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CHAPTER 6
R645-301-600 GEOLOGY

R645-301-610 INTRODUCTION

R645-301-611 GENERAL REQUIREMENTS

Descriptions of the geology within and adjacent to the permit area are provided in R645-301-621 and R645-301-627. A description of the proposed operation plan for the casing and sealing of exploration holes and boreholes is provided in R645-301-630.

R645-301-612 CROSS SECTIONS, MAPS, AND PLANS

Certified cross sections, maps, and plans have been provided per R645-301-622 and R645-301-512.100.
ENVIRONMENTAL DESCRIPTION

GENERAL REQUIREMENTS

Regional Geologic Description

The Book Cliffs contain major coal beds of economic importance in central Utah. The rocks of this continuous, roughly horseshoe-shaped band of Cretaceous age rocks partly surround and dip gently away from the broad regional dome of the San Rafael Swell. Steep escarpments and deeply incised canyons are prominent features, above which are gently rolling plateaus. In the Book Cliffs coal field, of which the lease area is part, elevations range from 4,000 to 6,000 feet along the base of the Book Cliffs to nearly 10,300 feet at the highest point. The strike of the beds in the Book Cliffs is generally parallel to the face of the cliffs with a dip of 3 to 8 degrees to the northeast. Scattered faults of a west-northwest trend are limited to a few miles in length and from 25 to 200 feet in displacement.

Clark (1928) mapped the geology and coal outcrops in the western part of the Book Cliffs coal field from the Standardville 7½ minute quadrangle on the west
to Patmos Head quadrangle on the east. Fisher (1936) mapped the eastern part
of the coal field. Osterwald (1962) made a detailed study of the structural
features of the Sunnyside No. 1 Mine area. Doelling (1972) has also summarized
geology and coal data reported in earlier reports.

The coal beds of economic importance in the Book Cliffs coal field are upper
Cretaceous in age and are found in the Blackhawk Formation of the Mesa Verde
Group. The Mesa Verde Group contains three formations that are, in ascending
order, the Blackhawk Formation, the Castlegate Sandstone, and the Price River
Formation. The upper Cretaceous Mancos Shale underlies and intertongues with
the Blackhawk Formation but lies well below the mining horizon.

The lowest bed of the Blackhawk Formation is the Kenilworth Sandstone
member. The lower section of this cliff-forming unit is thinly bedded and
divided by shale partings, but the major part is a massive sandstone member
about 130 feet thick. The coal-bearing portion of the Blackhawk Formation lies
above the Kenilworth Sandstone and has been divided roughly into three
members recognized by Fisher (1936). The lower division consists of alternating
sandstone, shaley sandstone, shale and coal. It contains the Kenilworth coal bed.
The middle division is dominated by massive cliff-forming sandstone but near
the top has lagoonal deposits which include the upper and lower Sunnyside coal
beds. The upper division is a sequence of shaley sandstone, shale and coal. The
entire Blackhawk Formation is about 700 feet thick.

The cliff-forming Castlegate Sandstone overlies the Blackhawk Formation. It is
about 180 feet thick and is composed mainly of fine to medium grained light gray
sandstone.

The Price River Formation overlies the Castlegate and is about 500 feet thick.
It consists of interbedded sandstone and shale. The sandstone is light colored,
slightly calcareous to argillaceous, and thinly bedded to massive. The shale is
medium to dark gray, carbonaceous, and contains minor beds of bony coal.

The strata successively overlying the Price River Formation include the North
Horn Formation (upper Cretaceous and Paleocene), the Colton and Wasatch
Formation (Eocene) and the Green River Formation (Eocene). The North Horn
Formation consists of interbedded yellowish-gray sandstone, light yellow to
greenish-gray shale and limestone, and a conglomeritic sandstone at the base of
the formation. The Colton Formation is composed of interbedded sandstone,
siltstone and shale. The Green River Formation is the youngest formation in the
area. The formation consists mainly of greenish-gray and white claystone and
shale.
Description of the Coal Seam Geology

In the West Ridge-C Canyon area there are six coal seams that have been identified, however, the four lowest seams are thin, of limited extent and not mineable. The lowest seam is the Kenilworth coal seam. This seam rests directly on the massive Kenilworth Sandstone Member of the Blackhawk Formation or is separated from it by several feet of shale. The C Canyon mining area is on the eastern margin of this coal seam. The seam averages two feet thick along the outcrop and does not exceed four feet anywhere on the property.

