R645-301-600.  **GEOLOGY**

As the Mathis Tract and New Federal Summit Creek Lease boundary change is simply an extension of underground mine workings under roughly 2,500 feet of cover there will be absolutely no effect on geology other than as we proceed further to the north, the depth of cover increases.

* SEE ALSO APPENDIX E

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R645-301-610.  **INTRODUCTION**

R645-301-611.  **GENERAL REQUIREMENTS**

R645-301-611.100.  **GEOLOGY WITHIN AND ADJACENT TO THE PERMIT AREA**

**Introduction**

The proposed permit area is in Book Cliffs which is the major physiographic feature in the region. The cliffs rise from a base at approximately 5,500 feet in elevation, to over 8,500 feet. Numerous canyons dissect the Book Cliffs. Soldier Creek and Coal Creek are the major area drainages. The permit area exhibits extreme topographic relief and is mountainous with steep cliffs and deeply incised drainages. With the exception of the Mancos Shale Formation, the Fiasco, Deadman, Straight Canyons, Hoffman Creek Canyon, Graves Lease and AEP Lease exhibit similar stratigraphic and topographic characteristics.

**Tectonic Setting**

The major coal seams of the Book Cliffs Coal Field lie within the Cretaceous Mesa Verde group which overlies the thick shales of the Cretaceous Mancos formation. The Mesa Verde group consists of the Star Point Sandstone, Blackhawk formation and Price River formation. The major coal seams lie within the Blackhawk formation.

The Tertiary Wasatch and Green River formations, along with the Price River formation, form the Roan Cliffs, the Tavaputs Plateau and the southern rim of the Uintah Basin. Lithologies present include fluvial, deltaic, and marine sandstones, mudstones, and shales.

**Geologic History**

During the Triassic and Jurassic periods, the area of the Book Cliffs was relatively stable, but gradually subsided and received sediments. The area, assumed to have been a relatively flat lowland, was occasionally covered by a shallow sea of short geologic duration. A thick red bed sequence suggests tropical conditions and the great thickness of sand accumulation suggests

Revised 03/04
acid conditions. During Triassic times, the sediments probably came from all directions but, during the Jurassic time, the major source areas lay to the south and west.

During the early Cretaceous time, a trough developed in the Colorado Rockies area and the sea invaded. Gradually the sea crept westward as the trough continued to subside, reaching the east edge of the Colorado Plateau by the beginning of the Upper Cretaceous age.

Unconformities and thinning of various members indicate that volcanic activity to the west caused sediments to fill the basin faster than it could subside, causing the shoreline to be pushed eastward. When lulls in this activity developed, the incoming sediments diminished and the sea moved westward once more. With each pulse, the boundaries of the depositional environments moved eastward and then returned westward. The sandstone tongues of the Mesa Verde, which project into the Mancos, were deposited at these times.

After the sea retreated, the area continued to receive sediments under continental conditions which lasted well into Eocene time. In Oligocene time, the area began to rise in earnest. Erosion attacked the newly formed formation creating the present mountain ranges and cliffs.

**Stratigraphy**

The main coal bearing beds in the region occur in the Blackhawk formation. There are various more or less distinct coal beds or zones as listed below from top to bottom according to stratigraphic position.

- Upper Sunnyside Bed
- Lower Sunnyside Bed
- Centennial Bed
- Rock Canyon Bed
- Fishcreek Bed
- Gilson Bed
- Kenilworth Bed
- Castlegate "B" Bed
- Castlegate "A" Bed

These zones are lenticular and reach minable thickness only in certain areas. The Lower Sunnyside Bed is the major bed in the area.

**Structure**

The Book Cliffs are basically a homocline (dip slope) dipping into the Uintah Basin with the cliff front roughly paralleling the strike of the feature. The strike of the beds is generally parallel to the face of the Book Cliffs. The beds are mostly uniform with dips of from 3° to 8° to the north and northeast.
toward the Uintah Basin.

Occasional faults cut the coal measures but are of small displacement and have been of little consequence in mining. The most serious group of faults lies in the Sunnyside area. These faults, which have a maximum separation of 200 feet, effect mining, but, fortunately, are not closely spaced.

**History of Mining**

Mining has been the major industry in the region for many years.

Coal was discovered in the Wasatch Plateau in 1874 and exploration soon spread to the Book Cliffs. Mines began operating in the area in 1889. The Castlegate and Sunnyside area was first developed, the areas in between being developed later. Coal was usually discovered away from settled areas and towns were built for employees by the companies.

