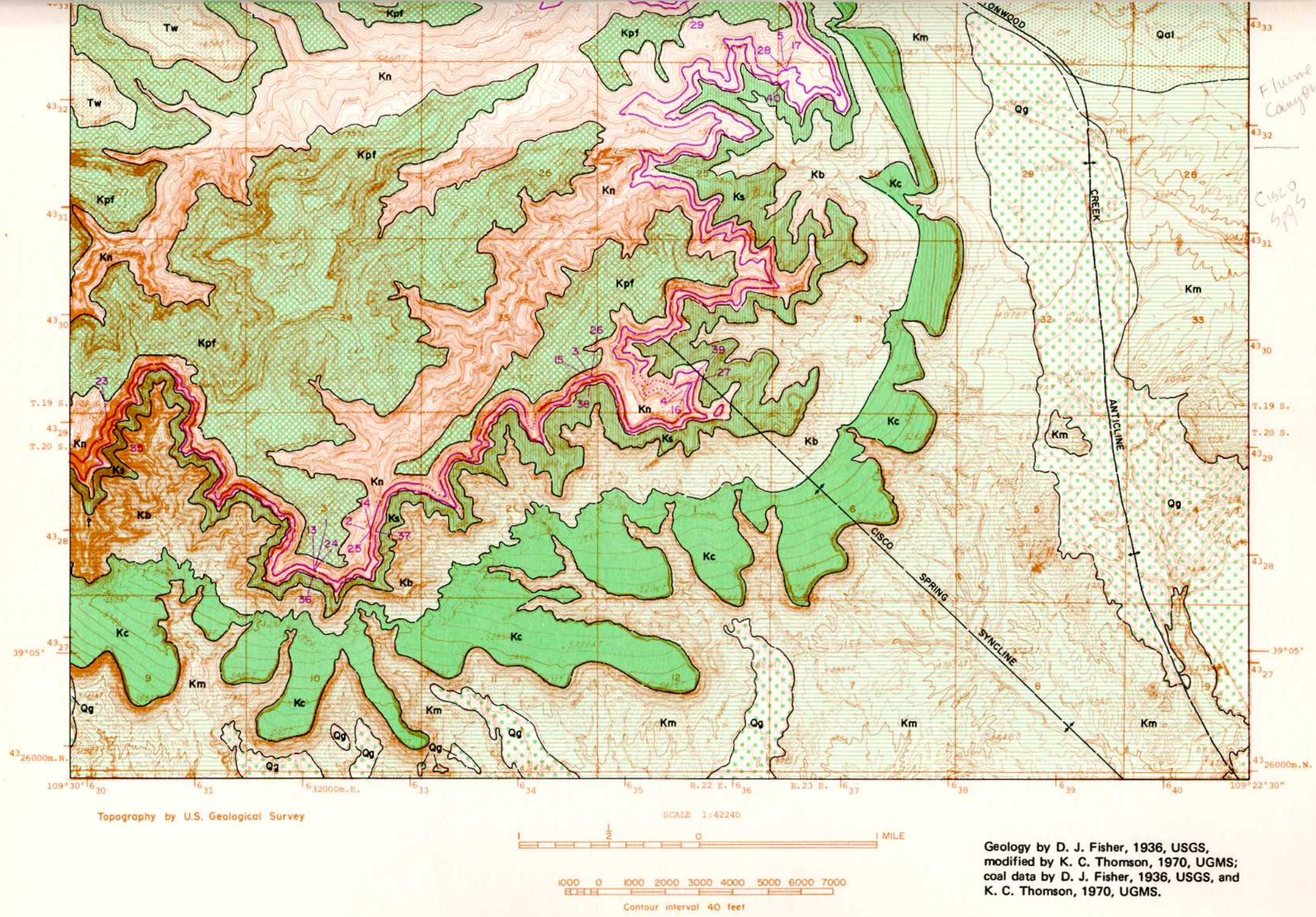
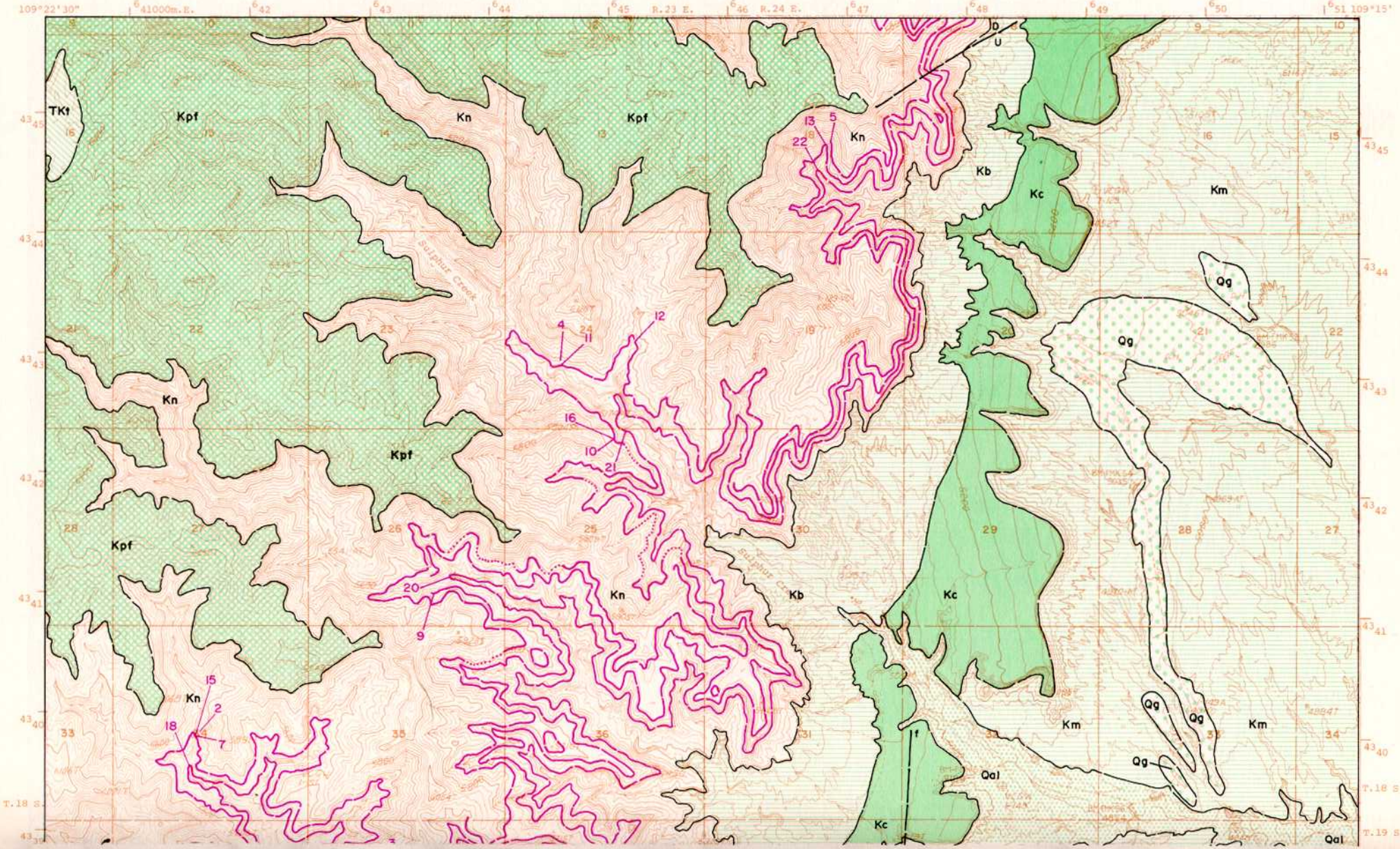


Figure 22. Coal and geology map, Cottonwood Creek quadrangle (explanation pages 218-219).

WESTWATER CREEK SOUTH, UTAH



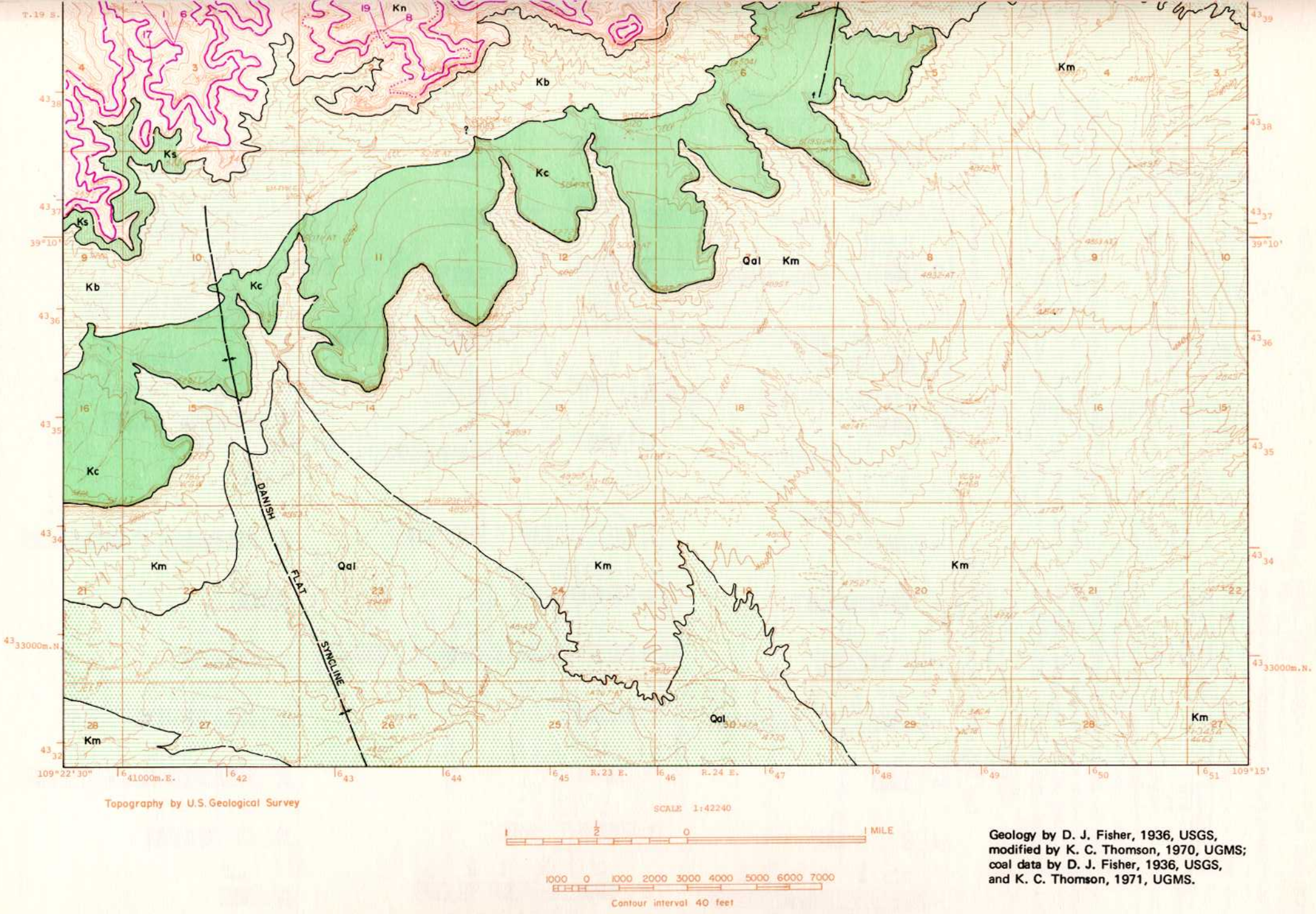


Figure 23. Coal and geology map, Westwater Creek South quadrangle (explanation pages 218-219).

PROPERTY CONTROL

Ownership of the lands in the two quadrangles is as follows:

	Percent	
	Cottonwood Creek	Westwater Creek South
Bureau of Land Management	83.0	86.3
State of Utah	12.7	9.9
Private property	4.3	3.8

None of the land is held for the purpose of extracting coal. The state lands are scattered in each township in the normal fashion (each section 2, 16, 32 and 36) and the private lands are located either along Cottonwood Creek or Sulfur Creek below the level of the coal.

COAL

Surface Information

There are forty-eight coal bed measurements for the Cottonwood Creek quadrangle (figure 24) and twenty-eight for the Westwater Creek quadrangle (figure 25). Most of these measurements were made by Fisher (1936) who indicates that most of the coal is impure. Unfortunately no channel sample analyses are available to verify this.

In the Cottonwood Creek quadrangle the first twelve locations are from beds above the Chesterfield zone. The individual beds cannot be correlated from one location to another and may be associated with several horizons. The impure beds range up to 3.7 feet thick. The Chesterfield zone (locations 13 to 22) is not

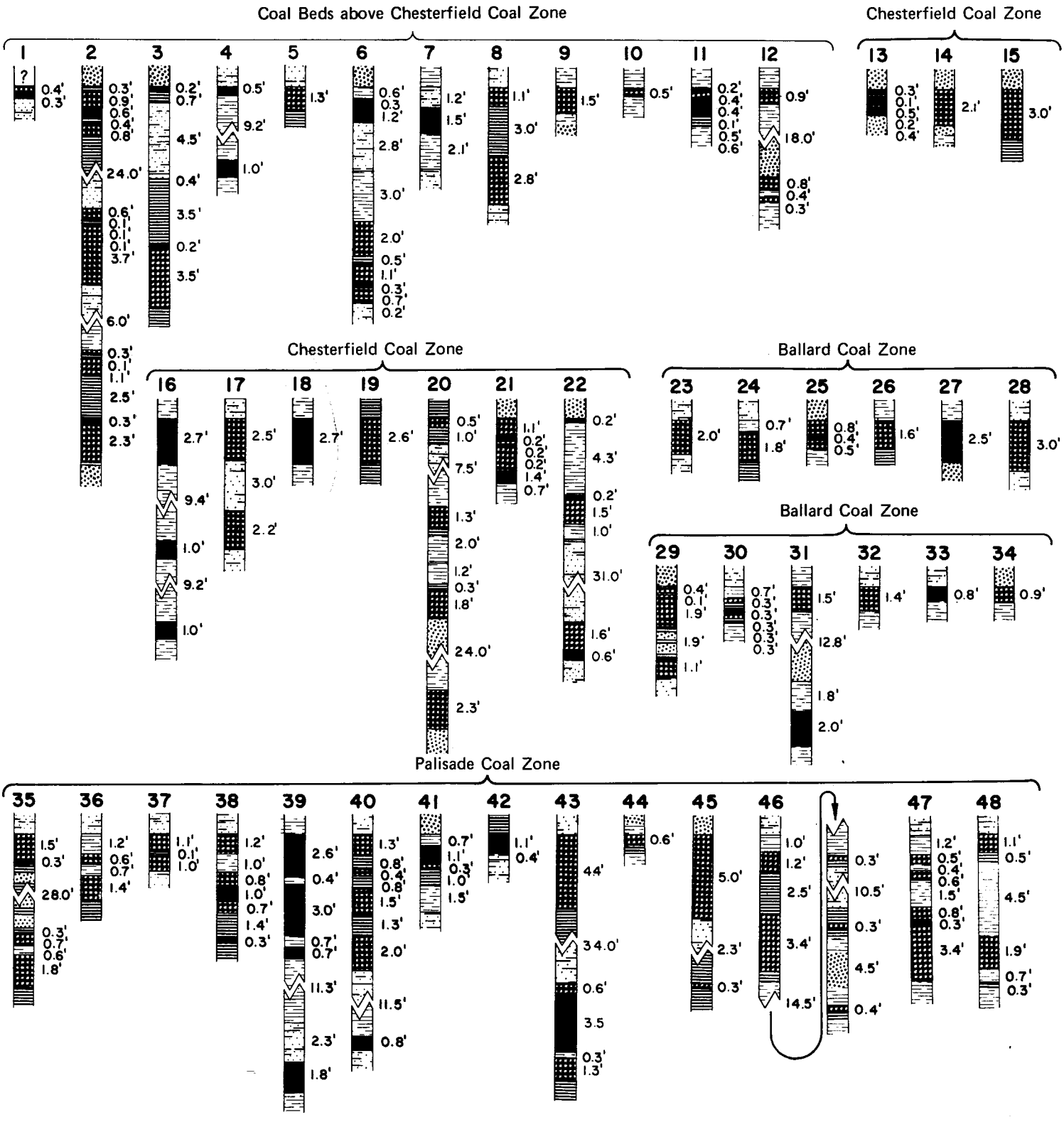


Figure 24. Coal sections of Cottonwood Creek quadrangle (vertical scale: 1 inch = 8 feet).

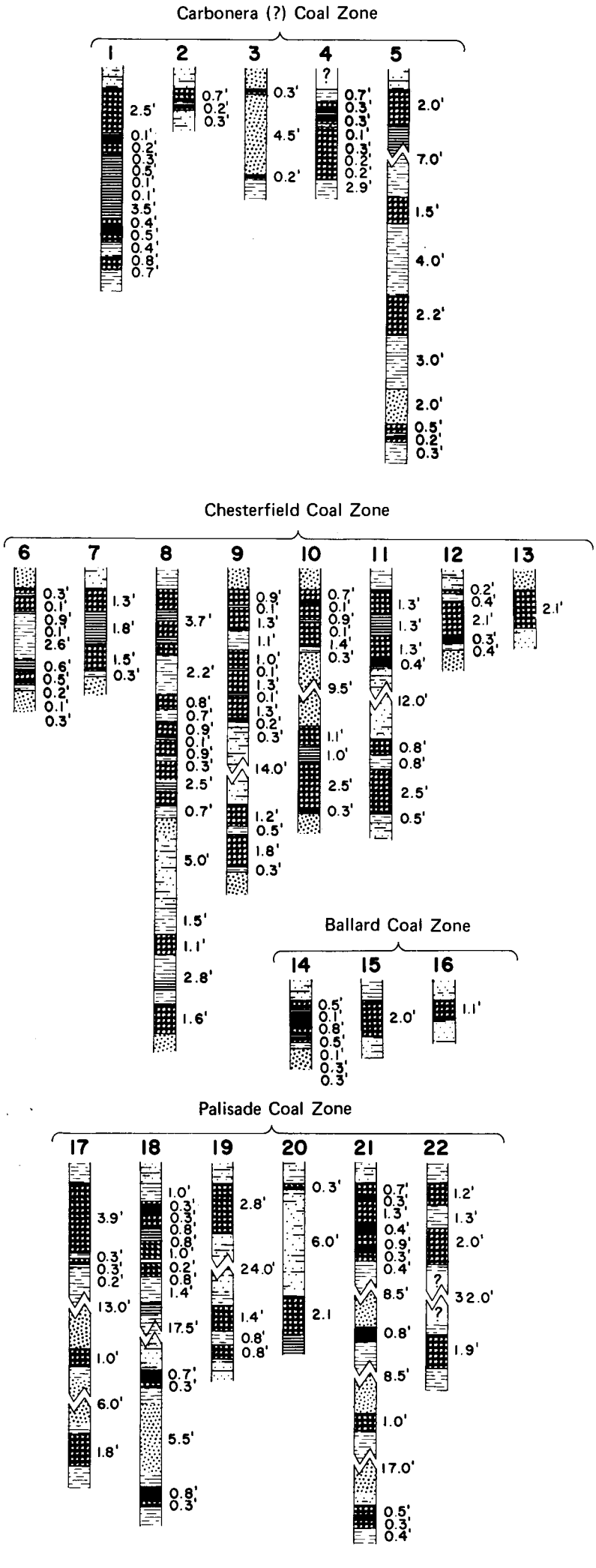


Figure 25. Coal sections of Westwater Creek South quadrangle (vertical scale: 1 inch = 8 feet).

better with the thickest seam 2.7 feet thick and averaging 2.4 feet. The Ballard zone coal (locations 23 to 34) ranges up to 3 feet thick for the best seam, but averages 1.7 feet. The Palisade (locations 35 to 48) has beds as thick as 5 feet in the Cottonwood Creek Canyon area, but averages 2.7 feet throughout the quadrangle. The Palisade with coal exceeding 4 feet thick has the best potential for local areas.

All the twenty-two locations of measured coal in the Westwater Creek South quadrangle show impure coal. Four zones are fairly persistent and are described as follows (table 18):

Table 18. Coal zones and their thicknesses in the Westwater Creek South quadrangle.

Zone	Feet		Locations
	Avg. thick bed	Thickest	
Carbonera zone	2.3	2.9	4
Chesterfield	2.5	3.8	9
Ballard	1.7	2.0	15
Palisade	2.9	4.0	21

Subsurface Information

There has been no drilling for coal on either quadrangle.

Quality of Coal

There are no analyses of coal for either quadrangle.

Mines and Development

There have been no mines and no development for coal on either quadrangle.

Reserves

Apparently no reserves of coal occur in either quadrangle because of the thin beds and impure quality. Fisher (1936, p. 56) eliminated this area from his reserve estimates. Even if the beds of coal were pure there would be no reserves in beds 4 feet or more thick, as per outcrop data.

PRINCIPAL WORK

The data presented here were mostly derived from Fisher (1936).

Abandoned homemade ventilator, Thompson Canyon mine, near Sego coal field.

WESTWATER CREEK NORTH, WEST BITTER CREEK AND COLORADO LINE QUADRANGLES

LOCATION, GEOGRAPHY AND ACCESSIBILITY

These three quadrangles lie in the easternmost part of the Sego coal field (figure 11). They are discussed together inasmuch as their coal potential is small. The Book Cliffs front is parallel to and 10 miles northwest of Interstate Highway 70 and about 13 miles northwest of the Denver and Rio Grande Western Railroad.

The elevation below the cliffs is about 5,300 feet. At the crest on top of the cliffs the elevations often exceed 8,400 feet. The coal crops out along the cliffs and in canyons at approximately the 6,000-foot level. The principal drainages include San Arroyo Wash, West Bitter Creek and the three branches of Westwater Creek that follow East Canyon, Middle Canyon and Hay Canyon.

Dirt and gravel roads provide access to the principal canyons and Hay and East Canyon roads extend upward to the crest. The area is remote and except for a ranch or two, uninhabited.

STRATIGRAPHY (figures 26 to 28)

The descriptions of the stratigraphic units are included in the Stratigraphy section of the field report and are listed here with expected thicknesses in the three quadrangles. The lower part of the Price River Formation also is presented in various measured sections:

Unit	Feet
Green River Formation	Incompletely exposed
Wasatch Formation	250-400 (thins eastward)
Tuscher Formation	300-600
Price River Formation	
Farrer Member	900±
Neslen Member	295-350
Sego Sandstone	215
Buck Tongue	340±
Castlegate Sandstone	0-60 (disappears eastward)
Mancos Shale	3,400-3,500

Section of lower part of Price River Formation, sec. 31-16S-26E, about 2 miles west of Utah-Colorado state line, by Fisher (1936, p. 32–34).

Price River Formation

Neslen coal-bearing member (lower part only): Feet

39. Sandstone, massive ledge maker, buff except near top, where it is light gray 27
38. Sandstone, buff, thin-bedded, locally shaley 28
37. Bone 1½
36. Shale, medium dark gray to brown, with a little thin-bedded buff sandstone 2½
35. Sandstone, thin-bedded, buff 1
34. Shale, like no. 36, with 4 inches of bone 2 feet below top 5½
33. Bone, with a little boney carbonaceous shale; this and no. 37 possibly mark the Carbonera coal zone 1½
32. Shale, like no. 36 10
31. Sandstone, buff, thin-bedded, carries a little shale with half an inch of bone 57
30. Shale and sandstone, like no. 28 10
29. Bone and coal (Chesterfield coal zone at location 256) 2 1/3
28. Shale, brown, carbonaceous, interlaminated with light gray sandstone 14
27. Sandstone, medium- to thin-bedded in general, though locally massive in lower part; cross-bedded; mainly buff, but upper part is light gray; forms a ledge (Sulphur Canyon sandstone bed) 14
26. Shale, dark gray, with some thin-bedded sandstone in the upper part 18
25. Sandstone, medium- to thin-bedded, cross-bedded, mostly light gray, but locally buff 4
24. Shale, dark gray 3
23. Sandstone, like no. 25 10
22. Shale, dark gray to brown, carbonaceous, with some thin-bedded sandstone, especially in the upper part; 7-inch seam of bone 4 feet above base 12
21. Sandstone, thin-bedded, light gray to buff 7
20. Shale, brown to dark gray 6½
19. Sandstone, massive to medium-bedded, except upper third, which is thin-bedded; cross-bedded, medium light gray 18
18. Shale, medium gray to black, carbonaceous, 4 inches of bone 1 foot below top 3
17. Sandstone, highly cross-bedded, medium light gray; grades from massive double ledge (1-foot shale break 25 feet above base) to thin-bedded shaley slope 48
16. Bone (Palisade coal zone) 1 1/3
15. Shale, mostly rich brown, weathering to medium light gray 2
14. Sandstone, thin-bedded 1
13. Shale, like no. 15; basal part concealed 16

Total Neslen coal-bearing member (lower part only) 324 1/6

Sego Sandstone Member:

12. Sandstone, very massive, cross-bedded, cliff maker; like no. 7 46
11. Sandstone, shaley, thin-bedded (except a small part slightly below the middle, which is medium-bedded), medium gray, with some interbedded shale; forms a slope 33
10. Sandstone, massive, like no. 7, but carries a few irregular limonite-stained concretions; locally nos. 7 to 10 form a single cliff 21½
9. Sandstone, medium light gray, forming a slope at most places, thin-bedded, rather shaley in upper part 30
8. Sandstone, like no. 7, but thinner-bedded 18½
7. Sandstone, massive to thick-bedded, cross-bedded, light gray, locally stained buff, cliff maker, composed mainly of rather fine, fairly well rounded glassy quartz grains, with 1 percent feldspar stained light buff and a smaller amount of dark mineral grains, all weakly cemented, contains shark teeth *(Lamna sp.)* 33
6. Siltstone, buff, thin-bedded, interbedded with shale 27

Total Sego Sandstone Member 209

Buck Shale Tongue of Mancos Shale:

5. Shale, interbedded with siltstone, buff, thin-bedded, grades upward into no. 6 27
4. Shale, medium light drab gray, like Mancos, lower third concealed by wash 319

Total Buck Tongue 346

Castlegate Sandstone Member:

3. Sandstone, thick-bedded, cross-bedded, buff with white stainings along joint places; composed mainly of extremely fine, fairly well rounded quartz grains, with a little feldspar, makes a very weak cuesta and dies out entirely a short distance to the east 1
2. Siltstone, thin-bedded, shaley, and shale, in alternating layers; largely concealed, marks gradation zone to Mancos ..... 14±

Total Castlegate Sandstone Member ..... 15±

Total Price River Formation (except Farrer Member and upper part of Neslen member), as measured ..... 894±

Gradational contact.

Mancos Shale.

1. Shale, drab-gray.

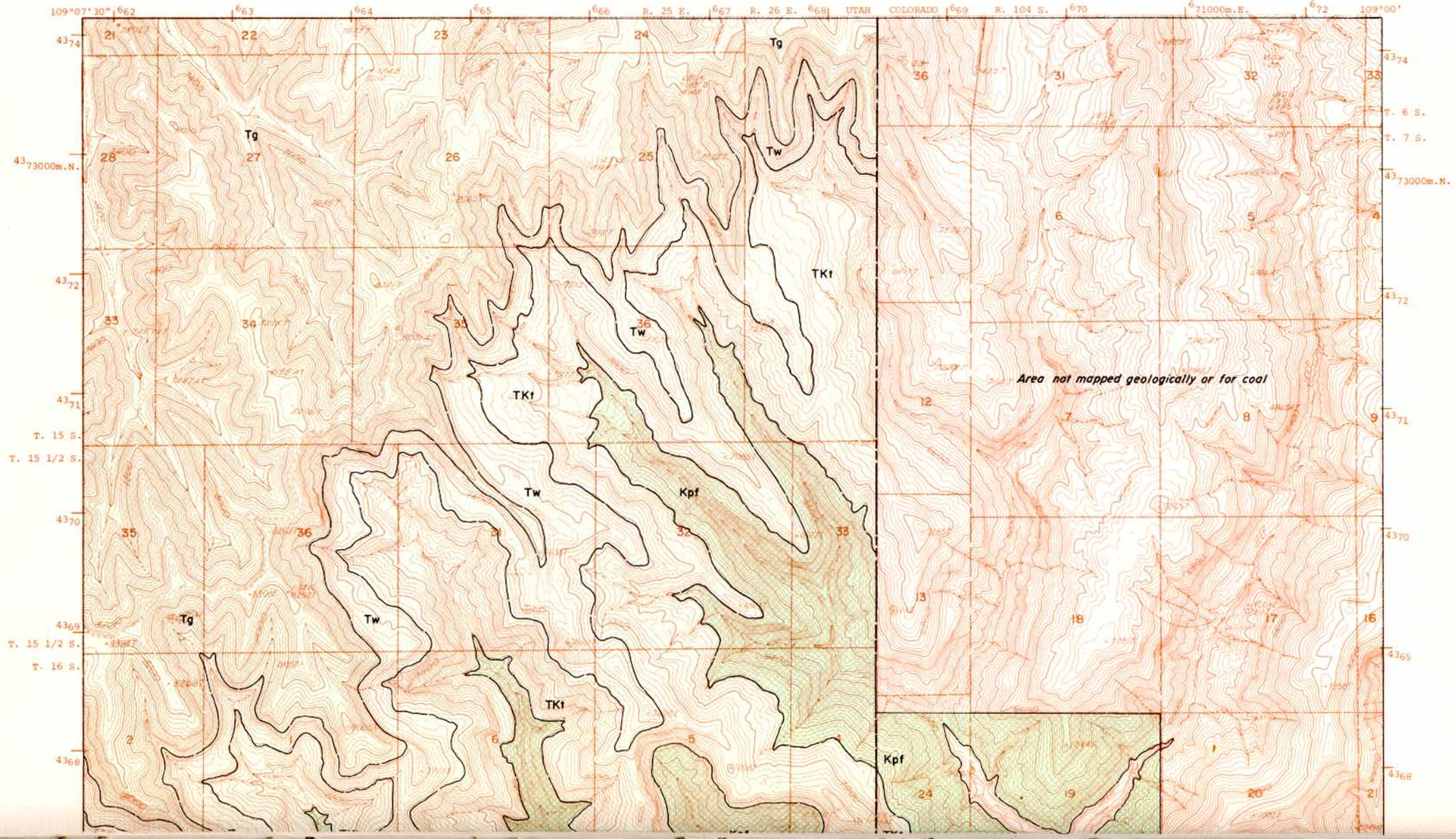
Three more sections of the Neslen coal-bearing member are given to illustrate the condition of coal in this sector of the Book Cliffs.

Prairie Canyon, Colorado

T. 7 S., R. 105 W., Garfield Co., 1.5 miles east of state line, by Thomson (1970).

Farrer Member: sandstone, light brown weathering to darker shade, medium-grained, massive cliff former.

COLORADO LINE, UTAH



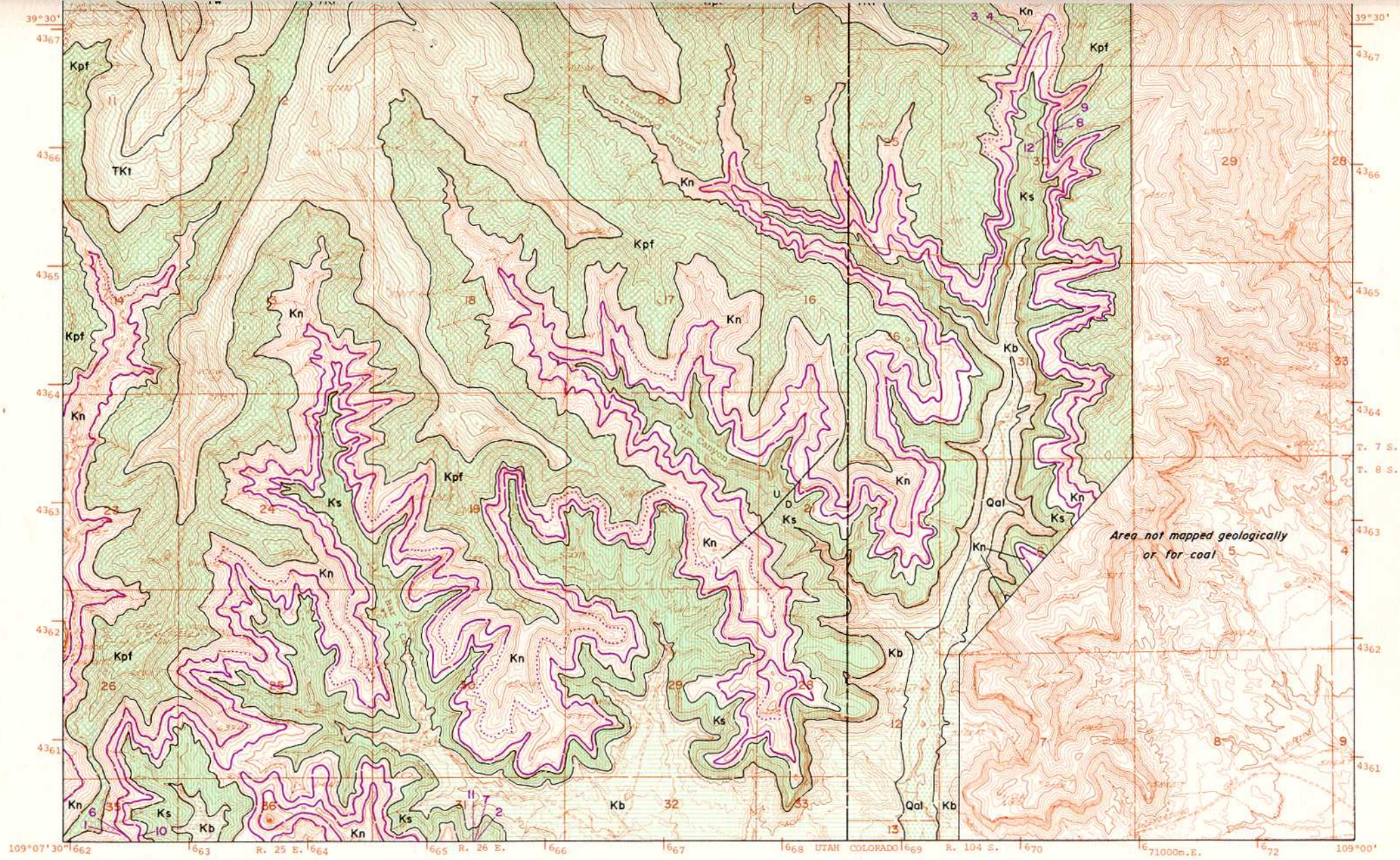
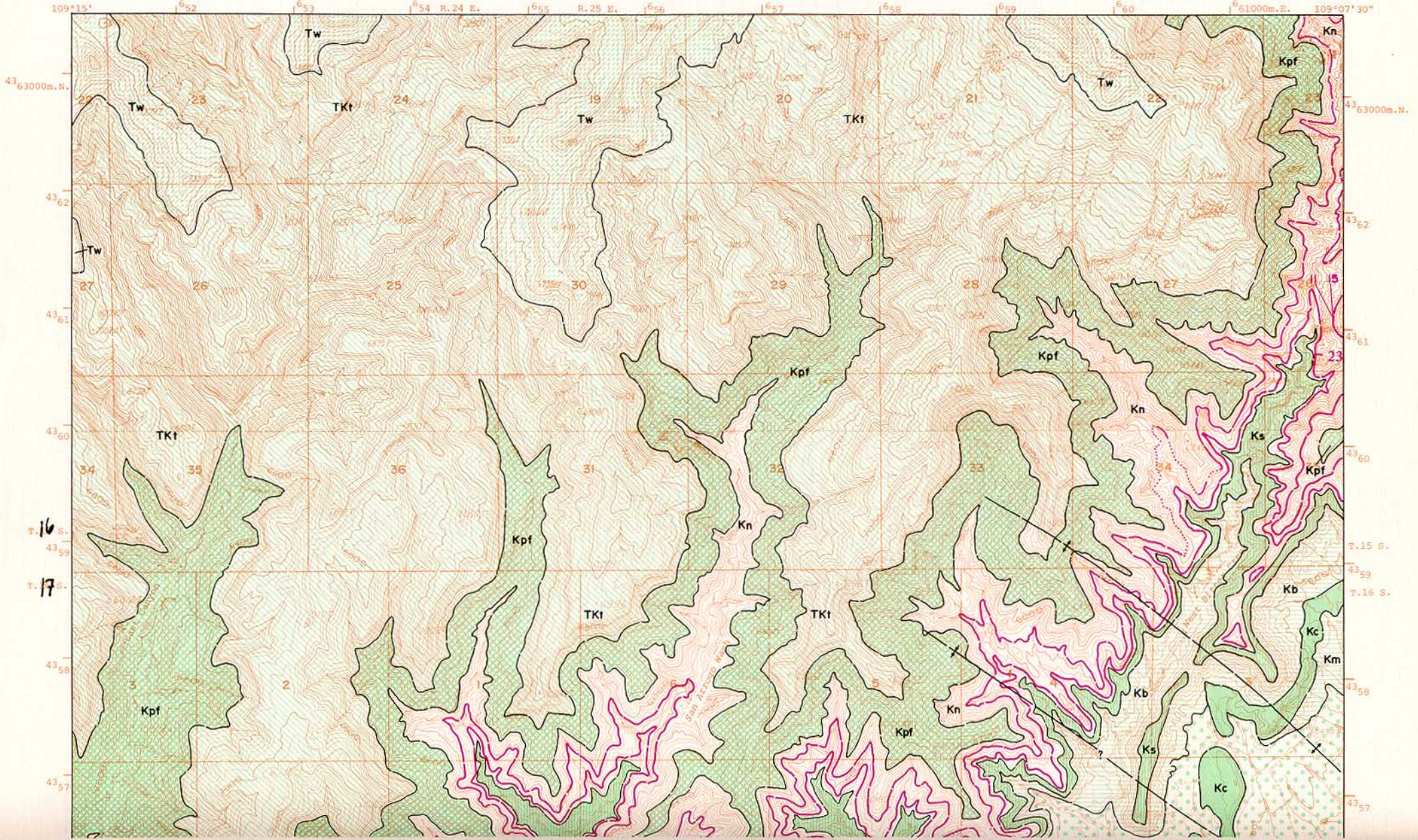


Figure 26. Coal and geology map, Colorado Line quadrangle (explanation pages 218-219).

WEST BITTER CREEK, UTAH



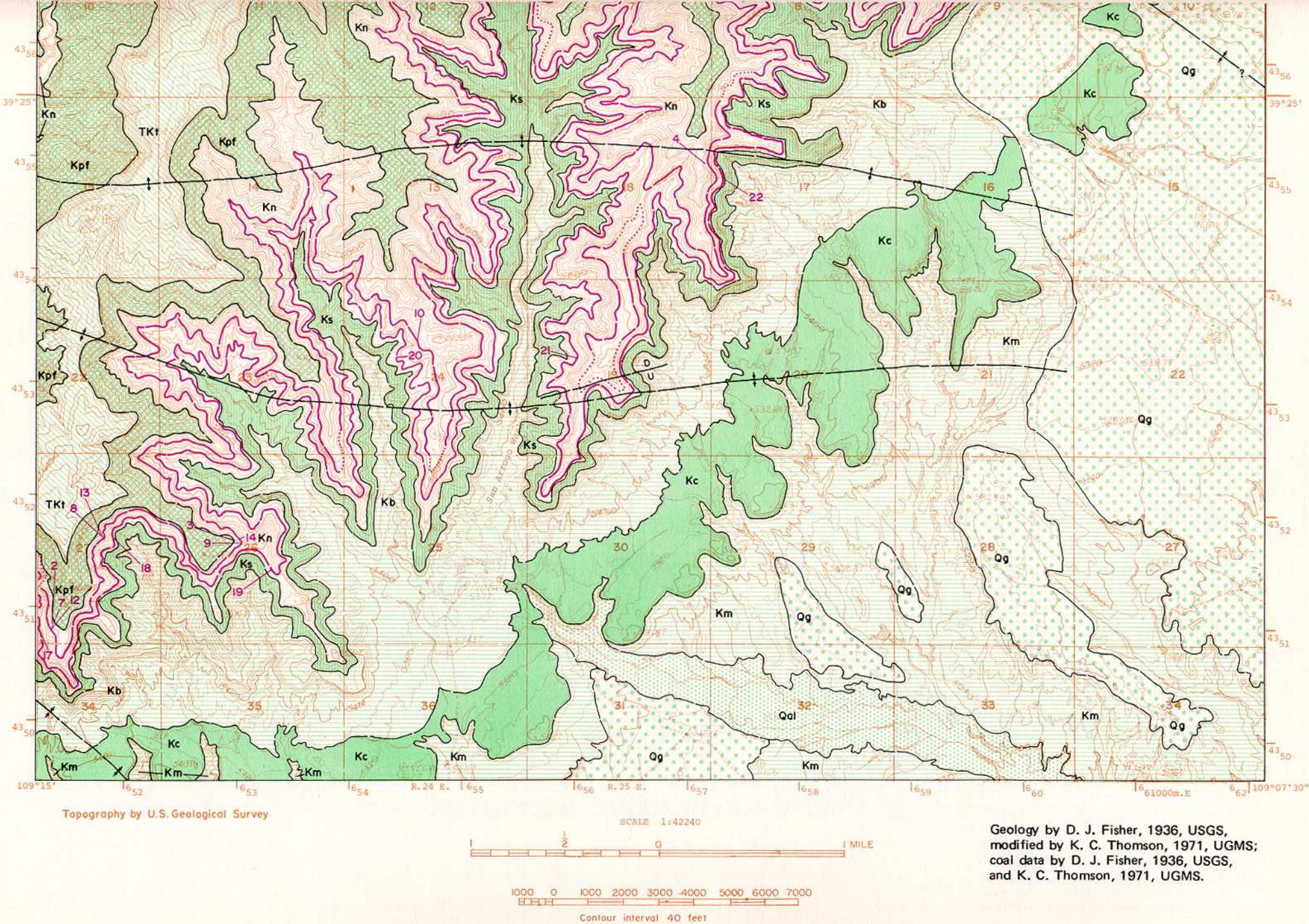
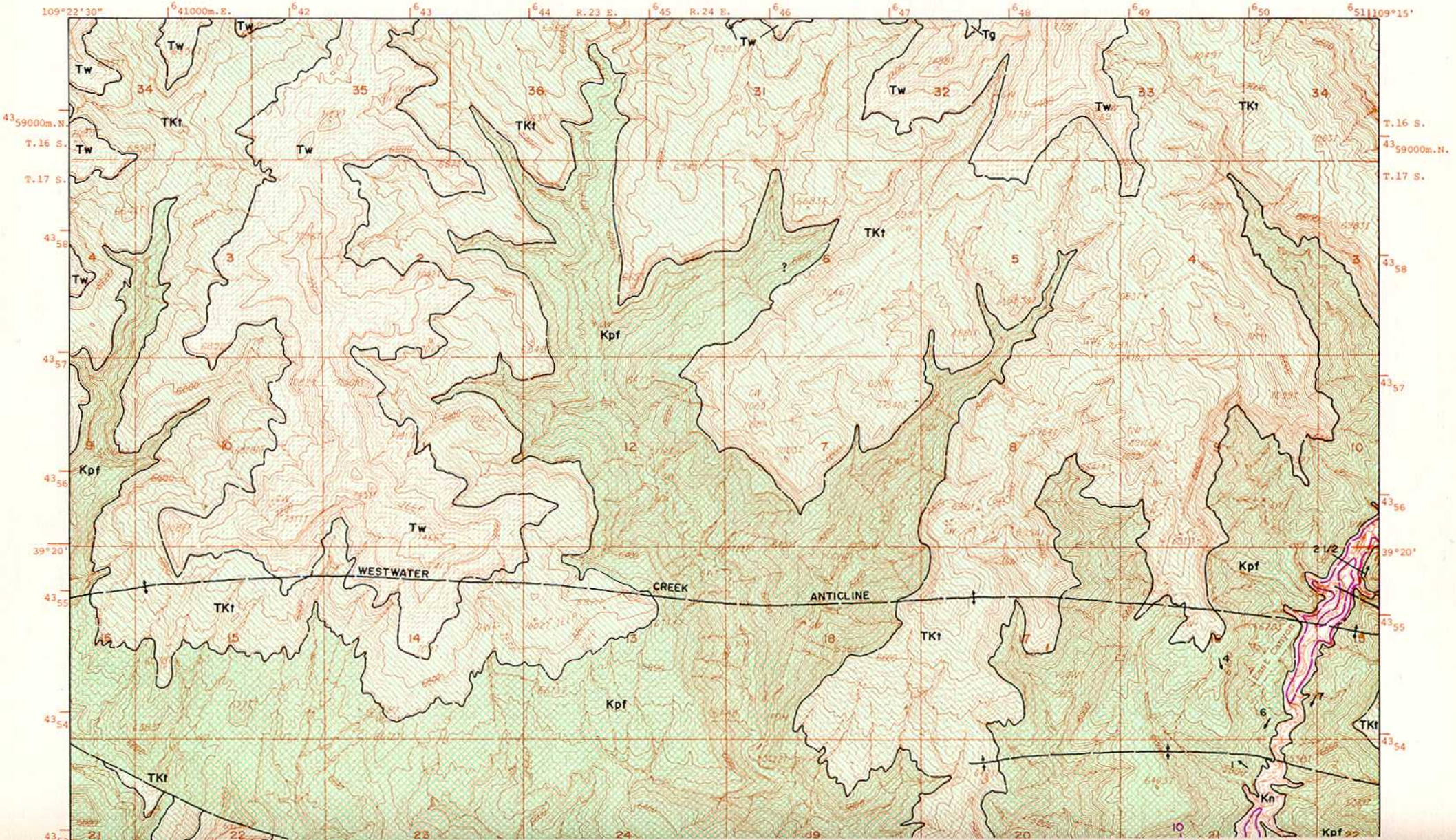


Figure 27. Coal and geology map, West Bitter Creek quadrangle (explanation pages 218-219).

WESTWATER CREEK NORTH, UTAH



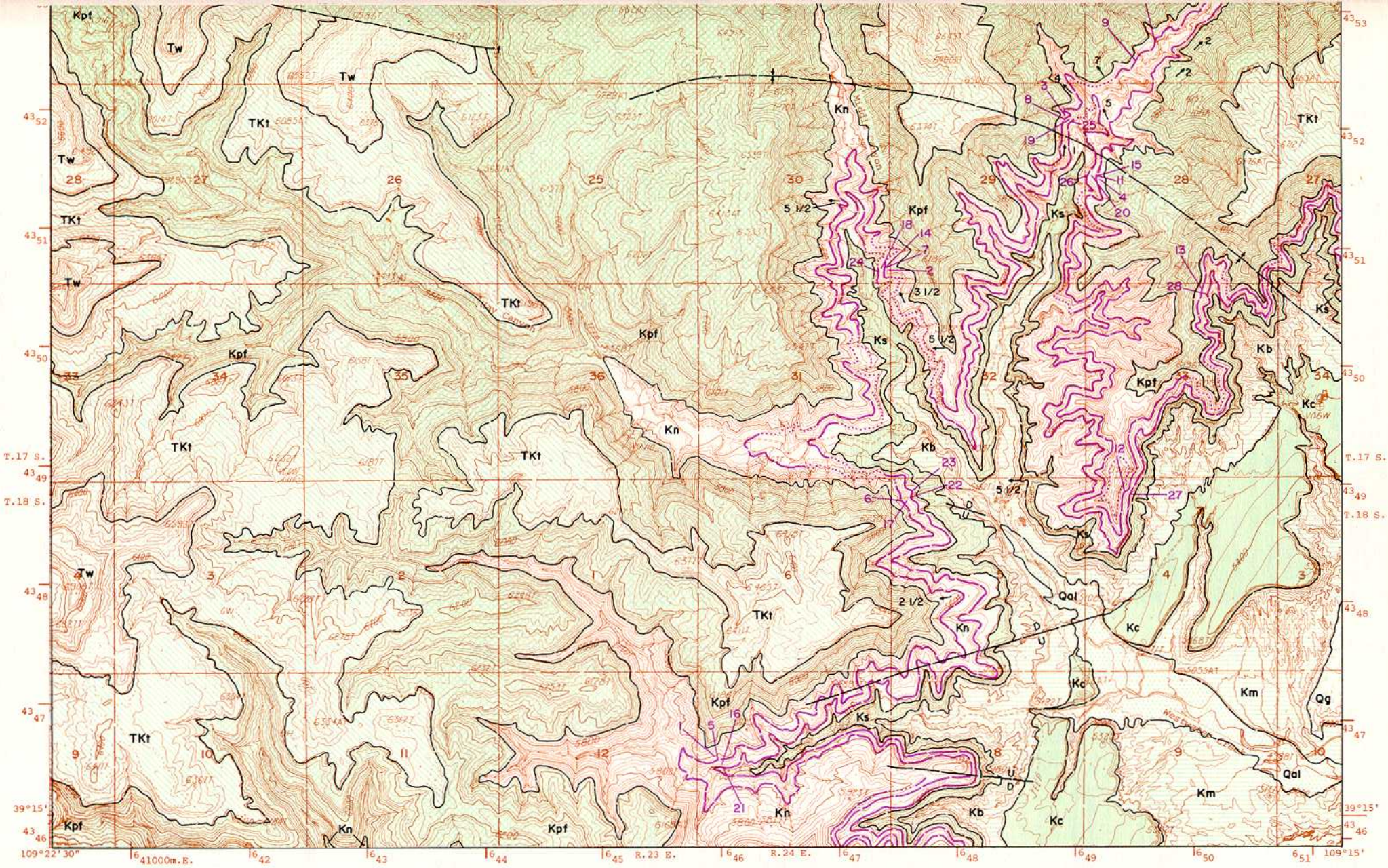


Figure 28. Coal and geology map, Westwater Creek North quadrangle (explanation pages 218-219).

Neslen Member	Feet
1. Coal	0.6
2. Shale and mudstone, carbonaceous	2.4
3. Coal	2.0
4. Shale, gray	6.7
5. Coal	1.0
6. Shale, gray	0.6
7. Sandstone, brown, fine-grained, thin- to medium-bedded, forms ledge, shale partings in lower ½ foot	4.3
8. Coal	1.2
9. Shale, gray	0.6
10. Sandstone, light brown, fine-grained, ledge former	5.6
11. Shale and mudstone, gray and brown	2.4
12. Coal	0.5
13. Sandstone, light gray weathers brown, fine-grained, thin- to medium-bedded, ledge former	8.6
14. Shale, gray	0.6
15. Coal	0.6
16. Shale, gray	5.5
17. Sandstone, gray to brown, fine- to medium-grained, medium-bedded, occasional shale partings, ledge former	11.2
18. Shale, gray	9.6
19. Interbedded sandstone and shale	5.4
20. Coal	1.4
21. Shale, gray	0.3
22. Sandstone, like 17 with some interbedded shale in lower part	7.5
23. Shale, gray	28.1
24. Interbedded sandstone and shale	7.4
25. Shale, gray	4.2
26. Interbedded sandstone and shale, sandstone thin-bedded and fine-grained	5.3
27. Shale, gray	7.3
28. Interbedded sandstone and shale, like unit 26	3.5
29. Coal	2.0
30. Shale, gray-black	5.0
31. Interbedded sandstone and shale, sandstone thin-bedded and medium-grained	2.8
32. Shale, gray	7.1
33. Sandstone, light brown weathers darker, medium-grained, thick-bedded to massive, cliff former	19.2
34. Shale, gray	7.1
35. Coal	0.5
36. Sandstone, gray, medium-grained, single massive bed, ledge	5.2
37. Coal	0.7
38. Shale and siltstone, gray	2.9
39. Sandstone, light brown, fine- to medium-grained, ledge	2.5
40. Shale, gray-black, thin sandstone bed near base	6.3
41. Sandstone, like 33	12.1
42. Shale, gray-black and carbonaceous	17.2
43. Sandstone, like 33	22.8
44. Interbedded sandstone and shale	4.8
45. Shale, gray	8.6
46. Coal	3.5
47. Shale and mudstone, gray and brown	17.3
48. Coal	0.5
49. Shale	0.6
50. Coal	1.0
51. Shale, mudstone and siltstone, gray and brown	6.7
52. Interbedded sandstone and shale, mostly gray shale at base	6.7
Total Neslen Member	297.5
Sego Sandstone: sandstone, light brown, weathers gray-white, medium-grained, massive cliff former.	

Bitter Creek Canyon

Partial section of Neslen Member of Price River Formation, sec. 25-16S-25E, by Thomson (1970).

1. Sandstone, gray-brown, medium-grained, cross-bedded, massive cliff-former	15.0+
2. Sandstone, light brown and gray, medium-grained, forms ledge, thin-bedded, interbedded with subordinate shale	3.0
3. Shale, gray	20.4
4. Interbedded sandstone and shale	6.8
5. Shale, gray	10.7
6. Sandstone, light brown, medium-grained, single bed or ledge	1.0
7. Shale, gray	2.0
8. Coal	2.0
9. Shale, gray	20.9
10. Sandstone, like 6	2.3
11. Shale, gray	12.4
12. Sandstone, like 6	1.5
13. Interbedded sandstone and shale	9.3
14. Coal	1.2
15. Shale, gray	0.4
16. Sandstone, like 6	1.4
17. Shale, gray	0.6
18. Sandstone, like 6	1.5
19. Shale, gray and brown with thin sandstone interbeds	21.1
20. Sandstone, like 6	1.1
21. Shale, gray	20.1
22. Sandstone, yellow-brown, medium-grained, thin to medium beds, ledge former	4.9
23. Interbedded sandstone and shale	5.4
24. Shale, gray	1.6
25. Coal	1.5
26. Shale, gray	3.8
27. Sandstone, light brown, medium-grained, cross-bedded, massive cliff former	21.6
28. Interbedded sandstone and shale	3.0
29. Coal	0.3
30. Shale, carbonaceous	2.5
31. Sandstone, gray brown, fine- to medium-grained, thick ledge	3.5
32. Shale, gray	3.2
33. Coal	0.5
34. Shale, gray	13.7
35. Coal	0.7
36. Shale, gray	1.0
Total measured Neslen Member	221.9+
Sego Sandstone	

East Canyon

Partial section of Neslen Member of Price River Formation, secs. 28-29, 17S-23E, by Thomson (1970).

Neslen Member	Feet
1. Coal	1.3
2. Shale and mudstone, gray and brown	6.5
3. Coal	5.5
4. Shale, gray with occasional thin sandstone interbeds	47.6
5. Limestone, gray to gray-brown, silty, thick-bedded	6.7
6. Interbedded sandstone and shale	4.7
7. Coal	0.5
8. Shale, gray	0.7
9. Sandstone, gray-white weathers light-brown, fine-grained, thick-bedded, ledge	7.5
10. Shale, gray with intermittent thin sandstone interbeds	33.3
11. Sandstone, like 9, except medium-grained and medium-bedded	8.5
12. Coal	1.1
13. Shale, gray	0.9
14. Interbedded sandstone and shale	3.9
15. Sandstone, gray, fine-grained, upper part silty, medium-bedded, ledge former	6.4
16. Shale, gray	2.7
17. Coal	2.2
18. Shale, gray	3.0
19. Sandstone, light brown, medium-grained, medium- to thick-bedded, cliff and ledge forming, intermittent with shale partings	38.5
20. Shale, gray	1.8
21. Coal	0.5
22. Shale, gray	1.3
23. Coal	1.0
24. Shale, gray	4.0
25. Interbedded shale and sandstone	8.1
26. Shale, gray	1.3
27. Coal	0.5
28. Shale and mudstone, gray and brown, thin sandstone bed at base	13.5
29. Coal	1.1
30. Shale, gray	2.0
31. Coal	0.6
32. Shale, gray	5.6
33. Interbedded sandstone and shale	18.9
34. Coal	0.5
35. Shale, gray	7.7
36. Coal	1.5
37. Shale, gray	6.3
38. Sandstone, gray-brown, fine-grained, single bed, ledge	1.3
39. Interbedded sandstone and shale	12.2
Total measured Neslen Member	271.2
Sego Sandstone: sandstone, gray to light brown, medium-grained, massive cliff	

STRUCTURE

Basically the structure contours parallel the cliff front, but between Hay Canyon and Bitter Creek a series of east-west fold axes influences the strata. The folds are gentle, but their effect is

noted at least 5 miles behind the cliff front. Dips exceeding 5 degrees are rare and the folds plunge westward.

Of the occasional faults, the most notable are near the mouth of Westwater Canyon, San Arroyo Canyon and Jim Canyon. The larger fault near Westwater Creek has a displacement of 80 feet, the one near San Arroyo Creek is displaced 16 feet and the Jim Canyon fault is displaced 225 feet.

PROPERTY CONTROL

Approximations of land ownership for the three quadrangles are as follows (Utah only):

	Percent		
	Westwater Creek North	West Bitter Creek	Colorado Line
Bureau of Land Management	86.5	86.1	87.8
State of Utah	11.8	7.8	11.3
Private Property	1.7	6.1	0.9

As of January 1, 1970, there were no leases or permits for coal and no land held for extracting coal.

COAL

Surface Information

On the Colorado Line quadrangle all the coal is in thin, mostly impure, beds. Of the twelve supplied locations (figure 29) four are in Colorado. The thickest bed of the Carbonera zone (locations 1 to 5) is 2.1 feet and located in Colorado. The Chesterfield is 2.5 feet thick, but is mostly spoiled by bone. The Ballard zone (location 9) is thin, less than a foot for the thicker bed. The Palisade is 3.7 feet thick in Prairie Canyon, Colorado, but no more than 1.3 feet thick in Utah.

The same four zones are represented in the West Bitter Creek quadrangle (figure 30). All measurements are of impure coal (table 19).

Table 19. Coal zones and their thicknesses in the West Bitter Creek quadrangle.

	Locations	Feet	
		Thickest seam range	Thickest seam average
Carbonera	1-4	1.0-7.0	3.3
Chesterfield	5-11	1.4-4.6	2.3
Ballard	12-15	1.2-2.4	1.8
Palisade	16-23	1.0-4.5	2.2

In the Westwater Creek North quadrangle five zones are represented (figure 31 and table 20). The additional zone is unnamed and lies between the Ballard and Palisade. Again much of the coal has been adjudged boney or impure.

Table 20. Coal zones and their thicknesses in the Westwater Creek North quadrangle.

	Locations	Feet	
		Thickest seam range	Thickest seam average
Carbonera	1-4	3.5-6.1	4.7
Chesterfield	5-13	1.1-4.4	2.3
Ballard	14-15	1.0-2.2	1.6 (?)
Unnamed	16-20	0.7-1.4	1.0
Palisade	21-28	0.7-2.8	1.7

Subsurface Information

There has been no drilling for coal on the three quadrangles.

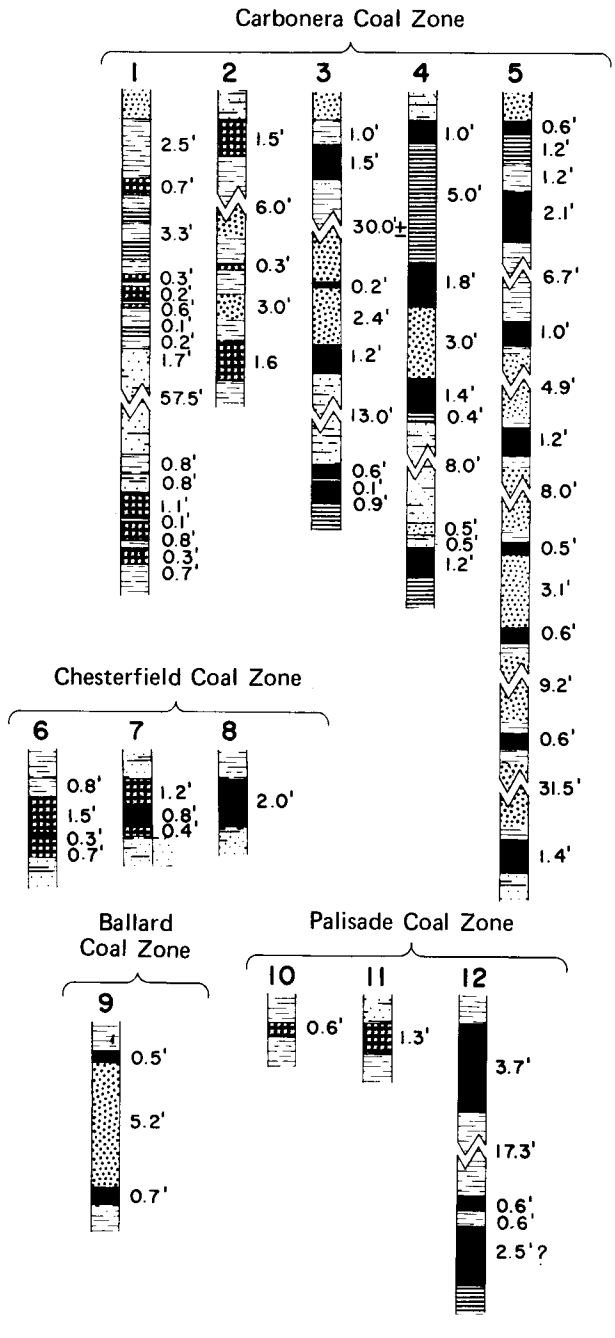


Figure 29. Coal sections of Colorado Line quadrangle (vertical scale: 1 inch = 8 feet).

Quality of Coal

The sample for the single available analysis was taken from the Carbonera (location 2) from Middle Canyon on the Westwater Creek North quadrangle. The coal contains 0.61 percent sulfur, 6.6 percent ash and 10 percent moisture. The Btu/lb rating is believed to be low and inaccurate (10,270).

Mines and Development

There are no mines and no development for coal on the three quadrangles.

Reserves

Fisher (1936, p. 56) considered the coal beds too thin and too impure to calculate reserves. Except for the sections measured by Thomson (1970), Fisher has been the only work in the area. One analysis of a coal bed in Middle Canyon (table 6) indicates the coal to be pure enough to mine so that at least local areas of reserve might be located. The coal in the Westwater Creek North quadrangle, Carbonera zone, averages 4.7 feet thick. A small reserve amounting to 7.9 million tons thus is calculated to exist in

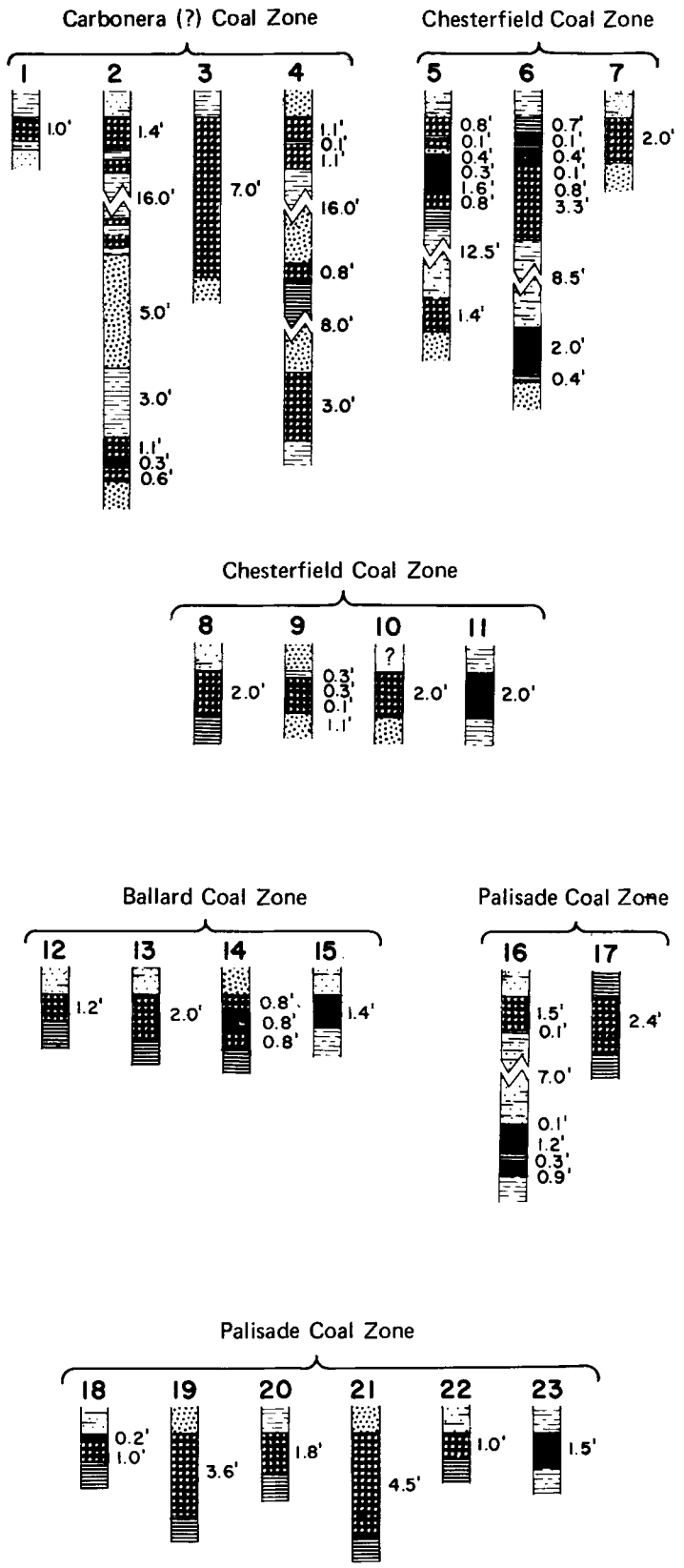


Figure 30. Coal sections of West Bitter Creek quadrangle (vertical scale: 1 inch = 8 feet).

sec. 29 and part of 28, T. 17 S., R. 24 E. in the Carbonera zone, approximately 960 acres; it presently classified as inferred (Class III) in a bed averaging 4.7 feet. Further exploration and sampling of the coal is needed in this area.

PRINCIPAL WORK

The data are a composite of work performed by Fisher (1936) and Thomson (1970).

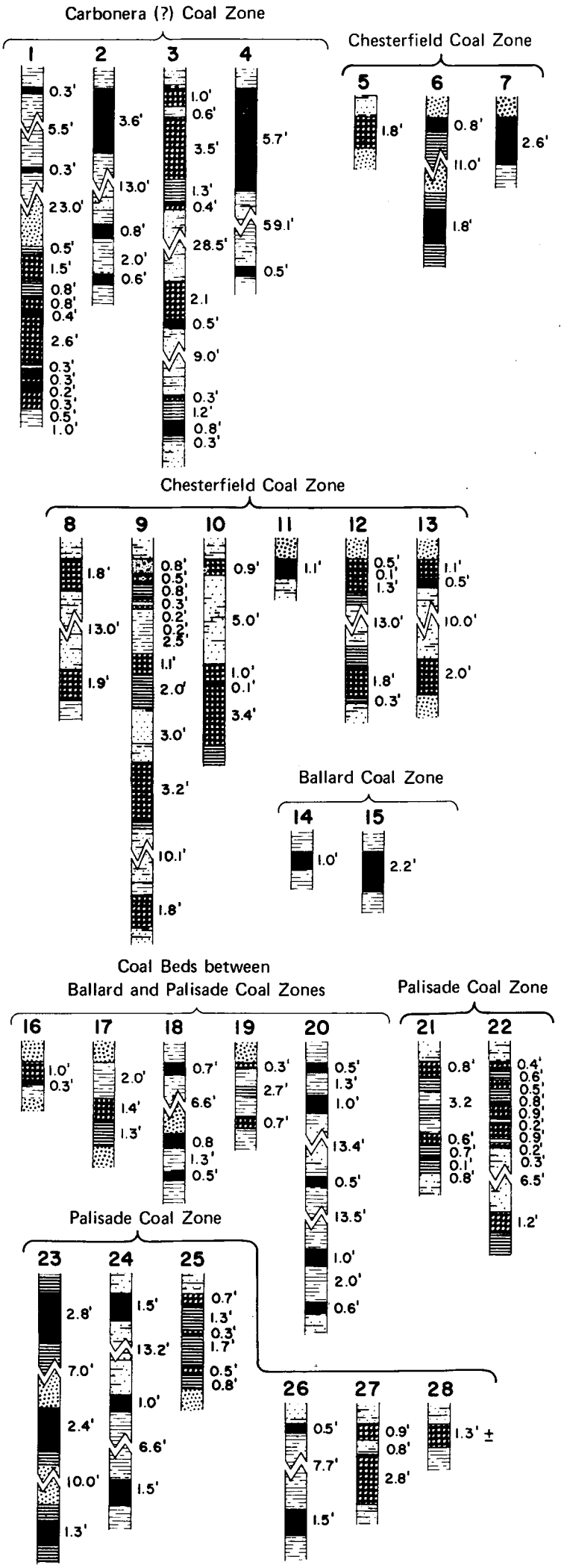


Figure 31. Coal sections of Westwater Creek North quadrangle (vertical scale: 1 inch = 8 feet).

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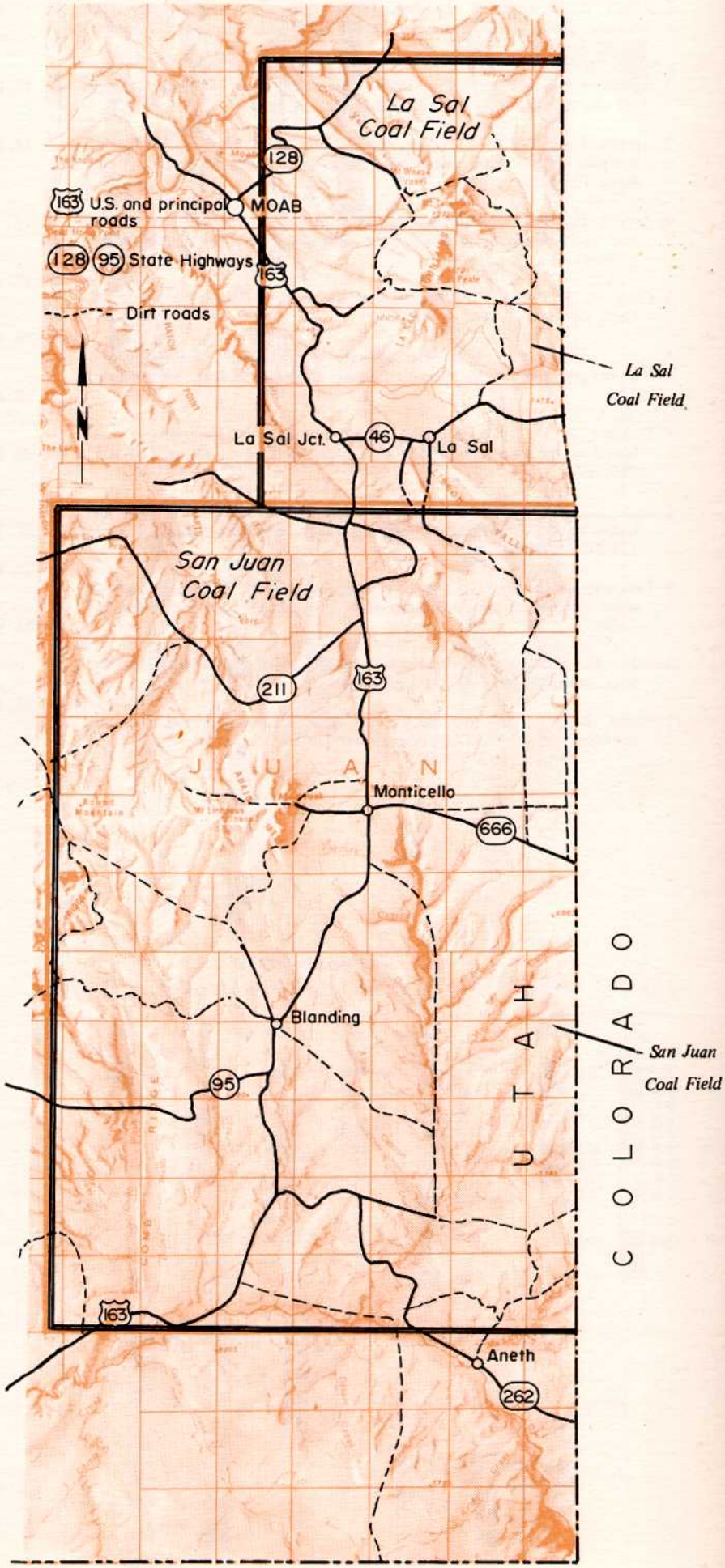


Figure 1. Topography and roads map, La Sal–San Juan coal fields.

LA SAL-SAN JUAN COAL FIELDS

by
H. H. Doelling[1]

INTRODUCTION

Location and Extent

The La Sal and San Juan coal fields are located in southeast Utah, mostly within San Juan County although a small part may extend into southeast Grand County (Preface, figure 1a). The coal-bearing rocks form a cap rock to mesas and benches that are the highest surfaces of the region; only the mountain peaks of the Abajo and La Sal mountains rise to higher elevations. The coal occurs in thin discontinuous seams and the area is of minor importance. Many hundreds of square miles are involved, but the potential area is about 70 miles long and 25 miles wide. That the field is so many square miles in area is misleading inasmuch as the extent of coal seams is unknown and the thickness of known coal beds is mostly subcommercial.

Topography and Drainage

The topography is plateau-like and the highest level is supported by the coal-bearing Dakota Sandstone. This surface is lowest to the south (about 5,200 feet) and gradually rises northward to the north third of Sage Plain at 7,000 feet. Northward the rocks have been disturbed by the intrusion of the La Sal Mountains and by salt anticline uplifts. Erosion has removed much of the surface so that generalizations may not be made.

The plateau surface has been partitioned by many deep canyons into mesas. The largest coherent surface is Sage Plain, a mesa or plateau about 22 by 15 miles. It extends eastwardly into Colorado and terminates westerly against the intrusive Abajo Mountains. South of Sage Plain the creeks all flow southerly in response to the regional dip and are tributaries of the San Juan River. The principal drainages are Recapture and Montezuma creeks. North of Sage Plain the creeks flow northerly or northwesterly into the Colorado River. These drainages are relatively unimportant and join in Dry Valley to form Hatch Wash.

Population, Industries and Transportation

On the mesa tops, agriculture–dry farming–is the most important endeavor. The area produces pinto beans and wheat; cattle are kept in the rougher lands. The principal centers of population are Monticello and Blanding (1970 populations 1,431 and 2,250, respectively). Moab, the Grand County seat, is not far distant (1970 population 4,793).

San Juan County has a total population of 9,606. Aside from agriculture, the area's industries include tourism and trade services, government services and mining (oil, potash, uranium). Coal mining has never been developed beyond the prospect stage.

The principal transportation route is U. S. Highway 163 which extends from Kayenta, Arizona, northward through Blanding, Monticello and Bluff to Interstate 70 at Crescent Junction. U. S. Highway 666 from Monticello and Utah Highway 46 from La Sal Junction extend easterly into Colorado (figure 1). Numerous graded roads reach nearly all the mesas from the main arteries. Monticello and Moab enjoy regular bus service and Moab has regular air service. The nearest railroad, a spur line of Denver and Rio Grande Western, reaches Moab from its main line to the north.

[1]Economic geologist, Utah Geological and Mineralogical Survey.

Climate

Except in the high mountains, most of the La Sal-San Juan region has the dry climate typical of mid-latitude steppes. Between 8 and 18 inches of precipitation fall annually and up to 30 inches fall on the Abajo and La Sal Mountains. The two mountain areas plus the higher Sage Plain constitute the more important water recharge areas.

Temperatures are generally cooler on the mesas than elsewhere in the county. Summer maxima may reach the 90's. The winters are cool and the average January minima are in the teens.

HISTORICAL OUTLINE

Mormon colonists arriving in the area from 1887 to 1888 established the principal towns. Prospecting activity produced gold, uranium and other commodities, but little effort was expended in the direction of coal. A few local mines were opened, perhaps to supply a ranch or two, but efforts were discouraging because of the thin seams and high ash content. Interest in the coal was revived recently. Uranium drilling on Sage Plain encountered coal beds, some reportedly of a commercial thickness. Proper logging of these intervals was not undertaken since the prime interest was uranium. There are no production figures but no more than an estimated 300 tons have been removed from both fields.

GEOLOGIC SETTING (figures 2 and 3)

Stratigraphy

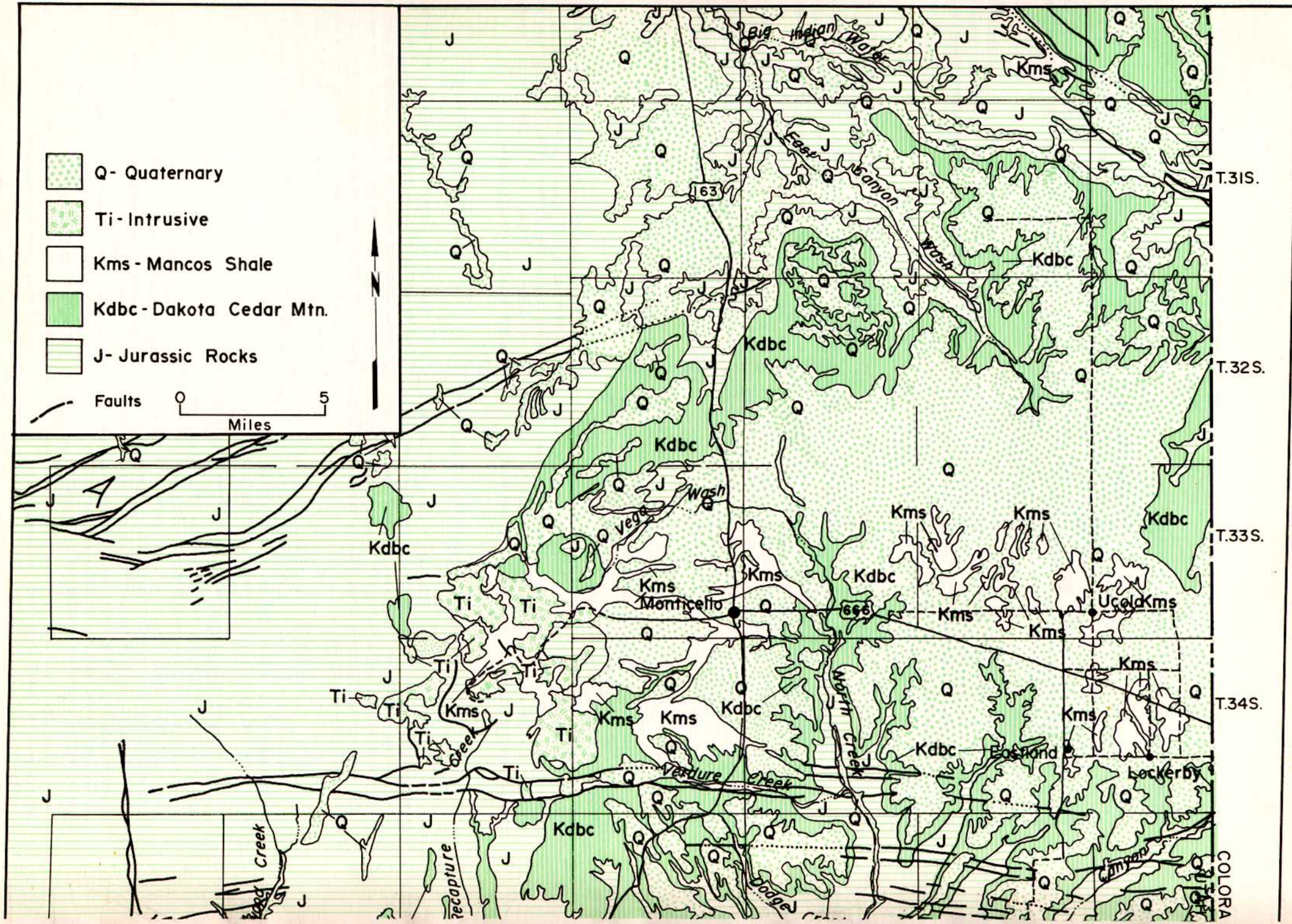
The Cretaceous of the La Sal-San Juan coal fields is made up of three units, the Burro Canyon Formation, the Dakota Sandstone and the Mancos Shale (figure 3). Rock units below the cliffs are mainly of Triassic and Jurassic age and consist of colorful sandstones, siltstones and shales.

Burro Canyon Formation

The Burro Canyon Formation lies below the coal-bearing Dakota and is often grouped with it in mapping. The units have similar appearing sandstone and conglomerate beds, but the shales are different. Burro Canyon shales are more colorful exhibiting shades of green and purple as well as gray. Another distinguishing feature is the absence of coal in the Burro Canyon. The unit is thickest in the La Sal area (up to 260 feet) and 50 to 75 feet near the Abajo Mountains. The shales are generally distributed in the upper part of the unit. The Burro Canyon is separated from the Dakota by a disconformity, which is an undulating surface that locally thins the lower unit.

Dakota Sandstone

The coal-bearing unit is the Dakota Sandstone which, according to Katich (1958, p. 194), is divisible into three parts: (1) a basal sandstone and conglomerate, (2) a middle unit of gray to black carbonaceous shale and (3) an upper unit of sandstone. In most places the unit provides the upper surface of the mesas and is partly removed by erosion. Exposures are poor except around the edges of the mesas because of the presence of covering colluvium and soil. To determine where the middle carbonaceous zone is eroded away presently is impossible.


Q- Quaternary
Ti- Intrusive
Kms - Mancos Shale
Kdbc - Dakota Cedar Mtn.
J- Jurassic Rocks
Faults
0
5
Miles
N
T.31S.
T.32S.
T.33S.
T.34S.
Big Indian Water
East Canyon Wash
Vega Wash
Monticello
Ucola
Eastland
Lockerby
North Creek
Verdure Creek
Recapture Creek
Dodge Creek
Canyon
163
666
COLORA

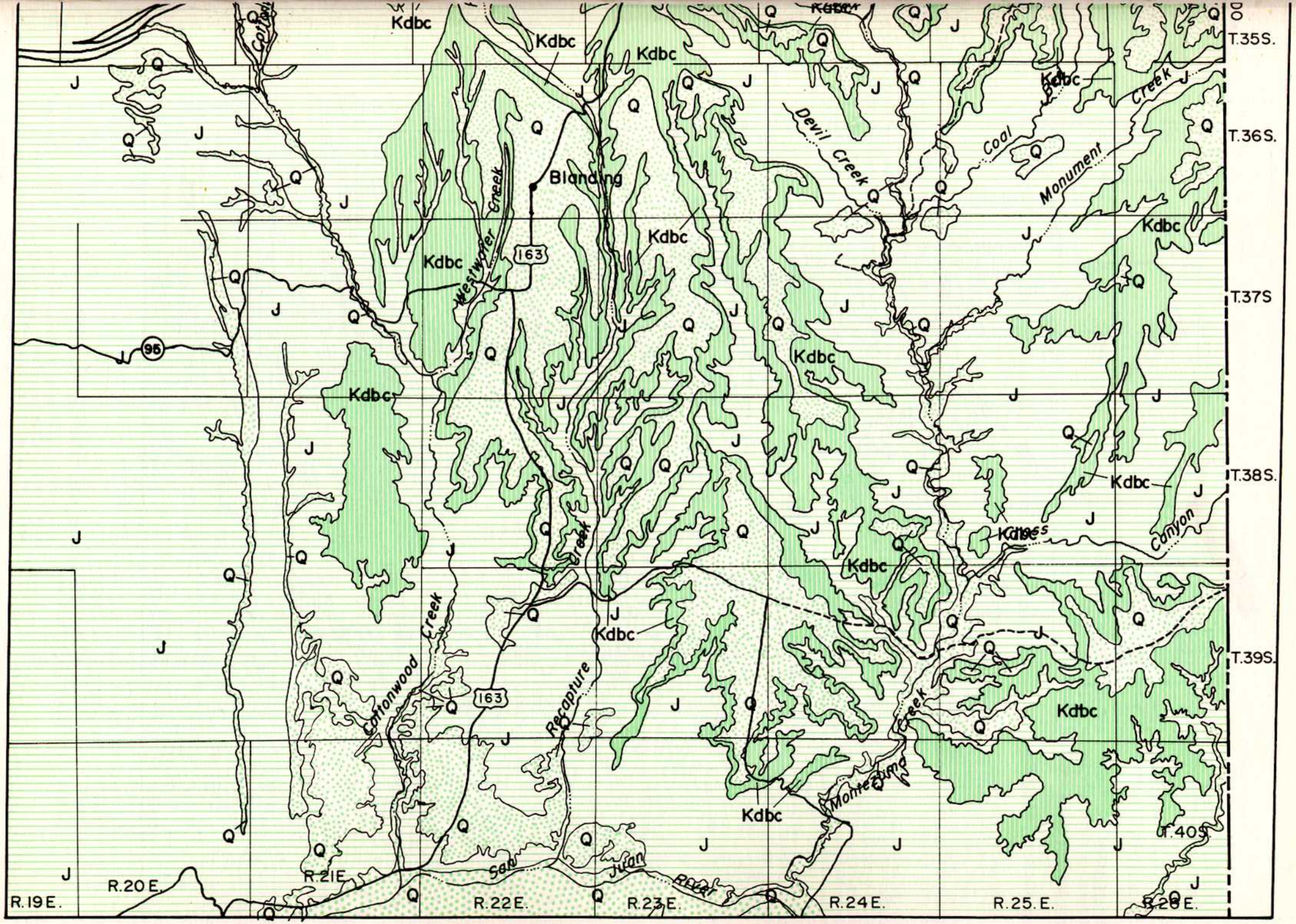


Figure 2. Generalized geology map, San Juan coal field.

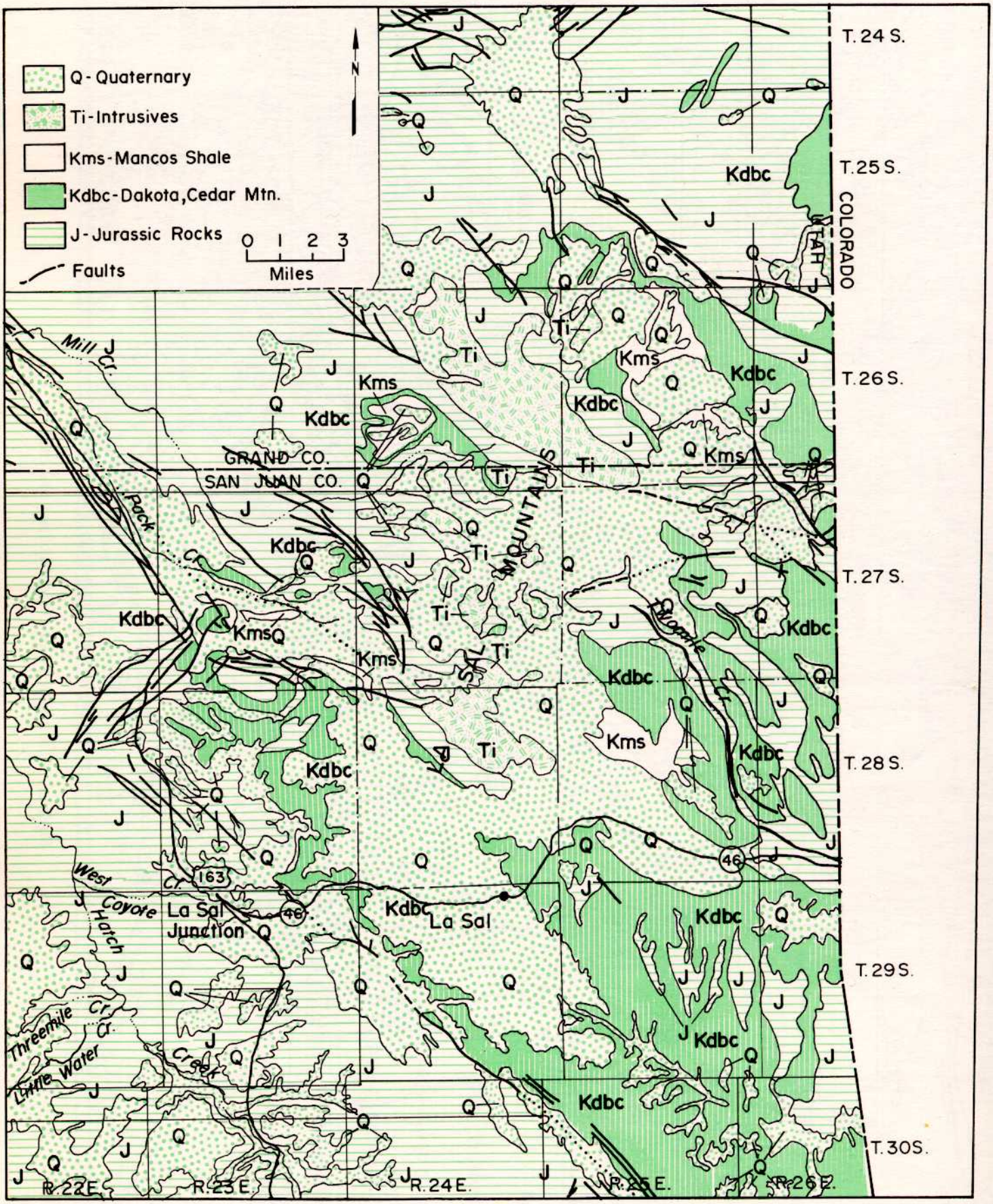


Figure 3. Generalized geology map, La Sal coal field.

System	Series	Stratigraphic unit	Thickness (feet)	Description
CRETACEOUS	Upper	Mancos Shale	0-800?	Dark gray shale and siltstone, soft and fissile, some fossiliferous sandy limestone near base.
		Dakota Sandstone	30-200	Yellow-brown sandstone and conglomerate with interbedded shale and coal, cliff forming.
	Lower	Burro Canyon	50-260	White, gray and yellow-brown sandstone and conglomerate, interbedded with purple and green shale, sandstones cliff forming.

Figure 4. Generalized section of rock formations, La Sal-San Juan coal fields.

