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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE NORTHWEST QUARTER OF THE MT. ELLEN 15-MINUTE QUADRANGLE, WAYNE AND GARFIELD COUNTIES, UTAH

[Report includes 10 plates]

Prepared for

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GEOLOGICAL SURVEY

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INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) Maps of the Northwest Quarter of the Mt. Ellen 15-minute quadrangle, Wayne and Garfield Counties, Utah. These maps and report were compiled to support the land planning work of the Bureau of Land Management and to provide a systematic coal resource inventory of Federal coal lands in the Henry Mountains Known Recoverable Coal Resource Areas (KRCRA's), Utah. Consequently, only those geologic features relevant to coal occurrences are described herein.

This investigation was undertaken by Dames & Moore, Salt Lake City, Utah at the request of the U.S. Geological Survey under contract number 14-08-0001-17489. The resource information gathered for this report is in response to the Federal Coal Leasing Amendments Act of 1976 (P.L. 94-377). Published and unpublished information available through June 1979 was used as the data base for this study. Neither drilling nor field mapping was performed; nor were any confidential data used.

Location

The Northwest Quarter of the Mt. Ellen 15-minute quadrangle is located in the center of the Henry Mountains coal field and contains part of the common, central border between Wayne and Garfield Counties. Hanksville, Utah is approximately 14.5 miles (23 km) to the northeast and Utah Highway 24 is 9 miles (15 km) north of the map area's northern border. The area is unpopulated.

Accessibility

An unimproved dirt road extends less than one mile (1.6 km) into the map area from its southern border. Otherwise, access is limited to horseback and foot travel.

Physiography

Mesa and badland terrain characterize the Northwest Quarter of the Mt. Ellen 15-minute quadrangle. To the north and east, badlands and steep-sided gulleys dominate topography. A gradually steepening and heavily dissected slope leads from the north to flat-topped mesas in the south.

Sweetwater Creek flows northward along the west side of the area and is flanked by steep slopes along Wildcat, Thompson and Stevens Mesas in the south and central-west portions of the map area. Steep escarpments on the faces of the mesas have been eroded into alluvial fans in several places in the southeast.

Elevations in the map area range from 4,800 ft (1,463 m) along minor drainages in the Upper Blue Hills to 7,120 ft (2,170 m) on Cedar Creek Bench. Total relief is 2,320 ft (707 m).

The map area lies within the Colorado River watershed. Water quality and stream flow reflect seasonal climatic changes. Most surface water is saline due to high summer evaporation rates.

Climate and Vegetation

The map area's climate is arid. Average annual precipitation is about 10 inches (25 cm), but varies from year to year due to the erratic nature of desert rainfall. Most moisture comes in localized, late summer thundershowers and light winter snows and rains. Droughts of two or more years are common.

Temperatures range from greater than 100°F (38°C) during late summer to less than 0°F (-18°C) during the winter. The yearly average for the region is 56°F (13°C) (U.S. Bureau of Land Management, 1978). Typically, temperatures drop and precipitation increases with increased elevation.

Winds generally blow from the west and southwest. The highest seasonal wind velocities occur in the spring and early summer.

Principal types of vegetation in the area include grass, sagebrush, pinon, juniper, salt brush and greasewood (U.S. Bureau of Land Management, 1978).

Land Status

The Northwest Quarter of the Mt. Ellen 15-minute quadrangle contains the central portion of the Henry Mountains Known Recoverable Coal Resource Area. The Federal government owns the coal rights for lands over most of the map area, as shown on plate 2 of the Coal Resource Occurrence Map. Ninety-four percent of the area is regarded as coal bearing.

State lands cover about 11.5 percent of the map area; the remainder, under Federal ownership. A preference right lease application (PRLA U6733) is outstanding for part of section 11, T. 31 S., R. 8 E., in the southwest corner of the Northwest Quarter of the Mt. Ellen 15-minute quadrangle.

GENERAL GEOLOGY

Previous Work

John Wesley Powell, one of the first explorers of the region, named the Henry Mountains in 1869 (Gilbert, 1877). G. K. Gilbert studied the area in 1875 and 1876. His report (Gilbert, 1877) is considered one of the classics of geological literature. Gregory and Moore (1931) and later Smith and others (1963) and Davidson (1967) reported on parts of the Waterpocket Fold in the region.

