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Petroleum Resources
Hon. Anne Edwards

MINERAL RESOURCES DIVISION
Geological Survey Branch

GEOLOGY AND RANK DISTRIBUTION OF THE ELK VALLEY COALFIELD, SOUTHEASTERN BRITISH COLUMBIA (82G/15, 82J/2, 6, 7, 10, 11)

by D. A. Grieve

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ABSTRACT

The Elk Valley coalfield is one of three structurally separate coalfields in southeastern British Columbia. Total potential *in situ* coal resources are a minimum of 7.8 billion tonnes.

The coal-bearing Mist Mountain Formation ranges from less than 425 to approximately 700 metres in thickness in the study area. An average of approximately 10 per cent of its total thickness is composed of coal seams, which range up to 13 metres in thickness. The basal 20 metres of the formation, referred to informally as the "basal coal zone", consistently contains coal and other carbonaceous strata. The "Imperial seam", in the lower half of the formation, is correlated laterally in drill core and surface exposures over a distance of approximately 17 kilometres.

Lithologies in the Mist Mountain Formation form a Markov chain. The data confirm a general fining-upward sequence typical of fluvial-alluvial depositional systems. The coal-forming environment is believed to have been relatively isolated from sources of clastic material. In terms of statistical sequence modelling, the lower half of the Mist Mountain Formation is not significantly different from the upper half.

Tonsteins are found throughout the Mist Mountain Formation. Lateral continuity of tonsteins over a distance of 1.4 kilometres is documented in two cases. The tonsteins are believed to represent volcanic ash, possibly reworked. All are kaolinite rich, and one example is also rich in the phosphate mineral gorceixite.

Vitrinite is the most abundant maceral in coals from the study area, comprising 51 to 93 per cent of total organic material. In general, the amount of vitrinite increases up-section. Semifusinite is the most abundant inertinite maceral and its concentration is inversely related to that of vitrinite. Liptinite is generally rare or nonexistent, although coals in sections of predominantly high-volatile rank contain 1 to 5 per cent liptinite. Petrographic indices suggest vegetation was deposited *in situ*, although there is some indication that the relative amount of movement of vegetation prior to deposition decreased up-section. It is also apparent that the height of the water table generally increased higher in the stratigraphy.

The major structure of the Elk Valley coalfield is the Alexander Creek syncline. Overall it has a north-northwest trend, and no net plunge. Locally its plunge is subhorizontal to gentle. It is generally asymmetric, open, and has an upright to steeply inclined axial plane. Thrust faults, including the Ewin Pass fault, are more common on the east limb than on the west. Other major structures in the coalfield are the Greenhills syncline, which is separated from the Alexander Creek syncline to the east by the west-dipping Erickson normal fault, and the Bourgeau thrust fault, which marks the western boundary of the northern part of the coalfield.

Based on mean maximum vitrinite reflectance ($\bar{R}_{max}$), coal ranks in the Mist Mountain Formation generally range from low-volatile to high-volatile A bituminous, with a few instances of high-volatile B bituminous. Reflectance gradients within measured stratigraphic sections range from 0.057 to 0.119 per cent per 100 metres, with no systematic geographic variation. At most locations, the lower part of the formation contains coals of medium-volatile bituminous rank, typically with reflectance values of 1.3 to 1.4 per cent. At three locations (Crown Mountain, Mount Banner and Weary Creek) the coals in the lower part of the formation are of low-volatile rank. At one location (Bleasdell Creek), the entire formation contains high-volatile coals.

Determination of the principal axes of the reflecting indicating surface (RIS) of coal samples suggests that all coals in the study area are biaxial. Values of R_{st}, the reflectance parameter which represents the style of the RIS, range from −16.537 (biaxial negative) to +5.209 (biaxial positive) and, for the most part, do not vary systematically. All of the following reflectance parameters are effective indices of rank variation: $\bar{R}_{max}$, $\bar{R}_{m}$ (mean random reflectance), R_{ev} (the radius of a sphere of volume equal to that of the RIS) and R_{max} (the magnitude of the maximum axis of the RIS).

There is no firm evidence of down-dip rank increases indicating the occurrence of post-folding coalificaton in the Elk Valley coalfield. However, the RIS analysis suggests that coalification was at least partly concurrent with compressional deformation, and other aspects of the rank distribution suggest that it continued after the compressional deformation stage. On balance, it is believed that coalification occurred before, during and after compressional deformation, but completely predated the later extensional phase.

A wide spread of bituminous coal quality is available in the coalfield. Volatile matter content (dry, ash-free) in selected raw bulk-sample analyses from three properties ranges from 20.9 to 30.9 per cent. Ash content in the same samples varies from 6.5 to 33.1 per cent, while sulphur values are all less than or equal to 0.7 per cent. Current products from the coalfield include coking coals of varying volatile matter content, semicoking coals and thermal coals.

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CHAPTER 1: INTRODUCTION

The Elk Valley coalfield is one of three structurally separate coalfields in southeastern British Columbia which together comprise the East Kootenay coalfields. The others are the Crowsnest and Flathead coalfields (Figure 1). The Elk Valley coalfield has also been referred to as the Upper Elk coalfield (Irvine, 1972).

Coal in southeastern British Columbia belongs mainly to the Mist Mountain Formation of the Jurassic-Cretaceous Kootenay Group (Figure 2). The structural setting of the East Kootenay coalfields is the Front Ranges of the southern Rocky Mountains. Major structures within the Elk Valley coalfield are the Alexander Creek syncline, named for a creek at its south end, and the Greenhills syncline, named for the Greenhills Range (Figure 3). The two synclines are separated by the west-dipping Erickson normal fault. The northernmost one-third of the coalfield is directly bounded to the west by the west-dipping Bourgeau thrust fault.

The coalfield is elongate, and its length within British Columbia is approximately 100 kilometres. It is widest near the Fording mine (12.5 kilometres), and otherwise generally averages 4 to 5 kilometres in width. Its south end is approximately 12 kilometres northeast of Sparwood, and its north end is north of Elk Pass on the British Columbia - Alberta border (Figure 1). With the exception of its southern extremity, the coalfield is continuous.

DEVELOPMENT HISTORY

Coal in southeastern British Columbia was discovered in 1873 at Morrissey Creek in the Crowsnest coalfield. Rapid development preceded and followed the construction of the Crows Nest Branch of the Canadian Pacific Railway, with collieries opened at five locations in the Crowsnest coalfield: Coal Creek in 1897, Michel Creek in 1899, Morrissey Creek in 1901, Hosmer Creek and Coal Mountain (Corbin) in 1908. The granting of freehold rights to coal lands in southeastern British Columbia, including large portions of the Elk Valley coalfield, representing land grants to railway companies, dates back to these early years of activity.

The Elk Valley coalfield was also explored near the turn of the century, but the lack of a rail line up the Elk Valley north of Sparwood precluded any development at that time. Nonetheless, adits were driven at several locations in the years 1908 to 1910, including Greenhills Range, Bingay Creek, Ewin Creek and Aldridge Creek. The owners of these coal rights, which included the Canadian Pacific Railway and the Imperial Coal and Coke Company, were confident that the necessary rail line would be built, allowing timely development.

Subsequently exploration of the coalfield tapered off for several decades, as the coal industry experienced uncertain times. Exploration of a large block of licences in the Fording River area was carried out by Utah Corporation of the Americas in the 1950s. By the middle to late 1960s several companies, including Cominco Ltd., Rio Tinto Canadian Exploration Limited, McIntyre Porcupine Mines Limited, Crows Nest Industries Limited, North American Coal Corporation and Scurry-Rainbow Oil Limited, were active in exploring parts of the coalfield. This activity was spurred by the potential of securing Japanese markets for coking coal. It culminated with the opening of the Fording River mine by Fording Coal Limited, then a Cominco subsidiary, in 1972.

Subsequent exploration throughout the coalfield continued at a high level until 1981. The most active areas were the Elk River property, especially Weary and Little Weary Ridges (Elco Mining Ltd. and partners), Line Creek (Crows Nest Industries Limited, later Crows Nest Resources Limited) and the Greenhills Range (Kaiser Resources Ltd., later B.C. Coal Ltd., now Westar Mining Ltd.). The climax of this activity was the opening of Crows Nest Resources' Line Creek mine and Westar Mining's Greenhills operations in 1982. A mine proposed by Elco Mining at Little Weary Ridge on the Elk River property has not been constructed, and the company has since sold its interest in the property. The Line Creek mine was sold to Manalta Coal Ltd. in 1991.

Most areas of the coalfield have received at least some exploration attention in the last 20 years, varying from hand trenching (for example, Imperial Ridge) to extensive rotary and diamond drilling and adit construction (for example, Ewin Pass). However, some parts of the field, including the Mount Tuxford area, have not been extensively explored and there is essentially no information about them in the literature.

COAL RIGHTS TENURE

The coalfield includes both Crown (public) and freehold (private) land (Figure 4). Coal rights on Crown land are covered by British Columbia coal licences or production leases. The only exceptions are the north end of the coalfield, known informally as the Vincent option, where coal rights are reserved to the Crown and at present may not be acquired for exploration or development, and the southernmost outlier, known as Crown Mountain, which is available but is not currently held (April 1991). Companies holding licences include Manalta Coal Ltd., Westar Mining Ltd. and Fording Coal Limited (Figure 4). In addition, one individual, Mr. W. Shenfield of Fernie, holds a group of licences at Bingay Creek. Companies holding production leases include Manalta Coal Ltd. and Fording Coal Limited. Companies with freehold coal rights include Westar Mining Ltd. and Cominco Ltd.

Currently producing mines (April 1991) in the coalfield include Fording Coal's Fording River operations, Manalta's Line Creek mine and Westar Mining's Greenhills operations (Figure 1). All are open-pit mines. Total 1988 production of clean coal from these three mines was 11.1 million tonnes (Coal Association of Canada, 1989), compared with a total for southeastern British Columbia of 18.5 million tonnes, with the largest contribution (5.9 million tonnes) from Fording Coal. Greenhills produced 3.1 million tonnes and Line Creek 2.1 million tonnes.

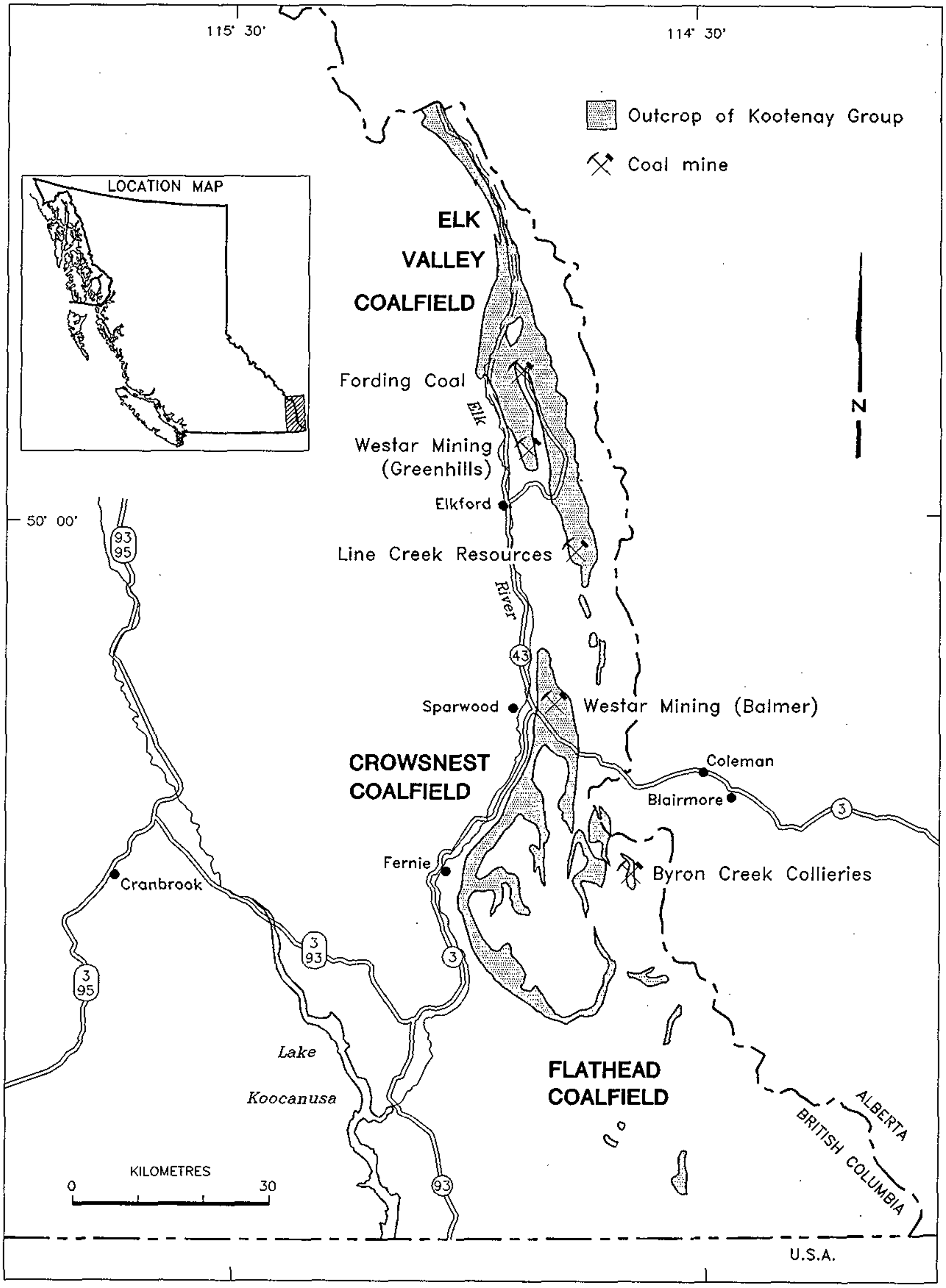


Figure 1. Location of the East Kootenay coalfields.

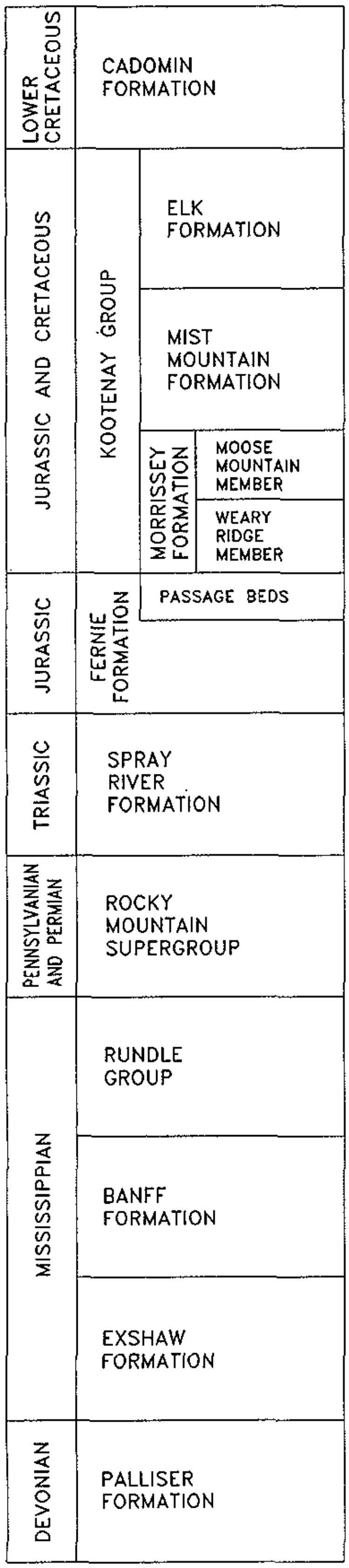


Figure 2. Generalized stratigraphic column of the study area.

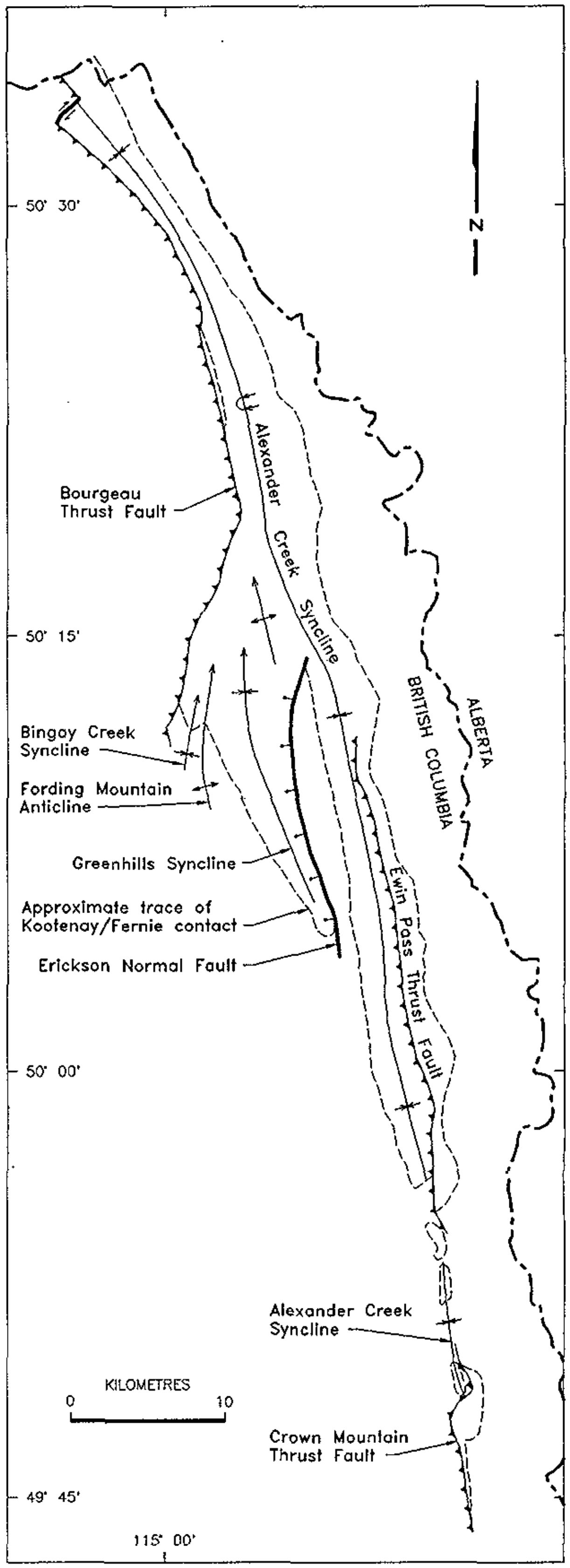


Figure 3. Major structural elements of the Elk Valley coalfield.

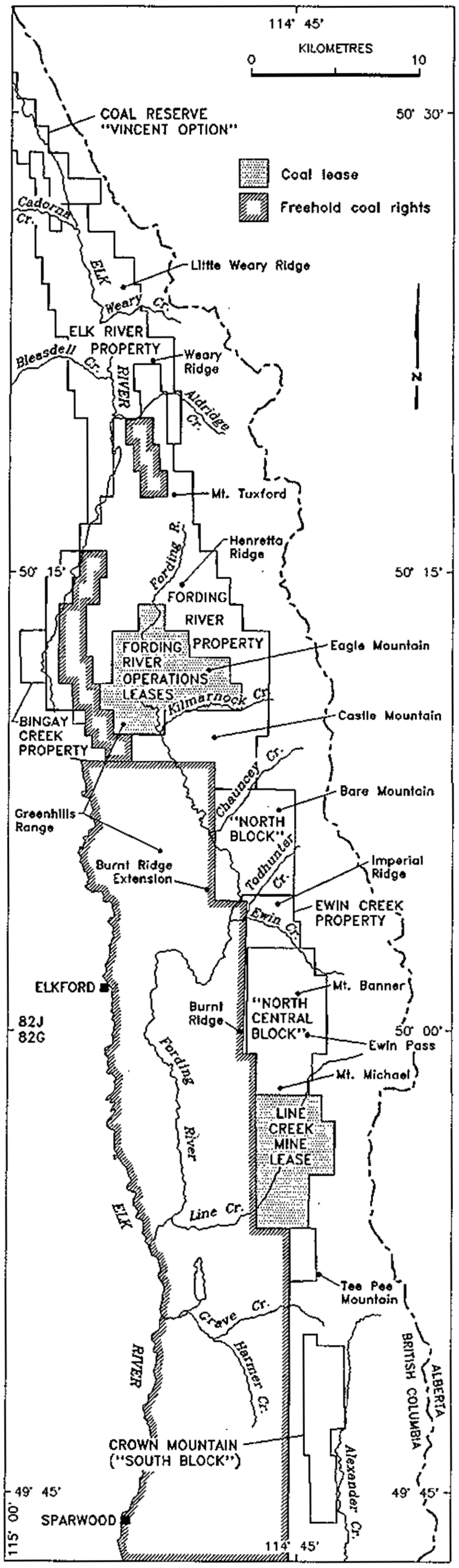


Figure 4. Locations and outlines of coal properties in the Elk Valley coalfield.

COAL RESOURCES

Total potential, *in situ* coal resources in the Elk Valley coalfield, based on the most recent Ministry of Energy, Mines and Petroleum Resources compilation (Kilby, 1986a), are in excess of 7.8 billion tonnes. This figure is probably conservative, as some properties, including the Vincent option, were omitted. Based on this compilation, Smith (1989) calculated coal resources of immediate interest in three categories, measured, indicated and inferred, as 600, 850 and 2800 million tonnes, respectively. New calculations of coal resources at Weary Ridge, based on a computer model constructed for this project, are included in Appendix 3.

Quantities of coal reserves in the Elk Valley coalfield are summarized in Table 1. These figures represent the three producing mines, together with the proposed mine site on the Elk river property. No other properties in the coalfield have been sufficiently explored to allow calculation of coal reserves. Mine reserve data are taken from the Coal Association of Canada 1989 Directory (Coal Association of Canada, 1989). The Elk River reserve figures were taken from the Stage II report of the mine development proposal (Elco Mining Ltd., 1978).

TABLE 1
SUMMARY OF COAL RESERVES IN THE ELK VALLEY COALFIELD

Site	Category of Reserve	Quantity (Mt)	Source
Fording River Operations	Not specified	347	Coal Association of Canada (1989)
Greenhills Operations	Clean	156	Coal Association of Canada (1989)
Line Creek Mine	In place	+200	Coal Association of Canada (1989)
Elk River property (proposed mine site)	In place	225	Elco Mining Ltd. (1978)
	Run-of-mine	220	
	Clean	139	

Coal reserve figures at the different properties are difficult to compare because they are reported differently in each case. Nonetheless, it is apparent that the Fording River property, with 347 million tonnes in an unspecified category, contains the largest reserves in the study area (Table 1). Reserves at Greenhills, 156 million tonnes of clean coal, are comparable to those at Line Creek, more than 200 million tonnes of in-place coal. The proposed Elco mine on the Elk River property contains 139 million tonnes of clean coal.

ACCESS AND TOPOGRAPHY

Main access into the region is provided by Highway 3 from Cranbrook to Alberta (Figure 1), Highway 43 north of Sparwood to Elkford, the highway connecting the Fording River mine and Elkford, and the unpaved Elk Valley road north of Elkford to Elk Lakes Provincial Park (Figure 5). Ease of entry into different parts of the coalfield is highly variable. The producing mines have excellent access roads, which are, however, restricted to vehicles on business only.

Some other parts of the coalfield have good forestry or exploration roads, although, unless maintained, their quality tends to deteriorate over time. Moreover, the roads in some areas have deliberately been made impassable. These and other areas, which probably take in the largest part of the coalfield, are reached on foot or by helicopter only. It is advisable to investigate access on a property-by-property basis, by contacting the company holding the coal rights, and the provincial government ministries of Forests and Environment, Lands and Parks.

Due to the nature and structure of the underlying rocks, topographic relief in the coalfield is moderate compared to the rugged carbonate mountain ranges to the east and west. Elevations range from 1400 to 2560 metres. Very little of the terrain is prohibitively steep for hiking. There are some steep cliffs, particularly associated with sandstone beds and recent landslide scarps. Large parts of the coalfield, including Mount Banner, Ewin Pass, Castle Mountain, Mount Tuxford and Mount Veits, are bare of trees.

By most standards, the quality of rock exposure in the Elk Valley coalfield is good. Sandstones and conglomerates are the most resistant, and hence the most visible units. In some areas, especially at lower elevations, these are the only rocks that crop out, while on some of the higher ridges, there is essentially 100 per cent exposure of all rock types. Road construction and trenching by exploration companies has created additional outcrop in many areas.

PREVIOUS WORK

Previous geological surveys in the area, excluding those associated with industry exploration programs, have included work in the north end of the coalfield by the Geological Survey of Canada (Graham *et al.*, 1977) and the British Columbia Geological Survey Branch (Pearson and Duff, 1977). The former study included the drilling of four diamond-drill holes for stratigraphic and coal-quality information. The southern part of the coalfield is covered by Price's (1962b) Fernie east-half regional geological map at 1:126 720 scale, as well as by Price and Grieve's compilations of sheets 82G/15 and 82J/2 at 1:50 000 (Grieve and Price, 1985; Price and Grieve, in press, a and b). Large-scale (1:10 000) geological maps on orthophoto bases have been produced for most of the coalfield by the Geological Survey Branch (Grieve and Pearson, 1983; Grieve and Fraser, 1985; Morris and Grieve, 1990). These last three maps are the foundation of this bulletin.

Several stratigraphic sections and core logs in D.W. Gibson's definitive stratigraphic work on the Kootenay Group (Gibson, 1985) are from the Elk Valley coalfield. Coal maceral analyses on seams from the Elk Valley coalfield were included in studies by Cameron (1972, 1984) and Cameron and Kalkreuth (1982). Results will be discussed in the appropriate section of this bulletin.

Hacquebard and Donaldson (1974) measured vitrinite reflectance (rank) on samples collected at Line Creek Ridge and Eagle Mountain. A regional-scale rank distribution map, based on vitrinite reflectance, was produced by Pearson and Grieve (1980). Cameron and Kalkreuth (1982), Cameron (1984), Hughes and Cameron (1986), and Hacquebard and Cameron (1989) included Elk Valley reflectance data in their studies. Again, relevant results of these studies will be addressed in the appropriate sections of this paper.

STUDY METHODS

All field, laboratory and office techniques used in this study are described below. Statistical techniques are described in the appropriate sections of the text and in Appendix 3.

FIELD METHODS

MAPPING

Field mapping was carried out using British Columbia government black-and-white air photographs enlarged to approximately 1:7500 scale. Geological features and station positions recorded in the field were transferred to 1:10 000-scale orthophotos.

MEASUREMENT OF STRATIGRAPHIC SECTIONS

Sections were measured using a combination of "pogo stick", compass, clinometer and chain. The "pogo stick" was used in areas of moderate to good exposure. In the case of well-exposed, cliff-forming units, a chain was used to measure the true thickness of the unit directly. In areas of moderate to poor exposure a chain was again used, this time to measure apparent thickness, which was then converted to true thickness.

CORE LOGGING

The core logging system of the Research Planning Institute, Inc. (RPI) was utilized in this study (Ruby *et al.*, 1981). The RPI system uses three-digit codes to represent rock type, composition/colour, and sedimentary structures; suffixes modify sedimentary structures and identify penecontemporaneous deformation, cement type and presence of coal banding (*see* Appendix 2 for an explanation of codes and modifiers). This method is readily applicable to Kootenay Group strata and it offers optimum degrees of detail, speed and consistency.

Individual units within core were measured to the nearest centimetre. Thicknesses of intervals representing sampled coal horizons were taken from company lithological and geophysical logs. Units thinner than 5 centimetres were not measured separately, with the exception of tonsteins and other very distinctive lithologies. Logs were converted to true thicknesses using core-bedding angles measured with a protractor. Logs were later generalized for presentation and discussion purposes.

COAL SAMPLING

Coal samples were taken for petrographic purposes only. Two types of sample were collected; grab samples for rank determination (vitrinite reflectance) and channel samples for both rank and coal-type determination (maceral analysis). Grab samples were not intended to be representative of the seam sampled, but they are considered adequate for rank determination by vitrinite reflectance. Channel samples, on the other hand, were taken from locations where the entire seam could be sampled uniformly, and are considered representative. Suites of channel samples were generally collected, representing as much of the Mist Mountain Formation as possible, in areas where exposure of coal seams was reasonably good throughout the section. All samples are known to be oxidized.

Grab Sampling

Grab samples were generally taken from one position within a coal seam using a trenching tool. Material which apppeared to be badly weathered, especially coal bloom, was avoided as much as possible. If better material was not available, then as much of the surface layer as possible was removed before sampling. In all cases, the outer surface of the coal-face was cleaned off prior to sampling. Samples were placed in kraft bags and air dried before further processing.

Channel Sampling

Channel samples were generally cut using shovels and trenching tools. Shovels were used to clean off the outer surface of the exposure, and, if necessary, to expose part of the seam. Trenching tools were used to chip a channel 5 to 10 centimetres wide through the seam.

Laboratory Methods

COAL

Sample Preparation

Because of the difference in size of grab and channel samples, different procedures were used in preparing them for analysis.

Grab Samples: Air-dried grab samples were ground in a pestle and mortar, and screened using a 20-mesh sieve, until enough fine material was generated to make a pellet (approximately 25 g). The fine fraction was placed in a plastic vial, and the coarse fraction returned to the kraft bag. Usually it was not necessary to grind and screen the entire sample.

Channel Samples: Channel samples were coned and quartered down to approximately 1 kilogram, and air dried. No pre-crushing was needed because the combination of the oxidized nature of the coal and the sample technique (chipping) ensured that all samples were already fine. The entire subsample was then ground until it passed through a 20-mesh screen.

Pellet Preparation

Coal pellets were made from air-dried grab and channel samples. Minus-20-mesh coal was combined on a one-to-one basis with a thermoplastic powder and thoroughly mixed. The mixture was poured into a metal mold equipped with a pneumatic press and a heating sleeve. The temperature was raised to 140°C, and the pressure to 31 000 kilopascals (4500 p.s.i.). The heat source was removed and the mold allowed to cool under pressure, to a temperature of 90°C. Finally the pressure was released and the pellet was ready for grinding and polishing.

Coal pellets were ground in three stages and polished in two stages, with the final polishing stage using 0.03-micron alumina powder. After polishing, the pellets were kept for at least 24 hours in a desiccator.

Coal Petrography

Coal petrographic analyses utilized here fall into two categories: vitrinite reflectance and maceral analyses. Both use a reflected-light microscope with an oil-immersion lens. A photometer is also used in the case of vitrinite reflectance analysis. The photometer is calibrated before, during and after analysis, using a glass standard of known reflectance.

Vitrinite Reflectance: Reflectance readings were taken on 50 grains of vitrinite A in both channel and grab sample pellets. In some cases, it was necessary to settle for fewer than 50 grains. Sample pellets are "traversed" along lines spaced 0.5 millimetre apart; the stepping distance is the same. When the cross-hair of the eye-piece falls on a suitable grain of vitrinite, some repositioning is allowed to ensure that the reading will not be affected by scratches or other interference. At this point the stage is rotated slowly through 360°. The highest and lowest reflectance readings registered during the rotation are recorded. These represent the apparent maximum (R'_{max}) and apparent minimum reflectance (R'_{min}) for the individual grain. These parameters are used to calculate the random reflectance (R_m) for each grain. The relationship is:

$$R_m = \sqrt{(R'_{max})(R'_{min})}$$

(Kilby, 1988)

In addition, the difference between R'_{max} and R'_{min} for each grain, known as the bireflectance, is also calculated.

After 50 grains have been measured and recorded, the mean of the apparent maximum reflectances is determined, and this value, known as the mean maximum vitrinite reflectance (or $\bar{R}_{max}$) is used as a rank index. Elk Valley coalfield samples are assigned to ASTM rank classes as follows (Davis, 1978):

$\bar{R}_{max} < 1.10$ per cent	high-volatile bituminous
$1.10 < \bar{R}_{max} < 1.50$ per cent	medium volatile
$\bar{R}_{max} > 1.50$ per cent	low volatile

The mean of the random reflectance values is also determined. This value, known as the mean random reflectance or $\bar{R}_m$, is also a commonly used rank parameter.

To determine if coals in the study area contain vitrinite with uniaxial negative or biaxial reflectance characteristics, the cross-plot method for particulate samples (Kilby, 1988) was applied to data generated from subsurface samples. Subsurface samples were chosen for this analysis for two reasons. First, they generally are free from weathering, and second, they represent discrete individual horizons within core. The relative ease of interpretation of most of the cross-plots (*see* Figure 46, for example) is a result of these factors.

The cross-plot method involves plotting two points for each grain on a graph of reflectance versus bireflectance. One point corresponds to R'_{max} versus bireflectance, and the other to R'_{min} versus bireflectance. A template is then overlaid, which assists in selecting three parameters, the *minimum* (R_{min}), *intermediate* (R_{int}) *and maximum* (R_{max}) reflectance axes of the reflectance indicating surface (RIS) for each sample. Criteria and methods for selecting these axes are outlined in Kilby (1988).

In the cases where R_{int} equals R_{max}, the RIS is an oblate spheroid and the sample is uniaxial negative. This is the case for vitrinite which has coalified under the influence of a major stress direction perpendicular to bedding (Kilby, 1988; Levine and Davis, 1989). The minimum reflectance axis is perpendicular to bedding, and the maximum reflectance axis lies in the bedding plane.

Where $R_{max} > R_{int} > R_{min}$ the RIS is an oblate ellipsoid and the sample is biaxial. If R_{int} is closer to R_{max} than to R_{min}, the sample is biaxial negative. When R_{int} is midway between R_{max} and R_{min} the sample is biaxial even, and when R_{int} is closer to R_{min} than to R_{max} the sample is biaxial positive. Biaxial coals occur where major tectonic stresses were present, together with the vertical stress, during coalification (Kilby, 1988). The principal reflectance axes have been reoriented with respect to bedding (Levine and Davis, 1989).

In order to classify the RIS in terms of its size and shape, two further parameters are derived from the values of R_{min}, R_{int} and R_{max}. The first of these, R_{st} (st = style), is defined as being equal to 30 − arctan (x/y), where:

$$y = R_{max}/(R_{max} + R_{int} + R_{min}) - 1/3,$$

and

$$x = [1/3 - R_{min}/(R_{max} + R_{int} + R_{min})]/\cos(30) - [(y)\tan(30)]$$

R_{st} varies from −30 to +30.

The second RIS classification parameter, R_{am} (am = anisotropy magnitude), is defined as being equal to the square root of the sum of x^2 and y^2. An isotropic RIS would have a value of zero, and increasing values of R_{am} represent increasing deviation from isotropy (state of equal reflectance axes). A value of 0.1 would appear to be very high (Kilby, 1988, Figure 6).

In classifying the RIS, values of R_{st} and R_{am} for each sample are plotted on a ternary diagram with apices corresponding to the three principal axes (Kilby, 1988). In actual fact only a portion of the triangle is utilized (see, for example, Figure 45). When R_{st} equals −30, the sample is considered to have a unaxial negative RIS, whereas when R_{st} equals +30 the RIS is unaxial positive. All values between −30 and +30 are considered to have a biaxial RIS, with the sign of R_{st} indicative of the sign of the RIS. In this study R_{st} values between −2.5 and +2.5 were considered to represent a biaxial even RIS. Values of R_{am} represent distance away from the centre of the triangle, which corresponds with an isotropic RIS.

The values of the three principal reflectance axes are also used to calculate another measure of rank, R_{ev} (ev = equal volume). This parameter represents the radius of a sphere of volume equal to the volume enclosed by the RIS. It is defined as the cube root of $R_{min}*R_{int}*R_{max}$. Mean random reflectance ($\bar{R}_m$) is a good approximation of R_{ev}, but deviates from it as the "eccentricity" of the RIS increases (Kilby, 1988).

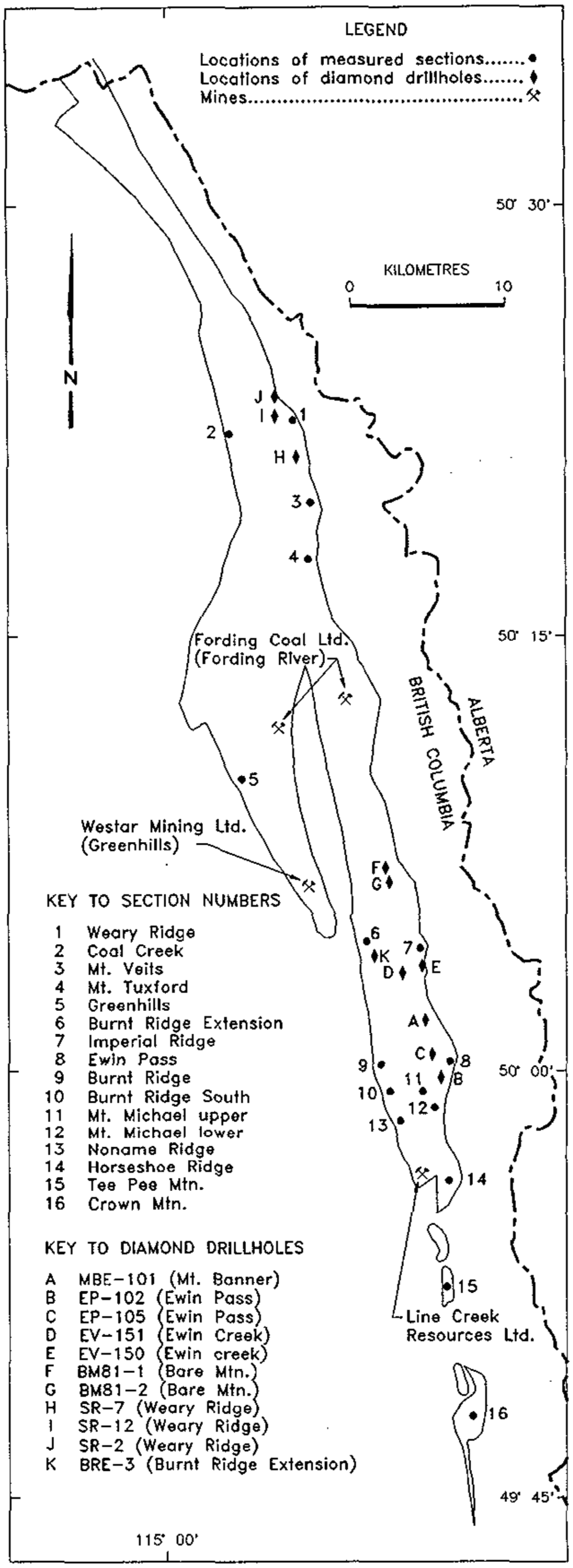


Figure 6. Outline of the Elk Valley coalfield with locations of stratigraphic sections and diamond-drill holes logged in this study.

