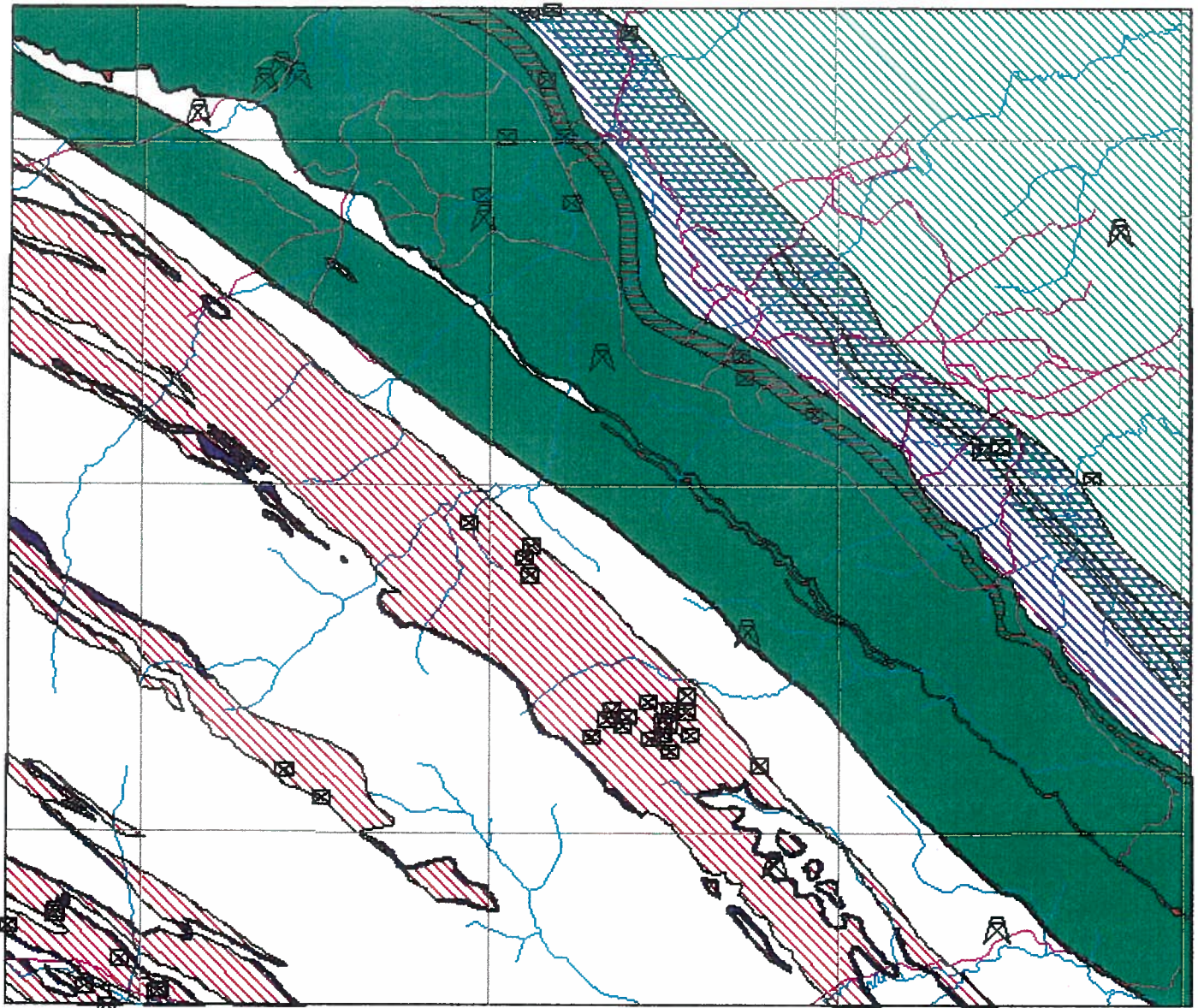


# ALBERTA GEOLOGICAL SURVEY - COAL GEOLOGY

## COAL COMPILATION PROJECT - MOBERLY CREEK

NTS 83E/9

R. J. H. Richardson, C. W. Langenberg, D. K. Chao and D. Fietz



Coal Compilation Project  
Open File Report: 1990-3  
Coal Geology Section  
Alberta Geological Survey

**ALBERTA  
RESEARCH  
COUNCIL**

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## **Foreword**

The prime objective of the pilot Coal Compilation Project (CCP) is to provide coal resource maps to stimulate and support industry exploration programs, and assist government in matters of resource management. An essential feature of the program is the use of cost effective Geoscience Information System (GSIS) technology that allows the database and various thematic maps to be analyzed, updated, and displayed with complete flexibility at any scale.