The first investigation of coal in the Henry Mountains was undertaken by C. B. Hunt and others, who commenced work on the area in 1935, completed field studies in 1939 and published the results in 1953 as U.S. Geological Survey Professional Paper 228. More recently, Henry Mountains' coals were studied in detail by Doelling (1972) of the Utah Geological and Mineralogical Survey and Law (1977) of the U.S. Geological Survey. The results of these later investigations provided most of the data used in this coal resource evaluation. Additional publications which describe geologic features in the region are included in the bibliography.

Stratigraphy

A small outcrop area of the Brushy Basin member of the Jurassic Morrison Formation occurs near the southeast corner of the map area. Overlying this are the Dakota Sandstone and Tununk Shale, Ferron Sandstone, Blue Gate Shale and Emery Sandstone members of the Mancos Shale, all of Cretaceous age.

A composite columnar section accompanied by lithologic descriptions on CRO plate 3 illustrates the stratigraphic relationships of these units.

The oldest coal bearing formation in the region is the Dakota Sandstone. It represents a westward transgressing littoral sequence and lies uncomformably atop the Jurassic Morrison Formation. Only a few small exposures of the formation appear in the southeast corner of the map area. These consist of sandstone and gray shale with a stratigraphic thickness of approximately 30 feet (9 m). Crossbedded sandstones in the Dakota Sandstone may have been derived by reworking of underlying Morrison Formation strata in a fluvial environment. Interbeds of gray shale reflect local marsh and lagoonal environments. A diagnostic bed of fossils containing Gryphaea, Exogyra and Inoceramus occurs either at the top of the Dakota Sandstone or in the lowermost beds of the overlying Tununk Shale member elsewhere in the region (Hunt, Averitt, and Miller, 1953).

The Mancos Shale lies conformably over the Dakota Sandstone and fills the sedimentary basin in this part of the Henry Mountains. Only four of the five members of the Mancos Shale are present in the map area; the uppermost Masuk Shale member has been completely removed by erosion.

The lowermost, Tununk Shale member of the Mancos Shale is gradational and interfingering with the underlying Dakota Sandstone. It is about 605 ft (184 m) thick in the map area and represents a continuation of the first westward transgression of the Cretaceous sea in which the Dakota Sandstone was deposited.

The Tununk Shale member is a dark gray, fissile shale with subordinate bentonitic shale and thin-bedded, medium-grained sandstone (Doelling, 1972). The sandstone is gray to yellowish-gray and becomes more abundant toward the top of the member, where it is transitional with the overlying Ferron Sandstone member. The top of the Tununk Shale member is placed beneath the first thick-bedded or massive sandstone ledge in the transition zone. A regressive sequence, partially the result of deltaic progradation, occurs in the upper part of the Tununk Shale member (Peterson and Ryder, 1975). The member weathers to a blue-gray, is generally poorly exposed and forms a broad bench near the southeast corner of the quadrangle.

The Ferron Sandstone member is the lowest significant coal bearing horizon in the map area. It is a regressive unit composed of littoral and coastal plain facies. A lower, littoral unit is characterized by interbedded gray shale and gray to brown, fine-to medium-grained sandstone. The middle portion of the member is a coastal plain deposit of fine-to coarse-grained sandstone with minor interbeds of shale and locally occurring thin lenses of coal. An upper unit, again possibly of coastal plain origin, is composed of interbedded gray to brown shale, tan, medium-grained sandstone, carbonaceous shale and lenticular coal (Hunt, Averitt, and Miller, 1953). In the map area the Ferron Sandstone member is an average 154 ft (47 m) thick.

The Ferron Sandstone member is unconformably overlain by the Blue Gate Shale member. The contact between the Ferron Sandstone member and the Blue Gate Shale member is generally sharp. Detailed correlation of sandstone beds in the Ferron Sandstone member suggests that 50 to 100 ft (15 m to 30 m) or more of the top of the Ferron Sandstone member have been removed by erosion at the unconformity in the region (Peterson and Ryder, 1975).