Maceral Analysis: Only channel sample pellets were used in this analysis. Pellets are traversed along lines spaced 0.5 millimetre apart. Stepping distance along lines is the same. A coal particle is counted when the cross-hair in the eye-piece falls on it; mineral matter and plastic mounting medium are not counted. Terminology of the International Committee for Coal Petrology (ICCP, 1963) is used. Particles counted are classified as vitrinite, liptinite, semi-fusinite, fusinite, macrinite or other inertinite (chiefly inertodetrinite). A total of 300 points per sample are counted, and the number of counts is converted to a percentage.

TONSTEINS

Standard thin sections were made of all competent samples, and these were examined with transmitted light microscopy. The analyses were purely descriptive; no point counts were made.

Mineralogy of tonstein samples was determined by x-ray diffraction.

Elemental analyses of tonstein samples reported here were carried out using emission spectrographic techniques. All results are semiquantitative. One sample, 81-217, was subjected to major oxide analysis.

METHODS OF STRUCTURAL ANALYSIS

Orientations of the axes of large-scale folds were determined using a Schmidt or equal-area stereonet. In all cases, the bedding orientation data used to construct the stereonets were taken from within a strike length of less than 2 kilometres. In the case of stereonets intended to correspond with cross-section lines, the data all fall within a kilometre north or south of the section line.

Poles to all available bedding attitudes were first plotted. Where possible, a *pi* girdle was drawn by inspection of the pattern of these poles. The fold axis was then determined as the normal to the plane represented by the girdle. Otherwise, average poles were chosen for both limbs, by inspection. The great circles for the two average limb orientations were then drawn; their intersection point was interpreted as corresponding with the axis.

A number of small-scale folds associated with the Ewin Pass thrust in the Mount Banner area were also analyzed by stereonet. In cases where a fold axis was measured in the field, it was plotted directly. In cases where bedding orientation measurements were taken on both limbs, the great circles for the limbs were plotted, and their intersection point used as the fold axis direction.

ACKNOWLEDGMENTS

The fieldwork for this study was carried out while I was a resident of the "coal town" of Fernie. I wish to express my sincere gratitude to geologists with all the coal mining and exploration companies in southeastern British Columbia, for their constant support during that period.

Dave Pearson supervised mapping of the Greenhills Range, and Bob Morris carried out the mapping of most of the north half of the coalfield. Janine Fraser mapped Horseshoe Ridge, Tee Pee Mountain and Crown Mountain. Capable field assistance over the years was provided by many, including Gerry Pellegrin, Suzanne Cannon, Greg Campbell, Mickey Welder, Bob Janowicz, Blair Krueger, Kevin Switzer and Jim Ryley. Paul Elkins logged some of the cores described here. Joanne Schwemler carried out most of the vitrinite reflectance measurements. Sharon Chapman performed all maceral analyses and contributed to the digitizing of data for the deposit model. Jim Hunter digitized the drill-core logs used in seam correlation.

Ward Kilby of the Geological Survey Branch helped immeasurably with computer applications, and provided much useful advice and support at all stages of preparation and write-up. Section Manager Vic Preto is thanked for his patience and support. The first draft of this bulletin was read by both. External reviewer Alex Cameron of the Geological Survey of Canada also read the first draft and provided many helpful comments and ideas. Any remaining errors or shortcomings are my responsibility.

Lastly, I am most grateful to Dave Pearson for introducing me to the geology of the East Kootenay coalfields.

CHAPTER 2: STRATIGRAPHY

STRATIGRAPHIC SETTING

The stratigraphic column of rocks found in the Elk Valley coalfield is illustrated by Figure 2. The only coal-bearing rocks belong to the Jurassic-Cretaceous Kootenay Group. The column is summarized here in terms of rocks older than the Kootenay, the Kootenay itself, and rocks younger than the Kootenay.

OLDER STRATA

Older strata in the study area range in age from Devonian to Jurassic (Figure 2). Devonian rocks, chiefly carbonates, belong mainly to the Palliser Formation. Overlying the Palliser are the Mississippian Exshaw and Banff formations, composed respectively of shale and carbonate. Younger Mississippian strata, chiefly of carbonate composition, belong to the Rundle Group. Overlying Permo-Pennsylvanian rocks, including sandstones, carbonates and phosphatic shales, belong to the Rocky Mountain Supergroup. The Triassic Spray River Group consists mainly of siltstone and shale, together with carbonate. The overlying Fernie Formation of Jurassic age contains shale, some sandstone and carbonate horizons, and a basal phosphorite. The uppermost unit in the Fernie Formation, known as the Passage beds, comprises interbedded shale and sandstone, with sandstone beds becoming thicker and more frequent upward. It is transitional to the base of the Kootenay Group (Plate 1).

KOOTENAY GROUP

The Kootenay Group was first defined by Gibson (1979) and its regional stratigraphy and sedimentology are described by the same author (Gibson, 1985). The latter reference is the source for information under this heading,

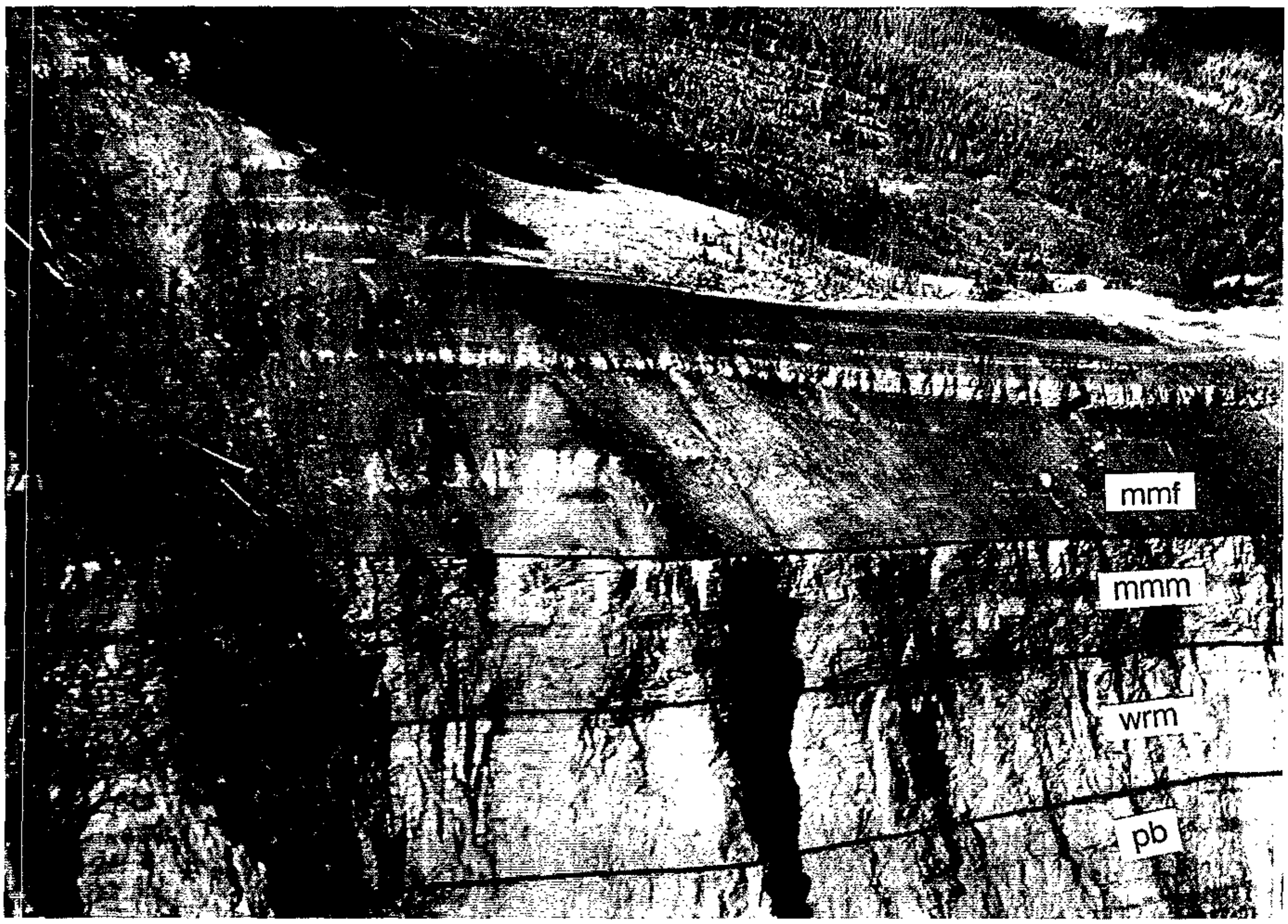


Plate 1. View of east face of Mount Veits from the air, showing contacts between the Passage beds of the Fernie Formation (pb), the Weary Ridge (wrm) and the Moose Mountain (mmm) members of the Morrissey Formation, and the Mist Mountain Formation (mmf). The Moose Mountain Member is approximately 25 metres thick in this area (Gibson, 1985). Note the contrast in colour between the Weary Ridge and Moose Mountain members, and the presence of a recessive, carbonaceous parting in the Moose Mountain Member. (Photo by R.J. Morris)

unless otherwise indicated. It should be referred to for more detailed information on the regional nature of the Kootenay.

The Kootenay Group consists of three formations, known in ascending order as the Morrissey, Mist Mountain and Elk formations.

TECTONIC SETTING AND PROVENANCE

Sedimentary rocks of the Kootenay Group were deposited in the foreland basin of the Canadian Cordillera. Deposition of the upper part of the Fernie Formation and the Kootenay Group represents the first of a series of clastic wedges derived from this uplift (Poulton, 1988; Stott, 1984). The second (overlying) clastic wedge is represented by the Lower Cretaceous Blairmore Group and its stratigraphic equivalents. In tectonic terms, deposition of the Fernie-Kootenay clastic wedge is correlated with collision and accretion of the Intermontane Superterrane with the craton (Cant and Stockmal, 1989). Sediment source areas were consequently mainly to the west, both within the present-day Rocky Mountains, and west of the Rocky Mountain Trench in the Omineca Belt (Jansa, 1972; Rapson, 1965; Gibson, 1985).

MORRISSEY FORMATION

The Morrissey Formation (Gibson, 1979) is the basal sandstone unit of the Kootenay Group. It is divided into two members, the lower Weary Ridge Member and the upper Moose Mountain Member (Plates 1 and 2). The Weary Ridge Member is the less resistant of the two, and is characterized by an orange-brown weathering colour. Its lower contact is defined as the top of the stratigraphically highest shale in the Passage beds (Plate 1). It consists of argillaceous and ferruginous quartzose sandstone, with rare interbeds of siltstone. The more resistant, grey-weathering Moose Mountain Member is a prominent marker unit. The contact between the two is abrupt and conformable. The Moose Mountain is composed of quartz-chert sandstone, with local occurrences of chert conglomerate. Thin interbeds of carbonaceous shale, with or without coal, occur in some parts of the study area.

Regionally, the Morrissey Formation ranges in thickness from 20 to 80 metres. Within the study area its thickness is estimated to be in the range of 40 to 50 metres. It usually forms a prominent, easily mapped cliff (Plates 1 and 2).

The Morrissey Formation is of probable Portlandian age (Late Jurassic). The depositional setting is believed to have

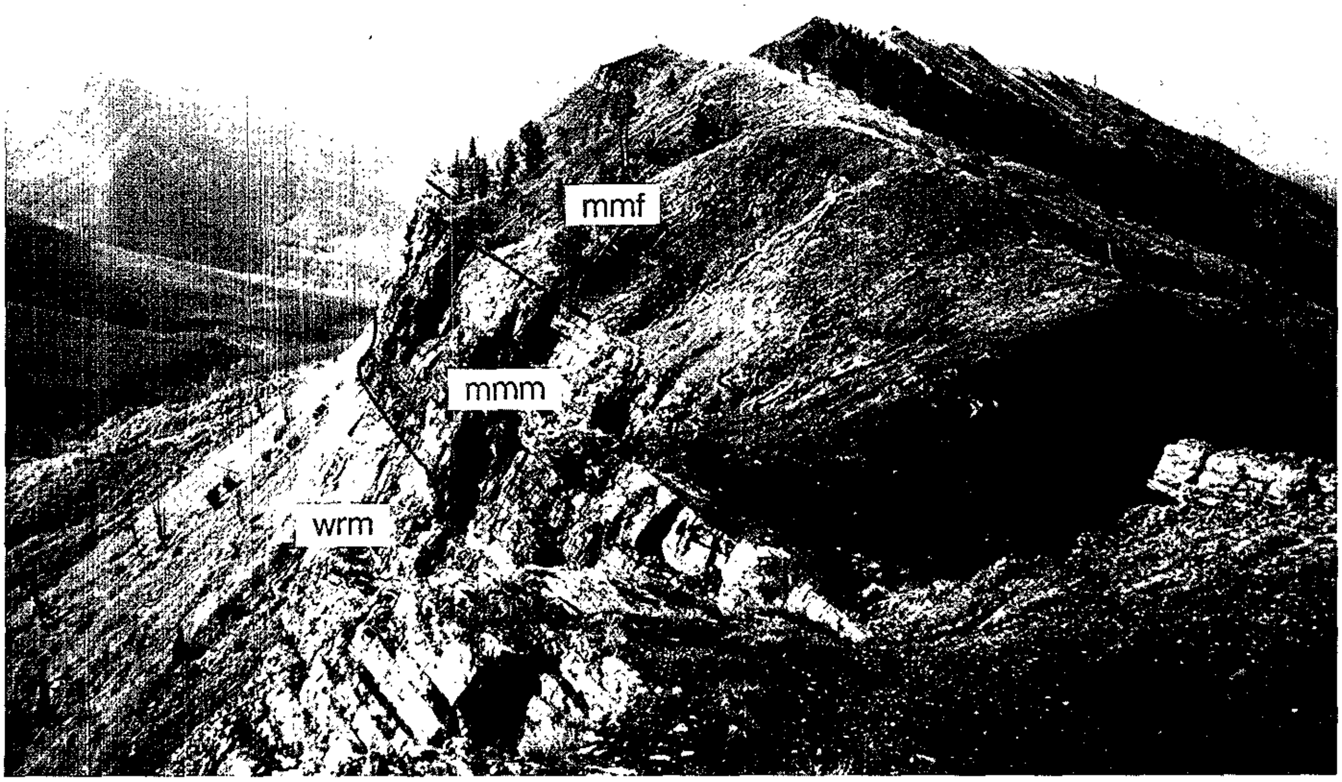


Plate 2. View to the south along Weary Ridge, showing the contacts between the Weary Ridge (wrm) and Moose Mountain (mmm) members of the Morrissey Formation, and the Mist Mountain Formation. This location marks the base of measured section No. 1. Note the contrast in colour between the Weary Ridge and Moose Mountain members.

been a combination of beach, beach-ridge and coastal-dune environments.

MIST MOUNTAIN FORMATION

The Mist Mountain Formation contains the economic coal seams of the Kootenay Group, and is the major focus of this study. The reader is referred to a subsequent section for detailed discussion of the stratigraphy and sedimentology of the formation in the Elk Valley coalfield; for a regional description see Gibson (1985).

The formation abruptly and conformably overlies the Morrissey Formation. It ranges in thickness from 25 to 665 metres throughout its area of occurrence (Gibson, 1979). The formation is believed to range from Late Jurassic to Early Cretaceous in age, although this is at present not firmly established.

The depositional environments of the Mist Mountain Formation are believed to range from an "extensive delta - interdeltaic coastal plain" low in the section, to a "fluvial-alluvial plain" in the upper part (Gibson, 1985, p.71). Conclusive faunal proof of marine influence has not been found, which is consistent with the low sulphur content of the coals. However, boron contents are somewhat elevated in coals near the base of the section (Goodarzi, 1987), suggesting a brackish influence for this part of the formation.

In southeastern British Columbia coal forms between 8 and 12 per cent of the total thickness of the Mist Mountain Formation, in seams ranging up to and occasionally exceeding 13 metres in thickness (Grieve, 1985). The formation generally contains a carbonaceous zone near its base. This zone, referred to here as the "basal coal zone", usually contains one or more coal seams, including, in some localities, a seam in direct contact with the Morrissey Formation (Plate 3).

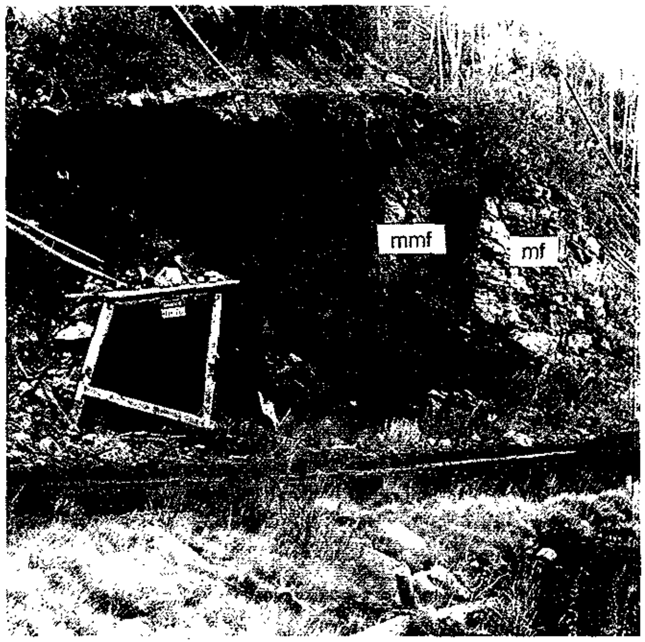


Plate 3. Steeply dipping strata of the upper Morrissey Formation (mf) and the basal coal zone of the Mist Mountain Formation (mmf) on Burnt Ridge.

ELK FORMATION

The Elk Formation overlies the Mist Mountain Formation at the top of the Kootenay Group. Its characteristics are similar to those of the Mist Mountain, but there are several important differences. Primarily, the Elk Formation lacks coal seams of potential economic thickness, and contains sapropelic coals in addition to humic coals. Also significant are the greater abundance and apparent greater lateral continuity of sandstone units in the Elk Formation (Plates 4 and 5). Consequently, it is, on average, more resistant to erosion. In some locations the Elk Formation is characterized by a concentration of conglomeratic units, and a more orange weathering colour to sandstones is sometimes noticeable in areas where both formations are well exposed.

The contact between the Mist Mountain and Elk formations is abrupt and conformable and of the interfingering type. It is placed at "the base of the first major sandstone or conglomerate above the uppermost major coal seam in the Mist Mountain Formation" (Gibson, 1985, p.27). Strict application of this definition in the field is sometimes difficult, leading to arbitrary decisions and lateral inconsistencies (Grieve and Ollerenshaw, 1989). This difficulty has led me to symbolize the contact as gradational on geological maps of the Elk Valley coalfield, including Figure 5 of this report.

Throughout the Kootenay Group's area of occurrence the Elk Formation ranges in thickness from 28 to 590 metres, and is absent in some locations. In general it thins from west to east. Within the study area it is estimated to be roughly 450 metres thick.

There is considerable doubt concerning the precise age of the Elk Formation. It is probably mainly Early Cretaceous, but may be as old as Late Jurassic in some locations.

For the most part, the formation is believed to have been deposited on a fluvial-alluvial plain. Local occurrences of distal alluvial-fan depostion are known to occur, for example on the west side of the Fernie basin, near Fernie (Grieve and Ollerenshaw, 1989; Gibson, 1985). At these locations the Elk is dominated by thick units of conglomeratic sandstone and conglomerate. Another example of coarse Elk facies has been documented within the study area (Morris and Grieve, 1990), at the extreme north end of the coalfield, where Elk Formation conglomerates are exposed along Elkan Creek in Elk Lakes Provincial Park.

The upper contact of the Kootenay Group is placed at the base of the first (or only) conglomeratic unit of the Cadomin Formation of the Blairmore Group (Plate 6). The contact is abrupt and disconformable, although it is probable that it is conformable at some locations (Ricketts and Sweet, 1986). The contrast between the uppermost Elk and the Cadomin is sufficient in the study area to ensure easy identification of the contact.

YOUNGER STRATA

Strata of the Cadomin Formation of the Lower Cretaceous Blairmore Group are exposed at several locations in the study area. The Cadomin is a prominent, massive pebble to cobble conglomerate unit. generally forming one or more continuous cliffs or ledges (Plate 7). Younger Blairmore strata may occur in the study area, but are not exposed.

STRATIGRAPHY OF THE MIST MOUNTAIN FORMATION

General comments concerning contact relations, thickness and age of the Mist Mountain Formation were made in the preceding section. Features of the formation's stratigraphy in the Elk Valley coalfield will now be discussed.

The following information is based on 16 sections of Mist Mountain Formation measured in the field, and 10 detailed lithological logs of drill cores. Locations of sections and holes are shown in Figures 5 and 6.

THICKNESS AND LITHOLOGIES

The Mist Mountain Formation averages about 500 metres in thickness in the Elk Valley coalfield, and ranges from less than 425 to approximately 700 metres. In the coalfield it is an interbedded sequence of nonmarine strata, including siltstone, sandstone, mudstone, shale, coal and, rarely, conglomerate.

SILTSTONE

Siltstone is the most common lithology in the Mist Mountain Formation. It is commonly dark grey on fresh surfaces and in drill core, and weathers to shades of brown and orange. It is usually recessive in weathering profile, although it can be resistant. It is generally thin bedded, and may be massive, laminated or crosslaminated. Initial structures may be modified by rooting, burrowing, slumping or other soft-sediment deformation. The formation commonly contains carbonaceous partings or bands. At outcrop scale it occurs as discrete units or interbedded with other lithologies, including sandstone, mudstone and coal. At a finer scale, it is seen to be generally the fine-grained component of "ISAS" (intermixed shale and sandstone) units as defined by Ruby *et al.* (1981) and recognized here in drill core only (see description, p.14).

SANDSTONE

Sandstone is the most conspicuous lithology in the Mist Mountain Formation, mainly due to its resistance to erosion. It ranges from very fine to very coarse grained, and thin to thick bedded. Finer grained sandstones may be flaggy or platy. Colour on fresh surfaces and in drill core ranges from light to dark grey, and on weathered surfaces from buff to

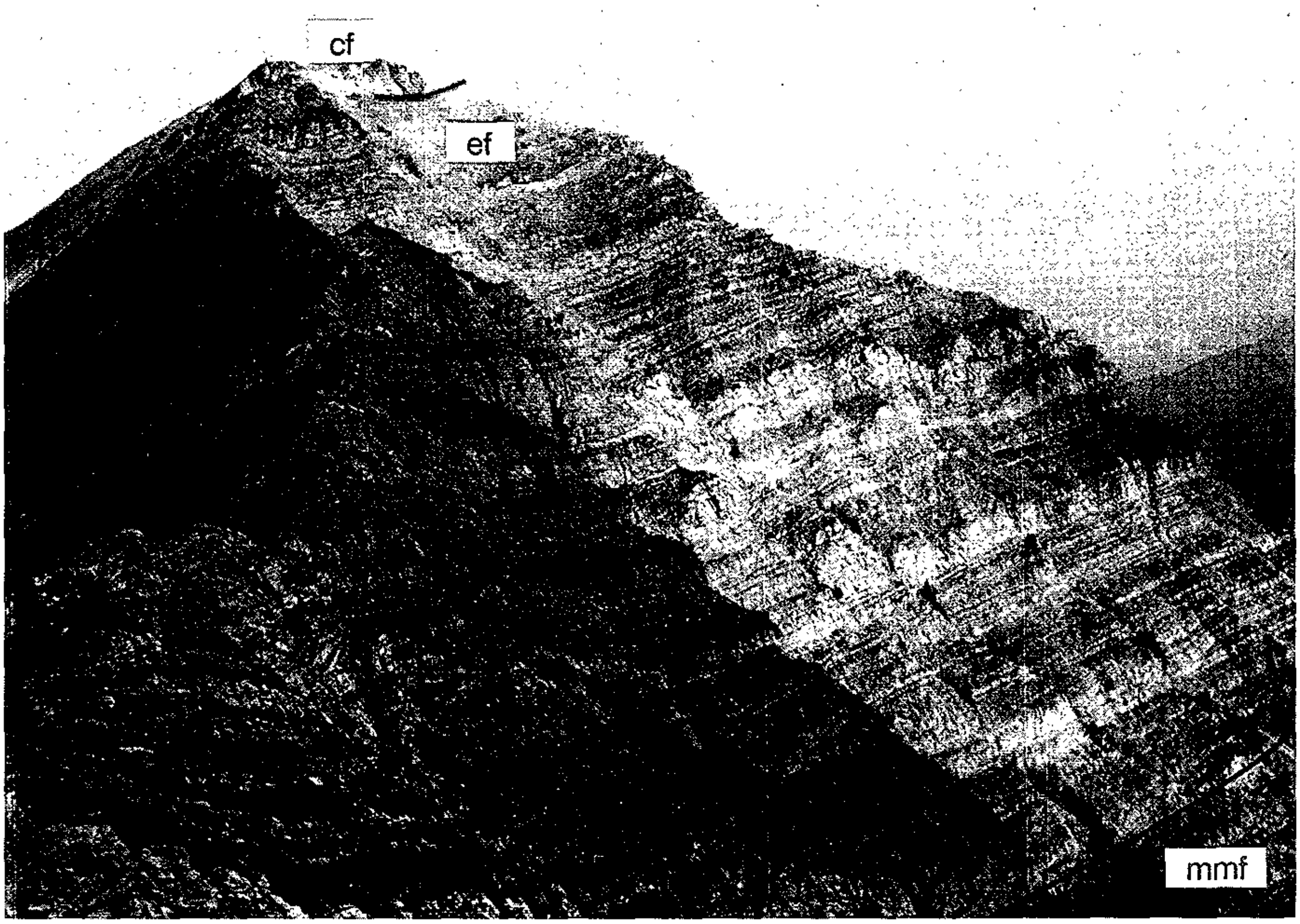


Plate 4. View of west-dipping Elk Formation (ef) strata in the vicinity of the Ewin Pass property. Note positions of contacts with underlying Mist Mountain (mmf) and overlying Cadomin (cf) formations.

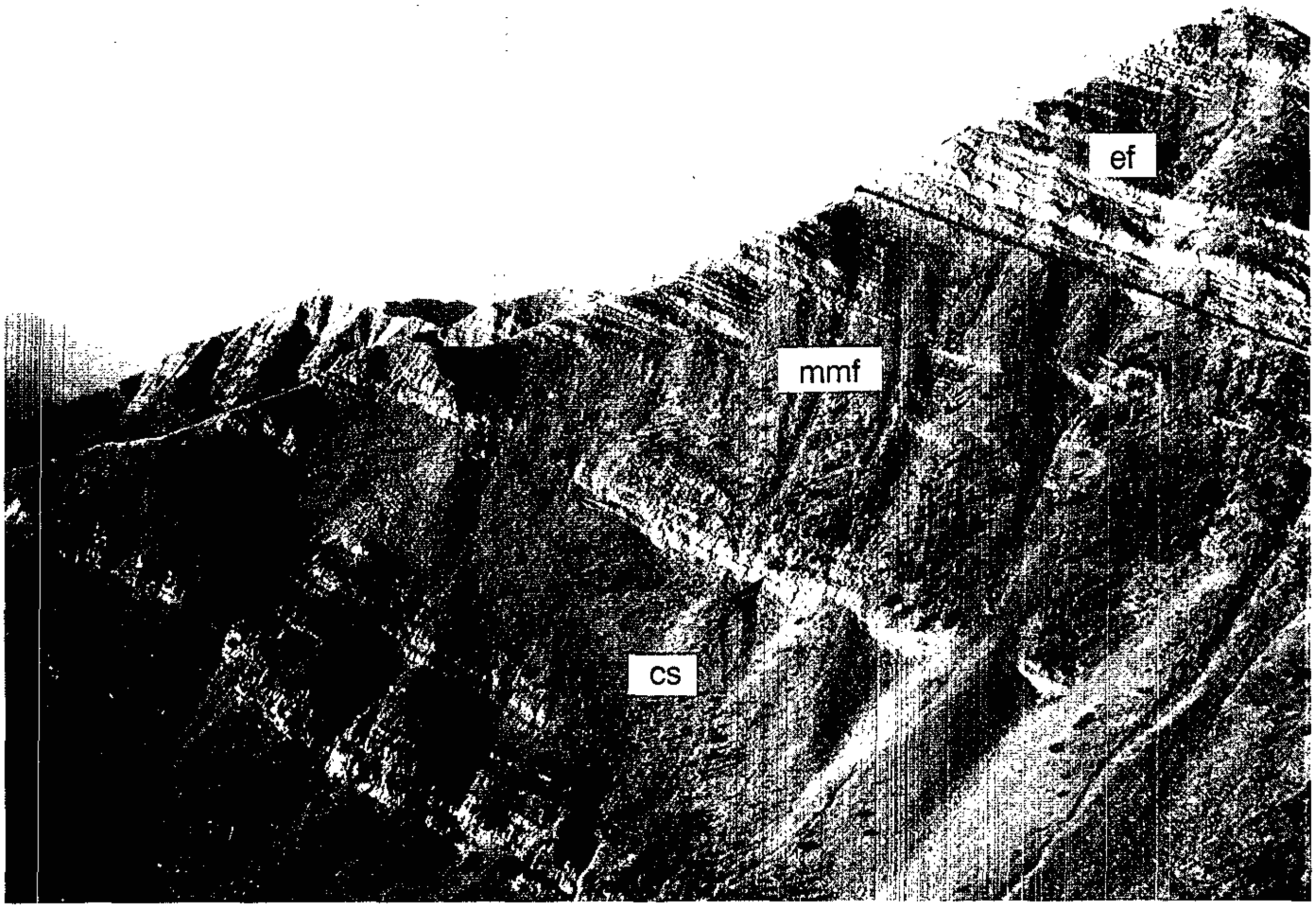


Plate 5. View of west-dipping upper Mist Mountain Formation (mmf) and lower Elk Formation (ef) strata on Mount Tuxford. Note channel sandstone units in Mist Mountain (cs). (Photo by R.J. Morris).

Plate 6. Contact between Elk (ef) and Cadomin (cf) formations. Same location as in Plate 4.

Plate 7. West-dipping Cadomin Formation cliff-forming conglomerate on Mount Tuxford. (Photo by R.J. Morris).

Plate 8. West-dipping Mist Mountain Formation strata at Weary Creek. A fining-upward channel sandstone unit directly overlies coal seam (No. 2).

Plate 9. Base of channel sandstone unit directly overlying carbonaceous shale in the Mist Mountain Formation on Burnt Ridge.

dark greyish brown. Conspicuous orange and red stains are a feature of weathered surfaces. In composition most sandstones in the formation are lithic arenites, with chert and quartzite grains comprising the bulk of the lithic clasts. Cement is usually silica, but may also be ferruginous and/or calcareous. Carbonaceous material is common in some sandstone units, usually as lenticles of coal spar.

The most common occurrences of sandstone are the so-called "channel sandstone" units. These occur as cliff-forming units ranging from approximately 2 to 15 metres in thickness (Plates 5 and 8), and form the base of fining-upward sequences related to point-bar deposition and migration (see section on depositional sequence modelling). These are generally medium grained or coarser at their base, and fine to very fine grained near the top, where they grade into siltstone. Sedimentary structures include scouring at the base, trough-shaped and tabular crossbedding (Plates 9 and 10), flaser bedding, and ripple-drift crosslaminations. Coal lenticles and wood imprints are commonly associated with the basal portions of the channel sandstone units.

Sandstone also occurs interbedded with siltstone, including as a component of ISAS units (*see* below), where it is usually fine or very fine grained.

ISAS UNITS

The term ISAS, intermixed shale and sandstone, as defined by Ruby *et al.* (1981), was applied in this study to drill core only. It describes alternating beds of fine to very fine grained sandstone and siltstone to finer grained lithologies, with individual bed thicknesses ranging up to 10 centimetres (Plate 11). Several distinct varieties of ISAS are recognized; they represent a gradational range of grain sizes and sedimentary structures. They include: wavy bedded sandstone with interbedded shale, in which the ratio of sandstone to shale is roughly 2:1; lenticular-bedded sandstone with interbedded shale, in which the ratio of sandstone to shale is roughly 1:1; shale with lenticular sandstone streaks, in which the ratio of sandstone to shale is roughly 1:2; and sandy shales, which are massive, in some cases due to excessive bioturbation or soft-sediment deformation. Rooting, burrowing (Plate 11) and soft-sediment deformation are a common feature of all ISAS lithologies.

MUDSTONE AND SHALE

The finest lithologies in the Mist Mountain Formation are mudstone and shale. Both are grey to nearly black in colour, depending on their carbonaceous content. They are both recessive in weathering profile. Mudstone may be banded or massive, and may contain coal partings or bands. Shale is more fissile and tends to contain a higher proportion of included carbonaceous material and coaly partings or bands. Both mudstone and shale are often associated closely with coal, where they occur as the floor, roof and parting rocks. Root structures are seen in some shale and mudstone units, but seldom occur in units forming the immediate floor of thick coal seams.

An unusual lithology which fits most closely with the shale and mudstone category is tonstein. Tonsteins are thin, extremely fine grained, kaolinite-rich bands associated primarily with coal seams. More descriptive details of tonsteins in the study area are given in the following chapter.

COAL

Coal in the Mist Mountain Formation in the Elk Valley coalfield occurs in seams which range up to and occasionally exceed 13 metres in true thickness. They are essentially all of humic type, although the original banding is often not visible because of shearing. They are closely associated and interbedded with shale and mudstone. Details concerning thickness, distribution and composition of coal seams are contained in the following sections.

CONGLOMERATE

Conglomerate is a very rare lithology in the Mist Mountain Formation in the Elk Valley coalfield. Where it occurs it is in close association with channel sandstone, either as lenses in sandstone beds or as discrete beds. Framework grains are generally in the granule to small cobble size range, with pebbles being the most common. Chert and quartzite are the most common types of framework grain.

Basal Coal Zone

The various lithologies described above occur throughout the stratigraphic section, with little or no tendency for specific lithologies to occur consistently at certain stratigraphic positions. An exception is the basal carbonaceous zone of the Mist Mountain Formation (Gibson, 1985), informally referred to as the "basal coal zone" in southeastern British Columbia (Grieve and Elkins, 1986). In the study area this zone is approximately 20 metres thick, always contains some coal, and at many locations contains very prominent coal seams (Plate 3), some of which are of great economic importance. More details concerning the basal coal zone are included later in this chapter, under the sections covering measured section and core descriptions, and seam correlation.

Selection of the Upper Contact

The upper contact of the Mist Mountain Formation was generally selected by application of its definition (Gibson, 1985) as already outlined. In all cases it was placed at the base of a prominent channel sandstone which overlies the stratigraphically highest significant coal seam. Above the

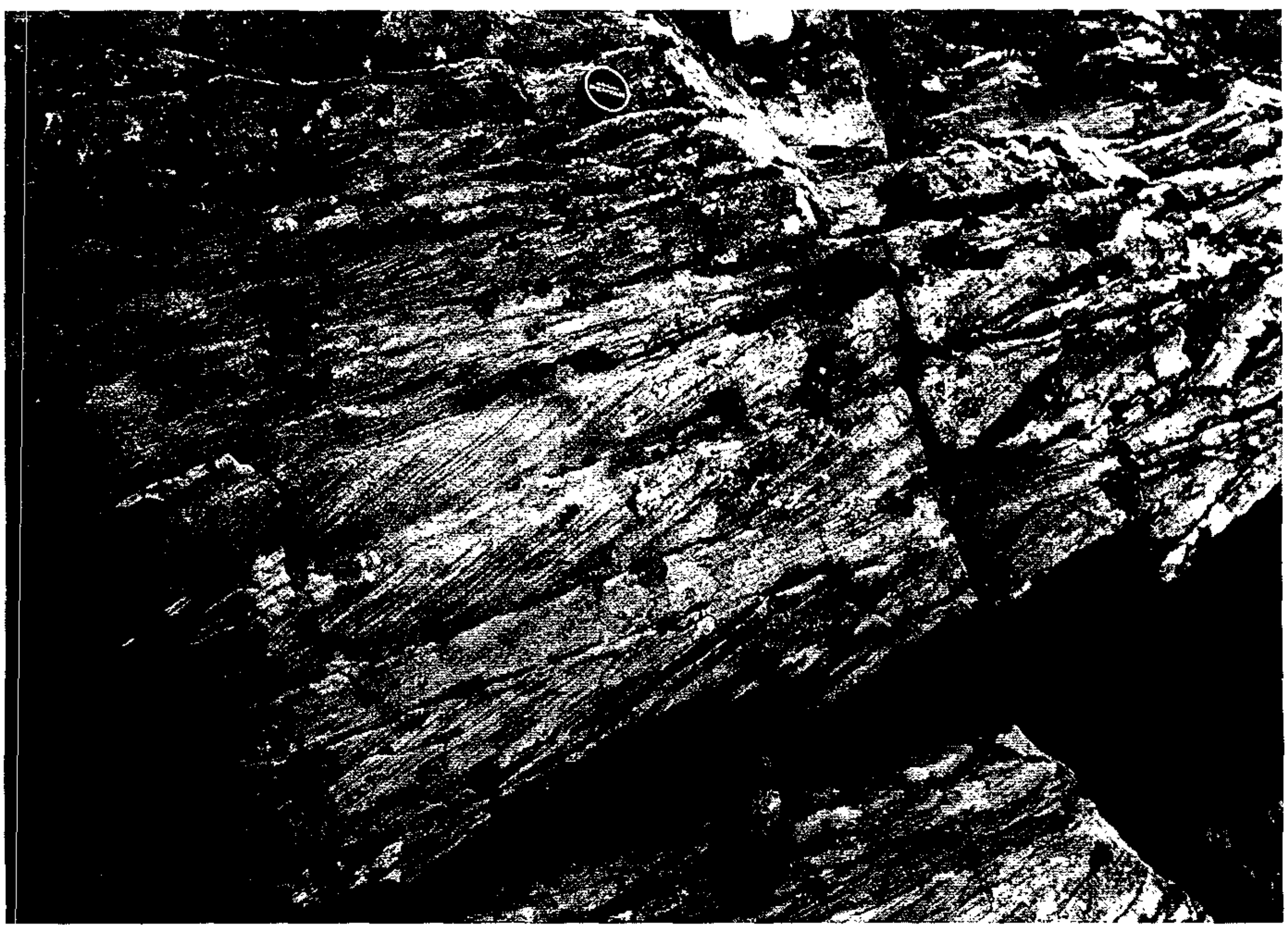


Plate 10. Tabular crossbedding in channel sandstone unit of the Mist Mountain Formation.

selected horizon the frequency and lateral continuity of channel sandstones is generally greater than in the Mist Mountain Formation. At the north end of Mount Tuxford, this point corresponds with a marked change in the weathering colour of the sandstones. Where possible, the horizon was mapped as a contact in the field. More often, however, it was necessary to select the contact at each location in isolation, which undoubtedly has led to some inconsistencies.