Production from mines generally increased until 1920, but began to decline in the 1920's and 1930's. World War II brought production back to the 1920 levels and production continued to increase until 1957 when production again declined.

Book Cliff mines to present have produced about 75 percent of Utah's coal annually. Well over 200 million tons of coal have been extracted from the coal measures of the area. Much coal remains and numerous mines are presently operating in the area.

**Geologic Hazard**

There are occasional faults cutting the coal measures of the area. They are of relatively small displacement. The most serious faults occur in the Sunnyside area. There is no indication of faulting within our lease area.

Faults in the Sunnyside district of the Book Cliffs field have been thought, by some, to have a causative relationship to the bounces experiences there. The outcrops on the lease premises and our own aerial photos have been carefully studied. In our judgement, no faults cut the lease area. The bulk of the tonnage to be mined is under less than 1,500 feet of cover, with only a very limited amount of coal under cover, up to 2,700 feet. Water inflows have never been a problem in the Book Cliffs field. The dip of the coal measures prevents entrapment of personnel, in any event.
Stratigraphy

The coal seams in the Blackhawk formation are listed stratigraphically:

- Upper Sunnyside Bed
- Lower Sunnyside Bed
- Centennial Bed
- Rock Canyon Bed
- Fishcreek Bed
- Gilson Bed
- Kenilworth Bed
- Castlegate "B" Bed
- Castlegate "A" Bed (Aberdeen)

Only the Lower Sunnyside, Centennial, Gilson, and Castlegate "A" beds are formed in commercial thickness on the Centennial Property. Andalex has discovered a new coal seam which is referred to as the Centennial Seam. This coal was originally thought to have been in the Lower Sunnyside Seam. This coal has been accessed through rock tunnels from the existing Pinnacle Mine. Waste from these rock tunnels was disposed of in the Pinnacle Mine. The Mine in the Centennial Seam as well as the Mine in the Aberdeen Seam will both progress onto the Graves Lease. Andalex is applying for approval for the new AEP Lease in the Centennial and Aberdeen Seams only.

Stratigraphic sections of the coal beds are shown in Figures III-1 and III-2. Seam thicknesses are shown on Plates 26, 27, 28, and 29.

Structure

The structure between Deadman and Soldier Canyons is relatively simple. Structure contours are aligned basically east-west. The coal beds dip northward at approximately six degrees. No faults are thought to exist in the Deadman Canyon area.

History of Mining

Several small operations have mined a considerable amount of coal over the past 70 years in the Deadman Canyon Area. Mining ceased in the area in 1964. These mines, however, merely scratched the surface of the reserve. The remaining recoverable reserve is estimated to be greater than twenty-eight million tons and ranging in cover from 0 to 2,700 feet.

Identification of Strata

Strata disturbed by surface operations consist of sandstone and siltstone of a colluvial nature.
Statement of Borings and Samplings

Design of Boring and Sampling Program

Sites - Numbers, Location and Relationship to the Disturbed Area

The number, locations, and relationship of drill holes and sampling are indicated on Plates 26, 27, and 28.

Methodology - Sample Collection, Compositing of Samples for Each Strata, Laboratory

Samples of the immediate floor and roof below and above each seam were sampled using conventional core drilling equipment. Also, samples of the overburden which was disturbed in surface operation has been sampled by "grab" methods, as well as auger drilling.

Data

Field Log and Description of Samples - Lithologic Classification, Description, and Hydrologic Aspects

In November and December, 1971, a five-hole drilling program was conducted by Centennial Coal Associates, supplemented by mine samples and outcrop information, and the results used to estimate the coal reserves of the leases. Pertinent information on these drill holes is given in Table III-1 and Appendix E. Complete lithologic logs of each drill hole are included in Appendix E. Numerous samples were taken from the outcrops of the Lower Sunnyside, Gilson, and Aberdeen seams, as well as from mine faces in the Hileman, Olsen, Star Point, and Blue Flame No. 1 mines. Information from those samples as well as the location of the drill holes is shown on Plates 26, 27, and 28.
## TABLE III-1