Mancos Shale

The Mancos is primarily a gray sandy shale that includes impure limestones, thin beds of yellow-brown sandstone and stringers of impure coal in its makeup. Only the lowermost 100 or so feet are present on Sage Plain and on some of the other mesas. In the deformed areas around the La Sal and Abajo mountains there is evidence that 800 feet of the unit are present. The Mancos is slope forming and easily eroded.

Unconsolidated Units

The most valuable unconsolidated unit, the colluvial soil which covers the mesas, makes possible the successful agricultural endeavors of the region, but it covers the Cretaceous units so well that it is impossible to determine the extent of any coal beds. Closer to the mountains are areas of pediment gravels, terrace gravels and talus.

Igneous Rocks

The igneous rocks of the Abajo and La Sal mountains are dominantly quartz diorite porphyry and diorite porphyry.

Structure

The strata of the major part of the San Juan coal field dip slightly to the south into the Blanding Basin centered just north of the San Juan River. This regimen changes at the Boulder Knoll anticline in the northeast Sage Plain area and in the vicinity of Summit Point, a slight northeasterly dip occurs. The inclinations rarely exceed 3 degrees in the San Juan field. Between the San Juan and La Sal fields the Cretaceous units are eroded over the Lisbon salt anticline. The structure has a northwest trend and except for the doming of the La Sal Mountains, the entire area north of it consists of closely spaced anticlines and synclines also trending northwest. Again the inclinations are not steep except perhaps near a fault or one of the La Sal intrusions.

Faults do not cut the coal-bearing formation to a great extent except in two zones, the Shay and Verdure grabens. These east-west structures are located north and south of the Abajo dome. In the area where the Shay graben may affect the coal horizon, the throw is 0 to 100 feet. The Verdure graben faults have throws of 180 feet in the Montezuma Canyon area. Several other branch faults to the Verdure graben lie east of Montezuma Canyon. Most of these features are shown on figure 2.

Geologic and Tectonic History

Stokes (1958, p. 30) summarized the geologic history:

Cretaceous-Flood Plains, Strandlines, and Swamps: Although the Cretaceous was a period of great marine sedimentation in the Colorado Plateau there were extensive periods of nonmarine deposition during the first half of the period and again near its close. The earliest sediments of Cretaceous age are similar to the Morrison (Jurassic) but may have accumulated under slightly more arid conditions. The thin but widespread Burro Canyon Formation is composed of river sediments derived from older Paleozoic terrain to the west and southwest. Pebbles that occur in the basal members of the Cretaceous contain many fossils and distinctive rock types proving that Mississippian, Pennsylvanian, Permian and Triassic rocks were being eroded.

Climatic and tectonic changes near the middle part of the Cretaceous resulted in the formation of a thin but very extensive sequence of sediments that has been termed the Dakota Group or Dakota Formation. It extends far beyond the Colorado Plateau and into the central part of the continent. The rock types are varied but sandstone and conglomerate are common with coal and carbonaceous shale appearing in moderate amounts for the first time. The abundant evidences of running water and luxuriant land vegetation sufficient to make up coal beds indicate that swamps alternating with shifting streams were prevalent natural features during this time. In the plains area marine fossils are found in certain members of the Dakota, but there are no proven occurrences in the Colorado Plateau. Such fossils as have been identified are thought to be of Late Cretaceous age. The lithologies of the pebbles in the Dakota conglomerate beds taken in connection with the evidence of primary structures indicates a western and southwestern source for most of the sediments.

After the deposition of the Dakota, the Mancos sea extended westward across the region. Essentially all evidence of what happened thereafter has been removed by erosion. On the basis of what happened elsewhere, continental deposition probably resumed at least on a limited basis. No basining occurred and great thicknesses of such sediments were probably not deposited.

The laccolithic centers could have been emplaced anytime between latest Cretaceous and middle Eocene time. Faulting assumedly was concurrent with magma emplacement. Faulting in connection with salt anticlines has not affected the coal to a great extent. The entire region is underlain by salt of the Paradox Basin and some of the structural warping of the mesa surfaces may be influenced by the flowage which has occurred intermittently from the Pennsylvanian to the present time. After Eocene time the entire Colorado Plateau region became uplifted and, to the present, has been dominated by a regimen of erosion.

Correlation with Surrounding Areas

Even though the Dakota Sandstone of the La Sal-San Juan region is cut off from other Dakota exposures in the state of Utah, they supposedly were once continuous. The Dakota extends westwardly into Colorado into the Nucla-Naturita coal field of that state.

COAL DEPOSITS

Status of Information

The poor showing of coal has not prompted much previous work in the La Sal-San Juan area. Most of the information is as a by-product of papers concerned with detailed investigations of the Abajo and La Sal mountains structure, or with uranium, petroleum and stratigraphy studies of the region.

Up to the present indications are that not enough coal is present to ever develop a commercial field in the area. Detail is

lacking to confirm or to deny such a statement and additional future investigations would be welcome.

A bibliography dealing with several geologic aspects of the region is presented at the end of this report.

Mines, Prospects and Production

The mines and prospects of this area are presently (1971) all closed. Coal activity appears to be limited to four areas, all in the San Juan field. The first group is located along the Recapture and Johnson Creek exposures of the Dakota in T. 35 and 36 S., R. 22 and 23 E. Outcrops in this area examined by Gregory (1938, p. 110) show only thin streaks of carbonaceous and bituminous shale. The second area is near Monticello where several openings (presently unlocatable) show stringers of coal 2 to 10 inches thick. Four miles north of the town, exact location unknown, an impure bed 2 feet 9 inches thick has been reported. The third area is situated south of U. S. Highway 666 in the vicinity of Lockerby and Eastland (unincorporated communities) in T. 34 S., R. 25 and 26 E., near the Colorado state line. Four prospect holes exist near the NW sec. 22, T. 34 S., R. 26 E; the most important was the Crepo mine. A measured section illustrates the general nature of all surface sections in the area (Gregory, 1938, p. 110):

Section in Crepo mine

	Feet
Sandstone, gray to buff, medium-grained, cross-bedded	17.0
Shale, carbonaceous	0.5
Shale, gray sandy	0.8
Coal, streaked with shale	0.8
Shale, gray	0.6
Coal, boney	1.0
Shale, carbonaceous, and streaks of poor coal	0.8
Shale, gray, floor	0.4

A bulldozed outcrop in the SW sec. 26, T. 34 S., R. 25 E. just north of the road represents the best showing in the field. Roof and floor were unobservable, but 3 feet of coal are underlain by an additional 3 feet of impure coal.

The last group of prospects are those located along Piute Creek. Several pits were opened in this area, some of which operated intermittently from 1927 to 1929. An attempt to reopen the Rasmussen mine occurred in 1947, but no production was achieved. The following is a section of the coal taken at the face of the mine in 1948.

Section in Rasmussen mine

	Feet
Sandstone, roof	30.0
Shale	0.5-1.3
Bone	0.4
Coal	1.5
Sandstone	0.1
Coal	1.0
Bone	0.4

The mine is located on lot 2, sec. 35, T. 33 S., R. 26 E., adjacent to the Colorado line (figure 5).

Gregory mentions a Pendergraff mine in the Piute Creek one mile east of the Colorado boundary; his section shows 1 foot 10 inches of good coal. Production from the region has been insignificant.

Land Ownership (figures 6 and 7)

No attempt has been made to place the lands of the La Sal-San Juan region into percentage blocks on the basis of land ownership. In general most of the arable lands on the mesas are privately owned in the San Juan field. The arable land closely coincides with the area believed underlain with coal. A small sprinkling of land is managed by the Bureau of Land Management and state of Utah. In addition some of the coal rights that are shown as private land are reserved to the United States. These parcels are

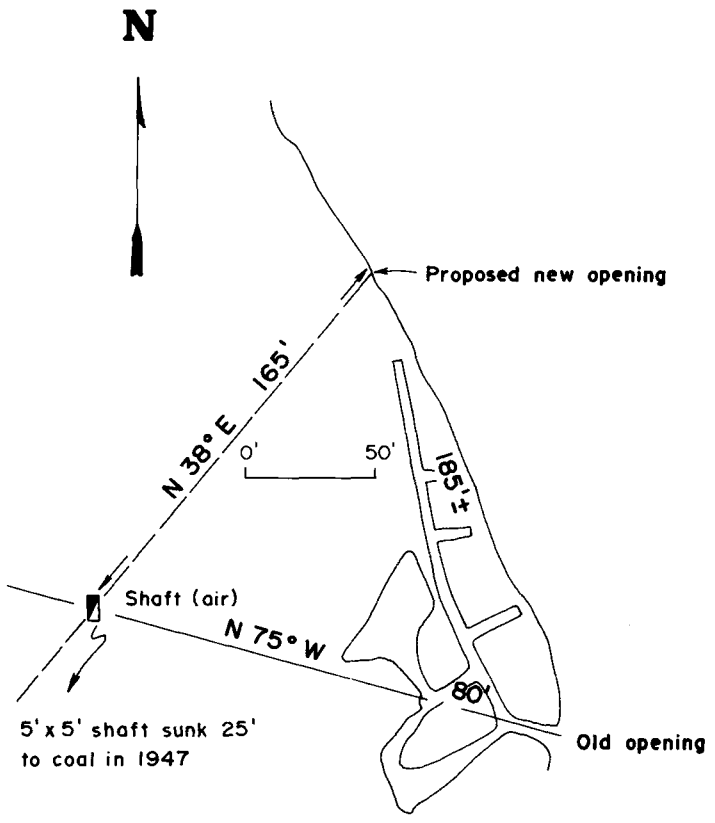


Figure 5. Diagram of the Rasmussen mine, September 27, 1948.

near the Colorado state line. The rough canyon lands are administered by the BLM.

In the La Sal field the lands appear equally divided by private ownership, National Forest administration and by the state of Utah. As far as is known no lands currently are held for the purpose of extracting coal.

Quality of Coal

The only known analysis of coal is from the Rasmussen mine located on the Eastland quadrangle (table 1).

Table 1. Average proximate analysis of coal, Rasmussen mine, Eastland quadrangle.

	AN	M	VM	FC	Ash	S	Btu/lb	ADL
1. 35-33S-26E	A	2.7	24.1	42.3	30.9	2.0	9,300	1.7
4,192,790m.N.	C	–	24.7	43.6	31.7	–	9,560	–
671,530m.E.	D	–	36.2	63.8	–	2.9	14,000	–
Shaley coal								
2. 35-33S-26E	A	4.3	32.3	52.3	11.1	3.8	12,480	3.3
4,192,790m.N.	C	–	33.8	54.6	11.6	3.9	13,040	–
671,530m.E.	D	–	38.2	61.8	–	4.5	14,750	–
Coal only								

The latter analysis shows that the coal is low in moisture, high in fixed carbon, but relatively high in ash and sulfur. If there were sufficient coal in this area for a power plant, removal of fly ash and sulfur to conform to standards would be a problem.

Reserves

From the available data on the La Sal-San Juan region, no reserves occur in beds 4 feet or more thick; because of the discontinuity of beds, reserves for beds between 14 and 48 inches are difficult to calculate.

Coal Seams

The La Sal-San Juan coal region is large in area, but little data exist. Therefore no quadrangle reports are appended which

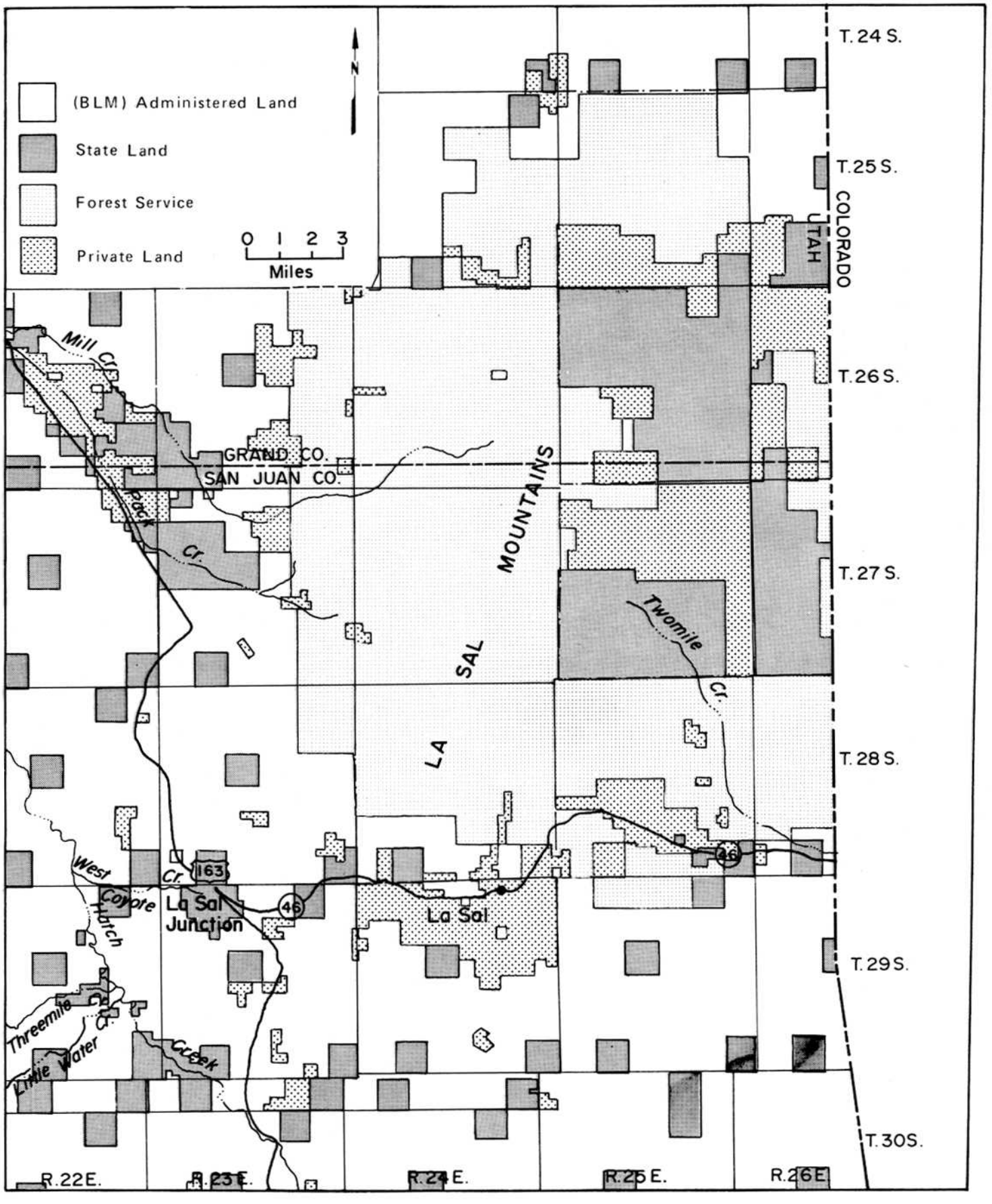
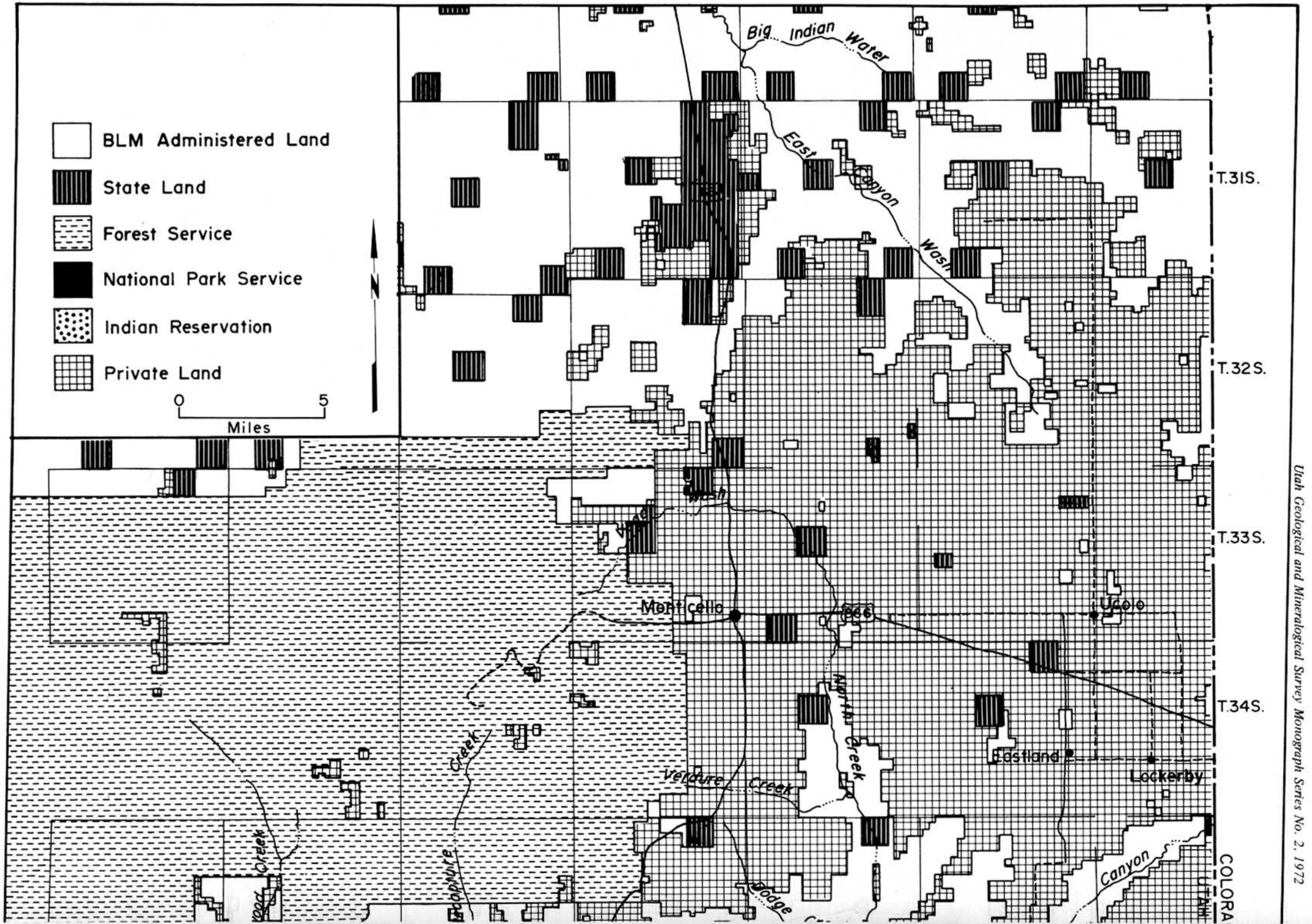


Figure 6. Land ownership map, La Sal coal field.


BLM Administered Land
State Land
Forest Service
National Park Service
Indian Reservation
Private Land
0
5
Miles
N
Big Indian Water
East Canyon Wash
T.31S.
T.32S.
T.33S.
T.34S.
Monticello
666
Ucolo
North Creek
Eastland
Leckerby
Verdure Creek
Canyon
COLORA
UTAH

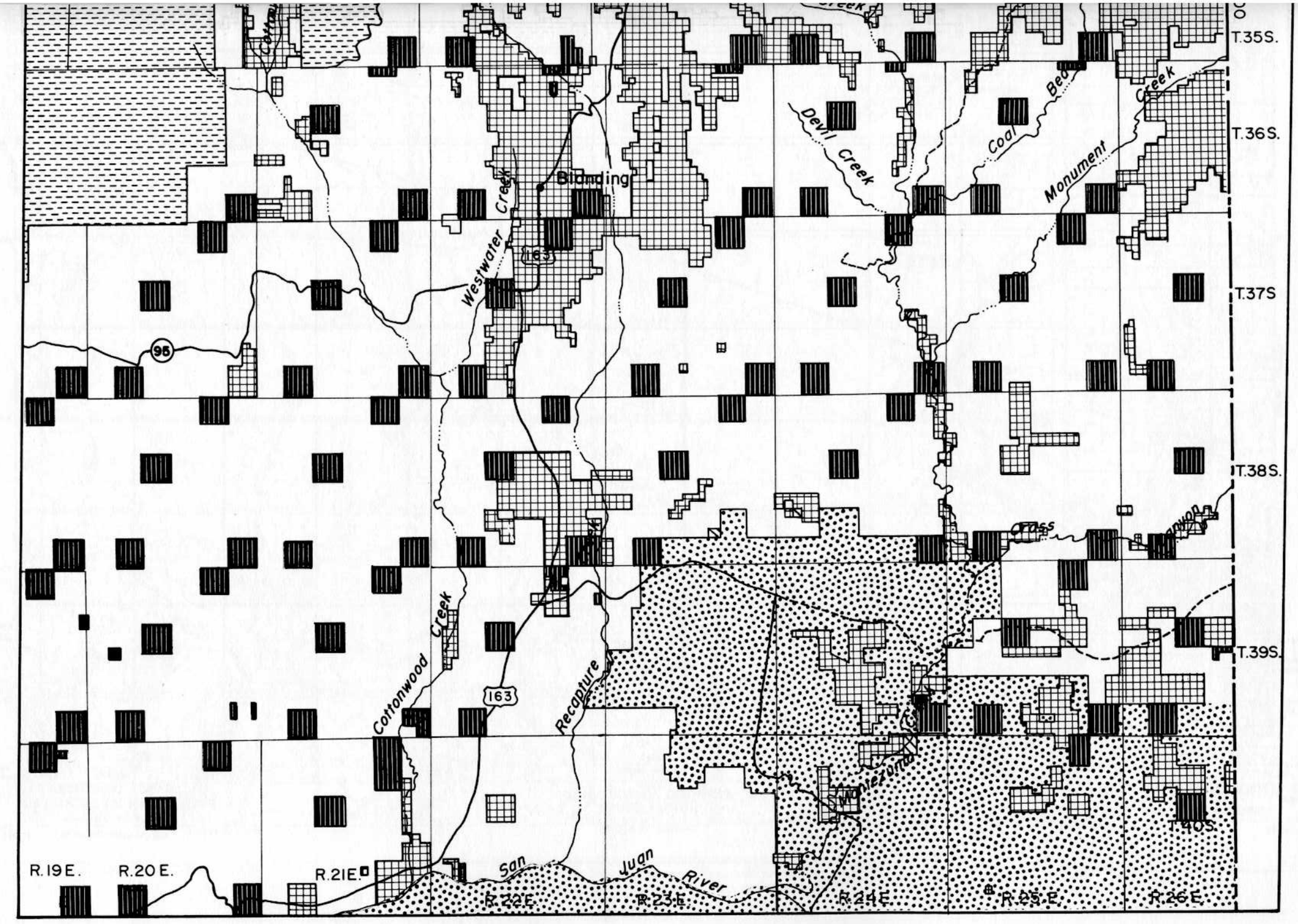
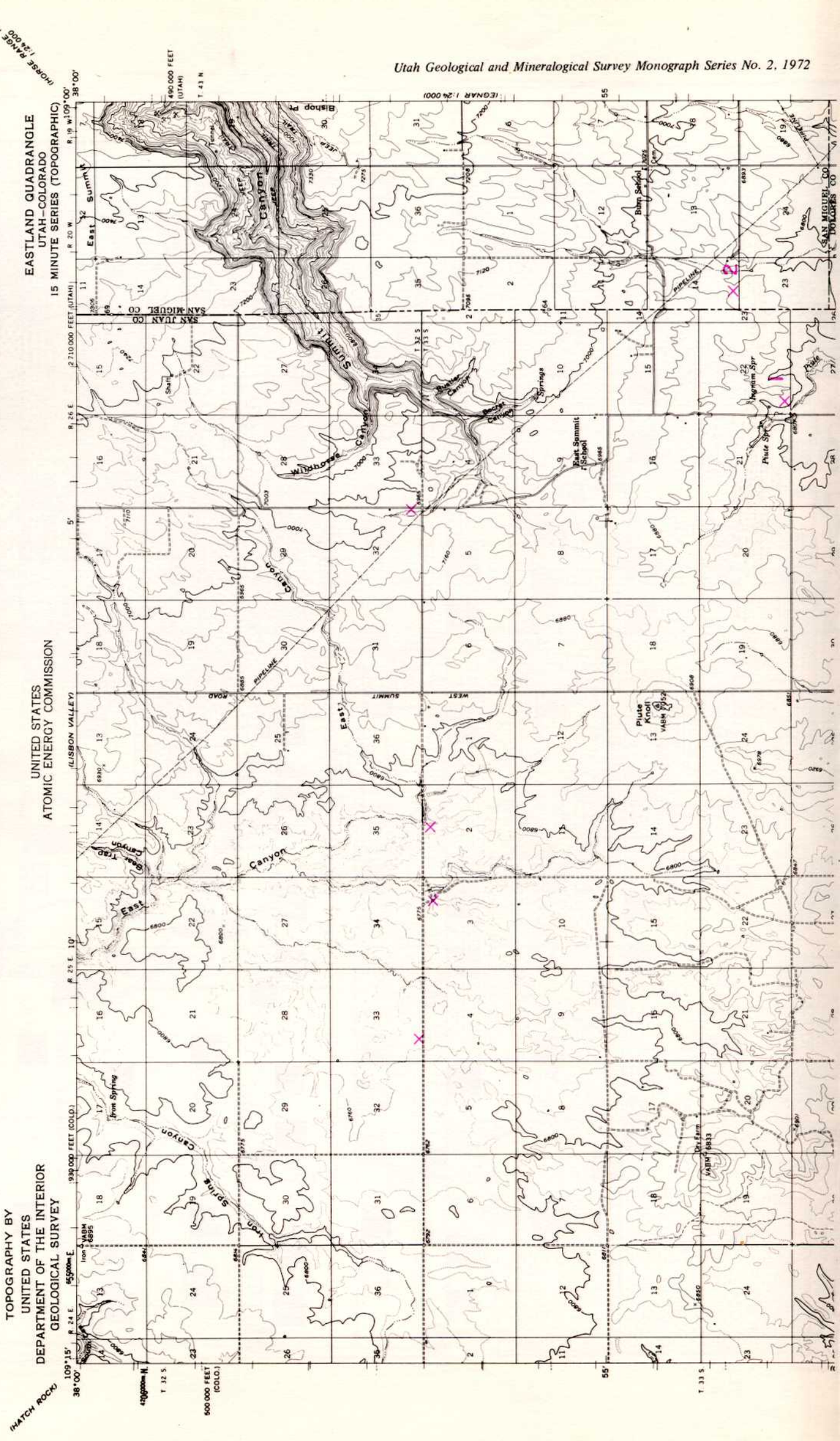


Figure 7. Land ownership map, San Juan coal field.


EASTLAND QUADRANGLE
UTAH–COLORADO
15 MINUTE SERIES (TOPOGRAPHIC)
UNITED STATES
ATOMIC ENERGY COMMISSION
TOPOGRAPHY BY
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
(HORSE RANGE MESA)
(EGNAR 1:24 000)
(LISBON VALLEY)
(HATCH ROCK)
SAN JUAN CO
SAN MIGUEL CO
DOLORES CO
Bishop Pt
East Summit
Canyon
Wildhorse Canyon
Rustler Canyon
Secret Canyon
Springs
East Summit School
Burn School
Ingram Spr
Piute Spr
Piute Knoll
Bear Trap Canyon
Iron Spring
Dry Farm
PIPELINE
WEST SUMMIT ROAD
490 000 FEET (UTAH)
2 710 000 FEET (UTAH)
930 000 FEET (COLO.)
500 000 FEET (COLO.)
38°00'
109°15'
109°00'
55'
5'
10'
R 24 E
R 25 E
R 26 E
R 20 W
R 19 W
T 32 S
T 33 S
T 43 N

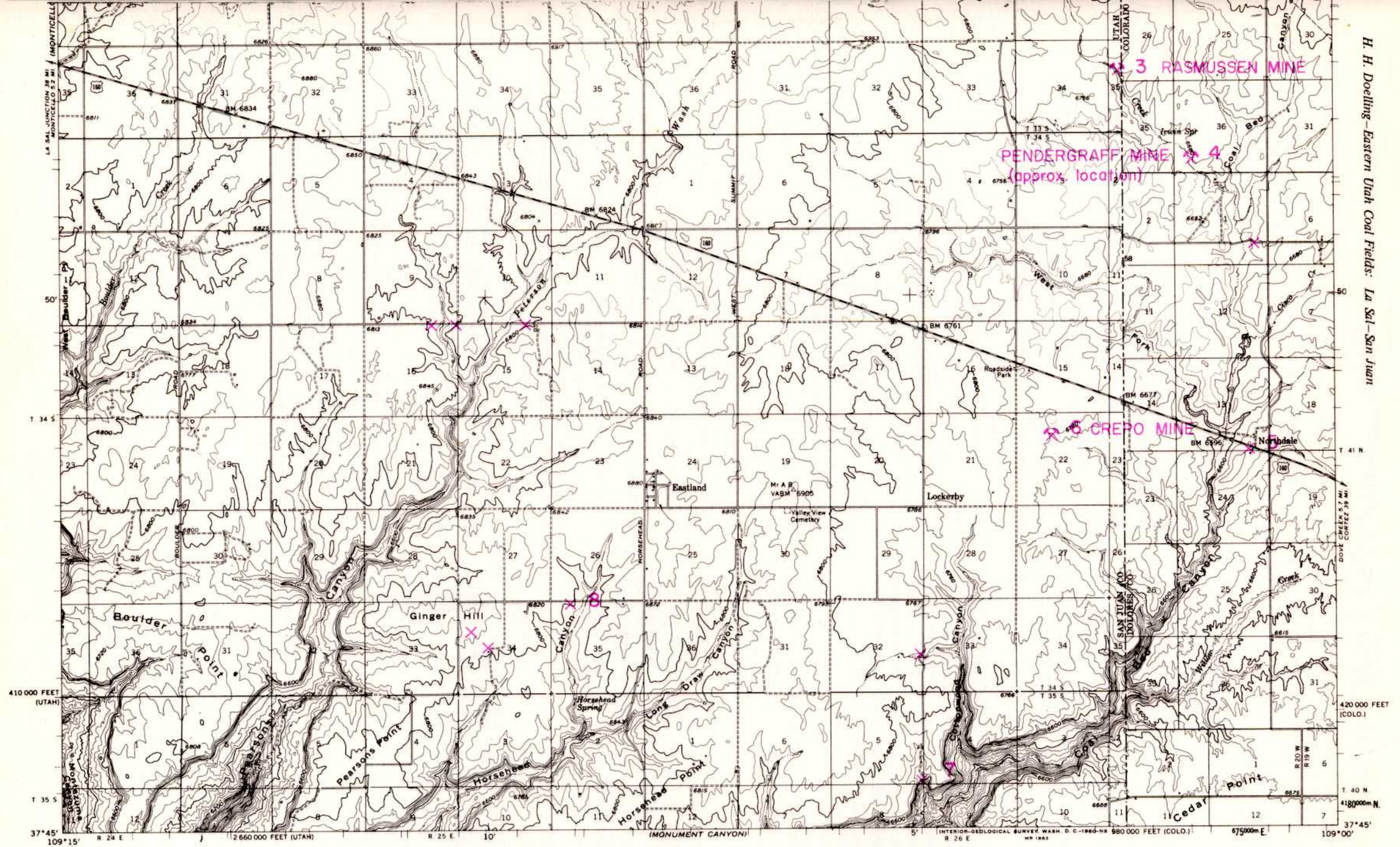


Figure 8. Coal map, Eastland quadrangle.

detail the region. Instead each field is discussed separately. Most of the coal shows are in the Eastland quadrangle. A map with the coal locations is given in addition to the field maps (figure 8).

San Juan Coal Field

The San Juan coal field includes the Sage Plain and several mesas to the south of it. As pointed out in the section on Mines, Prospects and Production, four areas are of interest: Johnson and Recapture Creek area, Monticello area, Eastland-Lockerby area and Piute Creek area.

The first area is located east and north of Blanding and outcrops there show thin streaks of coal and carbonaceous shale. The second area is around the town of Monticello where the coal is 2 to 10 inches thick. A bed of impure coal 2 feet 9 inches thick has been reported 4 miles north of town.

The Eastland-Lockerby and Piute Creek areas are on the Eastland quadrangle near the Colorado border, the first south of U. S. Highway 666 and the latter north of the highway. The Eastland-Lockerby area has two sections of interest, one at the Crepo mine, the other near Ginger Hill (figure 9). The first has 22 inches of impure coal split by 7 inches of shale. The latter shows 3 feet of coal over an additional 3 feet of shaley impure coal. Near Northdale, Colorado, in a road cut, 4.5 feet of coal were measured.

According to Gregory (1938, p. 110) the Piute Creek area has thin coal beds of fair quality. The beds are discontinuous and the same bed is not visible in two mines of the six on both sides of the state line.

Recently rumors of thick coal in the Eastland to Piute Creek area followed drilling activity on the Sage Plain. The drilling was to intersect uranium ore in the Jurassic Morrison Formation well below the coal. Coal was intersected in many of the holes, but quantitative data are lacking. Reportedly 9 feet of coal were found in a core hole in 14-42S-20W (Colorado), but are unconfirmed.

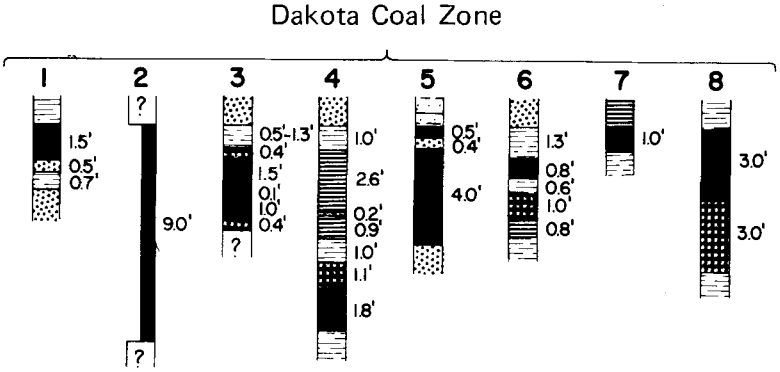


Figure 9. Coal sections of Eastland quadrangle (vertical scale: 1 inch = 8 feet).

La Sal Coal Field

Carter and Gualtieri (1965), in studying the uranium and vanadium deposits of the La Sal quadrangle southeast of the dome, noted coal in the Dakota Sandstone. In their description (p. 17) it is placed in the middle member; it is a unit composed of light gray carbonaceous shale, siltstone and mudstone that is about 100 feet thick in which coal seams occur at various levels less than 3 feet thick. Further (p. 74):

> Thin seams, ranging from a few inches to three feet in thickness, are erratically distributed throughout the area in the middle member of the Dakota Sandstone of Late Cretaceous age. In much of the area, however, the middle and upper members of the Dakota have been removed by erosion and only the lower conglomeratic sandstone is left, especially in the southern third of the mapped area (La Sal quadrangle). To the north the Dakota has been preserved in entirety mainly in structural basins or in fault blocks associated with collapse. . .areas where coal beds of possible economic interest were noted were in secs. 14 and 17, T. 27 S., R. 25 E., and secs. 4 and 15, T. 28 S., R. 25 E., of San Juan County, Utah.

Hunt (1958, p. 313) states that at the head of Horse Canyon, on the west side of Middle Mountain in the La Sal dome, the Dakota is 60 feet thick with a 14-inch bed of shaley coal.

ECONOMIC CONSIDERATIONS AND FORECAST

In view of the thin beds, high sulfur and ash content, the coal has no foreseeable future for development. Other spot locations of coal seams will be discovered, but they too will be thin and discontinuous. The best potential is on the east Sage Plain where drilling will have to prove the presence of commercial coal.

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TABBY MOUNTAIN COAL FIELD

by

H. H. Doelling[1]

INTRODUCTION

Location and Extent

The Tabby Mountain (Blacktail Mountain) coal field is located along the southwest flank of the Uinta Mountains (Preface, figure 1a). Part of the field is located in Wasatch County, the other part in Duchesne County. The area is 60 miles east and slightly south of Salt Lake City.

Most of the coal outcrops, which extend east-west for about 35 miles, are in steeply dipping beds so that each coal zone is expected to be little more than a mile wide. Thus the area of the field is limited to about 70 square miles.

Topography and Drainage

Hard and soft stratigraphic units dipping southerly provide a ridge and valley topography (figure 1). In the south end of the quadrangles the units are overlapped by younger sediments deposited in the Uinta Basin and sloping slightly to the south. The major drainages flow southeasterly toward the deepest part of the Uinta Basin where they become tributary to the Green River (from east to west): Rock Creek, Duchesne River, Red Creek and Currant Creek. They have cut valleys or canyons across the ridges. The secondary (subsequent) streams parallel the ridges for the most part.

The land is high and rugged and elevations range from about 6,500 feet in the lower parts of the major valleys to more than 10,000 feet on the highest prominences. Elevations gradually rise to the north and in the Uinta Mountains some peaks exceed 13,000 feet. The coal occurs at elevations between 6,500 to 9,000 feet.

Population, Industries and Transportation

The sparsely populated Tabby Mountain field area supports two communities, Hanna and Tabiona. In the 1970 census Tabiona had a population of 125 and Hanna 25; probably not more than 200 permanent residents live in the coal field area and they are tied economically to Duchesne rather than to Wasatch County. The county seat, Duchesne, whose 1970 population was 1,094, lies about 30 miles southeast of Tabiona. Most of the people in the Hanna-Tabiona area are ranchers and farmers. A petroleum pipeline pumping station in Hanna employs a few of the residents. Services include a gas station, cafe, motel and two small grocery stores.

The main route of travel is Utah Highway 35 which follows the Duchesne River Valley from Duchesne town northwestward through Tabiona and Hanna. The road continues over high mountain passes to Kamas and Salt Lake City, but is paved only in the vicinity of Tabiona and Hanna. Paved Utah Highway 208 joins Tabiona with U. S. Highway 40, 10 miles to the south. Graded and mountain roads connect the two towns with the remainder of the field. No railroads serve the area. The nearest line is the Park City spur of the Union Pacific Railroad 40 miles northwest. The mountain grades between Park City and Hanna are too steep for inexpensive railroad construction.

Climate

The Tabby Mountain coal field has the mountain climate of a temperate zone. Only the low valleys are affected greatly by the semiarid regional climate of Utah. Winters are severe; snow and ice in the mountains normally cover the slopes five months of the year. Summers are pleasant with cool nights. Total precipitation ranges from 12 inches in the lower part of the Duchesne River Valley to 30 inches on the higher prominences.

[1]Economic geologist, Utah Geological and Mineralogical Survey.

HISTORICAL OUTLINE

From 1844 to 1910 two brief accounts were given of the area as part of U. S. government expeditions. Simpson (1859, p. 296-298) made one report and the other was the report of the Fortieth Parallel Survey of 1869 and 1871 that was published in 1877. The reports noted the presence of coal. A few other minor reports alluded to the presence of coal in the Tabby Mountain area. Some of the early settlers attempted to use the coal. Lupton (1912, p. 626) reports from field work done in 1910 that the old Currant Creek, Red Creek and Farm Creek mines and prospects had been started. He noted that a few tons were mined from the Winchester prospect a few miles from Hanna for local blacksmithing and domestic purposes. The active period of the Winchester mine ended soon and the intermittent activity was transferred to the Red Creek mine. The Red Creek mine was closed down and sealed off in 1941 because of a fire in the mine. An attempt to strip-mine the coal in 1948 failed because of the lack of a market. An underground mine dug opposite the old mine has yielded little or no production. All mines are presently (1971) inoperative or abandoned. Total past production for the Tabby Mountain coal field is around a few thousand tons.

GEOLOGIC SETTING

Stratigraphy

The south flank of the Uinta Mountains exposes rocks of Precambrian, Mississippian, Pennsylvanian, Permian, Triassic, Jurassic, Cretaceous, Tertiary and Quaternary age (figures 2 and 3). This involves at least 30,000 feet of rock. The coal, however, is entirely contained in the Cretaceous rocks and these, plus a few of the units that encase them, are important enough to discuss.

Dakota Sandstone

The lowermost Cretaceous unit, the Dakota Sandstone, has been subdivided into separate formations by several workers. The most familiar division is into the Dakota and Cedar Mountain formations. All were mapped as one unit in this report. Nevertheless, the Dakota Sandstone has a tripartite division: a lower conglomerate, conglomeratic sandstone or sandstone, a medial mudstone and an upper sandstone. The lower two members are usually included with the Cedar Mountain Formation. The total thickness ranges from 150 to 235 feet. Although the Dakota is coal bearing in many parts of Utah, in the Tabby Mountain coal field it appears barren.

Mowry Shale

The Mowry Shale has been assigned as part of the Mancos Shale by some investigators. It consists of gray calcareous clay shale and some siliceous shale which weathers silver gray and contains many teleost fish scales. The whole unit ranges from 85 to 390 feet thick and forms a valley between the ridges formed by the Dakota Sandstone below and the Frontier Sandstone above.

Frontier Sandstone

The Frontier is one of the more important units inasmuch as it is a coal bearer (figure 1). It is a light gray to yellowish brown,

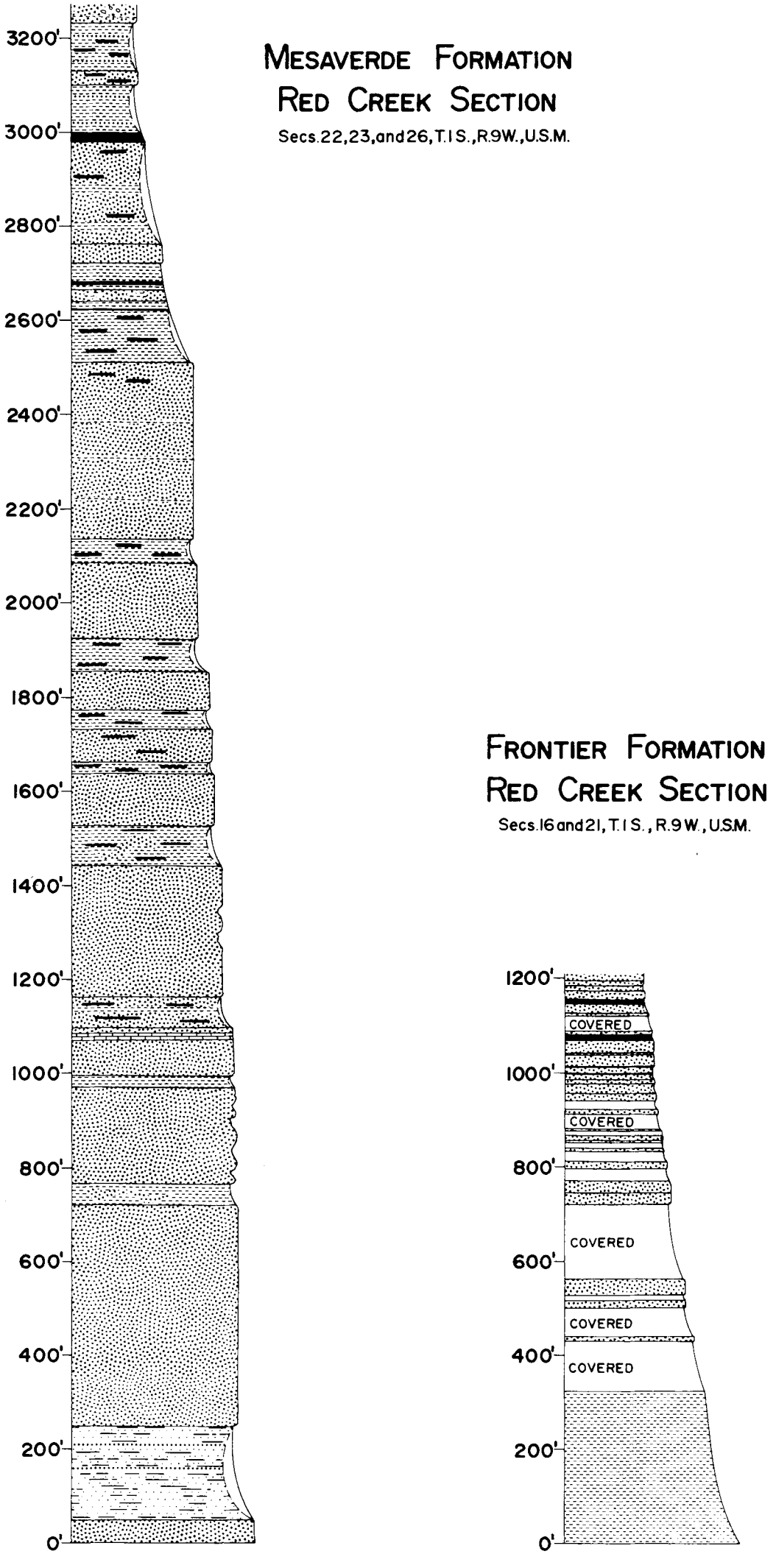


Figure 1. Sections of Mesaverde and Frontier formations, Tabby Mountain coal field (after Lupton, 1910).

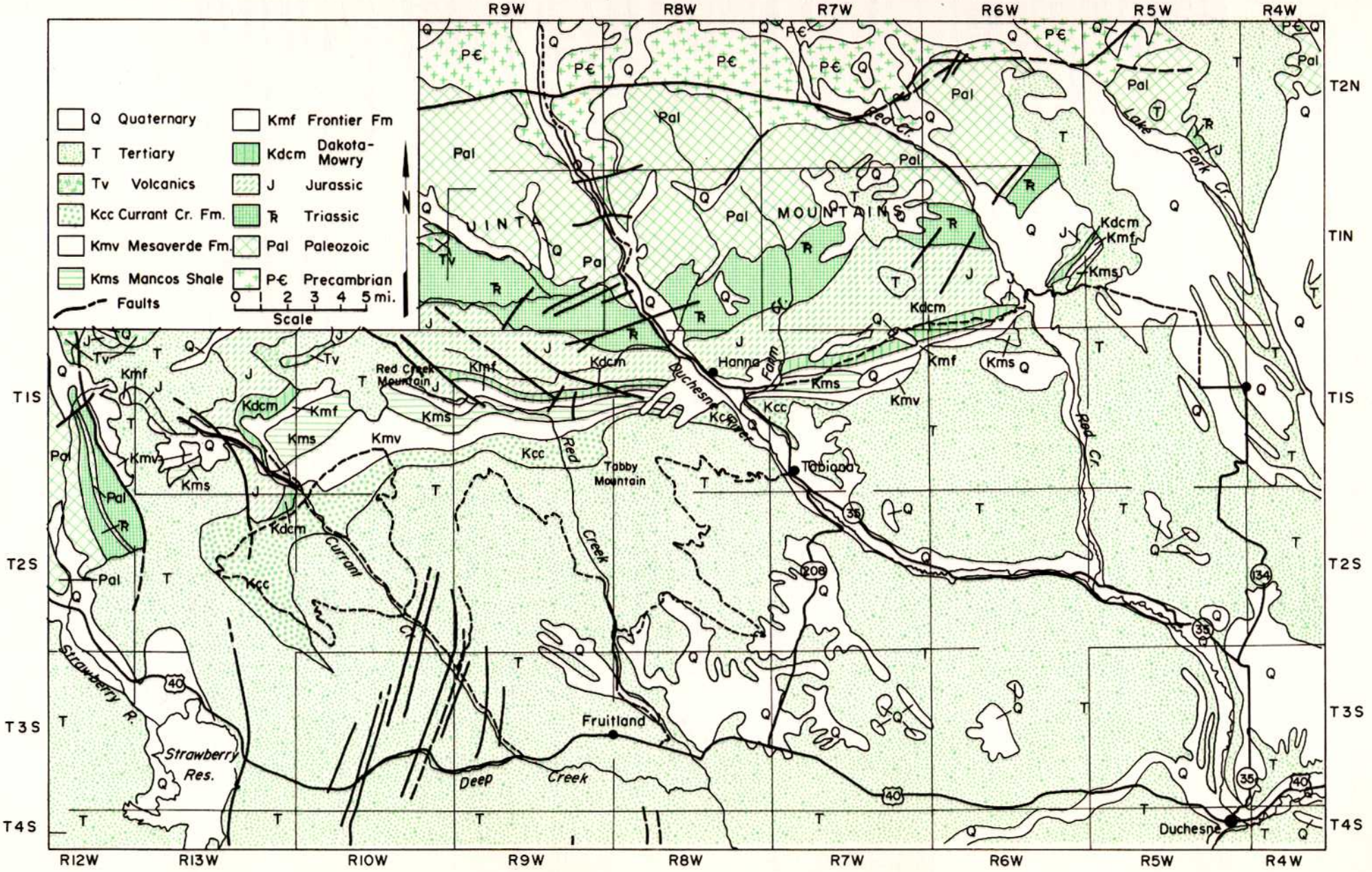


Figure 2. Generalized geology map, Tabby Mountain coal field.

System	Series	Stratigraphic Unit	Thickness (feet)	Description
TERTIARY	Miocene	Bishop Conglomerate	0- 100	Conglomerate; red to grayish white; generally loosely consolidated; contains boulders from many older formations.
	Oligocene?	Unnamed	1,000-1,500	Andesite tuff and breccia.
	Eocene	Uinta Formation	4,500	Conglomerate, sandstone, mudstone, siltstone and shale; gray to white; variegated; interbedded; channels.
		Green River Formation	1,800-2,400	Shale, oil shale, siltstone, sandstone and limestone; variegated colors, divided into several members. Subsurface only.
		Wasatch Formation	780	Conglomerate, sandstone, siltstone and shale; light gray to reddish brown, interbedded, thin- to thick-bedded. Subsurface only.
		Currant Creek Formation	0-4,800	Conglomerate, sandstone and siltstone, some shale; light gray to yellowish brown; interbedded; conglomerate lower part; sandstone and siltstone upper part.
	Paleocene			
				Unconformity
CRETACEOUS	Upper	Mesaverde Formation	550-4,000	Sandstone; light gray; with some interbedded shale and coal; very fine- to coarse-grained, cross-bedded; massive; marine lower part; mostly nonmarine.
		Mancos Shale: Upper Shale Member	800-2,200	Shale; gray; clayey; calcareous; interbeds of thin sandstone.
		Mancos Shale: Frontier Sandstone Member	445- 660	Sandstone; light gray to yellowish brown; fine- to coarse-grained; thin- to thick-bedded; cross-bedded; thickens westward; coal bearing in upper part.
				Unconformity
	Lower	Mowry Shale	85- 390	Shale; gray, siliceous and calcareous, water-laid volcanic ash; contains fish scales.
		Dakota Sandstone	5- 40	Sandstone; gray; contains interbedded conglomerate; black chert pebbles; fine- to coarse-grained. Thick to very thick-bedded.
				Unconformity
		Cedar Mountain Formation	100- 160	Mudstone; green, purple and reddish brown; calcareous; many nodules.
			20- 50	Conglomerate, conglomeratic sandstone and conglomeratic mudstone with gray, black and pink chert pebbles.
JURASSIC	Upper	Morrison Formation	1,100-1,500	
		Curtis-Stump Formation	100- 275	
		Entrada-Preuss Sandstone	700-1,585	
	Middle	Twin Creek Limestone	700- 950	
	Lower	Nugget Sandstone	1,100-1,240	

Figure 3. Generalized section of rock formations, Tabby Mountain coal field.

fine- to coarse-grained, thin- to thick-bedded and in part cross-bedded sandstone. Thin interbeds of shale, carbonaceous shale and coal occur especially in the upper part. There are occasional oyster beds and the unit gradually thickens westward.

Section of the Frontier Sandstone along Red Creek in secs. 16 and 21, T. 1 S., R. 9 W., USM, by Lupton (1912, p. 611).

Mancos Shale: shale, drab to yellowish gray.	
Frontier Sandstone	Feet
Sandstone, light gray, weathers yellow to brown, massive ledge maker.	15
Sandstone, light gray, weathers yellow to brown, moderately thin-bedded (4 to 18 inches thick), contains *Ostrea* sp	10
Covered, probably thin-bedded sandstone	10
Sandstone, light gray, weathers from yellow to brown, fairly massive, ledge maker	18
Coal	10
Covered, probably thin-bedded sandstone.	20
Sandstone, yellow and brown.	5
Covered.	30
Sandstone, yellowish gray, weathers brown.	8
Coal.	11
Sandstone, yellowish gray, beds near top fairly massive.	25
Shale, reddish gray and brown.	4
Sandstone, light gray near top, weathering yellow and brown, yellow near bottom, ledge maker.	25
Coal.	3
Sandstone, yellow and light gray, thin-bedded	10
Coal.	3
Covered, probably thin-bedded sandstone.	10
Sandstone, yellow, thin-bedded.	10
Covered, probably soft, thin-bedded sandstone	20
Sandstone, yellow, massive at top, thin-bedded near bottom, ledge maker.	15
Covered.	20
Sandstone, yellow.	10
Covered.	30
Sandstone, light gray, weathers yellow, poorly exposed.	5
Covered.	10
Sandstone, light gray, weathers yellow, poorly exposed.	10
Sandstone, brown, rather soft.	3
Covered.	10
Sandstone, brown, massive, ledge maker.	6
Covered.	20
Sandstone, light brown, massive, ledge maker.	15
Covered.	25
Sandstone, brown, massive ledge maker, contains *Ostrea*.	25
Sandstone, brown, thin-bedded near middle, fair ledge maker.	25
Covered.	159
Sandstone, contains great numbers of *Ostrea*.	35
Covered.	10
Sandstone, light brown at top, light gray near base, *Ostrea* near middle.	15
Covered.	57
Sandstone, gray, weathers brown, thin-bedded.	10
Covered.	106
Total Frontier	868
Mowry Shale	

The measured section was combined with the Mowry and Mancos shales and part of the measurement includes units transitional between the three formations. These transitional beds have been assigned to the shaley units by most investigators. At least four beds of coal have been noted in the Frontier and coal is known to exist along the entire length of outcrop.

Mancos Shale

The Mancos Shale between the Frontier Sandstone and Mesaverde Formation is mostly a calcareous gray drab shale, but a few sandstone lentils occur in the upper part. It is a slope and valley former that thickens eastward. The Mancos Shale is about 2,000 feet thick at the mouth of Farm Creek, 1,450 feet thick at Red Creek and 800 feet along Currant Creek.

Mesaverde Formation

The Mesaverde Formation is one of the more important coal bearers of the Tabby Mountain coal field. Huddle and McCann (1947) describe it:

The Mesaverde Formation consists mainly of sandstone with some interbedded shale and coal. The formation is 550 feet thick on Duchesne River, but its thickness increases to about 1,700 feet east of the river; it is about 4,000 feet thick near the southwest corner of the area. The small thickness at Duchesne River is probably due to the removal of the upper part of the formation by erosion prior to the deposition of the overlying Currant Creek Formation. Some marine beds are present in the lower part, but most of the formation appears to be nonmarine. The sandstone is lenticular, massive, cross-bedded locally, and some beds contain scattered small chert pebbles; the beds are gray to white on fresh surfaces and weather gray or yellow-brown. The massive cross-bedded sandstone grades laterally into thin-bedded sandstones and shales. The sand grains are angular to subrounded and range from very fine to coarse. The shale is gray to black and is commonly calcareous. The coal beds are confined to the upper part of the formation, and are thickest and most numerous in the southwestern part of the area. . .

Section of Mesaverde Formation along Red Creek in secs. 22, 23 and 26, T. 1 S., R. 9 W., USM, by Lupton (1910, p. 609).

Conglomerate (Currant Creek Formation)	Feet
Sandstone, gray, massive in places, slightly conglomeratic, with thin layers of sandy shale.	40
Unexposed, mainly shale, with some sandstone and probably some coal.	100
Sandstone, yellowish gray, coarse-grained, contains carbonaceous material.	30
Unexposed, probably for the most part shale and thin-bedded sandstone.	100
Coal.	20+
Unexposed, mostly gray and yellow sandstone, with probably some shale and coal.	215
Sandstone, gray, part massive	40
Shale, drab and brown, part sandy	40
Coal	6+
Shale, brown and gray	10
Sandstone, thin-bedded and sandy shale	25
Shale, drab, sandy	15
Coal bed	2½
Unexposed, probably contains shale and some coal	110
Sandstone, gray, massive, cross-bedded, medium fine-grained, with some drab and brown shale alternating, three or four unexposed portions near the top may contain coal	375
Unexposed, probably contains shale and some coal	50
Sandstone, gray, massive	160
Unexposed, probably contains shale and some coal	70
Sandstone, yellow and gray, alternating with shale and probably coal	85
Unexposed, probably contains shale and some coal	40
Sandstone, partly massive, and shale, gray and yellow	70
Unexposed, probably contains shale and some coal	25+
Sandstone, yellow and gray, in places iron-stained, having a reddish brown color, also containing a few thin beds of sandy shale, limonite and marl observed at top	110
Unexposed, probably contains shale, sandstone and some coal	85
Sandstone, yellowish gray, mainly massive, lower part thin-bedded (in places sandstone is soft and forms a depression)	280
Unexposed, probably contains shale, soft sandstone and some coal	65
Sandstone, gray and yellow alternating, very hard, thin-bedded, in places alternating with sandy shale; some limestone beds near the top 1 to 2 feet thick (in these and in the adjacent sandstone, marine fossils were collected)	100
Poorly exposed, probably shale and thin-bedded sandstone	25
Sandstone, gray, yellowish, in places green, mainly massive, mostly fine-grained, upper part somewhat thin-bedded; two or three soft zones in the sandstone, resulting in depressions in the outcrop	205
Shale, sandy, and sandstone, soft, poorly exposed (a few prospects for coal have been opened but no coal found)	45
Sandstone, yellow, gray, mainly massive, in places rather soft near the center	470
Unexposed, probably sandy shale and thin-bedded soft sandstone	200
Sandstone, yellow and gray, poorly exposed, resistant, fine-grained	50±
Total	3,263½±
Mancos Shale	

Currant Creek Formation

The Currant Creek unconformably overlying the Mesaverde consists of interbedded conglomerates and sandstone with subordi-

nate siltstones and shale. The conglomerates are made up of boulders, granules, pebbles and cobbles with cobbles dominating. The larger fragments are well rounded, the smaller are angular. The contact between Mesaverde and Currant Creek is usually placed at the first occurrence of conglomerate. At Currant Creek the formation is 4,800 feet thick, at Red Creek 4,000 feet thick and 1,500 feet thick in the Duchesne River area. It continues to thin eastward and eventually pinches out completely at the east end of the Tabby Mountain coal field. The Currant Creek is believed to extend in age from Late Cretaceous to Eocene being equivalent to the North Horn, Flagstaff and Colton formations of the Wasatch Plateau.

Wasatch and Green River Formations

The Wasatch and Green River formations do not crop out near Tabby Mountain and along much of the south flank of the Uinta Mountains. They are known from the subsurface a few miles to the south. The Wasatch is a reddish conglomerate, sandstone and siltstone. The Green River is a light gray, green or brown shale, sandstone and limestone.

Uinta Formation and Younger Consolidated Units

The Uinta overlaps the Currant Creek in the Tabby Mountain area. It in turn is covered by the Duchesne River Formation. The two are difficult to distinguish and no attempt is made here to differentiate them. They comprise a thick sequence of variegated sandstone, shale and conglomerate. According to Huddle and McCann (1947):

> They include gray to white, poorly sorted, unconsolidated or slightly indurated sand, gravel, cobble and boulder beds; red, gray and greenish gray mudstone; siltstone and sandy shale. The bedding is irregular with lenses of coarse sediments included in the finer sediments, and there is considerable evidence of scour and fill. Many of the cobbles and boulders are rounded, including even quartzite boulders that apparently were derived from the Uinta Mountain Group (Precambrian); the sandstone boulders, whose lithology is similar to the Cretaceous sandstone, tend to be angular.
>
> The Duchesne River Formation includes red, gray and buff sandstone, conglomerate, and sandy shale. In the Duchesne River area the formation is particularly difficult to distinguish from the earlier Tertiary rocks; it seems to include more sandstone, and from a distance looks more golden and more regularly bedded than the Uinta Formation. . .Tabby, Red Creek and Little Red Creek Mountains are capped with a conglomerate that is referred tentatively to the Bishop Conglomerate of Miocene age . . . The Bishop Conglomerate is a red to grayish white, generally unconsolidated boulder conglomerate, containing boulders that were derived from many of the older formations in the area. It rests unconformably on and overlaps older formations.

All of these units are mapped as Tu–Tertiary undivided in the quadrangle geology maps.

Structure

The field is located along the south flank of the anticlinal Uinta Mountains, the most significant feature. The dips are mostly southward ranging from 24 to 75 degrees, averaging about 35 degrees along the coal-bearing units. The overlapping Tertiary units also dip south into the Uinta Basin although at a much reduced inclination.

The few faults that affect the coal are west of the Duchesne River Valley. At least four northwest-trending faults spaced from ½ to 2 miles apart occur between Red Creek Mountain and the Duchesne River. They displace the Frontier outcrop considerably and all but the westernmost one have their downthrown block to the northeast. The west fault forms a horst with its immediate east neighbor. None of the faults cuts the Mesaverde beds.

In the far west part of the field near Currant Creek the structure becomes complex; the trends do not continue in the regional pattern. The large North Strawberry thrust, whose trace occurs 5 or 6 miles west of the Currant Creek area, has deformed the strata in front of it so that the trends are sympathetic to it. East of Currant Creek the beds dip generally south; to the west they dip easterly. In addition some faults parallel the strike of the beds. The effective west boundary of the Tabby Mountain coal field lies in this tectonically disturbed area.

Figure 4 illustrates the most important structural features of the region.

Geologic History

During the Paleozoic the area of the Tabby Mountain coal field was either a positive or a slowly subsiding shelf. Sediments were deposited during the Mississippian, Pennsylvanian and Permian periods and perhaps the earlier periods as well, but the Lower Paleozoics were removed prior to the Mississippian deposition. These sediments were deposited mostly in marine shelf environments and the deposits were not thick compared with the corresponding geosynclinal units in west Utah.

This regimen continued into Mesozoic time except that the Tabby Mountain area alternated between continental and marine conditions and the geosynclinal area ceased to receive sediment and became positive. By Cretaceous time two important events combined to produce the coal beds. The area to the west became involved in orogeny and a marine invasion proceeded from the east and progressed to a point west of the present-day Tabby Mountain coal field. The mountains to the west dumped their erosional debris into the sea and, when an orogenic pulse pushed the mountains to higher elevations, a clastic wedge quickly pushed the shoreline eastward and created a low lagoonal area behind it to produce coal. The Frontier beds may have been deposited in this way. The normal deposition in the sea was the gray Mancos-type shale. In time the sea returned. Figure 5 illustrates the situation during Mancos time.

Eventually the orogenic activity pushed eastward and the shoreline in turn regressed across Utah never again to return. As this occurred, shoreline and lagoonal environments also moved from west to east and the Mesaverde coal beds were deposited. Uplift of the land followed and erosion created a rolling landscape when a new orogenic event to the northwest piled the Currant Creek conglomerates on top of the Mesaverde. Deformation in the area mounted; thrusting a short distance to the west took place and the Uintas began their initial rise. Erosion cut into the upturned Precambrian, Paleozoic and Mesozoic sediments. The products of erosion filled a newly formed Uinta Basin and the new sediments eventually covered the bevelled edges of the older rocks. Finally deposition ceased and the entire area became one of erosion as it is today.

Correlation with Surrounding Areas

The Frontier and Mesaverde of the Tabby Mountain field are continuous with those in the Vernal coal field. The Frontier, however, is thinner and the age of the Mesaverde at Vernal is younger. The general relations from Coalville to Vernal are shown on figure 6. The approximate positions of coal beds also are included.

At least part of the Mesaverde undoubtedly correlates with the coal-bearing Blackhawk Formation of the Book Cliffs and Wasatch Plateau coal fields and is probably continuous with it in the subsurface. The Frontier is thought to be partly correlative with the Ferron Sandstone beneath the Book Cliffs near Price and Wellington.

COAL DEPOSITS

Status of Information

The only important coal study of the Tabby Mountain field has been that of Lupton (1912). It was supplemented by stratigraphic work by Huddle and McCann (1947), Huddle, Mapel and McCann (1951), Bissell (1952) and Garvin (1969). A few coal

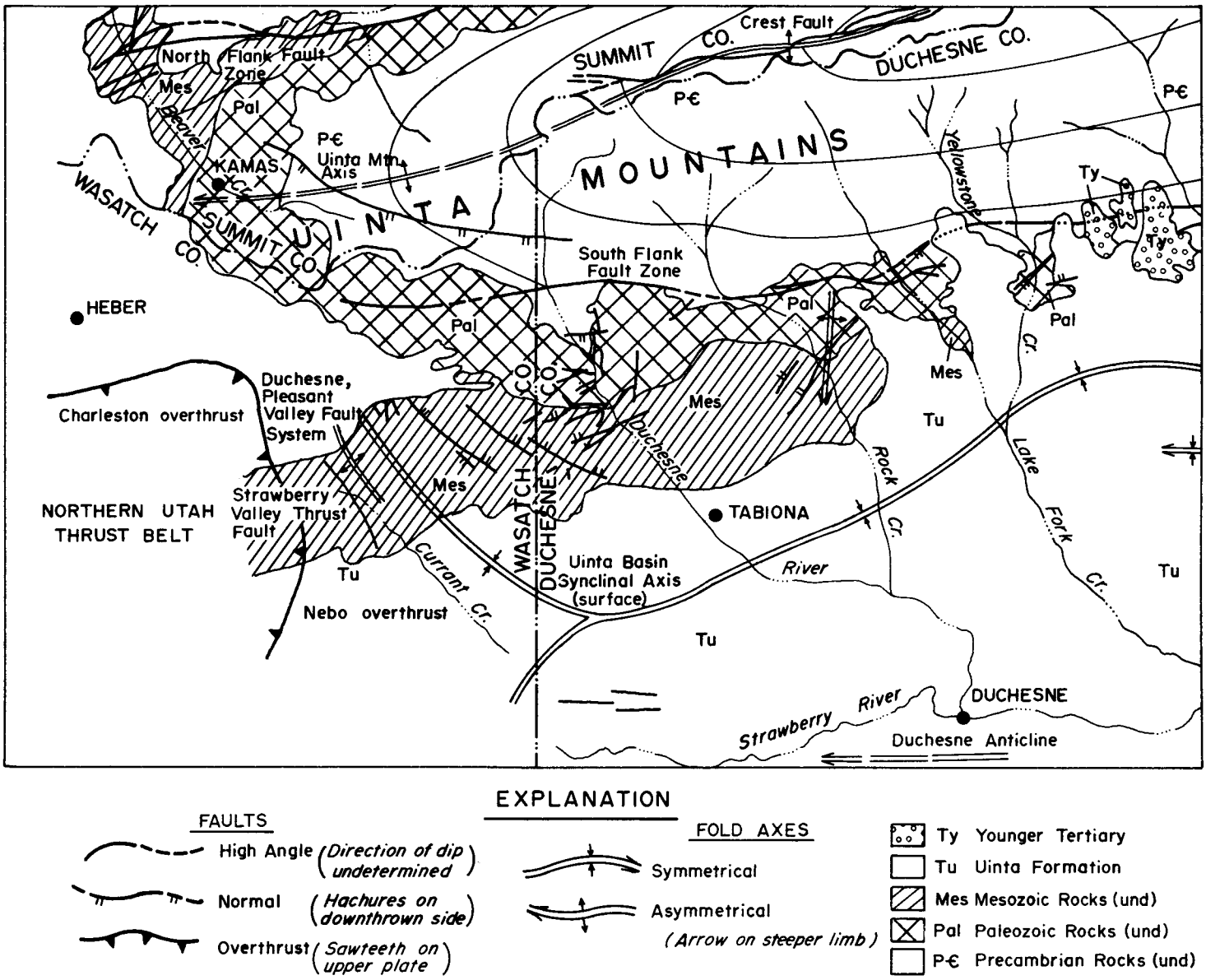


Figure 4. Generalized tectonic map of the Tabby Mountain coal field area.

localities were added as a result of the present study. The References section presents the principal work done in this area.

Mines, Prospects and Production

Prospecting between 1885 and 1910 revealed the significant outcrops of the field. Many small prospects opened, but only three achieved any degree of importance (table 1).

After 1910 only the Red Creek mine remained active and after 1948 no coal was mined in the field. Production is unknown, but thought to be inconsequential and probably around a few thousand tons.

Land Ownership

The quadrangles as shown for this report are owned as follows: private property 45.4 percent, National Forest Service 36.4 percent, Uintah and Ouray Indian Reservation 16.9 percent, state of Utah 0.9 percent and Bureau of Land Management 0.4 percent (figure 7).

The coal rights, however, belong mainly to the Uintah and Ouray Indian Reservation and a minor amount belongs to the U. S. Government on National Forest land (Currant Creek) and private interests. The Uintah and Ouray lease of 200 acres to the Red Creek Coal Corp. in the Red Creek area is all that is currently held for the purpose of extracting coal (January 1, 1970).

Table 1. Mines in the Tabby Mountain coal field.

Quadrangle	Location	Remarks
Currant Creek		
Cummings mine (Currant Creek)	SW.SE.31-1S-10W USM 4,466,030m.N. 495,595m.E.	Active prior to 1910
Raspberry Knoll		
Red Creek mine (Fraughton)	NW.NW.NW.26-1S-9W 4,468,820m.N. 510,500m.E.	Intermittently active 1900-1949
Tabby Mountain		
Redden mine	NE.NW.NW.26-1S-9W USM 4,468,820m.N. 510,765m.E.	Active in 1940's
Tabiona		
Unknown	NE.SW.SE.12-1S-8W USM 4,472,425m.N. 522,655m.E.	Activity unknown
Unknown	SW.NE.SE.12-1S-8W USM 4,472,740m.N. 523,000m.E.	Shaft?
Winchester	NE.NW.SW.8-1S-7W USM 4,472,725m.N. 525,030m.E.	Activity early 1900's
Unknown	NE.NW.SW.9-1S-7W USM 4,472,785m.N. 526,700m.E.	Activity unknown; entry partly caved

Quality of Coal

Of the seven analyses available for the coal field, three are from Frontier coal and four from Mesaverde coal (table 2).

The coal from both formations ranges from subbituminous C to high-volatile C bituminous rank. The coal from the Redden

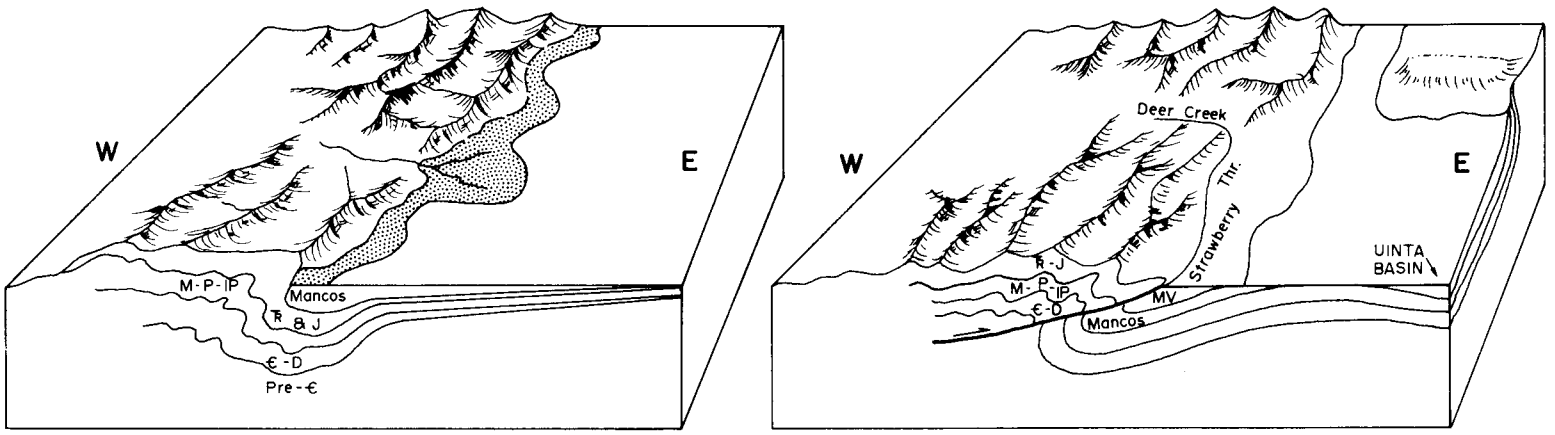


Figure 5. Geologic conditions of the Tabby Mountain coal field during Upper Cretaceous time (modified from Bissell, 1952).

mine exhibits a peacock iridescence. The physical characteristics after Lupton (1912, p. 623), are as follows:

The coal of both the Mesaverde and Mancos (Frontier) ages . . . is a rather low-grade bituminous variety. The fresh coal is pitch black in color, but the faces of the joints and weathered surfaces are usually dull black. When fresh the coal is hard and brittle. The luster is generally vitreous and the fracture ranges from uneven to regular. When pulverized the coal is a dark brown powder and its streak made by rubbing on unglazed porcelain is almost black, with a slightly brownish tint. The coal is bedded but not prominently and its jointing is cubical. It burns with a flame of medium length and gives off a bituminous odor. The quantity of ash remaining is not excessive.

Table 2. Average proximate analysis of coal, Tabby Mountain coal field.

	Percent			
	Frontier Coal		Mesaverde Coal	
	Average	Range	Average	Range
Moisture	19.4	14.8-27.4	15.0	10.1 -19.2
Volatile matter	33.5	32.0-36.5	38.4	37.0 -39.9
Fixed carbon	36.9	35.6-37.9	40.5	37.6 -45.7
Ash	10.2	2.6-17.6	6.6	5.9 - 8.2
Sulfur	0.7	0.6- 0.83	1.0	0.69- 1.47
Btu/lb	8,110	7,430-8,830	9,895	8,723-10,382

Reserves

Lupton (1912, p. 628) calculated the presence of 1,857,600,000 short tons of coal for the field. He included all coal less than 3,000 feet below the surface and all beds exceeding 14 inches thick. Recalculating to eliminate all potential (Class IV) reserve and all beds less than 4 feet thick leaves an original reserve of 231,120,000 tons. The breakdown is as follows (table 3).

Table 3. Original coal reserves in Tabby Mountain coal field (in beds more than 4 feet thick; in short tons).

Quadrangle	Frontier	Mesaverde
Rock Creek	–	–
Tabiona	10,700,000	–
Tabby Mountain	15,260,000	3,120,000
Raspberry Knoll	37,190,000	88,200,000
Currant Creek	–	76,650,000
	63,150,000	167,970,000
Class II (estimated)	51,110,000	91,665,000
Class III (inferred)	12,040,000	76,305,000

Coal Seams

Because coal seams cannot be correlated except over extremely short intervals, few generalizations can be made. Four beds have been noted in the Farm Creek area of the Frontier Formation and four beds are present in the Red Creek area. They are compared in table 4.

Table 4. Comparison of Frontier coal seams, Farm Creek and Red Creek areas.

Farm Creek Area	Feet	Red Creek Area	Feet
Winchester bed		Bed 4	
Interval	9	Interval	63
Bed 3		Bed 3	
Interval	6	Interval	54
Bed 2		Bed 2	
Interval	10-15	Interval	10
Bed 1		Bed 1	

The coal-bearing part of the Frontier is covered between the two areas. The Mesaverde is known to contain at least twenty-one coal beds between Currant Creek and Red Creek. East of Red Creek, probably under Tabby Mountain, the coal-bearing beds have been removed by erosion and the truncated end covered by thick Tertiary formations. The coal beds of the Mesaverde, because of heavy cover, cannot be traced from ridge to ridge and no generalization can be made about their individual condition.

Coal beds in the Frontier range up to 10 feet thick; those in the Mesaverde occasionally exceed 20 feet thick.

ECONOMIC CONSIDERATIONS AND FORECAST

Lupton (1912, p. 627) noted that the future development of the Tabby Mountain coal field would be governed by the settlement of the Uinta Basin, by the exhaustion of the cedar and pine and by the extension of railroads across the basin. Since 1912 the population has not increased; cedar and pine are still plentiful, but the idea to construct a railroad has died away. The construction of better roads into the area has allowed outside, better quality coal to enter the area. Other forms of heating and power supply have largely supplanted the use of coal for heating homes and buildings. Considering the small amount of proven reserve, the steep dip on the coal beds, the remoteness to market and lack of railroads precludes a large development in the near future. Apparently water is sufficient in the major streams for a prospective power plant. The water rights would have to be negotiated. Drilling activity could undoubtedly develop a measured (Class I) reserve large enough to support a 500 mw (or less) power plant for many years. Other Utah areas with better coal quality and less complex structure will probably be developed first.

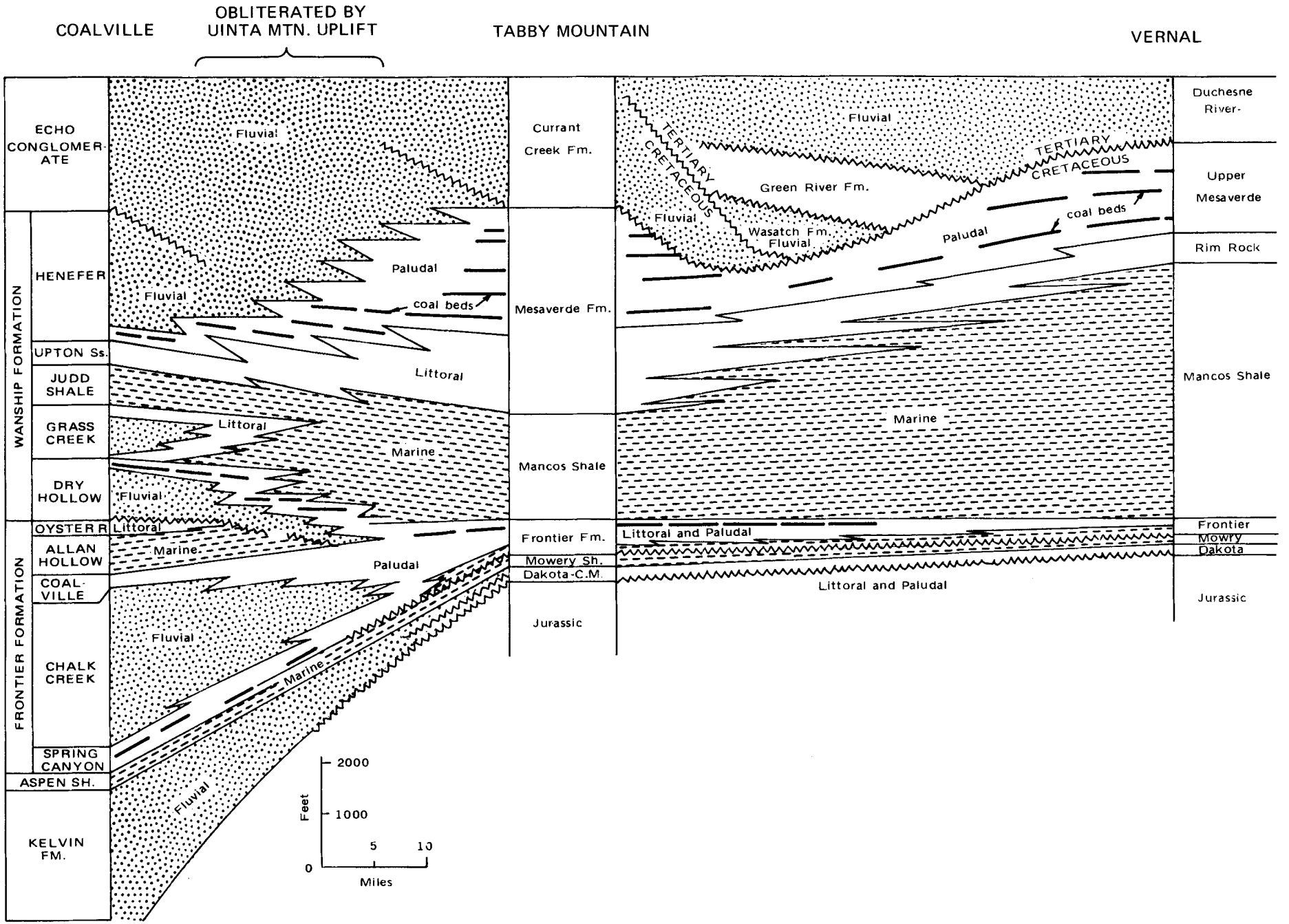


Figure 6. Correlation diagram of Coalville to Tabby Mountain to Vernal.

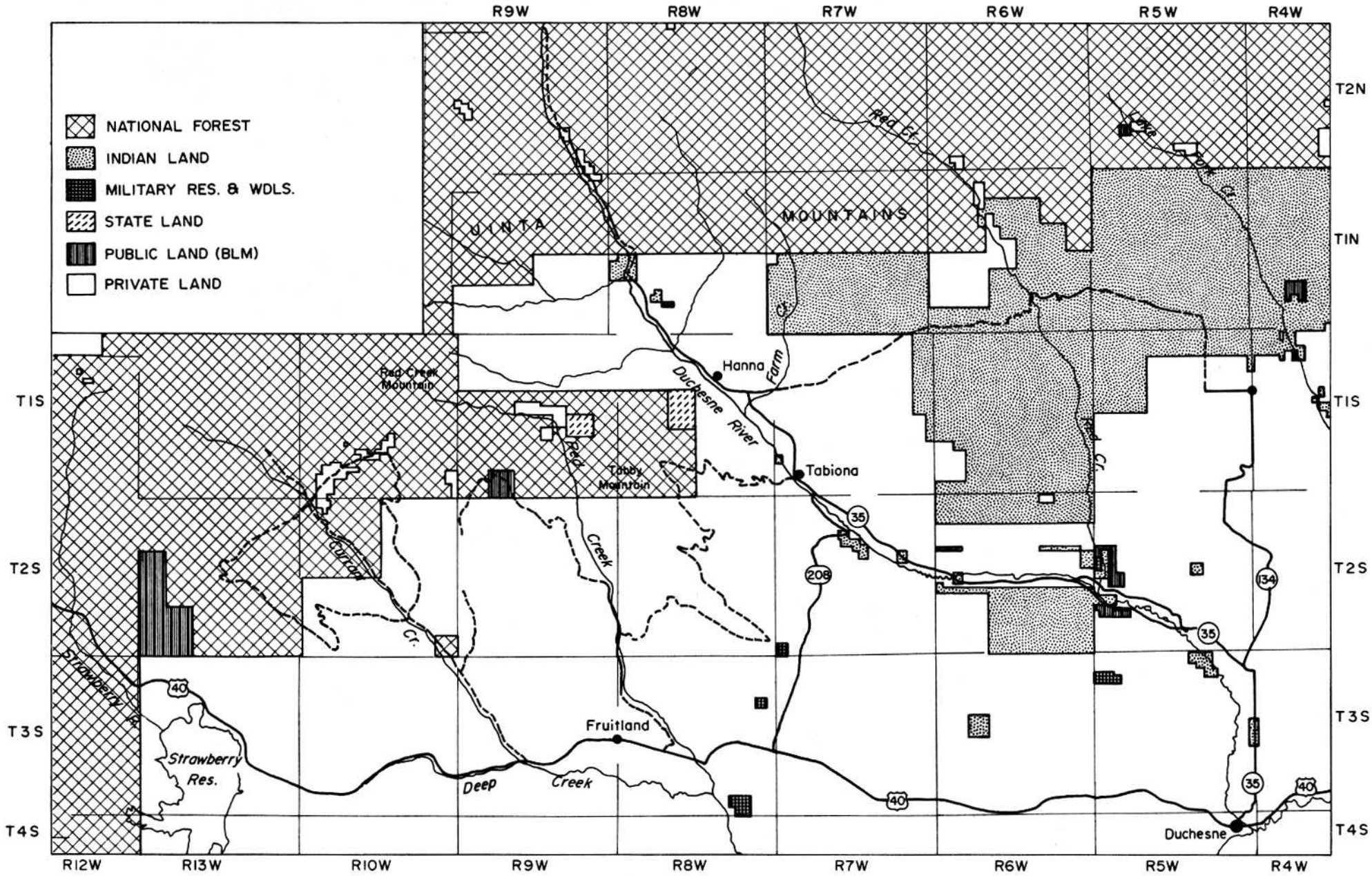


Figure 7. Land ownership map, Tabby Mountain coal field.

Remains of the Red Creek mine after stripping bared the 25-foot coal bed, Raspberry Knoll quadrangle.

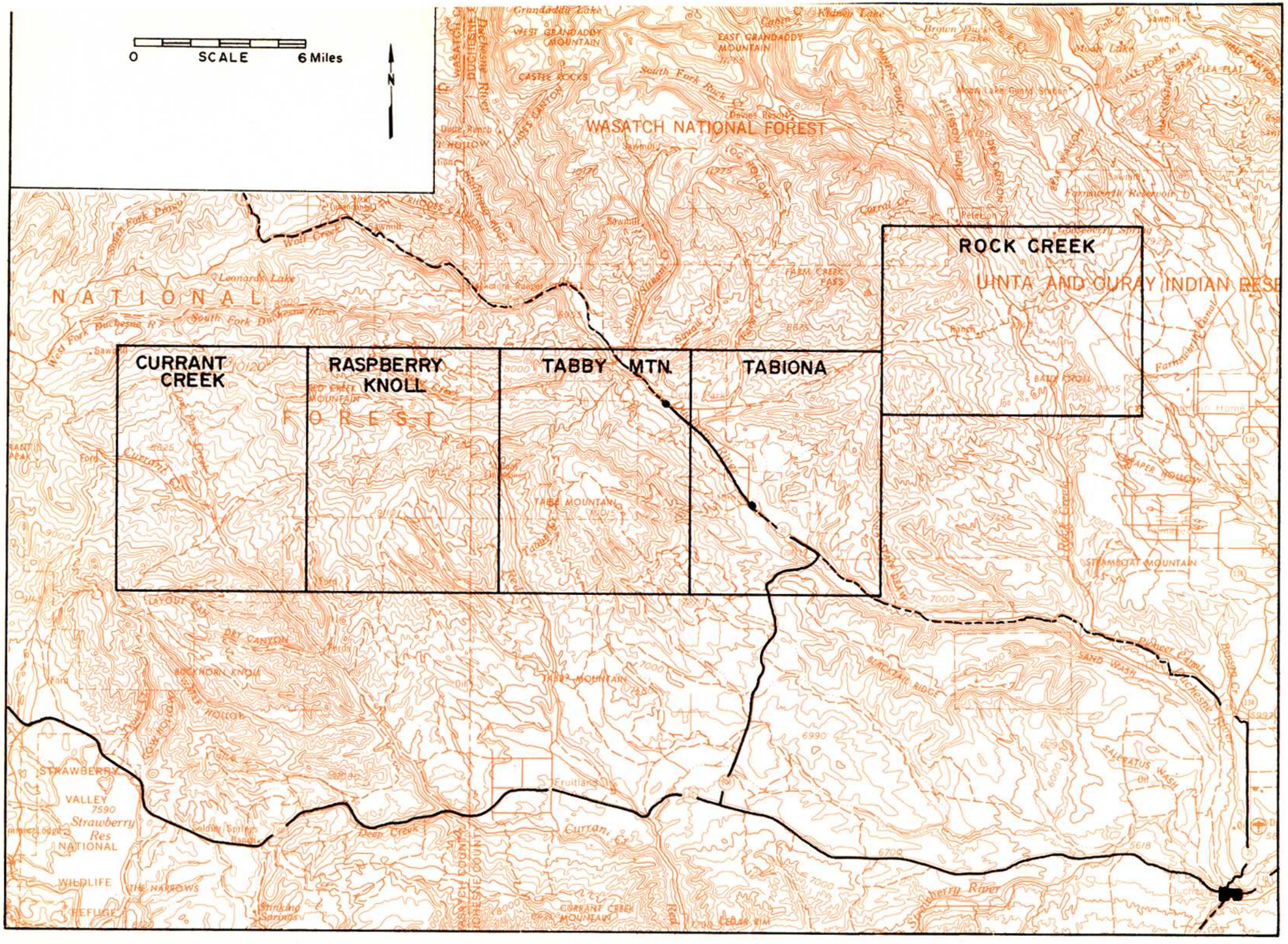


Figure 8. Topography, roads and quadrangle index map, Tabby Mountain coal field.

QUADRANGLE REPORTS

CURRANT CREEK QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

Currant Creek quadrangle is a composite of parts of the U. S. Geological Survey Wolf Creek Summit and Jimmies Point topographic quadrangles. It is located in Wasatch County in the west end of the Tabby Mountain coal field (figure 8). The area is 10 miles northwest of U. S. Highway 40 at the Currant Creek-Deep Creek junction and about 15 miles west of Hanna. Forest-type roads extend to many parts of the quadrangle and connect with the main access road that parallels Currant Creek.

The landscape is mountainous and elevations range from a low of 7,400 feet along Currant Creek to 10,595 feet on Red Creek Mountain. Coal beds are located between 7,600 and 9,600 feet above sea level.

STRATIGRAPHY

The Currant Creek quadrangle exposes rocks of Jurassic, Cretaceous, Tertiary and Quaternary age (figure 9). Two formations bear coal beds, both of Cretaceous age. Pre-Cretaceous units are described as follows: Navajo Sandstone, light red to white, fine- to medium-grained, cross-bedded sandstone, 1,240 feet; Twin Creek Limestone, dark to light gray thin-bedded fossiliferous limestone, 950 feet; Entrada Sandstone, dark red, fine-grained sandstone with minor shale and mudstone, 1,585 feet; Curtis Formation, greenish gray, glauconitic sandstone, shale and oolitic limestone, 725 feet; and the Morrison Formation, calcareous varicolored shale, sandstone, siltstone and conglomerate, 1,100 feet.

The Dakota Formation is the initial Cretaceous unit in the Currant Creek quadrangle; it was measured by Bissell (1952, p. 605) in SW 7-1S-11W USM.

Mowry Shale
Dakota Sandstone — Feet

- Sandstone; upper 12 feet are white to gray, stained yellow-gray, medium-grained, and contain criss-cross silica striped veinlets; this is underlain by 3 feet of coarse-grained, light to dark gray, friable, calcareous to carbonaceous sandstone which weathers yellow-gray. Basal 34 feet consist of white to yellow-gray sandstone, hard to friable, medium- to fine-grained, locally coarse to gritty, with pebbles of white silica (this is the upper unit) 50
- Shale, gray to black with platey sandy limestone containing an 8-foot calcareous sandstone bed near top. Beds are alternately hard and soft 115
- Sandstone, in part calcareous, medium gray to medium light gray, alternately hard and soft; macerated plant remains present in carbonaceous shale; few small random quartzitic and chert pebbles present 15

Thickness of measured section 180
Morrison Formation

The lower two parts of the Dakota, differentiated from the upper by later investigators, are known as the Cedar Mountain Formation. In some parts of Utah the Dakota is coal bearing, but not in the vicinity of the Tabby Mountain coal field.