Each map set is intended to be a stand alone, unique product contributing to an overall synthesis of information. Maps generated will be at a regional or reconnaissance level. Collection of new data was limited. Data compiled and evaluated will be based on the following principal sources; Alberta Research Council/Alberta Geological Survey (ARC/AGS); Energy Resources Conservation Board (ERCB); Geological Survey of Canada (GSC/ISPG); and information from the coal industry sector. Industry cooperation and support is shown in the making available of unpublished corporate reports to the AGS. The availability of these reports is an essential ingredient for the success of this project.

The CCP will encompass some eighteen 1: 50 000 scale mapsheets to be completed over a three year period.

Custom maps and database searches can be obtained by contacting the Coal Geology Section, Alberta Geological Survey, Alberta Research Council. Raw coal exploration data<sup>1</sup> that are in the 'public' domain can, for a nominal fee, be viewed in microfiche form at the Records Center of the Energy Resources Conservation Board in Calgary, Alberta. Arrangements can also be made to acquire copies of all/selected data.

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<sup>1</sup>specifically, the geophysical logs (and other associated data) of coal exploration drillholes and, as available, analytical data relating to coal quality.

### **Acknowledgments**

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## **Executive Summary**

The study area of mapsheet NTS 83E/9 (Moberly Creek) is located in west-central Alberta. The communities of Hinton (83F/5) and Grande Cache (83E/14) are the primary population centers near the study area. Much of the Regional mapsheet 83E/9 is located within the proposed Yellowhead North IRP. Willmore Wilderness Provincial Park, in part, located in the southwest half of the mapsheet, is located outside of the Yellowhead North IRP.

Within the mapsheet 83E/9, coal measures are deposited amid thick successions of sandstones, siltstones, shales and conglomerates. These coal-bearing sequences are part of the Lower Cretaceous Luscar Group, Upper Cretaceous Brazeau Formation and Paleocene Coalspur Formations.

The Luscar Group consists of sandstones, shales, conglomerates and coals, deposited predominantly in nonmarine environments. Strata of the Lower Cretaceous Luscar Group have been subjected to deformation which has produced northwesterly trending thrust faults and folds. As a result, the Luscar Group coal seams are now exposed in a series of northwest trending thrust sheets and associated folds. Often the coal seams have been further locally folded and faulted. Depending on the severity of these local structural complexities, and acknowledging a general discontinuity of coal outcrops in the Inner Foothills, coal seam correlations and evaluations can be extremely difficult. Several seams have been identified within the mapsheet. No correlations could be established for the Luscar Group coal seams. Individual seam thicknesses vary to a maximum of 10 meters.

The Upper Cretaceous Brazeau Formation and the Paleocene Coalspur Formation are located in a gentle monocline that trends in a northwesterly strike direction. Strata dip to the northeast, generally between 5 and 20 degrees. No other major structures were noted from the available outcrop or drillhole data.

The Brazeau Formation consists of nonmarine sandstones, conglomerates, shales and coals and lies conformably above the marine Wapiabi Formation. The Brazeau Formation is overlain by the Entrance Conglomerate (or an equivalent sandstone). In the upper 200 meters of the Brazeau Formation, coal seams have been identified. On the mapsheet, at least two Brazeau coal seams have been intersected in a limited number of drillholes.

The Coalspur Formation consists of nonmarine sandstones, siltstones, shales and coals and overlies the Entrance Conglomerate (or an equivalent sandstone). Within the mapsheet, as many as 12 coal seams have been identified within the Coalspur Formation. The seams have an average aggregate thickness of 17.5 meters and are contained within a 250+ meter-thick sedimentary sequence. It should be noted that some of the 'traditional' Coalspur coal zones (ie, Silkstone and Mynheer) have not been recognized within the mapsheet area. It is believed there is a stratigraphic interval of 400-450 meters from Seam 1 to the underlying Entrance Conglomerate.

A promising area for future work is the coal zone trend to the north of the Jarvis Lake Coal Field. Additional subsurface geological studies, including the construction of regional cross-sections and seam correlations, are needed in the eastern and northeastern regions of the map area. Structural geology studies are critical for an evaluation of the central and western areas.



## **Introduction**

### **Objective**

The objective of the pilot Coal Compilation Project (CCP) is to provide coal resource maps on a 1: 50 000 scale, which will

- o stimulate and support industry exploration programs, and
- o assist government in matters of resource management (eg, Integrated Resource Plans) in areas that may have good coal development potential, but have a lack of data or understanding.