### Centennial Drill Holes

<table>
<thead>
<tr>
<th>Number</th>
<th>Location</th>
<th>Total Depth</th>
<th>Coal Seams</th>
</tr>
</thead>
<tbody>
<tr>
<td>DH-1</td>
<td>NW1/4 NW1/4 SE1/4</td>
<td>516 ft.</td>
<td>Lower Sunnyside</td>
</tr>
<tr>
<td></td>
<td>Sec. 8 T13S, R11E, SLBM</td>
<td></td>
<td>Gilson</td>
</tr>
<tr>
<td></td>
<td>Elevation - 7,230 ft.</td>
<td></td>
<td>Aberdeen</td>
</tr>
<tr>
<td>DH-2</td>
<td>SW1/4 NW1/4 NW1/4</td>
<td>580 ft.</td>
<td>Lower Sunnyside</td>
</tr>
<tr>
<td></td>
<td>Sec. 7 T13S, R11E, SLBM</td>
<td></td>
<td>Gilson</td>
</tr>
<tr>
<td></td>
<td>Elevation - 7,275 ft.</td>
<td></td>
<td>Aberdeen</td>
</tr>
<tr>
<td>DH-2-A</td>
<td>SW1/4 NW1/4 SE1/4</td>
<td>303 ft.</td>
<td>Gilson</td>
</tr>
<tr>
<td></td>
<td>Sec. 7 T13S, R11E, SLBM</td>
<td></td>
<td>Aberdeen</td>
</tr>
<tr>
<td></td>
<td>Elevation - 7,165 ft.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DH-5</td>
<td>SE1/4 SW1/4 NE1/4</td>
<td>832 ft.</td>
<td>Lower Sunnyside</td>
</tr>
<tr>
<td></td>
<td>Sec. 7 T13S, R11E, SLBM</td>
<td></td>
<td>Gilson</td>
</tr>
<tr>
<td></td>
<td>Elevation - 7,275 ft.</td>
<td></td>
<td>Aberdeen</td>
</tr>
<tr>
<td>DH-6</td>
<td>NW1/4 SE1/4 SW1/4</td>
<td>2,275 ft.</td>
<td>Lower Sunnyside</td>
</tr>
<tr>
<td></td>
<td>Sec. 5 T13S, R11E, SLBM</td>
<td></td>
<td>Gilson</td>
</tr>
<tr>
<td></td>
<td>Elevation - 8,558 ft.</td>
<td></td>
<td>Aberdeen</td>
</tr>
</tbody>
</table>
In October and November, 1977, a seven-hole drilling program was conducted by Andalex in order to better define the coal reserves for mine planning on the Zion's fee. Pertinent information on these drill holes is presented in Table III-2. Complete lithologic logs of each drill hole are included in Appendix E. Locations are indicated on Plates 26, 27, and 28. Andalex drilled six holes underground and one on the surface in the summer of 1989 (Drill hole numbers 89-1-AP, 89-2-AP, 89-3-AP, 89-1-PIN, 89-2-PIN, 89-3-PIN, 89-1-CP). These holes were primarily to substantiate the existence of the new Centennial Seam.

Andalex has also acquired lithologic logs of two drill holes completed by North American Coal Corp., in 1948 and one by Pacific Gas & Electric in 1980. Although these holes are not located within the permit area, but to the west and east of its boundary, the information has been utilized in estimating reserves. Pertinent information is given in Table III-3. Complete lithologic logs are included in Appendix E and their location is indicated on Plates 26, 27, 28, and 29.
TABLE III-2
Andalex Drill Holes