The Mowry Shale overlies the Dakota and is a medium to dark gray siliceous, thin-bedded shale. A more detailed description is in the following measured section (Bissell, 1952, p. 606).

NW1/4 sec. 18, T. 1 S., R. 10 W., USM.

Frontier Formation
Mowry Shale — Feet

- Limestone: argillaceous and shaley, medium to light gray to flesh colored, weathers pale pinkish gray 12
- Shale: black to medium and dark gray, alternately hard and siliceous with teleost scales, and soft, chippy and like gumbo when wet 61
- Shale: hard, black to brown black, weathers silvery gray, contains abundant teleost scales 2
- Shale: black to brownish black, hard to soft, siliceous, weathers medium somber gray in chunks 13

Total Mowry Shale 88
Dakota Sandstone

Although the Mowry does not form good outcrops, a float of shale chips bearing fish scales defines it. The Frontier Sandstone is the next overlying unit and is the first coal bearer. It was measured on the ridge between the Right Fork of Currant Creek and Low Pass Creek. Bissell (1952, p. 609), who measured the section, makes no mention of coal. Lupton (1912) on his coal map shows no mapped coal seams in the Currant Creek area. Coal beds are known in the Frontier in the Raspberry Knoll quadrangle immediately to the east.

Mancos Shale
Frontier Formation — Feet

- Sandstone: prominent ledge, medium pinkish gray to buff, weathers dark reddish brown, very hard, well cemented, in part calcareous; locally displays festoon bedding. In general the rock is medium- to coarse-grained with rough and pitted, "meringue-appearing" weathered surface 40
- Sandstone and calcareous sandstone: alternating in thin beds, soft to hard, well cemented to friable, light to dark gray to mustard yellow-brown 50
- Sandstone: hard, medium-grained, light tan, slightly calcareous, well bedded 35
- Sandstone: soft, mustard yellow-brown, with dark reddish brown limonite concretions and small pebble-size balls. Has a 20- to 40-foot ledge of hard, buff to tan calcareous sandstone at base 195
- Shale: gray to black, soft to hard to chunky, alternating with an equal amount of gray and yellow-brown soft sandstone 265
- Sandstone: white and yellow-gray, platy to cross-bedded, in part calcareous, locally hard and massive in prominent ledges. Commonly contains white silica striped ¼ to ½-inch veinlets. Contains a coarse-grained light gray sandstone with limonite concretions in the basal 12 to 15 feet. A 3-foot bed of calcareous sandstone containing abundant *Ostreas* above the latter 75

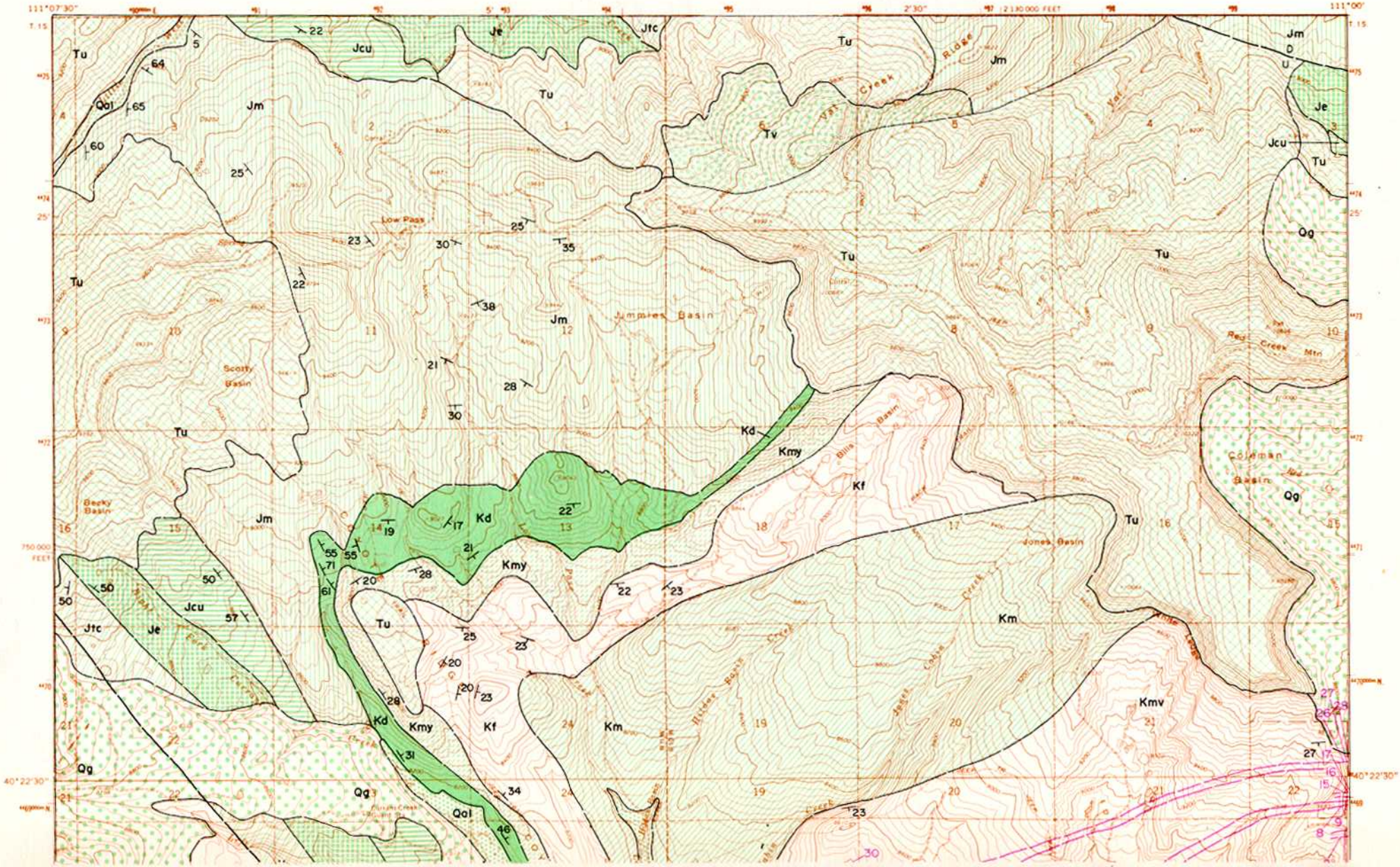
Total thickness of Frontier 660
Mowry Shale

The Mancos Shale overlies the Frontier and consists of dark to medium gray marine clay shale. It is homogeneous throughout the 1,680 feet believed present east of Low Pass Creek (Bissell, 1952, p. 610). The shale thins westward. The Mesaverde Formation is the next coal bearer of the Tabby Mountain coal field. Bissell (1952, p. 611) measured 5,165 feet of sandstones, shales, sandy shales, carbonaceous shales, limestones and coal beds in cyclothermic order. His section measured in the area of Coal Mine Hollow is repeated here:

Currant Creek Formation
Mesaverde Formation — Feet

- Sandstone: mustard yellow-brown to white and light gray, with dark reddish brown limonite balls, ¼ to 1 inch in diameter, along with similar concretions. Most beds are friable and poorly indurated. Locally thin coal beds and carbonaceous shales are interbedded. In addition, gray to brown, calcareous, festoon-bedded sandstones are present 950
- Sandstones, shales, and coal beds interbedded: sandstones are for the most part white and friable, becoming silty to true siltstones upward; locally contain limonite concretions; some of the beds are calcareous, well indurated, festoon-bedded. The shales are dark gray to black, commonly are carbonaceous. Coal beds are variable in thickness, are pure to impure and carbonaceous, and very few exceed 2 feet in thickness 1,500
- Shale and sandstone, the former predominant: shales are light to dark gray, black and carbonaceous grading to thin coal beds. Sandstones are primarily dark reddish brown to mustard yellow-brown, some are calcareous, others quartzitic. Seams, concretions and balls (up to 3 inches diameter) are common in the darker colored sandstones 265

CURRANT CREEK, UTAH



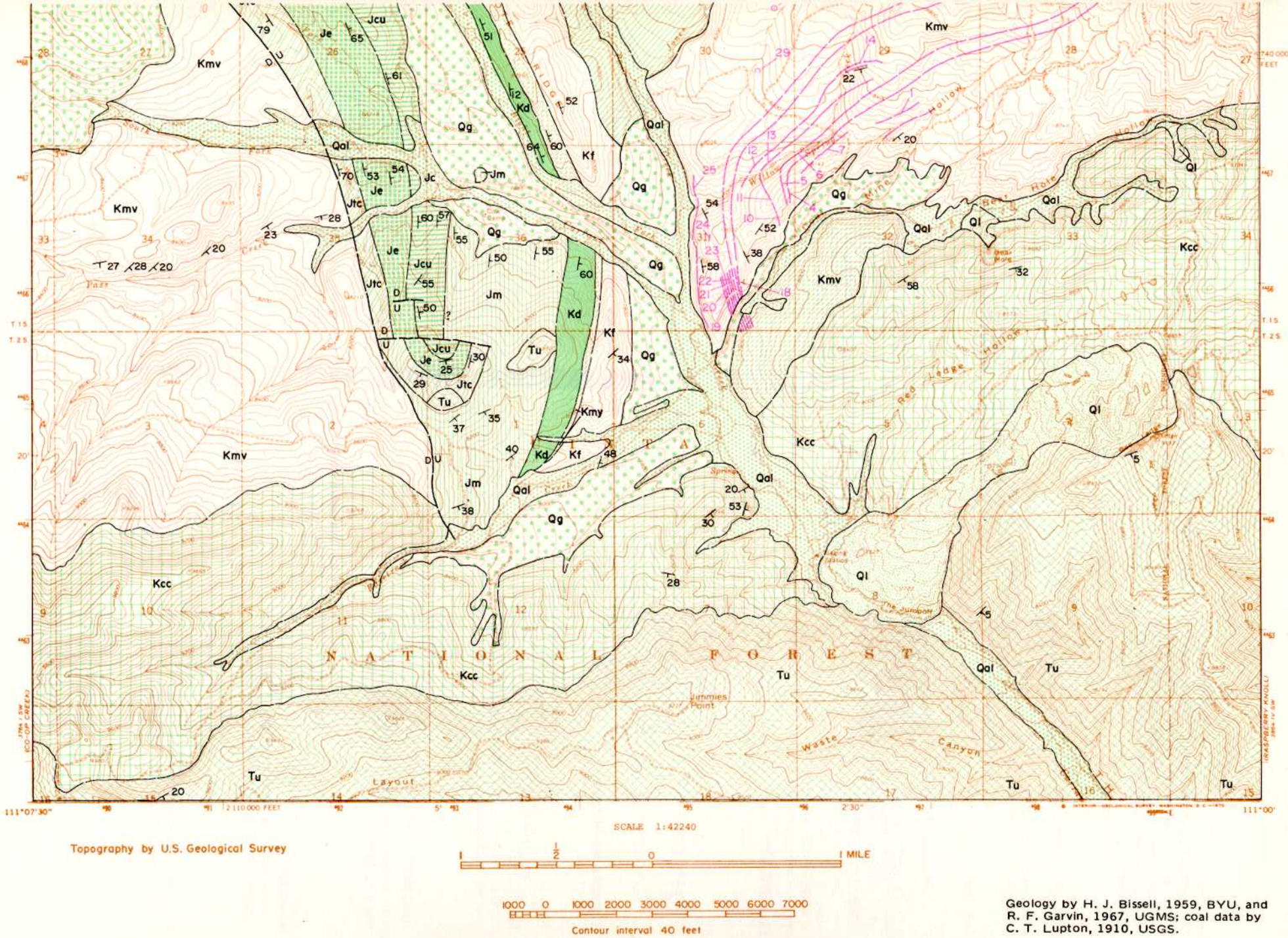


Figure 9. Coal and geology map, Currant Creek quadrangle (explanation pages 296-297).

EXPLANATION (figures 9, 11, 13, 15 and 17)

32 1.0 — Purple

Coal bed
Dashed where inferred or poorly exposed, dotted where burned. Thickness of coal in feet measured at triangles. Larger numbers refer to location of measured section shown on accompanying sheets.

Prospect

Coal mine

Purple

Burned zone
Area covered with natural clinker or red-burned sandstone.

DH

Coal drill hole

3

Strike and dip of beds

Apparent dip of beds

Syncline
Axis, dashed where approximately located or where ill defined.

Anticline
Axis, dashed where approximately located or where ill defined.

Monocline
Arrow points in direction of dip, dashed where approximately located or where ill defined.

Geologic unit contact
Dashed where location is approximate.

Horizontal strata

D U

Fault
Dashed where inferred or ill defined.

Explanation For Measured Sections

22 — Section numbers corresponds to map numbers on corresponding quadrangles

5.0' — Thickness of unit in feet.

Top of unit below not found-thickness is a minimum

Sandstone

Siltstone

Limestone

Carbonaceous Shale

Gray Shale

Bone Shale

Coal

Shaley Sandstone or Sandy Shale

Natural Clinker

Ash

Carbonaceous Shale and Coal poorly exposed

Base of unit above not found-thickness is a minimum

0 5 10 15

Vertical scale in feet

Complete thickness not shown

No horizontal scale intended.

EXPLANATION (continued)

QUATERNARY

Qal — Alluvium

Stratified clay, silt, sand, gravel and some unsorted flood deposits.

Ql — Landslide Deposits

Mixed rubble and blocks of material slumped from formations at higher elevations.

Qg — Gravel

Gravel deposits composed of pebbles, cobbles and sand, includes terrace and pediment deposits.

TERTIARY

Tv — Volcanics

Andesitic pyroclastic rocks.

Tu — Tertiary Undivided

Variegated sandstone, shale and conglomerate, usually reddish or greenish gray, poorly sorted and consolidated, includes Uinta, Duchesne River and Bishop formations.

Unconformity

CRETACEOUS

Kcc — Currant Creek Formation

Conglomerate, sandstone and siltstone, some shale, light gray to yellowish brown; interbedded; conglomerate lower part; sandstone and siltstone upper part. 0-4,800 feet.

Unconformity

Kmv — Mesaverde Formation

Sandstone; light gray; with some interbedded shale and coal; very fine- to coarse-grained, cross-bedded; massive; marine lower part; mostly nonmarine. 550-4,000 feet.

Km — Mancos Shale

Shale; gray; clayey; calcareous; interbeds of thin sandstone. 800-2,220 feet.

Kf — Frontier Formation

Sandstone; light gray to yellowish brown; fine- to coarse-grained; thin- to thick-bedded; cross-bedded; thickens westward; coal bearing in upper part. 445-660 feet.

Unconformity

Kmy — Mowry Shale

Shale; gray, siliceous and calcareous, water-laid volcanic ash; contains fish scales. 85-390 feet.

Kd — Dakota Formation

Sandstone; gray; contains interbedded conglomerate; black chert pebbles; fine- to coarse-grained. Thick to very thick-bedded, forms upper member 5-40 feet thick. Middle member of mudstone; green, purple and reddish brown; calcareous; many nodules, 100-160 feet thick. Lower conglomerate, conglomeratic sandstone and conglomeratic mudstone with gray, black and pink chert pebbles, 20-50 feet thick.

Unconformity

JURASSIC

Jm — Morrison Formation

Jcu — Curtis Formation

Je — Entrada Sandstone

Jtc — Twin Creek Limestone

Jn — Nugget Sandstone

TRIASSIC

Ru — Triassic Undivided

PALEOZOIC

Ppc — Park City Formation

Sandstones: upper 175 feet consist of mustard yellow-brown colored beds, commonly hard and well indurated, stained with dark reddish brown limonite, and containing abundant dark reddish brown limonite concretions and irregular masses which stand out on weathered surface. Middle 175 feet consist of yellow-brown to gray, soft, friable sandstones, practically no limonite, containing a few poorly preserved plant fossils and carbonaceous shale. Basal 65 feet of this unit consist of hard, well consolidated, slightly calcareous sandstone, dark mustard-brown, containing a few poorly preserved plant fossils 415
Sandstones: hard, reddish brown to mustard yellow, and containing limonite nodules at the base. Overlain by hard, gray to olive-drab limestones, platy and silty; these in turn overlain by soft, light yellow to mustard-brown friable sandstones and interbedded, gray sandy shales; capped by hard, mustard-brown, limonite-stained medium-grained sandstone 175
Sandstone: white and mustard yellow-brown, soft, alternating with very hard, calcareous, platy sandstone, very fine-grained, and containing numerous limonite concretions, ½ inch in diameter 160
Shale and coal: interbedded, black to very dark brown, soft, impure; some platy very fine-grained sandstone stained with limonite is present 20
Sandstone: hard, calcareous, mustard yellow-brown at base; grades upward through soft gray shales and white friable sandstone and silty sandstone, with series of alternating carbonaceous shales and impure coal beds commonly less than 3 feet thick. Platy, calcareous, very fine-grained yellow sandstone containing much limonitic material occurs at top of this unit 150
Sandstone: hard, rough, weathering tan to buff; grades into calcareous sandstone and sandy limestone, white and yellow-brown with dark reddish brown limonite concretions less than 1 inch diameter present 130
Coal: moderately good quality, black to dark brown, 3 feet thick, grading upward into black flaky carbonaceous shale, and this in turn overlain by gray shales alternating with soft to hard, gray to mustard-brown and yellow, coarse-grained sandstone 20
Underclay: dark to medium gray, gumbo-like when wet 3
Limestone: hard, dark gray, brown weathering, grading downward into calcareous sandstone, hard, coarse-grained, nodular weathering. Below that is sandstone, mustard yellow-brown, friable, very fine-grained 175
Sandstone: hard, mustard, yellow-brown, calcareous, well cemented, overlain by gray-brown to black, soft and hard, carbonaceous shales which grade upward into limestone 120
Shales: gray to gray-black, interbedded with thin platy yellow-brown, friable to hard sandstone, limonite-stained. Overlain by massive light yellow-gray, friable, very fine-grained, sandstone to siltstone and silty sandstone; at top is gray shale and dark red-brown calcareous sandstone, limonite stained 92
Sandstone: white, very fine-grained, grading to silt with thin interbedded shale at base; overlain by shale, gray to gray-black, locally carbonaceous, and this in turn overlain by hard to soft, brown limestone and sandstone, then carbonaceous shale and gray shale. Top consists of massive, white, very fine-grained sandstone, limonite-stained, containing limonite concretions and interbedded with hard calcareous brown sandstone 155
Shale: gray to black, soft and crumbly, locally carbonaceous, in part calcareous, mostly covered 25
Sandstone: buff to yellow, some beds white, medium- to fine-grained, moderately to strongly calcareous with a few thin limestone coquina beds. Hard, more or less resistant, weathers pale brown 65
Shale: black, carbonaceous, more or less hard but crumbles to chips and locally to silty soil 15
Sandstone: white, yellow to buff, medium-grained, partly calcareous, tightly cemented, forms resistant ledges 115
Sandstone: white but weathers to yellow-stained surface with some limonite concretions; weakly calcareous, more or less friable, fine-grained, in part cross-bedded, locally well defined 160
Shale: mostly covered, but soil is gray to black, silty in part 20
Sandstone: limonite-brown to pale brown, weathers darker brown with numerous limonite concretions; in part calcareous and tightly cemented, weathers to rounded forms but rather prominent ledges 185
Sandstone: medium to light gray to buff, fine-grained, rather soft and friable, locally small-scale cross-bedding, massive to thick-bedded 135
Sandstone: medium gray, calcareous and tightly cemented, massive, resistant, with thinner more calcareous and thinner beds containing mollusks 115
Total thickness of Mesaverde 5,165
Upper Mancos Shale

The final Cretaceous unit is the Currant Creek Formation, a series of conglomerates, sandstones and variegated shales, approximately 4,800 feet thick. Dominating are the conglomerates with boulders 6 to 12 feet in diameter; many pebble- and cobble-sized beds, however, occur. About 10 percent are coarse-grained or gritty and pebbly sandstone; the amount of shale in sections farther east is negligible.

To the south the outcrops consist of Tertiary rocks representative of the Uinta Formation and possibly the Duchesne River Formation. They are mainly reddish sandstones, shales and conglomerates and are differentiated from the Currant Creek by color, lesser degree of cementation and less conglomerate. On top of some of the higher mountains to the north are remnants of the Bishop Conglomerate: grayish white to pale red almost unconsolidated cobble and boulder conglomerate. Tertiary rocks unconformably overlie all other units.

The Quaternary is exemplified by gravels of fluvial and glacial origin, landslides and stream alluvium.

STRUCTURE

The strata in the east part of the quadrangle are associated with the Uinta Mountains anticline; the strike is east-west, paralleling the anticlinal axis and the dip is to the south 25 to 35 degrees.

In the middle of the map area the strata twist and become north-south in strike paralleling the Wasatch Mountains to the west and more closely paralleling the North Strawberry thrust fault a few miles west of the west map edge. Here all strata dip eastward 25 to 65 degrees. The north-south trend is the east flank of an anticline cut off from its west flank by a fault. West of the fault the rocks dip southward 8 to 35 degrees.

The anticline west of Currant Creek is cut by a high-angle normal fault with the downdropped block to the west. Jurassic rocks lie adjacent to the Mesaverde Formation. A few other faults occur at right angles to this important break. Apparently the Currant Creek laps over the fault and dates the structure as post Mesaverde-pre Currant Creek.

PROPERTY CONTROL

Most of the surface lands of the Currant Creek quadrangle belong to the National Forest Service (93.6 percent); the remainder is private property (6.4 percent). Some of the private property extends along the Coal Mine Hollow road, but even so most of the coal rights are either reserved to the United States or to the Uintah and Ouray Indian Reservation. Coal rights totalling at least 1,160 acres are controlled either by Delbert Coleman, H. C. Cummings or the Wasatch County School District.

COAL

Surface Information

The available coal measurements are in the Mesaverde Formation (figure 10) even though the Frontier crops out on the quadrangle. Lupton (1912, p. 622) notes that in the westernmost part of the field it was impossible to obtain measurements on any Frontier coal beds because the coal-bearing rocks are deeply covered. Bissell (1952, p. 609) in measuring a section of Frontier over Coyote Ridge does not mention the presence of coal.

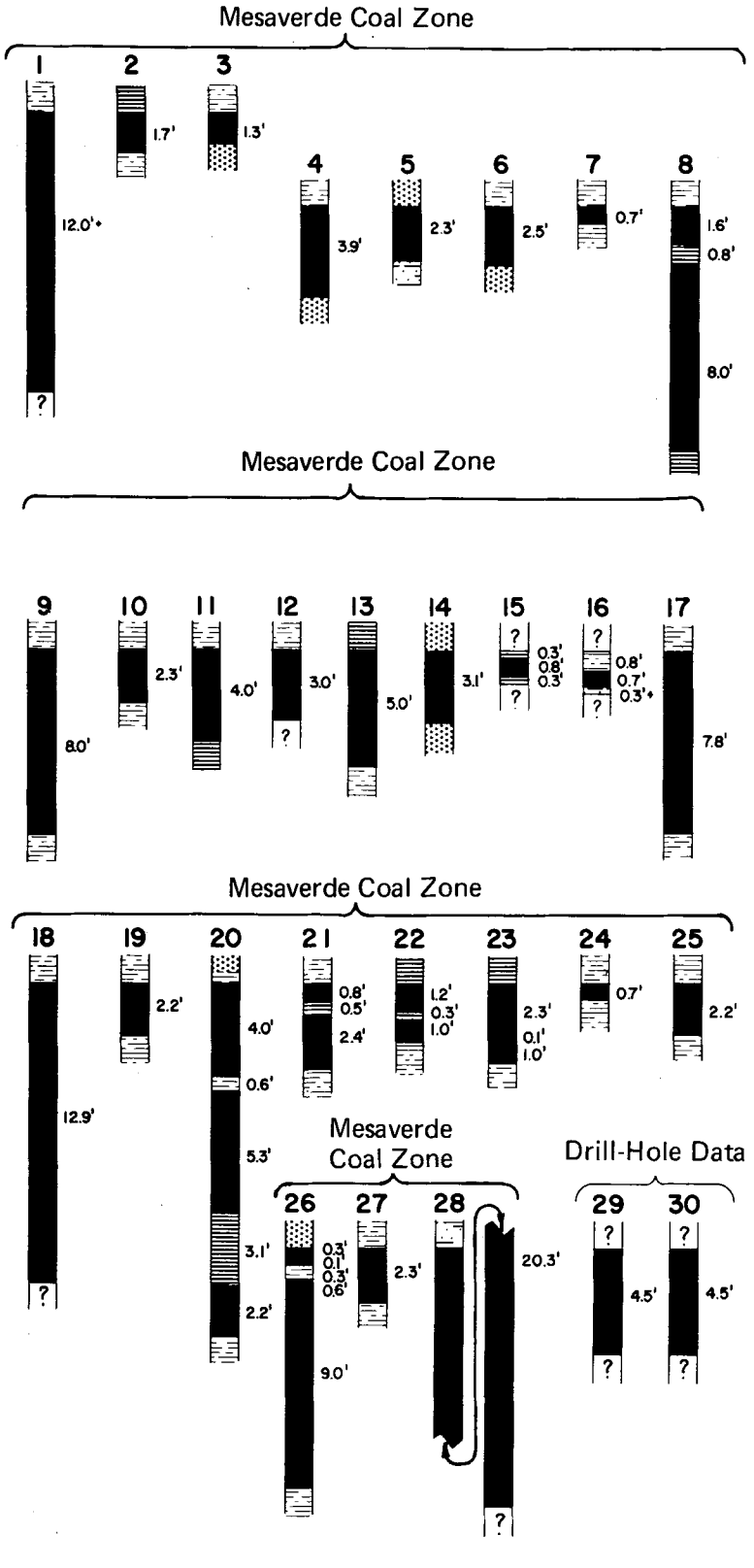


Figure 10. Coal sections of Currant Creek quadrangle (vertical scale: 1 inch = 8 feet).

Thirty localities are available for Mesaverde coal. Lupton (1912, p. 619) describes the Currant Creek coal seams:

> The lowest bed of Mesaverde age noted in the Blacktail (Tabby) Mountain coal field was observed just east of Currant Creek above a massive yellowish-gray sandstone, which probably marks the arbitrary boundary drawn between the coal-bearing and noncoal-bearing rocks. . .Approximately 500 feet above this bed is another only 8 inches thick. A mass of about 425 feet of alternating sandstone and shale lying directly above the last mentioned coal bed is apparently barren of coal. Above this barren mass 14 coal beds are fairly evenly distributed throughout a stratigraphic distance of 1,050 feet.

The locations are divided into three zones, but none of the individual coal beds can be correlated over a long distance so no assumptions are made on a bed basis. The Upper zone has one measurement 12 feet thick, the other two are less than 2 feet thick. The Middle zone has fourteen measurements with beds ranging up to 9 feet. The Lower zone (locations 18 to 30) has beds up to 20 feet thick. At least three beds containing over 4 feet of coal may be encountered at any one location. The total thickness of thick coal expected in any location is 15 feet minimum.

Subsurface Information

No drilling for coal has taken place on the Currant Creek quadrangle, but several holes were drilled as a part of the Strawberry aqueduct, Vat Tunnel line of the U. S. Bureau of Reclamation Central Utah Project. The data were assembled on a cross-profile map dated Nov. 29, 1969. Two of the holes each penetrated 4.5 feet of coal in the lower part of the Mesaverde Formation (locations 29 and 30).

Quality of Coal

The one available analysis was collected during Lupton's 1910 visit. The collection was made at the then-abandoned Cummings mine. The sample was high in moisture (19.2 percent), low in sulfur (0.69 percent) and low in calorific value (8,723 Btu/lb). Table 5 gives the complete analysis.

Mines and Development (table 6)

At the time of Lupton's 1910 visit the entry to the Cummings mine was caved so badly that it was inaccessible. Apparently considerable mining had been done several years earlier. The coal extracted there was hauled over the mountains to Heber; the lack of good roads was one of the reasons for abandonment. The quality was not as good as that from other areas of Utah.

Reserves

Lupton (1912, p. 628) calculated the reserve for the quadrangle by township. All coal beds in both Frontier and Mesaverde

Table 5. Coal quality data, Tabby Mountain coal field.

No.	Mine or Prospect-Coal bed	Township & Range UTM grid		PROXIMATE ANALYSES				ULTIMATE ANALYSES						Btu/lb	OTHER TESTS			Kind of Samples	Ref. Source
				AN	M	VM	FC	Ash	S	H	C	N	O		AST	ADL	HGI		
CURRANT CREEK QUADRANGLE																			
1	Cummings mine	SW.SE.31-1S-10W USM	A	19.15	37.04	37.60	6.21	.69	–	–	–	–		8,723	2,040	5.6	–		6
	Mesaverde Lower zone	4466030mN 495595mE	C	–	45.81	46.51	7.68	.85	–	–	–	–		10,789	–	–	–		
			D	–	49.62	50.38	–	.92	–	–	–	–		11,687	–	–	–		
RASPBERRY KNOLL QUADRANGLE																			
1	Red Creek mine	NW.NW.NW.26-1S-9W	A	14.58	38.48	41.00	5.94	.82	–	–	–	–		10,382	2,130	9.0	–		6
	Fraughton bed	4468820mN 510500mE	C	–	45.05	48.00	6.95	.96	–	–	–	–		12,155	–	–	–		
			D	–	48.42	51.58	–	1.03	–	–	–	–		13,063	–	–	–		

Table 5. (continued)

No.	Mine or Prospect-Coal bed	Township & Range UTM grid		PROXIMATE ANALYSES AN	M	VM	FC	Ash	ULTIMATE ANALYSES S	H	C	N	O	Btu/lb	OTHER TESTS AST	ADL	HGI	Kind of Sample	Ref. Source
2	Red Creek mine		A	16.2	39.9	37.7	8.2	1.0	–	–	–	–	10,260	2,120	5.8	–		7
	Fraughton bed		C	–	47.7	44.8	7.5	1.2	–	–	–	–	12,240	–	–	–		
									TABBY MOUNTAIN QUADRANGLE										
1	Redden mine	NE.NW.NW.26-1S-9W	A	10.1	38.1	45.7	6.1	1.47	–	–	–	–	10,213	–	–	–		1
	Mesaverde	4468820mN 510765mE	C	–	42.4	50.8	6.8	1.64	–	–	–	–	11,360	–	–	–		
									TABIONA QUADRANGLE										
1	Winchester Prospect	NE.NW.SW.8-1S-7W. USM	A	27.4	32.1	37.9	2.6	.6	–	–	–	–	7,430	2,040	19.0	–		6
	Winchester bed	4472725mN 525030mE	B	10.4	39.7	46.7	3.2	.74	–	–	–	–	9,170	–	–	–		
			C	–	44.3	52.1	3.6	.8	–	–	–	–	10,230	–	–	–		
			D	–	45.9	54.1	–	.86	–	–	–	–	10,610	–	–	–		
2	Winchester Prospect		A	14.8	32.0	35.6	17.6	0.66	–	–	–	–	8,070	–	–	–		1
	Winchester bed		C	–	37.6	41.7	20.7	0.77	–	–	–	–	9,471	–	–	–		
3	Prospect	NE.NW.SW.9-1S-7W. USM	A	15.9	36.5	37.1	10.5	0.83	–	–	–	–	8,830	–	–	–		1
	Winchester bed	4472785mN 526700mE	C	–	43.4	44.1	12.5	0.99	–	–	–	–	10,499	–	–	–		

Table 6. Mines in the Currant Creek quadrangle.

Mine	Location	Remarks
Cummings mine (Currant Creek)	SW.SE.31-1S-10W USM 4,466,030m.N. 495,595m.E.	Active prior to 1910

formations over 14 inches thick, but buried beneath less than 3,000 feet below the surface, are included.

Location	Tons
T.1S. R.10W. USM	495,911,000
T.2S. R.10W. USM	117,894,000
T.1S. R.11W. USM	2,118,000
Total coal	615,923,000

A recalculation eliminates the thin coal and the potential (Class IV) reserve (table 7). About one-half of the following can be considered Class II (estimated) and the remainder Class III (inferred).

Table 7. Original coal reserves (excluding Class IV), Currant Creek quadrangle.

Location	Area	Avg. thickness (ft.)	Tonnage
T.1S. R.10W.USM	1,920	15.0	50,400,000
T.2S. R.10W. USM	100	15.0	26,250,000
		Total coal	76,650,000

The writer concurs with Lupton that much more coal is present and the above represents only what can be assigned on the basis of known information. Additional data certainly will augment rather than diminish the reserve, but for the present most of Lupton's reserve can only be considered a potential reserve.

PRINCIPAL WORK

The coal data are mostly from Lupton (1910) and the geologic data are from Bissell (1952).

RASPBERRY KNOLL QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

Raspberry Knoll quadrangle is a composite of the south part of the Wolf Creek and the north part of the Raspberry Knoll U. S. Geological Survey topographic quadrangles. It is located in the west part of the Tabby Mountain coal field, 7 or 8 miles west of Hanna (figure 8). The Duchesne-Wasatch County line extends north-south through the east part of the map.

The coal occurs in two east-west trending bands that are a part of the ridge and swale topography associated with the south flank of the Uinta Mountains. In the south part of the quadrangle the ridge and swale physiography is replaced by a high homogeneous mountain (Raspberry Knoll and Bobby Duke Ridge). Elevations range from 7,600 feet along the Red Creek to 10,400 feet on Red Creek Mountain on the west map edge. The coal beds are mostly exposed between 8,000 and 9,000 feet.

A myriad of forest roads provide access; the most important is the Red Creek road. It links the area with Hanna and Tabiona to the east and U. S. 40 to the south.

STRATIGRAPHY

The various formations exposed on the north half of Raspberry Knoll quadrangle roughly lie in east-west trending bands with the older beds of Jurassic and Cretaceous age to the north (figure 11). The Jurassic units contain no coal and are adequately described in the Tabby Mountain quadrangle report or in the coal field Stratigraphy section.

Two of the five Cretaceous units are coal bearing, but the remainder are discussed for identification purposes. All units are poorly exposed; the high altitude is conducive to increased moisture which in turn develops thicker soil and slope wash cover. The initial Cretaceous unit is the Dakota consisting of two resistant sandstones separated by a medial shale. The lower two units often are assigned to the Lower Cretaceous Cedar Mountain Formation. The lower sand is 30 to 40 feet thick, the medial shale is 160 feet thick and the upper sandstone ranges between 5 and 26 feet thick. The sandstone is lenticular, yellow-gray to tan, fine- to coarse-grained and locally conglomeratic. The shales are gray or varicolored and soft.

Overlying the Dakota is the Mowry Shale, a gray calcareous shale that is sandy toward the top and that contains a peculiar siliceous, fish-scale bearing horizon that weathers into silver-gray chips. The Mowry is 360 to 390 feet thick.

The Frontier Sandstone forms a hogback in part of the quadrangle and is a coal bearer. The 600-foot unit consists of white, gray and tan, lenticular, fine- to coarse-grained, thick-bedded sandstones separated by subordinate amounts of sandy shale, gray shale, carbonaceous shale and coal. The best coal beds all are located in the upper half of the formation.

A swale or valley follows under which the soft Mancos Shale occurs. It is basically a drab gray marine shale with interspersed and widely separated thin brown sandstone beds. The Mancos is 1,450 feet thick on the east edge of the quadrangle, 1,000 feet thick in the middle and continues to gradually thin in a westward direction. Bissell (1952, p. 610) believes that 1,680 feet, however, are present at Low Pass Creek in the Currant Creek quadrangle.

The second coal bearer, the Mesaverde Formation, is 3,000 to 4,000 feet thick in the Raspberry Knoll area. The Mesaverde consists mainly of gray, tan and white lenticular thick-bedded to massive sandstones with very fine to coarse grains. Between the beds are subordinate amounts of shaley sandstone, sandy shale, gray shale, carbonaceous shale and coal. The lower 1,600 feet are mostly barren of coal and contain fewer soft beds than the upper sequence. In the upper part, the more resistant sandstones stand out as ribs on the outcrop.

The Mesaverde is unconformably overlain by the Currant Creek Formation, a mostly conglomeratic unit that contains sandstone and shaley beds toward the top. The Currant Creek is 3,940 feet thick along Red Creek.

Tertiary outcrops occur over much of the south part of the quadrangle. They are not differentiated into formations on the map, but include Bishop Conglomerate, Uinta Formation and Duchesne River Formation. Raspberry Knoll and Bobby Duke Ridge are capped with Bishop Conglomerate. The basic lithologies of the three Tertiary units are similar consisting of variegated shale, sandstone and conglomerate, usually reddish or greenish gray. Most of these clastics are poorly sorted with irregular strata and poor consolidation. Glacial and terrace gravels and alluvium represent the Quaternary to complete the stratigraphic picture of the area.

STRUCTURE

The east-west trending ridges and swales occur on the south flank of the anticlinal Uinta Mountains. The strata dip 30 to 60 degrees southward. To the south the Tertiary formations have lapped onto the east-west hogbacks as the leading edge of the Uinta Basin. The Tertiary units dip southeasterly 10 to 15 degrees.

A group of northwest-trending faults cut the Frontier coal beds but do not extend far enough south to affect the Mesaverde. These *en echelon* faults have their downthrown blocks to the northeast. The displacements are on the order of several hundred feet in the maximum positions.

PROPERTY CONTROL

The lands of the Raspberry Knoll quadrangle are owned as follows: National Forest Service 49.9 percent, private property 48.1 percent, Bureau of Land Management 1.8 percent and state of Utah 0.2 percent.

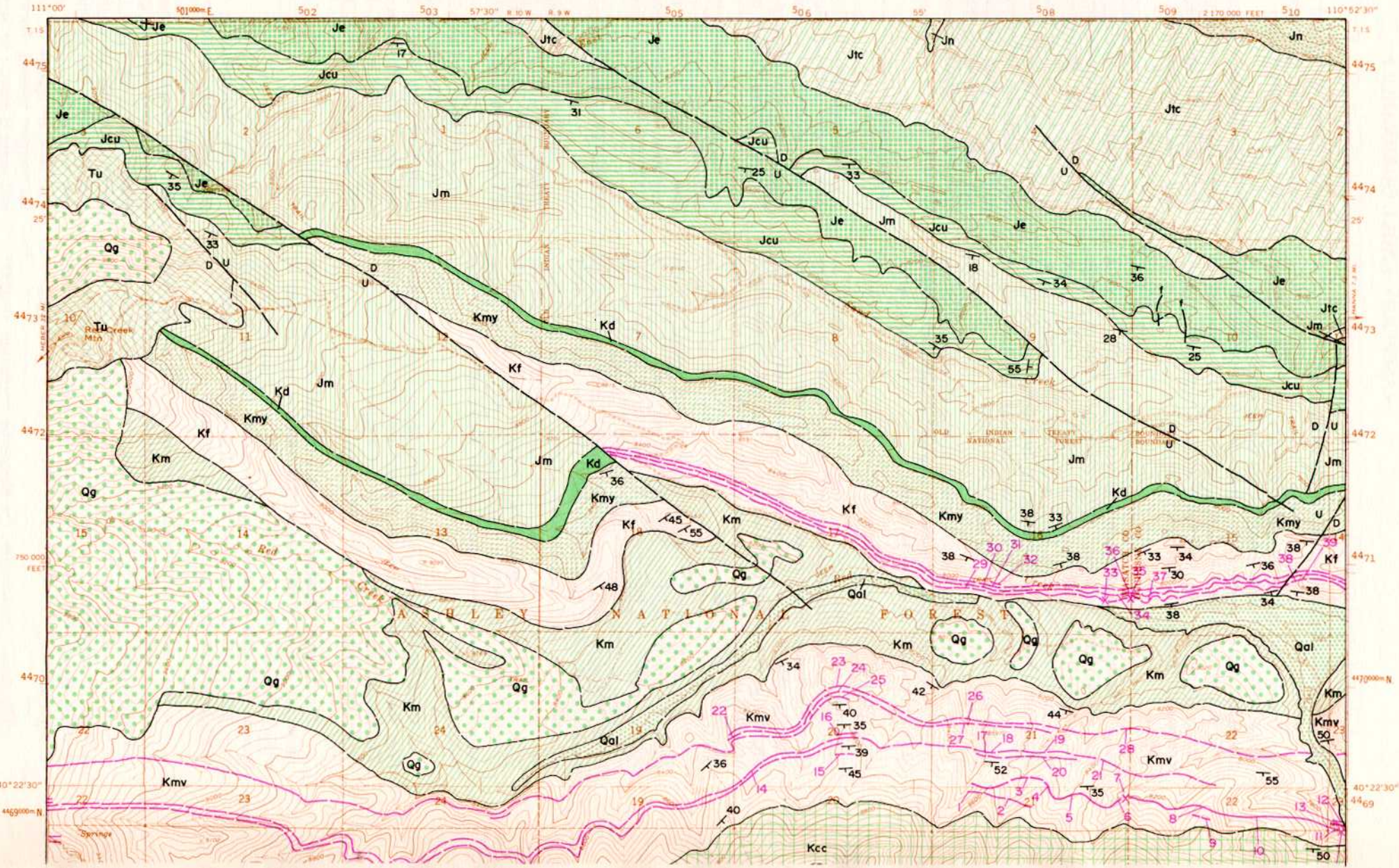
The above represents surface rights only; almost all the coal is owned by the Uintah and Ouray Indian Reservation. The Red Creek Coal Corp. holds a lease of 200 acres that extends slightly onto the Tabby Mountain quadrangle. Included in the lease is the south half of SW sec. 22, NE NE sec. 27, SW SW sec. 23 and NW NW sec. 26, all in T. 1 S., R. 9 W.

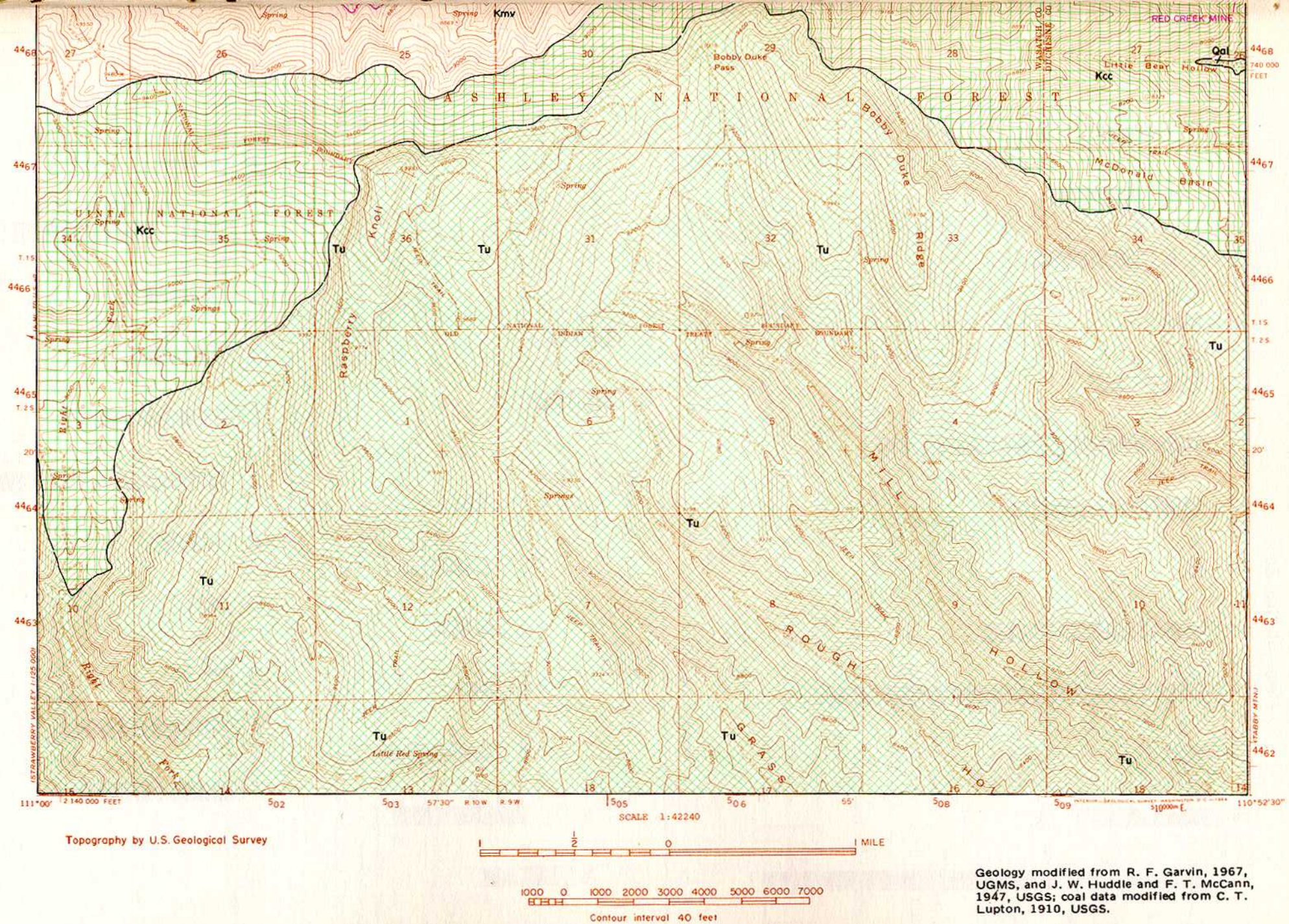
COAL

Surface Information

The coal occurs in two formations and in approximately twenty-five beds. Generally the coal seams are poorly exposed and correlation of beds for more than one-half mile is almost impossible. The Mesaverde Formation contains the thickest beds in the quadrangle and these are grouped by approximate position in the upper coal-bearing part of the formation (figure 12). The first thirteen localities are in the Upper zone, but are not necessarily from the same bed. Locality 4 has 28 feet of coal separated by two shale splits totalling 0.5 feet for the thickest bed observed. Generally an average of 13.2 feet of coal can be expected along the mapped interval. Locations 14 to 21 are in the Middle zone and again it cannot be verified that all are of the same bed. The coal ranges in thickness from 2.3 to 14.3 feet and averages 8.3 feet. The Lower zone (locations 22 to 28) has coal beds ranging from 2.3 feet to 7.2 feet, averaging 4.5 feet. Measurements were made only in the east half of the quadrangle, the area to the west being too poorly exposed. Good coal is known to exist farther

RASPBERRY KNOLL, UTAH





Geology modified from R. F. Garvin, 1967, UGMS, and J. W. Huddle and F. T. McCann, 1947, USGS; coal data modified from C. T. Lupton, 1910, USGS.

Figure 11. Coal and geology map, Raspberry Knoll quadrangle (explanation pages 296-297).

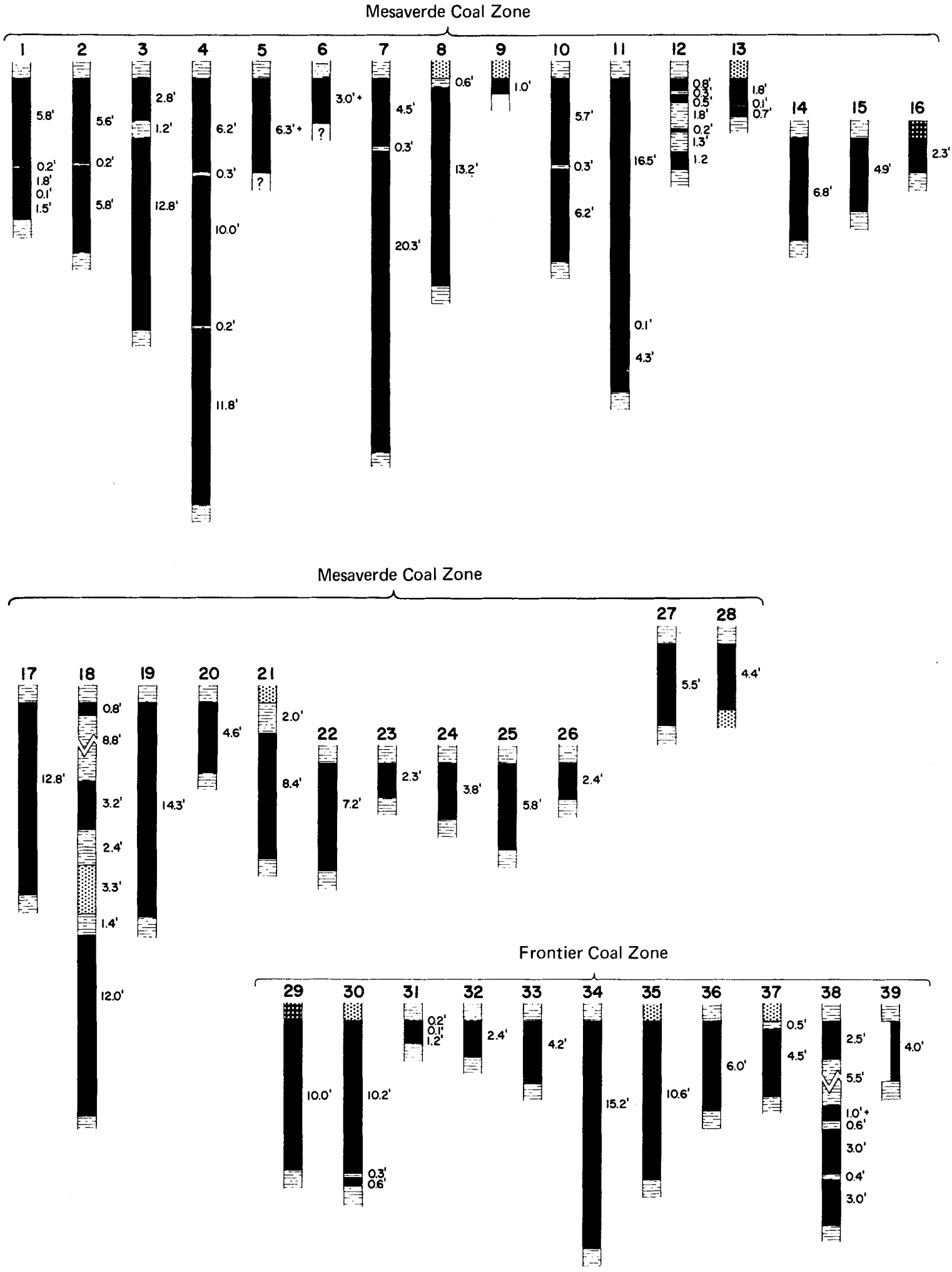


Figure 12. Coal sections of Raspberry Knoll quadrangle (vertical scale: 1 inch = 8 feet).

west and the zones, at least, are thought to persist across the quadrangle.

The Frontier Sandstone has thick coal in four beds near the top of the unit.

	Feet
Bed 4	
Interval	63
Bed 3	
Interval	54
Bed 2	
Interval	10
Bed 1	

Bed 4, represented by seven locations, ranges in thickness from 4 to 10 feet and averages 6.6 feet. The bed was traced at least one mile farther west than the westernmost locality and although poorly exposed was definitely still present. Bed 3 has two localities, 30 and 34, with 10 and 15 feet thicknesses respectively. It has not been adequately explored to the west of the two localities, but contains thick seams a mile or two east of the quadrangle. Bed 2 (locality 31) and bed 1 (locality 32) are thin and their continuity in either direction is doubtful.

Subsurface Information

There has been no drilling for coal in the Raspberry Knoll quadrangle. The dips in the Frontier are approximately 35 degrees indicating 3,000 feet of cover would be reached in less than a mile south of the outcrops. The dips in the Mesaverde are somewhat steeper and with the overburden added by the elevation of the ground surface, the effective minable width is expected to be no more than one-half mile.

Quality of Coal

Two analyses are available, both from the Red Creek mine on the Upper zone (Fraughton bed) of the Mesaverde Formation. The average analysis is as follows: moisture 15.4 percent, volatile matter 39.2 percent, fixed carbon 39.4 percent, ash 7.1 percent, sulfur 0.91 percent and Btu/lb 10,321. Individual analyses are given in table 5.

Mines and Development

The Red Creek mine was a tunnel 100 feet in length in 1910 when Lupton visited it (table 8). It was operated sporadically as a small truck mine until 1941 when it caught fire and had to be closed and sealed off. The workings may have been destroyed in 1948 or 1949 when the coal bed was strip-mined. The Red Creek mine has the distinction of being the first strip-mine in Utah, but it operated only a month or two during a coal mine strike that affected the larger mines of the state in Carbon and Emery counties. Presumably less than 2,000 tons of coal were mined since its opening. Some prospect pits were dug in other Mesaverde beds and others in the Frontier coal beds. These apparently did not produce more than a few tons each.

Table 8. Mine in the Raspberry Knoll quadrangle.

Mine	Location	Remarks
Red Creek mine (Fraughton)	NW.NW.NW.26-1S-9W 4,468,820m.N. 510,500m.E.	Intermittently active 1900-1949

Reserves

Lupton (1912, p. 628) calculated the following tonnages for the quadrangle.

Location	Tonnage
T.1S. R.9W.	399,720,000
T.1S. R.10W.	354,222,000
Total coal	753,942,000

The estimate includes all coal beds in both formations to a depth of 3,000 feet. A recalculation is made to eliminate potential (Class IV) reserve (table 9).

Table 9. Original coal reserves (excluding Class IV), Raspberry Knoll quadrangle.

Location and beds	Acres	Avg. seam thickness (ft.)	Tonnage	Class Reserve
T.1S. R.9W. USM				
Mesaverde				
Upper	960	13.2	22,070,000	II
Upper	640	10.0	11,150,000	III
Middle	1,260	8.3	18,220,000	II
Lower	1,260	4.5	9,930,000	II
Frontier				
Bed 4	1,440	6.6	16,560,000	II
Bed 4	640	6.0	6,690,000	III
Bed 3	640	12.5	13,940,000	II
		Total	98,560,000	
T.1S. R.10W.				
Mesaverde				
Upper	700	10.0	12,190,000	III
Middle	700	8.0	9,760,000	III
Lower	700	4.0	4,880,000	III
		Total	26,830,000	
		Grand Total	125,390,000	

Of the total, 88.2 million tons are Mesaverde coal and 37,190,000 tons are Frontier coal. The calculation represents a minimum coal figure based on reliable evidence. The writer concurs with Lupton that the potential is much greater.

PRINCIPAL WORK

Much of the coal data are from Lupton (1912) and the geology is by Huddle and McCann (1947) and Garvin (1969).

Stripping operation at old Red Creek mine, west of Red Creek. The main seam is about 25 feet thick; a 6-foot seam lies about 60 to 70 feet below it.

ROCK CREEK QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Rock Creek quadrangle is a composite of parts of the U. S. Geological Survey Dry Mountain and Mountain Home topographic quadrangles. It is located in the far east part of the field (figure 8). The center of the quadrangle lies 10 miles east of Hanna and 22 miles northwest of Duchesne.

The most important topographic feature is the valley of Rock Creek which flows southeasterly across the quadrangle. The remaining area consists of ridges and knolls with elevations ranging from less than 6,800 feet to 9,100 feet. The coal outcrop follows one of the mostly east-west trending ridges.

The main road into the area extends from Duchesne, parallels Pigeon Water Creek and then drops over Mountain Sheep Pass into Rock Creek Valley. A road parallels the creek and another extends westward to Hanna over Farm Creek Pass.

STRATIGRAPHY

The system of ridges and inter-ridge areas is controlled by hard and soft units ranging in age from Permian to Cretaceous. They are best exposed west of Rock Creek. To the east windows of these units appear through a blanket of rock slide, talus and terrace gravel. Tertiary units lap onto the more steeply dipping older rocks from the south and in the far east part of the quadrangle, they completely blanket the older rocks. The oldest rocks are generally to the north. Rocks older than Cretaceous age are of little concern in the study of the coal; they are listed below with approximate thicknesses.

		Feet
Jurassic	Morrison Formation	1,170-1,450
	Curtis Formation	140- 210
	Entrada Sandstone	440- 745
	Twin Creek Limestone	540- 780
	Navajo Sandstone	1,190-1,300
Triassic	Chinle Formation	375- 465
	Shinarump Conglomerate	50±
	Ankarah Shale	700
	Thaynes Limestone	400
	Woodside Shale	700
Permian	Park City Formation	625

The Triassic units are combined on the map (figure 13). Exposed Cretaceous formations include the Dakota, Mowry, Frontier and Mancos Shale. The Mesaverde is covered completely by the Tertiary onlap. The Dakota outcrops are poorly exposed in the Rock Creek area. The lower two parts of the tripartite Dakota often are assigned to the Cedar Mountain Formation; the middle part is a shale and the upper and lower bodies are sandstone units. The total thickness ranges between 150 and 225 feet. The lenticular and in part discontinuous sandstones are responsible for the variation in thickness. They are fine- to coarse-grained, locally conglomeratic, poorly sorted and cemented by calcite. The shale is a soft medium gray clayey material about 120 feet thick. The sandstone units of the Dakota generally produce a slight ridge.

The Mowry Shale, which overlies the Dakota, is mostly gray calcareous mudstone. Within it a siliceous 10- to 20-foot thick shale that weathers into silvery chips contains numerous teleost fish scales. The entire unit is 360 to 390 feet thick with the siliceous zone about 80 to 170 feet below the top. The Mowry is basically a soft unit forming a swale between ridges.

The Frontier Sandstone is the only coal-bearing unit on the quadrangle. It is mostly a cross-bedded lenticular sandstone, fine- to coarse-grained and calcareous with interbedded shales, mudstones, siltstones and coal. The number and value of the coal beds in the Rock Creek quadrangle have not been fully determined. The Frontier is succeeded by the Mancos Shale, a gray marine shale with a few sandstone lentils and tongues scattered within it. The Mancos is a soft valley former and is poorly exposed in most places.

Tertiary rocks are subdivided into several units within the Uinta Basin. In the Rock Creek quadrangle area they probably include parts of the Uinta, Duchesne River and Bishop formations. They are not subdivided on the map. The rock type is similar to all: poorly sorted and cemented sandstone and conglomerate, mostly gray and white with red, gray and green siltstone, shale and mudstone.

The area also contains patches and larger areas of Quaternary landslides, rockslides, talus, terrace gravel and alluvium.

STRUCTURE

Cretaceous and older rocks normally dip between 15 and 25 degrees to the south. East of Rock Creek the strike is more northeasterly rather than east-west. A possible subtle anticlinal nose trends north-south in the west third of the quadrangle. Two northeast-trending faults were mapped in the northwest map area, each with its downdropped block to the northwest. They do not extend far enough south to cut the Frontier coal-bearing beds.

PROPERTY CONTROL

The lands of the Rock Creek quadrangle are owned as follows: Uintah and Ouray Indian Reservation 80.0 percent, National Forest Service 9.1 percent and private property 10.9 percent.

All of the coal land is on the Indian reservation and none is held to extract coal.

COAL

Surface Information

Five surface sections of the coal in the Frontier formations are available for the quadrangle (figure 14). All were taken on the east side of Rock Creek and the thickest location (2) is 2 feet thick. The bed averages 1.6 feet in the area of the measured locations. A prospect in sec. 35, T. 1 N., R. 6 W., USM, has coal on the dump, but the outcrop is too badly exposed to obtain a proper measurement. No coal measurements are available from the remainder of the quadrangle because of poor exposures.

Subsurface Information

There has been no drilling for coal on the quadrangle. A 25-degree dip lowers the coal beds 2,231 feet per mile. Drilling for oil 6 to 8 miles to the south indicates that the Frontier horizon is more than 15,000 feet below the surface.

Quality of Coal

No analyses are available for the Rock Creek quadrangle.

Mines and Development

A prospect is shown in the Frontier on a map by Huddle, Mapel and McCann (1951) in sec. 24, T. 1 N., R. 6 W. in the area of the measured locations. A second prospect is shown in

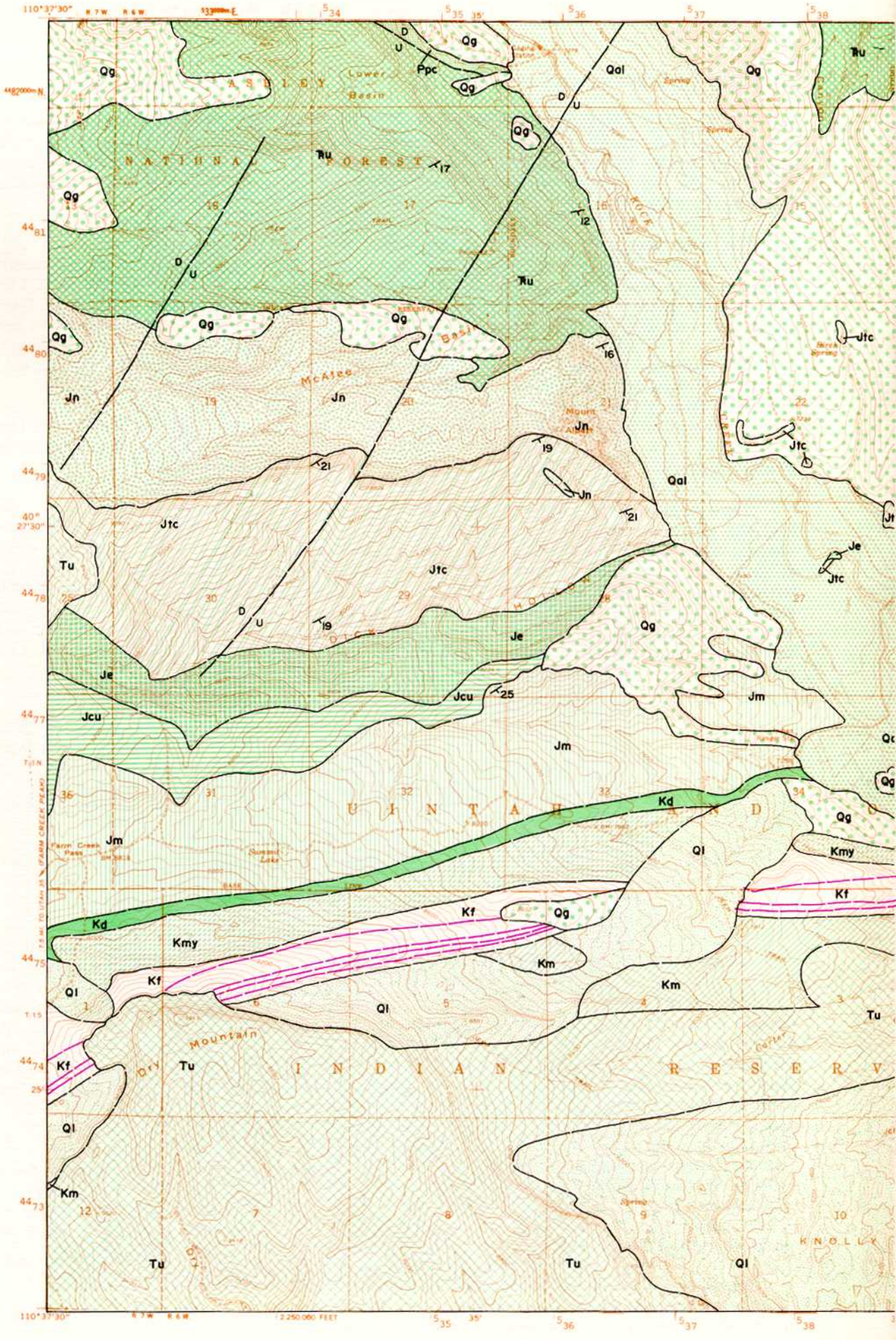
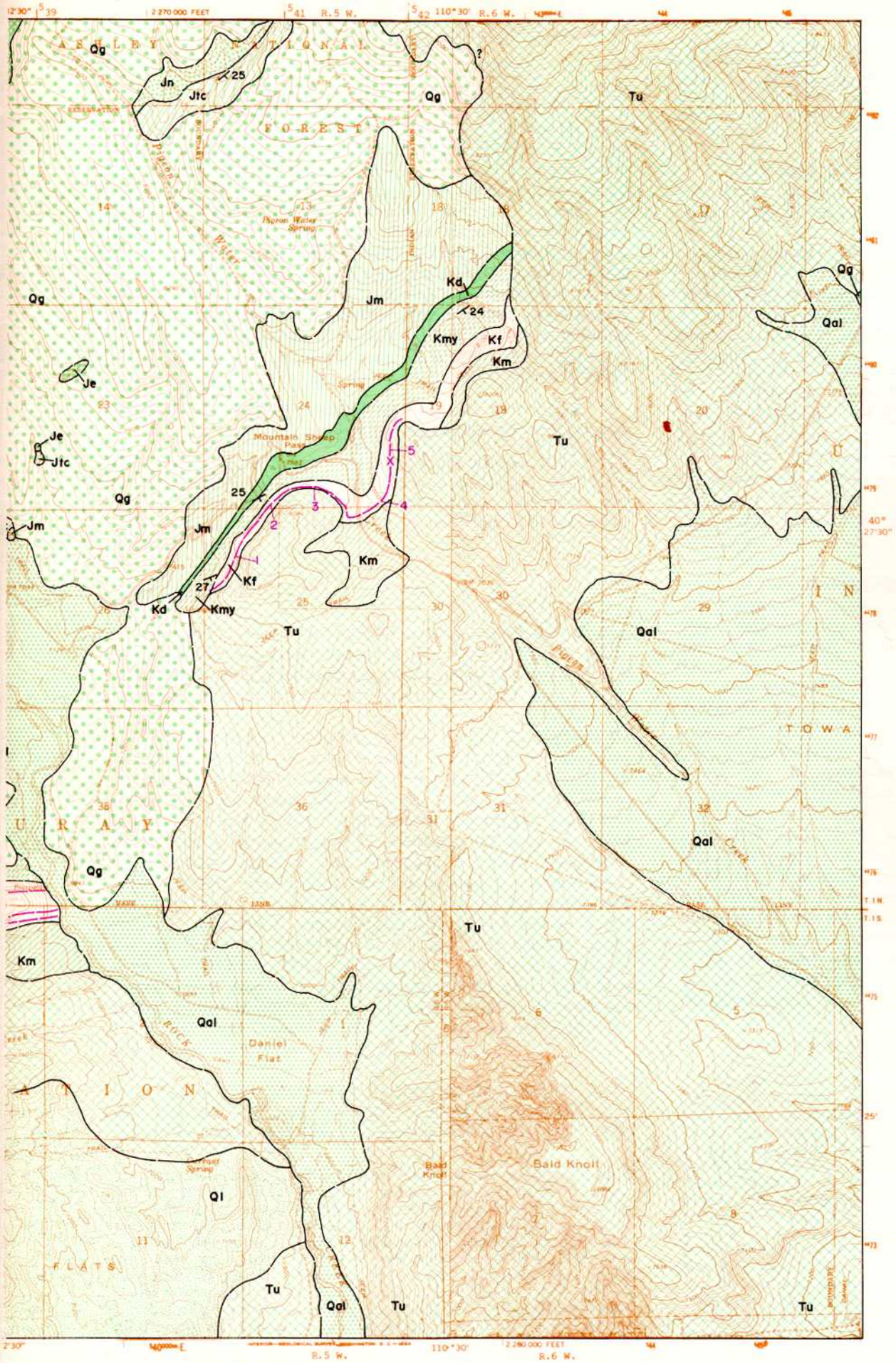


Figure 13. Coal and geology map, Rock Creek quadrangle (explanation pages 296-297).



SCALE 1:42240

1 0 1 Mile

1000 0 1000 2000 3000 4000 5000 6000 7000

Contour interval 40 feet
Datum mean sea level

Geology by J. W. Huddle, F. T. McCann and J. W. Mapel, 1951, USGS; coal data by C. T. Lupton, 1910, USGS.

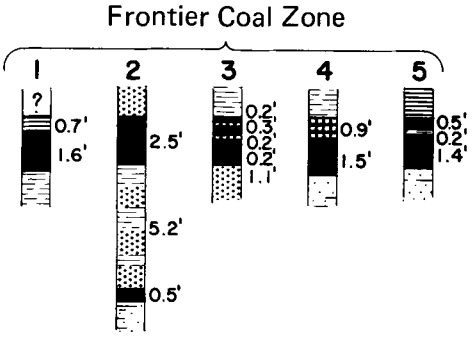


Figure 14. Coal sections of Rock Creek quadrangle (vertical scale: 1 inch = 8 feet).

SE.SW.SW.35-1N-6W. The author visited the latter prospect (1970) which consists of a dump in front of a collapsed adit. The condition of the dump indicated that it had been abandoned many years ago.

Reserves

Lupton (1910, p. 628) calculated reserves for the Rock Creek area by township. These are tabulated below.

Township	Tons
T.1S. R.6W.	57,072,000
T.1S. R.5W.	1,628,000
T.1N. R.5W.	8,211,000
T.1N. R.6W.	7,236,000
	75,147,000

None of this coal is in beds 4 feet or more thick. The only reliable reserve is in the vicinity of the measured sections involving perhaps 2 square miles before the 3,000-foot burial limit is reached. Using a 1.6-foot average for the coal bed, a total of 3.5 million tons would fall in the estimated (Class II) category and the remainder of Lupton's reserve must be considered either inferred or potential (Class III and IV).

PRINCIPAL WORK

All the coal data are from Lupton (1912) and the geological data are from Huddle, Mapel and McCann (1951).

TABBY MOUNTAIN QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Tabby Mountain quadrangle in this report is a composite of the south part of the Hanna and north part of the Tabby Mountain U. S. Geological Survey topographic quadrangles. It is the center of the Tabby Mountain coal field (Preface, figure 1a). The town of Hanna in the Duchesne River Valley lies in the northeast map corner. It is 40 miles northwest of Duchesne and 20 miles north of U. S. Highway 40.

The north half of the quadrangle consists of ridge and swale topography along the south flank of the Uinta Mountains. The south half represents the north edge of the Uinta Basin and is more plateau-like in its landforms. The dominant physiographic feature, Tabby Mountain, is 10,000 feet high and the leading edge of the basin rocks. The lowest elevation is 6,700 feet in the valley of the Duchesne River. The coal outcrops normally lie between 7,500 and 8,500 feet.

The main route of travel along Utah 35 in the Duchesne River Valley connects to the more important transportation routes to the south. Forest dirt and gravel roads extend into the mountainous portion of the quadrangle at convenient locations. The Red Creek and Tabby Swale roads are important with respect to coal bed access.

STRATIGRAPHY

Triassic, Jurassic and Cretaceous rocks make up the east-west trending ridge and swale country in the north half of the quadrangle (figure 15); older units are to the north. The south half is dominated by Tertiary rocks that lap on to the older units.

The Cretaceous formations contain all the coal beds and the remaining formations are discussed briefly for identification purposes. The Triassic rocks are undifferentiated on the map, but consist of five formations containing shale, limestone, shale, conglomerate and mudstone and siltstone respectively. Most units are reddish or brown except the limestones which are gray. The Jurassic also consists of five formations: (1) Navajo Sandstone, reddish orange, thick-bedded and cross-bedded, 1,100 feet thick, (2) Twin Creek Limestone, gray thin-bedded limestone with green-gray sandy shale near the top, 700 to 800 feet thick, (3) Entrada Sandstone, red-brown, thin-bedded soft siltstone, sandy shale and sandstone, 700 to 800 feet thick, (4) Curtis Formation, greenish gray calcareous friable sandstone with gray-green shale, limestone and sandstone toward top, 140 to 200 feet thick and (5) the Morrison Formation, varicolored shale, sandstone, siltstone and conglomeratic lenses about 1,500 feet thick.

The contact between the Jurassic Morrison and the Cretaceous Dakota generally is poorly exposed or concealed. The Dakota Sandstone was described by Huddle and McCann (1947):

> The Dakota Sandstone includes a lower sandstone, 30 to 40 feet thick, a middle shale, 160 feet thick, and an upper sandstone, 5 to 26 feet thick. The lower sandstone and the shale is tentatively considered to be of Lower Cretaceous age and the upper sandstone is considered to be of Upper Cretaceous age. The lower sandstone is lithologically similar to overlying sandstone beds, and it is not everywhere easily differentiated from sandstone in the underlying Morrison Formation. It is a fine- to coarse-grained, locally conglomeratic, gray sandstone with black grains, and weathers buff. It contains many weathered feldspar grains and the angular to subrounded quartz grains are clear or pink and opaque. It is loosely cemented, calcareous, porous and friable. Pebbles, when present, are rounded and range in diameter from 4 to 15 millimeters. This sandstone differs from the sandstones of the Morrison mainly in that it is more arkosic and weathers brown or buff rather than light gray. The beds are 1 to 5 feet thick and exhibit small-scale cross-bedding.
>
> The shale unit includes varicolored, soft clay shale which is poorly exposed but is quite similar in appearance to shale in the Morrison Formation. Sandstone lenses as thick as 15 feet are present in the shale unit.
>
> The upper sandstone is calcareous and friable and is composed of angular to subrounded grains of quartz, weathered feldspar, and fine, rounded, black grains. Locally it is conglomeratic. Interbedded fine-grained sandstone and siltstone is commonly light gray and weathers gray brown to buff. The sandstone is commonly cross-bedded and in the more shaley parts is laminated.

The Dakota is coal bearing in other parts of Utah, but not near Tabby Mountain. The lower two subunits of the Dakota often are differentiated into the Cedar Mountain Formation.

The Mowry Shale overlying the Dakota produces a swale between it and the Frontier Sandstone. The Mowry consists of 360 to 390 feet of gray clay shale–sandy in the upper 80 feet and 15 feet of siliceous black shale below the sandy part. The siliceous horizon is an easily recognized marker bed that contains teleost fish scales and weathers into silvery chips.

The Frontier Sandstone contains coal beds but is dominated by yellow-gray and tan, fine- to coarse-grained, lenticular, thick-bedded sandstones. These are separated by shale, carbonaceous shale, sandy shale and coal in subordinate quantities. In the Duchesne River Valley two main sandstone sequences are separated by a middle shale unit. The sandstone forms ridges and the shale makes a swale. The coal occurs in the upper part of the 450- to 600-foot unit.

The valley-forming Mancos Shale is 1,800 to 2,600 feet thick and consists of drab gray marine shale occasionally interrupted by thin brown sandstone beds. It is normally heavily covered with soil and poorly exposed.

The Mesaverde Formation is the next coal bearer of the Cretaceous system and consists of a sequence of sandstone and sandy shale with subordinate gray shale, carbonaceous shale and coal. White and gray to yellowish brown sandstone is dominant; it is very fine- to coarse-grained and cemented with calcite in thick to massive beds. The lower part has some marine beds, but most of the unit is nonmarine. The lower 1,600 feet of the unit are resistant because of the thicker and more numerous sandstone beds. The upper part has many resistant sandstone ribs between which the softer shaley and coaley beds occur. The Mesaverde is more than 3,000 feet thick in the west edge of the quadrangle, but only 550 feet thick along the Duchesne River. The diminution of the formation is believed the result of erosion of the unit prior to the deposition of the overlying Currant Creek Formation. Thus the coal may have been completely removed from the east half of the quadrangle.

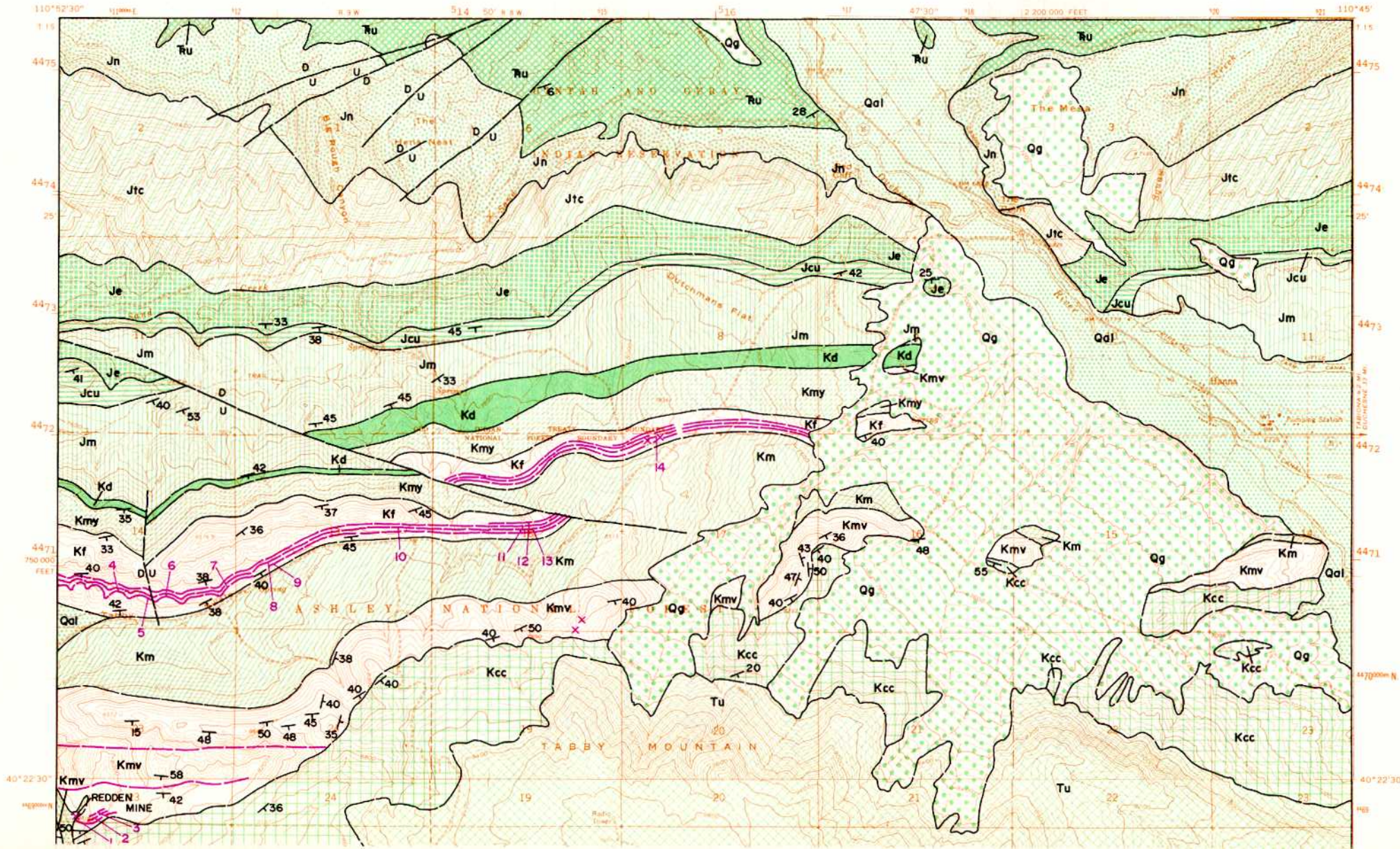
According to Garvin (1969, p. 11):

> The Currant Creek unit is a series of interbedded conglomerates and sandstones with some beds of siltstone and shale. The conglomerates are lithic, with frameworks of boulders, pebbles, granules and cobbles, which predominate. Generally gray to light gray, the conglomerates are composed primarily of quartzite from the Pennsylvanian Weber Quartzite, Precambrian Mutual Quartzite, black Paleozoic chert, and minor amounts of limestone. Usually fragments are rounded, but with decreasing size, become more angular. In the lower part of the Currant Creek, conglomerate predominates. Sandstones are light gray to light yellow or yellowish brown in color. They are poorly to well sorted, contain subangular to rounded grains and are loosely to tightly cemented with calcareous cement. They range in composition from subgraywacke near the base of the formation to orthoquartzite near the top. Beds are lenticular, blanket or wedge-shaped. Most sandstone tongues or wedges pinch out westward. Sandstone predominates in the upper section of the Currant Creek. Siltstones and shales are reddish brown to variegated in color, calcareous and poorly exposed . . .

The Currant Creek Formation is 3,940 feet thick along Red Creek and 1,534 feet thick along the Duchesne River Valley.

Tertiary units lap over the Currant Creek and older units from the south. They are not subdivided on the map and those units that appear in the area probably include the Uinta, Duchesne

TABBY MTN., UTAH



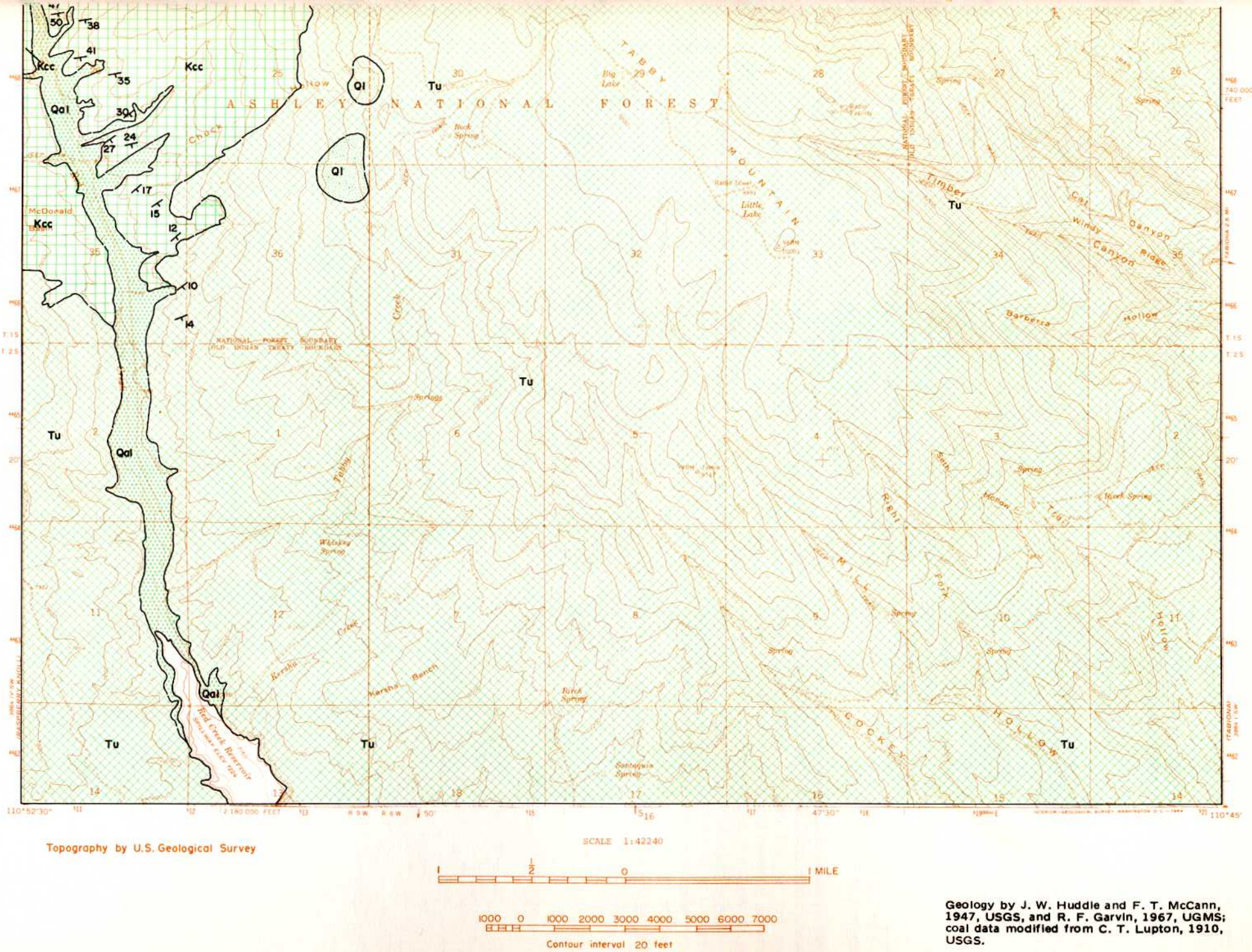


Figure 15. Coal and geology map, Tabby Mountain quadrangle (explanation pages 296-297).

River and Bishop formations. The Bishop Formation caps Tabby Mountain with basically a similar lithology of variegated sandstone, shale and conglomerate usually reddish or greenish gray. The strata are irregular; all are poorly sorted and only partly consolidated.

Quaternary units include large patches of terrace or glacial gravel, landslide or talus and stream valley filled alluvium.

STRUCTURE

The east-west trending ridges and swales are on the south flank of the Uinta Mountain anticlinal upfold. The inclinations on the beds vary considerably, but most are steep, 35 to 50 degrees southward. The dip on the Frontier beds (35 to 45°) is generally less than those on the Mesaverde (40 to 50°). The upper beds of the Currant Creek Formation dip more gently than the lower beds. Significant unconformities occur above and below the Currant Creek. The one below may cut off the coal-bearing portion of the Mesaverde in the east half of the quadrangle. The Tertiary beds lap over the Currant Creek Formation and although they also dip southerly, the inclination is much more moderate, 10 to 15° at the north-leading edge and decreasing southward. The Tertiary beds mark the north limit of the Uinta Basin.

Several northwest-trending faults along the north map edge, most with their downthrown block to the southeast, cut Triassic and Jurassic strata but do not extend into the coal-bearing horizons. Two faults do, however. One extends from sec. 17, T. 1 S., R. 8 W., east by northeast into sec. 11, T. 1 S., R. 9 W., where it continues into the Raspberry Knoll quadrangle. The outcrop trace of the coal appears to be displaced one-half mile along the fault; the downthrown block is to the north. The second fault also cuts the Frontier beds in sec. 14, T. 1 S., R. 9 W. It trends north and the displacement appears to be minor.

PROPERTY CONTROL

The lands of the Tabby Mountain quadrangle are owned as follows: private property 66.2 percent, National Forest Service 29.5 percent and state of Utah 4.3 percent.

Practically all the coal land is in Ashley National Forest, but most of the coal rights are the property of the Uintah and Ouray Indian Reservation. At present the Red Creek Coal Corp. holds a lease extending onto the SW SW corner of sec. 23 and the NW NW corner of sec. 26 in the area of the Redden mine. The leased property extends into the Raspberry Knoll quadrangle and the total acreage is 200 acres.

COAL

Surface Information

The coal of the Tabby Mountain quadrangle is located in the Frontier and Mesaverde formations (figure 16). The four coal beds in the Frontier are near the top of the unit.

	Feet
Bed 4	
Interval	63
Bed 3	
Interval	54
Bed 2	
Interval	10
Bed 1	

Bed 4 is represented by five locations, four of which have thick seams. All are in the vicinity of sec. 14, T. 1 S., R. 9 W. The thickest seam averages 5.7 feet. The greatest amount of coal is at location 5 where 18.4 feet of coal in five benches occur with splitting shale only 1.5 feet. Bed 3 is represented by four locations. Thick seams in sec. 13, T. 1 S. R. 9 W. average 6.3 feet of coal. Bed 2 is represented by locality 11 where the coal is 3.2 feet thick. Locality 12 represents Bed 1 with a 4.1-foot thick coal bed. The coal is expected to thin in an easterly direction. The thickness of these beds may be greater than the measurements indicate, because of poor or covered conditions.

The Mesaverde Formation is poorly exposed except along Red Creek and Duchesne River. Coal is known at Red Creek but is probably eroded off at the Duchesne River by a pre-Currant Creek erosional interval. Each of the three measured sections is from a different bed near Red Creek. The thickest section is 5.6 feet. Lupton (1912, p. 615) notes at least five coal beds occur near the top of the Mesaverde. A 20-foot coal bed lies on the opposite side of the creek 20 feet above the bed at locality 1. The identity of the thick bed could not be ascertained on the east side; the prospective outcrop is obscured by talus and hillwash. The bed at location 2 is about 20 feet below locality 1; location 3 is much lower yet in the column.

Subsurface Information

There has been no drilling for coal on the quadrangle. The inclination of the coal beds indicates that coal is buried under 3,000 feet of rock within a ¾- to 1-mile distance south of the outcrop.

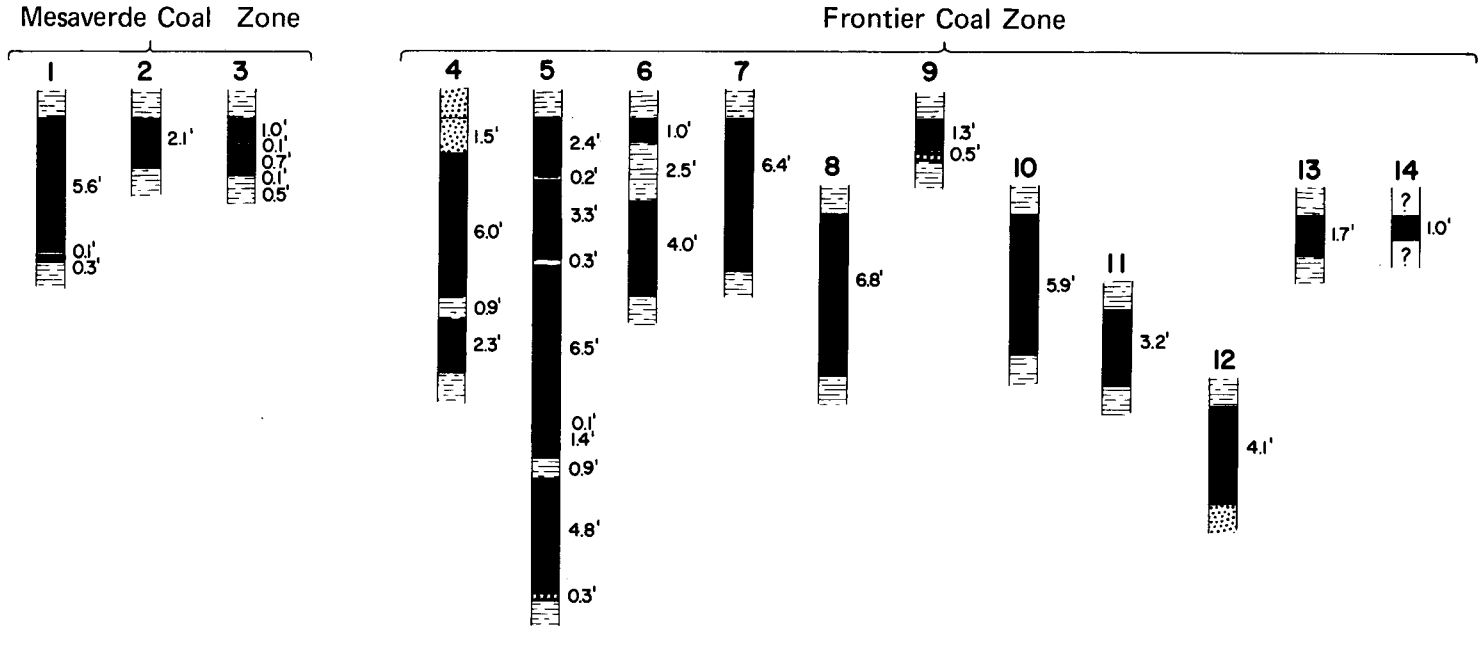


Figure 16. Coal sections of Tabby Mountain quadrangle (vertical scale: 1 inch = 8 feet).