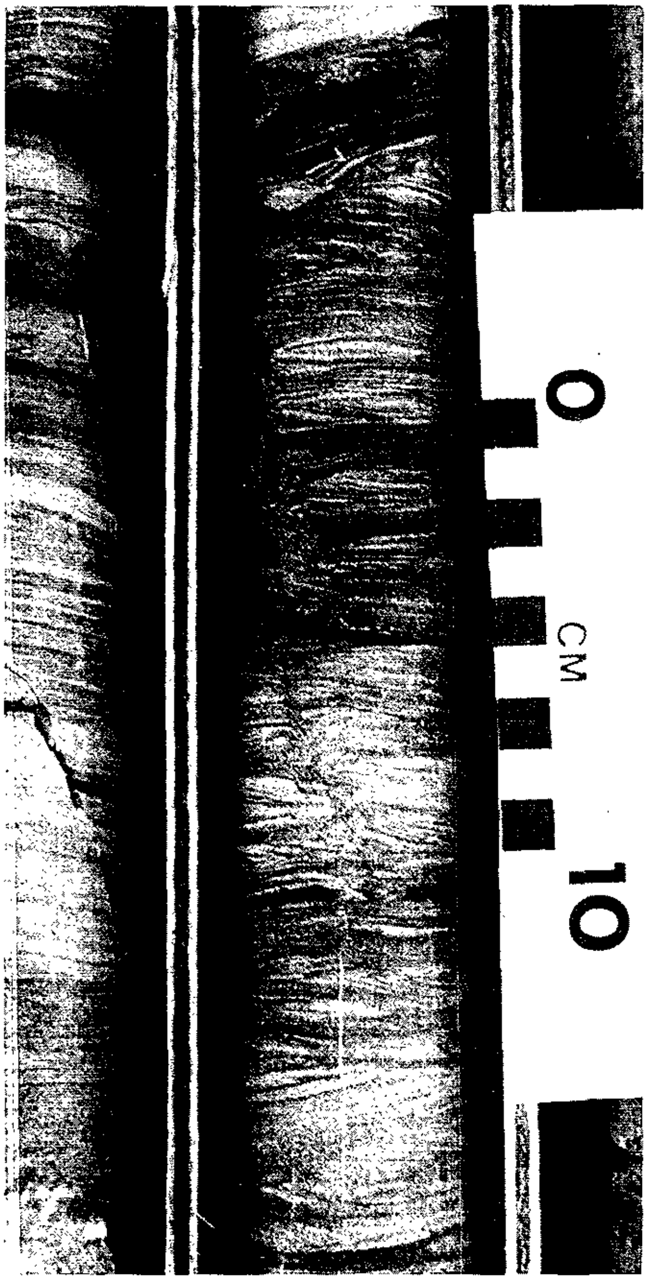


Plate 11. Example of ISAS unit in drill core of the Mist Mountain Formation. Note crosslaminations and burrowing in central column.

Descriptions of Measured Sections

The 16 stratigraphic sections measured in this study are shown in generalized form on Figure 7, and reported in detail in Appendix 1. Their locations are shown on Figures 5 and 6. Figure 7 also indicates local seam nomenclature in certain cases. The following discussion will focus on the coal seams in the various sections.

In generalizing the measured sections for display and discussion the minimum thickness of individual units was arbitrarily set at 2 metres, with the exception of coal seams and seam partings, given a minimum thickness of 1 metre. Arbitrary decisions were sometimes made in the process of combining individual units together into generalized units.

WEARY RIDGE

The Weary Ridge section (Section 1 in Figure 7) was measured from north to south along the ridge top. A series of old trenches and roads provided most of the exposure. The base of the section is the contact between the Mist Mountain and Morrissey formations (Plate 2). The section is greater than 513 metres thick. The base of the Elk Formation is believed to overlie within 50 metres of the top of the section (compare with log for drill-hole SR-7 in Figure 8).

Two seam nomenclature systems are indicated in Figure 7. The one using letters is that applied by North American Coal Corporation, which carried out exploration on Weary Ridge in 1968. This system applies specifically to my section location. The system using numbers was first applied by Scurry-Rainbow in 1969, later adopted by Elco Mining and applied to the Elk River property as a whole. This system is therefore the more familiar one. A total of 64 metres, or approximately 12.5 per cent of the total thickness of the section, is composed of coal, in seams which range up to 7.9 metres in thickness. Some interesting features of the Weary Ridge section include the presence of four coal seams, each greater than 4 metres in thickness, in the uppermost 150 metres, and the lack of thick channel-sandstone units within the section.

COAL CREEK

A partial section of Mist Mountain Formation was measured at Coal Creek, a tributary of Bleasdell Creek (Section 2 in Figure 7). The bottom of the section, which is believed to correspond to a point roughly 100 metres above the base of the formation, is an arbitrary horizon near the floor of a prominent coal seam in the lower Mist Mountain Formation. A structurally complex area within the lowest part of the Coal Creek exposures was not included. The starting point of the section is on the north side of the creek. On the opposite side, the seam corresponding with the lowest seam in the measured section has been tectonically thickened (Plate 12). The top of the section corresponds with the last of the exposures in the creek. It is estimated to be within 100 metres of the top of the Mist Mountain Formation.

Exposure throughout the section is nearly perfect, and of the greater than 307 metres of section represented in Figure 7, 29.4 metres, or 9.6 per cent, is in coal seams which range in thickness up to 5.9 metres. Only three seams are greater than 3 metres in thickness. Prominent channel-sandstones occur near the base of the section, notably in the roof of the lowest seam, and at the top of the section.

MOUNT VEITS

The Mist Mountain Formation on Mount Veits (Section 3) dips westerly and underlies the west slope (dip slope) and upper east slope. A partial section was measured on the east slope. The base of the section is the contact between the Morrissey and Mist Mountain formations (Plate 1); the top corresponds with the peak of the mountain. Exposures are excellent throughout the section.

The Mount Veits section includes 127.7 metres of strata, of which only 7.6 metres (6.0 per cent) is coal. Seams range from 1.5 to 2.5 metres in thickness. A prominent channel-sandstone unit marks the top of the section.

MOUNT TUXFORD

A complete section of Mist Mountain Formation was measured along the north-trending flank of Mount Tuxford, roughly 3 kilometres south of Mount Veits (Section 4). This location has not been trenched. At this point, the Mist Mountain Formation is 550.5 metres thick. It contains at least 37.5 metres of coal (6.8 per cent of the total section), and it is possible that more coal seams underlie the covered intervals, particularly those in the lowest 50 metres. The observed seams range up to 5.6 metres thick, and four seams are in the range of 4.8 to 5.6 metres. Channel-sandstone units are mainly confined to the lowermost and uppermost 200 metres of the section. The intervening 150 metres of predominantly recessive strata contains two closely spaced coal seams each greater than 5 metres in thickness.

Plate 12. Deformed coal zone on the south side of Coal Creek (tributary of Bleasdell Creek) adjacent to the Bourgeau thrust fault (off photo to right).

GREENHILLS RANGE

A complete section of Mist Mountain Formation was measured on the west-facing slope of the Greenhills Range, roughly 2 kilometres northwest (along strike) of the boundary between Westar Mining and Fording Coal's holdings (Section 5). The section is 696 metres thick. It contains several relatively thick covered intervals; all coal seam occurrences noted had been exposed by hand-dug trenches. Overall the section contains 35.0 metres of coal, only 5.0 per cent of the total formation thickness, although it is almost certain that other coal seams underlie some of the covered intervals. The observed seams range up to 5.3 metres thick, with a total of five seams having a thickness of 3.0 metres or greater. Several very prominent sandstone units occur throughout the section.

BURNT RIDGE EXTENSION

A partial section of Mist Mountain Formation, 453 metres thick, was measured on Burnt Ridge Extension (Section 6). Road-cut exposures were used throughout. The base of the section is the Mist Mountain - Morrissey contact, and the top of the section is believed to be within 50 to 100 metres of the top of the Mist Mountain Formation. A total of 40.3 metres, 8.9 per cent of the section, is composed of coal seams ranging up to 7.6 metres in thickness, and it is possible that coal seams occur within covered intervals. The interval between 275 and 415 metres is distinguished by a closely spaced series of coal seams ranging in thickness from 1.0 to 4.6 metres, and with a total thickness of 31.4 metres. Prominent channel-sandstone units occur in the lower part of the section, and at the top of (and overlying) the section.

IMPERIAL RIDGE

A complete section of Mist Mountain Formation, with a total thickness of 508.2 metres, was measured along Imperial Ridge (Section 7). Coal seams are exposed in hand-dug trenches. The total coal thickness is 36.9 metres (7.3 per cent of the total section thickness) and individual seams range up to 10.5 metres thick. The most prominent of these, referred to here as the Imperial seam, is roughly 160 metres above the base of the section (Figure 7). More information concerning this seam, and its projected extensions in other parts of the coalfield, is provided in the section covering seam correlation, later in this chapter. Three prominent channel-sandstone units are exposed in the lower half of the section, including one overlying the Imperial seam by approximately 10 metres.

EWIN PASS

The entire Mist Mountain Formation was measured along exploration roads on the Ewin Pass property (Section 8). The section is 487 metres thick, of which 43 metres or 8.8 per cent is comprised of coal. The seam numbers (Figure 7) were applied by Crows Nest Resources Limited, and are intended to indicate correlation with seams in the company's Line Creek mine, roughly 7 kilometres to the south. Included in this total coal thickness are two seams, 4.9 and 5.3 metres thick, in the basal coal zone, and the 13-metre 4-seam with its rider 1.5 metres thick near the top of the section. Three prominent channel-sandstone units occur in the lowest 300 metres of the section, the uppermost of which, in the roof of 7-seam, is conglomeratic, representing one of the few occurrences of Mist Mountain conglomerate in the Elk Valley coalfield.

BURNT RIDGE

The entire Mist Mountain Formation, totalling 576.4 metres in thickness, was measured along exploration roads on Burnt Ridge (Section 9). Coal comprises a total of 65.3 metres, or 11.3 per cent of the total thickness of the formation. Individual seams range from 1.0 to 11.8 metres in thickness. The basal coal zone contains a total of approximately 7.5 metres of coal in a 10.7-metre interval, making it one of the most coal-rich examples of this zone in the study area (Plate 3). Other seams, including five which are 8 or more metres in thickness, are scattered throughout the section. Thick channel sandstone deposits also occur throughout, with some concentration in the upper half. Seam nomenclature (Figure 7) was copied from Westar Mining Ltd., and is not intended to imply correlation with other properties.

BURNT RIDGE SOUTH

A complete section of Mist Mountain Formation was measured along an east-trending spur at the south end of Burnt Ridge (Section 10). Of a total thickness of 576.0 metres, 47.0 metres (8.0 per cent) consists of coal. Most of the coal seams are exposed in hand-dug trenches. A cluster of four seams, ranging in thickness from 4.8 to 8.4 metres, occurs in a 90-metre interval near the top of the lower half of the section. Channel sandstone bodies are exposed at several horizons throughout the section.

MOUNT MICHAEL (UPPER SHEET)

The thickness of the partial section of Mist Mountain Formation exposed in the immediate hangingwall of the Ewin Pass thrust near the summit of Mount Michael (Section 11) is apparently 455.1 metres. The base of the section is believed to be in the lower Mist Mountain Formation, while the top is the Elk - Mist Mountain contact. The lowest 218.3 metres of the section is devoid of coal, which makes it by far the thickest barren interval in the formation in southeastern British Columbia, unless structural thickening of the Mist Mountain Formation has occurred here (see chapter on structural geology). The interval between 218 metres and the top of the section, on the other hand, contains an anomalous concentration of coal seams, which are exposed in hand-dug trenches. They total 42.0 metres in thickness, representing 17.7 per cent of this part of the section. These seams range in thickness from 1.0 to 7.3 metres. Channel sandstone bodies are restricted to the lower, barren portion of the section, while the upper coal-rich portion is essentially devoid of these units.

MOUNT MICHAEL (LOWER SHEET)

The thickness of the Mist Mountain Formation below the Ewin Pass thrust, exposed along exploration roads on the lower slopes of Mount Michael, is a relatively thin 422.7 metres (Section 12). A total of 51.6 metres, or 12.2 per cent, is composed of coal seams which range in thickness from 1.0 to 9.5 metres. Seam nomenclature (Figure 7) is that of Crows Nest Resources Limited, and is intended to imply correlation with seams at Line Creek mine. The portion of the section richest in coal is the basal 44.0 metres, which contains 20.4 metres of coal (9 and 10-seams), including seams 6.6 and 5.8 metres thick occurring essentially within the basal coal zone (10-seam). Prominent channel sandstone units are uncommon, and occur mainly in the upper half of the formation.

NONAME RIDGE

The complete Mist Mountain Formation was described along the east-trending ridge north of Noname Creek (Section 13) which is, in turn, north of Line Creek mine. The total thickness of the section is 527.1 metres, of which 44.7 metres or 8.5 per cent consists of coal seams. Most of the seams are exposed in hand-dug trenches. They range in thickness from 1.3 to 8.0 metres, the latter representing the lower bench of a zone 15.4 metres thick containing 13.6 metres of coal in two seams in the lower third of the formation. An unusually thick channel sandstone occurs in the lowest 100 metres of the formation.

HORSESHOE RIDGE

A 311.0-metre partial section of Mist Mountain Formation, starting at the Mist Mountain - Morrissey contact, was measured along exploration roads on Horseshoe Ridge (Section 14), east of Line Creek mine. Coal seams, which range from 1.2 to 6 metres in thickness, comprise a total of 25.2 metres, or 8.1 per cent of the total thickness. Seam nomenclature (Figure 7) is that of Crows Nest Resources, and indicates proposed correlation with seams at Line Creek mine. Seam 10, the basal coal zone, consists of 4.1 metres of coal in three separate seams in the lowest 13.4 metres of section. Seam 8 upper, at 6.0 metres, is the single thickest seam. Channel sandstones occur throughout the section, notably below and above 8-seam.

TEE PEE MOUNTAIN

An erosional remnant of the basal portion of the Kootenay Group is preserved on Tee Pee Mountain (Section 15), south of Line Creek mine. The section was measured along exploration roads and in trenches. The base is at the base of a 2.0-metre coal seam within the Moose Mountain Member of the Morrissey Formation. Only the lowermost 22.4 metres of the Mist Mountain Formation is exposed. It contains two thin coal seams.

CROWN MOUNTAIN

Crown Mountain is underlain by an erosional remnant of the basal portion of the Kootenay Group. Trenches and exploration roads expose the lowest 72.4 metres of the Mist Mountain Formation (Section 16). Of this thickness, 5.8 metres is represented by three coal seams, ranging in thickness from 1.3 to 3.0 metres. A very prominent channel sandstone unit immediately overlies the thickest coal seam and is the uppermost unit in the section.

Descriptions of Drill Cores

Graphic logs of the ten cores examined in this study are shown on Figure 8; detailed logs are in Appendix 2. In generalizing the cores, units less than 2 metres in thickness were not plotted, excepting coal seams and seam partings, for which 1 metre was the minimum thickness. Grouping of units, necessitated by these minimum thickness rules, was somewhat arbitrary. Thus the appearance of the sections in Figure 8 is partly a function of the generalization process; they are not intended to be used for paleoenvironmental interpretation.

Locations of the various drill-hole sites are shown on Figures 5 and 6.

EP-102 (EWIN PASS)

This core represents approximately 265 metres of true thickness. The hole cut seven coal seams, with a total thickness of 40.5 metres and ranging up to 15 metres in thickness. The three thickest seams are named 9, 8 and 7-seam, from oldest to youngest. This nomenclature represents Crows Nest Resources' correlation of seams from Ewin Pass to Line Creek mine, 7 kilometres to the south. The bottom of the hole is probably about 35 metres above the Morrissey Formation (P. Gilmar, personal communication, 1985); therefore the zone corresponding to 10A and 10B-seams at Line Creek, the basal coal zone, is not present.

A conspicuous series of three channel sandstone deposits occurs between 9 and 8-seams. One channel sandstone lies between 8 and 7-seams, and a channel deposit of sandstone interbedded with conglomeratic sandstone and conglomerate was intersected above 7-seam, near the top of the hole.

EP-105 (EWIN PASS)

This core represents approximately 194 metres true thickness; the lowest 72 metres overlaps with strata intersected by EP-102. Five seams are present, ranging up to 9 metres in thickness and aggregating 21.6 metres. Four are named, from oldest to youngest, 7, 5, 4, and 4-rider. Therefore, 7-seam and the conglomeratic unit overlying it are common to both EP-102 and EP-105. Seams 4 and 4-rider form the most significant coal zone above 7-seam, with a combined thickness of 9 metres. There are no channel sandstone deposits above the conglomeratic unit.

MBE-101 (MOUNT BANNER)

This hole penetrated approximately 290 metres true thickness, of which 30 metres are Morrissey Formation. Several sections of the core are missing or jumbled due to vandalism. Thirteen seams, ranging from 35 centimetres to 8 metres in thickness, had been sampled by the exploration company. Six seams, with a total combined thickness of 28.7 metres, exceed 1 metre in thickness. Six thin seams, numbered 10-6 to 10-1, occur in the basal 14 metres of the Mist Mountain Formation (basal coal zone). The other major seams are named, from oldest to youngest, E, G, I, and J-seams. Channel sandstone units are relatively scarce and thin. There are three between 10-seam and E-seam and two more between E-seam and G-seam.

EV-151 (EWIN CREEK)

This core consists of a maximum 354 metres true thickness, but contains a 2.5-metre fault zone 44 metres above the base, which probably caused a small but unknown amount of repetition. Fourteen metres of Morrissey Formation was cored at the bottom of the hole. Eleven seams, ranging from 60 centimetres to 15 metres in thickness had been removed for sampling. Seven seams, aggregating 39.7 metres, exceed 1 metre in thickness. The thickest are named, from oldest to youngest, 3 lower, 3, 4 (which has a thin, unnamed rider), 5, 7, 8 lower and 8-seams. Prominent channel sandstone units occur between 4 and 5-seams, 5 and 6-seams, and 6 and 7-seams.

EV-150 (EWIN CREEK)

This core represents 302 metres true thickness of strata, of which 44 metres is Morrissey Formation. The interval between 4 and 5-seams has been thickened by approximately 60 metres as a result of thrust faulting. Consequently, all Mist Mountain strata contained in this core are also found in EV-151, but this hole was collared below 7-seam and only 3 lower, 3, 4 and 5-seams are represented. The total thickness of coal in EV-150 is 25.8 metres.

BM81-1 (BARE MOUNTAIN)

The base of this core contains a considerable thickness of Morrissey Formation, only 6 metres of which were logged for this study. The true thickness of Mist Mountain Formation in BM81-1 is 490.9 metres, so that the top of the core is in the upper part of the formation. The core sampled 16 seams, ranging from 1.1 to 12.5 metres thick, and totalling 57.7 metres. They are numbered upward from 1 (basal coal zone) to 9, with the thickest being 4, 7 and 8, each of which contains more than one bench. Seam 7 contains 19.1 metres of coal in a 21.7-metre interval. Channel sandstone units are conspicuously rare.

BM81-2 (BARE MOUNTAIN)

This hole penetrated two separate thrust sheets; the fault appears to have caused about 120 metres of true stratigraphic displacement. The hangingwall contains the Mist Mountain - Morrissey contact, and in excess of 294 metres true thickness of Mist Mountain Formation, all of which is common to drill hole BM81-1. This includes a total of 31.3 metres of coal, corresponding with seams 1 to 7. The sandstone between seams 2 and 3 in drill hole BM81-1 is considerably thicker in BM81-2.

The lower thrust sheet contains the Mist Mountain-Morrissey contact and about 64 metres of Mist Mountain Formation. The only coal belongs to the basal coal zone (1-seam) and is 2.8 metres thick.

SR-7 (WEARY RIDGE)

This core contains the Elk - Mist Mountain contact and 225.2 metres true thickness of Mist Mountain Formation. Seven coal seams occur in the section, ranging in thickness up to 4.4 metres, and with a combined thickness of 20.2 metres. These include seams P, Q and S, corresponding to the Weary Ridge measured section (Figure 7). Two channel sandstone units occur above S-seam.

SR-12 (WEARY RIDGE)

This hole cored 173.2 metres true thickness of Mist Mountain Formation, corresponding to the lower to middle part of the formation. Nine coal seams were intersected, with a total combined thickness of 22.1 metres, and a range of 1.1 to 5.3 metres. The thickest of these correspond with H and J-seams in the Weary Ridge measured section (Figure 7). There are no channel-sandstone units in the section.

SR-2 (WEARY RIDGE)

This core contains the Mist Mountain - Morrissey contact and 140.9 metres true thickness of the lower Mist Mountain Formation. Of this total, 23.1 metres is composed of coal, in seams ranging from 1.3 to 6.3 metres thick. These correspond to seams B through G in the Weary Ridge measured section (Figure 7). The basal coal zone is represented by B-seam, a 6.3-metre seam which sits directly on the Morrissey Formation. Another major seam is D-seam, which is 5.9 metres thick. There are no channel sandstone units in the section.

Coal Seam Distribution and Frequency

Tables 2 and 3 provide summaries of total coal thicknesses in the measured sections and drill cores, respectively; Table 4 summarizes the frequencies of individual coal seam thicknesses occurring in the measured sections only. As was the case in the generalized diagrams, individual seams under 1 metre thick are not considered in these summaries.

An average of 8.7 per cent of the stratigraphic thickness of the measured sections is represented by coal seams more than 1.0 metre thick, while the drill cores contain an average of 11.7 per cent coal. This discrepancy has two likely causes. It is possible that coal seams buried under covered intervals have been missed in the case of some of the measured sections. The average value for the measured sections may therefore be too low. On the other hand, the sampled (missing coal) intervals in the drill cores may contain shale partings or thinly interbedded shale and coal units, which would have been described separately in a measured section. Thus the average value for the cores may actually be too high. Ten per cent of the aggregate thickness

TABLE 2
SUMMARY OF MEASURED STRATIGRAPHIC SECTIONS OF THE MIST MOUNTAIN FORMATION

Section No.	Location	Relative Stratigraphic Positions		Thickness of section (m)	Thickness of coal (m)	% Coal
		Base of Section	Top of Section			
1	Weary Ridge	Base of MM	Upper MM	>513	64.0	12.5
2	Coal Creek	Lower MM	Upper MM	>307	29.4	9.6
3	Mt. Veits	Base of MM	Lower MM	127.7	7.6	6.0
4	Mt. Tuxford	Base of MM	Top of MM	550.5	37.5	6.8
5	Greenhills	Base of MM	Top of MM	696.0	35.0	5.0
6	Burnt Ridge Extension	Base of MM	Upper MM	453.0	40.3	8.9
7	Imperial Ridge	Base of MM	Top of MM	508.2	36.9	7.3
8	Ewin Pass	Base of MM	Top of MM	486.8	43.0	8.8
9	Burnt Ridge	Base of MM	Top of MM	576.4	65.3	11.3
10	Burnt Ridge South	Base of MM	Top of MM	587.0	47.0	8.0
11	Mt. Michael Upper	Lower MM	Top of MM	455.1	42.0	9.2
12	Mt. Michael Lower	Base of MM	Top of MM	422.7	51.6	12.2
13	Noname Ridge	Base of MM	Top of MM	527.1	44.7	8.5
14	Horseshoe Ridge	Base of MM	Middle/Upper MM	311.0	25.2	8.1
15	TeePee Mtn.	Base of MM	Lower MM	22.4	1.2	5.3
16	Crown Mtn.	Base of MM	Lower MM	72.4	5.8	8.0
						Average 8.7

MM = Mist Mountain Formation

TABLE 3
SUMMARY OF DRILL-CORE LOGS OF THE MIST MOUNTAIN FORMATION

Drillhole	Location	Relative Stratigraphic Positions		True Thickness (m)	Thickness of coal (m)	% Coal
		Collar	Bottom			
A) MBE-101	Mt. Banner	Middle MM	Base of MM	290.2	28.7	9.9
B) EP-102	Ewin Pass	Middle MM	Lower MM	256.6	40.5	15.8
C) EP-105	Ewin Pass	Upper MM	Middle MM	193.8	21.6	11.1
D) EV-151	Ewin Creek	Middle/Upper MM	Base of MM	353.6	39.7	11.2
E) EV-150	Ewin Creek	Lower MM	Base of MM	257.0	25.8	10.0
F) BM81-1	Bare Mtn.	Upper MM	Base of MM	496.9	57.7	11.6
G) BM81-2	Bare Mtn.	Middle/Upper MM	Base of MM	291.4	34.0	11.7
H) SR-7	Weary Ridge	Basal Elk	Upper MM	227.7	20.2	8.9
I) SR-12	Weary Ridge	Middle MM	Lower MM	173.2	22.1	12.8
J) SR-2	Weary Ridge	Lower MM	Base of MM	140.9	23.1	16.4
						Average 11.7

MM = Mist Mountain Formation

therefore appears to be a realistic average for the coal content of the Mist Mountain Formation in the Elk Valley coalfield.

When considering the frequency distribution of coal seam thickness categories in the measured sections (Table 4), it is clear that the 1-to-2-metre category contains the largest share, 43 per cent. If sections containing only a part of the Mist Mountain Formation are eliminated, the 1-to-2 metre category remains the most important, its share of the total essentially unchanged. In both cases, the second most frequently occurring thickness interval is 2-to-3 metres. In order to gain an understanding of the relative volumes of each thickness category (in the complete sections only), the percentage contribution of each thickness range has been multiplied by the mid-point of the thickness range (for example, 2.5 for the 2-to-3-metre range). The results are shown in the last column of Table 4. The 1-to-2 metre interval is again the most significant, with a value of 63.3. The next most significant category is 5-to-6 metres, with a value of 50.6. Seams thicker than 6 metres appear to represent a relatively small volume of coal, although this is somewhat misleading, as in many cases seams in this range make a very significant contribution to measured reserves on individual properties.

Seam Correlation

With the exception of the basal coal zone, regional correlation of coal seams and other strata of the Mist Mountain Formation is difficult. This difficulty is related to pronounced facies variations, and the lack of known regionally extensive markers and is compounded by structural complications. On a local scale, seam correlation is successfully accomplished using any of a variety of methods, including geological mapping, seam tracing, visual recognition of coal seams based on physical characteristics, characterization of seams based on analytical parameters, and interpretation of geophysical logs. Two cases where tonsteins are used to correlate coal seams over short distances are documented in this study (see chapter on tonsteins).

An attempt at more regional correlation of coal seams in the south half of the study area is described in this section. Figure 9 shows simplified versions of six of the core logs and three measured sections, while Figure 10 reproduces geophysical logs for these drill holes, together with one definite and two proposed seam correlations. These correlations are based on relative stratigraphic positions, relative seam thicknesses, the nature of the roof and floor rocks, and geophysical log signatures.

BASAL COAL ZONE

The only firmly established correlation shown on Figure 9 is that of the basal coal zone. It rests directly on the Morrissey Formation, but its upper contact cannot be rigidly defined. Although correlation of this zone is self-evident, it is worth discussing for two reasons. First, the zone contains important reserves of coal in the Elk Valley coalfield, including 1-seam at Greenhills operations and 10A and 10B-seams at Line Creek mine (Plate 13). Second, there are considerable differences in its appearance, even in closely spaced holes, which emphasize the difficulty in correlating coal seams in the region.

The lowermost 20 metres or so of the Mist Mountain section in each drill core which contains the base of the formation is plotted in detail on Figure 11. The 20-metre cutoff was chosen arbitrarily, but in all cases this interval contains most of the coal which can reasonably be assigned to the basal zone. The tops of the sections from EV-151 and SR-2 have been extended slightly to include the top of a significant coal seam.

A few generalizations can be made about Figure 11. Each example contains at least two separate coal seams. In most cases a coal seam rests directly on or within a metre of the top of the Morrissey Formation. The thickest individual seam is 2-seam in SR-2 from Weary Ridge at 5.65 metres, while the thickest coal zone is the combination of 3 and 3-lower-seams in EV-151 from Ewin Creek, with a total thickness of 7.4 metres, including a 60-centimetre shale parting. The remainder of the seams range from 20 cen-

TABLE 4
FREQUENCY OF OCCURRENCE OF COAL SEAMS OF VARIOUS THICKNESSES IN MEASURED SECTIONS OF THE MIST MOUNTAIN FORMATION.

Thickness Intervals (m)	Section Numbers																Totals		Contribution to Complete Sections	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	All Sections	Complete Sections	Per cent	Relative Volume
1–2	6	6	3	10	5	4	1	4	6	7	8	5	8	4	1	2	80	46	42.2	63.3
2–3	2	3	1	4	4	3	3	1		2	6	4					33	18	16.5	41.3
3–4	4	1			2	3	4	2	1	2	1		1	1		1	23	12	11.0	38.5
4–5	3	1		1	1	2		2	1	1		2	2	1			17	10	9.2	41.4
5–6		2		2	1		1	1	1	1		2	1	1			13	10	9.2	50.6
6–7	1								1			1		1			4	2	1.8	11.7
7–8	2					1			1	1	2		1				8	3	2.8	21.0
8–9									1	1			1				3	3	2.8	23.8
9–10												1					1	1	0.9	8.6
10–11							1		1								2	2	1.8	18.9
11–12									1								1	1	0.9	10.4
12–13																				
13–14								1									1	1	0.9	12.2

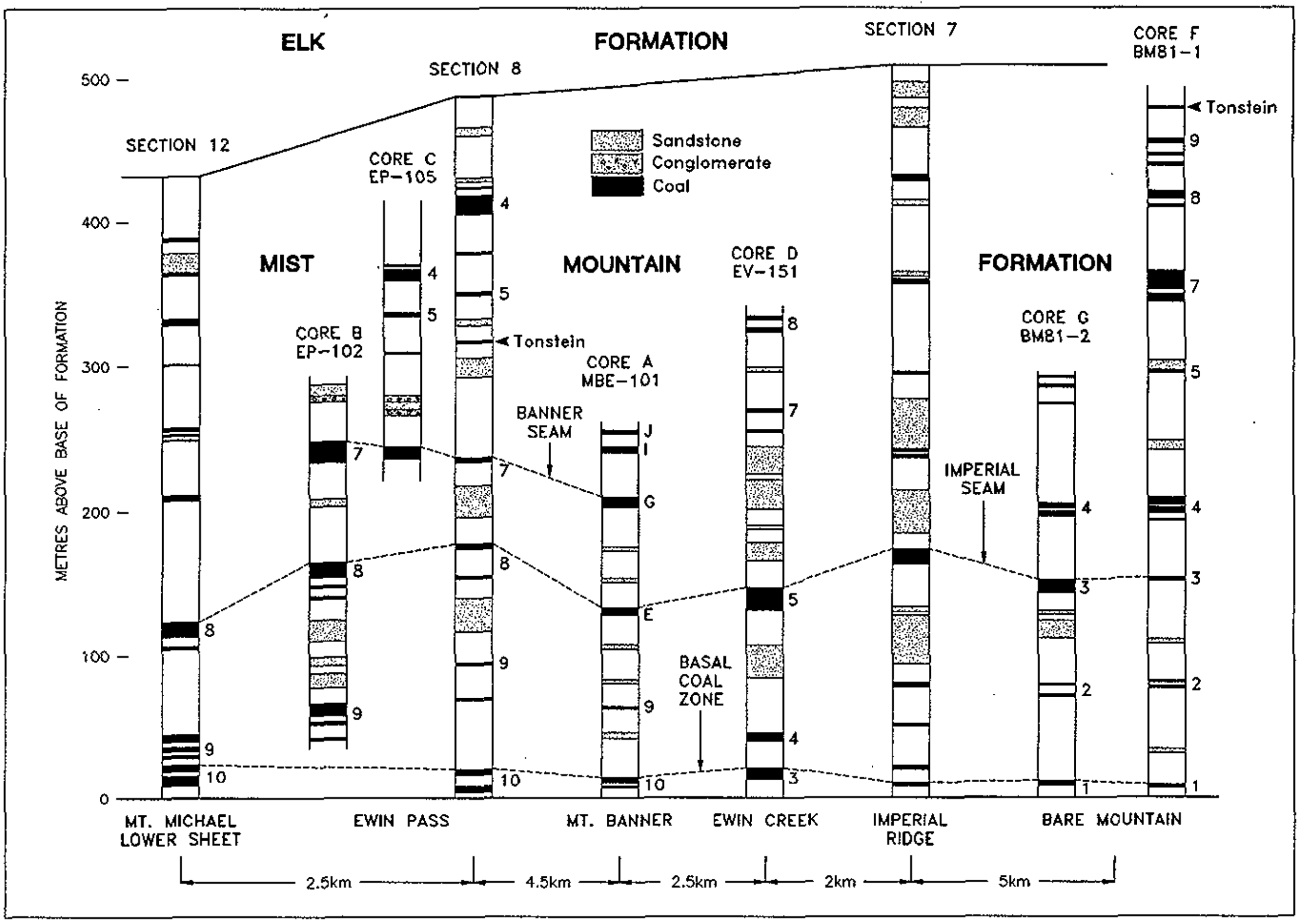


Figure 9. Proposed coal seam correlations in the south half of the Elk Valley coalfield.

timetres to 3 metres in thickness. In general, the thicknesses and positions of individual seams vary widely between holes, even in the cases of the closely spaced pairs EV-150 and EV-151, and BM81-1 and BM81-2.

Interbedded strata within the basal coal zone are mainly shales and shale-dominant varieties of ISAS units. They are massive to well laminated and may be rooted, burrowed and distorted. Coal banding and coal spar are also very common features, especially close to the seams. One thin carbonaceous sandstone occurs in each of EV-151, MBE-101 and SR-2. The strata overlying the basal coal zone are also fine grained and are indistinguishable from clastic rocks within the zone.

Kaolinite-rich grey clay bands, which have been identified as tonsteins, occur at equivalent positions in EV-150 and EV-151, and are clearly correlateable (Figure 11). Correlation with a similar band in BM81-2 may be possible, as the upper surface of the Morrissey Formation is known to have local relief of several metres.

The basal coal zone described here correlates with the lower part of Donald's (1984) Unit I on Eagle Mountain at the Fording River mine to the north. At that locality all the coal within Unit I, comprising 1, 2 and 3-seams, appears to lie well within the basal 20 metres of the formation and 1-seam rests directly on the Morrissey Formation. Coals of Unit I are too thin to form mineable reserves. At Line Creek mine, on the other hand, the basal coal zone contains 10A and 10B-seams, with the former resting directly on the Morrissey Formation (Plate 13). These seams feature prominently in Line Creek's current (1991) production.

IMPERIAL SEAM

The name Imperial seam was first applied to the thickest seam on Imperial Ridge in the Ewin Creek property north of Ewin Creek (Grieve and Fraser, 1985). On the ridge summit it attains a thickness of 10.5 metres, with very little interbanded shale. It has been traced northward, in the field, with some confidence from Imperial Ridge to Bare Mountain, a strike distance of 5 kilometres (Grieve and Fraser, 1985, Sheets 8 and 9).

The Imperial seam is referred to by Westar Mining as 5-seam on the Ewin Creek property, which includes Imperial Ridge, and it was intersected in both drill holes EV-150 and EV-151 (Figures 8 and 9) south of Imperial Ridge. The true thickness of the Imperial seam in these holes is 15 metres. According to Huryn (1982) the bottom 12 to 13 metres contains very little interbanded shale. The roof and floor rocks in EV-151 are black, coal-streaked and banded shales, while in EV-150 they are black, coal-banded, laminated shales.

To the south, the Imperial seam is tentatively correlated with E-seam in core MBE-101 (Figures 8 and 9). This correlation is based on three lines of evidence: relative thickness and position of E-seam with respect to overall stratigraphy; similarity of roof and floor lithologies to those in the EV cores; and similarity of geophysical logs to the EV drill holes (Figure 10). E-seam in MBE-101 is 7.4 metres thick and contains very little interbanded shale. As was the case in the EV cores, it is about 130 metres stratigraphically above the base of the Mist Mountain Formation and between the two most prominent channel-sandstone horizons. Roof and floor rocks are massive, coal-banded, black to dark grey shales.

Moving farther south, the Imperial seam is tentatively correlated with 8-seam in core EP-102 and the Ewin Pass measured section (Figures 8 and 9). The latter seam is 150 metres above the base of the Mist Mountain Formation and is the first major seam above the most significant concentration of channel-sandstone units in the section. The seam is 10.3 metres thick and contains 50 centimetres of shale in five interbands (Beavan, 1981). Roof and floor rocks are laminated, black, coal-banded shales. The geophysical response of this seam is similar to that of E-seam in MBE-101 (Figure 10). Seam 8 at Ewin Pass has been correlated with 8-seam on Mount Michael to the south by mapping (Figure 9; Grieve and Fraser, 1985, Sheet 6).