Each map set is intended to be a stand alone, unique product contributing to an overall synthesis of information. Maps generated will be at a regional or reconnaissance level. Collection of new data and/or actual time in the field will be limited. Data compilation and evaluation will be based on the following principal sources

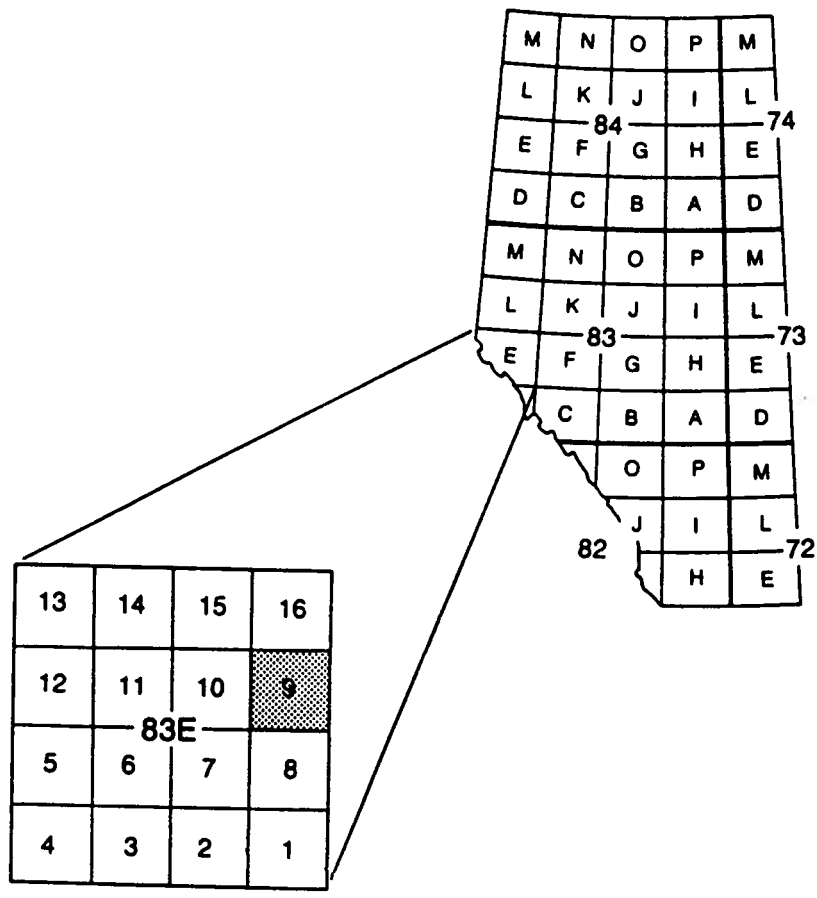
- o Alberta Research Council/Alberta Geological Survey (ARC/AGS)
- o Energy Resources Conservation Board (ERCB)
- o Geological Survey of Canada (GSC/ISPG)
- o cooperation from the coal industry sector.

The CCP will encompass some eighteen 1: 50 000 scale mapsheets to be completed over a three year period.

When completed, the CCP can be evaluated to determine if the project should be expanded province wide. As each map represents a complete product, the technical committee could monitor the progress of the research and react to changing priorities without being committed to spending funds more than one year in advance.

The fiscal year, 1989-90, was the first year of the CCP. The CCP focussed on the Hinton - Grande Cache Corridor and included four contiguous NTS mapsheets (see Figure 1). From

**Figure 1. Coal Compilation - Moberly Creek NTS 83E/9: Location**



southeast to northwest, they are 83F/5 (Entrance), **83E/9 (Moberly Creek)**, 83E/15 (Pierre Greys Lakes) and 83E/14 (Grande Cache).

For each mapsheet, a product has been generated that includes

- o a coal resource map (scale 1: 50 000)
- o 'snapshot' maps (scale 1: 250 000)
- o supplementary text.

### **Methodology and Discussion of GIS**

Geographic Information Systems (GIS) which encompass spacial data storage, display and analysis by computer have been employed in the municipal, environmental and forestry sectors for many years. The term GIS has been applied to mainly surface or geographic studies and has not as a rule been extended to the 3rd dimension (depth) or temporal aspects (time). A Geoscience Information System (GSIS) goes beyond what is generally thought of as traditional GIS and is focused strongly on subsurface information. An essential feature of the Coal Compilation Project is the use of cost effective Geoscience Information System (GSIS) technology that allows the database and various thematic maps to be analyzed, updated, and displayed with complete flexibility at any scale. In addition custom maps can be produced from the various data and graphic elements that have been entered into the information system.

Much of the present methodology, software and hardware used in this study is described in detail in Alberta Research Council, Open File report 1989-03A (Richardson et al., 1989). In general both digital and hard copy data or graphic elements are entered into a GIS software product (pcARC/INFO) where they can be analyzed, displayed or plotted to hardcopy.

During this first year of the CCP, substantial time was spent in

- o developing the hardcopy, product template, and
- o replicating the above template into the electronic medium of GIS.