Quality of Coal

One analysis is available for the Tabby Mountain quadrangle taken at the Redden mine in the Mesaverde Formation. The sample contained 1.47 percent sulfur, 6.1 percent ash and had a heating value of 10,213 Btu/lb. Table 5 lists the complete analysis.

Mines and Development

Other than a few long abandoned shallow prospect pits the only mine is the Redden (table 10).

Table 10. Mine in the Tabby Mountain quadrangle.

Mine	Location	Remarks
Redden mine	NE.NW.NW.26-1S-9W USM 4,468,820m.N. 510,765m.E.	Active 1940's

A fire in the Fraughton mine located on the west side of Red Creek in the Raspberry Knoll quadrangle caused its shutdown in 1941; the Redden mine was opened to replace it. The Redden tunnel is less than 100 feet long and limits the amount of coal taken to about 200 tons. All of the activity presumably took place in the 1940's.

Reserves

Lupton's (1912, p. 628) calculated reserves by township are repeated here. They include a small segment of the Tabiona quadrangle to the east.

Location	Tonnage
T.1S. R.8W.	142,893,000
T.1S. R.9W.	199,856,000
Total coal	342,749,000

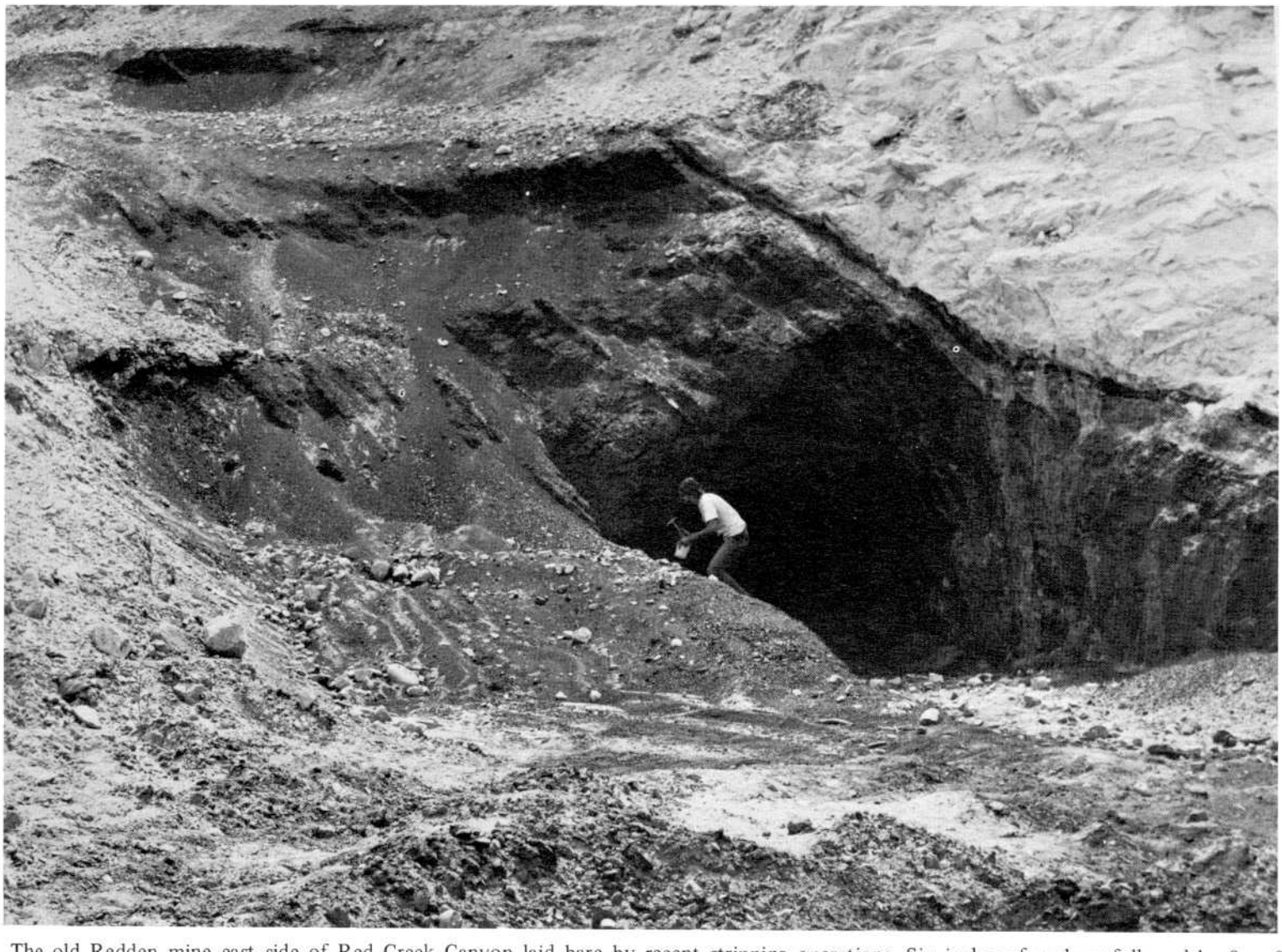
To eliminate Class IV (potential) reserves a recalculation was made based more closely on allowable evidence (table 11).

Table 11. Original coal reserves (excluding Class IV), Tabby Mountain quadrangle.

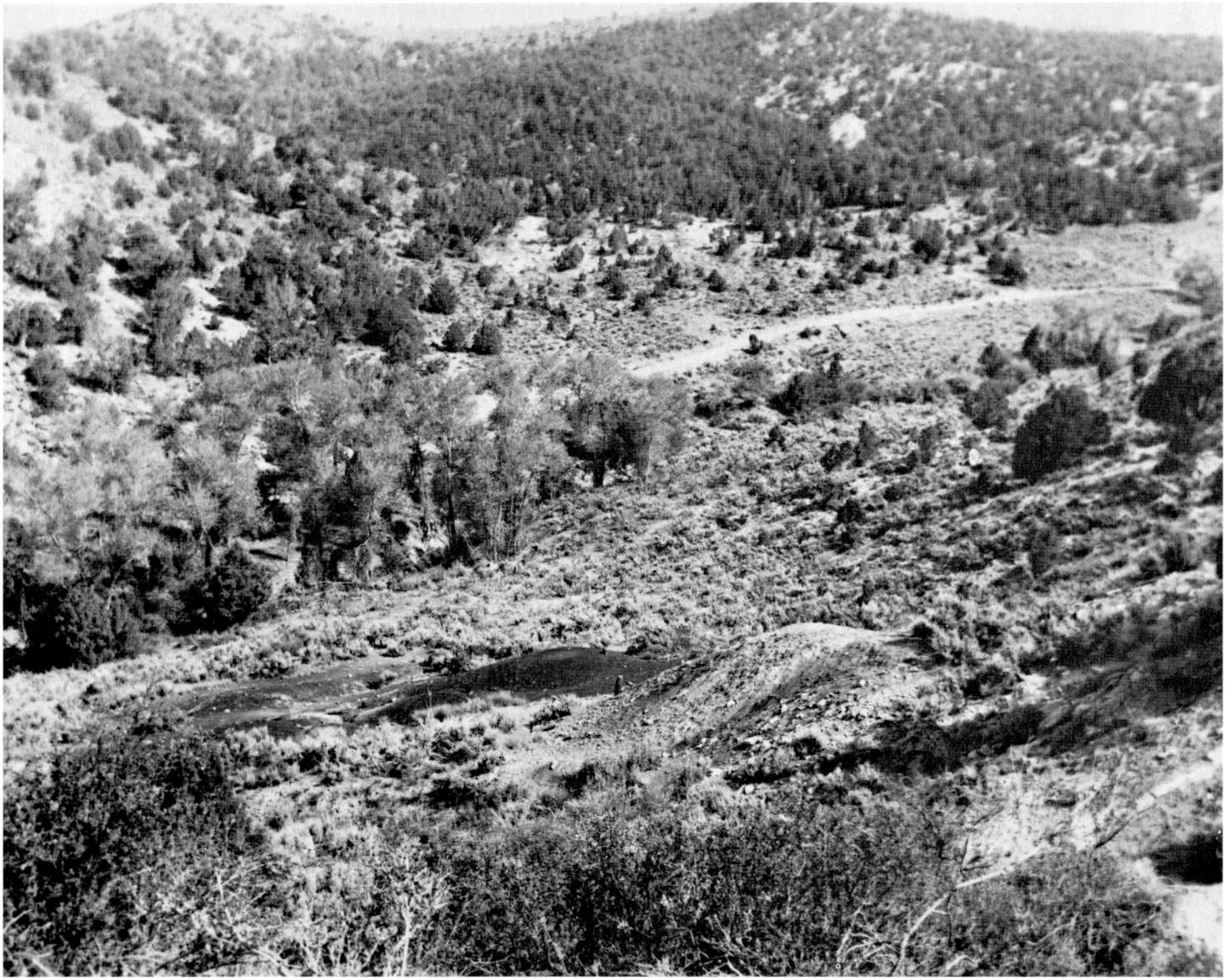
Location and bed	Area	Avg. thickness (ft.)	Tonnage	Remarks
T.1S. R.8W. USM				
Frontier 2	320	3.2	1,780,000	sec.18
Frontier 1	320	4.1	2,280,000	sec.18
		Total	4,060,000	
T.1S. R.9W.				
Mesaverde	320	5.6	3,120,000	pts. sec. 23, 26
Frontier 4	600	5.7	5,960,000	sec. 14
Frontier 3	640	6.3	7,020,000	sec. 13
		Total	16,100,000	
		Grand Total	20,160,000	
	Coal beds greater than 4 ft.		18,380,000	

PRINCIPAL WORK

Most of the coal data are from Lupton (1912) and the geological data are from Huddle and McCann (1947) and Garvin (1969).



The old Redden mine east side of Red Creek Canyon laid bare by recent stripping operations. Six inches of coal are followed by 8 or 9 inches of sandy shale, 12 feet of coal, 1 foot of coaley shale and another 14 feet of coal.



Winchester coal bed prospect, Frontier Sandstone, Tabiona quadrangle. The prospect is collapsed and no measurement of coal thickness is available. Section 18 on the map, the location of the prospect, indicates the presence of only 1.5 feet of coal.

TABIONA QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

Tabiona quadrangle is a composite of parts of U. S. Geological Survey Farm Creek Peak and Tabiona topographic quadrangles. The ridges and swales of the south flank of the Uinta Mountains occupy the north third of the map area and the Duchesne River Valley is diagonally portrayed northwest to southeast. The area is in the east half of the Tabby Mountain coal field (figure 8).

The village of Tabiona is located on the quadrangle in the Duchesne River Valley. Utah Highway 35 follows the valley and connects Tabiona with Hanna and Duchesne. Utah Highway 208 links U-35 with U. S. 40, 10 miles to the south. An important graded road joins Hanna with Rock Creek to the east following the Right Fork of Farm Creek passing between the coal-bearing stratigraphic units.

The principal topographic feature, Duchesne River Valley, is from ½ to 1 mile wide. The remaining part of the south two-thirds of the map is badly dissected, mountainous-appearing plateau land. The north third is east-west trending ridge and swale. Elevations range from less than 6,300 feet to more than 9,400 feet. Mapped coal beds appear between 7,000 and 9,000 feet of elevation.

STRATIGRAPHY

Jurassic and Cretaceous units make up the ridge and swale physiography and Tertiary units overlap them and make up most of the outcrop area in the south map area (figure 17).

The Jurassic ridges and swales appear in the northernmost area. They contain no coal, but are described briefly for identification. The Navajo Sandstone is a light red-orange, thick-bedded and highly cross-bedded unit, 1,190 to 1,300 feet thick. It is the oldest formation appearing on the quadrangle. The Twin Creek Limestone, 540 to 780 feet thick, has a lower part of light and dark thin-bedded gray limestone and shale and an upper shale and siltstone. The Entrada Sandstone, 700 feet thick, is dark red-brown soft siltstone, sandstone and mudstone. The Curtis Formation has a lower cliff-forming greenish gray to white sandstone and an upper greenish gray glauconitic shale, limestone and sandstone. It varies in thickness from 140 to 210 feet. The final and youngest Jurassic unit is the Morrison Formation, a varicolored mudstone, siltstone, conglomerate and freshwater limestone 1,170 to 1,450 feet thick.

Six Cretaceous units appear on the map. The Dakota contains no coal in the Tabby Mountain field. The Dakota, poorly exposed north of Tabiona, is roughly divisible into three parts, the lower two of which are often assigned to the Cedar Mountain Formation. The middle part is a shale and the upper and lower bodies are sandstone units. The sandstones are gray, fine- to coarse-grained, loosely cemented with calcite and friable. They often become conglomeratic and weather gray-brown to yellow-gray. The shale is gray to varicolored and soft. The lower sandstone is 30 to 40 feet thick, the shale 160 feet thick and the upper sandstone is 5 to 26 feet thick.

The Mowry Shale is a soft unit between the Dakota and Frontier ridges. The 360- to 390-foot unit is mostly gray calcareous shale, sandy at the top and containing a siliceous horizon 80 feet below the Frontier that carries teleost fish scales.

The Frontier Sandstone is a coal bearer consisting mainly of yellow-gray and tan cross-bedded, lenticular thick sandstone beds. Thin beds of gray shale, carbonaceous shale and coal separate the thicker groupings of sandstone beds. Near the Duchesne River Valley, the Frontier has a tripartite division, two sandstone units separated by a shale bed, which form two ridges and a swale. The sands are fine- to coarse-grained and often contain pebbles. The upper part of the Frontier contains most of the coal beds, some exceeding 4 feet thick.

The overlying Mancos Shale is 1,800 to 2,000 feet thick and consists of poorly exposed gray marine shales occasionally interrupted by thin brownish sandstone beds. The Right Fork of Farm Creek flows in the valley formed by the Mancos Shale.

The Mesaverde Formation is the second coal bearer exposed on the quadrangle although no coal has been recorded or measured. Its hogback near the Duchesne River is 550 feet thick, but it thickens to 1,700 feet farther east. The upper beds and presumably the more favorable coal horizons were removed by erosion in the vicinity of the Duchesne River. The formation features white, gray and tan sandstone beds that are lenticular, thick-bedded to massive and locally cross-bedded. The sandstones are interbedded with gray and carbonaceous shales, shaley to thin-bedded sandstones and coal.

The final Cretaceous unit, the Currant Creek, unconformably overlies the Mesaverde beds. The Currant Creek Formation is 1,534 feet thick in Little Valley north of Tabiona and consists of interbedded conglomerate, sandstone, siltstone and shale in which the finer constituents are more abundant toward the top of the unit.

Tertiary units, which overlap and overlie the Currant Creek, Mesaverde and Mancos formations unconformably, are undifferentiated on the map and probably consist of three formations: Uinta, Duchesne River and Bishop. For the most part the units consist of reddish mudstone and shale in alternating sequences.

Unconsolidated Quaternary units consist of scattered patches of gravel and landslide. Alluvium fills the larger valleys.

STRUCTURE

The Cretaceous coal-bearing units participate in the ridge and swale physiography reflected in southward-dipping beds along the south flank of the Uinta Mountain anticlinal arch. The dips range from 27 to 55 degrees. To the south the Tertiary rocks overlap the Cretaceous units and also dip southward toward the Uinta Basin. The dips are up to 30 degrees locally, but are generally 20 degrees in the northernmost exposures; they gradually decrease southward. No faults have been observed on the Tabiona quadrangle.

PROPERTY CONTROL

The Tabiona quadrangle is mostly privately owned (95.4 percent); the remainder is the property of the Uintah and Ouray Indian Reservation. Practically all the coal is on private property, but coal rights mainly belong to the Indian reservation. It is not believed that any land is held to exploit coal.

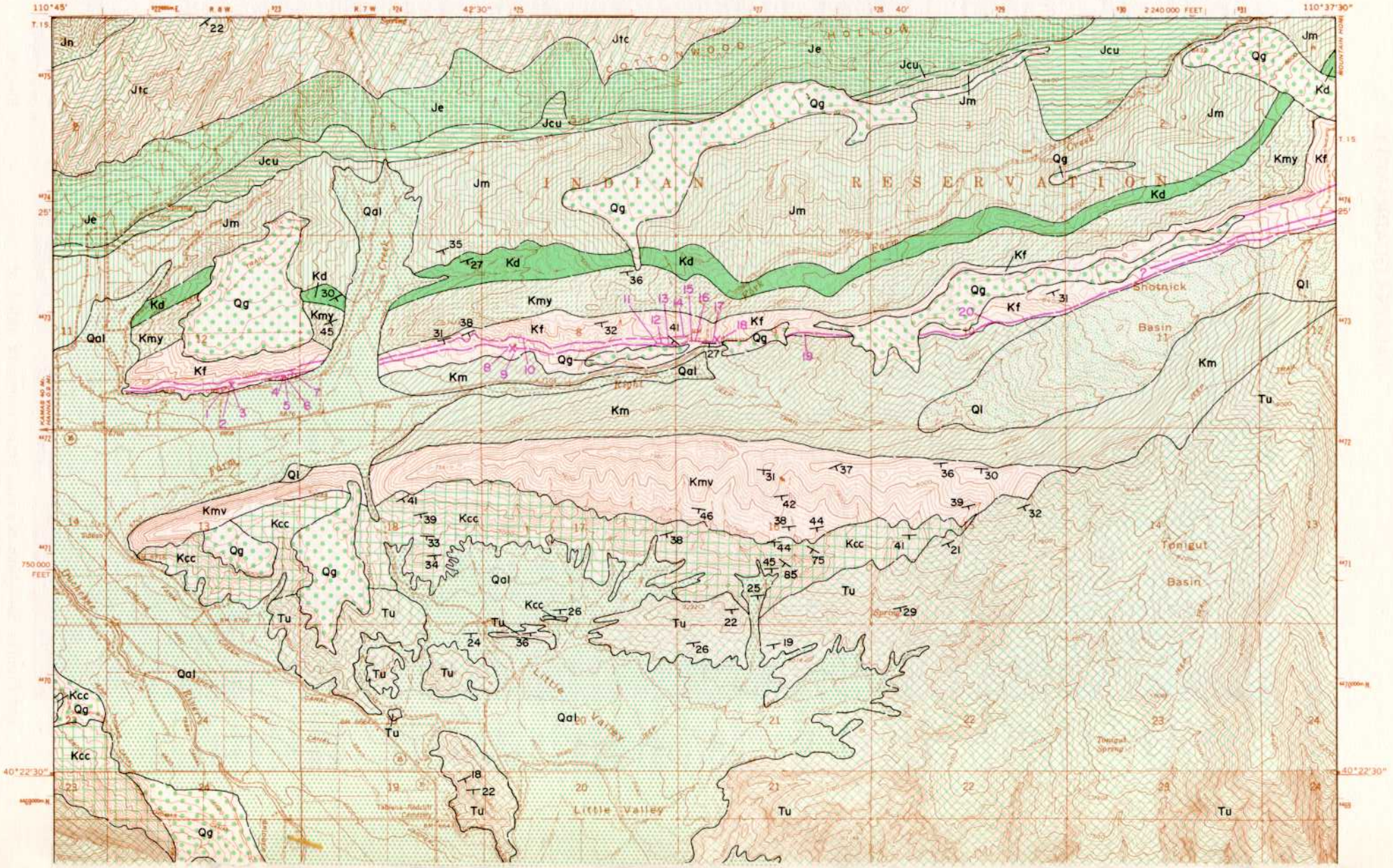
COAL

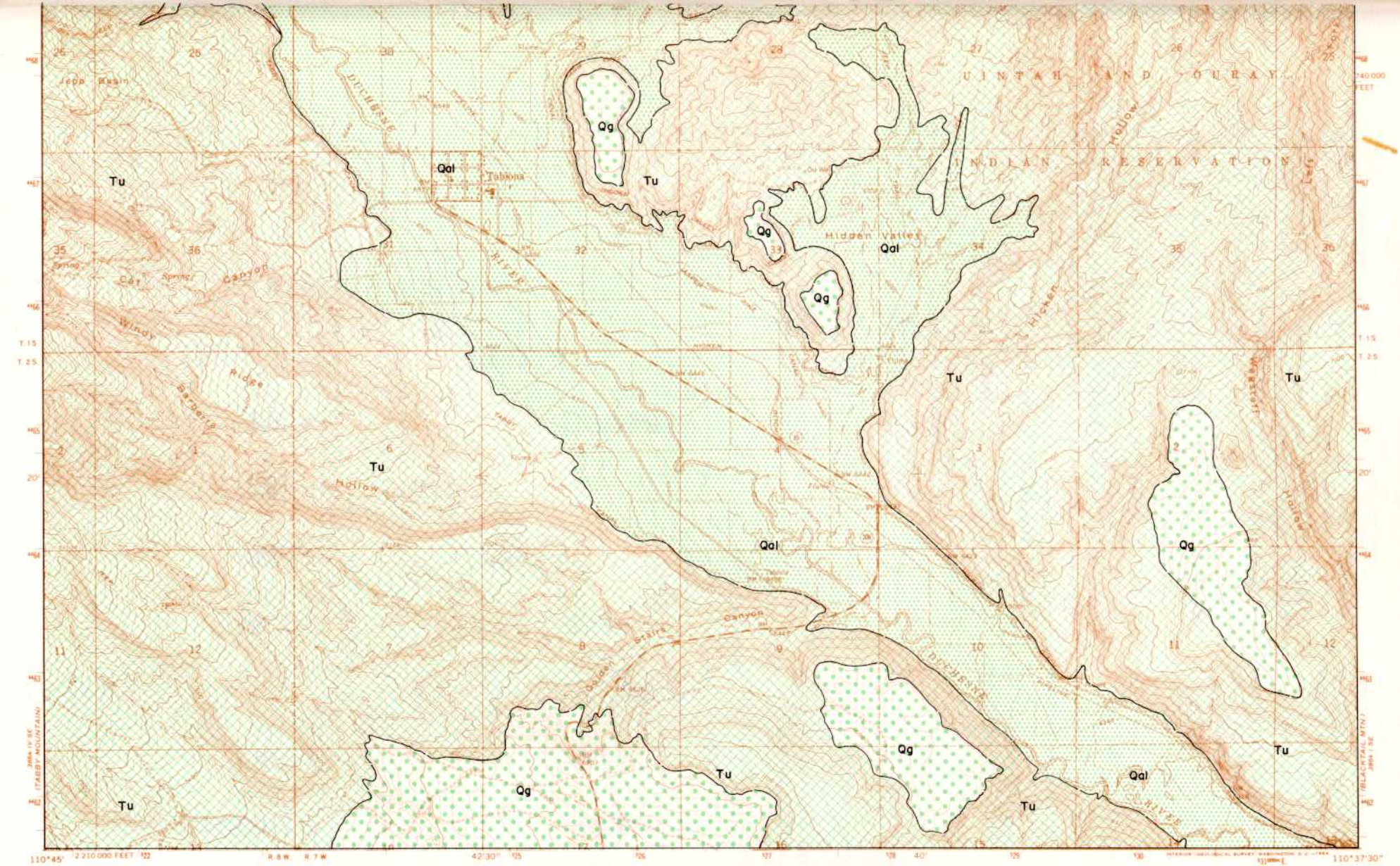
Surface Information

The four coal beds in the Frontier Sandstone along the Right Fork of Farm Creek are labeled beds 1, 2, 3 and Winchester.

	Feet
Winchester bed	
Interval	9
Bed 3	
Interval	6
Bed 2	
Interval	10-15
Bed 1	

TABIONA, UTAH





Geology by J. W. Huddle, F. T. McCann and J. W. Mapel, 1951, USGS, and R. F. Garvin, 1967, UGMS; coal data modified from C. T. Lupton, 1910, USGS.

Figure **17.** Coal and geology map, Tabiona quadrangle (explanation pages 296-297).

Eleven sections illustrate the condition of the Winchester bed (figure 18). The thickness ranges from 0.5 to 4.0 feet and averages 2.4 feet. At locations 2 and 8, thickness exceeds 4 feet. Lupton (1910, p. 621) notes that location 4, between 2 and 8, may be of a lower bed rather than a Winchester measurement. It has 1.8 feet of coal split in two places by 0.6 feet of shale.

Bed 3 has four measurements ranging from 0.6 feet to 1.7 feet. It is slightly thicker to the west. Bed 2 has two measurements; the thickest unsplit bed is 1.7 feet. The lowest bed shows three locations. Two are less than 1 foot thick, the third is 2.3 feet.

No coal beds were mapped and no sections have been reported from the Mesaverde Formation of the Tabiona quadrangle.

Subsurface Information

There has been no drilling for coal on the quadrangle. In the vicinity of the Winchester mine, the beds dip 35° southward indicating a drop of 3,000 feet per mile.

Quality of Coal

Three analyses are available of the coal (table 5). Table 12 shows the average proximate analysis.

Table 12. Average proximate analysis of coal, Tabiona quadrangle.

	Percent	
	Average	Range
Moisture	19.4	14.8-27.4
Volatile matter	33.5	32.0-36.5
Fixed carbon	36.9	35.6-37.9
Ash	10.2	2.6- 1.76
Sulfur	0.7	0.6- 0.83
Btu/lb	8,110	7,430-8,830

Mines and Development

Several small mines or prospects have been opened on the Winchester bed between sec. 12, T. 1 S., R. 8 W. and sec. 9, T. 1 S., R. 7 W., USBM. Lupton (1912, p. 626) notes the presence of the Winchester prospect only and that a few tons were removed each year for local blacksmithing and domestic purposes. Remains of prospects were noted at the locations shown in table 13.

Table 13. Mines in the Tabiona quadrangle.

Mine	Location	Remarks
Unknown	NE.SW.SE.12-1S-8W USM 4,472,425m.N. 522,655m.E.	Activity unknown
Unknown	SW.NE.SE.12-1S-8W USM 4,472,740m.N. 523,000m.E.	Shaft?
Winchester	NE.NW.SW.8-1S-7W USM 4,472,725m.N. 525,030m.E.	Activity early 1900's
Unknown	NE.NW.SW.9-1S-7W USM 4,472,785m.N. 526,700m.E.	Activity unknown; entry partly caved

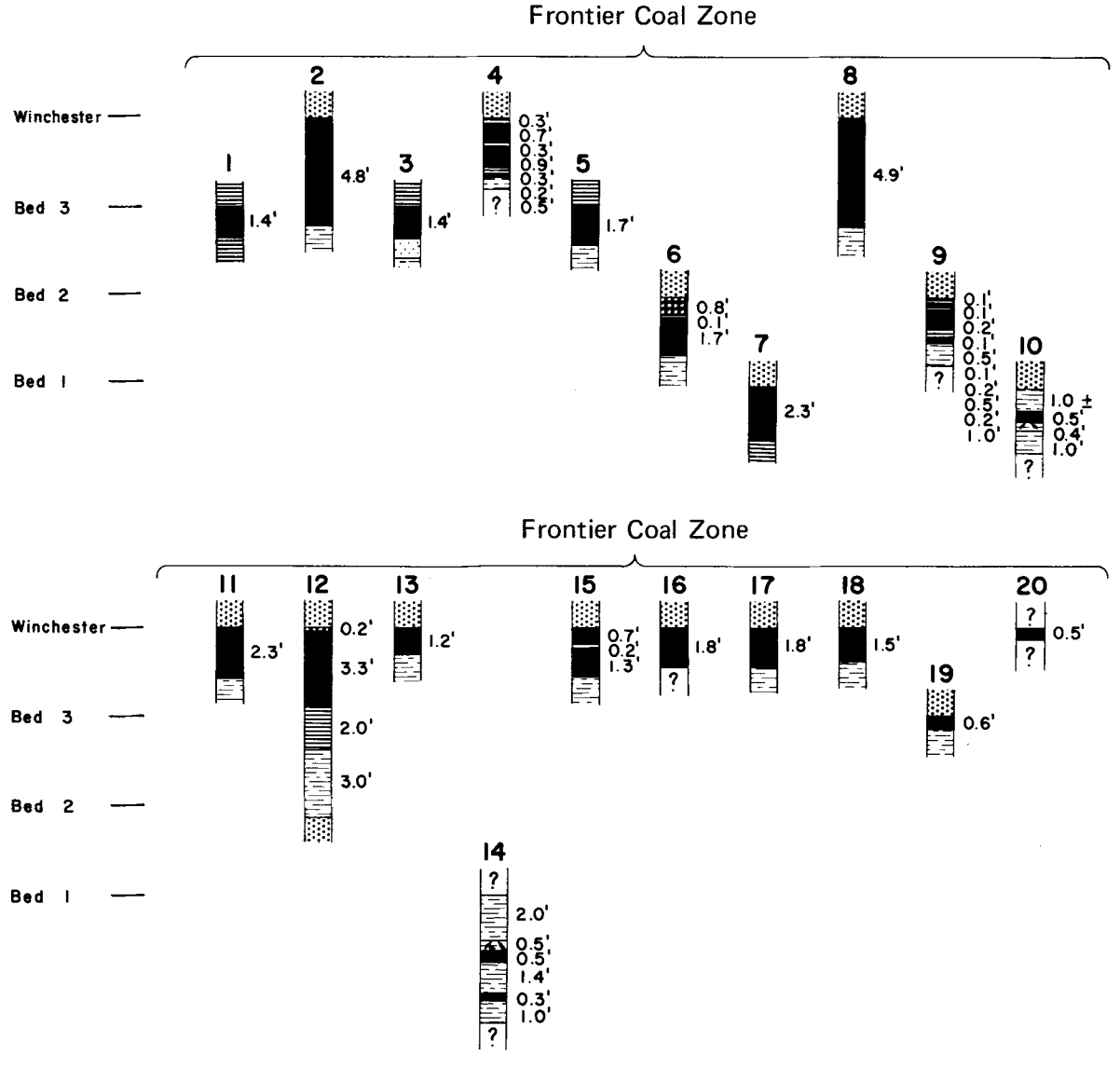


Figure 18. Coal sections of Tabiona quadrangle (vertical scale: 1 inch = 8 feet).

The production from all of these prospects is considered insignificant and probably less than 1,000 tons.

Reserves

Lupton (1912, p. 628) calculated reserves for the quadrangle by township. For T. 1 S., R. 7 W. 70,839,000 tons are calculated for the quadrangle; the R. 8 W. summary is included with the Tabby Mountain quadrangle report.

In a recalculation to eliminate all potential reserve (Class IV) the following is deduced (table 14). Part is considered Class II and part Class III.

Table 14. Original coal reserves (excluding Class IV), Tabiona quadrangle.

Location	Area	Avg. thickness (ft.)	Tons
T.1S. R.7W.			
Winchester bed	640	4.8	5,350,000
Winchester bed	640	2.4	2,680,000
Bed 3	640	1.7	1,900,000
			9,930,000
T.1S. R.8W.			
Winchester bed	640	4.8	5,350,000
Bed 3	640	1.4	1,560,000
Bed 2	60	1.7	180,000
Bed 1	60	2.3	240,000
			7,330,000
		Grand Total	17,260,000
		Tons in beds 4 ft. or more thick	10,750,000

PRINCIPAL WORK

Most of the coal data are from Lupton (1912); the geological data are from Huddle, Mapel and McCann (1951) and Garvin (1969).

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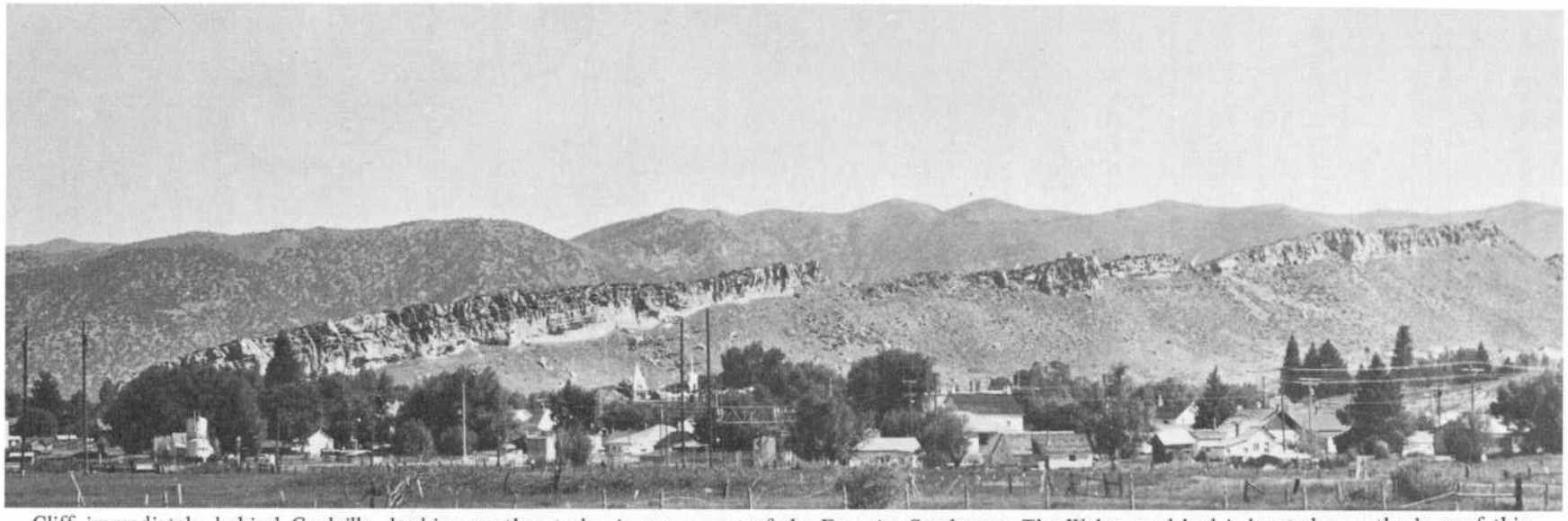
Chappell mine tipple, 1970, Coalville coal field.

Portal to Chappell mine, 1970.



Cliff immediately behind Coalville, looking northeasterly, is upper part of the Frontier Sandstone. The Weber coal bed is located near the base of this cliff.

COALVILLE COAL FIELD

by

H. H. Doelling[1]

INTRODUCTION

Location and Extent

The Coalville coal field lies midway between Salt Lake City and the southwest corner of Wyoming (Preface, figure 1a). The road distance from Salt Lake City to Coalville is about 40 miles. All the mapped coal beds lie in an area 9 miles by 7 miles, all within Summit County, the county seat of which is Coalville. The length of the field parallels the northeasterly structural trend of the strata. The coal-bearing outcrops are in a large irregular hole through a blanket of Tertiary rocks and the edges of the hole or window provide the effective limit of the coal field.

Topography and Drainage (figure 1)

The area is mountainous; the strata underneath the Tertiary blanket have been folded and provide a ridge and swale province within one of more homogeneous character. The ridges trend northeasterly and the swales between provide avenues for the secondary and some of the tertiary drainages (subsequent streams). Of these the more important include Echo Canyon Creek, Grass Creek, Chalk Creek and Spring Canyon Creek flowing southwesterly and Carruth Canyon Creek flowing northeasterly. They flow into the valley of Weber River which flows northerly and across the structural trend. Echo Reservoir has been constructed north of Coalville in the ½- to 1-mile wide valley. When full, the reservoir is 4 miles long.

Elevations range from 5,400 feet in the floor of the Weber River Valley below the reservoir to almost 8,000 feet atop the higher ridges and peaks. Coal beds occur from 5,600 to 7,000 feet above sea level.

Population, Industries and Transportation

Three towns occur in the two represented quadrangles: Coalville, Echo and Hoytsville. The villages of Henefer and Wanship are nearby. 1970 population figures are given below:

	1970	1960
Coalville	864	907
Hoytsville	(may be included in Coalville)	
Echo	60	60
Henefer	446	408
Wanship	200	200
Summit County	5,879	5,673

Population peaked from 1900 to 1930 and then declined until 1960; it has increased slightly since 1960.

Presently (1970) the dominant industry, agriculture, employs at least one-third of the labor force. Livestock and livestock products include dairying, poultry, beef cattle, sheep and swine. Field crops are devoted to livestock, hay and other forage crops. Mining, the second largest industry, is divided into the base metal mines at Park City and the coal mines at Coalville. The Coalville mines were never as important as the Park City enterprise and today coal mining is limited. Manufacturing, trades and services also are carried on a limited scale. Manufacturing companies produce lumber and wood products or are engaged in livestock associated with food processing.

A main line of the Union Pacific Railroad enters the state from Wyoming via Echo Canyon to Echo, then follows the Weber River Valley northwesterly to Ogden. The line continues southerly to Nevada and south California. A spur line links the main line from Echo to Park City and passes along the Weber River Valley past Coalville.

Highway access is good; Interstate Highway 80 joins Salt Lake City and Ogden to Wyoming via the Weber River Valley and Echo Canyon. U. S. Highway 189 also parallels the Weber Valley and follows the east shore of Echo Reservoir with the Interstate Highway following the west shore. At Coalville Utah Highway 133 extends easterly up Chalk Creek Canyon. Graded or dirt roads extend up most of the more important canyons. Many of these are locked by gates because the property is privately owned and access must be obtained by permission. Bus service is regular through Coalville and tourist accommodations are adequate.

Climate

Table 1 lists average temperatures and precipitation amounts for Coalville.

Table 1. Average temperatures and precipitation amounts, Coalville coal field.

Temperature °F						
January			July			Frost-
Day	Night	Daily mean	Day	Night	Daily mean	free days
36.6	9.2	22.9	87.2	45.1	66.2	63

Precipitation (inches)												
J	F	M	A	M	J	J	A	S	O	N	D	Total
1.23	1.34	1.63	1.24	1.25	1.09	0.90	1.17	0.64	1.25	1.25	1.09	14.08

The growing season is short and frost occurs during autumn, winter and spring because of night cooling. Even in the summer an occasional frost is not uncommon. The amount of rainfall is the same as at Salt Lake City (figure 2) but because of generally cooler temperatures, Coalville has a subhumid rather than a steppe climate. The rainfall pattern shows a slight increase during late winter and early spring; otherwise it is evenly distributed. A slight increase in August results from summer thundershowers which often produce violent flash floods. These are less destructive near Coalville because of heavier vegetation than the drier, more vulnerable areas of Utah.

HISTORICAL OUTLINE

The town of Coalville was founded on May 17, 1859, and there is no record of any other name and hints as to the date of coal discovery. Hawkes (1959, p. 12) reports that in 1854 the territorial legislature of Utah offered a reward of $1,000 for the first discovery of minable coal within 40 miles of Salt Lake City. The hills surrounding Salt Lake City were not heavily forested and the wood supply was quickly exhausted. The reward was claimed in 1859 when the first coal mine was developed; In the next 10 years several mines opened, but the cost of shipping the coal by wagon to Salt Lake City was enormous. In 1863 coal cost $40 a ton in Salt Lake City. Most of the coal supplied the local Coalville area only. With the completion of the transcontinental railroad in 1869, development of the Coalville industry was supposedly insured. The land was surveyed mostly prior to the railroad which received every other section in a broad swath on both sides of the tracks. But most of the coal lands already had been claimed in the region of Coalville and the railroad received little. In 1869 the Utah Central Railroad began construction to connect the Union

[1]Economic geologist, Utah Geological and Mineralogical Survey.

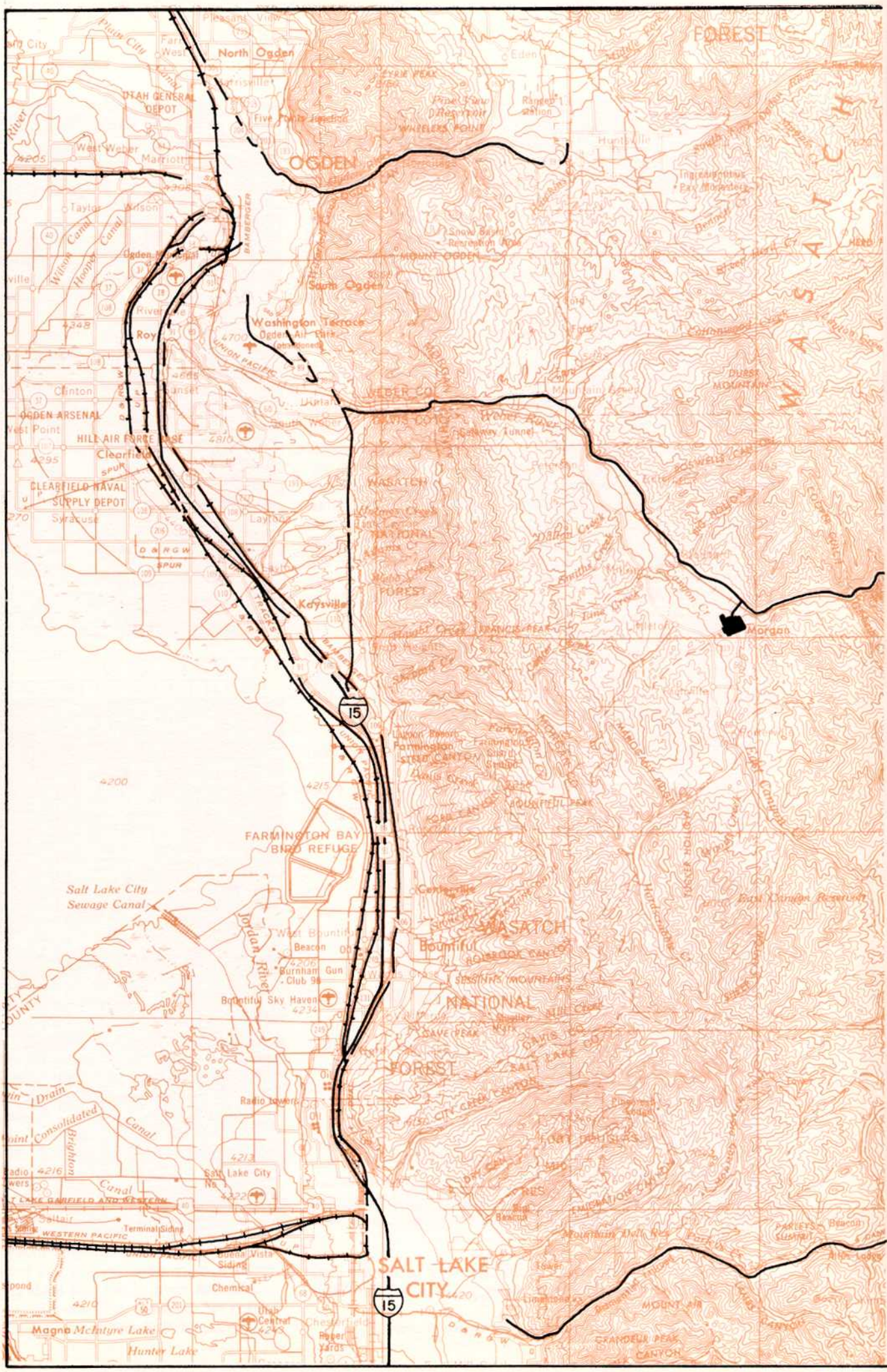
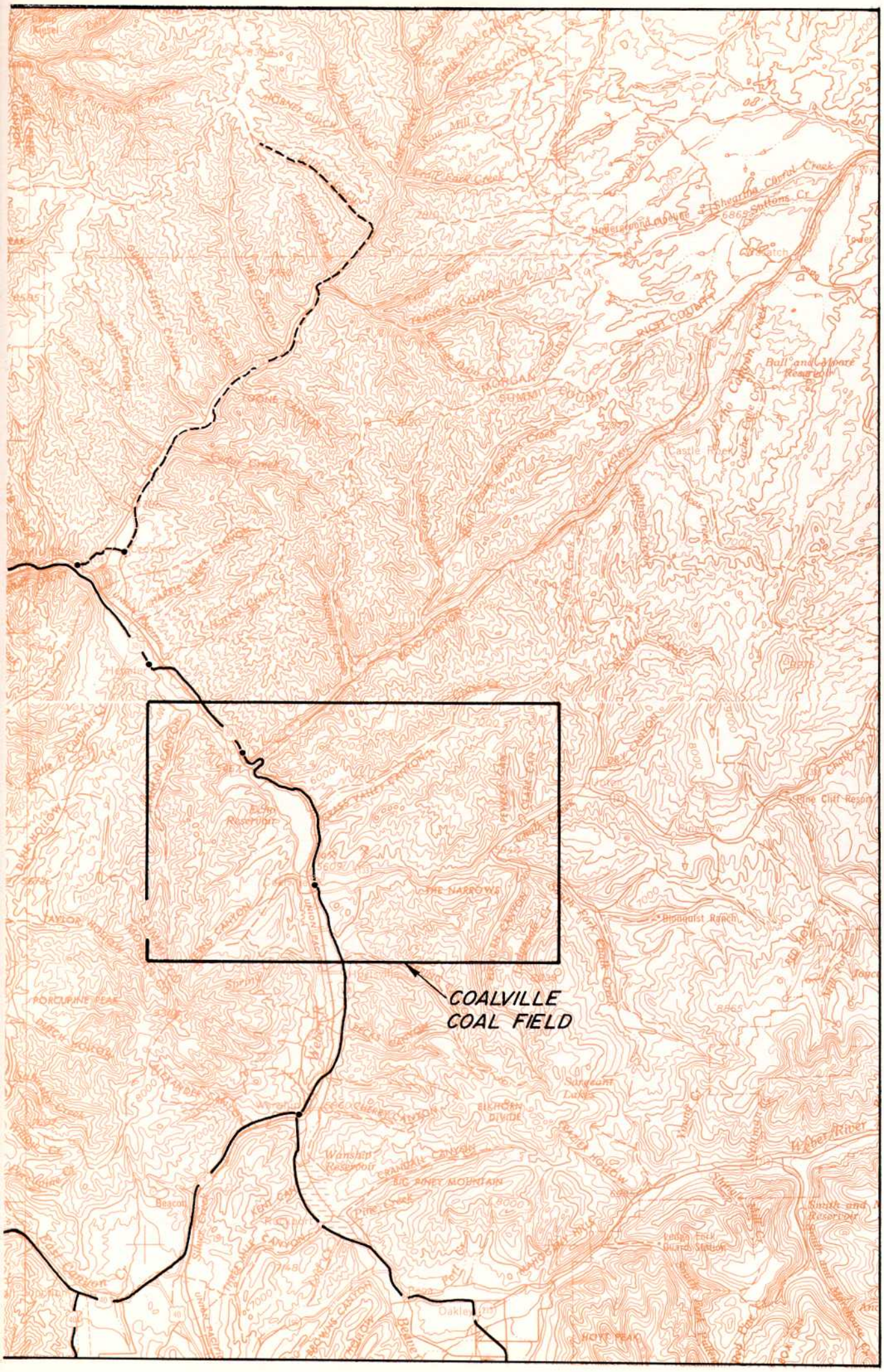


Figure 1. Topography, roads and quadrangle index map, Coalville coal field.


COALVILLE
COAL FIELD
THE NARROWS
Castle Rock
Ball and Moore Reservoir
Echo Canyon Creek
Pine Cliff Resort
Dinquist Ranch
Sargeant Lakes
Wanship Reservoir
Weber River
Smith and Morehouse Reservoir
Oakley
Beacon
Echo Reservoir
PORCUPINE PEAK
HOYT PEAK
MORGAN COUNTY
SUMMIT COUNTY
RICH COUNTY

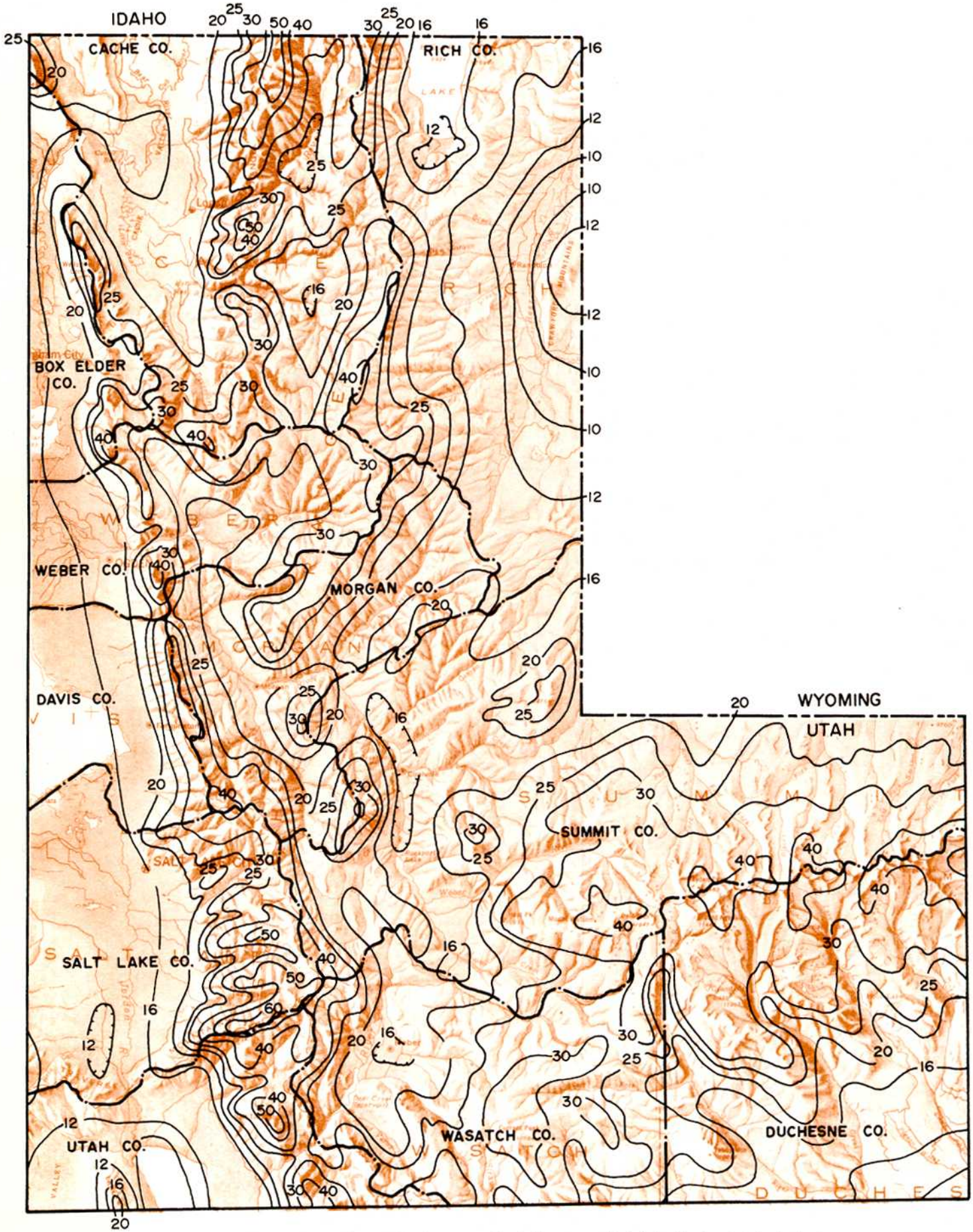


Figure 2. Normal annual precipitation map, Coalville area and vicinity (isohyetals in inches).

Pacific at Ogden with Salt Lake City to move Coalville coal cheaply from Echo to Salt Lake City. In the same year the Coalville to Echo line was surveyed but was not built following the discovery of superior coal near Rock Springs, Wyoming.

Coal prices remained high, however, and with the discovery of the rich silver mines of Park City, the interests at Coalville hoped to supply the mines with their coal. The Summit County Railroad Company was formed to connect Coalville and Echo with Park City and finally with Salt Lake City; in 1873 Echo and Coalville were connected. Eight mines operated during the winter of 1873 to 1874 and shipped 200 tons per day to Salt Lake City which were then sold at cheaper rates. Fearing the loss of its Rock Springs coal market, the railroad hiked freight prices between Echo to Ogden from $1.50 to $3.76 per ton. In the summer of 1874 public pressure forced the Union Pacific to reduce rates to $1.75 for the 37-mile run, but the Union Pacific allowed only a limited quantity of Coalville coal to move to preserve its Rock Springs interests.

In 1875 the Utah Central and the Summit County railroads failed and were sold or came under the control of the Union Pacific Railroad. By 1878 Coalville was almost forced out of business. It was as cheap to move the coal by wagon to Salt Lake as by railroad. Late in 1879 the Utah Eastern Railroad was formed by Salt Lake people and Park City mine owners. In 1880, track, an engine and ten cars were purchased from the bankrupt Nevada Central Railroad and Coalville was linked to Park City. The price of coal dropped to $4 per ton saving the mines $200 per day. Insufficient funds prevented further construction and Salt Lake still had to pay $10 per ton for coal which cost less than $2 per ton to mine. The Union Pacific built a parallel line to Park City which was completed one month after that of the Utah Eastern. In negotiations with California investors who gained control of the Utah Eastern, the Union Pacific by 1883 bought the small railroad and closed it. The parallel line now moved the coal to Park City and removed Park City ore as well. The Union Pacific coal monopoly in north Utah died shortly afterward because of the competition from the central Utah coal area and the Denver and Rio Grande Railroad (see Arrington, 1955).

Thereafter the Union Pacific Railroad served to develop and maintain a market for Coalville coal in Salt Lake City, their own locomotives and the Park City mines and mills. In addition, Coalville served its own local market. In 1880 the production was about 30,000 tons; by 1892 it was almost up to 45,000 tons. Production reached a maximum in 1900 when more than 75,000 tons of coal were produced. At that time the two leading mines, the Grass Creek and the Wasatch, were both owned by Salt Lake City interests.

Coalville, in spite of heavy competition with higher rank coal in Wyoming and central Utah, has continually maintained a small market. Its decline is comparable to that experienced in all west coal areas. In 1970 Coalville produced about 12,000 tons and the total production through 1970 is estimated to be at least 3,864,000 tons. For the last 20 years, only one mine has operated at Coalville.

GEOLOGIC SETTING (figure 3)

Stratigraphy

Cretaceous and Tertiary rocks made up of at least 18,000 feet of strata crop out in the Coalville area. As represented on the quadrangle maps, five of the six formations are of Cretaceous age, two of which are coal bearing. The two coal-bearing units are thick and have been subdivided by stratigraphic investigators into several members. The mapping on the quadrangles is not detailed and does not show member divisions. Essentially three coal zones occur: Dry Hollow coal about 900 feet above the base of the Wanship; Wasatch coal about 1,100 feet below the top of the Frontier and the Spring Canyon zone, about 100 feet above the base of the Frontier. All the members are briefly described in figure 4.

Kelvin Formation

The oldest unit exposed in the Coalville area, the Kelvin Formation, occurs only in the core of the Coalville anticline. Trexler (1966, p. 10-15) measured 1,926 feet of the unit made up of interbedded claystones, siltstones, sandstones and subordinate pebble conglomerate. Essentially it is a redbed sequence; the claystones are variegated gray, purple and reddish brown, the siltstones are mostly gray and calcareous and the sandstones are light gray, calcareous and fine-grained. The base of the unit is unexposed.

Aspen Shale

The Aspen rings the Kelvin outcrops of the Coalville anticline. The thin unit does not exceed 210 feet and in many places is much thinner. Essentially it is a gray siliceous shale with several thin layers of gray calcareous siltstone or shale near the base. The Aspen contains teleost fish scales in abundant quantity which aid in its recognition.

Frontier Formation

In this report the Frontier consists of six members, two containing coal. The base of the unit is the Longwall Sandstone Member, 70 to 100 feet thick. It is a yellow-gray fine-grained sandstone, massive and ridge forming and deposited in a regressing marine environment. Trexler (1966) called it the Skunk Point Sandstone.

Overlying the Longwall, the Spring Canyon Member is coal bearing and up to 375 feet thick. It consists of alternating sandstone, gray shale, carbonaceous shale and at least five coal beds. They are mostly thin beds deposited in a paludal environment.

The thick Chalk Creek Member is not entirely exposed everywhere; Hale (1960, p. 138) explains:

> The Frontier Formation, as interpreted from this study, contains a thick, middle redbed sequence 3,150 feet thick, considered by some writers as belonging to the Kelvin Formation. The sequence is here named the Chalk Creek member for typical exposures on the north side of Chalk Creek valley between the Spring Hollow fault and the "Great" fault. The entire member, with exception of local covered areas, is found on the east (upthrown) side of the "Great" fault and occupies part of the SE ¼, T. 3 N., R. 5 E., between the Chalk Creek Narrows and Grass Creek valley. Only the lower 800 to 900 feet of the Chalk Creek member is present on the overturned east flank of the anticline. The remainder of the section, approximately 2,300 feet, has been omitted by a thrust fault. Wegemann (1915, p. 181) suspected this, but concluded that only 850 feet of strata separated the basal sand (Longwall) from the "Wasatch" coal bed. Writers since then have followed Wegemann's thinking and, therefore, inherited the same mistake. The writer, on the other hand, has the advantage of well data heretofore unavailable that makes this clarification possible. The lower part of the member was drilled from surface to 2,010 feet in the Mountain Fuel Supply Company No. 1 Wilde in NE SE sec. 9, T. 2 N., R. 5 E. The surface part of the section northwest of the well was measured up to the unconformity by plane table survey.
>
> The Chalk Creek member is a sequence of gray to tan, medium-grained to conglomeratic sandstone alternating with claystone varying in shades of gray, pink, maroon and green. On the outcrop and in the subsurface, reddish shales predominate. The sandstones commonly have calcareous matrix, are poorly sorted and generally angular.

The Chalk Creek Member was deposited as an orogenic pulse in the west pushed the coastal swamp environment of the Spring Canyon eastward. When the supply of sediment was reduced after a long interval, the paludal environment returned. These latter beds are known as the Coalville Member and contain the Wasatch coal bed. Wegemann (1915, p. 163) measured the unit near Coalville:

	Feet
Sandstone, in places conglomeratic	30-130
Coal bed, locally known as the "Wasatch"	5- 12
Sandstone, in some sections very shaley	40- 80

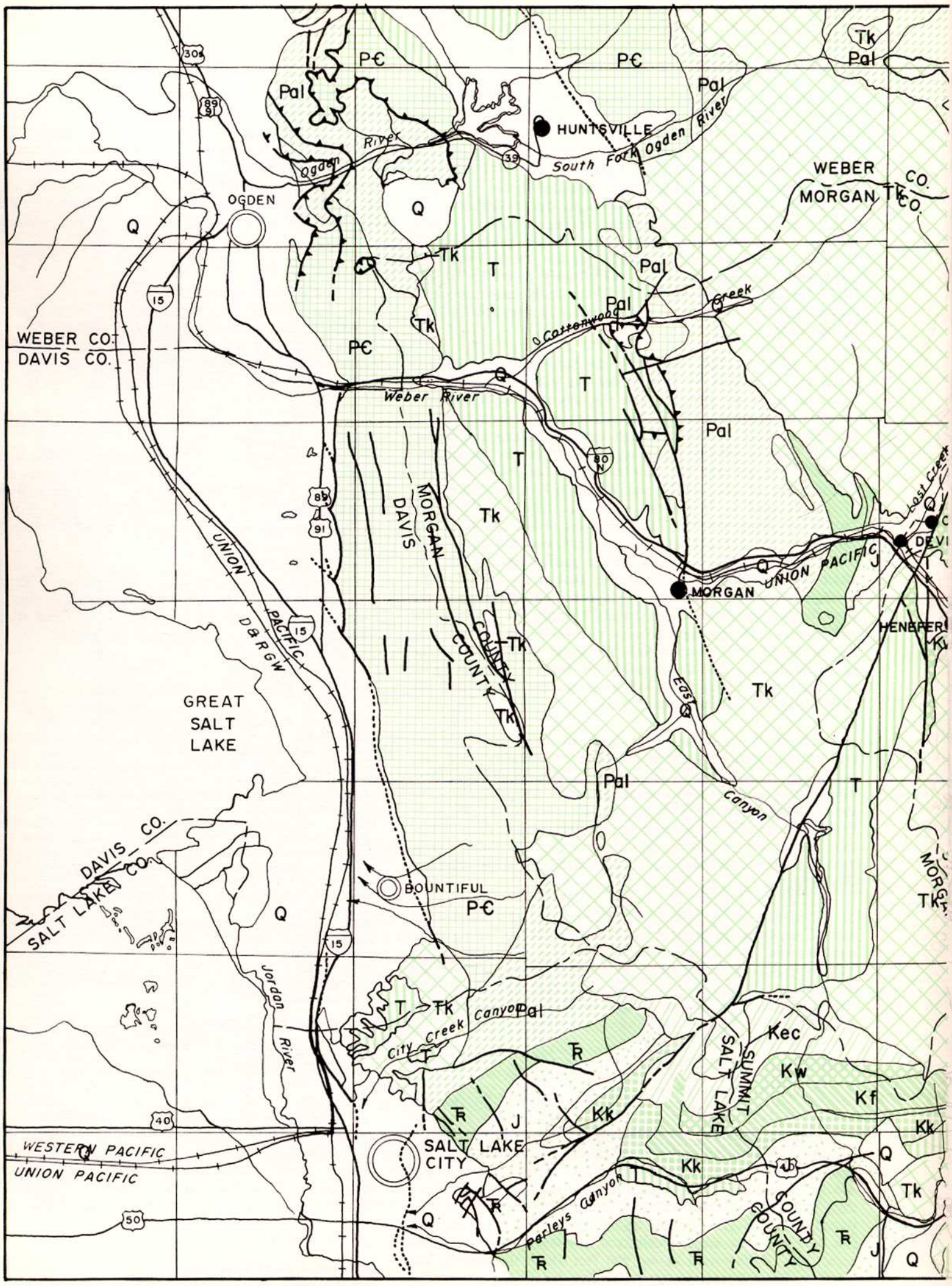
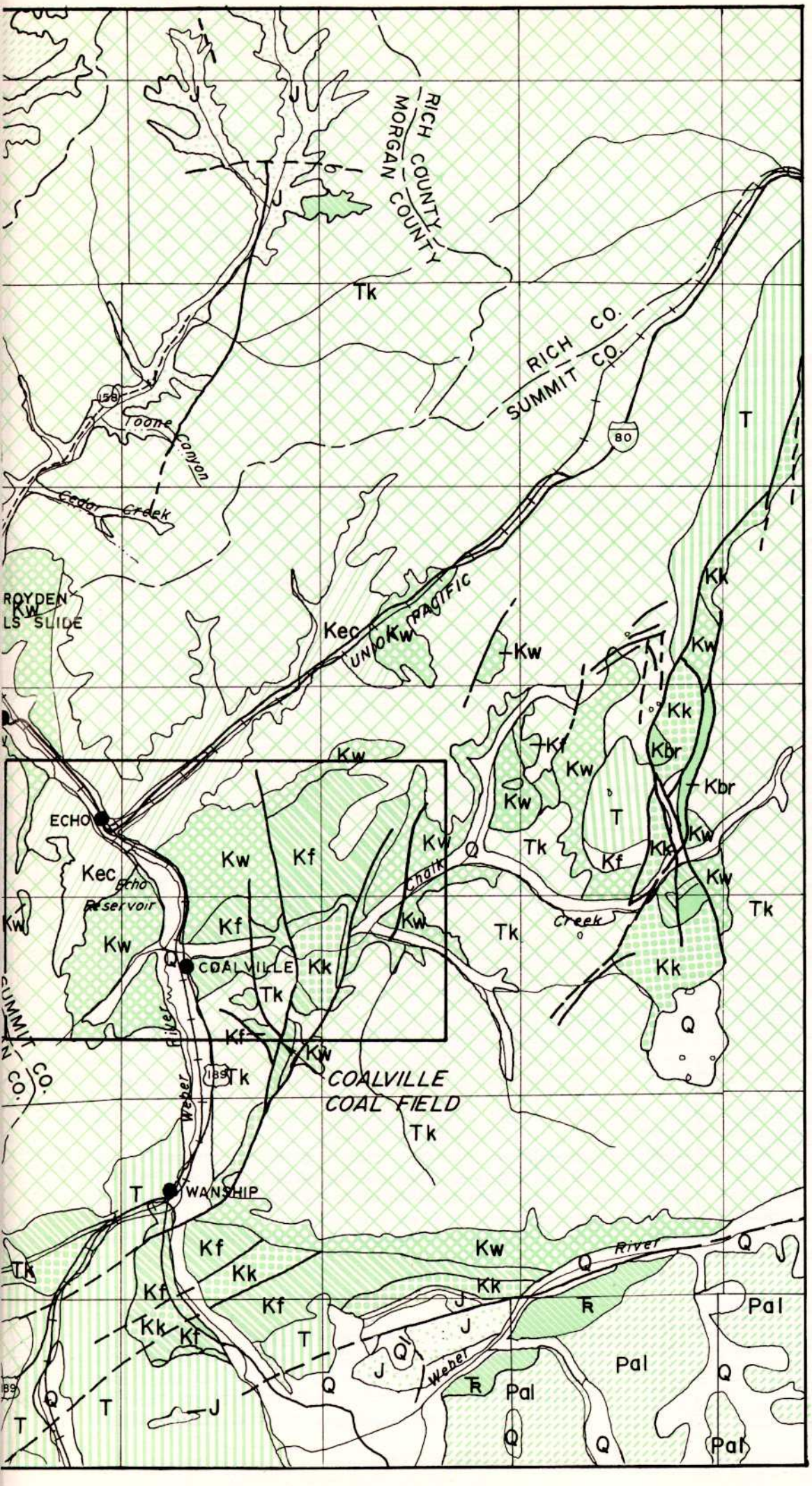


Figure 3. Generalized geology map, Coalville coal field.


RICH COUNTY
MORGAN COUNTY
RICH CO.
SUMMIT CO.
Toone Canyon
Cedar Creek
ROYDEN LS SLIDE
UNION PACIFIC
ECHO
Echo Reservoir
COALVILLE
Chalk Creek
Weber River
COALVILLE COAL FIELD
WANSHIP
Weber River
SUMMIT CO.
LOST CREEK–COALVILLE AREA
GENERALIZED GEOLOGY
Q Quaternary
T Tertiary
Tk Knight Fm.
Kec Echo Canyon
Kw Wanship Fm.
Kf Frontier–Aspen
Kbr Bear River Fm.
Kk Kelvin Fm
J Jurassic
TR Triassic
Pal Paleozoic
P-€ Precambrian
LEGEND

System	Series	Stratigraphic Unit		Thickness (feet)	Description
TER-TIARY	Eocene	Knight Formation		2,000+	Red to variegated clays, sands and conglomerates.
					Unconformity
CRETACEOUS	Maestrichtian	Echo Canyon Conglomerate		3,000±	Gray, red weathering boulder and pebble conglomerate interbedded with gray and red shale and gray sandstone.
	Campanian				
	Santonian				
					Unconformity
	Coniacian	Wanship Formation	Henefer Member	2,450-2,500	Light brown to light yellowish gray, fine- to medium-grained sandstone and red, brown, yellow and tan claystone.
			Upton Sandstone	450	Light yellow to blue-gray, fine-grained, calcareous, well bedded sandstone.
			Judd Shale	350- 760	Gray marine shale, thickens eastward.
			Grass Creek Member	875-1,025	Tan thin-bedded sandstone, alternating with gray shale in upper third with lenticular coarse-grained sandstone and red clay shale in lower part, thickens westward.
			Dry Hollow Member *COAL*	1,000-1,220	Upper white sandstone hogback, Dry Hollow coal zone, and lower part divided into an upper shale and conglomerate, middle nonmarine shale and basal conglomerate.
					Unconformity
	Turonian	Frontier Formation	Oyster Ridge Sandstone	200- 28	Light yellow, orange to gray, massive, ridge-forming very fine-grained calcareous sandstone.
			Allan Hollow Shale	780	Gray marine calcareous shale.
			Coalville Member *COAL*	175- 223	Dark gray conglomeratic sandstone overlies Wasatch coal zone, yellow-gray ridge-forming fine-grained calcareous sandstone at base, thickens westward.
	Cenomanian		Chalk Creek Member	3,150	Nonmarine redbeds; pink to red claystone, coarse sandstone and conglomerate sandstone.
			Spring Canyon Member *COAL*	350+	Dark shales, carbonaceous shales, sandstone and thin coal beds.
	Albian		Longwall Sandstone	70- 100	Light gray ridge-forming, massive, fine-grained sandstone, thickens eastward.
		Aspen Shale		210	Dark gray shale and tan sandstone with interbedded light gray shale containing teleost fish scales.
		Kelvin Formation		2,500+	Nonmarine redbeds, shale and sandstone with lenses of conglomerate.
	?				
	Aptian				
	?				
	Neocomian				

Figure 4. Generalized section of rock formations, Coalville coal field.

Trexler (1966, p. 24) also measured the interval on the east limb of the Coalville anticline.

Sandstone, dark gray, very hard, very fine-grained, pebbly 1.0
Coal, subbituminous, over and underlain by thin beds of tan, silty claystone 13.5
Sandstone, light yellowish gray, hard ridge forming, fine-grained, subrounded, clayey, calcareous, quartzose; grades into claystone along the strike 70

Although Trexler's upper unit is not as thick as Wegemann's, Trexler notes the presence of 10-foot beds of lenticular, light yellowish gray, hard, fine-grained sandstone in the lower part of his next lower unit. The Coalville Member is followed by the Allan Hollow Shale, a dark marine shale with interbedded thin sandstones at the base and top, 780 feet thick. The uppermost unit of the Frontier as herein designated is the Oyster Ridge Sandstone. A good exposure of the Oyster Ridge is near the Chalk Creek bridge at the north end of Coalville. It is resistant and forms a white sandstone hogback. The sandstone is a yellow, orange to light gray, fine- to coarse-grained sandstone that is slightly calcareous.

Wanship Formation

An unconformity lies immediately above the Oyster Ridge. A conspicuous conglomerate occurs just above the plane filling channels in the unit below. In places there is evidence that it is angular. The conglomerate is the initial unit of the Wanship Formation, the lowermost member of which is the Dry Hollow. Above the basal conglomerate is an interval of red, brown and tan claystone interbedded with lenticular sandstone and pebble conglomerate suggesting a fluvial environment. Above this, a fossiliferous 4-foot bed of sandstone contains oysters and gastropods. This in turn is followed by carbonaceous shale beds, shaley sandstone and in places coal. The Dry Hollow coal zone is thought to be 90 feet thick. A prominent white to gray cliff-forming sandstone caps the sequence and is 200 feet thick.

The Grass Creek Member is poorly exposed and has a lower unit of interbedded lenticular coarse-grained sandstone and reddish clay shale 600 to 700 feet thick. The upper part is gray shale alternating with thin-bedded tan gray shale about 300 feet thick. The upper part of the Grass Creek grades into the Judd Shale, gray calcareous marine shale, 350 to 760 feet thick thinning to the west. The Upton Sandstone is yellow to blue-gray fine-grained calcareous sandstone with alternating hard and soft beds. It is conspicuous enough to be differentiated easily from units above and below and in some places forms a ridge. A good exposure occurs in a road cut about 2¼ miles north of Coalville on U. S. Highway 189.

The Henefer Member is the uppermost unit of the Wanship Formation. The brown and gray fine- to coarse-grained sandstones alternate with reddish, tan and yellow mudstones; a few lenses of conglomerate also occur. The Henefer is about 2,500 feet thick.

Echo Canyon Conglomerate

The Echo Canyon is a thick sequence of red-weathering boulder, cobble and pebble conglomerate interbedded with gray sandstones and grayish to red shale. It overlies the Wanship beds unconformably and the best exposures are along Echo Canyon and the lower part of the Weber River Valley.

Knight Formation

Angularly overlying all other beds are the reddish conglomerates and variegated shales of the Knight Formation. In the west part of the area, all units are more red; toward the east, other colors become common. Trexler (1966, p. 58) roughly divided the Knight into four units of varying thicknesses:

Clay and sandstone, predominantly red and yellow.
Cobble conglomerate, brown weathering, thickness diminishes southward.
Clay and sandstone, predominantly gray in color but becoming red toward the southwest.
Cobble conglomerate, brown weathering, thins southward.
Angular unconformity

The Knight more or less surrounds the Coalville area in outcrop; it is removed by erosion from the central area because of the Coalville anticlinal uplift.

Unconsolidated Deposits

Quaternary deposits include gravels of several modes of origin, landslide debris and valley alluvium. The larger areas of such deposits appear on the map.

Structure

The dominant structural feature of the area is the Coalville anticline located near the junction of three larger structures: the Wasatch Mountains, the Uinta Mountains and the Wyoming thrust belt. It is an asymmetrical and complexly faulted anticline 10 miles long and 6 to 8 miles wide with the axis trending northeast. The east limb beds are vertical to overturned and dips to the west vary from 8 to 60 degrees but average 15 to 30 degrees. The axis crosses Chalk Creek 4 miles east of Coalville and seems to plunge in both directions.

About 1½ miles to the east of the Coalville anticline and aligned with it is the Clark Canyon syncline. The strata on its east flank dip 15 to 25 degrees and some of the coal-bearing beds reappear in the vicinity of Upton, a mile or so east of the Turner Hollow quadrangle. The west flank of the Coalville anticline terminates along the Bromleys Canyon syncline 8 miles distant. Beds on the west flank of this syncline dip 25 to 60 degrees. Some of the subtle changes in the strike and dip between the anticline and the synclines are illustrated by Wegemann (1913, p. 168):

In the Coalville anticline, north of the town of Coalville, the beds strike, about N. 35° E. Near the town, however, the strike changes, so that in the vicinity of the Sargent mine, on the west side of the Weber, it is N. 19° E. The upper beds hold the same strike for about a mile farther south to the point where they are covered by the overlying Wasatch (Knight) deposits. They give no indication of a minor fold which involves the lower beds just southeast of the town of Coalville. The outcrop of the principal bed of coal, the "Wasatch" bed, formerly mined at the town, takes a direction approximately north and south at the old Buell and Bateman mine and, swinging to the southeast, is opened at the mine of the Superior Fuel and Briquette Co. From this place it swings to the northeast and east, thus outlining the small fold above mentioned, and is opened on the north end of the adjoining syncline at the old Howard mine in the NW ¼ sec. 15. From this opening it can be traced a short distance to the southeast but is soon lost under cover of Wasatch (Knight)...The abrupt change in strike of the rocks at the northeast end of the fold (Coalville anticline) is noteworthy. The beds on Grass Creek strike approximately N. 50° E., and this strike changes abruptly near the mine of the Union Fuel Co. to S. 52° E. Holding this direction for about 2 miles across the northeast end of the field, it again changes abruptly at the old prospects in Fewkes Canyon to S. 36° W., the two bends thus produced being almost right angles.

The Coalville anticline is badly faulted especially on the west limb and three prominent north-striking normal faults have been mapped. They lie about 1 to 1½ miles apart between the axis and the Weber River and probably cut across both Chalk and Grass creeks. Other faults, unknown at present, may occur between the major faults. Several of these smaller faults encountered in the mines may prove that the larger ones are complex fault zones. The area between the faults in which the Chappell mine is located is a graben.

A group of faults is known to cross Grass Creek between the anticlinal axis and the first major fault; all of these have the downthrown block to the northeast or east. Farther west are three east-west trending faults, each with the downthrown block to the north. They start on the east side of the Weber River and cross the valley and reservoir and extend to the Bromleys Canyon syncline.

The Knight Formation unconformably overlies all the other units and does not participate in the lower structures. Figure 5

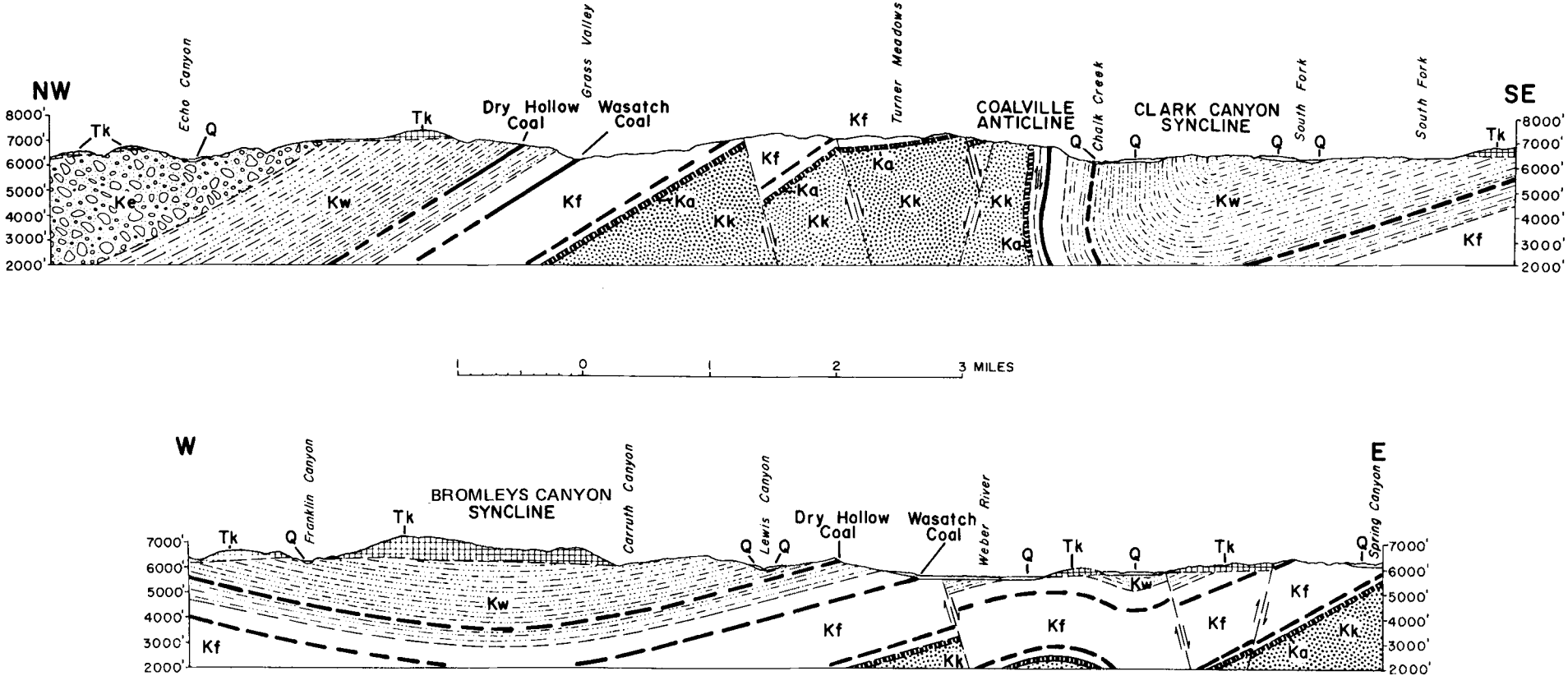


Figure 5. Geologic sections across the Coalville area, Utah (modified from Trexler, 1966).

illustrates the nature of the structures in the Coalville area. One cross section is approximately aligned northwest-southeast extending from sec. 18, T. 3 N., R. 5 E. to Turner Meadows then bending more easterly toward South Fork and beyond the east edge of the Turner Hollow quadrangle. A second cross section is approximately east-west across the south edge of the area showing the south extension of the small folds south of Coalville. Refinements are necessary in the geological and structural mapping of the Coalville area and that shown may be somewhat outdated in light of new studies. Generally, however, it presents the conditions as they are with respect to coal. The beds and seams are involved in moderate to steep folds and often are displaced by limiting faults.

Geologic and Tectonic History

Hale (1960, p. 144 to 145) summarized the geologic history and his information follows (figure 6). Where the nomenclature of this report differs from his, the name as prescribed by this report follows in italics:

1. Withdrawal of the Mowry (Aspen) sea near the close of Lower Cretaceous was accompanied by regressive deposition of littoral and coastal-swamp deposits (Longwall and Spring Canyon members) of the basal Frontier. *Spring Canyon coal deposited.*

2. A major orogenic uplift in the source area to the west began in early Colorado time. This resulted in a rapid influx of fluviatile sediments that continued until near the close of the Greenhorn. During this time, the thick redbed facies comprising the Chalk Creek Member was deposited. While fluviatile redbeds accumulated to the west, the Cumberland Gap, *Wyoming*, region fluctuated between fluviatile, coastal-swamp and flood-plain deposition.

3. A fairly rapid transgression of the sea occurred at the close of Greenhorn time. This advance was preceded by paludal conditions in which the "Wasatch" coal of the Coalville Member was formed.

4. Marine conditions persisted through part of early Carlile and muds comprising the Allan Hollow Shale were deposited in a shallow seaway. The westward extent of this advance is unknown.

5. After deposition of the Allan Hollow Shale, a second regression of the sea occurred. This regression was accompanied by littoral marine deposition of the Oyster Ridge Sandstone, and this in turn by a brief period of fluviatile conditions at the close of early Carlile.

6. The absence of late Carlile rocks in the Coalville area is attributed to a second orogenic disturbance at the close of early Carlile. The eastward migration of the orogenic belt is attested by the local tectonic disturbances (Wanship area). This orogeny apparently affected basin structure to the east by subaerially exposing the southern part of the present Green River Basin region. This is apparent from the fact that all rocks down to and including part of the Aspen Shale were removed prior to deposition of late Carlile rocks.

7. In late Carlile the Cretaceous basin subsided and the sea returned to the area between Church Buttes and Vermilion Creek, *Wyoming*. Uplifting and erosion in area to the west contributed sediment to the late Carlile sea.

8. During early Niobrara fluviatile deposition (accompanied by areal subsidence) existed in the Cumberland Gap-Coalville regions while shallow marine deposits (lower Hilliard) accumulated in the basin to the east. *Preceding the transgression below, paludal conditions prevailed for depositing the Dry Hollow coal. The unconformity between the Early Carlile and Early Niobrara rocks separates the Frontier from the Wanship Formation of the current report.*

9. The first transgression of the early Niobrara sea is recorded by the littoral sandstones (*Cardium curtum zone*) overlying the Kemmerer and Dry Hollow coal groups.

10. Mixed marine and nonmarine sandstones and shales of the Grass Creek Member accumulated in the Coalville area as the sea advanced and retreated across the area.

11. Following deposition of the Grass Creek Member, continued subsidence of the area brought complete inundation and deposition of the Judd Valley Shale Member ensued.

12. Final retreat of the sea with deposition of the Frontier Formation, *Wanship Formation*, in the Coalville region.

Hale's number 12 was followed by deposition of the Henefer Member of the Wanship Formation. The Henefer was deposited under mainly fluvial conditions in which some swampy periods occurred and even thin coal and carbonaceous shale were deposited in the lower part of the unit. After the Henefer a period of erosion followed. Uplift to the west is attested by the coarse Echo Canyon Conglomerate. Thereafter the principal folding and much of the faulting took place. Much erosion occurred prior to the deposition of the Knight (Eocene) which eventually covered most of the area. The final events include the deposition of the Knight, uplift, some additional faulting and exhumation by erosion to the present landscape.

Correlation with Surrounding Areas

Several investigators have studied the stratigraphy around Coalville and their work is compared on figure 6 to avoid confusion when using the given references. Each contributed much to unravel the complicated stratigraphy and structure of the region. The last column correlates the nomenclature with that at Cumberland Gap, Wyoming, in the Kemmerer coal field. Figure 7 clarifies the facies changes that took place between the two coal fields and illustrates the geologic events that developed the stratigraphy.

A similar diagram links the Coalville area to coal fields on the south flank of the Uinta Mountains and shows what facies changes may have taken place and the positions of coal beds within the column (see Tabby Mountain coal field report, figure 6, page 289).

COAL DEPOSITS

Status of Information

Wegemann (1915) presents the only coal work of significance for the Coalville area. Most coal beds are poorly exposed and much of Wegemann's data was collected from the old, now abandoned mines whose portals have collapsed or are unattainable at the present time. Additional data from the Upton area would be welcome along with drill-hole data. Several investigators have studied the stratigraphy and in recent years notable advances have been made. Of these, the work of Hale (1960), Trexler (1966) and Williams and Madsen (1959) are the most important.

Mines, Prospects and Production

Many mines have been opened in the Coalville field; these with their locations are listed in the quadrangle report. Several mines operated until World War I, but since 1890 activity has been confined to three larger ones and after World War I, only these larger mines persisted. In 1944 the largest and one of the oldest mines of the field, the Wasatch or Weber mine, was shut down because of a mine fire. The Chappell mine continued to operate and is the only surviving mine at present. By 1880 the mines were producing 30,000 tons annually. Production gradually increased so that in 1900 more than 75,000 tons were produced. The annual figure then fluctuated mostly between 50,000 and 75,000 tons until 1930. Field production is estimated on table 2 (page 339).

Land Ownership (figures 8 and 9)

Most of the land of the Coalville area is private property. A few additional details are afforded in the quadrangle report.

Quality of Coal

The average and range of proximate analyses are given in the quadrangle report. The coal is medium sulfur (1.32 percent), low ash (4.4 percent) and subbituminous. It is dense and brittle, black and crumbles or slacks on exposure to the air and sunlight. It has a high ash fusion (2,350° F), a grindability of 50 and does not coke.

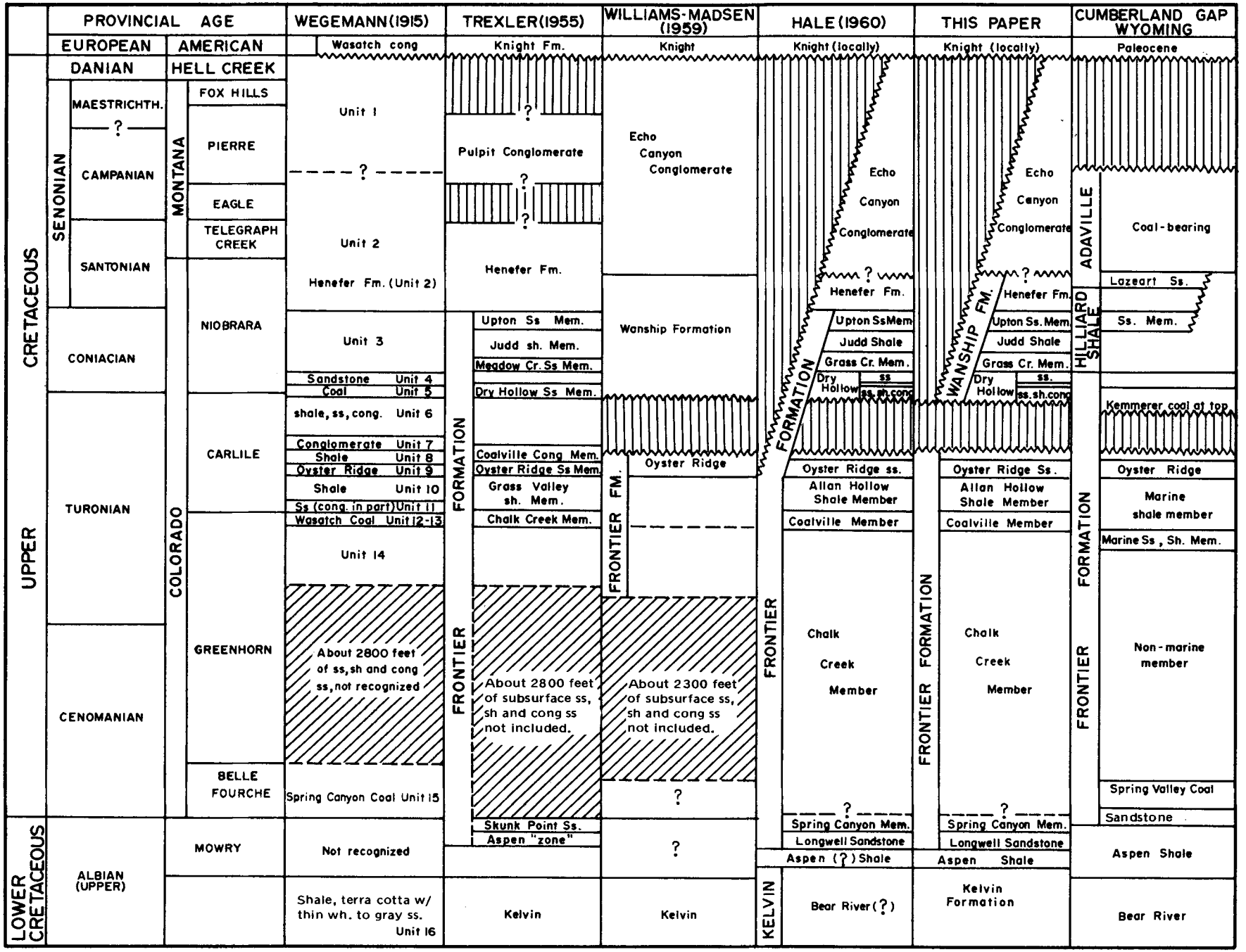


Figure 6. Nomenclature history of Cretaceous rocks, Coalville area, Utah (modified from Hale, 1960).

