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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE ALTON QUADRANGLE, KANE COUNTY, UTAH

(Report Includes 13 Plates)

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

by

MEIIJI RESOURCE CONSULTANTS

LAYTON, UTAH

This report has not been edited to conform with U.S. Geological Survey editorial standards or stratigraphic nomenclature.

CONTENTS

ILLUSTRATIONS

Coal resource occurrence maps of the Alton quadrangle, Kane County, Utah.

Coal development potential maps of the Alton quadrangle, Kane County, Utah.

TABLES

INTRODUCTION

Purpose

This report is to be used with the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) Maps of the Alton quadrangle, Kane County, Utah. This report was compiled to assist the land planning work of the Bureau of Land Management by providing a systematic coal resource inventory of Federal Coal lands for the Alton 7½-minute quadrangle of the Alton-Kanab Known Recoverable coal Resource Area (KRCRA) in southwestern Utah. This investigation was performed by Meiiji Resource Consultants of Layton, Utah for the U.S. Geological Survey under contract number 14-08-0001-17460. Resource information was gathered for this report in response to the Federal Coal Leasing Amendments Act of 1976 (P.L. 94-377). Published and unpublished information was used as the data base for this study. Neither new drilling nor field mapping was done, and confidential data were not used.

Location

The Alton quadrangle is in southwestern Utah in northwestern Kane County near the west end of the Alton-Kanab KRCRA. The southern border of the quadrangle is about 40 miles (64 km) north of Kanab, Utah and eight miles (13 km) northwest of Glendale, Utah. Kanab, Utah, three miles (5 km) north of the Utah-Arizona border, is the nearest town with complete services.

Accessibility

U.S. Highway 89 extends north from Kanab through Glendale. The highway is four miles (6 km) to the west and roughly parallels the western boundary of the quadrangle. Utah State Road 136 branches from U.S. 89, 10.5 miles (17 km) north of Glendale and provides access to the quadrangle. In addition, a number of light-duty and unimproved dirt roads connect U.S. 89 with the quadrangle area.

The paved portion of Utah State Road 136 ends a mile inside the western quadrangle boundary at the small community of Alton, the only town within the quadrangle. The unpaved portion of Utah 136 then continues south from Alton. Unimproved dirt roads branching from the highway provide access to the southern part of the quadrangle. Another well maintained road extends northeastward from Alton along Kanab Creek and branches into several dirt roads, providing access to much of the northern part of the quadrangle.

Physiography

The Alton quadrangle lies within the High Plateaus section of the Colorado Plateau physiographic province (Sargent and Hansen, 1976). The quadrangle is within a hilly lowland between the Markagunt Plateau to the west and the Paunsaugunt Plateau to the east. The quadrangle lies on the dissected west side of the Paunsaugunt Plateau with the eastern quadrangle boundary lying on top of and parallel to the plateau rim. The remainder of the quadrangle is hilly with the exception of the central and southwestern portions. The central one-third and southwestern one-third of the quadrangle are lowlands, composed of valleys and low hills. The valleys have gentle gradients, and range from .25 miles (0.4 km) to a little over a mile (1.6 km) in width. The hills have moderate to steep slopes with less than 600 feet (183 m) of relief. Altitudes range from over 9200 feet (2904 m) on top of the Paunsaugunt Plateau in the northeast corner of the quadrangle to 6550 feet (1996 m) along Kanab Creek in the southwest corner.

Kanab Creek, a tributary of the Colorado River, is the only perennial stream in the Alton quadrangle. It flows northeast to southwest across the quadrangle, draining all except the extreme northwestern corner, which drains northward into the Sevier River drainage basin.

Climate and Vegetation

The climate in the Alton quadrangle is variable, depending on the elevation. Valley floors are dry, averaging 16 inches (41 cm) of precipitation each year, while higher elevations receive over 30 inches (76 cm) of precipitation. Temperatures range from an average low of 10^{o} F (-12^{o} C) in winter to an average high of 80^{o} F (27^{o} C) in summer at the town of Alton, Utah (Department of Interior, Part I, p. II-1 to II-4). Temperatures at higher elevations are 10^{o} F (6^{o} C) to 15^{o} F (8^{o} C) cooler.