About 20 feet above the Kenilworth coal is the Gilson coal horizon. This seam is most developed in the northwestern part of the property in the vicinity of Pace Canyon where thicknesses in the range of 12 feet have been measured. Toward the southeast in B Canyon, the seam splits and thins. By Whitmore Canyon, the coal has been replaced by marine sands. Over the northern portion of the lease area, the main Gilson bed is less than 2 feet thick. It is separated from the Kenilworth seam approximately 30 feet in the northern area.

The Fish Creek coal horizon lies about 15 to 25 feet above the Gilson seam. This seam averages 1 to 2 feet in thickness in the lease area, never developing into a mineable reserve. About 55 to 70 feet above the Gilson seam is the Rock Canyon coal horizon. This seam is not developed anywhere in the lease area.

The principal coal-bearing horizon beneath the C Canyon lease area is the Sunnyside coal zone. This zone begins 125 feet above the Rock Canyon seam and ends 200 to 275 feet below the Castlegate Sandstone. This zone varies between several feet to more than 60 feet in thickness between the lower and upper seams. Within this zone, the Sunnyside Mine has found nine coal beds. The bottom three have been assigned to the Lower Sunnyside Seam and the remainder to the Upper Sunnyside Seam.

The Lower Sunnyside Seam is the most important coal seam in the area. It exceeds 6 feet throughout most of the lease area. But, toward the south and east within the Sunnyside #3 Mine, the seam thins to 3.5 feet. The seam has a characteristic sandstone floor. The roof of the Lower Sunnyside Seam throughout the lease area is composed of either a black sandy shale or a fine grained sandstone with shale partings. To the north and west of C Canyon the Lower Sunnyside seam occurs as a single seam. However, to the south and east, one or two rider seams are present above the main coal seam. Neither of the rider seams reaches mineable thickness. Within the vicinity of the Sunnyside Mines to the south, the rider seams combine with the Upper Sunnyside to form a single seam 10-15 feet thick.
The Lower Sunnyside coal is brittle, tough and hard to pick. It has a metallic ring when struck with a hammer (Clark, 1928). It is a bright coal lacking definite fracture lines and breaks into large irregular lumps (Thiessen and Sprunk, 1937). Doelling (1972) summarized the coal's description as "a uniform attrital-anthraculous bright coal largely derived from small plant material such as small stems, twigs, roots and leaves". Clark (1928) reported that the Upper and Lower Sunnyside coal beds contain the best coking coal known in the Book Cliffs coal field in Utah and that "the coal weathers very slowly on exposure to the air and therefore makes a good stocking fuel..."

The Upper Sunnyside Seam is the least well defined of all of the coal horizons. Many of its six beds are lenticular and cannot be correlated between widely spaced data points. The seam ranges in overall thickness from 2.0 to 15.0 feet in the Sunnyside Mine to an average of 7 feet in the Sunnyside No. 1 Mine and 5.7 in the workings of the Sunnyside No. 3 Mine. On the C Canyon lease area, the average seam height is less than 4 feet. Because of its thinness and close proximity to the Lower Sunnyside Seam, none of the Upper Sunnyside is considered to be mineable.

Overburden depths (cover lines) for the Lower Sunnyside Seam are shown on Map 5-7. The maximum cover exceeds 2,500 feet. The average overburden under West Ridge is approximately 1,500'. For more details regarding overburden depths refer to Map 5-7.
### Table 6-1
**Generalized Stratigraphic Section**
**West Ridge Permit Area**

**Scale:** Not to Scale

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<td><strong>MESAVERDE GROUP</strong></td>
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**ANDALEX RESOURCES, INC.**
Tower Division

**Utah Division Oil, Gas and Mining**
R645-301-622 CROSS-SECTIONS, MAPS AND PLANS

622.100 Elevations of the coal seam to be mined and locations of drill holes are shown on Map 6-2, Coal Seam Structure Map. Drill hole collar elevations and intervals cored and plugged are presented in Appendix 6-2 in a table format.

622.200 The depth and thickness of surrounding strata are depicted in the stratigraphic column (Table 6-1). For additional information on the typical stratigraphic lithology and coal thickness within the permit area refer to the drill logs contained in Appendix 6-2. The mineable thickness of the Lower Sunnyside Seam is shown on the isopach map (Map 6-3, Lower Sunnyside Coal Seam Isopach Map). Map 6-1A, Geologic Cross-Section A-A’, is an east-west cross-sections through the permit area. The depth of the Lower Sunnyside Seam is depicted by overburden contours on Map 5-7.