### **Location and Access**

The study area of mapsheet NTS 83E/9 (Moberly Creek) is located in west-central Alberta between Latitudes 53° 30' and 53° 45' North, and Longitudes 118° 00' and 118° 30' West (West of the 6th Meridian, between Townships 52 and 55 inclusive, and Ranges 1 to 4 inclusive).

The communities of Hinton (83F/5) and Grande Cache (83E/14) are the primary population centers near the study area.

Paved access to and within the area is provided by Highways No. 16 and 40 . Numerous all-weather, gravelled wellsite and logging roads also exist. Additional secondary seasonal access is provided by a network of roads, trails and seismic lines.

The area is serviced by the Canadian National Railway and the Alberta Resources Railway; the rail lines have the capacity to accomodate coal unit trains. Coal could be shipped to:

- o Ridley Island at Prince Rupert, B.C. located
  - o 1170 rail-kilometres from Hinton
  - o 1310 rail-kilometres from Grande Cache
- o Neptune Terminals at Vancouver, B.C. located
  - o 1010 rail-kilometres from Hinton
  - o 1150 rail-kilometres from Grande Cache.

### **Geological Setting**

Within the mapsheet 83E/9, coal measures are deposited amid thick successions of sandstones, siltstones, shales and conglomerates. These coal-bearing sequences are part of the

- o Lower Cretaceous Luscar Group
- o Upper Cretaceous Brazeau Formation
- o Paleocene Coalspur Formation.

Stratigraphic nomenclature for the above strata is shown in Figure 2.

### Stratigraphy of Coal-Bearing Units

#### Luscar Group

The Luscar Group consists of sandstones, shales, conglomerates and coals, deposited predominantly in nonmarine environments. The strata of the Group have been divided into four formations (Langenberg and McMechan, 1985), ie:

- o Cadomin Formation, a basal conglomerate
- o Gladstone Formation, predominantly nonmarine sandstones and shales
- o Moosebar Formation, marine shales and sandstones
- o Gates Formation, nonmarine sandstones, shales and coals.

#### Gates Formation

The Gates Formation can be divided into three members - the Torrens, Grande Cache and Mountain Park members. The Grande Cache Member contains the economic coal seams within the Luscar Group.

Several seams have been identified within the mapsheet. No correlations could be established for the Luscar Group coal seams. Individual seam thicknesses vary to a maximum of 10 meters.

#### Brazeau Formation

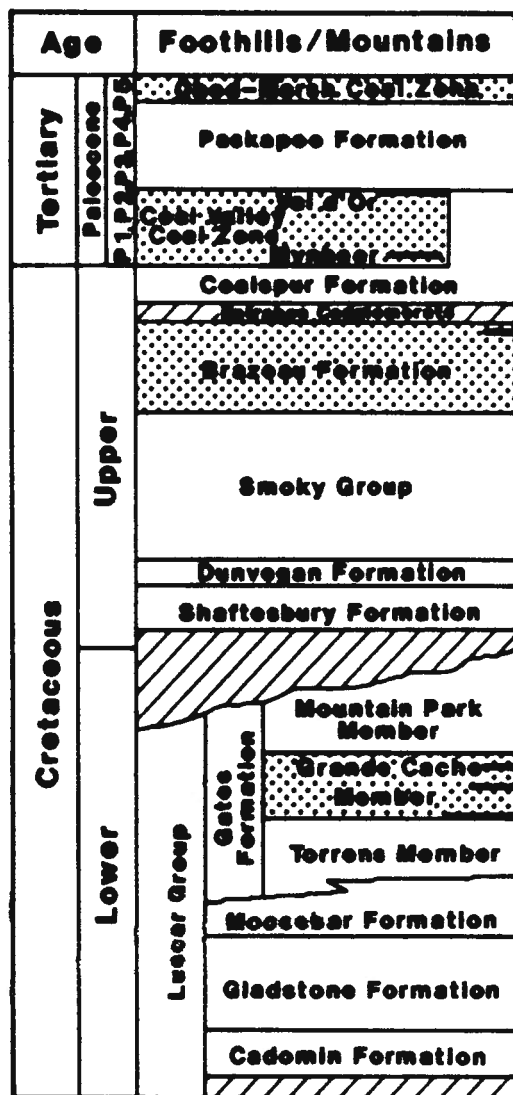
The Brazeau Formation consists of nonmarine sandstones, conglomerates, shales and coals and lies conformably above the marine Wapiabi Formation. Further, the Brazeau Formation is underlain by the Entrance Conglomerate (or an equivalent sandstone).

