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

(Report Includes 5 Plates)

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

By

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INTRODUCTION

Purpose

This report is to be used with the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) Maps of the Podunk Creek 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 Podunk Creek 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 Published and unpublished information was used as the data base for this study.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 Podunk Creek quadrangle is in northwestern Kane County in southwestern Utah. It is situated in the north central part of the Alton-Kanab Known Recoverable Coal Resource Area. The western boundary of the quadrangle is seven miles (11 km) east of Alton, Utah, and 14 miles (22 km) east of Glendale, Utah. Kanab, Utah is the main population center in Kane County. The Podunk Creek quadrangle is 25 miles (40 km) northeast of Kanab.

Accessibility

U.S. Highway 89 is the main highway through the region. The highway extends north from Kanab, through Glendale, and east from Kanab toward Page, Arizona. Utah State Road 136, a well-maintained gravel road for most of its length, branches from U.S. 89 10.5 miles (17 km) north of Glendale. Utah 136 connects U.S. 89 with Alton, Utah and then continues southeast to rejoin U.S. 89 nine miles (14 km) east of Kanab, Utah.

An unpaved county road branches to the northeast from Utah 136, halfway between Alton and its southern junction with U.S. 89 east of Kanab. The county road originates from a junction near the southwest corner of the Skutumpah Creek quadrangle, and proceeds north and east across that quadrangle toward Cannonville, Utah 28 miles (45 km) to the northeast.

A number of jeep roads and dirt trails extend north from the county road along canyons to provide limited access to the southern part of Podunk Creek quadrangle, immediately to the north of Skutumpah Creek quadrangle. A few jeep trails extend further north to the top of the Paunsaugunt Plateau. The Plateau surface may also be reached from the north over a number of dirt roads branching south from Utah State Road 12, which is about 15 miles (24 km) north of Podunk Creek quadrangle.

Physiography

The Podunk Creek quadrangle lies within the High Plateaus section of the Colorado Plateau physiographic province (Sargent and Hansen, 1976).

Approximately two-thirds of the quadrangle is located on top of the Paunsaugunt Plateau. The elevation of the plateau varies from 8,200 ft. (2,499 m) to 9,335 ft. (2,485 m), and the plateau is broken into several sections by the steep northeast to northwest-trending canyons of the Kanab, East Fork, and Podunk Creeks. Relief along these canyons reaches a maximum of about 1,000 ft. (305 m) in the middle section of East Fork Creek.

The Pink Cliffs form the rim of the Paunsaugunt Plateau, extending southward along the eastern margin of the quadrangle within Bryce Canyon National Park. Outside the Park, the cliffs trend southwestward, separating the southern third of the quadrangle from the northern portion. The topography below the plateau to the southeast is mountainous and drops from an elevation of more than 9,300 ft. (2,835 m) at the rim to 6,710 ft. (2,045 m) along Broad Hollow.

Climate and Vegetation

The climate is arid to semi-arid with annual precipitation reaching 24 inches (61 cm) at the edge of the Paunsaugunt Plateau in Bryce Canyon National Park. Very dry conditions exist in the valleys below the rim, due to the rain shadow of the plateau. Average precipitation in the valleys southeast of the plateau is about 16 inches (41 cm).

Winters are cold with an average annual low temperature of about 8^{0} F (-13^{0} C). Summers are warm with an average yearly high temperature of 80^{0} F (27^{0} C).

The largest valleys south of the plateau are dry and support mainly Sagebrush, Grass and related plant species. The remainder of the mountainous area below the plateau rim supports an open forest of Juniper and Pinyon trees. The higher elevations on top of the plateau support a more dense forest growth, characterized by various Fir species and aspen.

Climate and vegetation information was modified from the Department of Interior, 1975, part I, p. II-1 to II-4, II-31 to II-35, fig. II-11.