Representative drill hole logs depicting the nature, depth and thickness of the coal seam to be mined and rider seams in the overlying strata are presented in Appendix 6-2. The drill holes selected are shown on Map 6-2.

A detailed cross-section of the lithology in the Whitmore Canyon area depicting the heterogeneous nature of the stratigraphy is included in Appendix 6-2 on Plate 1.

622.300 The outcrop line of the seam to be mined (i.e. the Lower Sunnyside Seam) is shown on Map 6-1, Regional Geology Map. The strike and dip of the seam in the permit area is also shown on Map 6-1.

622.400 There are a total of four gas wells (GVH wells) located at a common site in Bear Canyon (Section 3, T 14 S, R 13 E. These GVH wells were installed by the company to liberate methane from the West Ridge mine workings (refer to Appendix 5-14 and 5-14A).

R645-301-623 GEOLOGIC INFORMATION

623.100 Acid or Toxic-Forming Strata

Analyses have been performed on strata above and below the coal seam to be mined. This data is presented in Appendix 6-1. Analyses of the rock strata indicate that the potential for acid and/or toxic-forming material is minimal. The guidelines to which the analyses are compared are designed to be used for material in the vegetative rooting zone. WEST RIDGE Resources, Inc. is not 

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AUG 3 1 2012

Div. of Oil, Gas & Mining
The only underground development waste generated as part of the mining operation would consist of roof rock that is shot down during construction of ventilation overcasts. This material will be stored permanently in underground mine workings such as cross-cuts or storage rooms; it will not be brought out of the mine for outside storage and will therefore not be a factor in the final reclamation of the minesite.

Because WEST RIDGE Resources, Inc. intends to ship a mine-run product from the mine no coal processing wastes are anticipated. WEST RIDGE Resources, Inc. has been successfully marketing a mine-run product from its central Utah operations for the last fifteen years.

623.200 Reclamation Feasibility

Within the proposed disturbed area, there has been previous coal exploration work that occurred from the mid 1950's through 1986. None of the sites have undergone reclamation work. However, native vegetation has been re-established naturally on the disturbed areas such as the road and drillhole sites. Evidence indicates that successful reclamation of the minesite should be achievable and capable of supporting postmining land uses. In most of the previously disturbed areas, vegetation has reestablished itself naturally on the regraded fill material. This is significant because post reclamation efforts at this site in the past were quite limited compared to today's standards. No topsoil was spread over the area. Seeding, mulching and imprinting generally were not done.

At the Horse Canyon mine site, about 5 miles to the south, reclamation was conducted on an old minesite. The canyon is similar in aspect and elevation to C Canyon. Reclamation has progressed quite successfully at this site. There appears to be no adverse affects from the previous coal mining activities to diminish successful reclamation.

Samples of the Lower Sunnyside seam and the adjacent roof and floor material were collected for analyses in November 1997. The samples were taken from the outcrop in the left fork of C Canyon were the coal seam was previously excavated for a bulk coal sample. The results of these analyses are presented in Appendix 6-1. The analyses were conducted according to Table 6 of DOGM's "Guidelines For Management Of Topsoil And Overburden For Underground And Surface Coal Mining". The location of the sampling site is shown on Map 2-2, Minesite Order 1 Soil Survey. The samples were collected by taking a channel
should not pose a significant problem because the coal will be stockpiled in a relatively contained area of the mineyard and all runoff from the site will flow to the sediment pond for containment. At the time of reclamation, the coal will be removed from the site prior to the commencement of any regrading activities. Also, any waste rock generated through underground activities, such as construction of overcasts, will be permanently stored underground and therefore should not be a factor in surface reclamation activities.

623.300 Subsidence Control Plan

Map 5-7 shows the locations of the subsidence monitoring control points proposed for the initial mining area. Refer to R645-301-525 in Chapter 5 for the discussion on subsidence. The geology of the area around Grassy Trail reservoir is discussed in a seismic analysis report (see Appendix 5-11) and the Phase II dam safety report (see Appendix 5-12). These reports conclude that it is unlikely that mining induced seismicity or subsidence will impact the performance of the Grassy Trail Dam and Reservoir. Based on the conclusion of this study the BLM has approved the R2P2 to allow full extraction longwall mining of Panel #7.