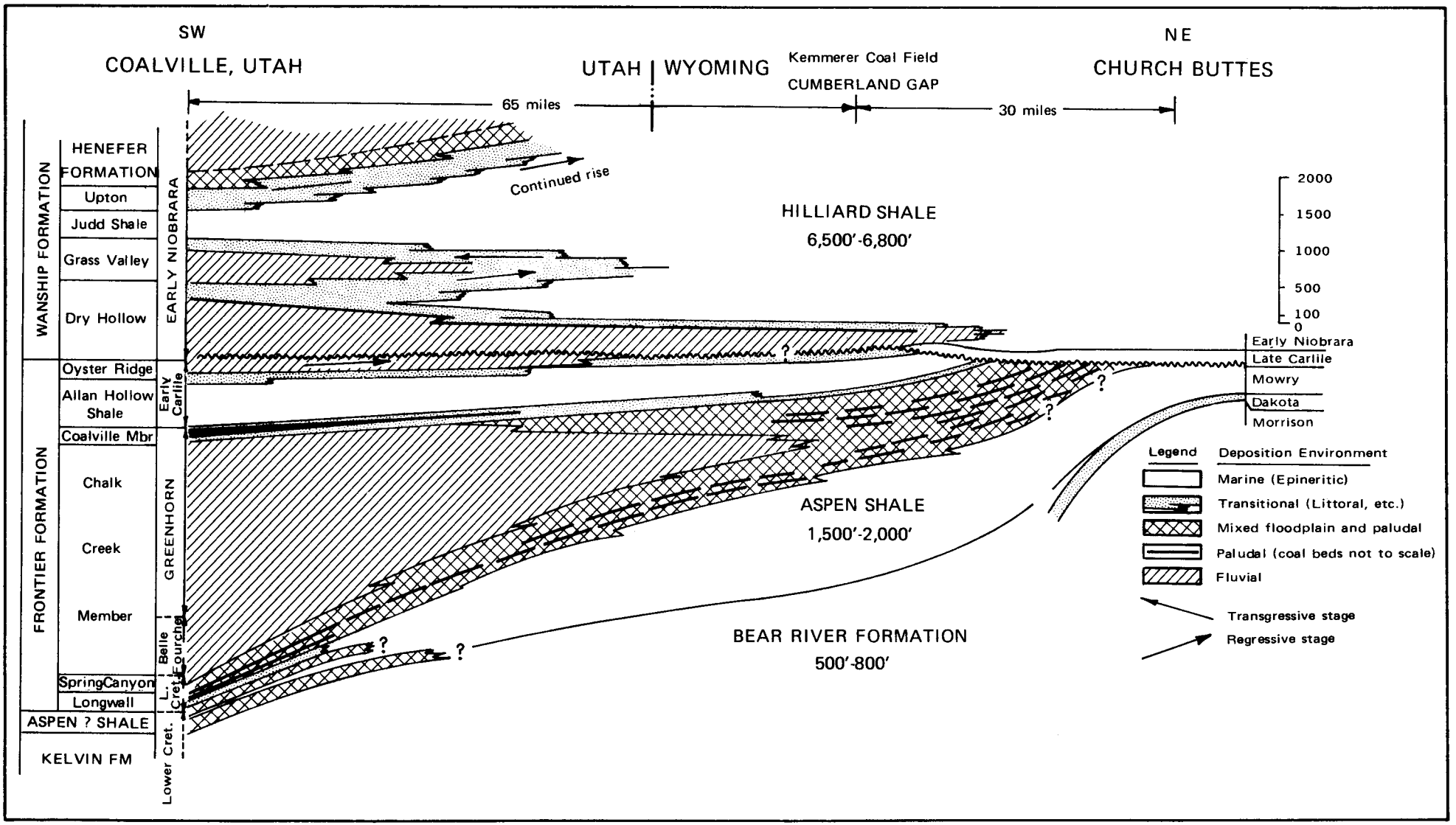


Figure 7. Stratigraphic relations of the Frontier and associated formations, Coalville, Utah, to Church Buttes, Wyoming (modified from Hale, 1960).

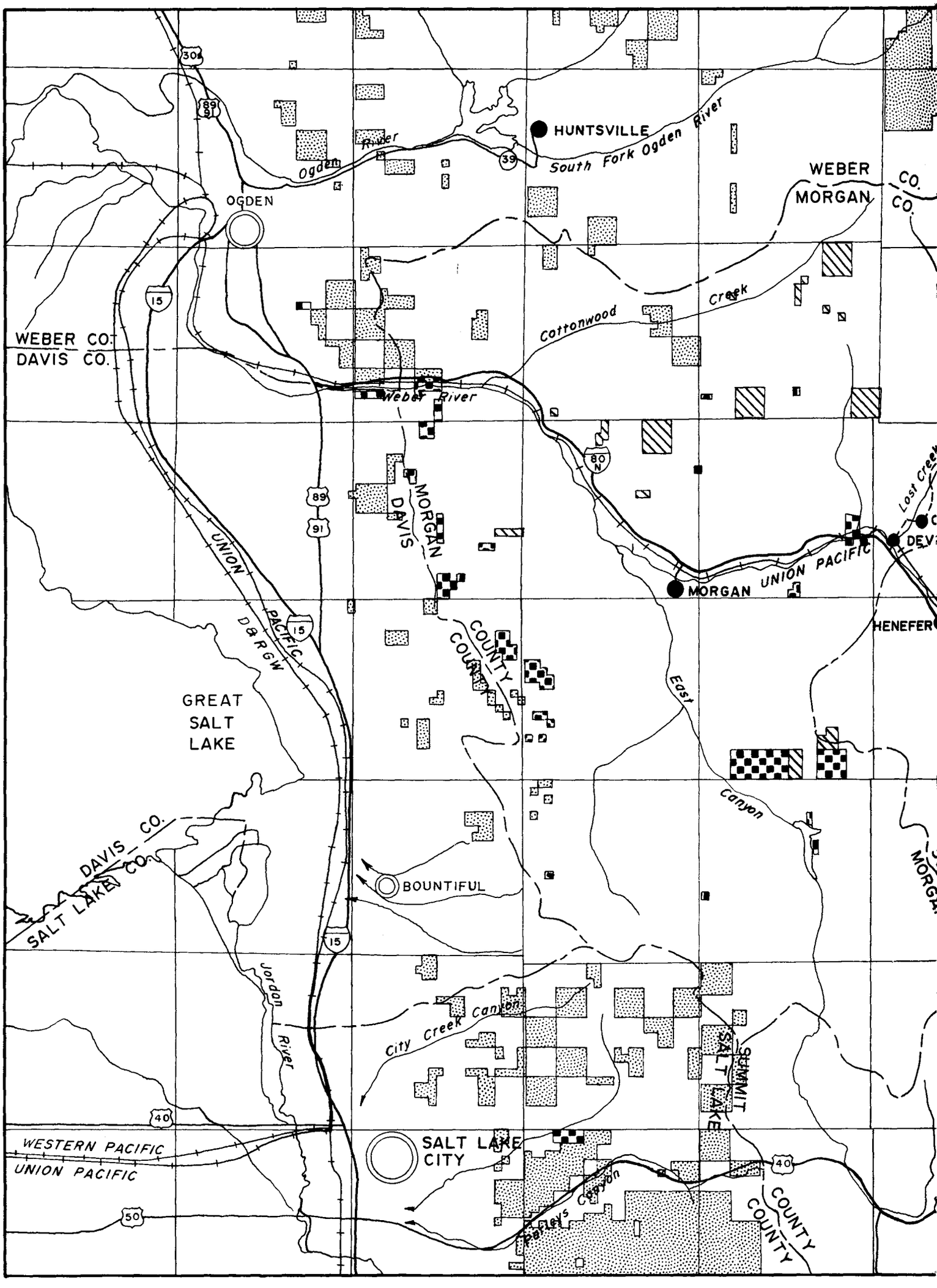
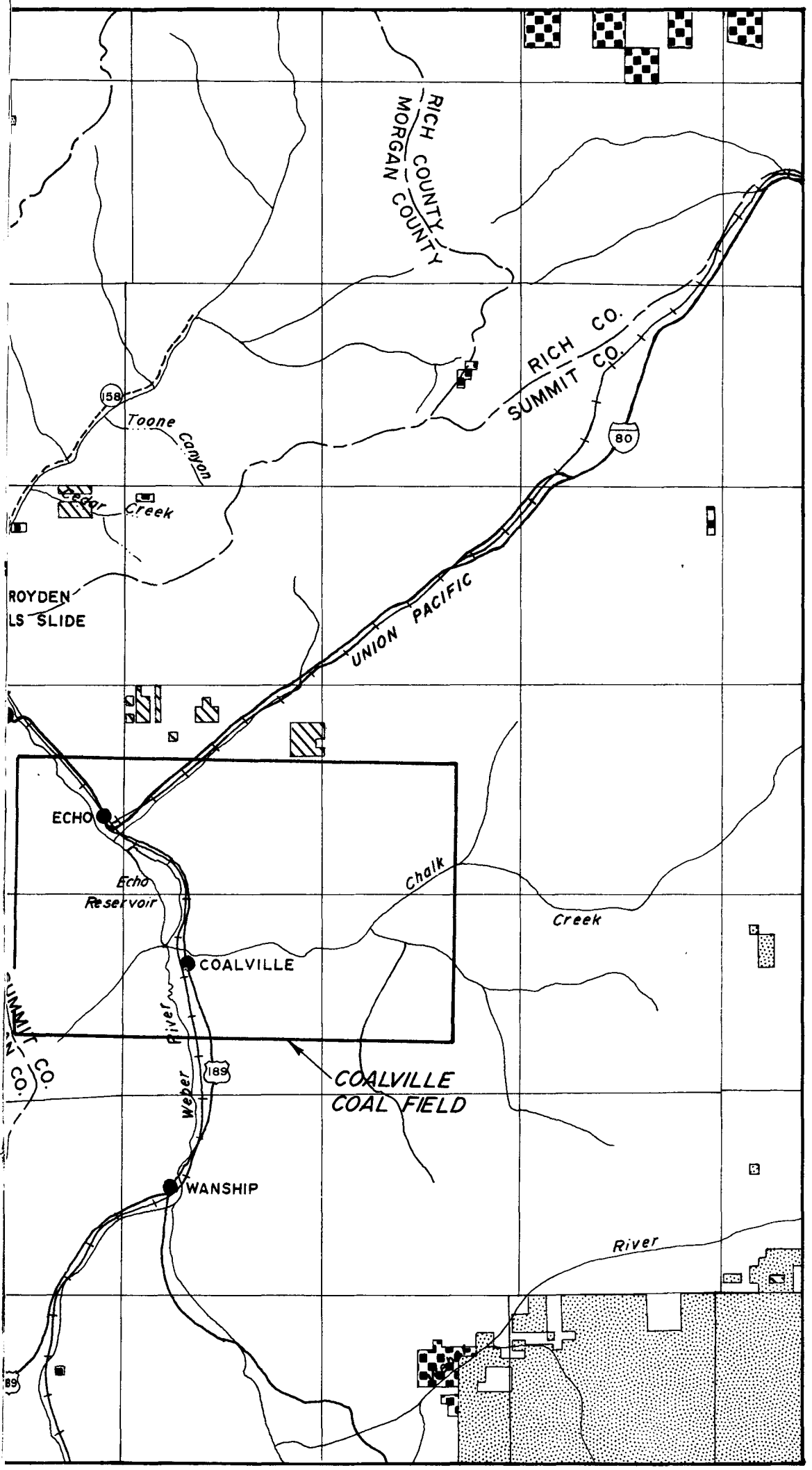


Figure 8. Land ownership map, Coalville coal field.



LOST CREEK—COALVILLE AREA

LAND OWNERSHIP MAP

State Lands

National Forest

Private Lands

BLM Lands

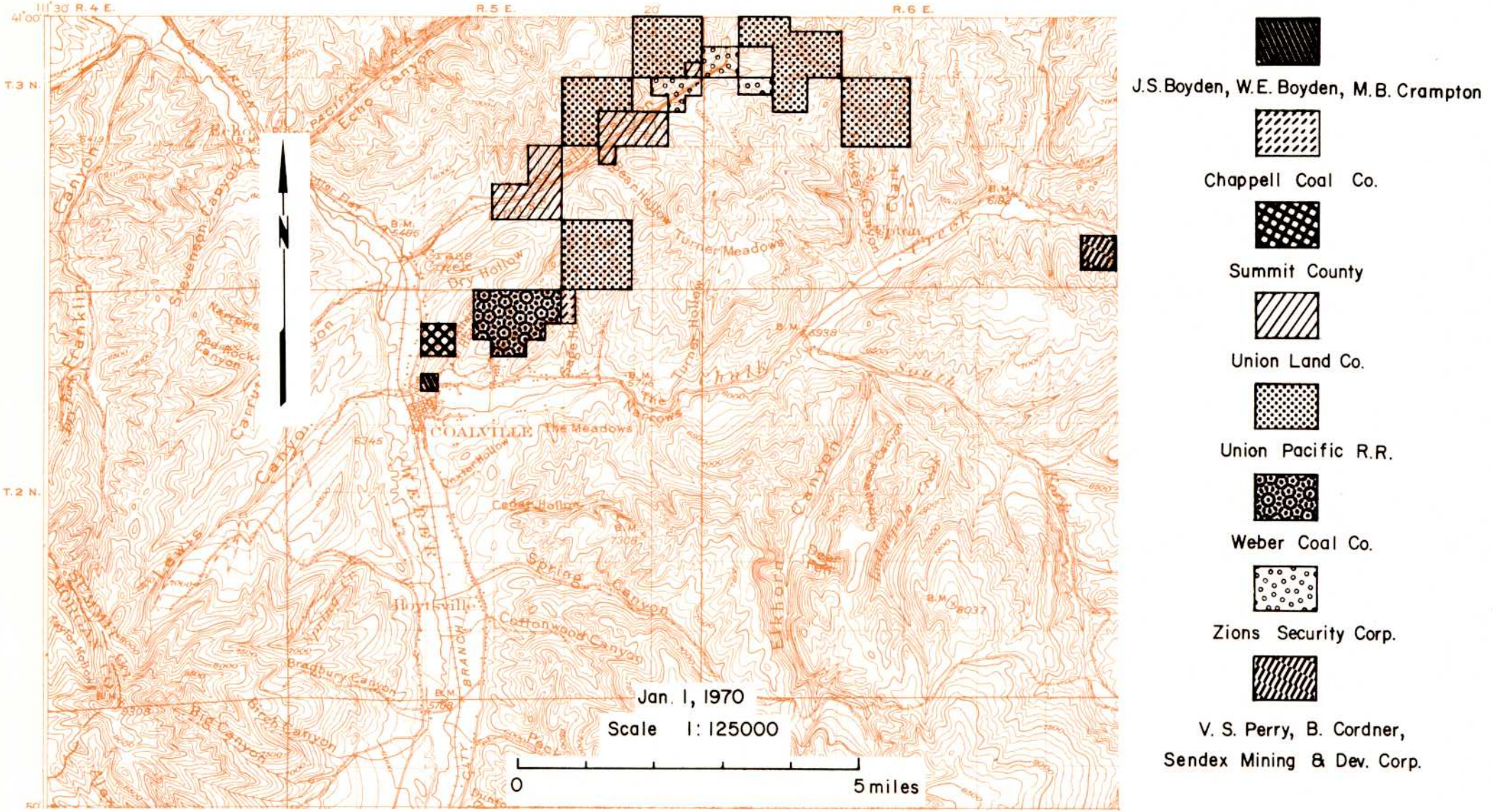


Figure 9. Coal land holdings, Coalville coal field.

Table 2. Estimated coal production, Coalville coal field.

	Tons
Prior to 1880	240,000
1880-1918	2,415,728
1919-1941	620,853-1,000,000
1942	44,991
1943	42,000 est.
1944	6,000 est.
1945	1,000 est.
1946	27,276
1947	27,575
1948	26,757
1949	25,731
1950	32,456
1951	22,728
1952	24,888
1953	21,931
1954	20,000 est.
1955	18,506
1956	17,367
1957	18,695
1958	17,555
1959	18,409
1960	20,082
1961	19,881
1962	19,509
1963	17,937
1964	17,338
1965	12,918
1966	15,063
1967	13,446
1968	13,000
1969	12,225
1970	12,511
Total coal	3,864,356-4,243,503

Walker and Hartner (1966, p. 38) determined the forms of sulfur from samples from each of the two important mines (table 3).

Table 3. Sulfur content of coal, Chappell and Wasatch mines, Coalville coal field.

	Percent			
Mines	Sulfate	Pyritic	Organic	Total Sulfur
Chappell	.01	0.17	0.95	1.13
Wasatch	.01	0.25	0.82	1.08

Gomez and others (1967, p. 13) calculated carbonization product yields for the Wasatch mine (table 4).

Table 4. Carbonization product yields at 500° C, weight percent maf coal, Wasatch mine, Coalville coal field.

Char	Water of decomposition	Tar plus light oil	Gas	Gas vol. scf/lb. maf coal	Heat val. of gas Btu/scf
70.3	7.1	13.5	8.3	1.253	622

Reserves

The reserves (Classes I, II and III) are calculated to be 156 million tons. All the coal is in beds 4 feet or more thick and under less than 3,000 feet of cover. The coal again crops out east of Upton in beds dipping 18 to 20 degrees. The coal bed is 7 to 8 feet thick east of Upton and reported to be 5 to 6 feet in Huff (Meadow) Creek, 4 miles to the north so that an additional 30 million tons might be appended. Mining practice has shown that 10,000 tons per acre are recovered in the Chappell mine indicating 50 to 60 percent recovery. If 4 million tons of coal have been produced at Coalville, 8 million tons are no longer available and a total of 90.5 million tons of coal remain to be extracted including the coal east of Upton. The Upton reserves are considered Class III or inferred.

Coal Seams

Of the three coal seams of the Coalville field, Dry Hollow, Wasatch and Spring Canyon, only the Wasatch bed is of importance. The Spring Canyon coals are local and mostly thin; they are only reported from one small area in sec. 26, T. 2 N., R. 5 E. It is the lowest coal and is 3,200 feet below the Wasatch coal bed. The Dry Hollow coal is about 2,000 feet above the Wasatch and contains reserves in beds 14 inches to 4 feet thick in an arc of outcrops extending along the west and northwest margins of the Coalville anticline. Isolated outcrops of the bed occur elsewhere, but not enough is know about their extent.

The Wasatch bed is mostly between 8 and 10 feet thick and has been found in beds exceeding 4 feet everywhere. It is the only bed that has been mined successfully. It has been eroded out of the core of the asymmetrical Coalville anticline and the trace of the bed forms an irregular circle around the axis. Along the east flank the bed is nearly vertical and parallel to the north-south structure. The west flank dips are moderate, 15 to 30 degrees, and when the beds reappear on the far side of the Clark Canyon syncline near Upton, they also dip moderately. The coal bed is thought to be buried at below sea level elevations under the synclinal axis.

ECONOMIC CONSIDERATIONS AND FORECAST

The most critical mining problem of the Wasatch coal bed is the moderate dip. If the dip should exceed 18 degrees, belt haulage becomes inoperational and presents a serious economic obstacle. The roof of the bed is usually a light colored, hard sandstone requiring normal roof support such as timber, cross-bars or roof bolts. The floor is a soft shale that tends to heave during the course of retreat work. The coal is highly susceptible to spontaneous combustion as demonstrated by the history of mining operations in the Coalville field. The advantages of the coal include its free burning nature, low-ash content, relatively high-ash fusion temperature, proximity of location with respect to truck coal markets and availability during peak heating seasons when other Utah mines cannot adequately serve truckers.

The present market is limited and includes the domestic business around the Coalville area, but coal is sold as far north as Idaho Falls, Idaho, and as far south as Provo, Utah. The truckers haul to creameries and small commercial plants in north Utah and Idaho. Coal was formerly sold to the cement plant at Devils Slide but the market was lost because of a spontaneous combustion problem in storage piles.

The Coalville area would be able to supply up to 700 or 800 tons per day for many years if the demand warranted it. To support a power plant, additional coal would have to be drawn from another source, probably Wyoming.

In light of the history of mining, faulting and folding of the strata and other unfavorable mining conditions, a large expansion of operations is not expected. The trucking market may continue for several years.

Looking south on Interstate Highway 80 near Coalville. Road cut is in the Wanship Formation and the thin coal beds represent the Dry Hollow zone.

QUADRANGLE REPORTS

COALVILLE AND TURNER HOLLOW QUADRANGLES

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Coalville and Turner Hollow quadrangles make up the area of the coal field (Preface, figure 1a) and correspond directly with the U. S. Geological Survey topographic quadrangles with the same names. They are discussed together because they constitute a single area. The location, geography and accessibility of the area were discussed in the coal field report.

STRATIGRAPHY (figures 10 and 11)

The stratigraphy was adequately described in the coal field report. Of the six formations exposed, two bear coal seams.

STRUCTURE

The structure was adequately discussed in the coal field report. The strata are involved in moderate to steep folds and often are displaced by limiting faults.

PROPERTY CONTROL

All but approximately 1,500 acres of state land are private property (figure 8).

The following are recorded as holding coal properties, which are plotted on figure 9. The accuracy of the list is not verified (January 1, 1970):

	Acres
Ernest Chappell	160
V. S. Perry, Blain Cordner, Sendex Mining and Development Corp.	160
M. E. Taylor	80
Alan Thomson	5
Union Land Co.	880
Union Pacific Railroad	3,120
Weber Coal Co.	811
Zion's Sec. Corp.	400
Total acres	5,616

COAL

Surface Information

Twenty-one surface sections are available for the coal field, seven on the Coalville quadrangle (figure 13) and the remainder on the Turner Hollow map (figure 14). They represent three coal zones: the Dry Hollow, Wasatch and Spring Canyon beds. The Dry Hollow bed occurs about 2,000 feet above the Wasatch and the lower lies 3,200 feet below the Wasatch. In some areas the lower coal apparently is removed from the Wasatch by only 850 feet of strata, but work by Hale (1960) shows that part of the section may have been overlooked by earlier investigators or was cut out by a fault. Hale's assumptions are based on subsurface data.

In T. 3 N., R. 5 E., the Dry Hollow coal bed is exposed on the north side of the Grass Creek Valley road in secs. 23, 26 and 27, then crosses over to Dry Hollow in secs. 34 and 33. East of the fault in sec. 23, an old mine map (figure 12) shows the outcrop covered. Near the fault the bed is in two benches, the thicker of which ranges between 2 and 3 feet. The older prospects are caved so that accurate measurements cannot be made. Location 3 describes the bed in Dry Hollow (Coalville quadrangle). The lower incompletely measured bed is thought to be less than 20 inches. After Dry Hollow the bed crosses under the Weber River Valley and again may be observed on the walls of the new Interstate Highway 80 roadcuts in T. 2 N., R. 5 E. (see photo, p. 340). Here they appear thin and impure. Locations 1 and 2 of the Coalville quadrangle show 3.0 and 2.6 feet of coal and they represent the old Carleton and Sargent mines.

The only important bed, the Wasatch, is rarely found less than 5 feet thick and may be up to 13 feet thick. The outcrop roughly surrounds the Coalville anticline in an irregularly running outcrop trace. It has not been mapped in much of the south part of the circle. Some of the first discoveries of coal were made along Chalk Creek on the east side of the Coalville anticlinal axis. The coal occurs in steeply dipping beds (70° to 80°). The bed is about 10 feet thick (location 5, Turner Hollow), but contains a few partings of shale. It continues northward into T. 3 N. where unverified measurements show the coal to be as thick as 11 feet. The The bed eventually crosses the axis and drops into Grass Creek (locations 1 to 3, Turner Hollow). The coal has been mined extensively in Grass Creek where its thickness is reported between 5 and 13 feet. Continuing counterclockwise around the circle, the coal is reported to be 7 to 10 feet thick in the Reese Grass Creek mine without any partings. The coal bed continues in a southwesterly direction to the "Great" fault in 26-3N-5E. On the west side of the fault, the bed is not exposed, but occurs below the Knight conglomerates and is mined at the Chappell mine (location 6). Another fault west of the Chappell mine brings the coal to the surface again and the bed loops around the town of Coalville. Locations 10 to 13 (Turner Hollow) are from around the Weber mine and show coal 8 to 12 feet thick. Locations 4 to 7 (Coalville) are measurements on the remaining part of the loop and show coal 7 to 13 feet thick. From there eastward to the far side of the Coalville anticlinal axis, the Frontier Formation is concealed mostly by overlying conglomerate.

The final coal bed is the Spring Canyon of doubtful value; only one measurement was obtained at location 14 (Turner Hollow) and the 3.3 feet of coal probably represent the best showing. About 25 feet below is an aggregate of about 4.2 feet of coal which is split by about 5 inches of shale in three partings. Spring Canyon is located in sec. 26, T. 2 N., R. 5 W. in the southwest corner of the Turner Hollow quadrangle.

Subsurface Information

Little or no drill-hole information is available for the area. Wegemann (1913, p. 178) reports that the Union Pacific Coal Co. put down several holes in secs. 15 and 16, T. 2 N., R. 5 E. southeast of Coalville and that coal was penetrated in all of them. Other drill holes are suspected of having been struck, notably in connection with the Grass Creek, Chappell and Weber properties, but the data are currently unavailable.

Mines and Development

Many mines have been opened in the Coalville area. Most are old and have been abandoned for many years. Names have been changed and some of the exact locations may be lost. Larger mines incorporated some of the smaller. Table 5 (page 350) hopefully is as accurate as the available research information would permit.

Some additional data are available from reports of the underground mines. At the Chappell mine a second coal bed occurs 800 feet above the Wasatch bed, 2 to 3 feet thick, and the present operations are confined to the thicker Wasatch averaging 8 to 10 feet thick. According to Westfield (1944) the thickness of the

EXPLANATION (figures 10 and 11)

32 1.0 — Coal bed
Purple
Dashed where inferred or poorly exposed, dotted where burned. Thickness of coal in feet measured at triangles. Larger numbers refer to location of measured section shown on accompanying sheets.

Prospect

Coal mine

Purple

Burned zone
Area covered with natural clinker or red-burned sandstone.

DH — Coal drill hole

Strike and dip of beds

Apparent dip of beds

Syncline
Axis, dashed where approximately located or where ill defined.

Anticline
Axis, dashed where approximately located or where ill defined.

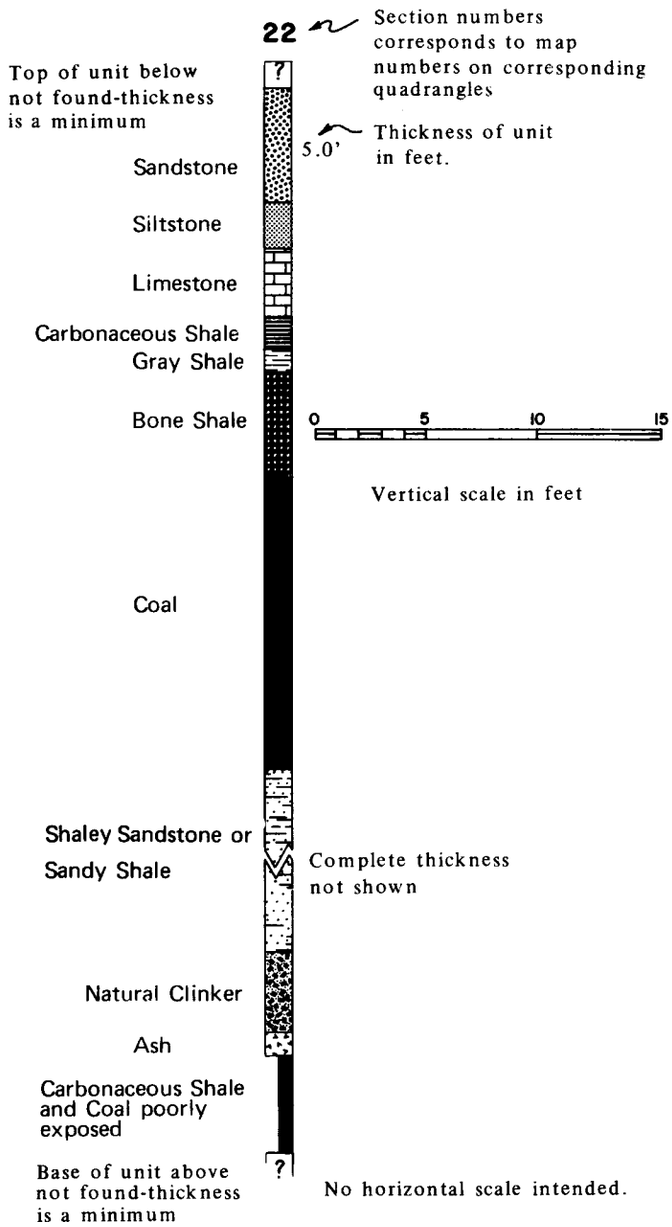
Monocline
Arrow points in direction of dip, dashed where approximately located or where ill defined.

Geologic unit contact
Dashed where location is approximate.

Horizontal strata

D U — Fault
Dashed where inferred or ill defined.

Explanation For Measured Sections



EXPLANATION (continued)

QUATERNARY

Qal

Alluvium
Stratified clay, silt, sand, gravel and some unsorted flood deposits.

Ql

Landslide Deposits
Mixed rubble and blocks of material slumped from formations at higher elevations.

Qt

Gravel Deposits
Partly consolidated, poorly sorted and stratified deposits of rock fragments of local origin, mostly terrace deposits.

TERTIARY

Tk

Knight Formation
Red to variegated clays, sands and conglomerates. 2,000+ feet.

-Unconformity-

CRETACEOUS

Ke

Echo Canyon Conglomerate
Gray, red weathering boulder and pebble conglomerate interbedded with gray and red shale and gray sandstone. 3,000± feet.

-Unconformity-

Kw

Wanship Formation
Henefer Member: *Light brown to light yellowish gray, fine- to medium-grained sandstone and red, brown, yellow and tan claystone. 2,450-2,500 feet.*
Upton Sandstone: *Light yellow to blue-gray, fine-grained, calcareous, well bedded sandstone. 450 feet.*
Judd Shale: *Gray marine shale, thickens eastward. 350-760 feet.*
Grass Creek Member: *Tan thin-bedded sandstone, alternating with gray shale in upper third with lenticular coarse-grained sandstone and red clay shale in lower part, thickens westward. 875-1,025 feet.*
Dry Hollow Member: *Upper white sandstone hogback, Dry Hollow coal zone, and lower part divided into an upper shale and conglomerate, middle nonmarine shale and basal conglomerate. 1,000-1,220 feet.*

Kf

Frontier Formation
Oyster Ridge Sandstone: *Light yellow, orange to gray massive, ridge forming very fine-grained calcareous sandstone. 200-280 feet.*
Allan Hollow Shale: *Gray marine calcareous shale. 780 feet.*
Coalville Member: *Dark gray conglomeratic sandstone overlies Wasatch coal zone, yellow-gray ridge-forming fine-grained calcareous sandstone at base, thickens westward. 175-223 feet.*
Chalk Creek Member: *Nonmarine redbeds; pink to red claystone, coarse sandstone and conglomerate sandstone. 3,150 feet.*
Spring Canyon Member: *Dark shales, carbonaceous shales, sandstone and thin coal beds. 350+ feet.*
Longwall Sandstone: *Light gray, ridge-forming massive, fine-grained sandstone, thickens eastward. 70-100 feet.*

-Unconformity-

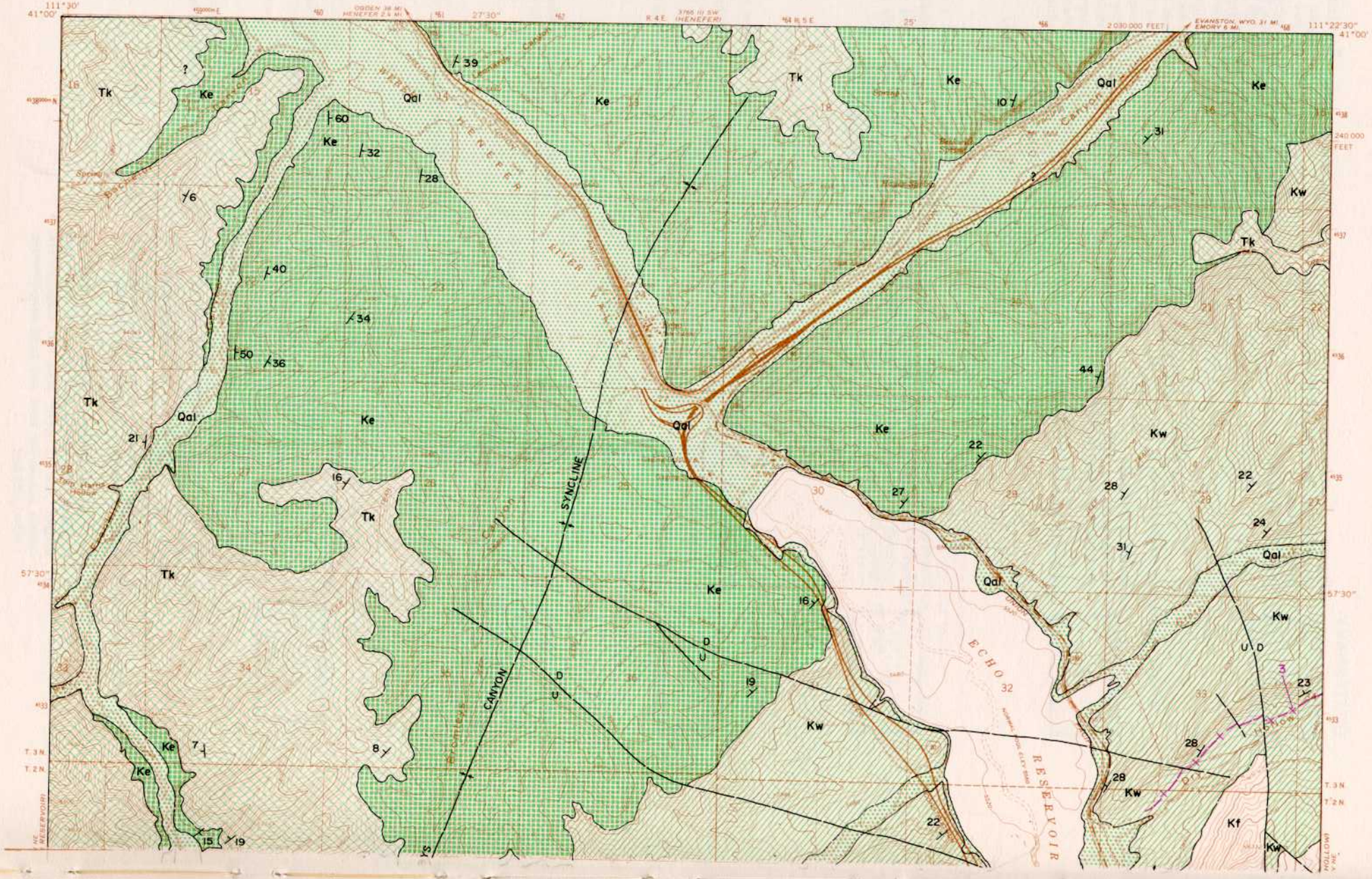
Ka

Aspen Shale
Dark gray shale and tan sandstone with interbedded light gray shale containing teleost fish scales. 210 feet.

Kk

Kelvin Formation
Nonmarine redbeds, shale and sand with lenses of conglomerate. 2,500+ feet.

COALVILLE, UTAH



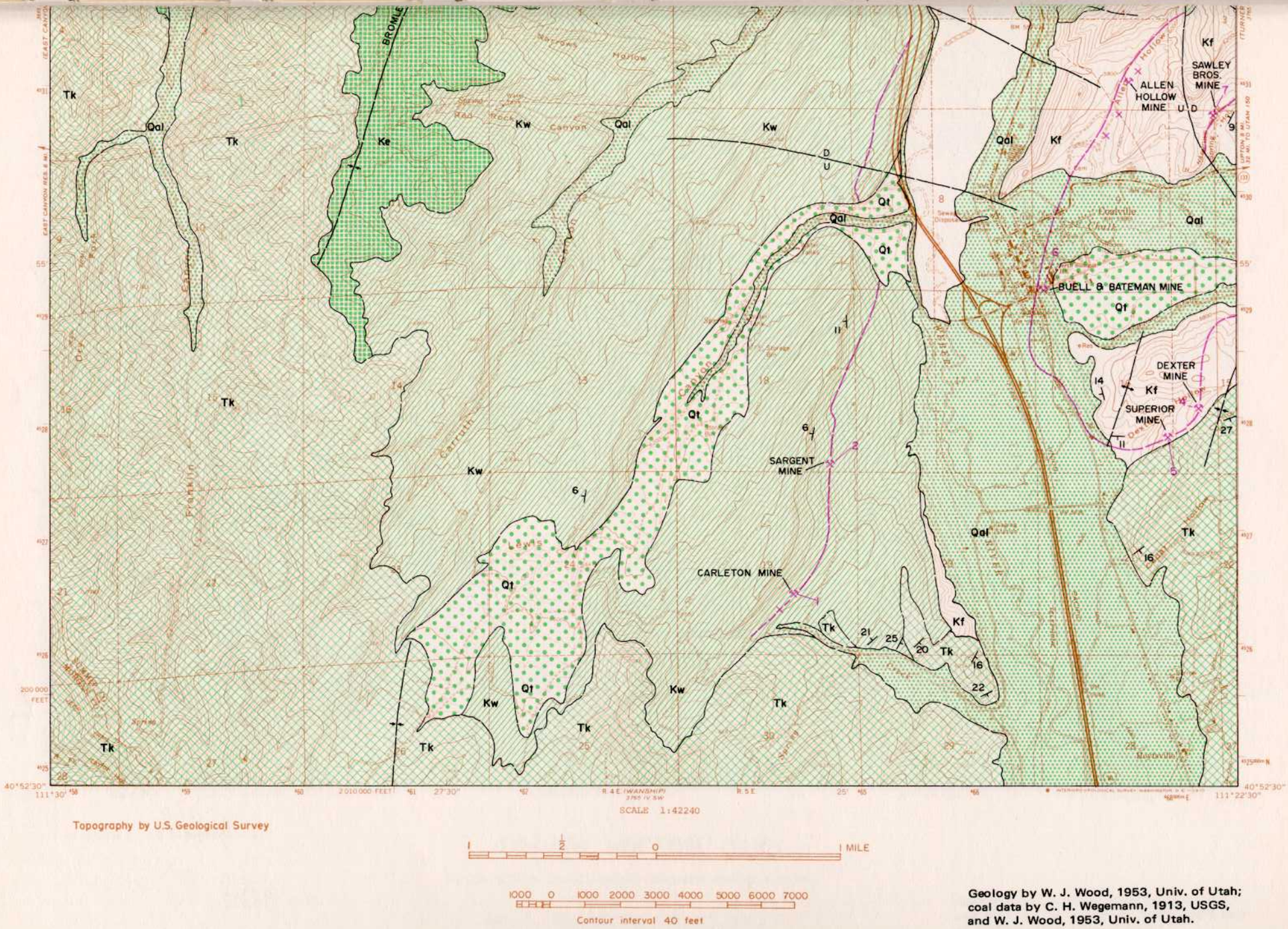
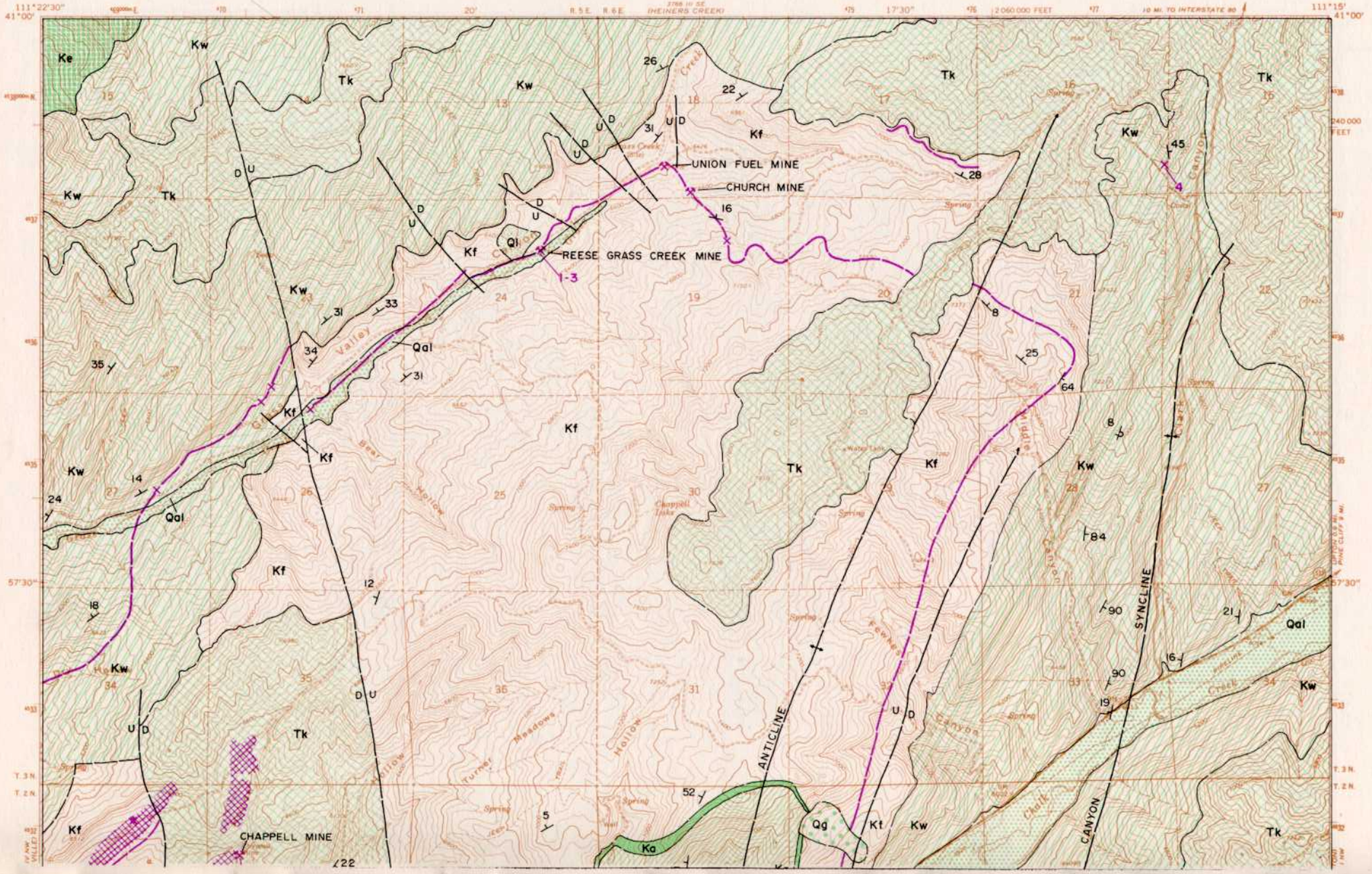


Figure 10. Coal and geology map, Coalville quadrangle (explanation pages 342-343).

TURNER HOLLOW, UTAH



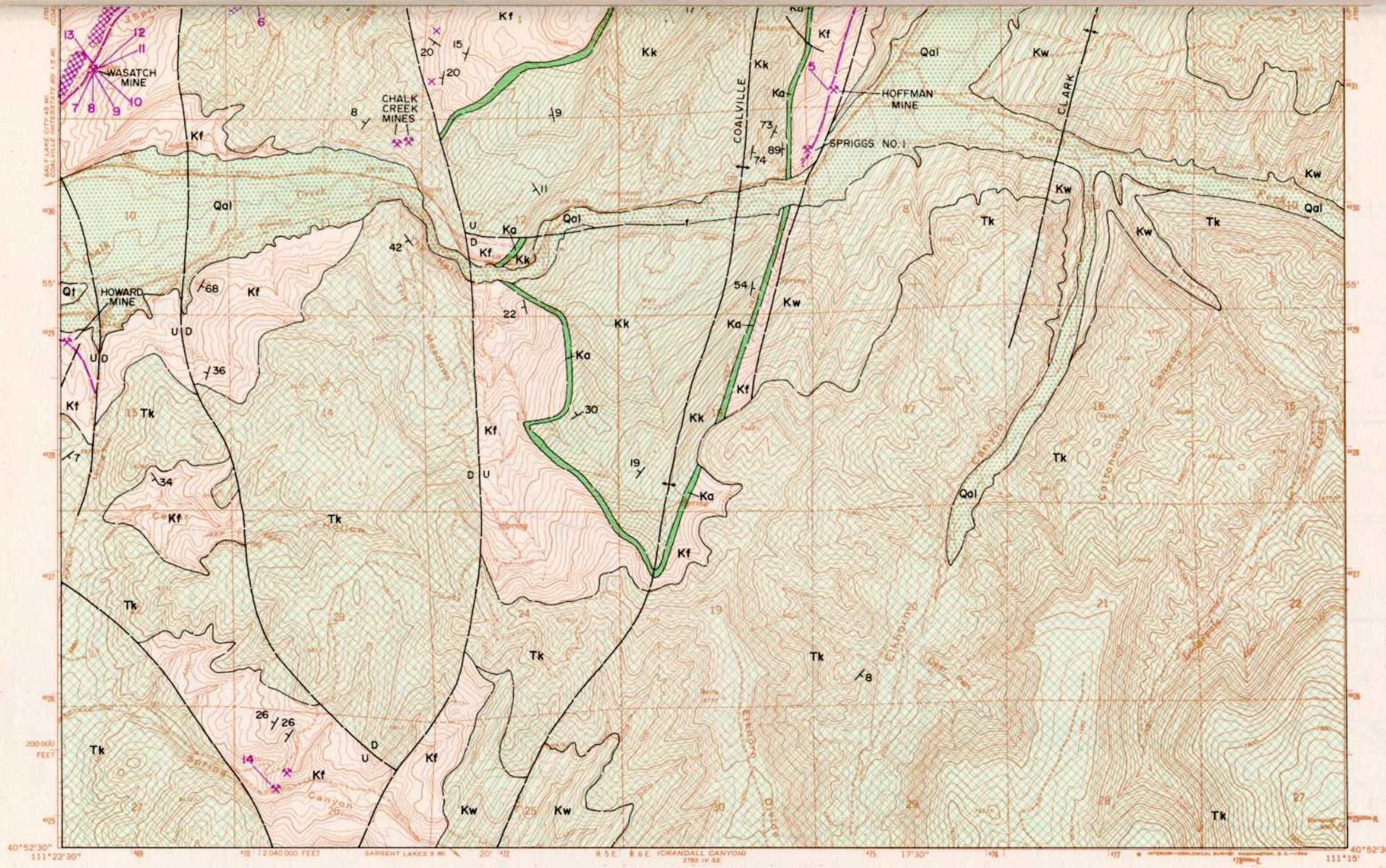


Figure 11. Coal and geology map, Turner Hollow quadrangle (explanation pages 342-343).

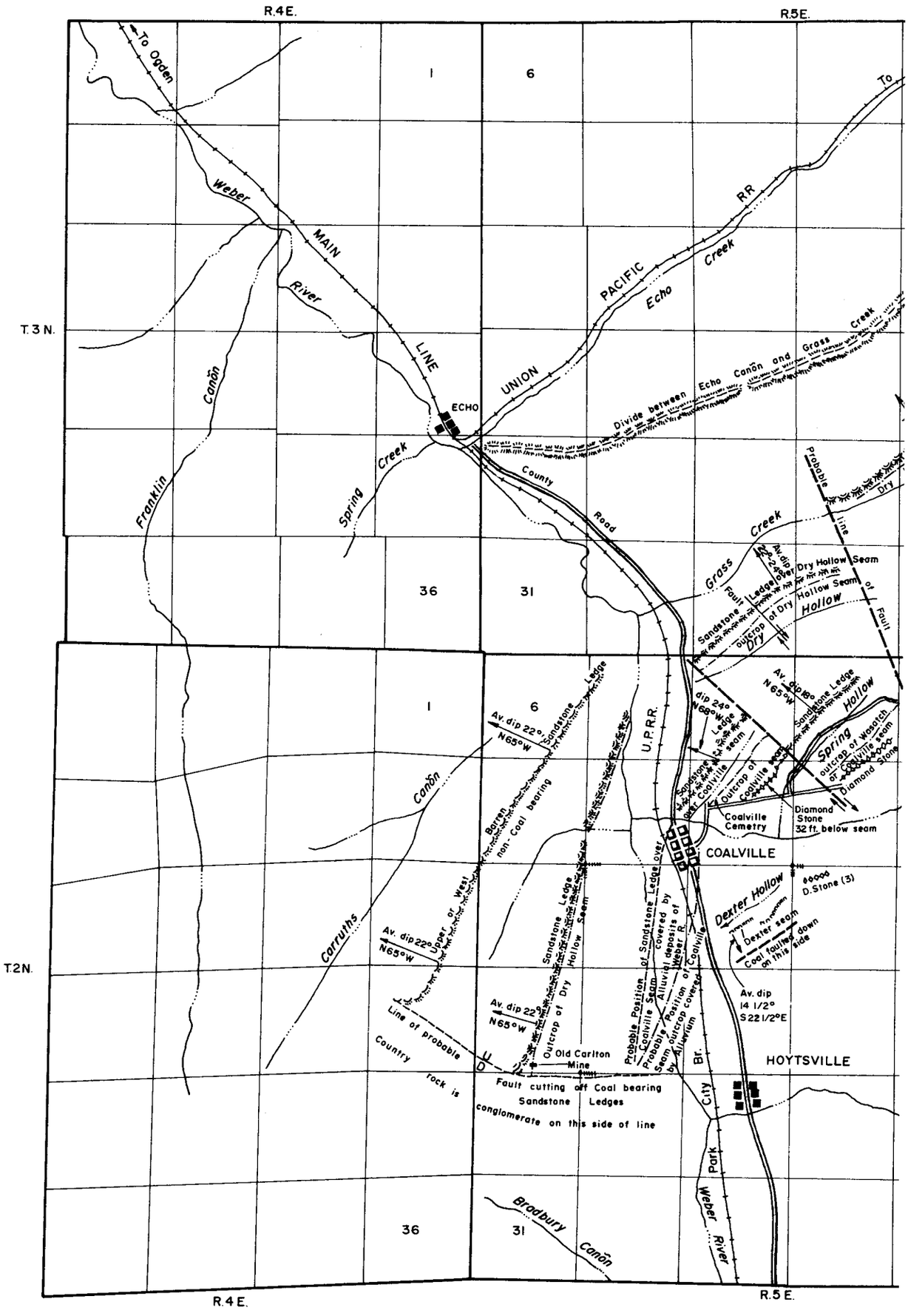
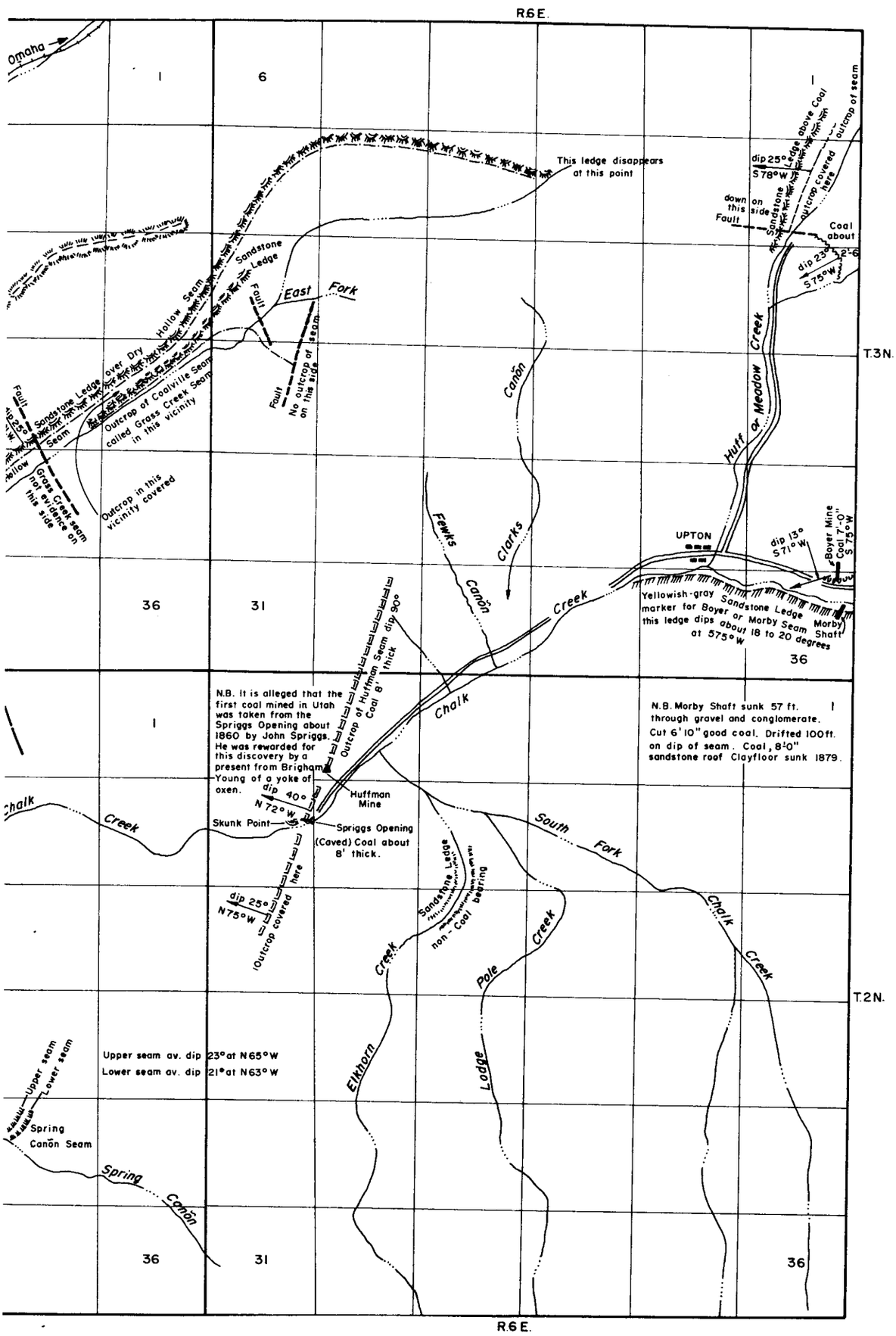


Figure 12. Prominent exposures of ledges and associated coal seams in the Weber coal field, Summit County, Utah.



COMPILED AND DRAWN FROM SURVEYS MADE BY HORACE R. BURRITT MIN. INSP. 10th. FD. DIV. G.L.O.
June, 1911

Table 5. Mines in the Coalville and Turner Hollow quadrangles.

Quadrangle	Location	Remarks
Coalville		
Allan Hollow (Johnson)	SW.SE.4-2N-5E 4,530,990m.N. 467,490m.E.	1864-1877, intermittent until 1920's
Buell and Bateman (Sprague, Spriggs 2)	NW.NW.16-2N-5E 4,529,120m.N. 466,715m.E.	1869-1999?
Carleton mine	NW.SE.19-2N-5E 4,526,440m.N. 464,475m.E.	Very old, active before 1900
Dexter mine	NE.SE.16-2N-5E 4,528,090m.N. 468,090m.E.	About 1900-1910
Sawley Bros. mine	NW.NW.10-2N-5E 4,530,680m.N. 468,260m.E.	1920's
Sargent mine	SE.SE.18-2N-5E 4,527,610m.N. 464,800m.E.	Very old, active before 1900
Superior mine (Gomer Thomas, Superior Fuel and Briquette)	SW.SE.16-2N-5E 4,527,820m.N. 467,800m.E.	Active about 1910-1920's
Turner Hollow		
Chalk Creek mines	NW.11-2N-5E Exact location unknown	1915?
Chappell mine (Wilson Bros.)	SW.NW.2-2N-5E 4,531,740m.N. 470,060m.E.	1890's-1970, active
Church mine (Robinson, Barber, Cullen, Muir)	SE.SW.18-3N-6E 4,537,170m.N. 473,735m.E.	1874-1887 and intermittently into early 1900's
Grass Creek mines Tom Reese	SW.NE.24-3N-5E 4,536,680m.N. 472,610m.E.	1880-1930's?
Union Fuel	SE.SW.18-3N-5E 4,537,380m.N. 473,415m.E.	
Hoffman mine	SW.SW.5-2N-6E 4,530,890m.N. 474,750m.E.	Intermittent early
Spriggs No. 1	NE.NE.7-2N-6E 4,530,300m.N. 474,520m.E.	1860-1880
Howard mine	NW.NW.15-2N-5E 4,528,790m.N. 468,470m.E.	Very old, active before 1900
Union Pacific mines (Bishops)	SW.23-3N-5E Exact location unknown, may join underground with Grass Creek mines	1870-1880
Wasatch mine (Weber, Chrisman, Crismon, Johnson, Home, United Park)	NW.SW.3-2N-5E 4,531,110m.N. 468,710m.E.	1866-1944
Upton		
Boyer mine (Black Hawk, Clark)	SE.NE.36-3N-6E 4,533,320m.N. 482,375m.E.	1897-1953, intermittent operations
Huff Creek Road prospects	NE.12-3N-6E Exact location unknown	Very old, active before 1900

Wasatch bed in the Weber mine averaged 11 feet. The thicknesses below are matched to several of the earlier mines.

Mine	Seam Thickness (ft)
Bishops mine	11
Grass Creek mine	10-11
Spriggs mine	10-11
Allan Hollow mine	10-12
Wasatch mine (Weber)	9-14
Chrisman mine	13
Sprague mine	11-14

From the geologic map the Wasatch bed should be near the surface below the Carleton mine along the Weber River. Other areas of potential coal are south of the Superior and Howard mines in the area of the old Union Pacific drilling and south of Chalk Creek in the graben in which the Chappell mine is situated. The latter is speculative since the structure is not understood. The dips suggest the width of coal under the outcrop with less than 3,000 feet of overburden will range from 0 to 3 miles. The steep flank is expected only to provide surface to 3,000-foot coal provided the difficulties of vertical mining can be economically surmounted.

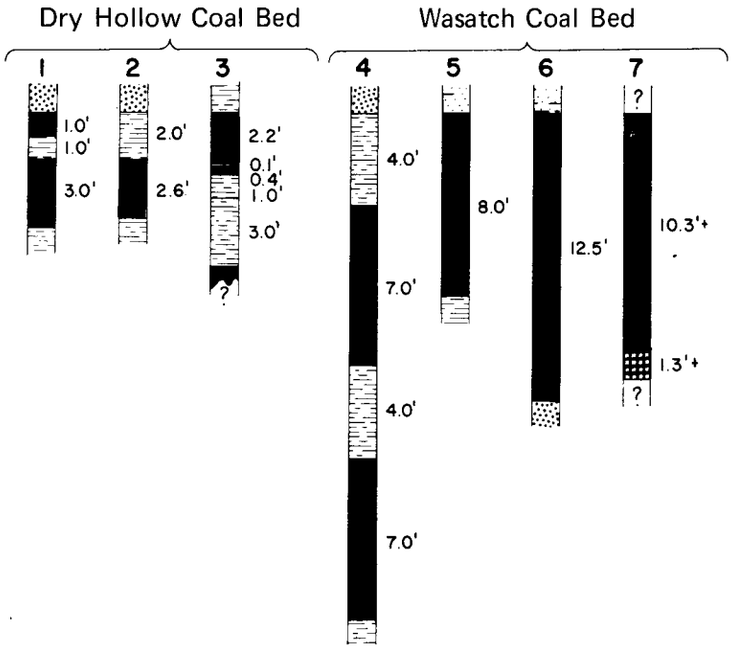


Figure 13. Coal sections of the Coalville quadrangle (vertical scale: 1 inch = 8 feet).

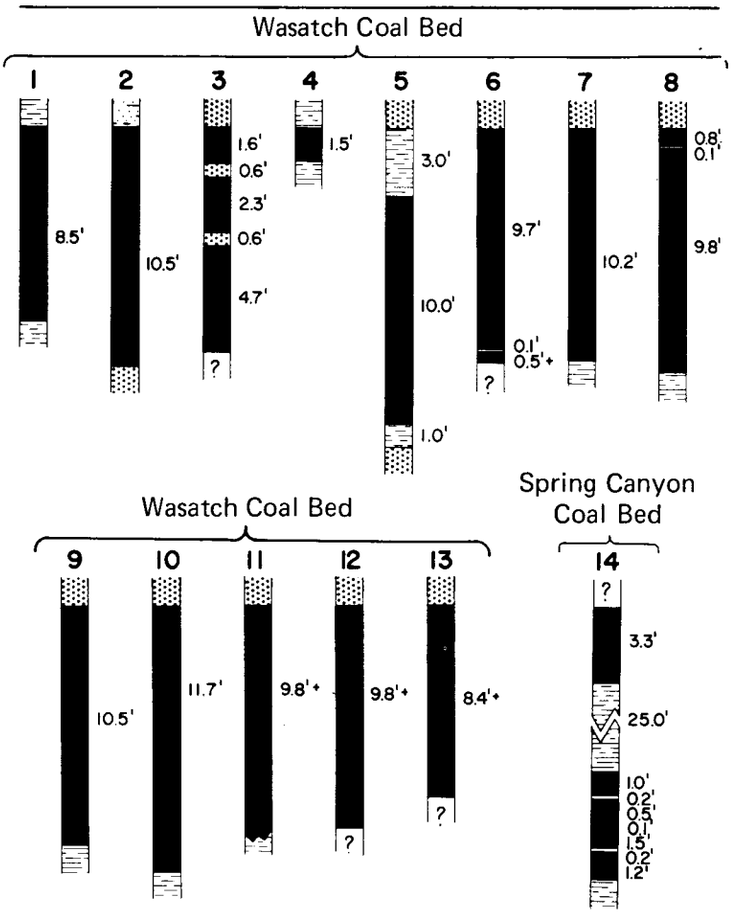


Figure 14. Coal sections of the Turner Hollow quadrangle (vertical scale: 1 inch = 8 feet).

Quality of Coal

Fifty-four analyses are available for the Coalville area, all in the Wasatch coal bed (table 6). Some are old, collected and

Table 6. Quality data of coal for the Coalville coal field.

No.	Mine or Prospect-Coal bed	Township & Range UTM grid		PROXIMATE ANALYSES					ULTIMATE ANALYSES						OTHER TESTS			Kind of Sample	Ref. Source
				AN	M	VM	FC	Ash	S	H	C	N	O	Btu/lb	AST	ADL	HGI		
									COALVILLE QUADRANGLE										
1	Allan Hollow mine Wasatch bed	SW.SE.4-2N-5E 4530990mN 467490mE	A	9.89	37.45	49.35	3.31	–	–	70.0	–	–	10,180	–	–	–		22
2	Allan Hollow mine Wasatch bed		A	10.33	39.0	47.83	2.89	–	–	70.59	–	–	10,267	–	–	–		22
3	Allan Hollow mine Wasatch bed		A	9.56	38.19	48.14	3.77	–	–	70.00	–	–	10,180	–	–	–		22
4	Allan Hollow mine Wasatch bed		A	9.83	37.56	48.91	3.69	–	–	69.20	–	–	10,137	–	–	–		22
5	Sawley Bros. mine Wasatch bed	NW.NW.10–2N–5E 4530680mN 468260mE	A	14.1	37.7	43.9	4.3	1.2	5.9	61.8	1.3	25.5	10,770	2,220	7.6	–		29
			C	–	43.8	51.1	5.1	1.4	5.1	72.0	1.5	14.9	12,540	–	–	–		
			D	–	46.2	53.8	–	1.5	5.3	75.8	1.6	15.8	13,210	–	–	–		
6	Spriggs No. 2 mine Wasatch bed	NW.NW.16–2N–5E 4529120mN 466715mE	A	8.62	38.54	49.03	4.01	–	–	68.23	–	–	9,923	–	–	–		22
7	Superior mine Wasatch bed	SW.SE.16–2N–5E 4527820mN 467800mE	A	17.1	36.9	41.3	4.7	1.53	–	–	–	–	10,180	2,130	7.8	–		29
			B	10.1	40.1	44.7	5.1	1.66	–	–	–	–	11,040	–	–	–		
			C	–	44.6	49.7	5.7	1.85	–	–	–	–	12,280	–	–	–		
			D	–	47.2	52.8	–	1.95	–	–	–	–	13,020	–	–	–		
8	Superior mine Wasatch bed		A	10.1	40.1	44.7	5.1	1.66	–	–	–	–	11,040	–	–	–		23
									TURNER HOLLOW QUADRANGLE										
1	Chappell mine Wasatch bed	SW.NW.2–2N–5E 4531740mN 470060mE	A	14.6	37.1	43.8	4.5	1.3	5.8	61.0	1.2	26.2	10,620	2,280	9.1	–		29
			C	–	43.5	51.3	5.2	1.5	5.0	71.4	1.4	15.5	12,430	–	–	–		
			D	–	45.8	54.2	–	1.6	5.2	75.3	1.5	16.4	13,110	–	–	–		
2	Chappell mine		A	13.6	–	–	3.9	1.13	–	–	–	–	–	–	–	–		32
3	Chappell mine		A	13.9	37.1	45.3	3.7	1.5	–	–	–	–	11,060	–	–	–		2
			C	–	43.1	52.6	4.3	–	–	–	–	–	12,850	–	–	–		
4	Chappell mine		A	13.3	37.6	45.6	3.5	0.9	–	–	–	–	11,160	–	–	–	T	3
			C	–	43.4	52.6	4.0	–	–	–	–	–	12,880	–	–	–		
5	Chappell mine		A	13.5	37.4	45.5	3.6	1.1	–	–	–	–	11,180	–	–	–	T	3
			C	–	43.2	52.6	4.2	–	–	–	–	–	12,850	–	–	–		
6	Chappell mine		A	14.2	36.8	45.3	3.7	1.2	–	–	–	–	11,050	–	–	–	T	3
			C	–	42.9	52.8	4.3	–	–	–	–	–	12,870	–	–	–		
7	Chappell mine		A	15.7	36.8	43.8	3.6	1.3	–	–	–	–	10,810	–	–	–	T	4
			C	–	43.7	52.0	4.3	–	–	–	–	–	12,820	–	–	–		
8	Chappell mine		A	15.0	37.5	43.0	4.5	1.5	–	–	–	–	10,810	–	–	–	T	4
			C	–	44.1	50.6	5.3	–	–	–	–	–	12,720	–	–	–		
9	Chappell mine		A	15.6	36.7	42.5	5.1	1.6	–	–	–	–	10,660	–	–	–	T	4
			C	–	43.5	50.4	6.1	–	–	–	–	–	12,630	–	–	–		
10	Chappell mine		A	13.8	38.1	44.2	3.9	1.8	–	–	–	–	10,980	–	–	–	T	5
			C	–	44.2	51.3	4.5	–	–	–	–	–	12,740	–	–	–		
11	Chappell mine		A	14.2	37.5	43.9	4.4	1.7	–	–	–	–	10,890	–	–	–	T	5
			C	–	43.7	51.2	5.1	–	–	–	–	–	12,690	–	–	–		
12	Chappell mine		A	14.2	38.4	43.2	4.1	1.7	–	–	–	–	10,950	–	–	–	T	5
			C	–	44.8	50.4	4.8	–	–	–	–	–	12,770	–	–	–		
13	Church mine Wasatch bed	SE.SW.18–3N–6E 4537170mN 473735mE	A	9.42	38.79	48.27	3.32	–	–	74.12	–	–	10,774	–	–	–		22
14	Grass Creek mine Wasatch bed	SW.NE.24–3N–5E 4536680mN 472610mE	A	8.67	39.10	48.60	3.32	.33	–	68.45	–	–	9,952	–	–	–		10
15	Grass Creek mine		A	8.4	32.1	45.0	14.5	.5	4.0	55.7	1.0	24.3	8,870	2,170	.4	–		12
			B	8.0	32.2	45.2	14.60	.52	3.96	55.90	.96	24.06	8,910	–	–	–		
			C	–	35.0	49.1	15.9	.6	3.3	60.7	1.1	18.4	9,680	–	–	–		
			D	–	41.6	58.6	–	.7	4.0	72.2	1.3	21.8	11,510	–	–	–		
16	Grass Creek mine		A	15.4	37.0	43.7	3.9	1.4	–	–	–	–	10,720	2,260	7.9	–		29
17	Grass Creek mine		A	16.0	36.9	43.3	3.8	1.7	6.0	61.0	1.3	26.2	10,680	–	9.1	–		29
			C	–	43.9	51.6	4.5	2.1	5.0	72.6	1.5	14.3	12,710	–	–	–		
			D	–	46.0	54.0	–	2.2	5.3	76.1	1.6	14.8	13,320	–	–	–		
18	Grass Creek mine		A	16.6	36.8	42.8	3.8	1.9	–	–	–	–	10,650	2,090	10.3	–		29
19	Grass Creek mine		A	12.2	42.2	42.2	3.39	1.90	5.80	63.77	1.27	23.87	11,260	2,420	4.5	–		29
			B	8.0	44.2	44.2	3.55	1.99	5.55	66.77	1.33	20.81	11,790	–	–	–		
			C	–	48.0	48.1	3.86	2.16	5.07	72.61	1.45	14.85	12,820	–	–	–		
			D	–	50.0	50.0	–	2.25	5.27	75.52	1.51	15.45	13,330	–	–	–		
20	Grass Creek mine		A	7.28	45.79	43.45	3.25	0.23	–	–	–	–	–	–	–	–		27
21	Grass Creek mine		A	8.0	44.2	44.2	3.55	1.99	–	–	–	–	–	–	–	–		23

Table 6. (continued)

No.	Mine or Prospect-Coal bed	Township & Range UTM grid	PROXIMATE ANALYSES					ULTIMATE ANALYSES						OTHER TESTS			Kind of	Ref.
			AN	M	VM	FC	Ash	S	H	C	N	O	Btu/lb	AST	ADL	HGI	Sample	Source
22	Grass Creek mine		A	8.97	39.10	48.6	3.32	–	–	68.45	–	–	9,952	–	–	–		10
23	Grass Creek mine		A	12.04	38.55	46.74	4.29	.78	6.94	63.24	1.37	23.38	11,043	–	–	–		
			B	8.86	39.95	46.74	4.45	.84	6.78	65.53	1.43	20.97	11,443	–	–	–		
			C	–	43.83	51.29	4.88	.89	6.36	71.90	1.56	14.41	12,555	–	–	–		
			D	–	45.70	54.30	–	–	–	–	–	–	11,591	–	–	–		
24	Spriggs No. 1 mine Wasatch bed	NE.NE.7-2N-6E 4530300mN 474520mE	A	1.68	45.59	48.78	3.95	–	–	69.12	–	–	10,502	–	–	–		22
25	Wasatch mine Wasatch bed "lower tunnel"	NW.SW.3-2N-5E 4531110mN 468710mE	A	8.38	38.68	49.68	2.26	–	–	76.17	–	–	11,077	–	–	–		22
26	Wasatch mine "upper tunnel"		A	47.80		49.75	2.22	–	–	74.41	–	–	10,821	–	–	–		22
27	Wasatch mine		A	13.6	41.3	41.0	4.08	1.37	5.84	62.11	1.06	25.54	10,980	–	5.3	–		29
			B	8.8	43.6	43.3	4.31	1.45	5.54	65.59	1.12	21.99	11,590	–	–	–		
			C	–	47.8	47.5	4.72	1.59	5.01	71.89	1.23	15.56	12,710	–	–	–		
			D	–	50.2	49.8	–	1.67	5.26	75.45	1.29	16.33	13,340	–	–	–		
28	Wasatch mine		A	11.53	38.91	43.83	5.73	1.4	–	–	–	–	–	–	–	–		8
			C	–	–	–	6.48	1.54	4.7	72.2	1.3	13.9	–	–	–	–		
29	Wasatch mine		A	9.32	39.68	45.05	5.95	1.4	–	–	–	–	–	–	–	–		8
			C	–	–	–	6.56	1.5	4.8	73.3	1.3	12.6	–	–	–	–		
30	Wasatch mine		A	10.02	39.82	43.41	6.75	1.3	–	–	–	–	–	–	–	–		8
			C	–	–	–	7.5	1.5	4.6	71.6	1.3	13.5	–	–	–	–		
31	Wasatch mine		A	12.66	38.30	43.19	5.85	1.39	–	–	–	–	–	–	2.3	–		25
			C	–	43.85	49.43	6.70	1.59	–	–	–	–	–	–	–	–		
			D	–	47.00	53.00	–	1.70	–	–	–	–	–	–	–	–		
32	Wasatch mine		A	13.86	39.69	41.19	5.26	1.32	–	–	–	–	–	–	5.2	–		25
			C	–	46.08	47.81	6.11	1.53	–	–	–	–	–	–	–	–		
			D	–	49.08	50.92	–	1.63	–	–	–	–	–	–	–	–		
33	Wasatch mine		A	14.9	34.0	46.5	4.6	1.1	–	–	–	–	10,770	–	5.7	–		25
			C	–	40.0	54.6	5.4	1.3	–	–	–	–	12,650	–	–	–		
			D	–	42.5	57.5	–	1.35	–	–	–	–	13,370	–	–	–		
34	Wasatch mine		A	14.2	36.0	44.8	5.0	1.4	5.8	61.4	1.1	25.3	10,630	–	4.8	–		25
			C	–	42.0	52.1	5.9	1.6	4.9	71.6	1.3	14.7	12,390	–	–	–		
			D	–	44.6	55.4	–	1.7	5.2	76.0	1.4	15.7	13,160	–	–	–		
35	Wasatch mine		A	13.92	37.96	43.67	4.45	1.03	–	–	–	–	10,942	–	6.9	–		25
			C	–	44.10	50.73	5.17	1.20	–	–	–	–	12,712	–	–	–		
			D	–	46.50	53.50	–	1.27	–	–	–	–	13,405	–	–	–		
36	Wasatch mine		A	14.07	37.21	42.46	6.26	1.28	–	–	–	–	10,471	–	5.7	–		25
			C	–	43.30	49.42	7.28	1.49	–	–	–	–	12,184	–	–	–		
			D	–	46.70	53.30	–	1.61	–	–	–	–	13,142	–	–	–		
37	Wasatch mine		A	14.2	38.4	43.3	4.1	1.5	–	–	–	–	10,820	2,200	7.0	–		29
38	Wasatch mine		A	13.7	38.3	43.6	4.4	1.5	5.9	62.1	1.2	24.9	10,870	–	7.0	–		29
			C	–	44.4	50.5	5.1	1.7	5.0	72.0	1.4	14.8	12,600	–	–	–		
			D	–	46.8	53.2	–	1.8	5.3	75.8	1.5	15.6	13,280	–	–	–		
39	Wasatch mine		A	14.2	38.3	43.1	4.4	1.5	–	–	–	–	10,790	2,230	7.4	–		12
40	Wasatch mine		A	14.5	37.2	44.0	4.3	1.3	–	–	–	–	10,710	2,240	7.2	–		29
41	Wasatch mine		A	12.1	39.2	44.2	4.5	1.4	–	–	–	–	11,040	2,200	6.6	–		29
42	Wasatch mine		A	10.32	38.90	46.37	4.30	–	–	–	–	–	–	–	–	–		22
43	Wasatch mine		A	9.83	37.63	48.91	3.69	–	–	69.70	–	–	10,132	–	–	–		22
44	Wasatch mine		A	8.33	46.89	40.45	3.33	0.95	–	–	–	–	–	–	–	–		27
45	Wasatch mine		A	1.17	31.43	64.45	2.95	–	–	88.39	–	–	12,851	–	–	–		10
46	Weber mine Wasatch bed		A	14.0	37.6	43.4	5.0	1.08	5.4	76.2	1.6	15.6	10,870	–	–	–		15

analyzed before 1900. A summary of the proximate analyses of all samplings is given in table 7 with a summary of analyses from the Chappell mine, all of which are recent.

In a report of the Utah Conservation and Research Foundation (1939, p. 80) low-temperature carbonization of coal from the Rees mine (Grass Creek) was tested and the results are repeated on table 8.

In addition a few names with no record of location are known to have been active in the late 1800's and early 1900's. Some reported considerable coal output and may have been alternate names to listed mines. These include the Robertson, Hopkins and Williams mines. The Wasatch, Chappell and Grass Creek mines produced the bulk of coal mined at Coalville. The largest producer has been the Wasatch mine which operated 78 years before it was shut down as a result of a coal mine fire. The Grass Creek mines are believed to have closed during the 1930's and a large portion of coal close to the outcrop has been removed. The Chappell mine is the only active mine in the field since 1953.

Reserves

Wegemann (1915) does not report any reserve for the Coalville coal field. Campbell (1917) using Wegemann's data calculated

Table 7. Summary of proximate analyses of coal, Chappell mine and Coalville coal field, as-received.

	No. Samples	Percent Average	Percent Range		No. Samples	Percent Average	Percent Range
	ENTIRE FIELD				**CHAPPELL MINE ONLY**		
Moisture	53	12.0	1.2 -17.1	Moisture	12	14.3	13.3-15.7
Volatile matter	52	38.4	31.4 -46.9	Volatile matter	11	37.4	36.7-38.4
Fixed carbon	53	44.7	40.5 -64.5	Fixed carbon	11	44.2	42.5-45.6
Ash	54	4.4	1.5 -14.5	Ash	12	4.0	3.5- 5.1
Sulfur	41	1.32	0.33- 2.0	Sulfur	12	1.39	0.9- 1.8
Btu/lb	45	10,728	8,870-12,851	Btu/lb	11	10,918	10,620-11,160

Table 8. Carbonization product yields, Rees mine, Coalville coal field.

		Yields, Percent of Coal by Weight[1]								Yields, Per Ton of Coal					
													$(NH_4)_2SO_4$ Pounds		
	Test Number	Carbonizing Temperature °C	Semi-Coke	Gas[2]	Tar[3]	Light Oil[4]	CO_2[5]	Liquor[6]	Total	Gas, Cu. Ft.[2]	Tar, Gallons[3]	Light Oil, Gallons[7]	Gas	Liquor	Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Vertical Retort External Heating	0-52	450	70.7	1.5	4.6	0.3	1.6	16.5	95.2	532	11.0	0.9	1.2	2.0	3.2
	0-2a	550	62.6	6.2	5.5	0.6	2.1	20.0	97.0	2,610	13.0	1.5	3.3	4.8	8.1
	0-30	650	59.0	9.2	5.5	0.4	2.9	21.0	98.0	4,237	12.9	1.4	7.4	5.8	13.2
	0-66[8]	650	58.3	10.5	6.3	0.3	2.9	19.1	97.4	4,656	15.2	1.0	3.8	6.2	10.0
	0-51[14]	650	68.1	7.0	8.0	0.6	2.3	9.4	95.4	3,450	19.3	1.6	2.1	2.2	4.3
	0-3a	750	57.9	13.2	5.7	0.5	2.7	19.3	99.4	6,091	13.7	1.6	10.8	5.8	16.6
	0-5a	850	55.5	13.7	5.1	0.6	2.3	20.9	98.1	7,261	12.2	1.8	10.4	6.6	17.0
[9]	0-45	550	67.5	3.0	4.6	0.4	1.7	–	–	990	10.7	1.1	0.5	9.7	10.2
	0-42	650	63.6	6.8	3.5	0.6	1.7	–	–	2,586	8.0	1.8	0.7	13.6	14.3
Rotary Retort External Heating	0-92	450	65.8	4.3	6.6	0.5	1.2	17.2	95.6	1,324	15.8	1.4	1.0	2.6	3.6
	0-111*	550	60.2	–	6.5	–	–	17.1	–	2,790	15.4	–	–	–	–
	0-85	650	57.2	10.7	6.9	0.4	3.1	20.2	98.5	4,275	16.7	1.2	2.8	4.1	6.9
	0-81[11]	650	55.4	10.6	7.7	0.3	1.9	20.9	96.8	4,471	18.5	0.8	3.1	3.9	7.0

[1] Does not include hydrogen sulphide and ammonia scrubbed from the gas.
[2] Stripped of light oil, ammonia and hydrogen sulphide, saturated with water vapor at 60° F. and 30 inches of mercury.
[3] Dehydrated. Does not include light oil stripped from the gas, but does include the light oil which condensed with the tar.
[4] Includes light oil scrubbed from the gas only and not that which condensed with the tar.
[5] Absorbed in scrubbing tower.
[6] Obtained by decantation and dehydration of the tar.
[7] Includes light oil scrubbed from the gas and that recovered from the gas by refrigeration with CO_2 ice and acetone mixture, and does not include the light oil which condensed with the tar.
[8] Rapid heating. Coal size: 4-mesh to 1-inch.
[9] Internal heating using superheated steam.
[10] Blend, 75 percent Coal 6. Coal-size: 10- to 4-mesh.
[11] Rapid heating. Standard size of coal used, except for Test No. 0-65.
[12] Blend, 70 percent Coal 6. Coal-size: 10- to 4-mesh.
[13] Blend, 60 percent Coal 6. Coal-size: 10- to 4-mesh.
[14] Blend, 80 percent Coal 6. Coal-size: 10- to 4-mesh.
[15] All coal minus 4-mesh.
[16] Blend, 10 percent Coal 6. Coal-size: 10- to 4-mesh.
[17] Blend, 30 percent Coal 6. Coal-size: 10- to 4-mesh.
[18] Blend, 80 percent Coal 6 (½- to 1-inch) and 20 percent semi-coke (10- to 4-mesh).

NOTE: The suffix "a" by the test number indicates that the data given are based upon the average results of two tests. Data for tests marked with an asterisk (*) were lost in fire, February 14, 1939.

156 million tons; the present writer agrees with this figure for the Wasatch coal bed as it surrounds the Coalville anticline. It might increase slightly as more becomes known of the south area. The Dry Hollow and the Spring Canyon zones have only local potential for beds over 4 feet thick.

PRINCIPAL WORK

Most of the coal data was collected by Wegemann (1915) and geologic data were mostly added by Trexler (1966) and Hale (1960).

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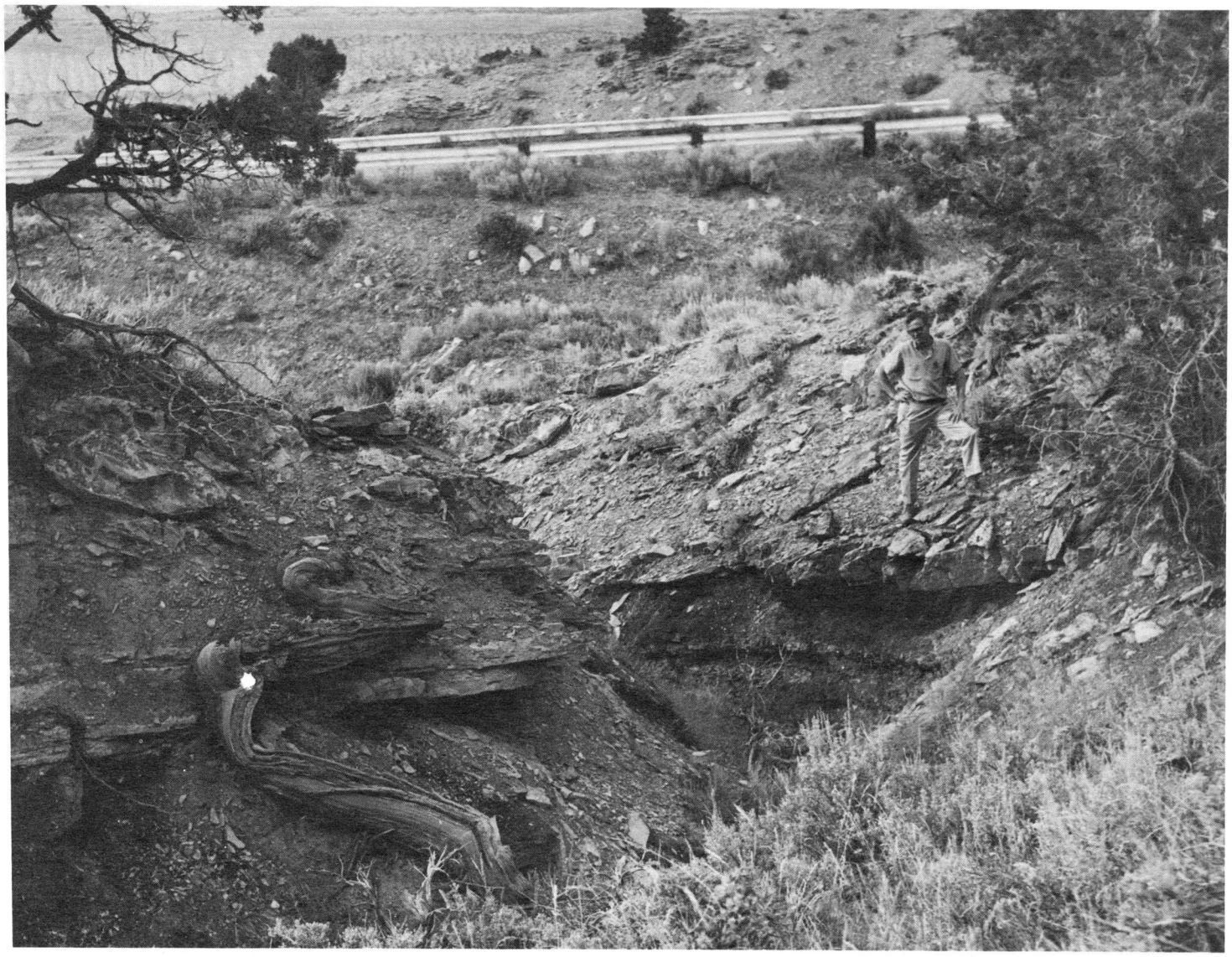


The thickest coal bed discovered in the Frontier Sandstone, Henrys Fork coal field. The bed is about 2 feet thick and located south of Antelope Flat and Utah Highway 260 on the east side of Flaming Gorge Reservoir.

HENRYS FORK COAL FIELD

by

H. H. Doelling[1]

INTRODUCTION

Location and Extent

The Henrys Fork field is a collection of small coal-bearing areas located along the north flank of the Uinta Mountains south of the Wyoming state line (Preface, figure 1a). Theoretically the length of the field is 107 miles long with a width of no more than a mile. Much of the area, however, has the coal-bearing units covered with Quaternary and late Tertiary unconsolidated or semiconsolidated debris, especially in the west 25 miles. Along much of the coal-bearing units, no coal of consequence can be demonstrated.

Topography and Drainage

The Uinta Mountains are anticlinal and form an east-west convexity in northeast Utah (figure 1). Ancient glaciers carved broad U-shaped canyons at right angles to the trend. The core of the Uintas exposes nearly homogeneous quartzites, but along the flanks hard and soft younger units are located. They are expressed as strike ridges and valleys, and occur at the position of greatest downward curvature. Farther out still younger rocks dip gently away from the mountains forming plateau landforms.

The Uinta Mountains with Kings Peak rising to 13,528 feet is the highest range in Utah. The altitude declines gradually from the crest northward to the ridges and valleys. The highest ridges rise to more than 9,000 feet and, where the stike valleys cross the glacial canyons, elevations drop to as low as 6,000 feet. The gentle slope of the south edge of the Green River Basin, constructed of the youngest rocks, is at 9,000 feet (lower in the canyons) at its ridge and valley boundary and then gradually lowers northward. Most of the coal is associated in the ridge and valley belt, some in the south edge of the Green River Basin.

Because of the Uinta Mountains' altitude, much snow accumulates on the crest in winter providing the source for many streams heading near the crest. A major canyon drainage flows north each 6 to 10 miles in the west part of the range. To the east the number of creeks is the same, but direction of flow is influenced more by ridge and valley coupled with the presence of the through-going Green River. The Green River was dammed to produce Flaming Gorge Reservoir.

Population, Industries and Transportation

The 1970 population of Daggett County was 666 and of Summit County, 5,879. The Summit County population is centered in the far west part of the county; probably less than 100 people live in the mountainous east part. The principal town of Manila, Daggett County seat, has 226 inhabitants. The remainder live at Dutch John, a support village for Flaming Gorge Dam, or are scattered in the various ranches and recreational facilities throughout the area.

Manila has tourist accommodations, as do some of the recreational sites surrounding Flaming Gorge Reservoir. Elsewhere facilities are completely lacking. The principal industries are ranching, tourism and governmental activities mainly of the Bureau of Reclamation. One or two oil and gas fields are located along the north flank, but most of the workers are permanently based in Wyoming.

[1]Economic geologist, Utah Geological and Mineralogical Survey.

There is no scheduled air or bus service into the area. The nearest railroad is the Union Pacific, 20 to 50 miles north of the area. The principal roads include Utah Highways 150, 44, 43 and 260. The first extends from Kamas in west Summit County over the Uintas at Mirror Lake northward to Evanston, Wyoming. Highway 44 joins Vernal to Manila in the east Uinta Mountains; Highway 43 and its Wyoming extensions connect Manila to Fort Bridger or Green River, Wyoming. Highway 260 links Utah 44 to the Flaming Gorge Dam and Dutch John. Several graded roads extend from Wyoming into the major canyons along the north flank.

Climate

Because of the variation in elevation, generalizations about climatic data are difficult to make. The lower areas have typical semiarid features and higher up the temperatures are cooler and precipitation increases. In general the east part is lower; during the summer warm days are expected, but nights are generally cool. In the mountainous high area, temperatures rarely exceed 80 degrees during the summer and usually cool off into the 40's or less at night. The winters are often bitterly cold and even the lower elevated areas are affected because of the frequent temperature inversions as the cool air rushes down from higher areas. Subzero temperatures are frequent.

Precipitation is mostly dependent on elevation – the higher the elevation, the more abundant the precipitation. A high occurs in winter and early spring as the passage of frontal storms deposits snow and occasionally rain. A second high occurs during late summer in the form of convectional thunderstorms. The rain is often torrential and local, causing devastating flash floods. The amount of rainfall is given on figure 2.

HISTORICAL OUTLINE

Three of the four great geological surveys of the West included the Uinta Mountains. In 1868, Powell studied the east half of the Uinta Mountains, F. V. Hayden the north slope in 1870 and Clarence King concentrated on the west half in 1869. Most of their studies had to do with stratigraphy and structure, but reports of the presence of coal also were included.

Until 1900 a few settlers moved into the area north of the mountains establishing ranches at the most favorable localities. Undoubtedly the ranchers who found thin coal seams attempted to use it for heating homes and other buildings. H. S. Gale of the U. S. Geological Survey visited the area in 1906 to study the coal of northwest Colorado and northeast Utah. His brief visit resulted in the only available reconnaissance publication of the field; no detailed investigation to the present day has been undertaken. Several other studies made along the Uinta Mountains since that time added little additional coal data. All prospecting activity for coal is believed to have stopped before World War I. Little or no production from the field has resulted.