Land Status

The southern third of the Podunk Creek quadrangle, about 12,800 acres (5,180 ha), is within the KRCRA boundary. The State of Utah owns about three and a half percent of the quadrangle, of which all 1340 acres (542 ha) are within the KRCRA boundaries. Less than one percent, 340 acres (138 ha), of the quadrangle is privately owned. The Federal Government owns coal rights to the private land, making it the major coal owner. Bryce Canyon National Park occupies 2175 acres (880 ha) of a strip less than a mile (1.6 km) wide along the north half of the eastern quadrangle boundary. The presence of the National Park does not affect this report as it is outside the KRCRA boundary.

Only one area in the quadrangle has been leased. An area of 140 acres (57 ha) in the southeast part of the quadrangle is currently under lease.

GENERAL GEOLOGY

Previous Work

G.B. Richardson (1909) investigated the coal in southwestern Utah, but his work did not extend east beyond Kanab Creek, which is roughly five miles (8 km) west of the quadrangle. Richardson judged that the coal did not extent as far east as Podunk Creek quadrangle. Gregory and Moore (1931) investigated coal occurrences in the upper Paria River valley, 25 miles (40 km) east of the quadrangle, but concluded that the coal thinned to the west and did not extend to the Podunk Creek quadrangle. Gregory (1951) later extended his investigations only as far as Jackson Valley along the western boundary of Skutumpah Creek quadrangle three miles (5 km) to the south of Podunk Creek quadrangle, possibly based on an inference that no coal of interest was present to the east.

W.B. Cashion (1961) completed the first extensive report concerned primarily with the Cretaceous coals in the Kolob-Kanab coal field. Cashion's work was of great importance on this quadrangle, as it formed the base from which the Utah Geological and Mineralogical Survey extended their coal investigations to the east (Robison, 1964; Doelling and Graham, 1972).

H.D. Goode (1973) has completed preliminary geologic maps of both the Skutumpah Creek quadrangle and the Bald Knoll quadrangle, south and southwest of the Podunk Creek quadrangle respectively. These maps have provided much needed information on the stratigraphy and structure. The U.S. Geological Survey conducted a drilling program which included this quadrangle and the Skutumpah Creek quadrangle to the south (Bowers, 1977).

Stratigraphy

Strata within 3000 feet (914 m) stratigraphically of the coal-bearing Dakota Formation range from the Jurassic Navajo Sandstone, 3000 feet (914 m) below the Dakota Formation, to the Eocene Claron Formation approximately 3000 feet (914 m) above the coal. None of the formations below the Dakota are exposed within the quadrangle. The Navajo Sandstone is the oldest formation described within this stratigraphic interval. It is a massive, cliff-forming sandstone at least 1000 feet (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 have led to the informal designation "white cliffs" for Navajo Sandstone outcrops in southern Utah. The Navajo Sandstone crops out in the southwest corner of the Skutumpah Creek quadrangle six miles (10 km) south of the Podunk Creek quadrangle, where only the upper 200 feet (61 m) is exposed (Goode, 1973). The Navajo Sandstone is presumed to underlie the entire Podunk Creek quadrangle.

The Jurassic Carmel Formation unconformably overlies the Navajo Sandstone. The Carmel Formation is divided into six members, five of which are present in the Skutumpah Creek quadrangle to the south and are believed to underlie the Podunk Creek quadrangle.

The lowest member of the Carmel Formation is the Kolob Limestone. This unit correlates with the limestone member described by Cashion (1967). The 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 is variable. Goode (1973) measured 120 feet (36.6 m) along

Johnson Canyon and 200 feet (61 m) along Skutumpah Creek.

The Crystal Creek Member conformably overlies the Kolob Limestone Member and consists of a gypsiferous siltstone and fine-grained sandstone. Alternating dark reddish-brown and white to light-gray beds give this member a banded appearance, suggesting the designation Banded Member, used by Cashion (1961). It contains some minor beds of gypsiferous shale, calcareous shale, and red and green clay-pebble conglomerate. It also contains lenses of gravel, boulders of rhyolite and andesite, plus some small lenses of gypsum. The thickness is variable from 50 to 125 feet (15-38 m). East of the Podunk Creek quadrangle, the Kolob and Crystal Creek members thin and merge, where they are mapped together as the Judd Hollow Member.