In the upper 200 meters of the Brazeau Formation, coal seams have been identified. On the mapsheet, at least two Brazeau coal seams have been intersected in a limited number of drillholes. In stratigraphically descending order, the following seams have been noted:




<u>SEAM</u>	<u>DESIGN</u>	<u>TH (m)</u>	<u>INTERBURDEN (m)</u>	<u>REMARKS</u>
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0.9

**Figure 2. Stratigraphic Nomenclature Adopted for the Coal Compilation Program (after McDonald et al., 1989)**



**LEGEND**

-  Coal-bearing unit
-  Major seams
-  Hiatus or missing interval

Coal Valley Coal Zone	
Val d'Or	—
Arbour	—
McLeod	—
McPherson	—
Silkstone	—
Mynheer	—

0.6

**Coalspur Formation**

The Coalspur Formation consists of nonmarine sandstones, siltstones, shales and coals and overlies the Entrance Conglomerate (or an equivalent sandstone).

Within the mapsheet, as many as 12 coal seams have been identified within the Coalspur Formation. The seams have an average aggregate thickness of 17.5 meters and are contained within a 250+ meter-thick sedimentary sequence. Seam designations, originated at the industry level, have been modified and incorporated into this compilation. In stratigraphically descending order, the following seams have been noted:

<u>SEAM DESGNTN</u>	<u>AVE COAL TH (m)</u>	<u>AVE INTERBURDEN (m)</u>	<u>REMARKS</u>
7	0.7		
		30	
6	1.5		
		13	
5	1.3		
		84	
4	3.5		?...Val d'Or equivalent
		31	
3D	0.8		
		1	
3C	1.5		
		2	
3B	2.8		
		17	
3A	1.5		?...Arbour equivalent
		11	
MCLD	0.7		?...McLeod equivalent
		9	
2	1.0		?...McPherson equiv.
		20	
1	1.5		?...McPherson equiv.
		2	

1L

0.7

?...McPherson equiv.

It should be noted that some of the 'traditional' Coalspur coal zones (ie, Silkstone and Mynheer) have not been recognized within the mapsheet area. A detailed stratigraphic study is required to prove the merits of the above noted seam equivalencies. These seam correlations are preliminary.

It is believed that there is a stratigraphic interval of 400-450 meters from Seam 1 to the underlying Entrance Conglomerate.

### **Structure**

Strata of the Lower Cretaceous Luscar Group have been subjected to deformation which has produced northwesterly trending thrust faults and folds. As a result, the Luscar Group coal seams are now exposed in a series of northwest trending thrust sheets. Often the coal seams have been further locally folded and faulted. Depending on the severity of these local structural complexities, and acknowledging a general discontinuity of coal outcrops in the Inner Foothills, coal seam correlations and evaluations can be extremely difficult.

The Upper Cretaceous Brazeau Formation and the Paleocene Coalspur Formation are located in a gentle monocline that trends in a northwesterly strike direction. Strata dip to the northeast, generally between 5 and 20 degrees. No other major structures were noted from the available outcrop or drillhole data.

### **Environmental Setting**

#### **Integrated Resource Plans (IRP's)**

Much of the Regional mapsheet 83E/9 is located within the proposed Yellowhead North IRP. Willmore Wilderness Provincial Park, in part, located in the southwest half of the mapsheet, is located outside of the Yellowhead North IRP. A separate IRP, for the Willmore Wilderness Provincial Park area, may be undertaken at some time in the future.

In the May, 1989 edition of Planning in Progress (Volume 6, Number 2), the status of the Yellowhead North IRP was capsuled in the following statement...

'Initiation of this plan has been deferred. (Resource Planner: Tom Cottrell).'



There is no mention of the Yellowhead North IRP in the January, 1990 edition of Planning in Progress (Volume 7, Number 1).

See also Figure 3 for locations/outlines of IRP's in the surrounding vicinity.

## **Resource Management**

### **Coal Dispositions**

The status of the rights\_to\_coal within an area can generally be categorized into one of the following

- o Crown coal lease
- o Crown coal lease under application
- o Areas with registered right of first refusal
- o Freehold coal rights
- o Coal withdrawn from disposition.

According to a recent (1989-05-19) Alberta Energy Coal Disposition Map of 83E/9, the following 2 companies are involved in one or more of the above activities

- o Dencoke Coal Limited
- o Seaton-Jordan & Associates Ltd.