GEOLOGIC DESCRIPTION

624.100 Regional and Structural Geology

The proposed permit area is located in the Sunnyside coal-mining district, an area in the western Book Cliffs on the northern margin of the Colorado Plateau. The proposed permit area is bounded on the southwest by East Carbon Valley and on the northeast by Whitmore Canyon. The permit area is bounded by the existing (abandoned) Sunnyside Mines on the south. Elevations in the area range from 7,000 to 8,500 feet.

The permit area is underlain by north to northeast dipping clastic sedimentary rocks deposited during the Cretaceous and Tertiary period. The regional dip is a result of the effect of the San Rafael Swell located to the southwest.

Professional papers by Osterwald et al. (1981) and Doelling et al. (1979) have described the geology of the region. Kaiser Coal Corporation (1986) has described the geology of the proposed permit area in a previous permit application submitted to the Division of Oil, Gas and Mining during the mid 1980’s. Pike Coal Company (1988) has prepared a report describing the geology and coal reserves of the general permit area (in-house report). Sunnyside Coal Company (1993) has described the geology of the coal leases located immediately to the southeast of the proposed permit area. The geologic description that follows is based on information from these sources.
immediately to the southeast of the proposed permit area. The geologic
description that follows is based on information from these sources.

Stratigraphy

Six bedrock formations, ranging in age from Cretaceous to Eocene, crop out in
the lease area. These formations are (from oldest to youngest), the Mancos
Shale, Blackhawk Formation, Castlegate Sandstone, Price River Formation,
North Horn Formation, and Colton Formation. These sedimentary rock units are
associated with the Western Cretaceous Interior Seaway and the highland areas
of the Sevier Orogenic Belt. Sediments eroded from highland areas were carried
eastward toward the seaway by fluvial systems and deposited in terrestrial,
shoreline, and marine depositional environments. Overall, this sequence of rocks
represents the regression of the interior seaway. Many smaller-scale regressions
and transgressions occurred during this time as well. This depositional history
has resulted in a heterogeneous rock record that has had a profound effect on the
water-bearing characteristics of these rocks.

Stratigraphy is illustrated on Table 6-1 and Map 6-1A and described below.

Mancos Shale

The Mancos Shale was deposited in deep, quiescent portions of the Western
Cretaceous Interior Seaway from Early to Late Cretaceous time. Consequently,
the Mancos Shale is over 4,000 feet thick and underlies vast portions of the
Colorado Plateau. The Mancos Shale is carbonaceous, gypsiferous, and slightly
calcareous. The unit is medium-gray to bluish-gray and is locally fissile with
discontinuous stringers of siltstone and mudstone. The Bluegate Member of the
Mancos Shale is exposed at the base of the Book Cliffs, on the floor of East
Carbon Valley, and in the mouth of Whitmore Canyon.

The contact of the Mancos Shale with the overlying Blackhawk Formation is
conformable and intertonguing. The shale units in the lower Blackhawk are
lithologically equivalent to the Mancos and the gradual change in depositional
environments resulting from a regression of the shallow Cretaceous sea.
Blackhawk Formation

The Late Cretaceous Blackhawk Formation intertongues with the upper Mancos Shale. The Blackhawk Formation is the product of an eastward-prograding deltaic complex that formed during the retreat of the Western Cretaceous Interior Seaway. In the West Ridge area, the Blackhawk Formation is a moderately resistant, cliff-forming sandstone that forms the lowermost and most predominant cliffs of the Book Cliffs. Slope-forming mudstones are interbedded with sandstone in the lower portion of the formation creating steep slopes. Unit thickness ranges from 625 to 800 feet.

Five distinct members of the Blackhawk are recognized in the proposed permit area. In ascending stratigraphic order, these are the Aberdeen Member, Kenilworth Member, lower mudstone member, Sunnyside Member, and upper mudstone member. The Aberdeen member is a shaley siltstone and sandstone member that is bounded above and below by the Mancos Shale.

The Kenilworth Member ranges from 110 to 220 feet thick and is comprised of three distinct sandstone tongues interbedded by shale. The base of the Kenilworth is defined as the lowest persistent sandstone bed in the Blackhawk.

