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Coal quality variation in the Cadomin-Luscar coalfield, Alberta

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ALBERTA RESEARCH COUNCIL

Alberta Geological Survey

Acknowledgments

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Abstract

Coal quality data were gathered from various sources and put in a geologic framework. The economic Jewel Seam forms part of the Lower Cretaceous Gates Formation and has a stratigraphic thickness of 10 m. Its depositional setting was on a coastal plain, well removed from marine clastic influences. Shortening of the strata by folding and thrusting amounted to 50 percent, often resulting in structural thickening of the Jewel Seam along fold hinges.

Ash and sulfur are largely determined by the original sedimentary environment. Volatile matter, fixed carbon, carbon, hydrogen and vitrinite reflectance are determined by subsequent burial and to some extent by deformation. Vertical sequences with upward increase in ash and low ash zones through the center of the Jewel Seam can be explained by the original chemical environment of the swamp. Average finely disseminated ash is about 14 percent. In places, the disseminated ash content has increased by tectonic shearing. For mining purposes, the 2 m sampling interval of the Jewel Seam results in a good characterization of ash variation. Sulfur contents of the Jewel Seam are low compared to those of many other coal deposits and average 0.3 percent. Sulfur, which is mostly organic, often shows elevated values at the base, and to some extent at the top of the seam. Volatile matter, fixed carbon, carbon, hydrogen and vitrinite reflectance are largely determined by depth and length of burial, and to some extent by deformation.

Rank of the Jewel Seam ranges from high to medium volatile bituminous, where the highest rank is found in the central part of the study area. The intersections of isorank surfaces and the Jewel Seam indicate components of syndeformational coalification. A good linear correlation between maximum vitrinite reflectance and volatile matter (dry and ash free) is observed. A contoured map of vitrinite reflectance predicts rank and volatile matter of the Jewel Seam for unexplored parts of the coalfield.

Introduction

In this report, data on coal quality variation in the Cadomin-Luscar area are presented. The application of geological models is discussed and some predictions of coal quality variables are given.

Objectives and goals

The objectives of the study are to document coal quality variations in the Cadomin-Luscar coalfield, to establish procedures for the assessment of coal quality, and to allow comparison between coal quality data from different areas of mountains and foothills. An understanding of the major geological parameters controlling coal quality will allow the development of predictive models of coal quality variations. Regional geological mapping has provided exploration targets in the past. In the future, detailed coal quality mapping will provide exploration targets in existing coalfields. The study is focused on in-situ coal quality variation and concentrates on raw coal analyses. However, some data from washed drill cuttings was also used.

Study area

The study area is located in west-central Alberta, between latitudes 53° and 53° 8′ and longitudes 117° 17′ and 117° 34′ (figure 1). The area forms part of the Cadomin (NTS 83F/3) and Miette (NTS 83F/4) map sheets and covers approximately 100 km^2. It conforms closely to the Cadomin-Luscar coalfield. The coal leases are held by Luscar Ltd., Manalta Coal Ltd. and Gregg River Resources Ltd.

Previous work

The existence of the Jewel Seam has been known since the turn of the century. An underground mine was developed at Cadomin in 1917 and at Luscar in 1921. These mines operated until the mid 1950's. The Cardinal River Mine at Luscar (open pits) was opened in 1970 and the Gregg River Mine (also open pits) started shipping coal in 1983.

The Cadomin area was mapped by the Geological Survey of Canada (MacKay 1929, 1930). Mountjoy (1959) mapped the Miette mapsheet. The area east of Gregg River was mapped by Hill (1980). The sections along the McLeod River at Cadomin have often been used in stratigraphic studies (e.g. Mellon 1967; McLean 1982).

General geology

The Cadomin-Luscar coal field is situated in the Inner Foothills. The area is largely underlain by Lower Cretaceous rocks of the Luscar Group as defined by Langenberg and McMechan, 1985 (figures 2 and 3). The coal-bearing Luscar Group was deposited in an overall regressive sequence, during early Albian time.

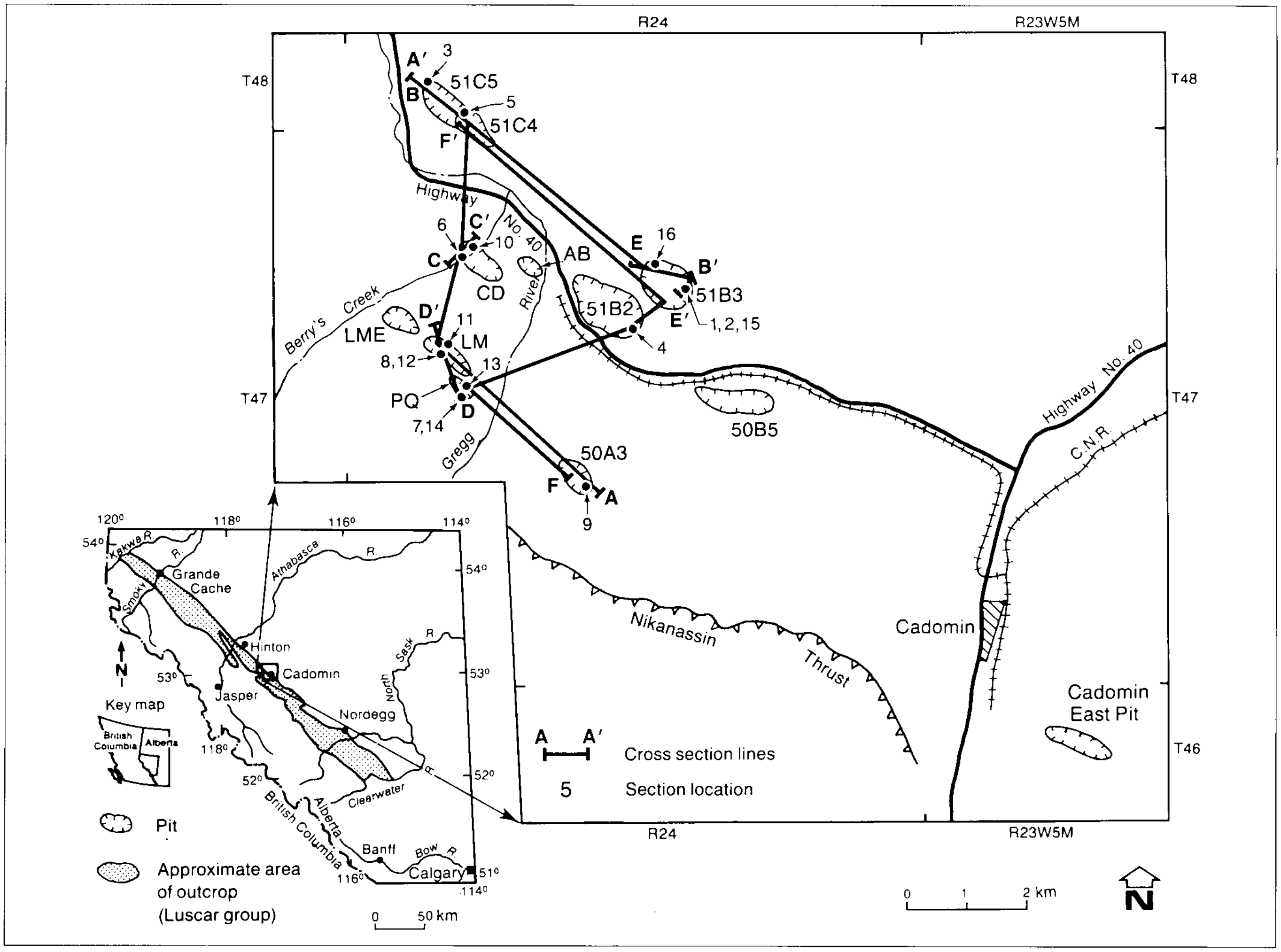

Figure 1. Location of Cadomin-Luscar coalfield with pits, stratigraphic cross sections and sections.

This sequence represents the second major, western sourced, Cretaceous clastic wedge to prograde into the Interior Cretaceous seaway. The first wedge is the Kootenay/Nikanassin succession. The Luscar Group consists of the Cadomin, Gladstone, Moosebar and Gates Formations. The Cadomin Formation consists of alluvial conglomerates. The Gladstone Formation consists of alluvial sandstone, shale and minor coal and is of Aptian-Early Albian age. The Moosebar Formation contains marine shale and minor sandstone and is also of Early Albian age. The largely nonmarine Gates Formation consists of sandstones, shales and coal and can be divided into three members, i.e., the Torrens, Grande Cache and Mountain Park Members. The age of the Gates Formation ranges from Early to Middle Albian. The basal Torrens Member consists of sandstones deposited in a shoreface environment. The Grande Cache Member shows coastal plain sandstones, shales and major economic coal seams. It grades into the Mountain Park Member, which consists of fluvial, fining-upward sandstones, shales, and minor coal seams. Four regional marine sedimentation

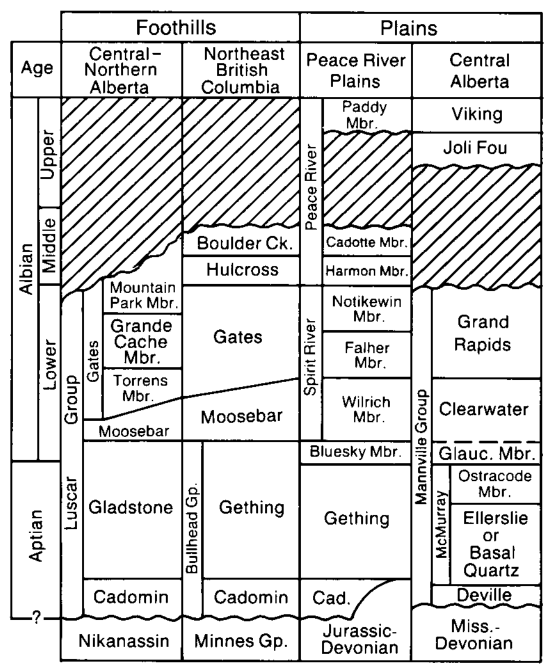

Figure 2. Lower Cretaceous stratigraphic nomenclature of north-central Alberta and northeastern British Columbia.

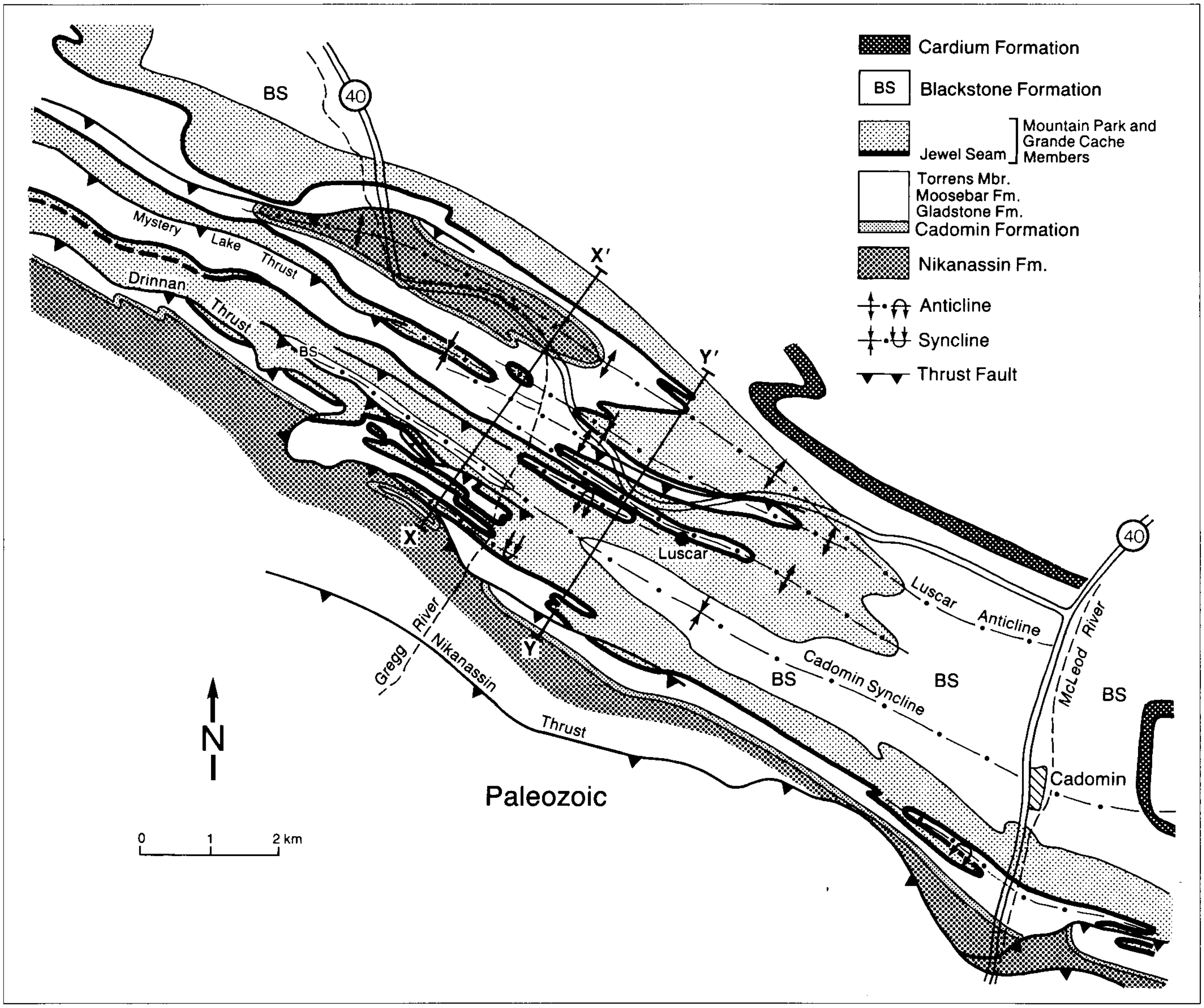

Figure 3. Simplified geological map of the Cadomin-Luscar coalfield, compiled and modified from Hill (1980) and Karst (Gregg River Resources, unpublished).

cycles can be distinguished in the transition from Moosebar to Gates Formations (Macdonald et al. 1988).

Two open pit coal mines (Cardinal River Coals and Gregg River Resources) are presently producing from the Grande Cache Member. All production comes from the Jewel Seam at the base of this member and a total of 4.4 million tonnes of raw metallurgical coal was produced in 1987 (ERCB 1987). The rank of the Jewel Seam is mainly medium volatile bituminous. The R seam (Ryder Seam of Cardinal River and Ruff Seam of Gregg River) is situated about 60 m above the Jewel Seam. The other stratigraphic units contain additional, generally thin coal seams.

The rocks of the area are highly deformed by folding and faulting, with major structures such as the Cadomin Syncline, the Luscar Anticline and the Drinnan Thrust (figures 3 and 4). In the south, the area is bounded by the Nikanassin Thrust, which forms the boundary between Foothills and Mountains in the region.

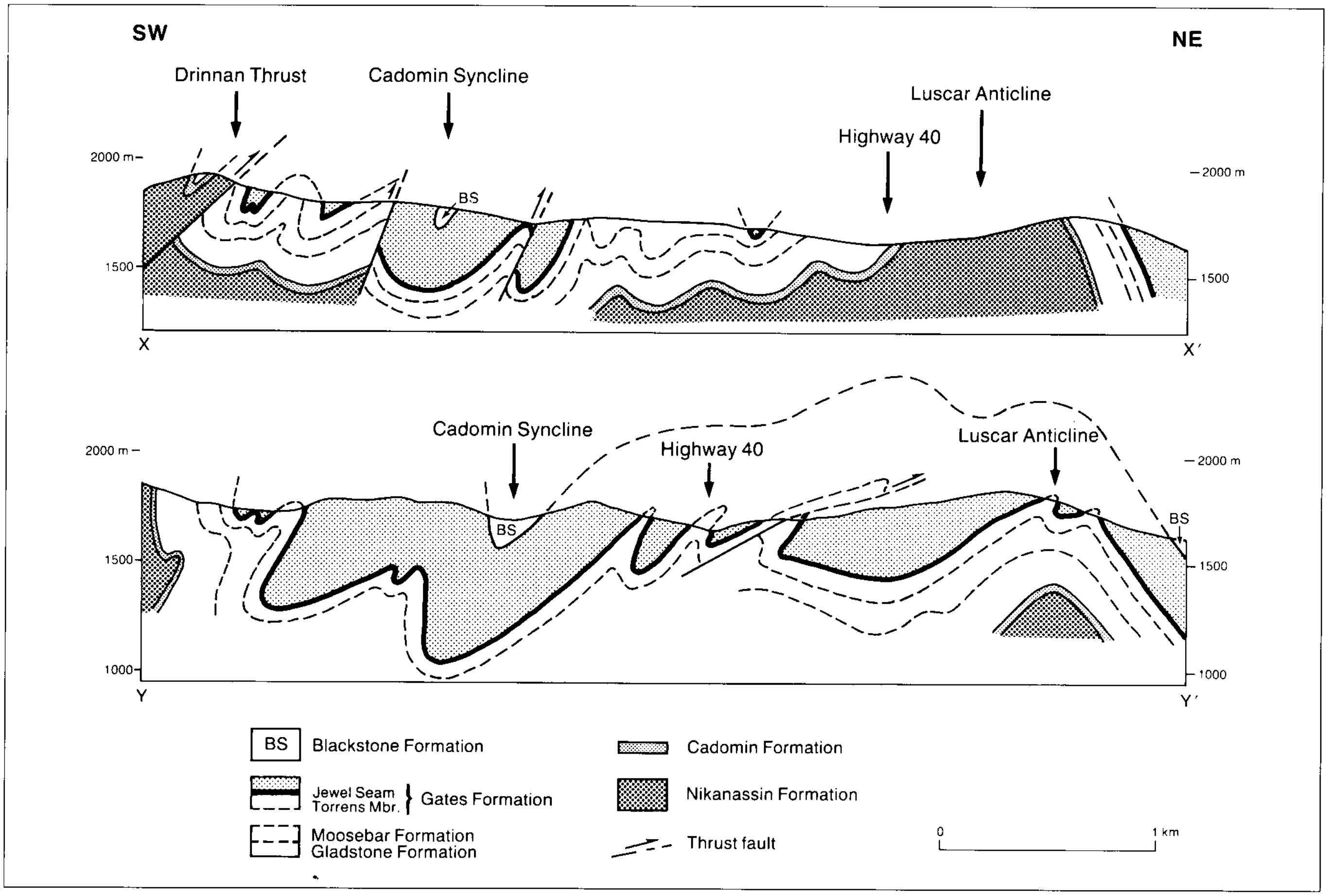

Figure 4. Cross sections XX′ and YY′ through the Cadomin-Luscar coalfield. Section XX′ is on the Gregg River property (after Karst, Gregg River Resources, unpublished). Section YY′ is on the Cardinal River property (modified from Hill, 1980).

Data collection

Three sources of information are available for collection of coal quality data. These are analyses done by mining companies, samples collected by the Alberta Research Council during the summer of 1987 and data from the ERCB database (appendices 1-5). Because the CANMET data (Bonnell and Janke 1986) do not have precise locational information, they were not included in the dataset. All locational information (mine coordinates from coal company maps and latitudes/longitudes from the ERCB database) was transformed to UTM coordinates of zone 11.

Mining companies

Gregg River Resources Ltd. supplied the Alberta Geological Survey with the same set of coal quality data that was supplied to the ERCB. Because the data from 18 coreholes drilled in 1982 were not yet present in the ERCB database, they were entered in the Alberta Research Council database. In this way, 196 proximate analyses, or an average of 11 analyses per drill hole, were added to our database.

Alberta Research Council

Coal samples were collected during the 1987 field season, mainly in fresh exposures of recent mining in the open pits of Cardinal River Coals Ltd. and Gregg River Resources Ltd. These samples are suitable for proximate and ultimate analyses, which were performed in the Alberta Research Council's coal laboratory in Devon. They were generally channel samples from intervals of varying thickness. Shale or sandstone intervals were not sampled. From these samples, 122 proximate and ultimate analyses were obtained (appendices 3 and 4). Most samples were from 18 sites of the Jewel Seam (appendix 3), but other seams were also sampled in 11 sites (appendix 4). From this sampling, a series of in-seam profiles were established. From 22 sites, composite samples were prepared and pellets made for determination of percentage maximum vitrinite reflectance. These sites are put in a geologic framework using measured stratigraphic sections (appendix 7). In addition, grab and channel samples of coal were collected from various outcrops for petrographic work (appendix 6).

ERCB

Data were retrieved from the digital public ERCB data files using an in-house computer program that reads information from the ERCB magnetic tapes. On the tape dated March 1988, 98 proximate and 12 ultimate analyses from 78 different drill holes were found. Most analyses were from washed drill cuttings (appendix 2). Almost all drill holes are situated on the Gregg River Resources property. One drill hole with one analysed sample (proximate analysis) is from the Cardinal River Coal property. Although the public ERCB tape does not have any seam indicators, it is clear that all data are from the Jewel Seam (Randy Karst, Gregg River Resources, pers. comm., 1987). Other data available on the ERCB tapes are rheological properties (such as FSI) and physical properties (such as washability and grindability). However, because these analyses were performed on cleaned coal only (not on raw coal), they are not discussed in this report.

Data processing

Various reformatting programs were written to put the proximate and ultimate data from different sources in the same format, with the analyses reported on a dry and dry-ash-free basis (appendices 1 to 5). The analyses are not reported on a mineral-free basis because sulfur determinations are not available for many of the samples and consequently the Parr Formula (Ward 1984) would only apply to 104 of the 303 proximate analyses. These same files were also used as input to a statistical graphics system, STATGRAPHICS, which runs on an IBM-PC compatible computer. In this way, unweighted means and standard deviations were calculated from all available analyses. Regression analysis was performed to establish correlations.

Another data set was prepared for map presentation of the data. Thickness weighted averages were calculated for 95 drill hole sites and 18 outcrop locations (appendix 5). These data were plotted using the inhouse GEOPLOTTER computer package.

For petrography, the samples were crushed to a maximum particle size of 850µm (20 mesh), mounted in epoxy resin, then ground and polished. From these pellets, the percentage maximum vitrinite reflectance was measured using reflected light in a petrographic microscope. This work was performed at the Institute of Sedimentary and Petroleum Geology in Calgary. The results are expressed in terms of arithmetic mean and standard deviation (appendix 6).

Proximate analyses, Jewel Seam

Proximate analysis is the method most commonly used to document coal quality variations. The Jewel Seam is the only economic seam in the area and most available data are from this seam. Samples with ash percentages larger than 50 percent are considered to be carbonaceous shales and were excluded from the evaluation of the data, although they are listed in appendices 1 to 5. This is consistent with our field sampling procedure, which excluded visible rock partings. In addition, the data from corehole 82RC109 were excluded, because the coal in this hole was close to the surface and weathered (as indicated by anomalously high moisture and volatile matter contents, appendix 1).

Ash (dry), volatile matter (dry) and fixed carbon (dry) of washed coal samples from drill cutting (listed in appendix 2) were excluded from the statistical analysis, because they are not representative of raw coal and because we are mainly interested in raw coal quality variations. However, the dry-ash-free volatile matter and fixed carbon percentages were used because their values are not affected by washing (the cleaning effects of removing mineral matter are annulled by the dry-ash-free reporting basis).

Moisture

Most moisture determinations were done on air-dried samples, also called "as determined" (AD). The average "as determined" moisture is 0.9 percent (N=368), with values ranging from 0.1 to 6.9 percent. Their distribution is highly positively skewed (asymmetric distribution with more measurements higher than the average; see table 1 and figure 5). The "as received" (AR) moisture distribution is much less asymmetric, with the 187 measurements having an average of 12.3 percent and values ranging from 1.1 to 42.1 percent (table 1, figure 5).

This distribution indicates generally low moisture content. However, weathering or special groundwater conditions may cause moisture to be higher in local areas. The regional distribution of moisture does not show any clear trends, because moisture does not vary much in the range of coal ranks dealt with in the Cadomin-Luscar area.

Ash

Ash may be due to visible rock partings or finely disseminated mineral matter. Samples with greater than 50 percent ash were excluded from the analysis, because strictly speaking they are not coal. The average ash (dry) is 15.9 percent, with values ranging from 3 to 45.9 percent (N=291). This range probably includes rock partings in the drill holes. The ash in the Alberta Research Council samples ranges from 4 to 30 percent and is probably more characteristic for disseminated ash of the Jewel Seam. The frequency distribution is slightly positively skewed, indicating that the median value of 13.6 percent is possibly a better estimate of disseminated dry ash (table 1, figure 5). The washed coal has much lower ash values (appendix 2), approaching the composition of the cleaned coal product (which has less than 9.5 percent ash; Karst and Gould 1985). For this reason, the analyses of ash from washed coal were not included in the calculation of the average.

The weighted averages of the "dry" ash content of the Jewel Seam in the central part of the study area show no clear regional trend (figure 6). This map includes all data points in our database, except two outlying stations in the northwest. Ash contents do not appear to correlate with rank, as indicated by low correlations between ash and volatile matter. In-seam ash variations are discussed in the 'depositional environment' section of this report.

Volatile matter

The histograms of volatile matter show two peaks (figure 7), indicating that this variable is not normally distributed. These peaks can easily be explained by the preferred location of data availability in two subareas of the study area. Figure 8 shows the location of all sample sites (a site is either a drillhole or an excavation) where dry, ash-free volatile matter has been

Table 1. Statistics of unweighted proximate analyses, Jewel Seam, including average, median, mode, variance, standard deviation, symmetry (skewness) and peakedness (kurtosis).

Analysis	n	Average	Median	Mode	Variance	S.D.	Minimum	Maximum	Range	Skewness	Kurtosis
Moisture, AR	187	12.3	10.1	6.4	61.1	7.8	1.1	42.1	41.0	0.9	0.5
Moisture, AD	368	0.9	0.7	0.7	0.5	0.7	0.1	6.9	6.8	4.2	27.3
Ash, dry	291	15.9	13.6	13.6	85.8	9.3	3.0	45.9	42.9	1.2	1.1
Fixed C., dry	291	63.6	65.3	65.7	64.7	8.0	36.3	76.2	39.9	-1	0.9
Fixed C., daf	369	75.4	75.7	74.9	9.0	3.0	60.2	80.7	20.5	-0.8	1.6
Vol. mat., dry	291	20.5	20.2	20.4	8.3	2.9	12.8	27.9	15.1	0.1	-0.4
Vol. mat., daf	369	24.6	24.3	25.1	8.9	3.0	19.3	39.8	20.5	0.8	1.6

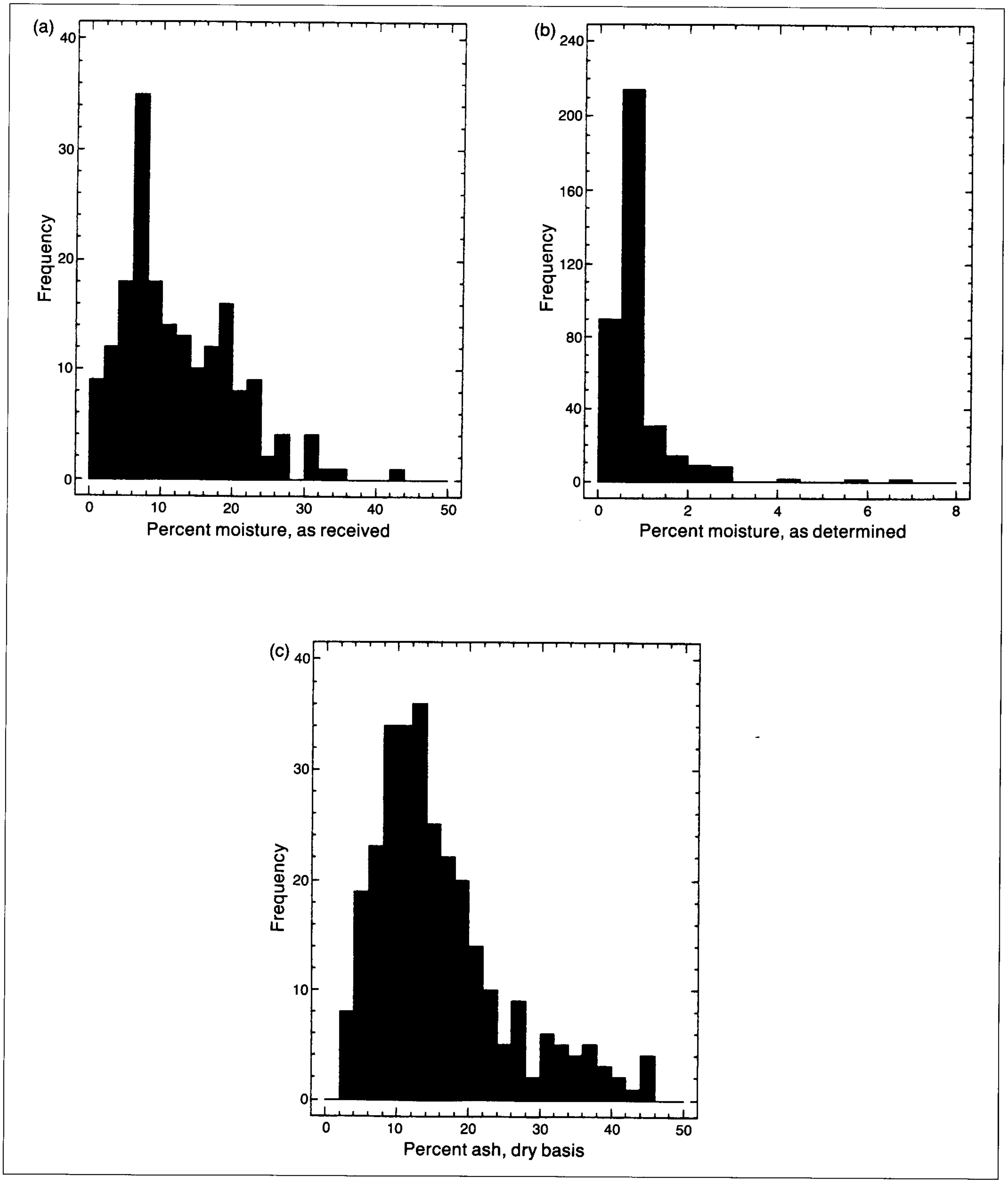

Figure 5. Histograms of proximate analyses of the Jewel Seam, (a) moisture, as received, (b) moisture, as determined, and (c) ash, dry.

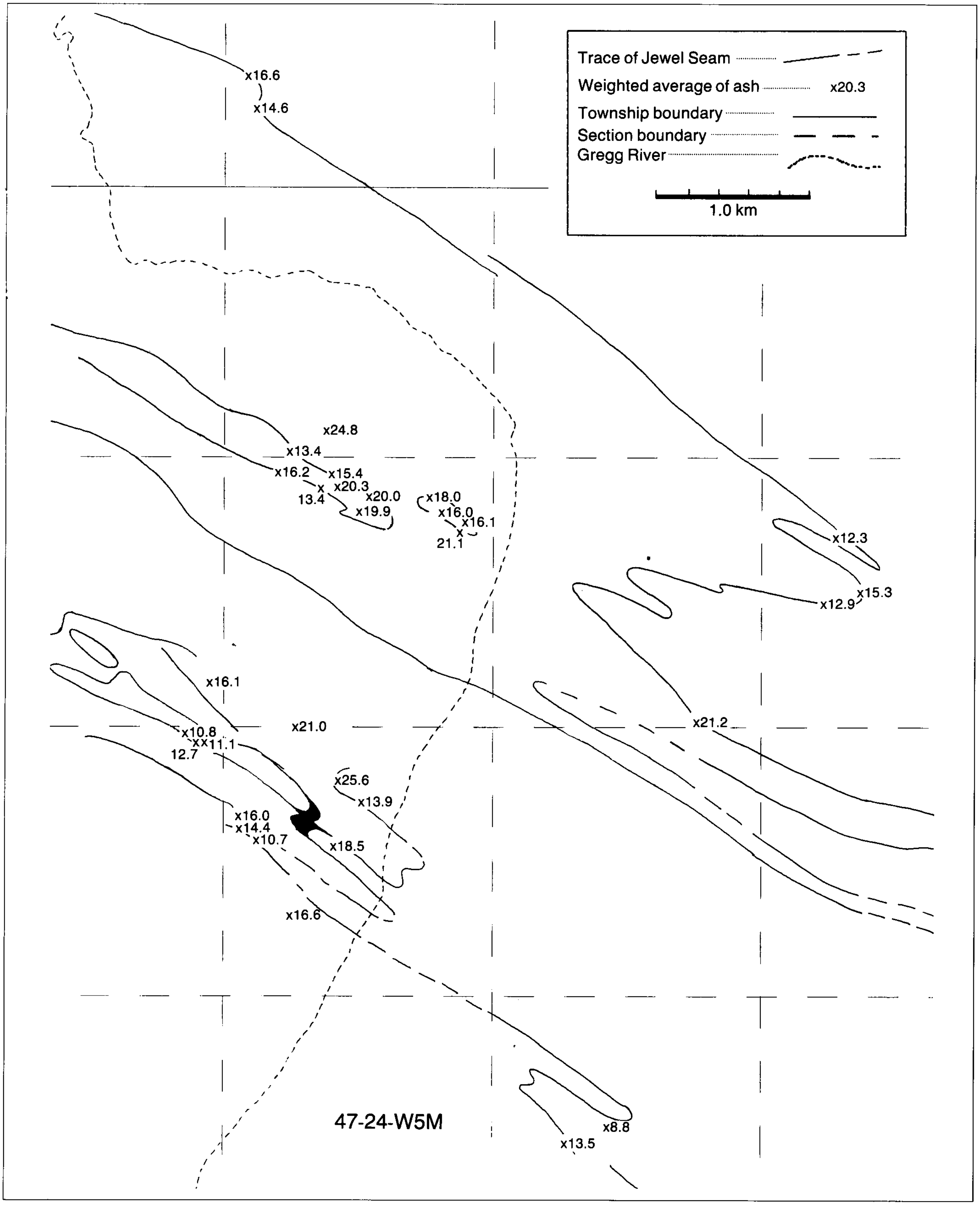

Figure 6. Map of central part of study area, showing the weighted averages of ash percentages (dry) of Jewel Seam posted beside the site locations.

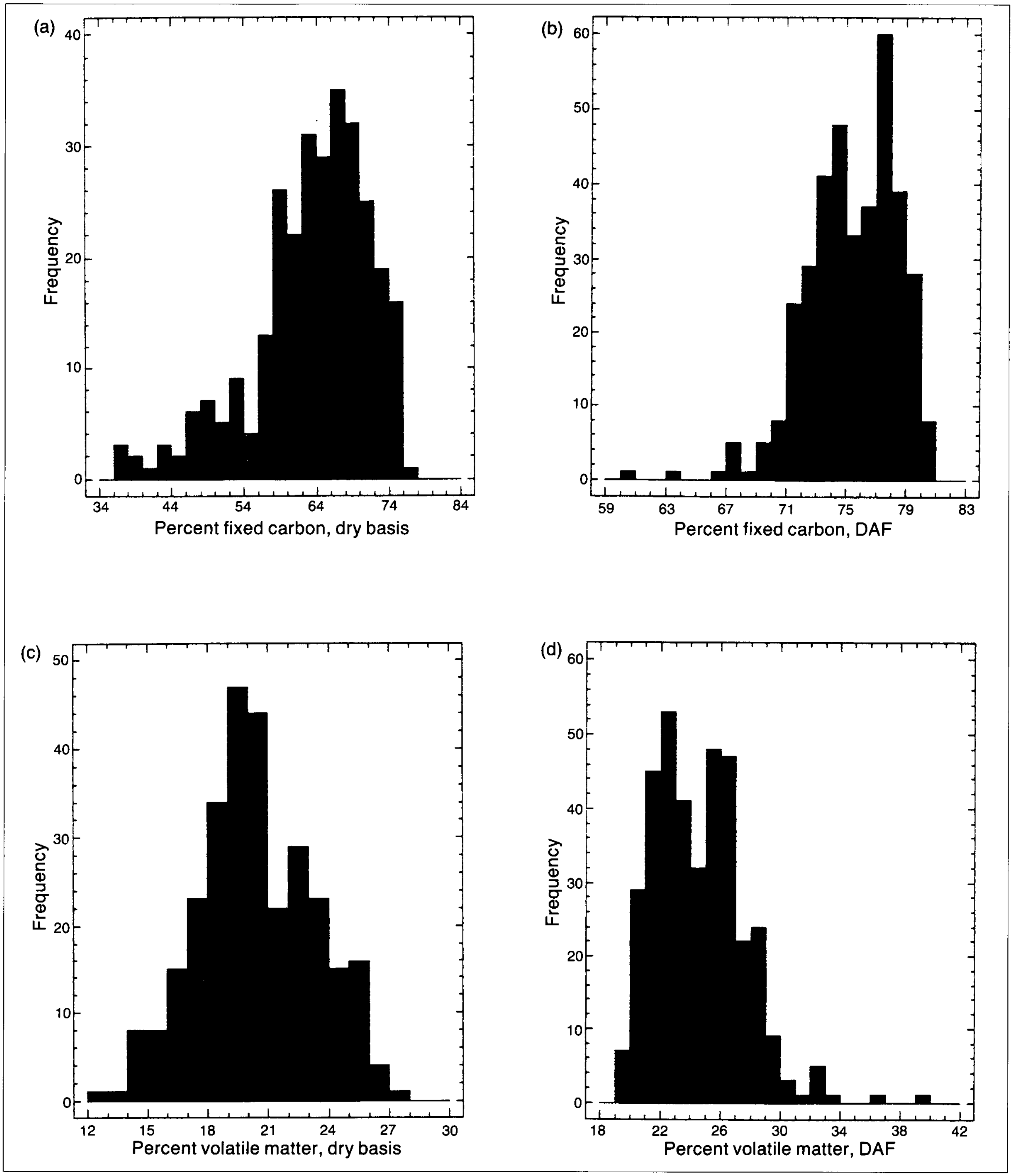

Figure 7. Histograms of proximate analyses of the Jewel Seam, (a) fixed carbon, dry, (b) fixed carbon, dry and ash free, (c) volatile matter, dry, and (d) volatile matter, dry and ash free.