<table>
<thead>
<tr>
<th>Number</th>
<th>Location</th>
<th>Total Depth</th>
<th>Coal Seams</th>
</tr>
</thead>
<tbody>
<tr>
<td>77-1-CP</td>
<td>NE1/4 SE1/4 SW1/4 Sec. 7 T13S, R11E, SLBM Elevation - 7,555 ft.</td>
<td>675 ft.</td>
<td>Gilson Aberdeen</td>
</tr>
<tr>
<td>77-2-CP</td>
<td>SE1/4 NE1/4 SW1/4 Sec. 7 T13S, R11E, SLBM Elevation - 7,520 ft.</td>
<td>690 ft.</td>
<td>Gilson Aberdeen</td>
</tr>
<tr>
<td>77-3-CP</td>
<td>SE1/4 SE1/4 NW1/4 Sec. 7 T13S, R11E, SLBM Elevation - 7,425 ft.</td>
<td>868 ft.</td>
<td>Lower Sunnyside Gilson Aberdeen</td>
</tr>
<tr>
<td>77-4-CP</td>
<td>SE1/4 SE1/4 SW1/4 Sec. 7 T13S, R11E, SLBM Elevation - 7,070 ft.</td>
<td>105 ft.</td>
<td>Aberdeen</td>
</tr>
<tr>
<td>77-5-CP</td>
<td>SE1/4 SE1/4 SW1/4 Sec. 7 T13S, R11E, SLBM Elevation - 7,085 ft.</td>
<td>85 ft.</td>
<td>Aberdeen</td>
</tr>
<tr>
<td>77-6-CP</td>
<td>NE1/4 NE1/4 NW1/4 Sec. 18 T13S, R11E, SLBM Elevation - 7,080 ft.</td>
<td>80 ft.</td>
<td>Aberdeen</td>
</tr>
<tr>
<td>77-7-CP</td>
<td>NE1/4 NE1/4 NW1/4 Sec. 18 T13S, R11E, SLBM Elevation - 7,010 ft.</td>
<td>45 ft.</td>
<td>Aberdeen</td>
</tr>
<tr>
<td>89-1-AP</td>
<td>SW1/4 SE1/4 NW1/4 Sec. 7 T13S, R11E, SLBM Elevation - 7,239 ft.</td>
<td>460 ft.</td>
<td>Centennial Aberdeen</td>
</tr>
<tr>
<td>89-2-AP</td>
<td>NE1/4 NW1/4 SW1/4 Sec. 7 T13S, R11E, SLBM Elevation - 7,283 ft.</td>
<td>90 ft.</td>
<td>Centennial</td>
</tr>
<tr>
<td>89-3-AP</td>
<td>SW1/4 SE1/4 NW1/4 Sec. 7 T13S, R11E, SLBM Elevation - 7,169 ft.</td>
<td>90 ft.</td>
<td>Centennial</td>
</tr>
<tr>
<td>89-1-PIN</td>
<td>SE1/4 NE1/4 SE1/4 Sec. 8 T13S, R11E, SLBM Elevation - 6,951 ft.</td>
<td>260 ft.</td>
<td>Aberdeen</td>
</tr>
</tbody>
</table>

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DIV OF OIL, GAS & MINING
<table>
<thead>
<tr>
<th>Number</th>
<th>Location</th>
<th>Total Depth</th>
<th>Coal Seams</th>
</tr>
</thead>
<tbody>
<tr>
<td>89-2-PIN</td>
<td>SW1/4 NW1/4 SW1/4</td>
<td>250 ft.</td>
<td>Aberdeen</td>
</tr>
<tr>
<td></td>
<td>Sec. 8 T13S, R11E, SLBM</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elevation - 7,014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>89-3-PIN</td>
<td>NW1/4 SE1/4 SW1/4</td>
<td>240 ft.</td>
<td>Aberdeen</td>
</tr>
<tr>
<td></td>
<td>Sec. 7 T13S, R11E, SLBM</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elevation - 7,483 ft.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>89-1-CP</td>
<td>SE1/4 SE1/4 SW1/4</td>
<td>1,880 ft.</td>
<td>Centennial</td>
</tr>
<tr>
<td></td>
<td>Sec. 6 T13S, R11E, SLBM</td>
<td></td>
<td>Aberdeen</td>
</tr>
<tr>
<td></td>
<td>Elevation - 8,307 ft.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE III-3
North American Drill Holes

<table>
<thead>
<tr>
<th>Number</th>
<th>Location</th>
<th>Total Depth</th>
<th>Coal Seams</th>
</tr>
</thead>
<tbody>
<tr>
<td>DH-NACC-6</td>
<td>SE1/4 SE1/4 SE1/4 Sec. 1 T13S, R10E, SLBM</td>
<td>Approx. 1,020 ft.</td>
<td>Centennial Gilson Aberdeen</td>
</tr>
<tr>
<td></td>
<td>Elevation - 7,460 ft.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DH-NACC-7</td>
<td>SW1/4 NE1/4 SE1/4 Sec. 12 T13S, R10E, SLBM</td>
<td>Approx. 7,192 ft.</td>
<td>Gilson Aberdeen</td>
</tr>
<tr>
<td></td>
<td>Elevation - 7,192 ft.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Pacific Gas and Electric Drill Hole

<table>
<thead>
<tr>
<th>Number</th>
<th>Location</th>
<th>Total Depth</th>
<th>Coal Seams</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC9-1</td>
<td>NW1/4 NW1/4 NW1/4 Sec. 9 T13S, R11E, SLBM</td>
<td>Approx. 930 ft.</td>
<td>Lower Sunnyside Gilson Aberdeen</td>
</tr>
<tr>
<td></td>
<td>Elevation - 7,225 ft.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Laboratory Analyses - Chemical Acidity, Toxicity, Alkalinity, and Physical (Erodibility and Compaction) Properties

Complete laboratory analysis is included in Appendix E. Appendix E has been updated to include coal quality information pertaining to the Centennial Seam.