The lower mudstone member of the Blackhawk has no formal stratigraphic name. It is 150 to 200 feet thick and made up of dark gray clayey mudstone, shales, and sandy siltstones. The lower part of the member is marine and the upper part is continental having been deposited east of the beaches that later formed the sandstones in the underlying Kenilworth. The Rock Canyon Coal Seam lies at the base of this member directly on top of the Kenilworth Member. The Rock Canyon Coal bed is lenticular and discontinuous, being exposed on the outcrop most notably in Rock Canyon.

The Sunnyside Member is predominately sandstone. The Aberdeen, Kenilworth, and Sunnyside Members represent beach and barrier bars depositional environments. The intervening mudstone members are shallow marine foreshore deposits. The Sunnyside Member overlies the lower mudstone and is approximately 100 to 190 feet thick. The basal portion of the unit is comprised of interbedded sandstone and siltstone. This lithology grades upward through thinly bedded, medium-grained sandstone in the upper Sunnyside Member. The upper part of the unit represents a high-energy depositional environment as evidenced by abundant crossbedding and ripple marks.
Overlying the Sunnyside Member is a 100 to 200 foot thick sequence of mudstone and siltstone with discontinuous sandstone beds that comprise the upper unnamed mudstone member of the Blackhawk. Large channel sandstone lenses are common in the upper part of the member and are equivalent to estuarine and beach deposits. The upper contact of the Sunnyside Member is a diastemic unconformity. Following deposition of this unit, stream channels cut into the mudstones and deposited channel sands similar to those in the overlying Castlegate Sandstone. Thin and discontinuous lenses of coal occur throughout the upper mudstone member; however, the principal coal bed in the member is the Sunnyside Coal bed that lies at the base of the unit. The Sunnyside coal often occurs in two splits. In the proposed permit area, the lower split is the seam that occurs in greater thickness.

Coal deposits in the Book Cliffs Coal Field occur within the Blackhawk Formation. Of economic interest in the proposed permit area is the Lower Sunnyside Seam, which lies directly above the Sunnyside Sandstone. The thickness of the Lower Sunnyside Seam in the proposed permit area ranges from 4 to 10 feet with an average mining thickness of approximately 7 feet. Coal seams which are not of economic interest include the Kenilworth Seam and Gilson Seam which occur in the Kenilworth Member, the Rock Canyon Seam, which occurs at the base of the lower mudstone member, and the Upper Sunnyside Seam. The stratigraphic location of these seams is shown on Table 6-1.

**Castlegate Sandstone**

The resistive Castlegate Sandstone forms a distinct cliff above the slope-forming upper mudstone member of the Blackhawk Formation. The formation is about 200 feet thick in the lease area. The Castlegate was deposited by a bed-load fluvial channel system. The unit lithology is dominated by sandstone with occasional siltstone and claystone interbeds. Sandstone channels are varied in size and interpenetrate. Sands within the channels are coarse grained and can be conglomeratic. The Castlegate forms a prominent cliff above the Blackhawk. The units overlying the Castlegate form a series of retreating ledges and slopes.
Price River Formation

The Price River Formation forms a series of ledges and slopes. It ranges in thickness from 160 to 600 feet. The formation is divided into two members, the lower mudstone member and the Bluecastle Sandstone. The lower member is 150-300 feet thick. The unit is poorly cemented, argillaceous sand that is easily eroded. The depositional environment of the lower Price River Formation is a mixed-load fluvial channel system, which created interbedded sandstone and shale/claystone layers. This unit was deposited on a coastal plain and as a result contains thin lenses of channel sands and thin, discontinuous coal beds. It is easily eroded thereby forming slopes.

The Bluecastle Sandstone is medium- to fine-grained sandstone with silica, carbonate, and ferruginous clay cement. The thickness of the Bluecastle Sandstone varies greatly within the permit area. The unit is 10-300 feet thick, and although it thins to the east, the Bluecastle Sandstone is a substantial unit in the lease area. The Bluecastle represents an alluvial fan/alluvial plain depositional environment and weathers to form abrupt vertical cliffs.

North Horn Formation

This unit is reddish-brown and grayish-brown mudstone with interbedded siltstone, sandstone, and limestone. Limestone beds are dark gray, dense, thin-bedded, and locally fossiliferous. The deposition of the North Horn Formation was in fluvial, alluvial plain, and lacustrine environments. Mud is more abundant than sand, which appears mostly in fluvial channels. Sandstone channels are isolated spatially by overbank mudstone deposits and lacustrine clays.

The North Horn Formation caps much of the permit area. Where exposed at the surface, it forms variegated slopes. The North Horn is about 800 feet thick in the West Ridge area.

