Open File Report 1987 - 9

A Regional Evaluation of Coal Quality in the Southern and Central Foothills/ Mountains Region of Alberta

A REGIONAL EVALUATION OF COAL QUALITY IN THE SOUTHERN AND CENTRAL FOOTHILLS/MOUNTAINS REGION OF ALBERTA

Open FIle Report 1987-9

D.E. Macdonald
N. Chidambaram
C.W. Langenberg
G.B. Mandryk
C.E. Sterenberg
A. Cameron *

December 1987

Open File Report 1987-9
Alberta Research Council
Alberta Geological Survey

* Institute of Sedimentary and Petroleum Geology

TABLE OF CONTENTS

APPENDICES

FIGURES

TABLES

FOREWORD

The amount of publicly available knowledge regarding coal quality in the Foothills/Mountains regions of Alberta has been shown to be very low (Langenberg et al. 1986). The coal industry contributes coal quality data to the Energy Resources Conservation Board (ERCB) on a regular basis. All data received by the ERCB is entered in the digital ERCB coal database.

The ERCB produces mean values for coal quality parameters within designated mine permits. No regional synthesis of available coal quality and geology data thus far has been produced for the foothills/mountains coals. This report is intended to provide an initial appraisal of the present state of knowledge.

ACKNOWLEDGEMENTS

D. Nikols, R. Richardson, S. O'Connell and R. Strobl reviewed the manuscript and provided constructive comments. R. Marsh, ERCB also provided many helpful suggestions. D. Wynne assisted with the decoding of the ERCB coal data. Coal quality determinations on samples collected were performed at the Alberta Research Council's Devon coal facility by N. Truony, R. Estigoy, K. Nesbitt, C. Murray, and M. Carmichael, under the supervision of A. Iachelli. M. FitzGerald prepared the final manuscript and D. MaGee drafted the diagrams. M. Tomica provided assistance with vitrinite reflectance measurements.

The Alberta Office of Coal Research and Technology (AOCRT) and the Alberta Research Council (ARC) provided joint funding for this project. The Energy Resources Conservation Board (ERCB) provided coal quality data in digital and microfiche formats. Chinook Coals Ltd. provided access to properties and information from the Crowsnest Pass region. P. McCabe (U.S. Geological Survey) is thanked for his assistance in initially formulating the project.

SUMMARY

The raw coal quality variations within the Lower Cretaceous Luscar and Jurassic - Cretaceous Kootenay Groups are documented by using several approaches. Techniques include classical descriptive and exploratory statistics, weighted means of coal quality parameters plotted on regional geological maps, and detailed in-seam vertical chemical profiles of coals. A geological understanding of these coal quality variations is gained by relating some parameters (e.g. ash, sulfur) to the original depositional environment, and others to depth of burial and/or structural deformation (volatile matter, fixed carbon, carbon). Some coal quality parameters can be related to both depositional environment and later burial/deformation history (ash, sulfur and calorific value).

Data were obtained from the ERCB coal hole database and consist of some 333 coal quality analyses from approximately 77 coal exploration holes. Coal quality parameters available include; ash, fixed carbon (FC), volatile matter (VM), moisture, sulfur (S) and calorific value (CV). Very few ultimate analyses, carbonization parameters, or detailed coal combustion properties are available for study. Many of the variables examined, within this study area, are normally distributed. Mean values for foothills/mountains coals in the central and southern Rockies are as follows (most on a dry basis): ash - 25.90%, FC - 51.49%, VM-22.61, CV - 25582.08 Kj/kg, and S - 0.56%. Volatile matter, calorific value and sulfur are the only variables that show a significant statistical difference between the Luscar and Kootenay Groups, with the presently available dataset.

Because the data is clustered within three or four small geographic areas within the region and because the exact stratigraphic horizon of the data is not known, interpretation of coal quality trends from the regional maps should only be done with extreme care. For example, fixed carbon and volatile matter show a systematic increase in rank to the north.

Measured stratigraphic sections of the Kootenay Group together with coal seams sampled in the Crowsnest Pass area, suggest that mean in-seam values of carbon (C), FC and VM might be used to assist in coal seam correlation in local areas. In-seam coal quality profiles show varying, patterns. Higher sulfur values at the top and base of the seam are thought to be related to the early diagenetic environment and generally not to the influences of possible overlying marine strata. Ash is both directly and inversely related to sulfur content at some locations. Ash increases with a higher degree of tectonic shearing at the center of some coal seams, while carbon values are reduced. Three distinct depositional environment and related coal quality facies can be recognized in the Crowsnest Pass area: 1) mid-coastal plain-mire facies that tend to have overall poor coal quality parameters, 2) distal fluvial/lacustrine-mire facies that has produced very thick, and high quality economic coals, and 3) a proximal fluvial-mire facies that often produces thick seams with very high ash contents.

Coal rank variations, depth of burial and structural influences on rank were explored by examining data from the ERCB database, existing published vitrinite reflectance measurements and by collecting additional samples (for vitrinite reflectance) in regions where data were missing. Volatile matter values, plotted for the base of the Kootenay Group, show a gradation from high-volatile bituminous "A"coals in the area south of Crowsnest Pass to semi-anthracite in the Canmore area. The increase in coalification from south to north must be explained in terms of depths of burial, geothermal gradients, and possible additional loading by thick thrust sheets. The inferred depth of burial for coals at the base of the Kootenay Group varies from 5 km in eastern regions to about 7 km in the west. Local tectonism causes shearing of the coal which in turn makes it more susceptible to oxidation, and at times, causes increased ash contents. Rank does not seem to be enhanced by proximity to major thrust faults. Structural thickening of coals occurs in anticline and syncline axes and through imbricate thrust sheets.

INTRODUCTION

OBJECTIVES

The objective of this project is to document and provide a geological understanding of the variation in coal quality parameters in the foothills/mountains regions of Alberta. It is known that the major aspects of coal quality are determined by original depositional environment, diagenesis, depth of burial, length of coalification, geothermal gradient and structural deformation. This study will document regional coal quality variations and attempt to explain the variations with respect to some of these controls.

The study is being undertaken in three phases. The first, phase is concentrated in the central and southern foothills/mountains region (Tp. 1 to 45) and resulted in the present report. The second phase will concentrate on the northern foothills/mountains (Tp. 46 to the British Columbia border), and will be reported on in 1988. The last phase will synthesize the foothills/mountains region into one unified coal quality study.

INCENTIVE

Alberta will continue to need to find new markets for both its metallurgical and thermal coals. The metallurgical market in particular has suffered considerably in the past 5 years. Potential customers often know as much (or more) about Alberta coal quality as the producer does. Well documented descriptions of coal quality variations should prove useful in marketing and contract negotiations for foothills/mountains coals.

A comprehensive review of available coal quality information in the foothills/mountains region will be valuable for government planners involved in making land use decisions. The information could be of particular use in the Integrated Resource Planning projects, undertaken by Alberta Forestry, Lands and Wildlife. The Energy Resources

Conservation Board may find it useful in its coal resource estimation capacity.

And lastly,..."any scientific hypothesis, however absurd, may be useful in science, if it enables a discoverer to conceive things in a new way; but that, when it has served this purpose by luck, it is likely to become an obstacle to further advance" (Bertrand Russell, 1985). A better understanding of the geological factors that control coal quality and resulting models will prove to be of benefit to the industry in regional grass-roots exploration and minesite development.

SCOPE OF PRESENT STUDY

This phase of the study is focused, geographically, in the southern and central regions, bounded by the U.S. border in the south and by Tp 45 in the north (figure 1). Coal-bearing strata are found throughout the Foothills and Front Ranges of the Rocky Mountains. The two major coal bearing Groups, the Luscar and Kootenay, are the geological focus of the study (figure 2). The extent of data collection consisted of coal quality data from the ERCB, existing published works, and data collected in the 1987 field season. The type of coal quality parameters addressed were mainly those from proximate and ultimate analysis and calorific value.

The study was undertaken by a team of geologists, statisticians, computing specialists, coal chemists and technologists over a seven-month period. This multi-disciplinary approach allowed for a number of topics to be addressed over a very short time period.

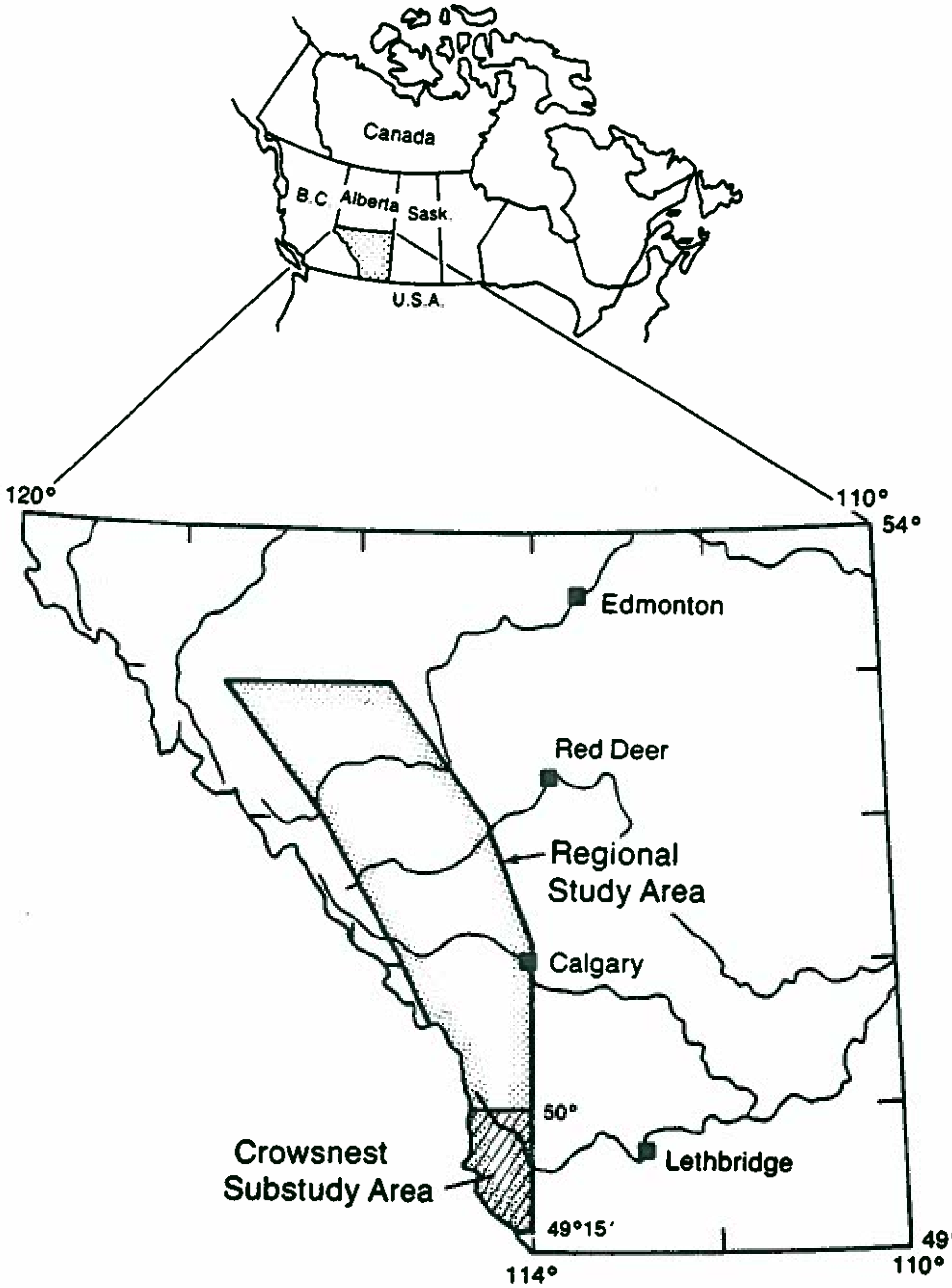


Figure 1. Coal quality variations in the south and central Rocky Mountains - Study areas.

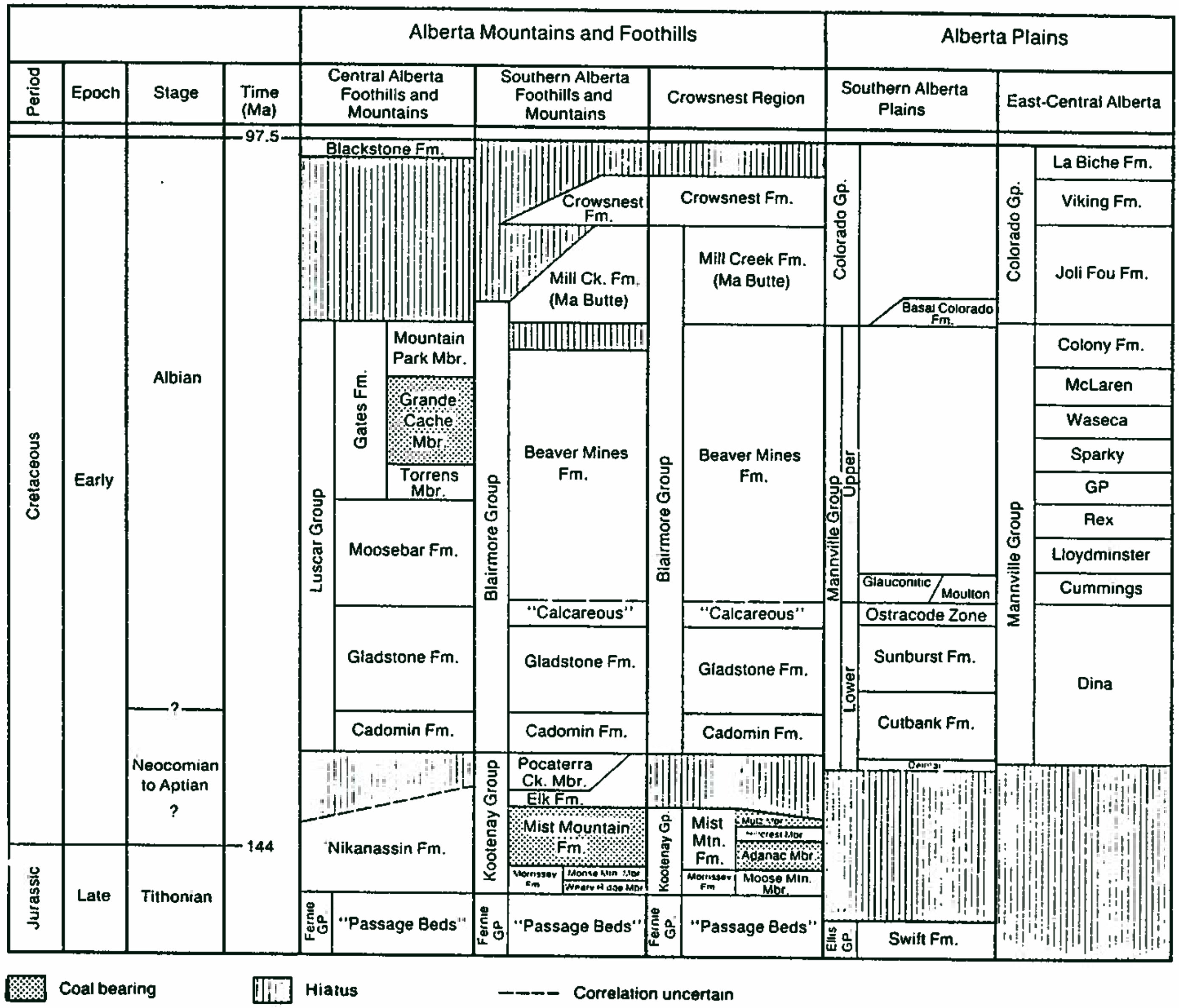


Figure 2. Stratigraphic nomenclature adopted - this study (modified from; ERCB, 1986).

PREVIOUS WORK

Regional coal quality variations in the foothills/mountains region have been addressed by Steiner et al. (1972) in a study dealing primarily with plains coals. Prior to this, the work by Stansfield and Lang (1944) was the most comprehensive. More recent workers have focused on coal rank variations, usually over small regions (Kalkreuth and Langenberg 1986; Kalkreuth and McMechan 1984; Hughes and Cameron 1985; and Bustin 1982).

To date then, little has been published about the regional calorific value, volatile matter, fixed carbon, sulfur, ash, moisture content, petrographic composition and trace element distribution within any of the foothills/mountains coal zones in Alberta, except at local minesites. Intraseam variations with respect to most coal quality parameters have not been documented, again except at minesites. To compound the coal quality problem, coal seam stratigraphic correlations are poorly understood throughout the region, except in local areas.

The most recent comprehensive lithostratigraphic study of the coal-bearing Kootenay Group is by Gibson (1985) and considers the stratigraphy, sedimentology and depositional environments of the Jurassic - Cretaceous Kootenay Group in Alberta and British Columbia. Hughes and Cameron (1985) provide a more detailed examination of the Kootenay Group in the Mt. Allan region.

Previous lithostratigraphic work on the coal-bearing Luscar Group is thoroughly covered in the historical review section of McLean (1982). More recently, Langenberg and McMechan (1985) proposed a new nomenclature scheme for the Luscar Group, and is adopted in this report.

DATA SOURCES AND PROCESSING

Sources

The coal quality data used in this study were collected from three sources. The main source of data is from the July 1987 version of Energy Resources Conservation Board (ERCB) coal hole digital data file. The ERCB coal quality information was used to document the variations in the ash, sulfur, volatile matter, fixed carbon, calorific value and moisture parameters. A limited number of ultimate analysis values are also available. This file contains approximately 333 analyses from 77 coal exploration holes in the southern and central Rockies.

The second source of quality data results from coal samples collected by the authors during the 1987 field season and analyzed at the Alberta Research Council's coal laboratory in Devon, and the GSC laboratory in Calgary. The data were used for two purposes: 1) channel samples were collected across individual seams to relate some coal quality parameters to depositional environments and, 2) grab samples were collected to show regional rank variations.

The third source of data came from existing published literature on coal quality, in particular vitrinite reflectance.

Processing

The ERCB provided the Alberta Geological Survey with a magnetic tape in mixed data format; an in-house computer program was written to reformat the data into a more readable standard ASCII format. As the ERCB data does not have any publically available geological or stratigraphic identifiers attached to the coal quality data, another program was written to select and write to separate files the locations of coal holes, and all associated quality data, which penetrated either the Luscar Group or Kootenay Group. This was done by noting the townships where the two Groups cropped out and then selecting coal holes coinciding with these townships based on their ERCB coal hole locater group (coalhol-loc-group). The Dominion Land Survey (DLS) locations were resolved to the nearest section number.

The Luscar and Kootenay Group coal quality data sets were further refined to include only the coal holes with analyses based upon raw coal. This refined data set was used in a statistical analysis of the data. From this smaller data set a thickness weighted average of proximate ash, sulfur, volatile matter, fixed carbon, calorific value and residual moisture was calculated for each coal hole (appendix 7). These values are plotted beside the coal hole locations and are represented in a series of regional coal quality maps (e.g. figure 3, in pocket). In less than 5% of the holes only a single value was present for a seam; this single value was included in the weighted averages.

Most of the statistical analyses were performed using the Statistical Analysis System (SAS Institute Inc.), on a VAX 8600 computer.

Reporting bases

Coal quality can be reported upon in at least five different bases, depending upon the intended use and to some extent, the laboratory performing the analysis. The most common bases include "as analysed", "as received", "dry", "dry-ash-free" (daf), "moist mineral matter-free" (mmmf), and "dry mineral matter free" (dmmf) (Ward, 1985). One of the biggest problems in comparing coal quality data and compilation studies is the lack of uniformity in reporting the basis, or worse yet, not reporting the basis at all.

REGIONAL GEOLOGY

GEOLOGICAL DIVISIONS

Geologists have traditionally divided the Canadian Rocky Mountains into the Foothills and Mountains based on geological and physiographic criteria. The ERCB division deviates somewhat from this convention. The traditional subdivisions are used in this report.

Changes in structural style have traditionally provided the basis of distinguishing a series of diverse sub-parallel geological regions in the southeastern Rocky Mountains. Each is characterized by particular features of topography and stratigraphy, as well as structure and are called Foothills, Front Ranges, and Main Ranges. Because no commercial coal is present in the Main Ranges, only the Foothills and Front Ranges divisions are dealt with here. Mountains will be considered equivalent to Front Ranges in this report and the general term foothills/mountains will be used for the Foothills and Front Ranges taken together.

The boundary between Plains and Foothills is defined by an abrupt change from relatively flat bedding to steeply dipping bedding. In the Foothills, where the main level of exposure is that of Cretaceous rocks, the structure at the surface is characterized by closely spaced imbricate thrust faults in southern Alberta, and folding and thrusting in central Alberta.

The Front Ranges are made up of thrust sheets with a moderate to steep southwesterly dip. For the most part they are exposed at the level of the Paleozoic and lower Mesozoic rocks, but Cretaceous strata are also locally represented. Because the Paleozoic rocks are often carbonates, the Front Ranges are more resistant to erosion than the Foothills and consequently the elevation is higher and the topography more distinct.

The McConnell Thrust defines the boundary between Foothills and Front Ranges in the northern part of the study area. South of the

Highwood Range the boundary skips to the Lewis Thrust. As a consequence, the only coalfields in the Mountains region of the study area are the Costigan, Bankhead, Canmore, Pocaterra, and Tent Mountain coalfields.

STRATIGRAPHIC UNITS

The two major coal-bearing geological groups are the Kootenay and the Luscar (figure 2).

Kootenay Group

In Alberta, the Kootenay Group is present in the Rocky Mountain Foothills and Front Ranges, and extends from the Crowsnest Pass area in the south to the North Saskatchewan River in the north (figure 3, in pocket). The Kootenay Group is of Jurassic - Lower Cretaceous age and occupies the stratigraphic interval between the Jurassic Fernie Formation, and the overlying Lower Cretaceous Blairmore Group.

The Kootenay Group is comprised of three formations; in ascending order these are the Morrissey Formation, the Mist Mountain Formation and the Elk Formation. The Mist Mountain Formation contains the economically significant coal deposits of the Kootenay Group. A complete stratigraphic sequence of the Kootenay Group is not present in the eastern Foothills nor in the Crowsnest Pass area. In these areas the Mist Mountain Formation is unconformably overlain by the Cadomin Formation.

Mist Mountain

The geologic distribution of the coal-bearing Mist Mountain Formation is well known, as interest in the formation's coal has been high for several decades. The Mist Mountain thins from west to east to a zero erosional edge along the eastern edge of the foothills (figure 29). Near the North Saskatchewan River the Mist Mountain is no longer coal-bearing and grades laterally into the Nikanassin Formation.

The Mist Mountain Formation is comprised of a thick, interstratified sequence of predominantly nonmarine siltstone, sandstone, mudstone, shale, and thin to thick coal seams (Gibson 1985). The predominant rock type is siltstone ranging to a fine-grained sandstone. Coal seams are thickest and most numerous in the Sparwood Ridge-Elk Valley region of British Columbia.

Luscar Group

The Luscar Group, as recently defined by Langenberg and McMechan (1985), is the northern coal-bearing equivalent of the Blairmore Group of southern Alberta. The Group is Lower Cretaceous in age and disconformably overlies marine and non-marine sandstones and shales of the Nikanassin Formation and is disconformably overlain by marine shales of the Blackstone Formation (Langenberg and McMechan 1985). The Luscar Group consists of the Cadomin, Gladstone, Moosebar and Gates Formations (figure 2). The Gates Formation contains the economically important coal deposits.

In general, the Luscar Group was deposited as the second major continental clastic wedge sequence to prograde into the western interior Cretaceous seaway as a result of Cordilleran orogenic activity. During this time (Aptian to Albian), the area that is now central Alberta was undergoing large-scale transgressive and regressive events. The Moosebar Formation represents a minor marine transgression that divides the Luscar Group into the two major continental units, i.e. Cadomin/Gladstone Formations and the Gates Formation.

Moosebar Formation

The Moosebar Formation abruptly and disconformably overlies the Gladstone Formation and grades upward into the Torrens Member of the Gates Formation (McLean 1982). The Moosebar Formation is comprised of mostly marine shales and sandstones. Very thin coal seams are present in the Moosebar Formation in the Bighorn coal basin, along the North Saskatchewan River (Taylor and Walker, 1984). McLean and Wall (1981) have shown that the Moosebar Formation thins to the south, and is generally thin throughout the study area. This has led to difficulties in defining the coal-bearing Grande Cache member.

Gates Formation

The Gates Formation as described by Langenberg and McMechan (1985) conformably overlies the Moosebar Formation and is disconformably overlain by the Blackstone Formation south of the Athabasca River. The formation is divided into the Torrens, Grande Cache, and Mountain Park Members. The Grande Cache Member contains the economically important coal seams.

The Grande Cache Member conformably overlies the Torrens Member and is finer grained and recessive in comparison. In some places a coal seam directly overlies the Torrens Member. The Grande Cache Member consists of thick coal seams interbedded with mudstone, siltstone and very fine-grained sandstone.

The coal seam stratigraphy of the Grande Cache Member in the central Rockies is not clearly understood except in the Nordegg area. McLean (1982) shows how the coal zone in general is correlated, from Grande Cache to the Nordegg area. Horachek (1985) has described the local coal seam stratigraphy in the relatively undeformed Nordegg coal basin. There, six major coal seams are present within the member. This area shows the thickest section of Grande Cache member and the thickest accumulation of coal, within this study area.

COAL QUALITY VARIATIONS

INTRODUCTION

It has been shown in other coal basins that the major aspects of coal quality are determined by original depositional environment, diagenesis, depth of burial, duration of coalification, geothermal gradient and structural deformation (table 1).

Controlling factors	Coal quality parameters
Original depositional environment including original plant communities	- ash content and composition - sulfur content - trace elements
Diagenesis	- sulfur content and form, rank
Depth of burial Length of time of burial Geothermal gradient Structural setting	- calorific value, rank, fixed carbon, moisture, volatile matter, ash content

Table 1. Coal quality parameters and controlling factors.

The original depositional environment of coals has been shown to determine or influence, the quality of the coal. For example, the relationship of marine depositional environments to sulfur content in coals is well known (e.g. Davies and Raymond 1983). The paleobotanical assemblage and the paleoclimate are also known to influence coal quality.

Diagenesis has been shown to influence some coal quality parameters, for example, the forms of sulfur present in a coal (Wiese and Fyfe 1986). Ash composition may also change through time, with varying diagenetic conditions. Clay minerals undergo alterations during diagenesis that change their chemical and mineralogical composition.

Moisture and volatile matter contents of coals progressively decreases with increasing rank. Rank is determined by temperature and length of time of heating during burial. In most stratigraphic sequences, the deeper the coals have been buried, the higher the temperature they have been exposed to, and usually, the greater their rank.

PROXIMATE, ULTIMATE AND CALORIFIC ANALYSIS

The majority of the ERCB coal quality data, is proximate and washability analysis. Very little trace element data are present.

Statistical Analysis

Statistical analyses were performed on proximate and ultimate analysis data for the Kootenay Group and Luscar Group coals. Analyses were performed separately, and on both groups combined; the latter grouping thereby representing foothills/mountains coals in general. (raw data in appendices 1 to 4).

Data analyses included descriptive statistics (tables 2, 3, and 4), histograms to describe how data are distributed and tests of normality. The variables used were proximate ash, moisture, volatile matter, fixed carbon, calorific value and sulfur. Well over 300 cases, or complete data sets, for these variables are available (table 2). There are seven complete sample analyses for the ultimate analysis variables, carbon, hydrogen, nitrogen, sulfur and oxygen (table 2).

The normality of the variables was first tested to determine if normal parametric statistics could be applied. Normality was tested in two ways: 1) visually through the use of histograms and, 2) by more rigorous statistical tests.

Histograms were generated for variables on a dry basis and give a first impression of the normality of the data (figures 4 to 9). These histograms suggest normality for volatile matter and fixed carbon in the entire data set (figures 4 and 5), and normality for ash and fixed carbon in the Kootenay Group coals (figure 6 and 7). None of the variables appears to be normally distributed in the Luscar Group coals (figures 8 and 9).

For the more rigorous testing of normality, the Kolmogorov-Smirnov test (Lilliefors 1967) was used (for sample size >50) and for smaller sample sizes, the Shapiro-Wilk test (Shapiro and Wilk, 1965). The significance levels of the normality tests and the results are shown in table 5 for the Kootenay Group, Luscar Group, and the foothills-mountains coals. Using a 5% level of significance, a p-value less than 0.05 indicates non-normality.

Many of the Kootenay and Luscar Group coal quality variables examined are normally distributed, under this more rigorous method. Because there were only seven sample observations for the ultimate analysis variables, no strong normality inferences can be drawn for these variables at this stage. All proximate variables and calorific value pass the normality test, when the Kootenay Group and Luscar Group data are combined (foothills-mountains coals).

FOOTHILLS-MOUNTAINS COALS

VARIABLE	LABEL	N	MEAN	MINIMUM VALUE	MAXIMUM VALUE	STANDARD DEVIATION
			BASIS=Dry			
EQMOIST	Equilibrium Moisture	0	.	.	.	.
PROXASH	Proximate Ash	333	25.90	3.60	50.00	11.16
VOLM	Volatile Matter	333	22.61	8.60	32.60	4.53
FXC	Fixed Carbon	333	51.49	30.80	86.60	9.69
CALVAL	Calorific value kj/kg	316	25582.08	15324.00	34169.00	4274.83
CARBON	Carbon	7	80.07	70.65	87.98	6.18
HYDRGN	Hydrogen	7	3.59	3.33	3.88	0.19
OXYGEN	Oxygen	7	1.68	0.80	2.79	0.63
NITRGN	Nitrogen	7	1.13	0.97	1.37	0.12
SULFUR	Sulfur	320	0.56	0.21	3.02	0.34
			BASIS=Dry Ash-Free			
EQMOIST	Equilibrium Moisture	0	.	.	.	.
PROXASH	Proximate Ash	0	.	.	.	.
VOLM	Volatile Matter	333	30.75	9.03	44.08	5.22
FXC	Fixed Carbon	333	69.25	55.92	90.97	5.23
CALVAL	Calorific value kj/kg	316	34531.69	27738.00	37024.00	1249.37
CARBON	Carbon	7	91.27	89.98	92.42	0.80
HYDRGN	Hydrogen	7	4.10	3.92	4.29	0.12
OXYGEN	Oxygen	7	1.94	0.84	3.25	0.78
NITRGN	Nitrogen	7	1.29	1.08	1.45	0.13
SULFUR	Sulfur	320	0.78	0.27	4.47	0.53

Table 2. Descriptive coal quality statistics for foothills/mountains coals.

KOOTENAY GROUP DATA

VARIABLE	LABEL	N	MEAN	MINIMUM VALUE	MAXIMUM VALUE	STANDARD DEVIATION
			BASIS=Dry			
EQMOIST	Equilibrium Moisture	0	.	.	.	.
PROXASH	Proximate Ash	173	26.43	4.80	49.85	10.02
VOLM	Volatile Matter	173	21.13	8.60	32.60	4.35
FXC	Fixed Carbon	173	52.45	31.28	86.60	10.38
CALVAL	Calorific value kj/kg	157	25006.55	15324.00	32657.00	3702.48
CARBON	Carbon	7	80.07	70.65	87.98	6.18
HYDRGN	Hydrogen	7	3.59	3.33	3.88	0.19
OXYGEN	Oxygen	7	1.68	0.80	2.79	0.63
NITRGN	Nitrogen	7	1.13	0.97	1.37	0.12
SULFUR	Sulfur	161	0.47	0.21	2.09	0.25
			BASIS=Dry Ash-Free			
EQMOIST	Equilibrium Moisture	0	.	.	.	.
PROXASH	Proximate Ash	0	.	.	.	.
VOLM	Volatile Matter	173	29.13	9.03	44.08	6.37
FXC	Fixed Carbon	173	70.87	55.92	90.97	6.38
CALVAL	Calorific value kj/kg	157	34116.95	27738.00	36980.00	1482.35
CARBON	Carbon	7	91.27	89.98	92.42	0.80
HYDRGN	Hydrogen	7	4.10	3.92	4.29	0.12
OXYGEN	Oxygen	7	1.94	0.84	3.25	0.78
NITRGN	Nitrogen	7	1.29	1.08	1.45	0.13
SULFUR	Sulfur	161	0.66	0.27	2.98	0.40

Table 3. Descriptive coal quality statistics for the Kootenay Group coals.

LUSCAR GROUP DATA

VARIABLE	LABEL	N	MEAN	MINIMUM VALUE	MAXIMUM VALUE	STANDARD DEVIATION
	BASIS=Dry					
EQMOIST	Equilibrium Moisture	0	.	.	.	.
PROXASH	Proximate Ash	160	25.33	3.60	50.00	12.27
VOLM	Volatile Matter	160	24.21	14.07	32.36	4.16
FXC	Fixed Carbon	160	50.46	30.80	70.03	8.81
CALVAL	Calorific value kj/kg	159	26150.36	16447.00	34169.00	4716.32
CARBON	Carbon	0	.	.	.	.
HYDRGN	Hydrogen	0	.	.	.	.
OXYGEN	Oxygen	0	.	.	.	.
NITRGN	Nitrogen	0	.	.	.	.
SULFUR	Sulfur	159	0.65	0.30	3.02	0.39
	BASIS=Dry Ash-Free					
EQMOIST	Equilibrium Moisture	0	.	.	.	.
PROXASH	Proximate Ash	0	.	.	.	.
VOLM	Volatile Matter	160	32.50	21.88	39.37	2.68
FXC	Fixed Carbon	160	67.50	60.63	78.12	2.68
CALVAL	Calorific value kj/kg	159	34941.22	31580.00	37024.00	776.34
CARBON	Carbon	0	.	.	.	.
HYDRGN	Hydrogen	0	.	.	.	.
OXYGEN	Oxygen	0	.	.	.	.
NITRGN	Nitrogen	0	.	.	.	.
SULFUR	Sulfur	159	0.90	0.36	4.47	0.61

Table 4. Descriptive coal quality statistics for the Luscar Group coals.

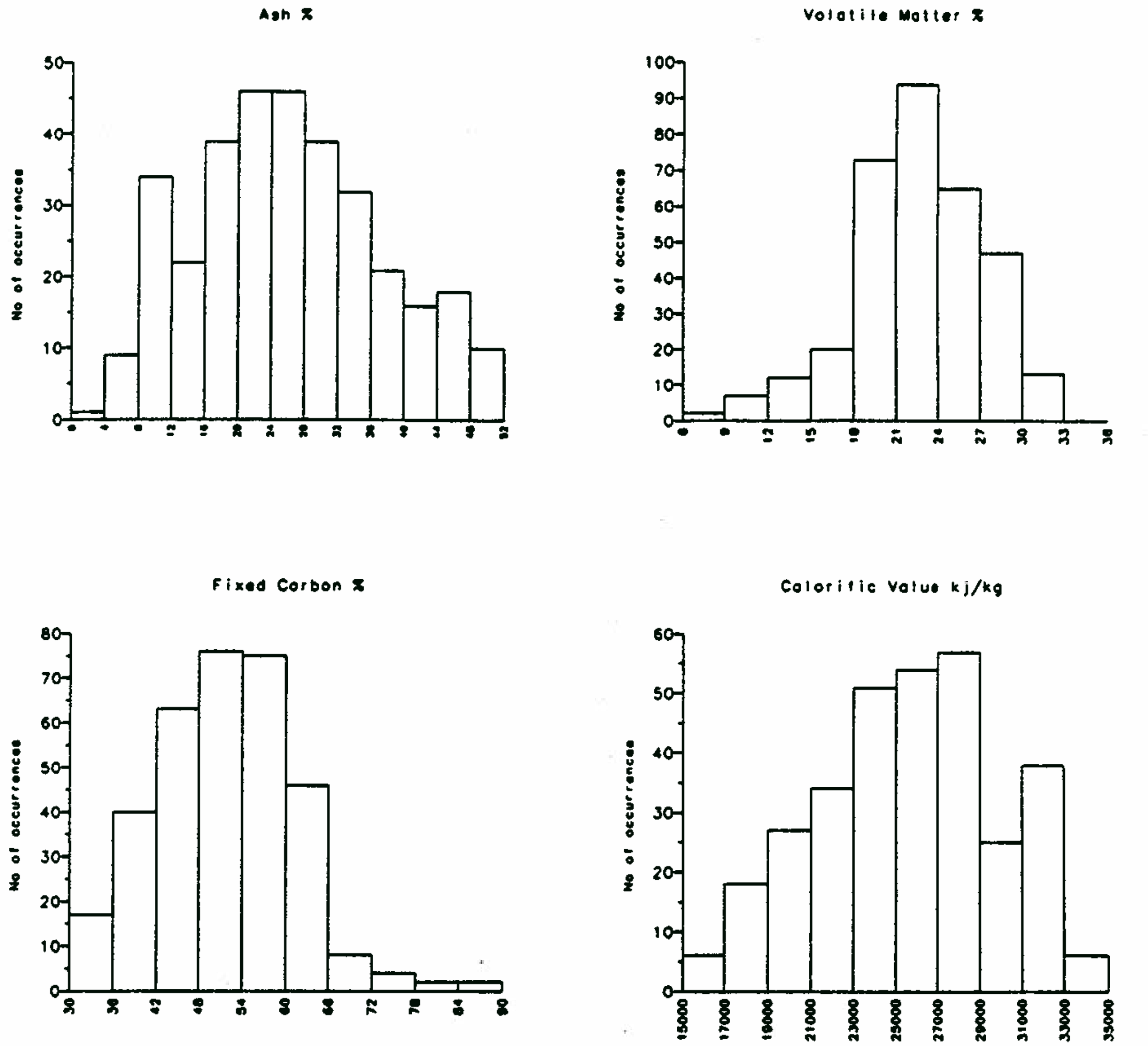


Figure 4. Histograms for the variables ash, volatile matter, fixed carbon, and calorific value (dry) - foothills/mountains coals.