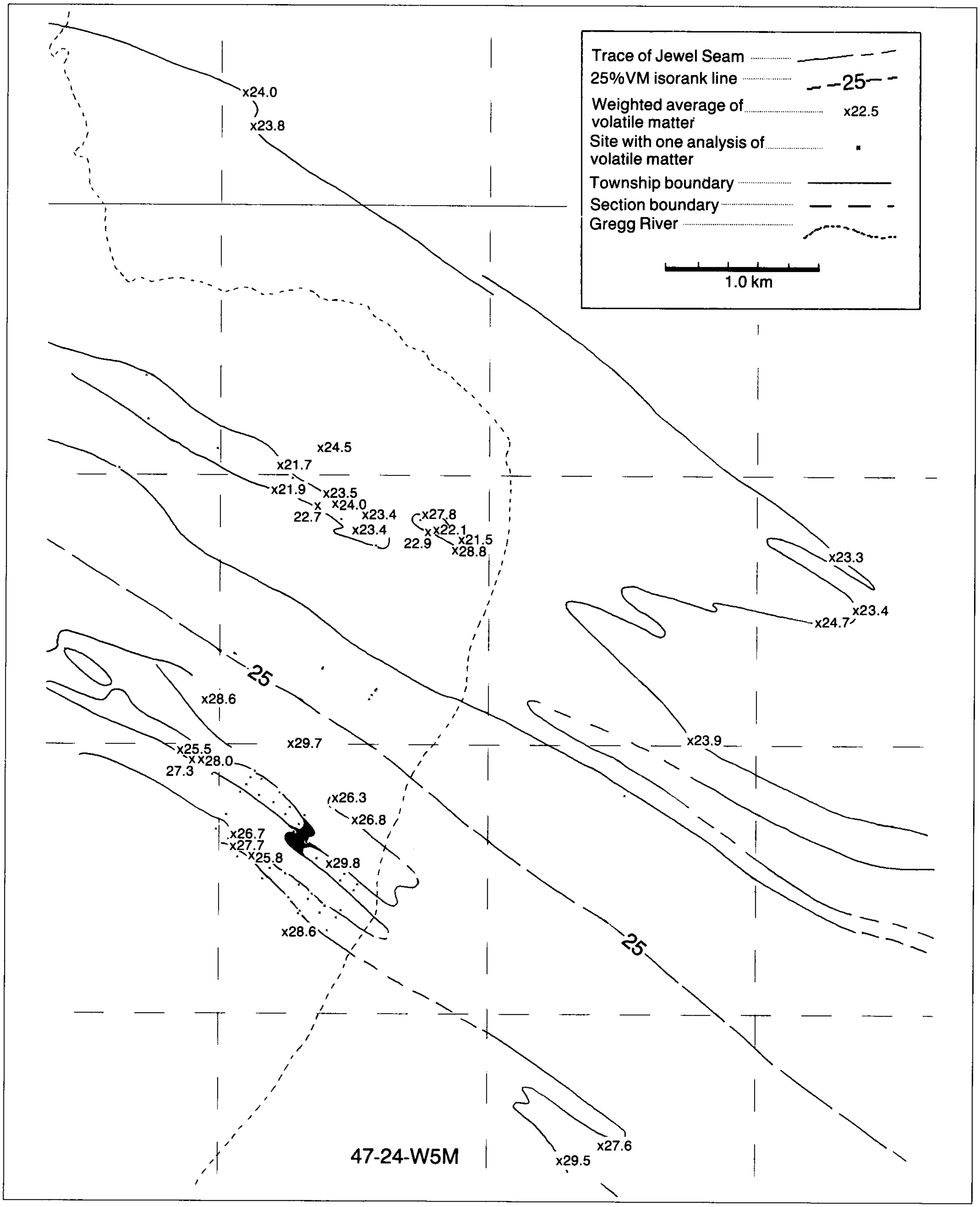

Figure 8. Map of the central part of the study area showing the weighted averages of volatile matter (dry and ash free) of Jewel Seam, together with locations of sites with one analysis of volatile matter. The 25 percent volatile matter isorank line is extrapolated from the posted values.

determined. In addition, the weighted averages are shown from sites with more than two individual analyses per site. This map clearly shows the concentration of sample sites in the area of the AB and CD pits in the northeast, and in the area of LM and PQ pits in the southwest (for location of pits see figure 1). The 25 percent volatile matter isorank line can be extrapolated between these two areas (figure 8). Consequently, the histogram of figure 7d can be interpreted to represent two populations, one with 23 and the other with 26 percent volatile matter (daf). The two populations are a result of sampling in two preferred areas of coals, whose ranks vary systematically over the study area. This variation in rank will be discussed in more detail in the section on 'vitrinite reflectance'.

The range of volatile matter (daf) is 19.3 to 39.8 percent (table 1); the higher percentages represent oxidized coal. This range indicates that a certain percentage of coal is low-volatile bituminous in rank. The systematic variation of volatile matter with location shown in figure 8, together with information on vitrinite reflectance (see section on 'vitrinite reflectance'), enables a prediction of volatile matter (dry and ash-free) based on location of the coal. Dry volatile matter (figure 7) is more variable, because it is dependent on the ash content (correlation coefficient of -0.52).

The cross plot of ash (dry) and volatile matter (daf) shows a correlation coefficient of 0.31, which is fairly low (figure 9). The formula relating these variables in the Cadomin-Luscar area is VM = 23 + 0.1 ASH. Consequently, although there is a relation between ash and volatile matter, the correlation between them is relatively low because of considerable rank variation in the area. However, the cross plot shows a tendency, for coals with high ash contents to result in anomalously high volatile matter percentages. The reason is that volatiles are driven off from clay minerals during ashing (see also Nurkowski 1985).

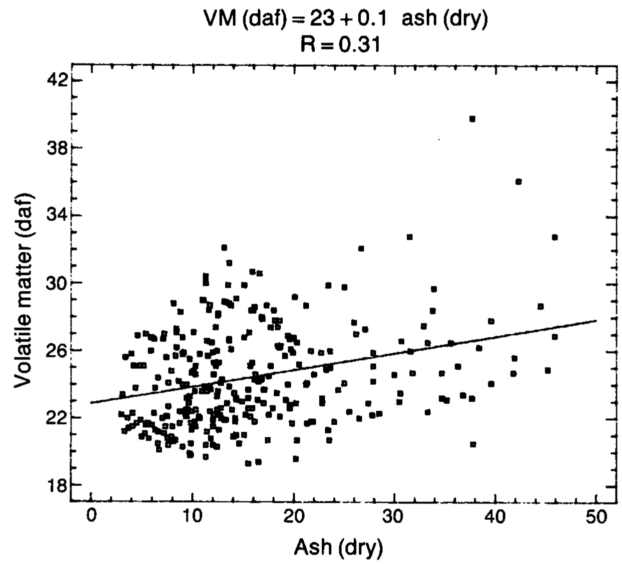

Figure 9. Cross plot and best fit linear correlation between ash (dry) and volatile matter (dry and ash free) of Jewel Seam.

Fixed carbon

Fixed carbon represents the material left after moisture, ash and volatile matter has been expelled. It is largely composed of carbon with minor amounts of nitrogen, sulphur, hydrogen and possibly oxygen (Ward 1984). The variation in fixed carbon of the study area can be compared with that of volatile matter. Fixed carbon ranges from 36.3 to 76.2 percent on a dry basis and from 60.2 to 80.7 percent on a dry, ash-free basis (table 1 and figure 7). The histograms show two peaks, indicating preferred sampling in two areas of a region with varying rank.

Ultimate analyses, Jewel Seam

Complete ultimate analyses of the Jewel Seam are available for 104 samples from excavations collected by the Alberta Research Council (appendix 4). Five complete ultimate analyses were found on the ERCB tape. Because these five samples had been washed before analysis, only dry-ash-free values are used in this report. In addition to these analyses, six individual sulfur analyses were found on the ERCB tape.

Carbon

Carbon (dry) ranges from 52.2 to 87.2 percent (table 2) and shows two peaks in a histogram (figure 11). The peaks reflect preferred sampling in two areas of a region with varying rank, resulting in two populations. On a dry-ash-free basis, carbon ranges only from 77.7 to 91 percent and the two populations do not show up very well in the histogram. There is a good correlation between carbon (dry) and fixed carbon (dry), as shown by a correlation coefficient of 0.93 (figure 10). This good correlation can easily be explained by the fact that fixed carbon is largely carbon with minor amounts of nitrogen, sulfur, hydrogen and oxygen.

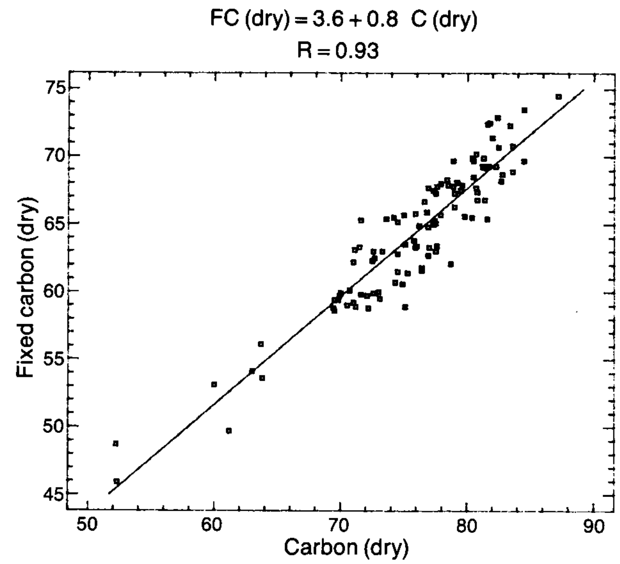

Figure 10. Cross plot and best fit linear correlation between carbon (dry) and fixed carbon (dry) of Jewel Seam.

Sulfur

Dry sulfur varies in a narrow range between 0.1 and 0.6 percent (table 2 and figure 11). It appears to be close to normally distributed. On a dry, ash-free basis, sulfur ranges from 0.1 to 3 percent. The high value of 3 percent sulfur is obtained from a washed sample from a drill hole in the extreme northwest of the coalfield, northwest of Drinnan Creek. The reason for this relatively high sulfur value cannot be given without further sampling in the Drinnan Creek area.

No significant trend in regional sulfur variations can be discerned from the postings of sulfur (dry) in the central part of the study area (figure 12). In-seam sulfur variations are discussed in the 'depositional environments' section of this report.

No correlation exists between sulfur (dry) and ash (dry). Similarly, sulfur (dry) and volatile matter (daf) are not correlated, indicating that sulfur contents show no correlation with rank.

Hydrogen

Hydrogen content of the Jewel Seam ranges from 2.7 to 4.6 percent on a dry basis and from 4.1 to 5 percent on a dry-ash-free basis (table 2). The histograms show two peaks, representing the two populations discussed earlier (figure 13).

Hydrogen does not show a good correlation with volatile matter (daf); the correlation coefficient is only 0.43. This confirms that hydrogen is not a good rank indicator in the range of rank of coal encountered in the Cadomin-Luscar area (Bustin et al. 1983).

Table 2. Statistics of unweighted ultimate analyses, Jewel Seam, including average, median, mode, variance, standard deviation, symmetry (skewness) and peakedness (kurtosis).

Analysis	n	Average	Median	Mode	Variance	S.D.	Minimum	Maximum	Range	Skewness	Kurtosis
Carbon, dry	104	76.8	76.9	74.5	37.7	6.1	52.2	87.2	35.0	-1.4	3.3
Carbon, daf	109	88.2	88.4	88.3	3.5	1.9	77.7	91.0	13.3	-2.2	9.1
Sulfur, dry	104	0.3	0.3	0.2	0.01	0.1	0.1	0.6	0.5	0.9	1.0
Sulfur, daf	115	0.3	0.3	0.2	0.1	0.3	0.1	3.0	2.9	6.9	62.4
Hydrogen, dry	104	4.0	4.0	4.1	0.1	0.3	2.7	4.6	1.9	-1.2	2.7
Hydrogen, daf	109	4.6	4.7	4.8	0.04	0.2	4.1	5.0	0.9	-0.4	-0.2
Nitrogen, dry	104	1.2	1.2	1.2	0.01	0.1	0.9	1.6	0.7	-0.3	0.7
Nitrogen, daf	109	1.4	1.4	1.4	0.01	0.1	1.1	1.8	0.7	0.0	0.9
Oxygen, dry	104	4.6	4.3	4.2	2.3	1.5	2.4	10.9	8.5	1.7	4.1
Oxygen, daf	109	5.4	4.9	4.8	3.9	2.0	2.6	16.3	13.7	2.3	8.9

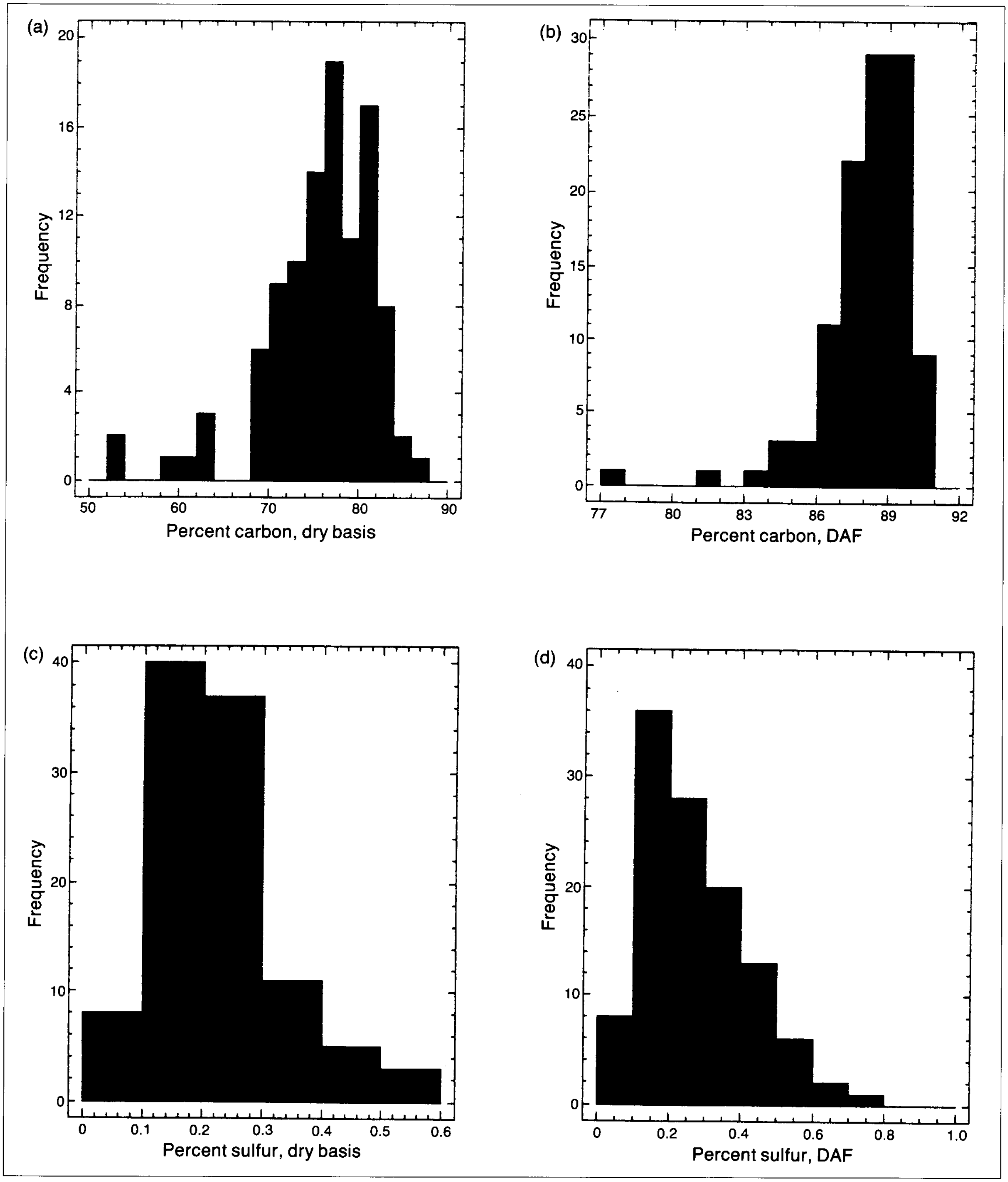

Figure 11. Histograms of ultimate analyses of the Jewel Seam, (a) carbon, dry, (b) carbon, dry and ash free, (c) sulfur, dry, and (d) sulfur, dry and ash free.

Nitrogen

Nitrogen content shows the most normal distribution of all variables measured, both on a dry and dry ash-free basis (figure 13 and table 2). It does not show any regional trends.

Oxygen

Oxygen has a slightly skewed distribution, ranging from 2.6 to 16.3 percent, with an average of 4.8 percent (table 2). It has tighter peaks than a normal distribution, as indicating by its kurtosis (figure 14).

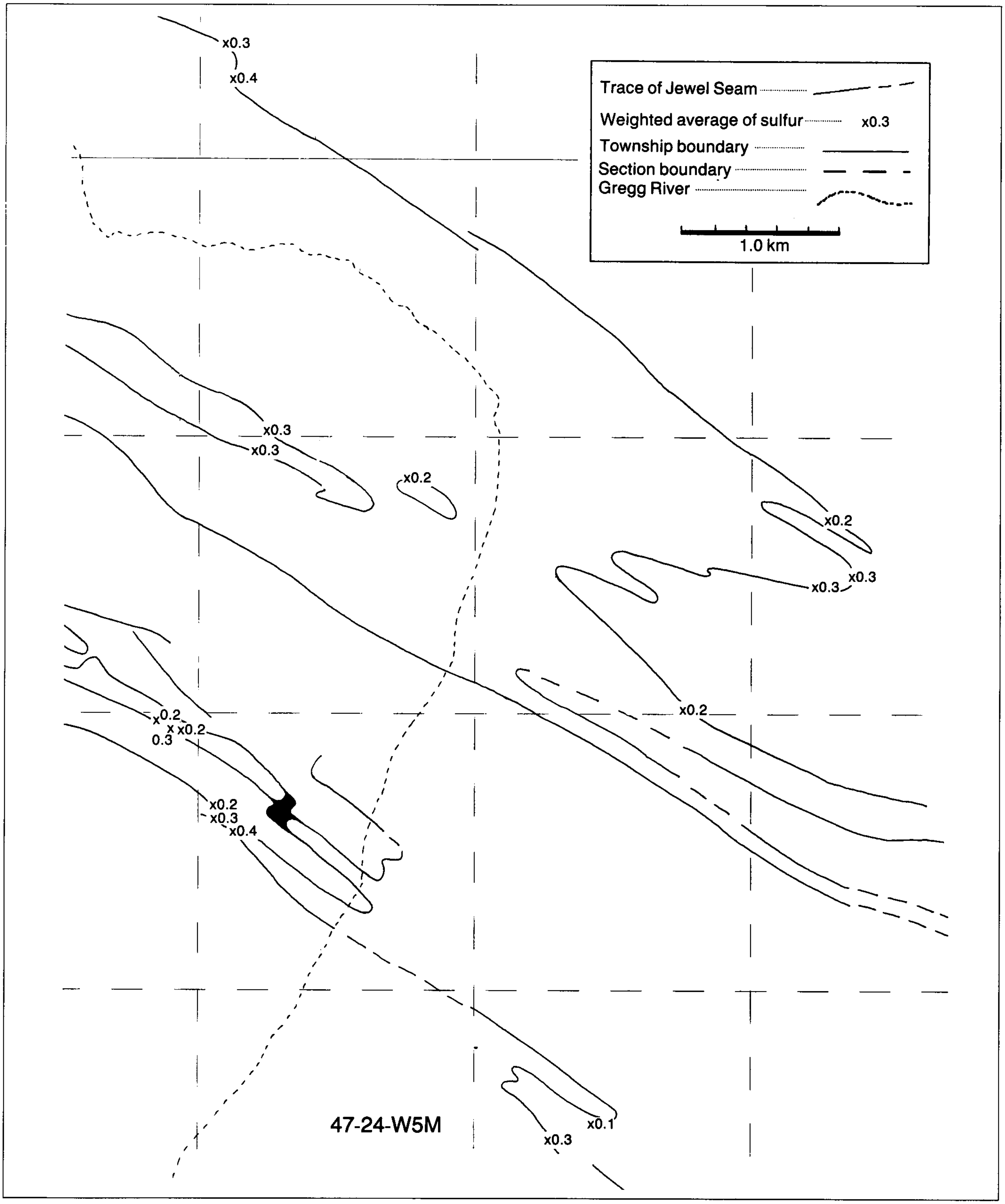

Figure 12. Map of central part of study area showing weighted averages of sulfur (dry) of Jewel Seam.

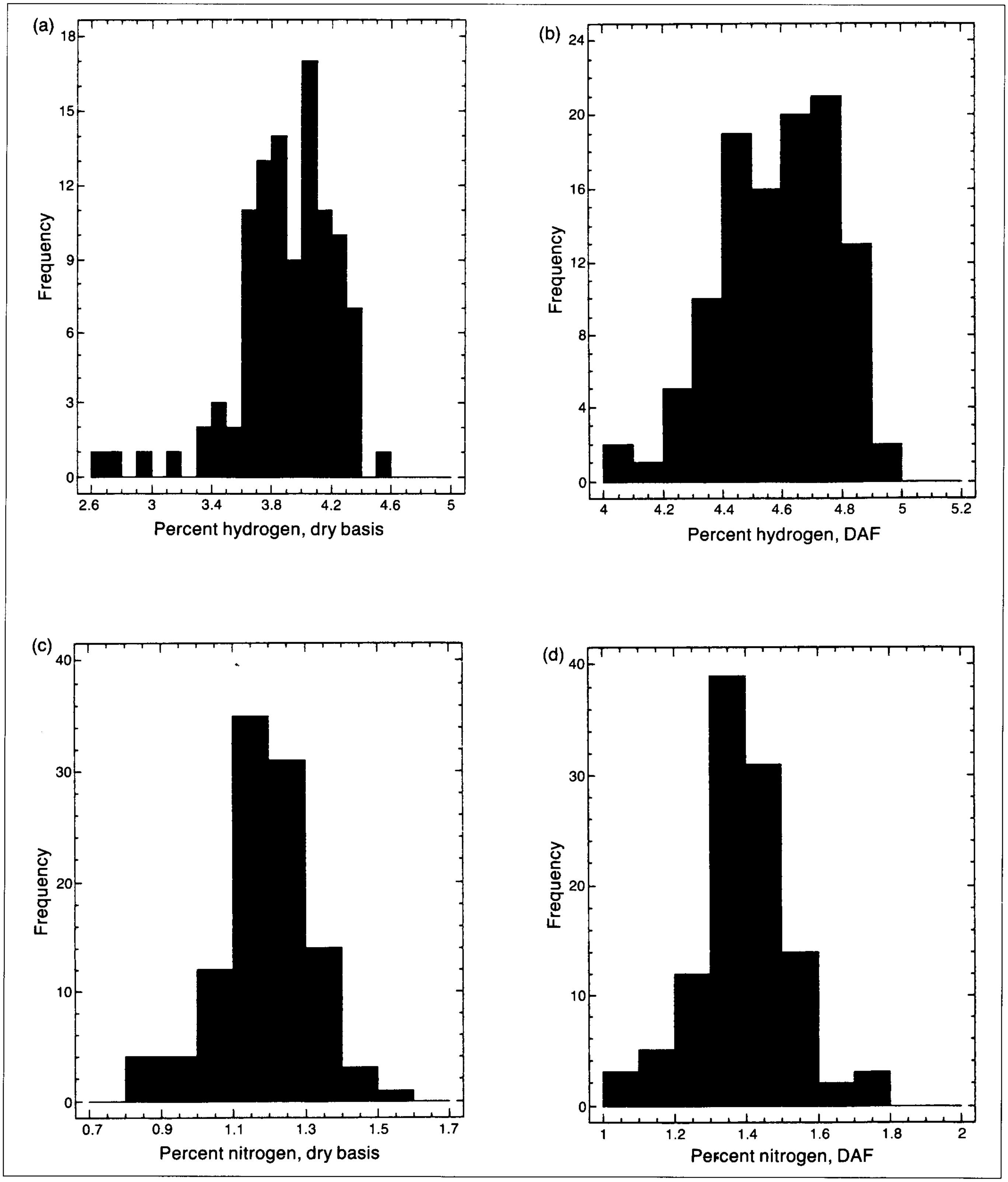

Figure 13. Histograms of ultimate analyses of the Jewel Seam, (a) hydrogen, dry, (b) hydrogen, dry and ash free, (c) nitrogen, dry, and (d) nitrogen, dry and ash free.

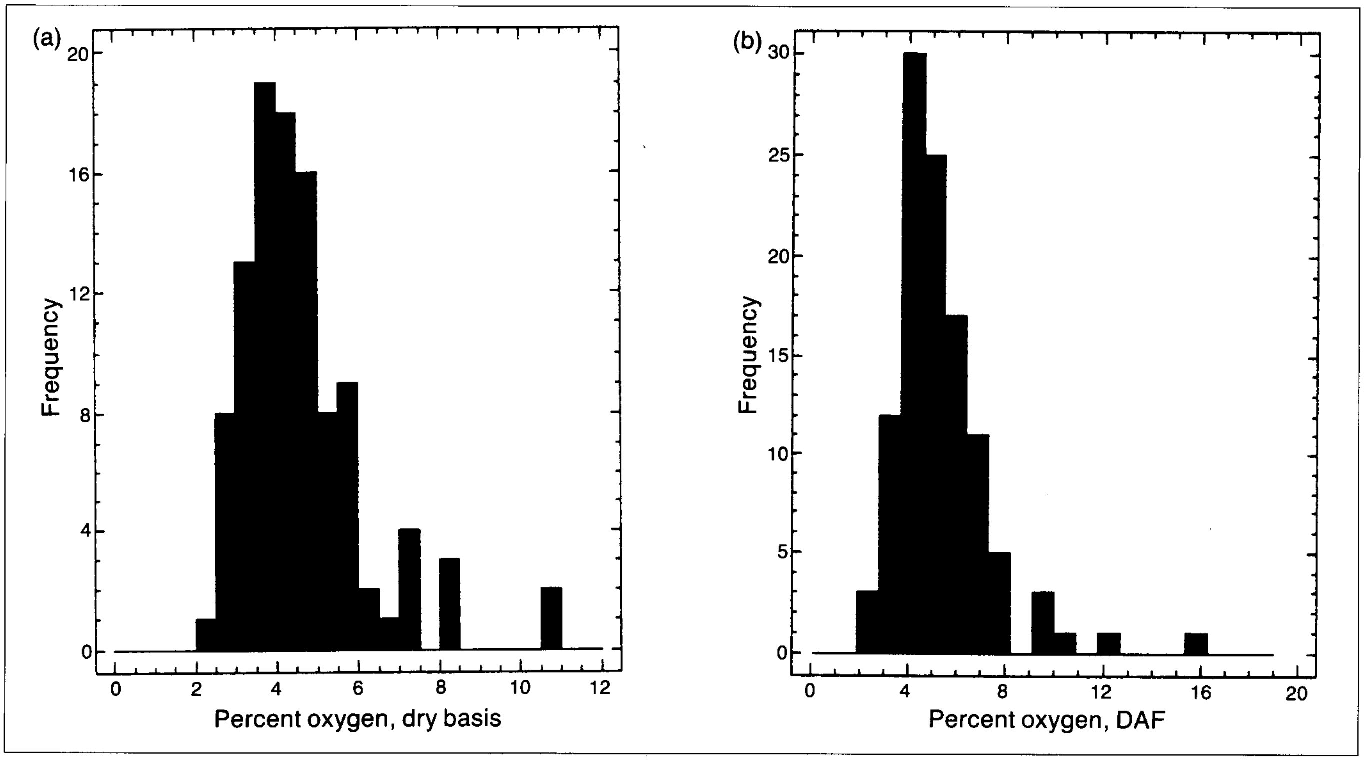

Figure 14. Histograms of ultimate analyses of the Jewel Seam, (a) oxygen, dry and (b) oxygen, dry and ash free.

Proximate and ultimate analyses, other seams

Proximate and ultimate analyses of seams other than the Jewel Seam are listed in appendix 4. The limited amount of data do not allow a statistical analysis.

Vitrinite reflectance

ASTM rank classification is based on dry-mineral matter-free fixed carbon. Because dry-mineral matter-free fixed carbon and volatile matter add up to 100 percent, volatile matter can also be used to designate ASTM rank class. Rank can also be determined by measuring the maximum reflectance of vitrinite. A good correlation between ASTM and vitrinite reflectance rank classification is generally reported (Bustin 1983). In this report, rank is determined by measuring vitrinite reflectance.

Samples were collected and vitrinite reflectances measured as described in the 'data collection' section. The results are listed in appendix 6, together with other information on the coal sampled.

Rank variation of the Jewel Seam

The rank of all samples as determined from vitrinite reflectance is in the medium- to high-volatile bituminous range. The regional rank variation of the Jewel Seam is shown in figure 15. It shows a concentration of higher rank coal (above 1.40 percent Rmax) in the central area, in the approximate area of Gregg River's AB and CD pits and Cardinal River's 50B5 pit. This map shows the maximum vitrinite reflectance percentage contours of the Jewel Seam, drawn by linear extrapolation. The seam, which is the sampled surface, is folded and consequently the isoreflectance lines of the Jewel Seam shown on this map are largely in the subsurface. Figure 16 is an at-

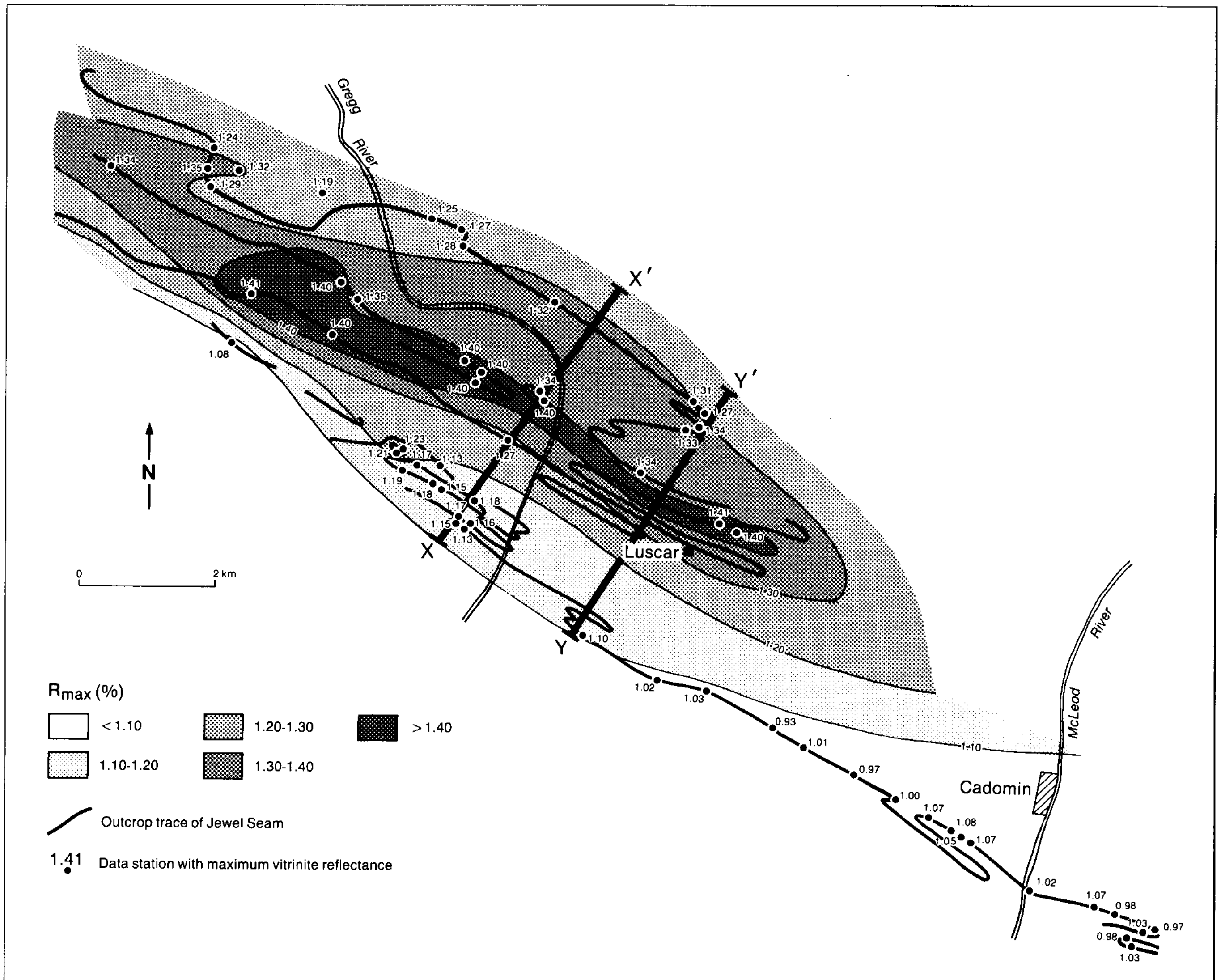

Figure 15. Regional vitrinite reflectance variations of the Jewel Seam.

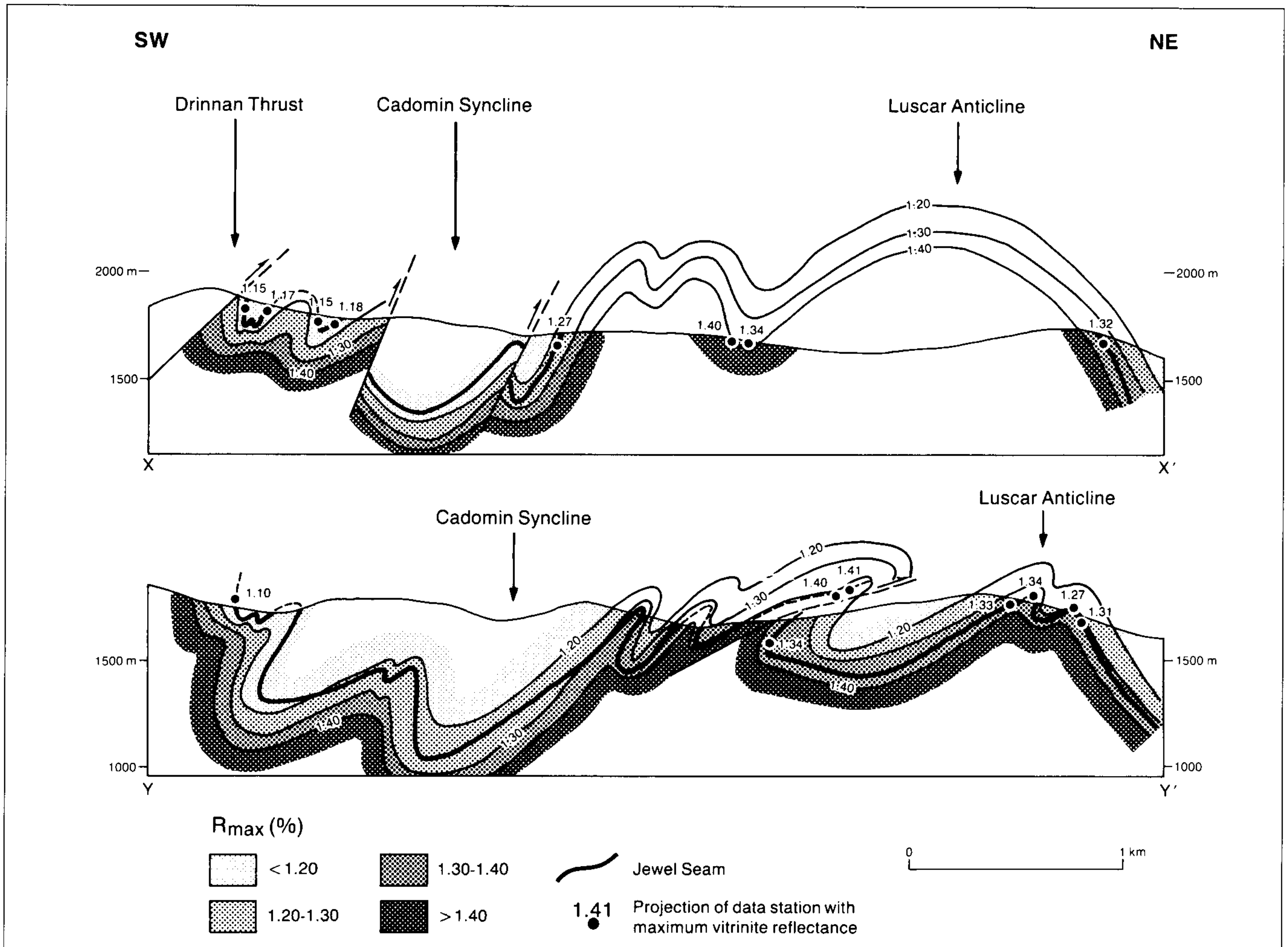

Figure 16. Cross sections, simplified from figure 4, showing the relation between coal rank of the Jewel Seam and deformed strata. The lines of section are shown on figure 3.

tempt to portray the iso-reflectance lines of the Jewel Seam in the two cross sections of figure 4. This figure is not realistic for other coal seams above or below the Jewel Seam, as will be discussed below. Notice that figure 8 shows the same rank variation as figure 15, where the 25 percent volatile matter (daf) isorank line roughly coincides with the 1.25 percent Rmax iso-reflectance line (not shown on figure 15, but situated between the 1.20 and 1.30 contours).

Figure 17 shows the roughly north-south stratigraphic cross section AA′ (section line shown on figure 1), in which the individual volatile matter (daf) determinations of the Jewel Seam across the coal field are given. This cross section illustrates the rank variation, where the highest rank is in the CD pit area. It also shows that there is no significant variation in rank from bottom to top of the Jewel Seam. The apparent lower rank near the bottom of section 3 (indicated by 28 percent volatile matter, daf) is related to high ash values (33 percent, see figure 23).

Section DD′ (figure 18) shows the detailed variation in four sections through the Jewel Seam in the PQ and LM pits, which are close together. It shows no significant variation in rank from bottom to top in the seam, nor in different areas of the pits.

None of the samples indicates low-volatile bituminous rank according to the classification by Bustin et al. (1983), where low-volatile coal is characterized by reflectances over 1.50 percent. The discrepancy between the ASTM and vitrinite reflectance methodology of rank determination can be explained by the relatively high inertinite contents of the coals of the Jewel Seam. Inertinite is relatively low in volatile matter compared to vitrinite (Kroeger and Pohl 1957). Consequently, coals with high inertinite contents (such as the Jewel Seam) will have lower volatile matter contents (and a higher ASTM rank) than coals rich in vitrinite.

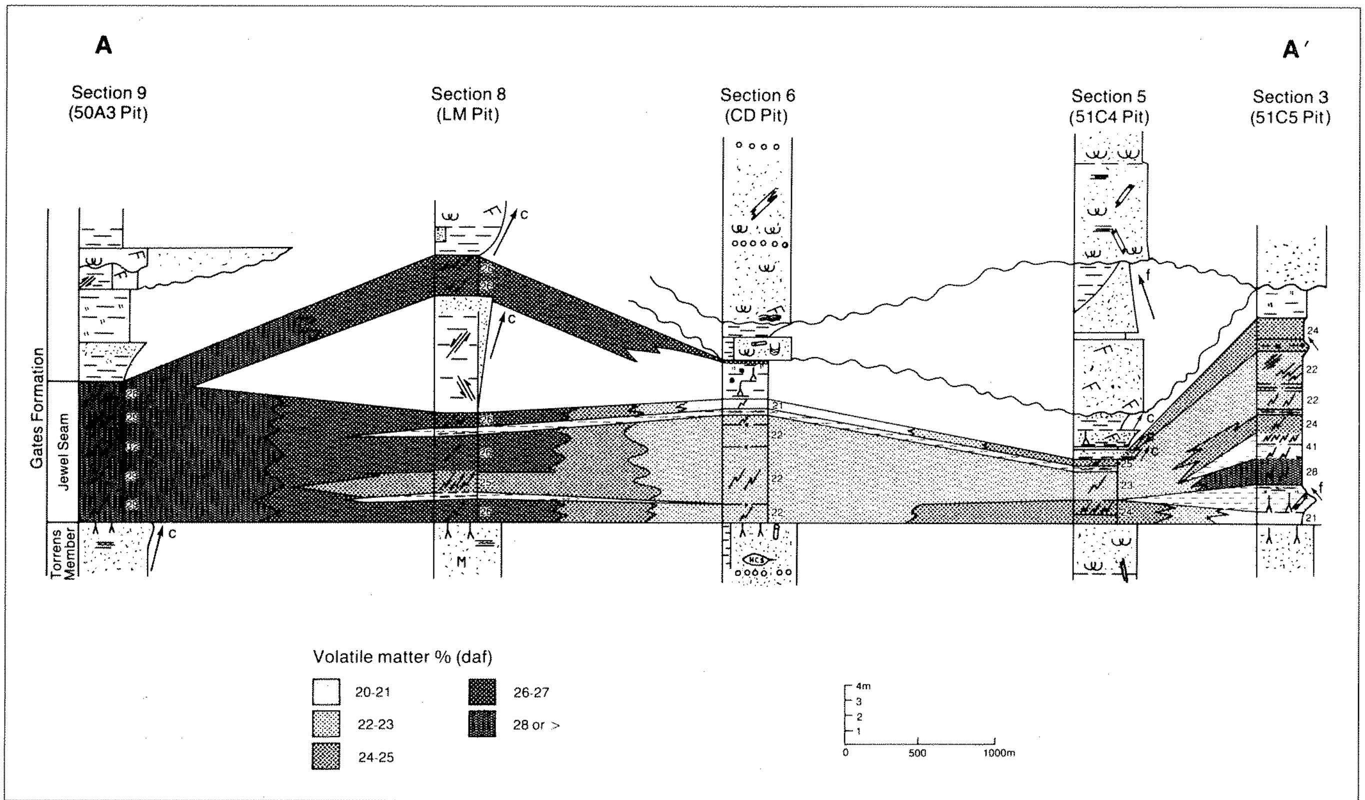

Figure 17. Stratigraphic cross section AA′ showing regional in-seam volatile matter variations in the Jewel Seam.