Colton Formation

The Eocene Colton Formation is the cap rock for much of West Ridge and forms the steep slopes and cliffs of the Roan Cliffs to the east. The unit is dark-reddish brown mudstone and shaley siltstone. Locally the formation is distinctly variegated red and gray. The formation is formed from clastic materials shed
from adjacent highlands in ancient Lake Flagstaff and Lake Uintah. Deposits include interbedded alluvial, marginal lacustrine, and lacustrine sediments. In the West Ridge area, the ancient Colton fan-delta formed an especially thick (1,600-2,700 feet) section of Colton Formation rocks.

The Colton Formation forms the Roan Cliffs located on the east side of Whitmore Canyon, east of the permit area. Within the lease area, the Colton is divided into two subunits. The lower one is comprised of mudstone with some channel sandstone deposits and some thin limestone interbeds. It is primarily a slope former. The upper unit is made up primarily of fluvial sandstone and forms cliffs and bluffs with an occasional intervening slope. The upper unit has been called the Wasatch Formation by some.

Colton Formation sediments were deposited during an intra lacustrine period between the time of deposition of the older Flagstaff limestones and the deposition of the limestones and marls of the Green River Formation, which overlies the Colton Formation. There is no Green River Formation remaining in the lease area.

Structure

The structure in the region is controlled predominately by uplift of the San Rafael Swell. Beds are mostly uniform and are inclined 3 to 8 degrees away from the uplift. The strike of the beds is generally parallel to the face of the cliffs. Steep escarpments and canyons are prominent features, above which are rolling plateaus, while below are pediments and plains.

No major faults have been mapped in the lease area. The Sunnyside fault is a major north-northwest striking fault throughout much of the Sunnyside Mining District to the south. The vertical displacement on this fault decreases northward and is not detectable from surface mapping within the lease area.

Doelling, 1973, shows dashed fault lines in the vicinity of C Canyon. However, an extensive field investigation by Agapito Associates, Inc. during October 1997 did not locate any faulting in this vicinity. See the letter report discussing the field investigation results in Appendix 6-3.
Groundwater

As noted above, the depositional history of the geologic formations in the permit and adjacent areas has resulted in a heterogeneous rock record that has a profound effect on the water-bearing characteristics of these rocks. This heterogeneous lithology creates alternating horizons of mostly impermeable rocks and relatively permeable rocks. Relatively permeable sandstone channels preferentially support groundwater systems, and areally extensive groundwater systems or aquifers are precluded.

As described in R645-301-724.100, active groundwater flow in the permit area occurs almost exclusively in near-surface groundwater systems that are often associated with colluvial and alluvial materials. Groundwater that is encountered in the Blackhawk Formation is associated with inactive groundwater flow systems. Mining is not expected to impact near-surface active groundwater systems. Mining may potentially dewater localized inactive groundwater systems of the Blackhawk Formation. These impacts will not affect the discharge of springs and streams in the permit and adjacent areas because the dip of the Blackhawk Formation into the Book Cliffs prevents water in the Blackhawk Formation from discharging.

624.110 Cross Sections, Maps, Plans.

624.120 Information for this section is found in R645-301-624.200, R645-301-624.300 and R645-301-625.

624.130 Geologic Literature and Practices.

The geologic literature utilized in preparing R645-301-600 is contained in the reference list at the end of this chapter.

Much of the geologic data of the permit area was obtained during exploration programs conducted by previous lease holders. WEST RIDGE Resources, Inc. has recently supplemented this data through additional field work within the permit area.

All practices and procedures for obtaining geologic information have been standard for the industry. This includes lithologic logs, drill hole E logs, columnar sections, detailed coal bed lithology, core photographs, and coal sample analysis. This data was then used to compile seam correlation maps, geologic
cross sections, fence diagrams, coal isopachs, rock isopachs, overburden isopachs and paleochannel delineation. Professional engineering and geological organizations were employed to collect and interpret the geologic information. The data was obtained from numerous drill holes in and adjacent to the permit area and from the adjacent Sunnyside Mines.

624.200 Drill hole logs did not contain any information about water encountered during the drilling process. It is unknown whether no water occurred or it was just not noted.

624.300 Drill Hole Sample Analyses

624.310 Lithologic logs of drill holes in the permit and adjacent areas are compiled in Appendix 6-2. A summary of the drill hole collar elevations and depths has been added to Appendix 6-2.