The Thousand Pockets Tongue of the Navajo Sandstone is included within the Carmel Formation, where it overlies the Crystal Creek Member. It may be as much as 50 feet (61 m) thick along the eastern quadrangle. It is a yellow to white, faintly cross-bedded sandstone.

The Paria River Member overlies the Crystal Creek Member west of Slide Canyon and the Thousand Pockets Tongue of the Navajo Sandstone to the east of Slide Canyon. The Paria River Member, termed the gypsiferous member by Cashion (1967), is a red, gypsiferous sandstone with some interbedded white sandstone and purplish-red mud and siltstones. This member is 150 to 200 feet (46 to 91 m) thick on the west side of the quadrangle but thickens to over 300 feet (91 m) along the east side.

The upper unit of the Carmel Formation, present in the Skutumpah Creek quadrangle and assumed to be present in the subsurface in the Podunk Creek quadrangle, is the

Winsor Member. The Winsor Member is predominantly fine-grained sandstone in shades ranging from white through brown. Thin, red siltstones are interbedded within the sandstones. Goode (1973) reported that the upper contact is marked by a white sandstone bed 10 to 20 feet (3 to 6 m) thick.

The Jurassic Entrada Formation is probably absent from the Podunk Creek quadrangle as the result of a pre-Dakota erosion interval (Goode, 1973), although it is present east of the quadrangle (Robison, 1966). Two members are present where the formation is best developed, along the eastern boundary of the Skutumpah Creek quadrangle. The Gunsight Butte Member is principally red siltstone and thin gray shale interbeds, and it reaches a maximum thickness of about 45 feet (14 m). The Gunsight Butte Member is overlain by the Cannonville Member, which is a white, very fine-grained sandstone containing lenses of pebbles and mudstone. Low-angle crossbeds are present near the top. The Entrada thins and becomes discontinuous towards the west. It has not been recognized west of Skutumpah Creek (Goode, 1973; Doelling and Graham, 1972).

The Dakota Formation unconformably overlies either the Winsor Member of the Carmel Formation or the Entrada Formation, as the result of erosional bevelling before the Dakota was deposited. The lower contact is distinct in color and lithology from the underlying units and is easily located. However, the upper contact of the Dakota with the overlying Tropic Shale 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 the Utah Geological and Mineralogical Survey practice (Doelling and Graham, 1972), which places the contact 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 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 zones 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 feet (15 m) of the Dakota Formation, while the Smirl coal zone is within the upper 50 feet (15 m). Although sandstone beds make up less than half of the section, the upper half to two-thirds of the Dakota Formation, where exposed, is characterized by prominent cliffs up to 30 feet (9 m) high. The sandstone beds are lenticular and grade laterally into shale. Goode (1973) reported that the base of the coal bed in the Bald Knoll coal zone is within six to ten feet (2 to 3 m) of the base of the Dakota Formation. The total thickness of the Dakota Formation on the Podunk Creek quadrangle is probably about 200 feet (61 m).

The Dakota Formation was deposited over an Upper Jurassic-Lower Cretaceous erosion surface of low relief during a Lower Cretaceous marine transgression. Deposition occurred in a complex environment, ranging from fluvial to marine. The basal beds are generally of fluvial or near-shore origin, 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, or occasionally regional, retreats followed by renewed transgression.

There is a gradual change from coarse sandstone, in places conglomeratic at the base of the Dakota Formation, upward through the section 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 Dakota Formation crops out in only one area of a few acres in the southeast corner of the quadrangle.