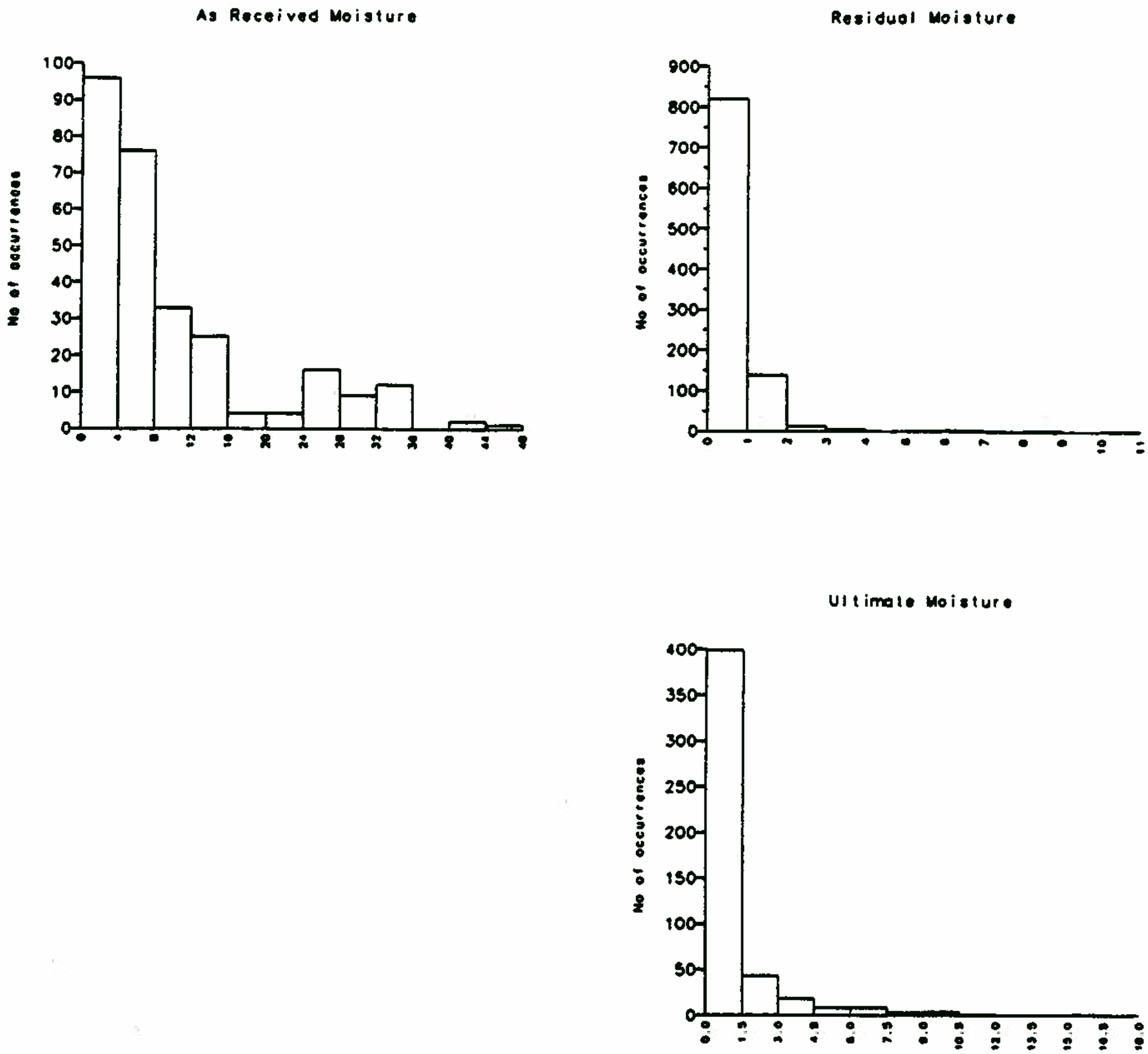


Figure 5. Histograms for the variables moisture (AR), moisture (residual), moisture (ultimate) - foothills/mountains coals.

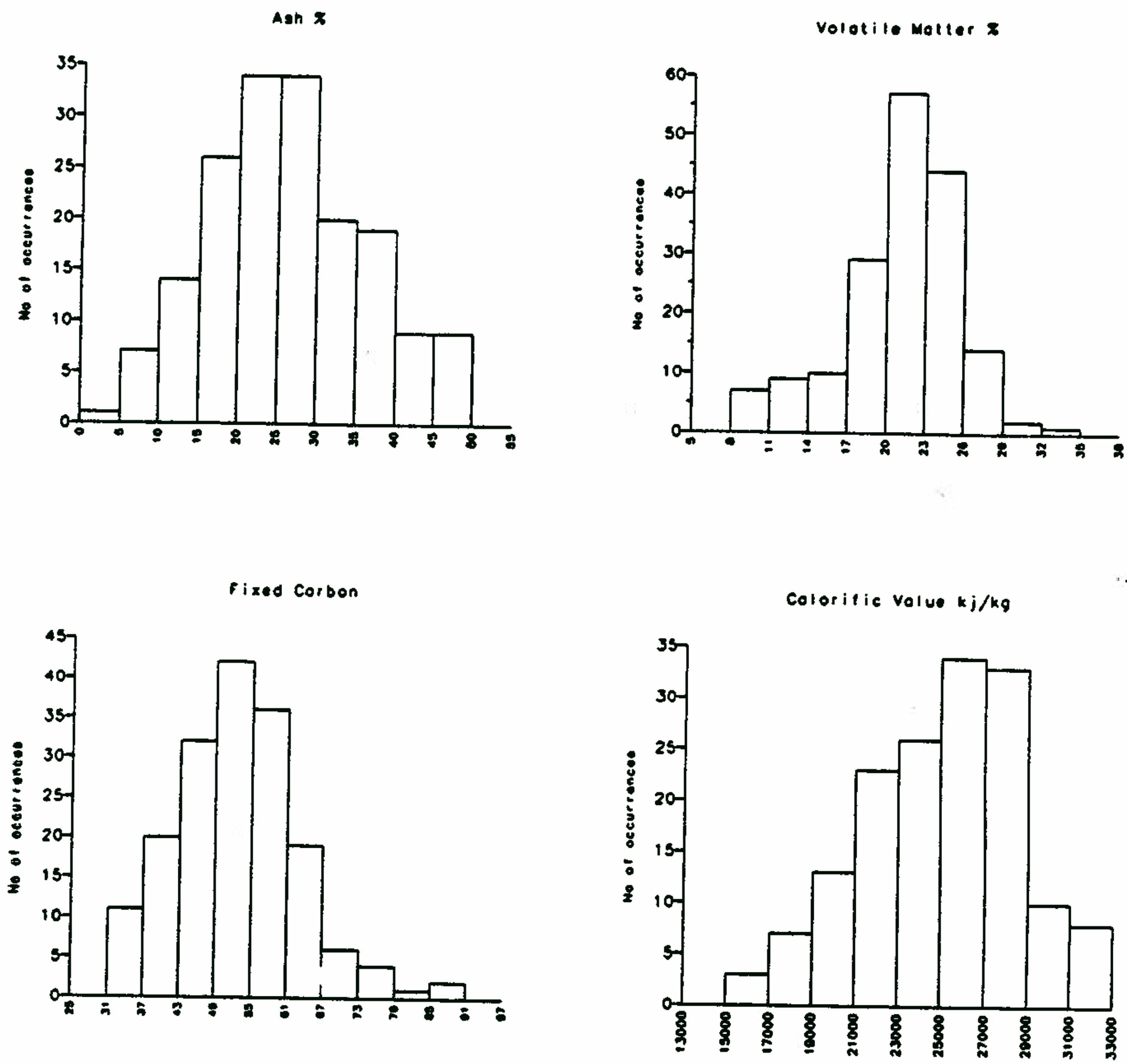


Figure 6. Histograms for the variables ash, volatile matter, fixed carbon, and calorific value (dry) - Kootenay Group coals.

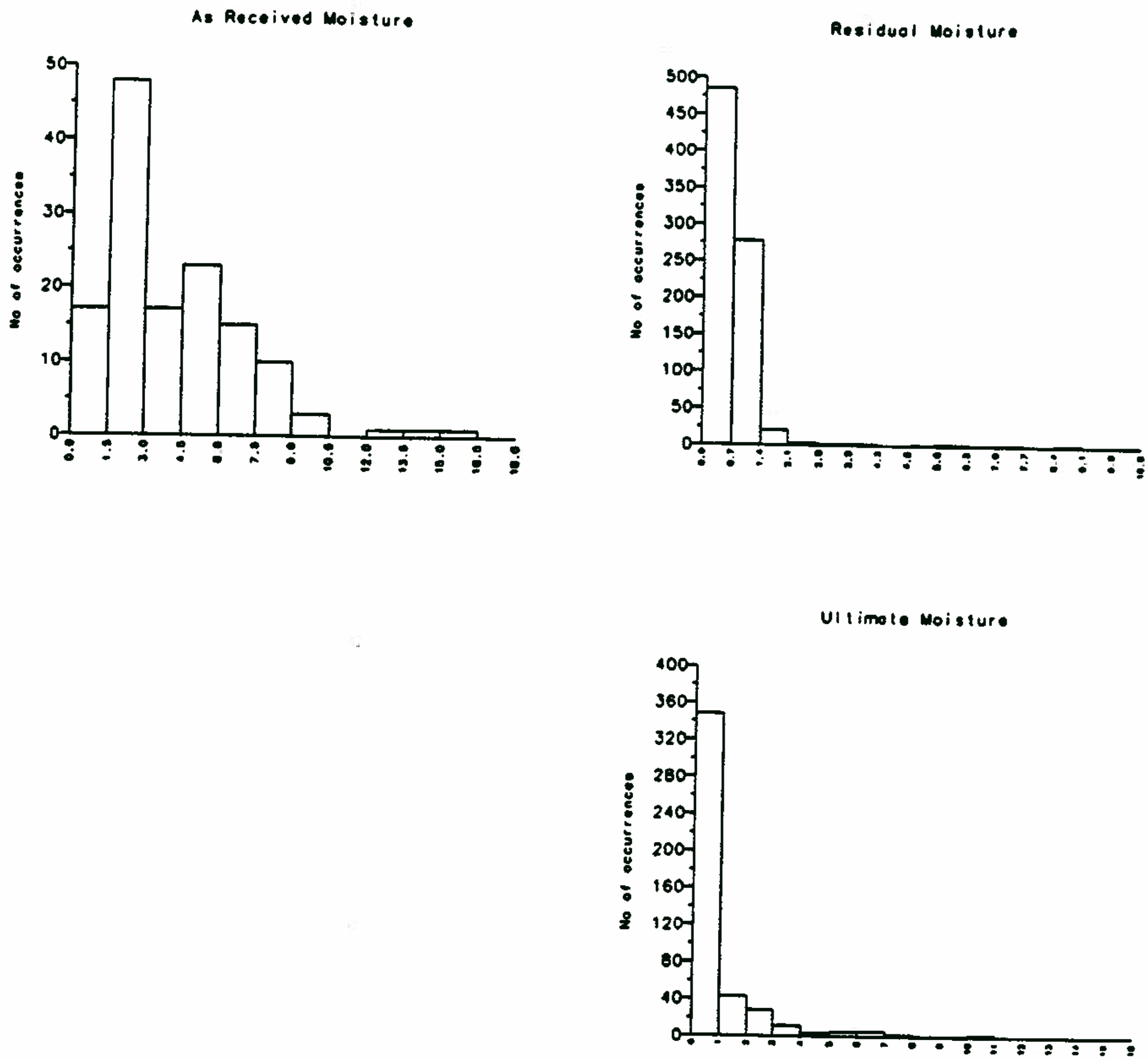


Figure 7. Histograms for the variables moisture (AR), moisture (residual), and moisture (ultimate) - Kootenay Group coals.

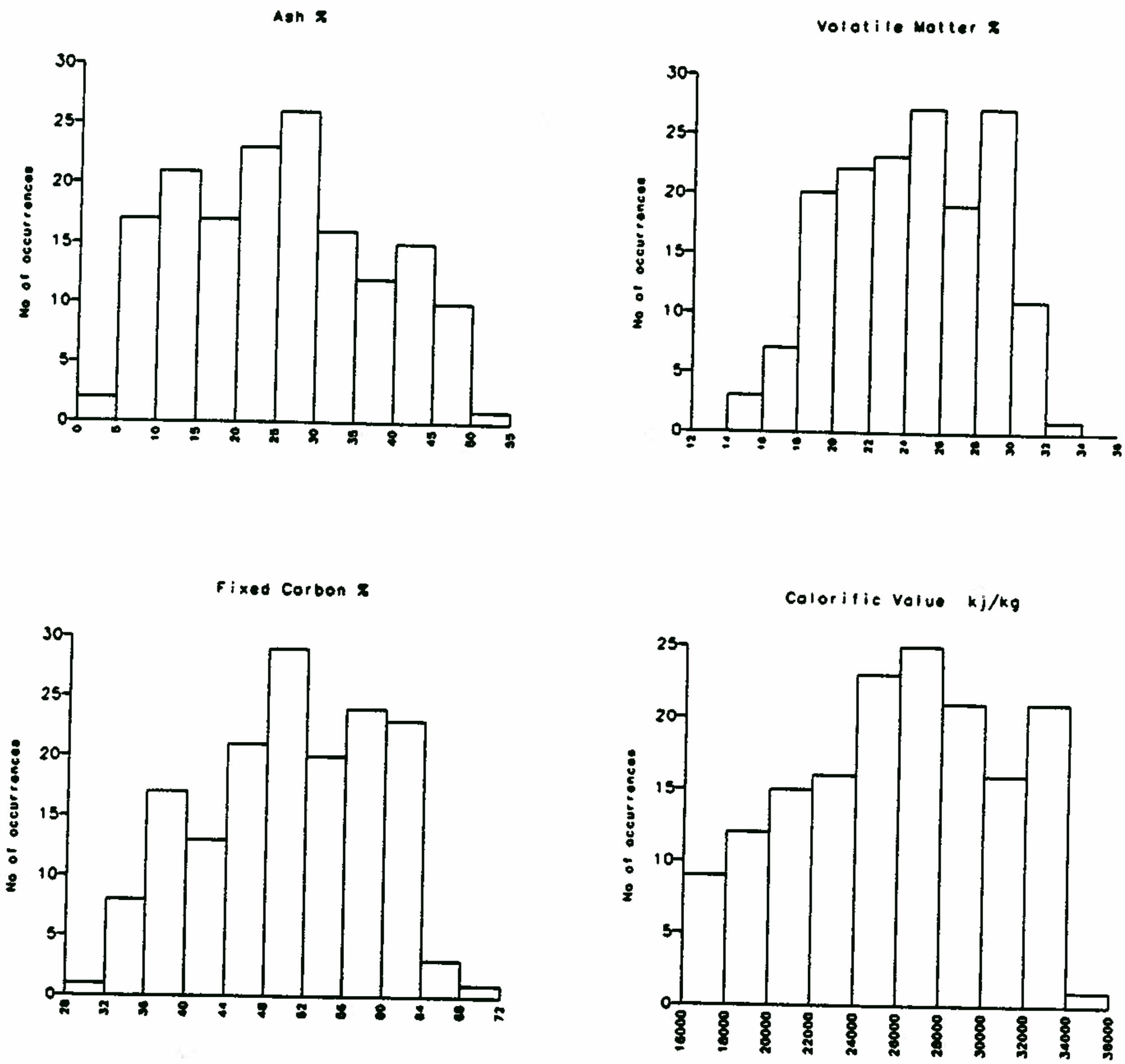


Figure 8. Histograms for the variables ash, volatile matter, fixed carbon, and calorific value (dry) - Luscar Group coals.

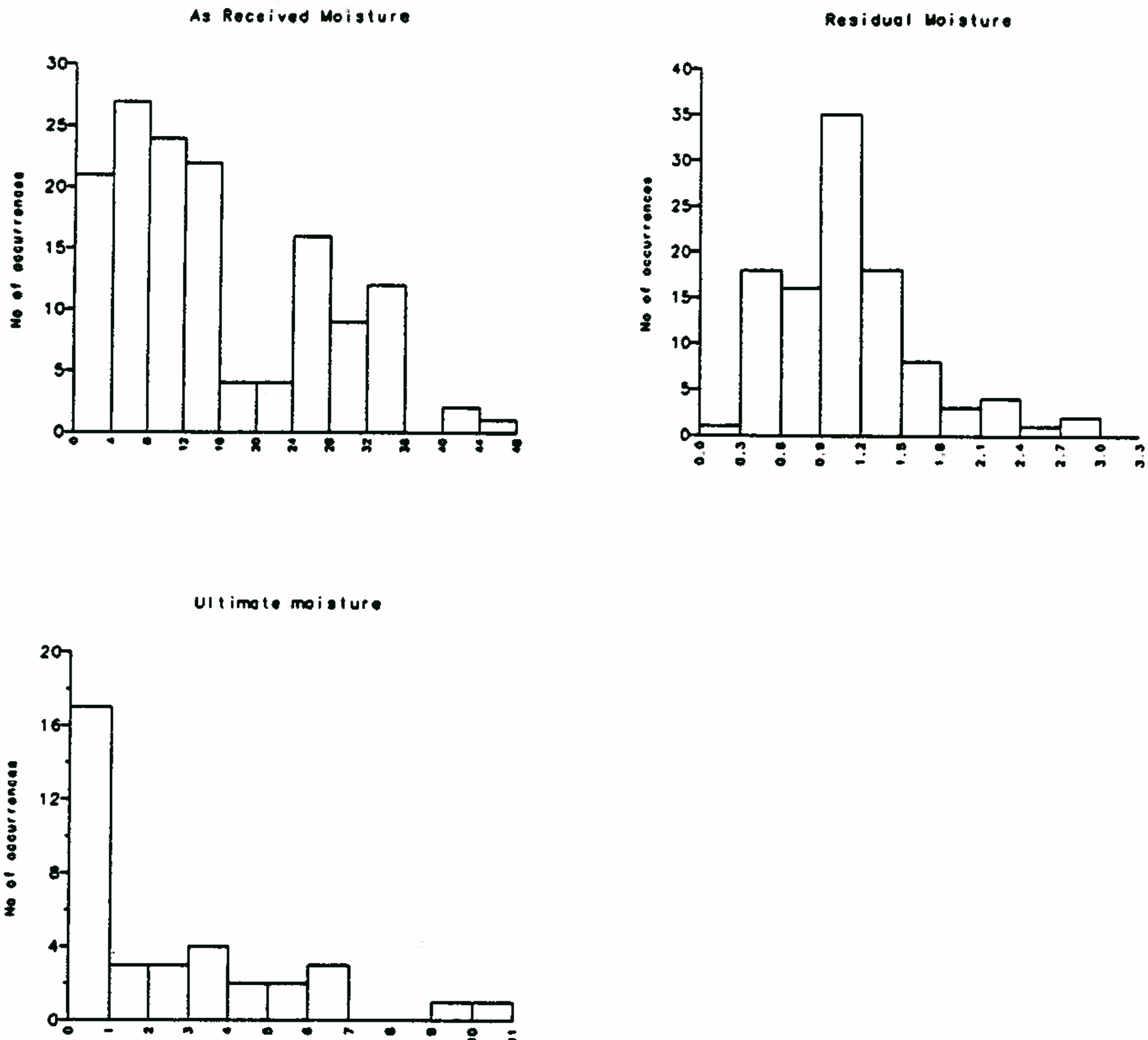


Figure 9. Histograms for the variables moisture (AR), moisture (residual), and moisture (ultimate) - Luscar Group coals.

	Foothills/Mountains			Kootenay Group			Luscar Group		
Variable\test	cases	P-value	N	cases	P-value	N	cases	P-value	N
Moisture (AR)	278	<0.010	No	136	<0.010	No	142	<0.010	No
Moisture (Res.)	978	<0.010	No	872	<0.010	No	106	<0.010	No
Moisture (equ)	24	0.051	M	24	0.051	M	0		
Moisture (ult.)	487	<0.010	No	452	<0.010	No	35	<0.010	No
Ash (dry)	333	>0.150	Yes	173	0.093	Yes	160	0.127	Yes
Volatile (d)	333	>0.150	Yes	173	<0.010	No	160	0.017	No
Fixed Carbon(d)	333	>0.150	Yes	173	0.091	Yes	160	0.060	M
H.V. (Kj/kg) (dry)	316	>0.150	Yes	157	>0.150	Yes	159	0.028	Yes
Carbon (d)	7	0.903	Yes	7	0.903	Yes	0		
Hydrogen (d)	7	0.680	Yes	7	0.680	Yes	0		
Nitrogen (d)	7	0.412	Yes	7	0.412	Yes	0		
Oxygen (d)	7	0.875	Yes	7	0.875	Yes	0		
Sulfur (d)	320	<0.010	No	161	<0.010	No	159	<0.010	No

N - normally distributed ?; Yes, No, Marginal (M).

Table 5. Test for normality of coal quality data.

Moisture

The moisture contents available on the ERCB datafile are mostly on the "as received" and "residual" basis, with only 24 "equilibrium" moisture contents being present (all of these from Kootenay Group coals). The "as received" and "residual" basis moisture values are not normally distributed (table 5, figures 5, 7 and 9), while the 24 "equilibrium" values were insufficient to describe statistically. Most of the non-normal moisture determinations show either a positive or negative skewness. This suggests that moisture values in these coals will tend to be clustered as either relatively high or low values.

The mean moisture content of foothills/mountains coals is 9.73% (as received), and 0.75% (residual) (table 6). Kootenay Group coals have mean moisture value of 0.70% (residual), while the Luscar Group coals have similar values of 1.07% (residual). Horachek (1985) gives typical moisture contents for Kootenay Group coals to be in the 1.5 to 4.0% range (basis not given), and for Luscar Group "clean coals" to be in the 6 to 7% range (basis not given). Steiner et al. (1972) suggests an average moisture content for foothills/mountains coals in general to be less than 5.0%, and seem to be based on about a dozen locations.

The regional distribution of residual moisture values varies considerably, most regions have a mixture of values less than 4% (figure 10). Variability within a local area can; however, be quite high (e.g. Crowsnest Pass area, 0.56% to 3.80%).

	N	Mean	Minimum Value	Maximum Value	Std. Dev.
As received basis					
Foothills/mountains	277	9.73	0.22	45.70	9.72
Kootenay Group	136	4.13	0.22	15.43	2.79
Luscar Group	141	15.13	2.00	45.70	10.90
Residual basis					
Foothills/mountains	903	0.75	0.10	10.15	0.76
Kootenay Group	797	0.70	0.10	10.15	0.78
Luscar Group	106	1.07	0.26	2.90	0.51

Table 6. Descriptive statistics for moisture contents, foothills/mountains, Luscar Group and Kootenay Group coals.

Ash

Ash values in the Kootenay and the Luscar Group coals are normally distributed (table 5) and have a mean value of 25.90% (dry) for all coals (table 2). Those samples with greater than 50% ash were not included in the analysis. Rocks with greater than 50% ash are, strictly speaking, not coals, although there is a continuum of carbonaceous lithologies from low ash coals to carbonaceous clastics (Ward, 1985). Since ash is normally distributed, the mean value is probably a reasonable estimate of the central tendency of ash. Kootenay Group coals have a slightly higher mean ash value than the Luscar Group coals (26.43%, versus 25.33%, respectfully tables 2 and 3). It can be concluded that on a statistical basis, the ash values within a random in-situ foothills/mountains coal is likely to be around 25%, with values ranging from 3.6 to 50.0%. This mean value is of course somewhat affected by the 50% cutoff in defining a coal. It is very important to point out that economic coals, within both of these geological Groups, frequently have much lower ash values.

Horachek (1985) states typical ash values for the Kootenay Group coals are in the 8 to 14% range (no basis given), and for the Luscar Group "clean" coals to be in the 7 to 10% range (no basis given). The apparent discrepancy with the ERCB data is likely related to the basis of the Horachek data. Another possibility is that the Horachek data were derived solely from economic coal seams, while the ERCB data includes exploration holes and is more representative of insitu coals. Steiner et al. (1972) cite an average ash content for Kootenay Group coals to be 15% (no basis given).

How a given coal seam is sampled, on what basis it is reported upon, and what is considered "coal" during sampling are three of the most significant factors in determining what the reported ash content will be. Only a few of these factors are known, with respect to the ERCB data (used in this study), or with respect to the previously cited works. Samples collected in the Crowsnest Pass area, during the course of this study, do have these factors known. These samples were collected so as to exclude all visible partings and thereby hopefully, represent inherent ash content.

The ERCB data were used to determine a weighted mean ash value for all drillholes in the study area that have coal quality information (figure 11). Since no stratigraphic information is publically available for the ERCB data, the mean value is of limited usefulness. The mean value likely represents several samples from several seams within either the Luscar or Kootenay Group, at any given location. Figure 11 shows the regional distribution of ash (dry basis). It is concluded that regional comparisons between ash values is very hazardous with the data available and the uncertainties surrounding the stratigraphic position and sampling techniques used.

Volatile matter

The rank of mountains/foothills coals is determined by using fixed carbon (based on measured volatile matter - see next section). The P-value test (table 5, figures 6 and 8) shows that volatile matter is not normally distributed in either the Kootenay or Luscar Group coals. This is to be expected because of regional variation in rank, which is reflected in volatile matter. However, taken collectively these same two coal-bearing Groups do appear to show a normal distribution (table 5, figure 4). This apparent contradiction can be explained by the combination of the two data sets resulting in a statistically more representative group.

Volatile matter varies from a mean of 32.50% for the Luscar Group coals (range 21.88 to 39.37% daf) to a mean of 29.13% (9.03 to 44.08% daf) in the Kootenay Group coals (table 3 and 4). The Kootenay Group coals, also have a greater standard deviation with respect to volatile matter than the Luscar Group coals. This shows that a wider variety of ranks of coals can be found in the Kootenay Group than in the Luscar Group coals evaluated so far.

The regional distribution of volatile matter (daf basis, figure 3) shows a discernable decrease from south to north. In the Kootenay Group coals this is a reflection of increasing rank to the north. A more detailed discussion of the regional volatile matter distribution and rank implications are considered in a later section of this report.

Fixed Carbon

Fixed carbon contents are normally distributed in Luscar Group and Kootenay Group coals and are also normally distributed within the foothills/mountains coals (table 5, figures 4, 6 and 8). Fixed carbon contents in the Luscar Group coals are perhaps only marginally normally distributed, as seen by the low P-value (table 5) and the slightly skewed histogram (figure 8).

Foothills/mountains coals have a mean fixed carbon content of 69.25% (daf) with a range of 55.92 to 90.97% (std. dev. 5.23, table 2). The variation reflects that of the Kootenay Group coals, which have a mean of 70.87% and this same range of values. Luscar Group coals have a mean of 67.50%, with a narrower range of values (60.63 to 78.12% daf). Fixed carbon is a coal quality parameter that generally increases with increasing coal rank. Thus, most of the variation in fixed carbon found in the Kootenay Group coals is related to the larger range of coal ranks found in the Kootenay Group.

Steiner et al. (1972) show regional fixed carbon values throughout this study area to be in the 62.0 to 86.0% (daf) range. These values are consistent with those determined within the present study. Horachek (1985) reports fixed carbon values in the 54 to 76% range (no basis given) for the Kootenay Group coals, and 58 to 72% range (no basis given) for Luscar Group "clean coals". Assuming the Horachek data is in a dry ash free basis, the values agree with these in the present study, except for the Luscar Group data reported by Horachek (op. cit.) on "clean coals".

Fixed carbon is a specifier of coal rank, where the highest fixed carbon percentages indicate the highest rank (on a dmmf basis). The regional distribution of fixed carbon does at least suggest this for the Kootenay Group coals (figure 12). Fixed carbon values in the Crowsnest Pass area are in the 60's, increase to the low 70's at Grassy Mountain and reach the high 80's in the Canmore area. The Luscar Group coals, evaluated so far show fixed carbon values in the 60 to 70% range. Again, caution should be exercised in interpreting regional fixed carbon distribution patterns, given the unknown factors outlined earlier.

Calorific Value

Calorific value of the foothills/mountains coals are normally distributed when the rigorous statistical P-value is generated (table 5). Histograms, however, suggest a slightly negatively skewed distribution (figures 4, 6, and 8). Wong et al. (1987) did not find any normal distributions with respect to calorific value in six seams from the Ardley coal zone at the Highvale minesite. However, Nurkowski (1985) shows histograms that suggest a normal distribution for regional Ardley coals, and perhaps, Horseshoe Canyon Formation coals.

The mean calorific value for foothills/mountains coals is 34531.69 Kj/kg (daf), with a range of 27738.00 to 37024.00 kj/kg. This range is a reflection of coals of varying ranks being present, particularly within the Kootenay Group coals. Kootenay Group coals range from 27738 to 36980 kj/Kg (daf) and Luscar Group coals from 31580 to 37024 Kj/kg (daf).

Horachek (1985) gives average coal calorific values for the Kootenay Group to be in the 29000 to 32000 Kj/kg range (no basis given) and for the Luscar Group "clean coals" to be 31000 to 34000 Kj/kg (no basis given).

The regional geographic distribution of calorific values (daf, figure 13) shows that many of these mean values tend to be in the 33 to 37 Mj/kg range (daf). Calorific value does not vary much with coal rank in this area. Coals that are higher than about medium volatile bituminous in rank show very little increase in calorific value (Teichmuller and Teichmuller, 1968), which explains the calorific value distribution in this study.

Ultimate Analysis

Only seven complete ultimate analyses are present in the ERCB data set, making observations on carbon, nitrogen, oxygen and hydrogen values difficult. The seven cases, all from Kootenay Group coals, have C, H, N, and O values that can be considered normal, as defined by the P-value (table 5). Descriptive statistics for ultimate analysis appear in tables 2, 3, and 4 and all available raw data appear in appendices 3 and 4.

Sulfur

Sulfur is the only element on which abundant data are available (n=320). None of the sulfur data are normally distributed, as shown by the histograms (figure 14) and the P-value test (table 5). This same general conclusion was found by Wong et al. (1987) for Ardley coals at the Highvale minesite and by Nurkowski (1985) for plains coals in general.

The mean sulfur value for foothills/mountains coals is 0.56% (dry), with a range of 0.21 to 3.02%. The highest sulfur value comes from Luscar Group coals (3.02% dry), however, this is likely an anomaly with most sulfur values being <1.0% (figure 14). Luscar Group coals tend to have a higher mean value and a larger standard deviation, compared to the Kootenay Group coals (tables 3 and 4).

The regional geographic distribution of sulfur shows that, within the Kootenay Group, sulfur is consistently below 0.50% throughout the region south of the Bow River (figure 15). No strong discernable pattern is obvious in the distribution of the Kootenay Group sulfur values, with the possible exception of a slight tendency for sulfur to be higher in the Highwood versus the Crowsnest Pass areas. No data are present north of the Bow River for Kootenay Group coals.

The geographic variation of sulfur within the Luscar Group, is only observable in the Ram River area, southeast of Nordegg (figure 15). Here, sulfur values are consistently in the 0.5 to 1.0% range with perhaps a slight increase in sulfur towards the extreme southwest (see insert map of figure 15).

Steiner et al. (1972) suggests that the central and southern

Rockies are characterized by moderately low sulfur coals (i.e. >0.5%). This study supports this idea, at least with respect to Luscar Group coals in the central part of the study. However, no evidence to support this claim was found for Kootenay Group coals in the area south of the Bow River, where exactly the opposite is the case. Extreme caution should be exercised in making generalizations about geographic distributions of sulfur where data are scarce.

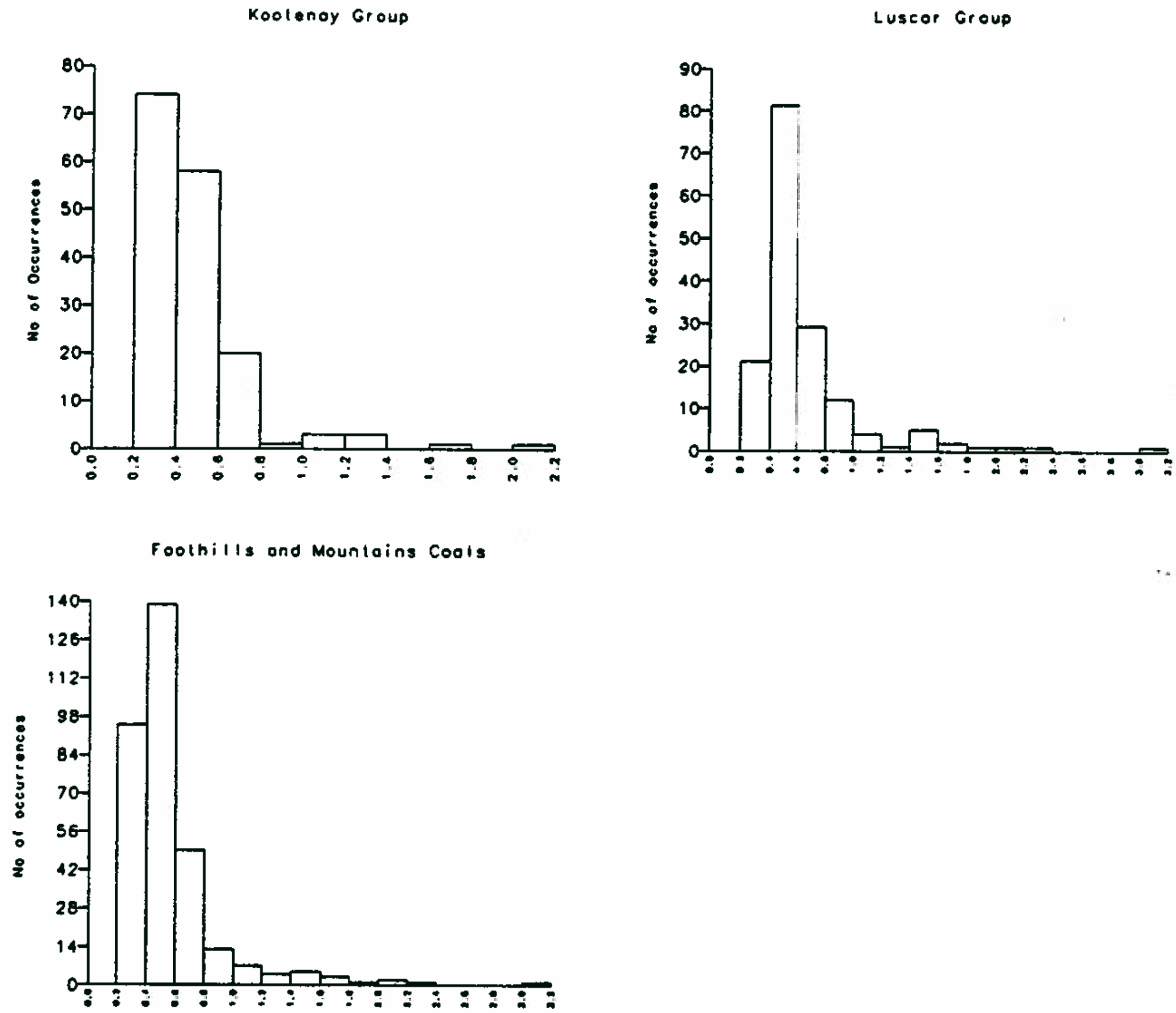


Figure 14. Histograms for sulfur (dry basis), foothills/mountains - Kootenay Group and Luscar Group coals.

RANK

Coal can be classified according to rank, that is, according to degree of metamorphism, or progressive alteration, in the series from lignite to anthracite. The ASTM classification is based on fixed carbon on the dry, mineral-matter-free basis for coals of anthracite, semi-anthracite, low-volatile bituminous, and medium volatile bituminous ranks. The economic coals of the Kootenay Group and Luscar Group of southern Alberta fall largely into those classes.

ASTM rank class can also be determined by measuring the maximum reflectance of vitrinite. A good correlation between ASTM rank determined according to the standard method and the rank determined from maximum vitrinite reflectance is generally reported (Bustin et al. 1985).

Three sources of coal rank information are available at the present time. These are: 1) the ERCB coal hole data file, 2) data published by the Geological Survey of Canada and 3) data from samples collected by the Alberta Geological Survey.

Energy Resources Conservation Board

The ERCB database contains information on volatile matter (VM), which can be expressed on a dry ash free basis. Weighted values are plotted on figure 3. The only stratigraphic information that can be inferred is whether the coals came from Kootenay or Luscar Groups as explained earlier. The data are concentrated in four areas, i.e. 1) around the Adanac Mine in the Coleman-Blairmore coal fields, 2) at Grassy Mountain in the Blairmore coal field, 3) at the Flat Creek deposit, and 4) in the Ram River coal field. The three southern areas, which are represented by 32 different drillhole locations, are in Kootenay Group coals. The areas show a gradual increase in rank, expressed as decreasing VM percentages, from 32% VM at Adanac Mine to 20% at the Flat Creek deposit. The Luscar Group analyses come from 45 drillholes and range in value from 35 to 24% VM.

Geological Survey of Canada

The Organic Petrology Section of the Geological Survey of Canada has been performing regional rank distribution studies in the Rocky Mountains since the early 1970's. Petrological techniques of measuring the reflection of the maceral vitrinite are used to establish rank. Because of the good correlation between % volatile matter and maximum vitrinite reflectance, an estimate of volatile matter (on a dry, ash free basis) can be obtained from the vitrinite reflectance values (see Bustin et al 1985, section 8.1). For the present study, reflectance data were obtained from Hacquebard & Donaldson (1974), Gibson (1985) and Hughes & Cameron (1985). The data comes from 12 different locations where relatively complete sections through the Mist Mountain Formation are present. These locations are labelled GSC-1 to GSC-12 in table 7. Because these sections are relatively complete, the stratigraphic position of the sampled coal seam is known. In table 7 the volatile matter of coals near the base and near the top of the Mist Mountain Formation are listed, if information was available. The samples near the base are generally within 50 m from the top of the Morrissey Formation, the samples near the top are generally within 50 m from the base of the Cadomin Formation. These sections generally show a gradual increase in VM from base to top, which indicates a decrease in rank (see also Hacquebard & Donaldson, 1974). Two sections deviate from this pattern, Cabin Ridge and Oldman River, indicating that either post-deformational coalification has played a role, or that the section has internal faults.

Figure 3 shows the VM of coals throughout the Mist Mountain Formation. The data again show a gradual decrease in VM for the Kootenay Group coals from south to north, as previously documented by Norris (1971).

Section	Location	UTM Coordinates	Location	VM (daf, Mist Mtn. Fm.) base	top
GSC					
GSC-1	Mt. Allan	626750	5649300	9.0	13.0
GSC-2	Bragg CK.	654000	5646500	13.0	16.3
GSC-3	Barrier Mtn.	597900	5728700	9.8	14.4
GSC-4	Mist Mtn.	645900	5602000	15.0	26.5
GSC-5	H.Ranger Stn.	666500	5586200	18.5	20.5
GSC-6	Wilkinson	670700	5565400	22.5	28.9
GSC-7	Cabin Ridge	678200	5547700	25.4	24.7
GSC-8	Ridge Ck.	688500	5554100	-	31.6
GSC-9	Oldman R.	692700	5527200	29.9	26.8
GSC-10	Grassy Mtn.	686800	5506100	25.0	27.0
GSC-11	Canmore	613000	5659700	8.0	16.0
GSC-12	Beaver Mines	703850	5481000	-	32.0
ARC					
CNP-2	York Ck.	681000	5496400	-	28.6
CNP-4	Vicary Ck.	678600	5515200	-	29.4
CNP-5	Vicary Ck.	685600	5514350	-	25.8
CNP-6	Tent Mtn.	666300	5492500	27.3	31.1
CNP-7	Grassy Mtn.	685900	5506100	-	27.0
CNP-8	Grassy Mtn.	685700	5504900	25.0	-
CNP-9	Adanac mine	687500	5484200	-	32.2
ARC-1	Tent Mtn.	666560	5491150	-	29.0
ARC-2	Cat Mtn.	687900	5522600	24.3	-
ARC-3	Oldman River	683300	5535900	26.5	-
ARC-4	Trap Ck.	670050	5596850	-	18.4
ARC-5	Fir Ck.	673450	5585450	17.5	19.8
ARC-6	Cat Ck.	662450	5587000	20.2	-
ARC-7	Trap CK.mine	670460	5593880	17.2	-
ARC-8	Wilkinson Ck.	673100	5563000	-	18.8
ARC-9	Hailstone Bu.	683100	5565250	-	26.2
ARC-10	Sheep River	671450	5613910	-	18.4
ARC-11	Sheep Falls	661550	5609860	-	16.4
ARC-12	Burn's mine	650630	5607500	10.0	-
ARC-13	Storm Ck.	648000	5598200	-	25.8
ARC-14	Gladstone Ck.	706250	5476820	-	32.6

Table 7. Volatile matter (daf) estimated from maximum percentage vitrinite reflectance for samples GSC-1 to 12 and ARC-1 to 15. Volatile matter (daf) for sections CNP-2 to 9 obtained by averaging VM proximate analysis. Samples labelled base are generallyb within 50 m from the top of the Morrissey Formation, those labelled ltop are generally within 50 m from the base of the Cadomin Formation.

Additional coal samples were collected during the 1987 field season, as described in the introduction. Nine stratigraphic sections were measured and sampled in open pits of the Crowsnest Pass area. Coal seams were sampled so as to exclude visible partings. From the proximate analyses (appendix 2) an average percentage volatile matter (daf) was calculated. Because the sampled intervals were generally 1 m thick, no weighting factor was applied. These values are shown in table 7 (see sections labelled CNP-2 to CNP-9) and plotted on figure 3.