The Blue Gate Shale member of the Mancos Shale, like the Tununk Shale member, represents a transgressive period of marine deposition. It is composed of blue-gray, finely laminated shale with thin beds of shaly sandstone and shaly limestone in the upper one-third of the unit (Hunt, Averitt, and Miller, 1953). The average thickness of the Blue Gate Shale member in this map area is 1,510 ft (460 m). The upper contact between the Blue Gate Shale member and the overlying Emery Sandstone member is interfingering and gradational.

The Emery Sandstone member of the Mancos Shale, like the Ferron Sandstone member, was deposited during a period of marine regression and can be divided into four units.

The lowermost unit consists of gray shale and light-tan, medium-grained, massive sandstone. The strata are even bedded to ripple laminated and typically form cliffs. Above this is a thick sequence of light-tan, massive, cliff forming sandstone with only occasional thin gray shale partings. The next higher unit is composed of interbedded gray shale, sandy shale and coal.

Above this is tan to brown, medium-grained massive sandstone with a few interbeds of gray sandy shale. The upper sandstone is thought to be of nearshore fluvial origin (Hunt, Averitt, and Miller, 1953).

The average thickness of the Emery Sandstone member in this map area is 371 ft (113 m). At least 100 feet (30 m) of upper sandstone have been removed from the member by erosion throughout the area.

Structure

Most of the Northwest Quarter of the Mt. Ellen 15-minute quadrangle lies in the east central portion of the Henry Mountains structural basin. The inferred axis of the Henry Mountains syncline trends north-south near the west boundary of the area.

Strata throughout the map area are essentially flat lying. Dips range around 2 degrees westward. However, inclinations increase toward the southeast corner of the area where bedding has been tilted northwestward by the doming of Mt. Ellen several miles to the east.

Two minor faults have been mapped in the area, but neither exhibit significant displacement or affect the coal resources.

Geologic History

Most pre-Cretaceous Mesozoic rocks in this part of the Colorado Plateau are continental in origin. Permian through Jurassic continental deposition was along coastal plains adjacent to principal seaways. The major types of depositional environments that existed during this period were eolian, intertidal mudflats, lacustrine, fluvial and flood plains (Hunt, Averitt, and Miller, 1953).

The Cretaceous history of the Henry Mountains coal field is similar to that of coal fields in central Utah and throughout the Colorado Plateau in general. The region is one in which classic transgressive and regressive sedimentation provided an environment for coal deposition.

During the early Cretaceous, the Henry Mountains region lay on a lowland plain over which neither subsidence nor uplift were occurring. However, sufficient erosion took place to remove lower Cretaceous strata and plane off the top of the Jurassic Morrison Formation.

Subsidence then resumed in the region and fluvial sand and clay were deposited to form the Dakota Sandstone. Broad flood plains with swamps, lakes and flourishing vegetation also developed. Resulting accumulations of carbonaceous material formed local, thin coal seams elsewhere in the region.

In the meantime, as subsidence increased, a sea in which the Mancos Shale was to be deposited began its encroachment from the east. The sea eventually covered all the Henry Mountains region and extended westward to the present-day Wasatch Plateau area. The shoreline remained there throughout Mancos Shale deposition except for two dramatic regressions which deposited the Ferron Sandstone and Emery Sandstone members. Orogenic pulses to the west supplied clastics for these sandstone members faster than the area could subside (Doelling, 1972). Shale deposition changed to nearshore sand and finally to lagoonal and fluvial sand and shale. Forests flourished, dead vegetation accumulated and, in places, coal was produced. All of the thick coal seams in the Henry Mountains Basin were deposited during these two events.

After deposition of the Mancos Shale the Cretaceous sea retreated permanently eastward. Although sedimentation undoubtedly continued in the Henry Mountains region, continental rather than marine beds were deposited and these were later removed by erosion.

According to Hunt and others (1953) the Henry Mountains structural basin was formed between the close of Cretaceous time and the Eocene epoch. Undisturbed eocene deposits are found in the basin.

Emplacement of the Henry Mountains intrusives may have occurred anytime after early to mid-Tertiary time. Thereafter the Colorado Plateau began its uplift and erosion instead of deposition dominated. This activity has continued to the present day.