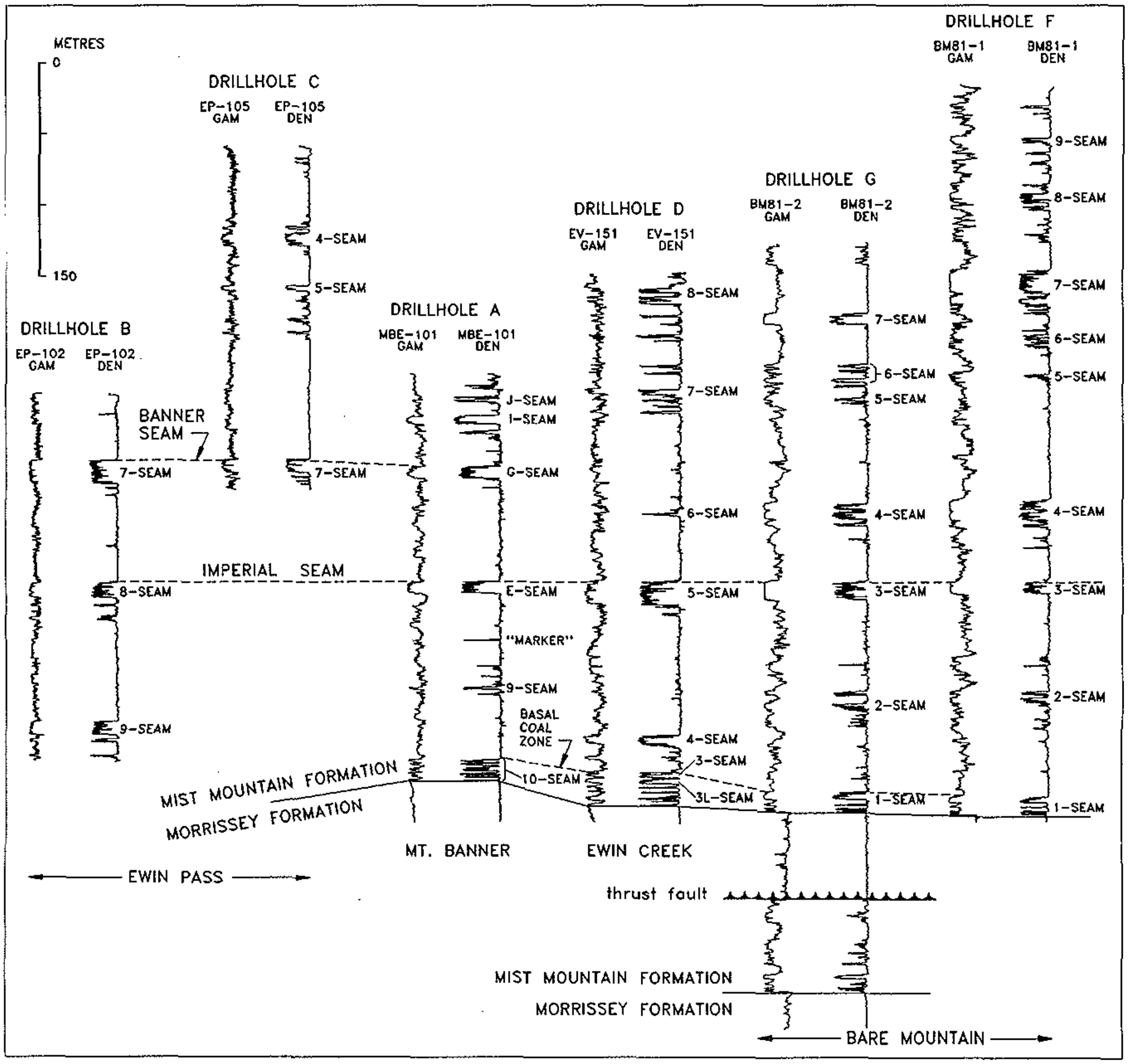


Figure 10. Geophysical logs of drill holes plotted in Figure 9. The Imperial seam is used as a datum. (GAM = gamma ray log; DEN = density log).

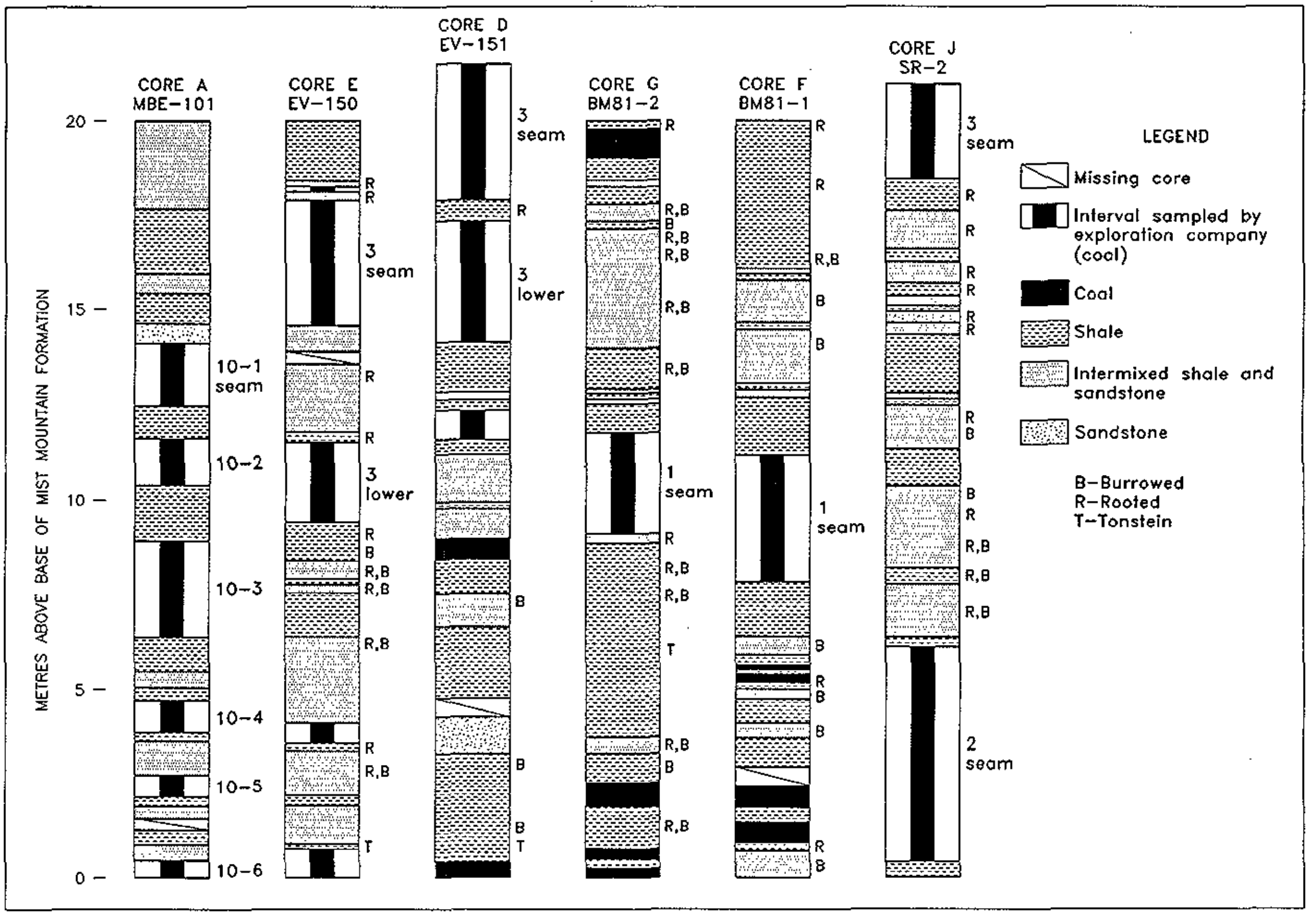


Figure 11. Detailed core logs of the basal coal zone of the Mist Mountain Formation in the Elk Valley coalfield.

The Imperial seam was correlated with a prominent seam on Bare Mountain to the north in the course of geological mapping, as was mentioned earlier. Number 3 seam in drill holes BM81-1 and BM81-2 is believed to be the equivalent of this seam (Figures 8 and 9). In BM81-2 it is 10.5 metres thick and occurs just over 150 metres above the base of the formation. Its roof and floor rocks are composed of laminated, black, coal-banded shale. The geophysical response of 3-seam on Bare Mountain (Figure 10) is again similar to that of the Imperial seam in other holes.

The overall strike length of the proposed Imperial seam correlation, which extends from Mount Michael in the south to Bare Mountain in the north, is close to 17 kilometres.

Stratigraphic equivalents of the Imperial seam may already constitute important reserves and production in the coalfield. For example, 8-seam on the Ewin Pass property was believed by Crows Nest Resources' geologists to be the same as 8-seam at the Line Creek mine (Plate 13). Moreover, the Imperial seam may have an equivalent on Eagle Mountain in the Fording River Operations area. Fording's 5-seam, for example, occupies approximately the same stratigraphic position as 3-seam on Bare Mountain.

BANNER SEAM

The term Banner seam was introduced by Grieve (1989) to represent 7-seam in drill holes EP-102 and EP-105 and the Ewin Pass measured section, and G-seam in drill hole MBE-101 on Mount Banner (Figures 8 and 9). This correlation is made with some confidence based on stratigraphic position, especially given the proximity of Ewin Pass and Mount Banner. Geophysical log responses appear to verify the correlation (Figure 10), as does the nature of the roof and floor rocks (coal-banded shales in all cases).

The Banner seam is believed to have been washed out by the stream which deposited the thick sandstone units between 5-seam and 7-seam in drill hole EV-151 on Ewin Creek (Figures 8 and 9). It may correlate with 4-seam in drill holes BM81-1 and BM81-2 on Bare Mountain, but this is highly speculative.

DEPOSITIONAL SEQUENCE MODELLING

An embedded, first-order Markov chain analysis of the sedimentary sequence in core logs was carried out, in order to generate a depositional model for sediments of the Mist Mountain Formation in the Elk Valley coalfield. This method is based on a test of the assumption that the occurrence of a particular sedimentary unit at any position within the stratigraphic column is dependent on the nature of the immediately underlying unit. Thicknesses of individual units are not taken into account.

To begin the analysis, the frequency of occurrences of upward transitions from one rock type to another is tallied and displayed in matrix form. A second matrix is generated, containing predicted frequencies, based on totally random sequences. The difference between the two matrices gives an indication of which upward transitions are occurring more often than at random. Presence of the Markov property is tested by means of a chi-square calculation which tests the significance of the transition matrix *vis à vis* random occurrence.

Substitutability analysis was also carried out (Davis, 1973). This type of analysis examines the tendency for two rock types to occur in a similar stratigraphic situation with respect to overlying and underlying units. Two rock types with high substitutability are usually assumed to have been deposited in similar sedimentary environments (Kilby and Oppelt, 1985).

STATISTICAL METHODS

Core-log data were entered into a computer database file using dBASE III PLUS (TM) software. Fields were created for hole name, base and top of intervals, rock-type code, suffix modifiers, comments, and lastly, a second three-digit generalized rock-type code. This last field was used for the statistical analysis. It was needed because the number of lithological types identified during core logging (Appendix 2) was too large to handle statistically in a meaningful way, and some of the types occur very infrequently. In effect, rock types were grouped together to produce a shorter list of lithologies to work with. The list of eight rock-type codes and what they represent is shown in Table 5. All unloggable and missing core, other than coal which had been previously removed for sampling, was given a 000 code and treated as a separate rock type.

The database file was converted to an ASCII file, compatible with the Cal Data software used in the analysis. Certain modifications to the ASCII file were made prior to statistical analysis. Most notably, all transitions from a specific rock type to the same rock type were eliminated, simply by deleting one of the records involved. In cases where the same rock type occurs three or more times in succession, all but one of the records were deleted. This was necessary because the type of Markov chain analysis employed (embedded) is based on changes in lithology. Another modification was the deletion of all records not belonging to the Mist Mountain Formation.

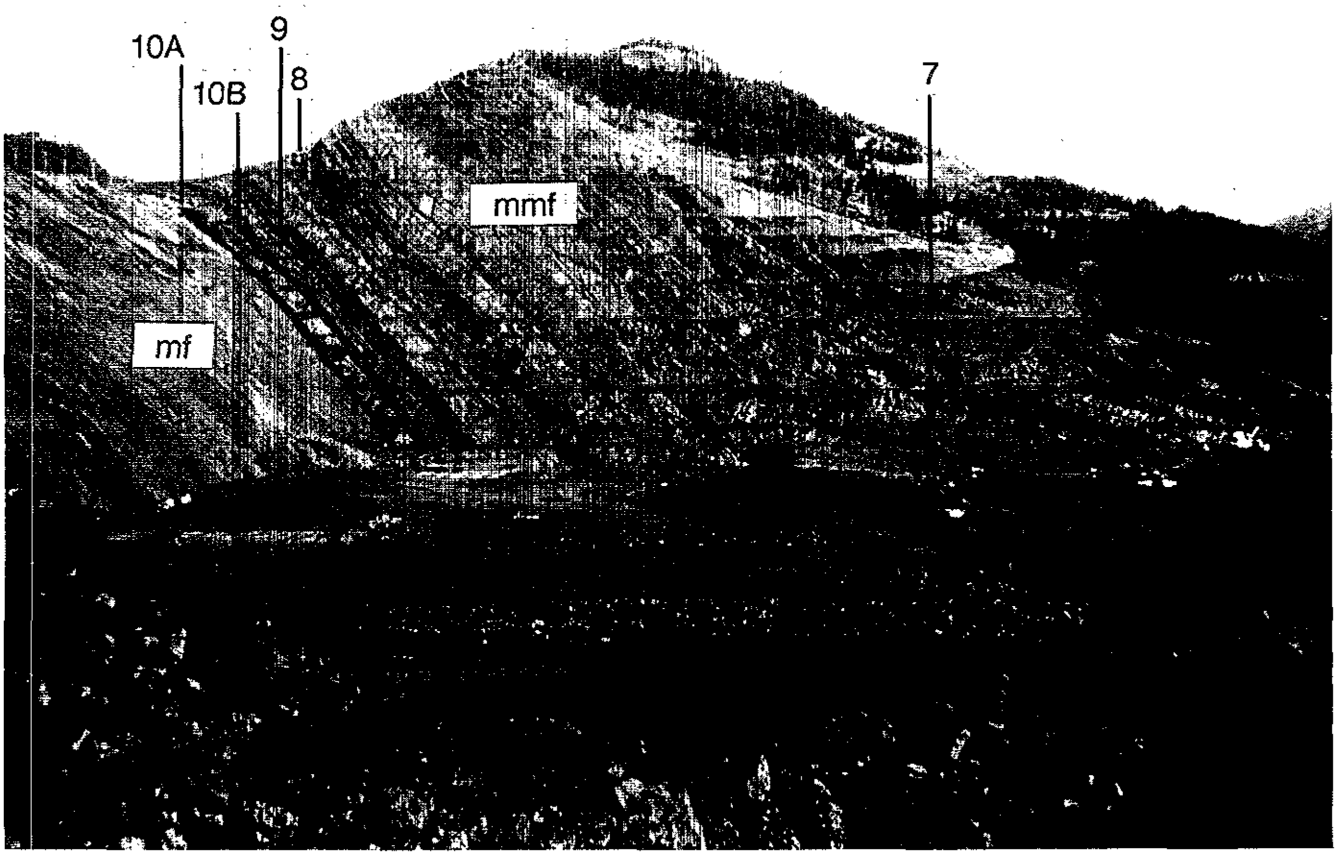


Plate 13. *View to the north of the highwall of Line Creek mine. Note large dip-slope footwall of Morrissey Formation (mf), and* the positions of seams 10A, 10B, 9 and 8 in the Mist Mountain Formation (mmf). The axis of the Alexander Creek syncline is to the right of the photograph.

TABLE 5
ROCK-TYPE CODES USED FOR MARKOV ANALYSIS
OF DRILL-CORE LOGS

Code	Explanation
CGL	Conglomerate. Generally chert-pebble composition.
SAND	Sandstone. Generally medium to very coarse grained. May be massive, flat bedded or crossbedded.
SS>SH	Intermixed shale and sandstone, with sandstone in greater abundance than shale. Includes flaser-bedded sandstone, and wavy-bedded sandstone with interbedded shale. Sandstones generally fine grained.
SS=SH	Intermixed shale and sandstone, with both in roughly equal amounts. Predominantly lenticular-bedded sandstone with interbedded shale. Sandstone generally fine or very fine grained.
SH>SS	Intermixed shale and sandstone, with shale in greater abundance than sandstone. Includes shale with lenticular sandstone streaks, and sandy shales. Sandstone generally fine or very fine grained.
SHALE	"Shale series". Generally noncarbonaceous, grey siltstone, silty mudstone or mudstone. May be massive or laminated.
C-SHL	Carbonaceous shale. Generally dark grey to black mudstone or shale with coal streaks, bands or spar.
COAL	Coal series. Most often missing from core. Where observed it includes banded coal, dull massive coal and coal with shale interbeds or streaked with shale.

(Derived from Ruby *et al.*, 1981.)

TRANSITION MATRIX

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL	X
CGL	0	15	2	0	1	0	0	0	0
SAND	15	0	58	21	47	32	10	1	0
SS>SH	2	48	0	47	114	76	15	1	7
SS=SH	0	21	34	0	196	159	39	2	3
SH>SS	0	43	125	173	0	377	137	8	9
SHALE	1	40	71	162	383	0	242	64	18
CARBS	0	17	15	43	105	252	0	158	7
COAL	0	1	2	4	11	73	146	0	5
X	0	0	3	4	12	19	7	4	0

EXPECTED MATRIX

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL	X
CGL	0	0	1	2	4	4	2	1	0
SAND	0	9	15	22	43	49	29	11	2
SS>SH	1	15	25	37	72	82	49	19	4
SS=SH	2	22	37	55	106	121	73	29	6
SH>SS	4	43	72	106	204	232	140	56	11
SHALE	4	48	82	120	230	261	157	63	12
CARBS	2	29	49	73	139	159	96	38	7
COAL	1	12	20	29	56	64	38	15	3
X	0	2	4	6	11	13	7	3	0

DIFFERENCE MATRIX

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL	X
CGL	0	15	1	-2	-3	-4	-2	-1	0
SAND	15	-9	43	-1	4	-17	-19	-10	-2
SS>SH	1	33	-25	10	42	-6	-34	-18	3
SS=SH	-2	-1	-3	-55	90	-38	-34	-27	-3
SH>SS	-4	0	53	67	-204	-145	-3	-48	-2
SHALE	-3	-8	-11	42	153	-261	85	1	6
CARBS	-2	-12	-34	-30	-34	93	-96	120	0
COAL	-1	-11	-18	-25	-45	9	108	-15	2
X	0	-2	-1	-2	1	6	0	1	0

DIFFERENCE MATRIX (POSITIVE VALUES CONVERTED TO % PROBABILITIES)

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL
CGL		83.3	5.6					
SAND	8.2		23.4		2.2			
SS>SH	0.3	10.6		3.2	13.5			
SS=SH					19.8	8.4		
SH>SS			6.1	7.7		16.6		
SHALE				4.3	15.6		8.7	0.1
CARBS						15.6		20.1
COAL						3.7	44.6	

Figure 12. Markov analysis matrices for drill-core logs (whole Mist Mountain Formation).

Subfiles of the overall modified database were defined, each subfile representing one core log. This was necessary to avoid inclusion of the transitions from the end of one hole to the beginning of the next in the database.

The modified database, which contains 3707 legitimate transitions, was then subjected to statistical analysis. The statistical computer programs developed and described by Kilby (in Kilby and Oppelt, 1985) were used. These in turn were based on techniques described by Siemers (1978) and Davis (1973). The first step in the procedure is generation of a "count-transition" matrix (Figure 12) which displays the number of occurrences of each possible type of upward transition in the data. Next, an "expected" matrix is generated, which represents the number of upward transitions of each type which would occur in a totally random sedimentary sequence containing the same number of units of the various rock types. The "difference" matrix is then generated by subtracting the expected matrix from the count-transition matrix (Figure 12).

At this point it is possible to analyse the difference matrix to discover which upward transitions occur more frequently than at random, that is, those which are represented by positive values. Two outstanding examples include transitions from SHALE to SH>SS and *vice versa,* with dif-

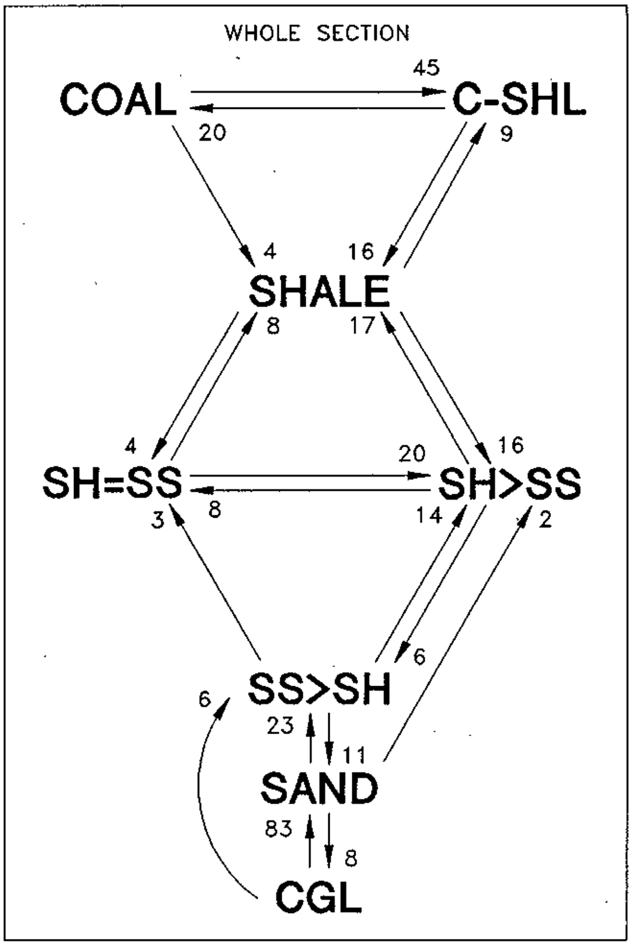


Figure 13. Facies transition diagram based on Markov analysis (whole Mist Mountain Formation).

ference values of 153 and 145, respectively (Figure 12; *see* Table 5 for explanation of abbreviations). Caution must be used in considering these numbers, however, because these two rock types occur most frequently in the database, and hence the number of transitions they are involved in is automatically high. To provide a more balanced analysis of the difference matrix, it is necessary to convert the positive frequency values in the difference matrix to probabilities based on the total number of transitions each unit is involved in, that is, to divide each positive element of each row in the difference matrix by the sum of all the elements in the corresponding row in the count-transition matrix. (This may also be accomplished by expressing the values in the first two matrices as probabilities in the first place, and simply subtracting the second from the first to generate the difference matrix.) The difference matrix with positive values expressed as probabilities (percentages) is shown in Figure 12. Examination of this matrix shows that, for example, the 15 transitions from CGL to SAND, representing an 83.3 per cent probability, are more significant than the seemingly impressive 153 transitions from SHALE to SH>SS, representing only a 15.6 per cent probability, referred to earlier.

All transitions involving missing or unloggable core were ignored.

The probability-difference matrix was converted to graphic form for easier interpretation (Figure 13). All positive upward transitions, except those below an arbitrary cut-off of 1 per cent, are portrayed as an arrow connecting the two lithologies. The positions of the various lithologies on the diagram were selected to simulate a general fining-upward sequence and to show the upward transitions in as simple a manner as possible.

The count-transition matrix was tested for the Markov property by means of a chi-square test, as described by Davis (1973). In this application, rejection of the null hypothesis implies that the transitions observed are dependent to a significant degree (not random) and thus form a Markov chain.

The process was repeated twice, once for each of two subsets of the database. The first represents all strata within 200 metres of the base of the Mist Mountain Formation, and the second strata more than 200 metres above the base. The first (Figures 14 and 15) contains 2216 transitions and the second (Figures 16 and 17) contains 1485 transitions. These were generated to see if there are any sedimentological differences between the lower and upper parts of the formation in the study area.

TRANSITION MATRIX

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL	X
CGL	0	12	2	0	0	0	0	0	0
SAND	12	0	39	10	34	22	7	1	0
SS>SH	2	34	0	27	80	57	6	0	2
SS=SH	0	9	22	0	118	91	27	0	1
SH>SS	0	33	84	107	0	220	93	7	2
SHALE	0	28	51	92	231	0	132	31	7
CARBS	0	9	8	29	71	137	0	83	4
COAL	0	0	1	1	5	45	74	0	0
X	0	0	1	1	4	6	3	1	0

EXPECTED MATRIX

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL	X
CGL	0	0	1	1	3	3	2	0	0
SAND	0	7	11	15	30	32	19	6	0
SS>SH	1	11	19	25	50	54	32	11	1
SS=SH	1	15	25	32	65	69	41	14	1
SH>SS	3	30	51	65	133	142	84	30	3
SHALE	3	32	53	68	140	149	88	31	4
CARBS	2	19	32	41	83	88	52	18	2
COAL	0	7	11	15	30	32	19	6	0
X	0	0	1	1	3	4	2	0	0

DIFFERENCE MATRIX

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL	X
CGL	0	12	1	-1	-3	-3	-2	0	0
SAND	12	-7	28	-5	4	-10	-12	-5	0
SS>SH	1	23	-19	2	30	3	-26	-11	1
SS=SH	1	-6	-3	-32	53	22	-14	-14	0
SH>SS	-3	3	33	42	-133	78	9	-23	-1
SHALE	-3	-4	-2	24	91	-149	44	0	3
CARBS	-2	-10	-24	-12	-12	49	-52	65	2
COAL	0	-7	-10	-14	-25	13	55	-6	0
X	0	0	0	0	1	2	1	1	0

DIFFERENCE MATRIX (POSITIVE VALUES CONVERTED TO % PROBABILITIES)

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL
CGL		85.7	7.1					
SAND	9.6		22.4		3.2			
SS>SH	0.5	11.1		1.0	14.4	1.4		
SS=SH					19.8	8.2		
SH>SS		0.5	6.0	7.7		14.3	1.6	
SHALE				4.2	15.9		7.7	
CARBS						14.4		19.1
COAL						10.3	43.7	

Figure 14. Markov analysis matrices for drill-core logs (strata within 200 metres of the base of the Mist Mountain Formation).

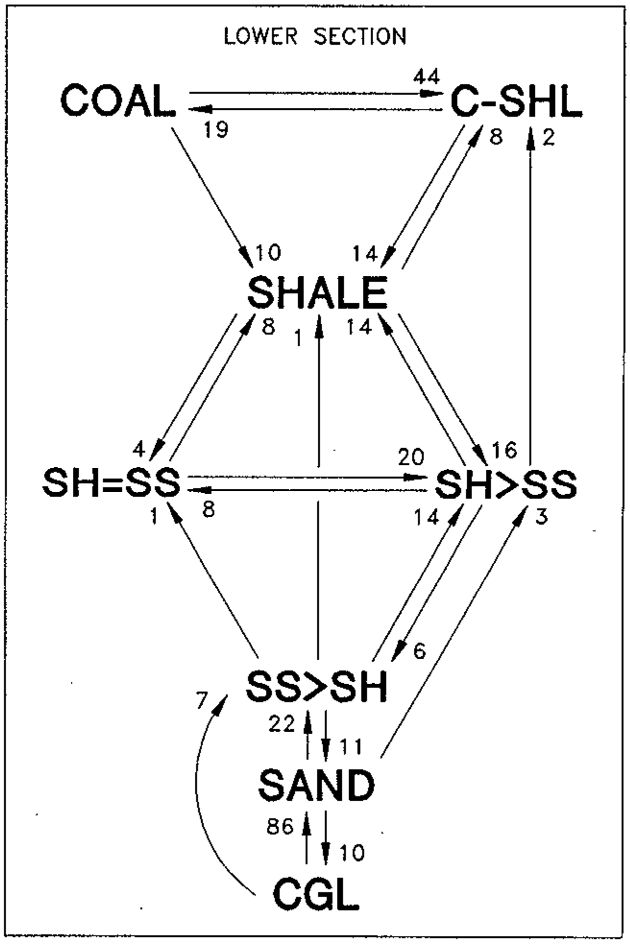


Figure 15. Facies transition diagram based on Markov analysis (strata within 200 metres of the base of the Mist Mountain Formation).

TRANSITION MATRIX

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL	X
CGL	0	3	0	0	1	0	0	0	0
SAND	3	0	19	11	13	10	3	0	0
SS>SH	0	14	0	20	34	19	9	1	5
SS=SH	0	12	12	0	78	68	12	2	2
SH>SS	0	10	41	66	0	157	44	1	7
SHALE	1	12	20	70	152	0	107	33	11
CARBS	0	7	7	14	34	115	0	74	3
COAL	0	1	1	3	6	28	71	0	5
X	0	0	2	3	8	13	4	3	0

EXPECTED MATRIX

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL	X
CGL	0	0	0	0	0	1	0	0	0
SAND	0	2	4	7	12	16	9	4	1
SS>SH	0	4	7	12	22	28	17	7	2
SS=SH	0	7	12	23	40	51	31	14	4
SH>SS	0	12	22	41	71	90	54	25	7
SHALE	1	16	27	51	89	112	68	31	9
CARBS	0	10	17	32	55	70	42	19	5
COAL	0	4	7	14	25	31	19	8	2
X	0	1	2	4	7	9	5	2	0

DIFFERENCE MATRIX

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL	X
CGL	0	3	0	0	1	-1	0	0	0
SAND	3	-2	15	4	1	-6	-6	-4	-1
SS>SH	0	10	-7	8	12	-9	-8	-6	3
SS=SH	0	5	0	-23	38	17	-19	-12	-2
SH>SS	0	-2	19	25	-71	67	-10	-24	0
SHALE	0	-4	-7	19	63	-112	39	2	2
CARBS	0	-3	-10	-18	-21	45	-42	55	-2
COAL	0	-3	-6	-11	-19	-3	52	-8	3
X	0	-1	0	-1	1	4	-1	1	0

DIFFERENCE MATRIX (POSITIVE VALUES CONVERTED TO % PROBABILITIES)

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL
CGL		75			25			
SAND	5.1		25.4	6.8	1.7			
SS>SH		9.8		7.8	11.8			
SS=SH		2.7			20.4	9.1		
SH>SS			5.8	7.7		20.6		
SHALE				4.7	15.5		9.6	
CARBS						17.7		21.7
COAL							45.2	

Figure 16. Markov analysis matrices for drill-core logs (strata more than 200 metres above the base of the Mist Mountain Formation).

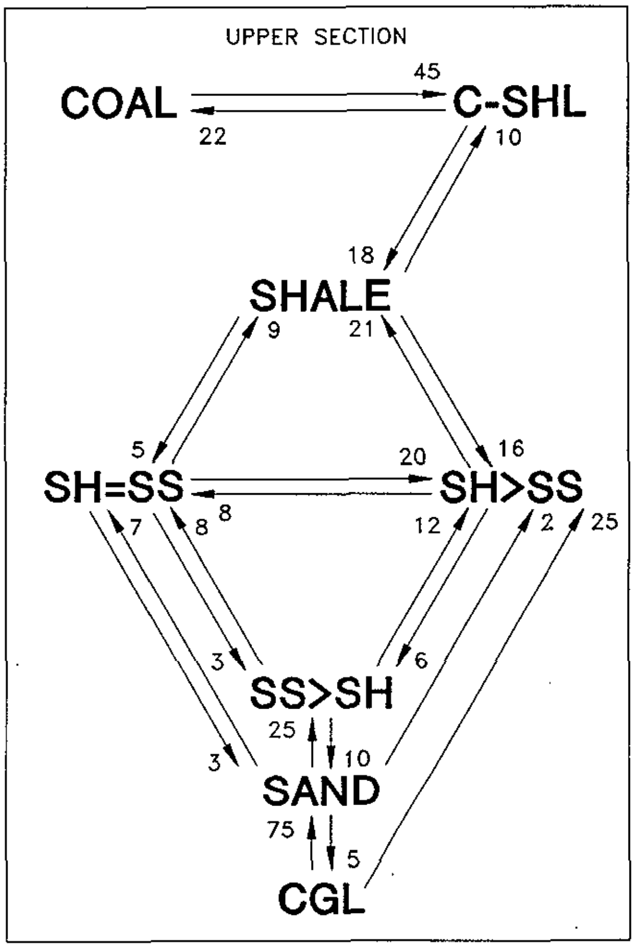


Figure 17. Facies transition diagram based on Markov analysis (strata more than 200 metres above the base of the Mist Mountain Formation).

Three additional matrices (Figure 18), termed the substitutability matrices, were generated for data from the entire formation, following the methods of Davis (1973). Values in the upward substitutability matrix indicate the probability of any two lithologic units being overlain by a similar lithological unit (maximum value 1). The downward substitutability matrix is the same except that the values indicate the probability of two lithologic units being underlain by a similar lithological unit. The mutual substitutability matrix measures the degree to which two units are overlain and underlain by similar units. The upward substitutability matrix was calculated from the transition matrix for each pair of lithologies by calculating the cross-product ratio of the respective rows (*see* Davis, 1973). The downward substitutability matrix was calculated in the same way, but using columns instead of rows. The mutual substitutability matrix was obtained by multiplying the corresponding values from the upward and downward substitutability matrices.

Results and Discussion

Results for the entire Mist Mountain Formation are presented and discussed first, followed by a comparison of the lower and upper parts of the formation. Rock-type abbreviations will be used throughout. Explanations of the abbreviations are given in Table 5.

Results for the entire formation are given in Figures 12 and 13. Starting at the base of the transition diagram, CGL, although a rare rock type, shows a very strong trend (83% probability) to be overlain by SAND and a weaker trend (6%) to be overlain by SS>SH. SAND is most likely to be overlain by SS>SH (23%), and less likely to be overlain by CGL (8%) or SH>SS (2%). SS>SH is most often overlain by SH>SS (14%), but is almost as likely to be overlain by SAND (11%), and less likely to be overlain by SS=SH (3%). SS=SH tends to be overlain by finer units, either SH>SS (20%) or SHALE (8%). SH>SS is most likely to be overlain by SHALE (17%), but is also overlain by coarser rock types SS=SH (8%) and SS>SH (6%). SHALE tends to be overlain by the coarser rock types SH>SS (16%) and, to a lesser extent, SS=SH (4%), but also may be overlain by CARBS (9%). CARBS shows roughly equal likelihood of being overlain by SHALE (16%) or COAL (20%). COAL is most likely to be overlain by CARBS (45%), with SHALE a distant second (4%).

The chi-square test of the transition matrix for the Markov property yielded a value of 4.5×10^5. This represents a very strong rejection of the hypothesis that the observed rock-type transitions are produced by random events.

UPWARD SUBSTITUTABILITY MATRIX

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL
CGL	1.000							
SAND	0.125	1.000						
SS>SH	0.358	0.680	1.000					
SS=SH	0.147	0.751	0.908	1.000				
SH>SS	0.129	0.620	0.584	0.597	1.000			
SHALE	0.150	0.662	0.754	0.690	0.322	1.000		
CARBS	0.010	0.545	0.697	0.749	0.729	0.376	1.000	
COAL	0.010	0.321	0.368	0.462	0.649	0.501	0.378	1.000

DOWNWARD SUBSTITUTABILITY MATRIX

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL
CGL	1.000							
SAND	0.109	1.000						
SS>SH	0.389	0.705	1.000					
SS=SH	0.152	0.837	0.891	1.000				
SH>SH	0.188	0.709	0.521	0.644	1.000			
SHALE	0.010	0.681	0.741	0.663	0.303	1.000		
CARBS	0.010	0.664	0.722	0.824	0.714	0.448	1.000	
COAL	0.010	0.406	0.295	0.442	0.531	0.514	0.308	1.000

MUTUAL SUBSTITUTABILITY MATRIX

	CGL	SAND	SS>SH	SS=SH	SH>SS	SHALE	CARBS	COAL
CGL	1.000							
SAND	0.010	1.000						
SS>SH	0.139	0.479	1.000					
SS=SH	0.010	0.629	0.809	1.000				
SH>SS	0.010	0.440	0.304	0.384	1.000			
SHALE	0.010	0.452	0.559	0.458	0.010	1.000		
CARBS	0.010	0.362	0.503	0.618	0.521	0.168	1.000	
COAL	0.010	0.130	0.108	0.204	0.344	0.258	0.116	1.000

Figure 18. Substitutability matrices for drill-core logs (whole Mist Mountain Formation).

Fluvial sediments in general can be subdivided into those derived from point-bar deposition and those deposited on the floodplain (Walker and Cant, 1984). In the Mist Mountain Formation the point-bar environment is represented by the prominent channel sandstones. The main rock types which make up these units are SAND or sandstone and CGL or conglomerate; the latter forms as channel lag deposits. In addition the intermixed sandstone and shale rock types, SS>SH, SS=SH and SH>SS, may, in some instances, be part of the upper part of the point-bar environment.

The floodplain environment in the Mist Mountain Formation is the more common; it includes levee, crevasse-splay and flood-basin deposits (Gibson, 1985). As pointed out by Dunlop and Bustin (1987), levee deposits are difficult to recognize in the Mist Mountain Formation, especially in vertical sections, and may be indistinguishable from crevasse-splay deposits. All rock types finer than SAND are included in the floodplain environment and it is probable that some of the SAND units are also part of this environment, probably as part of proximal splays.

The results documented here suggest a fining-upward depositional sequence with sandstone (with or without conglomerate) at the base and coal at the top, with numerous combinations of transitional events possible within the cycle. (It must be reiterated that although the transition diagrams were deliberately drawn to simulate a general fining-upward sequence, the results of the analysis are definitely consistent with this model). For example, CGL (channel lag), where it occurs, is nearly always overlain by SAND. SAND is overlain by an intermixed sandstone and shale unit, usually SS>SH. Interestingly, the direct fining-upward transition from SAND to SHALE is not observed to a significant degree. If SAND is assumed to be the characteristic component of a point-bar deposit, and SHALE is taken as a major component of a flood-basin deposit, then it is apparently not possible to make the transition from the one environment to the other without "passing through" the intermediate lithologies. This suggests that either the intermixed sandstone and shale rock types are an integral part of the point-bar deposits, perhaps as the last sediment types laid down before a channel was abandoned, and/or that another floodplain environment must first be "passed through" before reaching the flood basin. The possibilities for the latter suggestion are levees and crevasse splays, which, as was pointed out earlier, are difficult to distinguish. The intermixed sandstone and shale rock types are expected to be characteristic of both (Dunlop and Bustin, 1987).

Deposition of distal crevasse-splay deposits on the floodplain is believed to have occurred in the instances where intermixed shale and sandstone units, either SS=SH or SH>SS, directly overlie SHALE. These results suggest that this is more likely to occur than the transition from SHALE to carbonaceous shale, CARBS, and perhaps ultimately COAL. Interestingly, COAL only occurs overlying CARBS, suggesting a gradual transition to the coal-forming environment, and perhaps suggesting a relatively isolated environment for coal deposition. This conclusion is consistent with McCabe (1984, 1987) who suggested that most thick, economic coals formed in an environment geographically far removed from any source of clastic sediment. COAL is most often overlain by fine-grained units, either CARBS or SHALE, suggesting that coal deposition was terminated by invasion of flood-basin sediments, perhaps related to increased rate of subsidence in the swamp, or a sudden rise in the water table (McCabe, 1984).

The results are also interesting in that they do not indicate how the depositional sequence begins. There is no evidence of SAND or CGL overlying units finer than SH>SS to a significant degree. It is known from field evidence that point-bar deposits in some cases overlie fine-grained sequences, and in some instances they are seen directly overlying carbonaceous units including coal (Plate 8). This contact, in effect, represents the end of one sequence and the start of the next. Two comments can be made here. The first is that the transition matrix (Figure 12) does indicate cases where SAND overlies either SHALE, CARBS or COAL, but the number of occurrences is less than that expected in random situations (expected matrix). This may be a function of the very detailed core logging. The significance of single large-scale events has perhaps been lost in the process of distinguishing such a large number of transitions, most of which perhaps represent only subtle changes in environment. The second comment relates to new concepts of peat deposition (for example, McCabe, 1984, 1987) which, as noted above, suggest that coal precursors were deposited in environments removed from sources of clastic sediment, like fluvial channels. Consequently, migration of a point-bar deposit into a peat-forming environment might be expected to be a rare event.