Identification of Potential Acid, Toxic or Alkaline Producing Horizons

Refer to Appendix E for the laboratory analyses. Andalex has committed to sampling roof and floor material in all four coal seams in the most recently mine areas. This material will be analyzed for identification of Potential Acid, Toxic or Alkaline Producing Horizons. As this material is collected it will be placed into Appendix E with the rest of the laboratory data.

Location of Subsurface Water at Face-Up Areas

No water was encountered at face-up areas.

Description of Coal Seams and Overburden - Mine Plan Area

General Description

Stratigraphy

There are four coal seams of minable thickness in the mine plan area. All four are part of the Blackhawk Formation of the Cretaceous Mesa Verde Group. The Blackhawk consists of three members. Stratigraphically, from bottom to top, they are the Aberdeen Member, the Kenilworth Member, and the Sunnyside Member (see Figure III-2).

The bottom coal seam is the Aberdeen (also known as the Castlegate "A" Seam). It is found in the Aberdeen Member of the Blackhawk. This coal seam rests directly on approximately 150 feet of basal sandstone. This sandstone is of littoral marine origin and is known as the Aberdeen Sandstone. The coal seam ranges from 4 feet to 13 feet in thickness over the property. Above the seam is approximately 90 feet of interbedded sandstone, siltstone, and carbonaceous shale containing coal riders.

The second seam is the Gilson Seam and ranges in thickness from 4 feet to 8 feet over the property. The Gilson is part of the Kenilworth Member of the Blackhawk. Directly below the Gilson is approximately 90 feet of interbedded sandstone, siltstone, and carbonaceous shale with coal riders. Below this is approximately 70 feet of barrier beach sandstone known as the Kenilworth Sandstone. Above the Gilson is approximately 100 feet of interbedded sandstone, siltstone, shale, and coal riders.

The third seam is the Centennial Seam ranging from 4' to 8' in thickness. The Centennial Seam is part of the Sunnyside member
of the Blackhawk. The Centennial Seam lies approximately 40' below the Lower Sunnyside Sandstone. Below the Centennial Seam is approximately 130' of interbedded sandstone, siltstone, shale, and coal riders.

The top seam is the Lower Sunnyside Seam, ranging from 4 feet to 5 feet in thickness. The Lower Sunnyside is part of the Sunnyside Member of the Blackhawk. Below the coal seam is approximately 50 feet of barrier beach sandstone known as the Lower Sunnyside Sandstone. Above the coal seam is about 250 feet of interbedded sandstone, siltstone, shale, and coal riders.

Above the Blackhawk, the Castlegate Sandstone and Price River Formation of the Mesa Verde Group can be found over various parts of the property. The North Horn Formation is also present in certain areas of the property. Total overburden on the mine plan area ranges from 0 to 2,700 feet.

There are unleased federally owned coal reserves adjacent to the permit area. Andalex has assumed ownership on part of this coal contained in the Graves Tract which is now a part of this MRP. Andalex will access this lease from the existing underground workings as has been done in the past when Andalex has added new leases. In addition to the Graves Tract there is still some unleased federal adjacent to the Centennial property which is of questionable value. The Centennial coal seam is accessed from the existing Pinnacle Mine which is in the Gilson Seam. It is accessed via rock tunnels which are approximately 500' in length. The Centennial and Aberdeen Seams on the AEP Lease will be accessed through an extension of existing underground workings.

The Aberdeen sandstone in our vicinity is 80 to 100 feet thick. Its lateral extent is from Castlegate to well east of the Centennial property. It is a very well known geologic marker in the Book Cliffs coal field. It is a medium grained, tightly cemented, cross bedded sandstone which contains very little or no water. It has been drilled into in every exploration hole in our leases. All other aquifers or water tables within our leases are perched.

Structure

Structure contours are aligned basically east-west. The coal beds dip northward at approximately six degrees. No faults are known to exist in the mine plan area. Overburden ranges from 0 to 2,700 feet.