COAL GEOLOGY

Significant coal occurs only in the Emery Sandstone member of the Mancos Shale in this area. The few small exposures of Dakota Sandstone in the area are not coal bearing. Ferron coal has been penetrated in drill holes at depths beyond 350 feet (107 m) along the east side of the map area, but the maximum seam encountered was only 1.8 feet (60 cm) thick.

Coal in the Emery Sandstone member underlies mesas in the southwest quarter of the map area. Coal occurs in the upper one third of the member and is overlain by 15 to 65 feet (4.6 to 20 m) of sandstone with gray and carbonaceous shale partings.

The Emery coal zone in the southwest central map area, beneath Stevens Mesa, contains two relatively persistent coal beds. The lower bed (Em-1) averages only 2.6 ft (80 cm) in thickness throughout most of the area. However, the bed thickens somewhat southward and in the southwest corner of the map area, beneath Wildcat Mesa, it contains an average 6.4 ft (2 m) of coal with .2 ft (6 cm) of rock partings. The maximum coal thickness in the bed, 9.8 ft (3 m) occurs in the northeast quarter of the section 12, T. 31 S., R. 8 E.

The upper coal bed (Em-2) in the Emery zone appears only beneath Stevens Mesa. It is an average 2.8 ft (86 cm) thick and achieves its maximum thickness of 6.0 ft (1.8 m) in the southwest quarter of section 34, T. 30 S., R. 9 E. The upper coal bed lies generally 10 to 15 feet (3 to 4.6 m) above the lower coal bed (Em-1).

Chemical Analyses of Coal

No analyses have been published for Emery zone coal in the Northwest Quarter of the Mt. Ellen 15-minute quadrangle. However, analytical results for nine samples obtained from the adjacent Southwest Quarter of the Mt. Ellen 15-minute quadrangle were reported by Doelling (1972). Analytical results are shown in table 1. The samples show a heat content of 11,300 Btu/lb, suggesting the coal to be subbituminous A in rank (ASTM, 1966).

Table 1 -- Average proximate analyses of coal samples in percent

	Moisture	Volatile Matter	Fixed Carbon	Ash	Sulfur	Btu/lb
1. Outcrop Emery Coal Zone T.32S., R.9E.	10.5	38.2	48.5	10.8	0.8	9,590
2. Outcrop Emery Coal Zone Sec. 36, T.31S., R.8E.	13.5	37.08	43.23	20.28	0.71	9,015
3. Outcrop Emery Coal Zone Sec. 36, T.31S., R.8E.	13.9	39.89	47.97	11.27	0.58	10,204
4. Prospect Pit South Creek Emery Coal Zone Sec. 27, T.31S., R.9E.	7.4	40.0	51.8	6.1	0.7	11,130
5. Prospect Pit Sweet Water Creek Emery Coal Zone Sec. 30, T.31S., R.9E.	10.1	39.8	50.0	7.0	0.9	10,900
6. Outcrop Sweet Water Creek Emery Coal Zone Composite Sec. 30, T.31S., R.9E.	7.70	38.50	40.80	11.50	1.50	12,491
7. Outcrop Sweet Water Creek Same as No. 6, upper 4 ft.	7.40	36.70	44.90	10.00	1.20	12,808
8. Outcrop Sweet Water Creek same as No. 6, 4 to 6 1/2 ft.	5.70	36.70	45.50	10.40	1.70	12,954
9. Outcrop Sweet Water Creek same as No. 6, lower 4 ft.	6.00	37.10	43.00	12.70	1.20	12,607
Average	9.2	38.7	47.7	10.6	0.9	11,300

Doelling (1972)

COAL RESOURCES

Data from one test hole and 40 measured surface sections and surface mapping by Doelling (1972) were used to construct outcrop, isopach and structure contour maps of coal zones and beds in the map area, (CRO plates 1 through 8).