GEOLOGIC SETTING (figure 3)

Stratigraphy

Precambrian to Tertiary sediments are exposed along the north flank of the Uinta Mountains in thirty consolidated formations (figure 4). In addition many varieties of unconsolidated

Quaternary deposits of fluvial, glacial and gravity origins occur. Six of the thirty formations have reported coal:

Wasatch Formation
Fort Union Formation
Ericson Sandstone
Rock Springs Formation
Frontier Formation
Manning Canyon Shale

Precambrian

The Precambrian units form the core of the Uinta Mountains anticlinal uplift and are exposed in a 15- to 25-mile wide zone. The Cambrian rocks crop out only in the extreme southeast corner of Daggett County on the south flank and may or may not be present in the subsurface in the north flank area.

Paleozoic

The Paleozoic is dominated by cliff-forming units of limestone, dolomite and sandstone. They form steeply dipping ridges from R. 21 E. westward except where covered by glacial moraine. The soft Manning Canyon Shale is sandwiched between cliffy units and between Henrys Fork and Sheep Creek, it contains coal beds. Its exposures continue around the west nose of the Uinta Mountains. In the west Uintas the Manning Canyon Shale consists of shale with about 11 percent limestone. In the coal area less limestone occurs and in Sols Canyon the unit is 545 feet thick. The upper 410 feet appear to be carbonaceous shale. The Manning Canyon Shale is the only Paleozoic coal bearer known in the Uinta Mountains. The Park City Formation contains medium- to low-grade phosphatic shales.

Mesozoic

On their north side Mesozoic rocks parallel Paleozoic rocks and over much of the west half of the Uintas, they are covered by Tertiary and Quaternary sediments. They are present in part from Burnt Fork (R. 17 E.) eastward. The Triassic and Jurassic sediments are not known to carry coal and are characterized by varicolored sandstone, siltstone, shale and minor conglomerate. Cretaceous units are exposed only from R. 19 E. eastward. They are, however, known to exist in the subsurface throughout the field. In the Cretaceous units, as in the remainder of Utah, are contained the more important coal beds. The oldest Cretaceous unit is the Dakota which is coaliferous in many parts of the state, especially in southwest Utah. It contains no coal in the Henrys Fork field. The following measured section describes the unit:

Section of the Dakota Sandstone on the Spring Creek nose in NE ¼ sec. 27, T. 3 N., R. 22 E., measured by W. R. Hansen and M. G. Bonilla, September 1953, *in* Hansen (1965):

	Feet
Mowry Shale: shale, dark gray, siliceous.	
Dakota Sandstone:	
Upper unit:	
Sandstone, pale yellow with rusty streaks, medium-grained, well rounded. Pink near middle of unit. Upper 5 feet are slabby and ripple marked in beds 6 to 8 inches thick, partly quartzite. Fills channels in middle member: channels have 3 feet or more of relief	91
Middle unit:	
Shale, gray, soft, sandy, in part carbonaceous	29
Lower unit:	
Sandstone, light yellowish gray, medium-grained, cross-bedded, contains cherty grit and shale pellets; base fills channels scoured in top of Morrison Formation	12
Total	132
Morrison Formation	

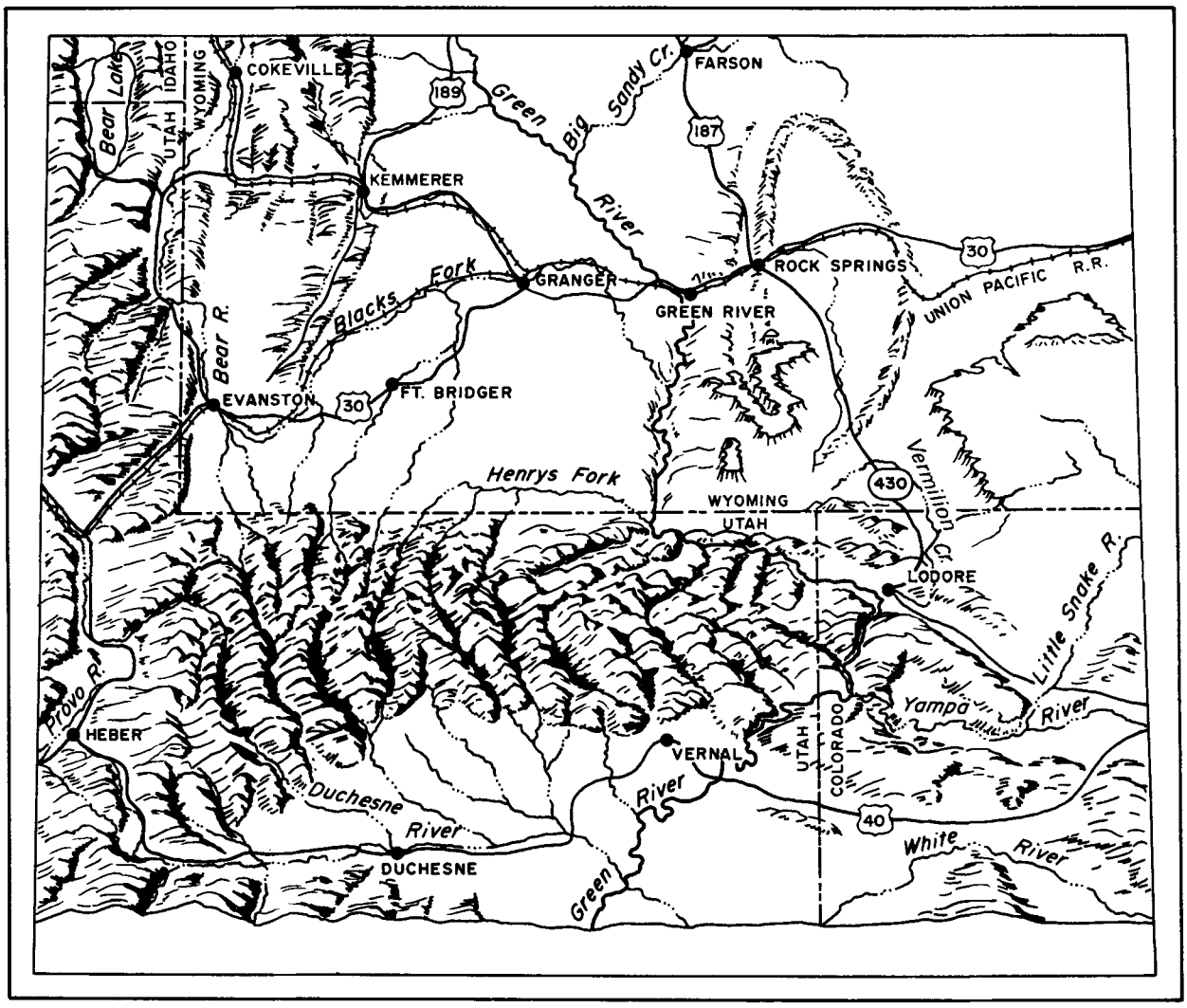


Figure 1. Physiographic map, Henrys Fork coal field and vicinity (after Knight, 1955).

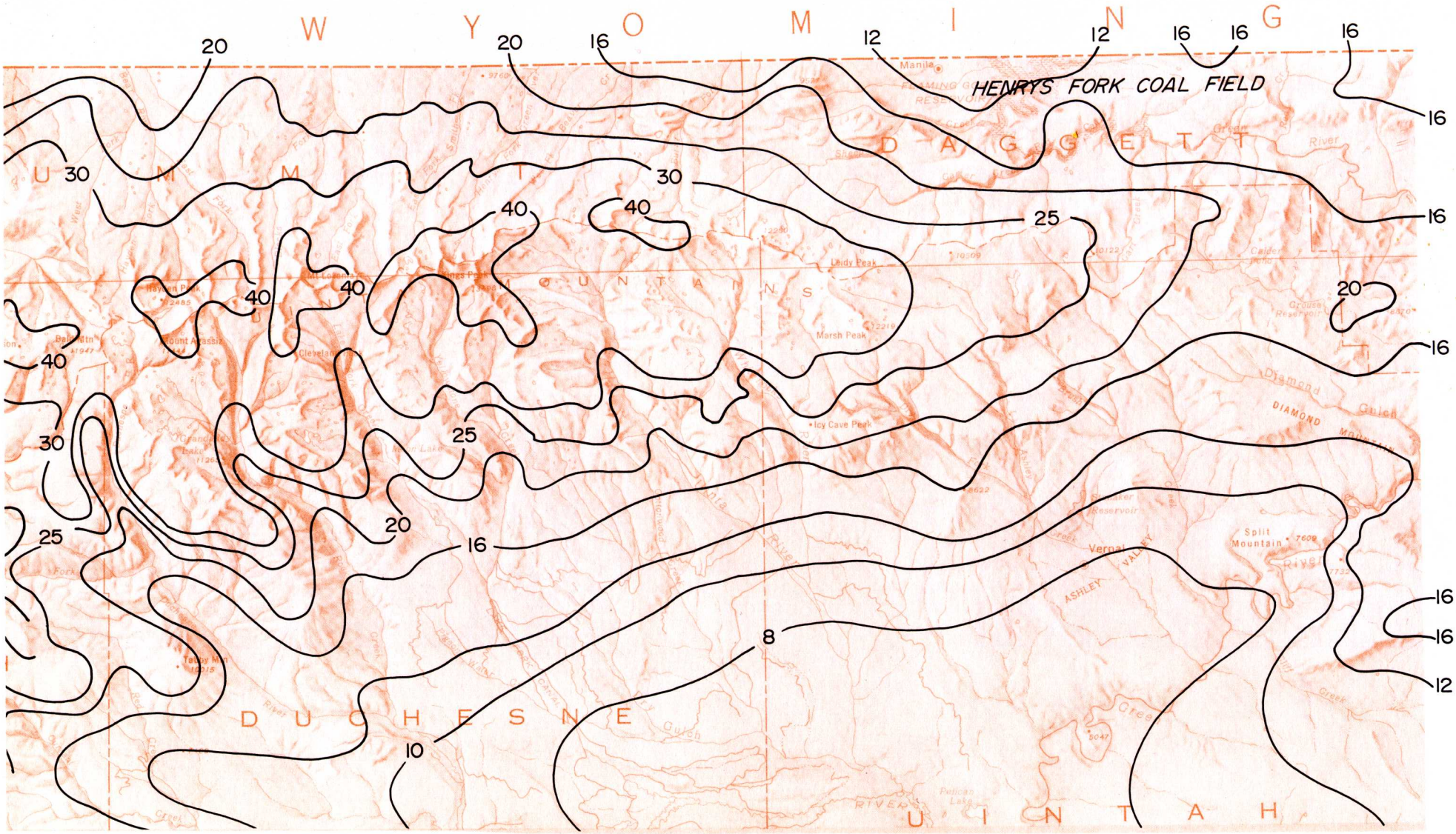
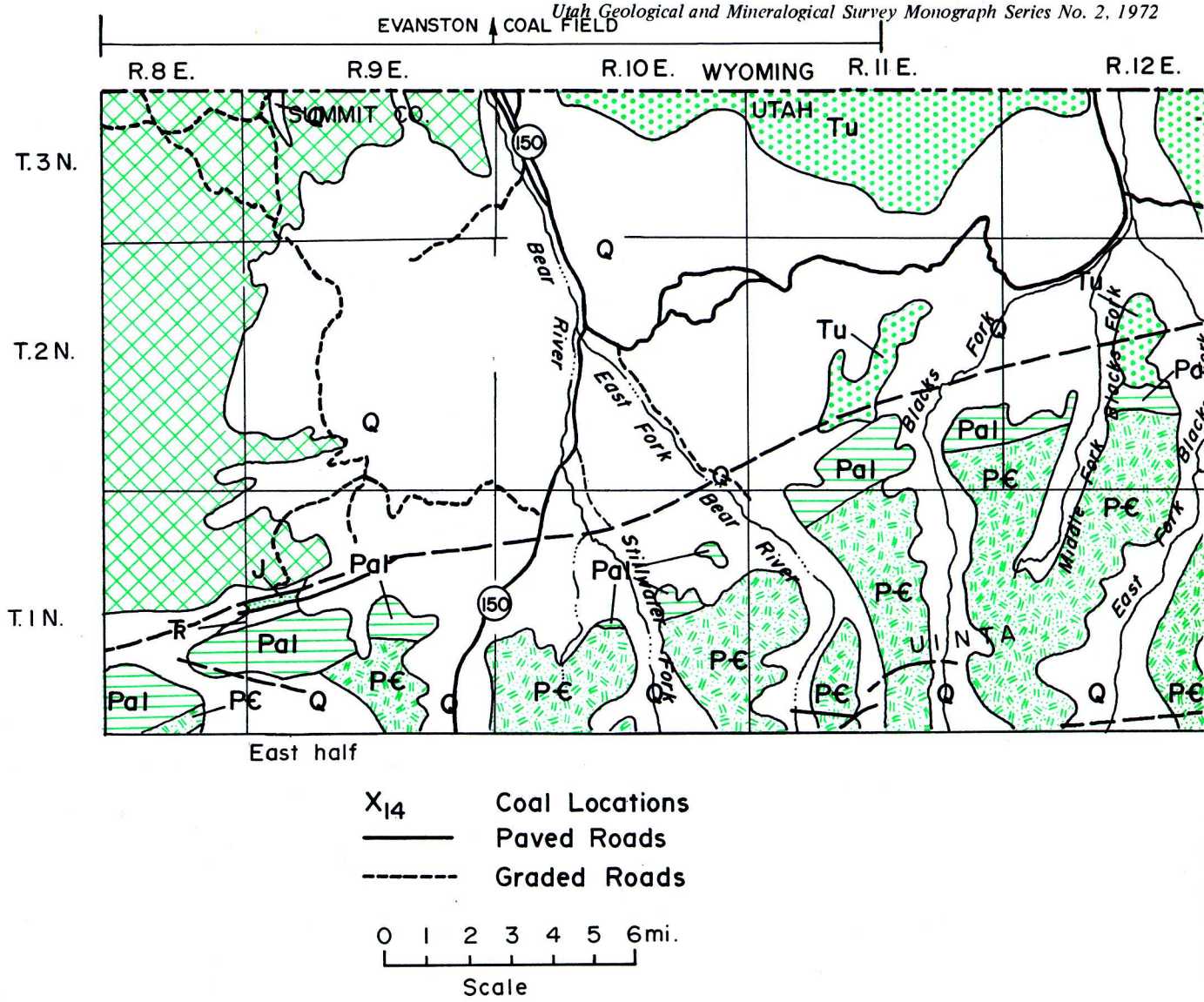


Figure 2. Precipitation map , Henrys Fork coal field.



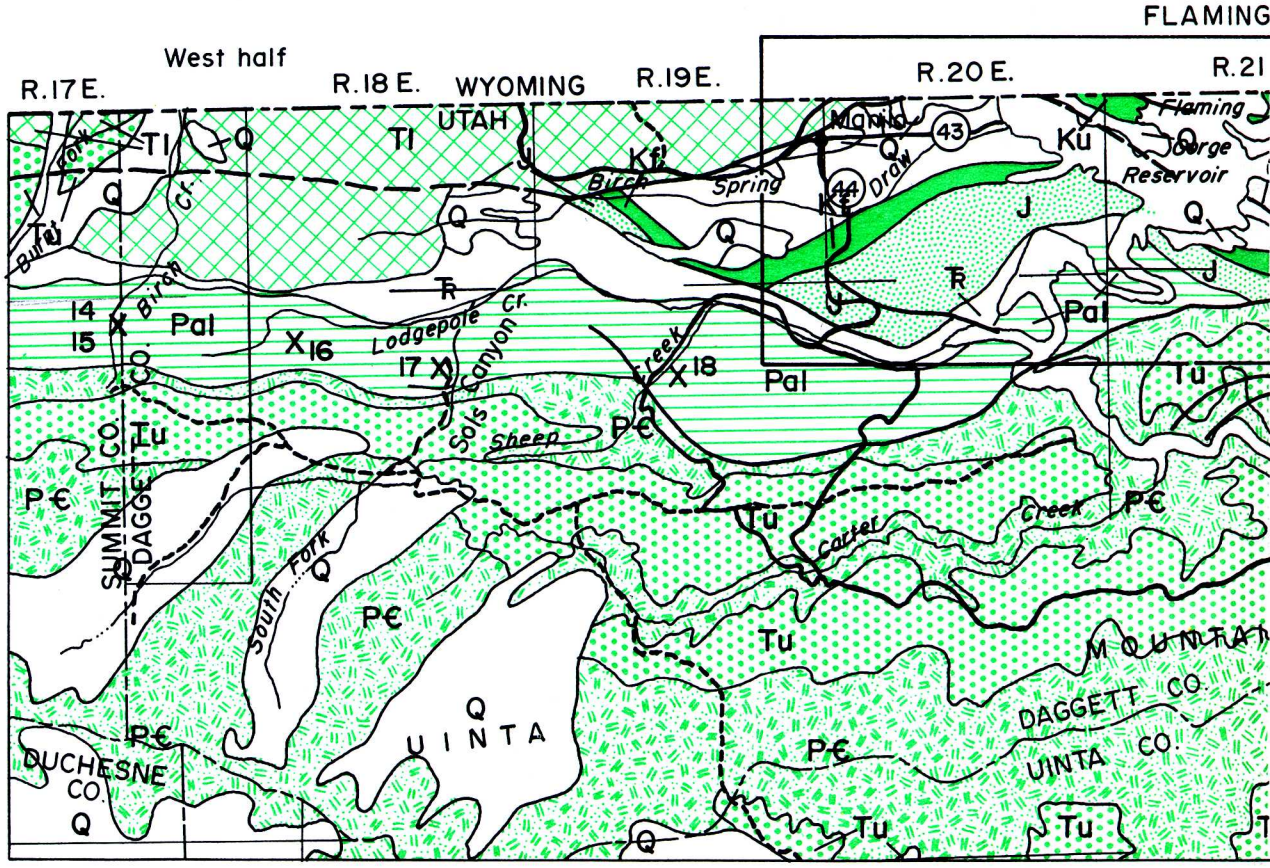
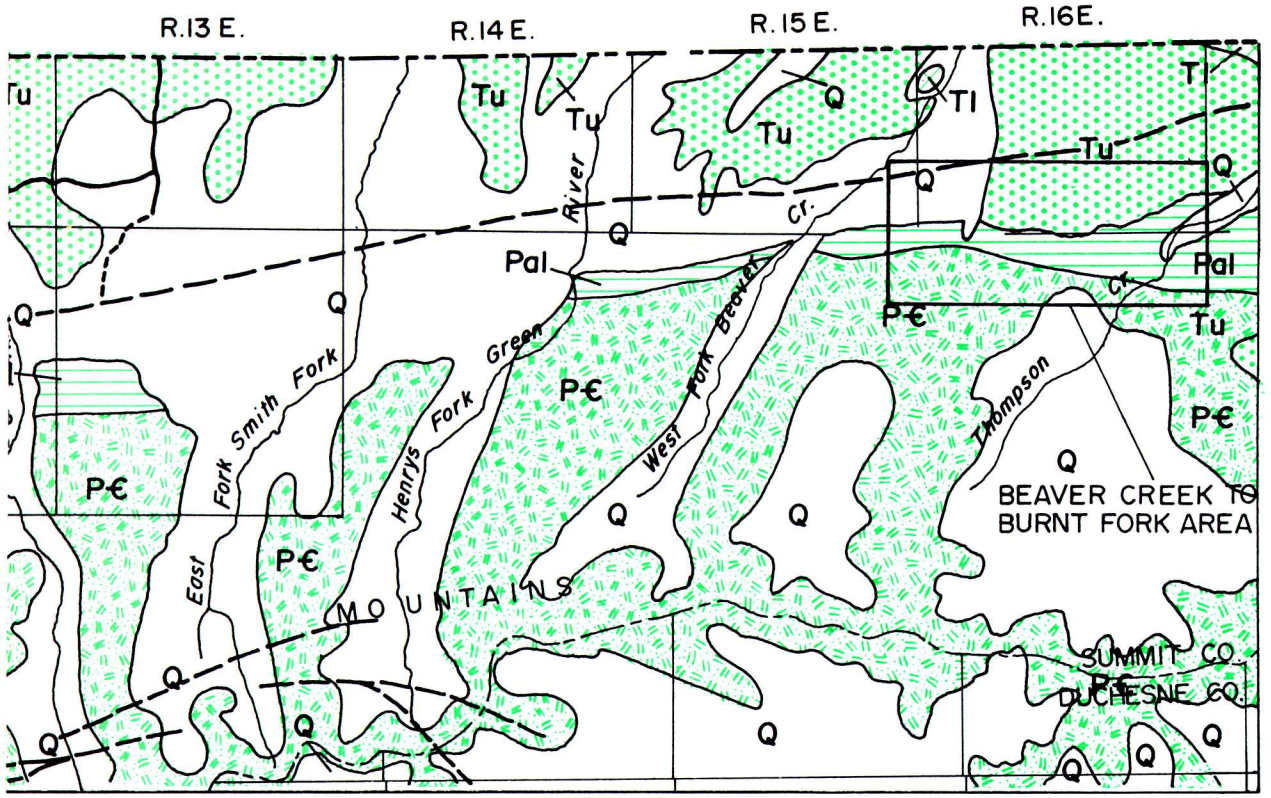
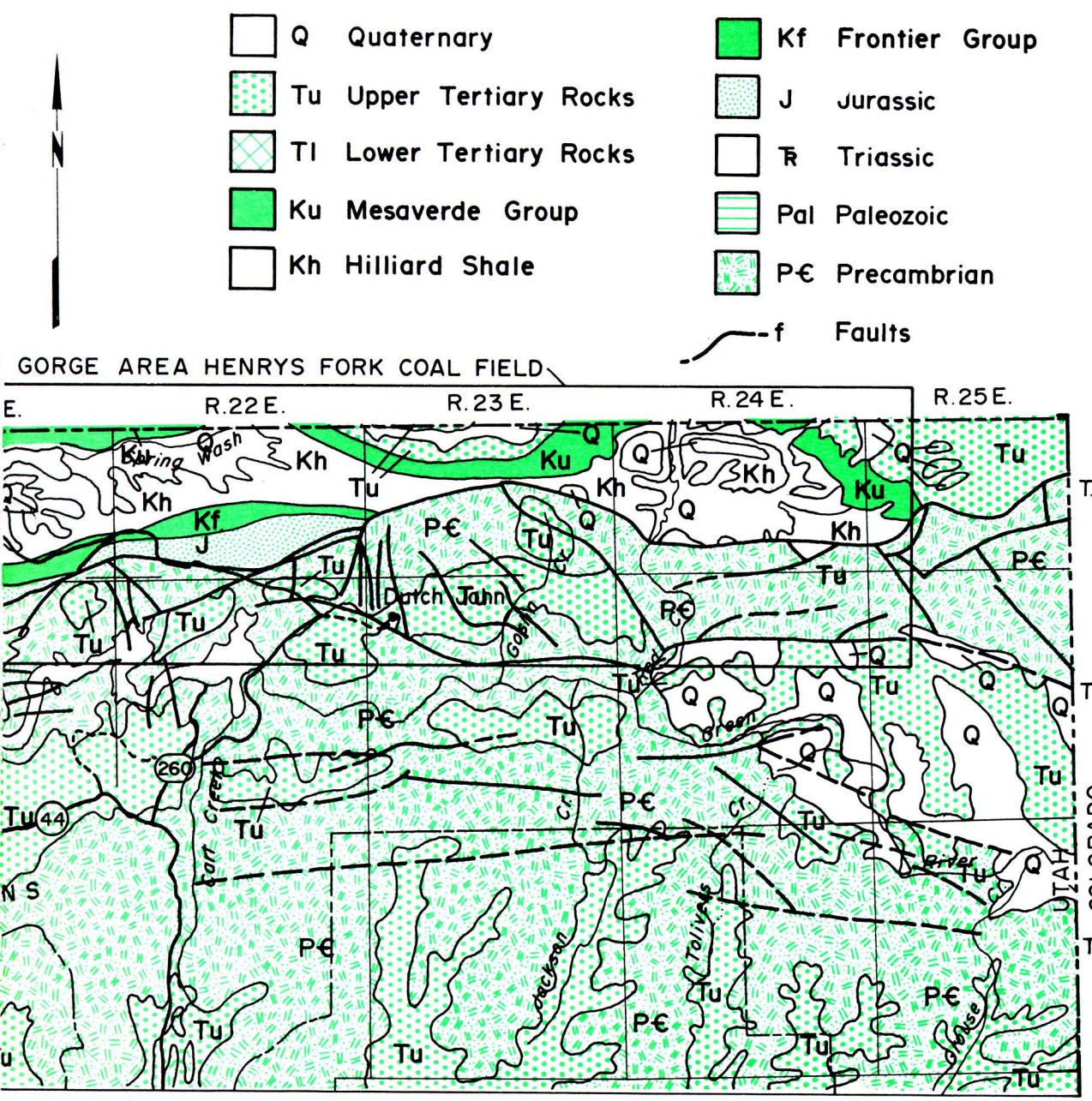


Figure 3. Generalized geology map, Henrys Fork coal field.


R.13 E.
R.14 E.
R.15 E.
R.16E.
Tu
Tl
Q
Pal
P€
Green River
Henrys Fork
East Fork Smith Fork
West Fork Beaver Cr.
Thompson Cr.
MOUNTAINS
BEAVER CREEK TO BURNT FORK AREA
SUMMIT CO.
DUCHESNE CO.


N
Q Quaternary
Tu Upper Tertiary Rocks
Tl Lower Tertiary Rocks
Ku Mesaverde Group
Kh Hilliard Shale
Kf Frontier Group
J Jurassic
TR Triassic
Pal Paleozoic
P€ Precambrian
f Faults
GORGE AREA HENRYS FORK COAL FIELD
R.22 E.
R.23 E.
R.24 E.
R.25 E.
T. 3 N.
T. 2 N.
T. 1 N.
Spring Wash
Kh
Ku
Kf
J
Tu
P€
Dutch Jann
Gobin Cr.
Red Cr.
Green River
Cart Creek
Jackson Cr.
Tolivers Cr.
Grouse Cr.
260
44
UTAH
COLORADO

System	Series	Stratigraphic Unit	Thickness (feet)	Description
TERTIARY	Miocene?	Browns Park Formation	820+	Gray to white, loose to compact tuff and tuffaceous sandstone interbedded with loosely cemented fine to coarse conglomerate, pale orange to gray siltstone and sandstone and olive-drab clay.
	Eocene	Green River Formation	600+	Chiefly dense gray limestone, some fine-grained sandstone.
		Wasatch Formation *Minor Coal*	2,000+	Red, gray and cream colored medium- to coarse-grained well cemented sandstone, conglomeratic near middle and sandy silt near base, also contains considerable carbonaceous shale and small amounts of *COAL*.
	Paleocene	Fort Union Formation *Minor Coal*	1,200-2,300	Drab claystone, shale, sandstone, *COAL*, coaley shale; conglomerate content increases upward in section.
CRETACEOUS	Campanian	Ericson Sandstone *Minor Coal*	290- 900+	Light gray to white, medium- to coarse-grained sandstone, massive, broken by a few coaley intervals.
		Rock Springs Formation COAL	0-1,090	Light gray to pale grayish orange massive fine-grained sandstone interbedded with carbonaceous shale and coal.
		Blair Formation	0- 360	Pale grayish orange massive fine-grained sandstone interbedded with dark gray shale.
	Santonian Coniacian	Hilliard Shale	6,200+	Chiefly drab gray calcareous soft shale containing occasional thin sandstone beds.
	Turonian	Frontier Formation COAL	170- 190	Upper part cream to white massive sandstone and lower gray and brown shale with occasional interbedded carbonaceous shale and coal.
				Unconformity ?
	Albian	Mowry Shale	200- 225	Dark gray fissile siliceous shale.
		Dakota Sandstone	130- 250	Upper and lower medium- to coarse-grained cross-bedded well cemented sandstone separated by carbonaceous shale. Lower unit disappears locally.
				Unconformity
	Upper	Morrison Formation	800- 940	Variegated red and gray siltstone with considerable sandstone and pebble conglomerate.
JURASSIC		Curtis Formation	145- 180	Glauconitic limestone, sandstone and siltstone.
		Entrada Sandstone	200- 245	Red and cream colored fine-grained sandstone.
		Carmel Formation	175- 331	Interbedded variegated silt and shale, gypsum and limestone.
	Lower	Navajo Sandstone	815- 840	Gray and cream colored highly cross-bedded massive sandstone.
TRIASSIC	Upper	Chinle Formation	300- 380	Varicolored siltstone, fine-grained sandstone, minor conglomerate and limestone.
	Lower	Moenkopi Formation	725	Soft shale, siltstone and sandstone.
		Dinwoody Formation	360- 530	Greenish gray soft shale and siltstone.
PERMIAN		Park City Formation	328	Upper member of gray limestone, gray dolomite, and brown sandstone; middle member of phosphatic shale, mudstone, limestone and dolomite; lower member of gray limestone, dolomite and sandstone.
PENNSYLVANIAN	Middle	Weber Sandstone	1,555	Yellow-gray, fine- to medium-grained, thickly bedded to massive cliff-forming sandstone, some cherty limestone in lower part.
	Lower	Morgan Formation	80±	Interbedded red and lavender shale, siltstone and limestone.
				Disconformity
		Round Valley Limestone	260+	Thick-bedded blue-gray cherty limestone.
MISSISSIPPIAN	Upper	Manning Canyon Formation COAL	545	Upper part mostly black carbonaceous shale and black dense limestone, lower part limy shale, thin sandstone and red clay.
				Disconformity
		Humbug Formation Deseret Limestone Madison Limestone	1,260	Massive gray cliff-forming limestone and dolomite with some limy sandstone and shaley sandstone near top.
				Unconformity
CAMBRIAN		Lodore Formation	275	Reddish quartzitic sandstone with greenish micaceous shale in upper part.
				Unconformity
PRECAMBRIAN		Uinta Mountain Group and Red Creek Complex	25,000+	Red to maroon quartzitic sandstone and white, gray, tan and pale green metaquartzite.

Figure 4. Generalized section of rock formations, Henrys Fork coal field.

The Dakota forms a slight hogback where well exposed. The Mowry Shale overlies the Dakota and is a slope former forming a swale between the units above and below. It is easily recognized by its weathering characteristic – it often disintegrates into splinter-like or platy chips that have a silver-gray color. The Mowry unit also contains layers of porcelanite and bentonite and the weathering chips often bear teleost fish scales.

Section of Mowry Shale in the NE ¼ sec. 27, T. 3 N., R. 22 E., about 1 mile east of Dutch John Gap, measured by M. G. Bonilla and W. R. Hansen, September 1953, *in* Hansen (1965):

Frontier Formation: shale, brownish, gray, soft, silty.

Mowry Shale:	Feet
Shale, dark gray to bluish gray, fissile	3.5
Bentonite	2.5
Shale, dark gray to bluish gray, fissile	17.0
Bentonite	4.0
Shale, dark gray to bluish gray, fissile, prominent porcelanite bed forms break in slope 21 feet below top. Many interbeds of porcelanite. Occasional impressions of *Inoceramus and Neogastroplites*. A bed of bentonite 16 inches thick 9 feet above base	194.0
Total	221.0

Dakota Sandstone: sandstone, pale yellow.

The next ridge former is the Frontier Formation, one of the coal bearers of the Henrys Fork coal field. The Frontier consists of two members, a lower shaley unit and an upper sandstone unit. The shaley unit does not contain the distinctive silver-weathering chips and splinters of the Mowry and weathers to a brown-gray. The shales are often carbonaceous, especially near the top, and contain thin beds of coal. The sandstone unit often has more than one layer of massive sandstone and carbonaceous shale with possible lignitic and coaley layers in between. The coal in the Frontier of the Henrys Fork field appears to be discontinuous and only locally present. The thickest beds have been discovered just east of Flaming Gorge Reservoir near Antelope Flat.

Section of the Frontier Formation 1.1 miles due south of Linwood in SE ¼ sec. 23, T. 3 N., R. 20 E., measured by W. R. Hansen and T. B. Piper, August 1951, *in* Hansen (1965):

Hilliard Shale: shale, dark gray, soft, fissile.

Frontier Formation:	Feet
Upper unit:	
Sandstone, cream colored to almost white, fine-grained, well sorted, massive. Forms crest of hogback and long dip slope	23
Lower unit:	
Shale, interbedded light and dark gray; coal horizon near top, but coal lacking in this section. A few poorly preserved pelecypods just below coal level. Scattered gypsum crystals	83
Sandstone, light brown, friable	8.3
Clay-shale, dark gray, carbonaceous	10
Shale, dark gray; interbedded with thin-bedded sandstone	5.9
Sandstone, buff, fine-grained, poorly cemented, irregularly bedded	8.5
Shale, buff, sandy	52
Total	190.7

Farther west toward Manila and farther east on the Spring Creek nose, the upper unit is considerably thicker.

Section of the Frontier Formation on Spring Creek nose in NE ¼ sec. 27, T. 3 N., R. 22 E., measured by W. R. Hansen and M. G. Bonilla, September 1953, *in* Hansen (1965):

Base of Hilliard Shale

Frontier Formation:	Feet
Upper unit:	
Sandstone, gray, fine-grained, cross-bedded, contains shale beds 0.5 to 1.0 feet thick	8
Sandstone, light brown to almost white, flaggy, fine-grained, shale interbeds toward top	83
Sandstone, light brown to cream colored, massive	20
Lower unit:	
Shale, dark gray, interbedded with fine-grained gray sandstone. Upper 18 feet mostly fine-grained gray thin-bedded sandstone containing casts of *Inoceramus*	60
Total	171

Top of Mowry Shale.

The Hilliard Shale overlying the Frontier is the counterpart to the Mancos Shale south of the Uinta Mountains. The Cretaceous sea which deposited both Hilliard and Mancos sediments was a single body and covered the then nonexistent Uinta Mountains. The Hilliard shows the same west to east pattern as does the Mancos and illustrates the spasmodic eastward retreat of the sea with eastward-projecting sandstone tongues each extending farther east toward the top of the unit (figure 5). The Hilliard is mostly gray silty shale with occasional lenses of light brown or tan sandstone beds. The unit exceeds 6,000 feet in thickness and forms a wide valley in most places where it is fully exposed.

The remaining Cretaceous units constitute the Mesaverde Group and are exposed in a ridge known as the Glades just south of the Wyoming line in Daggett County. The ridge extends from R. 20 E. to R. 25 E., a distance of about 25 miles. At two places, however, for a distance of 3 miles each, the ridge bends into Wyoming (Minnies Gap and Richards Gap). All have similar lithologic characteristics, cliff-forming sandstone interbedded with shale. In Utah the lower Blair Formation is devoid of coal. The Rock Springs has coal beds which thicken westward and the Ericson contains thin coal beds in the easternmost exposures. The full description of the units is given in the following measured sections.

Section of the Blair Formation at west end of the Glades in SE ¼ sec. 16, T. 3 N., R. 21 E., measured by W. R. Hansen and M. G. Bonilla, August 14, 1952, *in* Hansen (1965):

Rock Springs Formation: shale, brown, soft, punky, coal bed at base.

Blair Formation:	Feet
Sandstone, gray to rusty, fine-grained, friable; beds 4 to 6 inches thick; well jointed; limonitic concretions at top	6
Shale, dark gray, marine, gypsiferous; a few very thin sandstone beds	9
Sandstone, very pale orange; middle third is yellowish gray (5Y 8/1). Fossil bone fragment near base	110
Shale, dark gray, marine; thin sandstone partings	16
Sandstone, mottled light grayish orange, fine-grained, cross-bedded, forms irregular outcrop containing weathering cavities	37
Sandstone, moderate yellowish brown, fine-grained, cross-bedded. Very dark desert varnish. Base irregular; channels with 10 feet of relief. Top an even plane. Conspicuous dark outcrop	17
Sandstone, light grayish orange, massive, fine-grained, upper 35 feet partly covered	67
Shale, light gray, silty; contains thin sandstone beds	18
Sandstone, light grayish orange (10YR 7.5/3), fine-grained, even-bedded	3
Shale, dark gray, silty, contains thin evenly bedded sandstone; weathers light gray in lower 16 feet and light tan in upper 40 feet	56
Sandstone, very pale orange, fine-grained, cross-bedded, massive, fairly well sorted; subangular grains. Pinches out a quarter of a mile to the east	12
Total	351

Hilliard Shale: shale, dark gray, silty, gypsiferous, even-bedded; contains fine-grained light brown calcareous sandstone.

Section of the Rock Springs Formation in SE ¼ sec. 16, T. 3 N., R. 21 E., measured by W. R. Hansen and M. G. Bonilla, August 14-16, 1952, *in* Hansen (1965):

Ericson Sandstone: sandstone, medium-grained, contains dark chert grains.

Rock Springs Formation:	Feet
Shale, brown, punky; occasional sandstone beds	26
Sandstone, light gray, fine-grained, massive; limonite strains	7
Shale, brown, punky; contains abundant carbonized stem and amber; 36-inch coal bed 1 foot above base; 30-inch coal bed 21 feet above base. Beds or lenses of ironstone near middle contain plant and leaf fragments. Upper 15 feet a transition zone containing interbedded shale and sandstone. Very rusty, reddish brown bed at top	96

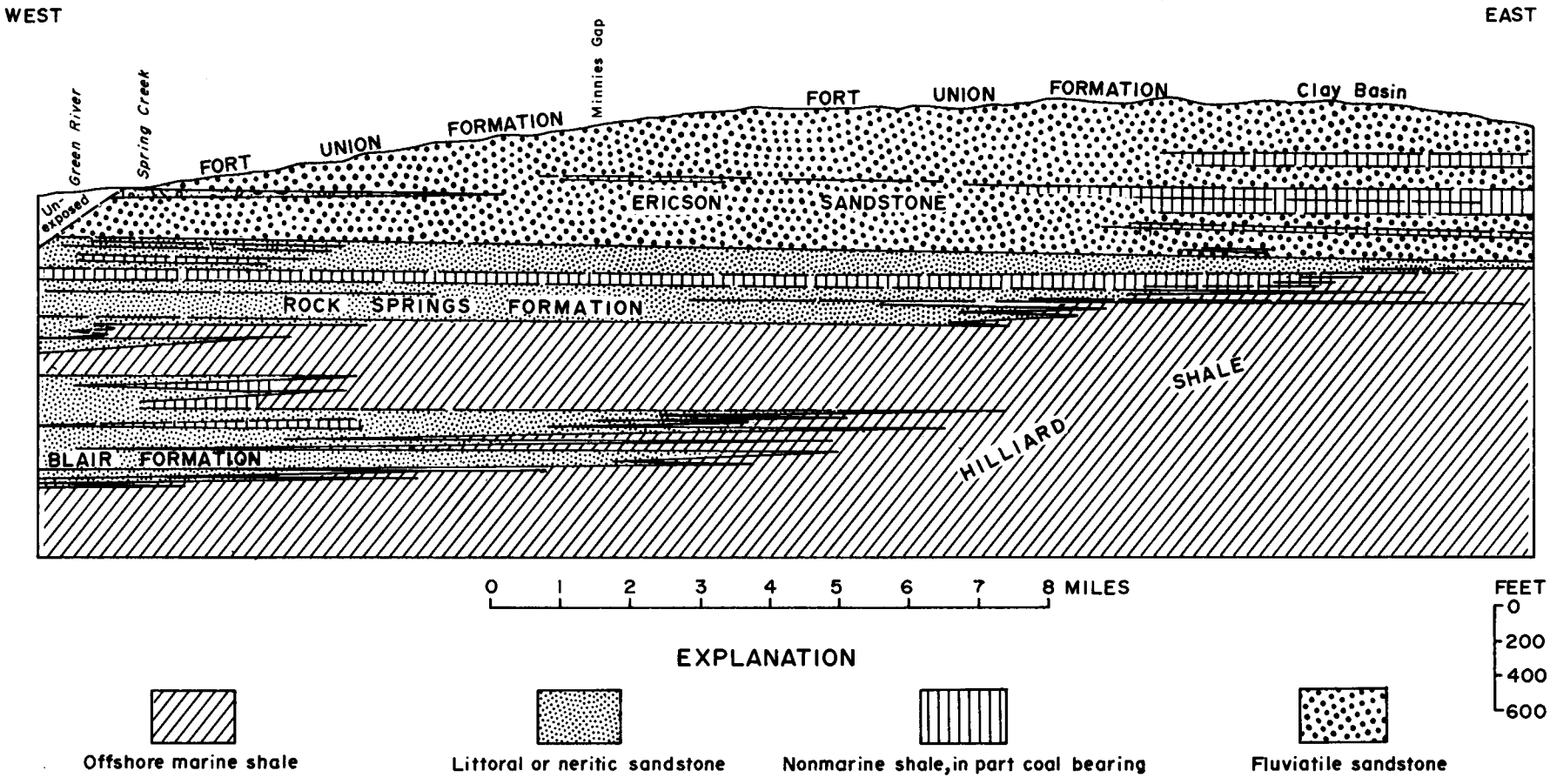


Figure 5. Diagrammatic relations of Hilliard Shale to Blair, Rock Springs and Ericson formations (from Hansen, 1965, p. 102).

Sandstone, almost white but containing rusty streaks; fine-grained, cross-bedded; occasional carbonaceous partings. Upper 7 feet are thin-bedded, even-bedded, very fine-grained and contain "tractor-tread" ripple marks. Shale partings 35
Sandstone, gray to brown, soft, fine-grained, carbonaceous. Interbedded punky shale beds toward top 38
Shale, brown, punky; 12-inch coal bed 3 feet above base, thin coal seams (about 6 inches thick) near middle. Grades upward into brown sandstone 44
Sandstone, pale whitish yellow, fine-grained, even-bedded 4
Sandstone, rusty brown, even-bedded, fine-grained, fresh exposures are light grayish orange 31
Shale, dark brown, punky. Coal bed 1 foot thick, 8 feet below top 25
Sandstone, rusty, thin-bedded 4
Shale, punky, coal bed 1 foot thick 3 feet above base 14
Sandstone, almost white but containing rusty streaks; very cross-bedded. Highly sculptured outcrop; many small cavities. Punky shale partings 4 to 5 feet thick near middle. Bedding of sandstone contorted in places 59
Shale, punky; contains a few thin sandstone beds near top 14
Sandstone, light gray, fine-grained, cross-bedded 8
Shale, brown, punky; 1½-foot coal bed 3 feet above base 7
Sandstone, light gray, even-bedded, fine-grained 4
Shale, brown, punky; 1-foot coal bed 5 feet above base, 1½-foot transition zone of sandstone and shale at top 11
Sandstone, light gray but containing rusty streaks; massive; fine-grained, hard. Channeling at base. Forms rounded outcrop 29
Shale and sandstone; punky brown shale containing thin rusty brown sandstone layers; carbonaceous layers 37
Sandstone, light gray, fine-grained, indistinct but even-bedded 6
Coal, bituminous 3
Shale, brown, punky, carbonaceous 7
Sandstone, light gray, a transition zone between units above and below. Contains thin carbonaceous shale partings 17
Sandstone, white but containing rusty and greenish gray streaks; fine-grained, cross-bedded; forms conspicuous outcrop. A punky shale break 1½ feet thick 90 feet above base. At the base of the unit are abundant sandstone "tubes" some several feet long and gently curved, some with branches, some parallel to and some across bedding 162
Sandstone, light grayish orange, even-bedded, a transition zone between units above and below 24
Shale, gray, marine (unlike punky paludal shales) 96
Sandstone, light grayish orange to rusty, fine-grained, even-bedded; beds a few inches to several feet thick 32
Covered interval. Appears to be mostly gray marine shale. Sandy toward top 171
Sandstone, yellowish gray, friable, even-bedded 12
Shale, brown, punky; thin coal seam 3 feet above base 12
Sandstone, pale grayish orange, fine-grained, very cross-bedded 24
Shale, brown, punky, a few thin sandstone beds 10
Sandstone, light gray to grayish orange, fine-grained, thick-bedded 3
Shale, brown, soft; punky toward base. Abundant carbonaceous plant impressions 19
Clay, carbonaceous 0.5
Coal 1.5
Total 1,093

Blair Formation

Section of Ericson Sandstone near center of sec. 16, T. 3 N., R. 21 E., measured by M. G. Bonilla and W. R. Hansen, August 16, 1952, *in* Hansen (1965):

Fort Union Formation
Unconformity
Ericson Sandstone — Feet
Sandstone, light gray, coarse-grained, cross-bedded 29
Conglomerate, gray; subrounded pebbles of chert, quartz, and occasionally limestone, mostly less than 1 inch across. Sandstone lenses in upper 6 feet 35
Sandstone, white, fine-grained 39
Sandstone, gray; contains coarse granule conglomerate 4
Sandstone, containing shale wafers 2
Sandstone, very pale orange to yellowish orange, darker on weathered outcrops. Alternate stringers of fine and coarse sand. Conglomeratic lenses 2 feet thick at base containing wafers of gray siltstone and a quartzite cobble 6 inches in diameter. Bedding very channeled 62
Sandstone, coarse-grained, lenticular, cross-bedded; contains black chert grains and quartz. Wedges of varying thickness 60
Shale, dark gray, flaky. Contains rolls and balls of deformed sandstone 8
Sandstone, medium-grained, cross-bedded, contains dark chert grains. Coarse-grained lenses, foresets from northeast. Upper 17 feet very channeled; shale fillings in some channels 48
Total 287

Rock Springs Formation

Cenozoic

Lower Tertiary rocks extend into Utah at the surface in a few places in the east part of the field. In the far west the sequence is mostly embodied in what is known as the Knight Formation, but herein termed the Wasatch. The Wasatch consists of interbedded conglomerate and conglomeratic sandstone. From R. 10 E. to R. 25 E. the Wasatch is not exposed and is either covered by younger sediments or eroded back into Wyoming. In between, the Wasatch of the west undergoes a facies change and splits into two units: the lower Fort Union Formation and the overlying Wasatch. Both contain minor coal beds in Daggett County. The relationships along with adequate descriptive material for the Wasatch and succeeding lower Tertiary formations is given in figure 6.

The upper Tertiary is represented by a single consolidated formation known as the Browns Park Formation. Some writers have subdivided the unit into the Bishop Conglomerate and Browns Park Formation. In this report they are grouped although they were deposited on different erosion surfaces. The formation appears as large patches exposed mainly on the Precambrian quartzites.

Pleistocene glacial deposits occur in all major canyons of the Uintas west of Manila and have covered many older rock exposures. Alluvium fills the lower reaches of the principal drainages below the glacial moraines. In addition the presence of bench gravels, talus and landslides in patches is expected throughout the area.

Structure

The highly complex structure of the north flank of the Uinta Mountains is little understood. At the surface most of the coal-bearing units dip sharply to the north and often are cut by faults of all types and degree of displacement. Some of the general structural features are described by Ritzma (1969, p. 61):

> The Uinta Mountains can be described as a hard structural plateau with oversteepened flanks on [the] north and south. Nearly horizontal Precambrian beds form the crestal portion of the fold with dips increasing outward toward the flanks. Oversteepening of the broad sigmoidal flank folding usually takes the form of reverse faulting. The effect is that of outward mushrooming of the Uinta anticline.

Ritzma (1971, p. 145) continued further:

> A complex system of faults forms the boundary between the Uinta Uplift on the south and the several adjacent basins and uplifts which lie to the north and northeast. Four major faults and innumerable associated faults of lesser magnitude make up this 200-mile long system. Along the entire mountain flank these faults are high-angle reverse or low-angle overthrust faults which carry the Uinta Uplift upward and outward, elevating it and causing it to override the margin of the adjacent and subjacent basins and lesser uplifts.

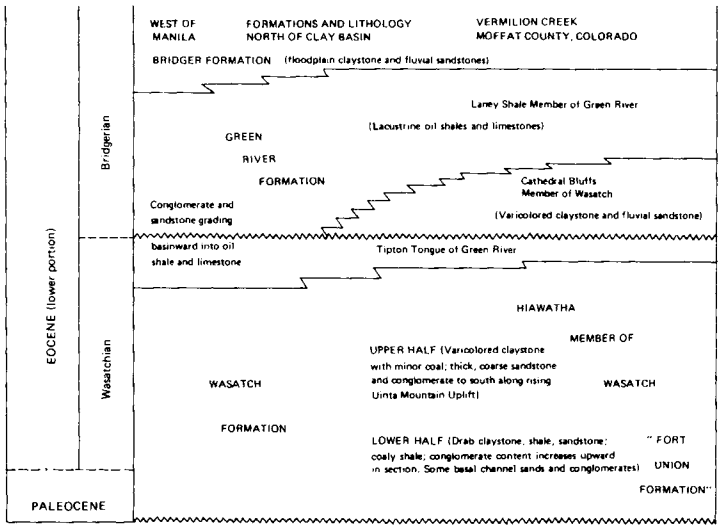


Figure 6. Diagrammatic section showing relationship of early Tertiary formations along north flank of Uinta Mountains (after Ritzma, 1959).

It is beyond the purpose of this report to describe most of these faults. Figures 7 to 9 developed by Ritzma illustrate what may happen at depth. The measured coal dips steeply and may be cut off by subsurface faults with the displaced portion so deep as to remove the resource from any possibility of extraction. This limits the retrievable resource to the immediate area of the outcrop. To the north in Wyoming, the coal-bearing beds are deeply buried under the Green River Basin except where local uplifts bring them close to the surface. Two such areas are the Rock Springs uplift where the coal is well developed and forms the basis of the Rock Springs coal field and in the western Wyoming thrust belt. Coal beds in the thrust belt are in the Kemmerer and Evanston coal fields of Wyoming. In the Evanston field the coal beds become buried under Pliocene and Pleistocene unconsolidated debris a short distance north of the Wyoming border with the structural lineaments trending toward Utah.

Geologic History

Throughout most of geologic history the area has been one of subsidence and sedimentation. Events in the Precambrian are hazy and little known, but most of the sediments are believed to have been deposited in a gradually subsiding basin under a shallow sea. During the early Paleozoic the area was elevated so as to receive little or no sediment. Perhaps a considerable amount of Precambrian rock was eroded in a broad uplift. Subsidence and marine conditions returned to the Uintas in the late Paleozoic. Mostly limestones and dolomites were deposited offshore. At the time of the Manning Canyon the sea became shallow and some lagoonal coal swamps developed, at least in part of the area.

The Triassic and Jurassic units were deposited either under shallow marine conditions or under marginal marine conditions. The few exceptions are in the Chinle (fluvial and lacustrine), Navajo (aeolian) and Morrison (fluvial). Little sedimentation or erosion is assumed to have taken place between Morrison and Dakota time. The Dakota is represented by a thin blanket of fluvial, paludal and perhaps littoral sediments. After the Dakota the Cretaceous sea swept across the area from east to west. Sandstone tongues swept eastward on occasion as a result of tectonic activity far to the west and occasionally some lagoonal activity produced coal beds. But for the most part the environment was offshore marine. When the sea retreated, marine offshore environments were replaced by nearshore, lagoonal and fluvial conditions in succession. The lagoonal sedimentation related to the marine invasion provided the area with its most important coal deposits.

The early Tertiary was dominated mostly by fluvial and lacustrine conditions. The Laramide orogeny struck the area sometime between the deposition of the Ericson and Fort Union formations. Several unconformities in the early Tertiary indicate orogenic pulsations. After the deposition of the Green River Formation the area slowly emerged and erosion and attendant minor faulting took place. During the Pleistocene glaciation covered the mountains and glacial moraines were deposited around the flanks.

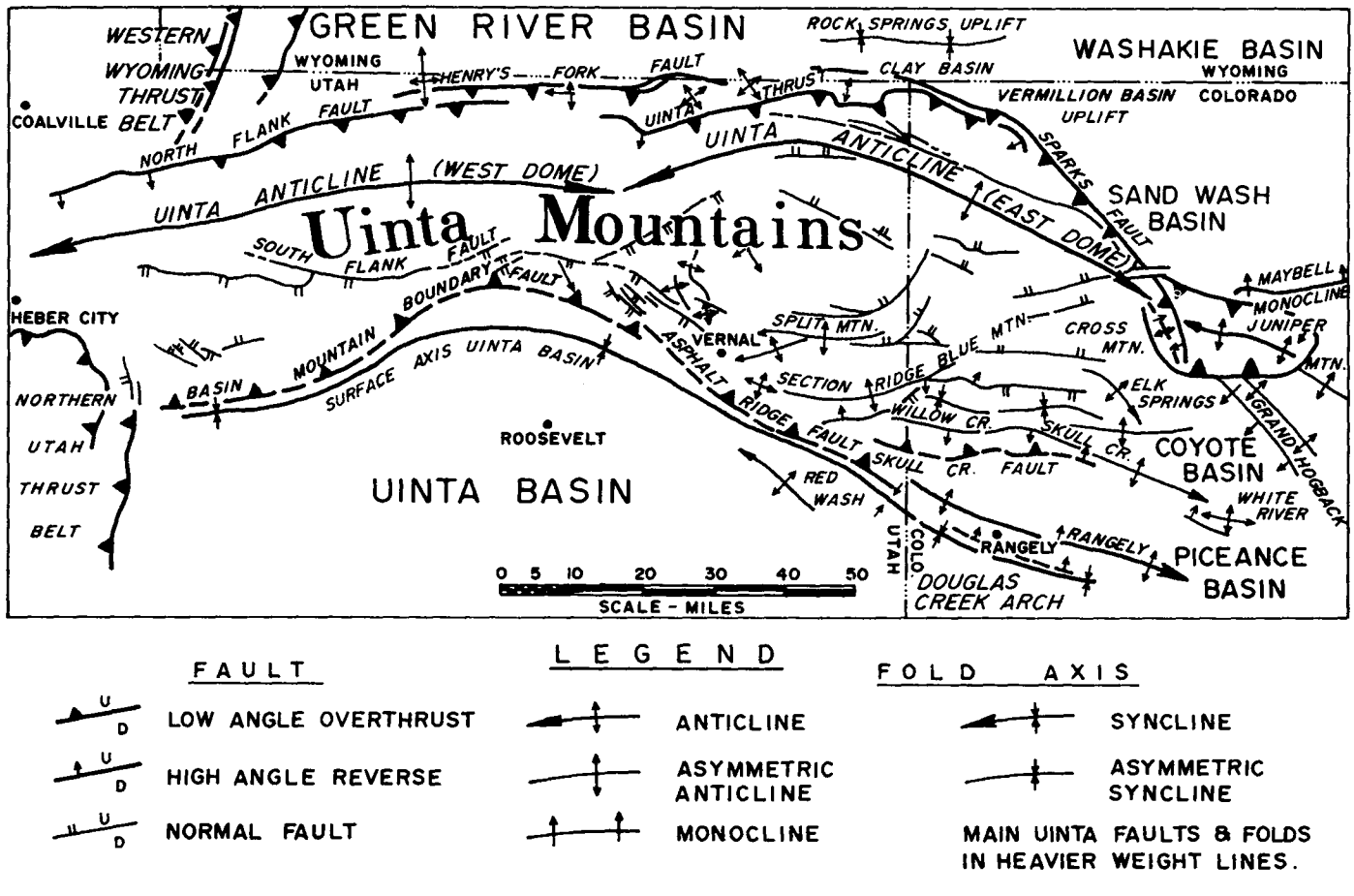


Figure 7. Generalized tectonic map, Uinta Mountains (after Ritzma, 1969).

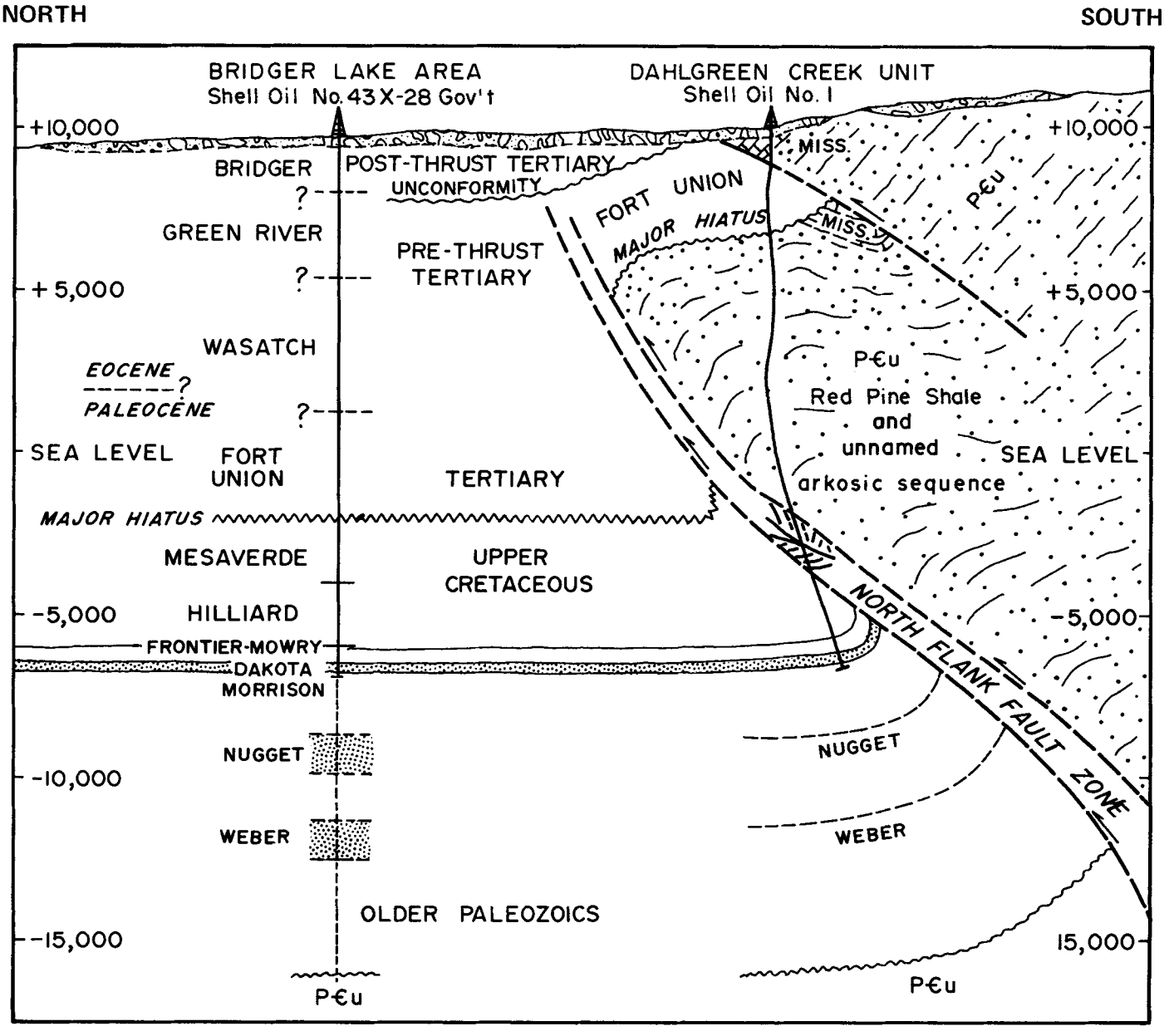
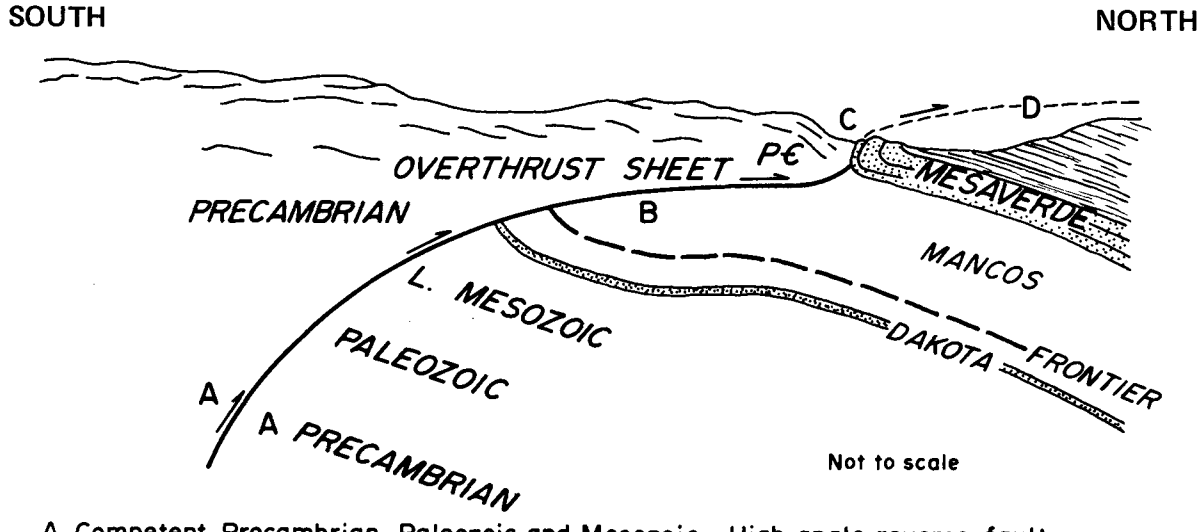


Figure 8. North-south section of Bridger Lake-Dahlgreen Creek, normal to north flank fault (after Ritzma, 1971).



A. Competent Precambrian, Paleozoic and Mesozoic – High angle reverse fault.

B. Incompetent Cretaceous shales – Shallow thrust.

C. Thrust encounters competent Mesaverde sandstones – Fault steepens. Note drag.

D. Shallow thrust across incompetent Tertiary claystones.

Figure 9. Diagrammatic north-south cross-section, north flank of the Uinta Mountains in eastern Daggett County (after Ritzma, 1969).

Correlation with Surrounding Areas

Figure 10 compares the north Uinta Mountains area with surrounding areas. The locations proceed clockwise around the Uinta Mountains. The Coalville column is representative of the Coalville coal field and the Kemmerer area is representative of the Kemmerer and Evanston coal fields and the west part of the nôrth flank. The Rock Springs uplift is the center of the Rock Springs coal field and the column is similar to that in Daggett County, Utah. Vermilion Creek is at the east end of the Uinta Mountains in Colorado. The Vernal coal field is centered near the Asphalt Ridge area along the south flank of the Uinta Mountains toward the east end. The Red Creek location is the center of the Tabby Mountain coal field near the west part of the south flank.

The Manning Canyon Shale is exposed on all sides of the Uinta Mountains and probably was deposited as a continuous blanket across north Utah. Coal occurs in the Henrys Fork field and near Vernal and thin beds have been reported from the Oquirrh Mountains in west Utah.

The early Tertiary units also are represented on the south flank of the Uinta Mountains and these also carry minor coal seams.

COAL DEPOSITS

Status of Information

Although several stratigraphic studies especially in the Daggett County part of the area are available, no comprehensive study of coal has been undertaken in the Henrys Fork coal field. Gale (1909 and 1910) made an early reconnaissance study and Hansen (1965) made a comprehensive geologic study of the Flaming Gorge area in which he noted the presence of coal seams.

Mines, Prospects and Production

Table 1 includes only those prospects known in Utah. All are in the Mississippian Manning Canyon Shale. Coal mines and prospects in the field also occur in the Rock Springs Formation, but all of these are in Wyoming. Hansen (1965, p. 182) notes that coal was once extracted from a mine just north of the Wyoming line in the Rock Springs Formation, just north of 15-3N-20E. The entry to the mine was caved and was afire at the time of Hansen's visit.

Table 1. Prospects of the Henrys Fork quadrangle.

Prospect	Location	Remarks
Sols Canyon	SW.11-2N-18E Exact location unknown	Period of activity unknown
Birch Creek	SW.3-2N-17E Exact location unknown	Activity unknown very early
Coal Mine Hill No. 1	NW.NE.4-2N-16E 4,532,380m.N. 573,300m.E.	Activity unknown; very early
Coal Mine Hill No. 2	NW.NW.4-2N-16E 4,532,550m.N. 572,310m.E.	
Lodgepole	NE.8-2N-18E Exact location unknown	Activity unknown; very early

The Manning Canyon prospects are all old and all activity probably ceased prior to World War I. Little coal was removed judging from the description of them by the various investigators.

Land Ownership

All of the Manning Canyon Shale outcrops are on National Forest Service lands. The area surrounding Flaming Gorge Reservoir is a recreational area administered by the NFS. The Frontier outcrops south of Manila are private property. Most of the area east of the reservoir along the Mesaverde outcrops is Bureau of Land Management land. A small amount of state of Utah and private land also is involved in this sector. The arrangement and location of these properties is shown on figure 11.

Currently (1970) no leases or permits are held for coal nor are any private lands thought to be held to extract coal.

Quality of Coal

No analyses are available for the Tertiary and Cretaceous coals. Those in the Tertiary are suspected of being subbituminous or lignitic and those in the Cretaceous are thought to be high-volatile C bituminous coals. The two available analyses for the Mississippian coal show much variation, especially in calorific value and sulfur content. One analysis indicated 5.2 percent sulfur, the next 0.52 percent. Btu/lb were 8,870 and 12,550 for as-received coal. Gale (1910, p. 235) states that the coal at the Edward prospect was tested by the Union Pacific Railroad and reported to be of good coking quality. This has not been verified. Table 2 lists individual analyses for the coal field.

Reserves

There are no reserves in the measured, estimated or inferred categories for coal in beds 4 feet or more thick; that such beds exist except locally is doubtful. The thickest known occurrences are inundated by the Flaming Gorge reservoir. Reserves from small and local areas of coal beds averaging 14 inches to 4 feet certainly could be developed if the need arose.

Coal Seams

The first of the three coal areas in the Henrys Fork coal field is the Flaming Gorge area which extends from Manila eastward to the Colorado line. This is the area of Cretaceous and Tertiary coal beds. The second extends from Sheep Creek Canyon westerly to Beaver Creek (R16-19E) and involves the coal of the Manning Canyon Shale. The third suggests the extension of coal from the Evanston coal field in Wyoming into the northwest corner of the field (R8-10E).

Flaming Gorge Area (figure 12)

Gale (1909, p. 313) reports the presence of coal beds in the Tertiary strata at a number of localities along the north side of Henrys Fork in Wyoming (figure 12; location 1). These coal beds are in the Wasatch Formation and Fort Union Formation. Ritzma (1959, p. 40) in his discussion of Daggett County reveals that the Wasatch contains minor coal and the Fort Union contains considerable carbonaceous shale and small amounts of low-grade coal. No locations were measured for this coal in Utah and the outcrop area is relatively small.

Table 2. Coal analyses of the Henrys Fork quadrangle.

No.	Mine or Prospect-Coal bed	Township & Range UTM grid	PROXIMATE ANALYSES					ULTIMATE ANALYSES					Btu/lb	OTHER TESTS			Kind of Samples	Ref. Source
			AN	M	VM	FC	Ash	S	H	C	N	O		AST	ADL	HGI		
1	Prospect Manning Canyon Shale	NE.–8–12N–18E exact location unknown	A	2.3	38.5	48.9	10.3	5.2	5.0	69.1	1.0	9.4	12,550	2,150	.2	–		2
			B	2.1	38.5	49.1	10.33	5.17	4.97	69.24	.99	9.30	12,570	–	–	–		
			C	–	39.4	50.0	10.6	5.3	4.8	70.7	1.0	7.6	12,840	–	–	–		
			D	–	44.0	56.0	–	5.9	5.4	79.1	1.1	8.5	14,360	–	–	–		
2	Prospect Manning Canyon Shale	NE.4–2N–16E 4532550mN 572310mE	A	8.4	32.1	45.0	14.5	0.52	3.99	55.67	0.96	24.32	8,870	–	.4	–		2
			B	8.0	32.2	45.2	14.6	0.52	3.96	55.90	0.96	24.06	8,910	–	–	–		
			C	–	35.0	49.1	15.9	0.57	3.34	69.74	1.05	18.44	9,680	–	–	–		
			D	–	41.6	58.4	–	0.68	3.97	72.19	1.25	21.91	11,510	–	–	–		

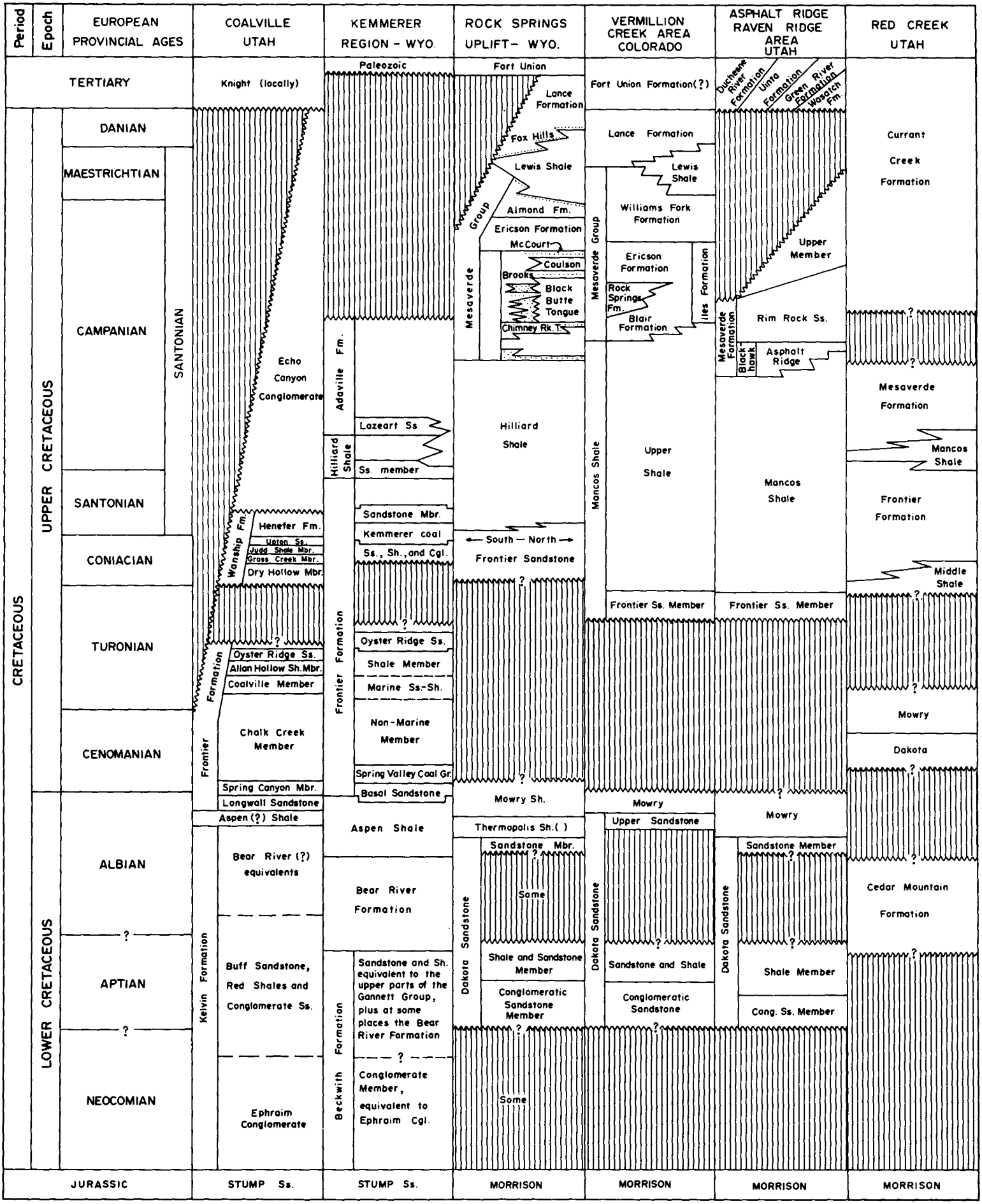
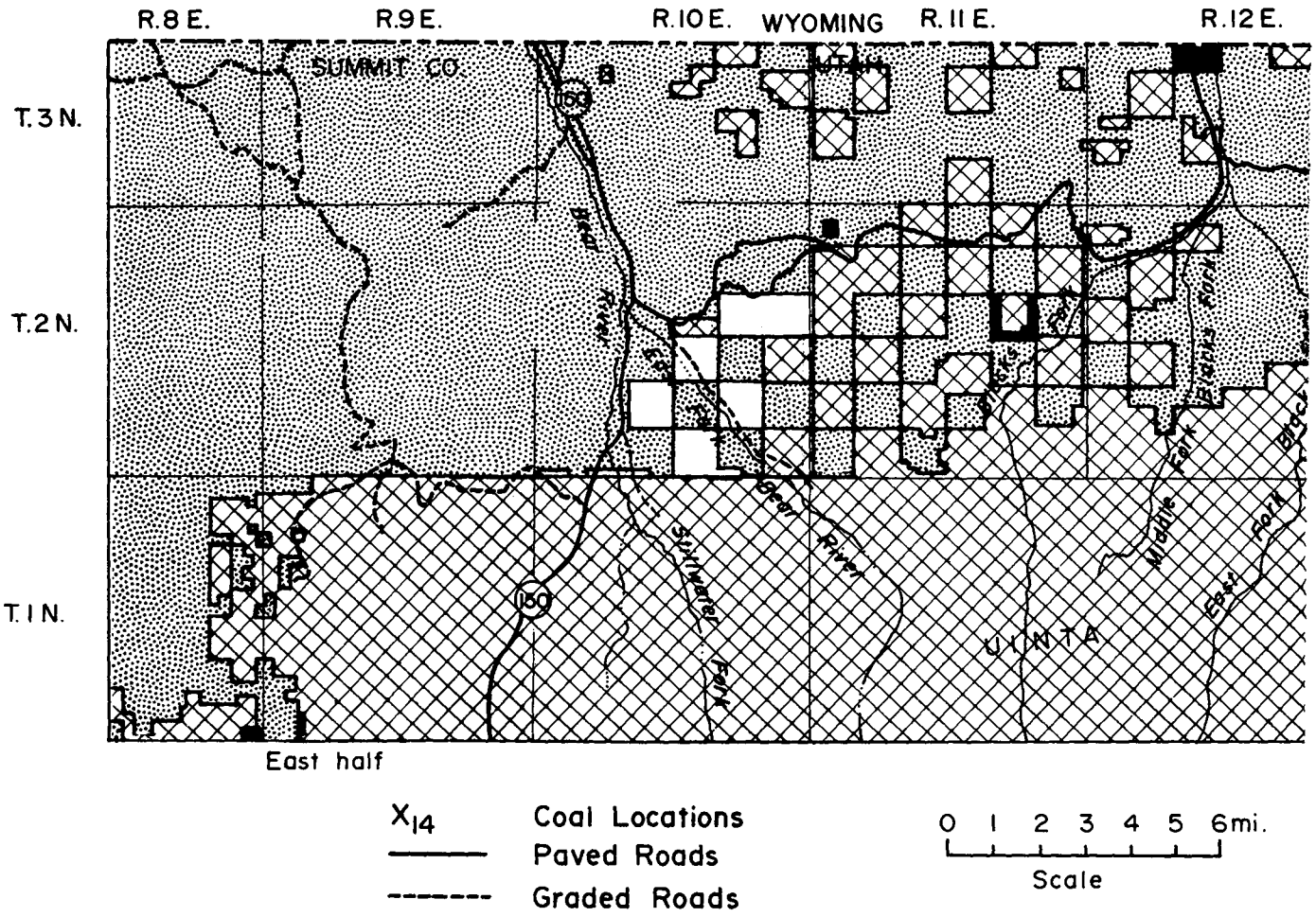


Figure 10. Correlations of Cretaceous formations adjoining Henrys Fork coal field.



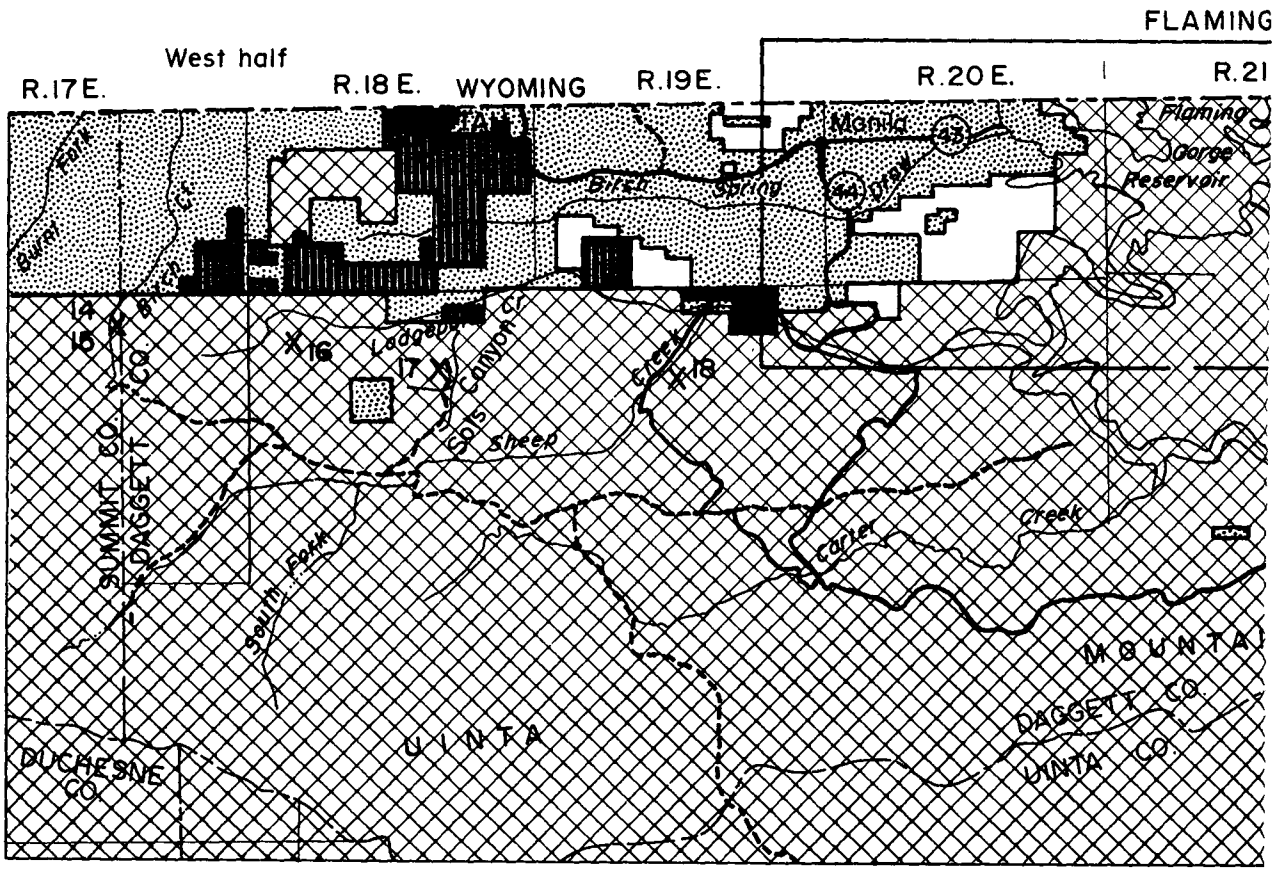
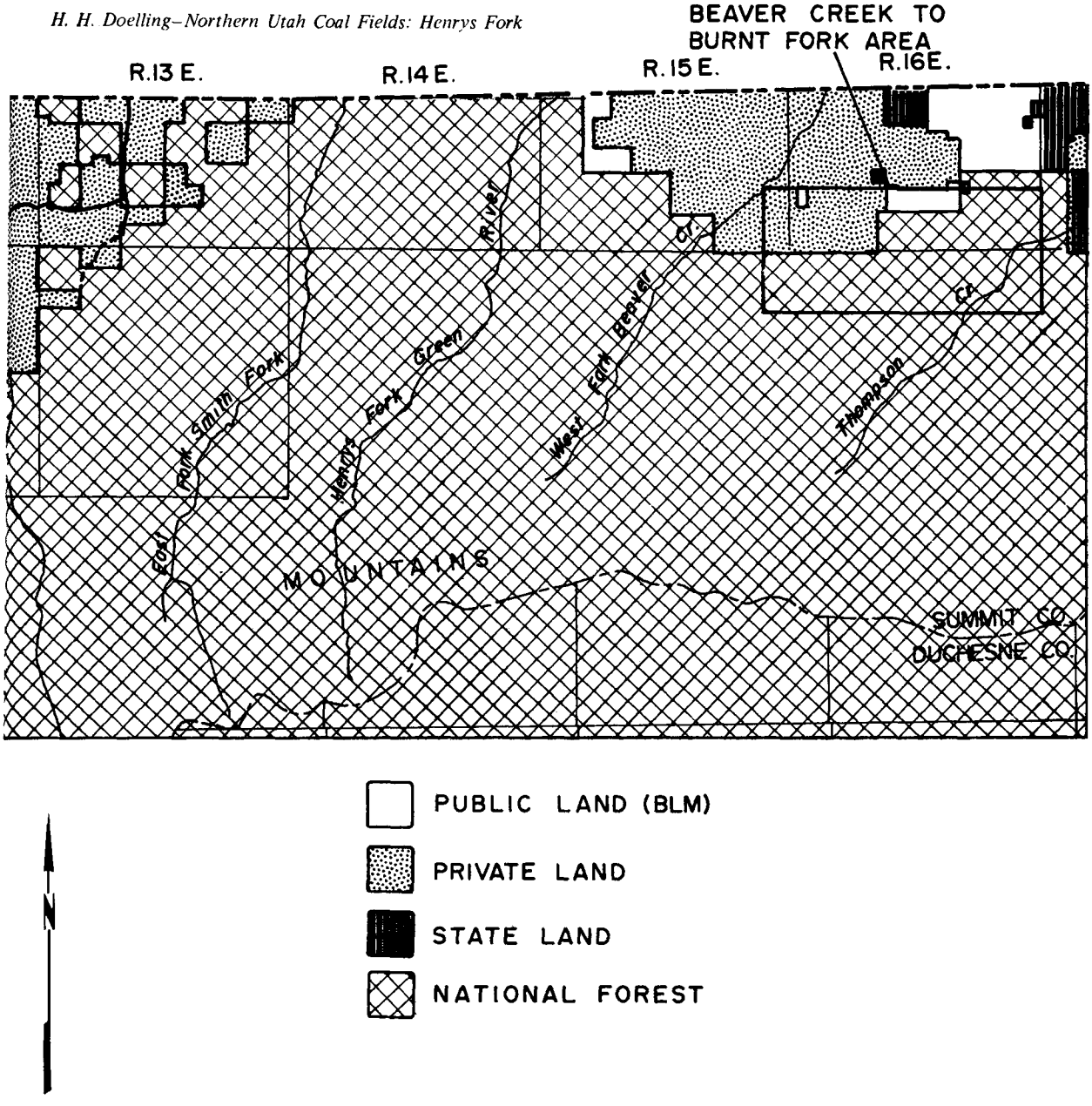
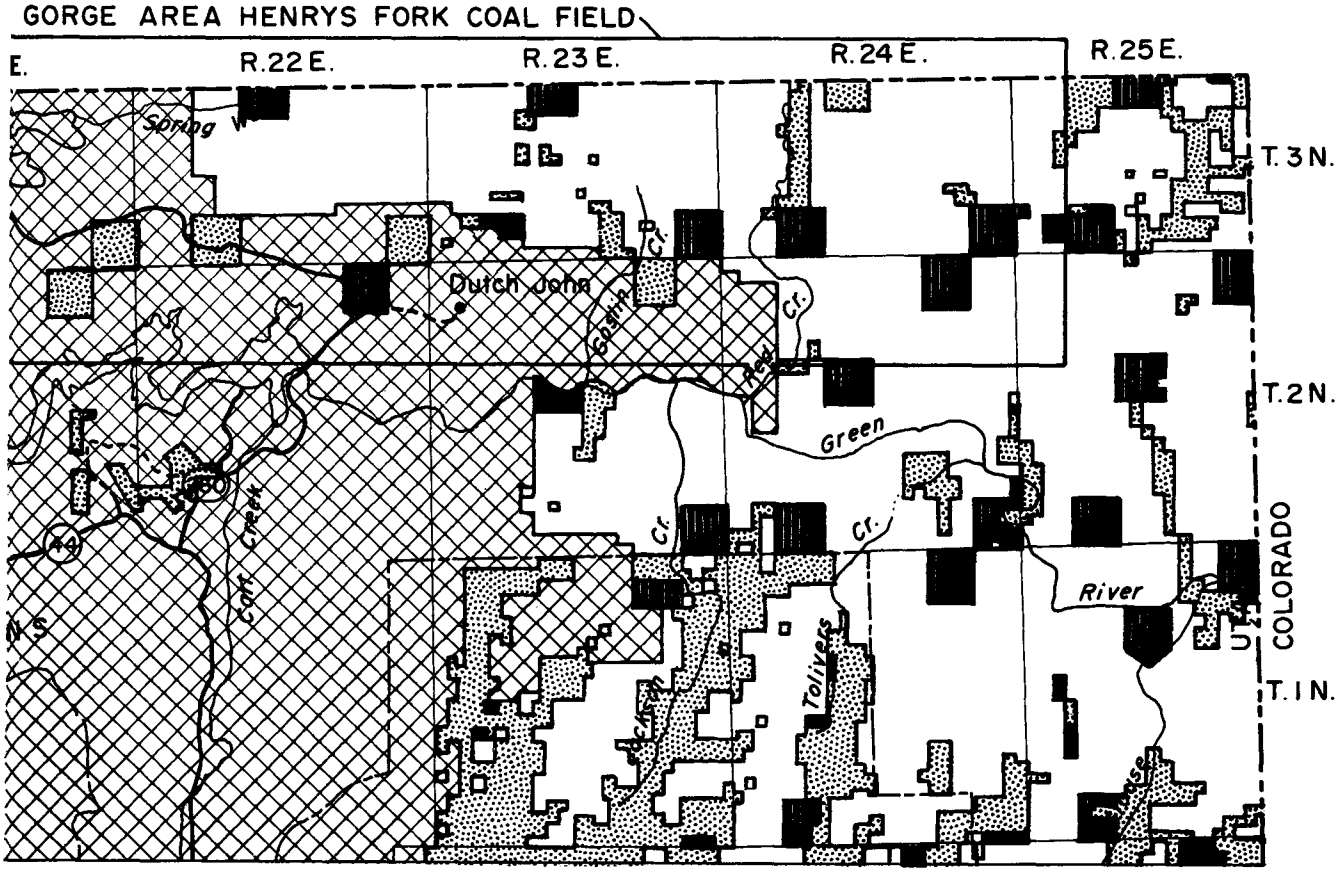
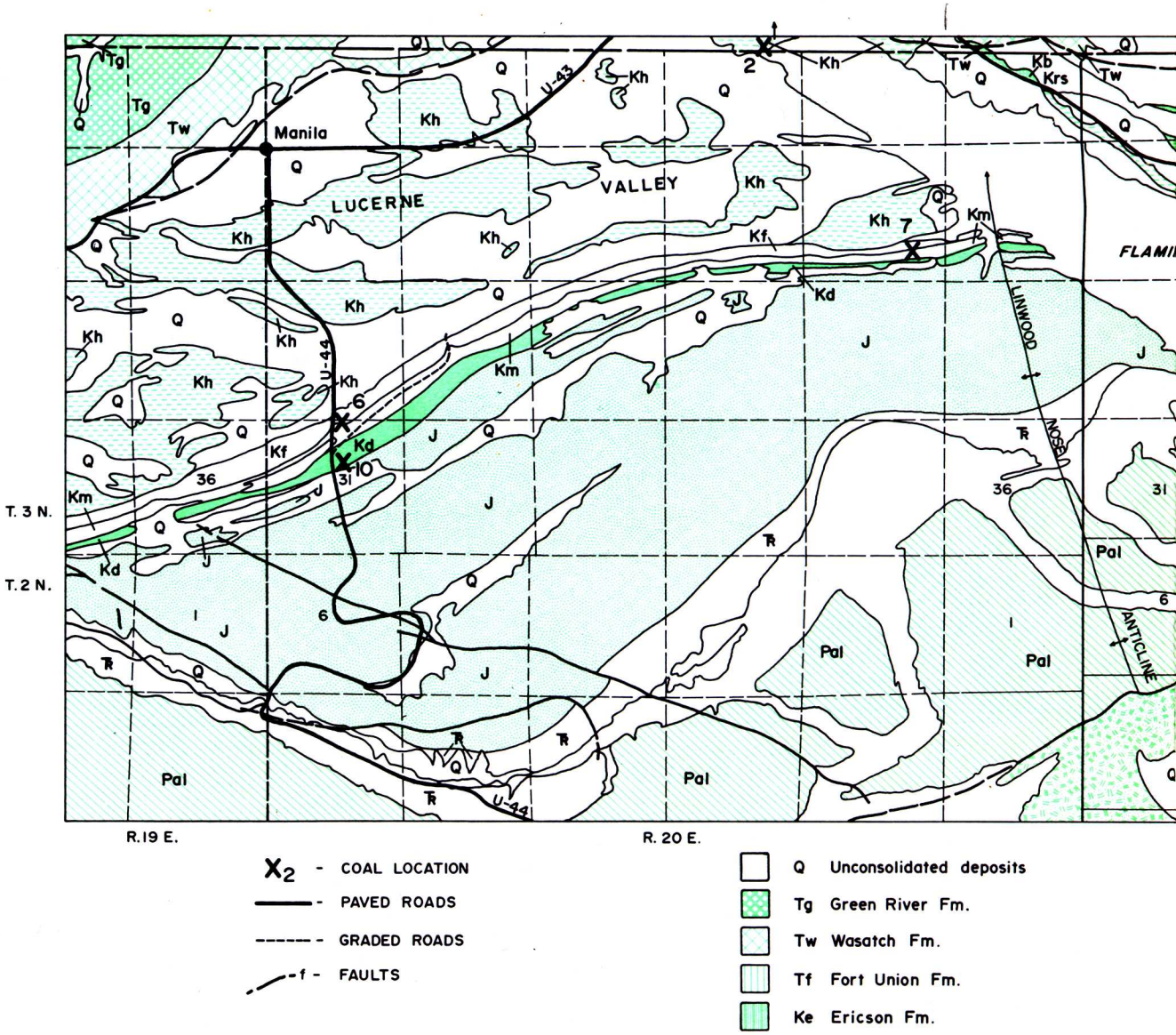


Figure 11. Land ownership map, Henrys Fork coal field.