The contact between the Cretaceous Tropic Shale and the Dakota Formation is gradational. The Tropic Shale has been described by a number of authors (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, respectively.

The Tropic Shale is predominantly marine shale in the Skutumpah Creek quadrangle to the south. 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 Podunk Creek quadrangle area suggest that the Tropic Shale was deposited in a shallow marine environment. The total thickness of the Tropic Shale in this quadrangle is about 650 feet (198 m) to 700 feet (213 m).

The Tropic Shale crops out along the larger valleys and washes in the southeast quarter of the Podunk Creek quadrangle, such as Slide Canyon, Broad Hollow, and Meadow Canyon. Most of the gravel-covered slopes in the southeast corner of the quadrangle are also underlain by Tropic Shale.

The Cretaceous Straight Cliffs Formation conformably overlies the Tropic Shale. The base of the Straight Cliffs Formation is the first massive sandstone above the transitional sandstone and shale of the Tropic Shale (Goode, 1973). The formation consists of massive, cliff-forming, tan or buff, fine-grained marine sandstone with some beds of shale and siltstone. Occasional thin coal or lignite beds are present and 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 Straight Cliffs Formation is 200 feet (61 m) to 250 feet (76 m) thick within the Podunk Creek quadrangle.

The Wahweap Sandstone conformably overlies the Straight Cliffs Sandstone and is very similar to it. The Wahweap Sandstone is a fine to very fine-grained sandstone, slightly feldspathic and silty, with some interbeds of blue-gray, green, and tan shale beds as well as some lenses and crossbeds of fine pebbles. It weathers to a topography dominated by ledges and low cliffs, which contrasts with the underlying, more massive cliff-forming Straight Cliffs Sandstone.

The Kaiparowits Formation is the youngest Cretaceous formation. It is a weak, friable sandstone, poorly cemented by calcite, with a weathering style more typical of a shale than a sandstone. The Kaiparowits Formation is dark gray to gray-green, fine to medium-grained sandstone. Some thin conglomerate beds are also present.

The total thickness of Upper Cretaceous formations on the Podunk Creek quadrangle is estimated to be about 2000 feet (610 m) (Doelling and Graham, 1972). The Upper Cretaceous sandstones crop out in a wide band covering the southern third of the quadrangle, with a mountainous topography which contrasts with the overlying plateau surface developed on the Claron Formation.

The Tertiary Claron Formation is the youngest consolidated sedimentary formation present in the quadrangle. It unconformably overlies the Cretaceous Kaiparowits Formation. The Claron Formation is predominantly pink to red, sandy limestone with some gray limestone and sandstone beds. The lower part is characterized by abundant calcareous conglomerate and sandstone. There is a general gradation from sandy and conglomeratic beds at the base upward to finer-grained material higher in the section. The total thickness of the Claron Formation may reach a maximum of 700 feet (123 m) (Doelling and Graham, 1972).

The Claron Formation caps the Paunsaugunt Plateau, and the edge of the Claron outcrop forms the "Pink Cliffs" of Bryce Canyon National Park and the edge of the Paunsaugunt Plateau, above the outcrops of the Upper Cretaceous formations.

Alkaline olivine basalt covers several small areas within a mile and northwest in the Skutumpah Creek quadrangle, south of the Podunk Creek quadrangle, all of which appear to have small displacements. Doelling and Graham (1972) reported that none appear to offset the coal to any degree. These faults appear to extend into the Podunk Creek quadrangle.

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 as thin, discontinuous beds.

Two persistent coal zones are present in the Dakota Formation. The lower zone near the base of the Dakota tends to be irregular and discontinuous (Doelling and Graham, 1972). No information is available on the lower or Bald Knoll coal zone for this quadrangle. No reserves were calculated because of the lack of information.

The upper coal zone near the top of the Dakota Formation, the Smirl coal zone, crops out in the southeast corner of the Podunk Creek quadrangle to the south. In addition, two drill holes give widely spaced spot information on the Smirl coal zone.