624.320 Strata above the coal seam to be mined consist of interbedded sandstone and shale. Samples of the roof and floor material was collected and analyzed for the parameters listed in Table 6 of "Guidelines For Management Of Topsoil And Overburden For Underground And Surface Coal Mining". The results are presented in Appendix 6-1. Based on laboratory analyses and observations on site, the strata above the seam does not contain material or elements in concentrations which would be adverse to vegetative growth when it is covered with backfill material.

624.330 Chemical analyses of the coal seam to be mined have been performed. The analyses include all of the parameters listed in Table 6 of "Guidelines For Management Of Topsoil And Overburden For Underground And Surface Coal Mining". The results of these analyses are included in Appendix 6-1. The analyses for total sulfur include organic, pyritic and sulfate sulfur. Based on the laboratory analyses and observations on site, the coal seam to be mined does not appear to contain constituents in concentrations that would adversely affect vegetative growth and should not produce acid soil problems.

In the Wasatch Plateau and Book Cliffs Coal Fields, acid mine drainage generally not a concern because of abundant carbonate minerals in the coal-bearing stratum and the relatively low concentration of sulfur within the coal. The dissolution of
carbonate minerals quickly consumes any acid produced from the oxidation of pyrite.

The sample location for the roof/floor material of the Lower Sunnyside seam is in the left fork in an area where the outcrop has been exposed and tested in the past. This sample is considered to be representative of the roof/floor material which is expected to be encountered throughout the mine. The Lower Sunnyside seam is also the most consistent and widespread seam in the area and will be the only seam mined at the West Ridge mine. The floor for the Lower Sunnyside seam is typically the Sunnyside Sandstone which is a distinctive beach sandstone. This sandstone member is continuous and widespread and is a distinguishable geologic member throughout the West Ridge area. Based on visual observations the roof lithology at the left fork site, it is similar to the lithology depicted in numerous drill holes throughout the reserve area.

WEST RIDGE will commit to taking additional roof/floor samples when the coal seam is exposed at the portal area in the right fork. These additional samples can be used to verify the results of the left fork sample. It should be noted that WEST RIDGE Resources intends to produce a mine run product and does not propose to process and of the coal or dispose of any mine generated reject material.

624.340 Engineering Properties

The mining technique to be utilized for the West Ridge Mine is longwall mining. This regulation is not applicable in this situation.
OVERBURDEN THICKNESS AND LITHOLOGY

The overburden thickness above the Lower Sunnyside Seam for the proposed mining area is depicted on Map 5-7. Typical drill logs have been provided in Appendix 6-2 for additional overburden and lithology information.

Due to the complex depositional environment of the coal deposits, roof rock types will vary throughout the mining area. In general, the Lower Sunnyside Seam is overlain by sandstone or shale. In areas where paleochannels exist, the immediate roof will be sandstone. Mine planning will take into account the variability of roof materials. Roof rock will be monitored during the mining operation through roof bolting activities, mine mapping and/or underground drilling.

OPERATION PLAN

PLAN FOR CASING AND SEALING EXPLORATION HOLES

All drill holes from previous exploration activities have already been sealed to the surface with cement and reclaimed. Any future drill holes will be sealed with cement to within one foot of the surface. The remainder of the hole will then be filled with local fill materials to allow regrowth of vegetation over the site. All drill holes will meet the specifications set forth by the State Engineer and the Division of Water Rights as required. A licensed driller will perform the work of sealing the drill holes.

SUBSIDENCE MONITORING

Refer to R645-301-525 in Chapter 5 for the subsidence information required for this section. Map 5-7 shows the locations of the subsidence monitoring control points proposed for the initial mining area.
PERFORMANCE STANDARDS

641 All exploration holes and boreholes will be permanently cased and sealed according to the requirements of R645-301-630.

642 All monuments and surface markers will be reclaimed in accordance with R645-301-521.210.
REFERENCES


Kaiser Coal Corporation, 1986, Mining and Reclamation Permit for the Sunnyside Number 5 Mine, Carbon County, Utah.