Five vegetation types are present within the quadrangle. These types are primarily dependent on precipitation and temperature, which vary with elevation. Hills bordering the eastern quadrangle boundary support an assemblage of Mountain Brush. This is bordered to the east by a wide band of Pinyon-Juniper Woodland, which covers the remaining lowlands and lower slopes of the Paunsaugunt Plateau. Pinyon-Juniper type vegetation forms an open forest, extending diagonally across the quadrangle from northwest to southeast. A small section of Sagebrush-Grass type vegetation covers about two square miles (5.1 km^2) within the Pinyon-Juniper Woodland at the south end of Sink Valley. Ponderosa Pine replaces the Pinyon-Juniper Woodland on the middle to upper slopes below the Paunsaugunt Plateau rim. The Ponderosa Pine is replaced in turn by Confier-Aspen Forest on the highest slopes and plateau surface (Department of the Interior, Part I, p. II-31 to II-35, fig. II-11).

Land Status

Approximately 80 percent of the quadrangle is within the KRCRA boundary with only the extreme northeast and northwest corners excluded. Private parties own roughly 74 percent of the land surface within the KRCRA, the Federal Government owns about 26 percent, and the State of Utah owns less than one percent (Doelling and Graham, 1972).

The U.S. Government owns all coal on private as well as Federal land, making it the only coal owner of consequence. Coal leasing is concentrated in the southwest portion of the quadrangle in the coal outcrop area. Most of the coal under less than 200 feet (61 m) of overburden is under lease (see plates 7 and 11).

GENERAL GEOLOGY

Previous Work

The first preliminary report on coal in southern Utah which included a part of the Alton quadrangle was prepared by G.B. Richardson (1909). Richardson gave a brief description of coal in the vicinity of the town of Alton and measured one coal section at the Johnson mine which is about two miles (3.2 km) to the southeast. This measured section is included as data point no. 2 on plates 1 and 3. Gregory completed a regional stratigraphic and geologic investigation of southeastern Utah and northern Arizona (Gregory and Moore, 1931) and a more detailed geologic and geographic survey of the Paunsaugunt region (Gregory, 1951). Both studies included brief discussions of the Cretaceous coals which occur near Alton.

Most of the available mapping of coal beds, coal outcrop measurements, and stratigraphy within the Alton quadrangle was done by Cashion (1961, 1967). Additional data on coal outcrops in the vicinity of Alton were collected by Robison (1964). The Utah Geological and Mineralogical Survey later compiled the information collected by the earlier writers into a monograph on southern Utah coal fields (Doelling and Graham, 1972), which includes the Alton quadrangle.

The only available drilling results are from three coal test holes drilled under the direction of W.E. Bowers (1977). The test holes, which are approximately three miles (5 km) downdip from the coal outcrops, test the depth, thickness and quality of coal in the upper or Smirl coal zone. The drill holes are: AK-1A in Sec. 21, T. 39 S., R. 5 W., AK-2A in Sec. 16, T. 39 S., R. 5 W., and AK-4A in Sec. 31, T. 38 S., R. 5 W.. Geophysical logging methods were used to locate the coal intersections.

Stratigraphy

Rock units which crop out in the Alton quadrangle range in age from Jurassic to Eocene. The Jurassic strata were not differentiated by Cashion (1961) or by Doelling and Graham (1972). However, Doelling and Graham did informally divide the Jurassic units using occurrence and estimated thickness from personal observation and descriptions, based on Thompson and Stokes' (1970) report on the San Rafael Group of southern Utah.

The Jurassic Navajo Sandstone underlies the entire quadrangle. It is a massive, cliff-forming sandstone, at least 1000 ft. (305 m) thick (Doelling and Graham, 1972). The sandstone is fine-grained, light gray, tan to almost white. The most conspicuous and diagnostic feature is the massive, sweeping crossbeds. The light color and cliff-forming character are responsible for the informal designation "white cliffs" for many of the Navajo outcrops in southern Utah.