Rank variation, other seams

The R seam generally has reflectances that are about 0.10 percent lower than that of the Jewel Seam near that locality (appendix 6). The relatively thin coal seams in the Torrens and Moosebar tend to have lower reflectances than the overlying Jewel Seam. This phenomenon was also observed in the Peace River Canyon, where thin seams tended to have lower reflectances than thick seams of similar stratigraphic position (Kalkreuth and McMechan 1988). Thick seams are assumed to act as heat collectors, which over geologic time leads to higher temperatures and increased reflectance for the thick seams, as compared to thin seams.

Determinations of reflectance in other seams of the Grande Cache and Mountain Park Members follow the same pattern as the R seam.

Correlation with volatile matter

Because both volatile matter and maximum vitrinite reflectance were determined for 25 samples, a linear regression could be carried out (figure 19). The correlation coefficient is -0.87, indicating a good correlation. The equation for the line of best fit is: VM(daf) = 58 -27 Rmax. The boundary between high- and medium-volatile bituminous rank is at 1.10 percent Rmax (Bustin et al. 1983). The above formula predicts this boundary to be at 28 percent volatile matter (daf), which compares to the ASTM rank boundary of 31 percent (dry-mineral matter-free). The boundary with low-volatile bituminous, which is at 1.50 percent Rmax, is predicted to be at 18 percent VM (daf) with our formula. The ASTM rank boundary is at 22 percent volatile matter (dry-mineral matter-free). This difference cannot be explained by the different reporting basis, because with the moderate ash and low sulfur values the difference between dry-ash-free and dry-mineral matter-free volatile matter is very small. The differences can probably be explained by the relatively high inertinite content of the coals of the Cadomin-Luscar coalfield, as compared to the eastern American coals on which the ASTM rank boundary is based. High inertinite contents lower the amount of volatiles (Kroeger and Pohl 1957), resulting in higher ASTM rank. Precise correlations between ASTM rank classes and vitrinite reflectance of western Canadian coals still have to be determined.

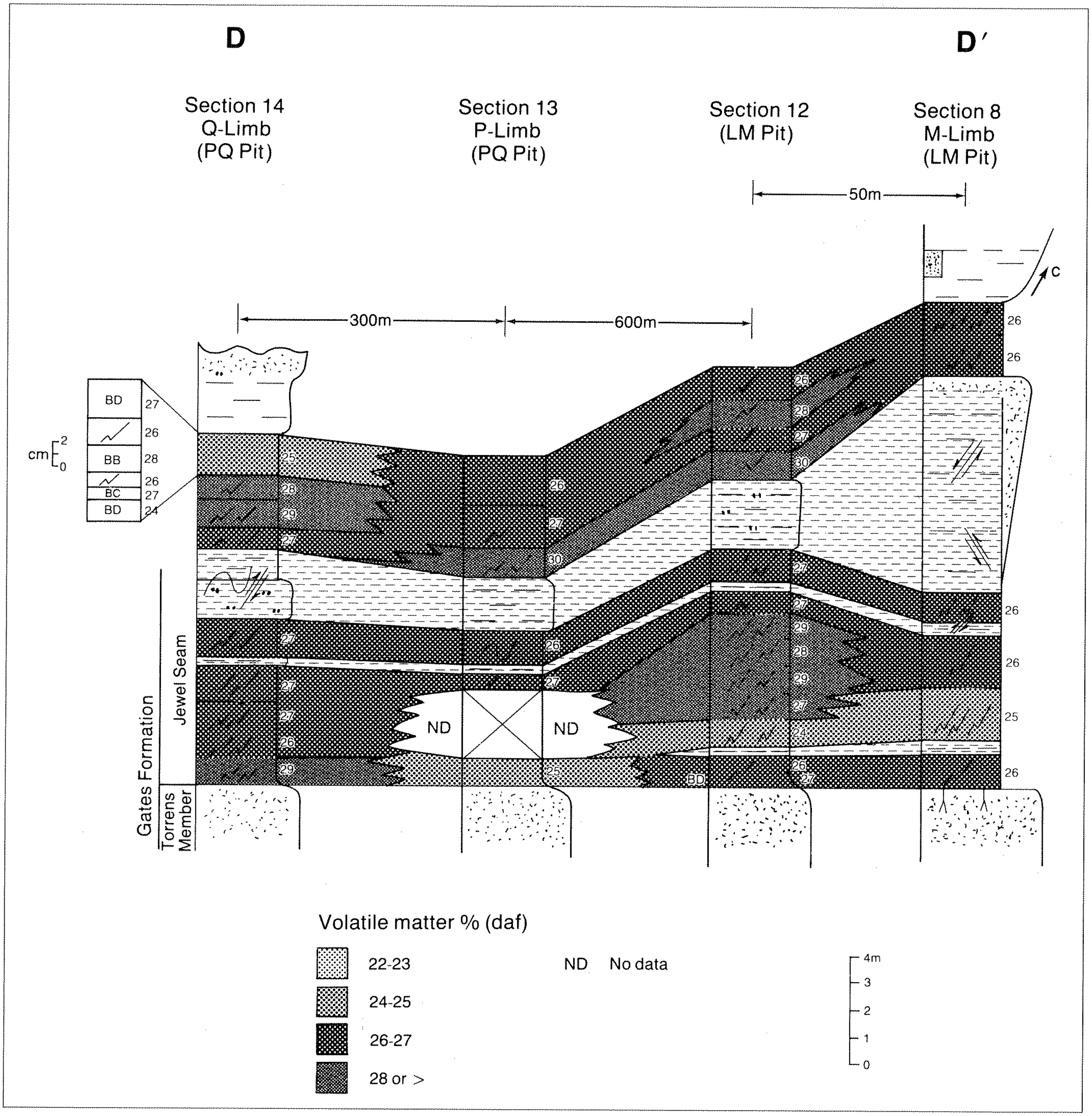

Figure 18. Stratigraphic cross section DD′ showing pit-scale volatile matter variations in the Jewel Seam, PQ and LM pits of Gregg River Resources Ltd.

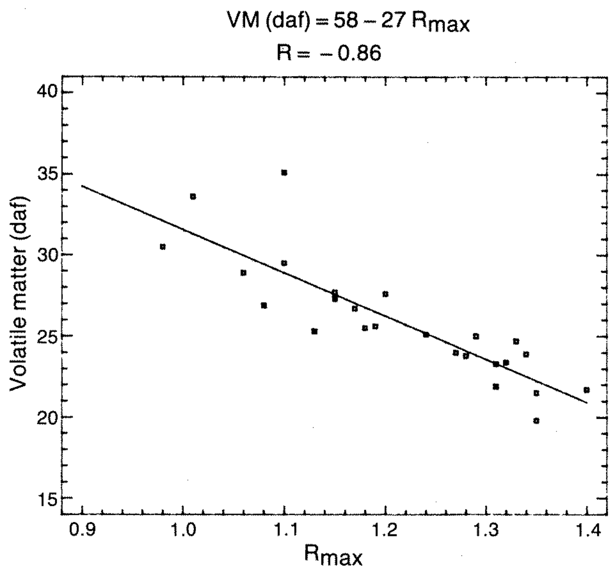

Figure 19. Cross plot and best fit linear correlation between volatile matter (dry and ash free) and maximum vitrinite reflectance.

Depositional environments and relation to coal quality

Coal quality parameters that are controlled by the original environment in the swamp and adjacent clastic environments include ash, sulfur and seam thickness. For this reason, detailed in-seam profiles of ash and sulfur will be discussed in this section in the context of depositional environments.

Depositional environments

The Luscar Group shows the transition from marine shelf environments (Moosebar Formation), to shallow shelf (Torrens Member), to coastal swamp (Jewel Seam), to well drained alluvial plain (Grand Cache Member) environments (figure 20). The economic coal of the Jewel Seam was deposited as peat in this transitional marine to nonmarine environment. The boundary between Moosebar and Gates Formation is not sharp, but is commonly an interdigitation of marine and nonmarine environments (figure 20).

In the Deep Basin (north of the Cadomin area), as many as eight marine cycles of marine sedimentation have been recognized in equivalent strata of the Luscar Group (Cant 1983; Smith et al. 1984). These include the Wilrich A and B cycles, the Falher A through G cycles and the Notikewin. In the western deformed part of the Deep Basin (Cadomin area), the Gates Formation is mostly nonmarine and it is not possible to recognize all of the Falher Member cycles.

Macdonald et al. (1988) suggest that the marine strata of the Moosebar Gates transition at Cadomin likely correlate with the more regional Wilrich and Falher cycles (figure 20). These marine strata are divided into the 1st, 2nd and 3rd regional cycles (figure 21), forming a series of prograding shorelines, coastal

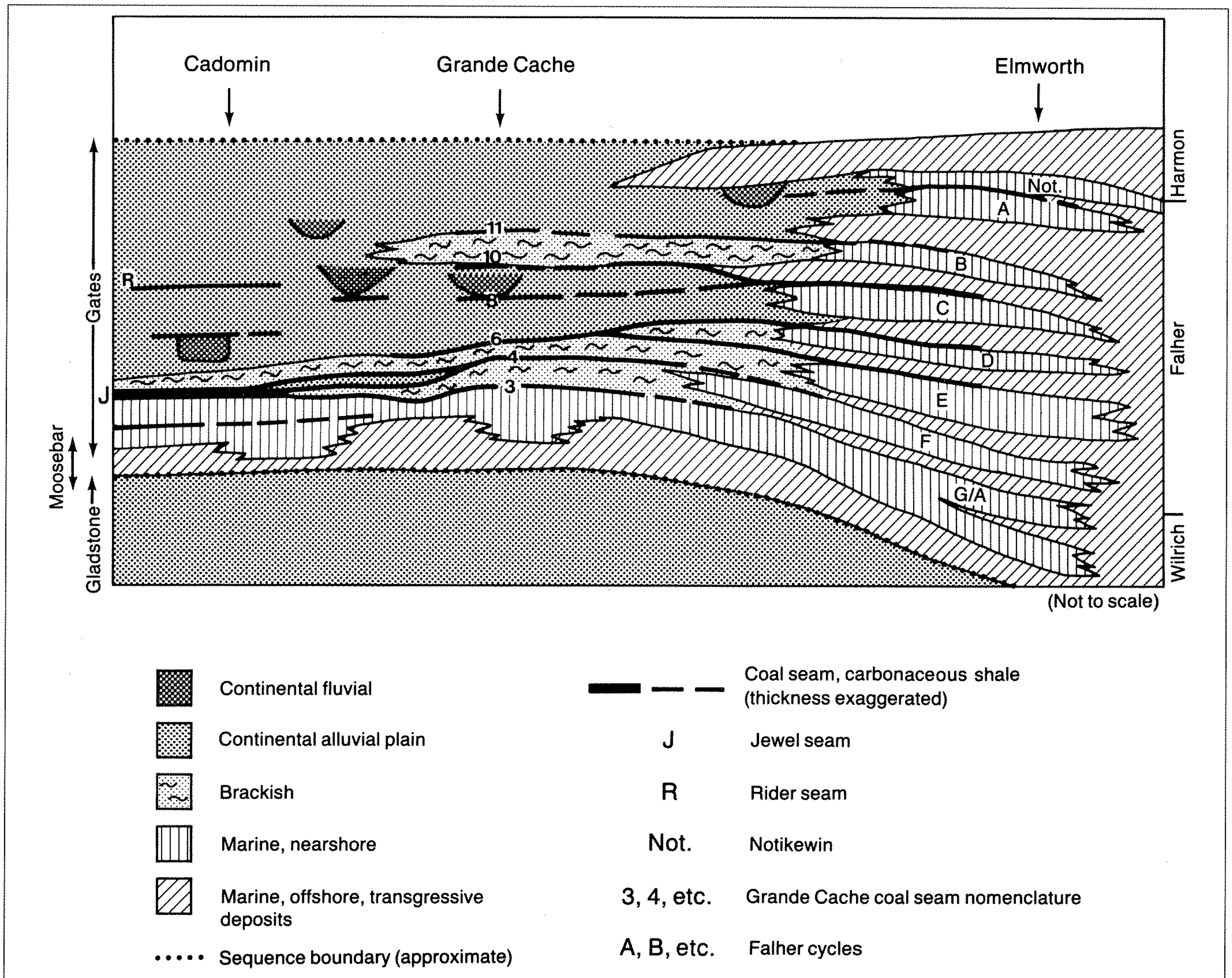

Figure 20. Schematic cross section of the Gates Formation clastic wedge, Cadomin to Elmworth area.

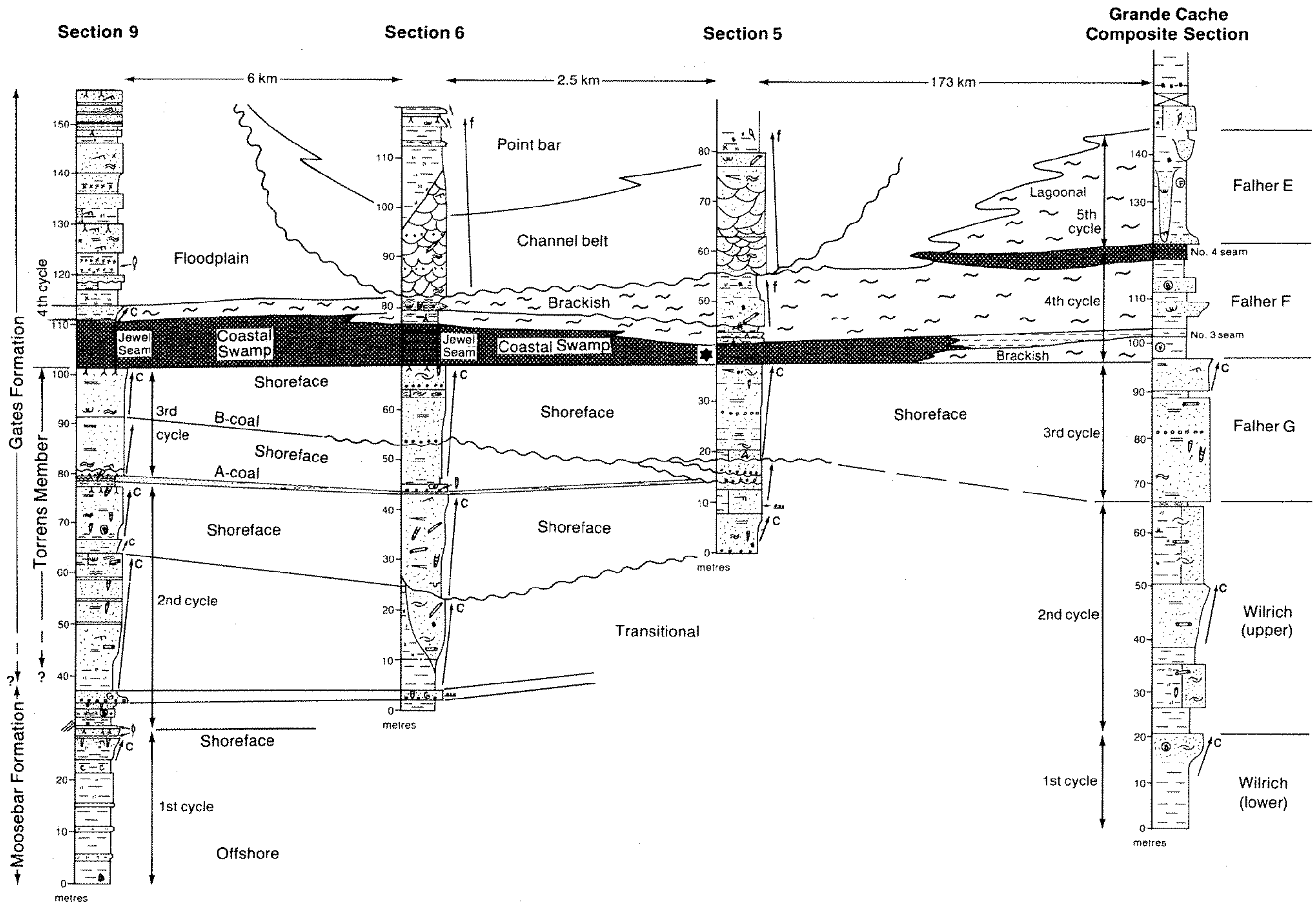

Figure 21. Cross section showing the marine to nonmarine transition of the Luscar Group, Cadomin-Luscar coalfield, together with correlations with the Grande Cache area.

plain deposits and possibly tidal deposits. More local scale cycles are also present in the outcrop area, probably representing delta lobe switching or local subsidence events. The fully marine succession includes offshore to lower shoreface (with storm deposits) and shoreface to foreshore (and possibly beach, figure 21). It is uncertain what type of prograding shorelines are represented in the Cadomin area. Very little evidence is present to support a tide- or river- dominated delta setting from sedimentological observations in the sections studied. McLean and Wall (1981) suggest a wave-influenced strandline environment for the Cadomin area. There is general agreement among all researchers that paleoflow was towards the north. Taylor and Walker (1981) argue specifically for a northwest paleoflow, parallel to the Cordillera, in the Nordegg area.

Peat swamps likely developed, initially, some distance landward on this coastal strandplain and migrated with time northward as the prograding shoreline moved north. Subsequent marine transgressive periods reached as far south as Grande Cache; one of these reached the Cadomin area (figure 20).

Marine environments

The Moosebar Formation (lower Wilrich or 1st cycle) in this area consists of a series of fine-grained mudstones interbedded with sharp-based siltstones and thin sandstones (figure 21). A thin argillaceous coal is present, as well as *Planolites* and *Skolithos* burrows. The cycle terminates in a 3 m coarsening-up sequence that is capped by a thin-rooted coal. Well preserved conifer cones and leaf impressions are present in a thin shale bed near the coal. This cycle is best exposed in Section 9 on the Cardinal River Coal property at Cadomin (figure 1). Only the upper portion of the cycle is exposed in Section 6 on the Gregg River Resources minesite (figure 21 and appendix 7).

This first cycle in the Moosebar Formation is interpreted to have formed in an offshore environment in which storm events periodically deposited thin turbidites. At Cadomin, the cycle terminated in an emergent offshore bar. A fairly major relative lowering of sea level, and consequent exposing of the shelf, is indicated by the preservation of well preserved plant fossils and the development of thin-rooted coals.

Transitional environments

The 2nd marine cycle (Torrens Member in part) at Cadomin is believed to correspond to one of the cycles in the Wilrich Member. This cycle at Cadomin consists of two or more coarsening-up sequences stacked on top of each other. A glauconitic, sharp-based pebble conglomerate bed, commonly graded, is found near the base of the cycle in Sections 6 and 9 (figure 21 and appendix 7). The coarsening-up cycles are commonly heterolithic, with fine sand dominating. Hummocky cross stratification, soft sediment deformation, wave ripples, and parallel laminations are all found in this cycle. Trace fossils include *Planolites*, *Diplocraterion* and *Skolithos*. The second cycle is capped by a rooted coal or carbonaceous mudstone, herein called the "Torrens A-coal" (figure 21). This coal can be traced in the subsurface as far north as township 57 (south of Grande Cache), where it disappears in another coarsening-up sequence (Macdonald et al. 1988). The Torrens A-coal varies from a 90 cm coal in the south (Section 9) to a carbonaceous shale at Section 6, and is locally eroded at Section 5 (figure 21).

The second cycle is interpreted to have formed, primarily, in the lower shoreface. Offshore transgressive deposits and storm-deposited gravels occur near the base, which may, in part, represent very slow deposition of a condensed section as described by Haq et al. (1987). The presence of glauconite in these pebble beds supports this idea (Weimer 1983). The offshore/transgressive deposits give way upsection to lower shoreface and finally to foreshore. The trace fossil assemblage is consistent with this interpretation. The hummocky cross stratification supports the storm-deposited origin and has been found in other locations of the Moosebar to Gates transition (Leckie and Walker 1982). The laterally extensive Torrens A-coal in the subsurface may suggest sea-level lowering at this time (Macdonald et al. 1988).

The 3rd marine cycle consists of massive (though occasionally thinly bedded), fine to very fine grained sandstone, which has been traditionally called the Torrens Member. Faint parallel laminations are the predominant structures, with some trough cross bedding and hummocky cross stratification also present (figure 21; appendix 7). Scour surfaces, with pebble lag deposits, are also common in the cycle. Mudstone is a very minor lithology in this cycle and is usually associated with the hummocky cross stratification. Trace fossils are particularly abundant near the top of the 3rd cycle and include *Skolithos, Ophiomorpha, Planolites*, and *Diplocraterion*. The sequence is capped by the thick Jewel Seam. The sandstones below the coal seam are commonly well rooted and show a discoloration in the top 50 cm. Tree trunk impressions and root casts can be found on the uppermost bedding plane surface of these sandstones.

The 3rd cycle probably correlates with the Falher G or Wilrich A cycles in the Deep Basin (Macdonald et al. 1988). This cycle is interpreted to be a succession of two prograding shorelines sequences, with upper shoreface to foreshore environment transitions. The thin Torrens "B-coal" that is present at Section 9, very likely represents a shifting away from this area of the prevailing sediment source and the development of a small lagoonal environment. This coal is not traceable throughout the Cadomin area (figure 21). The trace fossil assemblage is typical of the *Skolithos* ichnofacies, which is most commonly found in high energy beach or beach-like facies (Ekdale et al. 1984). The presence of hummocky cross stratification high up in the sequence precludes a true beach environment, because these structures generally form below fair wave base (Walker 1984).

The 4th marine cycle at Cadomin directly overlies the Jewel coal seam and extends upsection until the first major fluvial sandstones are encountered (figure 22, unit GC2). Brackish water indicators are not overly convincing, with the main evidence being the presence of trace fossils (*Diplocraterion* and *Planolites*) at Section 6, above the Jewel coal seam (appendix 7), and the presence of lenticular bedding throughout this interval. The fourth cycle may be related to the transgressive portion of the Falher F cycle in the Deep Basin further north. It is suggested that the depositional environment was tidal.

Nonmarine environments

The nonmarine environments examined, within the Grande Cache Member at Cadomin, lie between the Jewel and R Seams. This interval can be divided into five lithofacies units (figure 22).

Lithofacies GC1 is the 10 m thick Jewel coal seam which overlies the Torrens Member. It has a well rooted seatearth, which often contains log and root impressions (figure 22). The Jewel coal seam is believed to have been deposited some distance landward on a broad coastal plain. Macdonald et al. (1988) suggest that a split from the Jewel Seam is stratigraphically equivalent, though not necessarily equivalent in time, to the No. 3 seam at Grande Cache. Farther towards the north, into the Deep Basin, the Jewel equivalent is seen to disappear into marine strata (figure 20). This evidence suggests a more landward position for the peat swamp development, perhaps up to 100 km from the coastline on a coastal plain. Englund et al. (1986) describe low ash, low sulfur, Pennsylvanian coastal coals, having no overlying marine strata, that are believed to be directly related to the development of peat swamps on top of abandoned delta lobes in an overall regressive sequence. McCabe (1987) describes coals from the Upper Cretaceous Horseshoe Canyon Formation and Judith River Group, forming in north-south belts parallel to the paleocoastlines

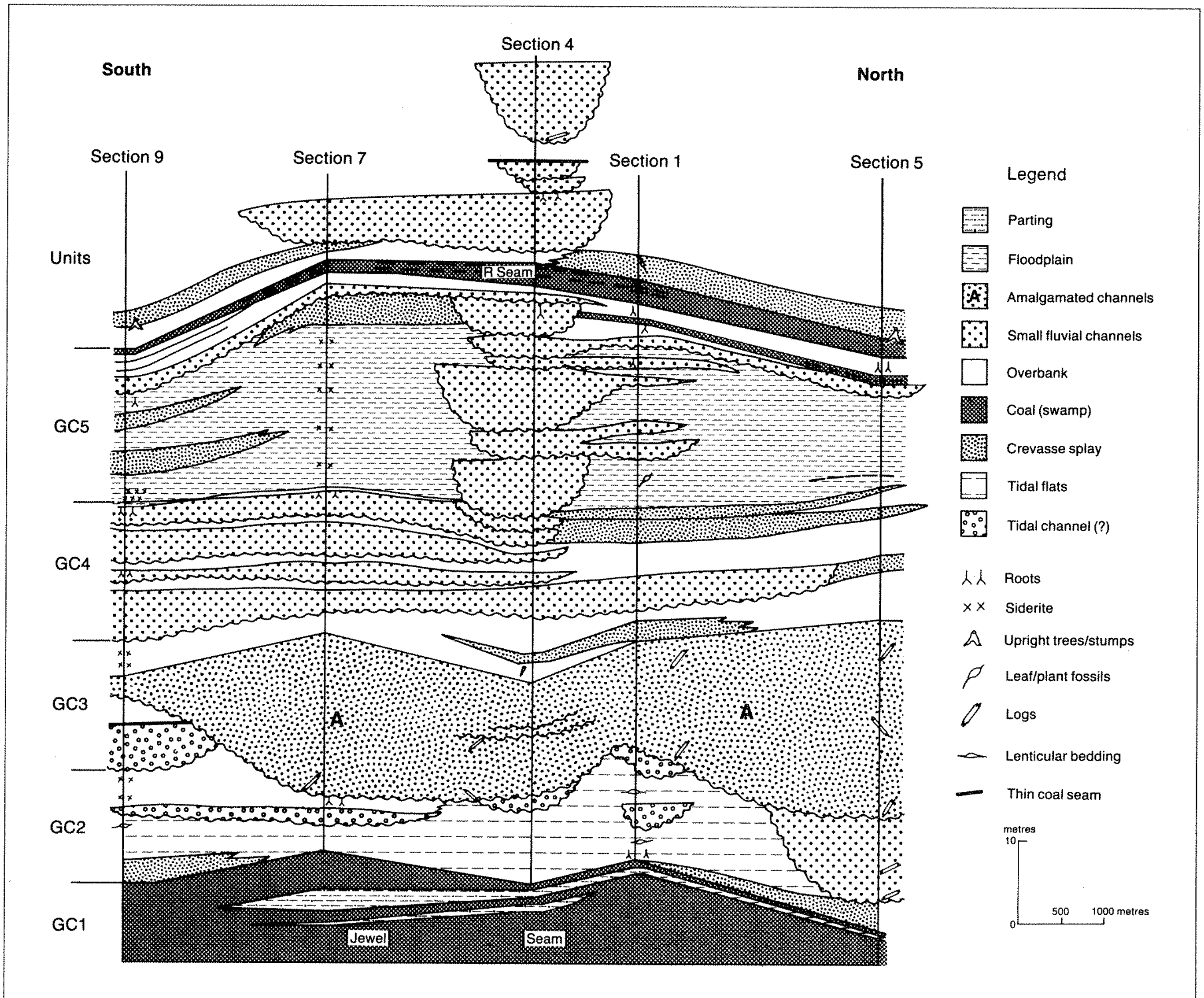

Figure 22. Stratigraphic cross section F-F′ showing facies interpretation for the Grande Cache member between the Jewel and R Seams.

and having the thickest accumulation of peats (coals) some 40-80 km landward of the shoreline. The Okefenokee Swamp is cited as a modern day analog for the Upper Cretaceous coals by McCabe, and this model may equally well apply to the Lower Cretaceous Jewel Seam. McCabe (1984) has suggested that in order for thick, low ash coals to form in a low lying coastal plain swamp, they must be some distance landward from active shoreline processes, yet still maintain high watertables. This would seem to be the case for the Jewel Seam at Cadomin. Kalkreuth and Leckie (in press) suggest a dry forest swamp on the upper delta plain as a possible depositional setting for the Jewel seam, an interpretation consistent with the one proposed herein.

The nonmarine sequence above the tidal flat facies (GC2, figure 22) is, for the most, non coal-bearing or contains only very thin seams. No trace or hard-bodied marine fossils have been observed above the tidal flat facies, at least up to the R coal seam.

The GC3 lithofacies unit overlies the tidal flat unit and consists of thick, amalgamated, trough-cross stratified, log-bearing, fine-grained sandstones (appendix 7). Some large lateral accretion bedding can be seen in the 51B2 pit at the Cardinal River minesite (Section 4, appendix 7). The unit is interpreted to be a series of amalgamated fluvial channel deposits. A meandering system is suggested by the lateral accretion bedding.

The GC4 lithofacies consist of a series of thin, fining-upward sandstones and mudstones and some coarsening-upward sequences. A very thin-rooted (10-20 cm) coal caps this unit over most areas, except where channeling has removed the seam (figure 22 and appendix 7). No coal quality information is available from this seam. However, field observations suggest a very high ash content. The GC4 lithofacies are interpreted to be a series of stacked, small fluvial channels, with associated crevasse splay deposits.

Over most of the area, the Unit GC5 consists of fine-grained mudstones, thin discontinuous sandstones, the R Seam capping the unit and minor coarsening-up sequences. Section 4 (figure 22), in contrast, shows a series of fining-up cycles, each about 2-6 m thick. This unit is interpreted to be primarily a floodplain deposit, with one area of stacked, small fluvial channel deposits. Paleocurrent measurements are not available, but the cross-section F-F′ orientation (figure 22) suggests either an east-west or northwest-southeast orientation for this channel system. The R Seam is considered to be a typical alluvial plain coal, which was probably deposited contemporaneously with very small fluvial channels.

The strata above the R Seam were not examined in detail as very few, if any, coal seams lie between the R Seam and the Mountain Park Member.

Geochemical model

A geochemical model is available that relates several of the coal quality parameters to the original chemistry of the swamp environment (Renton and Cecil 1980; Cecil et al. 1980; Donaldson et al. 1980; Andrejko et al. 1983). The model is based on 6 basic premises (Renton and Cecil 1980): 1) the source of major finely disseminated ash (i.e. non-partings) was from the inorganic portion of the swamp plants; 2) ash concentration is directly dependent upon degree of peat degradation; 3) plant degradation results from microbial activity (most important) and oxidation; 4) microbial activity, and hence plant degradation, is directly related to ph of the swamp (above pH 5.0, microbial activity is so high that no coals form); 5) thickness of a coal is the result of the relative balance and rate between plant accumulation and degradation; and 6) microbial activity is also responsible for sulfate to sulfide and biogenic gas production. Low pH (acidic conditions) results in a minimal amount of microbial action in the swamp, and hence, little degradation of organic material.

This reduction in microbial activity reduces the sulfate to sulfide production capability of the swamp (i.e. less pyrite is formed), reduces the release of mineral matter locked up in plant material, may cause dissolution of existing mineral matter if conditions are acidic enough, and will not likely form carbonate minerals in the peat. The resulting coal tends to be rich in vitrinite macerals. With increased pH, microbial activity increases, resulting in more organic degradation (more ash), better sulfate reducing conditions (more sulfur) and the possible precipitation of carbonate minerals (more ash).

The model results in three generalized swamp conditions, that will lead to three sets of unique properties in the resultant coals (Cecil et al. 1980). Anaerobic peat with pH values less than 4.5 will yield low ash, low sulfur, vitrinite-rich coals. Anaerobic environment where pH conditions exceed 4.5 will result in enrichment of ash, sulfur and liptinite. Intermittent aerobic conditions will yield low sulfur and enrichment of ash and inertinite. The Jewel Seam fits largely in the latter catagory (see also Kalkreuth and Leckie, in press). The model implies that ash, sulfur and seam thickness will be related. However, the range of sulfur contents is narrow (from 0.1 to 0.6 percent) and regression does not show any correlation between ash and sulfur. This contradiction is not fully understood and needs to be investigated further.

Jewel Seam

The Jewel Seam varies in thickness from 5 to 30 m. The original, pre-deformational thickness is believed to have been approximately 10 to 12 m in this area. Structural thickening and thinning account for most thickness variations seen. However, the possibility of sedimentary thickening and thinning has to be considered.

Ash

The variation in ash content throughout the Cadomin-Luscar coalfield was examined on a regional coalfield scale, a local scale (several adjacent pits) and on a more detailed pit scale (<1000 m, figure 1; see also Macdonald et al. 1988). The original mineral matter content of the Jewel Seam is divisible into two parts: visible rock partings and depositionally derived inherent mineral matter within the coal itself. Locally, mineral matter contents may have increased through tectonic shearing.

The most significant visible parting in the Jewel Seam occurs in the vicinity of the LM and PQ pits on the Gregg River Resources property in the western part of the coalfield (figures 23 and 24). In the LM and LM-extension (LME, figure 1) pits, this parting can be seen to increase from less than 50 cm to over 10 m, over less than 1000 m along the strike. This parting may be related to an earlier development of the major channel deposits which overlie the Jewel Seam in this area (figure 22, unit GC3; see also appendix 7). Most partings throughout the Jewel Seam tend to be less than 30 cm, with many being 2-5 cm tonsteins or discontinuous enigmatic partings. Renton and Cecil (1980) point out that thin enigmatic partings in coal may be the result of the degradation of peat, where inorganic material is concentrated in a discrete layer. The only other major parting in the area occurs at the base of seam along the northernmost extension of the Cardinal River property, where this crevasse splay is approximately 1-2 m thick (Section 3, figure 23).

The finely disseminated ash content of the Jewel Seam varies from 4 to 30 percent (dry). However,

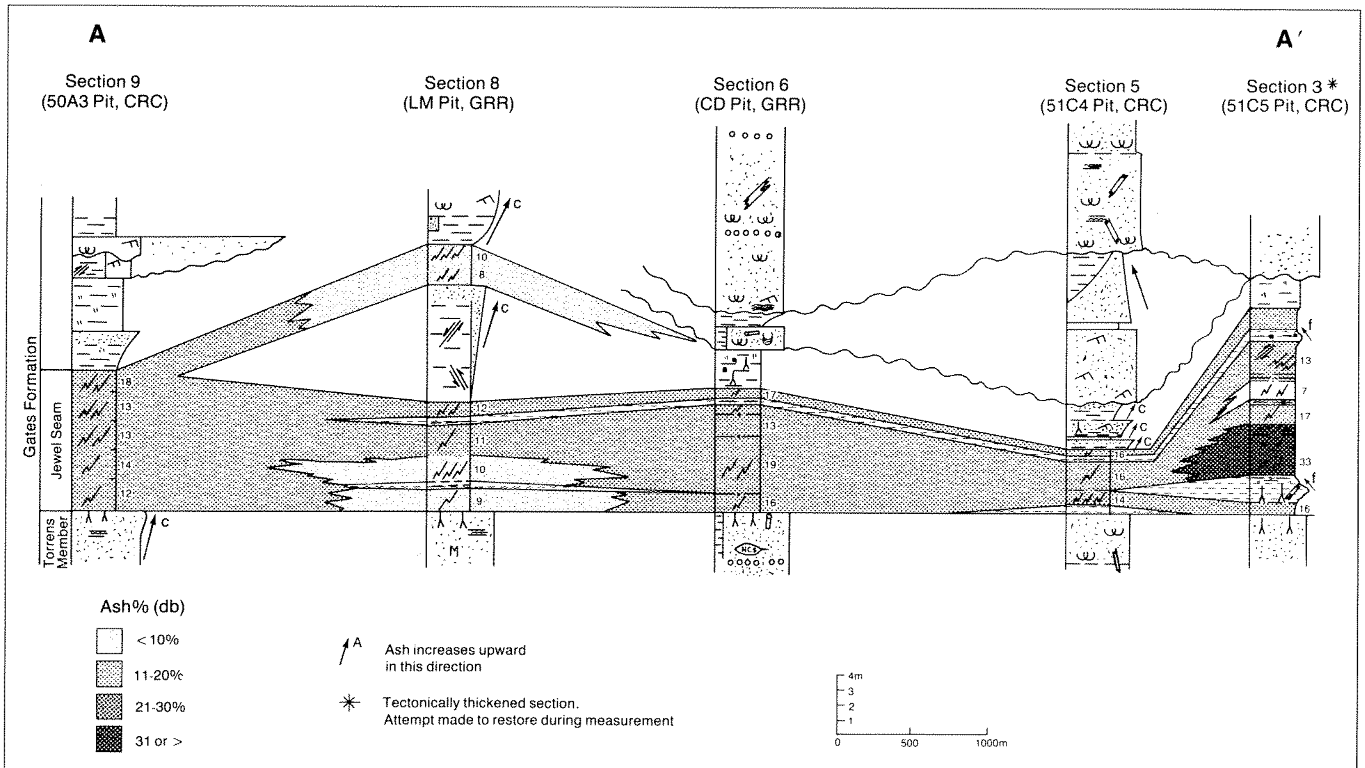

Figure 23. Stratigraphic cross section A-A′ showing regional in-seam ash variations in the Lower Cretaceous Luscar Group, Jewel Seam, throughout the Cadomin-Luscar coalfield, Alberta. Section runs approximately from south to north.

most values are in the 11 to 20 percent (dry) range (figure 23). The in-seam distribution (within this 11 to 20 percent range) is difficult to generalize over the area. Some sections of the Jewel Seam show an overall vertical profile of upward increase in ash content or an "ashing upward" sequence (figure 24 and 25). Most ashing up profiles seem to be depositional in origin, as tectonic shearing is generally uniform or only slight in intensity. These profiles may result from changing chemical conditions at the time of peat development (Cecil et al 1980) or from the gradual encroachment of a fluvial system supplying detritus.

On a more detailed pit-scale, observations about finely disseminated ash distribution can also be made. The Cardinal River 51B3 pit shows a relatively low ash zone near the base of the seam (<10 percent dry, figure 25), with a higher ash zone above this (21-30 percent dry). Both zones are within the lower half of the seam. Esterle and Ferm (1986) describe thick, dull coals (Pennsylvanian), which have low sulfur and ash contents and which formed near alluvial clastic environments. These authors suggest that these coals resulted from a nutrient-deficient, shrub-dominated, slightly domed and oxidizing peat swamp. Domed portions of the original swamp would act as detrital–"shields" and may account for these low ash zones in the Jewel Seam. The upper half of the Jewel Seam, at the 51B3 pit, tends to be in the 11 to 20 percent (dry) range with some sections showing upward increases in disseminated ash content or "ashing upward" sequences (Section 15). One very low ash zone (<8 percent dry) is also present in the upper half of the seam in the 51B3 pit (Section 15, figure 25). The PQ and LM pits on the Gregg River property show a tendency for ash content to increase upward, particularly above the upper major split (figure 24). Finely disseminated ash contents tend to be relatively constant both above and below major partings, which would suggest that these partings represent short periodic events in the swamp formation.

The in-seam ash horizontal profiles show that ash contents generally tend to increase or decrease at a regular rate with distance. However, very rapid changes within a given zone do occur. In the PQ pit, immediately above the major parting, inherent ash is in the 11-20 percent range at Section 12 (figure 24) and in the 10 percent or less range at Section 8, which is only 50 m away. The lower ash values are found immediately above the thickest portion of the split. This phenomenon may be related to the increased split thickness at Section 8. After the split was deposited during a major clastic event, the thickest accumulation of clastics may have formed a very slight topographic high. Swamp conditions were established on this high, slightly sheltered from further clastic influx.