Analysis of the three substitutability matrices for the entire formation (Figure 18) is both instructive and somewhat confusing. For example, they show that the rock types SS=SH and SS>SH have a very high degree of substitutability, suggesting their depositional environments were similar. Given the lithological similarity of these two units (Table 5), and their common presumed association with the upper part of point-bar and crevasse-splay depositional environments, this result is not surprising. More unexpected, however, are the relatively high substitutabilities for such pairs of rock types as CARBS and SS=SH, SHALE and SS>SH, and CARBS and SS>SH. The depositional model derived from the Markov analysis does not suggest that any of these pairs would be highly substitutable, as their presumed depositional environments were significantly different. Further work is necessary to explain these results.

The results for the lowest 200 metres of the Mist Mountain Formation and the overlying portion of the formation are given in Figures 14 through 17. They are broadly similar to those for the whole formation, and will not be described in detail. Moreover, the results for the two subsets of data are not markedly different from each other, suggesting that the same depositional processes apply to both. This is somewhat surprising, given the different depositional settings postulated for the lower and upper parts of the formation, referred to earlier (Gibson, 1985). There are in fact some subtle differences which show up, such as the fairly weak tendency for SAND to overlie and be overlain by SS=SH in the upper part of the formation, which is not apparent in the lower part or in the formation as a whole. This may suggest a subtle contrast in the deposition of the upper part of point-bar deposits between the upper and lower parts of the formation. Another contrast is in the roof-rock of coal seams. COAL in the upper part of the formation is only overlain by CARBS to a significant degree (Figure 17), in contrast with the lower part of the formation, in which COAL is overlain by both CARBS and SHALE. This may suggest a more gradual drowning of the coal depositional environment in the upper part of the formation.

Chi-square tests of the count transition matrices for the lower and upper parts of the formation are both high, at 2.9×10^5 and 2.0×10^4, respectively.

CHAPTER 3: TONSTEINS

BACKGROUND

Tonsteins are kaolinitic, fine-grained sedimentary rocks associated with coal and coal-bearing strata; they are superficially similar to the shale partings found in most coal seams. Tonsteins are normally thin, but often have considerable areal extent, a factor which has made them extremely useful as correlation tools in many coalfields (*see*, for example, Williamson, 1961, or Eden *et al.*, 1963). It was their potential as correlation tools which led to my detailed study of tonsteins in the Elk Valley coalfield.

The term "tonstein" does not, strictly speaking, imply any particular mode of formation. Much recent work suggests that many tonsteins are the end product of the reworking and/or alteration of volcanic ash (*see*, for example, Price and Duff, 1969, and Kilby, 1986b), and this concept is generally accepted. Other theories for the origin of tonsteins have included: deposition of kaolinite-rich sediments; leaching of clays in the acidic peat-forming environment; and soil formation processes (Williamson, 1961; McCabe, 1984).

Tonsteins contain kaolinite as their major component, with lesser amounts of quartz, feldspar and mica, and minor amounts of carbonate, apatite, anatase, zircon and minerals of the goyazite-gorceixite series (Williamson, 1967; Moore, 1968; Price and Duff, 1969). They have been classified in numerous ways. They have been divided into those occurring in or adjacent to coal seams (coal tonsteins) and those associated with the interbedded strata (non-coal; Price and Duff, 1969). They have also been divided into two types, based on their morphology observed by transmitted light microscopy: crystalline (krystall) and granular (graupen) tonsteins (Williamson, 1967). Schuller and Hoenhe (1956) classified tonsteins into four types: crystalline, granular, dense non-crystalline and pseudomorphous (*see* also ICCP Handbook, 1963).

Bouroz (1962) proposed a descriptive classification, with corresponding implied origins (Table 6). The four major origins he proposed for tonsteins are: alteration of a primary deposit of tuff (orthotonstein); redeposition and subsequent alteration of a tuff (stratotonstein); colloidal sedimentary deposits (cryptotonstein); and metamorphosed orthotonsteins (metatonsteins). The first two of these can be subdivided into textural varieties, resulting in a total of seven types.

The presence of tonsteins in the Mist Mountain Formation has been noted previously by Mériaux (1972, 1974) and Gibson (1985). In this study they were first noted at two locations and stratigraphic positions (Figure 19), at Ewin Pass in a thin seam between 7 and 5-seams (Figure 9), and on Line Creek Ridge in the immediate roof of 10B-seam (Grieve, 1984). In both cases, it was possible to trace the tonstein (or group of tonsteins in the case of Line Creek Ridge) for a distance of about 1.4 kilometres. Tonsteins were also found at several other locations (Figure 19), but none of these could be correlated over any significant distance.

Tonsteins were also found at various stratigraphic horizons in some of the drill cores (Figures 9 and 11) although they were not nearly as abundant in these cores as had been hoped (Grieve and Elkins, 1986; Grieve, 1989). This was partially due to the fact that almost all coal seams had been removed from the core boxes for analysis. With the exception of a tonstein in the basal coal zone of two closely spaced cores (EV-150 and EV-151 in Figure 11), correlation of tonsteins between holes was not possible.

Tonstein sample locations are shown on Figure 19. Table 7 summarizes the locations, stratigraphic positions and general features of all tonsteins found during this study. Information concerning mineralogy, petrography and chemistry of the tonstein samples is given in Tables 8 to 10.

TABLE 6
CLASSIFICATION OF TONSTEINS

Origin	Variety	Character
Alteration of a primary deposit of tuff ORTHOTONSTEIN	Orthotonstein alpha	Conspicuous irregular nodules containing vermicular or crystalline kaolinite
	Orthotonstein beta	Numerous small crystals and vermicules of kaolinite
Redeposition and subsequent alteration of a tuff STRATOTONSTEIN	Stratotonstein alpha-1	Ovoid or flattened nodules with sharp margins and crypto or occasionally microcrystalline kaolinite. Possessing a definite layered texture
	Stratotonstein alpha-2	Irregular masses of crypto or microcrystalline kaolinite and altered feldspars
	Stratotonstein beta	Numerous small crystals or vermicules of kaolinite. (Differs from orthotonsteins beta in containing an abundance of detrital quartz and having a less homogeneous texture)
A colloidal sedimentary deposit CRYPTOTONSTEIN	Cryptotonstein	A homogeneous and cryptocrystalline mass of kaolinite
Probably developed from orthotonsteins by metamorphism METATONSTEIN	Metatonstein	Composed predominantly of micaceous minerals having a similar form to kaolinite (May contain abundant detrital quartz and other sedimentary fragments)

(After Bouroz, 1962.)

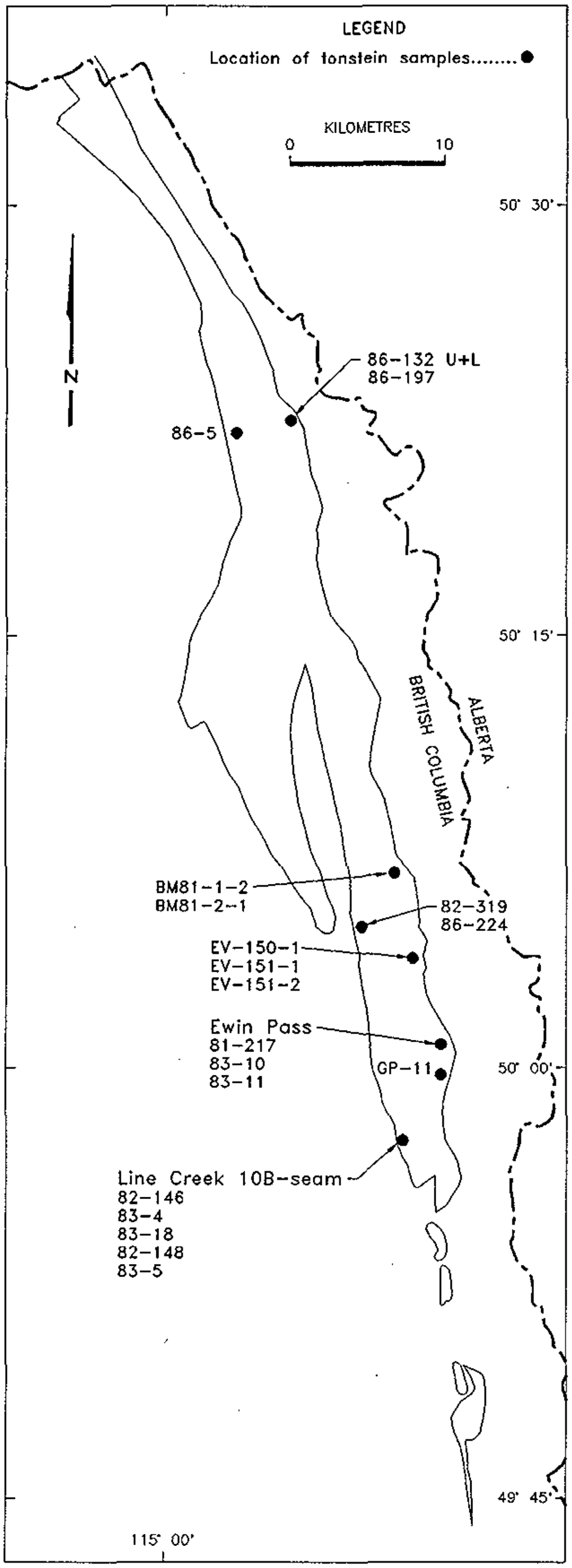


Figure 19. Locations of tonstein samples.

These data are discussed below. For the sake of clarity, the samples referred to in the tables have been divided into different groups for discussion: the Ewin Pass tonstein (Samples 81-217, 83-10 and 83-11); Line Creek Ridge 10B-seam tonsteins (82-146, 83-4 and 83-18); samples from shales within the basal coal zone in cores (EVO-1 from core EV-150, EV1-1 and EV1-2 from EV-151, and BM2-1 from BM81-2); other samples from the lower part of the Mist Mountain Formation (GP-11, G82-148, G86-5, G86-132U, and G86-132L); and other samples from the upper part of the formation (G82-319, G83-5, G86-197, G86-224, and BM1-2 from core BM81-1).

In addition to data reported here, exhaustive geochemical analysis of these same samples has been carried out by Goodarzi *et al.* (1990).

EWIN PASS TONSTEIN

SAMPLES (TABLE 7)

The Ewin Pass tonstein occurs within a coal seam 1 metre thick, between 7 and 5-seams, in the upper half of the Mist Mountain Formation on the Ewin Pass property (Figures 9 and 19). The initial find (Sample 81-217) was sampled during geological mapping of the south half of the coalfield. Its positive identification as a tonstein followed petrographic and mineralogical analyses, leading to closer investigation of the Ewin Pass area to find more examples of the same horizon. Careful search of an area 1.4 kilometres to the north of 81-217 revealed a band of similar appearance in a thin seam at the same relative stratigraphic position (Samples 83-10 and 83-10F). Sample 83-11 was later collected within 100 metres of the original outcrop, which had subsequently been buried by road reclamation work.

PHYSICAL DESCRIPTION (TABLE 7)

The Ewin Pass tonstein is a fine-grained, argillaceous unit 5 to 6 centimetres thick. It is dark brownish grey to greyish brown with black streaks of organic material, and has a dull to subvitreous lustre, a regular, orthogonal joint pattern and a conchoidal breakage fracture. Sample 83-11 is distinctive in being composed of two distinct zones, the lower and thicker one conforming to the description just given, and the upper one, comprising the uppermost 2 centimetres of the unit, containing irregular patches of dull, lighter grey material, and suggesting volcanic tuff in its overall texture.

MINERALOGY (TABLE 8)

The Ewin Pass tonstein is distinctive in that it contains a major proportion of the mineral gorceixite, $(Ba,Ca)Al_3(PO_4)_2(OH)_5.H_2O$, which, together with goyazite, $SrAl_3(PO_4)_2(OH)_5.H_2O$, is a member of the crandallite group. A solid solution probably exists between the two end-members. The other minerals are kaolinite, which is only a minor constituent in the case of Sample 83-10, minor apatite, and tentatively identified plagioclase.

TABLE 7
LOCATION, PHYSICAL CHARACTERISTICS AND STRATIGRAPHIC POSITIONS OF TONSTEINS

Sample Number	Seam Name	Location	Colour	Thickness	Metres above Morrissey Formation
81-217	6	Ewin Pass	dark brownish grey	5-6 cm	335
83-10	6	Ewin Pass	dark brownish grey	5-6 cm	335
83-10F	6	Ewin Pass	dark brownish grey	5-6 cm	335
83-11	6	Ewin Pass	dark brownish grey	5-6 cm	335
82-146B	10B	Line Creek Extension	medium brown	1 cm	20
83-4A	10B	Line Creek Extension	medium grey	< 1 cm	20
83-4B	10B	Line Creek Extension	medium brown	1 cm	20
83-18A	10B	Line Creek Mine highwall	medium grey	< 1 cm	20
83-18B	10B	Line Creek Mine highwall	medium brown	1 cm	20
83-18C	10B	Line Creek Mine highwall	medium grey	< 1 cm	20
EV0-1	basal	DDH EV-150, at 296.8 m	medium grey	< 1 cm?	1
EV1-1	basal	DDH EV-151, at 375.8 m	medium grey	3 mm	1
EV1-2	basal	DDH EV-151, at 376.2 m	medium grey	2 cm	1
BM1-2	—	DDH BM81-1, at 21.03 m	dark greyish brown	5 cm	480
BM2-1	basal	DDH BM81-2, at 525.78 m	grey	3 cm	5
86-5	—	Coal Creek (Bleasdell)	—	—	100
82-148	8	Line Creek Extension	dark grey	—	85
GP-11	7	Mount Michael/Ewin Pass	dark brownish grey	1 cm	185
86-132U	J	Weary Ridge	—	1-2 cm	225
86-132L	J	Weary Ridge	—	1-2 cm	225
83-5	5	Line Creek Extension	dark grey to black	4-5 cm	250
82-319	—	Burnt Ridge Extension	—	3-4 cm	400
86-224	10	Burnt Ridge Extension	—	—	335
86-197	Q	Weary Ridge	dark greyish brown	—	435

PETROGRAPHY (TABLE 9)

The samples have a brownish, fine-grained matrix, and are generally granular (graupen texture). Individual graupen are ovoid and elongated (Plate 14) and aligned parallel to bedding. Organic matter occurs as dispersed stringers or patches, which in some cases surround the graupen.

CHEMISTRY (TABLE 10)

The tonstein contains high levels of phosphorus (4.5% P_2O_5) and barium (up to and exceeding 2%), a result of its high gorceixite content. Strontium values, at 0.15 to 0.7 per cent, are also elevated, probably as a result of substitution in gorceixite. Titanium, at 0.18 to 0.5%, is in relatively low concentration compared with samples from other locations.

LINE CREEK 10B-SEAM TONSTEINS

SAMPLES (TABLE 7)

The Line Creek 10B-seam tonsteins occur within the shales and mudstones immediately overlying the seam. They were first noted at an adit site on the Line Creek Extension property above Noname Creek, to the north of the mine. At that location (82-146), two tonsteins are separated by approximately 1.2 centimetres of dark grey, very fine grained carbonaceous rock. The sample designation 82-146 actually refers to the lower band only in Tables 7 to 9. The same pair of tonsteins was sampled at a site roughly 700 metres to the south, above West Line Creek, still within the Line Creek Extension property and north of the mine (Plate 15). These samples are designated 83-4A (lower) and 83-4B (upper). The third occurrence of the 10B-seam tonsteins sampled was along the highwall of Line Creek mine, a further 700 metres to the south. At this location the pair of tonsteins are separated by 1 centimetre of carbonaceous shale. The lower band is designated sample 83-18B and the upper 83-18A. A third tonstein, which underlies 83-18B by 15 centimetres, is designated 83-18C.

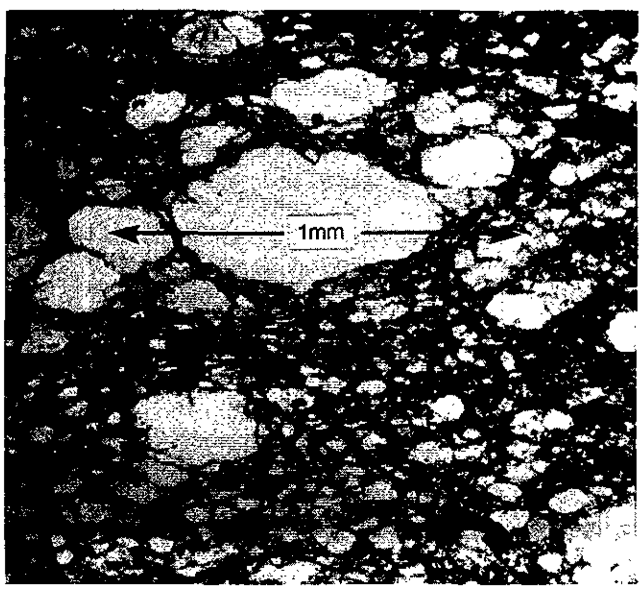


Plate 14. Photomicrograph (plane-polarized light) of tonstein sample 81-217 from Ewin Pass property.

TABLE 8
MINERALOGY OF TONSTEINS AS DETERMINED BY X-RAY DIFFRACTION

Sample Number	Mineralogy
81-217	gorceixite, kaolinite, trace apatite, plagioclase?
83-10	gorceixite, minor kaolinite, trace apatite?
83-10F	gorceixite, minor kaolinite & apatite
83-11	gorceixite, kaolinite, trace apatite, plagioclase?
82-146B	kaolinite, quartz, trace apatite & gorceixite?
83-18B	kaolinite, minor quartz, trace apatite? & plagioclase?
83-18C	kaolinite, quartz, trace apatite & pyrite
EV0-1	kaolinite>>minor quartz, anatase & siderite (Mg-rich?)
EV1-1	kaolinite>quartz>>anatase & minor pyrite
EV1-2	kaolinite>>quartz, siderite & minor anatase
BM1-2	kaolinite>>minor gorceixite & quartz
BM2-1	kaolinite>quartz>>minor anatase, siderite, pyrite, apatite
86-5	kaolinite>>quartz>>minor anatase, trace gorceixite
82-148	kaolinite>>quartz
GP-11	kaolinite, minor dickite>>quartz
86-132U	kaolinite>>quartz>>minor anatase
86-132L	kaolinite>>quartz & minor anatase?
83-5	kaolinite>quartz>>trace gorceixite?, anatase?
82-319	kaolinite>>minor quartz
86-224	kaolinite>>quartz>trace gorceixite, anatase?
86-197	kaolinite>>minor quartz, anatase & trace siderite

Physical Descriptions (Table 7)

The lower band of the closely spaced pair, which has sample designations 82-146, 83-4B and 83-18B, is 1.8 centimetres thick, with two distinct colour zones. The lower 12 millimetres is medium brown with black carbonaceous stringers, while the upper 6 millimetres is dark grey to black. Overall, the band is very fine grained and has two regular sets of fractures, similar to those in the Ewin Pass tonstein samples. Some fracture planes have a vitreous lustre. Breakage planes are conchoidal. Rounded, light grey blebs up to 2 millimetres in diameter are concentrated near the contacts of the band, and also occur in the enclosing 4 to 5 millimetres of shale. The band is very difficult to physically separate from its enclosing rock.

The upper band of the pair (designated 83-4A and 83-18C) is 5 millimetres thick and medium grey in colour. Its other features are similar to those of the lower band.

Mineralogy (Table 8)

Three of the six samples (82-146, 83-18B and 83-18C) of the 10B-seam tonsteins were analyzed by x-ray diffraction. All three contain kaolinite as the major constituent, with lesser amounts of quartz and trace amounts of apatite.

Petrography (Table 9)

Two samples of the lower brown tonstein (82-146 and 83-18B) and one sample of the upper grey tonstein (83-18C) were examined petrographically. The brown tonstein is characterized by a uniform, cryptocrystalline matrix, with a definite bedding-parallel fabric. It has a granular texture, with the graupen corresponding with the whitish blebs noted in hand specimen. Granules are concentrated near the base and top of the band. They are roughly circular in shape with very irregular outlines. Internally, the graupen are composed of irregular intergrowths of vermicular and microcrystalline kaolinite (Plate 16). Organic matter occurs chiefly in stringers, which bend around the graupen, but is concentrated in the dark grey portion of the band.

The matrix of the grey band consists mainly of microcrystalline kaolinite with rare, angular quartz clasts. The sample is granular, with the graupen mainly ovoid in shape and aligned parallel to bedding. Internally the graupen are mainly crypto- to microcrystalline. Organic matter is generally dispersed, with some patches and stringers, especially near the upper contact.

Chemistry (Table 10)

Analyses were obtained for Samples 82-146 and 83-18B (brown tonstein) and 83-18C (grey tonstein). In contrast with the Ewin Pass tonstein, the 10B-seam tonsteins contain minimal amounts of strontium, barium, calcium and phosphorus. This is certainly related to the lack of gorceixite in these samples. Values for magnesium (0.12 to 2.0%) and iron (0.4 to 1.25%) are higher than in the Ewin Pass tonstein, while one of the 10B samples (83-18B) has a high titanium analysis (1.7%). Zirconium was not detected in the first two samples, but was found at a concentration of 0.02 per cent in 83-18C.

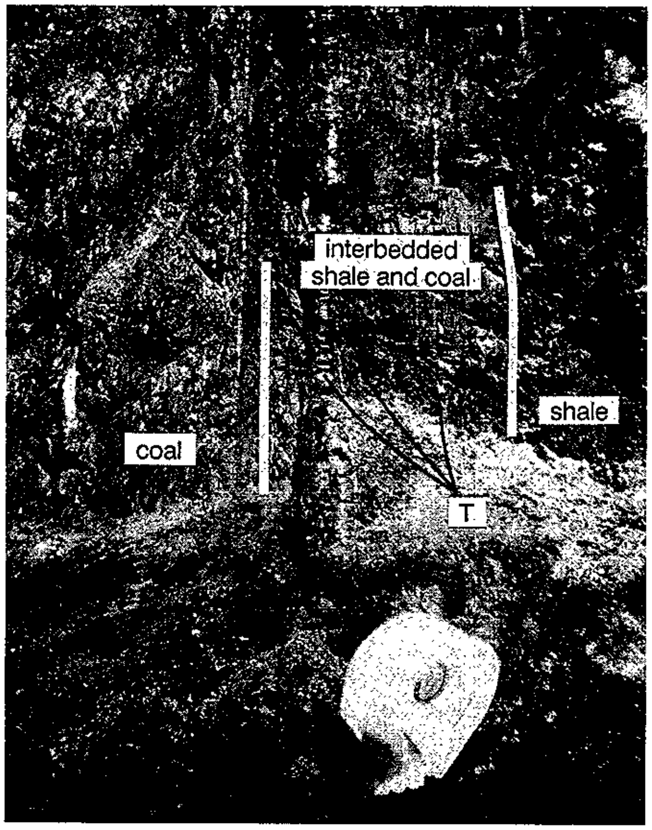


Plate 15. Close-up view of the uppermost part and roof of 10B-seam on Line Creek Ridge, showing tonsteins (T).

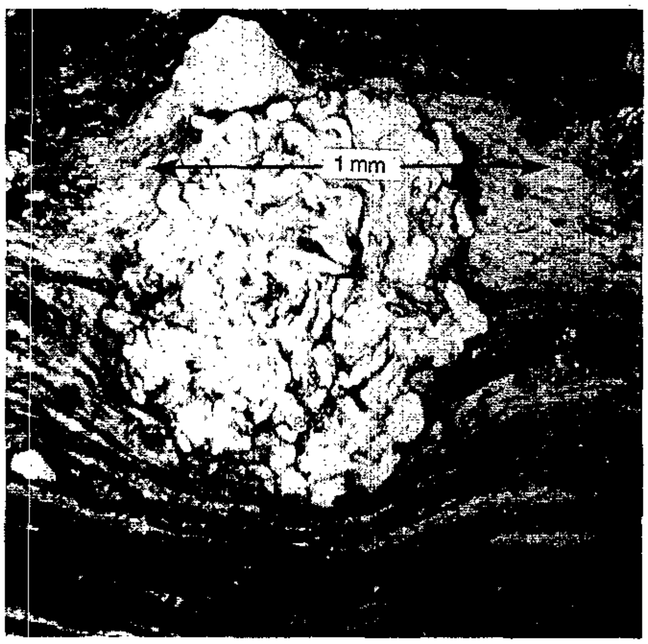


Plate 16. Photomicrograph (plane-polarized light) of tonstein sample 82-146 from the roof of 10B-seam on Line Creek Ridge.

BASAL COAL ZONE TONSTEINS

Samples (Table 7)

Four tonstein samples were collected from drill core of the basal coal zone. Exact positions within the respective cores are listed in Table 7 and shown on Figure 11. Sample EV0-1 was taken from core EV-150, in the roof of the thin seam which rests directly on the Morrissey Formation. It is enclosed by dark grey shale. Samples EV1-1 and EV1-2 were collected from black shale in core EV-151 at a stratigraphic position nearly identical to EV0-1. Consequently, one or the other of them is believed to correlate with EV0-1. Sample BM2-1 was found within a thick shale unit, at a slightly higher stratigraphic position than the other tonsteins from the basal coal zone (roughly 5 metres above the base of the Mist Mountain Formation). It is conceivable that it correlates with the others, because the top of the Morrissey Formation has considerable local relief.

Physical Descriptions (Table 7)

All the basal coal zone tonsteins are thin (3 mm to 3 cm), fine grained, grey in colour, and have a dull lustre. Sample EV1-1 contains flame structures of enclosing shale, and round, light grey blebs along one contact.

Mineralogy (Table 8)

All the basal coal zone tonstein samples are composed predominantly of kaolinite, with minor amounts of quartz, and possibly small amounts of anatase, siderite, pyrite and apatite.

Petrography (Table 9)

Thin sections were made of Samples EV0-1, EV1-1, and EV1-2.

SAMPLE EV0-1 (EWIN CREEK)

This sample consists of two distinct zones, one granular and the other essentially nongranular. The matrix is brown, very fine grained and pseudo-isotropic. Graupen are small, generally round to ovoid in shape and are internally microcrystalline. Organic matter is dispersed.

SAMPLE EV1-1 (EWIN CREEK)

The matrix of this sample is crypto- to microcrystalline, pseudo-isotropic and contains abundant quartz grains. Its texture is granular, with round to ovoid graupen distributed randomly. The graupen are generally cryptocrystalline internally and are difficult to distinguish from the matrix under crossed nicols. They probably correspond with the light grey blebs observed in hand specimen. Organic matter is dispersed, except for stringers near the top of the unit.

SAMPLE EV1-2 (EWIN CREEK)

This sample is nongranular and the fine-grained matrix has no fabric or regular extinction pattern. Organic matter is almost nonexistent.

Chemistry (Table 10)

Analyses were carried out on Sample EV0-1 only. It contains relatively high levels of iron (1.0%), titanium (1.2%), magnesium (0.4%), calcium (0.25%) and zirconium (0.03%).

OTHER TONSTEINS FROM THE LOWER HALF OF THE FORMATION

Samples (Table 7)

Five other samples were collected from the lower half of the Mist Mountain Formation (Figure 19). Two are from the south half of the coalfield; Sample 82-148 is from about 50 centimetres below the top of 8-seam (Imperial seam?) on the Line Creek Extension property, approximately 85 metres above the base of the formation, and Sample GP-11 is from 7-seam (Banner seam) at Mount Michael/ Ewin Pass, roughly 185 metres above the base (Table 7). The other three are from the north half of the coalfield. Samples 86-132U and 86-132L are a pair of tonsteins roughly 50 centimetres below the top of J-seam on Weary Ridge, which is about 225 metres above the base of the formation, while Sample 86-5 was collected from the lowest prominent seam in the Coal Creek section, estimated to be 100 metres above the base. As they come from a variety of stratigraphic positions, these samples will be described individually; refer to Tables 7 to 10 for further information.

SAMPLE 82-148 (LINE CREEK EXTENSION)

The thickness of this tonstein was not recorded. It is dark grey in colour, and has a subconchoidal breakage pattern. It contains kaolinite and a minor amount of quartz. In thin

TABLE 9
PETROGRAPHY AND CLASSIFICATION OF TONSTEINS

Sample Number	Variety	Fabric	Granules	Groundmass	Organic Matter	Other
81-217	Stratotonstein alpha-1	Granular; granules aligned.	Ovoid; crypto and microcrystalline.	Brownish; cryptocrystalline, pseudo-isotropic.	Dispersed, stringers or patches; encloses some granules.	Rare kaolinite vermicules.
82-146	Orthotonstein alpha	Granular; granules concentrated near base and top.	Irregular shape; intergrowths of vermicular and microcrystalline kaolinite.	Uniform and cryptocrystalline; bedding-parallel fabric; goes to extinction simultaneously.	Stringers which bend around granules; concentrated near base and top of unit.	
82-148	Stratotonstein alpha-1 to cryptotonstein.	Granular; granules aligned.	Ovoid; cryptocrystalline.	Uniform and cryptocrystalline; goes to extinction simultaneously.	Rare; stringers.	
83-3	Orthotonstein beta to stratotonstein alpha-1.	Granular; no preferred orientation.	Round, ovoid or irregular; wide range in size; crystalline; vermicular; some crypto to microcrystalline.	Brown; micro and cryptocrystalline; pseudo-isotropic.	Dispersed; a few stringers and blebs.	
83-5	Orthotonstein alpha to stratotonstein alpha-1.	Granular; no preferred orientation.	Round to irregular; wide range in size; crystalline; some are crypto to microcrystalline.	Brown; microcrystalline; goes to extinction simultaneously.	Dispersed and in stringers; latter bend around granules.	
83-10	Cryptotonstein to stratotonstein alpha-1.	Granular; granules extremely rare (<1%).	Small; elongated; crypto to microcrystalline.	Red-brown; cryptocrystalline; pseudo-isotropic.	Rare; small stringers and blebs.	
83-10F	Cryptotonstein.	Nongranular.	Red-brown; cryptocrystalline; pseudo-isotropic.	Rare; small stringers.		
83-11A	Stratotonstein alpha-1.	Granular; granules aligned.	Ovoid; crypto to microcrystalline.	Brown; microcrystalline; pseudo-isotropic; goes to extinction simultaneously.	Dispersed; stringers and patches surround granules.	Vermicules of clay mineral(?).
83-11B	Cryptotonstein to stratotonstein alpha-1.	Granular; granules aligned, very rare, concentrated in certain horizons.	Ovoid; micro and cryptocrystalline.	Greyish brown; cryptocrystalline; pseudo-isotropic.	Dispersed and stringers.	
83-18B	Orthotonstein alpha.	Granular; granules localized, especially near top; groundmass aligned parallel to bedding.	Roughly circular; intergrowths of vermicular and microcrystalline kaolinite.	Cryptocrystalline; goes to extinction simultaneously.	Stringers, which bend around granules; concentrated near top.	Contains smaller bodies of crypto or microcrystalline kaolinite.
83-18C	Stratotonstein alpha-1 grading to cryptotonstein.	Granular; gradational from granule-rich to granule-poor; granules aligned.	Mainly ovoid; some irregular; crypto or microcrystalline; some vermicular.	Brown; microcrystalline; contains angular quartz clasts.	Dispersed; some patches and stringers near upper contact.	
EV0-1	Stratotonstein alpha-1 and cryptotonstein.	Two zones, granular and nongranular.	Small; dispersed; round to ovoid; crypto and microcrystalline.	Brown; pseudo-isotropic.	Dispersed.	Kaolinite vermicules.
EV1-1	Stratotonstein alpha-1 to cryptotonstein.	Granular; granules not evenly distributed.	Round to ovoid; cryptocrystalline.	Crypto to microcrystalline; pseudo-isotropic; contains abundant angular quartz grains.	Dispersed; stringers near top.	
EV1-2	Cryptotonstein.	Nongranular.	No fabric.	Essentially none.		

TABLE 9
PETROGRAPHY AND CLASSIFICATION OF TONSTEINS — *Continued*

Sample Number	Variety	Fabric	Granules	Groundmass	Organic Matter	Other
BM1-2A	Stratotonstein alpha-1.	Granular; granules somewhat aligned.	Ovoid to irregular; considerable size range; crypto to microcrystalline to vermicular.	Brown; microcrystalline and pseudo-isotropic.	Dispersed; some stringers.	
BM1-2B	Orthotonstein alpha to stratotonstein alpha-1.	Granular; granules sparse, concentrated near one edge of the section	Crypto to microcrystalline and vermicular; round to irregular.	Noncoloured; cryptocrystalline; goes to extinction simultaneously.	Dispersed; stringers near one edge	
86-197	Stratotonstein alpha-1.	Granular; granules abundant, well aligned.	Ovoid; margins distinct; cryptocrystalline, some microcrystalline.	Crypto to microcrystalline and pseudo-isotropic.	Dispersed and in stringers.	

Note: Not all tonsteins are described in this table

section it is seen to consist of a uniform cryptocrystalline matrix with a definite bedding-parallel fabric and simultaneous extinction, and contains ovoid graupen more or less aligned with bedding. It contains 0.7 per cent titanium and trace zirconium, and is relatively low in iron, calcium and magnesium.

SAMPLE GP-11 (MOUNT MICHAEL/EWIN PASS)

This tonstein is roughly 1 centimetre thick and is dark brownish grey in colour. It is composed of kaolinite, minor dickite and some quartz. It contains 0.6 per cent titanium, trace zirconium and relatively low amounts of magnesium, calcium and iron.

SAMPLES 86-132U AND 86-132L (WEARY RIDGE)

These samples are separated by roughly a 10-centimetre interval. They are both 1 to 2 centimetres thick. Both contain kaolinite with quartz and minor anatase.

SAMPLE 86-5 (COAL CREEK)

This sample is 3.5 centimetres thick. It contains kaolinite with quartz, minor anatase and trace gorceixite.

OTHER TONSTEINS FROM THE UPPER HALF OF THE FORMATION

Samples (Table 7)

Four other samples were collected in the field and one from core from the upper half of the Mist Mountain Formation. Of these five, four are from the south half of the coalfield (Figure 19). Sample 83-5 is from 5-seam, roughly 250 metres above the base of the formation, on the Line Creek Extension property. Sample 86-224 is from 10-seam, approximately 335 metres above the base of the formation, on the Burnt Ridge Extension property. Sample 82-319 was taken from a seam 2.8 metres thick on the Burnt Ridge Extension property, roughly 400 metres above the base of the formation. Sample BM1-2 was collected from the base of a 1.2-metre seam some 480 metres above the base of the formation, near the top of drill core BM81-1 on Bare Mountain. The one sample from the north half of the coalfield, 86-197, is from Q-seam on Weary Ridge, about 435 metres above the base of the formation. These samples are described below and further data are found in Tables 7 to 10.

SAMPLE 83-5 (LINE CREEK EXTENSION)

This tonstein is 4 to 5 centimetres thick and does not exhibit a particularly regular or smooth fracture pattern. Its mineralogy consists of kaolinite with quartz and possible trace gorceixite and anatase. In thin section it has a brown, microcrystalline matrix which goes to extinction simultaneously. Its texture is granular, with round to irregularly shaped graupen with no preferred orientation. Internally the graupen are crystalline, some with intergrown vermicules of kaolinite. Organic matter is both dispersed and in discrete stringers which bend around granules. This sample contains low magnesium, calcium and iron concentrations, only 0.25 per cent titanium, and trace zirconium.

SAMPLE 86-224 (BURNT RIDGE EXTENSION)

This sample is composed of kaolinite and quartz with trace gorceixite and possible anatase.

SAMPLE 82-319 (BURNT RIDGE EXTENSION)

This tonstein is 3 to 4 centimetres thick. The sample consists of kaolinite with minor quartz. It contains low levels of magnesium, calcium, and iron, 0.4 per cent titanium and trace zirconium.

SAMPLE BM81-1-2 (BARE MOUNTAIN)

This tonstein is 5 centimetres thick and is dark greyish brown in colour. It has a subconchoidal fracture. Its mineralogy consists of kaolinite with minor gorceixite and quartz. Two distinct zones are apparent in thin section. The lower is distinctly granular, while the upper contains only scattered small graupen. Matrix is generally brown in colour, micro to cryptocrystalline, and goes to extinction simultaneously. Graupen in the lower zone are generally ovoid and sub-

TABLE 10A
CHEMICAL ANALYSIS OF TONSTEINS SEMI-QUANTITATIVE EMMISSION SPECTROGRAPHIC RESULTS (%)

Sample	Si	Al	Mg	Ca	Fe	Pb	Cu	Zn	Mn	V	Ti	Ni	Co	Na	K	Sr	Ba	P	La	Zr	Traces
81-217	>10.0	>15.0	T	<1.0	0.04	0.04	T	—	—	T	0.35	—	—	—	—	0.5	0.75	>>3.0	0.01	T	Ga,Cr,B,Y,Yb
83-10	5.0	>15	—	1.25	0.12	T	T	—	T	—	0.2	—	—	<0.3	<0.3	0.5	>2.0	>5.0	—	T	B,Y,Yb,Li,Ga
83-10F	4.0	>15	—	1.75	0.08	T	T	—	T	—	0.18	—	—	<0.3	<0.3	0.7	>2.0	>5.0	—	T	B,Y,Yb,Ga
83-11	>10	>15	—	0.25	0.1	—	T	—	T	—	0.5	—	—	<0.3	<0.3	0.15	1.0	4.0	—	T	B,Ga
82-146B	>10	>15	0.12	<0.1	0.4	T	T	—	T	T	0.4	—	—	<0.3	<0.3	T	<0.05	T	—	—	W,B,Y,Yb,Sc,Cr,Ga
83-18b	>10	>15	0.2	0.1	1.25	T	T	T	T	T	1.7	0.006	0.007	<0.3	<0.3	T	<0.05	T	—	—	B,Y,Yb,Ce,Sc,Mo,Ga
83-18C	>10	>15	0.12	<0.1	0.6	—	T	—	T	T	0.4	T	T	<0.3	<0.3	T	<0.05	T	—	0.02	W,B,Y,Yb,Sc,Ga
EV0-1	>10	>10	0.4	0.25	1.0	T	T	—	0.01	T	1.2	T	T	0.3	<0.3	T	T	—	—	0.03	Ga,Y,Yb,Sc,Be,B
BM1-2	>10	>10	<0.1	0.2	0.3	T	T	T	T	—	0.4	T	—	<0.3	<0.3	0.1	0.2	T	—	T	Ga,Be,B
82-148	>10	>10	<0.1	0.13	0.1	—	T	T	T	—	0.7	—	—	<0.3	<0.3	T	T	—	—	T	B
GP11	>10	>10	<0.1	0.1	0.1	—	T	T	T	—	0.6	—	—	<0.3	<0.3	T	T	—	—	T	B
83-5	>10	>10	<0.1	<0.1	0.1	—	T	—	T	—	0.25	—	—	<0.3	<0.3	T	T	—	—	T	B
82-319	>10	>10	<0.1	<0.1	0.1	—	T	—	T	—	0.4	—	—	<0.3	<0.3	T	T	—	—	T	B

TABLE 10B
CHEMICAL ANALYSIS OF TONSTEINS
MAJOR OXIDE ANALYSIS OF SAMPLE 81-217

Oxide	Per Cent	Oxide	Per Cent
SiO_2	35.52	MnO	<0.002
Al_2O_3	34.45	H_2O	14.38
Fe_2O_3 T	<0.10	SO_3	0.09
MgO	<0.05	P_2O_5	4.5
CaO	0.22	SrO	>0.5
Na_2O	<0.02	BaO	>0.5
K_2O	<0.03	CO_2	9.09
TiO_2	1.020	FeO	<0.3

aligned with bedding. Organic matter is generally dispersed, except for stringers concentrated near the contact between the two zones. The composition of the sample includes 0.2 per cent barium, 0.1 per cent strontium, 0.4 per cent titanium, and trace zirconium and phosphorus. The phosphorus, strontium and barium are probably present in the gorceixite.