The Jurassic Carmel Formation unconformably overlies the Navajo Sandstone. The Carmel Formation is divided into six members, four of which are reported to be present in the subsurface of the Alton quadrangle (Doelling and Graham, 1972). The lowest member of the Carmel Formation is the Kolob Limestone, which correlates with the limestone member described by Cashion (1967). This member is composed of dense gray to tan, silty limestone, with thin, sandy red shale near the base and thin gypsum interbeds near the top. The thickness of this unit in the Alton quadrangle is about 350 feet (107 m).

The Crystal Creek Member conformably overlies the Kolob Limestone Member. The Crystal Creek Member is a gypsiferous siltstone and fine-grained sandstone, with alternating dark reddish-brown and white to light-gray beds, which give this member a banded appearance. It contains some minor beds of gypsiferous shale, calcareous shale, and red and green clay-pebble conglomerate. The thickness is estimated to be about 190 ft. (58 m) in the Alton quadrangle area. This member corresponds to the banded member reported by Cashion (1967).

The Paria River Member overlies the Crystal Creek Member and corresponds to the gypsiferous member reported by Cashion (1967). The unit consists of about 55 ft. (17 m) of interbedded gypsum, sandstone, limestone, siltstone, and shale. The color is light gray with some reddish beds.

The youngest member of the Carmel Formation and the oldest Jurassic unit exposed in the Alton quadrangle is the Winsor Member. This member is fine to very fine-grained sandstone, gray to light brown, interbedded in the lower quarter with thin red silt or mudstone beds. The upper portion of the member has been truncated by an unconformity, and the lower portion is unexposed. Thickness is reported to be about 180 ft. (55 m) by Cashion (1967). The Winsor crops out along the southern portion of Kanab Creek, where it is unconformably overlain by the Cretaceous Dakota Formation.

The Cretaceous Dakota Formation unconformably overlies the Jurassic Carmel Formation. The lower contact is distinct in color and lithology and is easily located. However, the upper contact is gradational with the overlying Tropic Shale. As a result, the contact of the Dakota with the overlying Tropic has been drawn at widely varying stratigraphic levels by different authors (Gregory and Moore, 1931; Cashion, 1961; Van DeGraff, 1963; Lawrence, 1965; Doelling and Graham, 1972). The division followed here is that advocated by Lawrence (1965) and modified by Utah Geological and Mineralogical Survey practice (Doelling and Graham, 1972). Accordingly, the contact is designated at the top of the highest coal bed in the upper or Smirl coal zone in the Alton-Kanab KRCRA.

The Dakota Formation consists of gray to dark gray shale, alternating with yellow-gray to brown, fine to medium-grained sandstone. Bentonite, carbonaceous shale, and coal are interbedded with the shale and sandstone. Coal beds five ft. (11.5 m) or more in thickness occur in two zones named the "lower" and "upper" coal zones by Cashion (1961). These lower and upper coal zones were later renamed the Bald Knoll and Smirl coal zone by Doelling and Graham, 1972). Both zones are composed of gray to dark gray shale, carbonaceous shale and coal. The Bald Knoll coal zone is within the lower 50 ft. (15 m) of the Dakota Formation, while the Smirl coal zone is within the upper 50 ft. (15 m). The total thickness of the Dakota Formation in the Alton quadrangle is about 400 ft. (122 m) to 450 ft. (137 m).

The Dakota Formation was deposited over an Upper Jurassic-Lower Cretaceous erosion surface of low relief during a Lower to Upper Cretaceous marine transgression. Deposition occurred in a complex environment ranging from fluvial to marine. The basal beds are usually fluvial or near-shore deposits, overlain by a complex interfingering of paludal, lagoonal, near-shore, and marine sediments. The marine advance was generally continuous but was marked by numerous local, occasionally regional, retreats followed by renewed transgression.

There is a gradual fining upward from coarse sandstone, in places conglomeratic, at the base of the Dakota Formation to fine-grained sandstone and shale. All lithologies are lenticular and discontinuous. The formation is predominantly shale (Doelling and Graham, 1972) with minor interbedded, lenticular, discontinuous beds of sandstone, carbonaceous shale, and coal. The sandstones form prominent ledges and low cliffs, in contrast to the weathered shale and mudstone of the overlying Tropic Shale.