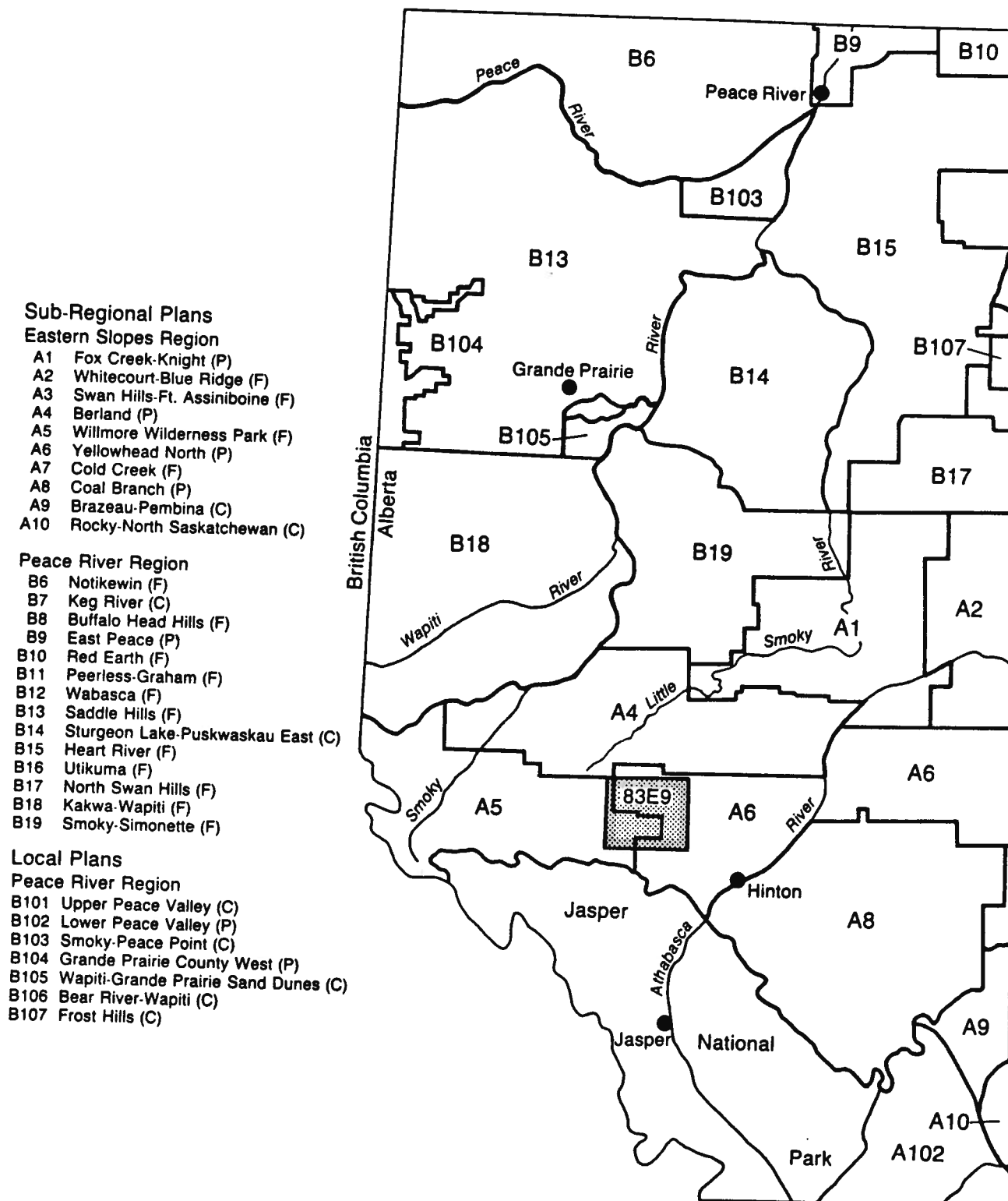
It should be noted that most of the corporate coal lease activity is concentrated on the first three categories.

### **Established Coal Resources and Reserves**

Coal resources and reserves have been calculated by the ERCB (1989) for the whole of Alberta.

The present mapsheet contains the following coal fields:

**Figure 3. Locations/Outlines of IRP's in the Surrounding Vicinity**



- o Jarvis Lake (Foothills Region)
- o Moberly Lake (Mountain Region).

The Coal Field outlines are shown on the GIS plot.

### **Exploration History**

#### **Coal**

##### **Coal Adits**

During 1969-70, McIntyre Mines Limited drove 7 adits on 6 sites in the Little Berland Area (Township 53, Range 2, W6<sup>th</sup> Meridian). Adit drivage totalled 329 metres.

The adit locations are shown on the GIS plot; it should be noted that these sites fall within the current boundaries of the Willmore Wilderness Park.

##### **Coal Exploration Drillholes**

Some 84 coal exploration holes have been drilled by 4 companies between 1970 and 1983. Of the holes drilled, 54 holes (64%) intersected coal as per the defined criteria (see Hughes et al., 1988); it follows that 30 holes (36%) did not intersect coal. Hole depths ranged from 14 to 451 meters in depth.