Grab samples were collected for petrographic analyses at natural exposures throughout the outcrop area of the Kootenay Group (sample locations ARC-1 to ARC-15, table 7). Observations about the thickness of the seams and the distance from stratigraphic marker horizons such as the Morrissey and Cadomin Formations were recorded. Pellets were prepared from these samples and maximum vitrinite reflectances determined at the Geological Survey of Canada in Calgary (table 8). The maximum vitrinite reflectances were transformed into volatile matter as explained earlier. These values are listed in table 7 according to position of coal seams within the stratigraphic section (base or top of Mist Mountain Formation). These values are also plotted on figure 3. Where information on the base and the top of the section is available, the value of the base is posted. Regional variations in rank will be further discussed in the section on regional coalification.

Sample	Location	Mist Mountain Fm. Top/Base	Maximum % Reflectance	Std. Dev.
CNP-2-5	York Creek	Top	1.10	0.05
CNP-5-4	Vicary Creek	Top	1.24	0.05
CNP-6-8	Tent Mountain	Middle	1.14	0.04
-6-17	Tent Mountain	Middle	1.04	0.04
-6-27	Tent Mountain	Top	1.02	0.05
ARC-1	Tent Mountain	Middle	1.09	0.04
ARC-2	Cat Mountain	Base	1.33	0.05
"	Cat Mountain	Base	1.30	0.05
"	Cat Mountain	Base	1.27	0.06
ARC-3	Oldman River	Base	1.22	0.05
ARC-4	Trap Creek	Top	1.58	0.08
ARC-5	Fir Creek	Middle	1.62	0.05
"	Fir Creek	Top	1.51	0.05
ARC-6	Cat Creek	Base	1.50	0.07
ARC-7	Trap Creek Mine	Base	1.64	0.05
ARC-8	Wilkinson Creek	Top	1.59	0.07
"	Wilkinson Creek	Top	1.54	0.07
"	Wilkinson Creek	Top	1.59	0.06
ARC-9	Hailstone Butte	Top	1.23	0.05
"	Hailstone Butte	Top	1.12	0.05
ARC-10	Sheep River	Top	1.58	0.06
"	Sheep River	Top	1.61	0.07
"	Sheep River	Top	1.51	0.06
ARC-11	Sheep Falls	Top	1.69	0.05
ARC-12	Burn's Mine	Top	2.18	0.08
ARC-13	Storm Creek	Top	1.25	0.05
"	Storm Creek	Top	1.22	0.03
"	Storm Creek	Top	1.25	0.05
ARC-14	Gladstone Creek	Top	1.00	0.07
"	Gladstone Creek	Top	0.86	0.06
"	Gladstone Creek	Top	0.96	0.10

Table 8. Vitrinite reflectance data (Romax), Mist Mountain Formation coals, Crowsnest Pass and Kananaskis area.

COAL QUALITY RELATIONSHIPS

A number of different linear relationships were observed in bivariate analysis of coal quality parameters from previous studies worldwide (Teichmuller and Teichmuller 1968; Berkowitz 1979; and Nurkowski 1985). Negative linear relationships have been documented, including calorific value to equilibrium moisture, calorific value to ash, and volatile matter/fixed carbon to calorific value (Renton and Hidalgo 1975).

Pearson product-moment correlation coefficients were calculated for bivariate comparisons of ash, volatile matter, fixed carbon, calorific value and sulfur on a dry and dry ash-free basis (tables 9, 10, and 11). The correlation coefficients can be used to test the degree to which two variables are related, without any normality assumptions. This analysis was performed on Kootenay Group, Luscar Group, and foothills/mountains coals. These matrix correlation tables should be used with caution in drawing geological conclusions. Relationships that did not meet the 5% confidence level, are not reported.

Correlation coefficients dealing with variables, like those derived from proximate analysis, have an inherent problem that can lead to erroneous results. The problem is related to the way in which a proximate analysis is performed. The four components of a proximate analysis (ash, fixed carbon, volatile matter, and moisture) must add up to 100%. Statistically this means the four proximate analysis variables are not independent variables. If one variable goes down, the other three will go up. This can lead to strongly negative correlations, for example, there is very strong negative correlation between volatile matter and fixed carbon on a dry ash-free basis (close to -1, table 9). It is known geologically that these two variables do in fact have a strong negative correlation. However, because of the reporting basis (daf) two of the four components have been set to zero, and consequently fixed carbon and volatile matter must show a perfect negative correlation (i.e. -1). The high value shown in table 9 is likely due to rounding off.

BASIS=Dry

	ASH	VOLM	FXC	CALVAL	SULFUR
ASH Ash		-0.50546 0.0001 333	-0.91495 0.0001 333	-0.98092 0.0001 316	
VOLM Volatile Matter			0.11425 0.0372 333	0.60437 0.0001 316	
FXC Fixed Carbon				0.92791 0.0001 316	-0.12931 0.0207 320
CALVAL Calorific Value kj/kg					
SULFUR Sulfur					

BASIS=Dry Ash-Free

	ASH	VOLM	FXC	CALVAL	SULFUR
ASH Ash					
VOLM Volatile Matter			-0.99998 0.0001 333	-0.26778 0.0001 316	0.23178 0.0001 320
FXC Fixed Carbon				0.26777 0.0001 316	-0.23151 0.0001 320
CALVAL Calorific Value kj/kg					
SULFUR Sulfur					

Key

-0.99981 - Pearson correlation coefficient (r)

0.0001 - Probability > |R| under H0:RHO=0

316 - Number of observations

Table 9. Correlation coefficient matrix - foothills/mountains coal quality parameters.

BASIS=Dry

	ASH	VOLM	FXC	CALVAL	SULFUR
ASH Ash			-0.90914 0.0001 173	-0.95967 0.0001 157	
VOLM Volatile Matter			-0.28904 0.0001 173	0.18179 0.0227 157	
FXC Fixed Carbon				0.92292 0.0001 157	
CALVAL Calorific Value kj/kg					
SULFUR Sulfur					

BASIS=Dry Ash-Free

	ASH	VOLM	FXC	CALVAL	SULFUR
ASH Ash					
VOLM Volatile Matter			-0.99997 0.0001 173	-0.44449 0.0001 157	0.20033 0.0108 161
FXC Fixed Carbon				0.44432 0.0001 157	-0.20003 0.0110 161
CALVAL Calorific Value kj/kg					
SULFUR Sulfur					

<u>Key</u>

-0.99981 - Pearson correlation coefficient (r)

0.0001 - Probability > |R| under H0:RHO=0

316 - Number of observations

Table 10. Correlation coefficient matrix - Kootenay Group coal quality parameters.

BASIS=Dry

	ASH	VOLM	FXC	CALVAL	SULFUR
ASH Ash		-0.88394 0.0001 160	-0.97533 0.0001 160	-0.99685 0.0001 159	
VOLM Volatile Matter			0.75891 0.0001 160	0.88260 0.0001 159	
FXC Fixed Carbon				0.97568 0.0001 159	
CALVAL Calorific Value kj/kg					
SULFUR Sulfur					

BASIS=Dry Ash-Free

	ASH	VOLM	FXC	CALVAL	SULFUR
ASH Ash					
VOLM Volatile Matter			-1.00000 0.0000 160	-0.18104 0.0224 159	0.23473 0.0029 159
FXC Fixed Carbon				0.18104 0.0224 159	-0.23473 0.0029 159
CALVAL Calorific Value kj/kg					-0.18231 0.0219 158
SULFUR Sulfur					

Key

-0.99981 - Pearson correlation coefficient (r)

0.0001 - Probability > |R| under H0:RHO=0

316 - Number of observations

Table 11. Correlation coefficient matrix - Luscar Group coal quality parameters.

ASH RELATIONSHIPS

Ash shows a negative correlation with calorific value (dry basis, r^2>90%) for all three cases of foothills/mountains coals (table 9), Kootenay Group coals (table 10) and Luscar Group coals (table 11). This relationship has been well established worldwide and, therefore applies to Alberta foothills/mountains coals as well. Scatter diagrams and linear regressions were performed on the data to calculate the equation that defines this relationship.

Foothills/mountains coals - ash versus calorific value

The foothills/mountains coals show a linear relationship between calorific value (CALVAL) and ash that is defined by the equation (figure 16):

Predicted CALVAL(DRY) = 35574 - 383 * ASH (dry)

The correlation coefficient matrix shows a strong relationship between these two variables, suggesting that much of the variability in calorific value can be explained by ash (r^2=.96 or 96%, table 9). However, calorific value is also controlled by the rank of coal and the scatter of the Kootenay coals in figure 16 can be explained by the variation in rank. The Luscar coals have less scatter because they show less variation in rank.

Ash is significantly related to volatile matter (negatively) for the foothills/mountains coals (r^2 =.25 or 25%, dry, table 9). Ash is also correlated to fixed carbon (r=-0.91, r^2 =.83 or 83%, dry). Ash is not significantly related to sulfur in any of the foothills/mountains coals (tables 9, 10, and 11). It is also important to point out that the volatile matter and fixed carbon of the organic fraction of a given coal seam and the ash content of the seam are in a sense independent variables because they originate from different causes; volatile matter and fixed carbon are largely dependent on the stage of maturity (rank) of the coal while ash is dependent upon the original depositional environment, tectonics, and perhaps on how the coal was sampled. There are some instances where high carbonate contents in the mineral matter fraction may yield anomalous volatile matter contents upon analysis of the coal.

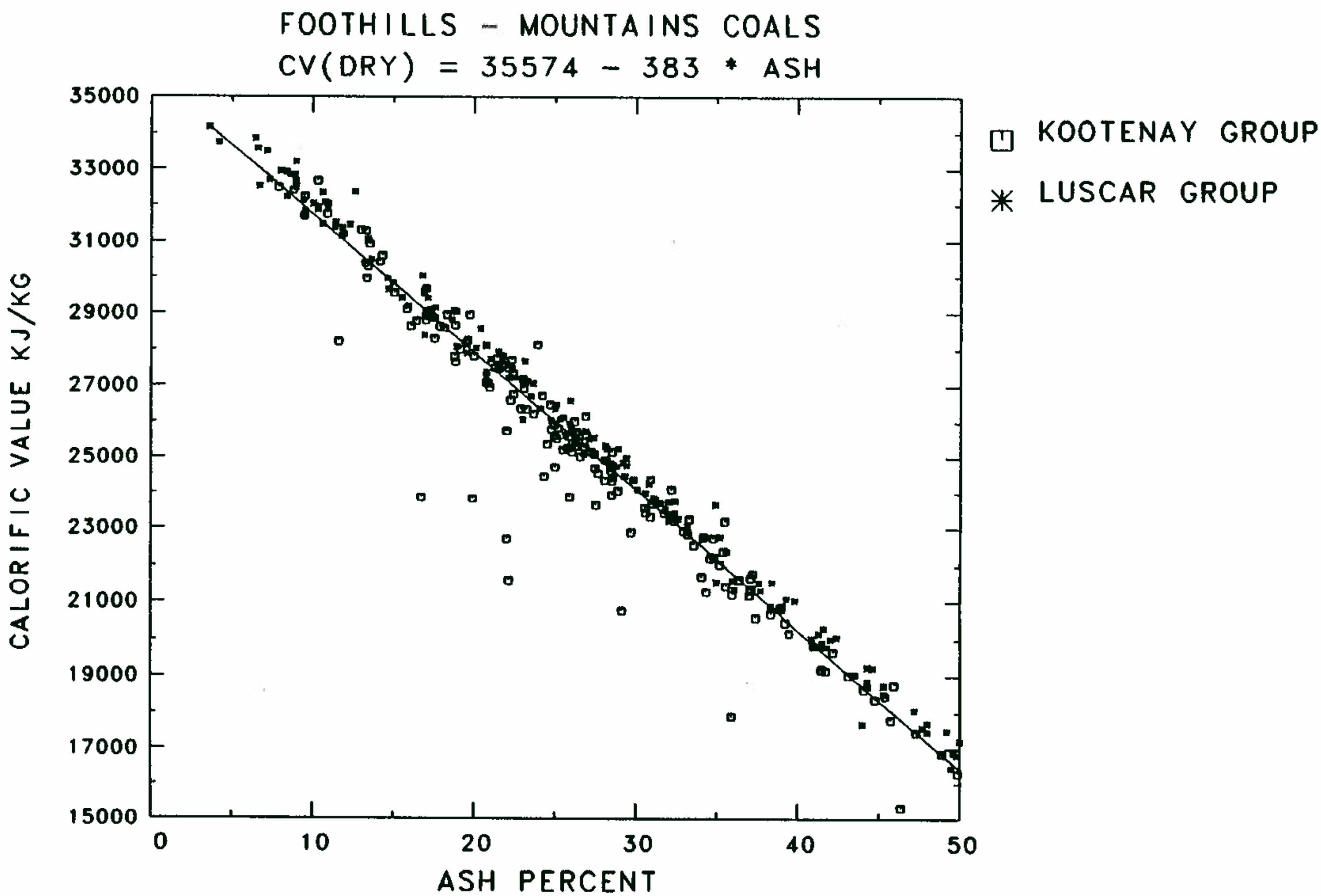


Figure 16. Scatter diagram and best-fit linear regression, calorific value versus ash (dry basis) - foothills/mountains coals.

Kootenay Group coals - ash versus calorific value

For the Kootenay Group, the linear relation between % ash content and calorific value (kj/kg) is (figure 17):

Predicted CALVAL (DRY) = 35181 - 379 *ASH

where CALVAL (DRY) and ASH refer to calorific value and ash on a dry basis. The correlation coefficient (r = - 0.96) shows a negative relationship (i.e. higher ash content result in lower heat of combustion). The value of r-squared is 0.92 (92%) which means that 92% of the variation in calorific value can be explained by ash. The scatter diagram shows the wider spread of coal ranks present in the Kootenay Group coals and also shows that not all of the calorific value variation is explained by ash.

Ash is negatively related to fixed carbon (r^2 =.83, table 10). It should be noted that fixed carbon is a coal rank indicator.

Luscar Group coals - ash versus calorific value

For the Luscar group, the relationship between calorific value and ash (dry) is defined by the equation (see also figure 18):

Predicted CALVAL (DRY) = 35845 - 382 *ASH

with a correlation coefficient of r = -0.997 (r^2 =.99 or 99%). The Luscar Group coals show a much closer relationship between calorific value and ash, i.e. almost 99% of the calorific value variation can be explained by ash. This is due to the Luscar Group coals being within a narrower rank range, than the Kootenay Group coals.

Ash is related to volatile matter (dry, r^2 =.77 or 77%) and to fixed carbon (dry, r^2 =.92 or 92%, table 11). Again, it is commonly known that both volatile matter and fixed carbon are indicators of by coal rank.

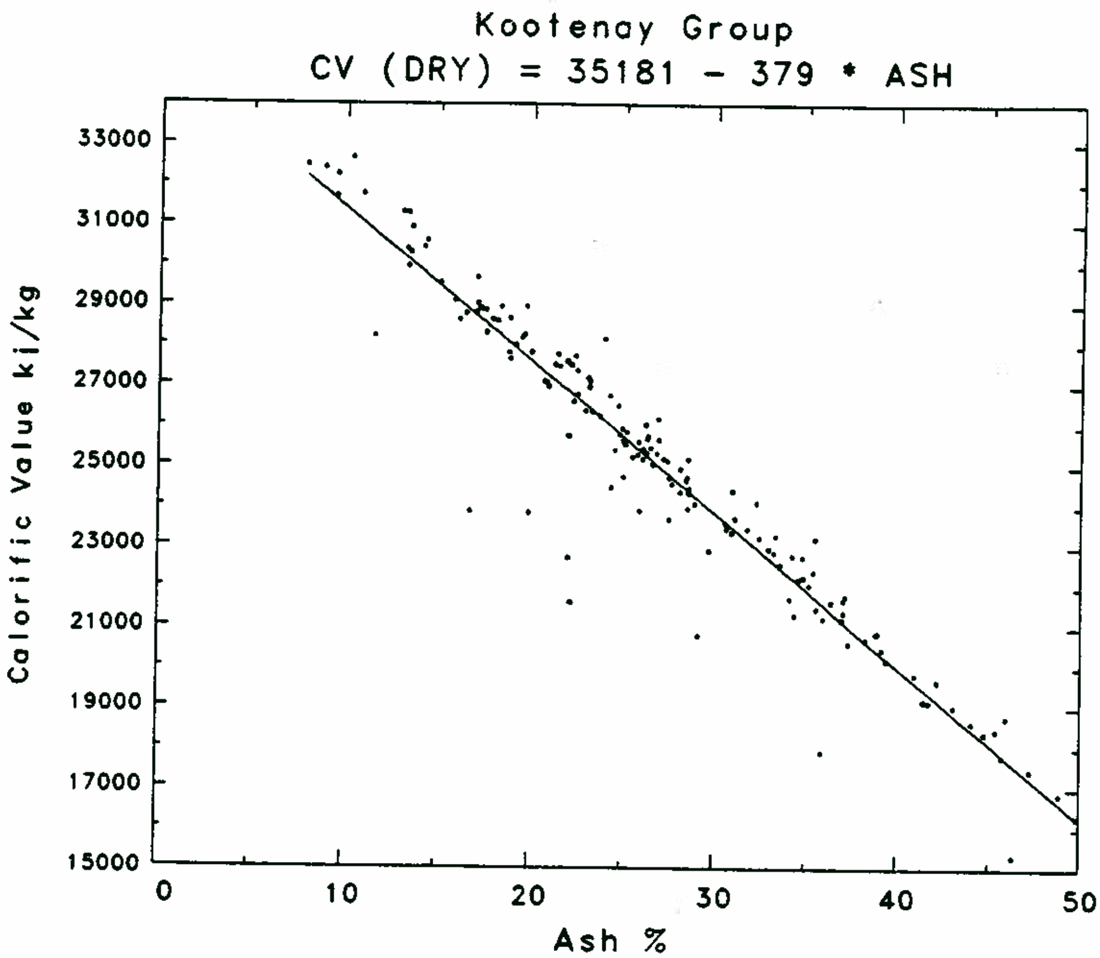


Figure 17. Scatter diagram and best-fit linear regression, calorific value versus ash (dry basis) - Kootenay Group coals.

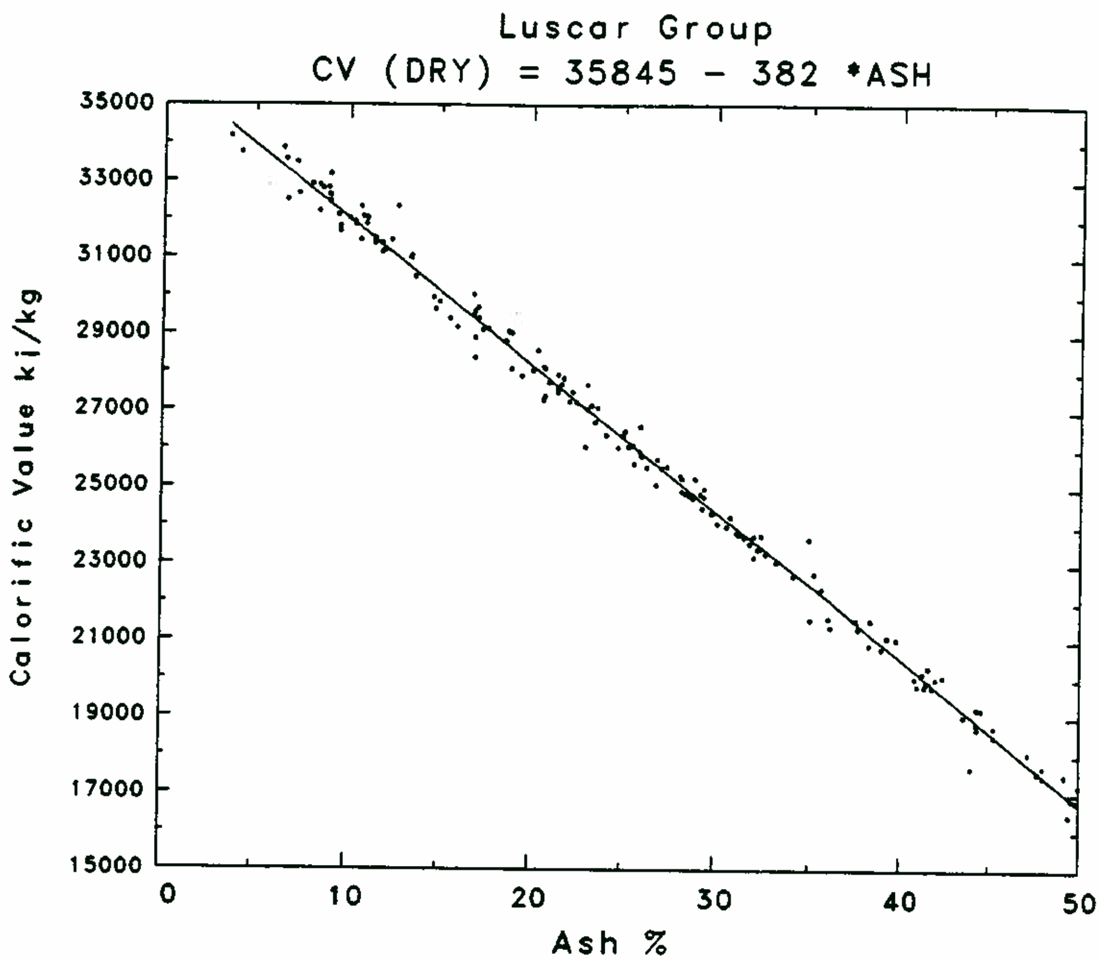


Figure 18. Scatter diagram and best-fit linear regression, calorific value versus ash (dry basis) - Luscar Group coals.

VOLATILE MATTER

Volatile matter is a direct measure of coal rank for bituminous coals (usually expressed as fixed carbon), when the analysis is reported on a dry mineral matter free basis (dmmf). This basis is not available for the ERCB data set used in this study, however, a dry ash free basis was calculated by using the Parr formulae (Ward 1984). Volatile matter on a "daf basis" is a close approximation to rank on a "dmmf" basis. The correlation matrices show that for foothills/mountains coals, in general, volatile matter is only slightly negatively correlated to calorific value ($r = 0.26778$, $r^2 = .07$ or 7%, table 9, daf). The analysis by geological Group shows that this relationship is also present in Kootenay Group coals ($r^2 =.19$ or 19%, table 10, daf), and in the Luscar Group coals ($r^2 = 0.03$ or 3%, table 11, daf). This relationship results from coalification driving off volatiles, thereby increasing the calorific value to about medium volatile bituminous rank. Because the coals of this report are generally in the medium volatile to semi-anthracite range, volatile matter accounts for very little in the the variation in calorific value

Volatile matter shows a positive relationship with sulfur ($r^2 = .05$ or 5%, daf, table 9). This might be explained by some sulfur-bearing volatiles being driven off with increased coalification.

FIXED CARBON

Fixed carbon, in foothills/mountains coals is positively correlated to calorific value on a "dry basis" ($r^2 =.86$ or 86%, table 9), and also positively correlated on a "dry ash free" basis ($r^2 =.08$ or 8%, table 9). However, in higher rank coals such as these, this is relatively minor as a comparison of the correlations between CV on the dry basis and DAF basis shows. The correlation of fixed carbon with calorific value on the dry basis is probably due mainly to non-contribution of ash to the calorific value, as ash content decreases, FC increases and so does CV.

Foothills/mountains coals also show a negative linear relationship between fixed carbon and sulfur on a "dry ash free" basis (r^2 =.06 or 6%, table 9). This relationship is to be expected and is explained similarly to the volatile matter/sulfur relationship observed in the previous section. Increasing rank will cause a higher fixed carbon value and drive off some sulfur with the volatiles, thus producing a minor negative correlation between fixed carbon and sulfur.

OTHER RELATIONSHIPS

A test of difference in means between the Kootenay and Luscar Groups coal quality variables (ash, volatile matter, fixed carbon, calorific value, and sulfur) was performed using the randomization student t-test (Edgington 1980). This test is usually used in exploratory data analysis with non-random samples. Whereas the classical t-test is based on the normality assumption, these tests are non-parametric (table 12). Note that while no difference is found for ash on a dry basis, using a 5% level of significance, the difference is highly significant with respect to volatile matter, calorific value and sulfur. The difference for fixed carbon is significant at the 6% level. The mean values of these variables are shown in tables 3 and 4.

Variable dry (basis)	Randomization t - test P - value (5% significance)
Ash	0.3589
Volatile Matter	0.0001
Fixed Carbon	0.0628
Calorific Value (Kj/kg)	0.0070
Sulfur	0.0001

Table 12. Test for difference in means values - ash, volatile matter, fixed carbon, calorific value and sulfur; Kootenay versus Luscar Group coals.

COAL QUALITY AND UTILIZATION

CARBONIZATION PROPERTIES

Most coals in the foothills/mountains region are of bituminous rank, with isolated deposits of semi-anthracite present. The ERCB estimates reserves of 4.42 gigatonnes of bituminous coal in the foothills/mountains region (ERCB, 1986).

Bituminous coals are the main coking coals, however, coal rank is but one important parameter used in determining whether a coal will make a good coke. Four mains groups of factors influence coking capacity of a coal, these being; rank, maceral distribution, chemical properties, and physico-chemical properties (figure 19). The conditions of coke utilization also determines the overall coking capacity.
Price and Gransden (1987) provide a very thorough treatment of all of these factors.

Rank

Coal rank is one of the most important factors in carbonization. The best coking coals are generally from the medium-volatile bituminous group, however, low and high volatile coals also will form coke. Low and medium volatile coals are usually blended with varying amounts of high-volatile coals to produce a suitable coke product (Bustin et al. 1985).

Coal rank within the bituminous rank coals is commonly measured by vitrinite reflectance, however, none of this type of data appears to be in the ERCB database. Volatile matter contents are available from the ERCB, thereby providing information on one of the four carbonization factors.

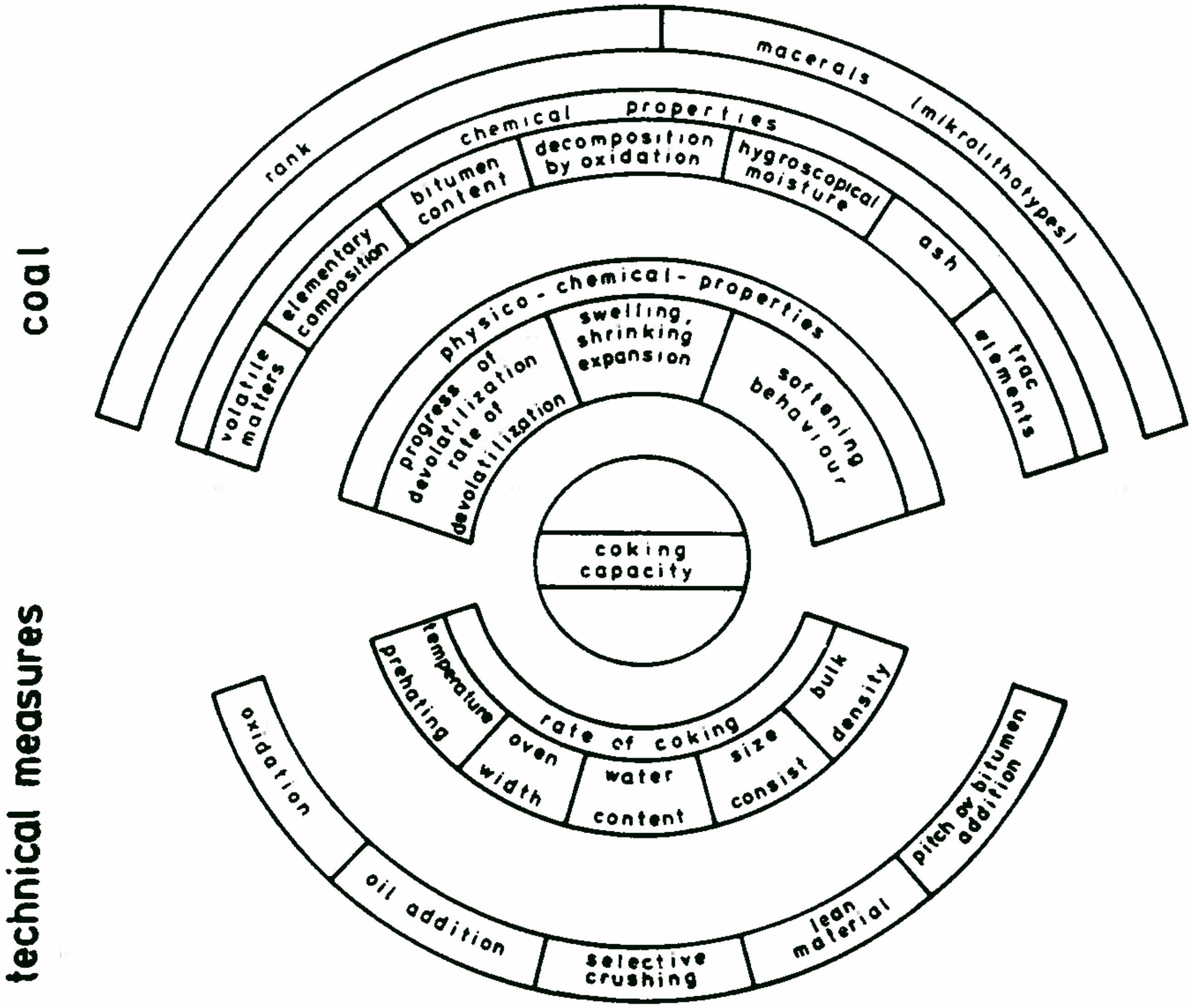


Figure 19. Diagram illustrating interaction of coal properties and coking conditions and influence upon coking capacity (from Mackowsky, 1982).

Chemical properties

The chemical properties which produce a good coke include volatile matter, ash, sulfur, calorific value and phosphorous content. In contrast, the chemical properties present in a coal, suitable for producing a good coke, are somewhat less well defined and depend, to some degree, on the specifications of the "target" coke. In practice, volatile matter, ash, sulfur, percent alkalies in the ash, and ash analysis are the most critical factors considered in the coal itself. These analysis are done on clean, marketable coals. Metallurgical coal companies will commonly report a complete proximate and ultimate analysis, calorific value, chlorine, mercury, and ash analysis. Some typical analyses of cleaned coal from five Western Canadian coal mines appear in table 13. Coals A, B, C and D are from the Kootenay Group in the Fernie coal basin of B.C. Coal "E", table 13, is said to be typical of Luscar Group metallurgical coals of the Grande Cache area (Price and Gransden, 1987).

The ERCB data set used in this study is based on raw coals and so is of limited use in assessing the chemical properties suitable for good coking coals. The ERCB data tape, provided to the Alberta Research Council, has clean coal proximate analysis data on it, which is suitable for assessing coking properties. These data were outside the scope of this initial study, but will be addressed in later phases of the project.

Physico-chemical properties

This group of properties, generally relate to a coal's potential to produce a strong coke (see Ignasiuk, 1974). Tests for fluidity, free-swelling index, grindability, dilation, size composition, density and porosity are some of the more common ones. Table 13 provides some typical analytical results from Western Canadian coals, and Bonnell and Janke (1986) provide analytical data on these properties, from mines across Canada. Ward (1984) provides an exhaustive treatment of the subject.

Some of these parameters are collected by the ERCB (e.g. F.S.I.), however, data tape it appears that information about these variables is confined to the two active metallurgical coal mining areas in the province (i.e. Grande Cache and Cadomin-Luscar coalfields).

	NOVA SCOTIAN	WESTERN CANADIAN COALS				
COAL CHARGE PROPERTIES	hva	Coal A (hv)	CoalB (mv)	Coal C (mv)	Coal d (mv)	Coal E (lv)
Mean Reflectance Ro	0.99	0.9	1.01	1.27	1.28	1.62
Volatile Matter, db %	31.8	31.9	26.5	21.7	21.6	17.3
Ash, db, %	4.1	6.1	7.1	9.6	9.3	7.2
Sulfur, db %	1.25	0.48	0.5	0.28	0.4	0.4
Alakalies in ash %	0.06	0.07	0.08	0.04	0.12	0.08
Pulverization (%-3mm)		84.5	93.4	90.1	91.1	88.2
Hardgrove index		66	89	84	889	92
CAKING PROPERTIES						
Free swelling index	8.5	8	7.5	6.5	6.5	5.5
Gieseler Plasticity (ddpm)	27800	195	11.4	3.8	6.7	1
Dilation (c+d) %	226	66	30	0	7	0
Expansion/contraction %	-15		-11.3	-13.5	-11.7	
CARBONIZATION RESULTS						
Maximum wall pressure, kPa	2.1	3.7	7.2	2.1	5.8	41.6
COKE PROPERTIES						
Ash %	4.2	8.7	9.3	12	11.6	8.4
Volatile matter %	0.9	0.8	0.8	0.7	0.8	0.9
Sulfur %	1.04	0.37	0.38	0.27	0.36	0.038
ASTM stability	38.1	45.1	55.7	51	58.1	55.4
JIS DI^{30}		92.1		90.8	94.6	92.9
CSR	37	62.1	64	61.4	73.9	68.7

Table 13. Analysis of cleaned coals and resultant cokes made from an eastern hv coal and five western Canadian coals in CANMET pilot-scale tests (from Price and Grandsden, 1987).

Maceral analysis

Petrographic analysis is becoming a very important tool in predicting many of the previously discussed coking coal parameters (e.g. rank, strength, fluidity, FSI, and volatile matter). The relative proportions of reactive versus inert macerals provide some of this prediction capability (Bustin et al. 1985).

No coal maceral analysis data is present in the ERCB dataset. Petrographic work done to date on metallurgical coals, mostly through the Geological Survey of Canada, has concentrated on vitrinite reflectance as a rank determinator. Some generalized maceral distributions for the Kootenay and Luscar Group coals have been completed (Cameron and Kalkreuth 1982), but detailed maceral analysis is in a very early stage of development in Alberta (Langenberg et al. 1986).

COMBUSTION

At the present time there are no active thermal coal mines in the foothills/mountains region, within this study area. Two such mines do exist in the northern study area, (neither of which are in the Kootenay or Luscar Group) and will be examined in the next phase of this project (Coal Valley and and Obed-Marsh mines). Several of the metallurgical mines in the northern area have at times produced thermal coal in small tonnages. The future potential for thermal coals in the central and southern foothills/mountains region is good. One area in the Crowsnest Pass is being examined at the present by Chinook Coals Ltd., in Kootenay Group coals.

Coal quality parameters related to combustion are calorific value, ash, fixed carbon, volatile matter, moisture, Cl, N, S, macerals, grindability, combustibility, and ash properties (Mitchell, 1974). As has been seen from the preceding sections, calorific value, and proximate and ultimate analysis variables are present in the ERCB data set used in this study.

UNDERSTANDING RELATIONSHIPS - MODELS

DEPOSITIONAL ENVIRONMENTAL MODEL

Introduction

The Kootenay Group, Mist Mountain Formation, coals were examined in the Crowsnest Pass area in some detail to better understand how depositional environment influence coal quality (figure 20). Some coal quality parameters are related to depositional environment, while others are related to diagenesis, depth of burial, and structural setting (table 1).

It was also the intent of this substudy to determine small scale, coal seam level variations in the coal quality. This aspect is dealt with in a cursory manner and will be explored more fully in reports to come, in later project phases.

The Crowsnest substudy was undertaken by measuring and sampling a series of stratigraphic sections of the Mist Mountain Formation from pits and roadcuts in the Crowsnest Pass area (figure 20). Outcrops were generally avoided, as weathered coals would make speculations on coal quality variations of dubious value. Some sections reported herein, along shallow roadcuts or pits, may fall into this catagory. The reader is cautioned about such suspect locations. Channel coal samples were collected at regular intervals excluding visable partings, within several of the coal seams in the area. The samples were analyzed for all of the proximate and ultimate parameters (including C, H, N and S). Results of this analytical work have been plotted as a series of bar graphs alongside the sampled coal seam (figures 21 to 27, appendix 6 for legend). The overall lithostratigraphic setting can be compared to the coal quality.

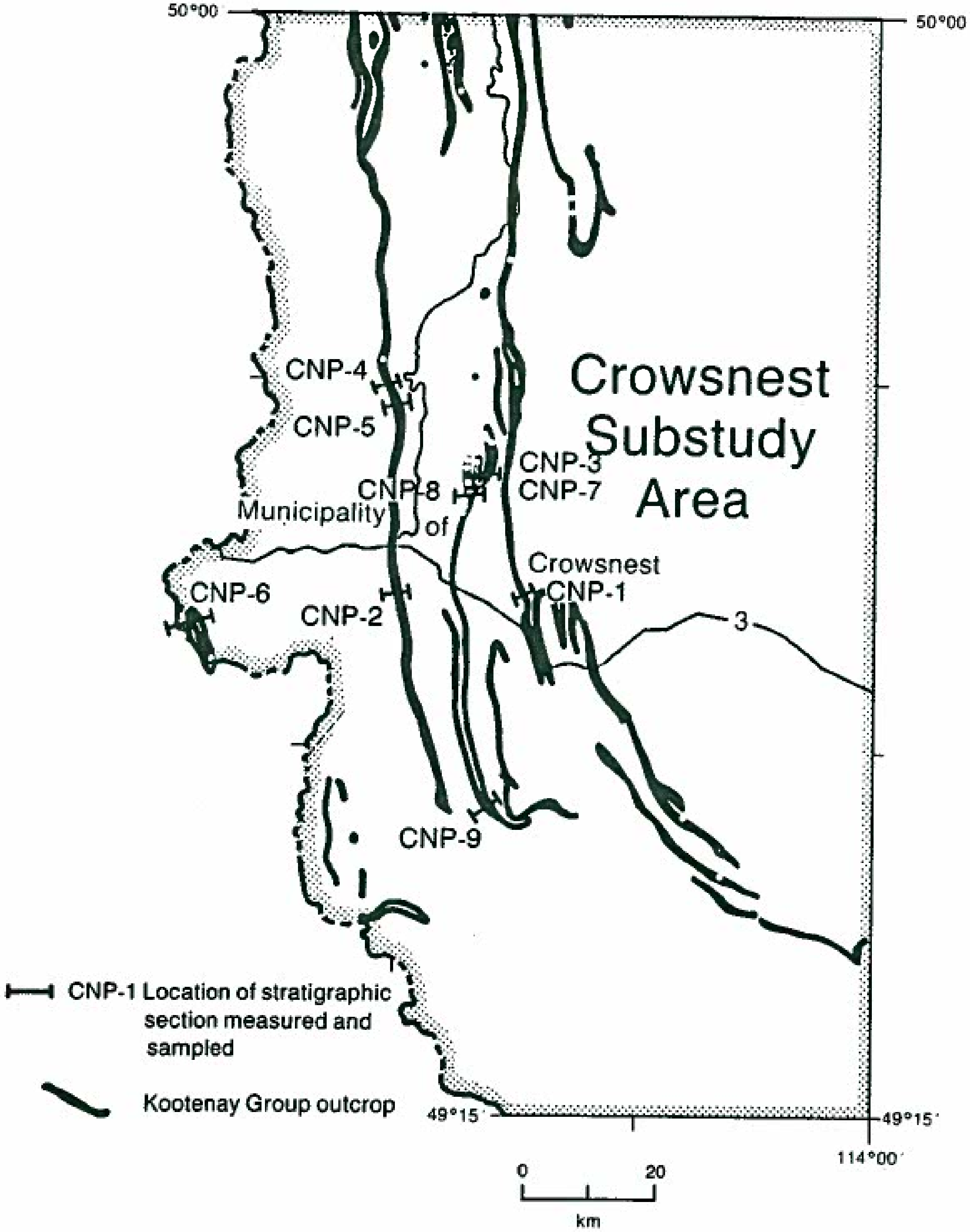


Figure 20. Location of stratigraphic sections measured and sampled - Crowsnest Pass area.