BEAVER CREEK TO
BURNT FORK AREA
R.13 E.
R.14 E.
R.15 E.
R.16E.
East Fork Smith Fork
Henrys Fork Green River
West Fork Beaver Cr.
Thompson Cr.
MOUNTAINS
SUMMIT CO.
DUCHESNE CO.
PUBLIC LAND (BLM)
PRIVATE LAND
STATE LAND
NATIONAL FOREST
N


GORGE AREA HENRYS FORK COAL FIELD
R.22 E.
R.23 E.
R.24 E.
R.25 E.
T.3 N.
T.2 N.
T.1 N.
Spring
Dutch John
Goslin Cr.
Red Cr.
Green
River
Cr.
Cr.
Tolivers
Cart Creek
COLORADO
UT



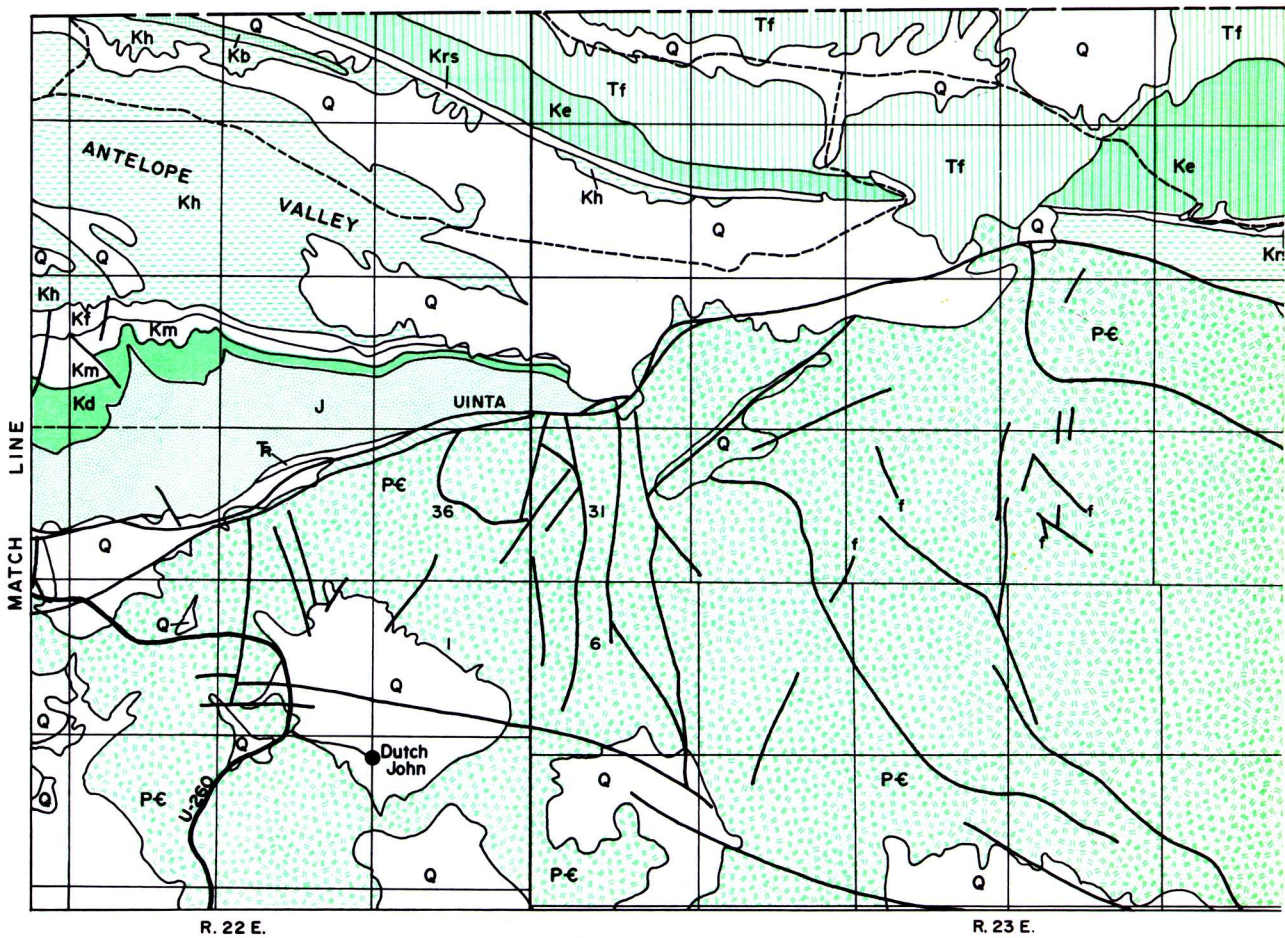
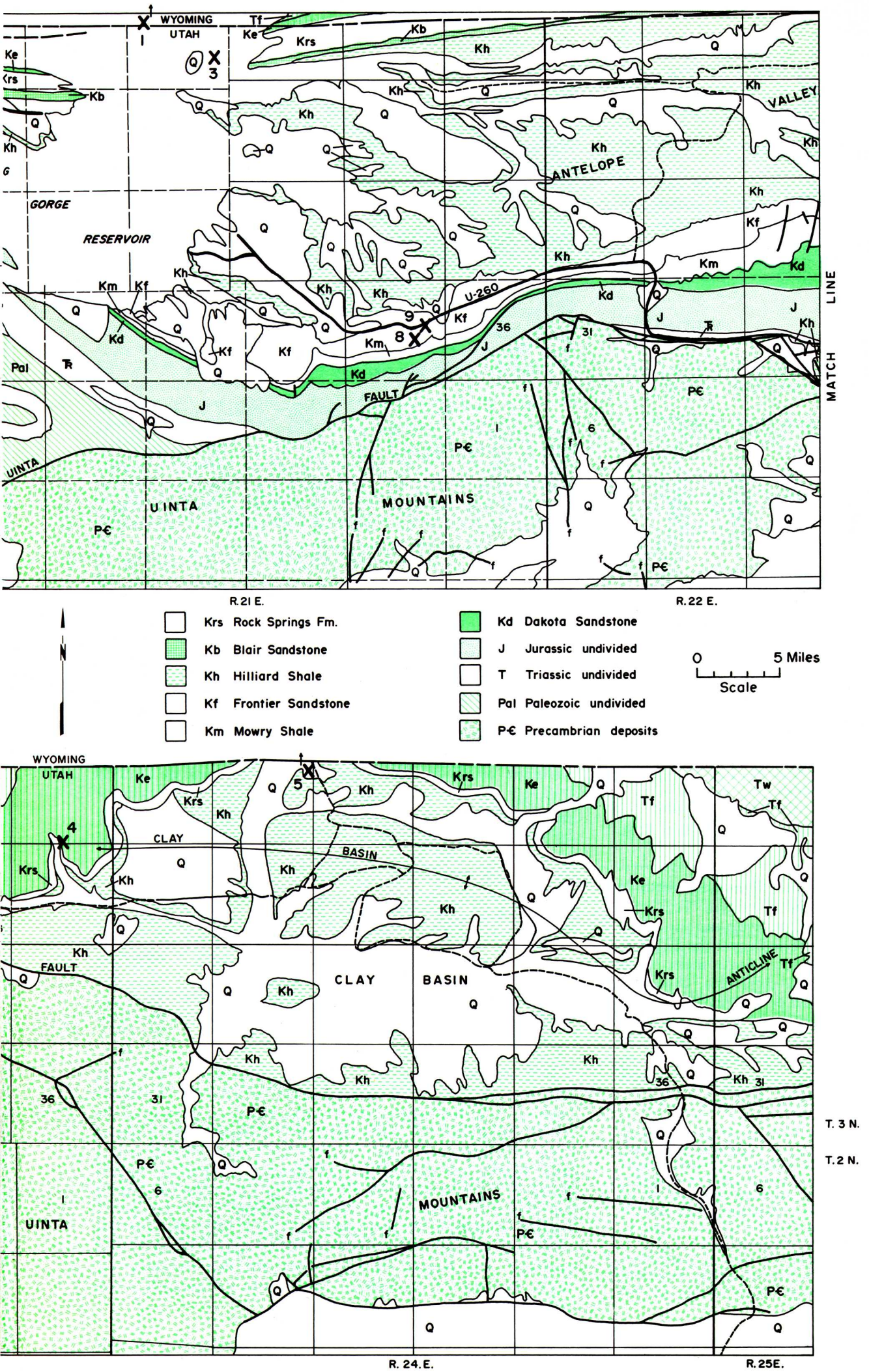


Figure 12. Flaming Gorge area, Henrys Fork coal field.


WYOMING
UTAH
GORGE
RESERVOIR
ANTELOPE
VALLEY
CLAY
BASIN
FAULT
ANTICLINE
UINTA
MOUNTAINS
MATCH LINE
U-260
R. 21 E.
R. 22 E.
R. 24. E.
R. 25E.
T. 3 N.
T. 2 N.
Krs Rock Springs Fm.
Kb Blair Sandstone
Kh Hilliard Shale
Kf Frontier Sandstone
Km Mowry Shale
Kd Dakota Sandstone
J Jurassic undivided
T Triassic undivided
Pal Paleozoic undivided
P€ Precambrian deposits
0 5 Miles
Scale

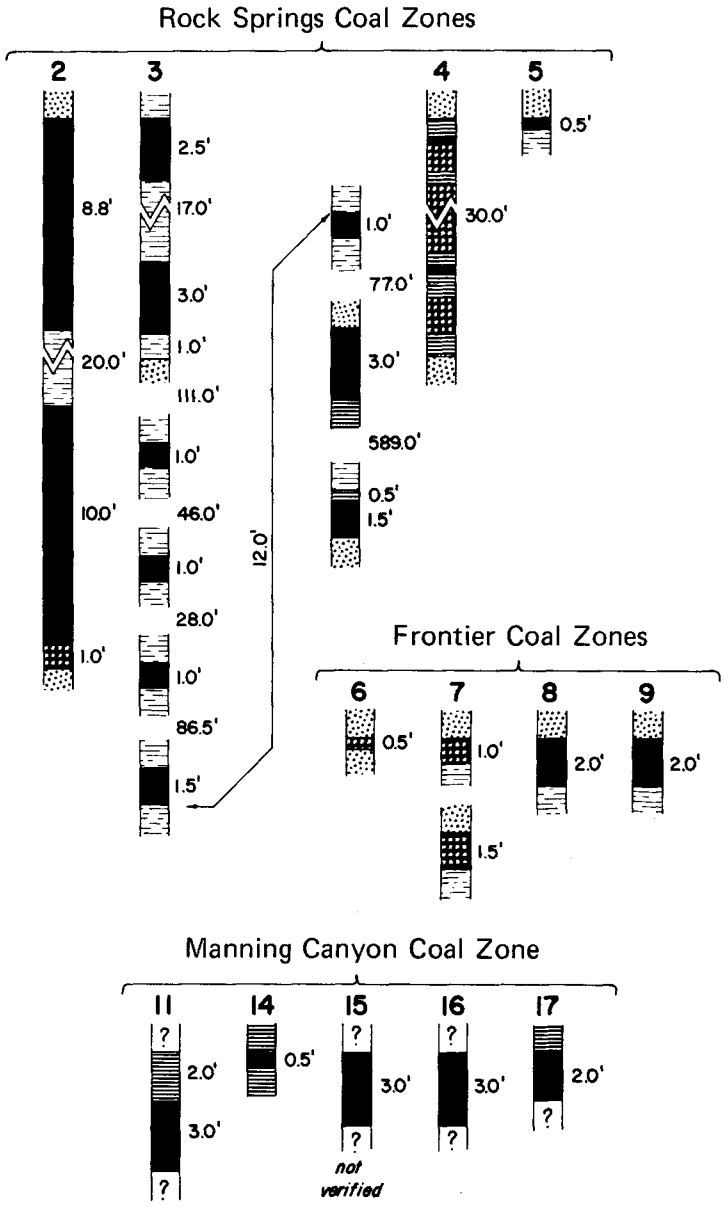


Figure 13. Coal sections of Henrys Fork coal field (vertical scale: 1" = 8 feet).

At least three coal-bearing Cretaceous formations occur in the Flaming Gorge area. The uppermost Ericson Formation extends from just west of Flaming Gorge Reservoir eastward along the Wyoming line until it is truncated by a fault near the Colorado line. Hansen (1965, p. 106) notes that subordinate shales in the formation are brown and carbonaceous, commonly containing many small fragments of carbonized wood or coal, locally containing thin beds of coal stringers—soft, friable and punky. The most important Cretaceous coal bearer is the Rock Springs Formation which lies just below the Ericson. Locations 2 to 5 are measurements made on the Rock Springs. Gale (1909) examined exposures not far east and west of the Green River:

A well exposed section was found near the east bank of the river at the mouth of Spring Creek about one-half mile southwest of the 289 milepost on the Utah-Wyoming state line . . . The whole formation was not examined in detail, but coal was found in it at several horizons. A small amount of prospecting uncovered some beds at least 5 feet thick and local reports state that the coal has been taken out at some point west of the river for use at the ranches in the valley.

Opposite Linwood post office, about one-fourth mile north of Henrys Fork, two thick beds of coal are exposed in nearly vertical position. These beds have been prospected somewhat but have never been worked to any considerable extent.

Gale presented a section found as location 2 on the Flaming Gorge area map. The position of the section is believed to have been just over the line into Wyoming. Gale notes that toward the east the coal disappears under the river deposits and in the next gulch appears to have reverted to coaley carbonaceous shale. Hansen (1965, p. 182) notes:

Coal has never been mined within the mapped area, although it was once mined from the Rock Springs (?) Formation just north of Linwood in Wyoming in the so-called Henrys Fork coal field. The entry to this mine was caved at the time of my mapping. The mine, moreover, was afire and reportedly had been smoldering for many years.

Hansen measured a section of Rock Springs Formation on the east bank of the Green River (location 3) and discovered 16.5 feet of coal in nine seams with the thickest bed 3 feet thick. To the east Hansen noted facies changes from onshore, coastal swamp and nearshore environments to predominantly offshore conditions. In Pigeon Canyon 15 miles east, a carbonaceous zone 30 feet thick (location 4) lies just above a massive white sand and beneath the lowermost thick cliff-forming Ericson Formation. The shales were full of twigs, leaves and nuts and interbedded with streaky shaley coal. Two miles farther east in Richards Gap in Wyoming (location 5) a thin stringer of coal was seen at the same horizon.

The Frontier coal zone or zones extend from south of Manila eastward to Martin Draw, a distance of about 20 miles. The coal is mostly thin and discontinuous and many sections are believed devoid of coal. In many areas the Frontier is poorly exposed. Gale (1909) did not mention the presence of Frontier coal. In a road cut made for Utah Highway 44 south of Manila (location 6), 0.5 feet of shaley coal were located between two of the upper sandstones of the formation. Hansen (1965, p. 94) measured two sections of the Frontier in 23-3N-20E and in 27-3N-22E. 11 miles apart, but found no coal in either section. He noted a discontinuous coal seam a few feet below the top of the lower unit at Finch Draw. At location 7, two seams of impure shaley coal occur, 1.5 and 1 foot thick. The first is at the top of the lower shaley member; the second is between two sandy layers in the upper part of the formation. The coals appear to be lignitic. A few other thin coaley horizons may occur in the lower shale unit. A 2-foot coal seam in the Frontier is known on the east side of the reservoir in 35-3N-21E. Hansen (p. 93) notes that it lies near the middle of the lower shale unit and that a few feet of sandstone overlie it. The present writer discovered an identical thickness of coal, but thought the position of the coal was in the upper sandstone beds (locations 8 and 9). Location 10 refers to some carbonaceous beds in the Dakota Formation.

Sheep Creek to Beaver Creek

Only the Manning Canyon Shale coal beds are exposed in this area. The formation is present in very steeply dipping beds sandwiched between two cliff-forming limestones. The area on top of the ridges between canyons is usually covered with heavy soil and growth and continuity is impossible to discern. Along the canyons where the slope steepens, erosion occasionally bares sections of the stratigraphy and most of the available data have been accumulated here.

Locations 11 and 16 are from Campbell and Clark (1916). The coal at location 11 was measured in 1914 at a prospect believed to be the same as the prospect shown on the map of the Burnt Fork-Beaver Creek area (figure 14). Presently the prospect is caved and only coal chips on an almost dissipated dump can be seen. Farther up the hill another prospect is similarly exposed (location 12). On the divide just south of Coal Mine Hill a gully has eroded a deep channel in which coaley shale is exposed. Digging a channel 1 foot deep does not bring up any less weathered material. Gale (1909, p. 235) indicates that several prospects were located on Burnt Fork and that the zone was thick, but not of commercial value, being carbonaceous shale rather than coal (location 13).

At Birch Creek on the east side of the canyon in a possible slumped block is a thick carbonaceous zone with coaley layers up to 6 inches thick (location 14). To evaluate the outcrop, which appears as a mass of coal particles in black carbonaceous mud, is

difficult. Gale (1909, p. 235) notes the presence of a prospect in Birch Creek Canyon south of the Edward Ranch:

> The exposure seen was in a very unsatisfactory condition. Some pits had been dug in a rather diversely wooded slope, in a block of strata very evidently slipped from higher on the ridge and tilted out of its normal position. The beds are very soft and broken in spite of which some of the coal was still hard. The coal itself lies in a very irregular bed of which no great thickness could be readily uncovered, apparently at no place more than a few inches, although it was stated by those who had worked the prospect that the coal was 3 feet at the bottom of the pit (location 15). No trustworthy estimate of the true character of the bed can be made until the coal is found in place and in a normal position.

Location 16 is measured at a prospect in a canyon not far from Lodgepole Creek. The bed is 3 feet thick and was measured in 1914. At least 2 feet of muddy coal in a poor outcrop were measured in a gully in Sols Canyon (location 17). Schemel (1950) collected coal here and identified Mississippian spores from a 2-foot coal bed at the base of a shale section 20 feet thick, 190 feet below the base of the Round Valley Limestone. Schell (1969) describes the same location as a caved and abandoned coal prospect 260 feet above the base of the formation. He noted coal fragments on the dump, but none in place. He also noted coal fragments in a shaley exposure on the south side of Sheep Creek Canyon (location 18) in a road cut. Farther east the Manning Canyon is cut off by the Uinta fault. Some coaley gouge appears in the fault zone between Precambrian and Pennsylvanian rock along the new Utah Highway 44 south of Manila.

Evanston Coal Field Extension (figure 15)

A generalized section of formations in southwest Wyoming in Lincoln and Uinta counties is as follows:

Formation	Thickness (ft.)	Character
Evanston or Almy	1,500	Coal beds workable in two benches
Adaville	5,000	Contains several beds near bottom of formation
Hilliard Shale	6,500	Marine shale
Frontier	2,400	Contains several coal beds throughout

The Almy coal beds are exposed 2 to 10 miles north of Evanston. The coal is about 18 feet thick and workable in two benches. The Union Pacific Railroad operated several mines in the area from 1869 to 1900 for a total of 2,750,834 tons of coal. In addition privately owned mines were operated in the area; one mine continued operations until 1947. The beds thin rapidly north and south from the favorable area and the beds probably do not extend in minable thicknesses into Utah. The Almy is considered Paleocene in age.

The Adaville coal beds correlate with the Mesaverde in Utah. They are exposed on the east flank of the Lazeart syncline, several miles east of Evanston adjacent to the Wyoming thrust belt. These coals have been reported up to 118 feet thick. In most places the coal is thinner, less than 15 feet. Adaville coal has been traced to a point 10 miles north of the Utah state line.

The Frontier coal beds lie a little to the east of the Adaville beds and have produced from several mines in Wyoming. The beds also have been traced to within a few miles of Utah. The possibility does exist that coals of the Adaville and Frontier extend into Utah and are shallow enough to be mined, but drilling is necessary to prove this. Coal in the Tabby Mountain field south of the Uinta Mountain field south of the Uinta Mountains contains thick seams in the correlative formations that were once continuous across the present-day Uinta uplift. Coal also is mined at Coalville in the Frontier beds several miles to the west in Utah. The coal in Wyoming is generally very low-ash, low-sulfur coal; the thick Adaville beds are subbituminous and the Frontier beds are high-volatile bituminous coals.

ECONOMIC CONSIDERATIONS AND FORECAST

No activity is expected in the Henrys Fork coal field in the near future. It may never be developed because of the (1) thin, discontinuous seams in most investigated areas, (2) steeply dipping beds, (3) remoteness from market and proximity to far better coal areas and (4) the resource is contained in a relatively unexplored and highly speculative area.

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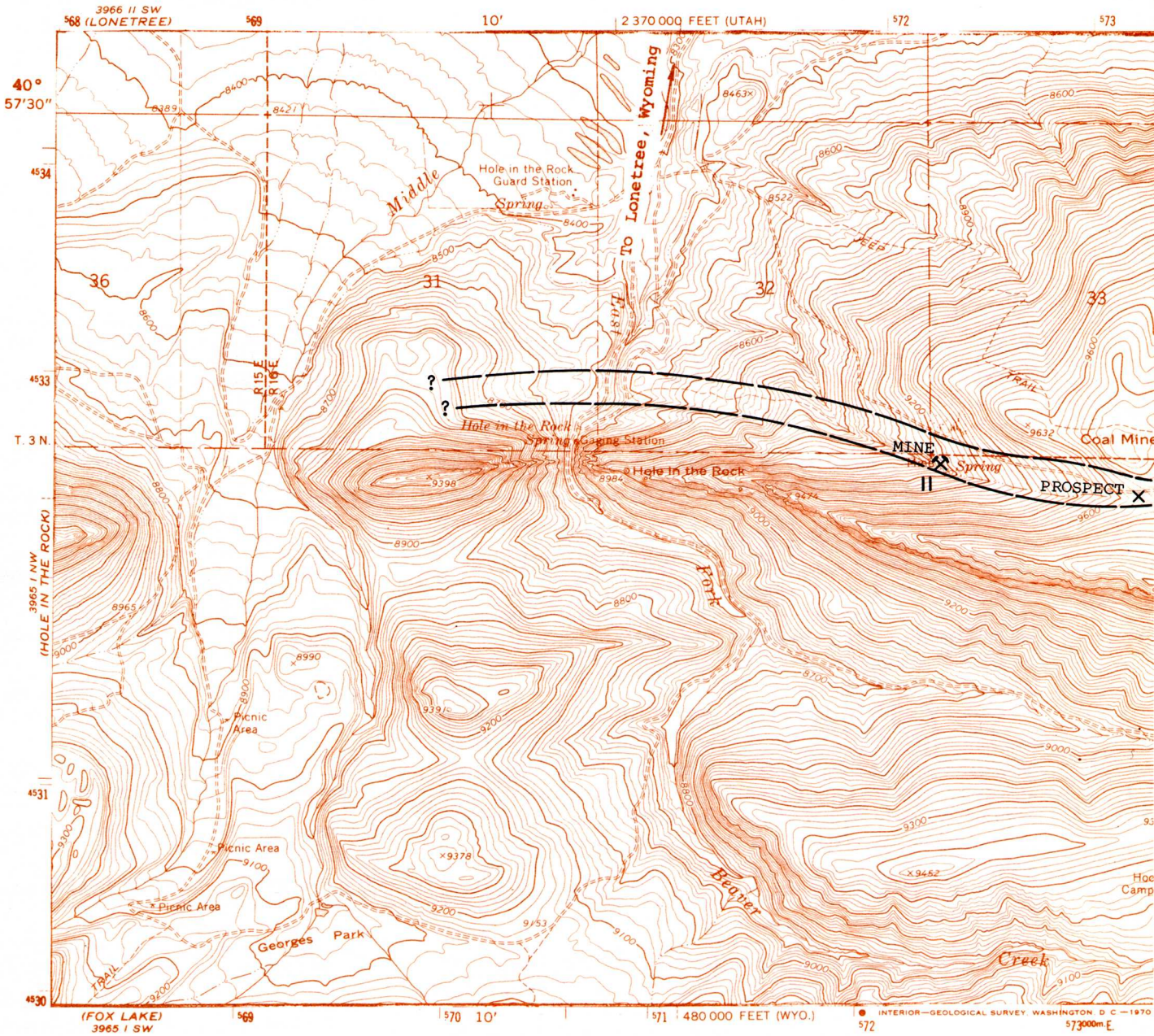
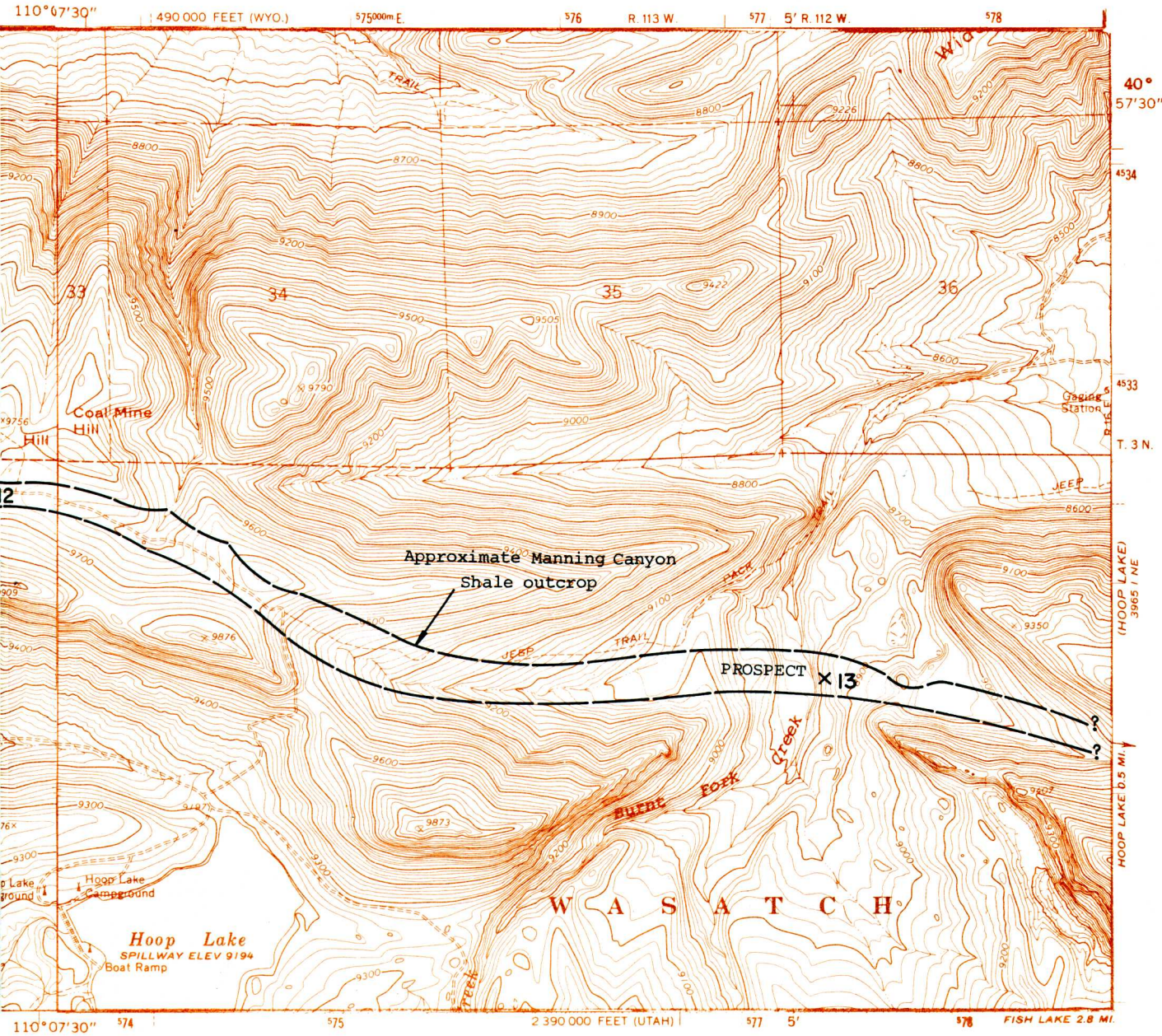
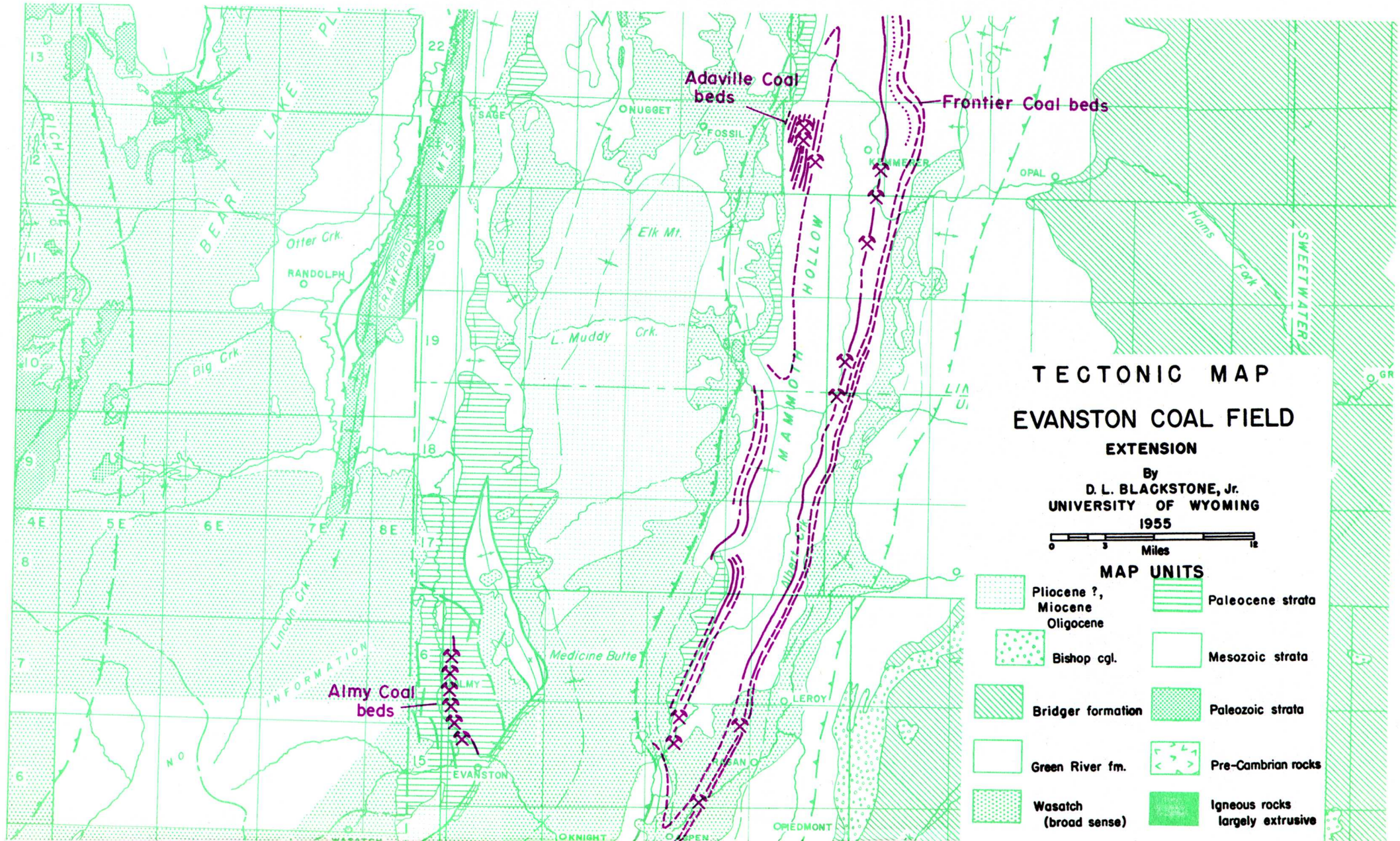


Figure 14. Beaver Creek to Burnt Fork area, Henrys Fork coal field.



0 1 2 3 4 5 Miles

Scale


Adaville Coal beds
Frontier Coal beds
Almy Coal beds
TECTONIC MAP
EVANSTON COAL FIELD
EXTENSION
By
D. L. BLACKSTONE, Jr.
UNIVERSITY OF WYOMING
1955
0 3 12
Miles
MAP UNITS
Pliocene ?, Miocene Oligocene
Bishop cgl.
Bridger formation
Green River fm.
Wasatch (broad sense)
Paleocene strata
Mesozoic strata
Paleozoic strata
Pre-Cambrian rocks
Igneous rocks largely extrusive
BEAR LAKE PL.
RICH CACHE
Otter Crk.
RANDOLPH
CRAWFORD MTS
SAGE
NUGGET
FOSSIL
KEMMERER
OPAL
Elk Mt.
L. Muddy Crk.
Big Crk.
MAMMOTH HOLLOW
Hams Fork
SWEETWATER
Lincoln Crk.
INFORMATION
Medicine Butte
ALMY
LEROY
EVANSTON
KNIGHT
OPEDMONT
4E
5E
6E
7E
8E

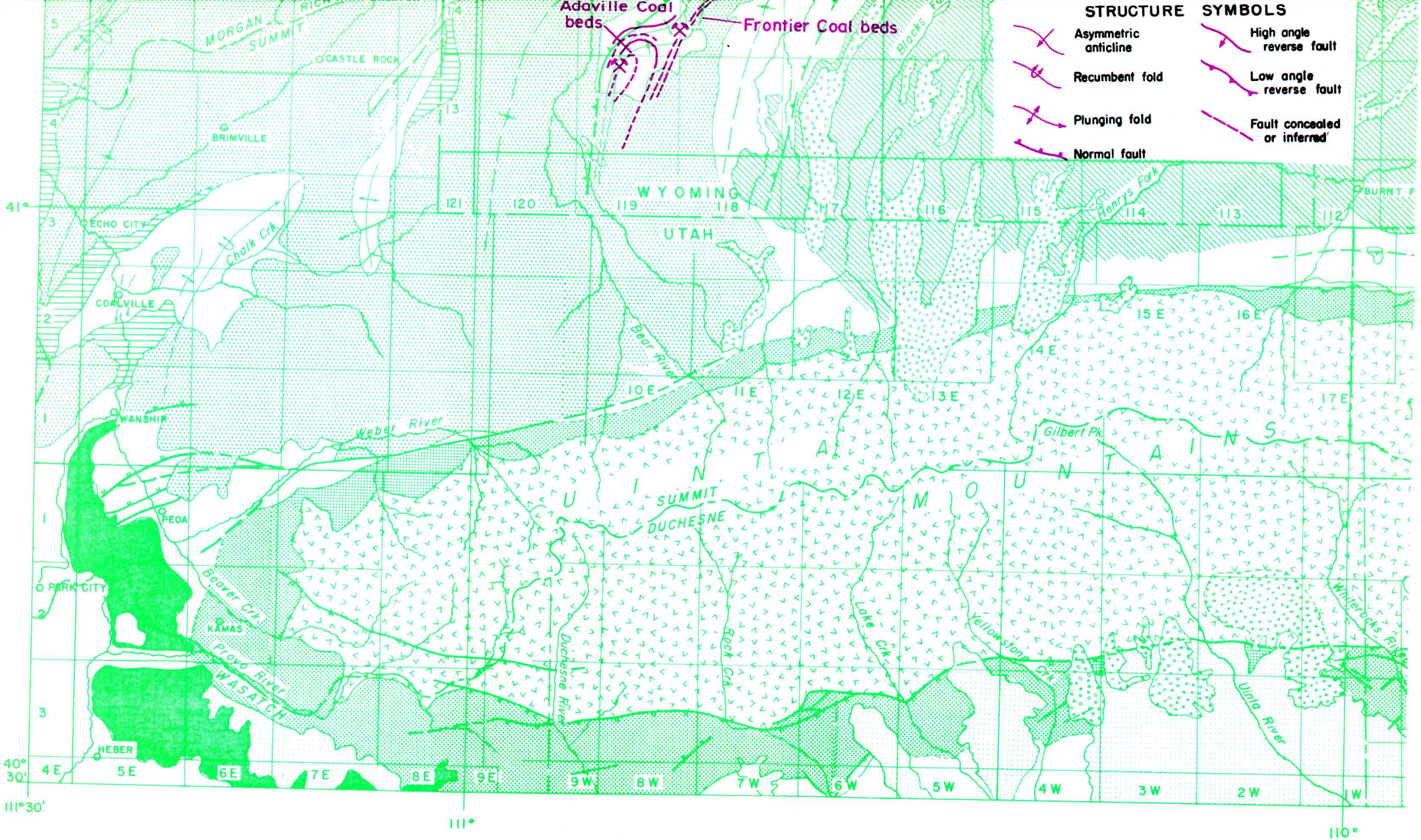
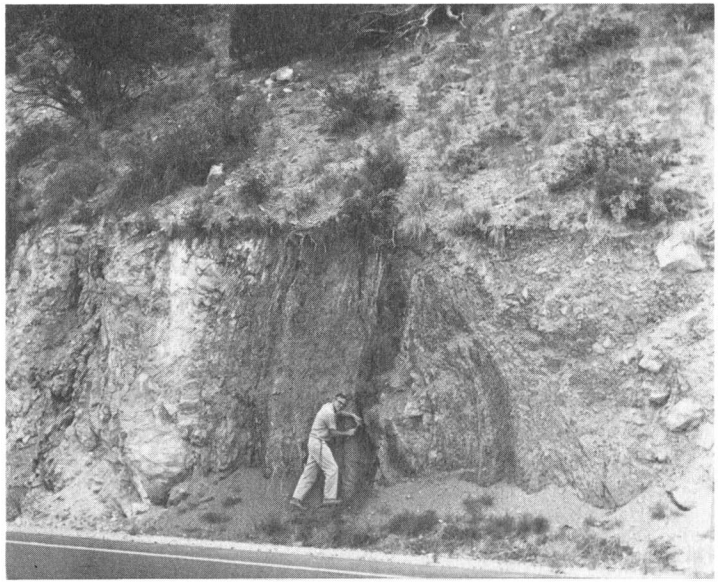
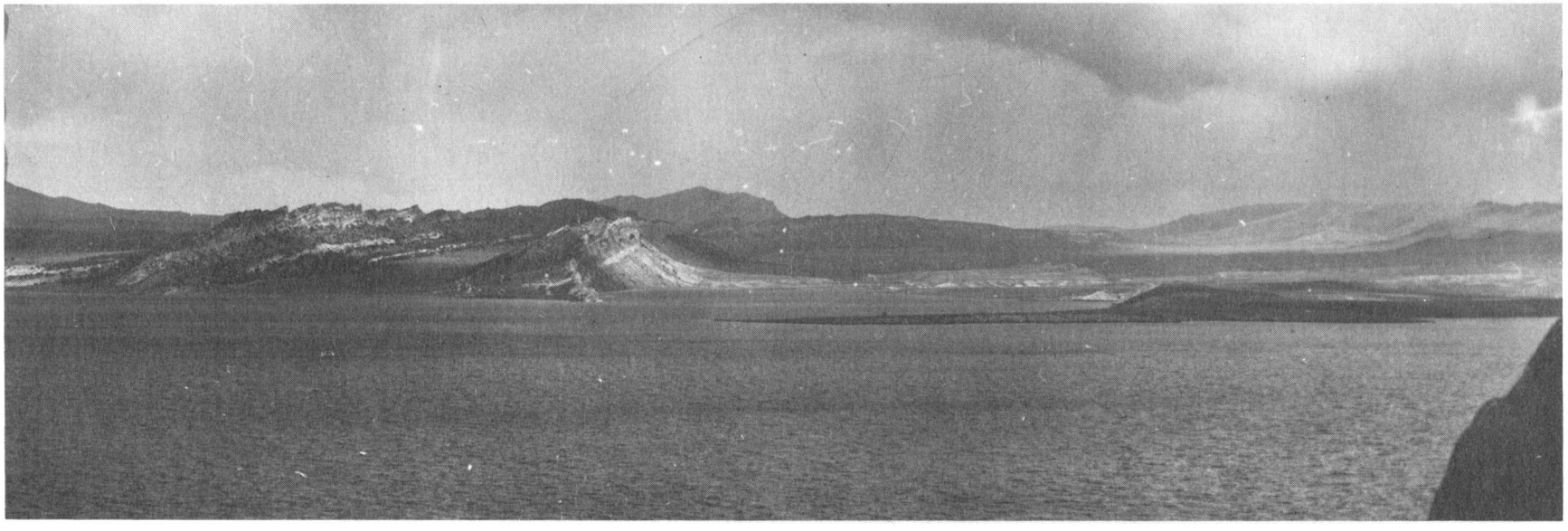


Figure 15. Tectonic map, Evanston coal field extension.



The Uinta fault along Utah 44 south of Manila, Henrys Fork coal field. Coaley beds in the Mississippian Manning Canyon Shale are caught in the fault gouge.

Cuesta of Frontier Sandstone south of Manila, Utah, Flaming Gorge area. Only thin beds of coal can be demonstrated. The valley to the right exposes Mowry Shale; the next cuesta is the Dakota Sandstone.



Rock Springs Formation and Ericson Formation cuesta looking east across Flaming Gorge Reservoir, Henrys Fork coal field. The best measured sections of coal in the Rock Springs Formation are now inundated by the reservoir. Only occasional shows of coal are noted in the Ericson. Antelope Flat is to the right of the cuestas.

GOOSE CREEK LIGNITE FIELD

by

H. H. Doelling[1]

INTRODUCTION

Location and Extent

The Goose Creek lignite field is located in the northwest corner of Utah and in adjoining parts of Idaho and Nevada (Preface, figure 1a and figure 1). The larger and more important part of the field lies in Idaho. The field occupies the Goose Creek Basin between the Cassia Mountains to the west and the Goose Creek Mountains to the east. The basin is 9 to 12 miles wide and approximately 25 miles long. In addition lignite beds are present in Grouse Creek Valley that are not adequately enough explored to determine their extent. Outcrop area of the host stratigraphic unit is about 8 by 20 miles.

Topography and Drainage

The basins containing the lignite consist of steep-sided buttes and mesas that are dissected by the principal drainage. The deeper canyons and gorges are located in Idaho; areas of lesser relief occur in Utah and Nevada. Rugged mountains border the basins. Elevations in the area of Utah and the immediate adjacent parts range from 4,900 feet along Goose Creek to about 6,000 feet in the basin areas and to more than 8,500 feet in the adjoining mountains.

Goose Creek, a large tributary of the Snake River, flows northeastward in the principal area, then northerly to the Snake River. Grouse Creek flows southerly in the less explored Grouse Creek Basin into the Great Salt Lake Desert where it disappears. Principal tributaries to Goose Creek include Birch Creek, Pole Creek and Hardesty Creek, all flowing northwesterly from the Goose Creek Mountains. Principal tributaries to Grouse Creek include Cotton Creek, Dahar Creek, Straight Fork Creek and Death Creek flowing from the Goose Creek Mountains and Pine Creek and Kimbell Creek flowing from the Grouse Creek Mountains.

Population, Industries and Transportation

The Goose Creek lignite field is sparsely settled with some permanent residents; Grouse Creek is considered the only settlement with a population of 100 (1970 census). This probably includes the scattered ranch houses of the area or the entire population of this portion of Utah.

The area is primarily agricultural dominated by cattle production; sheep and horse grazing and hay production are also prevalent. The major roads are maintained by the county and are not paved (figure 1). Principal roads include the Goose Creek road, Hardesty Creek-Dahar Creek road, the Grouse Creek road and the Cotton Creek-Yost road. No railroads exist and no air service is scheduled for the area. The nearest regular service, both rail and air, is Burley, Idaho, 40 miles north. A railroad spur extends to Oakley, 20 miles north.

Climate

The area has a mid-latitude steppe climate averaging about 10 inches of moisture annually. The winters can be bitterly cold and the summers very hot. The January mean temperature is about 29° F and the July mean, 71° F.

[1] Economic geologist, Utah Geological and Mineralogical Survey.

HISTORICAL OUTLINE

Existence of coal in Goose Creek and its major tributaries was known prior to 1888 when the first published reference to coal was made in a brochure of the Union Pacific Railroad Co. The Worthington mine, on a tributary of Beaverdam Creek in Idaho, reportedly produced, team-hauled and sold a few hundred tons of coal in Oakley, Idaho (town 20 miles north of the Utah-Idaho line) during the 1911 season. Other prospects were opened about the same time; no coal was produced to sell but it may have been bartered to local ranchers. No record exists of coal being produced from the field within the state of Utah.

GEOLOGIC SETTING

Stratigraphy

The Goose Creek lignite occurs entirely in Tertiary rocks (figure 2). These rocks fill basins between mountain ranges made of Paleozoic and perhaps Precambrian strata. In addition volcanic flows of Late Tertiary age occur, especially along the margins of the basins.

Permian and Older Rocks, Undifferentiated

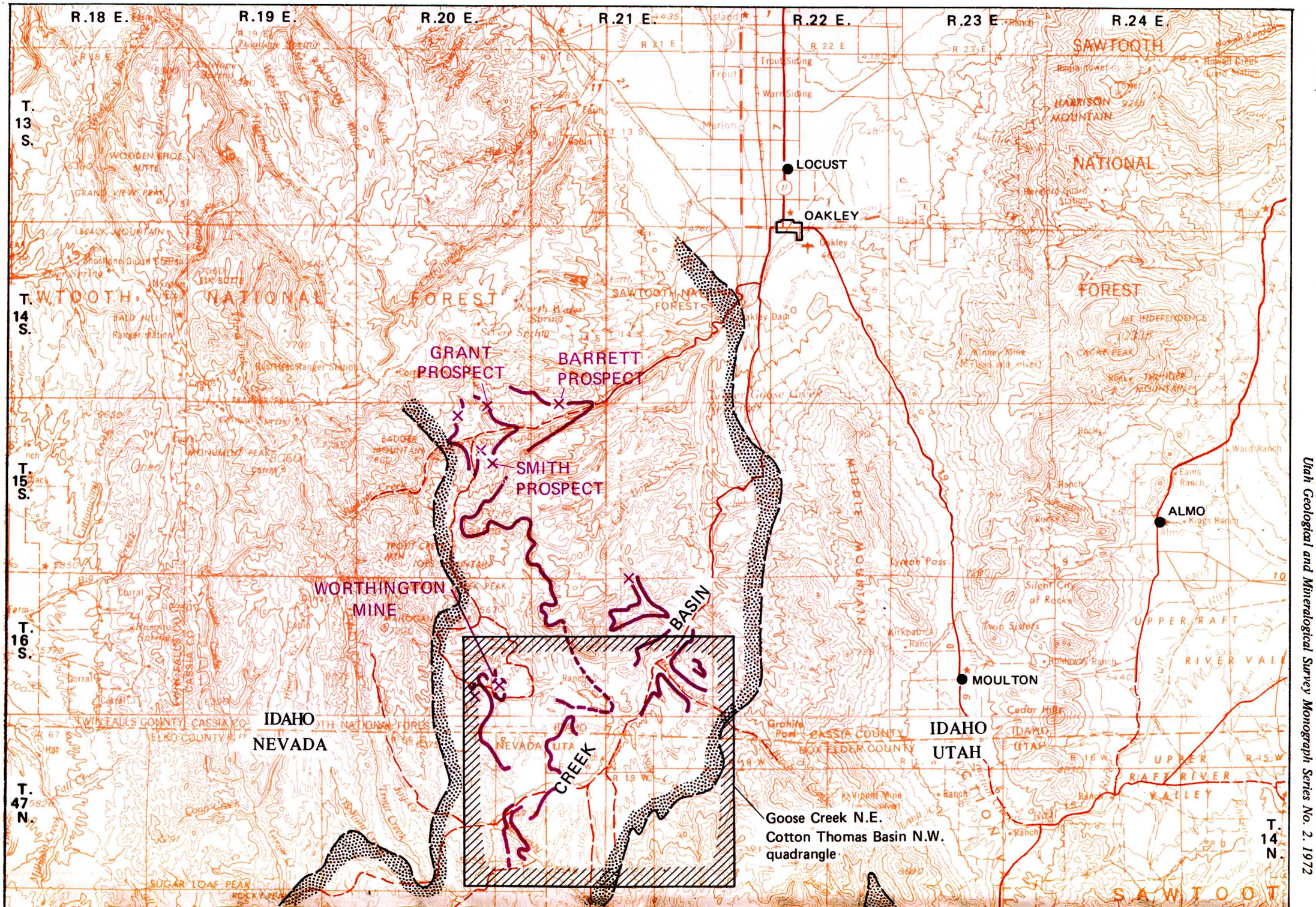
These rocks crop out in the Goose Creek, Grouse Creek and Cassia mountains and are only partly investigated and mapped. The northwest quarter of the Geologic Map of Utah (1962) indicates the presence of Permian Park City Formation, Pennsylvanian Wells Formation and Precambrian quartzites with possibly a few patches of Triassic Thaynes Formation in the area. These are undifferentiated on the map. In the south part of the Muddy Range (Grouse Creek Mountains), rocks of Mississippian and Devonian age also are present. Most commonly seen are limestones of varying shades of gray, often sandy, cherty and quite resistant. The quartzites range in color from white to red and are micaceous. Small amounts of dark black shale also are present in the east part of the area especially near the Vipont mining district.

Rhyolite

The largest exposure of rhyolite outcrops in the Goose Creek Mountains between Birch and Hardesty creeks. Piper (1923, p. 27) describes the rhyolite:

> These specimens are rather dense red-brown banded tridymite quartz latites. . .They carry about 20 percent of phenocrysts as much as 3 millimeters across, most of which are oligoclase feldspar. Quartz in resorbed crystals is abundant, and orthoclase, also resorbed is less abundant. Dark minerals are absent, though they may have been present in small amounts but are now decomposed. Magnetite and zircon are fairly abundant, and apatite is present. The ground-mass in one specimen from Pole Creek is mostly a very fine sponge-like intergrowth of feldspar and tridymite with some coarser intergrowths and some unusually large crystals of tridymite in the porous parts. A little quartz is closely associated with the coarse tridymite in the porous parts, and the two look as if they were contemporaneous.

The rock is evidently a quartz latite, but all maps including those in this report indicate the outcrop areas as rhyolite. The age of the rhyolite is considered to be early Miocene (?).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R.19 E.
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T. 13 S.
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T. 15 S.
T. 16 S.
T. 47 N.
T. 14 N.
LOCUST
OAKLEY
ALMO
MOULTON
GRANT PROSPECT
BARRETT PROSPECT
SMITH PROSPECT
WORTHINGTON MINE
BASIN
CREEK
IDAHO
NEVADA
IDAHO
UTAH
CASSIA COUNTY
BOX ELDER COUNTY
TWIN FALLS COUNTY
ELKO COUNTY
SAWTOOTH NATIONAL FOREST
SAWTOOTH NATIONAL RECREATION AREA
MINIDOKA NATIONAL FOREST
Goose Creek N.E.
Cotton Thomas Basin N.W.
quadrangle

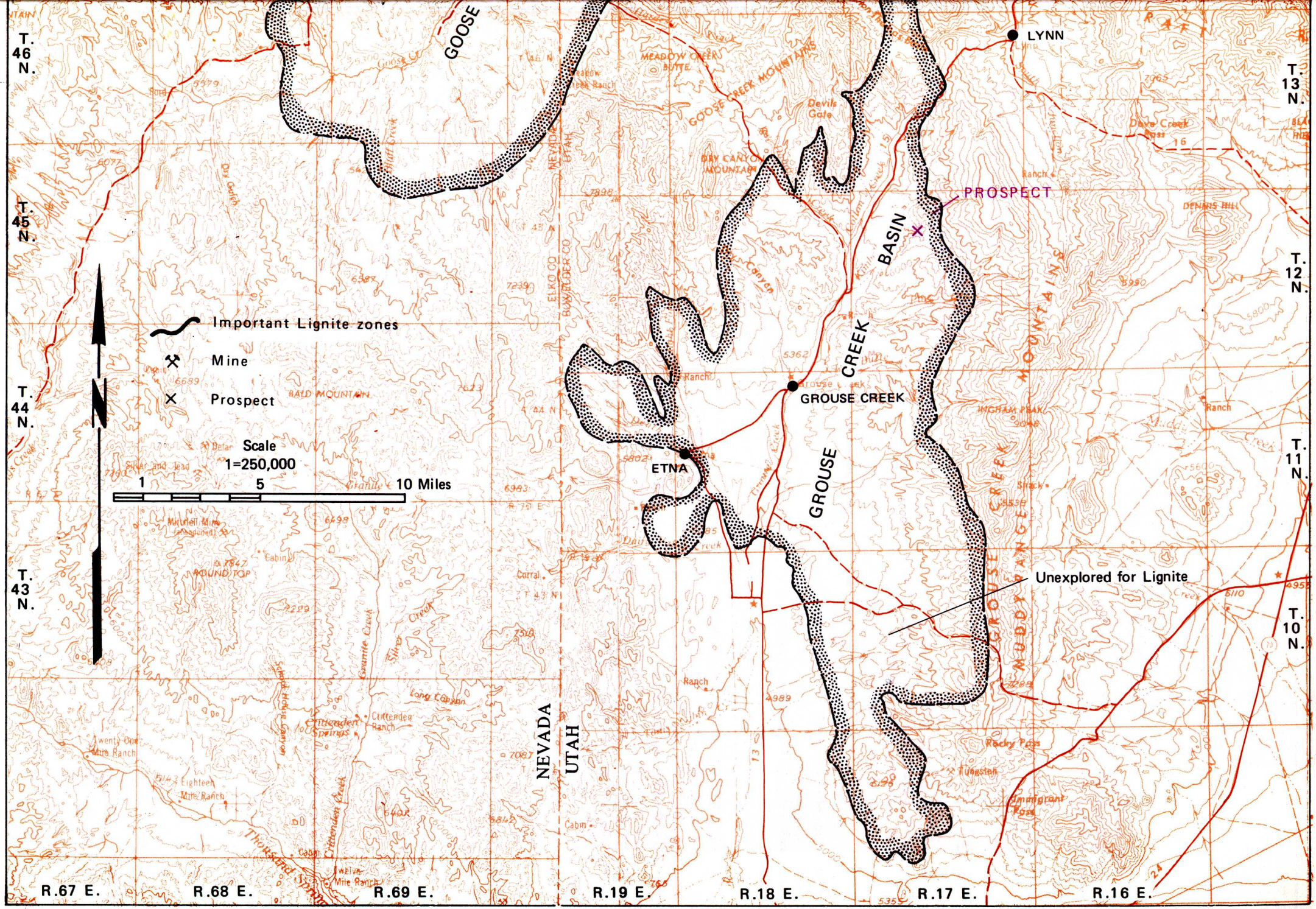


Figure 1. Topography, roads, mines, prospects and seams map, Goose Creek lignite field.

System	Series	Stratigraphic Unit		Thickness (feet)	Description
TERTIARY	Pliocene	Salt Lake Formation	"Upper" Member	700-1,000	Interbedded white and grayish orange volcanic ash, with a few lenticular beds of conglomerate: a thick persistent bed of welded tuff is at the base.
			"Lower" Member *LIGNITIC*	1,200-1,600	Mainly white volcanic ash containing a few beds of shale, sandstone and conglomerate; conspicuous beds of black to dark reddish brown welded tuff in the upper half, lenticular beds of carbonaceous shale and *lignite* in lower half.
	Miocene	Payette (?) Formation *LIGNITIC*		900±	Interbedded shale and volcanic ash, with some thin beds of sandstone and conglomerates; a few lenticular beds of carbonaceous shale and *lignite*.
					Unconformity
		Rhyolite		?	Massive dark reddish brown rhyolite porphyry.
					Unconformity
Permian and older systems		Undifferentiated		?	Bluish gray and light gray cherty limestone; light gray quartzite, quartz mica schist and marble, some dark shale.

Figure 2. Generalized section of rock formations, Goose Creek lignite field.

Payette (?) Formation (figure 3)

The Payette (?) Formation crops out along the west flank of the Goose Creek Basin along the Cassia Mountains. Whether or not the formation exists in Utah is unknown. Insufficient detailed studies have been made of the Grouse Creek Basin to determine its existence there. The rocks consist of interbedded tuff-bearing shales and volcanic ash. To a lesser extent the unit contains conglomerate, sandstone and lignitic beds. It is not resistant except in some conglomeratic beds and forms gentle slopes. It is about 900 feet thick near the Worthington mine, but may not have been deposited to the east. Mapel and Hail (1959, p. 225) indicate:

> About 50 percent of the Payette (?) Formation is slabby, evenly bedded, light greenish gray and yellowish gray tuffaceous shale. At some places the shale is diatomaceous; fossil leaves and seeds are abundant in some beds, and the formation contains several lenses and thin beds of brown carbonaceous shale and lignite. Interbedded with the shale and making up most of the rest of the formation are beds of friable light gray to white volcanic ash which range in thickness from a few inches to more than 100 feet. Beds of sandstone or conglomerate, locally as much as 40 feet thick, occur at various levels in the formation; their resistance to erosion makes them useful key beds for mapping and correlation.

The Payette (?) is considered partly Miocene and partly Pliocene in age. It contains the Worthington lignite zone 400 feet below the top of the unit.

Salt Lake Formation (figure 3)

The Pliocene Salt Lake Formation comprises most of the outcrop area of the Goose Creek Basin and the upper half of the Grouse Creek Basin. The thick unit has been subdivided into a lower and upper member. The thickness of the lower member ranges between 1,200 and 1,600 feet and the upper member, 700 to 1,000 feet. Division of the lithologically similar members is made at the base of the stratigraphically highest beds of welded tuff. The unit consists largely of friable volcanic ash with lesser amounts of welded rhyolitic tuff, shale, sandstone, conglomerate, lignite, carbonaceous shale and limestone. Most of the unit is nonresistant but the welded tuffs crop out as ledges and hogbacks.

Volcanic ash and welded tuff make up most of the Salt Lake Formation which is white to light gray, fairly well stratified in the lower part of the unit and poorly stratified in the upper. These tuffs and volcanic ash beds are made up mostly of fine-grained glass shards. Sometimes the volcanic ash is devitrified, producing a bentonitic clay which is especially prevalent in the lower part of the unit. Some of these bentonite units are 20 feet thick.

The Salt Lake Formation contains several zones of carbonaceous shale or lignite, all confined to the lower member. Most consistent is the uppermost Barrett zone 500 to 600 feet below the top of the lower member. The other zones occur lower and are labelled with letters of the alphabet. Zones A, B and C have been recognized. Zone C is about 300 feet below the Barrett zone.

Surficial Deposits

Three types of Quaternary surficial deposits occur in the area. Alluvium fills the immediate valleys of Goose Creek and Grouse Creek. It consists of clay, silt, sand and gravel and is roughly stratified. The floodplains of these creeks vary up to a half-mile in width.

Landslides are few and consist of slumped older strata mostly of the Salt Lake Formation. Some high-level gravel deposits are as much as 15 feet thick. The source of the gravel, which consists of streamworn pebbles, cobbles and boulders of rhyolite, Paleozoic limestone and Precambrian quartzite, is the Goose and Grouse Creek mountains.

Structure

The structure of the area, especially of the Grouse Creek Basin, is incompletely known. The Tertiary rocks of both basins are known to be faulted and folded. In addition the strata were deposited in an area of some relief so that the unconformity at the base of the Tertiary controls its thickness. Faults with displacements as high as 900 feet cut the Tertiary. Most faults trend north and south.

Strike and dip symbols on maps indicate Tertiary strata dipping more than 50 degrees, but generally dip is much less, averaging between 3 and 15 degrees. In Goose Creek Basin, the inclination is mainly to the east. The regional dip in the Grouse Creek Basin is unknown.

In addition to the unconformity on top of the Permian and older rocks, local unconformities exist within the Tertiary units which would affect mining locally if a suitable reserve of lignite were located to be mined.

Geologic and Tectonic History

No available studies diagnose the geologic history of the Grouse Creek Basin. It is believed similar to that of Goose Creek Basin and other basins of northeast Nevada. According to Mapel and Hail (1959, p. 240):

> . . .in parts of northeastern Nevada the Miocene basins of deposition originated as a result of downwarping or faulting, and that faulting continued during later Tertiary time. Although folding and faulting in the Goose Creek district may not have been strictly contemporaneous. . .(to) nearby areas in Nevada, a similar structural history can be postulated as follows: (1) folding or faulting which originated the basin of deposition of the Payette (?) Formation, (2) faulting during deposition of the Payette (?) and Salt Lake Formations with progressive deepening of the basin and rejuvenation of the adjacent highlands, and (3) renewed faulting and folding after deposition of the Salt Lake Formation, perhaps in adjustment to downwarping of the Snake River plains to the north.

Deposition took place in a fluvial environment, the lignite and carbonaceous shales forming in quiet floodplains. Volcanism was prominent around the margins of the basins and supplied much of the clastic materials.

Correlation with Surrounding Areas

The lignite beds of the Goose Creek lignite field do not correlate with any other known coal or lignite fields in Utah. An approximate correlation with adjacent areas is given in figure 4 (page 385).

COAL DEPOSITS

Status of Information

Parts of the Goose Creek field have been studied by a few investigators; others have not been adequately examined. Little is known about the Grouse Creek Basin and no geologic map at a suitable scale is available. The best reference for the Goose Creek Basin is Mapel and Hail (1959), who examined the area on behalf of the U. S. Atomic Energy Commission. Small amounts of uranium are associated with the carbonaceous shales and lignites. The lignites cropping out in Idaho were investigated earlier by Bowen (1913).

Preliminary investigations, however, indicated the marginal condition of the lignites and further investigations are probably unnecessary, at least from an economic point of view, at this time.

Mines, Prospects and Production

No mines have been opened in the Utah portion of the Goose Creek field (figure 1). Examination of a deposit located in sec. 9, T. 12 N., R. 17 W. in the Grouse Creek Basin not far from Kimbell Creek showed a modest dump with some bulldozer cuts. The condition of the prospect indicates that work was done some time ago and weathering prevents the obtaining of an accurate lignite section. The prospect was opened in the lower Salt Lake Formation.

The Worthington mine in Idaho is the only one in the entire field that has produced. The mine, located in SE ¼ sec. 26 (unsurveyed) T. 16 S., R. 20 E., was driven 300 feet at a 10-degree inclination. The thickness of the seam is about 4 feet but contains a 2-inch shale split. The seam is in the Worthington zone of the Payette (?) Formation.

Production is unknown but is considered insignificant; it may have been confined to the winter of 1911. Lignite users in Oakley thought the product inferior.

Land Ownership

The land in northwest Utah is owned by the federal government (Bureau of Land Management), by private individuals and by the state of Utah. Most is controlled by the BLM at least in the Goose Creek and Grouse Creek basins.

Interest in the lignite is nil and no leases or permits currently are held. The last known permit, which expired in 1938, was located in Idaho. The Worthington mine and the Kimbell Creek prospect appear to be on private land.

Quality of the Lignite

Three analyses, all from Idaho within 2½ miles of the Utah line, are available (table 1). One is from the Worthington mine, Payette (?) Formation, the other two from a drill hole to zone B, Salt Lake Formation. Evenso it is believed that they represent the field. Sulfur content is approximately 1 percent on an as-received basis. A quick examination reveals that many of the seams are carbonaceous shale rather than a pure lignite. Numerous uranium analyses also included ash determinations. In many cases the ash content exceeded 50 percent.

Reserves

No attempt has been made to estimate the lignite reserves in the Goose Creek and Grouse Creek basins at this time or by previous investigators for the following reasons:

1. The lignite-bearing area has not been precisely defined.
2. The lignite beds are lenticular and the quality and thickness of the explored part does not justify the extensive explorations necessary to define the remainder of the field.
3. The lignite occasionally grades into carbonaceous shale and it is difficult to distinguish between the two.

Coal Seams

The two areas in the Utah part of the Goose Creek field are: Goose Creek Basin and Grouse Creek Basin. Not enough data are known about Utah outcrops to warrant a separate discussion. Only measured sections 21 and 27 are located in the state. Section 21

Table 1. Quality data of coal, Goose Creek lignite field.

No.	Mine or Prospect-Coal bed	Township & Range UTM grid	PROXIMATE ANALYSES					ULTIMATE ANALYSES						OTHER TESTS			Kind of Samples	Ref. Source
			AN	M	VM	FC	Ash	S	H	C	N	O	Btu/lb	AST	ADL	HGI		
1	Worthington Mine	SW.23-16S-20E	A	34.5	26.4	21.1	18.0	0.6	–	–	–	–	5,810					2
	Idaho, Worthington zone		C	–	40.3	32.2	27.5	1.0	–	–	–	–	8,870					
2	Drill hole (22)	SW.24-16S-21E	A	33.4	11.8	11.7	43.1	1.0	5.0	16.6	0.3	34.0	2,925					5
	Idaho, zone B upper bed		C	–	17.7	17.6	64.7	1.5	2.0	24.9	0.5	6.4	4,390					
3	Drill hole (22)	SW.24-16S-21E	A	21.6	8.7	8.1	61.6	1.0	3.4	10.6	0.2	23.2	2,050					5
	Idaho, zone B lower bed		C	–	11.2	10.3	78.5	1.3	1.2	13.5	0.3	5.3	2,620					

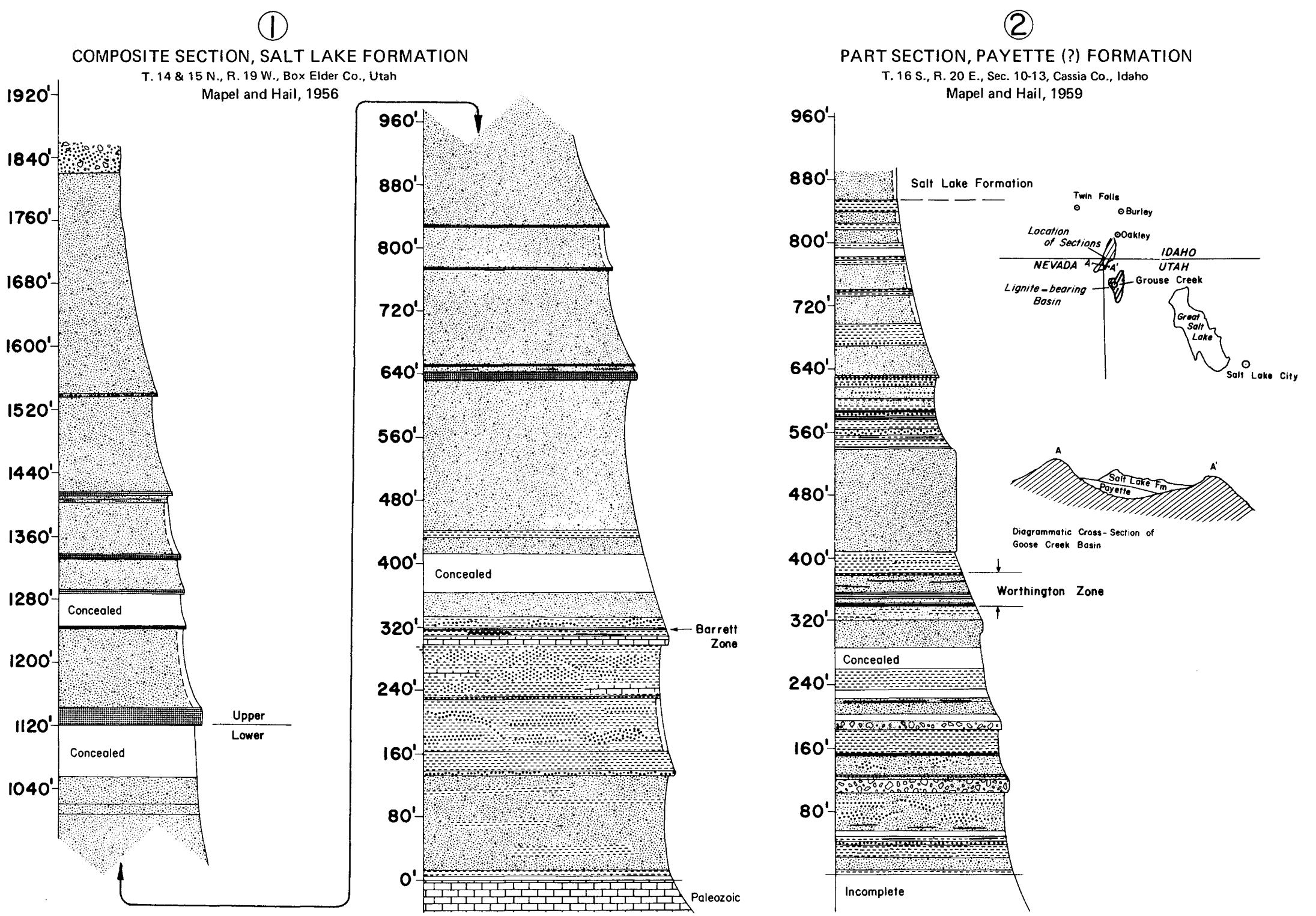


Figure 3. Sections of Salt Lake and Payette (?) formations, Goose Creek lignite field.

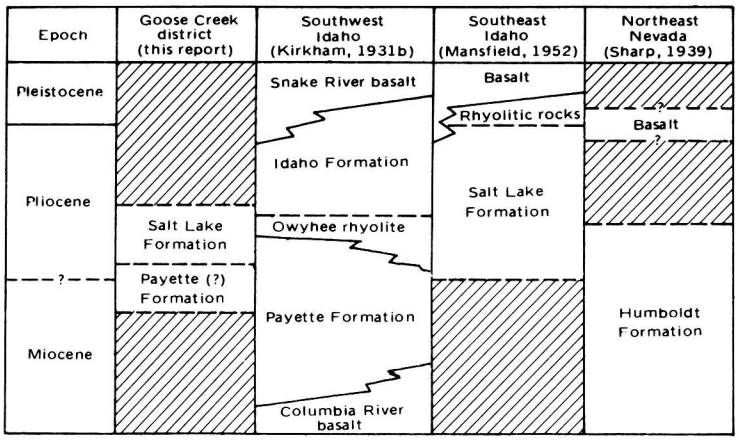


Figure 4. Approximate correlation of some rocks of Tertiary and Quaternary age in south Idaho and northeast Nevada, as described by several writers (after Mapel and Hail, 1959, p. 225).

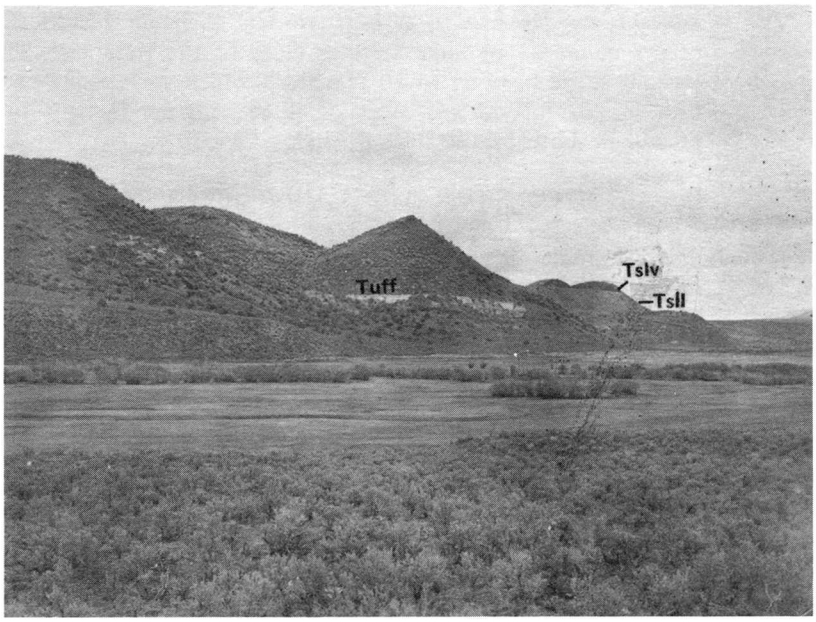
indicates 0.8 feet of lignite and section 27, four feet in a split section. The Kimbell Creek prospect in the Grouse Creek area indicates the presence of at least two feet of lignite. Lignitic shale occurs in many adjoining sections close to the state line. These contain single beds up to 10 feet thick which are considered too high in ash for mining. Most of these beds are thought to be present in subsurface sections in Utah.

ECONOMIC CONSIDERATIONS AND FORECAST

To mine lignite from the area would require underground methods and its cost of extraction would compare closely with mine costs elsewhere in coal or lignite seams of comparable thickness. In terms of cost-per-unit of energy, however, the cost would be prohibitively high because of the low heat content.

Because of the low grade of lignite in the area no possibility for its development exists within the foreseeable future. Its uranium content is not sufficiently high for economic extraction at the present time. It is doubtful that lignite from this area will ever be mined except for limited local use.

An upper 5-inch lignitic shale and a lower 7- or 8-inch lignite bed in the Salt Lake Formation near Kimbell Creek, sec. 8, T. 12 N., R. 17 W., Grouse Creek Basin, Goose Creek coal field.



Looking northwest across Goose Creek Valley, NE ¼ sec. 27, T. 16 S., R. 21 E., Cassia County, Idaho. Upper and lower Salt Lake formations are indicated (photo by C. S. Westerberg, 1970). Tslv = Salt Lake Formation, upper volcanic sequence; Tsll = Salt Lake Formation, lower shale and lignite.

Dump at lignite diggings near Kimbell Creek, sec. 8, T. 12 N., R. 17 W., Grouse Creek Basin. Probably little if any usable lignite was produced.

QUADRANGLE REPORT

GOOSE CREEK NE–
COTTON THOMAS BASIN NW QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Goose Creek coal field lies to the extreme northwest where Utah borders with Nevada and Idaho (Preface, figure 1a). The Goose Creek NE–Cotton Thomas Basin NW quadrangle is a composite formed from portions of each U. S. Geological Survey quadrangle. Although the area is remote, it is served by well graded county roads. Burley, Idaho, is the nearest large town (about 8,000) 40 miles to the north. Some services are available at Oakley, Idaho (population about 600), 20 miles to the north. The nearest Utah community is Grouse Creek, 21 miles to the southeast, with a population of 100. Only a few ranches are located on the quadrangle. Four-wheel drive roads extend from the county roads to provide access to most parts of the quadrangle. The counties involved are Box Elder County, Utah, Cassia County, Idaho, and Elko County, Nevada.

The hilly to mountainous land with normally nearly horizontal strata has provided the area with a rolling bench topography, especially in areas underlain by lignite. Nevertheless, steep slopes, cliffs and high prominences dot the area. The drainage is controlled by the northeast-flowing Goose Creek. Streams join Goose Creek from each side at near right angles. Most of these tributaries are intermittent and all the important ones flow from the southwest heading in the Goose Creek Mountains. These include Birch Creek, Pole Creek and Hardesty Creek. The Cassia Mountains are located to the northwest.

Elevations on the quadrangle range from 4,900 feet along Goose Creek to more than 7,000 feet in the southeast map corner. The lignite seams are all exposed between 5,000 and 5,600 feet.

STRATIGRAPHY

Rocks in the area are either Paleozoic or Cenozoic in age. The older rocks consist of hard indurated cherty limestones, quartzite, dark shale and quartz mica-schist. Some of the rocks may be Precambrian in age and they outcrop in knolls and cliff faces in the south part of the area.

Of most importance with respect to lignitic coal are the Tertiary units–basically three sedimentary units and one volcanic unit. The lower unit is rhyolite, dark reddish brown and porphyritic. It is early Miocene in age and up to 20 percent of its mass contain phenocrysts, mostly oligoclase feldspar. Other minerals include quartz, orthoclase, magnetite and zircon. The groundmass consists basically of an intergrowth of feldspar and tridymite. The unit may be in part a quartz latite rather than a rhyolite. The thickness of the flow has not been determined and most of the outcrops occur in the southeast map area.

Unconformably overlying the rhyolite is the Payette (?) Formation (figure 5), Miocene and Pliocene in age, and the Salt Lake Formation, thought to be Pliocene in age. The Payette (?) consists of interbedded tuffaceous shale, volcanic ash with small amounts of lignite, sandstone and conglomerate. At least 50 percent of the unit are light greenish gray and yellowish gray slabby and evenly bedded tuffaceous shale. In places it is diatomaceous and contains fossil vegetal matter. The best lignite beds occur in one, possibly two zones. The lower Worthington zone is recognized by both Mapel and Hail (1959) and Bowen (1913). The Worthington zone occurs 500 feet below the top of the approximately 900-foot unit. It is the only Payette (?) zone mapped in the quadrangle. About 200 feet above the Worthington is a zone of carbonaceous shale which may correlate with Mapel and Hail's Grant zone exposed 10 miles to the north of the map area. During deposition of the Payette (?) outcrops, which lie only in the west part of the area, relief may have been considerable. The Payette (?) is completely missing in outcrop southwest of Goose Creek and may not be present in Utah at all.

The Salt Lake Formation is subdivided into a lower member and an upper member. The lower unit is almost 1,200 feet thick along Hardesty Creek at the Nevada-Utah border. The unit consists of alternating bentonite, volcanic ash, sandstone, shale, siltstone, limestone and welded tuff. Volcanic ash and welded tuff beds dominate. Gray-white colors are common; light green-gray colors are also prominent. In addition brown to black lignite beds have been subdivided into zones. These include the Barrett zone and zones A, B and C. The Barrett zone is the highest and lies about 325 feet above the base of the unit.

The upper part of the Salt Lake Formation is divided from the lower by the first persistent thick beds of welded tuff. Mapel and Hail (1959, p. 233) measured an incomplete section of 710 feet, ½ mile west of Pole Creek. Most is welded tuff and volcanic ash; some thin conglomerate also is present. The complete unit is probably more than 1,000 feet thick. No lignite zones have been discovered in the upper part of the Salt Lake Formation. Outcrop areas of the Salt Lake Formation dominate the map.

In addition Quaternary unconsolidated deposits include alluvium, landslides and high-surface gravels. The alluvium is mainly confined to Goose Creek Valley. The gravelled surfaces are located mainly southeast of Goose Creek.

STRUCTURE

Goose Creek Valley and the surrounding benches represent a structural basin in the north part of the Basin and Range Province (figure 6). The basin is filled with the Tertiary rhyolite, Payette Formation (?) and the Salt Lake Formation. The beds are gently folded and significantly faulted.

The beds dip gently southeastward with inclinations up to 46 degrees. The steeper dips occur between faults and for the most part beds dip 3 to 9 degrees. Near Hardesty Creek the Salt Lake Formation is tightly folded into a syncline and anticline, with the latter faulted along the crest.

Several north-south faults, most prevalent to the east, cut the Tertiary units. Some have displacements up to several hundred feet. Most have the upthrown block to the east causing a repetition of section.

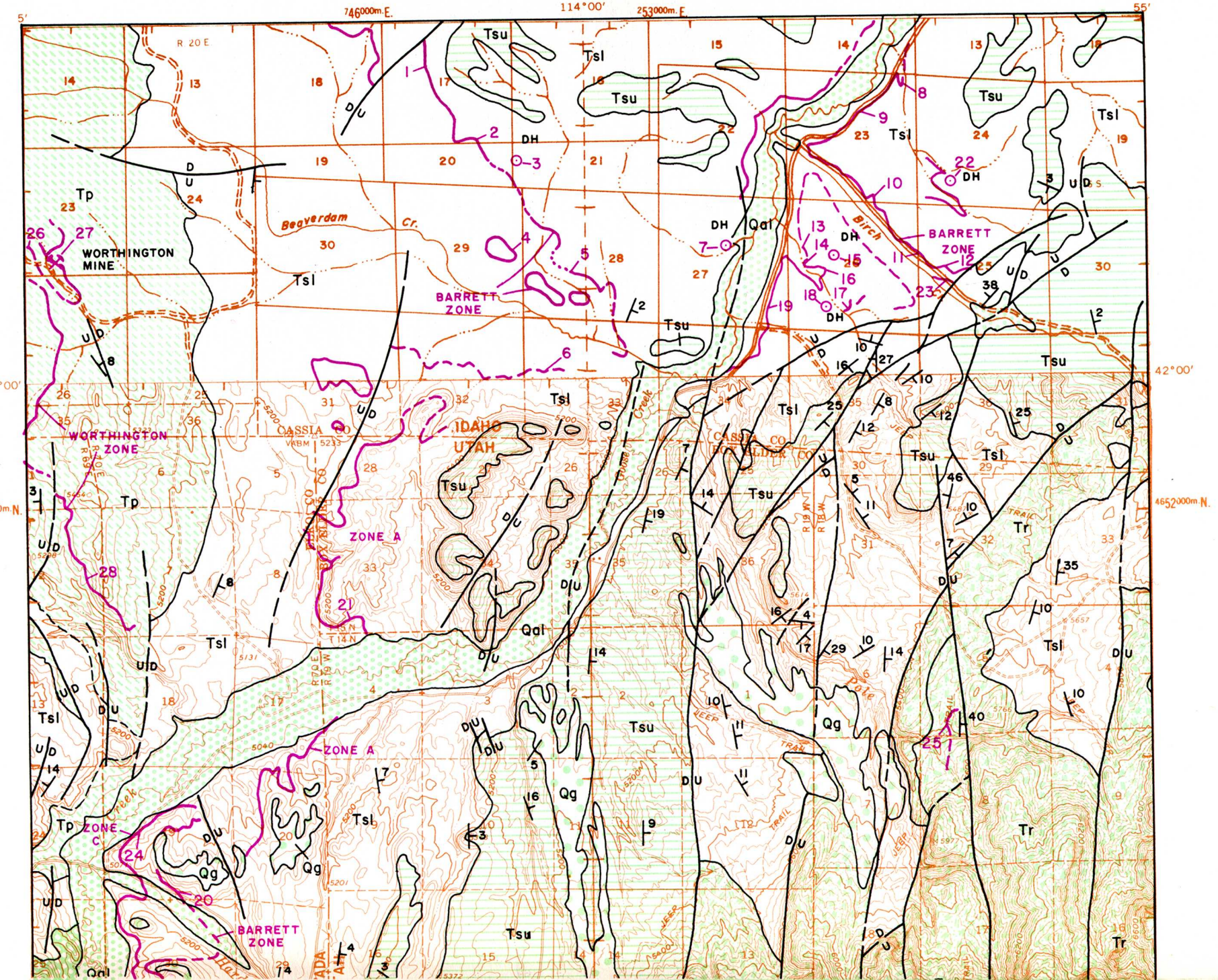
PROPERTY CONTROL

Only the Utah portion of the mapped area was accounted for in this report. The lands are divided by private interests, the Bureau of Land Management and the state of Utah. Most is federal (71 percent) and only 9 percent are Utah land. Presently leasing for coal or lignite on the quadrangle is nonexistent.

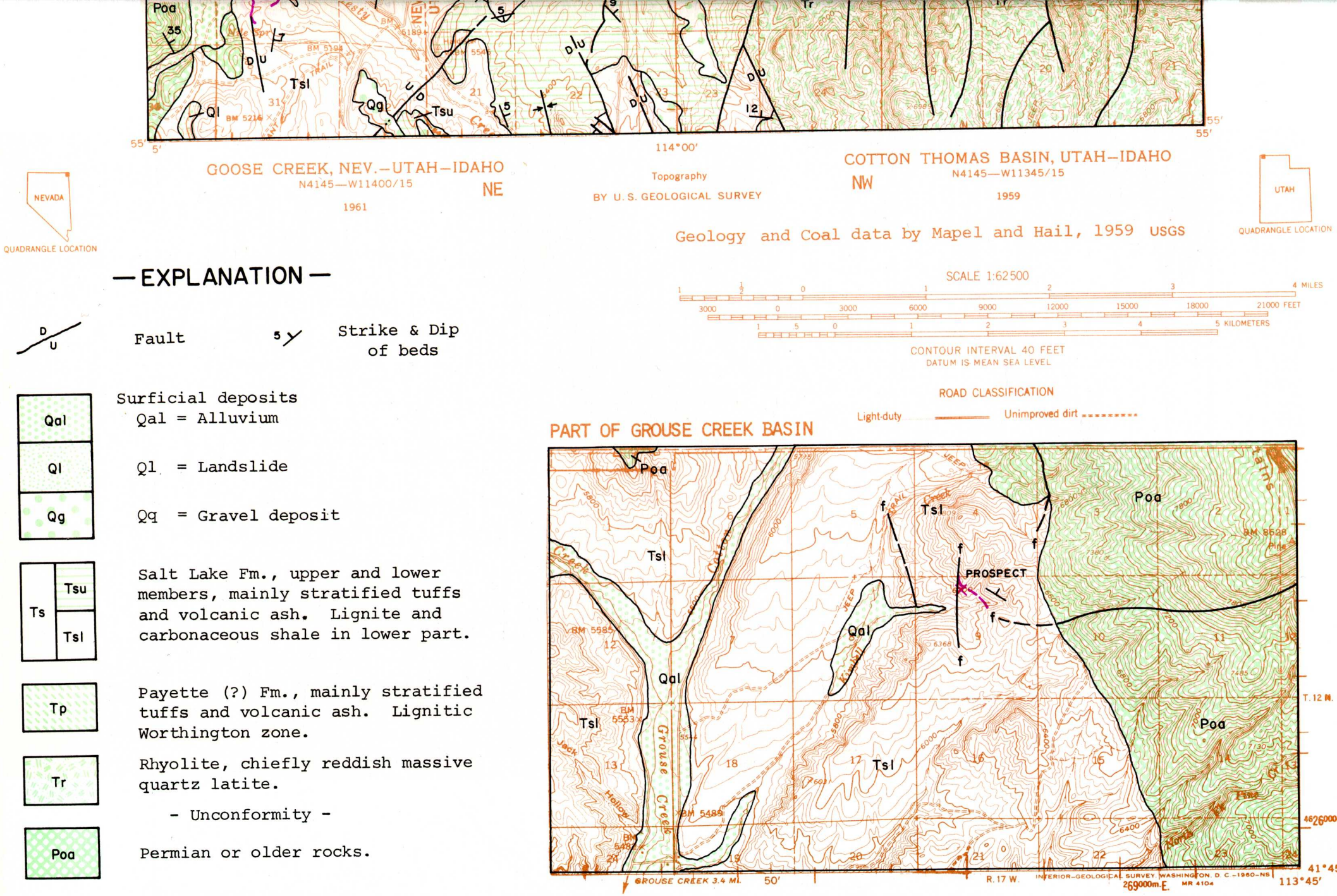
COAL

Surface Information

Twenty-seven sections (figure 7) attest to the condition of the lignite zones. About five of these are drill-hole data. Best represented is the uppermost Barrett zone which includes twenty sections, three of which are from drill-hole data. Most of the



5'
746000m.E.
114°00'
253000m.E.
55'
42°00'
4652000m.N.
R 20 E
WORTHINGTON MINE
Beaverdam Cr.
BARRETT ZONE
WORTHINGTON ZONE
CASSIA CO
IDAHO
UTAH
ZONE A
ZONE C
Birch
Creek
Pole
JEEP TRAIL
Tsu
Tsl
Tp
Qal
Qg
Tr
DH



— EXPLANATION —

D / U — Fault

5 — Strike & Dip of beds

Surficial deposits

Qal — Qal = Alluvium

Ql — Ql = Landslide

Qg — Qq = Gravel deposit

Ts (Tsu, Tsl) — Salt Lake Fm., upper and lower members, mainly stratified tuffs and volcanic ash. Lignite and carbonaceous shale in lower part.

Tp — Payette (?) Fm., mainly stratified tuffs and volcanic ash. Lignitic Worthington zone.

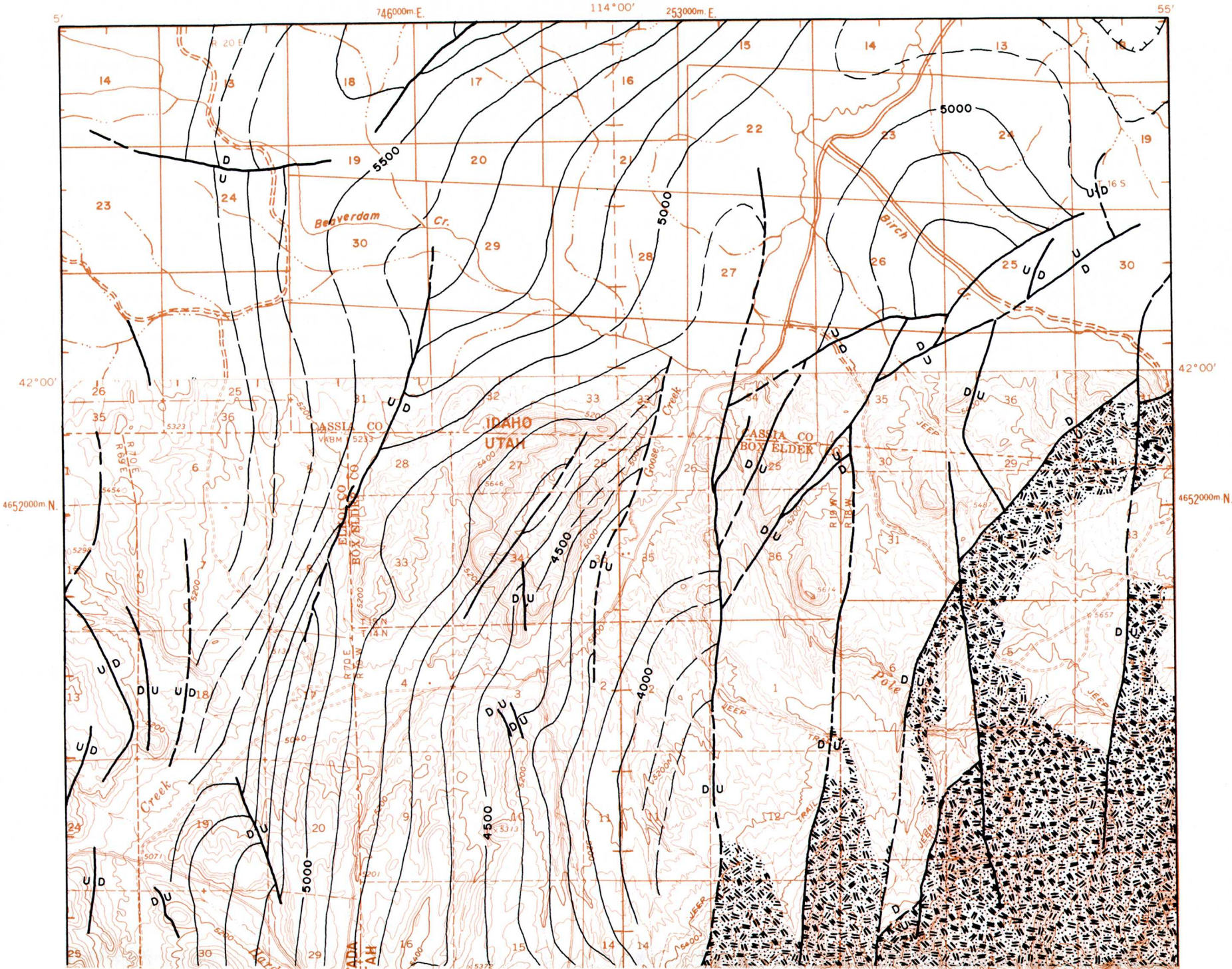
Tr — Rhyolite, chiefly reddish massive quartz latite.