Finely disseminated ash contents have apparently been tectonically augmented in some portions of the seam. The 1 m coal interval immediately below the

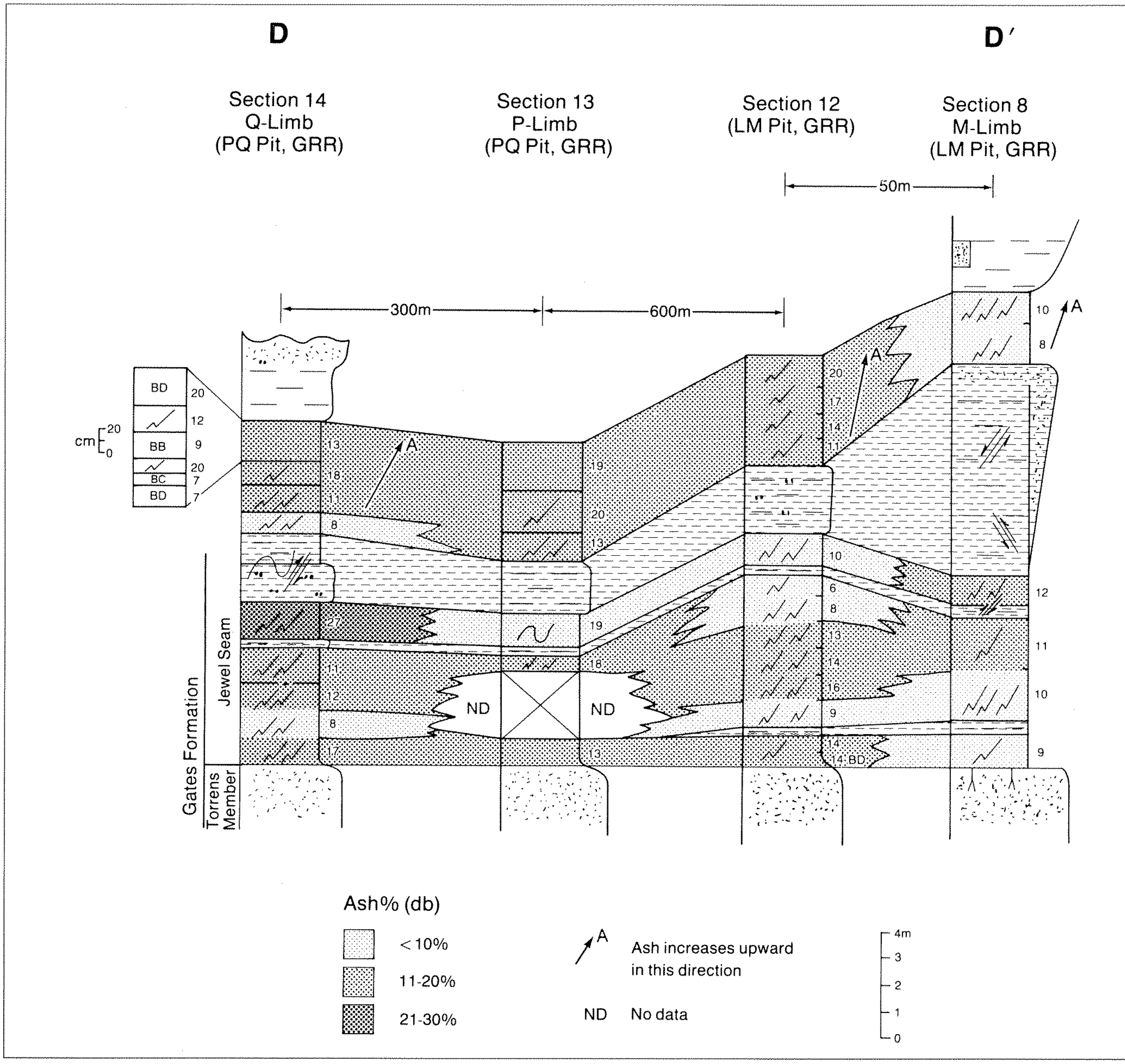

Figure 24. Stratigraphic cross section D-D′ showing local in-seam ash variations in the Lower Cretaceous Luscar Group, Jewel Seam, throughout the PQ and LM pits, Gregg River Resources Limited. Section runs approximately west to east.

upper major parting in the PQ pit (figure 24) changes from 27 percent ash (dry) in the Q limb (Section 14) to 9 percent (dry) in the P limb (Section 13). This rapid change in ash content over a distance of less than 300 m is likely due to shearing and thrusting in the Q-limb (resulting in high ash). This ash augmentation is very pronounced at Section 3 (figure 26), where the entire Jewel section has been tectonically thickened. Ash values are very high above the lower split, in association with a major fault zone. Interestingly, Section 5 (approximately 500 m south) is a tectonically thinned section of the Jewel Seam and shows near normal ash values. Shearing has the affect of grinding portions of visible partings into otherwise low ash zones of the seam and thereby enhancing the original depositional ash content. Shearing also allows for increased rates of surface oxidation due to the finer grain size, which also results in a relative increase in ash (see Bustin 1982 and Macdonald et al. 1987). This phenomenon has not taken place in all sheared coal zones, as many examples of sheared, low ash coal can be found in the in-seam profiles. Recognizing the overprinting effects of deformation on original ash contents is difficult.

Very detailed in-seam vertical sampling was undertaken in a few locations to obtain a better idea of very

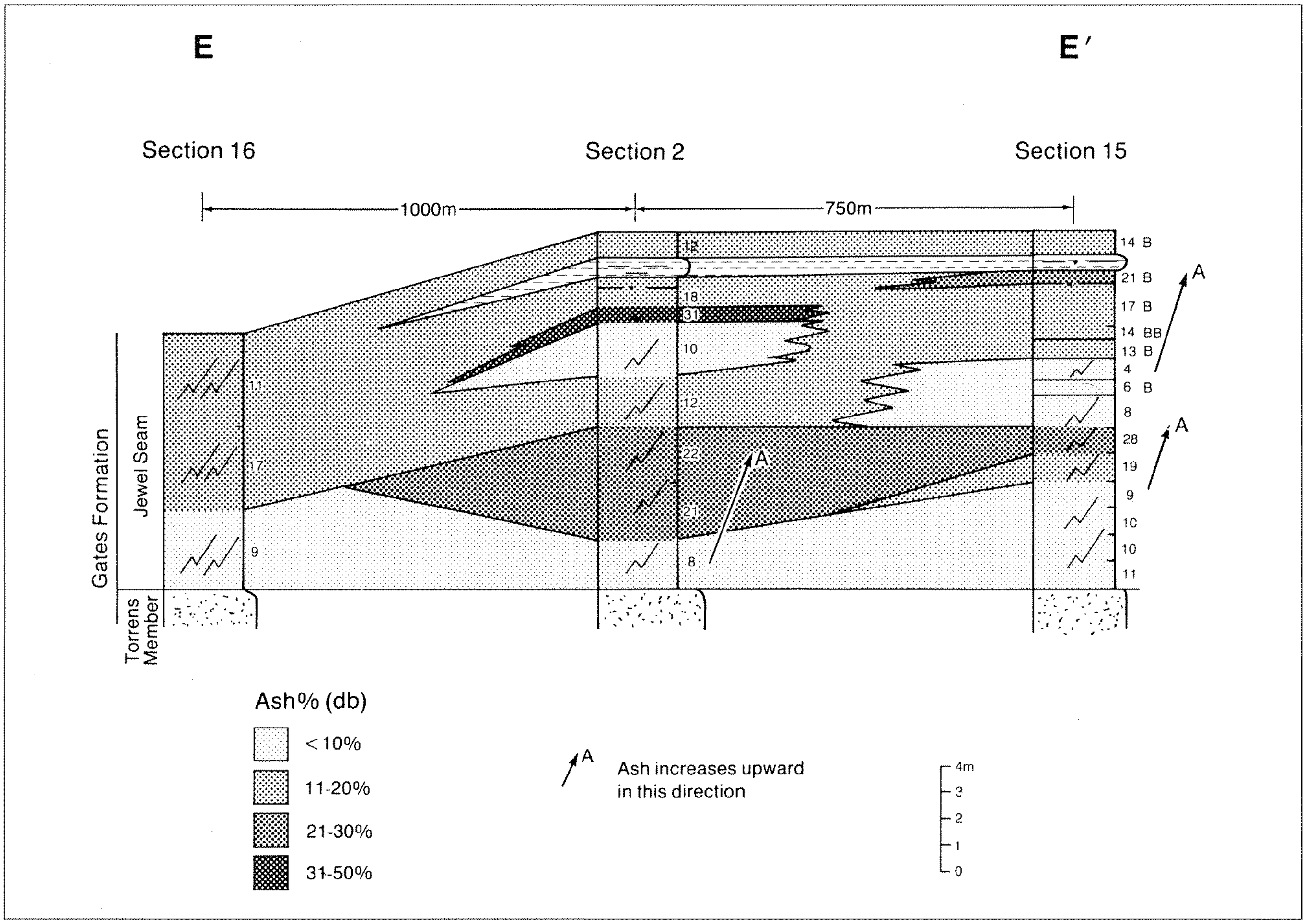

Figure 25. Stratigraphic cross section E-E′ showing pit-scale in-seam ash variations in the Jewel Seam, throughout the Cardinal River Coals Ltd. 51B3 pit.

small-scale coal quality variations. At the CD pit, Gregg River Resources, a detailed petrographic analysis was compared to the ash analysis completed for this same location (figures 27 and 28). If the ash content in the coal is mainly derived from plant cell wall material that has been concentrated by certain pH conditions in the swamp development, the inertinite content should increase with increasing ash (Cecil et al. 1980). This does seem to be the case for the upper succession with upward increase in ash at Section 10, but the model does not apply in the lower part of the seam. Kalkreuth and Leckie (in press) report the Jewel Seam in general to be high in inertinites (40-52 percent vol), moderate in visible mineral matter (2-23 percent volume), and rare in liptinite. This assemblage is indicative of a swamp that formed under relatively dry, oxidizing conditions. A treed dry forest setting is further suggested. The large tree stumps and logs seen at the base of the Jewel Seam at several of the sections examined in this study would support this conclusion. These conditions are consistent with the intermittent aerobic conditions predicted by the Cecil et al. (1980) model.

Another detailed section of the uppermost Jewel Seam was sampled on a centimeter scale (PQ pit, Section 14, figure 24). This 1.3 m section shows the overall upward increase in ash described earlier and also illustrates the effects of very localized shearing on ash content. A 15 cm bed of sheared coal, near the middle of this 1.3 m profile, has an ash value of 20 percent compared to the upper and lower undeformed beds which generally have less than 9 percent ash (dry). In contrast, the upper 20 cm bed of sheared coal has 12 percent ash, which is likely the original finely disseminated ash content. The uppermost undeformed 35 cm interval has a relatively high ash content (20 percent dry-F basis), which was probably derived from aerobic pH conditions toward the end of the peat swamp development. Unfortunately, the influences of sedimentary and tectonic processes are difficult to distinguish.

The effects of interval of coal sampling on ash profiles are well illustrated by figure 25. Sections 16 and 2 were sampled at 3 and 2 m intervals respectively, while Section 15 was sampled on either 1 m or a finer interval depending on coal macrolithotype. With

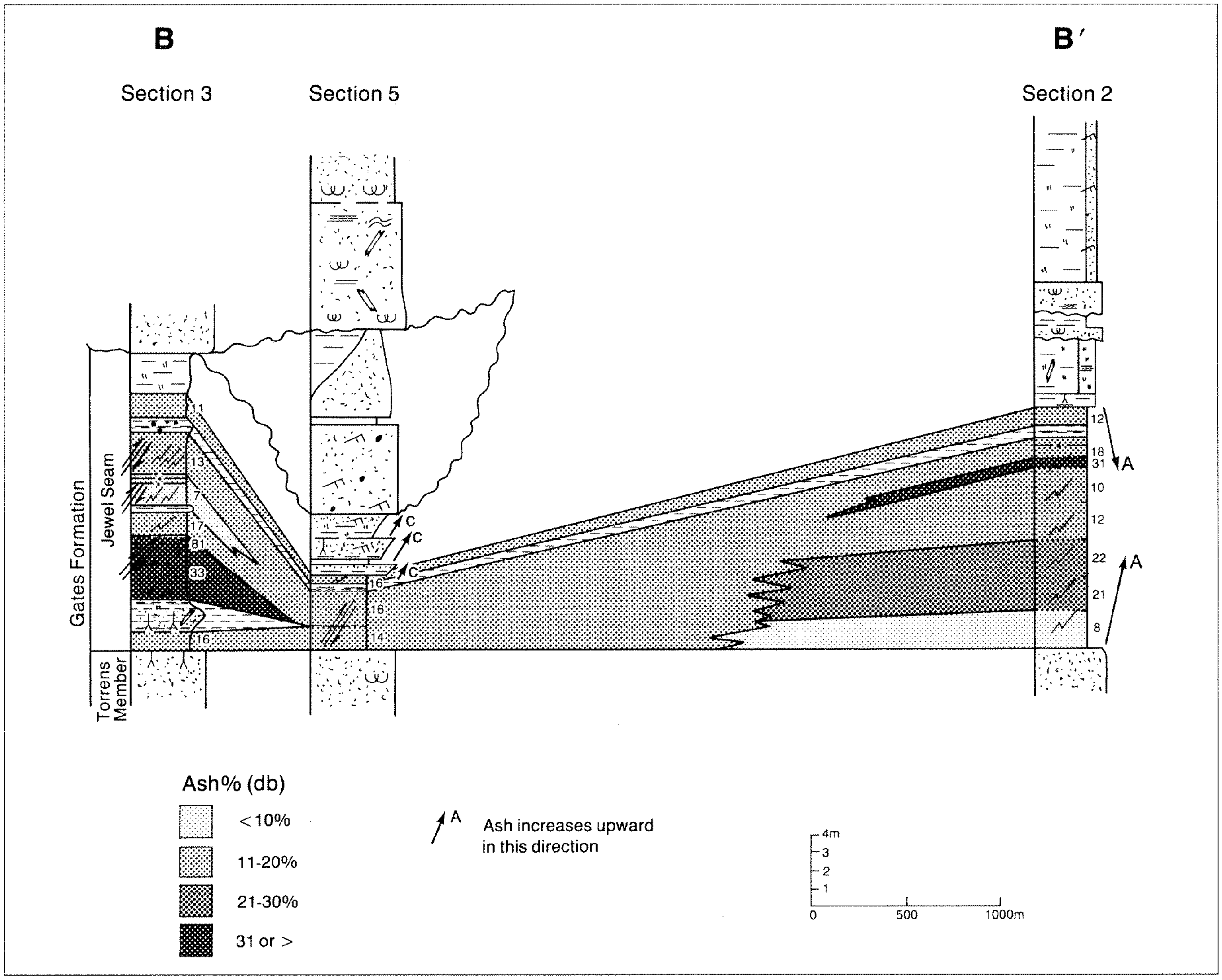

Figure 26. Stratigraphic cross section B-B′ showing regional in-seam ash variations in the Jewel Seam, throughout the Cadomin-Luscar coalfield. Section runs from the northwest to southeast.

wider sampled intervals it is more difficult to discern in-seam ash variations. However, with very detailed sampling, a great deal of minor ash variations appear, which can sometimes confuse the major trends. For mining purposes of the Jewel Seam, the 2 m interval sampling interval appears to result in a good characterization of ash variations. However, a few profiles with more detailed sampling will be useful to confirm the trends on a more detailed scale.

Sulfur

It is important to note that the Jewel Seam is a low sulfur coal with a mean value of 0.3 percent (dry). Most coals marketed from this coalfield have sulfur restrictions specified in contracts and are not expected to exceed 0.5 percent for cleaned coal (Karst and Gould 1985). Operators report few problems in meeting this standard for sulfur. However, somewhat higher sulfur contents (i.e. up to 1 percent) are sometimes unexpectedly encountered in mining operations. Knowing something about in-situ sulfur distribution in the coal may help preparation plant operators better deal with sulfur.

Sulfur can be derived from organic or inorganic (pyrite, marcasite) sources during peat formation, or it can be deposited in cracks during coalification. Most sulfur in the Jewel Seam, at Cadomin, is probably organic sulfur (based on seven samples analyzed by CANMET, Bonnell and Janke 1986). No visible pyrite was seen during the field investigations of the present study. Donaldson et al. (1980) describe eight special locations in the seam that could have anomalous sulfur values, depending upon the particular swamp chemical conditions (figure 29).

The distribution of sulfur in the Jewel Seam will be related to this geochemical model.

Above average sulfur values (i.e., 0.4 to 0.6 percent dry) are frequently found at the base of the seam,

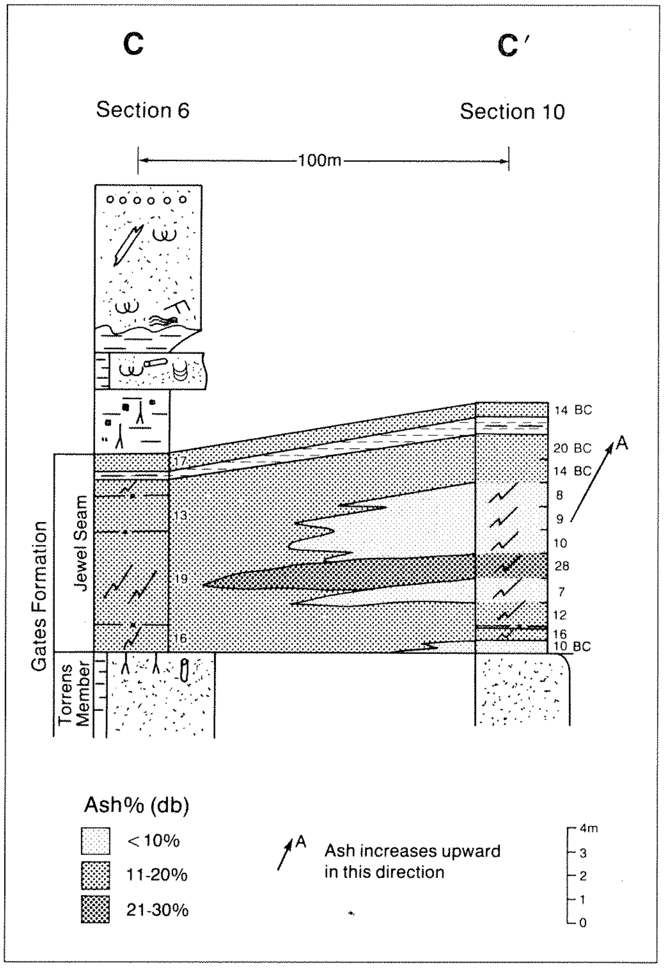

Figure 27. Stratigraphic cross section C-C′ showing pit-scale in-seam ash variations in the Jewel Seam, within the CD pit, Gregg River Resources Limited.

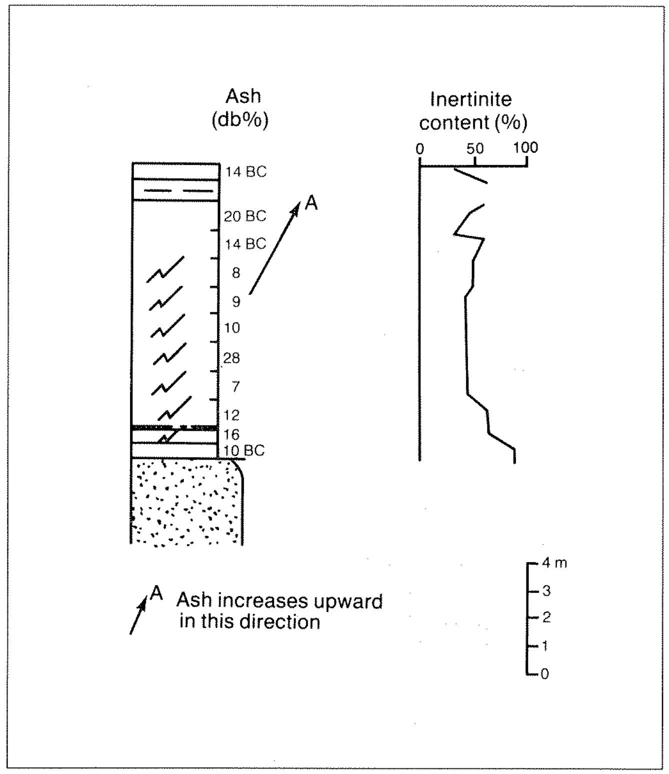

Figure 28. Vertical in-seam profile comparing ash variations to inertinite content, Jewel Seam (CD pit, Gregg River Resources). Petrographic data determined using TAS (Texture Analysis System) and supplied by M. Steller, Essen, W. Germany.

within the first 1-2 m. Cross-section A-A′ (figure 30), which runs approximately southeast to northwest and north-south throughout the coalfield, shows this moderately low sulfur at the base of the seam. The northwest to southeast section B-B′ (figure 31) also shows above average sulfur values near the base. These above average values are also observed on a detailed pit-scale. However, the highest sulfur values are not necessarily found at the exact Jewel/Torrens contact. The PQ and LM detailed section (figure 32) shows how quickly sulfur values can change within this basal zone. Sections 13 and 14 are less than 500 m apart along the coal seam, but the sulfur values at the base of the seam nearly double from P to Q limb. High sulfur zones (i.e.,>2-3 percent) at the base of coal seams have been documented in other parts of the world (for example, Donaldson et al. 1980). Figure 29 (position 1) shows that these zones may be related to peat accumulation in swamps of limited size, with greater opportunity for peat degradation by alkaline waters. The lower sulfur contents at the base of section 13 may be related to a more widespread swamp having more acidic chemical conditions (position 2, figure 29).

Within relatively undisturbed sections of the Jewel Seam, and those having very few partings, there is often a very low sulfur zone in the middle of the seam. This is visible on the pit scale (figure 33) and on the more regional scale (figures 30 and 31). Values in this very low sulfur zone are commonly less than 0.2 percent (daf). Very low sulfur zones can be explained by the general chemical model as being the result of a time when the swamp reached its widest extent, thereby having the most acidic conditions (little sulfide generation, figure 29, position 4). Tectonically altered coal sections and those having multiple partings have more complex sulfur distributions and do not always show this very low sulfur zone.

Above average sulfur values (i.e. up to 0.7 percent) are sometimes found at the top of the Jewel Seam, on both the local and regional scale (figure 33 and 31). Section 5 has the highest sulfur value at the top of the seam, and also has the thickest amount of overlying channel deposits (figure 22). The other sections with above average values (i.e., around 0.5 percent daf), seem to have the thickest sections of tidal flat facies (unit GC2, figure 22) overlying them. The top of coal seams has long been recognized as a site for elevated

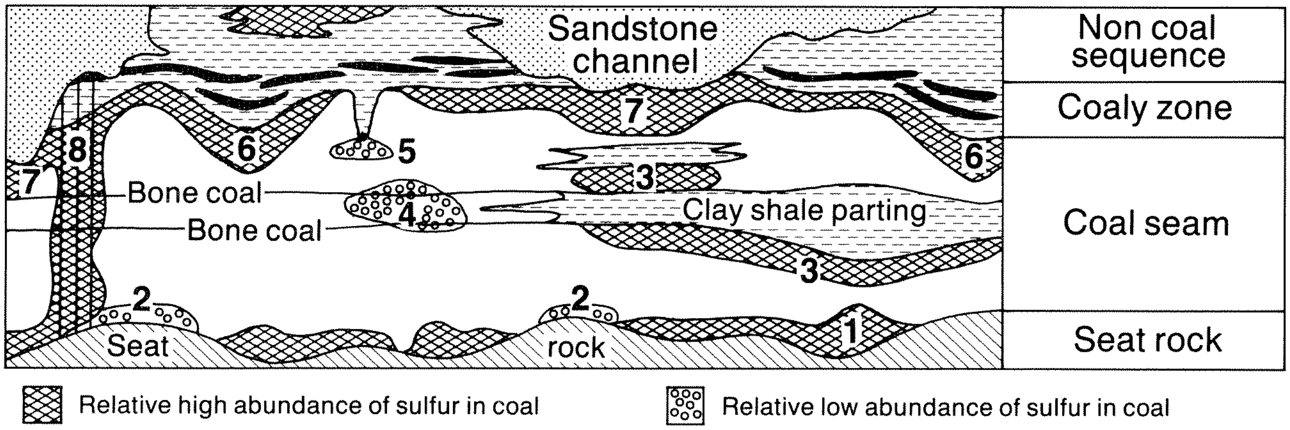

Figure 29. A model for sulfur variations in the Jewel Seam based on chemical environment and inferred acidity of original swamp (modified from Donaldson et al. 1980). High sulfur concentrations in original swamp found in following positions, 1) Base of swamp, resulting from degradation of peat by alkaline waters in swamps of limited extent, 3) Near partings, from degradation of previously formed peat by alkaline waters, related to parting deposition, 6) Top of swamp, below lake deposits, resulting from introduction of alkaline waters and degradation of peat, 7) Top of swamp, below channel sands, resulting in increased alkaline conditions, 8) Cleats filled with pyrite. Low sufur concentrations found in following positions, 2) Base of swamp, where peat degradation was reduced in extensive swamps with acidic conditions, 4) Mid swamp position suggests swamp was at its maximum extent (i.e. most acidic conditions), often indicated by "bone coal partings", 5) Near swamp drainage channel, filled with acid waters, maintaining acidic conditions in underlying peat.

sulfur values. If the overlying strata are marine in origin, a potentially large source of sulfate ions for reduction to sulfide in the underlying peat is available. Another possibility is offered by the Donaldson et al. (1980) model. Their model suggests that those regions of the seam that are immediately overlain by channel or lake deposits (positions 6 and 7, figure 29) may have experienced more alkaline waters, which resulted in sulfate reduction. The locations of low sulfur at the top of the Jewel Seam would seem to fit into one or both of these explanations. However, if the tidal flat facies was as widespread as is suggested (figure 22), the upper Jewel would show elevated sulfur values at all locations. This is not the case and so one might conclude that either the tidal flat facies was not as widespread, or that overlying channel or lake deposits were the cause of elevated sulfur values.

Therefore, sections with both the upper and lower above average sulfur zones and the central very low zone show a characteristic in-seam sulfur pattern of decreasing percentages toward the center of the seam (figure 34). This pattern is best recognized in tectonically undisturbed portions of the seam that have few partings.

Sulfur does not seem to be preferentially concentrated immediately below partings, regardless of the thickness of the parting (figures 32 and 33). Sulfur values remain about average below and above the major parting in the region of the PQ and LM pits, on the Gregg River Resources property (figures 30 and 32). The one possible example of elevated sulfur associated with partings occurs at Section 3, where 0.5 to 0.6 percent sulfur is found above and below the lowermost parting (see the model of figure 29, position 3).

The 2 m interval sampling appears to be adequate to characterize sulfur variations in the Jewel Seam.

R Seam

The R seam occurs approximately 60 to 70 m above the Jewel Seam and caps the floodplain facies (figure 22, unit GC5). The seam is up to 2 m thick locally, but is generally not economic because of poor coal quality properties. The R seam is the only other major seam within the Grande Cache Member in the Cadomin area.

Ash

The total ash content of the R seam tends to be high due to visible partings and high inherent ash contents (15 to 44 percent, dry, appendix 7, Sections 4, 5, and 9). High inherent ash values do not seem to be related to tectonic shearing. Both these factors make the R seam very high in "as mined" ash content and hence, uneconomic.

The R seam at Gregg River Resources Limited was found by Kalkreuth and Leckie (in press) to be high in vitrinite (96 percent vol), with mineral matter content of 21 percent (vol). The authors suggest that the R seam may "...represent a locally flooded moor of the upper delta plain with a fair input of mineral matter associated with a relatively high water table." The Cecil et al. (1980) model predicts that an anaerobic, acidic swamp would produce low ash, low sulfur and vitrinite enrichment. While sulfur is generally low and the vitrinite enrichment exists, ash tends to be high. Section 5 (appendix 7) suggests an evolution of the swamp from an acidic environment periodically indurated with aerobic waters (very low sulfur/moderate

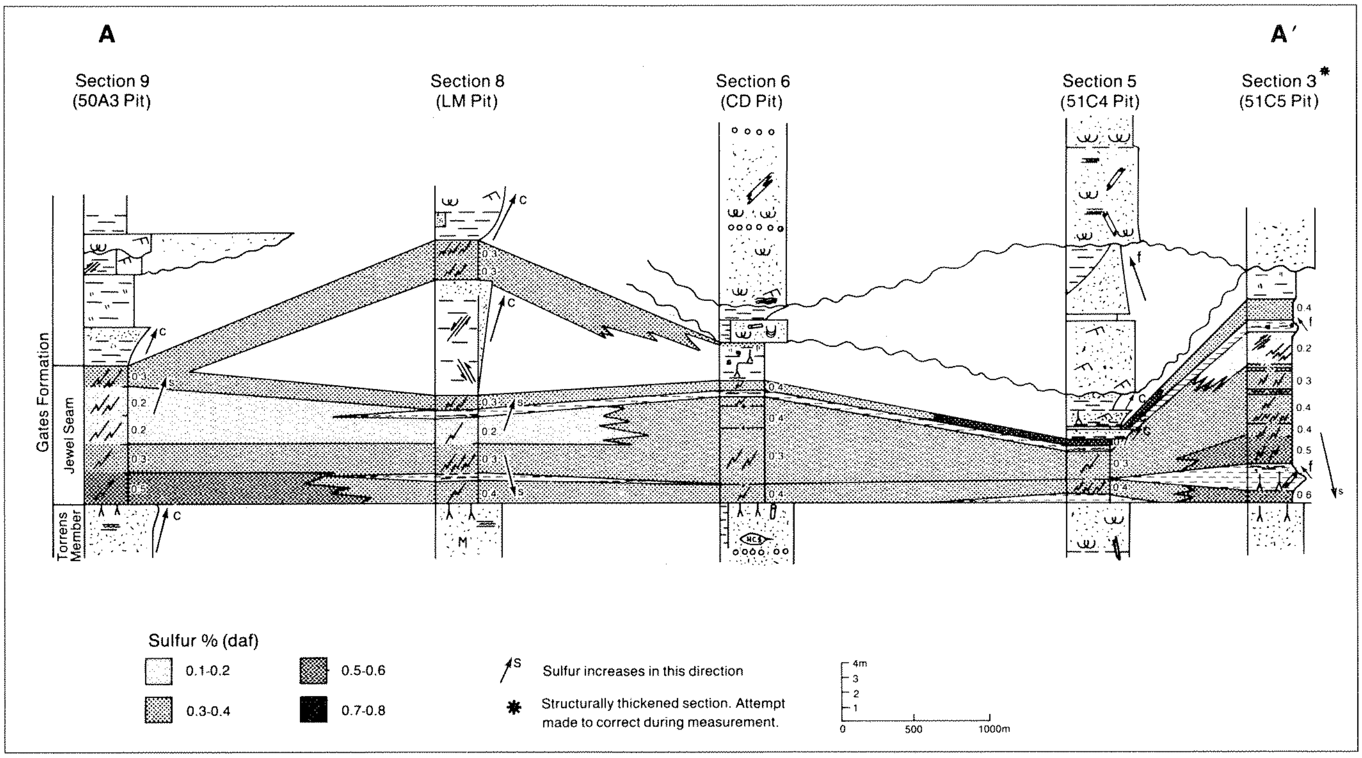

Figure 30. Stratigraphic cross section A-A′ showing regional in-seam sulfur variations in the Jewel seam, through the Cadomin-Luscar coalfield. Section runs approximately from the south to north.

ash) to slightly more alkaline conditions brought on by rising water tables and the development of intra-seam lacustrine environments (above average sulfur/very high ash).

Sulfur

Sulfur values in the R seam tend to be similar to those in the Jewel Seam, with most values in the 0.3 to 0.5 percent (dry) range. This seam has a tendency to have more extreme sulfur values than does the Jewel (0.1 to 2.9, dry, appendix 4). Very low sulfur values are associated with the very thin (<50 cm) lower portions of the R seam and may be related to the early swamp that was highly acidic, due to a stable environment shortly after the swamp developed. The highest value (2.9 percent dry) is also found at the base of the R seam and is probably related to undetected pyrite in cleats, i.e. late diagenetic (figure 29, position 8).

Moosebar/Torrens Seams

Ash

The ash contents of the two Torrens "A" coals sampled were very high (34.5 and 54.0 percent dry, Station CF8-1 and CF9-3). This coal was likely deposited in a coastal plain setting, reasonably close to the active shoreline. In this environment, thin high-ash coals such as the Torrens "A" would be expected. Kalkreuth and Leckie (in press) show that this coal tends to be very high in vitrinite (93 percent vol), a low inertinite content (7 percent vol), and a very high mineral matter content. This suggests that the bulk of the mineral matter content in the Torrens "A" coal was derived from detrital sources. Kalkreuth and Leckie suggest high water tables at the time of formation of the Torrens "A" seam under fen to marsh conditions. This seam is probably a good example of the surrounding clastic environment being more important to overall ash content than the original swamp chemical environment.

The Moosebar Formation coals sampled showed both high and low ash values (7.3 and 79.6 percent dry, appendix 4). Sample CF9-2 (Section 9, appendix 7, 79.6 percent ash) is actually a carbonaceous shale that lies at the top of a well rooted coarsening-up section, interpreted to be an offshore bar. The other sample is from the offshore lithofacies assemblage. This coal may represent transported peat mats or logs that have no lateral continuity.

Sulfur

The Torrens "A" coal was sampled in two locations and yielded sulfur values of 1.8 and 2.8 percent (dry, appendix 4, station numbers CF8-1 and CF9-3; and appendix 7, Section 8). Above average sulfur values are found in the two very thin coals/carbonaceous shales of the Moosebar Formation (0.8 and 0.7 percent, dry, station numbers CF9-1 and CF9-2, appendix 4). These results support the generally accepted view that coals bounded by marine sediments tend to be "high" in sulfur.

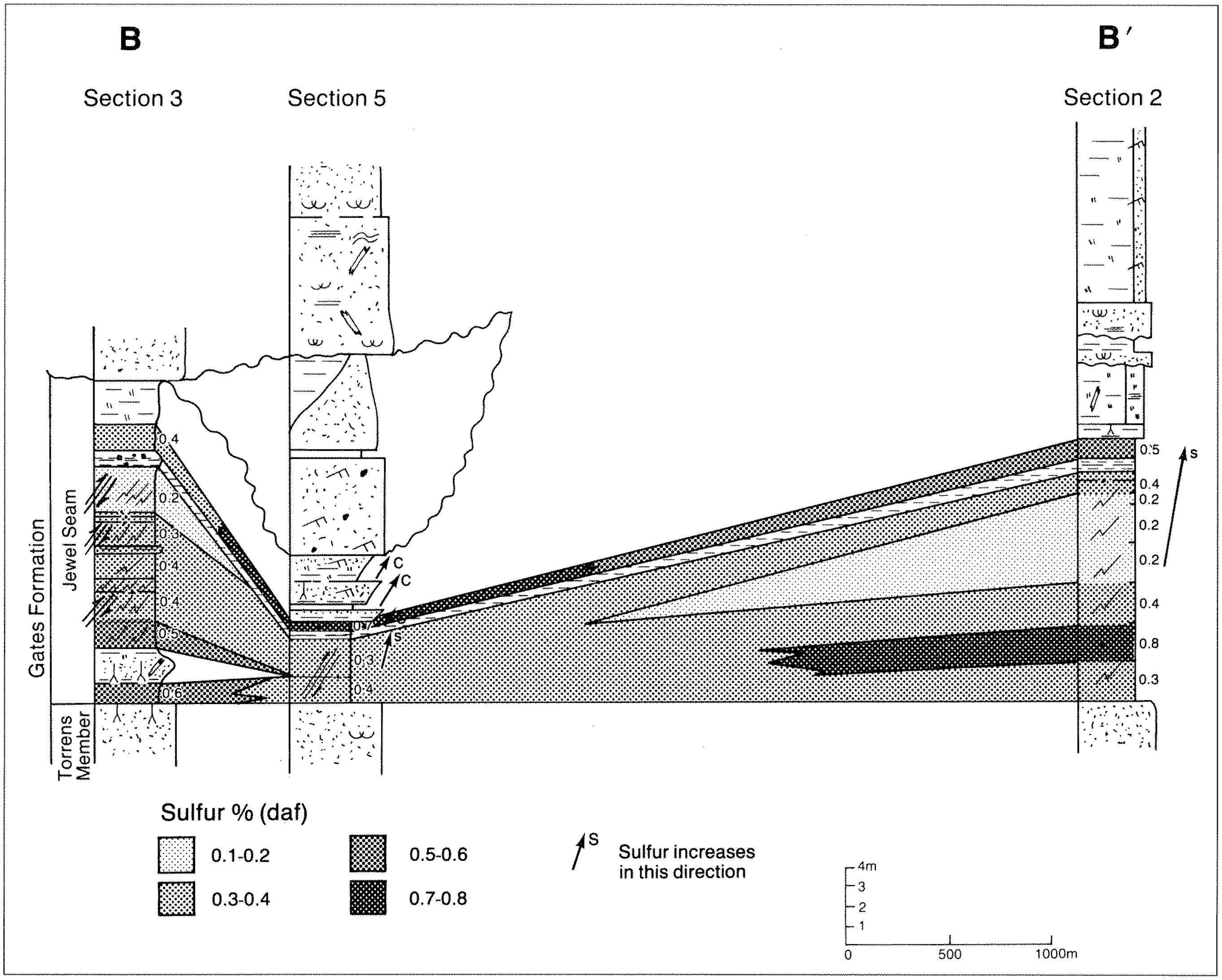

Figure 31. Stratigraphic cross section B-B′ showing regional in-seam sulfur variations in the Jewel Seam, throughout the Cadomin-Luscar coalfield. Section runs from the northwest to southeast.

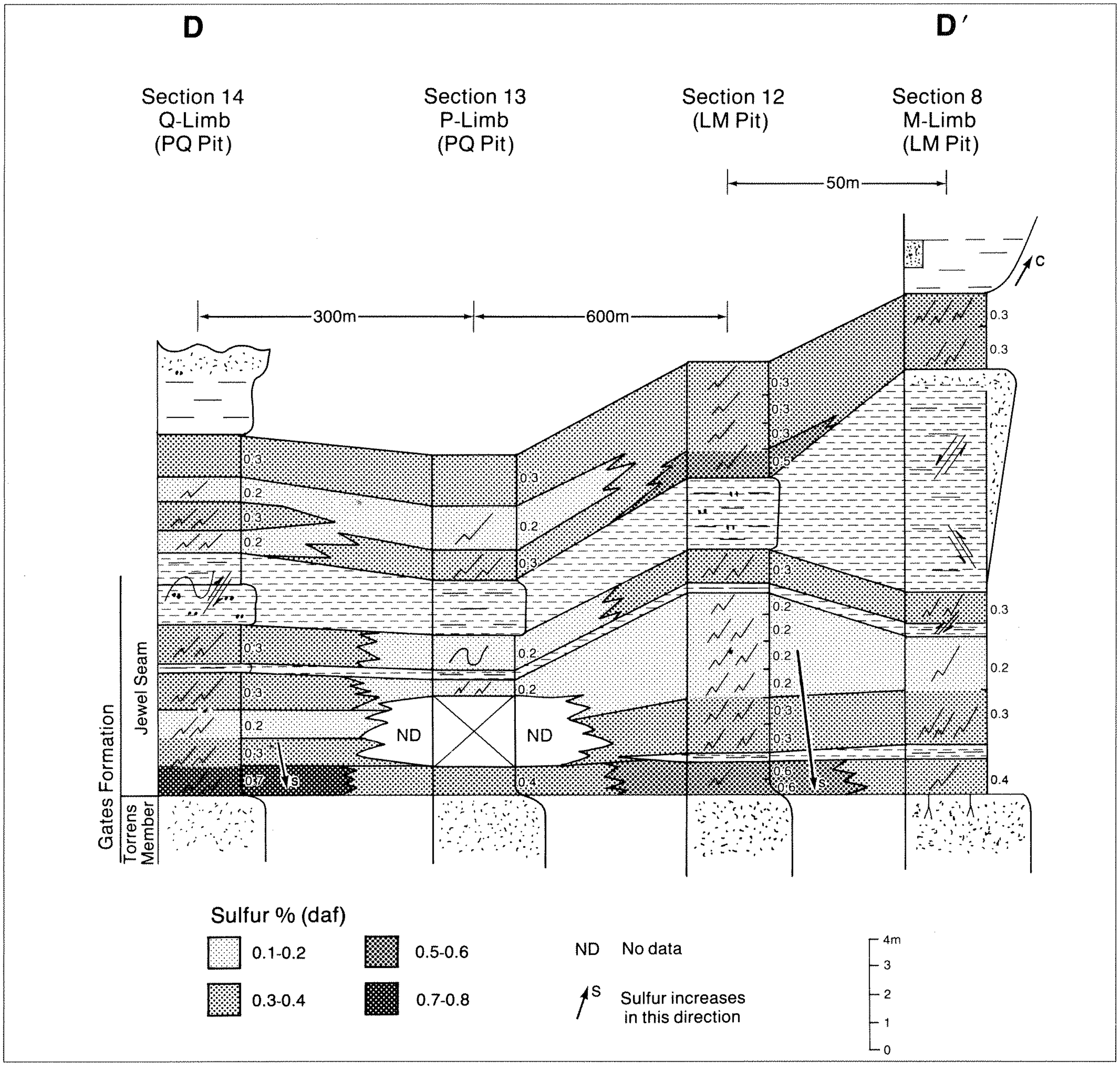

Figure 32. Stratigraphic cross section D-D′ showing local in-seam sulfur variations in the Jewel Seam, throughout the PQ and LM pits, Gregg River Resources Limited. Section runs approximately west to east.