Stratigraphic and coal correlations

Stratigraphic correlations within the Mist Mountain Formation are believed to be well established in the Crowsnest Pass area. Norris (1959b) described four members (figure 2) within the "Kootenay Formation" (now called Mist Mountain Formation) and showed how major coal seams were thought to be correlated. Gibson (1985) suggests that these members are only correlatable within the Crowsnest Pass area.

Coal seams in the Crowsnest Pass area are all, excepting the Tent Mountain section, on splay faults off the main Livingstone Thrust. Displacement on these splays (e.g. Coleman and Turtle Mountain faults) are believed to be less than 10 km. The Tent Mountain section (CNP-6, this report) is on the Lewis Thrust sheet and has likely been transported more than 35 km from its original depositional site. The Mist Mountain Formation at Tent Mountain is also stratigraphically 10 times thickner than that seen at the Adanac minesite (estimate from Gibson 1985).

Norris (1959b) correlates the thick seam at Grassy Mountain, at the base of the Mutz Member (# 2 seam, Gibson and Hughes 1981), with the uppermost seams at York Creek and Adanac strip mine. Coals within the Mist Mountain Formation at Tent Mountain have not been correlated with anything in the eastern Crowsnest Pass area. The seam numbering used at Tent Mountain (figures 26 and 27) is from Manalta Coal Ltd. and these seam numbers do not correspond to numbers in the eastern Crowsnest Pass area. Jansa (1972) correlated the coals at Grassy Mountain to the lowermost coals in the Fernie Basin region, using the top of the Morrisey Formation as a datum.

The coal seam correlations established for this study (figures 21 to 25) have been based on chemical as well as stratigraphic characteristics. With the assumption that depth and length of burial, was uniform throughout the Crowsnest Pass area, the coal rank, as expressed by volatile matter (daf), fixed carbon (daf), and Carbon (daf), can be used to verify coal seam correlations. This assumption is reasonable over relatively short north-south distances. However, as it has been seen in preceding sections, coal rank does increase from south to north. Mean values for VM, FC and C were calculated for each seam.

The uppermost seam, #1, at West Grassy Mountain (figure 23, CNP-7,8) shows mean V.M., F.C. and C values very close to those of the upper seam at York Creek (figure 25). Both locations also show a tendency for sulfur to increase upwards in the seam and for having a number of partings in the coal. The number 1 seam at York Creek pits is structurally thickened, however, the upper portion of the seam appears less disturbed. Correlating the two seams in this way leaves approximately the same thickness of Mutz Member strata between the top of the seam and the Cadomin Formation. The number 1 seam at Adanac mine (this study, figure 21) has a somewhat problematical geochemistry. There appears to be two distinct geochemical regimes with respect to many of the parameters examined. The upper part of the seam has mean V.M., F.C. and C very close to those at West Grassy Mountain and York Creek. The lower part of the seam (samples 2 to 5) has V.M., F.C and C values that appear to be from a lower rank coal seam. The apparent increase in volatile matter in the lower part of the seam may be attributable to the presence of carbonate or clay minerals in the ash, yielding an anomalously high V.M. The presence of carbonate minerals should show a relative increase in C content. This does not seem to have happened. A bedding plane fault is possible within this seam, as the Adanac mine stratigraphic section has always been anomalously thin. There is also a thin silicified zone between samples 5 and 6 which may be a fault zone. The upper part of seam 1 at Adanac also shows a slight tendency for sulfur content to increase upward in the seam, as was seen at West Grassy Mountain and York Creek.

From this geochemical approach to coal seam correlation, as described above, a seam can be characterized or "fingerprinted" with a number of different chemical parameters. This technique cannot be applied as easily to the Tent Mountain coals, because the thickness of the Mist Mountain Formation is greater at this locality than in the east Crowsnest Pass area.

Depositional environments

The Kootenay Group, and portions of the Fernie Formation - Passage Beds, represent the first western-sourced clastic wedge shed off the rising Cordillera. Throughout Jurassic time a large seaway covered much of Alberta, into which the Kootenay Group prograded from west to east. The entire package of sediments, from Upper Fernie to Cadomin Formation, represents a transition from shelf environments (Passage Beds) to alluvial fan deposits (Cadomin Formation - Gibson, 1985). Some controversy exists as to the origin of the Morrissey Formation; however, it is generally agreed upon that the lower Mist Mountain Formation was deposited in a coastal plain grading into an alluvial plain setting represented by the upper Mist Mountain Formation. Figure 28 summarizes the generalized paleographic interpretation for the Kootenay Group.

The interpreted depositional environments for the sections studied within this report appear in figures 21 to 27. The focus for deposit-ional environmental interpretations, in the following discussion, will be as they relate to coal quality. More detailed interpretations of the general Kootenay Group depositional model have been done by Gibson (1985), Hughes and Cameron (1985), and Jansa (1972).

Coals in the eastern Crowsnest Pass are found at three stratigraphic horizons in the Mist Mountain Formation, the number 4 and equivalents at the base, number 2 - on top of the Hillcrest Member, and the number 1 near the top of the formation. These three coal zones also have unique depositional environmental associations (both clastic and mire) and possibly unique geochemical patterns. They can be grouped into three generalized depostional/geochemical facies; coastal plain mire, alluvial plain (fluvial-distal) mires, and alluvial plain (fluvial-proximate) mires.

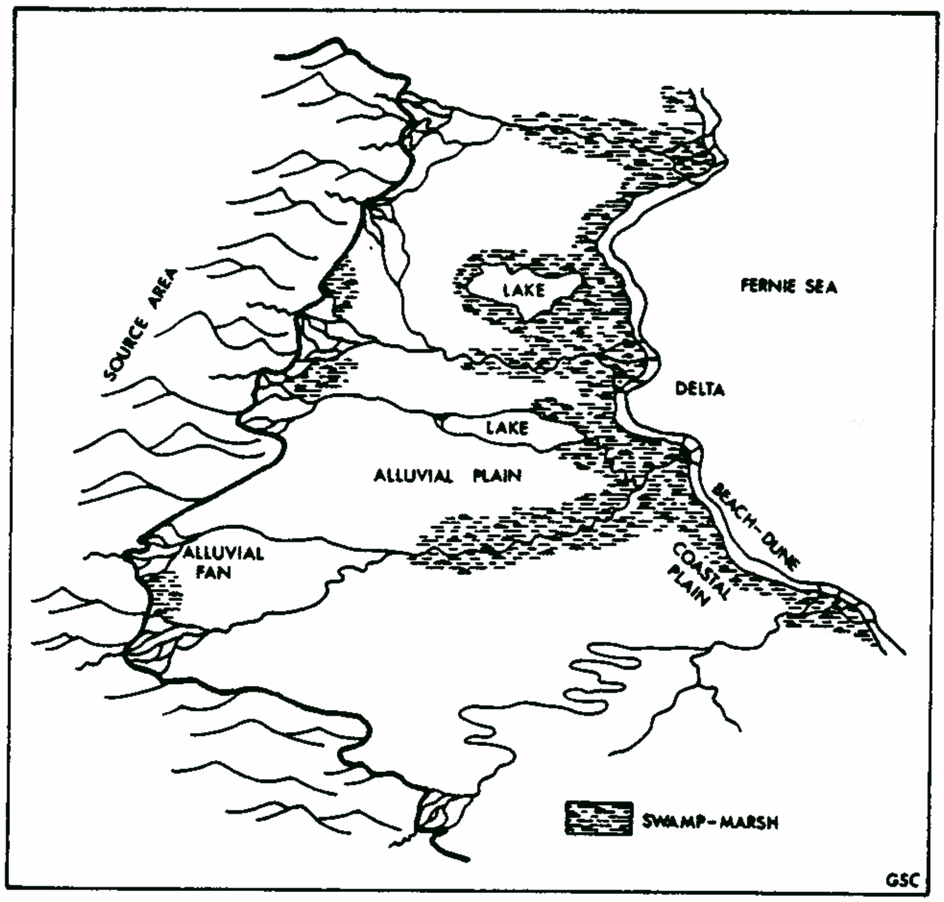


Figure 28. Schematic paleogeographic map illustrating environments of deposition of Kootenay Group (from Gibson, 1985).

Coastal plain mire facies

The coastal plain-mire facies is characterized by peat swamps (mires) that developed in some kind of marine coastal association. High-sulfur contents can be expected if the peat was covered by marine sediments. Raised mires or mires that developed some distance landward of active shorelines or at a much later time than active clastic sedimentation, can be expected to be low in ash and sulfur. McCabe (1984) points out that in order to form thick, clean coals in coastal settings a considerable time and/or geographic distance must have existed between shelf sedimentation and mire development. McCabe (op.cit.) also suggests raised mires as a way of producing thick, clean coals. McCabe et al. (in prep.) and Macdonald et al. (1987) suggest a coastal plain setting - some distance landward of shorelines - for the Drumheller and Belly River coastal coals in the Upper Cretaceous in the plains region. Gibson (1985) claims no convincing evidence has ever come forth for the existence of brackish or marine sediments above the Morrissey Formation.

The number 4 coal seams in the Crowsnest Pass area are from the coastal-mire facies. The lower number 4 seam immediately overlies the Morrissey Formation, which is interpreted in this study to be some kind of a shallow shelf deposit (figures 21 and 24). The lower number 4 seam at the Grassy Mountain type section (figure 24) is only 2 m thick, contains one major split, and even the ash content in the coaly portion tends to be high (19-42%). The equivalent seam at Adanac minesite (figure 21) is also less than 1 m thick, with moderately high inherent ash contents (18%). At Grassy Mountain sulfur shows a slight tendency to increase upward in the seam and shows an inverse relationship with ash. High ash values at the base of the seam are associated with lower sulfur values compared to the top of the seam. This inverse relationship between ash and sulfur was noted by Hackney (1983) in British coals. Hackney (op. cit.) explains this as being related to sulfur concentrating bacteria, in the original mire environment, thriving in an anaerobic environment. High ash content represents depositional events that brought in oxygenated waters, causing bacterial action to cease or be suppressed. The major split in the lower number 4 seam (this study) shows a very low sulfur content (0.20%) which would tend to support the Hackney (op. cit.) idea. The form that sulfur takes in these coals is not known, making the distinction between the three possible stages of sulfur emplacement as described by Davies and Raymond, 1983 difficult to discern.

This evidence would tend to support the idea that these coastal mires developed some distance inland, though perhaps not as far as the distances suggested by the generalized coaltal plain model. The other possibility is the peats formed in raised mires, proximal to active shorelines. The relatively high ash content in seams 4 would tend not to support the raised mire theory. Hence, back barrier or lower delta plain settings are not likely, because coal thicknesses would be much less and ash contents are generally higher in such environments. The number 4 seam(s) likely formed in low-lying mires on the sand platform deposited by the Morrissey Formation. The mire was periodically subjected to active clastic deposition. Rooting is fairly common below the seam, tending to support an autochthonous origin.

Thick coastal plain coals are known to occur in the Fernie Basin region and immediately overly the Morrissey Formation (Balmer seam, Gibson and Hughes, 1981). These coals represent the more westward better developed coastal plain coals, as predicted by the general model. The Crowsnest Pass coals (seam 4, upper and lower) represent the less developed, mid to proximal positional mires.

Alluvial plain (fluvial-distal) mire facies

This facies is thought to have formed in an overall alluvial plain setting, well removed from both marine and major fluvial systems. Strata above and below the coals are from fluvial, lacustrine, or floodplain origin. All of these coal seams in this facies tend to be very thick (>4.0 m, depositionally), and are of economic importance. These coals tend to have very few partings, and are often tectonically thickened. The number 2 seam in the eastern Crowsnest Pass, and the number 4 and 5 seams at Tent Mountain are characteristic of this facies.

All of these fluvial-distal mire facies coals have some unique coal quality parameters. Sulfur in all of these coals tends to increase away from the center of the seam, and reach a maximum at the top and base of the seam. Sulfur values will typically be in the 0.20% range in the middle of the seam, and double or sometimes triple toward the top and bottom. This pattern has been long recognized by many workers in coal geology (Chandra et al. 1983; Gluskoter and Simon 1968). Gluskoter and Simon (op. cit.) explains this pattern in Illinois coals as being related to the very early diagenetic environment in which the seam base and top contacts with underlying and overlying strata would represent a boundary in which geochemical conditions would be expected to change. This would make the upper and lower parts of the seam ideal locations for iron sulfide precipitation. It is important to note, however, that the Illinois coals are associated with overlying marine sediments and that high sulfur in this context can be up to 8.0%, compared to the relatively high values in this study of 0.69%. The same process may still explain the relative increase in sulfur at the top and base of the seam in this study.

The inherent ash content in this facies is relatively low and usually shows a fluctuating vertical variation within the seam. Some inverse relationships with sulfur, as suggested by Hackney (1983), do occur (figure 23, West Grassy Mountain). Seam 5 at Tent Mountian (figure 26) shows high ash-high sulfur (base of the seam), high ash - low sulfur (samples 12 and 16), and low ash-low sulfur (samples 13 and 14, center of seam) relationships. Three different processes may have been operative to form these relationships. The high ash-low sulfur relationship may be explained by the Hackney (op. cit.) idea, as both of these regions in seam 5 that show this relationship is associated with "upward-ashing" versus "stable" sulfur geochemical patterns (figure 26). The low sulfur-low ash regions may be related to the time of maximum mire development well removed from clastic sources with very little sulfur and/or iron-bearing waters. The high ash-high sulfur relationship occurs at the base of the number 5 seam, and is probably a result of early peats forming while the final stages of fluvial abandonment were still active (i.e. yielding high ash) and the later early diagenetic enrichment of sulfur along the seam/seatearth contact. The high ash and low sulfur relationship is also seen at seam 4, Tent Mountain (figure 26), but is believed to be related to thin partings being sheared into the middle of the seam through Laramide tectonism (see next major section).

The number 2 seam at Grassy Mountain is underlain by fluvial channel deposits (Hillcrest Member) and overlain by interbedded sandstone/claystones of floodplain origin. This sequence suggests a major fluvial event through the area, river avulsion and abandonment, mire development well away from fluvial activity and final destruction of the mire by resumption of fine-grained floodplain sedimentation. The number 5 seam at Tent Mountain shows a very similar sequence of a major meandering river system, fining upward and gradual abandonment, mire development (in place), and fairly abrupt return to high water levels with the formation of an extensive lacustrine environment (figure 27). Seam 4 at Tent Mountain shows almost the exact opposite depositional sequence; alternating shallow lacustrine/mire environment, progradation of a small lacustrine delta and a lowering of water tables, mire formation in place for several 10's of thousands of years - well removed from major fluvial activity, and finally a major braided river system moves in through the area, halting mire formation.

<u>Alluvial plain (fluvial-proximate) mire facies</u>

The fluvial-proximate mire facies characterizes coals that formed in a depositonal setting where mires (or parts of them) were forming in close association with fluvial systems of varying sizes. The number 1 in the eastern Crowsnest Pass area, the number 6 seam at Tent Mountain, and several thinner coals in both areas belong to this facies. Seams may be up to 5 m thick, however, much of this thickness consists of numerous partings (figures 21, 23 and 24). These partings are crevasse splays and thin claystone overbank deposits at regular intervals. This facies can grade into the fluvial-distal facies over a given geographic distance.

The geochemical pattern of coals in this facies frequently shows an upward increase in sulfur (figures 21, 23, and 24). Values up to 1.0% are present (section CNP-6, figure 27). One section shows an upward decrease in sulfur (CNP-4, North Vicary Creek). Inherent ash is generally in the 10 to 20% range, however, values up to 40% are not uncommon. This pattern has also been recognized by other workers (Chandra et al. 1983; Crelling et al 1983). Both authors attribute this pattern to an association with overlying marine strata. The coals examined in this facies do not seem to have any coastal or marine influence; therefore, the pattern observed may reflect an overall increasing supply of sulfur/and or iron as the mire developed.

The sequence of depositional environments preceding and succeeding this facies is typically; floodplain deposits with numerous crevasse splay or small channel deposits fining upward and passing gradationally upward into mire environments, mire with frequent crevasse splays or overbank interruptions, termination of mire formation by resumption of floodplain sedimentation or by larger fluvial systems.
Poor quality coals are the result of mires formed in this type of environment.

REGIONAL COALIFICATION AND STRUCTURAL DEFORMATON

Regional rank variations

Figure 3 provides information about regional rank variation. However, it should be realized that the area has been structurally shortened significantly since deposition of the coal-bearing strata. Consequently, in order to say something about the burial history, all data locations have to be palinspastically restored to their original location of deposition (Gibson 1985). Gibson shows a palinspastic isopach map of the Mist Mountain Formation. The additional ERCB and ARC data points could be easily plotted by interpolation between Gibson's sections (Gibson's data are listed as GSC-1 to 12 in table 7). Because the ERCB data are clustered in three areas, only selected ERCB points within the existing range of Volatile Matter were plotted and the resulting map is shown in figure 29. The thickness of the Mist Mountain Formation is shown by the isopach map as contoured by Gibson (1985). The Volatile Matter values can be hand contoured. The contours shown include the limits of ASTM rank classes of 31, 22 and 14% Volatile Matter, indicating that the rank at the base of the Mist Mountain Formation increases from high-volatile bituminous in southern Alberta, to medium-volatile bituminous in the Crowsnest Pass area, to low-volatile bituminous in the Highwood River area and to semi-anthracite in the Canmore area. Those isorank lines cut across the isopachs (figure 29).

It was first noticed by Norris (1971) that the isorank lines cut across the isopachs. He explained this by suggesting that the geothermal gradient may have been higher in the Canmore area than in southern Alberta, assuming that all coalification resulted from pre-Laramide sedimentary loading. However, Hughes and Cameron (1985) explain the high ranks in the Canmore area by post-deformational coalification resulting from loading by the Rundle Thrust sheet and inpart by a high geothermal gradient. Post-deformational coalification is also documented from deep oil and gas wells by England and Bustin (1986). However, as noted by these authors, relatively low rank coals occur south of the Crowsnest Pass area below the Lewis Thrust sheet, indicating that not all large thrust sheets cause increased levels of coalification. The increase in coalification from south to north in the disturbed belt has to be explained by a combination of variation in depth of burial, geothermal gradients and deformational history.

Depth of burial

The depth of burial can be inferred from published data, but is not very precise because of erosion in the mountains and foothills. Depth of burial in the plains gradually increases from east to west. This is also indicated by the isopachs of the Mist Mountain Formation (figure 29). The overlying Elk Formation and Blairmore/Alberta groups show a similar pattern. Hughes and Cameron (1985) assume 3800 m of burial for the base of the Mist Mountain Formation in the Canmore area.

In the western part of the Alberta plains, the top of the Jurassic is generally at 3 km depth. Nurkowski (1985) has estimated that in this area about 2 km of overburden has been removed by erosion, bringing the estimate of burial of the base of the Mist Mountain at 5 km. Based on isopachs of the Kootenay and Blairmore groups (Gibson, 1985 and Norris 1964 respectively) it seems reasonable to assume that the burial of the base of the Mist Mountain Formation increases from 5 km in the eastern part to possibly 7 km for the western part of the area. The length of time and depth of burial has subsequently been affected by the Laramide deformation. Undoubtedly varying geothermal gradients also played a role. All these factors together explain the regional coalification pattern shown by figure 29.

Effects of structural deformation

The effects of deformation on the quality of the Kootenay coals has further been investigated by Bustin (1982 & 1983) and Pearson & Grieve (1985). Extensive deposits of sheared coal are present in the study area, and even in areas of mild deformation the coal may be locally sheared.

At Tent Mountain (figure 26) the ash content of seam 4 increases toward the center of the seam, while the sulfur content decreases. The qualitative degree of tectonic shearing of the coal, observed in the field, also increases toward the center of the seam. Other variables such as V.M., F.C., C, and H all show tendencies to either increase or decrease away from the center of the seam. Bustin (1982) has shown the correlation of sheared coals and finer grain size, resulting in increased susceptibility to surface oxidation. Bustin (op. cit.) also showed that within oxidized near surface coal zones, the C and H values tend to increase and finally level off with increasing depth i.e. away from the zone of oxidation. In comparison, oxygen contents tend to decrease away from the near-surface weathered zone. Some of the variables measured within the vertical seam profile of this study show similar trends relative to the most intensely sheared coal. This suggests that shear zones within the number four seam at Tent Mountain can act as oxidation conduits down to great depths below the surface (section CNP-6, figure 26, was measured on a mine bench approximately 40 m below ground surface). The increase in ash in sheared coal may reflect both the greater susceptibility to shearing of coal with abundant rock partings and the dissemination of formerly discrete rock partings (Bustin, op. cit.).

Bustin (1983) studied the rank of coals close to thrust faults in the area, noticing only minor effects on rank very close to the faults. Pearson & Grieve (1985) documented syn-deformational coalification in the Fernie area (B.C.).

The thickening of coal seams in the hinges of folds has been documented by Bustin (1985) at Grassy Mountain and Tent Mountain. He also describes thickening by imbricate faulting at Vicary Creek and Tent Mountain. Fieldwork in July 1987 showed that similar thickening is present in the York Creek open pits. Drilling in this area confirms that the seam pinches and swells parallel to strike, resulting in mineable coal pods (P. Graham, Manalta Coal Ltd. pers. comm.). The exact nature of this thickening is still poorly understood and warrants further investigations.

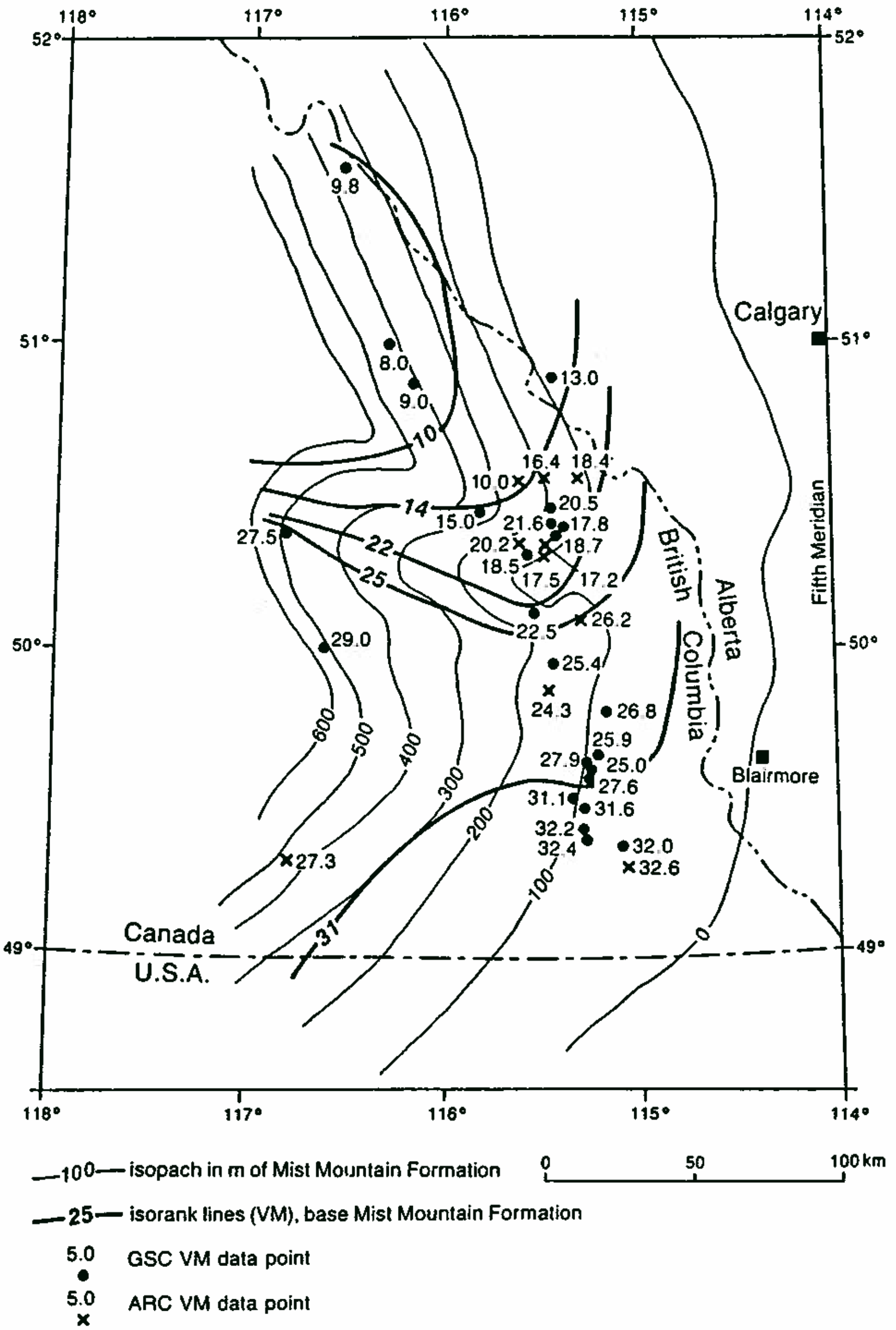


Figure 29.Palinspastic map showing isorank lines and isopachs of the Mist Mountain Formation (modified from Gibson, 1985).

CONCLUSIONS

1. Coal quality data in a digital format, for coals in the central and southern Rockies, are publicly available from the Energy Resources Conservation Board. The data consists primarily of proximate analysis, sulfur, and calorific value parameters, from some 333 individual coal analyses - representing approximately 77 coal exploration holes in this area. No stratigraphic information is publically available in this data (such as geologic formation or coal seam number), only depths from the surface are given.

2. Very little data on coal quality parameters for the utilization of coal for carbonization or combustion seems to be available outside of established minesites, where at least, F.S.I. measurements are present.

3. Coal quality values can be very different, depending upon how the coal is sampled, and on what basis it is reported. Local variations in coal quality can also be very high, within a given seam; however, the sulfur and inherent ash (i.e. not including partings) values examined in the detailed Crowsnest Pass study are generally less than the mean values reported in the regional study and rarely exceed the maximum values reported. The values reported for the regional study are probably reasonable first estimates for raw mineable coal intervals.

4. Three distinct depositional environment/coal quality facies can be recognized in the Crowsnest Pass area: mid to proximal-coastal plain mire facies that tend to have overall poor coal quality parameters, alluvial plain (fluvial-distal) mire facies that has produced very thick and high quality economic coals and an alluvial plain (fluvial-proximate) mire facies that often has thick seams but very high ash contents.

5. Standardized volatile matter values, plotted for the base of the

Kootenay Group, show a gradation of high-volatile bituminous coals in the area south of Crowsnest Pass to semi-anthracite in the Canmore area. The increase in coalification from south to north must be explained by a combination of varying depths of burial, geothermal gradients, and locally additional loading by thrust sheets.

6. Mean values for foothills/mountains coals are as follows (most on a dry basis): ash - 25.90%, FC - 51.49%, CV - 25582.08 Kj/kg, and S - 0.56%. Volatile matter, calorific value, and sulfur are the only variables that show a significant statistical difference between the Luscar and Kootenay Groups.

7. Pearson correlation coefficients were calculated to explore relationships within the variables. Strong negative linear correlations exist between ash to calorific value and ash to fixed carbon, as has been determined in other coalfields worldwide. Strong positive linear correlations exist between fixed carbon and calorific value. Correlations between components that, by methodology add up to 100% must be viewed with some caution. Calorific value in foothills/mountains coals can be predicted with the formulae:

   CV (dry) = 35574 - 383 *Ash (dry)

   Calorific value is also controlled by coal rank, as expressed by volatile matter content.

8. Measured stratigraphic sections of the Kootenay Group and coal seams sampled for proximate and ultimate analysis in the Crowsnest Pass area, suggest that mean in-seam values of C, FC and VM can be used to assist in local coal seam correlation.

9. In-seam coal quality chemistry profiles show increasing, decreasing, stable and fluctuating geochemical patterns. Sulfur increases at the top and base of the seam is related to the early diagenetic

environment, and in most cases, not to overlying marine strata. Ash is depositionally inversely and directly related to sulfur, at some locations. Ash can increase with a higher degree of tectonic shearing at the center of coal seams, while C values are reduced by shearing.

10. The inferred depth of burial for coals at the base of the Kootenay Group varies from 5 km in eastern regions to about 7 km in the western region.

11. Local tectonism causes shearing of the coal which makes it more susceptible to oxidation, and locally causes increased ash contents. Rank does not seem to be enhanced by proximity to major thrust faults. Structural thickening of coals occurs in anticlines and syncline axes and through imbricate thrusting.

12. Most of the coal quality variables examined are normally distributed, with the exception of moisture and sulfur. Standard parametric statistics can be applied to many of the data variables.

13. Volatile matter and fixed carbon show south to north trends for the Kootenay Group coals which reflect the increased rank of coals to the north. The regional distribution was obtained by vitrinite reflectance data from grab samples. The distribution of calorific values is remarkably constant over the area with the majority in the range of 34 to 36 Mj/kg (daf). The regional geographic distribution of the other coal quality parameters is difficult to comment on as yet. The data tends to be clustered into three or four small regions, and it is also not certain from what stratigraphic zone the coal samples were taken. In order to obtain a regional distribution more core analysis has to become available in outlying areas.

REFERENCES

Berkowitz, N, 1979. An Introduction to coal technology, New York. Academic Press.

Bonnell, G.W. and Janke, L.C. 1986. Analysis directory of Canadian commercial coals. CANMET Report 85-11E: (6) 350.

Bustin, R.M. (1982). The effect of shearing on the quality of some coals in the southeastern Canadian Cordillera. Canadian Institute of Mining and Metallurgy Bulletin 75: (841) 76-83.

Bustin, R.M. 1983. Heating during thrust faulty: friction or faction? Tectonophysics. 95: 305-328.

Bustin, R.M. (1985). Characteristics and mechanisms for the formation of structurally thickened coal deposits, southeastern Canadian Cordillera. In A.T. Cross (ed), Neuvieme Congres International de Stratigraphie et de geologie du Carbonifere. Compte Rendu. 4: 709-721.

Bustin, R.M., Cameron, A.R., Grieve, D.A. and Kalkreuth, W.D. (1985). Coal petrology, its principles, methods, and applications. Geological Association of Canada, Short Course Notes 3: 230.

Cameron, A.R. and Kalkreuth, W.D. 1982. Petrologic characteristics of Jurassic-Cretaceous coals in the Foothills and Rocky Mountains of Western Canada, Utah Geological and Mineral Survey. Bulletin 118, Proceedings - 5th ROMOCO Symposium. 1982, 163-167.

Chandra, D., Mazumdar, K. and S. Basumallick 1983. Distribution of sulfur in the Tertiary coals of Meghalaya, India. International Journal of Coal Geology 3: 63-75.

Crelling, J.C., Stutzman, P.E., and P.D. Robinson 1983. Evidence from the Herrin no. 6 coal seam for pre-and post-burial differences in the sulfur and mineral contents of peat, Proceedings of workshop on mineral matter in peat: its cccurrence, form and distribution, Raymond Jr., R. and Andrejko, M.J. eds. 113-121.

Davies, T.D. and Raymond, R., Jr. 1983. Sulfur as a reflection of depositional environments in peat and coals. In: Raymond, Jr., R. and Andrejko, M.J. (editors), Mineral Matter in Peat: Its occurrence, form and distribution. Los Alamos National Laboratory, Los Alamos, N.M. 113-121.

Edgington, E.S. (1980). Randomization tests: Marcel Dekker, New York. 287.

England, T.D.J. and Bustin, R.M. 1986. Effect of thrust faulting on organic maturation in the southeastern Canadian Cordillera. Advances in Organic Geochemistry 10: 609-616.

ENR 1986. Nordegg - Red Deer River sub-regional integrated resource Plan. Alberta Energy and Natural Resources, Technical Report Number T/1 - (10) 162.

ERCB 1986. Reserves of Coal, ERCB ST 87-31, Energy Resources Conservation Board.

Gibson, D.W. 1985. Stratigraphy, sedimentology and depositional environments of the coal-bearing Jurassic-Cretaceous Kootenay Group, Alberta and British Columbia. Bulletin 357, Geological Survey of Canada, 108.

Gibson, D.W. and D. Hughes 1981. Structure, stratigraphy, sedimentary environments and coal deposits of the Kootnay Group, Crowsnest Pass area. Field guide to geology and mineral deposits, GAC Annual Meeting, Calgary, 1981, 1-40.

Gluskotor, H.J. and Simon, J.A. 1968. Sulfur in Illinois coals, Illinois State Geological Survey. Circular 432: 27.

Hackney, A.M. 1983. Investigations into ash and sulfur impurities. Collery Guardian 231: (7) 353-356.

Hacquebard, P. and Donaldson, J. (1974). Rank studies of coals in the Rocky Mountains and inner Foothills Belt, Canada. In Carbononaceous materials as indicators of metamorphism. Edited by R. Dutcher, P. Hacquebard, J. Schopf and J. Simon. Geological Society of America, Special Paper 153: 75-94.

Horachek, Y. 1985. Geology of Alberta coal, in edt. T.H. Patching, Coal in Canada. Canadian Institute of Mining and Metallurgy, Special Volume 31: 115-133.

Hughes, J.D. and Cameron A.R. 1985. Lithology, depositional setting and coal rank-depth relationships in the Jurassic-Cretaceous Kootenay Group at Mount Allan, Cascade coal basin, Alberta, Paper 81-11, Geological Survey of Canada, 41.

Ignasiuk, B.S. (1974). Prediction of coke properties. In J.F. Fryer, J.D. Campbell, J.G. Speight: Symposium on coal evaluation, Alberta Research Council, Information Series 76, 70-80.

Jansa, L. 1972. Depositional history of the coal-bearing Upper Jurassic Lower Createaceous Kootenay Formation, Southern Rocky Mountains, Canada. Bulletin of the Geological Society of America 83: 3199-3222.

Kalkreuth, W. and Langenberg C. W. 1986. The timing of coalification in relation to structural events in the Grande Cache area, Alberta, Canada. Canadian Journal of Earth Science 23: 1103-1116.

Kalkreuth, W. and McMechan, M.E. 1984: Regional pattern of thermal matureation as determined from coal rank studies, Rocky Mountain Foothills and Frotn Ranges north of Grande Cache, Alberta-implications for petroleum exploration; Bulletin of Canadian Petroleum Geology 32: 249-271.

Langenberg, C. W. 1984. Structural and sedimentological framework of Lower Cretaceous coal-bearing rocks in the Grande Cache area, Alberta. In D.F. Stott and D.J. Glass, The Mesozoic of Middle North America. Canadian Society of Petroleum Geologists, Memoir 9, 533-540.

Langenberg, C.W. and McMechan, M.E. 1985. Lower Cretaceous Luscar Group (revised) of the northern and northcentral Foothills of Alberta. Bulletin of Canadian Petroleum Geology 33: 1-11.

Langenberg, C.W., Macdonald, D.E. and Richardson, R.J.H. (1986). Geological studies of coal in Alberta: A status report, Alberta Research Council, Openfile report 1986-14, 106.

Lillefors, H.W. (1967). On the Kolmogorov-Smirnov test for normality with mean and variance unknown. Journal American Statistical Association 62: (318) 399-402.

Mackowsky, M. -Th. 1982. The application of coal petrography in technical process; in Stach, E, Mackowski, M. -Th, Teichmuller, M, Taylor, G.H., Chandra, D, and Teichmuller, R, editors. Coal Petrology, 3rd edition, Gerbrunder Borntraeger, Berlin-Stuttgart 413-474.

Macdonald, D.E., Ross, T.C., McCabe, P.J. and A. Bosman. 1987. An evaluation of the coal resources of the Belly River Group , to a depth of 400 m, in the Alberta plains area. Alberta Geological Survey, Openfile Report 1987-8: 76.

McCabe, P.J. 1984. Depositional environments of coal and coal-bearing strata. Special publications of the International Association of Sedimentologists 7: 13-42.

McCabe, P.J., Strobl, R.S., Macdonald, D.E., Nurkowski, J.R. and Bosman, A. (in prep.). An evaluation of the coal resources of the Horseshoe Canyon Formation and laterally equivalent strata, to a depth of 400 m, in the Alberta plains area. Alberta Geological Survey, Openfile Report.

McLean, J.R. and Wall, J.H. 1981. The early Cretaceous Moosebar sea in Alberta. Bulletin of Canadian Petroleum Geology. 29: 334-377.

McLean, J.R. 1982. Lithostratigraphy of the Lower Creaceous coal-bearing sequence, Foothills of Alberta, Gological Survey of Canada. Paper 80-29: 46.

Mitchell, E.R. (1974). Coal properties bearing on combustion. In J.F. Fryer, J.D. Campbell, J.G. Speight: Symposium on coal evaluation. Alberta Research Council Information Series 76: 134-151.

Norris, D.K. 1959. Carbondale River, Alberta-British Columbia, Geological Survey of Canada. Map 5-1959.

Norris, D.K. 1959b. Type section of the Kootenay Formation, Grassy Mountain, Alberta. Alaberta Society of Petroleum Geologists, Journal 7: 223-233.

Norris, D.K. 1964. The Lower Cretaceous of the southeastern Canadian Cordillera. Bulletin of Canadian Petroleum Geologists, Field Conference Guidebook 12: 512-535.

Norris, D.K. 1971. The geology and coal potential of the Cascade Coal Basin; <u>In</u> A guide to the geology of the eastern Cordillera along the Trans Canada Highway between Calgary, Alberta and Revelstoke, British Columbia, I.A.R. Halladay and D.H. Mathewson, eds; Calgary. Alberta Society of Petroleum Geologists 25-39.

Nurkowski, J.R. 1985. Coal quality and rank variation within the Upper Cretaceous and Tertiary sediments, Alberta plains region Earth Science Report 85-1, Alberta Research Council 39.

Pearson, D.E. and D.A. Grieve. 1985. Rank variation, coalification pattern and coal quality in the Crowsnest coalfield, British Columbia. Canadian Institute of Mining and Metallurgy 78:(881) 39-46.

Price, J.T. and Gransden, J.F. 1987. Metallurgical coals in Western Canada: Resources, Research and Utilization. CANMET, Report 87-2E

Renton, J.J. and R.V. Hidalgo 1975. Some geochemical consideration of coal, West Virginia Geological and Economic Survey. Coal-Geology Bulletin 4: 38.

Russell, B. 1985. A history of Western Philosophy Unwin Paperbacks, London, U.K. 842.

Shapiro, S.S and Wilk, M.B (1965). An Analysis of variance test for normality. Biometrika 52: 591-611.

Stansfield, E. and Lang, W.A. (1944). Coals of Alberta - their occurrence, analysis and utilization: Part V1 - analytical and technical data by coal areas. Alberta Research Council Report 35: 93-174.

Steiner, J., Williams, G.D. and Dickie, G.J. 1972. Coal deposits of Alberta Plains, In edt. G.B. Mellon, J.W. Kramers and E.J. Seagel. Proceedings First Geological Conference on Western Canadian Coal. 73-108.

Taylor, D.R. and Walker, R.G. 1981. Depositional environments and paleogeography in the Albian Moosebar Formation and adjacent fluvial Gladstone and Beaver Mines Formations, Alberta. Canadian Journal of Earth Sciences 21: 698=-714.

Teichmuller, M. and Teichmuller, R. 1968. Geological aspects of coal metamorphism; in Coal and coal-bearing strata, D. Murchison and T.S. Westoll, editors, New York. American Elsevier Publishing Company 233-267.

Ward, C.R. (1984). Coal Geology and Coal Technology. Blackwell Scientific Publications :345.

Wiese, J.R. (Jr.) and Fyfe, W.S. 1986. Occurrence of iron sulfides in Ohio coals. International Journal of Coal Geology 6: 251-276.