Coal resources were calculated using data obtained from the coal isopach maps (CRO plates 4 and 7). The coal-bed acreage (measured by planimeter) multiplied by the average isopached thickness of the coal bed times a conversion factor of 1,770 short tons of coal per acre-foot for subbituminous coal yielded the coal resources in short tons of coal for each isopached coal bed. Reserve Bases for the Em-1 and Em-2 coal beds are shown on CRO plates 6 and 9 and are rounded to the nearest tenth of a million short tons. Only that coal equal to or thicker than the 5.0 ft (1.5 m) minimum advocated in U.S. Geological Survey Bulletin 1450-B is included in the Reserve Base. Thinner beds presently being mined or for which there is evidence that they could be mined commercially at this time are not included in the Reserve Base calculation. Total coal Reserve Base for all coal beds thicker than 5.0 ft (1.5 m), as shown on CRO Plate 2, total about 1.06 million short tons. Reserve Base (in short tons) in the various development-potential categories for surface mining methods is shown in table 2.

Dames & Moore has not made any determination of economic recoverability for any of the coal beds in this report.

COAL DEVELOPMENT POTENTIAL

Coal development potential areas are drawn so as to coincide with the boundaries of the smallest legal land subdivisions shown on plate 2. In sections or parts of sections where no land subdivisions have been surveyed by the BLM, approximate 40-acre (16-ha) parcels have been used to show the limits of the high, moderate, or low development potentials. A constraint imposed by the BLM specifies that the highest development potential affecting any part of a 40-acre (16-ha) lot, tract, or parcel be applied to that entire lot, tract, or parcel. For example, if 5 acres (2 ha) within a parcel meet criteria for a high development potential, 25 acres (10 ha) a moderate development potential, and 10 acres (4 ha) a low development potential, then the entire 40 acres (16 ha) are assigned a high development potential.

Development Potential for Surface Mining Methods

Areas where the coal beds are overlain by 100 ft (30 m) or less of overburden are considered to have potential for strip mining and were assigned a high, moderate or low development potential based upon the mining ratio (cubic yards of overburden per ton of recoverable coal). The formula used to calculate mining ratios is as follows:

$$MR = \frac{t_o (cf)}{t_c (rf)}$$

where MR = mining ratio

t_o = thickness of overburden in feet

t_c = thickness of coal in feet

rf = recovery factor (85 percent for this quadrangle)

cf = conversion factor to yield MR value in terms of cubic yards of overburden per short tons of recoverable coal:

0.911 for subbituminous coal

Note: To convert mining ratio to cubic meters of overburden per metric ton of recoverable coal, multiply MR by 0.8428.

Areas of high, moderate, and low development potential are here defined as areas underlain by coal beds having respective mining-ratio values of 0 to 10, 10 to 15, and greater than 15, as shown on CRO plates 5 and 8. These mining-ratio values for each development-potential category are based on economic and technological criteria; they are applicable only to this map area and were derived in consultation with J. Moffit, Area Mining Supervisor, U.S. Geological Survey.

Areas where the coal data are absent or extremely limited between the 100-foot (30 m) overburden line and the outcrop are assigned unknown development potentials for surface mining methods. This applies to those areas where no known coal beds 5 feet (1.5 m) or more thick occur or where coal exceeds 5 feet (1.5 m) but data is insufficient to properly evaluate coal development potential. Limited knowledge pertaining to the areal distribution thickness, depth and attitude of the coal beds prevents accurate evaluation of the development potential in the high, moderate or low categories.

The coal development potential for surface mining methods (<100 ft or 30 m of overburden) is shown on plate 10 of the Coal Development Potential Maps. Of those Federal land areas assigned a development potential for conventional surface mining methods, 94 percent are rated high and 6 percent are rated moderate.

No coal reserves are present below the stripping limit within this map area thus excluding the compilation of a coal development potential for conventional subsurface mining methods.

Table 2 -- Coal Reserve Base data for surface mining methods for Federal coal lands (in short tons) in the Northwest Quarter of the Mt. Ellen 15-minute quadrangle, Wayne and Garfield Counties, Utah

[Development potentials are based upon mining ratios (cubic yards of overburden/ton of underlying coal). To convert short tons to metric tons, multiply by 0.9072; to convert mining ratios in yd^3/ton coal to m^3/t, multiply by 0.842]

Coal bed	High development potential (0-10 mining ratio)	Moderate development potential (10 - 15 mining ratio)	Low development potential (>15 mining ratio)	Total
Em-2	130,000	---	---	130,000
Em-1	880,000	50,000	---	930,000
Total	1,010,000	50,000		1,060,000

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