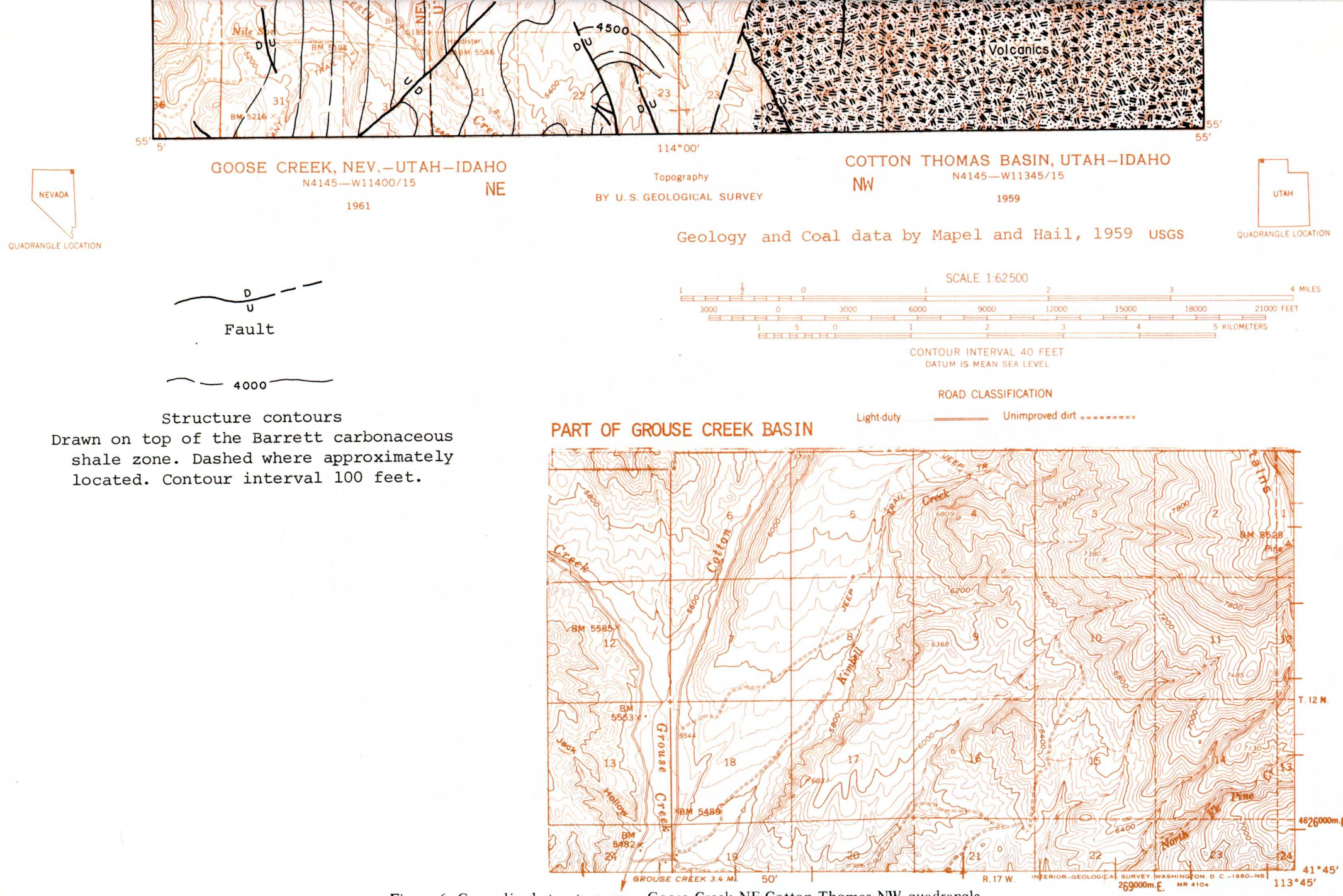
- Unconformity -

Poa — Permian or older rocks.

Geology by Stokes, 1962

Figure 5. Generalized geology map, Goose Creek NE-Cotton Thomas NW quadrangle.


5'
746000m.E.
114°00'
253000m.E.
55'
42°00'
4652000m.N.
Beaverdam Cr.
Birch Cr.
Goose Creek
Pole
Creek
CASSIA CO
IDAHO
UTAH
CASSIA CO
BOX ELDER CO
ELKO CO
BOX ELDER CO
5500
5000
4500
4000
JEEP TRAIL
JEEP
R 20 E
R 70 E
R 69 E
R 19 W
R 18 W
T 16 S
T 15 N
T 14 N



Fault

4000

Structure contours
Drawn on top of the Barrett carbonaceous shale zone. Dashed where approximately located. Contour interval 100 feet.

Figure 6. Generalized structure map, Goose Creek NE-Cotton Thomas NW quadrangle.

Geology by Stokes, 1962

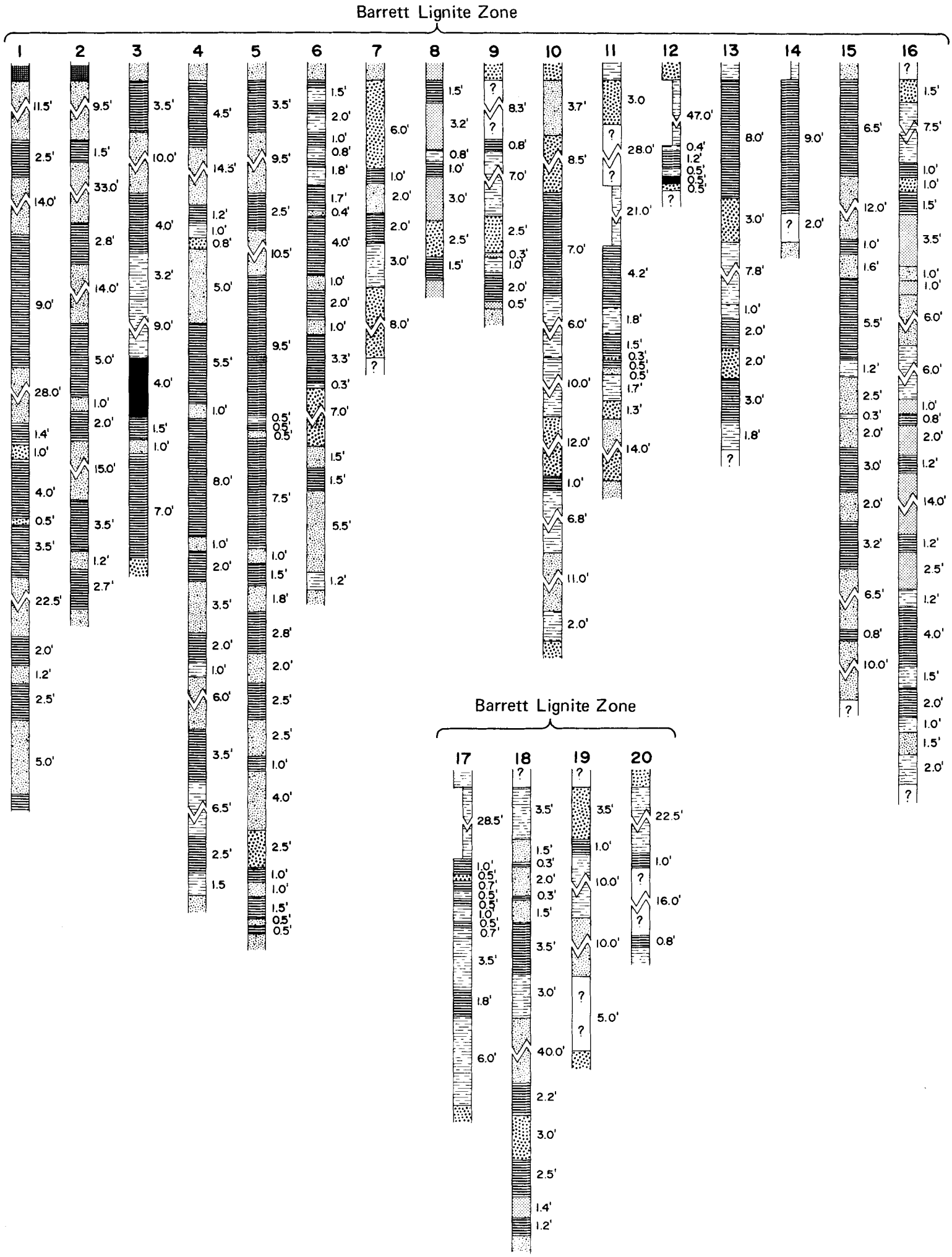


Figure 7. Coal sections of Goose Creek NE–Cotton Thomas NW quadrangle (vertical scale: 1" = 8 feet).

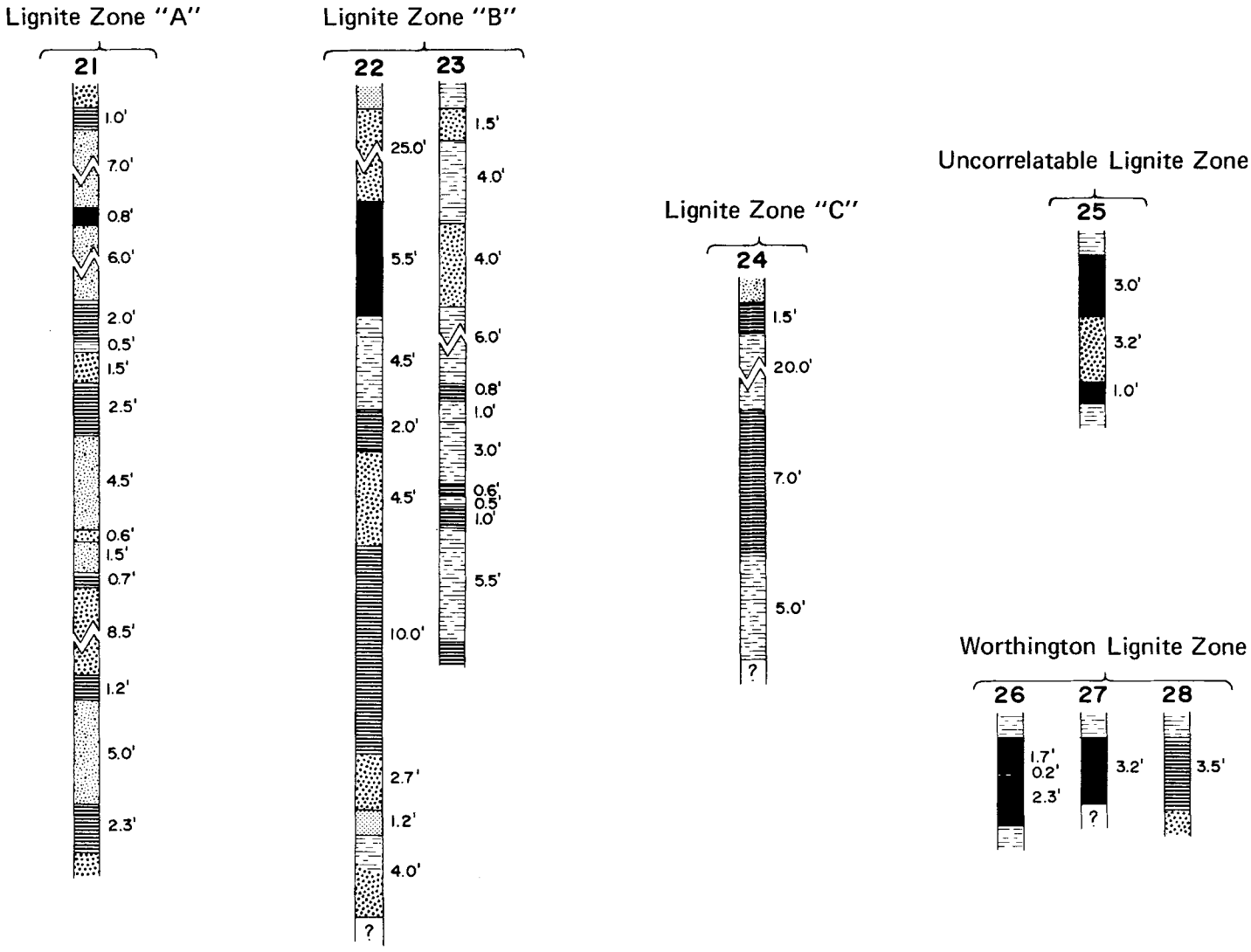


Figure 7. (continued)

sections reveal a mixture of carbonaceous shale with insignificant amounts of lignite.

Zone A is exposed in the northwest corner of the state of Utah and the carbonaceous beds are similar to those of the Barrett, basically carbonaceous shale. Zone B outcrops both in Idaho and Nevada, but only those in Idaho are represented with sections. The two sections are located about 2 miles north of the Utah line. Section 23 again consists of carbonaceous shales with insignificant pure lignite. Zone C is best exposed in Nevada and is represented by one section of impure lignite and carbonaceous shale. An outcrop in secs. 5 and 8, T. 14 N., R. 18 W. (Utah) is caught in a fault sliver and cannot be correlated; the section indicates about 3 feet of lignite. The Worthington lignite zone occurs in the Payette (?) Formation whereas the others are all included with the Salt Lake Formation. The Payette (?) may not have been deposited in Utah. Three to four feet of lignite with a 2-inch split of shale are present at the Worthington mine.

Subsurface Information

The data from five drill holes are included with the measured sections. All are in Idaho a few miles north of the Utah line. The holes were drilled in August and September of 1953 by a company contracted by the U. S. Geological Survey who in turn worked on behalf of the U. S. Atomic Energy Commission. The basic purpose was to test the uranium content of the lignites and carbonaceous shales. The location of the drill holes is indicated on the map. The data are insufficient and the geology is too complex to generalize the depths to the lignite. Locally the investigator may ascertain the amount of overburden from the map. Mapel and Hail (1959) provided some structure contours and in these areas the depth to the zones is less than 1,000 feet.

Quality of Coal

Three analyses are available for the quadrangle (table 1), one for the Worthington mine and two from a single drill hole (section 22). The sulfur content from the Worthington is 0.6 percent on an as-received basis, but contains 34.5 percent moisture and 18 percent ash. The heating value is 5,810 Btu/lb. The drill-hole lignite-carbonaceous shale contained a similar amount of moisture, about 1 percent sulfur, but averaged about 50 percent ash with about 2,500 Btu/lb all on an as-received basis.

The Worthington mine coal contains .001 percent uranium. Samples collected for uranium contained an average of 25 percent ash. The most uranium discovered on the mapped area was .044 percent for the Barrett zone (section 18); lignite zone B, section 22, had shale readings as high as 0.101 percent uranium, but most had less.

Mines and Development

No mines have opened in either the Utah or Nevada portion of the map area. In Idaho the Worthington mine was opened on the Payette (?) Formation lignite beds. Bowen (1913, p. 258) reports:

> The Worthington mine in the SE ¼ section 26 (unsurveyed), T. 16 S., R. 20 E. is the only one in the district that has marketed any coal. At this place a slope extending N 70° E and inclined about 10° is reported to have been driven on the lignite for about 300 feet. Beyond the first 200 feet the workings are now inaccessible on account of water . . . The mine was operated during one winter a few years ago and the product hauled by team to Oakley, a distance of about 25 miles. The lignite did not give good satisfaction as a fuel chiefly because of its high moisture and ash content and the mine has not been operated since.

Reserves

No reserves have been calculated for the Goose Creek NE-Cotton Thomas Basin NW quadrangle. Most of the measured sections indicate a substandard lignite, both in terms of thickness of seams and quality. This report deals primarily with the Goose Creek field in Utah. Most measurements are located in Idaho and the nature of seams and the quality of the lignite are unknown on the Utah side.

PRINCIPAL WORK

Mapping of the area was performed by U. S. Geological Survey geologists W. J. Mapel, W. J. Hail, Jr., J. N. Babcock and J. E. Conkin in 1952 (published in 1959 and 1956) for the purpose of determining the uranium content of the lignites. An earlier work by Bowen (1913) covered mainly the Idaho portion of the map area with emphasis on the Worthington lignite bed.

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LOST CREEK COAL FIELD

by

H. H. Doelling[1]

INTRODUCTION

Location and Extent

The Lost Creek coal field is located in the northeast part of Morgan County near the corner of the rectangle cut out of Utah by Wyoming (Preface, figure 1a and figure 1). Most of the coal outcrops and prospects are within the drainage basin of the Lost Creek tributary of the Weber River. The distance from the junction of Toone Canyon and Lost Creek to Ogden or Salt Lake City is about 35 miles. The area of interest is about 8 miles long and 7 miles wide, but the effective area of the field is unknown and expected to be small (no more than 6,400 acres).

Topography and Drainage

The coal field lies in the Wasatch Mountains and the terrain consists roughly of canyons and ridges in dendritic fashion. The principal drainage is Lost Creek which flows southwesterly in a broad alluvial valley. Several larger tributaries, such as Francis Canyon Creek, Toone Canyon Creek, Cedar Canyon Creek, Hell Canyon Creek, Guilder Sleeve Canyon Creek and Pine Canyon Creek, flow into it. Lost Creek is itself tributary to the Weber River which eventually flows into Great Salt Lake. The junction with the Weber River is about 6 miles south of the coal field center. Elevations range from 5,500 feet in Lost Creek Valley to 8,500 feet along the highest divides.

Population, Industries and Transportation

No towns or cities mark the Lost Creek area, but a few ranch houses are scattered in the valley. The nearest town is Croydon located near the junction of Lost Creek and the Weber River. Just below Croydon is the Union Pacific Railroad siding of Devils Slide and a cement plant. Croydon has a population of about 80. Morgan County had a 1970 population of 3,983, increasing 40.4 percent over 1960. Most of this population lives in Morgan (1,586) and Henefer (446) 6 miles west and 4 miles east of Croydon.

Land use in the Lost Creek area is primarily for summer grazing of cattle and sheep. In the valley, hay is the principle crop. Some timber is locally harvested but resources are limited and of negligible economic importance. A reservoir was constructed near the confluence of Francis and Lost Creek canyons for recreational and water storage purposes. A graded road extends up Lost Creek Canyon from Devils Slide and U.S. Highway 30 S (I-80 N).

Climate

The climate at Lost Creek is a mountain-modified mid-latitude steppe. The area receives 16 to 20 inches of precipitation annually; the evapotranspiration rate is 18 to 21 inches. Temperatures are cold in winter and January lows in the teens are common. The January mean temperature is about 22 degrees. In July the daily highs are generally in the high 80's with a mean of about 65 degrees.

HISTORICAL OUTLINE

Coal was discovered in the area just before 1900. Some mining occurred at three localities: Toone Canyon, Paradise Canyon and along Lost Creek. The most successful operator was the Robinson mine in Toone Canyon, but when closed down prior to 1920, it ended the productive life of the field. An estimated 1,000 tons of coal were mined from the field in the interim.

GEOLOGIC SETTING

Stratigraphy

A blanket of Tertiary rock covers most of the area and in the vicinity of Lost Creek covers Mesozoic rock unconformably. A window of these Mesozoic exposures is present along Lost Creek between Francis and Guilder Sleeve canyons. These formations include the Nugget, Twin Creek, Preuss, Stump, Morrison and Kelvin formations; all are Jurassic, except the Cretaceous Kelvin. Generalized descriptions and thicknesses are given in the Generalized Section of Rock Formations (figure 2). Additional detail is summarized in the quadrangle report.

Of most importance with respect to coal is the Tertiary Knight Formation (figure 3, pages 400-401). The blanket is at the most 2,000 feet thick with the upper parts missing. The basal contact is easily recognized in the Lost Creek area where it truncates the dipping Jurassic beds. The major lithologic constituent is conglomerate with sandstone and shale. In general appearance the Knight Formation has a reddish cast. The basal conglomerate of the unit is made up of quartzite cobbles and boulders up to 18 inches in diameter firmly cemented in coarse-grained sand. This lower member is 700 to 900 feet thick. Next is a relatively thin (±100 feet) group of coarse-grained sandstones and shales. Coal usually occurs immediately above the basal conglomerate and is capped by a structurally competent sandstone. Above the middle member is another conglomerate, also very coarse and of the same constituents as the lower, but generally its matrix is deep red in color. The latter has eroded into cone-shaped spires, some over 100 feet in height with a base diameter of 75 feet. These interesting structures are seen at the head of Toone Canyon where an area of several acres is locally known as Chinatown from the suggestive appearance of the hat-like sandstone-capped pinnacles.

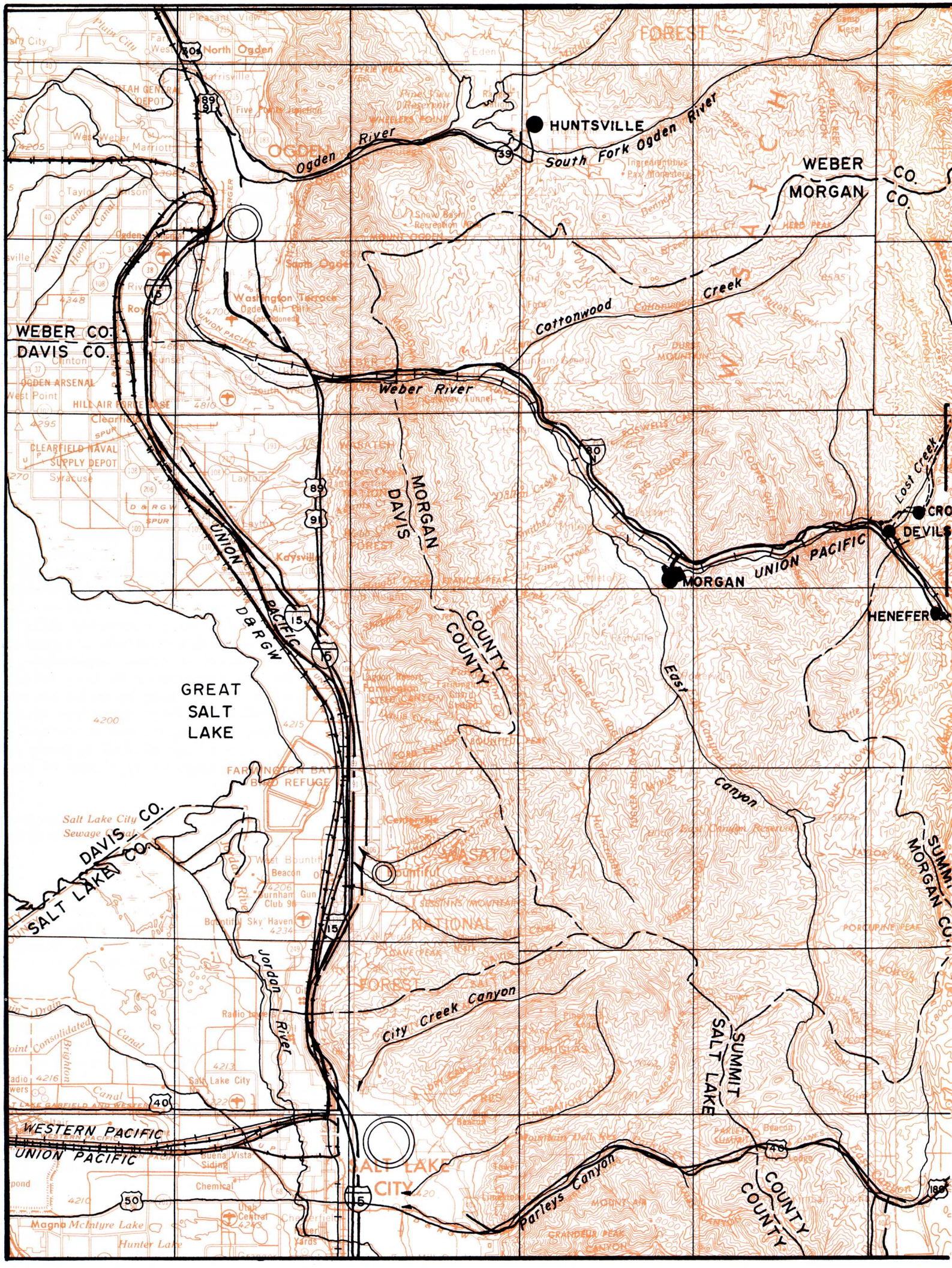
The only unconsolidated unit of importance is alluvium—stratified clay, silt and gravel that make up the floor of Lost Creek Canyon.

Structure

The major structural elements of the Lost Creek area have a definite northeasterly orientation. Madsen (1959, p. 33) considers it related both to the structures of the Wasatch Mountains to the west and the Uinta Mountains on the southeast.

In the Lost Creek area the structure may be divided into two categories: that under the unconformity at the base of the Knight and that above. Below the unconformity the most significant feature, the Toone Canyon anticline, parallels Lost Creek ½ mile to the east. It appears to be nearly symmetrical with beds dipping 40 to 45 degrees on each limb. In the vicinity of Francis Canyon the dips are 60 to 70 degrees. West of Lost Creek the Twin Creek beds beneath the unconformity participate in an alternation of closely spaced anticlines and synclines. These trend parallel to the Toone Canyon anticline. Above the unconformity the beds are basically lying flat or very gently undulating. The average dip is generally less than 5 degrees, but locally increases to 10 degrees.

[1] Economic geologist, Utah Geological and Mineralogical Survey.


North Ogden
HUNTSVILLE
South Fork Ogden River
Ogden River
WEBER CO.
MORGAN CO.
WASATCH FOREST
Cottonwood Creek
WEBER CO.
DAVIS CO.
Weber River
MORGAN
DAVIS
COUNTY
UNION PACIFIC
D & RGW
GREAT SALT LAKE
Lost Creek
MORGAN
HENEFER
East Canyon
SALT LAKE CO.
DAVIS CO.
Jordan River
City Creek Canyon
SUMMIT
SALT LAKE
COUNTY
WESTERN PACIFIC
UNION PACIFIC
SALT LAKE CITY
Parleys Canyon
Magna
Hunter Lake

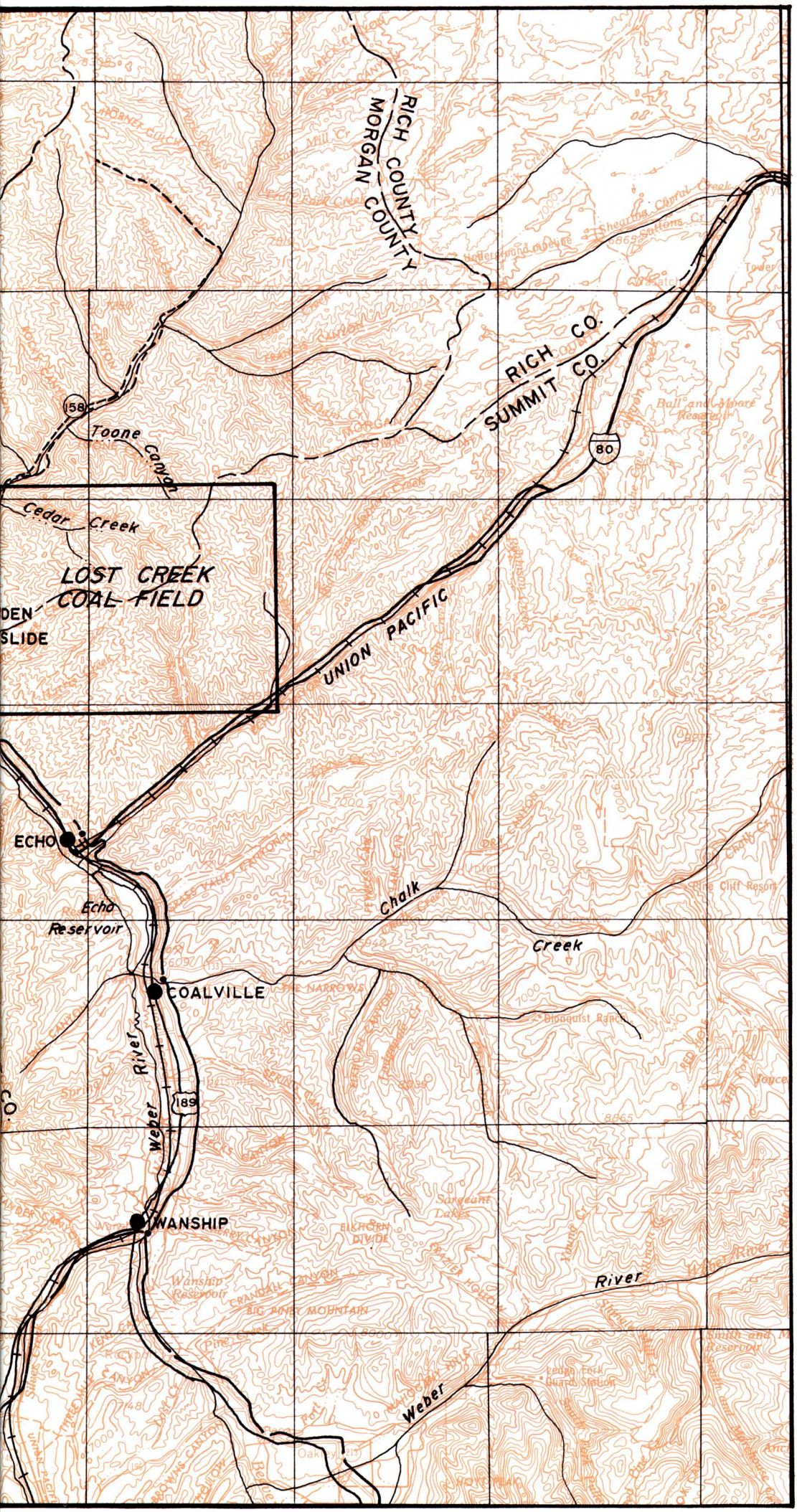


Figure 1. Topography and roads map, Lost Creek coal field.

System	Series	Stratigraphic Unit	Thickness (feet)	Description
TERTIARY	Eocene	Knight Formation *COAL*	2,000	Conglomerates, red to brown, pebble to boulder sizes, variegated shales and sandstones, *coal* 700 to 900 feet above base.
				Angular Unconformity
CRETACEOUS	Lower	Kelvin Formation	900+	Conglomeratic at base, reddish sands and silts.
JURASSIC	Upper	Morrison Formation	480	Siltstones, concretionary limestone, pebble conglomerate, predominantly red sandy matrix.
		Stump Sandstone	420	Sandstone, pale green to tan, glauconitic, calcareous.
		Preuss Formation	370	Siltstone, brick red, shaley.
		Twin Creek Formation	3,140	Limestone, dark gray, siliceous, shaley to massive, some redbeds, near top of formation, fossiliferous.
	Lower	Nugget Sandstone	1,100	Sandstone, pale orange to tan, massive, cross-bedded, fine- to medium-grained.

Figure 2. Generalized section of rock formations, Lost Creek coal field.

One fault of significant magnitude is recognized as the Toone Canyon fault. It trends northeasterly and is located ½ to 1½ miles east of the Toone Canyon anticline. The east side is downthrown and has a maximum displacement of 1,000 feet north of Francis Canyon.

Geologic and Tectonic History

The events that shaped the geology of the Lost Creek area are summarized by Madsen (1959, p. 47-53). The more important events are presented here as a series of excerpts from his account.

Early Jurassic time was characterized by a regional accumulation of eolian sands under an arid climate. Subsequent to the accumulation of the Nugget sands, the Twin Creek sea, probably an arm of the Sundance sea, encroached upon the area from the north. As the sea advanced, it locally reworked the surface sands of the Nugget and deposited the Twin Creek Limestone.

The Preuss and Stump formations represent the shoreline fluctuation of late Jurassic seaways, whereas the Morrison Formation represents an accumulation of lacustrine and fluvial sediments from a western and southwestern source . . . The Cedar Hills orogeny, an early Cretaceous disturbance, is represented by the coarse clastic sediments of the Kelvin Formation . . .

Additional Cretaceous sediments continued to be deposited even though the units are not represented and undoubtedly are covered by the Knight in the Lost Creek area. Such formations include the Aspen Shale, Frontier Formation, Wanship Formation and Echo Canyon Conglomerate. The Aspen is marine; the Frontier represents a fluctuation between marine and continental conditions and contains coal beds. These environments continued through deposition of the Wanship and the Echo Canyon represents a return to continental conditions. Orogenic disturbances probably occurred with regularity during this time and were centered to the west.

After the accumulation of the Echo Canyon and prior to the deposition of the next younger beds, a period of intense deformation ensued. The Echo Canyon conglomerate and older formations . . . were most severely deformed . . . Subsequent to folding there was a period of erosion which left the area . . . with low relief. Upon this surface the Knight detritus was deposited.

The dominant source of the Knight was to the west of the present Wasatch Mountains. Mountains probably existed in the area presently occupied by the Great Salt Lake. Initially the unit is conglomeratic followed by shales and coal-bearing beds. The energy of the fluvial environment subsided during this interval, the streams became sluggish, the land was of low relief and some large swamps developed. Vegetation flourished and carbonaceous material accumulated to eventually be coalified. The area continued to receive sediments for a time and as much as 5,000 feet of Knight Formation may have been deposited.

In late Tertiary time uplift occurred and since that time the area has been gradually exhumed by erosion in a process continuing to the present day.

Correlation with Surrounding Areas

The coal beds in the Knight Formation of the Lost Creek area do not correlate with other known coal or lignite fields. It is reasonable to assume that other local coal beds may occur in the formation over its extensive outcrop area in north Utah. Tertiary coals are known in Wyoming to the east and along the north flank of the Uinta Mountains. These coals are dated as Paleocene and the age of the Knight is regarded as Lower Eocene. In Wyoming the Knight is overlain by the Green River Formation.

COAL DEPOSITS

Status of Information

The only examinations of the Lost Creek coal field that were published are Clark's (1918) and Madsen's (1959). Evenso the data are probably adequate because of the low potential for the field. Undoubtedly coal may be discovered in other areas in the vast outcrop of the Knight, but these will probably be local in extent.

Mines, Prospects and Production

Two mines and several prospects have been opened in the Lost Creek coal field: the Robinson mine in a side canyon of Toone Canyon to the east of Lost Creek and the Smith mine on the west side of Lost Creek. The mines supplied less than 1,000 short tons of subbituminous coal to nearby ranches and to the town of Croydon between 1900 and 1920. The exact location of these mines is given in the quadrangle report.

Land Ownership

Morgan County is nearly all privately owned, including the Lost Creek area. A few scattered parcels of state and Bureau of

Table 1. Quality data of coal, Lost Creek coal field.

No.	Mine or Prospect-Coal bed	Township & Range UTM grid		PROXIMATE ANALYSES					ULTIMATE ANALYSES						OTHER TESTS			Kind of Samples	Ref. Source
				AN	M	VM	FC	Ash	S	H	C	N	O	Btu/lb	AST	ADL	HGI		
1	Heber Robinson mine	SE.SW.28-5N-5E	A	18.1	27.4	35.3	19.2	.6	5.3	47.5	.8	26.6	8,180	2,500	8.7	–		3
	Knight zone	4553175mN 467310mE	B	10.3	30.0	38.7	21.05	.69	4.73	51.97	.89	20.67	8,950	–	–	–		
			C	–	33.4	43.1	23.5	.8	4.0	57.9	1.0	12.8	9,980	–	–	–		
			D	–	43.7	56.3	–	1.0	5.2	75.7	1.3	16.8	13,040	–	–	–		
2	Lucas & Smith mine	NW.NW.17-5N-5E	A	17.55	27.78	36.87	17.80	.46	–	–	–	–	8,563	2,560	6.4	–		3
	Knight zone	4557460mN 465210mE	B	11.9	29.7	39.4	19.0	.49	–	–	–	–	9,150	–	–	–		
			C	–	33.69	44.72	21.59	.56	–	–	–	–	10,386	–	–	–		
			D	–	42.97	57.03	–	.71	–	–	–	–	13,246	–	–	–		

Land Management land are shown on figure 4 (pages 402-403). There has never been any leasing or permitting activity on the government lands and the coal mines lie on private land. In most cases the mineral rights are privately owned as well.

Quality of Coal

Two coal analyses are available which indicate the coal to be a high-ash, low-sulfur subbituminous B coal (tables 1 and 2).

Table 2. Average proximate analysis of coal, Lost Creek coal field.

	Average analysis as-received (percent)
Moisture	17.8
Volatile matter	27.6
Fixed carbon	36.1
Ash	18.5
Sulfur	0.53
Btu/lb	8,372

Reserves

From a 4-foot lower limit to calculate reserves, only 160 acres in the vicinity of the Robinson mine qualify. At an average of 4 feet, about 1.1 million tons of coal are in place.

Coal Seams

Eighteen coal sections were measured in the Lost Creek coal field, but these seem adequate because the coal is mostly present in thin boney seams and are of little value. Only the thicker seams in the vicinity of the Robinson mine should have any potential.

ECONOMIC CONSIDERATIONS AND FORECAST

The mines of the Lost Creek field served a useful purpose when fuel from other sources was not available and could be exploited again in conditions of emergency for local use. Unfavorable mining conditions, poor coal quality and lack of coal reserves, however, preclude any possibility that coal from this area will again be produced to sell under normal conditions or until the distant future. Any discussion of present or potential market for its coal is presently of no value.

Portal of Robinson mine, north side of Mine Hollow off Toone Canyon. Coal is reported 6 feet thick with a 2-inch sandy clay parting 2 feet 2 inches below sandstone roof; it lies a few feet above a coarse conglomerate and is covered with a coarse sandstone. Remains of a gravity hoist to lower coal to valley floor in foreground (photo by C. S. Westerberg, 1970).

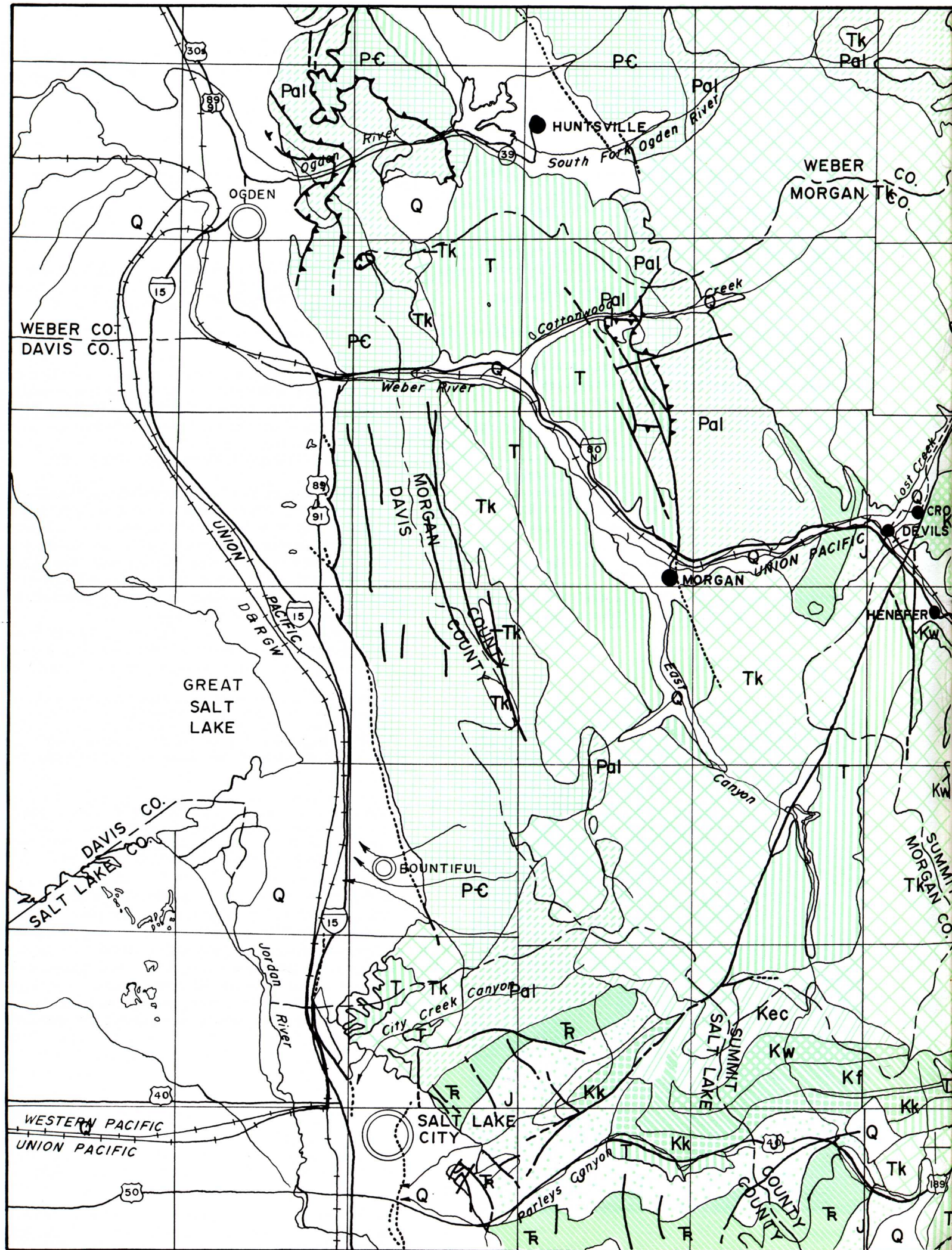
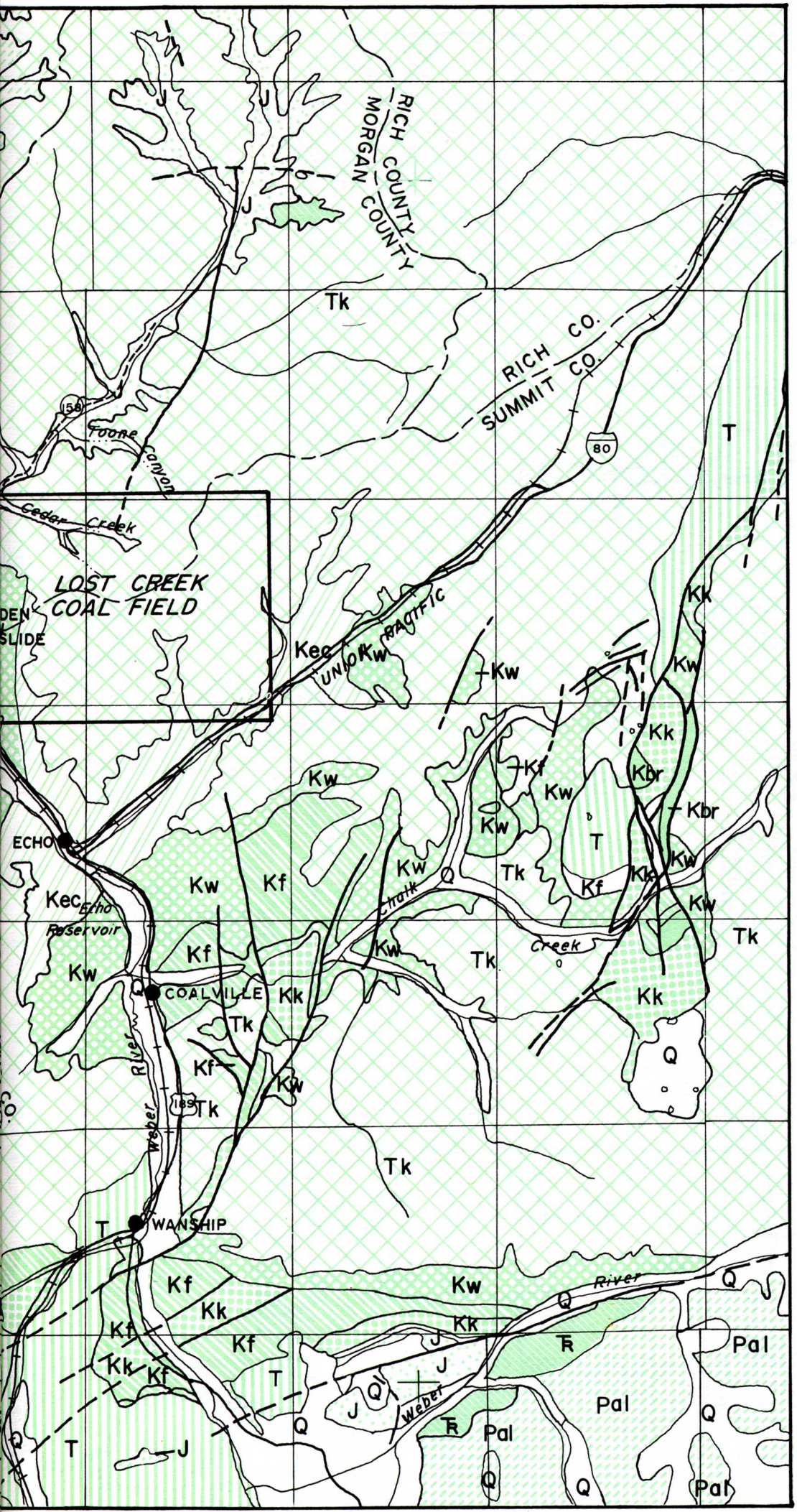


Figure 3. Generalized geology map, Lost Creek coal field.



LOST CREEK–COALVILLE AREA

Q
Quaternary

T
Tertiary

Tk
Knight Fm.

Kec
Echo Canyon

Kw
Wanship Fm.

Kf
Frontier–Aspen

Kbr
Bear River Fm.

Kk
Kelvin Fm

J
Jurassic

Tr
Triassic

Pal
Paleozoic

P-C
Precambrian

LEGEND

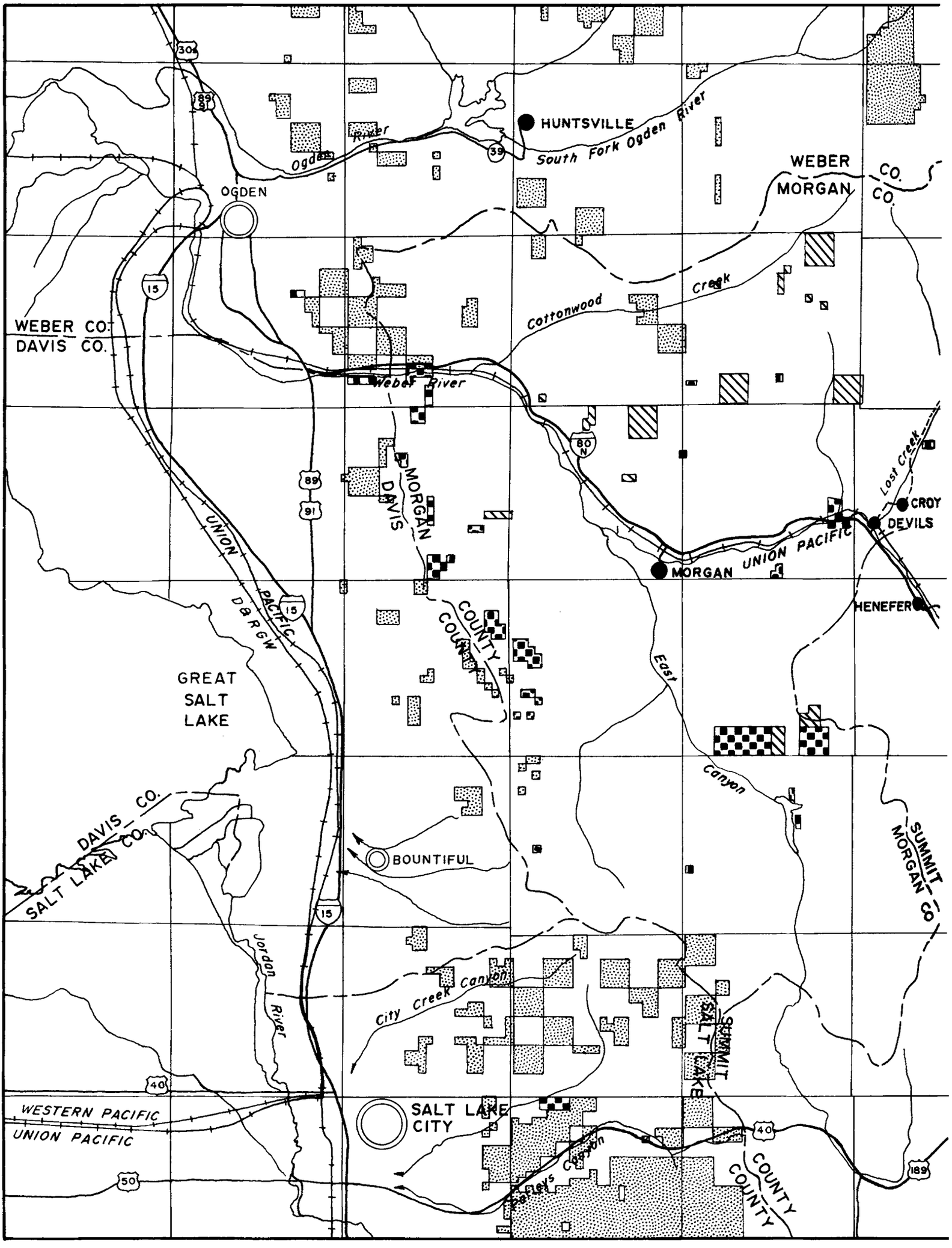
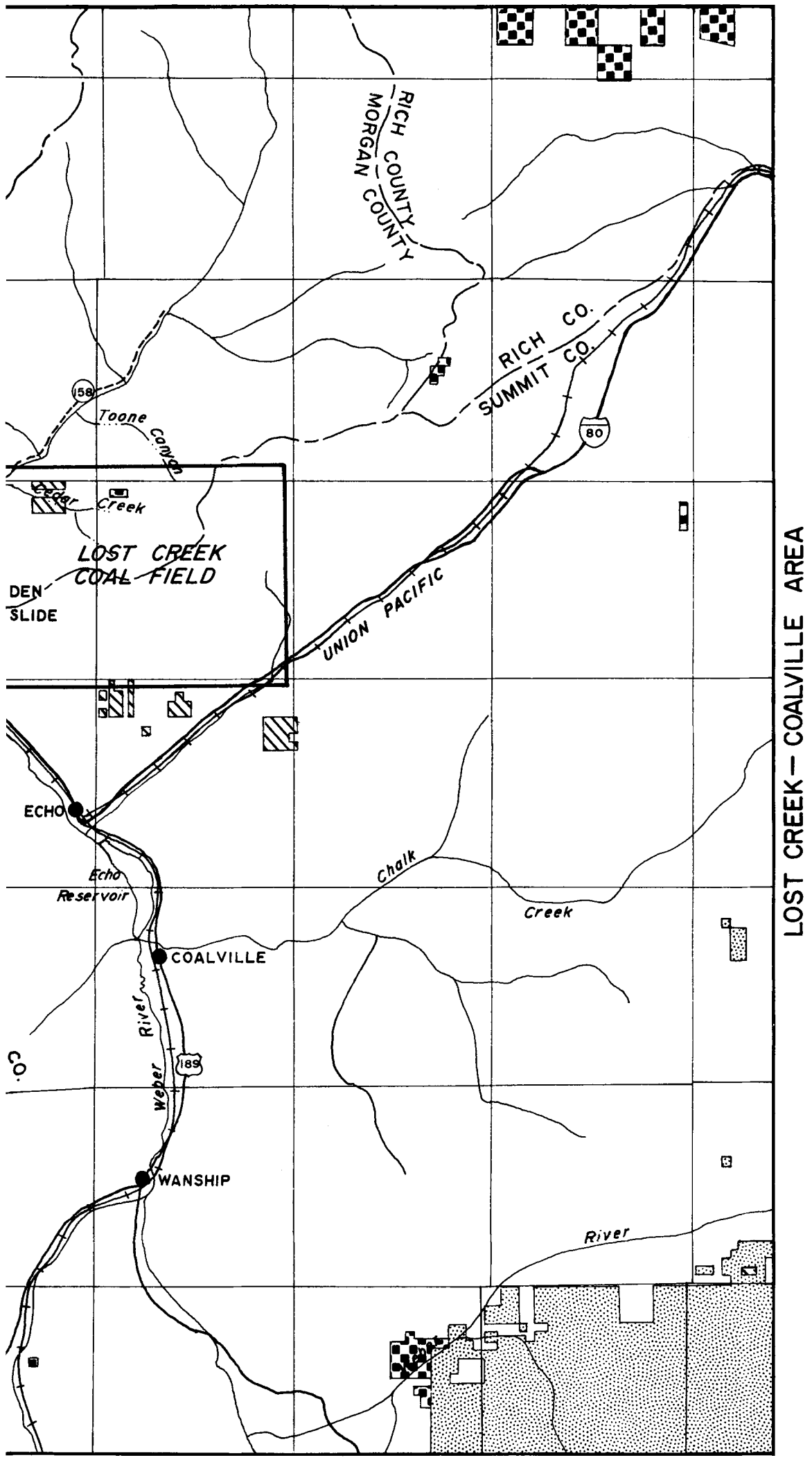


Figure 4. Land ownership map, Lost Creek coal field.



LOST CREEK— COALVILLE AREA

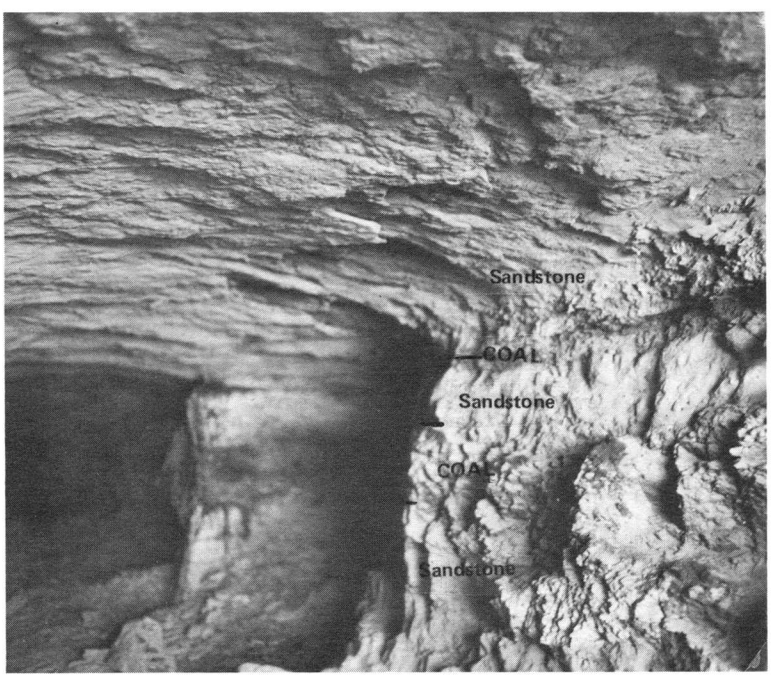
State Lands

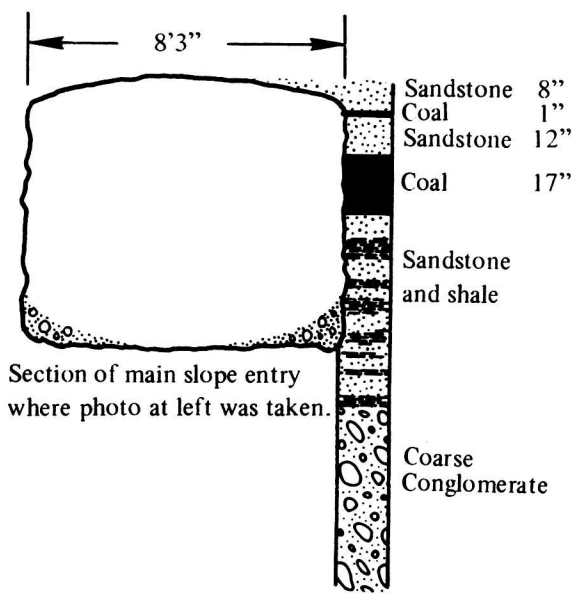
National Forest

Private Lands

BLM Lands

Portal of the Smith mine on west side of Lost Creek, about 395 feet above creek bottom. Opening is 1.3 miles southwest of Lost Creek Dam from which the mine's spoil dump can be seen (photo by C. S. Westerberg, 1970).





Section of main slope entry where photo at left was taken.

About 25 feet inside Smith mine opening. Arched roof is all pick work. Coal is less than 24 inches thick (see sketch). Top is coarse sandstone and quite competent. Entry proceeds downdip for 200 feet to where water has risen. No rock falls were encountered (photo by C. S. Westerberg, 1970).

QUADRANGLE REPORT

LOST CREEK QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Lost Creek quadrangle nearly coincides with the area of the Lost Creek coal field, but small portions extend into the Francis Canyon and Henefer quadrangles (figure 5). The map is a composite of these quadrangles plus a small corner of Heiners Creek quadrangle. The location is in northeast Morgan County and centered about Lost Creek, an important tributary of the Weber River. The distance from Lost Creek Reservoir to Devils Slide station on the main line of the Union Pacific Railroad is about 12 miles. The railroad follows the Weber River Canyon to Ogden, a major railroad center in Utah. The canyon also carries Interstate Highway 80 N which coincides with U. S. Highway 30 S.

The area is mountainous and cut by many canyons. Lost Creek, flowing southeasterly, is in a wide canyon or valley filled with alluvium. The principal graded access road is located here and dirt roads provide access to the other principal canyons. The dirt roads are not regularly maintained and are sporadically reconditioned by local stockmen.

STRATIGRAPHY

The oldest unit exposed is the Jurassic Nugget Sandstone. It consists of tan to orange (salmon colored), well cemented and cross-bedded sandstone and is normally massive. The Nugget correlates directly with the Navajo Sandstone of south Utah. About 1,100 feet are exposed at two localities: the first immediately east of the junction of Lost Creek and Francis Canyon and the second south of the confluence of Trail and Francis canyons. Both of these localities are near the Lost Creek Reservoir.

The Twin Creek Limestone is exposed along Lost Creek from Toone Canyon to Francis Canyon and in some of the tributary canyons in this interval. It is a white to gray weathering shaley limestone with subordinate redbeds and calcarenites. The calcarenites stand out as topographically resistant ribs, but usually the outcrops are obscured by talus slopes of silver-like fragments from the shaley beds. The exposures are incomplete in Lost Creek, but the thickness is expected to be more than 3,000 feet. The unit is fossiliferous with *Pentacrinus asteriscus* being a guide fossil. The Twin Creek is quarried at Devils Slide station where a cement plant converts the raw material into approximately 2 million barrels of high-quality portland cement annually.

The Preuss Sandstone, Stump Formation, Morrison Formation and Kelvin Formation are exposed only in Toone Canyon. The Preuss consists of red sandstones and siltstones that are slope forming, thin-bedded and estimated to be 370 feet thick. The Stump exposures are poor in Toone Canyon. In nearby areas the Stump is divisible into three units:

Upper Member: greenish gray glauconitic limestone.
Middle Member: light red and yellow shale and soft sandstone.
Lower Member: gray and yellow-gray sandstone.

The Stump is easily differentiated from the Preuss by the color change and is estimated to be 420 feet thick. The Morrison is poorly exposed as well and again a pronounced color change marks the contact with the underlying unit. The Morrison consists of reddish siltstones, white concretionary limestones and occasional pebbly conglomerate beds. The Morrison is 480 feet thick.

The only Cretaceous unit is the Kelvin and only the lower part is exposed. Pebbles locked in a red sandy matrix with some interbedded sandstones and siltstones describe the Kelvin in Toone Canyon.

Most of the area of the quadrangle is covered by exposures of the Knight Formation of Tertiary age. It is the coal bearer of the Lost Creek coal field. The unit is described by Clark (1918, p. 313-315) and repeated here:

> The Wasatch (Knight) in the Lost Creek field may be divided for convenience of description into three parts–an upper and a lower conglomerate and intervening sandstone and shale. It is composed largely of coarse materials, the greater part being coarse conglomerate; a minor portion near the middle consists of conglomeratic sandstone, coarse sandstone, shale, and in places thin, lenticular and valueless coal beds.
>
> The Wasatch (Knight) beds rest unconformably upon the upturned and eroded edges of Jurassic rock. The thick, massive beds of coarse conglomerate lie mainly in small areas east of Lost Creek, namely, in Coal Hollow, Joes Hollow, Paradise Canyon and the head of Cedar Canyon. A small outcrop occurs at Smith's mine, on the west side of Lost Creek. The Wasatch (Knight) in surrounding areas is composed of thin beds of shale and of coarse sandstone which at many places is conglomeratic.
>
> The maximum thickness of the Wasatch (Knight) in this area is about 1,800 feet. At the head of Toone Canyon it is coarse conglomerate except for 300 or 400 feet of sandstone and shale near the middle. In Toone and Paradise canyons the lower conglomerate is from 700 to 900 feet thick and is composed largely of quartzitic pebbles and boulders which range from a fraction of an inch to 1½ feet in diameter. The lower conglomerate is usually gray to white, but locally it may be distinctly red. The upper surface of this conglomerate is exceedingly uneven and in many places varies as much as 12° from the bedding of the overlying sandstone, shale and coal. The coal beds rest almost directly on this lower conglomerate and are overlain by the sandstone and shale member above-mentioned. In most places where exposed the coal rests on the conglomerate or is separated from it by only a few feet of shale or sandstone . . . Above the middle sandstone and shale member lies the upper conglomerate, which is distinctly red owing to the red sand matrix in which the pebbles are embedded. The pebbles and boulders are similar in character and size to those of the lower conglomerate and were laid down under similar conditions . . .
>
> . . . Interbedded with the upper conglomerate are small lenses of coarse sandstone, which being more resistant to weathering than the conglomerate, form benches and "caps" to the resulting fantastic erosional forms . . . Examples of such weathering of the lower conglomerate are well shown in Coal Hollow and of the upper conglomerate in the head of Toone Canyon at what is locally called Chinatown . . .

STRUCTURE

The structure of the units lying below the plane of unconformity beneath the Knight Formation is complex. The principal feature is the nearly symmetrical Toone Canyon anticline east of Lost Creek. West of Lost Creek is a series of closely spaced anticlines which have tightly distorted the beds of the Twin Creek Limestone into Z folds and other intricacies. The Knight was deposited on an area of little relief, the surface previously eroded nearly flat. Slight warping or minor relief on this surface causes perceptible dips in the Knight. These are gentle, generally under 5 degrees. Occasionally inclinations up to 10 degrees occur.

PROPERTY CONTROL

Within the area that may contain minable coal (secs. 15, 16, 17, 20, 21, 22, 27, 28, 29 and 33, T. 5 N., R. 5 E.) containing approximately 6,400 acres, 71 percent (including coal rights) are privately owned, 21 percent are owned by the state and the remaining 8 percent of the coal rights are owned federally. The land

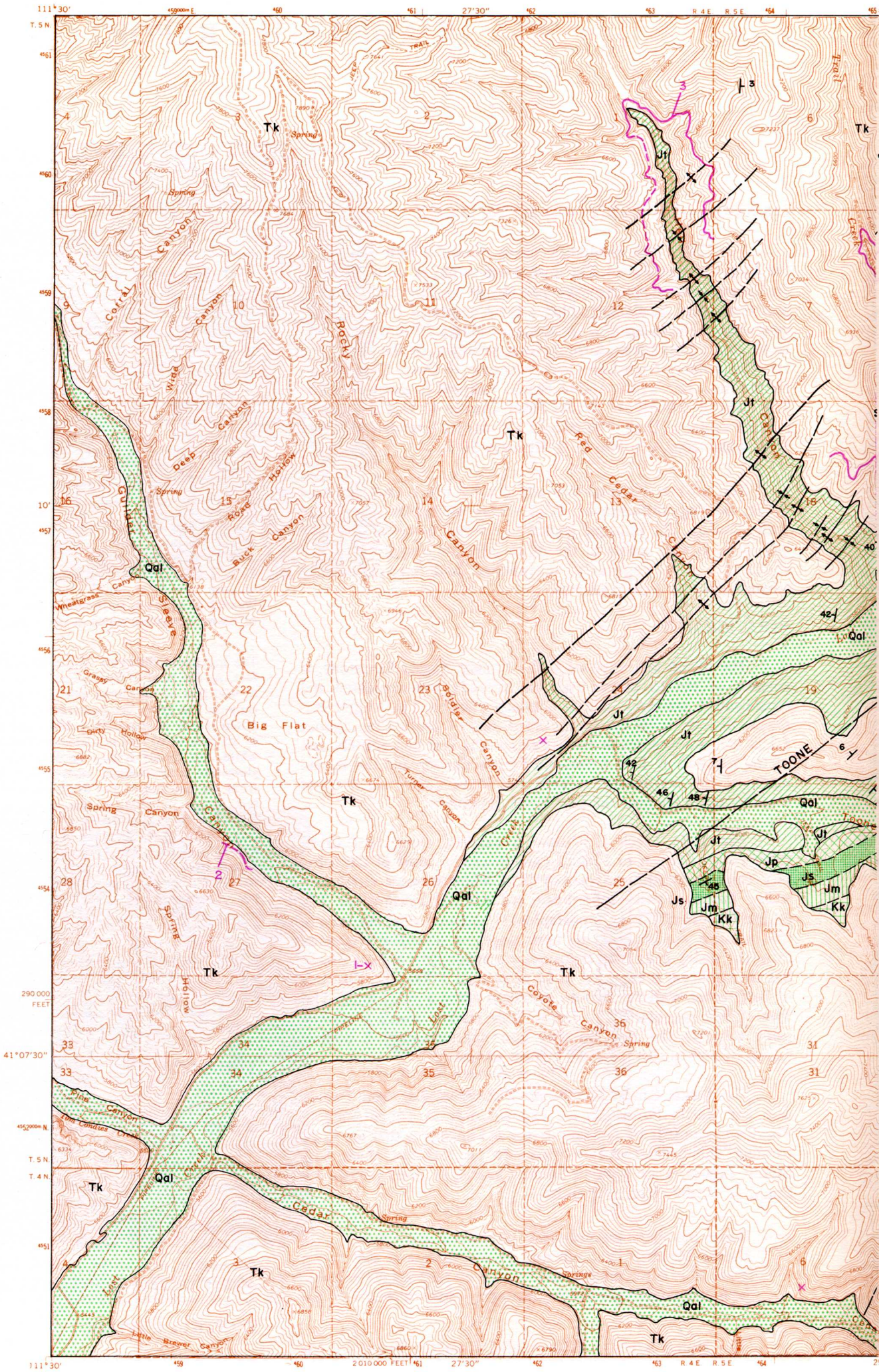
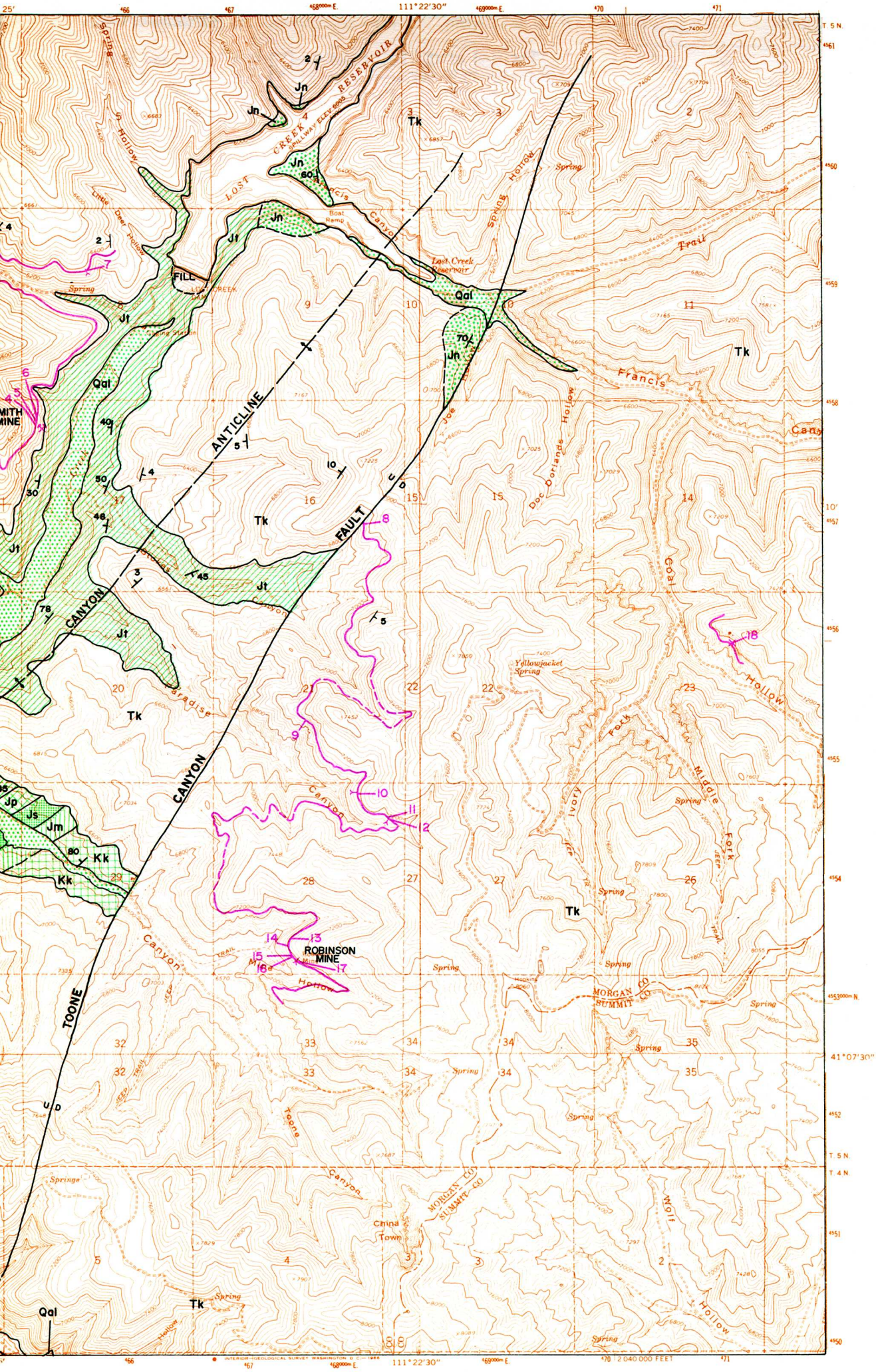


Figure 5. Coal and geology map, Lost Creek quadrangle.



SCALE 1:42240

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000

Contour interval 40 feet

Geology by J.H. Madsen, (1959), USGS
Coal data by F.R. Clark, (1918). USGS

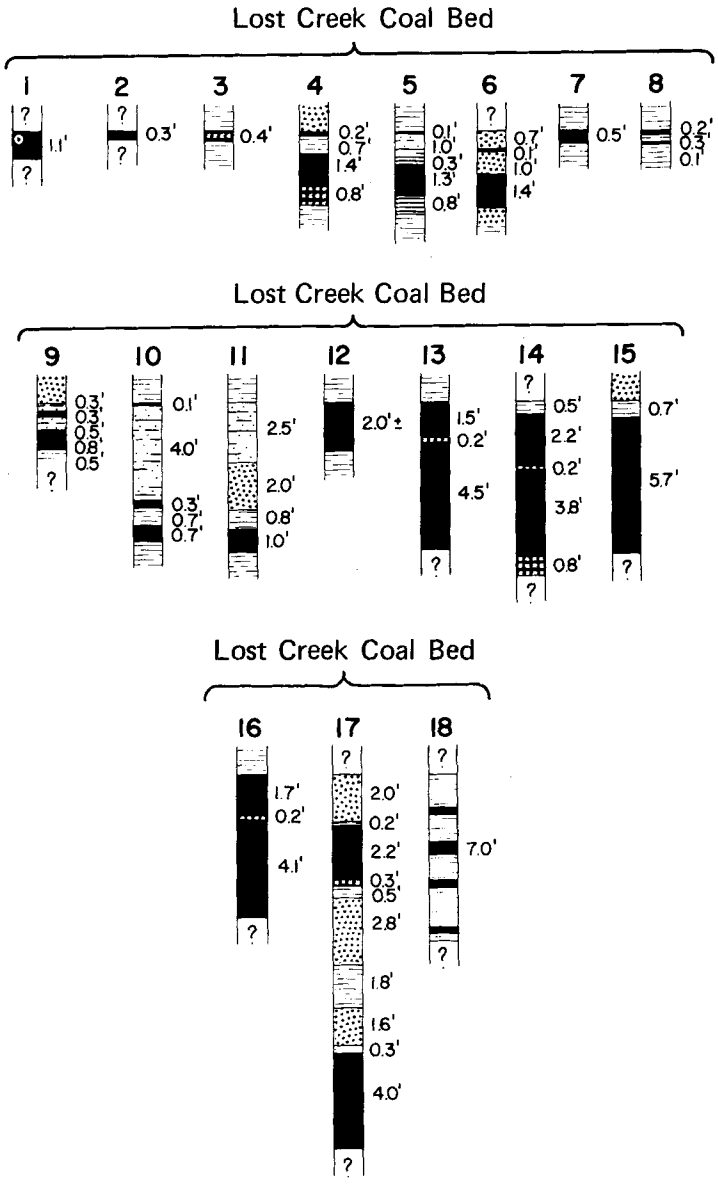


Figure 6. Coal sections of Lost Creek quadrangle (vertical scale: 1" = 8 feet).

office records in Salt Lake City show no coal lease or permit activity on any of the federal land or state land. The activity in mines and prospects of the field was on private land (figure 4).

COAL

Surface Information

The only available surface data are from Clark (1918, plate XL and p. 315-317). The coal lies in a zone in the middle shaley member of the Knight Formation. According to Westerberg (1970, p. 2) the zone is located 700 to 900 feet above the base and is about 100 feet thick. Multiple seams are believed present although, because the bed is located near the base of the zone at one locality and near the top at another, they were observed at only one place. Thicknesses of the measured sections range up to 6 feet (figure 6) with the best development at the Robinson mine. Everywhere else the reported thicknesses are less than 4 feet and generally split with bone. In Coal Hollow the bed is present and appears to be 7 feet thick, but close examination shows a 7-foot stratum of dark shale containing several thin seamlets of coal.

Subsurface Information

No drilling for coal is believed to have occurred in the Lost Creek coal field. Depth to the coal will be less than 1,000 feet at any point on the mapped area.

Quality of Coal

The coal of the Lost Creek coal field is brown and black, banded with dull and vitreous layers. The dull bands are often boney and high in ash. The coal is ranked as a subbituminous B coal with low sulfur. As-received moisture ranges from 17 to 18 percent, volatile matter 27 to 28 percent, fixed carbon 35 to 37 percent, ash 17 to 19 percent, sulfur 0.4 to 0.6 percent and Btu/lb 8,100 to 8,600.

Mines and Development

The only mines believed to have operated and produced in the Lost Creek coal field are the Smith and Robinson mines. Records of production do not exist, but is estimated to be less than 1,000 tons. Clark (1918, p. 317) notes three localities by adding prospects in Paradise Canyon (table 3).

Table 3. Mines and prospects, Lost Creek quadrangle.

Mine	Location	Remarks
Robinson mine Knight zone	SE.SW.28-5N-5E 4,553,175m.N. 467,310m.E.	1900-1920?
Smith mine Knight zone	NW.NW.17-5N-5E 4,557,460m.N. 465,210m.E.	Activity early 1900's
Paradise Canyon prospects Knight zone	NE.28-5S-5E several localities	Activity prior to 1914

Clark examined the area in 1914 and notes that the Robinson mine supplied the demands of ranchers and people in Croydon. An inclined tram ran from the mine mouth to a tipple by a wagon road along which deliveries were made. The mine cars were used on the tram, loaded cars pulling up emptied ones. He notes that considerable coal had been taken out and that the coal had been poorly mined resulting in several cave-ins within the mine. The elevation of the portal is 6,965 feet, 165 feet above the creek bottom on the north side of Mine Hollow off Toone Canyon. Presently the opening is almost closed from inflow of surface dirt. If this were removed, entry likely would be standing. The coal is 6 feet thick with a 2-inch sandy clay parting 2 feet 2 inches below the sandstone roof. The remains of part of the gravity hoist are still present in the ruin.

An enormous amount of work has been expended in the Smith mine to extract its coal. At least five tons of rock were removed to mine a ton of coal. The skill at pick work in the main entry of this mine is apparent in the beautifully arched sandstone roof which has been standing for about 60 years without support. The mine had shut down at the time of Clark's visit who noted that the coal was hauled up the slope to the mouth of the mine by a windlass and cable powered by a horse. Water had filled the tunnel within 200 feet of the mouth. The coal in the mine is 17 inches thick and it is located on the west side of Lost Creek at an elevation of 6,190 feet, 395 feet above the creek bottom. The opening is 1.3 miles southwest of Lost Creek Dam from which the spoil dump of the mine can be seen.

The prospects in Paradise Canyon are also in section 28. The prospect openings are completely caved and mining is not believed to have surpassed the prospecting stage. It probably indicates the coal was too thin to mine.

Reserves

Only one area at the Robinson mine was noted where the coal exceeds 4 feet thick. In Paradise Canyon three-quarters of a mile to the north the coal bed is 2 feet thick. Perhaps in 160 acres the coal bed averages 4 feet. This calculates to be 1.1 million tons.

PRINCIPAL WORK

Most of the coal data and the description of the Knight Formation are from Clark (1918). Madsen (1959) supplied geologic data and a reconnaissance investigation was made by Westerberg (1970) for this report.

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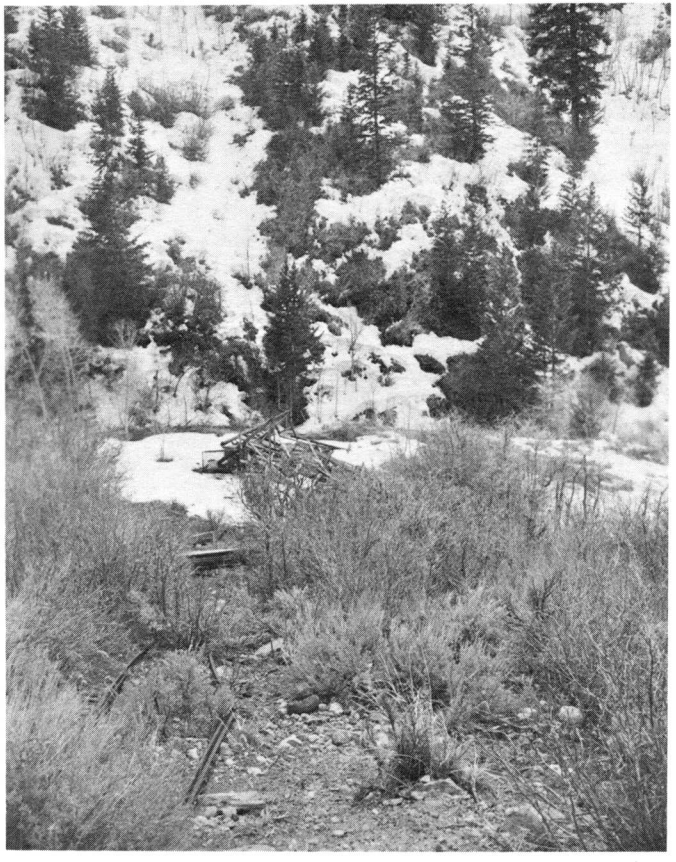
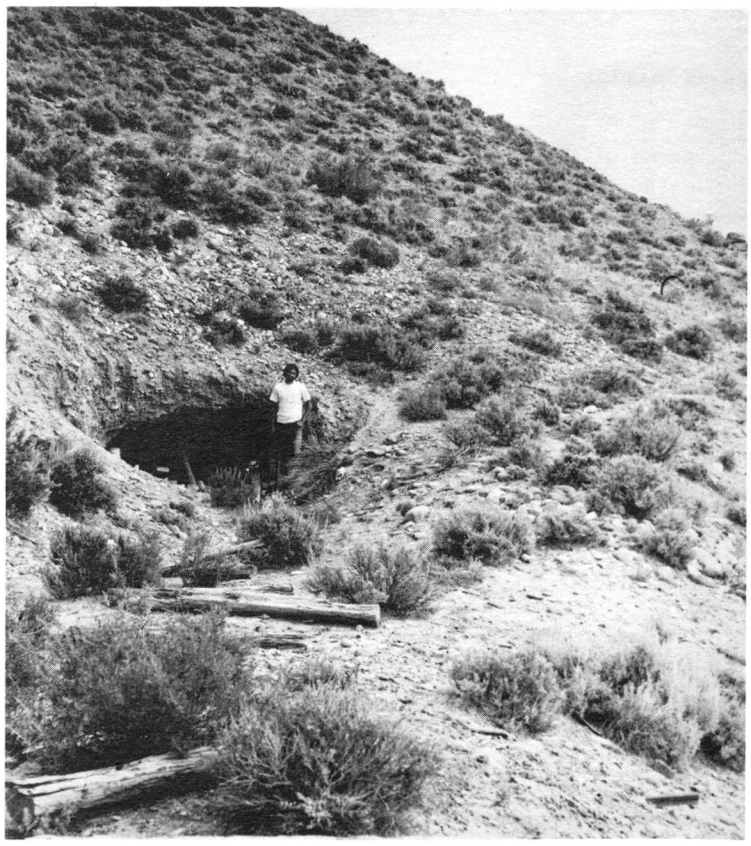
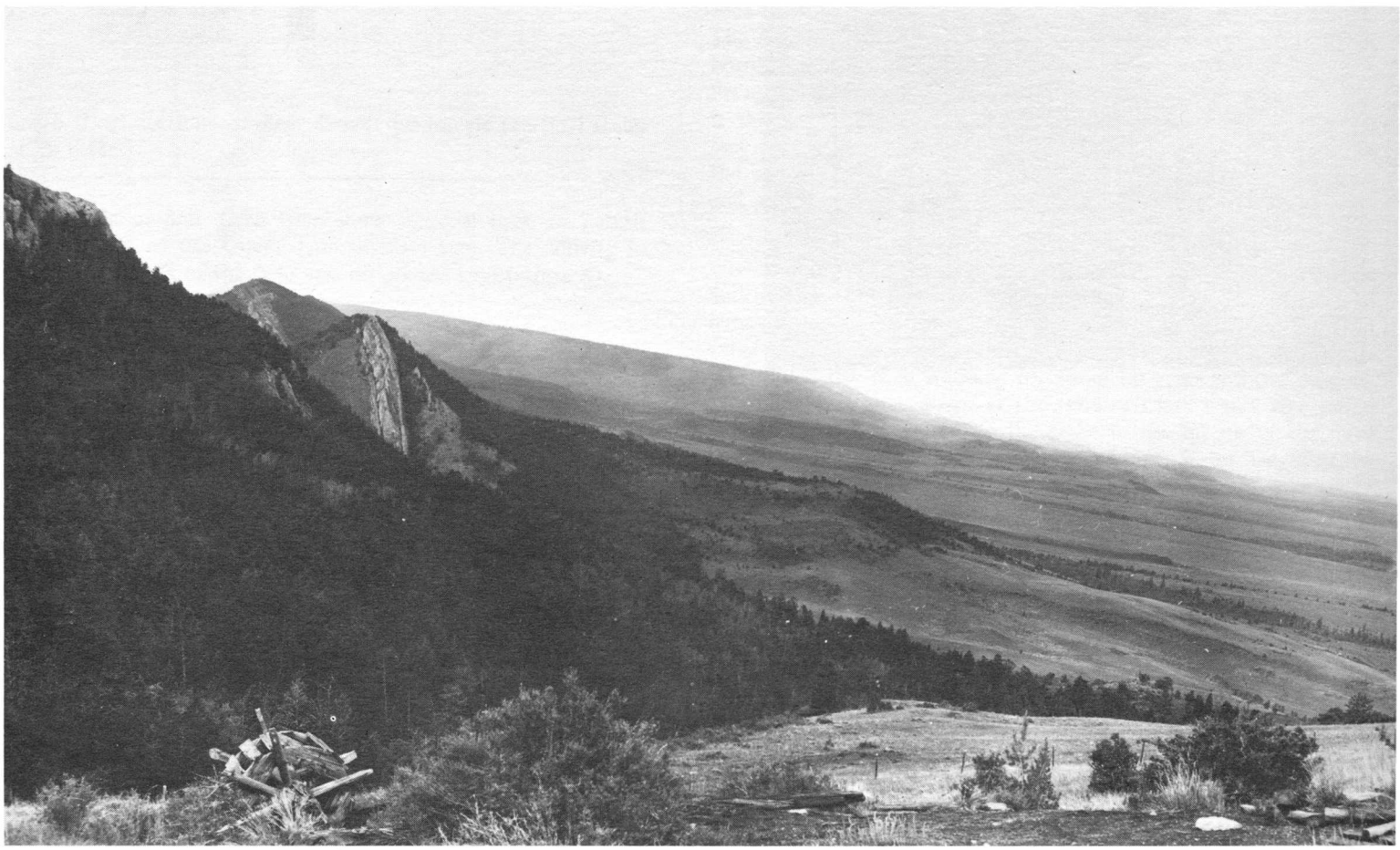


Lower portion outside Robinson mine tramway. Coal was hauled by wagon and team to Croydon, 9.5 miles southwest of Lost Creek.

Old hoist wheel, Henrys Fork coal field.



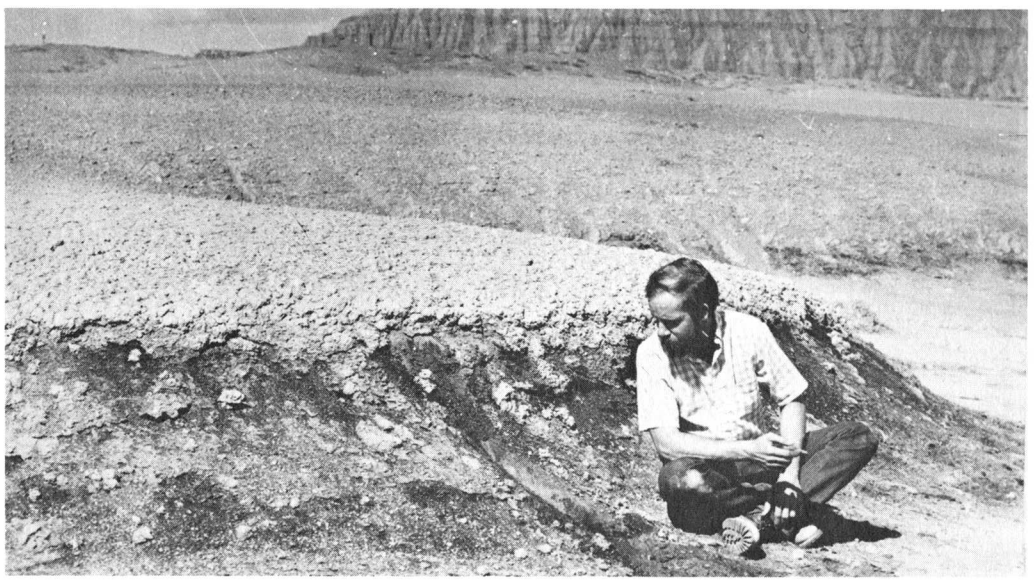
Entrance to abandoned coal mine just north of Henrys Fork Creek in Wyoming, less than 1 mile from the Utah line. The thickness of the bed was indeterminable, but early reports indicate the presence of at least 8 feet of coal (section 2 on Flaming Gorge area map).



Abandoned coal workings in the Manning Canyon Shale near Hole-in-the-Rock, Henrys Fork coal field. Beds are nearly vertical. Note the steeply dipping Mississippian limestone.

Looking southward across Steamboat Point quadrangle, Henry Mountains coal field. The hole in the strata penetrates the Ferron Sandstone exposing thin (0.5- to 1-foot) coal beds. South Caineville Mesa is to the right in the background and Utah Highway 24 passes east-west across the picture.

Oblique view of Flaming Gorge and Flaming Gorge Reservoir (taken from model at Visitor's Center, Flaming Gorge Dam), Henrys Fork coal field.



Coal bed in the top of the Ferron Sandstone at the south end of the Factory Butte NW quadrangle, Henry Mountains coal field. The 7-foot thick beds at the north end thin rapidly southward. This bed is less than a foot thick. North Caineville Mesa is in the background.

Remains of Manning Canyon Shale mine near Hole-in-the-Rock, Beaver Creek to Burnt Fork area, Henrys Fork coal field. The crude wheel hoisted coal from a now collapsed shaft. Small particles of coal can still be seen on the dump.

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

103 Utah Geological Survey Building
University of Utah
Salt Lake City, Utah 84112

THE UTAH GEOLOGICAL AND MINERALOGICAL SURVEY since 1949 has been affiliated with the College of Mines and Mineral Industries at the University of Utah. It operates under a director with the advice and counsel of an Advisory Board appointed by the Institutional Council of the University of Utah from organizations and categories specified by law.

The survey is enjoined to cooperate with all existing agencies to the end that the geological and mineralogical resources of the state may be most advantageously investigated and publicized for the good of the state. The *Utah Code, Annotated, 1953 Replacement Volume 5, Chapter 36, 53-36-2,* describes the Survey's functions.

Official maps, bulletins, and circulars about Utah's resources are published. (Write to the Utah Geological and Mineralogical Survey for the latest list of publications available.)

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The objective is to collect, catalog, and systematically file geologically significant specimens for library reference, comparison, and research, particularly cuttings from all important wells driven in Utah, and from strategic wells in adjacent states, the formations, faunas, and structures of which have a direct bearing on the possibility of finding oil, gas, salines or other economically or geologically significant deposits in this state. For catalogs, facilities, hours, and service fees, contact the office of the Utah Geological and Mineralogical Survey.

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DIRECTORS:
William P. Hewitt, 1961
Arthur L. Crawford, 1949-1961