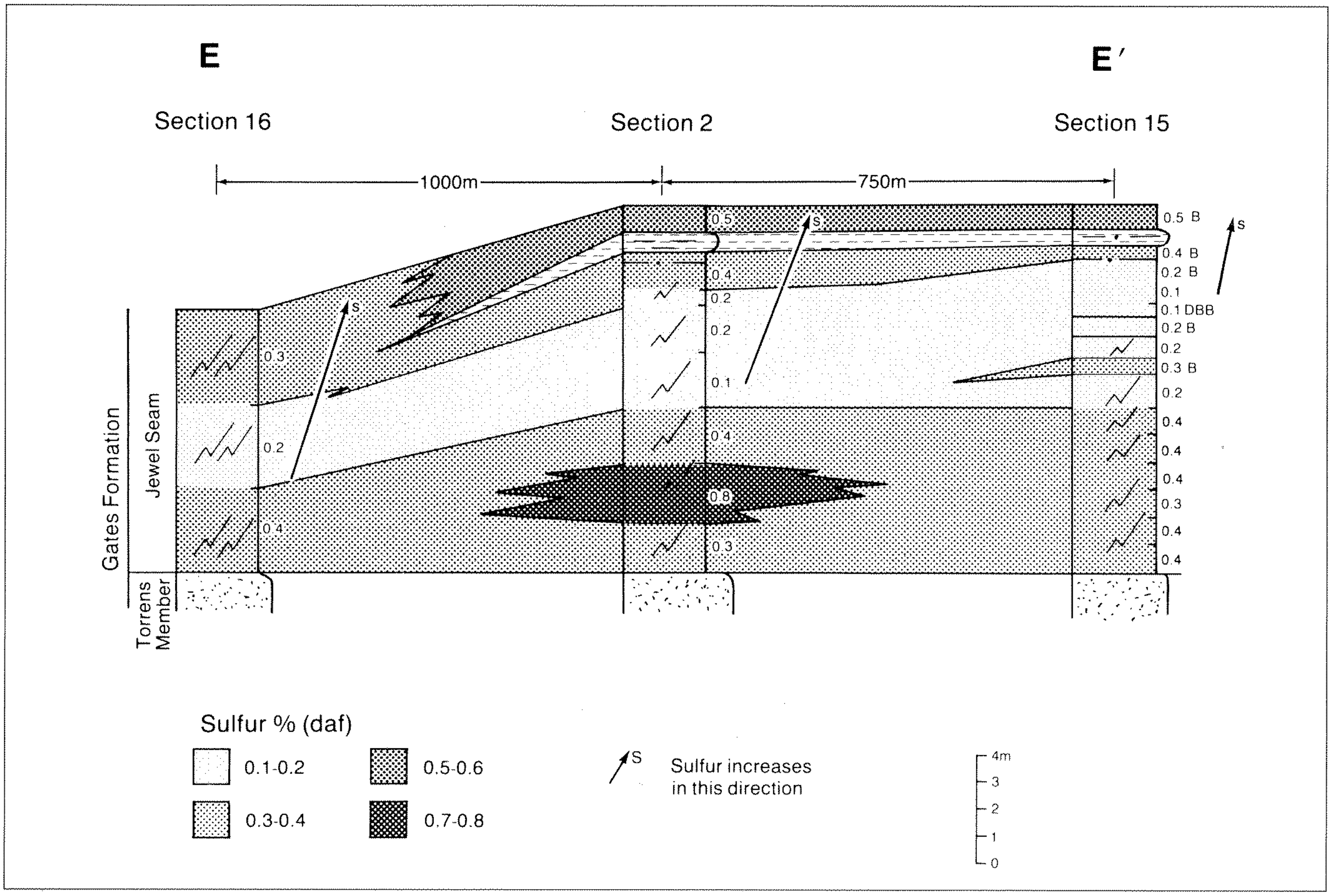

Figure 33. Stratigraphic cross section E-E′ showing pit-scale in-seam sulfur variations in the Jewel Seam, throughout the Cardinal River Coals Ltd. 51B3 pit.

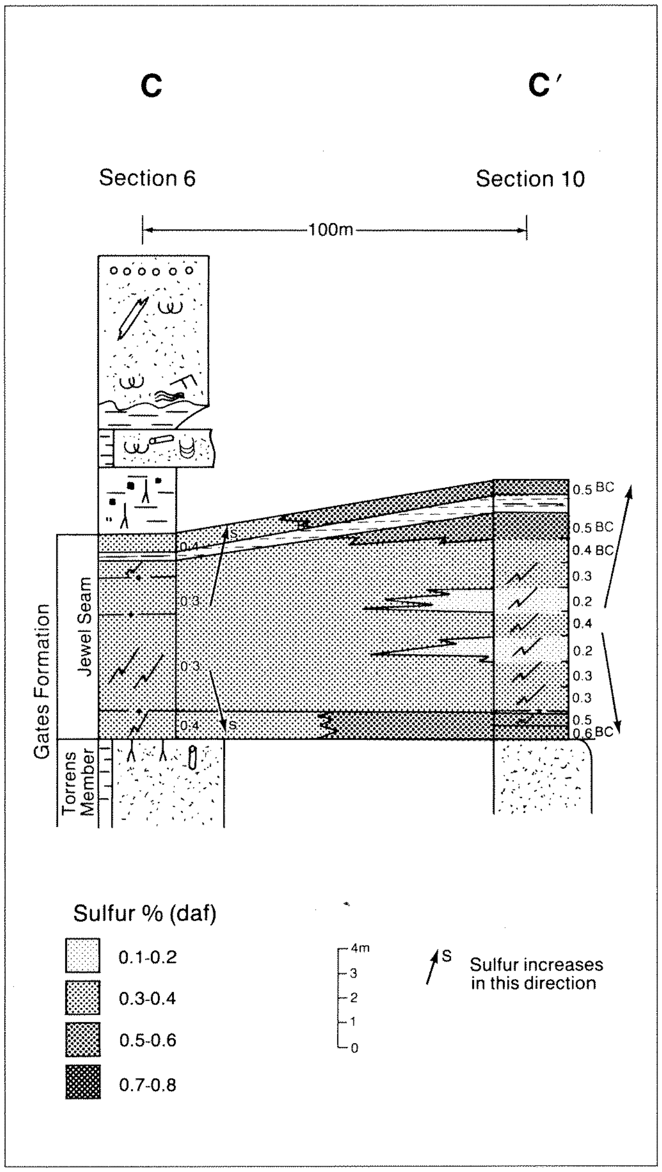

Figure 34. Stratigraphic cross section C-C′ showing pit-scale in-seam sulfur variations in the Jewel Seam, within the CD pit, Gregg River Resources Limited.

Effects of structural setting on coal quality

The geological map (figure 3) and cross sections (figure 4) show the nature of the deformation in the area. The cross sections show overturned folds, which are tight in places. The shortening can be calculated to be around 50 percent. This can be compared with the around 30 percent shortening in the Grande Cache area (Langenberg et al. 1987). The intersection of isorank lines and the folded Jewel Seam, as illustrated in figure 16, indicates that the central part of the area was buried somewhat deeper, resulting in the higher rank. This configuration of rank surfaces is generally described as syndeformational coalification. It should also be noticed that the highest ranks are not along the axis of the Cadomin Syncline as would be expected in the syndeformational coalification model, but along the southwestern flanks of the Luscar Anticline (figure 16). This might be explained by a late stage adjustment of the structure, where parts of the Cadomin Syncline have moved upwards by secondary folding and thrusting (Mystery Lake Fault and fault near Luscar).

Folding has also had a profound effect on coal quality by the resulting thickening in fold hinges. This process was described for the Grande Cache area (Langenberg et al. 1987). Most existing open pits are along the hinges of folds, indicating the economic significance of this thickening. The examples show that coal has flowed into these hinges from the nearby limbs. This process can be seen to have taken place by the extensive shearing in the coal, as illustrated in the measured stratigraphic sections of appendix 7.

As discussed in the section on 'depositional environments', the shearing has effects on the ash contents, which in general have increased both by the shearing process and by enhanced oxidation (see also Bustin 1982). However, exceptions to this general tendency can be observed in several places.

Conclusions

The following conclusions can be drawn about some of the coal quality parameters of the Cadomin-Luscar area. Ash and sulfur are largely determined by the original sedimentary environment. Volatile matter, fixed carbon, carbon, hydrogen and vitrinite reflectance are largely determined by subsequent burial and to some extent by deformation.

Ash

Ash of the Jewel Seam comes either from visible rock partings or from finely disseminated mineral matter within the coal. In places, the disseminated ash content may have increased by tectonic shearing. Qualitative field observations suggest that the more highly sheared a coal is, the more likely it is to have elevated ash values. These factors make ash percentage prediction difficult. Average disseminated ash contents of the Jewel Seam is about 14 percent. Vertical successions with upward increase in ash, and low ash zones continuous on pit scale through the center of the seam, can be explained by the original swamp chemical environment.

The overall depositional setting of the Jewel Seam is believed to have been on a coastal plain, perhaps up to 100 km inland from the shorelines. Thus, the Jewel Seam was allowed to attain its large thickness well removed from marine clastic influences. Smaller fluvial or tidal channels may have dissected or been adjacent to the Jewel swamp, providing the visible partings. For mining purposes, the 2 m sampling interval of the Jewel Seam results in a good characterization of ash variation.

Ash values in R, Torrens and Moosebar coals all tend to be high, and are more likely related to nearby clastic environments than to the original swamp chemical environment.

Volatile matter

Volatile matter (dry and ash free) of the Jewel Seam ranges from 19.3 to 39.8, where the higher percentages represent oxidized coal. This range indicates largely medium volatile bituminous rank. There is a systematic variation of volatile matter in the study area, where the central part has the lowest percentages. Consequently, volatile matter (dry and ash free) can be predicted fairly precisely by extrapolation of existing data, based on the location of the coal.

Sulfur

Sulfur contents of the Jewel Seam are low compared to many other coal deposits and average 0.3 percent. Low sulfur, combined with moderate high ash and high inertinite contents, points to acidic swamps, with intermittent aerobic conditions (Cecil et al. 1980). Sulfur, which is mostly organic in the Jewel Seam, often shows elevated values at the base, and to some extent at the top of the seam. Basal elevated sulfur values can drop back to average values over short distances. Elevated sulfur values at the top of the seam may be related to overlying thick channel or brackish water deposits. A very low sulfur zone (i.e. <0.2 percent dry) is often found in the middle of the Jewel Seam, particularly when there are few partings.

Sulfur values in the R seam (alluvial plain setting) generally lie around 0.4 percent. Sulfur values in the Torrens Member and Moosebar Formation (marine to transitional environment) tend to be higher than in the Jewel Seam (i.e. >0.7 percent dry), and support the general model of high sulfur coals associated with overlying marine strata.

Vitrinite reflectance

Maximum vitrinite reflectance for the Jewel Seam ranges from 0.97 to 1.43 percent. The highest rank is found in the central part of the study area, along the southwest limb of the Luscar Anticline. High volatile bituminous coals are present in the southeast. The rank variation indicates syndeformational coalification. A good linear correlation between maximum vitrinite reflectance and volatile matter (dry and ash free) is observed, enabling volatile matter to be determined from vitrinite reflectance. The map of maximum vitrinite reflectance variation predicts rank and volatile matter of the Jewel Seam for unexplored parts of the Cadomin-Luscar coalfield.

Tentative models

Variation of ash and sulfur in this coalfield can be explained with a tentative model. This model involves considering the original geochemical conditions of the peat swamp, paleogeography, and later Laramide deformation. All of these conditions played a role in determining the present distribution of ash and sulfur, as described in this report.

Coal rank variations are predictable in the Cadomin-Luscar coalfield from the observed rank distribution and structural deformation model. The coalification history can be inferred from these data, resulting in predictions for volatile matter, fixed carbon, carbon, hydrogen and vitrinite reflectance. Using these principles, the rank variations in other coalfields can be predicted. The regional coal quality study has shown that coal rank can vary considerably, but predictably, throughout the Foothills region. The present detailed study shows that variations can also occur over a fairly small area.

It has been shown that detailed scales of examination are necessary to be able to truly understand coal quality variations and to be able to obtain models that predict these variations on a more regional scale.

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Appendix 1. Proximate and ultimate analyses, Jewel Seam (raw coal from coreholes).

Hole	Location		Depth		AR	AD	Dry								Dry Ash Free						
Number	East	North	Upper	Lower	H2O	H2O	Ash	VM	FC	C	H	N	S	O	VM	FC	C	H	N	S	O
82RC108D	469821	5881881	18	19	5.7	0.7	15.7	18.6	65.7	--	--	--	--	--	22.1	77.9	--	--	--	--	--
82RC108D	469821	5881881	20	21	11.1	0.6	12.4	20.4	67.2	--	--	--	--	--	23.3	76.7	--	--	--	--	--
82RC108D	469821	5881881	21	22	17.4	0.7	23.2	19.1	57.7	--	--	--	--	--	24.9	75.1	--	--	--	--	--
82RC108D	469821	5881881	22	23	7.6	0.6	7.4	20.4	72.2	--	--	--	--	--	22.1	77.9	--	--	--	--	--
82RC108D	469821	5881881	23	24	6.5	0.6	26.2	20.0	53.9	--	--	--	--	--	27.0	73.0	--	--	--	--	--
82RC108D	469821	5881881	24	25	8.3	0.4	12.8	21.0	66.2	--	--	--	--	--	24.1	75.9	--	--	--	--	--
82RC108D	469821	5881881	25	26	11.7	0.6	13.4	19.8	66.8	--	--	--	--	--	22.9	77.1	--	--	--	--	--
82RC108D	469821	5881881	26	27	9.6	0.5	12.0	18.9	69.1	--	--	--	--	--	21.5	78.5	--	--	--	--	--
82RC109	470414	5881755	0	1	33.8	9.2	21.4	25.4	53.2	--	--	--	--	--	32.3	67.7	--	--	--	--	--
82RC109	470414	5881755	1	2	33.0	7.4	35.1	21.5	43.4	--	--	--	--	--	33.2	66.8	--	--	--	--	--
82RC109	470414	5881755	2	3	44.4	5.6	19.9	24.7	55.4	--	--	--	--	--	30.9	69.1	--	--	--	--	--
82RC109	470414	5881755	3	4	41.8	12.0	12.0	27.5	60.4	--	--	--	--	--	31.3	68.7	--	--	--	--	--
82RC109	470414	5881755	4	5	25.5	10.3	17.0	25.8	57.3	--	--	--	--	--	31.0	69.0	--	--	--	--	--
82RC109	470414	5881755	5	6	26.2	7.8	11.9	25.5	62.5	--	--	--	--	--	29.0	71.0	--	--	--	--	--
82RC109	470414	5881755	6	7	18.5	4.0	19.1	20.6	60.3	--	--	--	--	--	25.4	74.6	--	--	--	--	--
82RC109	470414	5881755	7	8	25.5	1.4	21.8	16.5	61.6	--	--	--	--	--	21.2	78.8	--	--	--	--	--
82RC109	470414	5881755	8	9	26.0	1.5	11.5	19.5	69.0	--	--	--	--	--	22.0	78.0	--	--	--	--	--
82RC109	470414	5881755	9	10	25.5	2.2	12.1	19.4	68.5	--	--	--	--	--	22.1	77.9	--	--	--	--	--
82RC109	470414	5881755	10	11	36.7	1.8	20.2	25.9	53.9	--	--	--	--	--	32.4	67.6	--	--	--	--	--
82RC109	470414	5881755	11	12	22.7	1.8	14.5	19.0	66.6	--	--	--	--	--	22.2	77.8	--	--	--	--	--
82RC110	470495	5881655	19	20	14.4	1.0	41.9	14.8	43.3	--	--	--	--	--	25.6	74.4	--	--	--	--	--
82RC110	470495	5881655	20	21	21.4	0.3	15.2	18.8	66.0	--	--	--	--	--	22.2	77.8	--	--	--	--	--
82RC110	470495	5881655	21	22	17.0	0.4	21.7	17.1	61.2	--	--	--	--	--	21.8	78.2	--	--	--	--	--
82RC110	470495	5881655	22	23	17.8	0.4	28.5	16.0	55.5	--	--	--	--	--	22.3	77.7	--	--	--	--	--
82RC110	470495	5881655	23	24	17.6	0.4	26.5	16.2	57.4	--	--	--	--	--	22.0	78.0	--	--	--	--	--
82RC110	470495	5881655	24	25	18.3	0.4	20.2	15.6	64.2	--	--	--	--	--	19.6	80.4	--	--	--	--	--
82RC110	470495	5881655	25	26	19.7	0.3	14.6	17.5	68.2	--	--	--	--	--	20.5	79.8	--	--	--	--	--
82RC110	470495	5881655	26	27	16.0	0.3	14.9	19.6	65.5	--	--	--	--	--	23.0	77.0	--	--	--	--	--
82RC110	470495	5881655	27	28	15.1	0.3	17.5	18.3	64.2	--	--	--	--	--	22.2	77.8	--	--	--	--	--
82RC110	470495	5881655	28	29	17.1	0.3	7.2	19.6	73.2	--	--	--	--	--	21.1	78.9	--	--	--	--	--
82RC110	470495	5881655	29	30	18.7	0.6	53.0	14.0	33.1	--	--	--	--	--	29.7	70.3	--	--	--	--	--
82RC110	470495	5881655	30	31	17.6	0.2	12.1	22.3	65.6	--	--	--	--	--	25.3	74.7	--	--	--	--	--
82RC110	470495	5881655	31	32	18.9	0.3	34.7	15.1	50.2	--	--	--	--	--	23.2	76.8	--	--	--	--	--
82RC110	470495	5881655	32	33	17.2	0.3	24.0	16.6	59.5	--	--	--	--	--	21.8	78.2	--	--	--	--	--
82RC110	470495	5881655	33	34	32.5	0.2	9.3	20.1	70.6	--	--	--	--	--	22.1	77.9	--	--	--	--	--
82RC110	470495	5881655	34	35	18.4	0.3	12.6	18.6	68.8	--	--	--	--	--	21.3	78.7	--	--	--	--	--
82RC110	470495	5881655	35	36	19.8	0.1	7.6	22.2	70.1	--	--	--	--	--	24.1	75.9	--	--	--	--	--
82RC110	470495	5881655	36	37	18.0	0.2	9.4	21.0	69.6	--	--	--	--	--	23.2	76.8	--	--	--	--	--
82RC110	470495	5881655	37	38	15.8	0.2	9.9	22.3	67.8	--	--	--	--	--	24.7	75.3	--	--	--	--	--
82RC110	470495	5881655	38	39	21.5	0.2	15.5	20.0	64.5	--	--	--	--	--	23.7	76.3	--	--	--	--	--
82RC110	470495	5881655	39	40	42.1	0.3	21.9	17.0	61.1	--	--	--	--	--	21.8	78.2	--	--	--	--	--
82RC110	470495	5881655	40	41	18.2	0.2	9.0	18.5	72.5	--	--	--	--	--	20.3	79.7	--	--	--	--	--
82RC110	470495	5881655	41	42	16.2	0.3	10.6	19.7	69.7	--	--	--	--	--	22.1	77.9	--	--	--	--	--
82RC110	470495	5881655	42	43	18.1	0.2	9.8	18.5	71.7	--	--	--	--	--	20.5	79.5	--	--	--	--	--
82RC110	470495	5881655	43	44	21.0	0.2	11.3	18.1	70.6	--	--	--	--	--	20.4	79.6	--	--	--	--	--
82RC110	470495	5881655	44	45	19.6	0.2	9.7	17.9	72.3	--	--	--	--	--	19.9	80.1	--	--	--	--	--
82RC110	470495	5881655	45	46	23.1	0.2	9.7	17.9	72.4	--	--	--	--	--	19.8	80.2	--	--	--	--	--
82RC110	470495	5881655	46	47	19.2	0.2	7.9	19.2	72.8	--	--	--	--	--	20.9	79.1	--	--	--	--	--
82RC110B	470492	5881658	19	24	6.2	1.1	55.6	10.5	33.8	--	--	--	--	--	23.7	76.3	--	--	--	--	--
82RC110B	470492	5881658	24	29	10.1	1.2	33.3	14.9	51.7	--	--	--	--	--	22.4	77.6	--	--	--	--	--
82RC110B	470492	5881658	29	34	8.3	1.0	11.4	18.8	69.8	--	--	--	--	--	21.2	78.8	--	--	--	--	--
82RC110B	470492	5881658	34	39	15.3	0.6	19.6	18.2	62.2	--	--	--	--	--	22.7	77.3	--	--	--	--	--
82RC110B	470492	5881658	39	44	6.6	0.4	14.1	20.2	65.7	--	--	--	--	--	23.5	76.5	--	--	--	--	--
82RC113	469767	5881807	10	11	14.9	0.2	7.4	23.7	68.9	--	--	--	--	--	25.6	74.4	--	--	--	--	--
82RC113	469767	5881807	11	12	10.9	0.4	6.2	20.9	72.9	--	--	--	--	--	22.3	77.7	--	--	--	--	--
82RC113	469767	5881807	12	13	20.7	0.5	15.1	17.8	67.0	--	--	--	--	--	21.0	79.0	--	--	--	--	--
82RC113	469767	5881807	13	14	9.7	0.4	20.5	20.1	59.4	--	--	--	--	--	25.2	74.8	--	--	--	--	--
82RC113	469767	5881807	14	15	16.5	0.4	44.5	15.9	39.5	--	--	--	--	--	28.7	71.3	--	--	--	--	--
82RC113	469767	5881807	15	16	6.0	0.5	22.7	20.0	57.3	--	--	--	--	--	25.9	74.1	--	--	--	--	--
82RC113	469767	5881807	16	17	21.5	0.2	5.7	19.7	74.7	--	--	--	--	--	20.8	79.2	--	--	--	--	--
82RC113	469767	5881807	17	18	1.9	0.3	3.7	20.6	75.7	--	--	--	--	--	21.4	78.6	--	--	--	--	--
82RC113	469767	5881807	18	19	1.8	0.4	37.8	12.8	49.4	--	--	--	--	--	20.5	79.5	--	--	--	--	--
82RC113	469767	5881807	19	20	1.7	0.3	3.7	20.6	75.7	--	--	--	--	--	21.4	78.6	--	--	--	--	--
82RC113	469767	5881807	20	21	15.4	0.5	7.5	20.5	72.0	--	--	--	--	--	22.1	77.9	--	--	--	--	--
82RC113	469767	5881807	21	22	3.5	0.3	4.5	20.8	74.8	--	--	--	--	--	21.7	78.3	--	--	--	--	--
82RC113	469767	5881807	22	23	1.6	0.4	3.6	21.2	75.3	--	--	--	--	--	22.0	78.0	--	--	--	--	--
82RC113	469767	5881807	23	24	7.8	0.4	4.1	20.6	75.2	--	--	--	--	--	21.5	78.5	--	--	--	--	--

Appendix 1. (continued)

Hole	Location		Depth		AR	AD	Dry								Dry Ash Free						
Number	East	North	Upper	Lower	H2O	H2O	Ash	VM	FC	C	H	N	S	O	VM	FC	C	H	N	S	O
82RC113	469767	5881807	24	25	11.7	0.5	3.1	22.6	74.2	--	--	--	--	--	23.4	76.6	--	--	--	--	--
82RC113	469767	5881807	25	26	5.1	0.4	3.3	20.5	76.2	--	--	--	--	--	21.2	78.8	--	--	--	--	--
82RC113	469767	5881807	26	27	4.9	0.4	14.2	18.9	66.9	--	--	--	--	--	22.0	78.0	--	--	--	--	--
82RC113	469767	5881807	27	28	18.6	0.9	45.9	14.5	39.5	--	--	--	--	--	26.9	73.1	--	--	--	--	--
82RC113	469767	5881807	28	29	6.0	0.5	7.6	21.0	71.4	--	--	--	--	--	22.7	77.3	--	--	--	--	--
82RC113	469767	5881807	29	30	13.3	0.4	27.4	16.6	56.0	--	--	--	--	--	22.9	77.1	--	--	--	--	--
82RC113	469767	5881807	30	31	26.1	0.4	14.3	19.8	65.8	--	--	--	--	--	23.1	76.8	--	--	--	--	--
82RC113	469767	5881807	31	32	9.0	0.4	6.3	19.9	73.7	--	--	--	--	--	21.3	78.7	--	--	--	--	--
82RC113	469767	5881807	32	33	6.8	0.5	6.6	19.2	74.2	--	--	--	--	--	20.5	79.5	--	--	--	--	--
82RC113	469767	5881807	33	34	9.7	0.5	5.0	19.9	75.1	--	--	--	--	--	20.9	79.1	--	--	--	--	--
82RC123A	469795	5882162	11	12	30.1	4.1	33.9	19.7	46.5	--	--	--	--	--	29.7	70.3	--	--	--	--	--
82RC123A	469795	5882162	12	13	20.1	1.2	72.8	11.2	16.0	--	--	--	--	--	41.0	59.0	--	--	--	--	--
82RC123A	469795	5882162	13	14	24.7	1.1	77.4	10.2	12.4	--	--	--	--	--	45.2	54.8	--	--	--	--	--
82RC123A	469795	5882162	14	15	19.0	0.6	23.5	15.8	60.7	--	--	--	--	--	20.7	79.3	--	--	--	--	--
82RC123A	469795	5882162	15	16	30.7	0.6	17.9	18.5	63.5	--	--	--	--	--	22.6	77.4	--	--	--	--	--
82RC123A	469795	5882162	16	17	21.6	0.8	35.6	17.1	47.4	--	--	--	--	--	26.5	73.5	--	--	--	--	--
82RC123A	469795	5882162	17	18	24.6	0.5	30.0	17.2	52.8	--	--	--	--	--	24.6	75.4	--	--	--	--	--
82RC123A	469795	5882162	18	19	34.7	0.4	12.9	21.2	65.9	--	--	--	--	--	24.3	75.7	--	--	--	--	--
82RC123A	469795	5882162	19	20	23.3	0.6	19.6	18.3	62.1	--	--	--	--	--	22.8	77.2	--	--	--	--	--
82RC123B	470624	5881607	12	13	22.1	0.8	9.5	20.4	70.1	--	--	--	--	--	22.5	77.5	--	--	--	--	--
82RC123B	470624	5881607	13	14	19.0	1.3	69.3	10.5	20.2	--	--	--	--	--	34.3	65.7	--	--	--	--	--
82RC123B	470624	5881607	14	15	24.6	0.9	54.6	12.6	32.8	--	--	--	--	--	27.7	72.3	--	--	--	--	--
82RC123B	470624	5881607	15	16	22.8	0.6	23.4	16.3	60.3	--	--	--	--	--	21.3	78.7	--	--	--	--	--
82RC123B	470624	5881607	16	17	27.8	0.5	6.7	18.7	74.6	--	--	--	--	--	20.1	79.9	--	--	--	--	--
82RC123B	470624	5881607	17	18	13.3	0.6	19.8	17.4	62.8	--	--	--	--	--	21.7	78.3	--	--	--	--	--
82RC123B	470624	5881607	18	19	20.5	0.6	21.3	17.0	61.6	--	--	--	--	--	21.7	78.3	--	--	--	--	--
82RC129	470450	5881646	2.0	2.5	23.4	6.9	31.5	22.5	46.1	--	--	--	--	--	32.8	67.2	--	--	--	--	--
82RC129	470450	5881646	2.5	3.0	19.5	5.8	23.4	22.9	53.7	--	--	--	--	--	29.9	70.1	--	--	--	--	--
82RC129	470450	5881646	3.0	3.5	15.2	2.9	6.3	22.3	71.4	--	--	--	--	--	23.8	76.2	--	--	--	--	--
82RC129	470450	5881646	3.5	4.0	12.6	2.2	4.4	22.7	72.8	--	--	--	--	--	23.8	76.2	--	--	--	--	--
82RC129	470450	5881646	4.0	4.5	13.2	2.8	12.4	19.7	67.9	--	--	--	--	--	22.5	77.5	--	--	--	--	--
82RC129	470450	5881646	4.5	5.0	13.3	2.7	17.0	19.7	63.4	--	--	--	--	--	23.7	76.3	--	--	--	--	--
82RC129	470450	5881646	5.0	5.5	14.4	2.5	8.7	20.5	70.8	--	--	--	--	--	22.4	77.6	--	--	--	--	--
82RC129	470450	5881646	5.5	6.0	12.9	2.2	15.9	19.0	65.1	--	--	--	--	--	22.6	77.4	--	--	--	--	--
82RC129	470450	5881646	6.0	6.5	12.7	2.2	9.3	20.4	70.3	--	--	--	--	--	22.5	77.5	--	--	--	--	--
82RC129	470450	5881646	6.5	7.0	10.6	2.3	10.3	20.2	69.5	--	--	--	--	--	22.5	77.5	--	--	--	--	--
82RC129	470450	5881646	7.0	7.5	7.6	1.3	7.6	18.9	73.5	--	--	--	--	--	20.4	79.6	--	--	--	--	--
82RC129	470450	5881646	7.5	8.0	10.1	1.3	4.9	20.9	74.3	--	--	--	--	--	21.9	78.1	--	--	--	--	--
82RC129	470450	5881646	8.0	8.5	9.7	1.5	34.7	16.1	49.2	--	--	--	--	--	24.7	75.3	--	--	--	--	--
82RC129	470450	5881646	8.5	9.0	6.8	0.8	11.3	17.4	71.3	--	--	--	--	--	19.7	80.3	--	--	--	--	--
82RC129	470450	5881646	9.0	9.5	5.3	0.6	5.4	20.4	74.2	--	--	--	--	--	21.6	78.4	--	--	--	--	--
82RC129	470450	5881646	9.5	10.0	6.9	0.7	3.0	21.5	75.5	--	--	--	--	--	22.2	77.8	--	--	--	--	--
82RC129	470450	5881646	10.0	10.5	8.7	0.8	5.6	20.5	73.9	--	--	--	--	--	21.7	78.3	--	--	--	--	--
82RC129	470450	5881646	10.5	11.0	8.9	0.7	9.9	19.2	70.9	--	--	--	--	--	21.3	78.7	--	--	--	--	--
82RC129	470450	5881646	11.0	11.5	9.9	0.7	6.0	20.3	73.7	--	--	--	--	--	21.6	78.4	--	--	--	--	--
82RC129	470450	5881646	11.5	12.0	7.8	0.6	41.8	14.4	43.9	--	--	--	--	--	24.7	75.3	--	--	--	--	--
82RC129	470450	5881646	12.0	12.5	6.6	0.5	13.3	19.0	67.8	--	--	--	--	--	21.9	78.1	--	--	--	--	--
82RC129	470450	5881646	12.5	13.0	7.6	0.6	14.2	18.7	67.1	--	--	--	--	--	21.8	78.2	--	--	--	--	--
82RC129	470450	5881646	13.0	13.5	6.6	1.6	22.8	17.9	60.3	--	--	--	--	--	23.2	78.1	--	--	--	--	--
82RC129	470450	5881646	13.5	14.0	6.9	1.5	11.2	21.2	68.6	--	--	--	--	--	23.9	77.3	--	--	--	--	--
82RC129	470450	5881646	14.0	14.5	6.4	1.5	12.5	20.7	67.9	--	--	--	--	--	23.6	77.5	--	--	--	--	--
82RC129	470450	5881646	14.5	15.0	6.1	1.5	9.8	19.6	71.6	--	--	--	--	--	21.7	79.4	--	--	--	--	--
82RC129	470450	5881646	15.0	15.5	6.7	1.7	10.3	19.3	71.4	--	--	--	--	--	21.5	79.6	--	--	--	--	--
82RC129	470450	5881646	15.5	16.0	6.1	1.7	7.5	19.2	74.2	--	--	--	--	--	20.8	80.3	--	--	--	--	--
82RC129	470450	5881646	16.0	16.5	9.6	1.0	8.1	19.0	72.9	--	--	--	--	--	20.6	79.4	--	--	--	--	--
82RC129	470450	5881646	16.5	17.0	13.1	1.4	12.0	19.2	68.7	--	--	--	--	--	21.9	78.1	--	--	--	--	--
82RC129	470450	5881646	17.0	17.5	16.2	2.0	8.7	20.5	70.9	--	--	--	--	--	22.4	77.6	--	--	--	--	--
82RC132	469875	5880056	22	24	23.8	0.4	33.3	17.7	49.0	--	--	--	--	--	26.5	73.5	--	--	--	--	--
82RC132	469875	5880056	24	26	23.1	0.6	23.6	19.8	56.5	--	--	--	--	--	26.0	74.0	--	--	--	--	--
82RC132	469875	5880056	26	28	30.5	0.7	38.4	16.1	45.5	--	--	--	--	--	26.2	73.8	--	--	--	--	--
82RC132	469875	5880056	28	30	26.2	0.9	66.0	14.9	19.1	--	--	--	--	--	43.8	56.2	--	--	--	--	--
82RC132	469875	5880056	30	32	31.8	0.8	73.3	13.6	13.0	--	--	--	--	--	51.2	48.8	--	--	--	--	--
82RC132	469875	5880056	32	34	22.0	0.7	31.6	17.8	50.6	--	--	--	--	--	26.0	74.0	--	--	--	--	--
82RC132	469875	5880056	34	36	23.3	0.5	18.6	21.3	60.1	--	--	--	--	--	26.2	73.8	--	--	--	--	--
82RC132	469875	5880056	36	38	25.5	0.6	15.1	22.7	62.1	--	--	--	--	--	26.8	73.2	--	--	--	--	--
82RC132	469875	5880056	38	40	22.9	0.5	18.4	21.5	60.1	--	--	--	--	--	26.3	73.7	--	--	--	--	--
82RC134	469999	5879922	22	23	5.8	0.7	19.4	21.7	58.9	--	--	--	--	--	26.9	73.1	--	--	--	--	--
82RC134	469999	5879922	23	24	9.3	0.7	20.0	21.4	58.6	--	--	--	--	--	26.8	73.2	--	--	--	--	--
82RC134	469999	5879922	24	25	4.4	0.8	21.7	20.4	57.9	--	--	--	--	--	26.0	74.0	--	--	--	--	--

Appendix 1. (continued)

Hole	Location		Depth		AR	AD	Dry								Dry Ash Free						
Number	East	North	Upper	Lower	H2O	H2O	Ash	VM	FC	C	H	N	S	O	VM	FC	C	H	N	S	O
82RC134	469999	5879922	25	26	6.9	0.7	12.3	24.0	63.6	--	--	--	--	--	27.4	72.6	--	--	--	--	--
82RC134	469999	5879922	26	27	6.8	0.9	45.9	17.8	36.3	--	--	--	--	--	32.8	67.2	--	--	--	--	--
82RC134	469999	5879922	27	28	7.5	1.0	71.4	9.9	18.7	--	--	--	--	--	34.7	65.3	--	--	--	--	--
82RC134	469999	5879922	28	29	5.2	0.5	7.2	25.0	67.8	--	--	--	--	--	27.0	73.0	--	--	--	--	--
82RC134	469999	5879922	29	30	5.5	0.7	26.0	20.5	53.5	--	--	--	--	--	27.7	72.3	--	--	--	--	--
82RC134	469999	5879922	30	31	4.8	0.6	33.8	18.8	47.3	--	--	--	--	--	28.4	71.6	--	--	--	--	--
82RC134	469999	5879922	31	32	6.2	0.6	6.0	25.2	68.9	--	--	--	--	--	26.8	73.2	--	--	--	--	--
82RC134	469999	5879922	32	33	10.3	0.6	4.6	25.7	69.7	--	--	--	--	--	26.9	73.1	--	--	--	--	--
82RC134	469999	5879922	33	34	11.9	0.6	5.4	25.6	69.0	--	--	--	--	--	27.0	73.0	--	--	--	--	--
82RC134	469999	5879922	34	35	8.3	0.8	4.2	24.0	71.8	--	--	--	--	--	25.1	74.9	--	--	--	--	--
82RC134	469999	5879922	35	36	12.4	0.8	5.2	23.8	71.1	--	--	--	--	--	25.1	74.9	--	--	--	--	--
82RC134	469999	5879922	36	37	7.9	0.8	4.8	23.9	71.3	--	--	--	--	--	25.1	74.9	--	--	--	--	--
82RC134	469999	5879922	37	38	7.3	0.8	3.4	24.8	71.8	--	--	--	--	--	25.6	74.4	--	--	--	--	--
82RC134	469999	5879922	38	39	8.5	0.4	4.0	24.8	71.2	--	--	--	--	--	25.8	74.2	--	--	--	--	--
82RC134	469999	5879922	39	40	8.0	0.5	12.3	22.1	65.7	--	--	--	--	--	25.1	74.9	--	--	--	--	--
82RC136	470057	5881764	42	45	4.0	0.5	11.7	19.8	68.5	--	--	--	--	--	22.4	77.6	--	--	--	--	--
82RC136	470057	5881764	45	48	6.4	1.1	80.5	8.2	11.3	--	--	--	--	--	42.1	57.9	--	--	--	--	--
82RC136	470057	5881764	48	51	7.2	0.8	60.8	11.8	27.4	--	--	--	--	--	30.1	69.9	--	--	--	--	--
82RC136	470057	5881764	51	54	6.6	1.0	80.5	7.7	11.8	--	--	--	--	--	39.4	60.6	--	--	--	--	--
82RC136	470057	5881764	54	57	6.0	0.6	27.9	17.5	54.6	--	--	--	--	--	24.2	75.8	--	--	--	--	--
82RC136	470057	5881764	57	60	6.1	0.6	17.5	20.2	62.2	--	--	--	--	--	24.5	75.5	--	--	--	--	--
82RC136	470057	5881764	60	63	4.5	0.7	20.2	18.3	61.5	--	--	--	--	--	22.9	77.1	--	--	--	--	--
82RC136	470057	5881764	63	66	6.4	0.7	22.8	17.7	59.6	--	--	--	--	--	22.9	77.1	--	--	--	--	--
82RC153	469836	5879661	30	32	19.2	0.5	9.0	24.3	66.7	--	--	--	--	--	26.8	73.2	--	--	--	--	--
82RC153	469836	5879661	32	34	13.4	0.4	20.1	23.3	56.6	--	--	--	--	--	29.2	70.8	--	--	--	--	--
82RC153	469836	5879661	34	36	12.1	0.6	42.3	20.8	36.9	--	--	--	--	--	36.1	63.9	--	--	--	--	--
82RC153	469836	5879661	36	38	9.2	0.8	56.2	15.5	28.2	--	--	--	--	--	35.5	64.5	--	--	--	--	--
82RC153	469836	5879661	38	40	9.1	0.9	57.5	14.3	28.2	--	--	--	--	--	33.6	66.4	--	--	--	--	--
82RC153	469836	5879661	40	42	9.4	0.5	12.5	24.6	62.9	--	--	--	--	--	28.1	71.9	--	--	--	--	--
82RC153	469836	5879661	42	44	7.3	0.6	11.3	26.9	61.7	--	--	--	--	--	30.4	69.6	--	--	--	--	--
82RC153	469836	5879661	44	46	9.2	0.6	16.0	23.9	60.1	--	--	--	--	--	28.4	71.6	--	--	--	--	--
82RC153	469836	5879661	46	48	5.3	0.8	56.7	17.2	26.1	--	--	--	--	--	39.8	60.4	--	--	--	--	--
82RC119	470609	5881561	10	11	10.7	2.3	11.7	21.1	67.2	--	--	--	--	--	23.9	76.1	--	--	--	--	--
82RC119	470609	5881561	11	12	26.9	1.4	16.5	20.2	63.4	--	--	--	--	--	24.2	75.8	--	--	--	--	--
82RC119	470609	5881561	12	13	26.1	1.8	37.7	24.8	37.5	--	--	--	--	--	39.8	60.2	--	--	--	--	--
82RC119	470609	5881561	13	14	31.8	2.8	18.4	22.3	59.2	--	--	--	--	--	27.4	72.6	--	--	--	--	--
81DD2	469871	5881842	30.3	31.3	3.8	0.7	31.8	16.8	51.4	--	--	--	--	--	24.7	75.3	--	--	--	--	--
81DD2	469871	5881842	32.6	33.8	4.4	0.5	16.2	20.6	63.1	--	--	--	--	--	24.6	75.4	--	--	--	--	--
81DD2	469871	5881842	33.8	37.8	6.8	0.5	25.0	18.1	56.9	--	--	--	--	--	24.1	75.9	--	--	--	--	--
81DD2	469871	5881842	37.8	39.0	6.4	0.5	10.3	22.0	67.7	--	--	--	--	--	24.6	75.4	--	--	--	--	--
81DD2	469871	5881842	39.0	42.4	4.1	0.5	16.4	19.4	64.3	--	--	--	--	--	23.1	76.9	--	--	--	--	--
81DD3	469995	5881675	75.5	76.2	6.4	0.8	45.2	13.6	41.2	--	--	--	--	--	24.9	75.1	--	--	--	--	--
81DD3	469995	5881675	78.0	81.0	4.4	0.6	17.0	19.0	64.0	--	--	--	--	--	22.9	77.1	--	--	--	--	--
81DD3	469995	5881675	81.0	82.3	2.3	0.6	11.8	18.4	69.8	--	--	--	--	--	20.8	79.2	--	--	--	--	--
81DD3	469995	5881675	82.3	87.4	11.1	0.8	20.3	16.5	63.2	--	--	--	--	--	20.7	79.3	--	--	--	--	--
81DD3	469995	5881675	87.4	88.7	3.3	0.6	16.6	25.6	57.9	--	--	--	--	--	30.6	69.4	--	--	--	--	--
81DD3	469995	5881675	88.7	91.5	11.0	0.9	27.1	19.9	53.0	--	--	--	--	--	27.3	72.7	--	--	--	--	--
81DD3	469995	5881675	91.5	96.6	9.4	0.8	24.4	18.0	57.7	--	--	--	--	--	23.7	76.3	--	--	--	--	--
81DD3	469995	5881675	96.6	102.1	6.3	0.8	12.8	19.7	67.5	--	--	--	--	--	22.6	77.4	--	--	--	--	--
81DD10	469572	5879254	181.4	186.1	2.3	0.8	15.8	23.9	60.3	--	--	--	--	--	28.4	71.6	--	--	--	--	--
81DD10	469572	5879254	186.1	191.0	2.6	0.9	11.1	25.8	63.1	--	--	--	--	--	29.0	71.0	--	--	--	--	--
81DD10	469572	5879254	191.0	196.0	1.7	0.8	15.1	25.4	59.5	--	--	--	--	--	29.9	70.1	--	--	--	--	--
81DD10	469572	5879254	196.0	201.0	4.0	0.4	18.6	22.6	58.8	--	--	--	--	--	27.8	72.2	--	--	--	--	--
81DD10	469572	5879254	201.0	204.1	8.7	0.9	30.7	18.5	50.8	--	--	--	--	--	26.6	73.4	--	--	--	--	--
81DD10	469572	5879254	205.8	208.8	2.4	1.2	67.1	12.8	20.1	--	--	--	--	--	38.8	61.2	--	--	--	--	--
81DD10	469572	5879254	208.8	213.9	3.0	0.7	13.3	25.1	61.6	--	--	--	--	--	28.9	71.1	--	--	--	--	--
81DD11	469610	5880381	95.1	96.1	1.1	0.7	15.9	25.8	58.3	--	--	--	--	--	30.7	69.3	--	--	--	--	--
81DD11	469610	5880381	96.6	97.8	1.6	0.9	25.0	22.4	52.7	--	--	--	--	--	29.8	70.2	--	--	--	--	--
81DD11	469610	5880381	98.3	99.3	1.4	0.8	21.2	22.6	56.2	--	--	--	--	--	28.7	71.3	--	--	--	--	--
81DD12	469089	5880652	95.3	100.9	6.1	0.9	16.1	24.0	59.9	--	--	--	--	--	28.6	71.4	--	--	--	--	--
00481200	471633	5880076	82.6	90.8	15.9	--	30.5	16.0	53.5	--	--	--	--	--	23.0	77.0	--	--	--	--	--
00516880	457650	5889423	13.9	14.7	12.5	1.4	36.8	14.8	48.4	--	--	--	--	--	23.4	76.6	--	--	--	--	--
00516880	457650	5889423	14.7	15.1	20.4	2.0	73.1	10.6	16.3	--	--	--	--	--	39.4	60.6	--	--	--	--	--
00516880	457650	5889423	15.1	15.8	17.2	2.4	61.5	10.9	27.7	--	--	--	--	--	28.2	71.8	--	--	--	--	--
00516880	457650	5889423	35.8	37.0	19.6	0.7	15.5	16.3	68.2	--	--	--	--	--	19.3	80.7	89.9	4.7	1.1	0.4	3.9