Wong, R, Strobl, R.S., Krzanowski, R., Chidambaram, N. 1987. Exploratory statistical analysis of coal quality at the Highvale Mine, (Ardley coal zone), central Alberta. Alberta Geological Survey, Internal Report :88.

Appendix 1.

Proximate analysis, ERCB data - Kootenay Group coals

KOOTENAY GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters) (UTM)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Proximate Ash	Volatile Matter	Fixed Carbon	Calorific value kj/kg	Sulfur
1	1	5482149	688368	120.09	120.40	0.31	1	17.30	29.24	53.46	28908	0.49
							2		35.36	64.64	34955	0.59
2	2	5482149	688368	119.48	120.09	0.61	1	24.77	24.32	50.91	25777	0.45
							2		32.33	67.67	34264	0.60
3	3	5482149	688368	118.87	119.48	0.61	1	25.17	24.23	50.60	25835	0.53
							2		32.38	67.62	34525	0.71
4	4	5482149	688368	118.26	118.87	0.61	1	36.98	19.51	43.51	21181	0.40
							2		30.96	69.04	33610	0.63
5	1	5483277	687952	81.38	81.99	0.61	1	43.11	21.53	35.36	19031	1.26
							2		37.84	62.16	33452	2.21
6	2	5483277	687952	74.07	74.55	0.48	1	34.21	22.86	42.93	22767	0.39
							2		34.75	65.25	34606	0.59
7	3	5483277	687952	73.46	74.07	0.61	1	27.47	19.34	53.19	24690	0.35
							2		26.66	73.34	34041	0.48
8	4	5483277	687952	72.85	73.46	0.61	1	20.94	18.55	60.51	26965	0.36
							2		23.46	76.54	34107	0.46
9	5	5483277	687952	26.09	26.52	0.43	1	45.74	21.58	32.68	17799	0.39
							2		39.77	60.23	32803	0.72
10	6	5483277	687952	23.47	24.08	0.61	1	28.53	24.29	47.18	24323	0.55
							2		33.99	66.01	34032	0.77
11	7	5483277	687952	22.86	23.47	0.61	1	18.84	23.88	57.28	27658	0.45
							2		29.42	70.58	34078	0.55
12	8	5483277	687952	22.25	22.86	0.61	1	24.50	19.27	56.23	25381	0.46
							2		25.52	74.48	33617	0.61
13	9	5483277	687952	21.64	22.25	0.61	1	35.57	23.46	40.97	21457	0.33
							2		36.41	63.59	33303	0.51
14	10	5483277	687952	21.03	21.64	0.61	1	24.97	24.92	50.11	25612	0.46
							2		33.21	66.79	34136	0.61
15	11	5483277	687952	88.09	88.39	0.30	1	17.05	25.71	57.24	29042	0.54
							2		30.99	69.01	35011	0.65
16	12	5483277	687952	87.48	88.09	0.61	1	26.26	23.34	50.40	25307	0.51
							2		31.65	68.35	34319	0.69
17	13	5483277	687952	86.87	87.48	0.61	1	26.47	23.18	50.35	25442	0.52
							2		31.52	68.48	34601	0.71
18	14	5483277	687952	86.26	86.87	0.61	1	36.42	19.41	44.17	21625	1.11
							2		30.53	69.47	34012	1.75
19	15	5483277	687952	20.36	20.73	0.37	1	45.96	21.38	32.66	18764	1.61
							2		39.56	60.44	34722	2.98
20	16	5483277	687952	14.63	15.24	0.61	1	26.04	32.60	41.36	25163	2.09
							2		44.08	55.92	34022	2.83
21	1	5484370	687513	86.56	87.33	0.77	1	19.60	26.69	53.71	28261	0.57
							2		33.20	66.80	35150	0.71
22	2	5484370	687513	85.95	86.56	0.61	1	30.54	23.13	46.33	23579	0.51
							2		33.30	66.70	33946	0.73
23	3	5484370	687513	85.34	85.95	0.61	1	21.26	24.64	54.10	27507	0.55
							2		31.29	68.71	34934	0.70
24	4	5484370	687513	84.73	85.34	0.61	1	17.16	25.26	57.28	28921	0.59
							2		30.49	69.15	34912	0.71
25	5	5484370	687513	84.12	84.73	0.61	1	37.05	20.74	42.21	21199	1.28
							2		32.95	67.05	33676	2.03

KOOTENAY GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Proximate Ash	Volatile Matter	Fixed Carbon	Calorific value kj/kg	Sulfur
26	6	5484370	687513	75.29	75.90	0.61	1	28.47	23.62	47.91	24716	0.39
							2		33.02	66.98	34553	0.55
27	7	5484370	687513	74.68	75.29	0.61	1	23.20	23.23	53.57	26344	0.40
							2		30.25	69.75	34302	0.52
28	8	5484370	687513	74.07	74.68	0.61	1	25.47	19.79	54.74	25207	0.35
							2		26.55	73.45	33821	0.47
29	9	5484370	687513	64.01	64.31	0.30	1	26.92	29.18	43.90	25639	0.62
							2		39.93	60.07	35083	0.85
30	10	5484370	687513	61.57	62.18	0.61	1	44.08	22.84	33.08	18638	0.45
							2		40.84	59.16	33330	0.80
31	11	5484370	687513	60.96	61.57	0.61	1	26.56	22.95	50.49	25030	0.48
							2		31.25	68.75	34082	0.65
32	12	5484370	687513	56.69	57.30	0.61	1	16.42	28.87	54.71	28787	0.60
							2		34.54	65.46	34442	0.72
33	13	5484370	687513	56.08	56.69	0.61	1	17.00	25.31	57.69	28808	0.51
							2		30.49	69.51	34708	0.61
34	14	5484370	687513	50.29	50.90	0.61	1	35.96	22.52	41.52	21218	0.47
							2		35.17	64.83	33132	0.73
35	15	5484370	687513	49.68	50.29	0.61	1	28.50	22.40	49.10	23930	0.48
							2		31.33	68.67	33469	0.67
36	17	5484370	687513	48.16	48.65	0.49	1	41.43	22.26	36.31	19178	0.45
							2		38.01	61.99	32744	0.77
37	18	5484370	687513	46.02	46.45	0.43	1	23.66	24.12	52.22	26226	0.48
							2		31.60	68.40	34354	0.63
38	19	5484370	687513	45.42	46.02	0.60	1	26.80	26.57	46.63	25298	0.55
							2		36.30	63.70	34560	0.75
39	20	5484370	687513	19.32	19.81	0.49	1	40.97	20.50	38.53	19827	0.48
							2		34.73	65.27	33588	0.81
40	21	5484370	687513	3.35	3.66	0.31	1	46.37	20.74	32.89	15324	0.34
							2		38.67	61.33	28574	0.63
41	22	5484370	687513	2.13	2.74	0.61	1	16.73	28.26	55.01	23865	0.25
							2		33.94	66.06	28660	0.30
42	23	5484370	687513	1.52	2.13	0.61	1	22.14	28.97	48.89	21597	0.21
							2		37.21	62.79	27738	0.27
43	24	5484370	687513	2.74	3.35	0.61	1	22.01	27.72	50.27	22711	0.29
							2		35.54	64.46	29120	0.37
44	1	5486268	686311	57.30	57.79	0.49	1	47.30	18.01	34.69	17447	0.23
							2		34.17	65.83	33106	0.44
45	2	5486268	686311	56.69	57.30	0.61	1	44.78	19.19	36.03	18373	0.33
							2		34.75	65.25	33272	0.60
46	3	5486268	686311	54.86	55.47	0.61	1	38.91	17.72	43.37	20843	0.29
							2		29.01	70.99	34119	0.47
47	4	5486268	686311	53.64	54.25	0.61	1	37.10	20.11	42.79	21676	0.36
							2		31.97	68.03	34461	0.57
48	1	5490303	686244	6.10	6.71	0.61	1	27.51	23.84	48.65	23658	0.45
							2		32.89	67.11	32636	0.62
49	2	5490303	686244	14.63	15.24	0.61	1	27.64	18.93	53.43	24544	0.28
							2		26.16	73.84	33919	0.39
50	3	5490303	686244	5.49	6.10	0.61	1	21.97	21.93	56.10	25742	0.40
							2		28.10	71.90	32990	0.51

KOOTENAY GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Proximate Ash	Volatile Matter	Fixed Carbon	Calorific value kj/kg	Sulfur
51	4	5490303	686244	4.27	4.72	0.45	1	24.99	19.36	55.65	24714	0.41
							2		25.81	74.19	32948	0.55
52	5	5490303	686244	3.66	4.27	0.61	1	22.02	20.26	57.72	25733	0.37
							2		25.98	74.02	32999	0.47
53	6	5490303	686244	3.05	3.66	0.61	1	24.31	23.23	52.46	24449	0.40
							2		30.69	69.31	32301	0.53
54	7	5490303	686244	8.00	10.00	2.00	1	34.35	22.05	43.60	21297	0.38
							2		33.59	66.41	32440	0.58
55	8	5490303	686244	1.83	2.44	0.61	1	11.59	27.39	61.02	28221	0.38
							2		30.98	69.02	31921	0.43
56	9	5490303	686244	1.22	1.83	0.61	1	19.90	27.35	52.75	23821	0.27
							2		34.14	65.86	29739	0.34
57	10	5490303	686244	0.61	1.22	0.61	1	29.13	24.62	46.25	20771	0.24
							2		34.74	65.26	29309	0.34
58	11	5490303	686244	0.00	0.61	0.61	1	35.92	24.52	39.56	17901	0.21
							2		38.26	61.74	27935	0.33
59	12	5490303	686244	42.67	43.28	0.61	1	31.73	20.96	47.31	23432	0.68
							2		30.70	69.30	34323	1.00
60	13	5490303	686244	138.00	140.00	2.00	1	26.33	22.65	51.02	25728	0.63
							2		30.75	69.25	34923	0.86
61	15	5490303	686244	34.29	34.90	0.61	1	34.77	24.54	40.69	22737	1.02
							2		37.62	62.38	34857	1.56
62	16	5490303	686244	29.41	30.02	0.61	1	35.17	18.98	45.85	22039	0.45
							2		29.28	70.72	33995	0.69
63	17	5490303	686244	19.20	19.51	0.31	1	26.89	24.18	48.93	26156	0.47
							2		33.07	66.93	35776	0.64
64	18	5490303	686244	18.59	19.20	0.61	1	33.20	22.10	44.70	22844	0.39
							2		33.08	66.92	34198	0.58
65	19	5490303	686244	16.46	17.07	0.61	1	15.05	22.66	62.29	29556	0.34
							2		26.67	73.33	34792	0.40
66	20	5490303	686244	15.85	16.46	0.61	1	19.98	19.69	60.33	27819	0.29
							2		24.61	75.39	34765	0.36
67	21	5490303	686244	15.24	15.85	0.61	1	25.77	20.30	53.93	25267	0.27
							2		27.35	72.65	34039	0.36
68	22	5490303	686244	14.02	14.63	0.61	1	28.89	20.13	50.98	24053	0.31
							2		28.31	71.69	33825	0.44
69	23	5490303	686244	13.41	14.02	0.61	1	18.12	20.09	61.79	28594	0.36
							2		24.54	75.46	34922	0.44
70	22	5491347	682044	44.97	62.38	17.41	1	34.07	21.54	44.39	21696	0.26
							2		32.67	67.33	32908	0.39
71	1	5491281	685048	19.20	19.81	0.61	1	32.92	24.03	43.05	22939	0.55
							2		35.82	64.18	34196	0.82
72	2	5491281	685048	16.64	17.25	0.61	1	39.01	22.67	38.32	20862	0.59
							2		37.17	62.83	34206	0.97
73	3	5491281	685048	14.02	14.63	0.61	1	31.03	24.93	44.04	23693	0.37
							2		36.15	63.85	34353	0.54
74	4	5491281	685048	81.38	81.99	0.61	1	26.28	26.36	47.36	25667	0.38
							2		35.76	64.24	34817	0.52
75	5	5491281	685048	80.77	81.38	0.61	1	41.73	20.96	37.31	19145	0.27
							2		35.97	64.03	32856	0.46

KOOTENAY GROUP DATA

Basis: 1 = Dry   2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Proximate Ash	Volatile Matter	Fixed Carbon	Calorific value kj/kg	Sulfur
76	6	5491281	685048	80.16	80.77	0.61	1	39.48	23.34	37.18	20187	0.27
							2		38.57	61.43	33356	0.45
77	7	5491281	685048	79.55	80.16	0.61	1	22.23	22.33	55.44	26602	0.27
							2		28.71	71.29	34206	0.35
78	8	5491281	685048	78.94	79.55	0.61	1	17.53	23.98	58.49	28310	0.26
							2		29.08	70.92	34328	0.32
79	9	5491281	685048	78.33	78.94	0.61	1	18.77	23.67	57.56	27812	0.24
							2		29.14	70.86	34239	0.30
80	10	5491281	685048	77.72	78.33	0.61	1	15.82	22.31	61.87	29112	0.26
							2		26.50	73.50	34583	0.31
81	11	5491281	685048	77.11	77.72	0.61	1	7.87	26.74	65.39	32485	0.30
							2		29.02	70.98	35260	0.33
82	12	5491281	685048	76.50	77.11	0.61	1	17.49	25.55	56.96	28870	0.33
							2		30.97	69.03	34990	0.40
83	13	5491281	685048	75.90	76.50	0.60	1	26.07	22.14	51.79	25407	0.28
							2		29.95	70.05	34366	0.38
84	14	5491281	685048	75.29	75.90	0.61	1	22.85	22.70	54.45	26361	0.26
							2		29.42	70.58	34169	0.34
85	15	5491281	685048	74.68	75.29	0.61	1	13.33	25.14	61.53	29964	0.27
							2		29.01	70.99	34573	0.31
86	16	5491281	685048	74.07	74.68	0.61	1	20.71	23.17	56.12	27093	0.24
							2		29.22	70.78	34170	0.30
87	17	5491281	685048	73.46	74.07	0.61	1	17.54	22.55	59.91	28312	0.24
							2		27.35	72.65	34334	0.29
88	18	5491281	685048	72.85	73.46	0.61	1	20.84	23.22	55.94	27063	0.25
							2		29.33	70.67	34188	0.32
89	19	5491281	685048	72.24	72.85	0.61	1	9.47	26.07	64.46	31696	0.29
							2		28.80	71.20	35012	0.32
90	20	5491281	685048	71.63	72.24	0.61	1	13.25	23.91	62.84	30387	0.28
							2		27.56	72.44	35028	0.32
91	21	5491281	685048	71.02	71.63	0.61	1	19.11	22.79	58.10	28000	0.30
							2		28.17	71.83	34615	0.37
92	1	5492859	685847	22.86	23.47	0.61	1	42.19	21.46	36.35	19664	0.45
							2		37.12	62.88	34015	0.78
93	2	5492859	685847	22.25	22.86	0.61	1	22.44	25.62	51.94	26775	0.45
							2		33.03	66.97	34522	0.58
94	3	5492859	685847	21.64	22.25	0.61	1	19.46	23.03	57.51	28182	0.45
							2		28.59	71.41	34991	0.56
95	4	5492859	685847	21.03	21.64	0.61	1	37.40	20.73	41.87	20594	0.33
							2		33.12	66.88	32898	0.53
96	5	5492859	685847	20.42	21.03	0.61	1	49.85	18.87	31.28	16301	0.32
							2		37.63	62.37	32504	0.64
97	6	5492859	685847	19.81	20.42	0.61	1	30.88	19.99	49.13	23334	0.38
							2		28.92	71.08	33759	0.55
98	7	5492859	685847	19.20	19.81	0.61	1	30.60	22.30	47.10	23434	0.40
							2		32.13	67.87	33767	0.58
99	8	5492859	685847	18.59	19.20	0.61	1	33.57	22.48	43.95	22546	0.39
							2		33.84	66.16	33939	0.59
100	9	5492859	685847	17.98	18.59	0.61	1	34.58	23.83	41.59	22192	0.39
							2		36.43	63.57	33922	0.60

KOOTENAY GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Proximate Ash	Volatile Matter	Fixed Carbon	Calorific value kj/kg	Sulfur
101	10	5492859	685847	17.37	17.98	0.61	1	16.08	27.27	56.65	28640	0.42
							2		32.50	67.50	34128	0.50
102	11	5492859	685847	16.15	16.76	0.61	1	28.08	21.33	50.59	24342	0.34
							2		29.66	70.34	33846	0.47
103	12	5492859	685847	15.54	16.15	0.61	1	13.43	23.14	63.43	30305	0.42
							2		26.73	73.27	35006	0.49
104	13	5492859	685847	14.94	15.54	0.60	1	17.87	23.08	59.05	28633	0.36
							2		28.10	71.90	34863	0.44
105	14	5492859	685847	14.33	14.94	0.61	1	9.49	24.65	65.86	32231	0.38
							2		27.23	72.77	35610	0.42
106	15	5492859	685847	13.72	14.33	0.61	1	29.68	24.49	45.83	22886	0.31
							2		34.83	65.17	32546	0.44
107	16	5492859	685847	12.19	12.80	0.61	1	25.09	20.58	54.33	25526	0.34
							2		27.47	72.53	34076	0.45
108	17	5492859	685847	11.58	12.19	0.61	1	34.83	18.50	46.67	22225	0.32
							2		28.39	71.61	34103	0.49
109	18	5492859	685847	10.97	11.58	0.61	1	30.91	24.65	44.44	24376	0.64
							2		35.68	64.32	35282	0.93
110	19	5492859	685847	10.36	10.97	0.61	1	35.41	18.06	46.53	22374	0.37
							2		27.96	72.04	34640	0.57
111	20	5492859	685847	9.75	10.36	0.61	1	28.57	20.42	51.01	24421	0.40
							2		28.59	71.41	34189	0.56
112	21	5492859	685847	9.14	9.75	0.61	1	37.10	18.72	44.18	21355	0.40
							2		29.76	70.24	33951	0.64
113	22	5492859	685847	4.57	5.18	0.61	1	48.90	18.04	33.06	16861	0.50
							2		35.30	64.70	32996	0.98
114	23	5492859	685847	236.00	238.00	2.00	1	37.11	21.25	41.64	21371	1.35
							2		33.79	66.21	33982	2.15
115	24	5492859	685847	70.71	71.20	0.49	1	38.36	17.82	43.82	20692	0.42
							2		28.91	71.09	33569	0.68
116	25	5492859	685847	68.88	69.49	0.61	1	10.90	28.02	61.08	31757	0.69
							2		31.45	68.55	35642	0.77
117	26	5492859	685847	64.62	65.23	0.61	1	23.06	25.72	51.22	26944	0.57
							2		33.43	66.57	35019	0.74
118	27	5492859	685847	65.23	65.84	0.61	1	28.52	26.78	44.70	25156	0.87
							2		37.47	62.53	35193	1.22
119	28	5492859	685847	33.22	33.83	0.61	1	39.24	18.87	41.89	20462	0.31
							2		31.06	68.94	33677	0.51
120	29	5492859	685847	33.83	34.44	0.61	1	24.92	21.42	53.66	25919	0.37
							2		28.53	71.47	34522	0.49
121	30	5492859	685847	34.44	35.05	0.61	1	21.51	21.52	56.97	27470	0.37
							2		27.42	72.58	34998	0.47
122	31	5492859	685847	32.61	33.22	0.61	1	25.83	20.43	53.74	25586	0.37
							2		27.54	72.46	34496	0.50
123	32	5492859	685847	35.05	35.36	0.31	1	45.40	16.98	37.62	18454	0.28
							2		31.10	68.90	33799	0.51
124	33	5492859	685847	36.58	37.06	0.48	1	37.22	20.97	41.81	21778	0.43
							2		33.40	66.60	34689	0.68
125	34	5492859	685847	12.80	13.41	0.61	1	28.41	21.52	50.07	24632	0.32
							2		30.06	69.94	34407	0.45

KOOTENAY GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Proximate Ash	Volatile Matter	Fixed Carbon	Calorific value kj/kg	Sulfur
126	4	5503918	685481	4.60	5.00	0.40	1	14.3	24.40	61.30	30601	0.64
							2		28.47	71.53	35707	0.75
127	8	5503918	685481	25.15	35.69	10.54	1	23.1	20.90	56.00	27093	0.37
							2		27.18	72.82	35231	0.48
128	1	5503680	685471	79.37	79.61	0.24	1	13.5	23.90	62.60	30936	0.52
							2		27.63	72.37	35764	0.60
129	1	5504626	685639	28.99	38.68	9.69	1	22.1	21.80	56.10	27512	0.29
							2		27.98	72.02	35317	0.37
130	18	5504626	685639	44.71	49.13	4.42	1	18.3	22.00	59.70	28952	0.30
							2		26.93	73.07	35437	0.37
131	4	5504145	685579	37.80	39.01	1.21	1	22.4	21.40	56.20	27354	0.62
							2		27.58	72.42	35250	0.80
132	4	5504460	685552	19.45	22.71	3.26	1	24.2	23.30	52.50	26735	0.44
							2		30.74	69.26	35270	0.58
133	4	5504432	685562	19.35	25.91	6.56	1	21.9	22.70	55.40	27596	0.35
							2		29.07	70.93	35334	0.45
134	2	5504267	685619	21.34	37.80	16.46	1	21.4	21.40	57.20	27763	0.41
							2		27.23	72.77	35322	0.52
135	1	5504366	685619	28.96	31.00	2.04	1	24.7	20.30	55.00	26479	0.45
							2		26.96	73.04	35165	0.60
136	1	5504370	685598	8.72	13.69	4.97	1	18.8	22.50	58.80	28663	0.39
							2		27.71	72.41	35299	0.48
137	4	5505756	685623	27.74	34.72	6.98	1	28.1	20.10	51.80	24921	0.37
							2		27.96	72.04	34661	0.51
138	4	5505529	685506	32.28	35.51	3.23	1	33.3	20.00	46.70	23262	0.41
							2		29.99	70.01	34876	0.61
139	4	5505646	685559	9.11	15.79	6.68	1	22.1	22.90	55.00	27491	0.61
							2		29.40	70.60	35290	0.78
140	8	5505646	685559	33.31	38.25	4.94	1	23.0	19.90	57.10	27186	0.51
							2		25.84	74.16	35306	0.66
141	5	5505737	685691	11.13	12.86	1.73	1	27.2	18.50	54.30	25167	0.39
							2		25.41	74.59	34570	0.54
142	9	5505737	685691	7.16	10.67	3.51	1	8.8	22.70	68.50	32404	0.38
							2		24.89	75.11	35531	0.42
143	26	5505737	685691	19.81	23.10	3.29	1	27.4	19.80	52.70	25102	0.64
							2		27.27	72.59	34576	0.88
144	1	5591506	671087	242.44	243.30	0.86	1	32.4	14.20	53.40	23216	0.45
							2		21.01	78.99	34343	0.67
145	2	5591506	671087	372.88	373.88	1.00	1	41.5	13.30	45.20	19199	0.43
							2		22.74	77.26	32819	0.74
146	3	5591506	671087	373.88	375.70	1.82	1	35.5	13.70	50.80	23200	0.44
							2		21.24	78.76	35969	0.68
147	1	5591350	671022	405.08	413.00	7.92	1	20.5	14.90	64.60	.	.
							2		18.74	81.26	.	.
148	1	5591787	671234	.	.	.	1	18.4	15.90	65.70	.	.
							2		19.49	80.51	.	.
149	3	5591787	671234	.	.	.	1	12.9	15.70	71.40	.	.
							2		18.03	81.97	.	.
150	2	5594337	669737	245.00	255.30	10.30	1	10.3	18.60	71.10	32657	0.68
							2		20.74	79.26	36407	0.76

KOOTENAY GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Proximate Ash	Volatile Matter	Fixed Carbon	Calorific value kj/kg	Sulfur
151	3	5594337	669737	292.20	292.43	0.23	1	25.90	13.70	60.40	23874	0.71
							2		18.49	81.51	32219	0.96
152	1	5594225	670042	132.90	137.50	4.60	1	19.70	14.00	66.30	28954	0.57
							2		17.43	82.57	36057	0.71
153	2	5594225	670042	144.50	147.00	2.50	1	23.90	13.80	62.30	28142	0.57
							2		18.13	81.87	36980	0.75
154	4	5594225	670042	52.00	55.62	3.62	1	13.30	17.70	69.00	31292	0.61
							2		20.42	79.58	36092	0.70
155	1	5593926	669224	57.61	59.74	2.13	1	8.60	17.60	73.80	.	.
							2		19.26	80.74	.	.
156	3	5593926	669224	62.18	64.62	2.44	1	8.20	17.90	73.90	.	.
							2		19.50	80.50	.	.
157	5	5593926	669224	65.53	70.41	4.88	1	29.80	18.50	51.70	.	.
							2		26.35	73.65	.	.
158	1	5594262	669549	336.80	337.41	0.61	1	24.10	14.70	61.20	.	.
							2		19.37	80.63	.	.
159	3	5594262	669549	351.13	353.57	2.44	1	30.90	13.40	55.70	.	.
							2		19.39	80.61	.	.
160	10	5596979	668571	338.33	346.25	7.92	1	48.30	10.80	40.90	.	.
							2		20.89	79.11	.	.
161	11	5596979	668571	274.93	281.64	6.71	1	45.20	11.80	43.00	.	.
							2		21.53	78.47	.	.
162	12	5596979	668571	269.44	274.62	5.18	1	44.30	12.80	42.90	.	.
							2		22.98	77.02	.	.
163	13	5596979	668571	241.10	242.32	1.22	1	34.00	15.80	50.20	.	.
							2		23.94	76.06	.	.
164	1	5598865	668312	77.25	78.82	1.57	1	13.00	16.60	70.40	31313	0.63
							2		19.08	80.92	35992	0.72
165	6	5598865	668312	108.02	109.23	1.21	1	32.20	13.80	54.00	24086	1.10
							2		20.35	79.65	35525	1.62
166	9	5598865	668312	135.82	141.43	5.61	1	26.20	15.40	58.40	26016	0.40
							2		20.87	79.13	35252	0.54
167	1	5652019	622826	.	.	.	1	22.31	10.95	66.74	27717	0.60
							2		14.09	85.91	35676	0.77
168	2	5652019	622826	.	.	.	1	14.15	10.99	74.86	30433	0.65
							2		12.80	87.20	35449	0.76
169	3	5652019	622826	.	.	.	1	17.03	10.75	72.22	29680	0.64
							2		12.96	87.04	35772	0.77
170	1	5652689	622134	.	.	.	1	5.60	9.80	85.10	.	0.71
							2		10.38	90.15	.	0.75
171	2	5652689	622134	.	.	.	1	4.80	8.60	86.60	.	0.64
							2		9.03	90.97	.	0.67
172	3	5652689	622134	.	.	.	1	10.00	11.60	78.40	.	0.61
							2		12.89	87.11	.	0.68
173	4	5652689	622134	.	.	.	1	12.20	8.60	79.20	.	0.59
							2		9.79	90.21	.	0.67

Appendix 2.

Proximate analysis, ERCB data - Luscar Group coals

LUSCAR GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters) (UTM)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Proximate Ash	Volatile Matter	Fixed Carbon	Calorific value kj/kg	Sulfur
1	1	5747319	611363	.	.	.	1	23.1	22.40	54.50	27679	0.73
							2		29.13	70.87	35993	0.95
2	6	5777281	602978	24.3	25.7	1.4	1	13.6	21.50	64.90	30499	0.59
							2		24.88	75.12	35300	0.68
3	10	5777281	602978	24.3	25.7	1.4	1	41.8	15.50	42.70	19797	0.55
							2		26.63	73.37	34015	0.95
4	7	5779746	601237	84.6	90.7	6.1	1	34.1	19.80	46.10	22704	1.60
							2		30.05	69.95	34452	2.43
5	10	5779746	601237	84.6	90.7	6.1	1	28.6	20.60	50.80	24809	0.54
							2		28.85	71.15	34746	0.76
6	14	5779746	601237	84.6	90.7	6.1	1	31.1	19.10	49.80	23842	0.39
							2		27.72	72.28	34604	0.57
7	18	5779746	601237	84.6	90.7	6.1	1	30.6	21.10	48.30	23995	0.87
							2		30.40	69.60	34575	1.25
8	22	5779746	601237	42.5	45.8	3.3	1	41.5	19.40	39.10	19918	0.93
							2		33.16	66.84	34048	1.59
9	26	5779746	601237	42.5	45.8	3.3	1	44.6	18.00	37.40	19217	0.84
							2		32.49	67.51	34688	1.52
10	30	5779746	601237	42.5	45.8	3.3	1	20.7	24.20	55.10	28135	1.64
							2		30.52	69.48	35479	2.07
11	33	5779746	601237	84.6	90.7	6.1	1	32.2	22.80	45.00	23411	0.64
							2		33.63	66.37	34529	0.94
12	4	5783928	602053	62.5	65.5	3.0	1	22.3	23.70	54.00	27491	0.44
							2		30.50	69.50	35381	0.57
13	8	5783928	602053	24.0	27.5	3.5	1	9.4	29.10	61.50	32113	0.75
							2		32.12	67.88	35445	0.83
14	12	5783928	602053	24.0	27.5	3.5	1	32.0	21.70	46.30	23748	0.42
							2		31.91	68.09	34924	0.62
15	16	5783928	602053	24.0	27.5	3.5	1	32.4	23.30	44.30	23437	2.40
							2		34.47	65.53	34670	3.55
16	1	5784330	601871	31.7	35.4	3.7	1	25.0	24.60	50.40	26370	0.61
							2		32.80	67.20	35160	0.81
17	5	5784330	601871	31.7	35.4	3.7	1	49.8	16.80	33.40	16831	0.72
							2		33.47	66.53	33528	1.43
18	10	5784330	601871	31.7	35.4	3.7	1	13.4	26.00	60.60	31059	0.52
							2		30.02	69.98	35865	0.60
19	18	5784330	601871	31.7	35.4	3.7	1	17.1	25.50	57.40	29415	0.67
							2		30.76	69.24	35483	0.81
20	4	5783966	601821	1.8	3.7	1.9	1	48.0	19.00	33.00	17710	1.51
							2		36.54	63.46	34058	2.90
21	7	5783966	601821	1.8	3.7	1.9	1	21.8	28.80	49.40	27842	1.00
							2		36.83	63.17	35604	1.28
22	1	5784351	601447	8.9	10.7	1.8	1	47.2	18.10	34.70	18068	0.49
							2		34.28	65.72	34220	0.93
23	4	5784351	601447	8.9	10.7	1.8	1	25.9	22.20	51.90	25940	0.60
							2		29.96	70.04	35007	0.81
24	1	5784180	601719	.	.	.	1	31.8	21.80	46.40	23553	0.52
							2		31.96	68.04	34535	0.76
25	10	5783858	602215	22.1	25.8	3.7	1	21.7	24.80	53.50	27684	0.48
							2		31.67	68.33	35356	0.61

LUSCAR GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Proximate Ash	Volatile Matter	Fixed Carbon	Calorific value kj/kg	Sulfur
26	14	5783858	602215	22.1	25.8	3.7	1	12.3	28.30	59.40	31461	0.72
							2		32.27	67.73	35873	0.82
27	21	5783858	602215	22.1	25.8	3.7	1	45.3	19.20	35.50	18748	.
							2		35.10	64.90	34274	.
28	4	5783177	603297	44.2	48.8	4.6	1	29.2	22.10	48.70	24846	0.44
							2		31.21	68.79	35093	0.62
29	8	5783314	603455	64.9	67.5	2.6	1	31.5	20.80	47.70	23716	0.45
							2		30.36	69.64	34622	0.66
30	10	5783314	603455	30.4	33.5	3.1	1	28.2	23.00	48.80	24907	0.56
							2		32.03	67.97	34689	0.78
31	20	5783314	603455	64.9	67.5	2.6	1	44.3	18.10	37.60	18848	0.34
							2		32.50	67.50	33838	0.61
32	40	5783986	602954	169.8	173.0	3.2	1	28.8	22.40	48.80	24725	1.06
							2		31.46	68.54	34726	1.49
33	60	5783986	602954	129.5	132.6	3.1	1	17.3	25.60	57.10	29117	0.60
							2		30.96	69.04	35208	0.73
34	81	5783986	602954	129.5	132.6	3.1	1	39.0	20.30	40.70	20790	0.69
							2		33.28	66.72	34082	1.13
35	1	5783448	603590	73.4	75.7	2.3	1	29.8	22.50	47.70	24337	0.56
							2		32.05	67.95	34668	0.80
36	7	5783448	603590	73.4	75.7	2.3	1	47.7	18.60	33.70	17575	0.48
							2		35.56	64.44	33604	0.92
37	11	5783448	603590	30.3	34.2	3.9	1	41.6	19.40	39.00	20315	0.46
							2		33.22	66.78	34786	0.79
38	15	5783448	603590	30.3	34.2	3.9	1	29.4	21.90	48.70	24767	0.50
							2		31.02	68.98	35081	0.71
39	1	5784343	603123	56.9	66.1	9.2	1	27.4	26.50	46.10	25551	0.57
							2		36.50	63.50	35194	0.79
40	5	5784343	603123	56.9	66.1	9.2	1	28.1	24.30	47.60	25328	0.65
							2		33.80	66.20	35227	0.90
41	9	5784343	603123	56.9	66.1	9.2	1	21.5	25.20	53.30	27945	0.61
							2		32.10	67.90	35599	0.78
42	8	5784045	602822	114.8	118.4	3.6	1	8.0	28.60	63.40	32932	0.64
							2		31.09	68.91	35796	0.70
43	7	5783840	602525	24.6	27.8	3.2	1	35.2	21.90	42.90	22762	0.56
							2		33.80	66.20	35127	0.86
44	11	5783840	602525	24.6	27.8	3.2	1	18.6	25.20	56.20	28812	0.69
							2		30.96	69.04	35396	0.85
45	16	5783840	602525	24.6	27.8	3.2	1	28.2	22.30	49.50	25239	0.78
							2		31.06	68.94	35152	1.09
46	4	5783775	602733	42.2	45.0	2.8	1	35.6	21.70	42.70	22369	0.39
							2		33.70	66.30	34734	0.61
47	8	5783775	602733	42.2	45.0	2.8	1	30.8	21.40	47.80	24237	0.45
							2		30.92	69.08	35025	0.65
48	11	5783775	602733	42.2	45.0	2.8	1	10.9	30.30	58.80	31892	0.70
							2		34.01	65.99	35793	0.79
49	4	5783798	602998	69.8	73.1	3.3	1	23.3	24.90	51.80	27133	0.63
							2		32.46	67.54	35375	0.82
50	4	5783172	603522	19.8	19.8	0.0	1	27.1	21.20	51.70	25505	0.48
							2		29.08	70.92	34986	0.66

LUSCAR GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Proximate Ash	Volatile Matter	Fixed Carbon	Calorific value kj/kg	Sulfur
51	2	5785171	602671	61.9	64.7	2.8	1	20.1	23.90	56.00	28047	0.63
							2		29.91	70.09	35103	0.79
52	21	5785068	601363	.	.	.	1	50.0	17.90	32.10	17215	0.57
							2		35.80	64.20	34430	1.14
53	6	5784421	601939	44.1	46.9	2.8	1	17.6	26.00	56.40	29147	0.55
							2		31.55	68.45	35373	0.67
54	10	5784421	601939	102.1	104.5	2.4	1	41.0	19.40	39.60	19836	0.75
							2		32.88	67.12	33620	1.27
55	18	5784421	601939	102.1	104.5	2.4	1	49.6	16.90	33.50	16887	0.40
							2		33.53	66.47	33506	0.79
56	1	5784947	601249	35.6	40.3	4.7	1	41.4	22.60	36.00	19813	0.30
							2		38.57	61.43	33811	0.51
57	5	5784947	601249	35.6	40.3	4.7	1	29.3	23.10	47.60	24470	0.54
							2		32.67	67.33	34611	0.76
58	41	5784947	601249	35.6	40.3	4.7	1	39.8	19.00	41.20	21041	0.68
							2		31.56	68.44	34952	1.13
59	8	5784844	602332	95.8	100.0	4.2	1	25.1	25.20	49.70	26477	0.61
							2		33.64	66.36	35350	0.81
60	12	5784844	602332	95.8	100.0	4.2	1	28.9	23.30	47.80	25237	0.48
							2		32.77	67.23	35495	0.68
61	15	5784844	602332	95.8	100.0	4.2	1	39.3	20.90	39.80	21090	0.54
							2		34.43	65.57	34745	0.89
62	4	5785799	602099	37.1	39.5	2.4	1	41.3	19.60	39.10	20166	0.52
							2		33.39	66.61	34354	0.89
63	4	5785921	600756	92.0	95.1	3.1	1	26.0	24.80	49.20	25821	0.63
							2		33.51	66.49	34893	0.85
64	8	5785921	600756	127.3	129.0	1.7	1	29.9	24.50	45.60	24367	1.41
							2		34.95	65.05	34760	2.01
65	12	5785921	600756	127.3	129.0	1.7	1	21.5	24.80	53.70	27584	1.01
							2		31.59	68.41	35139	1.29
66	20	5786356	600711	82.3	87.6	5.3	1	11.8	28.70	59.50	31375	0.55
							2		32.54	67.46	35573	0.62
67	22	5786356	600711	82.3	87.6	5.3	1	42.4	20.70	36.90	20062	0.65
							2		35.94	64.06	34830	1.13
68	58	5786356	600711	82.3	87.6	5.3	1	49.2	20.00	30.80	17492	1.43
							2		39.37	60.63	34433	2.81
69	95	5786356	600711	135.6	138.2	2.6	1	21.5	25.00	53.50	27468	0.62
							2		31.85	68.15	34991	0.79
70	6	5787289	599840	96.5	98.9	2.4	1	8.9	27.70	63.40	32650	0.91
							2		30.41	69.59	35840	1.00
71	10	5787289	599840	58.9	61.9	3.0	1	19.8	20.10	60.10	.	0.46
							2		25.06	74.94	.	0.57
72	14	5787289	599840	58.9	61.9	3.0	1	33.2	21.80	45.00	23060	0.92
							2		32.63	67.37	34521	1.38
73	4	5787059	600051	93.9	95.5	1.6	1	45.3	16.00	38.70	18520	0.54
							2		29.25	70.75	33857	0.99
74	5	5787059	600051	55.4	58.9	3.5	1	48.0	16.80	35.20	17468	0.30
							2		32.31	67.69	33592	0.58
75	9	5787059	600051	55.4	58.9	3.5	1	28.4	24.10	47.50	24849	0.57
							2		33.66	66.34	34705	0.80