One drill hole, AK-2-PC (Bowers, 1977), is located within the Podunk Creek quadrangle (plates 2 & 3). Another drill hole, AK-1-SC (Bowers, 1977), is

(1.6 km) of the southern boundary of the quadrangle. The flow is characterized by abundant augite phenocrysts, in addition to olivine.

Quaternary pediment gravels are present from near stream level to 700 feet (213 m) above the present stream levels in the southeast corner of the quadrangle. These gravels have been deposited on less resistant units such as the Tropic Shale. The gravels and cobbles are derived primarly from the Eocene Claron Formation.

STRUCTURE

Folds

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

Podunk Creek quadrangle is located along the axis of the Paunsaugunt Syncline (Doelling and Graham, 1972). The structure plunges north, and dips do not exceed 3^{o} on either limb. Dips at the outcrop in the Podunk Creek quadrangle are north at 1^{o} to 3^{o}.

Faults

H.A. Goode (1973) mapped a number of normal faults trending northeast located 1800 feet (549 m) south of the southern quadrangle boundary in section 34, T. 39 S., R. 4½ W. No analysis is available for coal in AK-2-PC, but AK-1-SC indicates a coal rank between sub-bituminous "B" and "C" with low sulfur and ash. The sample was from the lower coal bed of the Smirl coal zone.

Six feet (1.8 m) of coal is present in the lower Smirl coal bed in field hole AK-2-PC, while 12 feet of coal (3.6 m) is present in the lower Smirl coal bed in drill hole AK-1-SC.

This information is too widely spaced to permit projection over large areas, but the limited available information does suggest that coal thicker than five feet (1.5 m) may underlie at least the southern part of the Podunk Creek quadrangle. Unfortunately, the coal is overlain by more than 700 feet (213 m) of overburden except in a small area in the southeast corner of the quadrangle, which is currently under lease.

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 an 85 percent recovery. The formula used to calculate mining ratios for surface mining of coal is shown below:

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

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

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. The source of each indexed data point shown on plate 1 is on table 1.

Coal reserves for Federal land were calculated using data obtained from the coal isopach maps and the areal distribution and identified resources maps. 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 ft. (1.5 m) which lie less than 3,000 ft. (914 m) below the ground surface are included. These criteria were provided by the U.S. Geological Survey. No coal reserves were calculated for this quadrangle due to the lack of data.

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

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.

An unknown development potential is assigned to areas under less than 3000 ft. (914.4 m) of overburden, where coal data is absent or very limited. Where coal is beneath 3000 ft. (914.4 m) or more of overburden, a ranking of no development potential is assigned. The surface development potential for this quadrangle is shown on plate 4.

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 a high potential. Coal with 1000 ft. (304.8 m) to 2000 ft. (609.6 m) of overburden is rated as having a low development potential.

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.

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______ 1966, Geology and coal resources of the Tropic area, Garfield County, Utah: Utah Geological and Mineralogical Survey Special Studies, 18.

Sargent, K.A. and Hansen, D.E., 1976, General geology and mineral resources of the coal area of south-central Utah: U.S. Geological Survey Open-File Report 76-811.

Where coal is beneath 3000 ft. (914.4 m) or more of overburden, a ranking of no development potential is assigned. The subsurface development potential for this quadrangle is shown on plate 5. The Federal coal lands on this quadrangle within the KRCRA are all assigned an unknown development potential for subsurface mining methods, for lack of data.

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Van De Graff, F.R., 1963, Upper Cretaceous stratigraphy of southwestern Utah, in Geology of southwestern Utah: Intermountain Association of Petroleum Geologists Guidebook, 12th Annual Field Conference, p. 65-70.

Table 1. Sources of data used on Plate 1.

Plate 1 Index Number	Source	Data Base
1	Bowers, 1977, U.S.G.S., Open-File Report 77-43	Coal Drill Hole No. AK-2PC