Coal exploration drilling activities were carried out by a number of companies. A summary follows

<b><u>COMPANY</u></b>	<b><u>NUMBER OF HOLES DRILLED</u></b>
Manalta Coal Limited	32
McIntyre Mines Limited	14
Shell Canada Resources Limited	6
Union Oil Company of Canada Limited	32

Based on the April, 1989 version of the ERCB Coal Hole File, details of the coal exploration drillholes are given in Appendix 1 and includes information on:

- o SITID; the assigned Site Identification Number within the AGS Coal Database
- o CAT\_ID; the assigned Catalogue Identification Number within the ERCB Coal Hole File (April, 1989 version)
- o ORIG; the Original Identification Number of the Datapoint (ie, drillhole number)
- o EDITED; within the ERCB Coal Hole File, the equivalent to ORIG has been limited to 6 spaces; this, in some cases, has not been sufficient to record the ORIGINAL corporate assigned drillhole number; within the AGS Coal Database, ORIG has been allocated 11 spaces; a 'X' in the EDITED column identifies those drillholes whose ORIG's were truncated; drillholes listed in the ORIG column of the listing have been edited and now reflect the 'true' Original Identification Numbers.
- o NCinDH; a 'NC' in the column indicates that no coal thicker than 0.5m was intersected in the drillhole; this implies that thin coal seams less than 0.5m may be present.
- o M; Meridian
- o T; Township
- o R; Range
- o S; Section
- o RSEC; Reference Section
- o RCNR; Reference Corner
- o METN; Metres north or south from the reference corner
- o METE; metres east or west from the reference corner
- o ELEV; Ground or surface elevation of the datapoint (drillhole)

- o TD; Total depth of drillhole reported in metres
- o CORPNUM; the assigned Corporation Number within the AGS Coal Database
- o CPDT; completion date of the datapoint (drillhole); date coded as yymmdd
- o COMPANY; identifies the company that generated the datapoint (drillhole).

### **Oil and Gas Wells**

Within the study area, 10 oil and gas wells have been drilled. Of the wells drilled,

- o 9 have been abandoned
- o 1 is a capped gaswell.

See Appendix 2 for additional data. The Appendix is based on queries from the ERCB oil and gas database (April, 1989 version).

### **Coal Occurrences**

#### **Coal Adits**

Seven coal adits were driven within the mapsheet 83E/9. Adit locations have been identified on the GIS plot.

Thicknesses of the coal seams within the adits range from 2.8 to 6.7m.

#### **Coal Exploration Drillholes**

On both Appendix 1 and the map, coal exploration drillholes have been identified as either

- o coal thicker than 0.5m intersected in the drillhole
- o or
- o no coal thicker than 0.5m intersected in the drillhole.

Coal is defined as greater than 50% carbonaceous material by weight and more than 70% carbonaceous material by volume as estimated from geophysical logs. The exclusion of coal seams thinner than 0.5m is consistent with Hughes et al. (1988), who exclude seams thinner than 0.5m in resource determination.

Coal intersections, per coal exploration drillhole, have been included in Appendix 3. The listing includes

- o SITID; the AGS Coal Database identification number
- o CAT\_ID; the ERCB catalogue identification number
- o ORIG; the original company-assigned drillhole number
- o M T R S ; Dominion Land Survey (DLS) information; ie, Meridian, Township, Range and Section
- o TOP DEPTH; depth to top of coal in meters
- o BOT DEPTH; depth to bottom of coal in meters
- o THICK; thickness of the coal seam in meters
- o SEAM; Correlated Coal Seam Name/Number (if known); a '0' indicates that the seam has not been correlated
- o MIN; Mineral Matter content of the coal (often a best-estimate from geophysical log interpretation); a '0' indicates that the mineral matter of the coal was not available and/or not derived.
- o REGOLITH; thickness, in meters, of the regolith
- o PIKNUM; the geological pick identification number as stored in the AGS Coal Database
- o REMARKS.

**Coal Outcrops**

Some forty two coal outcrops have been identified within the mapsheet 83E/9. Coal seam outcrop locations have been identified on the GIS plot. The maximum thickness of coal in outcrop is 10 meters.

### **Coal Quality Summary**

#### **Coal Rank**

Within the Regional mapsheet 83E/9, the rank of the coal varies from

- o high volatile bituminous C in the Paleocene Coalspur Formation to
- o low volatile bituminous in the Lower Cretaceous Luscar Group.

Although coal of the Upper Cretaceous Brazeau Formation is known to be deposited within the mapsheet area, coal quality information was not available. The rank of said coal would likely be high volatile bituminous C.