SAMPLE 86-197 (WEARY RIDGE)

This tonstein is dark greyish brown and contains kaolinite, with minor quartz, anatase and trace siderite. Thin sections show a crypto to microcrystalline, pseudo-isotropic matrix, with numerous ovoid graupen which are well aligned with bedding. Organic matter is dispersed and in stringers. It is considered to be a classic example of a stratotonstein alpha-1 as defined by Bouroz (1962).

SIGNIFICANCE OF TONSTEINS

ORIGIN

The tonsteins in the Mist Mountain Formation are believed to have been derived from volcanic ash. Several lines of evidence have been used in drawing this conclusion. For example, their Bouroz classification types (Table 6) correspond with primary and reworked volcanic ash-fall material, although this in itself is not conclusive evidence. Secondly, the constant thickness of the two tonsteins which were traced for any distance, is thought to be good evidence for air-fall rather than subaqueous deposition (Price and Duff, 1969). Moreover, the absence or presence of very small amounts of quartz in almost all samples is thought to distinguish some tuffaceous rocks from normal sediments (Spears and Kanaris-Sotiriou, 1979). Furthermore, the angular nature of the quartz grains argues for a volcanic origin (Spears *et al.*, 1988). The high titanium content (relative to average sedimentary rocks) of many of the samples, in combination with the fact that when a titanium mineral is detected it tends to be anatase rather than rutile, has also been used to infer a volcanic derivation (Spears and Kanaris-Sotiriou, 1979); the presence of apatite is further supporting evidence (Price and Duff, 1969). Presence, and in certain cases abundance, of the mineral gorceixite is thought to represent further evidence of a volcanic affinity, because this mineral is generally thought to form from alteration of igneous rocks (Price and Duff, 1969). The granular texture common to many of the samples collected in this study is consistent with tonsteins from many parts of the world that have been inferred to be volcanic (*e.g.*, Spears *et al.*, 1988). Individual graupen are thought to represent original lithic or vitric fragments. Lastly, the presence, albeit of trace amounts, of certain elements in the tonsteins, including zirconium, yttrium, vanadium and chromium, which are associated with resistate minerals, is thought to provide further proof of a volcanic origin.

Much more exhaustive and quantitative geochemical analysis of the samples collected in this study and from other parts of southeast British Columbia has been carried out by Goodarzi *et al.* (1990). These data provide further evidence for a volcanic origin of Mist Mountain Formation tonsteins. Subtle geochemical differences between the lower and upper parts of the formation were also noted. For example, the tonsteins from the lower part are enriched in cobalt and hafnium relative to those from the upper part. Those from the upper part are enriched in thorium and rare-earth elements.

The apparently limited regional extent of individual tonsteins in the Elk Valley coalfield is perhaps difficult to reconcile with a volcanic origin. This problem will be discussed in the next section.

Correlation

In both cases referred to above, where tonsteins were correlated over distances of 1.4 kilometres, a high degree of stratigraphic control existed before the correlation was effected. In other words, a case of true correlation, based on tonstein evidence alone, has not yet been realized. Nevertheless, these two cases provide impressive evidence for continuity of features such as thickness, colour, grouping, petrographic texture and mineralogy, and therefore imply that certain diagnostic features might possibly be used to identify specific tonsteins over distance.

Despite this, and the obvious potential of volcanic-ash horizons, by their nature, to serve as regional markers, the tonsteins in the Elk Valley coalfield do not as yet appear to provide geologists with useable correlation tools. There are several possible reasons for this: they are difficult to recognize in the field and in core, and certainly may have been overlooked to some degree; exposure of Mist Mountain Formation strata, particularly the fine-grained and carbonaceous sections, is not always good; cores logged in this study were devoid of essentially all coal seams; even in ideal sampling conditions there are discontinuities in tonstein beds, related to variations in the preservation of strata in different depositional sites; shearing and faulting in coal seams are often marked features on an outcrop scale, and have the effect of destroying continuity and visual impact of individual horizons.

Nonetheless I believe that regional distribution of individual tonsteins in the Elk Valley coalfield will be demonstrated. In that case there is potential for using tonsteins to correlate specific horizons.

CHAPTER 4: COAL SEAM MACERAL COMPOSITION

Suites of channel samples of coal seams were collected at selected locations throughout the coalfield. The total number of samples is 98. Each sample represents one coal seam or bench; no attempt was made to sample on a ply-by-ply basis. As many of the seams in a stratigraphic section as possible were taken at each collection site. Most sites correspond with measured sections.

Channel samples were split, pelletized and polished to be used for both vitrinite reflectance determinations and maceral counts (*see* sections covering study methods in Chapter 1). The maceral count data are summarized here.

Because of the nature of the sampling only general trends in maceral composition, on a stratigraphic basis, can be detected. These, however, can be used to infer changes in the coal-forming depositional environment with respect to stratigraphic position.

PREVIOUS WORK

Maceral composition of Mist Mountain coal seams in southeastern British Columbia has been previously studied by Cameron and Babu (1968), Cameron (1972) and Pearson and Grieve (1985). The first of these studies was concerned with the petrology of the Balmer or 10-seam in the Sparwood area of the Crowsnest coalfield. Three column samples were collected, and analyzed on a ply-by-ply basis. Based on petrographic composition, it was shown that separate plies could be traced with some confidence over a distance of 4 kilometres. The Balmer seam was found to be relatively high in semifusinite.

Cameron (1972) pointed out trends in maceral composition of whole seams in the Mist Mountain Formation, with varying stratigraphic position. In particular, he noted that seams in the lower part of the formation tend to have relatively high inertinite contents, while those in the upper part tend to be relatively high in vitrinite. It was pointed out, however, that the lowest seam in the formation usually is not the richest in inertinite; that tends to occur at some interval above the base.

Pearson and Grieve (1985) verified the general trends noted by Cameron (1972). Maceral compositions were converted to percentage of inerts, and results were plotted on graphs of vitrinite reflectance *versus* maceral composition (% inerts) to demonstrate variation in fundamental characteristics of coal seams throughout the section.

RESULTS

Maceral composition data for channel samples collected from the Elk Valley coalfield are summarized in Table 11 and on Figure 7. Graphs showing changes in maceral composition with stratigraphic position at each site are shown in Figures 20 to 22.

VITRINITE (FIGURE 20)

Vitrinite is the most common maceral present in all of the samples analyzed. It ranges from 51 to 93 per cent (average 78%) of the organic portion of the samples. Qualitatively, vitrinite A (telinite and telocollinite) is far more abundant than vitrinite B (chiefly desmocollinite). At most locations the vitrinite composition increases with increase in stratigraphic position above the base of the formation, although there is much variability in some of the data, particularly in the lowermost part of the formation. The net result is that, although the highest vitrinite values are associated with samples from the highest stratigraphic positions, the lowest samples stratigraphically do not necessarily have the lowest vitrinite contents. In fact, in most cases the sample with the lowest vitrinite content occurs at some position above the base of the formation, generally in the range of 50 to 200 metres above the base. Furthermore, samples from the basal coal zone often have among the highest vitrinite contents in the entire section.

LIPTINITE

Liptinite is relatively rare in the samples analysed here, as is typical for the Mist Mountain Formation coals in southeastern British Columbia. The range in liptinite values in these samples is from zero (35% of the samples) to 6.7 per cent, with the majority of samples (65%) having values less than or equal to 1.0 per cent.

In part, this low percentage of liptinite is related to the rank of the seams studied. It is well known that liptinite achieves the reflectance of the associated vitrinite in coal in the medium-volatile bituminous rank range (Bustin *et al.*, 1985). Given that many of the coals here are of this rank or higher (see next chapter), much of the original liptinite in these seams is no longer distinguishable. The suite of samples from Weary Ridge (Table 11), where the overall rank of the coals is higher than in any other suite studied here, exemplify this phenomenon. Twelve of the sixteen samples from Weary Ridge have no liptinite and three of the remaining four, all of which have liptinite contents of 0.3 per cent, are from the uppermost part of the formation, where the lowest rank coals occur. In sharp contrast to Weary Ridge is the Coal Creek (tributary of Bleasdell Creek) area, immediately to the west of Weary Ridge but on the opposite limb of the Alexander Creek syncline. Here the entire exposed section is high-volatile bituminous in rank, and the liptinite contents of the ten channel samples collected here range from 1.0 to 6.7 per cent, with no obvious systematic variation with stratigraphic position. It is possible that this range is more typical of the Mist Mountain Formation in the absence of rank effects. Coals at one other location of predominantly high-volatile coals, Mount Michael upper sheet, also have relatively high liptinite values (range of 1.0 to 5.0%; Table 11).

SEMIFUSINITE (FIGURE 21)

The second most abundant maceral, and most abundant inertinite maceral, in virtually all samples analysed here, is semifusinite. It ranges from 1.3 to 31.3 per cent of the total organic content, with an average of 13.4 per cent. The

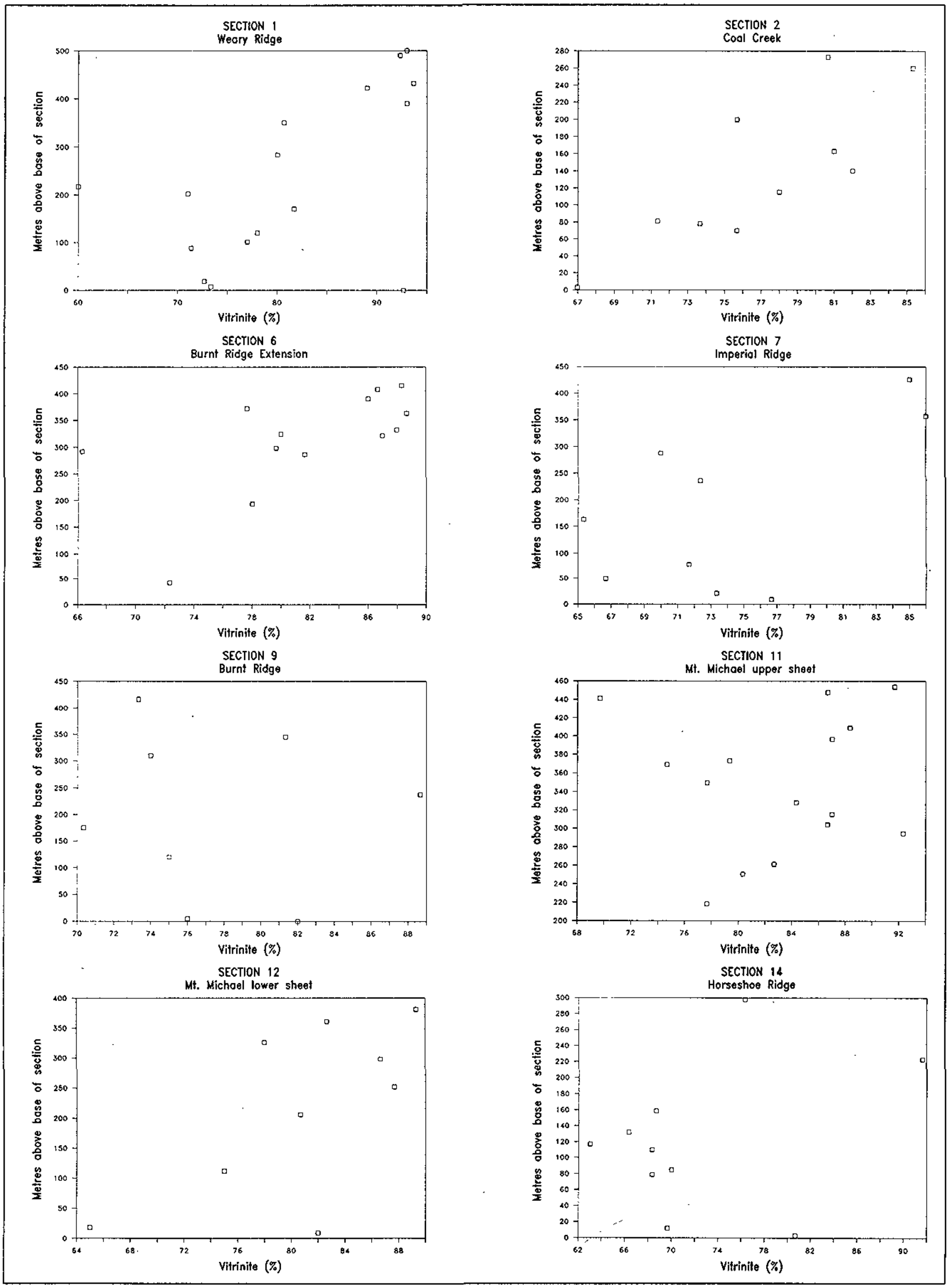


Figure 20. Variation in vitrinite content with stratigraphic position.

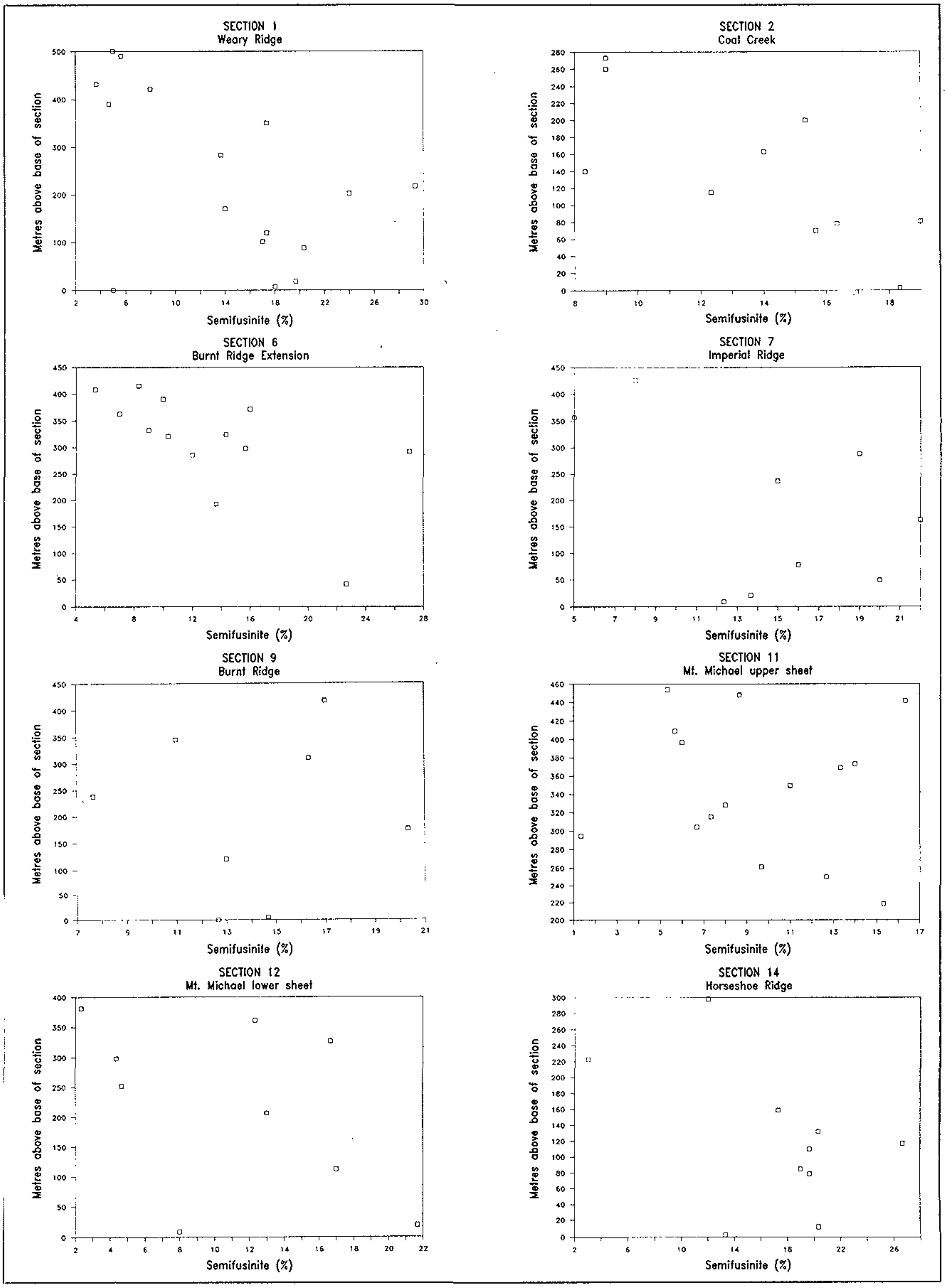


Figure 21. Variation in semifusinite content with stratigraphic position.

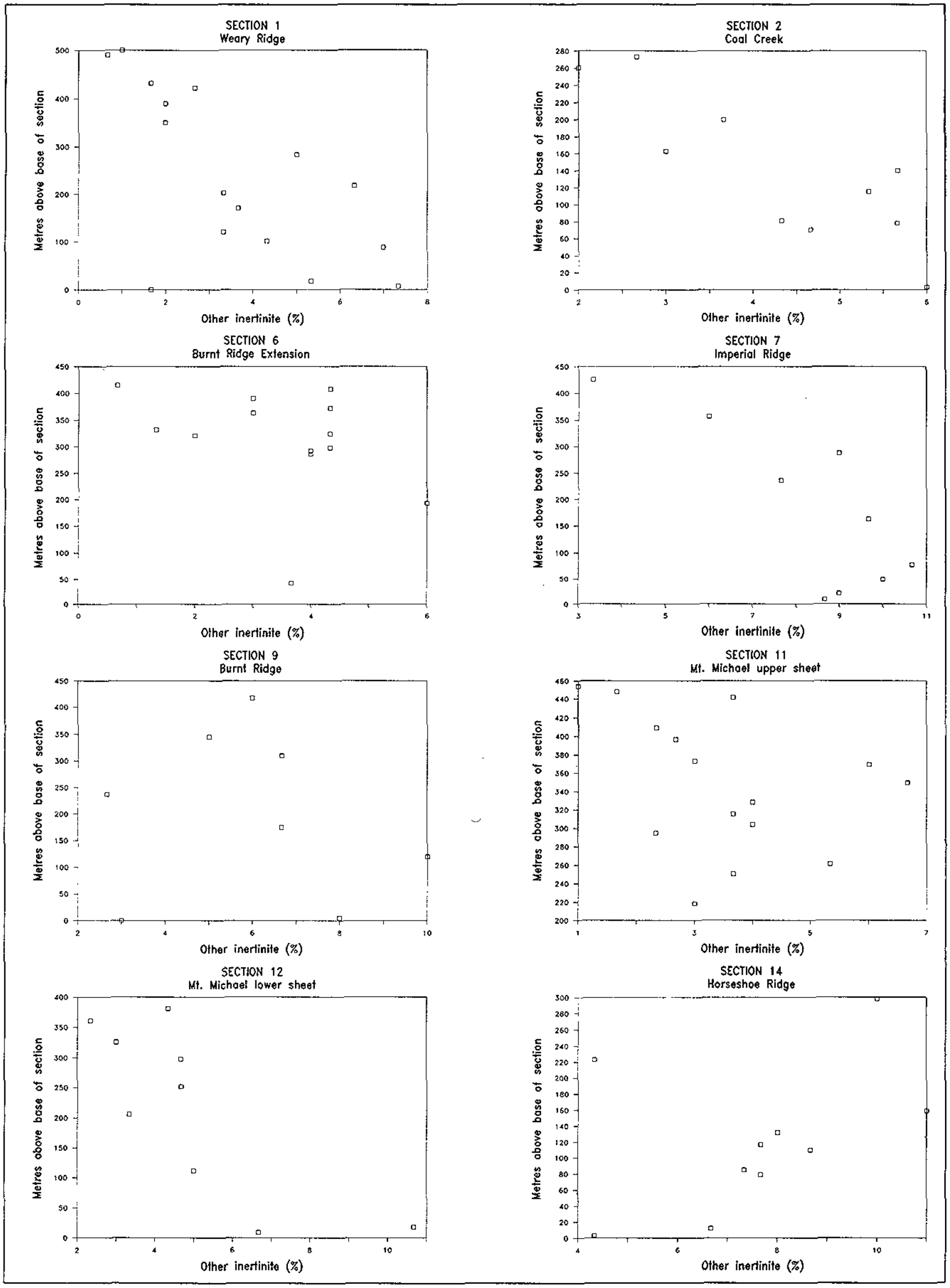


Figure 22. Variation in other inertinite (chiefly inertodetrinite) content with stratigraphic position.

amount of semifusinite is inversely related to the quantity of vitrinite in a sample (Figures 20 and 21). Thus, on average, semifusinite values decrease up-section, but with the variations inverse to those for vitrinite.

Fusinite

Contents of the inertinite maceral fusinite in Elk Valley coal samples ranges from zero (6 samples only) to 4.0 per cent, with an average of 1.4 per cent. There is no obvious correlation between the amount of fusinite and stratigraphic position.

Macrinite

Amounts of the inertinite maceral macrinite in these samples range from zero (28% of the samples) to 3.3 per cent, with an average of 0.5 per cent. As was the case with fusinite, there is no obvious correlation between macrinite and stratigraphic position.

Other Inertinite (Figure 22)

The predominant maceral in this category is classified as inertodetrinite, and in calculations in the next section the value of other inertinite is substituted for the amount of inertodetrinite. There are, at most, only minor amounts of micrinite and/or sclerotinite in some samples. However, it is suspected that some proportion of the "other inertinite" is composed of very small particles of fusinite and semifusinite (inertodetrinite) produced by the sample preparation process, rather than true inertodetrinite, which is produced from fusinite and semifusinite by depositional processes. The amount of other inertinites in the samples ranges from 0.7 to 14.3 per cent, with an average of 5.1 per cent. In some of the sections (Weary Ridge, Coal Creek, Imperial Ridge, Mount Michael lower sheet and, to some extent, Mount Michael upper sheet), there is a general decrease in amounts of other inertinites up-section (Figure 22).

Petrographic Indices

Maceral analytical data are frequently used to generate indices which reflect facies of coal deposition. Unfortunately, these indices have been derived mainly from Australian coals (*e.g.* Diessel, 1986), and rigorous application to coals of western Canada is probably not feasible (F. Goodarzi, personal communication, 1989). A few of the more fundamental indices have nonetheless been calculated to derive general depositional conditions of Elk Valley coals. Rigorous facies analysis is not attempted here.

INERT RATIO (FIGURE 23)

The inert ratio (or IR) is equal to the ratio of the sum of fusinite and semifusinite to the amount of inertodetrinite. Inert ratio provides a rough measure of the amount of movement of coal-forming material prior to deposition, as inertodetrinite is formed by physical breakdown of fusinite and semifusinite. High values, greater than 2.0, reflect a mainly autochthonous source for the coal with little transportation (Langenberg *et al.*, in press).

In these samples it ranges from 0.5 to 10.0, with an average of 3.3 (Table 11). However, as some of the inertodetrinite is believed to have been derived from the sample preparation technique, these values are believed to be too low. There is no apparent relationship between IR and stratigraphic position (Figure 23).

T/F RATIO (FIGURE 24)

The T/F ratio is derived by dividing the vitrinite content by the sum of fusinite and semifusinite. It is considered to reflect the relative wetness or dryness of the coal-forming environment. Samples with a T/F ratio greater than 1, as is the case with all samples here, are believed to have formed in relatively wet conditions, as the water table was high enough to prevent drying out and oxidation of the coal precursors (Diessel, 1982). In effect the T/F ratio provides an index of tissue preservation. In other words, the amount of preserved tissue, which increases in wetter conditions, is reflected in a comparison of the amount of vitrinite to amounts of the macerals derived from vitrinite by oxidation, namely semifusinite and fusinite.

In these samples the T/F ratio ranges from 1.6 to 25.0, with one highly anomalous value of 69.3 and an average value of 7.6 (Table 11). The ratio tends to increase with ascending stratigraphic position (Figure 24).

GI RATIO (FIGURE 25)

The gelification index ratio or GI ratio is a measure of the ratio of gelified to nongelified material. It is derived by dividing the sum of vitrinite and macrinite contents, by the sum of fusinite, semifusinite and other inertinites.

Values here range from 1.1 to 25.3 with an average of 5.3 (Table 11). Values tend to increase up-section (Figure 25), because of the trends in vitrinite and semifusinite contents.

INTERPRETATION OF MACERAL DATA

The results described above are generally consistent with the trends noted previously by Cameron (1972): there is a trend toward relatively higher vitrinite contents and lower semifusinite contents moving upward in the stratigraphic section. As Cameron also noted, the sample lowest in vitrinite does not usually occur at the base of the stratigraphic section, but at some distance above, and the lowest seam or coal zone is often quite rich in vitrinite. There are, however, discrepancies in the absolute values of data between the two studies. On average, Cameron found there was less vitrinite and more semifusinite in his samples from similar stratigraphic positions as samples in this study. The extra semifusinite, which may occur in amounts more than 10 per cent higher than in samples recorded here, was almost certainly identified at the expense of vitrinite. These differences are probably partly due to the subjective nature of maceral analysis, expecially given that the properties of the two macerals are gradational, but may also reflect different sample quality, and sampling, preparation and analytical procedures.

TABLE 11
MACERAL CONTENTS OF WHOLE-SEAM CHANNEL SAMPLES

Sample	STRAT	VITR	LIPT	SEMIFUS	FUS	MACR	O.I.	V/I	GI	T/F	IR
WEARY RIDGE											
1-1	0.0	92.7	0.0	5.0	0.3	0.3	1.7	12.6	13.3	17.4	2.7
1-2	7.0	73.3	0.0	18.0	1.0	0.3	7.3	2.8	2.8	3.9	2.5
1-3	18.0	72.7	0.0	19.7	2.3	0.0	5.3	2.7	2.7	3.3	4.1
1-4	88.0	71.3	0.0	20.3	0.7	0.7	7.0	2.5	2.6	3.4	2.7
1-5	101.0	77.0	0.0	17.0	1.0	0.7	4.3	3.3	3.5	4.3	3.6
1-6	120.0	78.0	0.0	17.3	1.3	0.0	3.3	3.5	3.5	4.2	5.6
1-7	170.0	81.7	0.0	14.0	0.0	0.7	3.7	4.5	4.7	5.8	3.2
1-8	202.0	71.0	0.0	24.0	1.3	0.3	3.3	2.4	2.5	2.8	6.9
1-9	217.0	60.0	0.3	29.3	2.7	1.3	6.3	1.5	1.6	1.9	4.2
1-10	283.0	80.0	0.0	13.7	0.7	0.7	5.0	4.0	4.2	5.6	2.5
1-11	350.0	80.7	0.0	17.3	0.0	0.0	2.0	4.2	4.2	4.7	8.7
1-12	390.0	93.0	0.0	4.7	0.3	0.0	2.0	13.3	13.3	18.6	2.5
1-13	422.0	89.0	0.0	8.0	0.3	0.0	2.7	8.1	8.1	10.7	3.1
1-14	432.0	93.7	0.3	3.7	0.3	0.3	1.7	15.6	16.6	23.4	2.0
1-15	490.0	92.3	0.3	5.7	1.0	0.0	0.7	12.6	12.6	13.9	10.0
1-16	500.0	93.0	0.3	5.0	0.7	0.0	1.0	14.0	14.0	16.4	5.7
COAL CREEK											
2-1	3.0	67.0	6.7	18.3	1.0	1.0	6.0	2.5	2.7	3.5	2.8
2-2	70.0	75.7	3.7	15.7	0.0	0.7	4.7	3.6	3.8	4.8	2.9
2-3	78.0	73.7	3.7	16.3	0.3	0.3	5.7	3.3	3.3	4.4	2.8
2-4	81.0	71.3	3.3	19.0	1.3	0.7	4.3	2.8	2.9	3.5	4.1
2-5	115.0	78.0	3.0	12.3	1.0	0.3	5.3	4.1	4.2	5.9	2.4
2-6	140.0	82.0	4.0	8.3	0.0	0.0	5.7	5.9	5.9	9.8	1.5
2-7	163.0	81.0	1.0	14.0	0.7	0.0	3.0	4.6	4.6	5.5	4.9
2-8	200.0	75.7	5.3	15.3	0.0	0.0	3.7	4.0	4.0	4.9	4.2
2-9	260.0	85.3	3.3	9.0	0.3	0.0	2.0	7.5	7.5	9.1	4.7
2-10	273.0	80.7	6.0	9.0	1.0	0.7	2.7	6.1	6.4	8.1	3.0
BURNT RIDGE EXTENSION											
6-1	42.0	72.3	0.0	22.7	1.3	0.0	3.7	2.6	2.6	3.0	6.5
6-2	193.0	78.0	0.0	13.7	1.7	0.7	6.0	3.5	3.7	5.1	2.3
6-3	286.0	81.7	0.0	12.0	1.7	0.7	4.0	4.5	4.7	6.0	2.9
6-4	292.0	66.3	0.3	27.0	2.0	0.3	4.0	2.0	2.0	2.3	6.7
6-5	298.0	79.7	0.0	15.7	0.3	0.0	4.3	3.9	3.9	5.0	3.7
6-6	321.0	87.0	0.0	10.3	0.7	0.0	2.0	6.7	6.7	7.9	5.5
6-7	324.0	80.0	0.0	14.3	1.0	0.3	4.3	4.0	4.1	5.2	3.3
6-8	332.0	88.0	0.7	9.0	1.0	0.0	1.3	7.8	7.8	8.8	7.5
6-9	363.0	88.7	0.3	7.0	1.0	0.0	3.0	8.1	8.1	11.1	2.7
6-10	372.0	77.7	0.0	16.0	1.7	0.3	4.3	3.5	3.5	4.4	3.8
6-11	390.0	86.0	0.7	10.0	0.3	0.0	3.0	6.5	6.5	8.3	3.4
6-12	408.0	86.7	2.0	5.3	1.3	0.3	4.3	7.6	7.9	13.0	1.4
6-13	415.0	88.3	1.7	8.3	0.7	0.3	0.7	8.8	9.2	9.8	9.0
IMPERIAL RIDGE											
7-1	9.0	76.7	0.0	12.3	1.7	0.7	8.7	3.3	3.4	5.5	1.5
7-2	21.0	73.3	0.0	13.7	3.0	1.0	9.0	2.8	2.9	4.4	1.7
7-3	49.0	66.7	0.0	20.0	3.0	0.3	10.0	2.0	2.0	2.9	2.2
7-4	78.0	71.7	0.0	16.0	1.3	0.3	10.7	2.5	2.6	4.1	1.6
7-5	163.0	65.3	0.0	22.0	2.3	0.7	9.7	1.9	1.9	2.7	2.4
7-6	236.0	72.3	0.7	15.0	3.0	1.3	7.7	2.7	2.9	4.0	2.0
7-7	288.0	70.0	1.3	19.0	0.3	0.3	9.0	2.4	2.5	3.6	2.1
7-8	357.0	86.0	2.3	5.0	0.7	0.0	6.0	7.4	7.4	15.2	0.9
7-9	426.0	85.0	2.7	8.0	1.0	0.0	3.3	6.9	6.9	9.4	2.7
EWIN PASS											
8-1	403.0	81.0	2.7	14.0	0.3	0.0	2.0	5.0	5.0	5.7	7.2
8-2	376.0	72.3	2.7	17.7	2.0	0.7	4.7	2.9	3.0	3.7	3.7
8-3	232.0	86.0	0.7	10.0	0.3	0.3	2.7	6.5	6.6	8.3	3.4
BURNT RIDGE											
9-1	0.0	82.0	0.0	12.7	2.3	0.0	3.0	4.6	4.6	5.5	5.0
9-2	5.0	76.0	0.0	14.7	0.7	0.7	8.0	3.2	3.3	5.0	1.8
9-3	120.0	75.0	0.3	13.0	1.7	0.0	10.0	3.0	3.0	5.1	1.5
9-4	175.0	70.3	0.3	20.3	2.3	0.0	6.7	2.4	2.4	3.1	3.4
9-5	238.0	88.7	0.3	7.7	0.7	0.0	2.7	8.1	8.1	10.6	3.1
9-6	310.0	74.0	0.7	16.3	1.7	0.7	6.7	2.9	3.0	4.1	2.5
9-7	345.0	81.3	0.0	11.0	2.0	0.7	5.0	4.4	4.6	6.3	2.3
9-8	417.0	73.3	3.0	17.0	2.3	0.3	6.0	2.9	2.9	3.8	3.1
MT. MICHAEL UPPER SHEET											
11-1	218.3	77.7	1.0	15.3	1.3	0.0	3.0	3.9	3.9	4.7	5.6
11-2	250.6	80.3	1.0	12.7	2.0	0.3	3.7	4.3	4.4	5.5	3.7
11-3	261.3	82.7	1.3	9.7	0.7	0.3	5.3	5.2	5.3	8.0	1.8
11-4	294.6	92.3	3.7	1.3	0.0	0.3	2.3	23.1	25.3	69.3	0.5
11-5	304.1	86.7	2.0	6.7	0.7	0.0	4.0	7.6	7.6	11.8	1.8
11-6	315.6	87.0	1.3	7.3	0.7	0.0	3.7	7.5	7.5	10.9	2.2
11-7	328.3	84.3	1.0	8.0	2.0	0.7	4.0	5.8	6.1	8.4	2.1
11-8	349.6	77.7	2.3	11.0	2.0	0.3	6.7	3.9	4.0	6.0	1.9
11-9	369.1	74.7	1.0	13.3	4.0	1.0	6.0	3.1	3.2	4.3	2.5
11-10	373.2	79.3	1.3	14.0	2.0	0.3	3.0	4.1	4.2	5.0	4.8
11-11	396.8	87.0	2.0	6.0	2.3	0.0	2.7	7.9	7.9	10.4	3.1
11-12	409.1	88.3	1.3	5.7	1.7	0.7	2.3	8.5	9.2	12.0	2.4
11-13	441.4	69.7	5.0	16.3	2.0	3.3	3.7	2.8	3.3	3.8	2.6
11-14	447.9	86.7	2.0	8.7	1.0	0.0	1.7	7.6	7.6	9.0	5.8
11-15	453.7	91.7	1.7	5.3	0.3	0.0	1.0	13.8	13.8	16.2	5.7
MT. MICHAEL LOWER SHEET											
12-1	9.0	82.0	0.3	8.0	2.3	0.7	6.7	4.6	4.9	7.9	1.4
12-2	18.0	65.0	0.0	21.7	2.0	0.7	10.7	1.9	1.9	2.7	2.1
12-3	112.0	75.0	0.3	17.0	1.7	1.0	5.0	3.0	3.2	4.0	3.1
12-4	206.0	80.7	0.0	13.0	2.7	0.3	3.3	4.2	4.3	5.1	4.3
12-5	252.0	87.7	0.7	4.7	1.0	1.3	4.7	7.5	8.6	15.5	0.9
12-6	298.0	86.7	1.3	4.3	2.7	0.3	4.7	7.2	7.5	12.4	1.4
12-7	326.0	78.0	1.0	16.7	1.0	0.3	3.0	3.7	3.8	4.4	5.3
12-8	361.0	82.7	1.3	12.3	0.7	0.7	2.3	5.2	5.4	6.4	4.3
12-9	381.0	89.3	2.3	2.3	1.3	0.3	4.3	10.7	11.2	24.4	0.8
HORSESHOE RIDGE											
14-1	3.0	80.7	0.3	13.3	1.0	0.3	4.3	4.2	4.3	5.6	3.1
14-2	12.0	69.7	0.7	20.3	1.0	1.7	6.7	2.3	2.5	3.3	2.6
14-3	79.0	68.3	0.3	19.7	2.7	1.3	7.7	2.2	2.3	3.1	2.5
14-4	85.0	70.0	0.0	19.0	3.0	0.7	7.3	2.3	2.4	3.2	2.8
14-5	110.0	68.3	0.3	19.7	1.7	1.3	8.7	2.2	2.3	3.2	2.1
14-6	117.0	63.0	0.0	26.7	1.3	1.3	7.7	1.7	1.8	2.3	3.1
14-7	132.0	66.3	0.7	20.3	2.7	2.0	8.0	2.0	2.2	2.9	2.3
14-8	159.0	68.7	0.7	17.3	1.0	1.3	11.0	2.2	2.4	3.7	1.5
14-9	223.0	91.7	0.0	3.0	0.7	0.3	4.3	11.0	11.5	25.0	0.8
14-10	298.0	76.3	1.0	12.0	0.3	0.3	10.0	3.4	3.4	6.2	1.2
TEEPEE MOUNTAIN											
15-1	−8.0	73.7	0.0	16.7	1.3	0.7	7.7	2.8	2.9	4.1	2.2
15-2	1.0	64.0	0.3	24.0	1.0	0.0	10.7	1.8	1.8	2.6	2.3
15-3	13.0	69.7	0.0	17.7	0.7	0.7	11.3	2.3	2.4	3.8	1.5
CROWN MOUNTAIN											
16-1	19.0	72.3	0.3	19.7	1.0	0.7	6.0	2.6	2.7	3.5	3.1
16-2	59.0	51.0	0.0	31.3	1.3	2.0	14.3	1.0	1.1	1.6	2.0

LIST OF ABBREVIATIONS

STRAT: Stratigraphic position (metres above base of section)
VITR: Vitrinite
LIPT: Liptinite
SEMIFUS: Semifusinite
FUS: Fusinite
MACR: Macrinite
O.I.: Other inertinite
V/I: V/I ratio; ratio of vitrinite to total inertinite
GI: Gelification index ratio; ratio of (vitrinite + macrinite) to (fusinite + semifusinite + other inertrinite)
T/F: T/F ratio; ratio of vitrinite to (fusinite + semifusinite)
IR: Inert ratio; ratio of (semifusinite + fusinite) to inertodetrinite

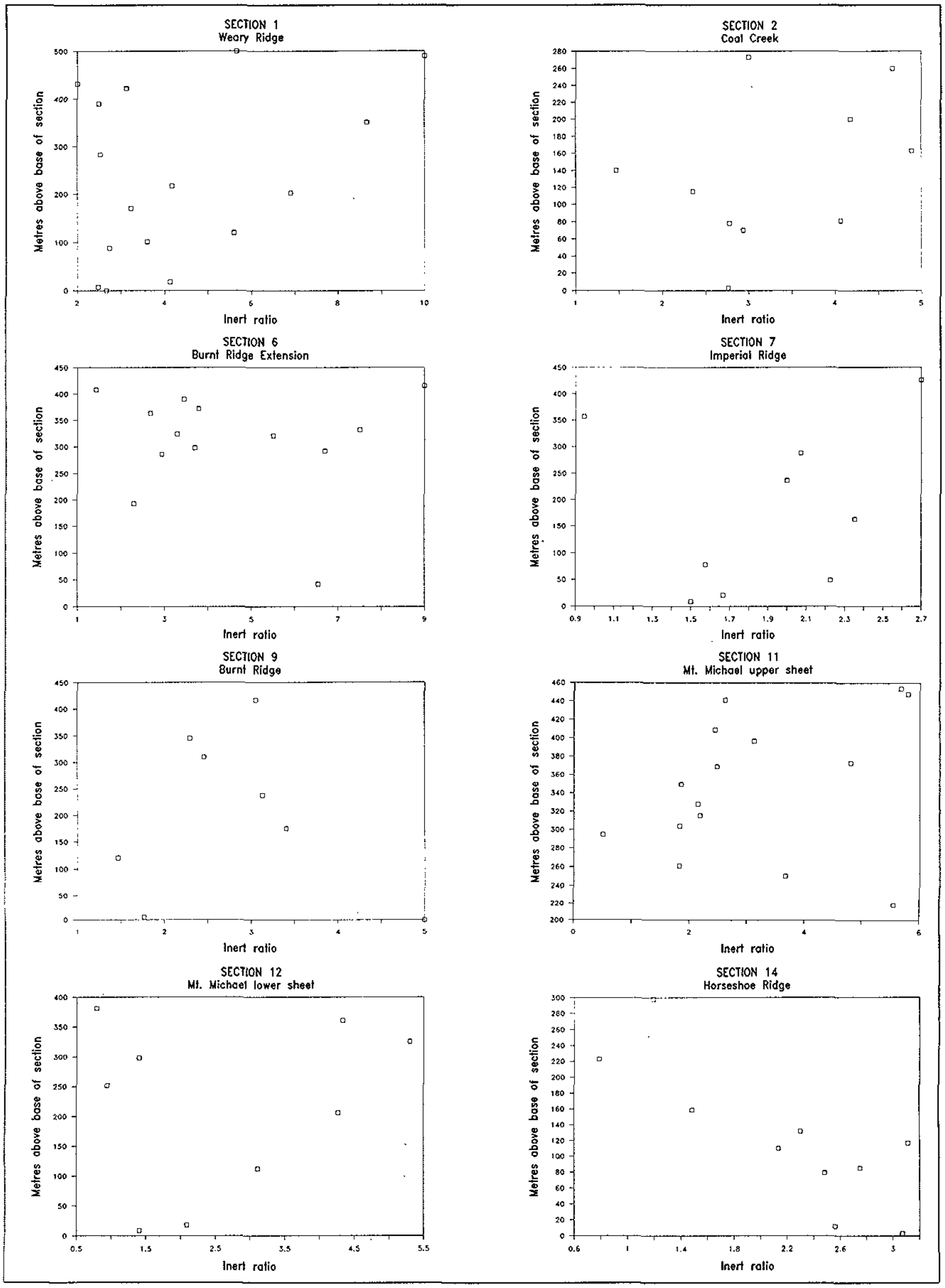


Figure 23. Variation in inert ratio with stratigraphic position.