The contact between the Cretaceous Tropic Formation and the underlying Dakota Formation is gradational. A number of authors have described this unit (Gregory and Moore, 1931; Van DeGraff, 1963). This slope-forming unit consists predominantly of light-to medium-gray shale and claystone, with minor carbonaceous shale and an occasional thin, lenticular coal bed. Some thin brown sandstone and thicker, yellow-gray sandstone beds of near-shore origin are also present. The sandstones are concentrated toward the lower and upper contacts with the underlying Dakota Formation and overlying Straight Cliffs Sandstone.

The Tropic Shale is predominantly marine shale in the Alton quadrangle. To the west, the Tropic Shale interfingers with the Straight Cliffs Sandstone (Cashion, 1961; Lawrence, 1965; Doelling and Graham, 1972), while to the east it is correlated with the Tununk Member of the Mancos Shale of eastern and central Utah. The close proximity of the time-equivalent, near-shore Straight Cliffs Sandstone to the west and interbedded sandstones and coal beds within the Alton area suggest that the Tropic Shale was deposited in a shallow marine environment. Total thickness of the Tropic Shale in this quadrangle was estimated to be approximately 750 ft. (299 m) by Doelling and Graham (1972).

Upper Cretaceous formations in this area have not received extensive study. The Straight Cliffs and Wahweap Sandstones are very similar and are mapped together on this quadrangle (Gregory and Moore, 1931). The sandstones are fine to medium-grained, tan to yellow-gray, and thin to thick-bedded. Occasional thin coal beds are present and are concentrated toward the center of the section. The sandstones were deposited in a near-shore environment as the Cretaceous sea retreated to the east (Van DeGraff, 1963).

The Kaiparowits Formation is the youngest Cretaceous formation exposed in the Alton quadrangle. It is a weak, friable sandstone, poorly cemented by calcite. The weathering style is more typical of a shale than a sandstone. The Kaiparowits Formation is dark-gray to gray-green, fine to medium-grained sandstone, with some thin conglomerate beds. The total thickness of the upper Cretaceous formations on the Alton quadrangle is estimated to be about 1900 ft. (579 m) (Doelling and Graham, 1972).

The youngest formation exposed within the quadrangle, the Eocene Claron Formation, caps the Paunsaugunt Plateau to the east and a small section in the northwest corner of the quadrangle, west of the Sevier Fault. The Claron Formation rests unconformably on the underlying Cretaceous Kaiparowits Formation. The Claron formation consists of sandstone and conglomerate in the lower portion, overlain by white to pink, sandy, lacustrine limestone. Erosion has removed part of the Claron Formation from the area of this quadrangle, and only about 500 ft. (152 m) of the estimated original 1000 ft. (305 m) of sediment remains.

Structure

Folds

Regional structure in the Alton quadrangle area is characterized by broad, open folds with an occasional north-trending normal fault, frequently with large displacement. The structure of the Alton quadrangle is typical of the Colorado Plateau province as a whole.

The Alton quadrangle is located on the west side of the Paunsaugunt

Syncline (Doelling and Graham, 1972). This structure plunges north, and dips do not exceed 3^{o} on either limb. Dips at the outcrop in the Alton quadrangle area are east to northeast about 2^{o}. This value appears to decrease in the subsurface, based on a comparison between outcrop measurements and Bower's (1977) drilling.

Faults

The Sevier Fault zone, a major structure, crosses the northwest corner of the quadrangle. It is a zone approximately a mile wide, composed of numerous subparallel, en echelon, and cross faults. Total displacement across the fault zone has been reported as 1000 ft. (305 m) to 2000 ft. (610 m), with the west side downthrown. Grose, Hileman, and Ward (1967) found that the Sevier Fault generally had a moderate effect on the coal beds and then only within 100 ft. (31 m) to 500 ft. (152 m) of a major branch.

The only other fault within the quadrangle which has significant displacement is the Bald Knoll Fault, which is located about three miles (4.8 km) east of the town of Alton. The fault strikes north and has a normal displacement, with the east side dropped about 500 ft. (152 m).

COAL GEOLOGY

General

Coal deposition occurred near the beginning and end of deposition of the Dakota Formation, with some minor deposition in between. The coal was deposited over broad areas as thin to moderately thick, discontinuous, and sometimes overlapping beds. Localized areas of greater than normal deposition are found within some beds, possibly deposited in the deeper parts of an oxbow lake, swamp or lagoon.