LUSCAR GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Proximate Ash	Volatile Matter	Fixed Carbon	Calorific value kj/kg	Sulfur
76	13	5787059	600051	55.40	58.90	3.50	1	31.20	25.30	43.50	23800	0.93
							2		36.77	63.23	34593	1.35
77	4	5786332	601191	119.90	124.20	4.30	1	6.60	30.70	62.70	33569	0.57
							2		32.87	67.13	35941	0.61
78	11	5786332	601191	119.90	124.20	4.30	1	26.30	24.30	49.40	25528	0.79
							2		32.97	67.03	34638	1.07
79	12	5786332	601191	119.90	124.20	4.30	1	23.50	25.70	50.80	26709	0.51
							2		33.59	66.41	34914	0.67
80	4	5786475	601310	50.60	57.80	7.20	1	42.00	19.70	38.30	20013	0.61
							2		33.97	66.03	34505	1.05
81	8	5786475	601310	50.60	57.80	7.20	1	10.00	27.80	62.20	32034	0.49
							2		30.89	69.11	35593	0.54
82	12	5786475	601310	50.60	57.80	7.20	1	37.60	22.20	40.20	21539	1.21
							2		35.58	64.42	34518	1.94
83	16	5786475	601310	50.60	57.80	7.20	1	8.40	30.30	61.30	32904	0.80
							2		33.08	66.92	35921	0.87
84	20	5786475	601310	50.60	57.80	7.20	1	22.50	28.20	49.30	27221	0.86
							2		36.39	63.61	35124	1.11
85	24	5786475	601310	50.60	57.80	7.20	1	21.00	27.70	51.30	27740	0.86
							2		35.06	64.94	35114	1.09
86	14	5786223	601080	90.80	95.30	4.50	1	14.60	26.80	58.60	29964	0.53
							2		31.38	68.62	35087	0.62
87	18	5786223	601080	90.80	95.30	4.50	1	44.30	19.60	36.10	19248	0.57
							2		35.19	64.81	34557	1.02
88	7	5786046	600908	104.20	107.40	3.20	1	10.30	28.30	61.40	31873	0.74
							2		31.55	68.45	35533	0.82
89	11	5786046	600908	104.20	107.40	3.20	1	29.40	23.90	46.70	24981	0.98
							2		33.85	66.15	35384	1.39
90	1	5794832	589708	115.82	116.43	0.61	1	24.09	27.17	48.74	26368	2.03
							2		35.79	64.21	34736	2.67
91	2	5794832	589708	116.43	117.04	0.61	1	20.76	27.48	51.76	27377	0.56
							2		34.68	65.32	34549	0.71
92	3	5794832	589708	117.04	117.65	0.61	1	23.08	24.53	52.39	27037	0.33
							2		31.89	68.11	35150	0.43
93	4	5794832	589708	117.65	118.26	0.61	1	7.16	32.36	60.48	33492	0.37
							2		34.86	65.14	36075	0.40
94	5	5794832	589708	118.26	118.87	0.61	1	16.85	29.78	53.37	29605	0.47
							2		35.81	64.19	35604	0.57
95	1	5795799	589284	138.07	138.68	0.61	1	25.50	25.00	49.50	26109	0.57
							2		33.56	66.44	35046	0.77
96	2	5795799	589284	138.68	139.29	0.61	1	13.37	28.42	58.21	31006	0.50
							2		32.81	67.19	35791	0.58
97	3	5795799	589284	139.29	139.90	0.61	1	32.02	22.06	45.92	23197	0.33
							2		32.45	67.55	34123	0.49
98	4	5795799	589284	139.90	140.51	0.61	1	8.56	30.48	60.96	32818	0.33
							2		33.33	66.67	35890	0.36
99	5	5795799	589284	140.51	141.12	0.61	1	8.97	30.71	60.32	32636	0.40
							2		33.74	66.26	35852	0.44
100	6	5795799	589284	141.12	141.73	0.61	1	6.44	30.56	63.00	33857	0.41
							2		32.66	67.34	36187	0.44

LUSCAR GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Proximate Ash	Volatile Matter	Fixed Carbon	Calorific value kj/kg	Sulfur
101	7	5795799	589284	141.73	142.34	0.61	1	10.95	29.71	59.34	32041	0.55
							2		33.36	66.64	35981	0.62
102	8	5795799	589284	179.83	180.44	0.61	1	10.31	29.71	59.98	31938	0.50
							2		33.13	66.87	35609	0.56
103	9	5795799	589284	180.44	181.05	0.61	1	11.36	29.60	59.04	31389	0.35
							2		33.39	66.61	35412	0.39
104	10	5795799	589284	181.05	181.66	0.61	1	11.93	29.55	58.52	31199	0.47
							2		33.55	66.45	35425	0.53
105	11	5795799	589284	181.66	182.27	0.61	1	24.72	25.22	50.06	26047	0.45
							2		33.50	66.50	34600	0.60
106	12	5795799	589284	182.27	182.88	0.61	1	11.79	28.66	59.55	31157	0.84
							2		32.49	67.51	35321	0.95
107	13	5795799	589284	182.88	183.49	0.61	1	14.93	28.43	56.64	29843	0.42
							2		33.42	66.58	35081	0.49
108	14	5795799	589284	183.49	184.10	0.61	1	12.61	28.58	58.81	32355	0.42
							2		32.70	67.30	37024	0.48
109	15	5795799	589284	184.10	184.71	0.61	1	8.96	29.52	61.52	32473	1.66
							2		32.43	67.57	35669	1.82
110	16	5795799	589284	184.71	185.32	0.61	1	10.60	28.09	61.31	32334	0.52
							2		31.42	68.58	36168	0.58
111	17	5795799	589284	185.32	185.93	0.61	1	8.89	28.62	62.49	32834	0.51
							2		31.41	68.59	36038	0.56
112	18	5795799	589284	186.54	187.15	0.61	1	25.30	24.55	50.15	26067	0.45
							2		32.86	67.14	34896	0.60
113	19	5795799	589284	187.15	187.76	0.61	1	18.91	27.15	53.94	28093	0.38
							2		33.48	66.52	34644	0.47
114	2	5795960	591255	41.56	42.17	0.61	1	15.90	29.70	54.40	29189	1.50
							2		35.32	64.68	34707	1.78
115	3	5795960	591255	35.36	36.39	1.03	1	25.60	26.00	48.40	25628	0.38
							2		34.95	65.05	34446	0.51
116	4	5795960	591255	34.27	34.75	0.48	1	20.70	25.20	54.10	27279	0.48
							2		31.78	68.22	34400	0.61
117	2	5795873	591797	33.83	34.20	0.37	1	16.90	27.60	55.50	28391	0.43
							2		33.21	66.79	34165	0.52
118	3	5795873	591797	33.22	33.83	0.61	1	3.60	31.20	65.20	34169	0.43
							2		32.37	67.63	35445	0.45
119	4	5795873	591797	32.61	33.22	0.61	1	4.20	31.90	63.90	33741	0.39
							2		33.30	66.70	35220	0.41
120	5	5795873	591797	32.00	32.61	0.61	1	6.70	28.00	65.30	32511	0.40
							2		30.01	69.99	34846	0.43
121	6	5795873	591797	31.39	32.00	0.61	1	14.70	29.30	56.00	29657	0.58
							2		34.35	65.65	34768	0.68
122	7	5795873	591797	30.78	31.39	0.61	1	23.00	25.30	51.70	26063	0.55
							2		32.86	67.14	33848	0.71
123	8	5795873	591797	30.21	30.78	0.57	1	44.00	19.60	36.40	17685	0.34
							2		35.00	65.00	31580	0.61
124	1	5795858	594270	9.14	10.67	1.53	1	11.40	30.10	58.50	31517	0.50
							2		33.97	66.03	35572	0.56
125	2	5795858	594270	14.51	15.42	0.91	1	30.10	24.40	45.50	24074	0.42
							2		34.91	65.09	34441	0.60

LUSCAR GROUP DATA

Basis: 1 = Dry   2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Proximate Ash	Volatile Matter	Fixed Carbon	Calorific value kj/kg	Sulfur
126	3	5795858	594270	12.19	13.00	0.81	1	37.70	23.40	38.90	21322	0.43
							2		37.56	62.44	34225	0.69
127	4	5795858	594270	10.67	12.19	1.52	1	16.90	29.00	54.10	28910	0.53
							2		34.90	65.10	34789	0.64
128	5	5795858	594270	7.62	9.14	1.52	1	19.50	28.40	52.10	27903	0.42
							2		35.28	64.72	34662	0.52
129	6	5795858	594270	6.10	7.62	1.52	1	10.60	30.20	59.20	31471	0.45
							2		33.78	66.22	35202	0.50
130	7	5795858	594270	4.57	6.10	1.53	1	9.50	29.20	61.30	31820	0.56
							2		32.27	67.73	35160	0.62
131	8	5795858	594270	3.78	4.57	0.79	1	15.50	27.90	56.60	29412	0.61
							2		33.02	66.98	34807	0.72
132	2	5795921	594177	54.25	54.71	0.46	1	18.90	26.80	54.30	29031	1.14
							2		33.05	66.95	35797	1.41
133	3	5795921	594177	53.64	54.25	0.61	1	8.40	30.20	61.40	32217	0.47
							2		32.97	67.03	35171	0.51
134	4	5795921	594177	53.04	53.64	0.60	1	7.30	29.80	62.90	32678	0.48
							2		32.15	67.85	35251	0.52
135	5	5795921	594177	52.43	53.04	0.61	1	35.00	23.70	41.30	21557	0.34
							2		36.46	63.54	33165	0.52
136	6	5795921	594177	51.82	52.43	0.61	1	9.50	29.10	61.40	31701	0.50
							2		32.15	67.85	35029	0.55
137	7	5795921	594177	51.18	51.82	0.64	1	36.10	20.40	43.50	21367	0.43
							2		31.92	68.08	33438	0.67
138	1	5795300	586921	152.70	153.92	1.22	1	38.33	19.60	42.07	20892	0.41
							2		31.78	68.22	33877	0.66
139	2	5795300	586921	153.92	154.53	0.61	1	26.80	23.66	49.54	25074	0.36
							2		32.32	67.68	34254	0.49
140	3	5795300	586921	154.53	155.14	0.61	1	10.73	26.20	63.07	32076	0.38
							2		29.35	70.65	35931	0.43
141	4	5795300	586921	155.14	155.75	0.61	1	22.12	25.26	52.62	27233	0.39
							2		32.43	67.57	34968	0.50
142	5	5795300	586921	155.75	156.36	0.61	1	17.07	27.58	55.35	29701	0.40
							2		33.26	66.74	35815	0.48
143	6	5795300	586921	156.36	156.67	0.31	1	25.95	25.85	48.20	26589	0.42
							2		34.91	65.09	35907	0.57
144	7	5795300	586921	190.20	190.80	0.60	1	35.98	20.40	43.62	21597	0.78
							2		31.87	68.13	33735	1.22
145	8	5795300	586921	190.80	191.41	0.61	1	18.73	26.97	54.30	29066	0.41
							2		33.19	66.81	35765	0.50
146	9	5795300	586921	191.41	192.02	0.61	1	16.78	27.73	55.49	30038	0.44
							2		33.32	66.68	36095	0.53
147	10	5795300	586921	192.02	192.33	0.31	1	32.41	23.31	44.28	23762	3.02
							2		34.49	65.51	35156	4.47
148	1	5795981	587294	182.58	183.18	0.60	1	44.35	19.16	36.49	18720	1.97
							2		34.43	65.57	33639	3.54
149	1	5796582	586973	141.43	142.04	0.61	1	43.60	18.30	38.10	19034	0.34
							2		32.45	67.55	33748	0.60
150	2	5796582	586973	142.04	142.65	0.61	1	34.91	21.86	43.23	23665	0.83
							2		33.58	66.42	36357	1.28

LUSCAR GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Proximate Ash	Volatile Matter	Fixed Carbon	Calorific value kj/kg	Sulfur
151	3	5796582	586973	142.65	143.26	0.61	1	32.62	22.54	44.84	23281	0.38
							2		33.45	66.55	34552	0.56
152	4	5796582	586973	144.48	145.08	0.60	1	26.87	23.99	49.14	25744	0.37
							2		32.80	67.20	35203	0.51
153	5	5796582	586973	145.08	145.69	0.61	1	16.83	26.67	56.50	29526	0.55
							2		32.07	67.93	35501	0.66
154	1	5805012	563374	.	.	.	1	23.63	19.30	57.07	27072	0.52
							2		25.27	74.73	35448	0.68
155	2	5805012	563374	.	.	.	1	20.37	20.33	59.30	28570	0.44
							2		25.53	74.47	35878	0.55
156	1	5805200	563570	.	.	.	1	38.40	16.13	45.47	21541	0.53
							2		26.19	73.81	34969	0.86
157	2	5805200	563570	.	.	.	1	20.76	17.34	61.90	28103	0.41
							2		21.88	78.12	35466	0.52
158	3	5805200	563570	.	.	.	1	49.46	14.07	36.47	16447	0.43
							2		27.84	72.16	32543	0.85
159	1	5808428	560299	.	.	.	1	8.96	21.01	70.03	33190	0.58
							2		23.08	76.92	36457	0.64
160	2	5808428	560299	.	.	.	1	40.85	15.39	43.76	20032	0.50
							2		26.02	73.98	33866	0.85

Appendix 3.

Ultimate analysis, ERCB data - Kootenay Group coals

KOOTENAY GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters) (UTM)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
1	1	5482149	688368	120.09	120.40	0.31	1	.	.	.	.	0.49
							2	.	.	.	.	0.59
2	2	5482149	688368	119.48	120.09	0.61	1	.	.	.	.	0.45
							2	.	.	.	.	0.60
3	3	5482149	688368	118.87	119.48	0.61	1	.	.	.	.	0.53
							2	.	.	.	.	0.71
4	4	5482149	688368	118.26	118.87	0.61	1	.	.	.	.	0.40
							2	.	.	.	.	0.63
5	1	5483277	687952	81.38	81.99	0.61	1	.	.	.	.	1.26
							2	.	.	.	.	2.21
6	2	5483277	687952	74.07	74.55	0.48	1	.	.	.	.	0.39
							2	.	.	.	.	0.59
7	3	5483277	687952	73.46	74.07	0.61	1	.	.	.	.	0.35
							2	.	.	.	.	0.48
8	4	5483277	687952	72.85	73.46	0.61	1	.	.	.	.	0.36
							2	.	.	.	.	0.46
9	5	5483277	687952	26.09	26.52	0.43	1	.	.	.	.	0.39
							2	.	.	.	.	0.72
10	6	5483277	687952	23.47	24.08	0.61	1	.	.	.	.	0.55
							2	.	.	.	.	0.77
11	7	5483277	687952	22.86	23.47	0.61	1	.	.	.	.	0.45
							2	.	.	.	.	0.55
12	8	5483277	687952	22.25	22.86	0.61	1	.	.	.	.	0.46
							2	.	.	.	.	0.61
13	9	5483277	687952	21.64	22.25	0.61	1	.	.	.	.	0.33
							2	.	.	.	.	0.51
14	10	5483277	687952	21.03	21.64	0.61	1	.	.	.	.	0.46
							2	.	.	.	.	0.61
15	11	5483277	687952	88.09	88.39	0.30	1	.	.	.	.	0.54
							2	.	.	.	.	0.65
16	12	5483277	687952	87.48	88.09	0.61	1	.	.	.	.	0.51
							2	.	.	.	.	0.69
17	13	5483277	687952	86.87	87.48	0.61	1	.	.	.	.	0.52
							2	.	.	.	.	0.71
18	14	5483277	687952	86.26	86.87	0.61	1	.	.	.	.	1.11
							2	.	.	.	.	1.75
19	15	5483277	687952	20.36	20.73	0.37	1	.	.	.	.	1.61
							2	.	.	.	.	2.98
20	16	5483277	687952	14.63	15.24	0.61	1	.	.	.	.	2.09
							2	.	.	.	.	2.83
21	1	5484370	687513	86.56	87.33	0.77	1	.	.	.	.	0.57
							2	.	.	.	.	0.71
22	2	5484370	687513	85.95	86.56	0.61	1	.	.	.	.	0.51
							2	.	.	.	.	0.73
23	3	5484370	687513	85.34	85.95	0.61	1	.	.	.	.	0.55
							2	.	.	.	.	0.70
24	4	5484370	687513	84.73	85.34	0.61	1	.	.	.	.	0.59
							2	.	.	.	.	0.71
25	5	5484370	687513	84.12	84.73	0.61	1	.	.	.	.	1.28
							2	.	.	.	.	2.03
26	6	5484370	687513	75.29	75.90	0.61	1	.	.	.	.	0.39

KOOTENAY GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
							2	.	.	.	.	0.55
27	7	5484370	687513	74.68	75.29	0.61	1	.	.	.	.	0.40
							2	.	.	.	.	0.52
28	8	5484370	687513	74.07	74.68	0.61	1	.	.	.	.	0.35
							2	.	.	.	.	0.47
29	9	5484370	687513	64.01	64.31	0.30	1	.	.	.	.	0.62
							2	.	.	.	.	0.85
30	10	5484370	687513	61.57	62.18	0.61	1	.	.	.	.	0.45
							2	.	.	.	.	0.80
31	11	5484370	687513	60.96	61.57	0.61	1	.	.	.	.	0.48
							2	.	.	.	.	0.65
32	12	5484370	687513	56.69	57.30	0.61	1	.	.	.	.	0.60
							2	.	.	.	.	0.72
33	13	5484370	687513	56.08	56.69	0.61	1	.	.	.	.	0.51
							2	.	.	.	.	0.61
34	14	5484370	687513	50.29	50.90	0.61	1	.	.	.	.	0.47
							2	.	.	.	.	0.73
35	15	5484370	687513	49.68	50.29	0.61	1	.	.	.	.	0.48
							2	.	.	.	.	0.67
36	17	5484370	687513	48.16	48.65	0.49	1	.	.	.	.	0.45
							2	.	.	.	.	0.77
37	18	5484370	687513	46.02	46.45	0.43	1	.	.	.	.	0.48
							2	.	.	.	.	0.63
38	19	5484370	687513	45.42	46.02	0.60	1	.	.	.	.	0.55
							2	.	.	.	.	0.75
39	20	5484370	687513	19.32	19.81	0.49	1	.	.	.	.	0.48
							2	.	.	.	.	0.81
40	21	5484370	687513	3.35	3.66	0.31	1	.	.	.	.	0.34
							2	.	.	.	.	0.63
41	22	5484370	687513	2.13	2.74	0.61	1	.	.	.	.	0.25
							2	.	.	.	.	0.30
42	23	5484370	687513	1.52	2.13	0.61	1	.	.	.	.	0.21
							2	.	.	.	.	0.27
43	24	5484370	687513	2.74	3.35	0.61	1	.	.	.	.	0.29
							2	.	.	.	.	0.37
44	1	5486268	686311	57.30	57.79	0.49	1	.	.	.	.	0.23
							2	.	.	.	.	0.44
45	2	5486268	686311	56.69	57.30	0.61	1	.	.	.	.	0.33
							2	.	.	.	.	0.60
46	3	5486268	686311	54.86	55.47	0.61	1	.	.	.	.	0.29
							2	.	.	.	.	0.47
47	4	5486268	686311	53.64	54.25	0.61	1	.	.	.	.	0.36
							2	.	.	.	.	0.57
48	1	5490303	686244	6.10	6.71	0.61	1	.	.	.	.	0.45
							2	.	.	.	.	0.62
49	2	5490303	686244	14.63	15.24	0.61	1	.	.	.	.	0.28
							2	.	.	.	.	0.39
50	3	5490303	686244	5.49	6.10	0.61	1	.	.	.	.	0.40
							2	.	.	.	.	0.51
51	4	5490303	686244	4.27	4.72	0.45	1	.	.	.	.	0.41
							2	.	.	.	.	0.55

KOOTENAY GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
52	5	5490303	686244	3.66	4.27	0.61	1	.	.	.	.	0.37
							2	.	.	.	.	0.47
53	6	5490303	686244	3.05	3.66	0.61	1	.	.	.	.	0.40
							2	.	.	.	.	0.53
54	7	5490303	686244	8.00	10.00	2.00	1	.	.	.	.	0.38
							2	.	.	.	.	0.58
55	8	5490303	686244	1.83	2.44	0.61	1	.	.	.	.	0.38
							2	.	.	.	.	0.43
56	9	5490303	686244	1.22	1.83	0.61	1	.	.	.	.	0.27
							2	.	.	.	.	0.34
57	10	5490303	686244	0.61	1.22	0.61	1	.	.	.	.	0.24
							2	.	.	.	.	0.34
58	11	5490303	686244	0.00	0.61	0.61	1	.	.	.	.	0.21
							2	.	.	.	.	0.33
59	12	5490303	686244	42.67	43.28	0.61	1	.	.	.	.	0.68
							2	.	.	.	.	1.00
60	13	5490303	686244	138.00	140.00	2.00	1	.	.	.	.	0.63
							2	.	.	.	.	0.86
61	15	5490303	686244	34.29	34.90	0.61	1	.	.	.	.	1.02
							2	.	.	.	.	1.56
62	16	5490303	686244	29.41	30.02	0.61	1	.	.	.	.	0.45
							2	.	.	.	.	0.69
63	17	5490303	686244	19.20	19.51	0.31	1	.	.	.	.	0.47
							2	.	.	.	.	0.64
64	18	5490303	686244	18.59	19.20	0.61	1	.	.	.	.	0.39
							2	.	.	.	.	0.58
65	19	5490303	686244	16.46	17.07	0.61	1	.	.	.	.	0.34
							2	.	.	.	.	0.40
66	20	5490303	686244	15.85	16.46	0.61	1	.	.	.	.	0.29
							2	.	.	.	.	0.36
67	21	5490303	686244	15.24	15.85	0.61	1	.	.	.	.	0.27
							2	.	.	.	.	0.36
68	22	5490303	686244	14.02	14.63	0.61	1	.	.	.	.	0.31
							2	.	.	.	.	0.44
69	23	5490303	686244	13.41	14.02	0.61	1	.	.	.	.	0.36
							2	.	.	.	.	0.44
70	22	5491347	682044	44.97	62.38	17.41	1	.	.	.	.	0.26
							2	.	.	.	.	0.39
71	1	5491281	685048	19.20	19.81	0.61	1	.	.	.	.	0.55
							2	.	.	.	.	0.82
72	2	5491281	685048	16.64	17.25	0.61	1	.	.	.	.	0.59
							2	.	.	.	.	0.97
73	3	5491281	685048	14.02	14.63	0.61	1	.	.	.	.	0.37
							2	.	.	.	.	0.54
74	4	5491281	685048	81.38	81.99	0.61	1	.	.	.	.	0.38
							2	.	.	.	.	0.52
75	5	5491281	685048	80.77	81.38	0.61	1	.	.	.	.	0.27
							2	.	.	.	.	0.46
76	6	5491281	685048	80.16	80.77	0.61	1	.	.	.	.	0.27
							2	.	.	.	.	0.45
77	7	5491281	685048	79.55	80.16	0.61	1	.	.	.	.	0.27

KOOTENAY GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
							2	.	.	.	.	0.35
78	8	5491281	685048	78.94	79.55	0.61	1	.	.	.	.	0.26
							2	.	.	.	.	0.32
79	9	5491281	685048	78.33	78.94	0.61	1	.	.	.	.	0.24
							2	.	.	.	.	0.30
80	10	5491281	685048	77.72	78.33	0.61	1	.	.	.	.	0.26
							2	.	.	.	.	0.31
81	11	5491281	685048	77.11	77.72	0.61	1	.	.	.	.	0.30
							2	.	.	.	.	0.33
82	12	5491281	685048	76.50	77.11	0.61	1	.	.	.	.	0.33
							2	.	.	.	.	0.40
83	13	5491281	685048	75.90	76.50	0.60	1	.	.	.	.	0.28
							2	.	.	.	.	0.38
84	14	5491281	685048	75.29	75.90	0.61	1	.	.	.	.	0.26
							2	.	.	.	.	0.34
85	15	5491281	685048	74.68	75.29	0.61	1	.	.	.	.	0.27
							2	.	.	.	.	0.31
86	16	5491281	685048	74.07	74.68	0.61	1	.	.	.	.	0.24
							2	.	.	.	.	0.30
87	17	5491281	685048	73.46	74.07	0.61	1	.	.	.	.	0.24
							2	.	.	.	.	0.29
88	18	5491281	685048	72.85	73.46	0.61	1	.	.	.	.	0.25
							2	.	.	.	.	0.32
89	19	5491281	685048	72.24	72.85	0.61	1	.	.	.	.	0.29
							2	.	.	.	.	0.32
90	20	5491281	685048	71.63	72.24	0.61	1	.	.	.	.	0.28
							2	.	.	.	.	0.32
91	21	5491281	685048	71.02	71.63	0.61	1	.	.	.	.	0.30
							2	.	.	.	.	0.37
92	1	5492859	685847	22.86	23.47	0.61	1	.	.	.	.	0.45
							2	.	.	.	.	0.78
93	2	5492859	685847	22.25	22.86	0.61	1	.	.	.	.	0.45
							2	.	.	.	.	0.58
94	3	5492859	685847	21.64	22.25	0.61	1	.	.	.	.	0.45
							2	.	.	.	.	0.56
95	4	5492859	685847	21.03	21.64	0.61	1	.	.	.	.	0.33
							2	.	.	.	.	0.53
96	5	5492859	685847	20.42	21.03	0.61	1	.	.	.	.	0.32
							2	.	.	.	.	0.64
97	6	5492859	685847	19.81	20.42	0.61	1	.	.	.	.	0.38
							2	.	.	.	.	0.55
98	7	5492859	685847	19.20	19.81	0.61	1	.	.	.	.	0.40
							2	.	.	.	.	0.58
99	8	5492859	685847	18.59	19.20	0.61	1	.	.	.	.	0.39
							2	.	.	.	.	0.59
100	9	5492859	685847	17.98	18.59	0.61	1	.	.	.	.	0.39
							2	.	.	.	.	0.60
101	10	5492859	685847	17.37	17.98	0.61	1	.	.	.	.	0.42
							2	.	.	.	.	0.50
102	11	5492859	685847	16.15	16.76	0.61	1	.	.	.	.	0.34
							2	.	.	.	.	0.47

KOOTENAY GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
103	12	5492859	685847	15.54	16.15	0.61	1	.	.	.	.	0.42
							2	.	.	.	.	0.49
104	13	5492859	685847	14.94	15.54	0.60	1	.	.	.	.	0.36
							2	.	.	.	.	0.44
105	14	5492859	685847	14.33	14.94	0.61	1	.	.	.	.	0.38
							2	.	.	.	.	0.42
106	15	5492859	685847	13.72	14.33	0.61	1	.	.	.	.	0.31
							2	.	.	.	.	0.44
107	16	5492859	685847	12.19	12.80	0.61	1	.	.	.	.	0.34
							2	.	.	.	.	0.45
108	17	5492859	685847	11.58	12.19	0.61	1	.	.	.	.	0.32
							2	.	.	.	.	0.49
109	18	5492859	685847	10.97	11.58	0.61	1	.	.	.	.	0.64
							2	.	.	.	.	0.93
110	19	5492859	685847	10.36	10.97	0.61	1	.	.	.	.	0.37
							2	.	.	.	.	0.57
111	20	5492859	685847	9.75	10.36	0.61	1	.	.	.	.	0.40
							2	.	.	.	.	0.56
112	21	5492859	685847	9.14	9.75	0.61	1	.	.	.	.	0.40
							2	.	.	.	.	0.64
113	22	5492859	685847	4.57	5.18	0.61	1	.	.	.	.	0.50
							2	.	.	.	.	0.98
114	23	5492859	685847	236.00	238.00	2.00	1	.	.	.	.	1.35
							2	.	.	.	.	2.15
115	24	5492859	685847	70.71	71.20	0.49	1	.	.	.	.	0.42
							2	.	.	.	.	0.68
116	25	5492859	685847	68.88	69.49	0.61	1	.	.	.	.	0.69
							2	.	.	.	.	0.77
117	26	5492859	685847	64.62	65.23	0.61	1	.	.	.	.	0.57
							2	.	.	.	.	0.74
118	27	5492859	685847	65.23	65.84	0.61	1	.	.	.	.	0.87
							2	.	.	.	.	1.22
119	28	5492859	685847	33.22	33.83	0.61	1	.	.	.	.	0.31
							2	.	.	.	.	0.51
120	29	5492859	685847	33.83	34.44	0.61	1	.	.	.	.	0.37
							2	.	.	.	.	0.49
121	30	5492859	685847	34.44	35.05	0.61	1	.	.	.	.	0.37
							2	.	.	.	.	0.47
122	31	5492859	685847	32.61	33.22	0.61	1	.	.	.	.	0.37
							2	.	.	.	.	0.50
123	32	5492859	685847	35.05	35.36	0.31	1	.	.	.	.	0.28
							2	.	.	.	.	0.51
124	33	5492859	685847	36.58	37.06	0.48	1	.	.	.	.	0.43
							2	.	.	.	.	0.68
125	34	5492859	685847	12.80	13.41	0.61	1	.	.	.	.	0.32
							2	.	.	.	.	0.45
126	4	5503918	685481	4.60	5.00	0.40	1	.	.	.	.	0.64
							2	.	.	.	.	0.75
127	8	5503918	685481	25.15	35.69	10.54	1	.	.	.	.	0.37
							2	.	.	.	.	0.48
128	1	5503680	685471	79.37	79.61	0.24	1	.	.	.	.	0.52

KOOTENAY GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
							2	.	.	.	.	0.60
129	1	5504626	685639	28.99	38.68	9.69	1	.	.	.	.	0.29
							2	.	.	.	.	0.37
130	18	5504626	685639	44.71	49.13	4.42	1	.	.	.	.	0.30
							2	.	.	.	.	0.37
131	4	5504145	685579	37.80	39.01	1.21	1	.	.	.	.	0.62
							2	.	.	.	.	0.80
132	4	5504460	685552	19.45	22.71	3.26	1	.	.	.	.	0.44
							2	.	.	.	.	0.58
133	4	5504432	685562	19.35	25.91	6.56	1	.	.	.	.	0.35
							2	.	.	.	.	0.45
134	2	5504267	685619	21.34	37.80	16.46	1	.	.	.	.	0.41
							2	.	.	.	.	0.52
135	1	5504366	685619	28.96	31.00	2.04	1	.	.	.	.	0.45
							2	.	.	.	.	0.60
136	1	5504370	685598	8.72	13.69	4.97	1	.	.	.	.	0.39
							2	.	.	.	.	0.48
137	4	5505756	685623	27.74	34.72	6.98	1	.	.	.	.	0.37
							2	.	.	.	.	0.51
138	4	5505529	685506	32.28	35.51	3.23	1	.	.	.	.	0.41
							2	.	.	.	.	0.61
139	4	5505646	685559	9.11	15.79	6.68	1	.	.	.	.	0.61
							2	.	.	.	.	0.78
140	8	5505646	685559	33.31	38.25	4.94	1	.	.	.	.	0.51
							2	.	.	.	.	0.66
141	5	5505737	685691	11.13	12.86	1.73	1	.	.	.	.	0.39
							2	.	.	.	.	0.54
142	9	5505737	685691	7.16	10.67	3.51	1	.	.	.	.	0.38
							2	.	.	.	.	0.42
143	26	5505737	685691	19.81	23.10	3.29	1	.	.	.	.	0.64
							2	.	.	.	.	0.88
144	1	5591506	671087	242.44	243.30	0.86	1	.	.	.	.	0.45
							2	.	.	.	.	0.67
145	2	5591506	671087	372.88	373.88	1.00	1	.	.	.	.	0.43
							2	.	.	.	.	0.74
146	3	5591506	671087	373.88	375.70	1.82	1	.	.	.	.	0.44
							2	.	.	.	.	0.68
147	1	5591350	671022	405.08	413.00	7.92	1	.	.	.	.	.
							2	.	.	.	.	.
148	1	5591787	671234	.	.	.	1	.	.	.	.	.
							2	.	.	.	.	.
149	3	5591787	671234	.	.	.	1	.	.	.	.	.
							2	.	.	.	.	.
150	2	5594337	669737	245.00	255.30	10.30	1	.	.	.	.	0.68
							2	.	.	.	.	0.76
151	3	5594337	669737	292.20	292.43	0.23	1	.	.	.	.	0.71
							2	.	.	.	.	0.96
152	1	5594225	670042	132.90	137.50	4.60	1	.	.	.	.	0.57
							2	.	.	.	.	0.71
153	2	5594225	670042	144.50	147.00	2.50	1	.	.	.	.	0.57
							2	.	.	.	.	0.75

KOOTENAY GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
154	4	5594225	670042	52.00	55.62	3.62	1	.	.	.	.	0.61
							2	.	.	.	.	0.70
155	1	5593926	669224	57.61	59.74	2.13	1	.	.	.	.	.
							2	.	.	.	.	.
156	3	5593926	669224	62.18	64.62	2.44	1	.	.	.	.	.
							2	.	.	.	.	.
157	5	5593926	669224	65.53	70.41	4.88	1	.	.	.	.	.
							2	.	.	.	.	.
158	1	5594262	669549	336.80	337.41	0.61	1	.	.	.	.	.
							2	.	.	.	.	.
159	3	5594262	669549	351.13	353.57	2.44	1	.	.	.	.	.
							2	.	.	.	.	.
160	10	5596979	668571	338.33	346.25	7.92	1	.	.	.	.	.
							2	.	.	.	.	.
161	11	5596979	668571	274.93	281.64	6.71	1	.	.	.	.	.
							2	.	.	.	.	.
162	12	5596979	668571	269.44	274.62	5.18	1	.	.	.	.	.
							2	.	.	.	.	.
163	13	5596979	668571	241.10	242.32	1.22	1	.	.	.	.	.
							2	.	.	.	.	.
164	1	5598865	668312	77.25	78.82	1.57	1	.	.	.	.	0.63
							2	.	.	.	.	0.72
165	6	5598865	668312	108.02	109.23	1.21	1	.	.	.	.	1.10
							2	.	.	.	.	1.62
166	9	5598865	668312	135.82	141.43	5.61	1	.	.	.	.	0.40
							2	.	.	.	.	0.54
167	1	5652019	622826	.	.	.	1	70.65	3.33	1.66	1.05	0.60
							2	90.94	4.29	2.14	1.35	0.77
168	2	5652019	622826	.	.	.	1	77.25	3.56	2.79	1.14	0.65
							2	89.98	4.15	3.25	1.33	0.76
169	3	5652019	622826	.	.	.	1	75.24	3.45	1.96	1.13	0.64
							2	90.68	4.16	2.36	1.36	0.77
170	1	5652689	622134	.	.	.	1	86.46	3.88	1.37	1.37	0.71
							2	91.59	4.11	1.45	1.45	0.75
171	2	5652689	622134	.	.	.	1	87.98	3.78	0.80	1.10	0.64
							2	92.42	3.97	0.84	1.16	0.67
172	3	5652689	622134	.	.	.	1	82.40	3.53	1.91	0.97	0.61
							2	91.56	3.92	2.12	1.08	0.68
173	4	5652689	622134	.	.	.	1	80.53	3.57	1.25	1.16	0.59
							2	91.72	4.07	1.42	1.32	0.67

Appendix 4.