Hydrologic Aspects

All groundwater exists as perched aquifers in the mine plan area. Due to the lenticular nature of the geology in the area, any groundwater is isolated and very limited. Please see Water Quality Data in Appendix L. Also, please note that the Sunedco property recently acquired by Andalex was included in the Vaughn
Hansen/Andalex Hydrologic Inventory prepared for the original PAP and the emergency lease (please see Appendix L). Also included in Appendix L are the Graves and AEP PHC's.

The occurrence the Division has referred to where Andalex intercepted groundwater was actually not groundwater per se but water which had accumulated in old mine workings over a number of years (45 to 50 years). This was a one time occurrence. Water accumulates in small burned out voids because they are down dip from the burned outcrop. Andalex uses the practice of advanced drilling to avoid these areas. This is the only water which has been or will be encountered as the Andalex permit area is free from faulting or any other means of water conveyance.

Location of Subsurface Water

Some of the sandstone beds of the Blackhawk Formation are water bearing in the mine plan area. Most of the beds are dry however, and partially drained of water near the cliff faces. Groundwater is perched due to the lenticular geology and any groundwater is isolated. The geology and specifically the lenticular nature of the beds on the new AEP lease are the same as what has been described in the original permit area. Also, any water bearing units are small in areal extent. The lowermost aquifer known in this area is the Aberdeen Sandstone, which is monitored below the lowermost coal seam. The newly acquired AEP Lease is included in the Andalex Hydrologic Inventory.

Detailed Analyses of Coal Seams and Surrounding Strata

Source of Data

Analysis was performed on rib samples and core samples obtained during the exploration activities described. Results of these analyses are listed according to seam in Appendix E.

Analysis was performed by: Commercial Testing and Engineering Company, 10775 East 51st Avenue, Denver, Colorado 80239, and other commercial testing laboratories.

Coal Seams

Total Sulfur Content

Please see Appendix E.

Other Characteristics

Please see Appendix E.

Stratum Immediately Overlying each Coal Seam to be Mined

Lithology (See Figure III-2)
Aberdeen Coal Seam (Castlegate "A") - overlying this seam is interbedded sandstone, siltstone, and carbonaceous shales of the Aberdeen Member of the Blackhawk.

Gilson Coal Seam - overlying this seam is interbedded sandstone, siltstone, and shale with coal riders of the Kenilworth Member of the Blackhawk.

Centennial Coal Seam - overlying is interbedded sandstone, siltstone, and shale, and coal riders of the Sunnyside Member of the Blackhawk.

Lower Sunnyside Seam - overlying this seam is interbedded sandstone, siltstone, shale and coal riders of the Sunnyside Member of the Blackhawk.

It should be noted however, that the immediate "roof" over each seam is a sandstone unit, over which is found the silts, shales, and various coal riders.

**Pyritic Content (Laboratory Analyses)**

Complete analyses of these strata are included in Appendix E.

**Potential Alkalinity (Laboratory Analyses)**

Complete analyses of these strata are included in Appendix E.

**Stratum Immediately Underlying Each Coal Seam to be Mined**

**Lithology (See Figure III-2)**

Aberdeen (Castlegate "A" Seam) - underlying this seam is basal sandstone of littoral marine sandstone, the Aberdeen Sandstone of the Aberdeen Member.

Gilson Seam - underlying this seam is interbedded sandstone, siltstone, shale, and coal riders of the Kenilworth Member.

Centennial Seam - underlying this seam is interbedded sandstone, siltstone, and shale, and coal riders of the Kenilworth Member.

Lower Sunnyside Seam - underlying this seam is barrier beach sandstone, the Lower Sunnyside Sandstone of the Sunnyside Member.

It should be noted however, that the immediate "floor" below the seams is sandstone in the case of the Lower Sunnyside and Aberdeen; and beneath the Gilson, and Centennial, siltstone.

**Pyritic Content (Laboratory Analyses)**

Complete analyses of these strata are included in Appendix E.

**Potential Alkalinity (Laboratory Analyses)**
Complete analyses of these strata are included in Appendix E.

Clay Content (Laboratory Analyses)

Complete analyses of these strata are included in Appendix E.

R645-301-611.200. PROPOSED OPERATIONS
See R645-301-551. and R645-301-529.100.

R645-301-612. CROSS SECTION, MAPS AND PLANS
See R645-301-510.

R645-301-620. ENVIRONMENTAL DESCRIPTION
See R645-301-510.