Six measured sections and three drill hole logs (see plate 3) are available for use in evaluating the coal resources within the Alton quadrangle. Three sections and the drill holes transect the Smirl coal zone, and three published outcrop sections exist for the Bald Knoll coal zone. Detailed mapping of the coal beds is not publicly available.

Eleven proximate analyses, all from the Smirl coal zone, are available for coal beds which occur within this quadrangle. The coal is most commonly sub-bituminous "B" in rank and ranges from sub-bituminous "C" to bituminous high-volatile "C" (Sargent and Hansen, 1976).

Past Production

Coal has been mined for many years on a small scale to supply local needs. G.B. Richardson (1909) reported the Johnson mine already operating and the Silver mine abandoned and caved when he visited the properties in 1907. A number of prospects have been opened since then. Two of these, the Alton (Alton-Smirl) and the Smirl mine have accounted for almost all of the production (Grose, Hileman, and Ward, 1967).

The Smirl mine was opened in an 18 foot (5.5 m) thick coal bed with no splits. This mine produced between 950 tons (862 metric tons) and 2,250 tons (2,041 metric tons) of coal per year between 1953 and 1959. A fire forced the closing of the Smirl mine in May, 1961.

The Alton mine was opened in October, 1962 on the same coal bed as

The Smirl mine, about one half mile (0.8 km) southwest of the Smirl portal. The Alton mine produced through 1969. Grose, Hileman, and Ward (1967) estimate that less than 50,000 tons (45,360 metric tons) of coal have been produced from the Alton quadrangle. Almost all of this has come from the Alton and Smirl mines.

Bald Knoll Coal Zone

The Bald Knoll coal zone crops out only in the southwest corner of the quadrangle. Outcrops appear to be continuous. Unfortunately, no subsurface data is available, but the zone is assumed to be about 200 ft. (61 m) below the Smirl coal zone. The coal is usually thin where exposed and contains a number of shale and bony coal splits. The thickest continuous coal section within the Bald Knoll coal zone is four and eight-tenths ft. (1.5 m) thick, within a measured section containing 10. 8 feet (3.3 m) of coal and two and a half feet (0.8 m) of interbedded shale. The two other sections show 7.0 feet (2.1 m) of coal with one and six-tenths feet (0.5 m) of shale interbeds, and two and seven-tenths feet (0.8 m) of coal with one and eight-tenths ft. (0.5 m) of shale. It did not appear valid to project the limited data to cover the entire quadrangle, so a "Limit of Data" line was drawn to show the extent of what is considered applicable data (see plates 4 and 7).

Smirl Coal Zone

The Smirl coal zone crops out in the southeast corner of the quadrangle, stratigraphically above the Bald Knoll outcrop. The coal zone appears to be continuous along the outcrop with no known interruptions. Subsurface data is available from two drill holes about three miles (4.8 km) to the east of the outcrop area and one drill hole about three miles (4.8 km) to the north of the outcrop area. Unfortunately, no analyses are available for the coal encountered in these three drill holes.

The subsurface data indicate an almost horizontal bed with less than 1^{o} dip to the north and east. The Smirl coal zone outcrop measured sections show 14 foot (4.3 m) and 18 foot (5.5 m) coal beds without any interbedded shale. The three drill holes shown seven ft. (21 m), 13 ft. (4.0 m), and 15 ft. (4.6 m) of coal in the Smirl zone (see plate 8). Data point 7, with 15 ft. (4.6 m) of coal, and data point 8, with 13 ft. (4.0 m) of coal, contain shale beds in the coal section of two ft. (0.6 m) and seven ft. (2.1 m), respectively (see plates 1 and 3). Interburden isopachs have not been developed, due to the limited data. "Limit of Data" lines were drawn for the Smirl coal zone as they were for the Bald Knoll coal zone.

Coal Resources

Coal reserves are calculated by multiplying the total tons of coal in place (the reserve base) by a recovery factor, which takes into account losses experienced under similar circumstances in other areas, to arrive at an assumed recoverable coal tonnage (the reserve). The recovery factors used, 0.85 for surface mining and 0.50 for subsurface mining, were provided by the U.S. Geological Survey and are based on economic and technical criteria. Reserve base and reserve tonnages are listed in tables 2 and 3.