Ultimate analysis, ERCB data - Luscar Group coals

LUSCAR GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters) (UTM)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
1	1	5747319	611363	.	.	.	1	.	.	.	.	0.73
							2	.	.	.	.	0.95
2	6	5777281	602978	24.3	25.7	1.4	1	.	.	.	.	0.59
							2	.	.	.	.	0.68
3	10	5777281	602978	24.3	25.7	1.4	1	.	.	.	.	0.55
							2	.	.	.	.	0.95
4	7	5779746	601237	84.6	90.7	6.1	1	.	.	.	.	1.60
							2	.	.	.	.	2.43
5	10	5779746	601237	84.6	90.7	6.1	1	.	.	.	.	0.54
							2	.	.	.	.	0.76
6	14	5779746	601237	84.6	90.7	6.1	1	.	.	.	.	0.39
							2	.	.	.	.	0.57
7	18	5779746	601237	84.6	90.7	6.1	1	.	.	.	.	0.87
							2	.	.	.	.	1.25
8	22	5779746	601237	42.5	45.8	3.3	1	.	.	.	.	0.93
							2	.	.	.	.	1.59
9	26	5779746	601237	42.5	45.8	3.3	1	.	.	.	.	0.84
							2	.	.	.	.	1.52
10	30	5779746	601237	42.5	45.8	3.3	1	.	.	.	.	1.64
							2	.	.	.	.	2.07
11	33	5779746	601237	84.6	90.7	6.1	1	.	.	.	.	0.64
							2	.	.	.	.	0.94
12	4	5783928	602053	62.5	65.5	3.0	1	.	.	.	.	0.44
							2	.	.	.	.	0.57
13	8	5783928	602053	24.0	27.5	3.5	1	.	.	.	.	0.75
							2	.	.	.	.	0.83
14	12	5783928	602053	24.0	27.5	3.5	1	.	.	.	.	0.42
							2	.	.	.	.	0.62
15	16	5783928	602053	24.0	27.5	3.5	1	.	.	.	.	2.40
							2	.	.	.	.	3.55
16	1	5784330	601871	31.7	35.4	3.7	1	.	.	.	.	0.61
							2	.	.	.	.	0.81
17	5	5784330	601871	31.7	35.4	3.7	1	.	.	.	.	0.72
							2	.	.	.	.	1.43
18	10	5784330	601871	31.7	35.4	3.7	1	.	.	.	.	0.52
							2	.	.	.	.	0.60
19	18	5784330	601871	31.7	35.4	3.7	1	.	.	.	.	0.67
							2	.	.	.	.	0.81
20	4	5783966	601821	1.8	3.7	1.9	1	.	.	.	.	1.51
							2	.	.	.	.	2.90
21	7	5783966	601821	1.8	3.7	1.9	1	.	.	.	.	1.00
							2	.	.	.	.	1.28
22	1	5784351	601447	8.9	10.7	1.8	1	.	.	.	.	0.49
							2	.	.	.	.	0.93
23	4	5784351	601447	8.9	10.7	1.8	1	.	.	.	.	0.60
							2	.	.	.	.	0.81
24	1	5784180	601719	.	.	.	1	.	.	.	.	0.52
							2	.	.	.	.	0.76
25	10	5783858	602215	22.1	25.8	3.7	1	.	.	.	.	0.48
							2	.	.	.	.	0.61
26	14	5783858	602215	22.1	25.8	3.7	1	.	.	.	.	0.72

LUSCAR GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
							2	.	.	.	.	0.82
27	21	5783858	602215	22.1	25.8	3.7	1	.	.	.	.	.
							2	.	.	.	.	.
28	4	5783177	603297	44.2	48.8	4.6	1	.	.	.	.	0.44
							2	.	.	.	.	0.62
29	8	5783314	603455	64.9	67.5	2.6	1	.	.	.	.	0.45
							2	.	.	.	.	0.66
30	10	5783314	603455	30.4	33.5	3.1	1	.	.	.	.	0.56
							2	.	.	.	.	0.78
31	20	5783314	603455	64.9	67.5	2.6	1	.	.	.	.	0.34
							2	.	.	.	.	0.61
32	40	5783986	602954	169.8	173.0	3.2	1	.	.	.	.	1.06
							2	.	.	.	.	1.49
33	60	5783986	602954	129.5	132.6	3.1	1	.	.	.	.	0.60
							2	.	.	.	.	0.73
34	81	5783986	602954	129.5	132.6	3.1	1	.	.	.	.	0.69
							2	.	.	.	.	1.13
35	1	5783448	603590	73.4	75.7	2.3	1	.	.	.	.	0.56
							2	.	.	.	.	0.80
36	7	5783448	603590	73.4	75.7	2.3	1	.	.	.	.	0.48
							2	.	.	.	.	0.92
37	11	5783448	603590	30.3	34.2	3.9	1	.	.	.	.	0.46
							2	.	.	.	.	0.79
38	15	5783448	603590	30.3	34.2	3.9	1	.	.	.	.	0.50
							2	.	.	.	.	0.71
39	1	5784343	603123	56.9	66.1	9.2	1	.	.	.	.	0.57
							2	.	.	.	.	0.79
40	5	5784343	603123	56.9	66.1	9.2	1	.	.	.	.	0.65
							2	.	.	.	.	0.90
41	9	5784343	603123	56.9	66.1	9.2	1	.	.	.	.	0.61
							2	.	.	.	.	0.78
42	8	5784045	602822	114.8	118.4	3.6	1	.	.	.	.	0.64
							2	.	.	.	.	0.70
43	7	5783840	602525	24.6	27.8	3.2	1	.	.	.	.	0.56
							2	.	.	.	.	0.86
44	11	5783840	602525	24.6	27.8	3.2	1	.	.	.	.	0.69
							2	.	.	.	.	0.85
45	16	5783840	602525	24.6	27.8	3.2	1	.	.	.	.	0.78
							2	.	.	.	.	1.09
46	4	5783775	602733	42.2	45.0	2.8	1	.	.	.	.	0.39
							2	.	.	.	.	0.61
47	8	5783775	602733	42.2	45.0	2.8	1	.	.	.	.	0.45
							2	.	.	.	.	0.65
48	11	5783775	602733	42.2	45.0	2.8	1	.	.	.	.	0.70
							2	.	.	.	.	0.79
49	4	5783798	602998	69.8	73.1	3.3	1	.	.	.	.	0.63
							2	.	.	.	.	0.82
50	4	5783172	603522	19.8	19.8	0.0	1	.	.	.	.	0.48
							2	.	.	.	.	0.66
51	2	5785171	602671	61.9	64.7	2.8	1	.	.	.	.	0.63
							2	.	.	.	.	0.79

LUSCAR GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
52	21	5785068	601363	.	.	.	1	.	.	.	.	0.57
							2	.	.	.	.	1.14
53	6	5784421	601939	44.1	46.9	2.8	1	.	.	.	.	0.55
							2	.	.	.	.	0.67
54	10	5784421	601939	102.1	104.5	2.4	1	.	.	.	.	0.75
							2	.	.	.	.	1.27
55	18	5784421	601939	102.1	104.5	2.4	1	.	.	.	.	0.40
							2	.	.	.	.	0.79
56	1	5784947	601249	35.6	40.3	4.7	1	.	.	.	.	0.30
							2	.	.	.	.	0.51
57	5	5784947	601249	35.6	40.3	4.7	1	.	.	.	.	0.54
							2	.	.	.	.	0.76
58	41	5784947	601249	35.6	40.3	4.7	1	.	.	.	.	0.68
							2	.	.	.	.	1.13
59	8	5784844	602332	95.8	100.0	4.2	1	.	.	.	.	0.61
							2	.	.	.	.	0.81
60	12	5784844	602332	95.8	100.0	4.2	1	.	.	.	.	0.48
							2	.	.	.	.	0.68
61	15	5784844	602332	95.8	100.0	4.2	1	.	.	.	.	0.54
							2	.	.	.	.	0.89
62	4	5785799	602099	37.1	39.5	2.4	1	.	.	.	.	0.52
							2	.	.	.	.	0.89
63	4	5785921	600756	92.0	95.1	3.1	1	.	.	.	.	0.63
							2	.	.	.	.	0.85
64	8	5785921	600756	127.3	129.0	1.7	1	.	.	.	.	1.41
							2	.	.	.	.	2.01
65	12	5785921	600756	127.3	129.0	1.7	1	.	.	.	.	1.01
							2	.	.	.	.	1.29
66	20	5786356	600711	82.3	87.6	5.3	1	.	.	.	.	0.55
							2	.	.	.	.	0.62
67	22	5786356	600711	82.3	87.6	5.3	1	.	.	.	.	0.65
							2	.	.	.	.	1.13
68	58	5786356	600711	82.3	87.6	5.3	1	.	.	.	.	1.43
							2	.	.	.	.	2.81
69	95	5786356	600711	135.6	138.2	2.6	1	.	.	.	.	0.62
							2	.	.	.	.	0.79
70	6	5787289	599840	96.5	98.9	2.4	1	.	.	.	.	0.91
							2	.	.	.	.	1.00
71	10	5787289	599840	58.9	61.9	3.0	1	.	.	.	.	0.46
							2	.	.	.	.	0.57
72	14	5787289	599840	58.9	61.9	3.0	1	.	.	.	.	0.92
							2	.	.	.	.	1.38
73	4	5787059	600051	93.9	95.5	1.6	1	.	.	.	.	0.54
							2	.	.	.	.	0.99
74	5	5787059	600051	55.4	58.9	3.5	1	.	.	.	.	0.30
							2	.	.	.	.	0.58
75	9	5787059	600051	55.4	58.9	3.5	1	.	.	.	.	0.57
							2	.	.	.	.	0.80
76	13	5787059	600051	55.4	58.9	3.5	1	.	.	.	.	0.93
							2	.	.	.	.	1.35
77	4	5786332	601191	119.9	124.2	4.3	1	.	.	.	.	0.57

LUSCAR GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
							2	.	.	.	.	0.61
78	11	5786332	601191	119.90	124.20	4.30	1	.	.	.	.	0.79
							2	.	.	.	.	1.07
79	12	5786332	601191	119.90	124.20	4.30	1	.	.	.	.	0.51
							2	.	.	.	.	0.67
80	4	5786475	601310	50.60	57.80	7.20	1	.	.	.	.	0.61
							2	.	.	.	.	1.05
81	8	5786475	601310	50.60	57.80	7.20	1	.	.	.	.	0.49
							2	.	.	.	.	0.54
82	12	5786475	601310	50.60	57.80	7.20	1	.	.	.	.	1.21
							2	.	.	.	.	1.94
83	16	5786475	601310	50.60	57.80	7.20	1	.	.	.	.	0.80
							2	.	.	.	.	0.87
84	20	5786475	601310	50.60	57.80	7.20	1	.	.	.	.	0.86
							2	.	.	.	.	1.11
85	24	5786475	601310	50.60	57.80	7.20	1	.	.	.	.	0.86
							2	.	.	.	.	1.09
86	14	5786223	601080	90.80	95.30	4.50	1	.	.	.	.	0.53
							2	.	.	.	.	0.62
87	18	5786223	601080	90.80	95.30	4.50	1	.	.	.	.	0.57
							2	.	.	.	.	1.02
88	7	5786046	600908	104.20	107.40	3.20	1	.	.	.	.	0.74
							2	.	.	.	.	0.82
89	11	5786046	600908	104.20	107.40	3.20	1	.	.	.	.	0.98
							2	.	.	.	.	1.39
90	1	5794832	589708	115.82	116.43	0.61	1	.	.	.	.	2.03
							2	.	.	.	.	2.67
91	2	5794832	589708	116.43	117.04	0.61	1	.	.	.	.	0.56
							2	.	.	.	.	0.71
92	3	5794832	589708	117.04	117.65	0.61	1	.	.	.	.	0.33
							2	.	.	.	.	0.43
93	4	5794832	589708	117.65	118.26	0.61	1	.	.	.	.	0.37
							2	.	.	.	.	0.40
94	5	5794832	589708	118.26	118.87	0.61	1	.	.	.	.	0.47
							2	.	.	.	.	0.57
95	1	5795799	589284	138.07	138.68	0.61	1	.	.	.	.	0.57
							2	.	.	.	.	0.77
96	2	5795799	589284	138.68	139.29	0.61	1	.	.	.	.	0.50
							2	.	.	.	.	0.58
97	3	5795799	589284	139.29	139.90	0.61	1	.	.	.	.	0.33
							2	.	.	.	.	0.49
98	4	5795799	589284	139.90	140.51	0.61	1	.	.	.	.	0.33
							2	.	.	.	.	0.36
99	5	5795799	589284	140.51	141.12	0.61	1	.	.	.	.	0.40
							2	.	.	.	.	0.44
100	6	5795799	589284	141.12	141.73	0.61	1	.	.	.	.	0.41
							2	.	.	.	.	0.44
101	7	5795799	589284	141.73	142.34	0.61	1	.	.	.	.	0.55
							2	.	.	.	.	0.62
102	8	5795799	589284	179.83	180.44	0.61	1	.	.	.	.	0.50
							2	.	.	.	.	0.56

LUSCAR GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
103	9	5795799	589284	180.44	181.05	0.61	1	.	.	.	.	0.35
							2	.	.	.	.	0.39
104	10	5795799	589284	181.05	181.66	0.61	1	.	.	.	.	0.47
							2	.	.	.	.	0.53
105	11	5795799	589284	181.66	182.27	0.61	1	.	.	.	.	0.45
							2	.	.	.	.	0.60
106	12	5795799	589284	182.27	182.88	0.61	1	.	.	.	.	0.84
							2	.	.	.	.	0.95
107	13	5795799	589284	182.88	183.49	0.61	1	.	.	.	.	0.42
							2	.	.	.	.	0.49
108	14	5795799	589284	183.49	184.10	0.61	1	.	.	.	.	0.42
							2	.	.	.	.	0.48
109	15	5795799	589284	184.10	184.71	0.61	1	.	.	.	.	1.66
							2	.	.	.	.	1.82
110	16	5795799	589284	184.71	185.32	0.61	1	.	.	.	.	0.52
							2	.	.	.	.	0.58
111	17	5795799	589284	185.32	185.93	0.61	1	.	.	.	.	0.51
							2	.	.	.	.	0.56
112	18	5795799	589284	186.54	187.15	0.61	1	.	.	.	.	0.45
							2	.	.	.	.	0.60
113	19	5795799	589284	187.15	187.76	0.61	1	.	.	.	.	0.38
							2	.	.	.	.	0.47
114	2	5795960	591255	41.56	42.17	0.61	1	.	.	.	.	1.50
							2	.	.	.	.	1.78
115	3	5795960	591255	35.36	36.39	1.03	1	.	.	.	.	0.38
							2	.	.	.	.	0.51
116	4	5795960	591255	34.27	34.75	0.48	1	.	.	.	.	0.48
							2	.	.	.	.	0.61
117	2	5795873	591797	33.83	34.20	0.37	1	.	.	.	.	0.43
							2	.	.	.	.	0.52
118	3	5795873	591797	33.22	33.83	0.61	1	.	.	.	.	0.43
							2	.	.	.	.	0.45
119	4	5795873	591797	32.61	33.22	0.61	1	.	.	.	.	0.39
							2	.	.	.	.	0.41
120	5	5795873	591797	32.00	32.61	0.61	1	.	.	.	.	0.40
							2	.	.	.	.	0.43
121	6	5795873	591797	31.39	32.00	0.61	1	.	.	.	.	0.58
							2	.	.	.	.	0.68
122	7	5795873	591797	30.78	31.39	0.61	1	.	.	.	.	0.55
							2	.	.	.	.	0.71
123	8	5795873	591797	30.21	30.78	0.57	1	.	.	.	.	0.34
							2	.	.	.	.	0.61
124	1	5795858	594270	9.14	10.67	1.53	1	.	.	.	.	0.50
							2	.	.	.	.	0.56
125	2	5795858	594270	14.51	15.42	0.91	1	.	.	.	.	0.42
							2	.	.	.	.	0.60
126	3	5795858	594270	12.19	13.00	0.81	1	.	.	.	.	0.43
							2	.	.	.	.	0.69
127	4	5795858	594270	10.67	12.19	1.52	1	.	.	.	.	0.53
							2	.	.	.	.	0.64
128	5	5795858	594270	7.62	9.14	1.52	1	.	.	.	.	0.42

LUSCAR GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
							2	.	.	.	.	0.52
129	6	5795858	594270	6.10	7.62	1.52	1	.	.	.	.	0.45
							2	.	.	.	.	0.50
130	7	5795858	594270	4.57	6.10	1.53	1	.	.	.	.	0.56
							2	.	.	.	.	0.62
131	8	5795858	594270	3.78	4.57	0.79	1	.	.	.	.	0.61
							2	.	.	.	.	0.72
132	2	5795921	594177	54.25	54.71	0.46	1	.	.	.	.	1.14
							2	.	.	.	.	1.41
133	3	5795921	594177	53.64	54.25	0.61	1	.	.	.	.	0.47
							2	.	.	.	.	0.51
134	4	5795921	594177	53.04	53.64	0.60	1	.	.	.	.	0.48
							2	.	.	.	.	0.52
135	5	5795921	594177	52.43	53.04	0.61	1	.	.	.	.	0.34
							2	.	.	.	.	0.52
136	6	5795921	594177	51.82	52.43	0.61	1	.	.	.	.	0.50
							2	.	.	.	.	0.55
137	7	5795921	594177	51.18	51.82	0.64	1	.	.	.	.	0.43
							2	.	.	.	.	0.67
138	1	5795300	586921	152.70	153.92	1.22	1	.	.	.	.	0.41
							2	.	.	.	.	0.66
139	2	5795300	586921	153.92	154.53	0.61	1	.	.	.	.	0.36
							2	.	.	.	.	0.49
140	3	5795300	586921	154.53	155.14	0.61	1	.	.	.	.	0.38
							2	.	.	.	.	0.43
141	4	5795300	586921	155.14	155.75	0.61	1	.	.	.	.	0.39
							2	.	.	.	.	0.50
142	5	5795300	586921	155.75	156.36	0.61	1	.	.	.	.	0.40
							2	.	.	.	.	0.48
143	6	5795300	586921	156.36	156.67	0.31	1	.	.	.	.	0.42
							2	.	.	.	.	0.57
144	7	5795300	586921	190.20	190.80	0.60	1	.	.	.	.	0.78
							2	.	.	.	.	1.22
145	8	5795300	586921	190.80	191.41	0.61	1	.	.	.	.	0.41
							2	.	.	.	.	0.50
146	9	5795300	586921	191.41	192.02	0.61	1	.	.	.	.	0.44
							2	.	.	.	.	0.53
147	10	5795300	586921	192.02	192.33	0.31	1	.	.	.	.	3.02
							2	.	.	.	.	4.47
148	1	5795981	587294	182.58	183.18	0.60	1	.	.	.	.	1.97
							2	.	.	.	.	3.54
149	1	5796582	586973	141.43	142.04	0.61	1	.	.	.	.	0.34
							2	.	.	.	.	0.60
150	2	5796582	586973	142.04	142.65	0.61	1	.	.	.	.	0.83
							2	.	.	.	.	1.28
151	3	5796582	586973	142.65	143.26	0.61	1	.	.	.	.	0.38
							2	.	.	.	.	0.56
152	4	5796582	586973	144.48	145.08	0.60	1	.	.	.	.	0.37
							2	.	.	.	.	0.51
153	5	5796582	586973	145.08	145.69	0.61	1	.	.	.	.	0.55
							2	.	.	.	.	0.66

LUSCAR GROUP DATA

Basis: 1 = Dry 2 = Dry Ash-free

Obs	Sample no	Northing (meters)	Easting (meters)	Upper depth (meters)	Lower depth (meters)	Thickness (meters)	Basis	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur
154	1	5805012	563374	.	.	.	1	.	.	.	.	0.52
							2	.	.	.	.	0.68
155	2	5805012	563374	.	.	.	1	.	.	.	.	0.44
							2	.	.	.	.	0.55
156	1	5805200	563570	.	.	.	1	.	.	.	.	0.53
							2	.	.	.	.	0.86
157	2	5805200	563570	.	.	.	1	.	.	.	.	0.41
							2	.	.	.	.	0.52
158	3	5805200	563570	.	.	.	1	.	.	.	.	0.43
							2	.	.	.	.	0.85
159	1	5808428	560299	.	.	.	1	.	.	.	.	0.58
							2	.	.	.	.	0.64
160	2	5808428	560299	.	.	.	1	.	.	.	.	0.50
							2	.	.	.	.	0.85

Appendix 5.

Proximate and ultimate data, Alberta Geological Survey - Kootenay Group coals

Sample #	Northing (UTM)	Easting (UTM)	Upper Depth	Lower Depth	Thickness	Seam #	Basis*	Moisture	Ash	Volatile Matter	Fixed Carbon	C	H	N	S
CNP2-2	5496400	681000	28.2	29.5	1.5		1	1.3	41.5	16.4	40.8	47.7	2.7	1.12	0.34
							2		42.1	16.6	41.3	48.3	2.7	1.14	0.34
							3			28.7	71.3	83.4	4.7	1.96	0.59
CNP2-3	5496400	681000	24.7	27.2	2.5		1	1.2	33.7	18.1	47.1	55.5	3	1.27	0.43
							2		34.1	18.3	47.6	56.2	3.1	1.28	0.44
							3			27.7	72.3	85.2	4.7	1.95	0.66
CNP2-5	5496400	681000	22.2	24.1	1.9		1	1.3	29.9	20.2	48.5	58.4	3.3	1.22	0.5
							2		30.3	20.5	49.2	59.2	3.3	1.24	0.51
							3			29.4	70.6	85	4.8	1.78	0.73
CNP3-1	5506100	685900	133.6	134.5	0.9	4	1	4.1	40.3	18.6	37.1	42	2.4	0.77	0.33
							2		42	19.4	38.6	43.8	2.5	0.8	0.35
							3			33.4	66.6	75.5	4.3	1.38	0.6
CNP3-3	5506100	685900	132.4	133.1	0.9	4	1	5.6	18.2	21.4	54.7	60	2.6	1.06	0.44
							2		19.3	22.7	58	63.5	2.8	1.12	0.47
							3			28.1	71.9	78.7	3.4	1.39	0.58
CNP3-4	5506100	685900	115.6	116.6	1	4	1	5.9	11.9	23.2	59	65.6	3.1	1.23	0.39
							2		12.6	24.6	62.7	69.7	3.3	1.31	0.41
							3			28.2	71.8	79.8	3.7	1.5	0.47
CNP3-5	5506100	685900	114.8	115.4	0.6	4	1	6	12.2	24.2	57.6	65.2	3.2	1.32	0.58
							2		12.9	25.8	61.3	69.4	3.4	1.4	0.61
							3			29.6	70.4	79.7	3.8	1.61	0.7
CNP3-7	5506100	685900	113	113.7	0.7	4	1	6.7	9	24.5	59.8	68	3.1	1.13	0.5
							2		9.6	26.3	64.1	72.9	3.3	1.21	0.54
							3			29.1	70.9	80.6	3.7	1.34	0.6

* 1. As recieved Basis   2. Dry basis   3. Dry ash free basis

Sample #	Northing	Easting	Upper Depth	Lower Depth	Thickness	Seam #	Basis*	Moisture	Ash	Volatile Matter	Fixed Carbon	C	H	N	S
CNP3-8	5506100	685900	25.8	26.6	0.2		1	7.7	30	23	39.4	47.3	2.5	1.1	0.59
							2		32.5	24.9	42.6	51.2	2.7	1.19	0.63
							3			36.9	63.1	75.9	4.1	1.76	0.94
CNP3-9	5506100	685900	9.2	9.5	0.3	1	1	7.1	27.9	23.30	41.7	49.2	2.5	0.9	0.49
							2		30.1	25.00	44.9	53	2.7	0.97	0.53
							3			35.80	64.2	75.7	3.9	1.39	0.76
CNP4-1	5515200	678600	38.7	39.4	0.7		1	6.8	10	24.9	58.3	66.3	3.1	1.25	0.43
							2		10.8	26.7	62.5	71.1	3.3	1.34	0.46
							3			29.9	70.1	79.7	3.7	1.5	0.51
CNP4-2	5515200	678600	38	38.7	0.7		1	6.1	10.8	23.6	59.5	66.7	3	1.3	0.37
							2		11.5	25.1	63.4	71.1	3.2	1.38	0.4
							3			28.4	71.6	80.3	3.6	1.56	0.45
CNP4-3	5515200	678600	35	38	3		1	5.2	7.2	23.3	64.2	71.7	3.3	1.4	0.36
							2		7.6	24.6	67.8	75.7	3.4	1.48	0.38
							3			26.6	73.4	81.9	3.7	1.6	0.41
CNP4-4	5515200	678600	34.2	35	0.8		1	9	11.2	26	53.8	61.7	2.8	1.27	0.33
							2		12.3	28.6	59.1	67.8	3	1.4	0.36
							3			32.6	67.4	77.3	3.5	1.59	0.41
CNP6-1	5492500	666300	143.7	143.9	0.2	4	1	1.3	18	23.5	57.5	69	4	1.18	0.42
							2		18.2	23.8	58.3	69.9	4	1.2	0.43
							3			29.1	71.2	85.4	4.9	1.46	0.52
CNP6-2	5492500	666300	142.7	143.7	1	4	1	1.4	13.3	23.3	62.1	74.3	4	1.14	0.42
							2		13.5	23.6	62.9	75.3	4.1	1.43	0.42
							3			27.3	72.7	87	4.7	1.65	0.49

* 1. As recieved Basis 2. Dry basis 3. Dry ash free basis

Sample #	Northing	Easting	Upper Depth	Lower Depth	Thickness	Seam #	Basis	Moisture	Ash	Volatile Matter	Fixed Carbon	C	H	N	S
CNP6-3	5492500	666300	141.5	142.7	1.2	4	1	1.3	17	21	60.6	70.8	3.7	1.38	0.31
							2		17.3	21.3	61.2	71.7	3.7	1.4	0.32
							3			25.7	74.3	86.7	4.5	1.69	0.38
CNP6-4	5492500	666300	140.5	141.5	1	4	1	1.2	18.6	21.9	58.3	68.6	3.5	1.28	0.36
							2		18.8	22.2	59	69.4	3.6	1.3	0.36
							3			27.3	72.7	85.5	4.4	1.6	0.44
CNP6-5	5492500	666300	139.5	140.5	1	4	1	1.2	31.8	19.3	47.6	56.2	3.1	1.1	0.03
							2		32.2	19.6	48.2	56.9	3.2	1.11	0.03
							3			28.9	71.1	83.9	4.7	1.64	0.43
CNP6-6	5492500	666300	138.5	139.5	1	4	1	1.3	28.5	21.5	48.7	58.8	3.5	1.42	0.43
							2		28.9	21.8	49.3	59.5	3.5	1.44	0.44
							3			30.7	69.3	83.7	5	2.02	0.62
CNP6-7	5492500	666300	137.5	138.5	1	4	1	1.3	14.6	21.8	62.3	72	3.8	1.35	0.46
							2		14.8	22.1	63.1	73	3.8	1.37	0.47
							3			25.9	74.1	85.7	4.5	1.61	0.55
CNP6-8	5492500	666300	136.6	137.5	0.8	4	1	1.2	17.8	19.4	61.6	69.9	3.5	1.26	0.38
							2		18	19.6	62.4	70.7	3.5	1.28	0.38
							3			23.9	76.1	86.3	4.3	1.56	0.46
CNP6-9	5492500	666300	87.2	88.2	1	5	1	1.2	18	19.5	60.8	72.2	4.2	1.55	0.6
							2		18.2	19.8	61.5	73	4.3	1.57	0.61
							3			24.2	75.2	89.3	5.2	1.92	0.75
CNP6-10	5492500	666300	86.2	87.2	1	5	1	1.4	13.7	25.3	59.6	71	3.7	1.22	0.32
							2		13.9	25.6	60.4	72	3.8	1.24	0.32
							3			29.8	70.2	83.7	4.4	1.44	0.37

* 1. As recieved Basis   2. Dry basis   3. Dry ash free basis

Sample #	Northing	Easting	Upper Depth	Lower Depth	Thickness	Seam #	Basis	Moisture	Ash	Volatile Matter	Fixed Carbon	C	H	N	S
CNP6-11	5492500	666300	85.2	86.2	1	5	1	1.5	16.3	21.5	60.6	68.2	3.6	1.24	0.22
							2		16.6	21.9	61.6	69.3	3.7	1.26	0.22
							3			26.2	73.8	83	4.4	1.51	0.26
CNP6-12	5492500	666300	84.2	85.2	1	5	1	1.6	19	21.1	58.3	74.8	3.9	1.48	0.23
							2		19.3	21.5	59.2	76	4	1.05	0.24
							3			26.6	73.4	94.2	4.9	1.86	0.29
CNP6-13	5492500	666300	82.9	84.2	1.3	5	1	1.7	10.8	26.8	60.6	75.7	3.7	1.4	0.26
							2		11	27.3	61.7	77	3.8	1.42	0.26
							3			30.6	69.3	86.6	4.3	1.6	0.03
CNP6-14	5492500	666300	81.6	82.6	1	5	1	1.6	11	22.2	65.2	72.6	3.7	1.3	0.26
							2		11.2	22.6	66.2	73.8	3.8	1.32	0.26
							3			25.4	74.6	83.1	4.3	1.49	0.3
CNP6-15	5492500	666300	80.6	81.6	1	5	1	1.5	14.8	21.9	61.9	72.3	4	1.61	0.29
							2		15	22.2	62.8	73.4	4.1	1.63	0.3
							3			26.2	74	86.4	4.8	1.92	0.35
CNP6-16	5492500	666300	79	80.6	1	5	1	1.4	17	21.7	60.6	70.3	3.7	1.48	0.31
							2		17.2	22	60.8	71.3	3.7	1.5	0.31
							3			26.5	73.5	86.2	4.5	1.81	0.38
CNP6-17	5492500	666300	78	78.6	0.6	5	1	1.3	13	26.3	59.5	73.6	4.4	1.61	0.68
							2		13.1	26.6	60.2	74.5	4.4	1.63	0.69
							3			30.7	69.3	85.8	5.1	1.88	0.79
CNP6-18	5492500	666300	49	49.3	0.3		1	1.1	62.1	13.7	23.1	28.6	2	0.93	0.66
							2		62.8	13.8	23.4	28.9	2	0.94	0.67
							3			37.2	62.8	77.7	5.3	2.53	1.79

* 1. As recieved Basis 2. Dry basis 3. Dry ash free basis

Sample #	Northing	Easting	Upper Depth	Lower Depth	Thickness	Seam #	Basis*	Moisture	Ash	Volatile Matter	Fixed Carbon	C	H	N	S
CNP6-19	5492500	666300	20.2	21.2	1		1	1.1	40.3	19.5	39.1	48.6	3	1.25	0.5
							2		40.7	19.7	39.6	49.1	3	1.26	0.51
							3			33.3	66.8	82.9	5.1	2.13	0.86
CNP6-20	5492500	666300	18.4	19.1	0.7		1	1.1	37.5	19.3	42.1	51.7	3	1.34	0.52
							2		37.9	19.5	42.6	52.2	3	1.36	0.52
							3			31.4	68.6	84.2	4.9	2.18	0.84
CNP6-21	5492500	666300	15.8	16.3	0.5		1	1.2	10.3	27.4	61	76.3	4.5	1.67	0.98
							2		10.5	27.8	61.8	77.2	4.6	1.69	1
							3			31	69	86.3	5.1	1.89	1.11
CNP6-22	5492500	666300	15.4	15.8	0.4		1	1.2	11.4	25	62.4	74.9	4.1	1.5	0.86
							2		11.6	25.3	63.1	75.8	4.1	1.52	0.87
							3			28.6	71.4	85.8	4.7	1.72	0.98
CNP6-23	5492500	666300	10.4	11.1	0.7		1	1.1	24.3	24.1	50.5	61.4	3.7	1.21	0.71
							2		24.6	24.4	51.1	62.1	3.7	1.22	0.72
							3			32.3	67.7	82.3	4.9	1.62	0.96
CNP6-24	5492500	666300	2.6	3.6	1	6	1	1.4	13.6	24.9	60.6	72.5	4	1.68	0.39
							2		13.8	25.3	60.9	73.6	4.1	1.7	0.4
							3			29.3	70.7	85.4	4.7	1.98	0.46
CNP6-25	5492500	666300	1.6	2.6	1	6	1	1.4	8.4	25.7	64.5	78	4.2	1.57	0.33
							2		8.5	26.1	65.5	79.1	4.3	1.59	0.33
							3			28.5	71.5	86.5	4.7	1.74	0.36
CNP6-26	5492500	666300	0.8	1.6	0.8	6	1	1.2	16	24	58.8	71.7	3.7	1.41	0.43
							2		16.2	24.3	59.5	72.6	3.7	1.43	0.43
							3			29	71	86.5	4.4	1.7	0.52

Sample #	Northing	Easting	Upper Depth	Lower Depth	Thickness	Seam #	Basis*	Moisture	Ash	Volatile Matter	Fixed Carbon	C	H	N	S
CNP6-27	5492500	666300	0	0.8	0.8	6	1	1	19.2	25.6	54.2	68.1	4.01	1.52	0.47
							2		19.4	25.9	54.8	68.7	4.05	1.54	0.47
							3			32.1	67.9	85.3	5.02	1.9	0.59
CNP7-1	5506100	685900	39	39.8	0.8		1	2	20.9	19.5	57.7	64.9	3.1	1.22	0.52
							2		21.3	19.9	58.8	66.2	3.2	1.24	0.53
							3			25.3	74.7	84.1	4	1.58	0.68
CNP7-2	5506100	685900	35.2	35.8	0.6		1	1.1	8.6	23.3	67	78.8	4.1	1.46	0.75
							2		8.7	23.5	67.8	79.7	4.1	1.48	0.76
							3			25.8	74.2	87.3	4.5	1.62	0.83
CNP7-4	5506100	685900	28.3	29	0.7	1	1	1.1	26.4	18.8	53.7	62.7	3.2	1.18	0.48
							2		26.7	19	54.3	63.4	3.2	1.19	0.49
							3			26	74	86.5	4.4	1.63	0.66
CNP7-5	5506100	685900	27.6	28	0.4	1	1	1.3	12.5	23.3	62.9	74.2	3.8	1.32	0.66
							2		12.7	23.6	63.7	75.2	3.9	1.34	0.67
							3			27.1	72.9	86.1	4.4	1.53	0.77
CNP7-6	5506100	685900	27.6	26.4	0.6	1	1	2.4	14.3	23.7	59.7	70.8	3.8	1.32	0.59
							2		14.6	24.2	61.2	72.6	3.9	1.35	0.61
							3			28.4	71.6	85	4.5	1.58	0.71
CNP7-7	5506100	685900	25.4	26.4	1	1	1	1.9	19.6	21.4	57.1	66.5	3.5	1.32	0.64
							2		20	21.8	58.2	67.8	3.5	1.35	0.65
							3			27.3	72.7	84.7	4.4	1.68	0.81
CNP7-8	5506100	685900	24	224.5	0.5	1	1	1.9	17.1	23.4	57.6	66.5	3.5	1.32	0.64
							2		17.5	23.9	58.7	67.8	3.5	1.35	0.65
							3			28.9	71.1	84.7	4.4	1.68	0.81

* 1. As recieved Basis 2. Dry basis 3. Dry ash free basis

Sample #	Northing	Easting	Upper Depth	Lower Depth	Thickness	Seam #	Basis*	Moisture	Ash	Volatile Matter	Fixed Carbon	C	H	N	S
CNP8-1	5504900	685700	11.4	12.6	1	2	1	1.2	17.8	20.7	60.3	69.8	3.5	1.2	0.4
							2		18	21	61	70.7	3.5	1.21	0.4
							3			25.6	74.4	86.1	4.3	1.48	0.49
CNP8-2	5504900	685700	10.4	11.4	1	2	1	0.9	15	20.9	63.3	73.6	3.8	1.28	0.32
							2		15.1	21	63.8	74.3	3.8	1.29	0.23
							3			24.8	75.2	87.5	4.5	1.52	0.28
CNP8-3	5504900	685700	9.4	10.4	1	2	1	1.2	15.9	22.1	60.9	73.6	3.8	1.28	0.32
							2		16	22.3	61.6	74.3	3.8	1.29	0.33
							3			26.6	73.4	87.5	4.5	1.52	0.38
CNP8-4	5504900	685700	8.4	9.4	1	2	1	1.3	14.8	19.3	64.6	73.4	3.3	1.08	0.23
							2		15	19.6	65.4	74.3	3.4	1.09	0.24
							3			23	77	87.5	4	1.29	0.28
CNP8-5	5504900	685700	7.4	8.4	1	2	1	1.1	20.7	20.1	58	67.2	3.3	1.14	0.22
							2		21	20.3	58.7	67.9	3.4	1.15	0.22
							3			25.7	74.3	86	4.3	1.46	0.28
CNP8-6	5504900	685700	6	7.4	1.4	2	1	1.3	10.2	21.7	66.9	78.3	3.7	1.24	0.37
							2		10.4	21.9	67.7	79.3	3.7	1.26	0.37
							3			24.5	75.5	88.4	4.1	1.4	0.41
CNP9-1	5484200	687500	56.6	57.6	1		1	6.1	16.6	25.7	51.6	59.7	2.8	1.06	0.44
							2		17.7	27.4	55	63.6	3	1.13	0.46
							3			33.2	66.8	77.2	3.6	1.37	0.56
CNP9-2	5484200	687500	21	22	1		1	7.8	12.8	27	52.4	60.1	2.6	1	0.26
							2		13.9	29.3	56.8	65.2	2.8	1.08	0.28
							3			34	66	75.8	3.3	1.26	0.32

* 1. As recieved Basis 2. Dry basis 3. Dry ash free basis

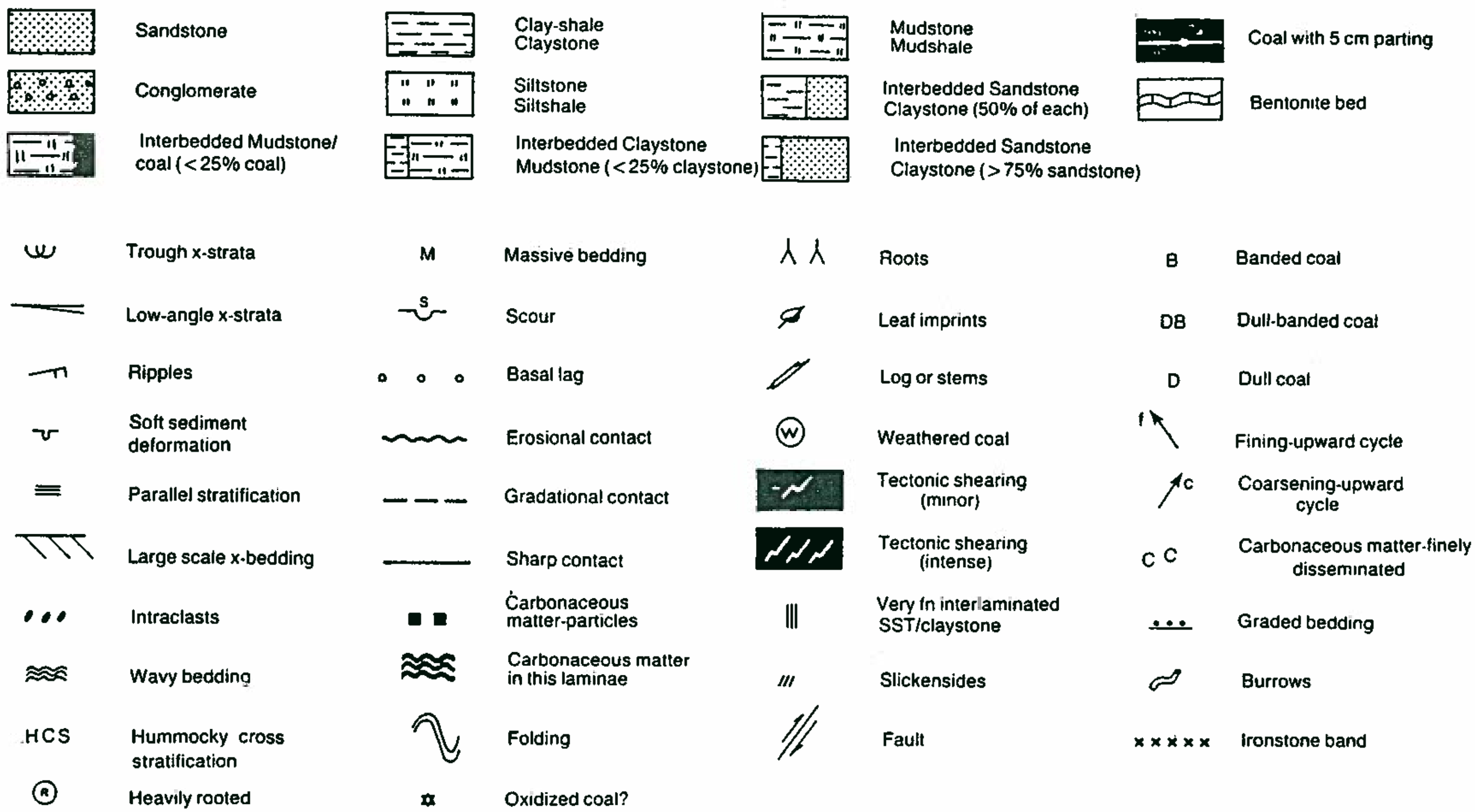
Sample #	Northing	Easting	Upper Depth	Lower Depth	Thickness	Seam #	Basis*	Moisture	Ash	Volatile Matter	Fixed Carbon	C	H	N	S
CNP9-3	5484200	687500	20.3	21	0.7		1	6.6	22.3	23	48	54.5	2.1	0.92	0.18
							2		23.9	24.7	51.4	58.3	2.3	0.99	0.19
							3			32.4	67.6	76.7	3	1.29	0.25
CNP9-4	5484200	687500	19.2	20	0.8		1	7.1	19.4	25.9	47.6	55.1	2.5	1.08	0.22
							2		20.9	27.9	51.3	59.3	2.7	1.16	0.24
							3			35.2	64.8	74.9	3.4	1.47	0.3
CNP9-5	5484200	687500	18.6	19.1	0.5		1	6.2	18.5	27.5	47.5	56.7	2.8	1.2	0.3
							2		19.7	29.3	51	60.4	3	1.28	0.32
							3			36.5	63.5	75.2	3.8	1.59	0.39
CNP9-6	5484200	687500	16.8	17.8	1		1	3.4	20	21.9	54.8	61.7	2.8	1	0.21
							2		20.6	22.6	56.7	63.8	2.9	1.03	0.22
							3			28.5	71.5	80.4	3.7	1.3	0.28
CNP9-7	5484200	687500	16.2	16.8	0.6		1	2.6	33.3	19.1	45	50.1	2.4	0.9	0.23
							2		34.2	19.6	46.2	51.4	2.5	0.92	0.24
							3			29.8	70.2	78.1	3.7	1.4	0.36
CNP9-8	5484200	687500	13.6	14.3	0.7		1	2.2	10.8	25.8	61.2	73.4	3.9	1.16	0.36
							2		11	26.4	62.6	75	4	1.19	0.37
							3			29.7	70.3	84.3	4.5	1.33	0.42

* 1. As recieved Basis 2. Dry basis 3. Dry ash free basis

Appendix 6.

Legend for Figures 21 to 27

Legend



Sandstone
Clay-shale Claystone
Mudstone Mudshale
Coal with 5 cm parting
Conglomerate
Siltstone Siltshale
Interbedded Sandstone Claystone (50% of each)
Bentonite bed
Interbedded Mudstone/ coal (<25% coal)
Interbedded Claystone Mudstone (<25% claystone)
Interbedded Sandstone Claystone (>75% sandstone)
Trough x-strata
M
Massive bedding
Roots
B
Banded coal
Low-angle x-strata
S
Scour
Leaf imprints
DB
Dull-banded coal
Ripples
Basal lag
Log or stems
D
Dull coal
Soft sediment deformation
Erosional contact
W
Weathered coal
f
Fining-upward cycle
Parallel stratification
Gradational contact
Tectonic shearing (minor)
c
Coarsening-upward cycle
Large scale x-bedding
Sharp contact
Tectonic shearing (intense)
C C
Carbonaceous matter-finely disseminated
Intraclasts
Carbonaceous matter-particles
Very fn interlaminated SST/claystone
Graded bedding
Wavy bedding
Carbonaceous matter in this laminae
Slickensides
Burrows
HCS
Hummocky cross stratification
Folding
Fault
Ironstone band
R
Heavily rooted
Oxidized coal?

Appendix 7.