Appendix 1. (continued)

Hole	Location		Depth		AR	AD	Dry								Dry Ash Free						
Number	East	North	Upper	Lower	H2O	H2O	Ash	VM	FC	C	H	N	S	O	VM	FC	C	H	N	S	O
00516880	457650	5889423	42.2	42.5	11.4	1.2	37.7	14.5	47.9	--	--	--	--	--	23.2	76.8	--	--	--	--	--
00516880	457650	5889423	43.1	43.8	12.9	1.1	35.2	15.0	49.8	--	--	--	--	--	23.1	76.9	--	--	--	--	--
00516880	457650	5889423	53.2	54.4	11.9	0.8	12.0	17.9	70.1	--	--	--	--	--	20.4	79.6	--	--	--	--	--
00516849	459334	5890088	25.9	29.3	4.0	0.4	7.3	19.9	72.8	--	--	--	--	--	21.5	78.5	89.7	4.9	1.1	0.3	3.4
00516849	459334	5890088	51.9	53.3	6.4	0.5	17.7	20.7	61.6	--	--	--	--	--	25.1	74.9	89.3	4.9	1.2	0.6	4.0
00516849	459334	5890088	53.3	53.6	3.1	1.0	76.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--
00516849	459334	5890088	53.6	54.4	4.3	0.6	25.5	16.7	57.8	--	--	--	--	--	22.4	77.6	--	--	--	--	--
00516849	459334	5890088	55.3	56.3	3.2	0.4	12.1	21.6	66.3	--	--	--	--	--	24.6	75.4	--	--	--	--	--
00516849	459334	5890088	71.4	72.6	6.3	0.9	23.6	19.1	57.3	--	--	--	--	--	25.0	75.0	89.8	5.0	1.1	0.8	3.3
00516856	458084	5889559	14.9	16.7	19.7	0.6	16.5	16.2	67.3	--	--	--	--	--	19.4	80.6	--	--	--	--	--
00516815	461387	5888963	16.0	16.7	7.8	1.6	5.3	20.0	74.7	--	--	--	--	--	21.1	78.9	--	--	--	--	--
00516815	461387	5888963	17.5	18.1	5.2	1.7	9.4	21.8	68.9	--	--	--	--	--	24.0	76.0	--	--	--	--	--
00516898	458670	5890718	41.2	42.8	19.7	0.5	14.0	18.0	68.0	--	--	--	--	--	20.9	79.1	89.7	4.9	1.2	0.4	3.8
00516898	458670	5890718	76.1	77.8	1.7	0.3	19.4	19.4	61.3	--	--	--	--	--	24.0	76.0	88.7	4.9	1.1	3.0	2.6
00516898	458670	5890718	77.8	79.3	6.7	0.7	36.3	16.0	47.7	--	--	--	--	--	25.1	74.9	--	--	--	--	--
00516898	458670	5890718	79.3	79.6	4.0	0.6	10.3	22.5	67.2	--	--	--	--	--	25.1	74.9	--	--	--	--	--
00516898	458670	5890718	45.5	48.2	17.5	0.6	39.6	16.8	43.6	--	--	--	--	--	27.8	72.2	--	--	--	--	--

Appendix 2. Proximate and ultimate analyses, Jewel Seam (washed coal from cuttings).

Hole	Location		Depth		AR	AD	Dry								Dry Ash Free						
Number	East	North	Upper	Lower	H2O	H2O	Ash	VM	FC	C	H	N	S	O	VM	FC	C	H	N	S	O
00272971	469429	5880180	12.5	24.7	--	0.6	7.9	25.5	66.6	--	--	--	--	--	27.7	72.3	--	--	--	0.3	--
00524074	469761	5879702	36.4	65.4	--	0.5	10.4	23.2	66.4	--	--	--	--	--	25.9	74.1	--	--	--	--	--
00524140	469654	5879909	15.0	34.8	--	0.8	8.5	22.8	68.8	--	--	--	--	--	24.9	75.1	--	--	--	--	--
00524157	469624	5879864	6.4	10.0	--	1.4	10.1	22.7	67.1	--	--	--	--	--	25.3	74.7	--	--	--	--	--
00524165	469299	5880103	40.2	54.9	--	1.2	8.8	24.3	66.9	--	--	--	--	--	26.6	73.4	--	--	--	--	--
00524165	469299	5880103	108.5	116.4	--	0.9	9.9	24.3	65.8	--	--	--	--	--	27.0	73.0	--	--	--	--	--
00524173	469690	5879962	3.6	12.4	--	1.2	7.9	23.7	68.4	--	--	--	--	--	25.7	74.3	--	--	--	--	--
00524181	469214	5879970	--	7.3	--	2.7	9.4	26.0	64.6	--	--	--	--	--	28.7	71.3	--	--	--	--	--
00524199	469151	5879882	104.2	118.3	--	1.1	8.5	23.7	68.6	--	--	--	--	--	25.9	74.9	--	--	--	--	--
00524199	469151	5879882	2.4	4.3	--	2.0	9.0	23.2	67.9	--	--	--	--	--	25.4	74.6	--	--	--	--	--
00524207	469574	5879969	35.3	61.0	--	0.8	7.5	23.5	69.1	--	--	--	--	--	25.4	74.6	--	--	--	--	--
00524215	469602	5880012	14.6	27.6	--	0.5	9.4	24.3	66.2	--	--	--	--	--	26.9	73.1	--	--	--	--	--
00524223	469226	5879822	98.4	115.8	--	0.7	8.8	24.0	67.3	--	--	--	--	--	26.3	73.7	--	--	--	--	--
00524231	469281	5879714	46.3	50.9	--	1.0	6.6	25.3	68.2	--	--	--	--	--	27.0	73.0	--	--	--	--	--
00524231	469281	5879714	55.2	59.1	--	0.8	10.6	22.4	67.0	--	--	--	--	--	25.0	75.0	--	--	--	--	--
00524231	469281	5879714	133.5	144.8	--	0.9	11.0	24.2	64.8	--	--	--	--	--	27.2	72.8	--	--	--	--	--
00524256	469503	5880041	54.8	67.6.	--	0.9	8.0	24.7	67.3	--	--	--	--	--	26.9	73.1	--	--	--	--	--
00524264	469539	5880100	6.1	20.6	--	0.6	9.4	24.2	66.4	--	--	--	--	--	26.7	73.3	--	--	--	--	--
00524280	469341	5879803	43.3	50.0	--	0.5	11.2	23.9	64.9	--	--	--	--	--	26.9	73.1	--	--	--	--	--
00524298	469316	5879764	85.9	118.9	--	0.9	10.3	22.9	66.8	--	--	--	--	--	25.5	74.5	--	--	--	--	--
00524306	469885	5880073	20.0	40.0	--	1.0	11.5	21.3	67.2	--	--	--	--	--	24.1	75.9	--	--	--	--	--
00524371	469415	5880084	73.5	89.9	--	0.8	9.8	24.4	65.8	--	--	--	--	--	27.0	73.0	--	--	--	--	--
00524389	469389	5880229	5.8	18.5	--	1.6	8.0	23.5	68.5	--	--	--	--	--	25.5	74.5	--	--	--	--	--
00524397	469363	5880190	38.0	43.3	--	1.0	9.5	24.1	66.4	--	--	--	--	--	26.7	73.3	--	--	--	--	--
00524405	469337	5880148	70.0	80.0	--	0.9	9.9	23.8	66.3	--	--	--	--	--	26.4	73.6	--	--	--	--	--
00524413	470009	5879545	29.3	49.1	--	1.0	11.3	22.7	66.0	--	--	--	--	--	25.6	74.4	--	--	--	--	--
00524439	469987	5879510	37.0	59.0	--	0.7	11.1	22.8	66.2	--	--	--	--	--	25.6	74.4	--	--	--	--	--
00524447	469387	5879696	10.7	18.9	--	1.4	11.0	24.7	64.3	--	--	--	--	--	27.8	72.2	--	--	--	--	--
00524462	469433	5879582	72.2	97.8	--	0.9	7.9	24.1	68.0	--	--	--	--	--	26.2	73.8	--	--	--	--	--
00524470	469823	5879268	6.1	10.7	--	0.5	13.3	28.0	58.7	--	--	--	--	--	32.3	67.7	--	--	--	--	--
00524496	469879	5879347	56.0	81.0	--	0.6	10.5	24.8	64.7	--	--	--	--	--	27.8	72.2	--	--	--	--	--
00524504	469908	5879390	22.0	28.0	--	0.3	9.3	25.8	64.9	--	--	--	--	--	28.4	71.6	--	--	--	--	--
00524678	469130	5880211	17.9	92.4	--	0.7	11.6	23.9	64.6	--	--	--	--	--	27.0	73.0	--	--	--	--	--
00524686	469865	5879681	7.4	13.0	--	0.9	8.3	23.3	68.4	--	--	--	--	--	25.4	74.6	--	--	--	--	--
00524702	469590	5879469	13.1	22.0	--	1.0	7.3	25.5	67.3	--	--	--	--	--	27.5	72.5	--	--	--	--	--
00524728	469572	5879612	10.7	36.2	--	2.0	10.9	30.1	59.0	--	--	--	--	--	33.8	66.2	--	--	--	--	--
00524736	469932	5879608	16.0	30.0	--	0.6	7.7	23.8	68.4	--	--	--	--	--	25.8	74.2	--	--	--	--	--
00524744	469478	5879645	3.7	89.9	--	1.1	7.5	26.0	66.5	--	--	--	--	--	28.1	71.9	--	--	--	--	--
00524751	469780	5879375	82.0	88.0	--	1.1	9.7	24.3	66.0	--	--	--	--	--	26.9	73.1	--	--	--	--	--

Appendix 2. (continued)

Hole Number	Location East	Location North	Depth Upper	Depth Lower	AR H2O	AD H2O	Dry Ash	Dry VM	Dry FC	Dry C	Dry H	Dry N	Dry S	Dry O	Dry Ash Free VM	Dry Ash Free FC	Dry Ash Free C	Dry Ash Free H	Dry Ash Free N	Dry Ash Free S	Dry Ash Free O
00524769	469700	5879801	20.0	30.0	--	0.9	8.5	23.9	67.6	--	--	--	--	--	26.1	73.9	--	--	--	--	--
00524777	469811	5879416	17.0	57.0	--	0.4	11.6	24.2	64.2	--	--	--	--	--	27.4	72.6	--	--	--	--	--
00524785	469812	5879417	22.3	33.5	--	0.4	7.1	27.1	65.8	--	--	--	--	--	29.2	70.8	--	--	--	--	--
00524835	469732	5879490	13.0	26.5	--	0.5	8.7	25.8	65.4	--	--	--	--	--	28.3	71.7	--	--	--	--	--
00524843	469709	5879458	26.2	31.7	--	1.1	7.0	22.8	70.3	--	--	--	--	--	24.5	75.5	--	--	--	--	--
00524868	469660	5879387	67.1	81.7	--	0.7	12.2	23.1	64.8	--	--	--	--	--	26.3	73.7	--	--	--	--	--
00524876	469649	5879372	35.4	66.4	--	0.8	11.9	23.8	64.3	--	--	--	--	--	27.0	73.0	--	--	--	--	--
00524876	469649	5879372	99.7	141.7	--	0.8	12.3	22.1	65.6	--	--	--	--	--	25.2	74.8	--	--	--	--	--
00524892	469906	5879568	14.0	76.0	--	0.5	9.5	24.1	66.3	--	--	--	--	--	26.7	73.3	--	--	--	--	--
00524918	469654	5879544	19.0	34.1	--	0.6	9.4	24.7	65.9	--	--	--	--	--	27.3	72.7	--	--	--	--	--
00525105	469867	5880045	21.0	37.8	--	1.8	8.8	23.0	68.2	--	--	--	--	--	25.2	74.8	--	--	--	--	--
00525139	469845	5880013	21.0	22.1	--	0.7	9.1	22.4	68.6	--	--	--	--	--	24.6	75.4	--	--	--	--	--
00272948	469551	5882055	10.7	25.0	--	1.0	8.2	21.0	70.8	--	--	--	--	--	22.9	77.1	--	--	--	0.3	--
00272997	469169	5882170	133.5	154.8	--	0.7	9.0	20.0	71.0	--	--	--	--	--	22.0	78.0	--	--	--	0.4	--
00524025	470488	5881690	27.9	39.8	--	0.6	6.6	19.8	73.5	--	--	--	--	--	21.2	78.8	--	--	--	--	--
00524033	470465	5881710	30.0	35.0	--	0.8	7.3	20.6	72.2	--	--	--	--	--	22.2	77.8	--	--	--	--	--
00524041	470395	5881735	9.1	32.4	--	0.8	11.9	19.3	68.9	--	--	--	--	--	21.9	78.1	--	--	--	--	--
00524058	470616	5881595	13.0	45.0	--	0.6	7.7	19.1	73.1	--	--	--	--	--	20.7	79.3	--	--	--	--	--
00524082	470546	5881709	2.8	17.0	--	0.7	5.9	20.1	73.9	--	--	--	--	--	21.4	78.6	--	--	--	--	--
00524090	470121	5880710	12.3	201.0	--	0.9	10.4	20.1	69.5	--	--	--	--	--	22.4	77.6	--	--	--	--	--
00524363	470083	5880658	68.9	88.4	--	1.1	12.1	19.7	68.1	--	--	--	--	--	22.4	77.6	--	--	--	--	--
00524363	470083	5880658	117.3	122.2	--	1.1	7.5	20.9	71.6	--	--	--	--	--	22.6	77.4	--	--	--	--	--
00524934	469916	5881742	69.0	102.0	--	0.8	9.5	18.2	72.3	--	--	--	--	--	20.2	79.8	--	--	--	--	--
00524942	470100	5880684	44.8	59.1	--	1.0	10.0	20.8	69.2	--	--	--	--	--	23.1	76.9	--	--	--	--	--
00524967	470128	5880720	8.2	24.4	--	0.7	9.2	21.3	69.5	--	--	--	--	--	23.5	76.5	--	--	--	--	--
00524975	469972	5881822	33.0	52.2	--	0.4	10.1	19.9	70.0	--	--	--	--	--	22.1	77.9	--	--	--	--	--
00524983	469798	5880841	14.3	19.8	--	0.9	10.2	20.9	68.9	--	--	--	--	--	23.3	76.7	--	--	--	--	--
00524991	469803	5880849	8.2	15.5	--	0.9	12.8	20.7	66.5	--	--	--	--	--	23.7	76.3	--	--	--	--	--
00525014	469693	5881924	21.0	29.0	--	0.5	13.0	19.7	67.3	--	--	--	--	--	22.6	77.4	--	--	--	--	--
00525022	469658	5881882	17.0	63.0	--	0.7	9.6	18.3	72.1	--	--	--	--	--	20.3	79.7	--	--	--	--	--
00525030	470125	5881686	20.0	37.0	--	0.7	11.7	19.8	68.5	--	--	--	--	--	22.5	77.5	--	--	--	--	--
00525048	470121	5881633	21.0	35.0	--	0.6	11.5	18.4	70.1	--	--	--	--	--	20.8	79.2	--	--	--	--	--
00525055	470126	5881583	6.0	23.5	--	0.7	5.8	19.3	74.8	--	--	--	--	--	20.5	79.5	--	--	--	--	--
00525063	469621	5881989	13.0	19.0	--	0.5	7.5	19.7	72.8	--	--	--	--	--	21.3	78.7	--	--	--	--	--
00525071	469593	5881960	38.0	50.0	--	0.5	15.9	19.0	65.1	--	--	--	--	--	22.6	77.4	--	--	--	--	--
00525089	469565	5881929	47.8	85.0	--	0.7	12.1	18.1	69.8	--	--	--	--	--	20.6	79.4	--	--	--	--	--
00272930	468573	5882057	14.5	26.7	--	1.2	8.9	21.8	69.3	--	--	--	--	--	23.9	76.1	--	--	--	0.3	--
00272955	468750	5882349	14.3	25.0	--	0.9	8.2	20.6	71.3	--	--	--	--	--	22.4	77.6	--	--	--	0.4	--
00272963	468739	5882611	13.1	25.0	--	0.6	9.0	21.6	69.4	--	--	--	--	--	23.7	76.3	--	--	--	0.4	--

Appendix 3. Proximate and ultimate analyses, Jewel Seam (raw coal from excavations).

Sample Number	Location East	Location North	Depth Lower	Depth Upper	AR H2O	AD H2O	Dry Ash	Dry VM	Dry FC	Dry C	Dry H	Dry N	Dry S	Dry O	Dry Ash Free VM	Dry Ash Free FC	Dry Ash Free C	Dry Ash Free H	Dry Ash Free N	Dry Ash Free S	Dry Ash Free O
CF-2-1	473040	5881172	0.0	2.0	--	0.9	8.0	19.8	72.3	83.4	4.1	1.4	0.3	2.8	21.5	78.5	90.6	4.5	1.5	0.3	3.1
CF-2-2	473040	5881172	2.0	4.0	--	0.9	21.3	19.0	59.7	69.9	3.7	1.4	0.6	3.0	24.1	75.9	88.8	4.7	1.8	0.8	3.9
CF-2-3	473040	5881172	4.0	6.0	--	0.9	22.0	19.2	58.8	69.4	3.5	1.4	0.3	3.3	24.6	75.4	89.0	4.5	1.8	0.4	4.3
CF-2-4	473040	5881172	6.0	8.0	--	0.9	11.8	20.9	67.3	79.0	3.8	1.3	0.1	3.9	23.7	76.3	89.6	4.3	1.5	0.1	4.5
CF-2-5	473040	5881172	8.0	10.0	--	0.9	10.2	21.2	68.5	80.5	3.8	1.3	0.1	4.0	23.6	76.3	89.7	4.3	1.5	0.1	4.9
CF-2-6	473040	5881172	10.0	10.4	--	0.9	30.6	16.3	53.1	60.0	3.0	0.9	0.1	5.3	23.5	76.5	86.5	4.4	1.3	0.1	7.9
CF-2-7	473040	5881172	10.4	11.6	--	0.8	18.3	19.2	62.5	72.7	3.7	1.0	0.3	3.9	23.5	76.5	89.0	4.6	1.2	0.4	4.8
CF-2-9	473040	5881172	12.1	13.1	--	0.7	12.1	19.5	68.3	78.4	3.9	1.1	0.4	4.0	22.2	77.7	89.2	4.5	1.3	0.5	4.9
CF3-1	469345	5884294	0.0	0.9	--	2.7	15.7	21.2	63.1	71.1	3.5	0.9	0.5	8.2	25.1	74.9	84.4	4.1	1.1	0.6	9.8
CF3-3	469345	5884294	2.7	4.7	--	3.0	32.9	18.5	48.7	52.2	2.8	0.9	0.3	10.9	27.5	72.5	77.7	4.1	1.4	0.5	16.3
CF3-4	469345	5884294	4.7	6.0	--	2.0	80.7	8.0	11.4	13.4	1.1	0.4	0.1	4.3	41.3	59.3	69.3	5.8	2.1	0.5	22.2
CF3-5	469345	5884294	6.0	7.4	--	1.6	17.1	19.6	63.3	71.5	3.8	1.2	0.3	6.1	23.7	76.3	86.3	4.5	1.5	0.4	7.4
CF3-7	469345	5884294	7.7	9.7	--	1.7	7.0	20.4	72.5	81.8	4.1	1.2	0.3	5.6	22.0	78.0	88.0	4.4	1.3	0.3	6.0
CF3-8	469345	5884294	9.7	11.7	--	0.8	12.7	19.4	68.0	77.9	3.9	1.2	0.2	4.0	22.2	77.9	89.3	4.5	1.4	0.2	4.6
CF3-10	469345	5884294	12.4	13.4	--	0.7	11.4	20.9	67.8	78.9	4.2	1.2	0.4	3.9	23.6	76.5	89.0	4.8	1.4	0.5	4.4
CF-4-1	472038	5880398	0.0	1.8	--	1.0	16.1	20.4	63.5	75.1	3.7	1.2	0.2	3.7	24.3	75.7	89.4	4.5	1.4	0.2	4.5
CF-4-3	472038	5880398	2.5	3.5	--	0.9	19.2	18.7	62.3	72.5	3.7	1.2	0.3	3.1	23.1	77.0	89.6	4.6	1.5	0.4	3.9
CF-4-5	472038	5880398	4.5	5.1	--	1.0	39.6	14.5	45.9	52.3	2.7	0.9	0.3	4.1	24.1	75.9	86.6	4.5	1.5	0.5	6.9
CF-5-1	469390	5884092	0.0	2.0	--	0.9	13.6	20.7	65.7	77.9	4.1	1.3	0.4	2.6	23.9	76.1	90.2	4.8	1.5	0.5	3.0
CF-5-2	469390	5884092	2.0	3.5	--	1.0	15.5	19.6	64.9	76.2	3.9	1.2	0.3	2.9	23.2	76.8	90.1	4.7	1.4	0.4	3.5
CF-5-3	469390	5884092	3.8	4.3	--	0.8	15.9	21.3	62.8	74.5	4.1	1.3	0.6	3.5	25.3	74.7	88.6	4.9	1.6	0.7	4.2
CF6-1	469510	5881910	0.0	2.0	--	0.9	16.1	18.3	65.7	75.0	3.7	1.3	0.3	3.5	21.8	78.3	89.4	4.5	1.6	0.4	4.2
CF6-2	469510	5881910	2.0	5.0	--	0.9	18.6	18.0	63.0	72.6	3.7	1.3	0.2	3.6	22.1	77.3	89.1	4.6	1.6	0.2	4.5
CF6-3	469510	5881910	5.0	7.5	--	0.8	13.1	19.1	67.8	77.6	3.9	1.4	0.3	3.6	21.9	78.1	89.3	4.5	1.6	0.3	4.2
CF6-5	469510	5881910	8.1	8.7	--	0.7	17.4	17.1	65.4	73.6	3.6	1.1	0.3	3.9	20.7	79.1	89.1	4.4	1.3	0.4	4.8
CF8-2	468936	5880344	0.0	0.9	--	1.5	9.0	23.5	67.5	79.5	4.2	1.2	0.4	5.7	25.8	74.2	87.4	4.6	1.3	0.4	6.2
CF8-4	468936	5880344	1.3	3.3	--	2.7	10.1	22.3	67.5	77.3	3.8	1.2	0.2	7.4	24.8	75.1	85.9	4.2	1.4	0.2	8.2
CF8-5	468936	5880344	3.3	5.4	--	2.5	11.5	22.8	65.8	75.9	3.9	1.3	0.2	7.2	25.7	74.4	85.7	4.4	1.5	0.2	8.1
CF8-7	468936	5880344	5.7	6.9	--	2.5	12.0	22.8	65.2	74.5	3.8	1.2	0.2	8.3	25.9	74.1	84.6	4.3	1.4	0.2	9.4
CF8-9	468942	5880352	0.0	2.0	--	1.7	8.3	23.6	68.1	79.2	4.2	1.3	0.3	6.6	25.7	74.3	86.5	4.6	1.4	0.3	7.2
CF8-11	468942	5880352	2.0	3.1	--	2.4	9.7	23.1	67.3	77.5	3.9	1.2	0.3	7.4	25.5	74.6	85.8	4.3	1.4	0.3	8.2
CF-9-4	471228	5877873	0.0	2.0	--	1.2	11.7	25.3	63.0	77.5	4.3	1.3	0.5	4.7	28.7	71.3	87.8	4.8	1.5	0.6	5.3
CF-9-5	471228	5877873	2.0	4.0	--	1.2	13.6	24.9	61.6	76.4	4.4	1.3	0.2	4.1	28.8	71.3	88.4	5.0	1.5	0.2	4.8
CF-9-6	471228	5877873	4.0	6.0	--	1.0	13.1	27.9	58.9	75.1	4.1	1.2	0.2	6.3	32.1	67.8	86.4	4.8	1.4	0.2	7.2
CF-9-7	471228	5877873	6.0	8.0	--	1.2	13.1	25.1	61.8	76.4	4.1	1.2	0.2	5.0	28.9	71.1	87.9	4.8	1.4	0.2	5.7
CF-9-8	471228	5877873	8.0	9.2	--	1.0	18.0	23.3	58.8	72.2	3.9	1.2	0.2	4.4	28.4	71.7	88.1	4.8	1.5	0.2	5.4
CF-16-6	472892	5881502	0.0	3.0	--	0.8	9.4	20.1	70.7	82.5	4.0	1.4	0.3	2.4	22.1	78.0	91.0	4.4	1.6	0.3	2.7
CF-16-7	472890	5881502	3.0	6.0	--	1.1	16.8	20.2	63.0	73.3	3.7	1.3	0.2	4.7	24.3	75.7	88.1	4.5	1.6	0.2	5.6
CF-16-8	472890	5881502	6.0	9.5	--	1.2	10.9	21.1	67.9	79.6	4.0	1.4	0.2	3.8	23.6	76.3	89.3	4.5	1.6	0.2	4.3
CF-15-16	472960	5881107	0.0	1.0	--	0.8	10.7	19.7	69.7	80.5	3.9	1.3	0.3	3.2	22.0	78.0	90.2	4.4	1.5	0.3	3.6
CF-15-17	472960	5881107	1.0	2.0	--	0.8	9.7	21.1	69.3	81.7	4.2	1.5	0.3	2.6	23.3	76.7	90.4	4.7	1.7	0.3	2.9
CF-15-18	472960	5881107	2.0	3.0	--	0.8	9.6	20.7	69.9	81.3	4.1	1.4	0.3	3.3	22.9	77.3	89.9	4.6	1.6	0.3	3.7
CF-15-19	472960	5881107	3.0	4.0	--	0.6	8.6	22.1	69.3	82.3	4.3	1.6	0.3	2.9	24.2	75.8	90.0	4.7	1.8	0.3	3.2
CF-15-20	472960	5881107	4.0	5.0	--	0.7	18.7	21.3	59.8	71.6	3.8	1.3	0.3	4.2	26.3	73.6	88.1	4.7	1.6	0.4	5.2
CF-15-21	472960	5881107	5.0	6.0	--	0.9	27.9	18.7	53.6	63.8	3.5	1.2	0.3	3.3	25.9	74.3	88.4	4.9	1.7	0.4	4.6
CF-15-22	472960	5881107	6.0	7.4	--	0.6	7.9	22.8	69.2	81.3	4.1	1.3	0.2	5.1	24.8	75.2	88.3	4.5	1.4	0.2	5.6
CF-15-9	472960	5881107	7.4	8.2	--	0.7	5.9	24.5	69.7	84.5	4.4	1.5	0.2	3.4	26.0	74.1	89.8	4.7	1.6	0.2	3.6
CF-15-10	472960	5881107	8.2	9.0	--	0.9	4.1	21.4	74.5	87.2	4.3	1.5	0.2	2.6	22.3	77.7	90.9	4.5	1.6	0.2	2.7
CF-15-11	472960	5881107	9.0	9.7	--	1.1	12.8	19.2	67.9	78.5	3.8	1.3	0.2	3.3	22.0	78.0	90.0	4.4	1.5	0.2	3.8
CF-15-12	472960	5881107	9.7	10.2	--	0.7	13.6	27.0	59.5	73.1	3.7	1.3	0.1	8.2	31.2	68.9	84.6	4.3	1.5	0.1	9.4
CF-15-13	472960	5881107	10.2	11.8	--	0.9	16.9	23.2	60.0	73.0	3.7	1.3	0.2	4.9	27.9	72.2	87.7	4.5	1.6	0.2	5.9
CF-15-14	472960	5881107	11.8	12.3	--	0.8	21.2	19.0	59.9	70.0	3.6	1.1	0.3	3.8	24.0	76.0	88.7	4.6	1.4	0.4	4.9
CF-15-15	472960	5881107	12.9	13.8	--	0.8	14.3	19.9	65.9	76.8	3.9	1.2	0.4	3.3	23.2	76.9	89.6	4.6	1.4	0.5	3.9
WL87-46	471485	5877957	0.0	1.0	--	0.8	11.6	25.1	63.3	77.0	4.4	1.2	0.1	5.6	28.4	71.6	87.1	5.0	1.4	0.1	6.4
WL87-47	471485	5877957	0.0	1.0	--	0.7	5.9	25.2	68.9	83.6	4.6	1.3	0.1	4.4	26.8	73.2	88.9	4.9	1.4	0.1	4.7
CF10-59	469583	5882035	0.0	0.5	--	0.6	9.9	20.2	69.9	80.4	4.0	1.2	0.5	4.0	22.4	77.6	89.2	4.5	1.3	0.6	4.5
CF10-58	469583	5882035	0.5	0.9	--	0.7	15.5	19.1	65.5	74.2	3.9	1.2	0.4	4.7	22.6	77.5	87.8	4.6	1.4	0.5	5.6
CF10-56	469583	5882035	1.0	2.0	--	0.7	12.4	17.8	69.7	78.9	3.8	1.1	0.2	3.6	20.3	79.5	90.0	4.4	1.3	0.2	4.1
CF10-55	469583	5882035	2.0	3.0	--	0.6	6.6	19.8	73.5	84.5	4.3	1.3	0.2	3.0	21.2	78.8	90.5	4.6	1.4	0.2	3.2
CF10-54	469583	5882035	3.0	4.0	--	0.7	27.8	16.0	56.1	63.7	3.2	1.1	0.2	3.9	22.2	77.7	88.3	4.5	1.5	0.3	5.4
CF10-53	469583	5882035	4.0	5.0	--	0.8	10.2	19.6	70.2	80.7	4.1	1.4	0.3	3.2	21.8	78.1	89.9	4.6	1.6	0.3	3.6
CF10-52	469583	5882035	5.0	6.0	--	0.7	8.7	19.8	71.4	82.0	4.1	1.4	0.2	3.6	21.7	78.2	89.7	4.5	1.5	0.2	4.0

Appendix 3. (continued)