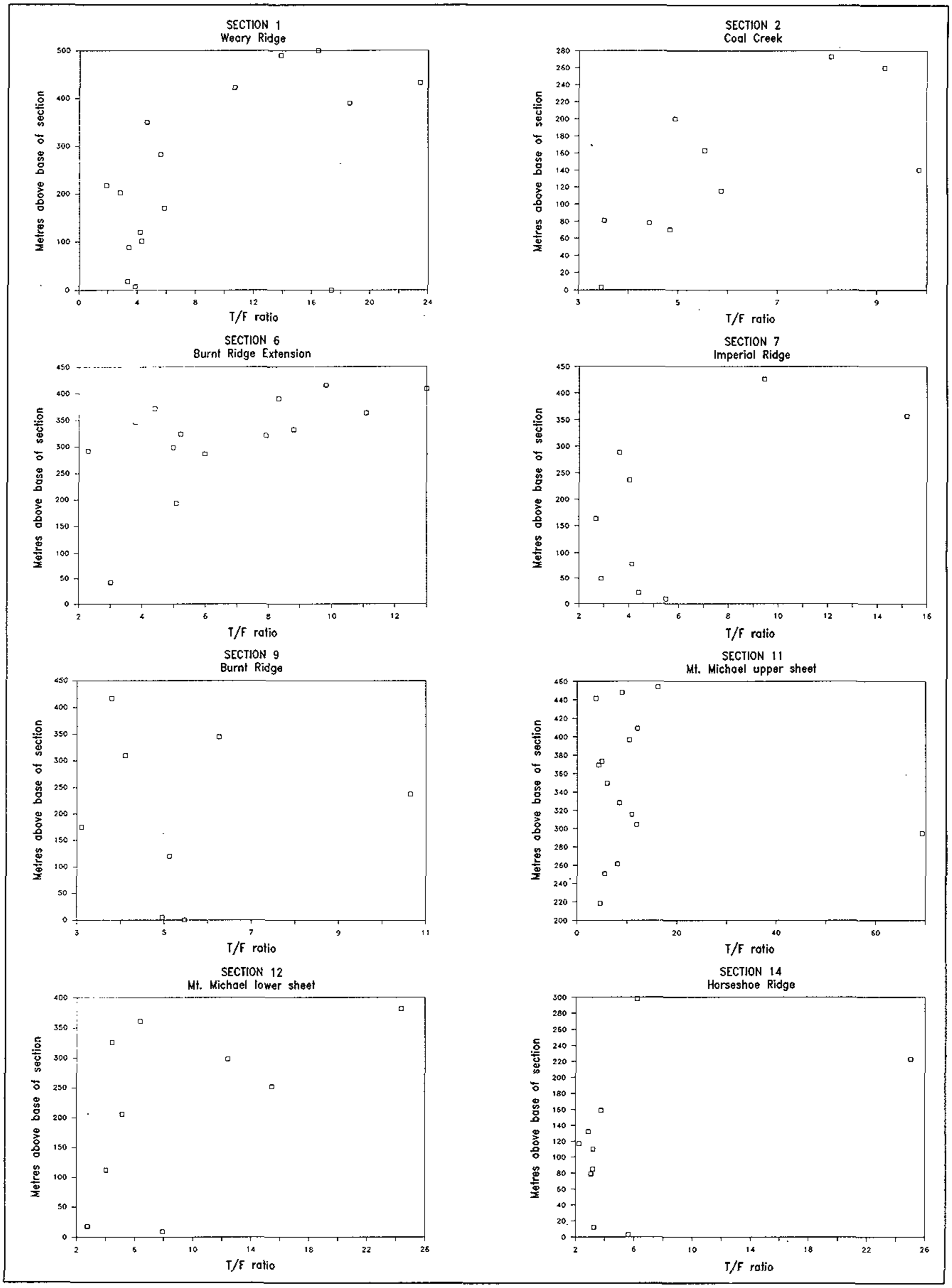


Figure 24. Variation in T/F ratio with stratigraphic position.

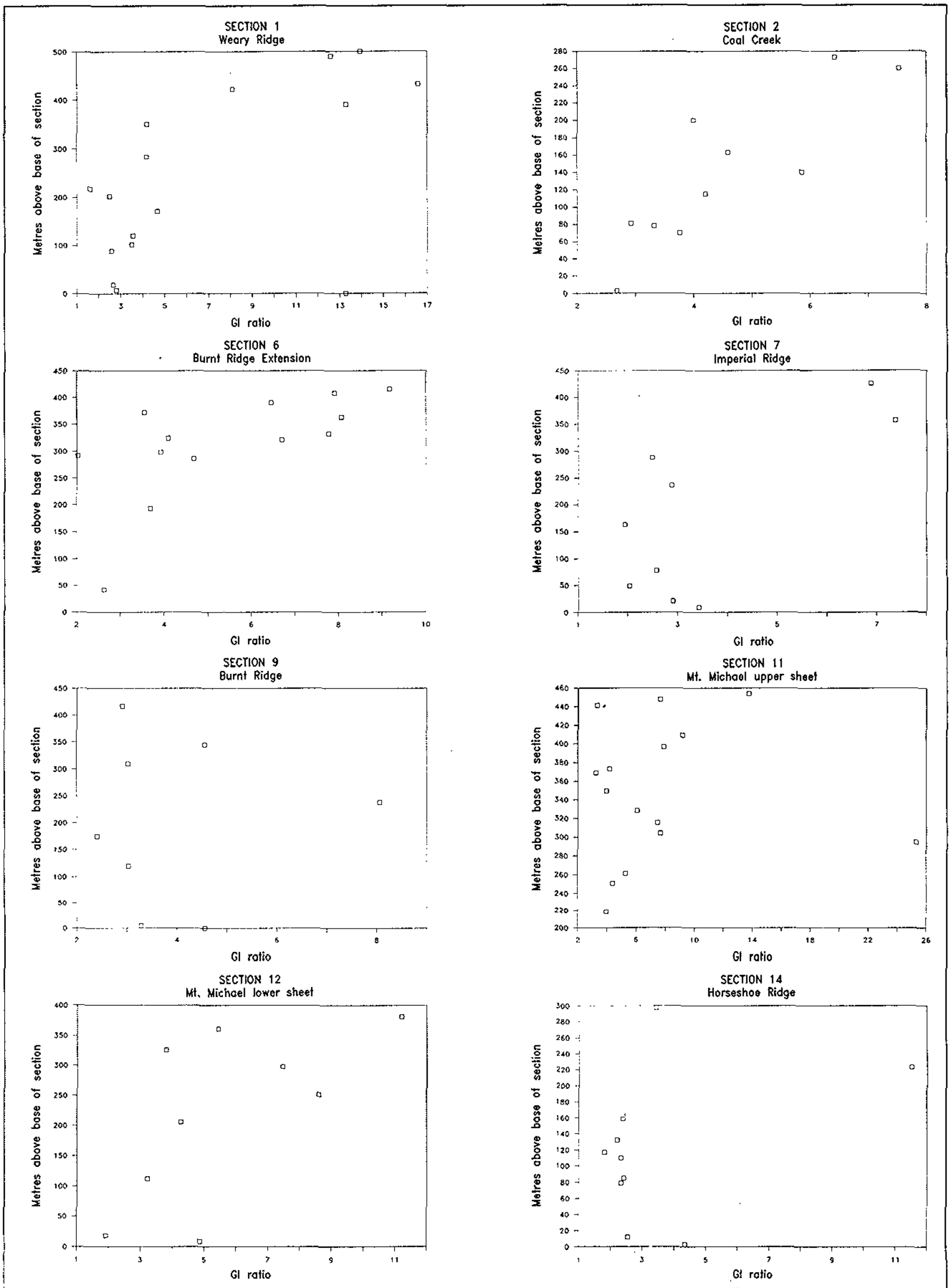


Figure 25. Variation in GI ratio with stratigraphic position.

The overall maceral composition suggests that the bulk of the coal precursor material was deposited *in situ* (autochthonous), with generally little movement either within or from other sources. There is some variation in IR, the parameter thought to reflect the amount of movement of material, but the variation is not systematic. The relative degree of wetness, or height of the water table, as indicated by T/F ratio values, increases up-section, but coals do not appear to have been deposited in lakes or ponds, as there are no examples of sapropelic coals. In the overlying Elk Formation, however, sapropelic coals are common, suggesting a further increase in water table height up-section. The bulk of coaly material passed through a gel state, and the overall proportion of gelified material, as reflected in GI ratio values, increased up-section.

Cameron (1972), in his regional maceral study of the Mist Mountain Formation, postulated that the coals from the lower part of the formation were of hypautochthonous origin, implying movement of material within the swamps, to explain their relatively higher inertinite, especially inertodetrinite, contents. Results here appear to contradict this interpretation, as the inert ratio does not vary consistently through the section. On the other hand, in some sections there is a decrease in inertodetrinite (here considered to be the "other inertinite" category) up-section, which does suggest there was relatively more movement of vegetation prior to deposition of seams in the lower part of the formation, causing physical break-up of inertinite macerals. Cameron further argued that the proportion of trees to total vegetation increases up-section, to explain the high vitrinite content of the seams in the upper section. This may be true, but this study suggests that an alternate explanation of the higher proportion of vitrinite in these seams is the higher water table and hence better tissue preservation.

CHAPTER 5: STRUCTURAL GEOLOGY

SETTING AND GENERAL STRUCTURE

The Elk Valley coalfield is situated in the Front Ranges of the southern Canadian Rocky Mountains (or foreland fold and thrust belt), a structural province characterized by north to northwest-trending, flexural-slip folds, and southwest to west-dipping thrust faults parallel to the folds. These structures were produced by compressional forces associated with the Late Cretaceous - Early Tertiary Laramide orogeny of the Canadian Cordillera. Later in the Tertiary, the area was affected by an extensional regime, in which normal movement took place on both new and previously existing fault planes. For a summary of the tectonic setting of the region see Price (1980).

The coalfield is part of the Lewis thrust sheet, as are the other two coalfields in southeastern British Columbia. In the study area the Lewis sheet is bounded to the east by the outcrop of the Lewis thrust fault, and to the west by the Bourgeau thrust fault (Grieve and Price, 1985). West-to-east horizontal displacement on the Lewis fault was at least 19 kilometres at the latitude of Fording Mountain (Dahlstrom *et al.*, 1962).

Folds in the surface of the Lewis thrust are exposed in outcrop in the Tornado Pass area, roughly 17.5 kilometres east of Elkford (see, for example, Price, 1962a). Other evidence for folding in the plane of the Lewis fault was inferred from results of drilling the California Standard Fording Mountain well (Dahlstrom *et al., op. cit.*), where the Lewis thrust fault was intersected at a depth of 3125 metres, considerably less than the depth predicted by projecting down-dip from the outcrop of the fault. Folding of the Lewis fault took place during movement on an underlying, younger thrust.

Outcrop expressions of subsurface folds in the Lewis thrust include the Alexander Creek syncline, a major structure of the Elk Valley coalfield, and the Fording Mountain anticline.

Coal deposits in southeastern British Columbia have generally been preserved in "structurally low" positions, or in other words, in the cores of synclines, the hangingwalls of normal faults, and the footwalls of thrust faults (Grieve, 1985). The major regional structures controlling the distribution of the Kootenay Group in the Elk Valley coalfield are the Alexander Creek syncline, the Erickson fault, the Greenhills syncline and the Bourgeau thrust fault (Figure 3).

The Alexander Creek syncline (Plate 17) underlies the entire length of the coalfield, and encompasses the Line Creek mine (Plate 13) and the Eagle Mountain component of the Fording Coal operation.

Coal occurrences in the Greenhills Range to the west, including the Greenhills pits of the Fording River and the Greenhills mine (Plate 18), are part of the Greenhills syncline, and are separated from the main body of the coalfield by the west-dipping Erickson normal fault. The Bourgeau thrust fault is in direct contact with, and delimits the westward extent of the northern half of the coalfield (Plate 19).

Other major structures within the coalfield include the Ewin Pass thrust fault (Plate 20) within the eastern limb of the Alexander Creek syncline throughout the southern half of the coalfield, and a large-scale fold-pair in the Ewin Pass - Mount Banner area (Plate 21). Thrust faults affecting the Morrissey and basal Mist Mountain formations are common on the east limb.

Folded thrust faults were not positively identified in the field, but are known to occur at some locations, including the Line Creek mine. At this location, these faults are in the west limb of the Alexander Creek syncline. They dip east at a shallower angle than the bedding; movement direction was to the east.

Minor compressional structures are ubiquitous and include mainly small-scale folds and thrust faults, products of the compressional stage of deformation. Many are directly related to other structures, for example, drag folds associated with thrusting (Plates 20 and 22) and thrust faults generated during flexural-slip folding. Minor extensional features were also noted, though much more rarely than the folds and thrusts. The scale of mapping did not allow time for detailed analysis of minor structures, with the exception of some of those obviously related to large-scale structures.

Late-stage gravity or mass-wasting features are also common, and affect primarily the Morrissey Formation (Plate 23).

More detailed descriptions of the major structural features of the Elk Valley coalfield follow.

ALEXANDER CREEK SYNCLINE

The Alexander Creek syncline is the dominant structure in the Elk Valley coalfield, as it underlies the main body of the coalfield throughout its entire 97-kilometre length (Figures 3 and 5; Plates 13 and 17). As already noted, it is believed to correspond with a syncline in the plane of the Lewis thrust fault.

The syncline is in general upright, but is locally steeply inclined (*e.g.* Section C-C′, Figure 5). It is mainly an asymmetric fold, with the west limb being the shorter in most cases (*e.g.* Section C-C′). This asymmetry is accentuated in parts of the north half of the coalfield by a tendency for dips to flatten on the east limb, producing a step-like cross-section (*e.g.* Section A-A′). The Alexander Creek syncline is generally open, but is close in some instances.

The most pronounced occurrences of axial plane inclination, fold asymmetry and close-fold tightness are where the west limb is vertical to overturned. This is true especially throughout the northern one-third of the coalfield, where the Bourgeau thrust is in close proximity to the west (*e.g.*, Sections A-A′, B-B′ and C-C′).

Another example of asymmetry is the greater tendency for the eastern limb to be thickened significantly by thrust faults, mainly in the Mist Mountain Formation (*e.g.*, Section G-G′). Some of these, including the Ewin Pass thrust fault, are described below.

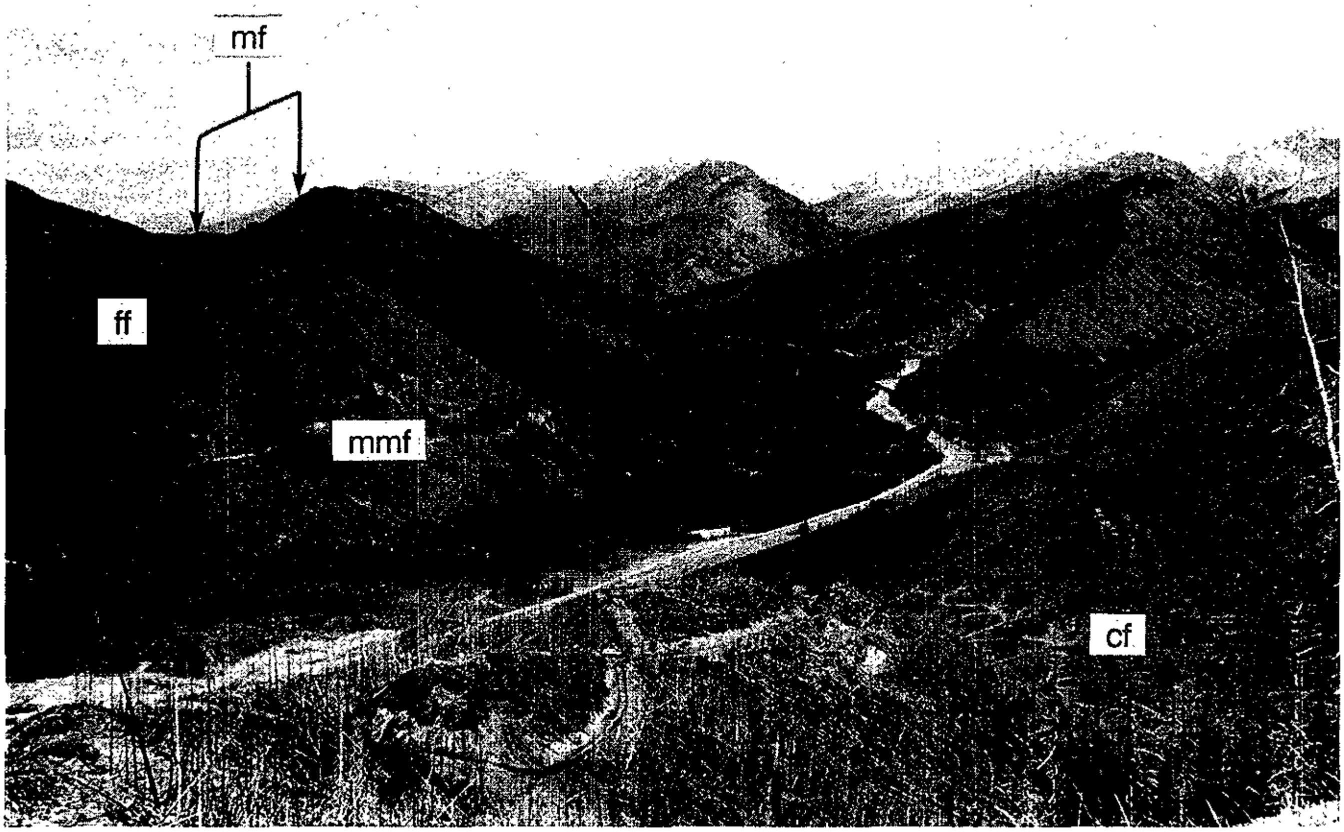


Plate 17. View to the north from Burnt Ridge, looking up the Fording River valley. Approximate trace of the Alexander Creek synclinal axis is plotted. (ff = Fernie Formation; mf = Morrisssey Formation; mmf = Mist Mountain Formation; cf = Cadomin Formation).

Plate 18. View to the north of the upper part of the Mist Mountain Formation in the core of the Greenhills syncline, exposed in a highwall of the Greenhills mine.

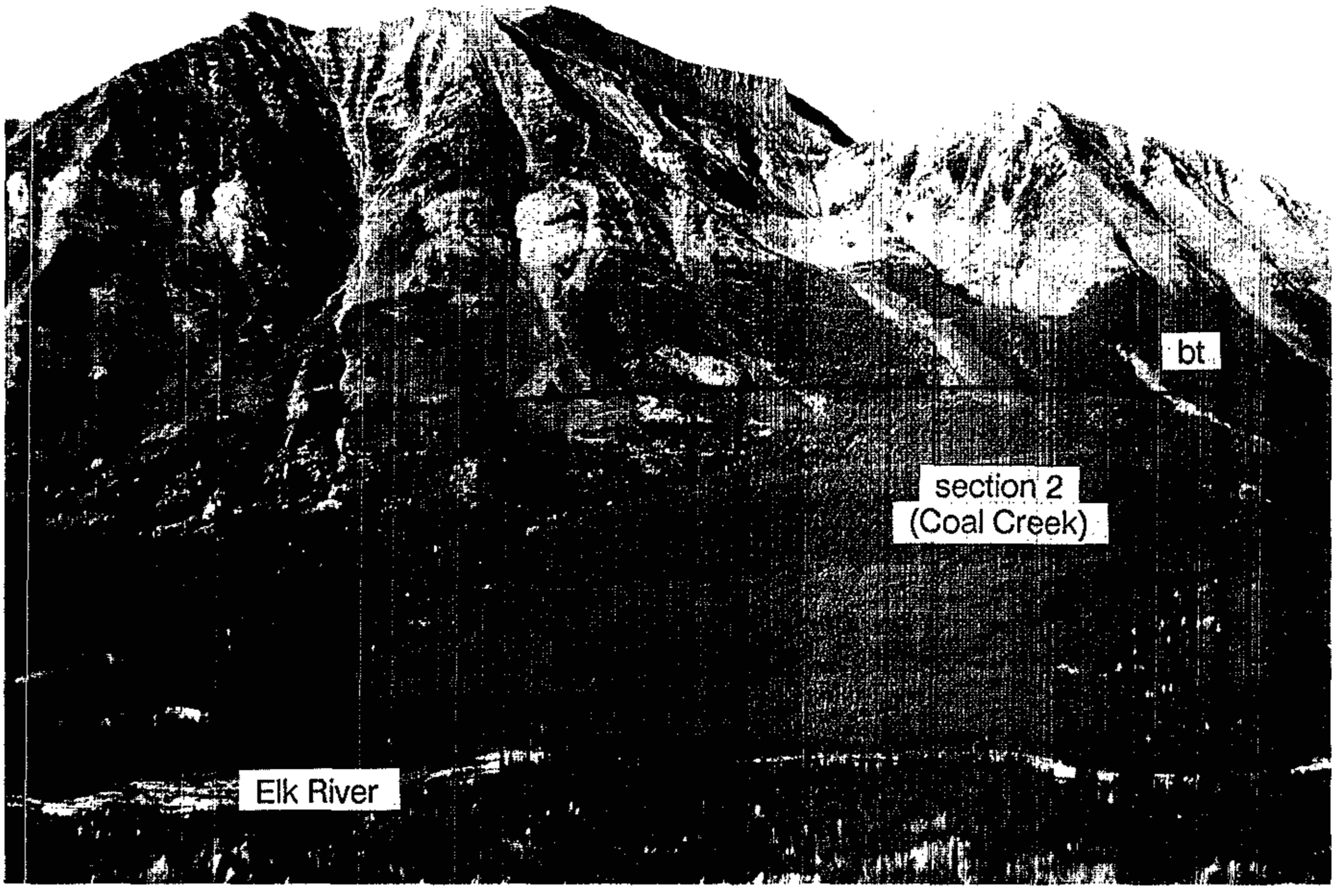


Plate 19. View to the west over the north part of the Elk Valley toward Mount Bleasdell. The approximate trace of the Bourgeau thrust fault (bt) is shown. Pennsylvanian, Permian, and Triassic strata are exposed in the hangingwall. The footwall, including all of the foreground, is underlain by Kootenay Group and Cadomin Formation. The location of the Coal Creek measured section (Number 2) is also shown.

The average trend of the axis of the Alexander Creek syncline is north-northwest, but locally the trend changes to northwest, north and north-northeast (Figure 26). Taken over its entire length, its axis can be considered to have no net plunge, although the plunge is in fact variable, with a subhorizontal to gentle plunge developed locally. Average axial orientations at the positions of the eight cross-sections are summarized below (*see* Figure 26):

- Section A-A′ : No plunge; axial trend 321°
- Section B-B′ : Plunge 8° to 337°
- Section C-C′ : No plunge; axial trend 334°
- Section D-D′ : Plunge 10° to 326°
- Section E-E′ : Plunge 3° to 163°
- Section F-F′ : Plunge 2° to 352°
- Section G-G′ : Plunge 8° to 345°
- Section H-H′ : Plunge 4° to 168°

This variation in plunge has produced a series of axial depressions and highs or culminations. Axial depressions are characterized by occurrences of Cadomin Formation preserved in the core of the fold (Pearson and Grieve, 1980). As a result, the plunge of the axis at any given site is in general toward one of the depressions, which occur at three general locations. The most southerly is in the Ewin Creek area (Fording Bridge depression, Pearson and Grieve, *op. cit.*). Another depression occurs north of the Fording Coal operations (Osborne Creek depression) and the most northerly is in the vicinity of Cadorna Creek (Cadorna Creek depression).

Thrust Faults Associated with the East Limb

EWIN PASS FAULT

The Ewin Pass fault occurs in the east limb of the Alexander Creek syncline throughout much of the south half of the coalfield, including the portion between Line Creek and Eagle Mountain (Figures 3 and 5; Plate 20). It may also continue southward from Line Creek to Crown Mountain, assuming that the Crown Mountain fault is the same structure, although there is no direct evidence for this. Throughout its length it has had the effect of thickening the

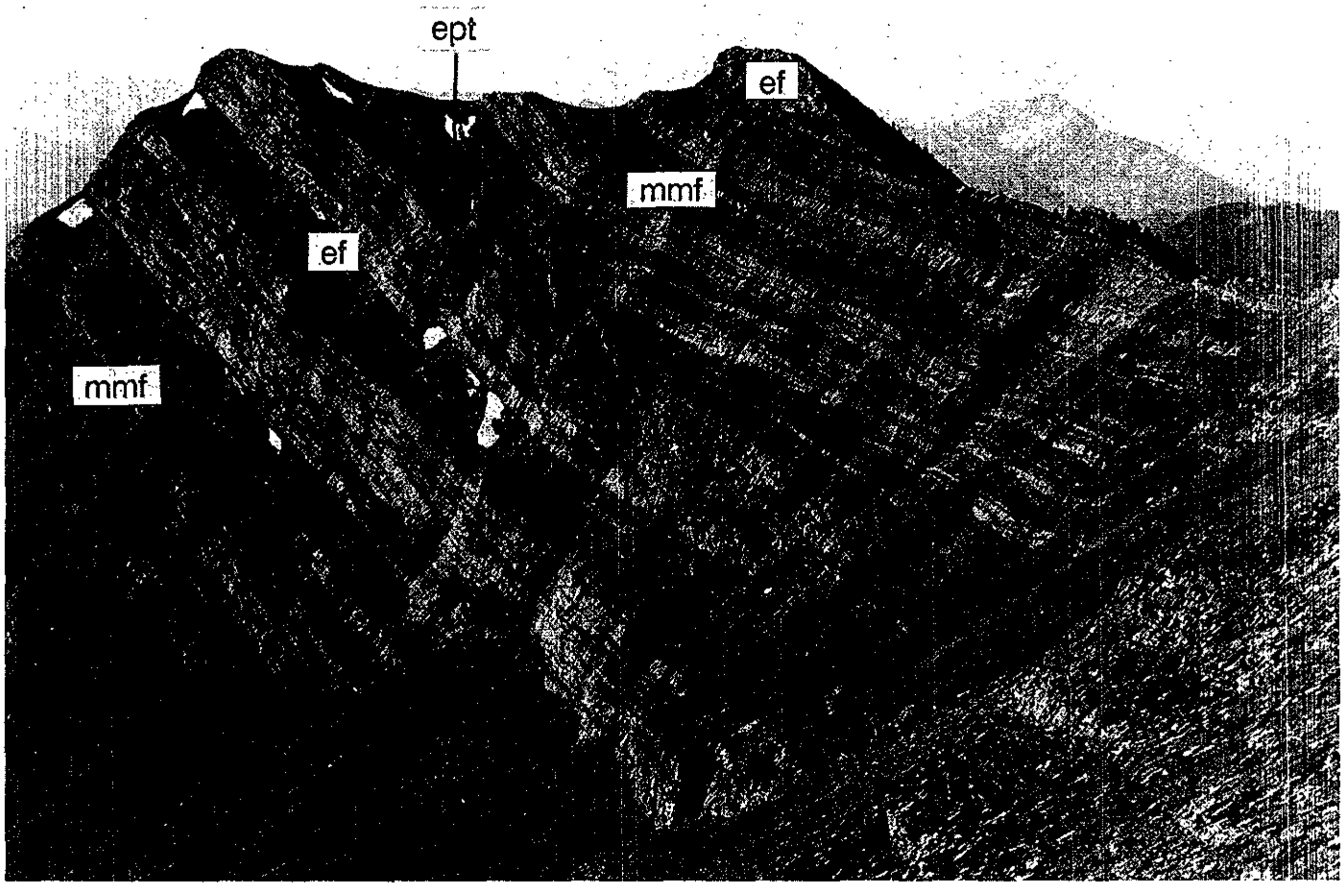


Plate 20. View of the east limb of the Alexander Creek syncline on Castle Mountain, showing the trace of the Ewin Pass thrust fault (ept). Note structural emplacement of the upper part of the Mist Mountain Formation (mmf) over the Elk Formation (ef). Note small-scale deformation related to movement on the thrust.

east limb by causing a repetition of strata. The Ewin Pass fault has been depicted in subsurface by Price and Grieve (in press, a) as a listric, west-dipping splay of the Lewis thrust.

The Crown Mountain fault has placed west-dipping Fernie Formation strata in the east limb of the Alexander Creek syncline over west-dipping strata of the lower part of the Mist Mountain Formation (Section H-H′). The hangingwall block of Kootenay is much less extensive than the footwall block at this location (Figure 5).

In the Line Creek mine area the Ewin Pass fault has placed Fernie Formation, Morrissey Formation and the lower part of the Mist Mountain Formation onto, for the most part, strata of the Mist Mountain Formation (Figure 5). Associated with it is a zone of subsurface disturbance between Line Creek and Horseshoe ridges (T. Hannah, personal communication, 1987). A splay referred to as the Horseshoe Ridge fault has produced large folds and related deformation on the lower slopes of Horseshoe Ridge.

To the north, the Ewin Pass fault climbs rapidly up-section with respect to its footwall. On Mount Michael (Section G-G′) Mist Mountain strata overlie, in fault contact, the Elk Formation. Farther north, at a point roughly 1000 metres north of Section G-G′, a thin limestone bed believed to belong to the Blairmore Group was noted in the immediate footwall of the fault (Grieve and Fraser, 1985).

Movement on the Ewin Pass fault in the Mount Michael area has thus produced two discrete blocks of coal measures (Section F-F′), commonly referred to as the Ewin block (footwall, named after the Ewin Pass coal property) and Michael block (hangingwall, named after the Mount Michael coal property). The characteristics of the coal-bearing section in the two blocks are dramatically different, as outlined earlier (*see* Sections 11 and 12 on Figure 7), suggesting a fairly large pre-thrusting separation distance for the two blocks.

Other thrust faults, interpreted as splays of the Ewin Pass fault, were also mapped in this area. Moreover, as noted earlier, the base of the Michael block contains an unprecedented thickness (roughly 210 m) of strata with no significant thicknesses of coal (Figure 7). This may be indirect evidence for one or more unmapped thrust faults associated with the Ewin Pass fault at this point, causing repetition of strata.

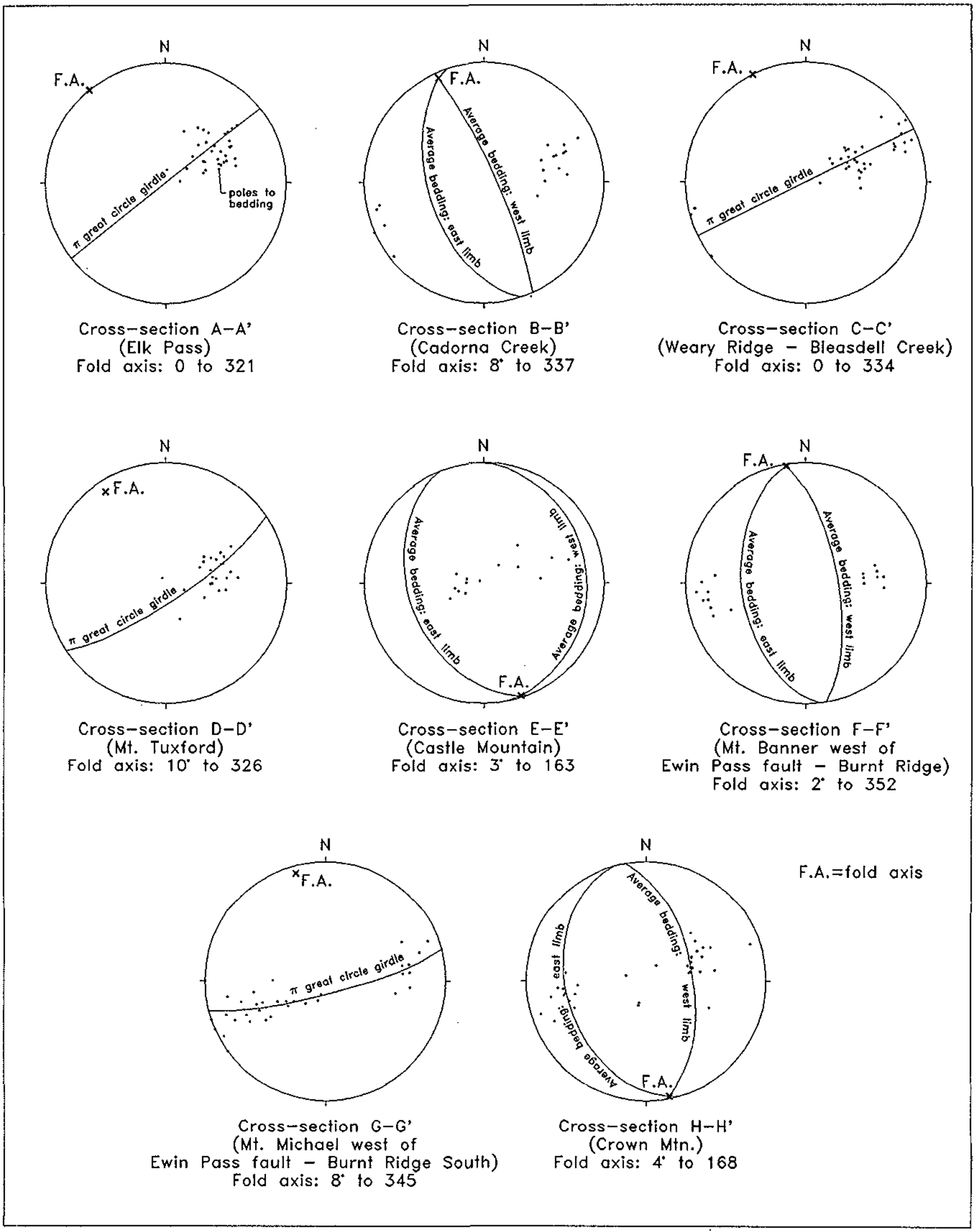


Figure 26. Schmidt stereonet plots of the Alexander Creek syncline.