Data from outcrop measurements and drill holes were used to construct outcrop, coal isopach and structure contour maps for both the Smirl coal zone and the Bald Knoll coal zone. The source of each indexed data point shown on plate 1 is on table 4.

Coal reserves for Federal land were calculated using data obtained from the coal isopach maps (plates 4 and 8) and the areal distribution and identified resources maps (plates 7 and 11). The coal zone acreage (measured by planimeter), multiplied by the average thickness of the coal zone and by a conversion factor of 1770 short tons of coal per acre-foot (13,017 metric tons per hectare-meter) for sub-bituminous coal yields the coal resources in short tons of coal for each coal zone. Coal beds thicker than five feet (1.5 m) which lie less than 3,000 feet (914 m) below the ground surface are included. These criteria were provided by the U.S. Geological Survey.

Reserve base and reserve tonnages for the isopached coal zones are shown on plates 7 and 11 and are rounded to the nearest 10,000 short tons (9,072 metric tons). Coal reserve base tonnages for each Federally owned section are shown on plate 2 and total approximately 42,720,000 short tons (38,760,000 metric tons) for the entire quadrangle.

No attempt has been made by Meiiji Resource Consultants to determine the economic recoverability of coal described in this report.

Coal Development Potential

Coal development potential maps are drawn, at the request of the BLM using the boundaries of the smallest legal land division shown on plate 2 as boundaries for the coal development potential areas. These divisions contain approximately 40 acres (16 ha) each. In portions of Federally owned sections containing no surveyed divisions, parcels of approximately 40 acres (16 ha) have been constructed and used as the development potential area boundaries. When a number of development potential areas are present in the same 40-acre (16 ha) parcel, the highest development potential is assigned to the entire 40-acre (16 ha) parcel in accordance with BLM guidelines.

Development Potential for Surface Mining Methods

Areas between the coal outcrop and 200 ft. (61 m) of overburden are designated surface mining areas. The divisions between high, moderate, and low development potential areas for surface mining methods are based on a calculated mining ratio. This ratio is defined as the cubic yardage of overburden overlying each ton of recoverable coal, assuming 85 percent recovery. The formula used to calculate mining ratios for the surface mining of coal is shown below:

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

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 sub-bituminous coal

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

A high development potential ranking is applied to those areas between the coal outcrop and a line representing a mining ratio value of 10. A moderate development potential is applied to areas which have mining ratio values between 10 and 15. A low development potential ranking is assigned areas with mining ratio values over 15, but under less than 200 ft. (61 m) of overburden. These mining ratio values for each development potential category are based on economic and technological criteria and were provided by the U.S. Geological Survey. The surface development potential for this quadrangle is shown on plate 12 and table 2. Sixty-three percent of the coal tonnage is rated high, 11 percent is rated moderate, and 26 percent is rated low. The total surface development potential for this quadrangle is 8,190,000 short tons of coal.

Development Potential for Subsurface Mining Methods

Areas where coal is overlain by more than 200 ft. (61 m) but less than 3000 ft. (914.4 m) of overburden are considered potentially minable by conventional subsurface mining methods. Coal with 200 ft. (61 m) to 1000 ft. (304.8 m) of overburden is rated as having high potential. Coal with 1000 ft. (304.8 m) to 2000 ft. (609.6 m) of overburden is rated as moderate, while that under more than 2000 ft. (609.6 m) of overburden is rated low.

An unknown development potential is assigned to areas under less than 3000 ft. (914.4 m) of overburden, where coal data are absent or very limited. Where coal is beneath 3000 ft. (914.4 m) or more of overburden, a rank of no development potential is assigned. The subsurface development potential for this quadrangle is shown on plate 13 and table 3.

An unknown development potential is assigned to large areas within the KRCRA. The remaining portion is divided, with 75 percent of the coal rated high and 25 percent assigned a moderate rating. The total subsurface development potential for this quadrangle is 34,530,000 short tons of coal.

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Table 1. Chemical analyses of coals in the Alton quadrangle, Kane County, Utah.