Sample Number	Location East	Location North	Depth Lower	Depth Upper	AR H2O	AD H2O	Dry Ash	Dry VM	Dry FC	Dry C	Dry H	Dry N	Dry S	Dry O	Dry Ash Free VM	Dry Ash Free FC	Dry Ash Free C	Dry Ash Free H	Dry Ash Free N	Dry Ash Free S	Dry Ash Free O
CF10-51	469583	5882035	6.0	7.0	--	0.8	8.3	19.0	72.9	82.4	4.1	1.3	0.3	3.6	20.7	79.5	89.8	4.5	1.4	0.3	4.0
CF10-50	469583	5882035	7.0	7.9	--	0.7	13.9	19.3	66.7	76.6	4.0	1.3	0.3	3.8	22.5	77.4	89.0	4.7	1.5	0.4	4.4
CF10-49	469583	5882035	7.9	8.9	--	0.7	19.6	18.1	62.2	71.0	3.7	1.1	0.4	4.1	22.6	77.4	88.3	4.6	1.4	0.5	5.1
CF10-48	469583	5882035	9.6	10.2	--	0.5	14.3	18.0	67.7	76.9	3.9	1.2	0.4	3.3	21.0	79.0	89.7	4.6	1.4	0.5	3.9
CF14-66	469254	5879780	0.0	1.0	--	0.7	17.3	23.8	58.9	71.2	4.0	1.2	0.6	5.6	28.7	71.3	86.1	4.9	1.5	0.7	6.8
CF14-67	469254	5879780	1.0	2.0	--	0.7	8.4	24.0	67.7	80.7	4.3	1.4	0.2	5.0	26.2	73.8	88.0	4.7	1.5	0.2	5.5
CF14-68	469254	5879780	2.0	3.0	--	0.7	11.9	23.4	64.8	76.9	4.2	1.2	0.2	5.5	26.5	73.5	87.3	4.8	1.4	0.2	6.3
CF14-70	469254	5879780	3.0	4.2	--	0.7	11.4	23.6	65.1	77.5	4.2	1.3	0.3	5.2	26.6	73.4	87.5	4.8	1.5	0.3	5.9
CF14-72	469254	5879780	4.5	6.0	--	0.7	26.7	23.6	49.7	61.2	3.4	1.0	0.2	7.5	32.1	67.9	83.5	4.7	1.4	0.3	10.2
CF14-74	469254	5879780	8.6	9.6	--	0.7	8.4	24.9	66.8	80.8	4.3	1.3	0.2	5.0	27.1	72.9	88.1	4.7	1.4	0.2	5.5
CF14-75	469254	5879780	9.6	10.6	--	0.7	11.0	25.8	63.4	77.6	4.2	1.3	0.2	5.6	29.0	71.3	87.2	4.8	1.5	0.2	6.3
CF14-76	469254	5879780	10.6	11.6	--	0.9	18.1	22.8	59.2	71.0	3.8	1.1	0.2	5.8	27.8	72.3	86.7	4.7	1.4	0.2	7.0
CF14-77	469254	5879780	11.6	11.8	--	0.8	6.6	22.8	70.8	83.6	4.3	1.2	0.3	4.0	24.4	75.7	89.4	4.6	1.3	0.3	4.3
CF14-78	469254	5879780	11.8	11.9	--	0.8	7.1	24.8	68.2	82.7	4.4	1.3	0.3	4.2	26.7	73.4	88.9	4.8	1.4	0.3	4.6
CF14-79	469254	5879780	11.9	12.05	--	0.8	19.9	20.8	59.4	69.5	3.7	1.1	0.2	5.6	25.9	74.1	86.7	4.7	1.4	0.3	7.0
CF14-80	469254	5879780	12.05	12.30	--	0.8	8.8	25.8	65.5	80.4	4.4	1.4	0.3	4.6	28.3	71.8	88.2	4.9	1.5	0.3	5.1
CF14-81	469254	5879780	12.30	12.55	--	0.7	12.4	22.8	65.0	77.3	4.0	1.2	0.3	4.7	26.0	74.1	88.3	4.6	1.4	0.3	5.4
CF14-82	469254	5879780	12.57	12.92	--	0.7	19.6	21.5	59.0	70.5	3.9	1.0	0.3	4.6	26.7	73.4	87.7	4.9	1.3	0.4	5.8
CF14-83	469254	5879780	11.6	12.92	--	0.7	12.6	22.2	65.3	71.6	3.9	1.0	0.3	10.6	25.3	74.7	81.9	4.5	1.2	0.3	12.1
CF13-85	469258	5879838	0.0	1.0	--	0.7	12.6	22.2	65.3	77.4	4.1	1.2	0.4	4.2	25.3	74.7	88.6	4.7	1.4	0.5	4.8
CF13-86	469258	5879838	3.5	5.1	--	0.7	17.7	22.6	59.7	72.1	4.0	1.2	0.1	4.8	27.4	72.6	87.6	4.9	1.5	0.1	5.9
CF13-87	469258	5879838	5.1	5.4	--	1.2	51.5	17.5	31.5	37.4	2.3	0.6	0.0	8.1	36.1	64.9	77.2	4.8	1.3	0.0	16.7
CF13-88	469258	5879838	5.4	6.7	--	0.7	9.1	23.6	67.4	80.8	4.3	1.3	0.2	4.3	25.9	74.1	88.8	4.8	1.4	0.2	4.8
CF13-89	469258	5879838	8.7	9.7	--	0.6	13.5	25.9	60.6	74.9	4.2	1.2	0.2	5.9	29.9	70.0	86.6	4.9	1.4	0.2	6.9
CF13-90	469258	5879838	9.7	11.2	--	0.8	20.3	21.2	58.6	69.5	3.8	1.1	0.1	5.2	26.5	73.5	87.1	4.8	1.4	0.1	6.6
CF13-91	469258	5879838	11.2	13.1	--	0.7	19.1	20.7	60.1	70.7	3.8	1.2	0.3	4.8	25.7	74.3	87.4	4.7	1.5	0.4	6.0
CF12-94	469011	5880294	0.0	0.5	--	0.7	13.6	23.1	63.3	75.9	4.1	1.2	0.5	4.6	26.7	73.3	87.9	4.8	1.4	0.6	5.4
CF12-95	469011	5880294	0.5	1.0	--	0.7	13.8	22.5	63.8	75.8	4.1	1.2	0.5	4.5	26.1	74.1	88.0	4.8	1.4	0.6	5.3
CF12-96	469011	5880294	1.2	2.2	--	0.7	9.0	21.9	69.3	81.2	4.0	1.2	0.3	4.3	24.0	76.1	89.2	4.4	1.3	0.3	4.8
CF12-97	469011	5880294	2.2	3.2	--	0.7	15.6	22.9	61.5	74.5	4.1	1.2	0.2	4.3	27.1	72.9	88.3	4.9	1.4	0.2	5.1
CF12-98	469011	5880294	3.2	4.2	--	0.7	14.3	25.0	60.7	74.3	4.1	1.3	0.2	5.7	29.1	70.9	86.7	4.8	1.5	0.2	6.7
CF12-99	469011	5880294	4.2	5.2	--	0.7	12.5	24.7	62.7	76.9	4.2	1.2	0.2	4.9	28.2	71.7	87.9	4.8	1.4	0.2	5.6
CF12-100	469011	5880294	5.2	6.2	--	0.6	8.1	26.5	65.4	81.6	4.3	1.3	0.2	4.4	28.8	71.2	88.8	4.7	1.4	0.2	4.8
CF12-101	469011	5880294	6.2	7.0	--	0.7	6.2	25.1	68.7	82.8	4.4	1.4	0.2	4.9	26.7	73.3	88.3	4.7	1.5	0.2	5.3
CF12-102	469011	5880294	7.2	8.3	--	0.7	10.1	24.4	65.6	79.8	4.3	1.3	0.3	4.2	27.1	72.9	88.7	4.8	1.5	0.3	4.7
CF12-104	469011	5880294	10.8	11.8	--	0.6	11.3	26.7	62.1	78.7	4.2	1.3	0.4	4.1	30.0	70.0	88.7	4.8	1.5	0.5	4.6
CF12-105	469011	5880294	11.8	12.8	--	0.7	13.6	23.0	63.4	76.0	4.1	1.4	0.2	4.6	26.6	73.4	88.0	4.8	1.6	0.2	5.4
CF12-106	469011	5880294	12.8	13.8	--	0.7	16.8	23.3	59.9	72.6	3.8	1.1	0.2	5.4	28.0	72.0	87.3	4.6	1.3	0.2	6.5
CF12-107	469011	5880294	13.8	14.9	--	0.6	19.7	20.9	59.4	69.8	3.8	1.1	0.2	5.3	26.1	73.9	87.0	4.8	1.4	0.3	6.6
WL87-109	469370	5879719	0.0	1.0	--	0.7	10.7	23.1	66.3	79.0	4.2	1.3	0.4	4.4	25.8	74.2	88.4	4.7	1.5	0.5	5.0
WL87-111	469061	5880296	0.0	3.0	--	0.7	8.4	25.0	66.8	81.4	4.4	1.4	0.2	4.2	27.3	72.9	88.8	4.8	1.5	0.2	4.6
WL87-112	469061	5880296	3.0	6.0	--	0.6	13.8	24.7	61.4	75.3	4.0	1.2	0.2	5.5	28.7	71.2	87.3	4.7	1.4	0.2	6.4
WL87-126	465610	5885687	0.0	1.0	--	0.7	27.9	18.1	54.1	63.0	3.4	1.1	0.3	4.2	25.1	75.0	87.4	4.7	1.5	0.4	5.9
WL87-127	465467	5885350	0.0	1.0	--	0.8	9.8	17.8	72.4	81.6	3.9	1.2	0.3	3.2	19.8	80.2	90.4	4.4	1.3	0.3	3.6
KBA-81/8	479920	5873100	4.2	8.0	--	1.6	27.0	21.4	51.5	61.3	3.7	1.0	0.2	6.8	29.4	70.6	84.0	5.0	1.4	0.3	9.3
CF19-94	479600	5872980	0.0	8.7	--	1.2	20.2	23.9	55.9	67.4	3.9	1.0	0.2	7.2	29.9	70.1	84.5	4.9	1.3	0.3	9.0
CF20-98	479640	5873060	0.0	2.2	--	1.3	8.2	27.8	63.9	77.9	4.7	1.3	0.3	7.6	30.2	69.6	84.9	5.1	1.4	0.3	8.3
CF21-101	479960	5873140	0.0	1.0	--	1.3	7.2	25.6	67.3	81.4	4.5	1.2	0.3	5.5	27.6	72.5	87.7	4.8	1.3	0.3	5.9
CF21-102	479960	5873140	1.0	2.0	--	1.1	7.5	29.3	63.2	79.2	4.8	1.5	0.4	6.7	31.7	68.3	85.6	5.1	1.6	0.4	7.2
CF21-103	479960	5873140	2.0	3.0	--	1.3	5.3	26.2	68.6	82.4	4.6	1.4	0.3	6.1	27.7	72.4	87.0	4.8	1.5	0.3	6.4
CF21-104	479960	5873140	3.0	4.0	--	1.0	6.6	23.9	69.5	80.9	4.4	1.3	0.3	6.5	25.6	74.4	86.6	4.8	1.4	0.3	6.9
CF21-105	479960	5873140	4.0	5.0	--	1.1	9.7	23.0	67.3	78.2	4.2	1.2	0.2	6.5	25.4	74.6	86.6	4.7	1.3	0.2	7.2
CF21-106	479960	5873140	5.0	6.0	--	1.0	11.8	25.2	63.0	76.1	4.3	1.3	0.2	6.3	28.5	71.5	86.3	4.9	1.5	0.2	7.1
CF21-107	479960	5873140	6.0	7.0	--	1.0	17.9	24.4	57.6	70.0	4.1	1.1	0.2	6.7	29.8	70.1	85.2	5.0	1.4	0.2	8.1
CF21-108	479960	5873140	7.0	8.0	--	0.9	21.7	23.7	54.6	66.1	4.0	1.1	0.2	6.9	30.3	69.7	84.4	5.2	1.4	0.3	8.8
CF21-109	479960	5873140	8.0	9.0	--	1.0	9.4	26.4	64.2	78.3	4.5	1.2	0.2	6.4	29.1	70.9	86.4	5.0	1.3	0.2	7.0
CF21-110	479960	5873140	9.0	10.0	--	1.1	20.3	25.4	54.3	67.6	4.0	1.1	0.1	6.8	31.9	68.1	84.9	5.1	1.4	0.1	8.5
CF21-111	479960	5873140	10.0	11.0	--	1.1	19.0	24.2	56.8	69.0	4.1	1.1	0.1	6.7	29.8	70.2	85.1	5.1	1.4	0.1	8.2
CF21-113	479960	5873140	11.0	12.0	--	1.4	18.8	24.4	56.8	68.8	4.1	0.6	0.2	7.6	30.1	69.9	84.6	5.0	0.7	0.2	9.4
CF21-114	479960	5873140	12.0	13.0	--	1.2	23.6	21.5	54.9	66.1	3.7	0.4	0.2	6.0	28.1	71.8	86.5	4.9	0.5	0.3	7.8
CF21-116	479960	5873140	13.0	14.0	--	1.4	10.8	25.4	63.9	77.3	4.4	0.6	0.2	6.8	28.4	71.6	86.6	4.9	0.7	0.2	7.6

Appendix 3. (continued)

Hole	Location		Depth		AR	AD	Dry								Dry Ash Free						
Number	East	North	Upper	Lower	H2O	H2O	Ash	VM	FC	C	H	N	S	O	VM	FC	C	H	N	S	O
CF17-162	468691	5880606	0.0	1.0	--	0.9	18.3	21.4	60.3	72.7	4.0	1.0	0.4	3.6	26.2	73.8	88.9	4.9	1.2	0.5	4.4
CF17-163	468691	5880606	1.0	2.0	--	0.9	10.2	23.7	66.1	79.3	4.4	1.2	0.3	4.5	26.4	73.6	88.3	4.9	1.3	0.3	5.1
CF17-164	468691	5880606	2.0	2.8	--	1.3	28.8	19.7	51.7	62.4	3.6	0.8	0.2	4.2	27.6	72.5	87.6	5.1	1.1	0.3	5.8
CF18-155	468450	5880588	0.0	5.5	--	1.1	19.4	21.4	59.2	72.3	4.0	1.0	0.3	2.9	26.6	73.4	89.7	5.0	1.3	0.4	3.6
CF18-171	468610	5880558	0.0	1.0	--	7.8	15.6	27.7	56.7	68.4	3.4	1.0	0.3	11.3	32.8	67.2	81.1	4.0	1.2	0.4	13.4
CF18-172	468610	5880558	1.0	2.0	--	9.6	19.4	27.1	53.5	62.4	2.8	0.8	0.2	14.5	33.6	66.4	77.4	3.4	1.0	0.3	18.0
CF18-173	468610	5880558	2.0	3.0	--	11.7	20.2	28.1	51.8	61.7	2.5	0.8	0.2	14.6	35.2	64.8	77.3	3.1	1.0	0.3	18.3
CF18-174	468610	5880558	3.0	4.1	--	10.8	13.0	29.3	57.8	67.7	2.9	0.9	0.2	15.2	33.6	66.5	77.8	3.4	1.0	0.3	17.5
CF18-177	468610	5880558	0.0	4.1	--	7.3	12.8	28.4	58.9	68.4	3.2	0.9	0.2	14.5	32.5	67.6	78.5	3.7	1.0	0.2	16.6
CF23-178	472160	5877209	0.0	2.2	--	0.7	7.6	27.2	65.3	80.3	4.5	1.2	0.4	6.0	29.4	70.6	86.8	4.9	1.3	0.4	6.5
CF23-177	472160	5877209	2.2	4.4	--	0.5	14.0	28.8	57.2	73.5	4.2	1.0	0.1	7.2	33.5	66.5	85.4	4.9	1.2	0.1	8.4
CF23-176	472160	5877209	4.4	6.6	--	0.6	13.8	25.6	60.7	76.2	4.3	1.0	0.2	4.5	29.6	70.4	88.3	5.0	1.2	0.2	5.3
CF23-175	472160	5877209	6.9	9.4	--	0.7	17.0	26.0	57.1	72.3	4.2	1.0	0.1	5.3	31.3	68.8	87.1	5.1	1.2	0.1	6.4

Appendix 4. Proximate and ultimate analyses, other seams (raw coal from excavations).

Sample	Location		Depth		AR	AD	Dry								Dry Ash Free						
Number	East	North	Lower	Upper	H2O	H2O	Ash	VM	FC	C	H	N	S	O	VM	FC	C	H	N	S	O
CF-4-7	472097	5880495	0.0	1.1	--	0.9	26.5	17.3	56.2	64.5	3.3	1.1	0.5	4.0	23.5	76.5	87.8	4.5	1.5	0.7	5.5
CF-4-9	472097	5880495	1.3	1.8	--	1.5	44.1	14.8	41.2	47.1	2.7	1.0	0.5	4.6	26.5	73.7	84.2	4.9	1.8	0.9	8.2
CF-4-10	472097	5880495	1.9	2.6	--	1.1	41.5	15.5	43.1	49.2	2.8	0.9	0.4	5.2	26.4	73.6	84.1	4.8	1.6	0.7	8.8
CF-4-11	472128	5880541	0.0	0.5	--	0.8	8.5	19.7	71.9	83.1	4.1	1.3	0.5	2.5	21.5	78.5	90.7	4.5	1.4	0.6	2.8
CF5-5	469436	5884153	0.0	0.2	--	0.9	18.2	20.7	61.2	71.4	3.8	1.3	0.1	5.1	25.3	74.7	87.3	4.7	1.6	0.1	6.3
CF-5-6	469436	5884153	1.7	3.2	--	1.1	26.9	19.7	53.5	63.3	3.5	1.2	0.5	4.6	27.0	73.2	86.6	4.8	1.7	0.7	6.2
CF-5-7	469436	5884153	3.2	4.8	--	1.4	43.5	16.1	40.4	47.6	2.7	0.9	0.3	5.0	28.5	71.5	84.2	4.8	1.6	0.5	8.8
CF6-6	469550	5881986	0.0	0.5	--	3.1	46.5	16.3	37.0	43.6	2.4	0.8	0.4	6.3	30.5	69.3	81.5	4.4	1.5	0.8	11.8
CF7-1	469250	5879765	0.0	0.2	--	0.9	24.6	19.1	56.3	65.8	3.5	1.1	0.5	4.4	25.3	74.7	87.3	4.7	1.5	0.7	5.9
CF7-2	469205	5879849	0.0	0.3	--	0.7	17.4	26.4	56.2	70.6	4.3	1.4	2.9	3.3	32.0	68.0	85.5	5.2	1.7	3.5	4.0
CF7-4	469205	5879849	0.5	1.0	--	0.7	25.1	27.7	47.2	64.2	3.9	1.3	0.5	4.9	37.0	63.0	85.8	5.2	1.7	0.7	6.6
CF8-1	468925	5880291	0.0	0.2	--	0.9	54.0	15.3	30.7	37.6	2.4	0.8	1.8	3.3	33.3	66.7	81.8	5.3	1.8	3.9	7.2
CF-9-1	471076	5877834	0.0	0.05	--	1.0	7.3	24.9	67.8	82.2	4.4	1.5	0.8	3.7	26.9	73.1	88.7	4.8	1.6	0.9	4.0
CF-9-2	471115	5877849	0.0	0.1	--	1.3	79.6	10.5	9.7	14.9	1.1	0.6	0.7	3.0	51.7	47.8	73.1	5.5	3.0	3.5	14.9
CF-9-3	471198	5877864	0.0	0.9	--	1.1	34.5	22.0	43.5	54.4	3.3	1.0	2.8	3.9	33.6	66.4	83.0	5.1	1.5	4.3	6.0
CF-9-10	471378	5877921	0.0	0.5	--	1.1	15.6	24.4	60.1	74.0	4.1	1.3	0.5	4.4	28.9	71.1	87.7	4.9	1.6	0.6	5.3

Appendix 5. Weighted averages of proximate and ultimate analyses, Jewel Seam, for washed coal dry basis not calculated.

Hole or	Location		AR	AD	Dry								Dry Ash Free						
Section	East	North	H2O	H2O	Ash	VM	FC	C	H	N	S	O	VM	FC	C	H	N	S	O
82RC108D	469821	5881881	9.7	0.6	15.4	19.8	64.8	--	--	--	--	--	23.5	76.5	--	--	--	--	--
82RC109	470414	5881755	30.0	5.4	18.0	22.6	59.3	--	--	--	0.2	--	27.8	72.3	--	--	--	0.2	--
82RC110	470495	5881655	19.7	0.3	16.0	18.5	65.5	--	--	--	--	--	22.1	77.9	--	--	--	--	--
82RC113	469767	5881807	10.2	0.4	13.4	19.5	67.1	--	--	--	--	--	22.7	77.3	--	--	--	--	--
82RC123A	469795	5882162	26.3	1.1	24.8	18.3	57.0	--	--	--	--	--	24.5	75.5	--	--	--	--	--
82RC123B	470624	5881607	21.3	0.6	16.1	18.0	65.9	--	--	--	--	--	21.5	78.5	--	--	--	--	--
82RC129	470450	5881646	10.4	1.8	12.9	19.8	67.5	--	--	--	--	--	22.9	77.3	--	--	--	--	--
82RC132	469875	5880056	24.4	0.6	25.6	19.6	54.8	--	--	--	--	--	26.3	73.7	--	--	--	--	--
82RC134	469999	5879922	7.6	0.7	13.9	22.9	63.2	--	--	--	--	--	26.8	73.2	--	--	--	--	--
82RC136	470057	5881764	5.4	0.6	20.0	18.7	61.3	--	--	--	--	--	23.4	76.6	--	--	--	--	--
82RC153	469836	5879661	11.8	0.5	18.5	24.0	57.5	--	--	--	--	--	29.8	70.2	--	--	--	--	--
82RC119	470609	5881561	23.9	2.1	21.1	22.1	56.8	--	--	--	--	--	28.8	71.2	--	--	--	--	--
81DD2	469871	5881842	5.4	0.5	20.3	19.1	60.6	--	--	--	--	--	24.0	76.0	--	--	--	--	--
81DD3	469995	5881675	7.9	0.8	19.9	18.7	61.4	--	--	--	--	--	23.4	76.6	--	--	--	--	--
81DD10	469572	5879254	3.4	0.7	16.6	23.9	59.6	--	--	--	--	--	28.6	71.4	--	--	--	--	--
81DD11	469610	5880381	1.4	0.8	21.0	23.5	55.5	--	--	--	--	--	29.7	70.3	--	--	--	--	--
81DD12	469089	5880652	6.1	0.9	16.1	24.0	59.9	--	--	--	--	--	28.6	71.4	--	--	--	--	--
CF2-1	473040	5881172	--	0.9	15.3	19.8	64.9	75.7	3.8	1.3	0.3	3.6	23.4	76.6	89.4	4.5	1.5	0.4	4.3
CF3-1	469345	5884294	--	1.8	16.6	19.8	63.6	71.7	3.7	1.1	0.3	6.5	24.0	76.1	85.6	4.4	1.4	0.4	8.3
CF4-1	472038	5880398	--	1.0	21.2	18.9	60.0	70.3	3.5	1.1	0.2	3.6	23.9	76.1	89.0	4.5	1.4	0.3	4.7
CF5-1	469390	5884092	--	0.9	14.6	20.4	65.0	76.8	4.0	1.3	0.4	2.8	23.8	76.2	90.0	4.8	1.5	0.5	3.3
CF6-1	469510	5881910	--	0.9	16.2	18.3	65.3	74.8	3.8	1.3	0.3	3.6	21.9	77.9	89.2	4.5	1.6	0.3	4.4
CF8-2	468936	5880344	--	2.4	10.8	22.7	66.5	76.6	3.9	1.2	0.2	7.3	25.5	74.5	85.8	4.3	1.4	0.2	8.1
CF9-4	471228	5877873	--	1.1	13.5	25.5	61.0	75.8	4.2	1.2	0.3	4.9	29.5	70.5	87.7	4.8	1.5	0.3	5.7
CF16-6	472892	5881502	--	1.0	12.3	20.5	67.2	78.5	3.9	1.4	0.2	3.6	23.3	76.6	89.5	4.5	1.6	0.2	4.2
CF15-16	472960	5881107	--	0.8	12.9	21.5	65.6	77.6	4.0	1.3	0.3	3.8	24.7	75.3	89.1	4.6	1.6	0.3	4.5
WL87-46	471485	5877972	--	0.8	8.8	25.2	66.1	80.3	4.5	1.3	0.1	5.0	27.6	72.4	88.0	5.0	1.4	0.1	5.6
CF10-59	469583	5882035	--	0.7	13.4	18.7	67.9	77.5	3.9	1.2	0.3	3.6	21.7	78.3	89.4	4.6	1.4	0.3	4.3
CF14-66	469254	5879780	--	0.7	14.4	23.6	62.1	73.9	4.0	1.2	0.3	6.2	27.7	72.4	86.3	4.7	1.4	0.3	7.3
CF13-85	469258	5879838	--	0.7	16.0	22.4	61.6	73.6	4.0	1.2	0.2	4.9	26.7	73.3	87.7	4.8	1.4	0.2	5.9
CF12-94	469011	5880294	--	0.7	12.7	23.9	63.4	76.9	4.1	1.2	0.3	4.7	27.3	72.7	88.1	4.7	1.4	0.3	5.5
WL87-109	469370	5879719	--	0.7	10.7	23.1	66.3	79.0	4.2	1.3	0.4	4.4	25.8	74.2	88.4	4.7	1.5	0.5	5.0
WL87-111	469061	5880296	--	0.7	11.1	24.9	64.1	78.4	4.2	1.3	0.2	4.8	28.0	72.1	88.1	4.8	1.4	0.2	5.5
WL87-126	465610	5885687	--	0.7	27.9	18.1	54.1	63.0	3.4	1.1	0.3	4.2	25.1	75.0	87.4	4.7	1.5	0.4	5.9
WL87-127	465467	5885350	--	0.8	9.8	17.8	72.4	81.6	3.9	1.2	0.3	3.2	19.8	80.2	90.4	4.4	1.3	0.3	3.6
KBA-81/8	479920	5873100	--	1.6	27.0	21.4	51.5	61.3	3.7	1.0	0.2	6.8	29.4	70.6	84.0	5.0	1.4	0.3	9.3
CF19-94	479600	5872980	--	1.2	20.2	23.9	55.9	67.4	3.9	1.0	0.2	7.2	29.9	70.1	84.5	4.9	1.3	0.3	9.0
CF20-98	479640	5873060	--	1.3	8.2	27.8	63.9	77.9	4.7	1.3	0.3	7.6	30.2	69.6	84.9	5.1	1.4	0.3	8.3
CF21-101	479960	5873140	--	1.1	13.5	24.9	61.6	74.4	4.3	1.1	0.2	6.5	28.9	71.1	86.0	5.0	1.2	0.2	7.6
CF18-155	468450	5880588	--	1.1	19.4	21.4	59.2	72.3	4.0	1.0	0.3	2.9	26.6	73.4	89.7	5.0	1.3	0.4	3.6
CF17-162	468691	5880606	--	1.0	18.4	21.7	59.9	72.1	4.0	1.0	0.3	4.1	26.7	73.4	88.3	5.0	1.2	0.4	5.1
CF18-177	468610	5880558	--	7.3	12.8	28.4	58.9	68.4	3.2	0.9	0.2	14.5	32.5	67.6	78.5	3.7	1.0	0.2	16.6
CF23-178	472160	5877209	--	0.6	13.2	26.9	60.0	75.5	4.3	1.0	0.2	5.7	31.0	69.1	86.9	5.0	1.2	0.2	6.6
00481200	471633	5880076	15.9	--	30.5	16.0	53.5	--	--	--	--	--	23.0	77.0	--	--	--	--	--
00516880	457650	5889423	14.3	1.0	23.4	16.1	60.5	--	--	--	--	--	21.3	78.7	89.8	4.7	1.1	0.4	4.0
00516849	459334	5890088	4.7	0.5	14.2	19.8	66.0	--	--	--	--	--	23.2	76.8	89.6	4.9	1.2	0.5	3.8
00516856	458084	5889559	19.7	0.6	16.5	16.2	67.3	--	--	--	--	--	19.4	80.6	--	--	--	--	--
00516815	461387	5888963	6.6	1.6	7.2	20.8	72.0	--	--	--	--	--	22.4	77.6	--	--	--	--	--
00516898	458670	5890718	11.9	0.5	28.2	17.7	54.2	--	--	--	--	--	24.9	75.1	89.5	4.9	1.1	1.7	3.2
00272971	469429	5880180	--	0.6	--	--	--	--	--	--	--	--	27.7	72.3	--	--	--	0.3	--
00524074	469761	5879702	--	0.5	--	--	--	--	--	--	--	--	25.9	74.1	--	--	--	--	--
00524140	469654	5879909	--	0.8	--	--	--	--	--	--	--	--	24.9	75.1	--	--	--	--	--
00524157	469624	5879864	--	1.4	--	--	--	--	--	--	--	--	25.3	74.7	--	--	--	--	--
00524165	469299	5880103	--	1.1	--	--	--	--	--	--	--	--	26.7	73.3	--	--	--	--	--
00524173	469690	5879962	--	1.2	--	--	--	--	--	--	--	--	25.7	74.3	--	--	--	--	--
00524181	469214	5879970	--	2.7	--	--	--	--	--	--	--	--	28.7	71.3	--	--	--	--	--
00524199	469151	5879882	--	1.2	--	--	--	--	--	--	--	--	25.8	74.9	--	--	--	--	--
00524207	469574	5879969	--	0.8	--	--	--	--	--	--	--	--	25.4	74.6	--	--	--	--	--
00524215	469602	5880012	--	0.5	--	--	--	--	--	--	--	--	26.9	73.1	--	--	--	--	--
00524223	469226	5879822	--	0.7	--	--	--	--	--	--	--	--	26.3	73.7	--	--	--	--	--
00524231	469281	5879714	--	0.7	--	--	--	--	--	--	--	--	26.7	73.3	--	--	--	--	--
00524256	469503	5880041	--	0.9	--	--	--	--	--	--	--	--	26.9	73.1	--	--	--	--	--
00524264	469539	5880100	--	0.6	--	--	--	--	--	--	--	--	26.7	73.3	--	--	--	--	--
00524280	469341	5879803	--	0.5	--	--	--	--	--	--	--	--	26.9	73.1	--	--	--	--	--
00524298	469316	5879764	--	0.9	--	--	--	--	--	--	--	--	25.5	74.5	--	--	--	--	--
00524306	469885	5880073	--	1.0	--	--	--	--	--	--	--	--	24.1	75.9	--	--	--	--	--
00524371	469415	5880084	--	0.8	--	--	--	--	--	--	--	--	27.0	73.0	--	--	--	--	--
00524389	469389	5880229	--	1.6	--	--	--	--	--	--	--	--	25.5	74.5	--	--	--	--	--
00524397	469363	5880190	--	1.0	--	--	--	--	--	--	--	--	26.7	73.3	--	--	--	--	--
00524405	469337	5880148	--	0.9	--	--	--	--	--	--	--	--	26.4	73.6	--	--	--	--	--

Appendix 5. (continued)

Hole or Section	Location East	Location North	AR H2O	AD H2O	Dry Ash	Dry VM	Dry FC	Dry C	Dry H	Dry N	Dry S	Dry O	Dry Ash Free VM	Dry Ash Free FC	Dry Ash Free C	Dry Ash Free H	Dry Ash Free N	Dry Ash Free S	Dry Ash Free O
00524413	470009	5879545	--	1.0	--	--	--	--	--	--	--	--	25.6	74.4	--	--	--	--	--
00524439	469987	5879510	--	0.7	--	--	--	--	--	--	--	--	25.6	74.4	--	--	--	--	--
00524447	469387	5879696	--	1.4	--	--	--	--	--	--	--	--	27.8	72.2	--	--	--	--	--
00524462	469433	5879582	--	0.9	--	--	--	--	--	--	--	--	26.2	73.8	--	--	--	--	--
00524470	469823	5879268	--	0.5	--	--	--	--	--	--	--	--	32.3	67.7	--	--	--	--	--
00524496	469879	5879347	--	0.6	--	--	--	--	--	--	--	--	27.8	72.2	--	--	--	--	--
00524504	469908	5879390	--	0.3	--	--	--	--	--	--	--	--	28.4	71.6	--	--	--	--	--
00524678	469130	5880211	--	0.7	--	--	--	--	--	--	--	--	27.0	73.0	--	--	--	--	--
00524686	469865	5879681	--	0.9	--	--	--	--	--	--	--	--	25.4	74.6	--	--	--	--	--
00524702	469590	5879469	--	1.0	--	--	--	--	--	--	--	--	27.5	72.5	--	--	--	--	--
00524728	469572	5879612	--	2.0	--	--	--	--	--	--	--	--	33.8	66.2	--	--	--	--	--
00524736	469932	5879608	--	0.6	--	--	--	--	--	--	--	--	25.8	74.2	--	--	--	--	--
00524744	469478	5879645	--	1.1	--	--	--	--	--	--	--	--	28.1	71.9	--	--	--	--	--
00524751	469780	5879375	--	1.1	--	--	--	--	--	--	--	--	26.9	73.1	--	--	--	--	--
00524769	469700	5879801	--	0.9	--	--	--	--	--	--	--	--	26.1	73.9	--	--	--	--	--
00524777	469811	5879416	--	0.4	--	--	--	--	--	--	--	--	27.4	72.6	--	--	--	--	--
00524785	469812	5879417	--	0.4	--	--	--	--	--	--	--	--	29.2	70.8	--	--	--	--	--
00524835	469732	5879490	--	0.5	--	--	--	--	--	--	--	--	28.3	71.7	--	--	--	--	--
00524843	469709	5879458	--	1.1	--	--	--	--	--	--	--	--	24.5	75.5	--	--	--	--	--
00524868	469660	5879387	--	0.7	--	--	--	--	--	--	--	--	26.3	73.7	--	--	--	--	--
00524876	469649	5879372	--	0.7	--	--	--	--	--	--	--	--	26.0	74.0	--	--	--	--	--
00524892	469906	5879568	--	0.5	--	--	--	--	--	--	--	--	26.7	73.3	--	--	--	--	--
00524918	469654	5879544	--	0.6	--	--	--	--	--	--	--	--	27.3	72.7	--	--	--	--	--
00525105	469867	5880045	--	1.8	--	--	--	--	--	--	--	--	25.2	74.8	--	--	--	--	--
00525139	469845	5880013	--	0.7	--	--	--	--	--	--	--	--	24.6	75.4	--	--	--	--	--
00272948	469551	5882055	--	1.0	--	--	--	--	--	--	--	--	22.9	77.1	--	--	--	0.3	--
00272997	469169	5882170	--	0.7	--	--	--	--	--	--	--	--	22.0	78.0	--	--	--	0.4	--
00524025	470488	5881690	--	0.6	--	--	--	--	--	--	--	--	21.2	78.8	--	--	--	--	--
00524033	470465	5881710	--	0.8	--	--	--	--	--	--	--	--	22.2	77.8	--	--	--	--	--
00524041	470395	5881735	--	0.8	--	--	--	--	--	--	--	--	21.9	78.1	--	--	--	--	--
00524058	470616	5881595	--	0.6	--	--	--	--	--	--	--	--	20.7	79.3	--	--	--	--	--
00524082	470546	5881709	--	0.7	--	--	--	--	--	--	--	--	21.4	78.6	--	--	--	--	--
00524090	470121	5880710	--	0.9	--	--	--	--	--	--	--	--	22.4	77.6	--	--	--	--	--
00524363	470083	5880658	--	1.1	--	--	--	--	--	--	--	--	22.4	77.6	--	--	--	--	--
00524934	469916	5881742	--	0.8	--	--	--	--	--	--	--	--	20.2	79.8	--	--	--	--	--
00524942	470100	5880684	--	1.0	--	--	--	--	--	--	--	--	23.1	76.9	--	--	--	--	--
00524967	470128	5880720	--	0.7	--	--	--	--	--	--	--	--	23.5	76.5	--	--	--	--	--
00524975	469972	5881822	--	0.4	--	--	--	--	--	--	--	--	22.1	77.9	--	--	--	--	--
00524983	469798	5880841	--	0.9	--	--	--	--	--	--	--	--	23.3	76.7	--	--	--	--	--
00524991	469803	5880849	--	0.9	--	--	--	--	--	--	--	--	23.7	76.3	--	--	--	--	--
00525014	469693	5881924	--	0.5	--	--	--	--	--	--	--	--	22.6	77.4	--	--	--	--	--
00525022	469658	5881882	--	0.7	--	--	--	--	--	--	--	--	20.3	79.7	--	--	--	--	--
00525030	470125	5881686	--	0.7	--	--	--	--	--	--	--	--	22.5	77.5	--	--	--	--	--
00525048	470121	5881633	--	0.6	--	--	--	--	--	--	--	--	20.8	79.2	--	--	--	--	--
00525055	470126	5881583	--	0.7	--	--	--	--	--	--	--	--	20.5	79.5	--	--	--	--	--
00525063	469621	5881989	--	0.5	--	--	--	--	--	--	--	--	21.3	78.7	--	--	--	--	--
00525071	469593	5881960	--	0.5	--	--	--	--	--	--	--	--	22.6	77.4	--	--	--	--	--
00525089	469565	5881929	--	0.7	--	--	--	--	--	--	--	--	20.6	79.4	--	--	--	--	--
00272930	468573	5882057	--	1.2	--	--	--	--	--	--	--	--	23.9	76.1	--	--	--	0.3	--
00272955	468750	5882349	--	0.9	--	--	--	--	--	--	--	--	22.4	77.6	--	--	--	0.4	--
00272963	468739	5882611	--	0.6	--	--	--	--	--	--	--	--	23.7	76.3	--	--	--	0.4	--

Appendix 6-1. Coal rank data, Cardinal River property and nearby areas.

Fm = Formation/Member. GR = Grande Cache. GL = Gladstone. TO = Torrens. M = Moosebar.
Sm = Seam. JL = Jewel. R = R seam. T = Top. M = Middle. B = Bottom. U = Upper. L = Lower.
Thic = Thickness. G = Grabsample. C = Cuttings. CO = Composite W = Weathered.

Sample Identification						Rmax			A.S.T.M. Rank	Location	
I.D.	Pellet	Fm	Sm	Thic	Type	Mean	SD	N		Easting	Northing
9/87	945/87	GR	JL	--	GM	1.31	0.04	50	Medium-Volatile Bituminous	472902	5881494
56/87	992/87	GR	JL	--	GT	1.26	0.04	50	Medium-Volatile Bituminous	473050	5881198
57/87	993/87	GR	JL	--	GB	1.34	0.06	50	Medium-Volatile Bituminous	473050	5881198
WL8734	80/88	GR	JL	--	G	1.27	0.04	50	Medium-Volatile Bituminous	472822	5881043
WL8735	81/88	GR	JL	--	G	1.27	0.05	50	Medium-Volatile Bituminous	473162	5881284
WL8736	82/88	GR	JL	--	G	1.29	0.05	50	Medium-Volatile Bituminous	473162	5881284
WL8739	84/88	GR	JL	--	G	1.32	0.05	50	Medium-Volatile Bituminous	470786	5883142
WL8743	87/88	GR	JL	--	G	1.34	0.04	50	Medium-Volatile Bituminous	468865	5884482
WL8744	88/88	GR	JL	--	G	1.25	0.04	25	Medium-Volatile Bituminous	468865	5884482
CF16-C5	61/88	GR	JL	9.50	CO	1.31	0.04	50	Medium-Volatile Bituminous	472892	5881502
CF15-C6	62/88	GR	JL	13.83	CO	1.33	0.04	50	Medium-Volatile Bituminous	472960	5881107
CF2-C7	63/88	GR	JL	10.60	CO	1.32	0.05	50	Medium-Volatile Bituminous	473040	5881172
CF3-C8	64/88	GR	JL	12.10	CO	1.27	0.05	50	Medium-Volatile Bituminous	469345	5884294
15/83	327/83	GR	JL	1.20		1.38	0.06	50	Medium-Volatile Bituminous	472374	5880957
25/83	337/83	GR	JL		G	1.41	0.06	50	Medium-Volatile Bituminous	472200	5880660
CF4-C9	65/88	GR	JL	5.20	CO	1.34	0.04	50	Medium-Volatile Bituminous	472038	5880398
CF5-C10	66/88	GR	JL	4.03	CO	1.28	0.05	50	Medium-Volatile Bituminous	469390	5884092
CF9-C11	67/88	GR	JL	10.00	CO	1.10	0.04	50	Medium-Volatile Bituminous	471228	5877873
178/87	2004/87	GR	JL	--	GB	1.39	0.05	50	Medium-Volatile Bituminous	473378	5879591
179/87	2005/87	GR	JL	--	GT	1.41	0.03	50	Medium-Volatile Bituminous	473375	5879579
194/87	2006/87	GR	JL	9.95		1.41	0.04	50	Medium-Volatile Bituminous	473375	5879585
195/87	2007/87	GR	JL	--	G	1.40	0.04	50	Medium-Volatile Bituminous	473417	5879500
196/87	2008/87	GR	JL	--	G	1.43	0.04	50	Medium-Volatile Bituminous	473482	5879484
197/87	2009/87	GR	JL	--	G	1.40	0.04	50	Medium-Volatile Bituminous	473539	5879475
198/87	2010/87	GR	JL	--	G	1.43	0.04	50	Medium-Volatile Bituminous	473527	5879527
6/87	942/87	GR	JL	--	G	1.02	0.03	50	High-Volatile Bituminous	478090	5873850
70/87	1960/87	GR	JL	--	G	1.07	0.04	50	High-Volatile Bituminous	479120	5873600
71/87	1961/87	GR	JL	--	G	1.05	0.04	50	High-Volatile Bituminous	479260	5873560
72/87	1962/87	GR	JL	--	G	0.98	0.05	50	High-Volatile Bituminous	479340	5873500
73/87	1963/87	GR	JL	--	G	0.98	0.04	50	High-Volatile Bituminous	479420	5873460
74/87	1964/87	GR	JL	--	G	0.97	0.04	50	High-Volatile Bituminous	479520	5873420
75/87	1965/87	GR	JL	--	G	0.96	0.04	50	High-Volatile Bituminous	479660	5873380
76/87	1966/87	GR	JL	--	G	0.97	0.04	50	High-Volatile Bituminous	480100	5873120
81/87	1067/87	GR	JL	3.8+		0.99	0.04	50	High-Volatile Bituminous	479920	5873100
82/87	1068/87	GR	JL	--	GT	0.98	0.04	50	High-Volatile Bituminous	479920	5873100
93/87	1069/87	GR	JL	--	GB	0.93	0.05	50	High-Volatile Bituminous	479600	5872980
94/87	1070/87	GR	JL	8.80		1.03	0.05	50	High-Volatile Bituminous	479600	5872980
95/87	1071/87	GR	JL	--	GT	0.98	0.08	25	High-Volatile Bituminous	479600	5872980
98/87	2094/87	GR	JL	2.20		0.97	0.04	50	High-Volatile Bituminous	479640	5873060
99/87	2095/87	GR	JL	--	GT	0.98	0.04	50	High-Volatile Bituminous	479640	5873060
116/87	2097/87	GR	JL	12.1+		1.03	0.04	50	High-Volatile Bituminous	479960	5873140
117/87	2098/87	GR	JL	--	GB	1.03	0.03	50	High-Volatile Bituminous	479960	5873140
100/87	2096/87	GR	JL	--	GB	1.04	0.04	50	High-Volatile Bituminous	479820	5873200
202/87	2099/87	GR	JL	--	GU					477223	5874576
203/87	2100/87	GR	JL	--	G	1.07	0.05	50	High-Volatile Bituminous	477141	5874629
205/87	2102/87	GR	JL	--	G	1.05	0.03	50	High-Volatile Bituminous	477001	5874721
209/87	2106/87	GR	JL	--	G	1.08	0.04	50	High-Volatile Bituminous	476910	5874782
210/87	2107/87	GR	JL	--	GT	1.10	0.04	50	Medium-Volatile Bituminous	476548	5874977
211/87	2108/87	GR	JL	--	GB	1.02	0.04	50	High-Volatile Bituminous	476530	5874946
DL86-19	926/87	GR	JL	--	G	1.00	0.04	50	High-Volatile Bituminous	476360	5874980
150/88	634/88	GR	JL	--	G	1.08	0.05	50	High-Volatile Bituminous	476494	5874992
151/88	635/88	GR	JL	--	G	1.03	0.04	50	High-Volatile Bituminous	476418	5875032
152/88	636/88	GR	JL	6.3+	G	1.07	0.05	50	High-Volatile Bituminous	476393	5875051
153/88	637/88	GR	JL	14.00	G	1.01	0.04	50	High-Volatile Bituminous	476366	5875072
154/88	638/88	GR	JL	0.4+	G	0.93	0.05	50	High-Volatile Bituminous	476166	5875186
155/88	639/88	GR	JL	--	G	1.00	0.04	50	High-Volatile Bituminous	476050	5875278
156/88	640/88	GR	JL	8.0+	G	0.95	0.04	50	High-Volatile Bituminous	475795	5875411
157/88	641/88	GR	JL	2.0+	G	0.97	0.04	50	High-Volatile Bituminous	475759	5875435
162/88	646/88	GR	JL	--	G	1.02	0.03	50	High-Volatile Bituminous	475722	5875457
163/88	647/88	GR	JL	--	G	1.00	0.03	50	High-Volatile Bituminous	475634	5875491
165/88	649/88	GR	JL	--	G	0.97	0.03	50	High-Volatile Bituminous	475415	5875645
167/88	651/88	GR	JL	1.0+	G	1.01	0.04	50	High-Volatile Bituminous	474924	5875964
168/88	652/88	GR	JL	--	G	0.92	0.04	50	High-Volatile Bituminous	474829	5876029
169/88	653/88	GR	JL	--	C	1.01	0.04	50	High-Volatile Bituminous	474669	5876164
170/88	654/88	GR	JL	--	G	0.93	0.03	50	High-Volatile Bituminous	474201	5876514
171/88	655/88	GR	JL	1.0+	G	1.01	0.05	50	High-Volatile Bituminous	474277	5876468
172/88	656/88	GR	JL	--	G	1.00	0.04	50	High-Volatile Bituminous	473411	5876973