R645-301-621. GENERAL REQUIREMENTS
See R645-301-510.

R645-301-622. CROSS SECTIONS, MAPS AND PLANS
Plates 21, 22, 23 & 24

R645-301-662.100. TEST BORINGS AND CORE SAMPLINGS
Appendix E

R645-301-622.200. COAL SEAMS AND BURDEN
Appendix E

R645-301-622.300. COAL OUTCROPS
Plates 26, 27, 28, 29.

R645-301-622.400. GAS AND OIL WELLS
N/A

R645-301-623. GEOLOGIC INFORMATION
See R645-301-611.100.

R645-301-623.100. POTENTIALLY ACID OR TOXIC FORMING STRATA
Appendix E
R645-301-623.200. RECLAMATION REQUIREMENTS
See R645-301-240.

R645-301-623.300. SUBSIDENCE CONTROL PLAN
See R645-301-525.

R645-301-624. GEOLOGIC INFORMATION
See R645-301-611.100.

R645-301-624.100. DESCRIPTION
See R645-301-611.100.

R645-301-624.110. CROSS SECTIONS, MAPS AND PLANS
See R645-301-510.

R645-301-624.120. OTHER INFORMATION

Alternative Water Supply Information

The underground coal mining activities will not result in any contamination, diminution, or interruption of any underground or surface water sources within the proposed mine plan or adjacent areas for domestic agricultural industry or any other legitimate use as the underground mining activities will not encounter any aquifers and there are no springs to interrupt.

There have been no changes in Andalex Resources' water rights. The wells, however, could be left open if a need other than Andalex's arose, with the permission of the State Engineer. Other water rights controlled by Andalex could be dedicated to a water right proven to be affected by Andalex's activities. Andalex controls 19 shares of primary water which could be used to supplement any interrupted water rights. There are no oil and gas wells in the vicinity of Andalex's permit area. There are no water wells in the area except on Andalex's surface facility, these are shown on figure 5 Appendix L, also in Appendix L tables 1 and 5 depict current existing water rights.

R645-301-624.130. GEOLOGIC LITERATURE AND PRACTICES
See R645-301-611.100.

R645-301-624.200. SAMPLING AND ANALYSIS
Appendix E

6-16
The Andalex mine property rarely encounters clays or clay-like rock in either the immediate roof or floor. The only clays encountered to date have been in the Aberdeen Seam where upon contact with water, the floor material became soft. The clay material in the floor has been local and temporary. To date, there has been no clay or clay-like material in the immediate roof of any of the coal seams.
R645-301-627. OVERBURDEN
N/A

R645-301-630. OPERATION PLAN
See R645-301-511.100.

R645-301-631. CASING AND SEALING OF EXPLORATION HOLES AND BOREHOLES
See R645-301-551.

R645-301-631.100. TEMPORARY CASING AND SEALING OF DRILLED HOLES
N/A

R645-301-631.200. PERMANENT CASING AND SEALING OF EXPLORATION HOLES AND BOREHOLES
See R645-301-551.

R645-301-632. SUBSIDENCE MONITORING
See R645-301-525.

R645-301-632.100. DEGREE OF SUBSIDENCE
See R645-301-525.

R645-301-632.200. MONITORING LOCATIONS
See R645-301-525.

R645-301-640. PERFORMANCE STANDARDS
See R645-301-551 and R645-301-529.100.

R645-301-641. ALL EXPLORATION HOLES AND BOREHOLES
See R645-301-551 and R645-301-529.100.

R645-301-642. MONUMENTS AND SURFACE MARKERS
See R645-301-525.170
Stratigraphic Sections

Figure III-1
CENTENNIAL PROJECT
DEADMAN CANYON

CASTLE GATE SANDSTONE

APEX MINE
LOWER SUNNYSIDE COAL SEAM
4' - 5'
LOWER SUNNYSIDE SANDSTONE

PINNACLE MINE
CENTENNIAL COAL SEAM
4' - 7'

PINNACLE MINE
GILSON COAL SEAM
4' - 9'

KENILWORTH SANDSTONE

ABERDEEN MINE
ABERDEEN COAL SEAM
4' - 13'
ABERDEEN SANDSTONE

MANCOS SHALE 3,000 FT

GENERALIZED SECTION, BLACKHAWK FORMATION
NOT TO SCALE

ANDALEX
RESOURCES, INC.
Tower Division
GENERALIZED SECTION