LOCATION	COAL BED NAME OR ZONE	Form of Analysis	Proximate: Moisture	Proximate: Volatile Matter	Proximate: Fixed Carbon	Proximate: Ash	Ultimate: Sulfur	Ultimate: Hydrogen	Ultimate: Carbon	Ultimate: Nitrogen	Ultimate: Oxygen	Heating Value: Calories	Heating Value: Btu/Lb
NE¼ Sec. 24, T39S, R6W	Smirl	A	18.5	-	-	6.3	0.56	-	-	-	-	-	-
W½ SE SE Sec. 13, T39S, R6W	Smirl	A	13.7	38.5	34.9	12.9	0.8	-	-	-	-	-	9,293
		C	-	44.6	40.5	14.9	0.9	-	-	-	-	-	10,782
	Smirl	A	17.3	-	-	-	-	-	-	-	-	-	9,870
		C	-	37.5	51.2	11.3	1.6	-	-	-	-	-	11,920
	Smirl	A	18.2	-	-	-	-	-	-	-	-	-	10,040
		C	-	38.0	52.4	9.6	1.2	-	-	-	-	-	12,240
	Smirl	A	19.0	-	-	-	-	-	-	-	-	-	9,810
		C	-	38.7	51.5	9.8	1.4	-	-	-	-	-	12,110
	Smirl	A	16.7	-	-	-	-	-	-	-	-	-	10,050
		C	-	40.0	49.4	10.6	1.5	-	-	-	-	-	12,060
	Smirl	A	17.7	-	-	-	-	-	-	-	-	-	10,090
		C	-	41.1	50.1	8.8	2.2	-	-	-	-	-	12,260
	Smirl	A	18.1	-	-	-	-	-	-	-	-	-	9,890
		C	-	40.6	49.8	9.6	2.3	-	-	-	-	-	12,070

Form of Analysis: A, as received
C, moisture free

Note: To convert Btu/pound to kilojoules/kilogram, multiply by 2.326

Table 1. Continued.

LOCATION	COAL BED NAME OR ZONE	Form of Analysis	Proximate				Ultimate					Heating Value	
			Moisture	Volatile Matter	Fixed Carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	Btu/Lb
	Smirl	A	17.3	-	-	-	-	-	-	-	-	-	10,100
		C	-	40.1	50.9	9.0	0.8	-	-	-	-	-	12,220
	Smirl	A	15.7	-	-	-	-	-	-	-	-	-	10,380
		C	-	40.1	51.4	8.5	1.5	-	-	-	-	-	12,310
	Smirl	A	17.4	-	-	-	-	-	-	-	-	-	10,100
		C	-	40.2	51.4	8.5	1.4	-	-	-	-	-	12,220

Form of Analysis: A, as received
C, moisture free

Note: To convert Btu/pound to kilojoules/kilogram, multiply by 2.326

Table 2. Coal Reserve Base data for surface mining methods for Federal coal lands (in short tons) in the Alton quadrangle, Kane County, Utah.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Bald Knoll Zone	1,950,000	890,000	2,120,000	4,960,000
Smirl Zone	3,230,000	-	-	3,230,000
Total	5,180,000	890,000	2,120,000	8,190,000

Note: To convert short tons to metric tons, multiply by 0.9072.

Table 3. Coal Reserve Base data for subsurface mining methods for Federal coal lands (in short tons) in the Alton quadrangle, Kane County, Utah.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Bald Knoll Zone	-	-	-	-
Smirl Zone	25,840,000	8,690,000	-	34,120,000
Total	25,840,000	8,690,000	-	34,530,000

Note: To convert short tons to metric tons, multiply by 0.9072.

Table 4. Sources of data on plate 1.

Plate 1 Index Number	Source	Data Base
1	Doelling and Graham, 1972, Utah Geological and Mineralogical Survey Monograph Series No. 1	Measured Section
2	"	"
3	"	"
4	"	"
5	Robison, 1964, U.G. & M.S., Special Studies 7	"
6	Doelling and Graham, 1972, U.G. & M.S., Monograph Series No. 1	"
7	Bowers, 1977, U.S.G.S., Open-File Report 77-43	Coal Drill Hole No. AK-4A
8	"	Coal Drill Hole No. AK-2A
9	"	Coal Drill Hole No. AK-1A