Appendix 6-1. (continued)

Sample Identification						Rmax			A.S.T.M. Rank	Location	
I.D.	Pellet	Fm	Sm	Thic	Type	Mean	SD	N		Easting	Northing
173/88	657/88	GR	JL	1.0+	G	0.98	0.04	50	High-Volatile Bituminous	473223	5877096
174/88	658/88	GR	JL	--	G	1.03	0.04	50	High-Volatile Bituminous	473111	5877121
179/88	627/88	GR	JL	9.40		1.02	0.04	50	High-Volatile Bituminous	472221	5877288
175/88	628/88	GR	JL	2.50	T	0.98	0.05	50	High-Volatile Bituminous	472221	5877288
176/88	629/88	GR	JL	2.20		0.99	0.05	50	High-Volatile Bituminous	472221	5877288
177/88	630/88	GR	JL	2.20		0.95	0.06	50	High-Volatile Bituminous	472221	5877288
178/88	631/88	GR	JL	2.20	B	0.99	0.05	50	High-Volatile Bituminous	472221	5877288
WL88-1	662/88	GR	JL	--	G	1.33	0.05	50	Medium-Volatile Bituminous	471894	5879658
Other seams than Jewel:											
58/87	994/87	GR	R	--	G	1.07	0.05	50	High-Volatile Bituminous	473219	5881344
63/87	999/87	GR	R	--	G	1.22	0.04	50	Medium-Volatile Bituminous	473100	5880912
64/87	1000/87	GR	R	--	G	1.19	0.05	50	Medium-Volatile Bituminous	473131	5881209
65/87	1001/87	GR	R	2.00		1.24	0.04	50	Medium-Volatile Bituminous	473202	5881268
66/87	1002/87	GR	R	0.40		1.22	0.03	50	Medium-Volatile Bituminous	473202	5881268
CF4-7	69/88	GR	R	2.37	CO	1.29	0.06	50	Medium-Volatile Bituminous	472097	5880495
20/83	332/83	GR	R	1.00		1.30	0.06	50	Medium-Volatile Bituminous	472380	5880860
CF5-5	68/88	GR	R	3.62	CO	1.20	0.05	50	Medium-Volatile Bituminous	469436	5884153
CF9-10	71/88	GR	R	0.50		1.06	0.05	50	High-Volatile Bituminous	471378	5877921
WL8725	1008/87	GR	R	--	G	1.22	0.04	50	Medium-Volatile Bituminous	472810	5880997
WL8729	1012/87	GR	R	--	G	1.18	0.04	50	Medium-Volatile Bituminous	472950	5881033
WL8730	1013/87	GR	R	--	G	1.20	0.04	50	Medium-Volatile Bituminous	473161	5881132
WL8740	85/88	GR	R	--	G	1.18	0.05	50	Medium-Volatile Bituminous	470296	5883663
199/87	2011/87	GR	R	--	GB	1.24	0.04	50	Medium-Volatile Bituminous	473550	5879341
200/87	2012/87	GR	R	--	GT	1.25	0.05	50	Medium-Volatile Bituminous	473550	5879341
WL8745	89/88	TO		--	G	0.89	0.06	50	High-Volatile Bituminous	471198	5877864
CF9-3	74/88	TO		0.90		1.01	0.06	50	High-Volatile Bituminous	471198	5877864
204/87	2101/87	TO		0.80		1.00	0.05	50	High-Volatile Bituminous	477095	5874644
206/87	2103/87	TO		0.25		0.93	0.05	50	High-Volatile Bituminous	476995	5874709
207/87	2104/87	TO		0.08		1.00	0.04	50	High-Volatile Bituminous	476995	5874709
208/87	2105/87	TO		0.15		0.97	0.04	50	High-Volatile Bituminous	476995	5874709
158/88	642/88	TO		0.29		0.95	0.04	50	High-Volatile Bituminous	475752	5875428
159/88	643/88	TO		0.26		0.94	0.04	50	High-Volatile Bituminous	475752	5875428
160/88	644/88	TO		0.32		0.97	0.06	50	High-Volatile Bituminous	475752	5875428
161/88	645/88	TO		0.91		0.94	0.05	50	High-Volatile Bituminous	475752	5875428
164/88	648/88	TO		1.0		0.98	0.04	50	High-Volatile Bituminous	475627	5875484
166/88	650/88	TO		0.85		0.90	0.04	50	High-Volatile Bituminous	475452	5875617
CF23-2	659/88	TO		0.32		0.95	0.05	50	High-Volatile Bituminous	472188	5877288
CF23-3	660/88	TO		0.40		0.94	0.05	50	High-Volatile Bituminous	472188	5877288
CF23-4	661/88	TO		0.37		0.98	0.03	50	High-Volatile Bituminous	472188	5877288
CF9-1	72/88	MO		0.05		1.08	0.05	50	High-Volatile Bituminous	471076	5877834
CF9-2	73/88	MO		0.10		0.94	0.05	50	High-Volatile Bituminous	471115	5877849
CF23-1	663/88	MO		0.10		1.01	0.03	50	High-Volatile Bituminous	472161	5877282
59/87	995/87	GR	A	0.10		1.20	0.04	50	Medium-Volatile Bituminous	473249	5881360
60/87	996/87	GR	A	0.70		1.12	0.04	50	Medium-Volatile Bituminous	473249	5881360
61/87	997/87	GR	B	0.30		1.07	0.04	50	High-Volatile Bituminous	473249	5881360
62/87	998/87	GR	B	0.50		1.22	0.04	50	Medium-Volatile Bituminous	473249	5881360
WL8742	86/88	GR		--	G	1.14	0.06	50	Medium-Volatile Bituminous	469717	5884298
CF4-11	70/88	GR	A	0.50		1.35	0.05	50	Medium-Volatile Bituminous	472128	5880541
WL8724	1007/87	GR	A	--	G	1.21	0.04	50	Medium-Volatile Bituminous	472776	5880954
WL8726	1009/87	GR	C	--	G	1.18	0.03	50	Medium-Volatile Bituminous	472819	5880921
WL8727	1010/87	GR	B	--	G	1.09	0.03	50	High-Volatile Bituminous	472840	5880948
WL8728	1011/87	GR	A	--	G	1.18	0.04	50	Medium-Volatile Bituminous	472923	5881008
WL8731	1014/87	GR	A	--	G	1.08	0.03	50	High-Volatile Bituminous	473239	5881068
201/87	2013/87	GR	A?	0.10		1.14	0.04	50	Medium-Volatile Bituminous	474424	5879241
CF23-10	632/88	GR		0.10		1.02	0.05	50	High-Volatile Bituminous	472222	5877340
CF23-11	633/88	GR		0.15		0.98	0.05	50	High-Volatile Bituminous	472225	5877340
7/87	943/87	MP		--	G	0.96	0.05	50	High-Volatile Bituminous	478160	5874120
8/87	944/87	MP		0.30		0.88	0.03	50	High-Volatile Bituminous	478160	5874140
WL8738	83/88	MP		--	G	1.11	0.04	50	Medium-Volatile Bituminous	470706	5883496
5/87	941/87	GL	2?	0.30		1.01	0.03	50	High-Volatile Bituminous	478040	5873760

Appendix 6-2. Coal rank data, Gregg River property.

Sample Identification						Rmax			A.S.T.M. Rank	Location	
I.D.	Pellet	Fm	Sm	Th.	Type	Mean	SD	N		Easting	Northing
WL8761	91/88	GR	JL	--	GW	1.36	0.06	50	Medium-Volatile Bituminous	468353	5882570
WL8762	92/88	GR	JL	--	GW	1.34	0.06	50	Medium-Volatile Bituminous	468299	5882812
WL8763	93/88	GR	JL	--	GW	1.04	0.05	50	High-Volatile Bituminous	467645	5881360
WL8764	94/88	GR	JL	--	G	1.27	0.04	50	Medium-Volatile Bituminous	468146	5882264
WL8765	95/88	GR	JL	--	G	1.40	0.05	50	Medium-Volatile Bituminous	469288	5882277
WL87113	97/88	GR	JL	--	C	1.35	0.05	50	Medium-Volatile Bituminous	467747	5883244
WL87114	98/88	GR	JL	--	C	1.40	0.06	50	Medium-Volatile Bituminous	467381	5882684
WL87116	100/88	GR	JL	--	G	1.33	0.04	50	Medium-Volatile Bituminous	466809	5883106
WL87117	101/88	GR	JL	--	C	1.40	0.06	50	Medium-Volatile Bituminous	467552	5883581
WL87118	102/88	GR	JL	--	C	1.41	0.04	25	Medium-Volatile Bituminous	466110	5883409
WL87120	103/88	GR	JL	--	GW	1.25	0.05	50	Medium-Volatile Bituminous	465880	5882551
WL87121	104/88	GR	JL	--	G	1.08	0.05	50	High-Volatile Bituminous	465763	5882582
WL87124	107/88	GR	JL	--	G	1.34	0.07	25	Medium-Volatile Bituminous	463968	5885433
WL87125	108/88	GR	JL	--	GW	1.25	0.05	50	Medium-Volatile Bituminous	464469	5884962
WL87126	109/88	GR	JL	--	C	1.24	0.05	50	Medium-Volatile Bituminous	465610	5885687
WL87127	110/88	GR	JL	--	C	1.35	0.04	50	Medium-Volatile Bituminous	465467	5885350
WL87128	111/88	GR	JL	--	G	1.29	0.06	50	Medium-Volatile Bituminous	465420	5885031
WL87129	112/88	GR	JL	--	C	1.32	0.07	50	Medium-Volatile Bituminous	465896	5885361
WL87130	113/88	GR	JL	--	C	1.19	0.05	50	Medium-Volatile Bituminous	467255	5884963
CF14-C1	56/88	GR	JL	10.05	CO	1.15	0.05	50	Medium-Volatile Bituminous	469254	5879780
CF13-C2	57/88	GR	JL	8.60	CO	1.17	0.04	50	Medium-Volatile Bituminous	469258	5879838
CF12-C3	58/88	GR	JL	12.05	CO	1.15	0.05	50	Medium-Volatile Bituminous	469011	5880294
CF8-C4A	59/88	GR	JL	6.60	CO	1.18	0.04	50	Medium-Volatile Bituminous	468936	5880344
CF8-C4B	60/88	GR	JL	3.10	CO	1.19	0.04	50	Medium-Volatile Bituminous	468942	5880352
75/86	942/86	GR	JL	--	G	1.34	0.04	50	Medium-Volatile Bituminous	470616	5881646
121/86	950/86	GR	JL	--	GT	1.31	0.03	50	Medium-Volatile Bituminous	469583	5882035
122/86	951/86	GR	JL	--	GB	1.40	0.04	50	Medium-Volatile Bituminous	469583	5882035
81/86	947/86	GR	JL	--	GT	1.40	0.05	50	Medium-Volatile Bituminous	469510	5881910
108/86	948/86	GR	JL	--	GB	1.31	0.04	50	Medium-Volatile Bituminous	469519	5881922
73/86	940/86	GR	JL	--	G	1.27	0.07	50	Medium-Volatile Bituminous	470043	5880948
79/86	946/86	GR	JL	--	G	1.13	0.04	50	Medium-Volatile Bituminous	469018	5880626
78/86	945/86	GR	JL	--	G	1.17	0.05	50	Medium-Volatile Bituminous	468999	5880615
74/86	941/86	GR	JL	--	GM	1.18	0.04	50	Medium-Volatile Bituminous	469578	5880080
77/86	944/86	GR	JL	--	GU	1.09	0.04	50	High-Volatile Bituminous	468963	5880374
76/86	943/86	GR	JL	--	GL	1.15	0.04	50	Medium-Volatile Bituminous	468958	5880359
123/87	1977/87	GR	JL	--	GB	1.13	0.03	50	Medium-Volatile Bituminous	469362	5879671
124/87	1978/87	GR	JL	--	GB	1.13	0.03	50	Medium-Volatile Bituminous	469370	5879719
125/87	1979/87	GR	JL	--	GB	1.16	0.03	50	Medium-Volatile Bituminous	469376	5879728
126/87	1980/87	GR	JL	--	GB	1.40	0.06	50	Medium-Volatile Bituminous	470683	5881540
139/87	1981/87	GR	JL	--	GM	1.15	0.04	50	Medium-Volatile Bituminous	468942	5880352
154/87	1983/87	GR	JL	--	GT	1.25	0.05	50	Medium-Volatile Bituminous	468450	5880588
155/87	1984/87	GR	JL	5.5		1.19	0.03	50	Medium-Volatile Bituminous	468450	5880588
160/87	1989/87	GR	JL	--	G	1.21	0.05	50	Medium-Volatile Bituminous	468371	5880810
161/87	1990/87	GR	JL	--	G	1.23	0.04	50	Medium-Volatile Bituminous	468429	5880879
162/87	1991/87	GR	JL	1.00		1.19	0.03	50	Medium-Volatile Bituminous	468691	5880606
163/87	1992/87	GR	JL	1.00		1.17	0.04	50	Medium-Volatile Bituminous	468691	5880606
164/87	1993/87	GR	JL	0.80		1.22	0.04	50	Medium-Volatile Bituminous	468691	5880606
165/87	1994/87	GR	JL	--	GB	1.18	0.05	50	Medium-Volatile Bituminous	468691	5880606
166/87	1995/87	GR	JL	--	GT	1.22	0.05	50	Medium-Volatile Bituminous	468691	5880606
167/87	1996/87	GR	JL	--	GB	1.15	0.04	50	Medium-Volatile Bituminous	468566	5880582
168/87	1997/87	GR	JL	--	G	1.18	0.03	50	Medium-Volatile Bituminous	468572	5880590
169/87	1998/87	GR	JL	--	GB	1.16	0.04	50	Medium-Volatile Bituminous	468583	5880607
169/87	1999/87	GR	JL	--	GT	1.18	0.04	50	Medium-Volatile Bituminous	468616	5880558
170/87	2000/87	GR	JL	--	G	1.09	0.04	50	High-Volatile Bituminous	468572	5880590
175/87	2001/87	GR	JL	--	GB	1.11	0.04	50	Medium-Volatile Bituminous	468610	5880558
176/87	2002/87	GR	JL	--	GT	1.04	0.05	50	High-Volatile Bituminous	468610	5880558
177/87	2003/87	GR	JL	4.10		1.13	0.04	50	Medium-Volatile Bituminous	468610	5880558
Other seams than Jewel:											
CF7-1	75/88	GR			G	1.13	0.05	50	Medium-Volatile Bituminous	469246	5879749
CF7-2,4	77/88	GR	R	0.90	CO	1.10	0.06	50	Medium-Volatile Bituminous	469205	5879849
109/86	949/86	GR	R	--	G	0.98	0.07	50	High-Volatile Bituminous	469550	5881986
CF8-1	76/88	TO		0.20		0.98	0.05	50	High-Volatile Bituminous	468925	5880291
156/87	1985/87	TO		0.08		0.98	0.04	50	High-Volatile Bituminous	468445	5880688
157/87	1986/87	TO		0.10		1.06	0.05	50	High-Volatile Bituminous	468445	5880688
158/87	1987/87	TO		0.03		1.05	0.03	50	High-Volatile Bituminous	468405	5880594
159/87	1988/87	TO		0.78		1.05	0.04	50	High-Volatile Bituminous	468405	5880594
WL87115	99/88	GL		--	C	1.55	0.06	50	Low-Volatile Bituminous	467558	5882769
WL87122	105/88	GL		--	G	1.16	0.05	50	Medium-Volatile Bituminous	465647	5882491
WL87123	106/88	GL		--	G	1.15	0.05	50	Medium-Volatile Bituminous	465689	5884018
WL8793	96/88	NI		--	G	1.06	0.05	50	High-Volatile Bituminous	469237	5879647

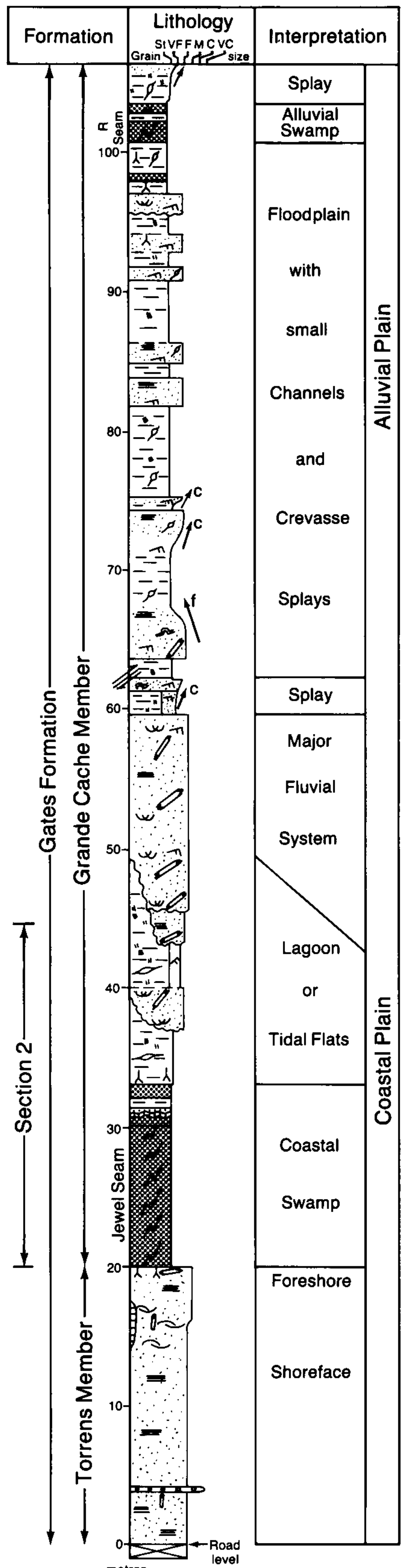
Appendix 7. Stratigraphic sections examined.

Legend:

Sandstone	Trough x-strata
Conglomerate	Ripples
Interbedded mudstone/coal (<25% coal)	Soft sediment deformation
Clay-shale Claystone	Roots
Siltstone Siltshale	Leaf imprints
Interbedded claystone Mudstone (<25% claystone)	Log or stems
Mudstone Mudshale	Basal lag
Interbedded sandstone Claystone (>50% sandstone)	Parallel stratification
Interbedded sandstone Claystone (>75% sandstone)	Intraclasts
Coal with 5 cm parting	Graded bedding
Bentonite bed	Slickensides
Low-angle x-strata	Fault
Hummocky cross stratification	G Glauconitic
Very fn interlaminated	(B) Bioturbated
Carbonaceous matter-particles	(F) Forams
Shells (marine)	Gradational contact
f Fining-upward cycle	Sharp contact
c Coarsening-upward cycle	Burrows (vertical, horizontal, with spriten, branching)
c C Carbonaceous matter-finely disseminated	x x x x Ironstone band
Carbonaceous matter in thin laminae	Erosional contact
Tectonically thinned coal	Brackish

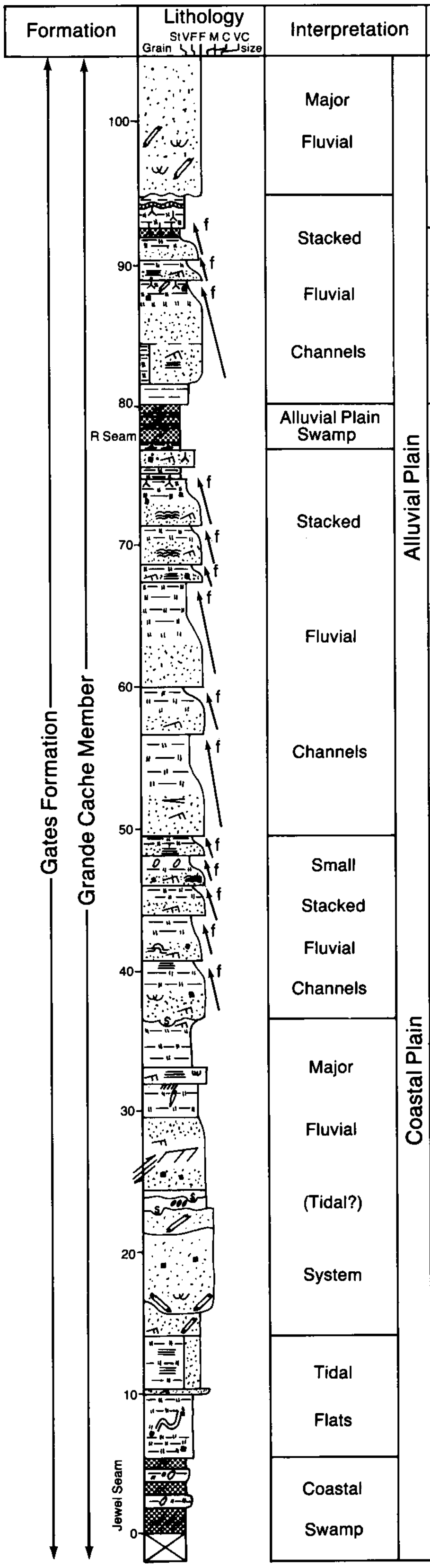
Appendix 7. (continued)

Sections 1 and 2



Appendix 7. (continued)

Section 4



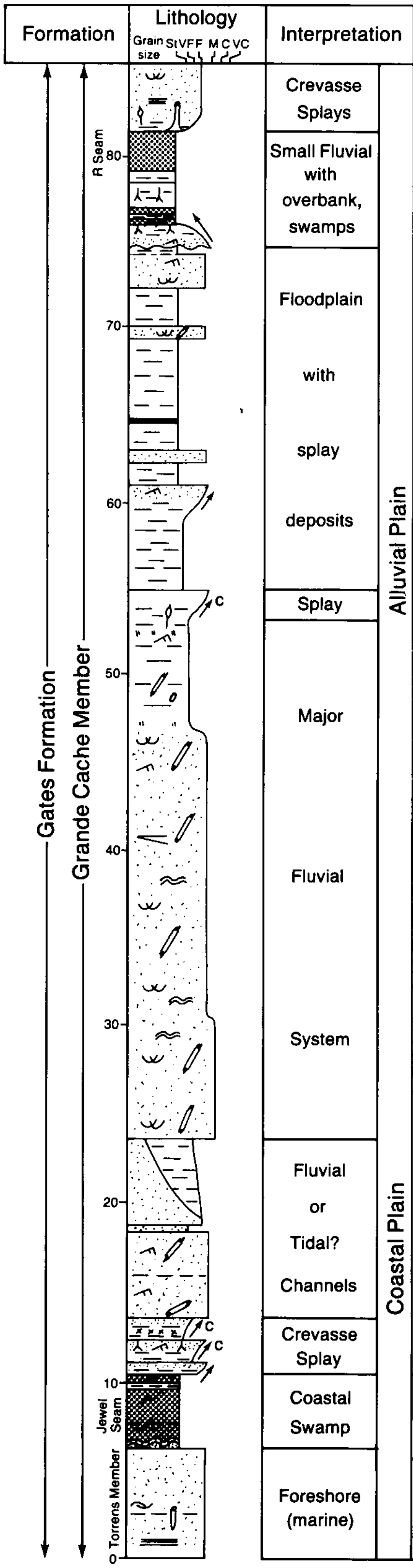
Ash (d)	V.M. (daf)	F.C. (daf)	C (daf)	H (daf)	N (daf)	S (d)
8.4	21.5	78.5	90.7	4.5	1.39	0.49

Ash (d)	V.M. (daf)	F.C. (daf)	C (daf)	H (daf)	N (daf)	S (d)
41.5	26.4	73.6	84.2	4.8	1.59	0.36
44.0	26.5	73.5	84.2	4.8	1.76	0.48
26.6	23.4	76.6	87.8	4.6	1.54	0.49

Ash (d)	V.M. (daf)	F.C. (daf)	C (daf)	H (daf)	N (daf)	S (d)
39.6	24.1	75.9	86.7	4.6	1.57	0.27
19.1	23.1	76.9	89.6	4.6	1.47	0.33
16.1	24.3	75.7	89.5	4.4	1.47	0.22

Appendix 7. (continued)

Section 5 (Upper half)



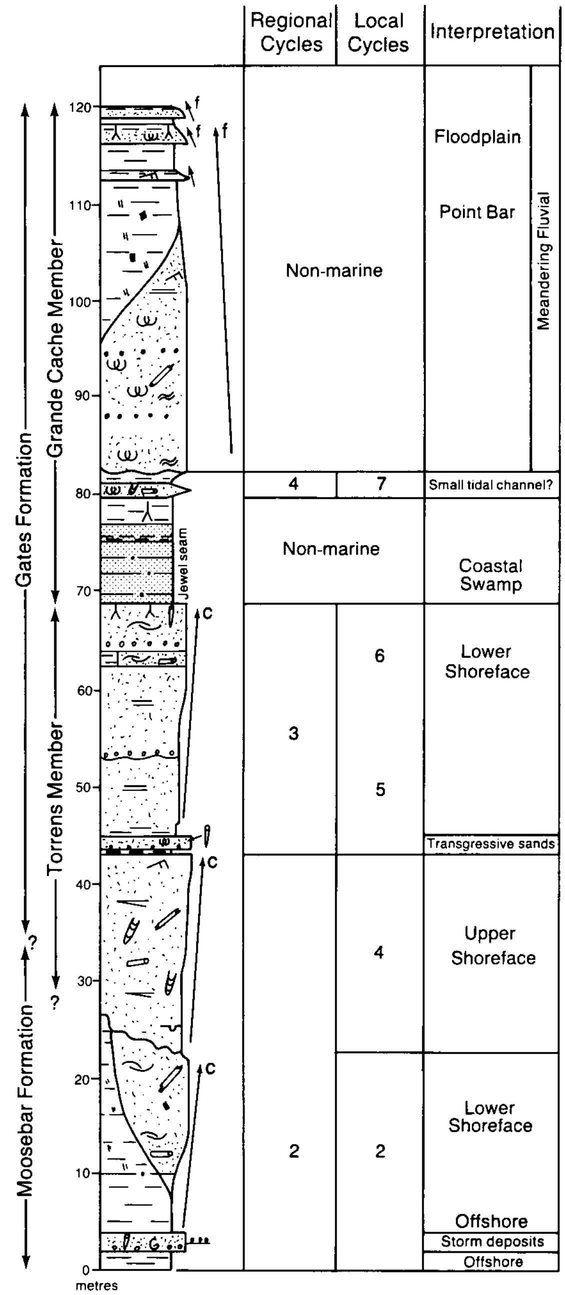
Coal Quality

Ash (d)	V.M. (daf)	F.C. (daf)	C (daf)	H (daf)	N (daf)	S (d)
43.5	28.5	71.5	84.2	4.9	1.65	0.30
26.8	26.9	73.1	86.6	4.8	1.66	0.54
18.2	25.2	74.8	87.4	4.6	1.58	0.14

Ash (d)	V.M. (daf)	F.C. (daf)	C (daf)	H (daf)	N (daf)	S (d)
15.9	25.3	74.7	88.5	4.9	1.53	0.61
15.5	23.1	76.9	90.2	4.6	1.48	0.28
13.6	23.9	76.0	90.1	4.8	1.48	0.38

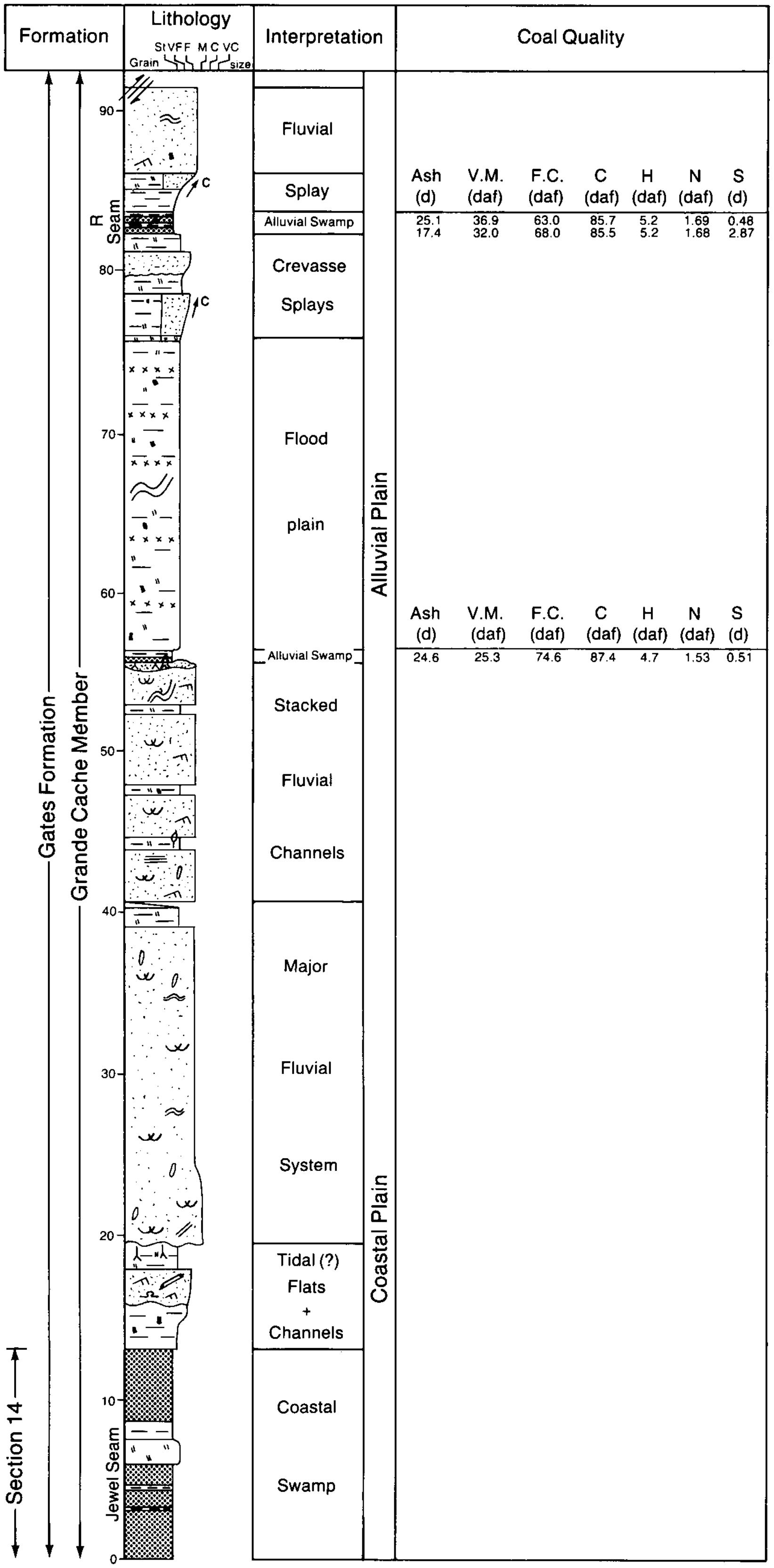
Appendix 7. (continued)

Section 6



Appendix 7. (continued)

Sections 7 and 14

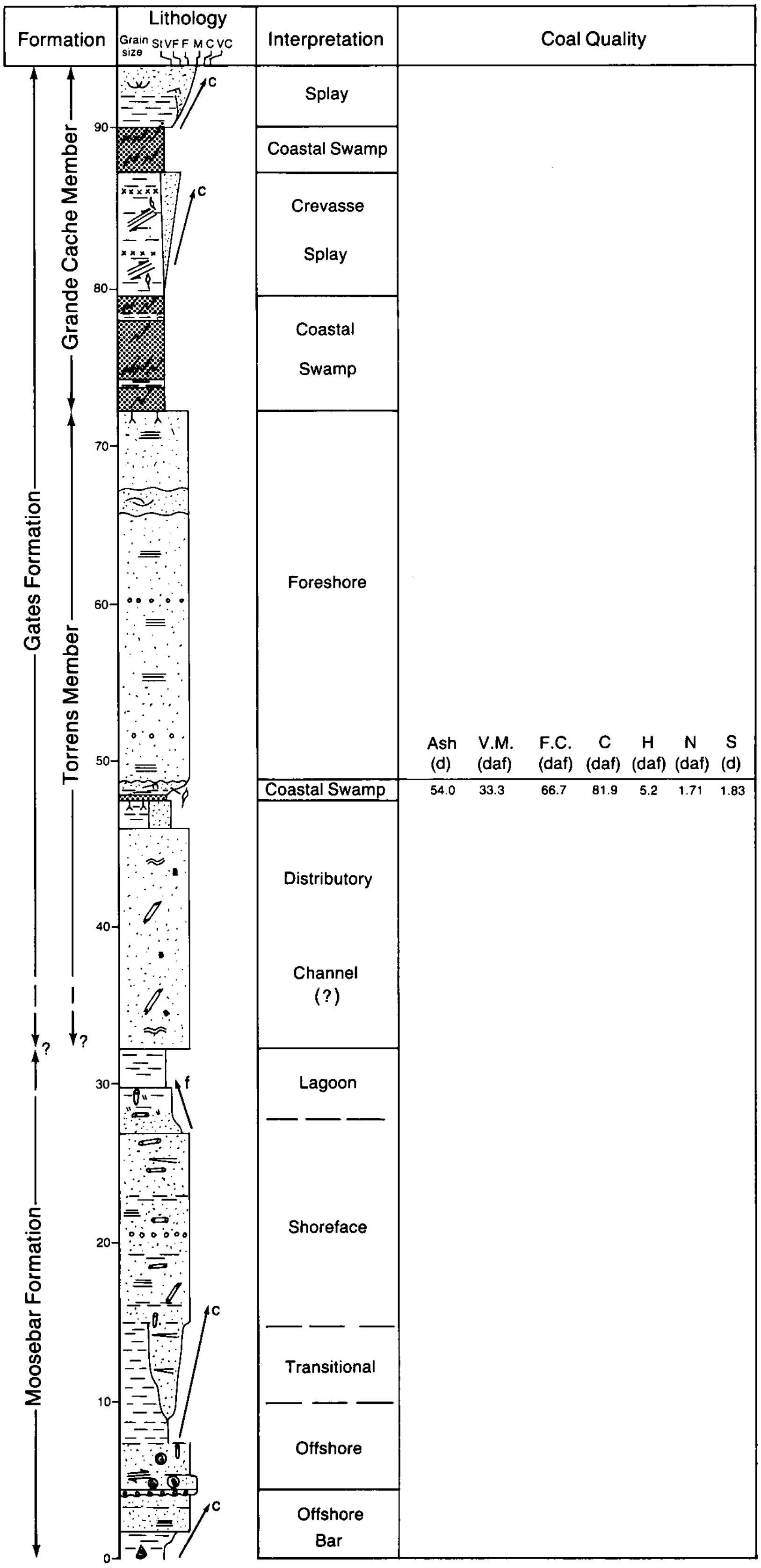


Ash (d)	V.M. (daf)	F.C. (daf)	C (daf)	H (daf)	N (daf)	S (d)
25.1	36.9	63.0	85.7	5.2	1.69	0.48
17.4	32.0	68.0	85.5	5.2	1.68	2.87

Ash (d)	V.M. (daf)	F.C. (daf)	C (daf)	H (daf)	N (daf)	S (d)
24.6	25.3	74.6	87.4	4.7	1.53	0.51

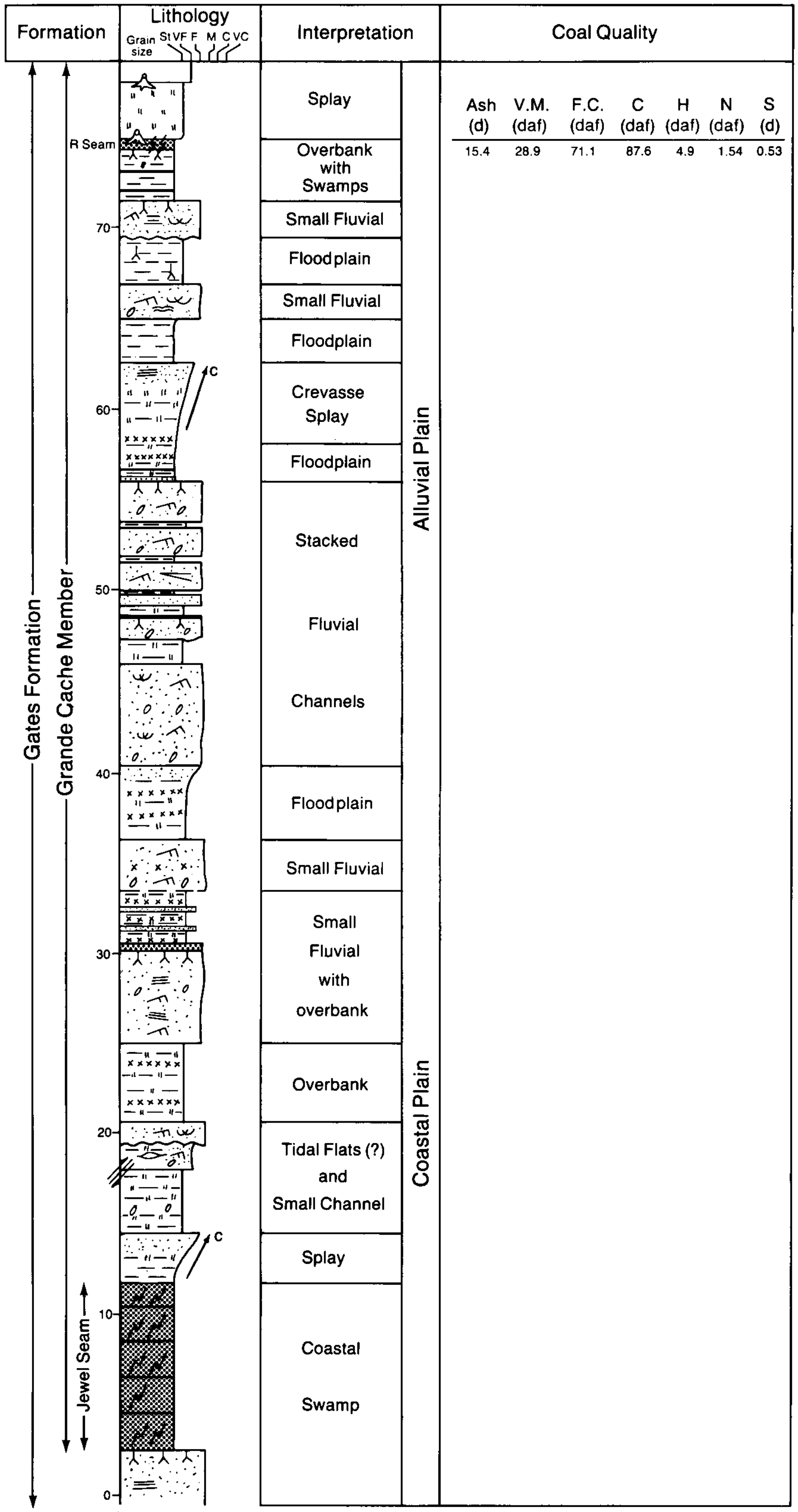
Appendix 7. (continued)

Section 8



Appendix 7. (continued)

Section 9 (upper half)



Appendix 7. (continued)

Section 9 (lower half)