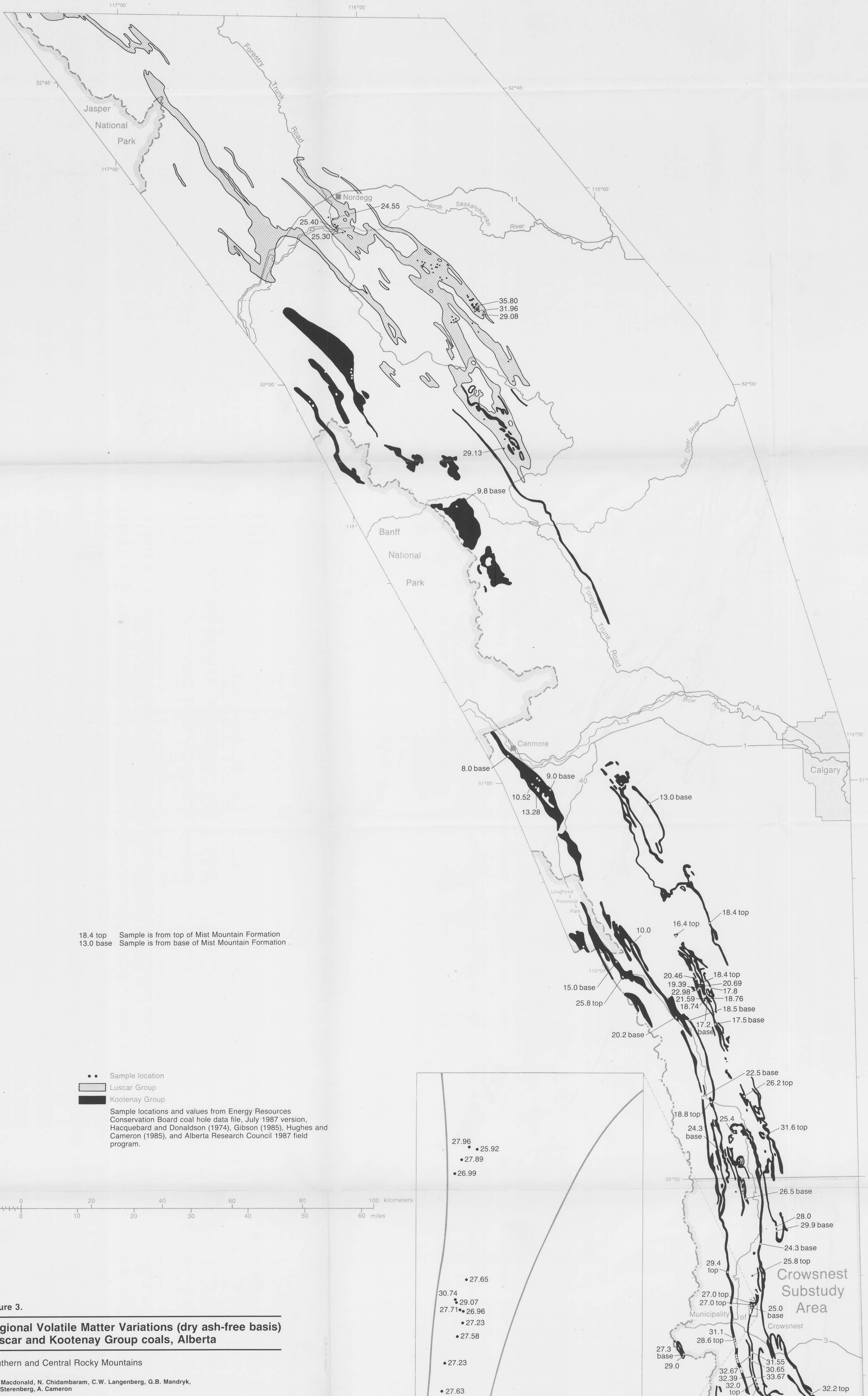
Weighted mean values for the variables: moisture, ash, volatile matter, fixed carbon, sulfur and calorific value - southern and central Rockies

FOOTHILLS AND MOUNTAINS COALS
WEIGHTED VALUES

OBS	Latitude	Longitude	Residual Moisture	Equilibrium Moisture	Proximate Ash (Dry)	Volatile Matter (Dry Ash-free)	Fixed Carbon (Dry Ash-free)	Sulfur (Dry)	Calorific Value (Dry Ash-free) Mj/Kg
1	49.464724	114.400314	0.87	.	27.28	32.39	67.61	0.46	34.3
2	49.474987	114.405524	1.04	.	29.78	32.83	67.17	0.70	34.0
3	49.484944	114.411057	2.04	.	27.06	33.67	66.32	0.49	33.2
4	49.502374	114.426741	0.56	.	41.75	32.39	67.61	0.31	33.8
5	49.538652	114.425757	2.26	.	26.89	30.65	69.35	0.42	33.2
6	49.549310	114.483273	1.10	.	34.07	32.67	67.33	0.26	32.9
7	49.547800	114.441815	0.79	.	22.54	31.03	68.97	0.31	34.4
8	49.561737	114.430032	0.81	.	30.07	31.55	68.45	0.51	34.2
9	49.661223	114.429872	.	.	22.78	27.23	72.77	0.38	35.2
10	49.659085	114.430113	.	.	13.50	27.63	72.37	0.52	35.8
11	49.667539	114.427341	.	.	20.91	27.65	72.35	0.29	35.4
12	49.663237	114.428397	.	.	22.40	27.58	72.42	0.62	35.3
13	49.666073	114.428630	.	.	24.20	30.74	69.26	0.44	35.3
14	49.665813	114.428503	.	.	21.90	29.07	70.93	0.35	35.3
15	49.664319	114.427785	.	.	21.40	27.23	72.77	0.41	35.3
16	49.665210	114.427743	.	.	24.70	26.96	73.04	0.45	35.2
17	49.665251	114.428038	.	.	18.80	27.71	72.41	0.39	35.3
18	49.677695	114.427024	.	.	28.10	27.96	72.04	0.37	34.7
19	49.675695	114.428757	.	.	33.30	29.99	70.01	0.41	34.9
20	49.676723	114.427975	.	.	22.48	27.89	72.11	0.57	35.3
21	49.677504	114.426095	3.80	.	19.71	25.92	74.03	0.48	35.0
22	50.452556	114.589995	0.50	.	36.41	21.59	78.41	0.44	34.7
23	50.451169	114.590981	1.10	.	20.50	18.74	81.26	.	.
24	50.455035	114.587804	1.05	.	15.65	18.76	81.24	.	.
25	50.478381	114.607711	0.40	.	10.64	20.69	79.31	0.68	36.3
26	50.477285	114.603476	0.57	.	18.52	18.60	81.40	0.58	36.3
27	50.474838	114.615123	0.55	.	19.44	22.98	77.02	.	.
28	50.477759	114.610395	0.40	.	29.54	19.39	80.61	.	.
29	50.502463	114.622946	0.43	.	45.50	21.79	78.21	.	.
30	50.519484	114.625745	0.50	.	24.60	20.46	79.54	0.54	35.4
31	51.008575	115.249268	0.54	.	17.83	13.28	86.72	0.63	35.6
32	51.014750	115.258897	0.75	.	8.15	10.52	89.61	0.64	.
33	51.867491	115.382602	.	.	23.10	29.13	70.87	0.73	36.0
34	52.138399	115.495336	0.80	.	27.70	25.76	74.24	0.57	34.7
35	52.160876	115.520028	1.06	.	32.37	30.60	69.40	0.89	34.6
36	52.198310	115.506850	1.08	.	24.09	32.31	67.69	1.02	35.1
37	52.201953	115.509387	1.60	.	26.33	31.76	68.24	0.63	35.0
38	52.198694	115.510233	1.05	.	34.90	36.68	63.32	1.26	34.8
39	52.202227	115.515576	1.50	.	36.55	32.12	67.88	0.55	34.6
40	52.200638	115.511658	1.50	.	31.80	31.96	68.04	0.52	34.5
41	52.197653	115.504490	1.70	.	26.43	33.01	66.99	0.60	35.2
42	52.191325	115.488880	1.50	.	29.20	31.21	68.79	0.44	35.1
43	52.192530	115.486521	0.97	.	34.28	31.66	68.34	0.46	34.4
44	52.198666	115.493644	.	.	28.37	31.89	68.11	0.79	34.7
45	52.193708	115.484517	2.17	.	36.71	32.75	67.25	0.49	34.6
46	52.201844	115.491062	0.90	.	25.67	34.13	65.87	0.61	35.3
47	52.199214	115.495559	1.10	.	8.00	31.09	68.91	0.64	35.8
48	52.197434	115.499966	1.47	.	27.33	31.94	68.06	0.68	35.2
49	52.196804	115.496939	0.93	.	25.77	32.88	67.12	0.51	35.2
50	52.196968	115.493065	0.80	.	23.30	32.46	67.54	0.63	35.4
51	52.191243	115.485586	1.10	.	27.10	29.08	70.92	0.48	35.0

FOOTHILLS AND MOUNTAINS COALS
WEIGHTED VALUES

OBS	Latitude	Longitude	Residual Moisture	Equilibrium Moisture	Proximate Ash (Dry)	Volatile Matter (Dry Ash-free)	Fixed Carbon (Dry Ash-free)	Sulfur (Dry)	Calorific Value (Dry Ash-free) Mj/Kg
52	52.209366	115.497429	.	.	20.10	29.91	70.09	0.63	35.1
53	52.208681	115.516600	.	.	50.00	35.80	64.20	0.57	34.4
54	52.202764	115.508363	1.55	.	35.09	32.60	67.40	0.57	34.2
55	52.207613	115.518292	1.27	.	36.83	34.27	65.73	0.51	34.5
56	52.206489	115.502486	1.43	.	31.10	33.62	66.38	0.54	35.2
57	52.215118	115.505603	1.40	.	41.30	33.39	66.61	0.52	34.4
58	52.216460	115.525220	1.03	.	25.84	33.39	66.61	0.93	34.9
59	52.220377	115.525754	1.21	.	32.64	35.37	64.63	0.84	35.0
60	52.228924	115.538220	1.08	.	21.47	29.29	70.71	0.75	35.1
61	52.226814	115.535193	1.02	.	37.11	33.59	66.41	0.59	34.2
62	52.220076	115.518737	0.90	.	18.80	33.15	66.85	0.62	35.2
63	52.221336	115.516956	0.93	.	23.58	34.16	65.84	0.81	35.1
64	52.219117	115.520384	0.95	.	29.45	33.29	66.71	0.55	34.8
65	52.217556	115.522967	1.05	.	19.85	32.70	67.30	0.86	35.5
66	52.298462	115.684515	.	.	18.39	34.61	65.39	0.75	35.2
67	52.307228	115.690476	.	.	14.53	32.93	67.07	0.53	35.5
68	52.308348	115.661532	.	.	21.70	34.34	65.66	0.72	34.5
69	52.307472	115.653607	.	.	15.83	32.98	67.02	0.45	34.3
70	52.306918	115.617357	.	.	17.14	34.32	65.68	0.49	34.9
71	52.307507	115.618693	.	.	19.39	33.11	66.89	0.53	34.6
72	52.303118	115.725252	.	.	25.39	32.40	67.60	0.57	35.0
73	52.309180	115.719611	.	.	44.35	34.43	65.57	1.97	33.6
74	52.314634	115.724157	.	.	30.98	32.87	67.13	0.49	35.1
75	52.393647	116.068693	0.28	.	22.00	25.40	74.60	0.48	35.7
76	52.395309	116.065776	0.75	.	36.21	25.30	74.70	0.46	34.3
77	52.424699	116.113258	.	.	24.90	24.55	75.45	0.54	35.2



18.4 top Sample is from top of Mist Mountain Formation
13.0 base Sample is from base of Mist Mountain Formation

▪ • Sample location
Luscar Group
Kootenay Group

Sample locations and values from Energy Resources Conservation Board coal hole data file, July 1987 version, Hacquebard and Donaldson (1974), Gibson (1985), Hughes and Cameron (1985), and Alberta Research Council 1987 field program.

Figure 3.

Regional Volatile Matter Variations (dry ash-free basis) Luscar and Kootenay Group coals, Alberta

Southern and Central Rocky Mountains

D.E. Macdonald, N. Chidambaram, C.W. Langenberg, G.B. Mandryk, C.E. Sterenberg, A. Cameron

Published 1987

Any revisions or additional geological information would be welcomed by the Alberta Research Council.

Geology based on Geological Survey of Canada maps.
Cartography by Alberta Research Council, Graphic Services.

ALBERTA RESEARCH COUNCIL
Natural Resources Division
Alberta Geological Survey

Figure 10.

Regional Moisture Variations (residual) Luscar and Kootenay Group coals, Alberta

Southern and Central Rocky Mountains

D.E. Macdonald, N. Chidambaram, C.W. Langenberg, G.B. Mandryk, C.E. Sterenberg, A. Cameron

Published 1987

Any revisions or additional geological information would be welcomed by the Alberta Research Council.

ALBERTA RESEARCH COUNCIL
Natural Resources Division
Alberta Geological Survey

Geology based on Geological Survey of Canada maps.
Cartography by Alberta Research Council, Graphic Services.

Figure 11.

Regional Ash Variations (dry basis) Luscar and Kootenay Group coals, Alberta

Southern and Central Rocky Mountains

D.E. Macdonald, N. Chidambaram, C.W. Langenberg, G.B. Mandryk, C.E. Sterenberg, A. Cameron

Published 1987

Any revisions or additional geological information would be welcomed by the Alberta Research Council.

ALBERTA RESEARCH COUNCIL
Natural Resources Division
Alberta Geological Survey

Geology based on Geological Survey of Canada maps.
Cartography by Alberta Research Council, Graphic Services.

OFR 1987-9
#3 of 6

Figure 12.

Regional Fixed Carbon Variations (dry ash-free basis) Luscar and Kootenay Group coals, Alberta

Southern and Central Rocky Mountains

D.E. Macdonald, N. Chidambaram, C.W. Langenberg, G.B. Mandryk, C.E. Sterenberg, A. Cameron

Published 1987

Any revisions or additional geological information would be welcomed by the Alberta Research Council.

ALBERTA RESEARCH COUNCIL
Natural Resources Division
Alberta Geological Survey

Geology based on Geological Survey of Canada maps.
Cartography by Alberta Research Council, Graphic Services.

Figure 13.

Regional Calorific Value Variations in MJ/kg (dry ash-free basis) Luscar and Kootenay Group coals, Alberta

Southern and Central Rocky Mountains

D.E. Macdonald, N. Chidambaram, C.W. Langenberg, G.B. Mandryk, C.E. Sterenberg, A. Cameron

Published 1987

Any revisions or additional geological information would be welcomed by the Alberta Research Council.

Geology based on Geological Survey of Canada maps
Cartography by Alberta Research Council, Graphic Services.

ALBERTA RESEARCH COUNCIL
Natural Resources Division
Alberta Geological Survey

OFR 1987-9
#5066

Figure 15.

Regional Sulfur Variations (dry basis) Luscar and Kootenay Group coals, Alberta

Southern and Central Rocky Mountains

D.E. Macdonald, N. Chidambaram, C.W. Langenberg, G.B. Mandryk, C.E. Sterenberg, A. Cameron

Published 1987

Any revisions or additional geological information would be welcomed by the Alberta Research Council.

ALBERTA RESEARCH COUNCIL

Natural Resources Division
Alberta Geological Survey

Geology based on Geological Survey of Canada maps.
Cartography by Alberta Research Council, Graphic Services.

OFR 1987-9
#6 of 6

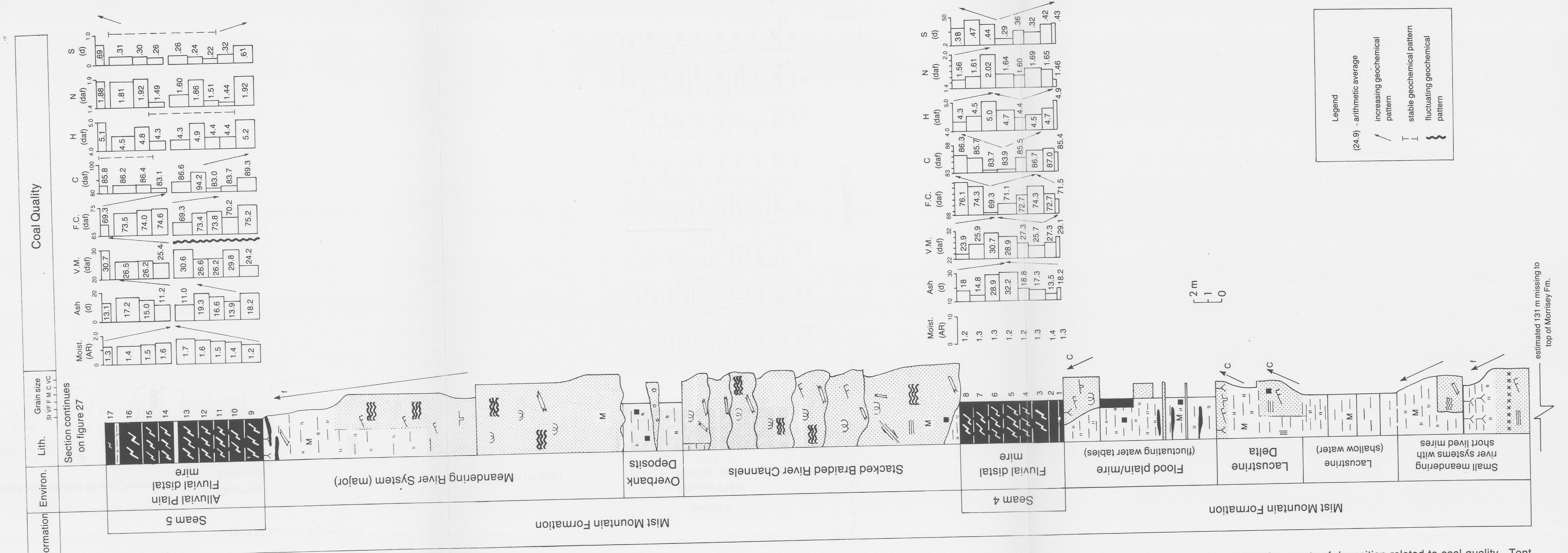


Figure 26. Stratigraphic section and environments of deposition related to coal quality - Tent Mountain, North Pit (CNP-6).

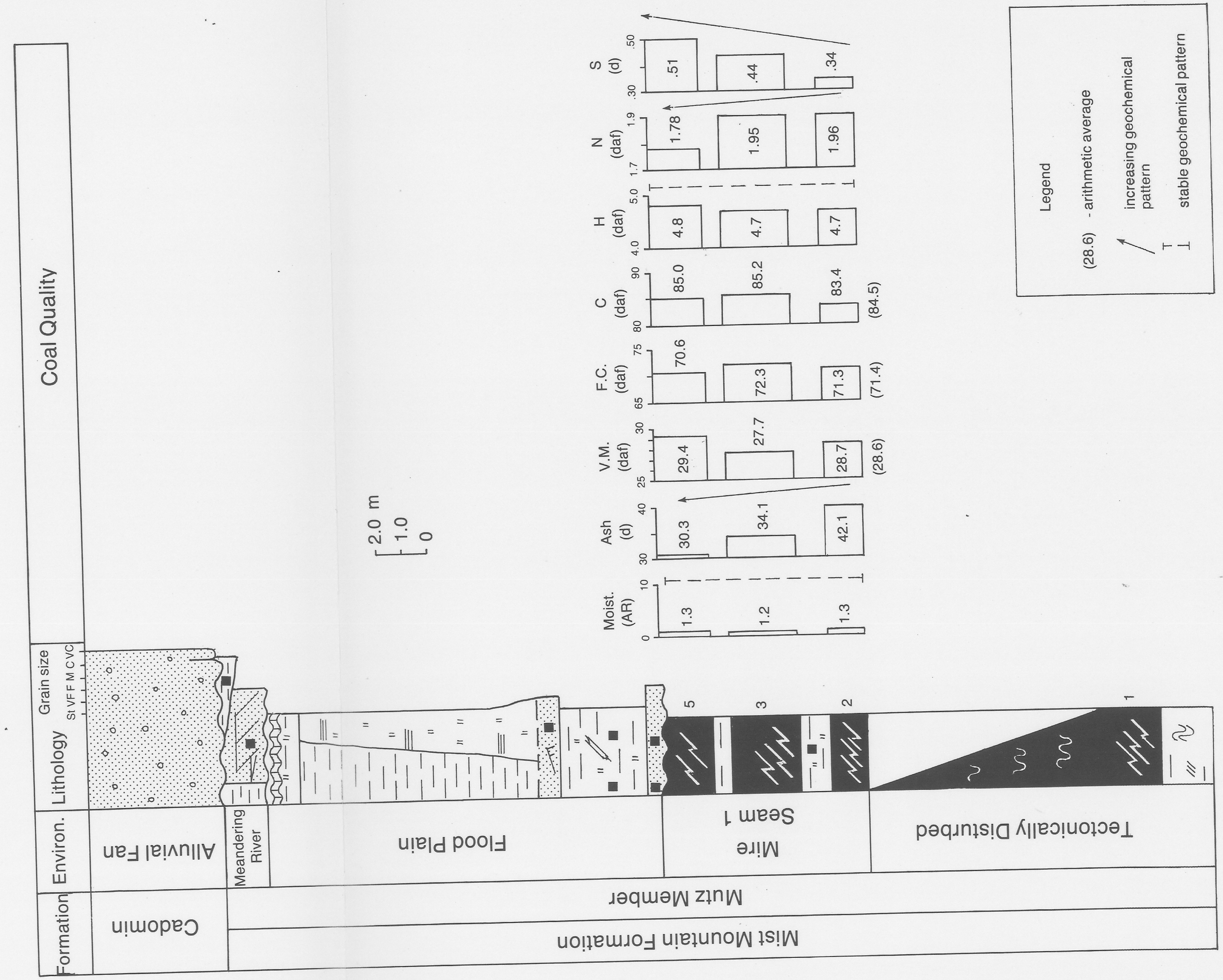


Figure 25. Stratigraphic section and depositional environments related to coal quality - York Creek open pitss (CNP-2).

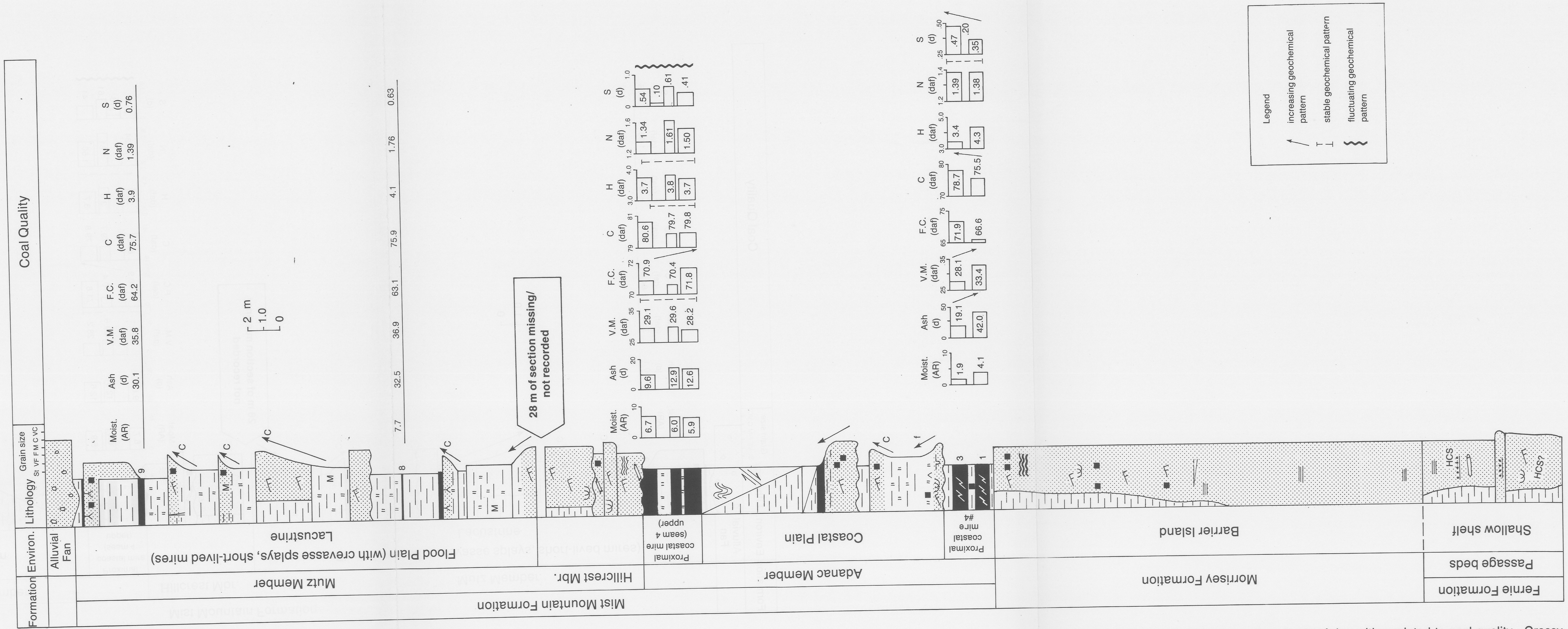


Figure 24. Stratigraphic section and environments of deposition related to coal quality - Grassy Mountain type section (CNP-3).

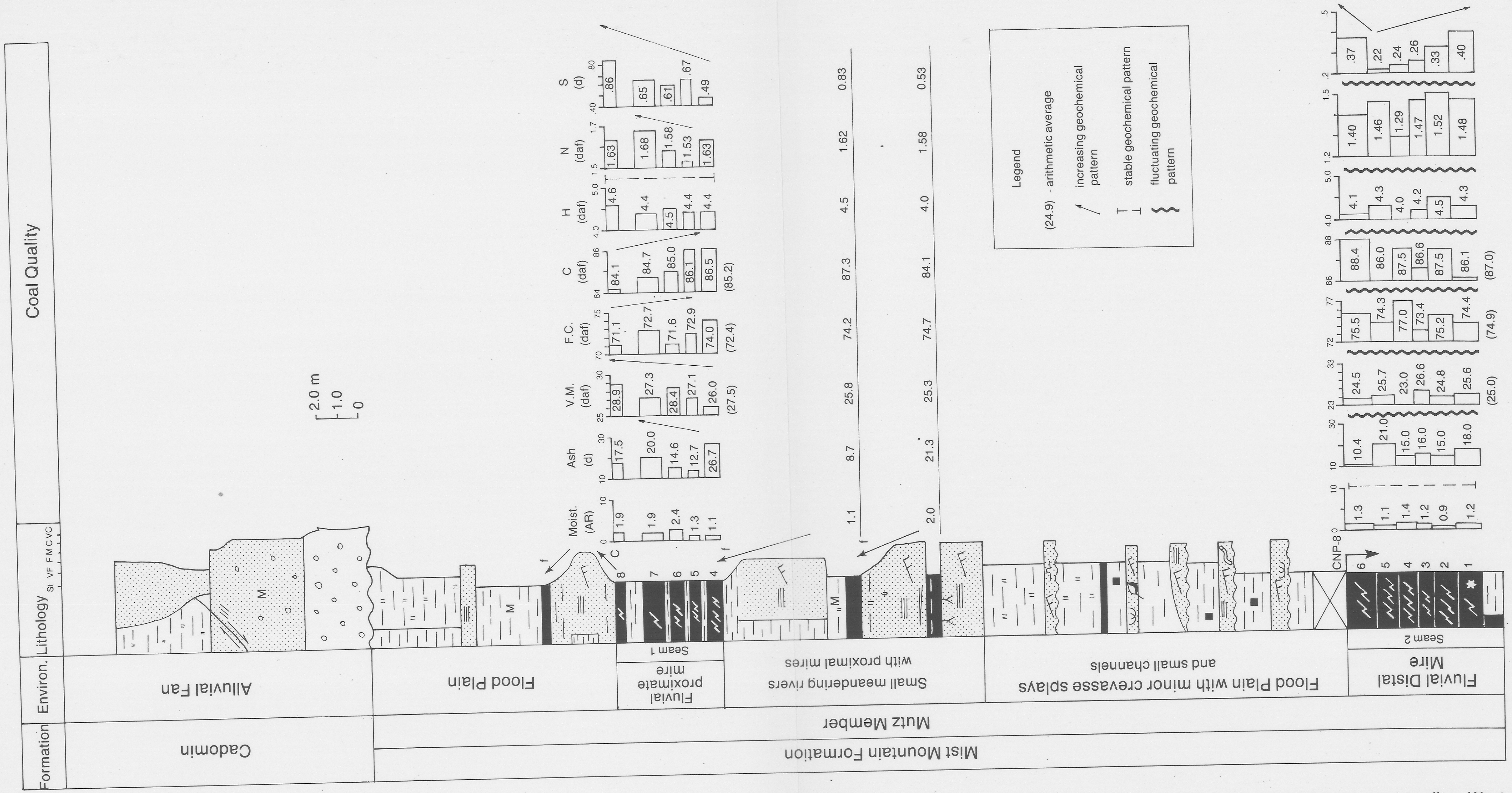


Figure 23. Stratigraphic section and environments of deposition related to coal quality - West Grassy Mountain (CNP-7, CNP-8).

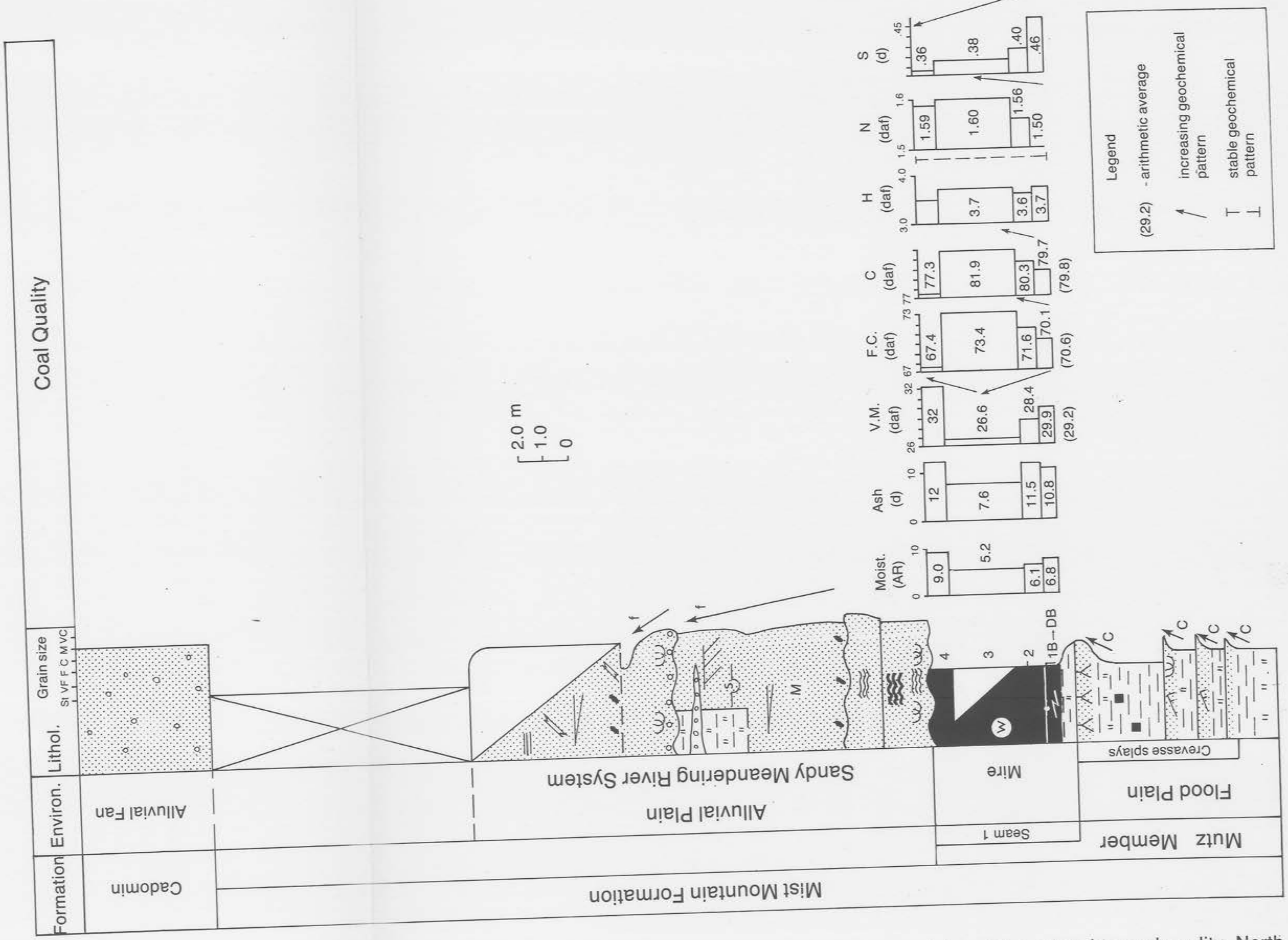


Figure 22. Stratigraphic section and environments of deposition related to coal quality -North Vicary Creek (CNP-4).

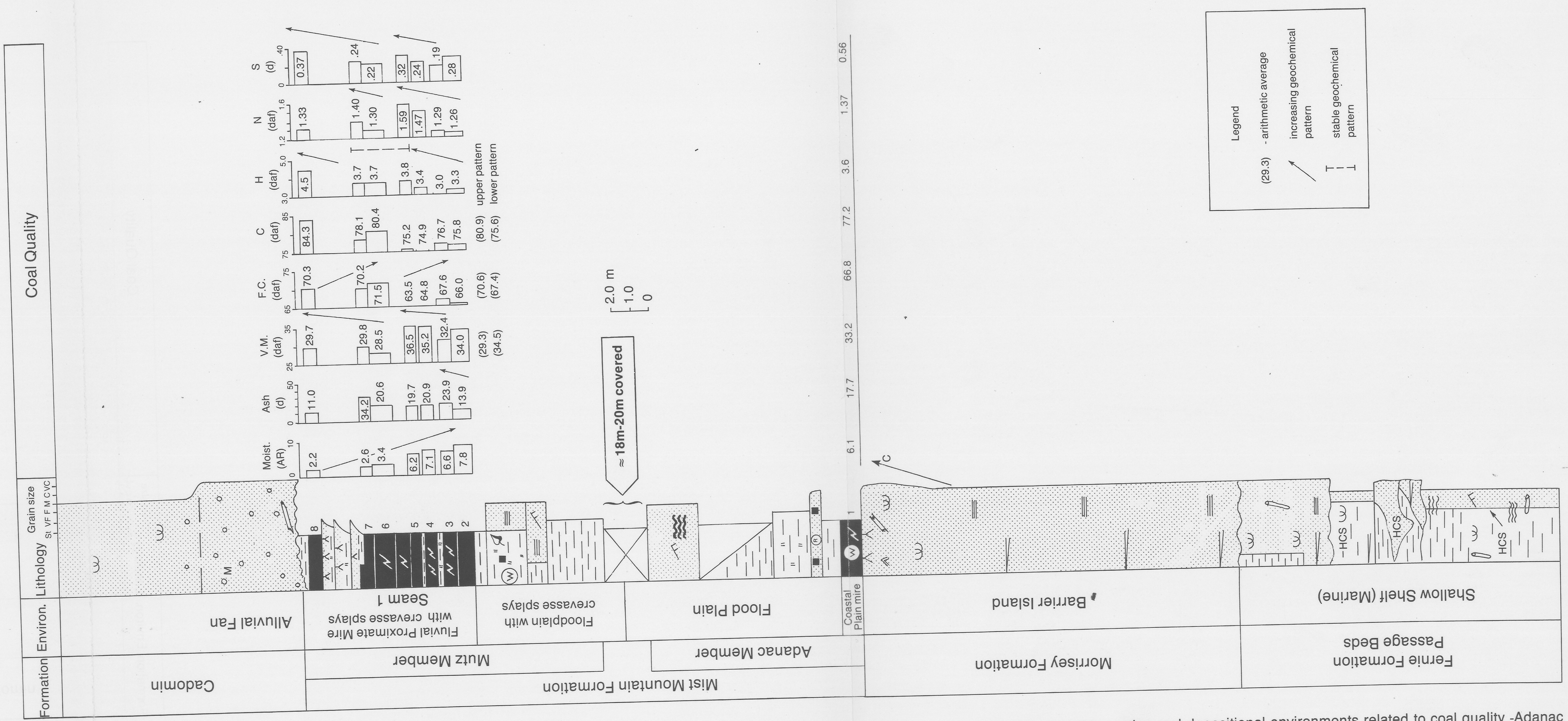


Figure 21. Stratigraphic section and depositional environments related to coal quality -Adanac Mine, south (CNP-9).

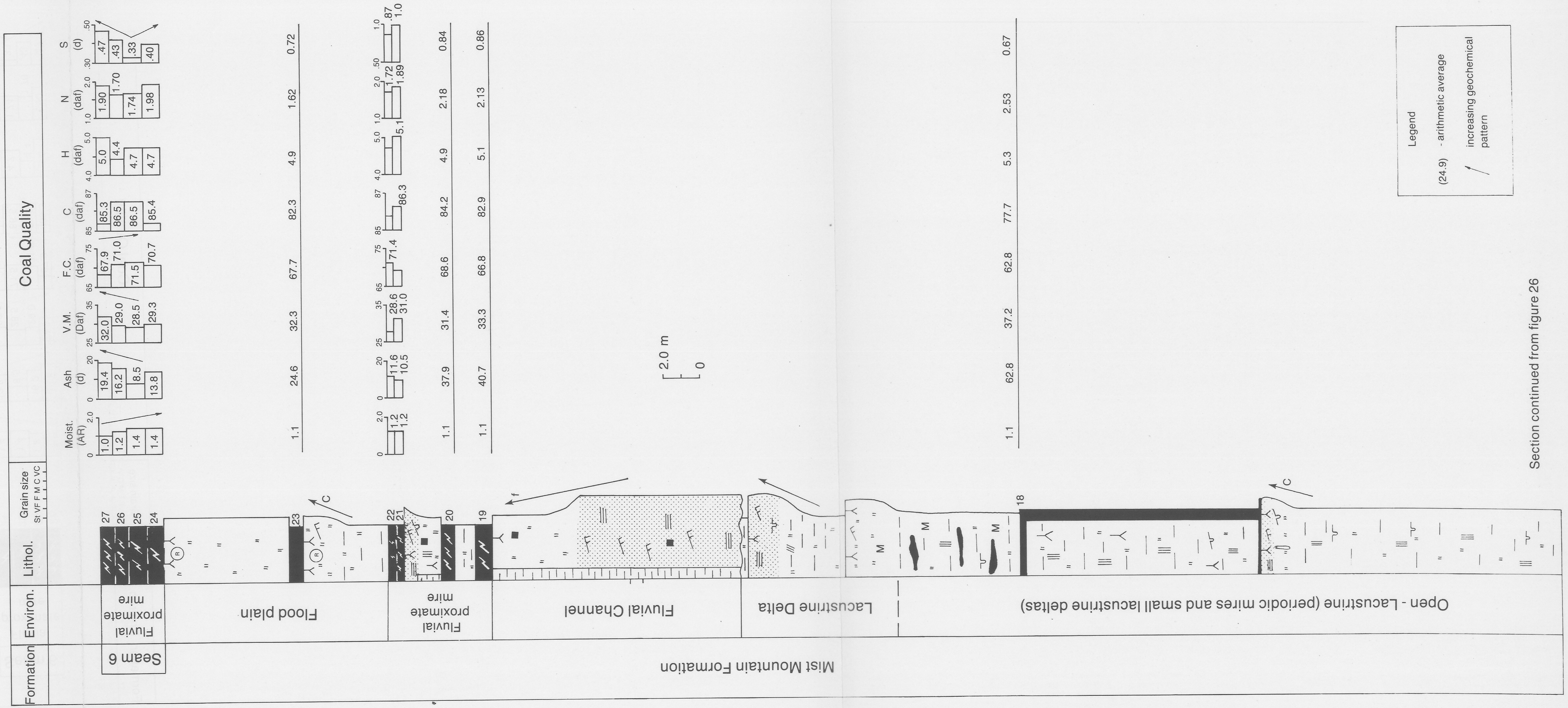


Figure 27. Stratigraphic section and environments of deposition related to coal quality - Tent Mountain, North Pit (CNP-6, cont).