Sunnyside Coal Company, 1993, Mining and Reclamation Permit for the Sunnyside Mines, Carbon County, Utah, Chapter 6-Geology, ACT 007/007.
APPENDIX 6-1

OVERBURDEN & COAL CHEMICAL ANALYSES
The following samples were collected in 1997 from the Lower Sunnyside Seam outcrop in C Canyon just above the proposed mineyard facility area. This area was disturbed in the early 1970's for collection of a bulk coal sample. The outcrop was left in an exposed condition. The samples taken from the roof, floor and coal seam were taken from the exposed outcrop material. The sample was sent to Inter-Mountain Laboratories, Inc. in Sheridan, Wyoming for analysis.
### SITE: OUTCROP - LEFT FORK

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<tr>
<th>Lab No.</th>
<th>Location</th>
<th>Depths</th>
<th>pH</th>
<th>EC (mhos/cm @ 25°C)</th>
<th>Saturation %</th>
<th>Calcium meq/l</th>
<th>Magnesium meq/l</th>
<th>Sodium meq/l</th>
<th>SAR</th>
<th>Very Fine Sand</th>
<th>Sand %</th>
<th>Silt %</th>
<th>Clay %</th>
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**Miscellaneous Abbreviations:** SAR = Sodium Adsorption Ratio, CEC = Cation Exchange Capacity, ESP = Exchangeable Sodium Percentage, Exch = Exchangeable, Avail = Available
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<th>Total T.S. AB</th>
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<th>Pyritic Sulfur</th>
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December 29, 1997

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# DRILL HOLE SUMMARY

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Hole 86-2

-15
-10
-5
0
5
10
15
20
25
30
35
40

Distance Above Roof (ft)

Siltstone
Coal
Upper Sunnyside Seam
Siltstone
Coal
Lower Sunnyside Seam
SS

INTEGRATING
EFFECTIVE:
APR 01 1999

UTAH DIVISION OF OIL, GAS AND MINING
Hole B-3

Coal
Lower Sunnyside Seam

Gray SS

Coal
Boney Coal
Sandy Shale

Gray SS

Coal
Boney Coal
Gray Sandy Shale

Gray SS

Coal
Upper Sunnyside Seam

Boney Coal
Sandy Shale

Black Sandy Shale

INCORPORATED
EFFECTIVE:
APR 01 1966

UTAH DIVISION OIL, GAS AND MINING
Hole N-12

-15
-10
-5
0
5
10
15
20
25
30
35
40

Distance Above Roof (ft)

Coal
Lower Sunnyside Seam

Coal
Upper Sunnyside Seam

Mudstone

Boney Coal

Mudstone

SS

Sandy Shale

SS
Coal

SS
Coal

Mudstone
Coal

Mudstone

SS
APPENDIX 6-3

C CANYON GEOLOGIC FIELD INVESTIGATION SUMMARY
Re: Andalex Resources Inc.

Regarding our conversation this morning about the Andalex Resources Inc. proposed longwall mine at West Ridge north of East Carbon City Utah. You were interested in any faults that I may have observed while doing a joint orientation survey on the property in October of 1997. My main focus while doing this job was to collect joint orientation data and my time was limited in the field. I was, however, aware of the importance of identifying any faults on the property, and to the best of my abilities kept my eyes open to any signs of faulting.

For the most part I concentrated on collecting joint data within the Castlegate Sandstone. To do this I typically traversed along the base of Castlegate cliffbands to examine the joint planes. While traversing I looked at the continuity of individual sandstone beds across drainage's and major joint/fracture systems. I also examined a number of other sandstone or siltstone beds above and below the coal seams of interest.

The “B” and “C” Canyon areas were where I spent the most time during the study. I did not find any direct or indirect evidence of faulting during my survey in this area. I specifically recall walking out the Castlegate cliffs above the site labeled as the proposed portal in my notes. I could not detect any faulting or offset in these cliffbands. Additionally, I could not locate the small faults mapped by Doelling by walking along the main drainage’s and following the sandstone beds with binoculars. The drainage’s on the property follow a rectangular pattern, indicating a structural control based on the regional jointing/fracturing patterns. My interpretation of the drainage’s is that they generally follow zones of closer-spaced or better developed joints, but I did not observe detectable offset.

To summarize, my survey did not reveal any faults in the “B” and “C” Canyon areas that would effect longwall operations. I do need to stress that my time spent examining outcrops was limited, and the existence of small faults cannot be ruled out. If such faults do exist, offsets are probably on the order of several feet. If faults with larger offset were located on the property, say several 10’s of feet or more, these features would probably have been noticed by myself or previous mappers.

I hope this answers your questions. If you have any further questions please give me a call.

Sincerely,

Eric R. Martin