#### **Coal Adits**

Seven adits, within the mapsheet 83E/9, have been sampled. Coal quality data generated from the samples include

- o 12 complete Proximate Analyses from 7 adits
- o 12 analyses of Sulphur from 7 adits
- o 12 analyses of Heating Value (air-dried basis) from 7 adits
- o 12 analyses of FSI (based on Size and Specific Gravity) from 7 adits
- o 10 analyses of Size Analysis (with determinations of Sulphur, Heating Value and Moisture) from 6 adits
- o 10 analyses of 'Weight % and Ash Distribution vs Size and Specific Gravity' from 6 adits

- o 10 analyses of 'Weight % and Volatile Matter Distribution vs Size and Specific Gravity' from 6 adits
- o 10 analyses 'Washability Data of Size Fractions' from 6 adits.

#### **Coal Exploration Drillholes**

Twenty two drillholes, within the mapsheet 83E/9, contain coal quality information. Thirteen are in the Luscar Group and nine are in the Coalspur Formation. Coal quality data generated includes

- o 204 complete Proximate Analyses from 21 drillholes
- o 113 analyses of Ash, Volatile Matter and Fixed Carbon from 11 drillholes
- o 179 analyses of Sulphur from 14 drillholes
- o 204 analyses of Heating Value (air-dried basis) from 21 drillholes
- o 113 analyses of Heating Value (dry basis) from 11 drillholes
- o 174 analyses of FSI from 13 drillholes.

Weighted averages of proximate analyses for the Luscar Group coals (raw) have been generated for thirteen of the drillholes. Results are presented in Appendix 4. The weighted average Volatile Matter (daf) values for the thirteen drillholes are presented on the GIS plot.

Because only moisture and ash values are available, no weighted averages of proximate analyses have been generated for the Paleocene Coalspur Formation coals.

#### **Coal Outcrops**

Twenty six outcrops, within the mapsheet 83E/9, have been sampled. Coal quality data generated from the samples include

- o 22 analyses of vitrinite reflectance from 16 outcrops; samples have been collected by the ARC/AGS and the GSC/ISPG between 1981 and 1989; reflectance values of the samples range between 0.78 and 1.87%.
- o 9 analyses of palynology from 9 outcrops; information is limited to location only.



### **Operating and Abandoned Coal Mines**

There are no operating or abandoned coal mines within the Regional mapsheet 83E/9.

### **Coal Resource Development Potential**

A semiquantitative and subjective evaluation of the potential of coal development in the map area is based on limited data. It is based on mainly geological criteria and does not take into account governmental restrictions on coal development or evaluate actual economic constraints to development now or in the future. The three criteria that have been used are Coal Potential, Mining Potential, and Data Availability (discussed in more detail below). Areas in Green on the companion map (thematic inset 'Coal Development Potential') reflect higher level of knowledge and potential for development of coal than the blue (medium) or red areas (low). Areas rated in blue indicate more information is needed to determine the coal development potential. Areas colored red indicate some potential for development. The remaining uncolored areas have no data available often because the coal, if present, is at depth under non coal-bearing rocks.

#### **Coal Potential**

##### **Resources**

The amount of data is too small for a quantitative evaluation of coal resources except in those limited areas with drilling. The ERCB (1989) provides estimates of in-place resources for the Moberly Creek and Jarvis Lake Coal Fields.

##### **Coal Quality**

Very little coal quality data is available but where test results are present the potential of the coal for development is strengthened. In general where a sample has been collected and analyzed the coal has an inherent development potential.

#### **Mining Potential**

##### **Overburden**

An evaluation of overburden for surface mining and depth for underground mining has been made. (The 'Mining Potential' criteria did not take into account governmental restrictions on coal development or evaluate actual economic constraints to development now or in the future.)

### **Geotechnical**

Geotechnical considerations included an evaluation of structural setting both simple and complex with the possibility of structurally thickened seams. Consideration was given to infrastructural concerns related to site, environment and potential mining problems.

### **Data Availability**

Very little coal data is available in the map area but where present the potential of the coal for development is strengthened. In general where a sample, drill hole, adit or outcrop is present the coal has an increased development potential. Some value was given to areas containing sediments that typically include coal.

### **Future Work**

In general, from a coal resource/exploration point of view, the map area has been superficially examined. Additional coal quality data needs to be collected. Only two areas, the ERCB's Moberly Creek and Jarvis Lake Coal Fields have a good exploration database. North and south of the Moberly Creek Coal Field (and outside of Willmore Wilderness Park) little data is available and the coal development potential is uncertain. The Moberly Creek Coal Field, located inside the Park, needs additional study to provide information on adjacent areas since it now contains the best database on the local Luscar Coals. The Thoreau Creek area in the extreme SW portion of the map is geologically very important and appears to have good coal development. A promising area for future work is the coal zone trend located north of the Jarvis Lake Coal Field. Additional subsurface geological studies, including the construction of regional cross-sections and seam correlations, are needed in the eastern and northeastern regions of the map area. Structural geology studies are critical for an evaluation of the central and western areas.