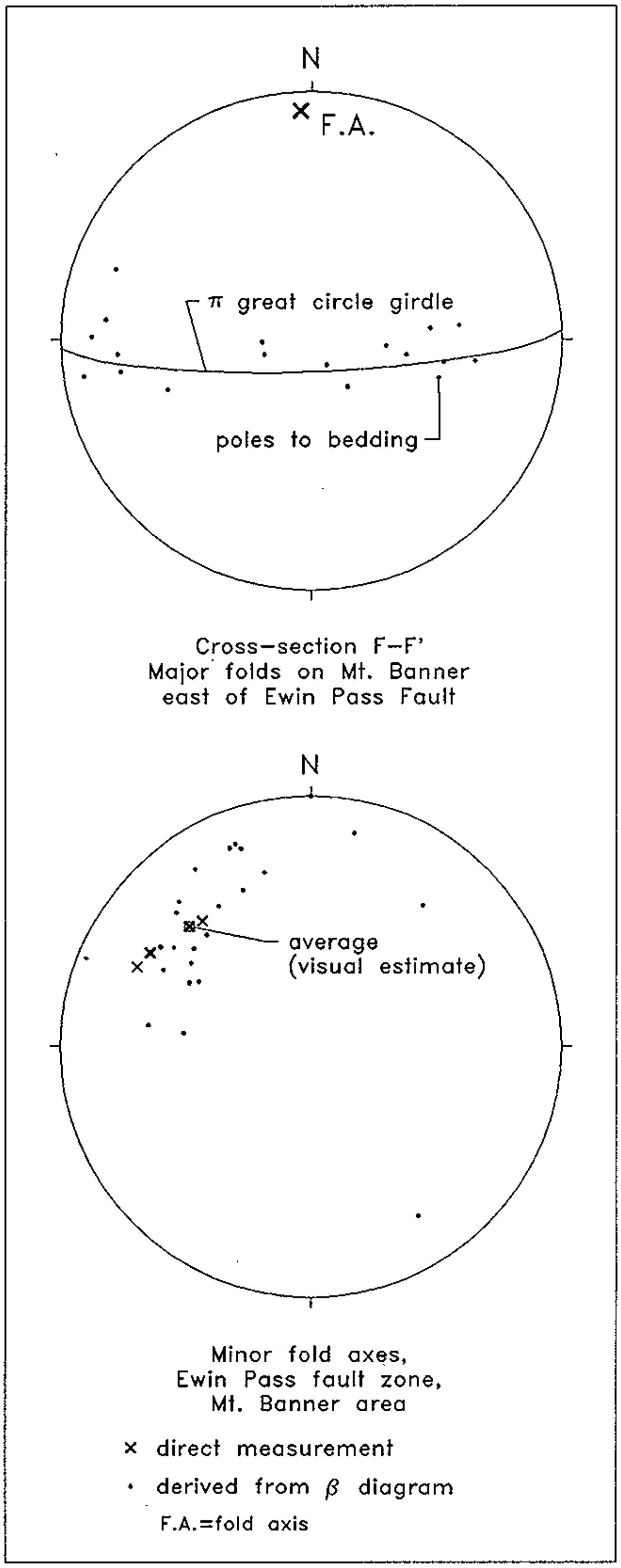


Figure 27. Schmidt stereonet plots of major and minor structures in the Mount Banner area.

Between the Ewin Pass property and Ewin Creek to the north, the Ewin Pass fault occupies a footwall stratigraphic position equivalent to the upper Mist Mountain and lower Elk formations. In this area, however, the immediate hangingwall rocks are higher stratigraphically than they are to the south (upper Mist Mountain Formation), and at one point, north of Mount Banner, the fault is believed to have caused the emplacement of Elk Formation onto Elk Formation (Figure 5).

Associated large-scale structures in this vicinity include a major splay in the hangingwall north of Mount Banner, and a fold pair in the footwall (Plate 21; *see* below).

On the south side of Ewin Creek the two separate blocks of coal measures, the Ewin block and the Michael block, are exposed with little if any intervening Elk Formation strata (Figure 5). Between Ewin Creek and Chauncey Creek the fault remains in the upper Mist Mountain and lower Elk formations with respect to its footwall. Overall displacement, as evidenced by stratigraphic thickening, appears to be decreasing to the north. Splays and drag folds continue to be commonly associated with the fault.

On Castle Mountain, north of Chauncey Creek, both footwall and hangingwall of the Ewin Pass fault are in the upper part of the Mist Mountain Formation (Section E-E′), except for one interval over which Mist Mountain Formation overlies lower Elk Formation on the fault (Figure 5; Plate 20). Drag folding is again evident. To the north, on Eagle Mountain, site of Fording Coal's surface operations, a significant fault which repeats a portion of the Mist Mountain Formation has been interpreted to be the Ewin Pass fault (mine geological staff, personal communication, 1984). On Mount Turnbull, to the north, the fault is believed to be very near the Elk - Mist Mountain contact (Figure 5). North of Mount Turnbull its existence is not established. A fault on Henretta Ridge (Figure 5) may be the Ewin Pass fault.

Structures Associated with the Ewin Pass Fault; Mount Banner Area

As mentioned above, the Mount Banner area is characterized by significant structures associated with the Ewin Pass fault. These include an upper splay and a large fold pair.

The splay of the Ewin Pass fault is continuous over a distance of 2.5 kilometres. It has not caused significant duplication of strata, but does have minor (drag) folds associated with it (Plate 22; Figure 5). Axes of these minor folds, and minor folds associated with the Ewin Pass fault itself in this area, tend to plunge moderately to the northwest [average orientation of 33/315 (plunge/plunge direction); *see* Figure 27]. This suggests northeasterly movement on the Ewin Pass fault.

Bedding orientations on the fold pair (Plate 21) near section line F-F′ suggest a fold axial orientation of 10° to 358° (Figure 27), more similar to that of the Alexander Creek syncline in this area (2° to 353°) than to those of the drag folds associated with the thrusting. Thus they are not believed to be drag folds related to the fault itself, despite their close spatial relationship to it.

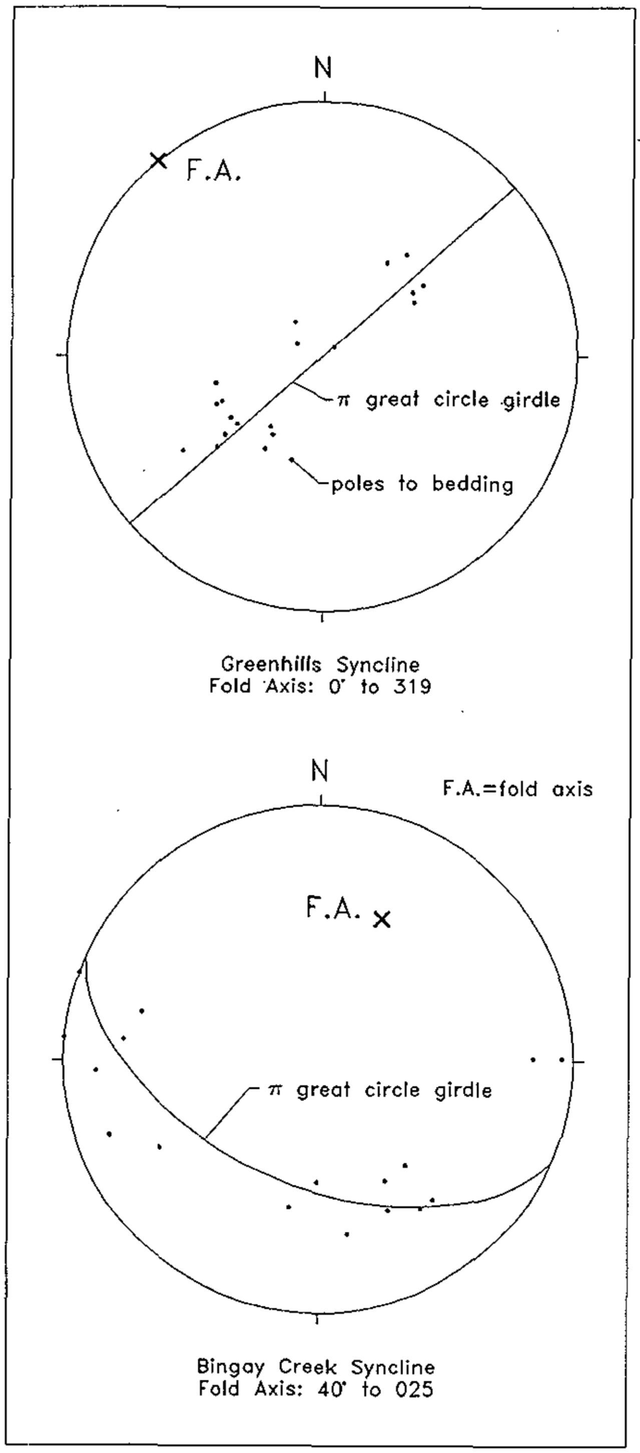


Figure 28. Schmidt stereonet plots of the Greenhills and Bingay Creek synclines.

This fold pair has had an impact on the resource potential of the east limb of the Alexander Creek syncline in this area, by bringing Mist Mountain Formation strata to the surface in an area where they would otherwise be deeply buried (*see* Section F-F′; Plate 21).

LOWER SECTION THRUSTS

West-dipping thrusts associated with the Morrissey Formation and the lower Mist Mountain Formation are common on the east limb of the Alexander Creek syncline throughout the Elk Valley coalfield. The most significant occur on Bare Mountain, Mount Turnbull and Henretta Ridge (Figure 5). These faults are believed to occupy a stratigraphic position within the upper Fernie Formation north and south of each of these occurrences. In all three cases the fault or faults reach their highest stratigraphic position at highest elevation. However, it is not known if the faults are related to each other, or to folding or deep-seated structures like the Ewin Pass thrust.

The net effect of these faults has been to duplicate the section, most notably in the Morrissey Formation (Figure 5). On Bare Mountain, it is possible to count three occurrences of Morrissey Formation separated by fault planes. At Mount Turnbull both the Morrissey Formation and the thrust fault itself are folded. At Henretta Ridge a part of the Mist Mountain Formation has been repeated, together with the Morrissey Formation.

ERICKSON FAULT

The Erickson fault is a west-dipping, listric normal fault which is part of the Flathead fault system (Price, 1962a). In the study area it separates the Alexander Creek and Greenhills synclines. At the south end of the Greenhills Range, the Erickson fault brings strata belonging to the Fernie Formation and Kootenay Group into contact with Mississippian rocks. This represents a net displacement of greater than 600 metres. Moving to the north, however, the net stratigraphic displacement diminishes rapidly, until, at some point, it reaches zero. The exact location of this point is not known, but it is certainly north of the Fording River mine and probably south of Henretta Creek. There is no evidence of normal faulting on Mount Tuxford, farther to the north.

The exact attitude of the fault is not known but it has been depicted on earlier cross-sections as steep at the surface and gentler at depth (Dahlstrom *et al.*, 1962; Price, 1962a). The possibility of two stages of movement, the first being reverse and the second normal, was first proposed by Dahlstrom *et al.* (*op. cit.*). This is now a generally accepted model for major normal faults in the southern Canadian Rocky Mountains.

A normal fault with the same sense of movement as the Erickson, and which affects the southern part of the Greenhills Range, is referred to as the Greenhills fault. It may be a splay of the Erickson fault, as indicated on Figure 5.

GREENHILLS SYNCLINE

The Greenhills syncline underlies the Greenhills Range, and is separated from the Alexander Creek syncline by the Erickson fault. Its most southerly occurrence is near the south end of the Greenhills Range (Figure 5). Its northern extent is buried under cover in the Elk Valley, west of Mount Tuxford. It may extend to the north and be cut off by the Bourgeau thrust, but this is not certain.

The Greenhills syncline is upright and open (Plate 18). Its axis trends northwest to north and, on average, plunges

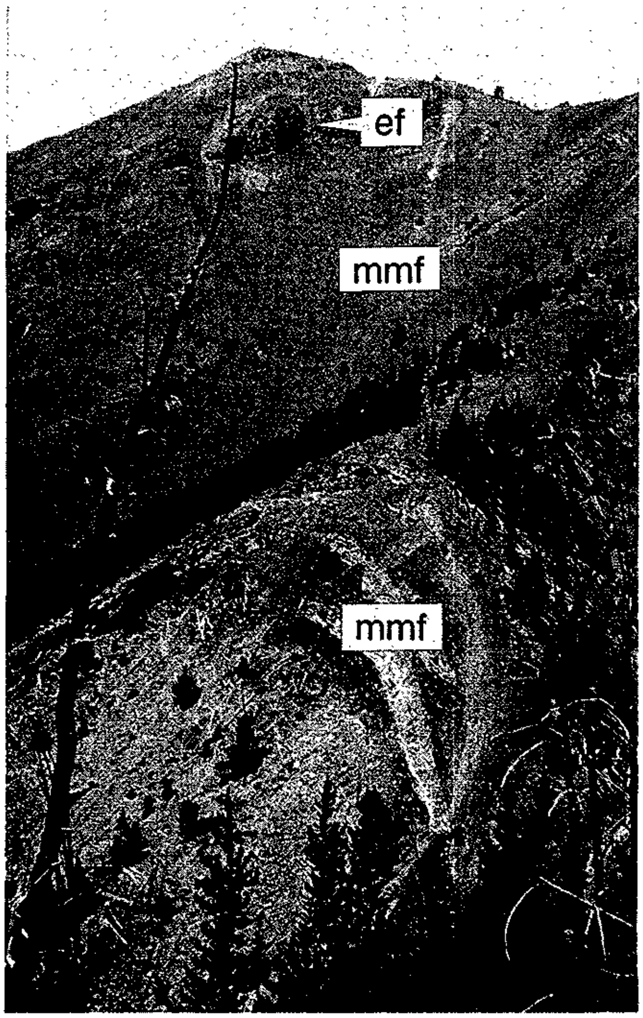


Plate 21. View to the northwest of upper Mist Mountain Formation (mmf) strata in the core of the large-scale anticline in the Ewin Pass – Mount Banner area. Note occurrence of basal Elk Formation (ef).

gently northward throughout the length of the Greenhills Range. At a position roughly 2 kilometres south of section line E-E′ the axis of the fold has no plunge and a trend of 319° (Figure 28).

FORDING MOUNTAIN ANTICLINE AND BINGAY CREEK SYNCLINE

The Fording Mountain anticline, which takes its name from a hill southeast of Elkford, is west of and parallel to the Greenhills syncline, with which it shares its east limb (Section E-E′). Its most northerly extent is also unknown, due to lack of exposure, but is somewhere north of the Greenhills Range. It is upright and open, and its axis, in general, plunges to the north.

The Bingay Creek syncline to the west contains a relatively small occurrence of Morrissey and Mist Mountain formations west of the Elk River near Bingay Creek (Figure 5). The east limb of the syncline (west limb of the Fording Mountain anticline) dips 45° to the northwest on average, while its west limb is vertical to overturned. This overturning is due to the proximity of the Bourgeau thrust fault (*see* below). The axis of the Bingay Creek syncline plunges 40° to 025° (Figure 28).

BOURGEAU FAULT

The Bourgeau thrust fault marks the western limit of the Lewis thrust sheet throughout the study area. It occurs west of the Elk River and dips to the west. Rocks in its hangingwall belong mainly to Triassic and older formations (Plate 19). There are no Kootenay Group exposures in the Bourgeau sheet.

In the south half of the coalfield (south of Bingay Creek) the Bourgeau fault-trace lies well to the west of the coalfield, in contact with Fernie Formation strata in its footwall. Its surface trace in this region is not indicated on the compilation map (Figure 5). At Bingay Creek and to the north, however, the trace is either immediately west of the coalfield, in contact with the upper Fernie Formation, or actually marking the western boundary of the coalfield, being in contact with Kootenay Group strata ranging from the Morrissey to the upper Elk formations.

A noticeable change in the surface trace of the Bourgeau fault occurs northward between Bingay Creek and a point in the Elk Valley west of Mount Veits. Specifically, it changes from a general north-northwest direction to northeast. This area is also marked by a notable decrease in the width of the coalfield in the same direction, which is caused by the position of the fault.

It thus appears that the Bourgeau fault ramped obliquely to the north, and in the process overrode and cut off the more westward structural elements of the coalfield, the Bingay Creek syncline, Fording Mountain anticline and possibly even the Greenhills syncline. Unfortunately, there is no outcrop in the Elk Valley at this point, and proof of this over-riding relationship is not established.

The point at which the trace of the Bourgeau fault returns to its more normal direction (opposite Mount Veits) also coincides with a change in orientation of the Alexander Creek synclinal axis from north-northeast back to the more typical orientation of north-northwest. From this point northward another distinctive change occurs in the synclinal geometry: it changes from upright and open to overturned and close, with a higher degree of asymmetry (compare Sections D-D′ and C-C′). It retains this geometry throughout most of the area north to the Alberta boundary (Sections B-B′, A-A′).

This increased asymmetry is probable due to the proximity of the leading edge of the Bourgeau sheet. The eastward vergence of the syncline is consistent with the direction of movement on the Bourgeau thrust.

The Bourgeau fault is offset 2 kilometres to the northeast by a transverse fault near Elk Lakes at the north end of the coalfield (Leech, 1979). Air-photo interpretation of this structure suggests a series of up to three faults produce the overall net offset (Morris and Grieve, 1990). With no field evidence to support this interpretation, only the single fault has been drawn.

Plate 22. Minor folds associated with a splay of the Ewin Pass thrust fault on the east limb of the Alexander Creek syncline, Mount Banner area.

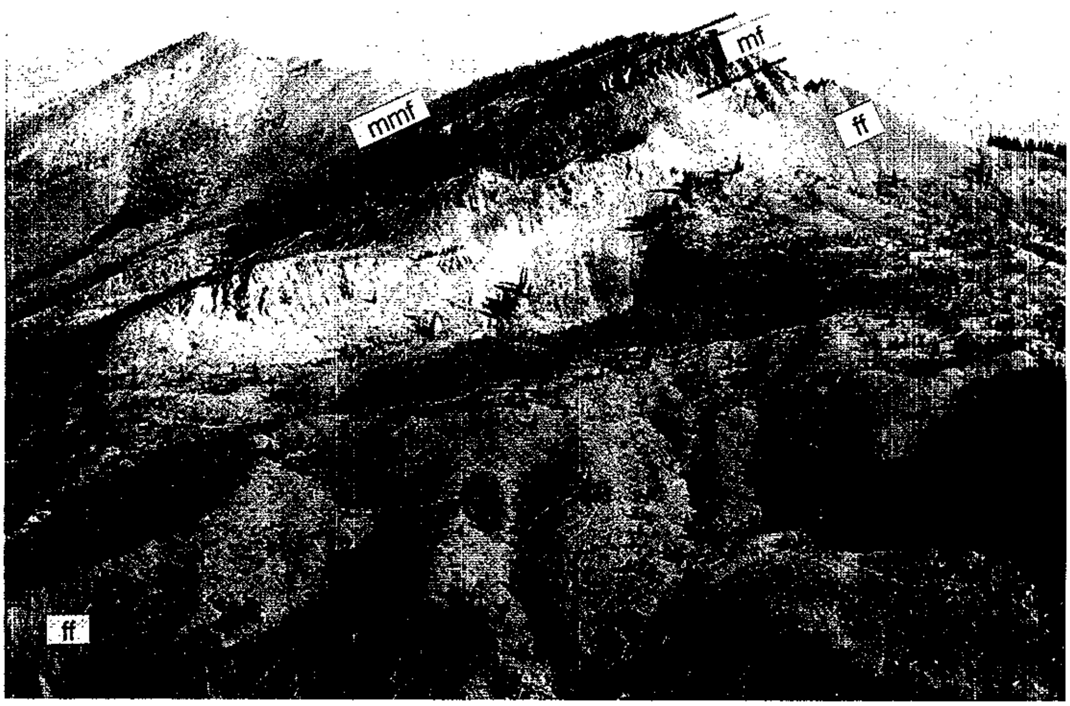


Plate 23. View from the south of Mount Veits on the east limb of the Alexander Creek syncline. Note landslide blocks of Morrissey Formation sandstone (marked with *). (ff = Fernie Formation, mf = Morrissey Formation, mmf = Mist Mountain Formation; photo by R.J. Morris).

Minor Structures Associated with the Bourgeau Fault; Coal Creek

Minor structures associated with the Bourgeau thrust are not generally observable within the coalfield because of poor exposure. The area known as Coal Creek, a tributary of Bleasdell Creek on the west limb of the Alexander Creek syncline, is one exception. Here the stratigraphically lowest outcrops of Mist Mountain Formation exposed in the footwall of the Bourgeau fault are severely deformed (Plate 12). Individual faults fall into two groups, those having average strikes of 340° and dipping steeply to the west, and those with strikes of 030° to 040° and dipping moderately to the southeast. The first set appears to be parallel to the Bourgeau fault and probably splays off the Bourgeau or is caused by movement on it, while the second set is transverse in orientation. The creek bed itself, with a bearing of 040°, is believed to follow the trace of a transverse fault, because the outcrops on the southeast side of the creek are significantly more deformed than those on the northwest side. In particular, the southeast bank contains exposures of a strongly deformed coal seam, which has been severely affected by faulting, producing a zone of thickened coal (Plate 12). The undeformed equivalent of this seam on the northwest side of the creek is 8.1 metres thick in two benches (Figure 7), compared with an apparent thickness exceeding 25 metres on the opposite bank. The sandstone forming the roof of the seam, however, is structurally continuous from one side of the creek to the other.

JOINTING

Joint plane orientations were measured routinely only in the Henretta Ridge and Mount Tuxford area in the north half of the coalfield (Morris and Grieve, 1990). At these locations two prominent sets of joints stand out. One (labelled A in Figure 29) is probably parallel to the axial plane of the Alexander Creek syncline. The other (labelled B) represents jointing perpendicular to the fold axis.

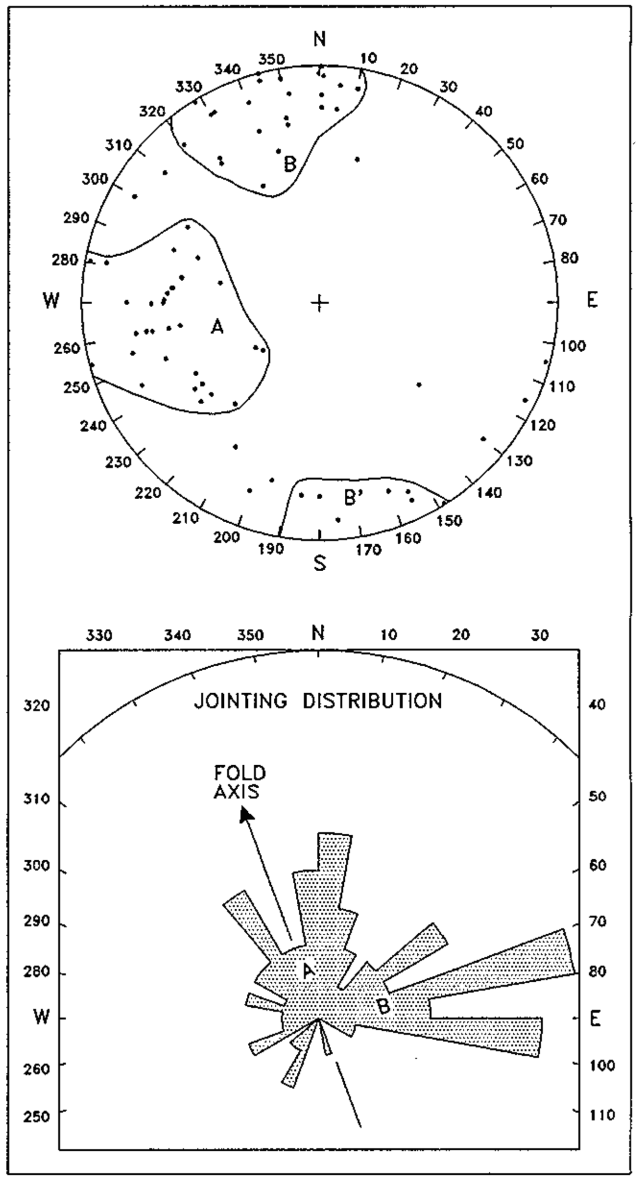


Figure 29. Schmidt stereonet plot and rose diagram of jointing in the Mount Tuxford area.

MASS-WASTING FEATURES

Large landslide blocks, with areas of up to a square kilometre, are prominent features of the Elk Valley coalfield. They mainly involve the Morrissey Formation, and take several forms. The first, and the smallest in scale, are blocks of Morrissey Formation which dip into a moderate to steep slope, and which have broken along planes oriented both perpendicular to strike and parallel to strike but dipping steeply down-slope. Individual blocks are up to a few hundred metres in strike length, and the amount of down-slope movement is on the scale of 100 metres. Because of their small size they do not show up on Figure 5.

A second style of mass-wasting feature involves down-dip movement of blocks of Morrissey Formation which are located on dip-slopes. The detachment planes are oriented parallel to bedding, and the boundaries of the blocks are oriented at right angles to bedding. The best example of this is a square kilometre block of Morrissey Formation at the north end of Weary Ridge which has moved downhill to the west (Figure 5).

A third type of mass-wasting has produced "steps" in the outcrop trace of the Morrissey Formation. The orientation of the breakage planes is again roughly perpendicular to strike, and vertical movement is a maximum of 50 metres. The best development of these structures is on the south side of Mount Veits (Plate 23) and the north end of Mount Tuxford (Figure 5).

CHAPTER 6: COAL RANK DISTRIBUTION

DATA

The surface distribution of ranks of grab and channel samples of Mist Mountain Formation coals from throughout the Elk Valley coalfield, as determined by the mean maximum vitrinite reflectance technique, is shown in Figure 5. Coal ranks have been classified as low, medium and high-volatile bituminous (*see* Chapter 1). The reflectance values of coals from the basal coal zone are also plotted on Figure 5, together with the ranges of reflectance values on samples collected from measured sections and drill cores. At measured section locations, where the reflectance values of channel samples from the basal coal zone differ from those recorded in previous publications and are based on grab samples only, the higher values are indicated.

The original data on which Figure 5 is based are found primarily in Grieve and Fraser (1985) and Morris and Grieve (1990), as well as on the generalized measured sections and drill logs contained in this bulletin (Figures 7 and 8, Tables 12 and 13). In the case of the Greenhills Range, new reflectance values were generated for this bulletin which are, on average, 0.1 per cent or one V-step, higher than those published previously (Pearson and Grieve, 1980; Grieve and Pearson, 1983). The new values reported here (Figures 5 and 7, Table 12) are believed to more accurately represent the rank of Greenhills Range coals than those in the earlier publication.

Data for the Line Creek and Fording mine areas are not presented on Figure 5. Rank boundaries in these areas are estimates, and are indicated by dashed lines.

Figure 5 is intended to provide only a general indication of coal rank at any location; values which do not conform to the divisions indicated are common. These nonconforming samples are believed to reflect natural scatter in vitrinite reflectance values, as well as variation introduced by uneven sample quality and by analytical techniques.

The maximum reflectance values plotted for the basal coal zone of the Mist Mountain Formation on Figure 5 are not necessarily the highest in the section at any given location. In fact, in many cases the highest values occur at some position stratigraphically above the basal coal zone. This tendency is apparent in the measured section rank distributions (Figure 7), referred to in the next paragraph.

As mentioned above, maximum vitrinite reflectance data are also displayed adjacent to the generalized stratigraphic sections (Figure 7) and are listed in Table 12. Most of these values represent channel samples, although in some cases grab samples were used (*see* Table 12). Additional data are plotted adjacent to generalized drill-core lithological logs (Figure 8), representing grab samples of thin coal seams or bands in the core. These data, listed in Table 13, provide information on subsurface rank variations.

Graphic plots of mean maximum reflectance ($\bar{R}_{max}$) *versus* stratigraphic position for each of the measured sections are shown on Figure 30. These are used to calculate average reflectance gradients, as change in reflectance per 100 metres of section (Table 14). Average gradients (*i.e.* straight line relationships) are calculated using the public domain software package CURVEFIT.

In the case of the subsurface samples, five reflectance parameters are plotted relative to depth on Figures 31 to 41. The parameters graphed are $\bar{R}_{max}$, mean random reflectance ($\bar{R}_m$), length of the maximum axis of the reflectance indicating surface or RIS(R_{max}), RIS style (R_{st}), and RIS anisotropy magnitude (R_{am}). In addition, R_{st} values are plotted *versus* R_{am} values on triangular graphs (*see* Chapter 1 and Kilby, 1988). Average reflectance gradients based on $\bar{R}_{max}$ were also calculated for each drill hole using CURVEFIT (Table 15).

A series of grab samples was collected at Line Creek mine near the southern end of the coalfield, in an attempt to document and quantify the presence of down-dip rank changes. The samples are from four seams at various known elevations within the mine. Results, shown on Figure 42, are discussed below.

Reflectance and depth data for four coal seams within one structural block on Eagle Mountain were obtained from Fording Coal. Graphs of reflectance *versus* depth were generated for each seam, in order to document any down-dip rank changes. One example is shown in Figure 43.

RANK DISTRIBUTION AND GRADIENTS

Rank of Elk Valley coals, as determined by maximum vitrinite reflectance, ranges from low to high-volatile bituminous (Figures 5, 7 and 8, Tables 12 and 13). Rank values, on average, decrease upsection at individual locations, and also vary along strike.

At most locations, the lower part of the Mist Mountain Formation contains coals of medium-volatile bituminous rank, typically with reflectance values of 1.3 to 1.4 per cent, while the upper part contains coals of high-volatile rank, with values of approximately 1.0 per cent or less. (The Elk Formation, although not discussed here, almost exclusively contains high volatile-coals in the study area). The relative stratigraphic position of the transition from medium to high-volatile is variable, and depends on absolute rank values of the lower part of the formation and the rank gradient (change per stratigraphic interval).

At three locations, the lower part of the formation contains low-volatile bituminous coals, and the remainder of the formation contains mainly medium-volatile. These three locations are at Crown Mountain in the extreme south end of the coalfield, at Mount Banner, and near Weary Creek in the north part of the coalfield (Figure 5).

Areas where the entire Mist Mountain Formation is of high-volatile rank occur in the north part of the coalfield, specifically on the west limb of the Alexander Creek syncline opposite Weary Creek. The northernmost 15 kilometres of the coalfield also appears to contain coals of relatively low rank. In addition, the partial Mist Mountain section exposed in the hangingwall of the Ewin Pass thrust

TABLE 12
SUMMARY OF REFLECTANCE PARAMETERS — OUTCROP SAMPLES

Sample Number	Sample Type	Metres Above Base of Section	Number of Readings	$\bar{R}_{max}$	Standard Deviation	$\bar{R}_m$	RIS Shape
Section 1	**Weary Ridge**						
1-1	C	0.00	50	1.48	0.076	1.36	B−
1-2	C	5.40	50	1.44	0.066	1.33	B−
1-3	C	17.20	50	1.47	0.044	1.36	B−
1-4	C	86.80	50	1.54	0.075	1.44	B−
1-5	C	101.40	54	1.51	0.066	1.42	B=
1-6	C	121.10	50	1.52	0.058	1.40	B−
1-7	C	170.30	30	1.32	0.053	1.21	B−
1-8	C	201.00	50	1.46	0.077	1.34	B=
1-9	C	218.50	50	1.54	0.061	1.43	B−
1-10	C	274.30	50	1.39	0.067	1.25	B−
1-11	C	349.70	50	1.41	0.093	1.33	**
1-12	C	389.90	50	1.25	0.055	1.18	B−
1-13	C	423.00	50	1.21	0.049	1.14	B−
1-14	C	433.30	50	1.20	0.056	1.14	B+
1-15	C	491.10	50	1.14	0.047	1.08	B−
1-16	C	500.30	50	1.07	0.029	1.01	B−
Section 2	**Coal Creek**						
2-1	C	6.50	49	0.86	0.061	0.82	**
2-2	C	70.30	49	0.85	0.057	0.81	**
2-3	C	73.90	32	0.86	0.068	0.82	**
2-4	C	80.00	50	0.88	0.041	0.85	**
2-5	C	114.20	47	0.86	0.068	0.82	**
2-6	C	138.10	50	0.82	0.057	0.78	**
2-7	C	161.90	50	0.83	0.060	0.80	**
2-8	C	199.60	48	0.74	0.069	0.72	**
2-9	C	259.50	49	0.84	0.053	0.80	**
2-10	C	273.90	49	0.59	0.053	0.57	**
Section 3	**Mt. Veils**						
3-1	G	14.50	50	1.44	0.060	1.32	B−
3-2	G	30.30	50	1.38	0.061	1.28	B=
3-3	G	86.00	50	1.49	0.064	1.35	B−
3-4	G	92.70	50	1.44	0.056	1.32	B−
Section 4	**Mt. Tuxford**						
4-1	G	55.70	50	1.45	0.064	1.34	B−
4-2	G	58.70	50	1.53	0.070	1.40	B+
4-3	G	91.50	50	1.39	0.096	1.23	B−
4-4	G	109.10	50	1.41	0.053	1.30	B=
4-5	G	152.40	50	1.36	0.079	1.24	B+
4-6	G	196.10	50	1.38	0.048	1.28	B−
4-7	G	200.90	50	1.29	0.049	1.20	B−
4-8	G	252.50	50	1.22	0.052	1.14	B−
4-9	G	256.60	50	1.31	0.033	1.22	B−
4-10	G	293.60	50	1.23	0.032	1.16	B−
4-11	G	376.20	50	1.18	0.042	1.10	B=
4-12	G	437.30	50	1.16	0.034	1.08	B−
4-13	G	548.30	50	1.02	0.035	0.92	B+
Section 5	**Greenhills**						
5-1	C	10.00	46	1.24	0.049	1.21	B=
5-2	C	162.50	51	1.16	0.054	1.11	B−
5-3	C	218.00	50	1.18	0.038	1.13	B−
5-4	C	296.00	49	1.21	0.040	1.17	B=
5-5	C	333.00	45	1.04	0.067	0.99	B−
5-6	C	381.50	48	1.05	0.052	1.01	B−
5-7	C	391.00	51	1.04	0.053	1.00	B=
5-8	C	507.60	51	0.94	0.060	0.90	**
5-9	C	519.80	50	1.03	0.046	0.99	B=
5-10	C	565.00	49	0.85	0.043	0.83	B−
5-11	C	618.60	50	0.81	0.056	0.79	**
5-12	C	664.50	43	0.74	0.063	0.72	**
5-13	C	694.00	49	0.71	0.085	0.69	**
Section 6	**Burnt Ridge Extension**						
6-1	C	42.50	50	1.47	0.075	1.35	B−
6-2	C	193.20	50	1.26	0.056	1.19	B−
6-3	C	279.60	50	1.17	0.074	1.08	B=
6-4	C	287.00	50	1.22	0.081	1.12	B=
6-5	C	292.40	50	1.05	0.092	0.91	B=
6-6	C	314.00	50	1.13	0.043	1.06	B−
6-7	C	317.00	50	1.04	0.056	0.93	B−
6-8	C	325.50	50	1.08	0.038	1.02	B−
6-9	C	357.90	50	1.10	0.046	1.04	B−
6-10	C	365.50	50	1.10	0.051	1.03	B+
6-11	C	383.90	50	1.06	0.051	0.98	B+
6-12	C	402.00	50	1.04	0.042	0.97	B=
6-13	C	408.80	50	1.01	0.052	0.92	B−
Section 7	**Imperial Ridge**						
7-1	C	8.80	52	1.22	0.080	1.18	B=
7-2	C	21.00	49	1.29	0.046	1.23	B−
7-3	C	51.00	50	1.19	0.057	1.14	B=
7-4	C	78.40	45	1.17	0.060	1.12	B=
7-5	C	167.50	47	1.18	0.062	1.14	B−
7-6	C	237.10	50	1.11	0.041	1.07	B−
7-7	C	292.90	49	1.10	0.059	1.06	B−
7-8	C	356.60	53	1.02	0.044	0.98	B=
7-9	C	426.90	48	1.04	0.045	1.01	B=
Section 8	**Ewin Pass**						
8-1	G	4.20	48	1.32	0.052	1.28	B−
8-2	G	91.60	49	1.29	0.039	1.24	B+
8-3	G	173.60	49	1.24	0.029	1.19	B−
8-4	G	232.60	45	1.12	0.047	1.08	B−
8-5	G	376.50	48	1.14	0.035	1.10	B=
8-6	G	403.80	49	1.07	0.053	1.04	B−
Section 9	**Burnt Ridge**						
9-1	C	0.00	50	1.31	0.154	1.18	B+
9-2	C	5.50	50	1.25	0.071	1.17	B−
9-3	C	125.30	50	1.32	0.066	1.23	B+
9-4	C	179.20	50	1.20	0.043	1.12	B=
9-5	C	237.40	50	1.11	0.046	1.04	B=
9-6	C	315.80	50	1.11	0.044	1.05	B+
9-7	C	347.20	50	1.10	0.059	1.04	B+
9-8	C	420.70	44	1.13	0.091	1.08	**
9-9	G	565.00	25	0.99			
Section 10	**Burnt Ridge South**						
10-1	G	169.40	48	1.25	0.067	1.20	B−
10-2	G	214.40	45	1.13	0.039	1.10	B−
10-3	G	250.20	50	1.09	0.067	1.05	B−
10-4	G	471.30	48	1.12	0.044	1.08	B−
10-5	G	516.60	45	1.04	0.052	1.04	B−
10-6	G	585.50	47	0.83	0.044	0.80	B=
Section 11	**Mt. Michael Upper**						
11-1	C	218.30	50	0.92	0.114	0.80	B−
11-2	C	250.60	50	1.03	0.076	0.91	B+
11-3	C	261.30	50	1.17	0.075	1.07	B=
11-4	C	294.60	50	0.85	0.050	0.70	B−
11-5	C	304.10	50	1.01	0.044	0.89	B=
11-6	C	315.60	50	1.06	0.051	0.99	B=
11-7	C	328.30	50	0.91	0.038	0.72	B−
11-8	C	349.60	50	0.99	0.037	0.86	B−
11-9	C	369.10	50	1.01	0.048	0.87	B−
11-10	C	373.20	50	1.01	0.052	0.93	B=
11-11	C	396.80	50	0.94	0.044	0.80	B=
11-12	C	409.10	50	0.99	0.049	0.90	B−
11-13	C	441.40	50	0.94	0.050	0.76	B−
11-14	C	447.90	50	0.95	0.038	0.93	B+
11-15	C	453.70	50	0.92	0.051	0.74	B−
Section 12	**Mt. Michael Lower**						
12-1	C	9.00	50	1.27	0.061	1.18	B=
12-2	C	18.00	50	1.23	0.065	1.16	B=
12-3	C	112.30	50	1.13	0.074	1.06	B−
12-4	C	206.40	50	1.16	0.069	1.06	B=
12-5	C	251.30	50	1.03	0.064	0.93	B=
12-6	C	298.60	50	1.10	0.085	0.99	B−
12-7	C	326.20	50	1.08	0.053	0.99	B+
12-8	C	361.00	50	1.00	0.054	0.90	B−
12-9	C	386.00	50	0.95	0.045	0.78	B−
Section 13	**Noname Ridge**						
13-1	G	154.40	50	1.19	0.047	1.12	B−
13-2	G	202.80	50	1.13	0.042	1.10	B−
13-3	G	368.30	42	1.03	0.044	0.99	B−
13-4	G	451.00	54	0.99	0.053	0.96	B+
13-5	G	517.70	49	0.92	0.037	0.90	B=
Section 14	**Horseshoe Ridge**						
14-1	C	3.00	50	1.38	0.122	1.30	B=
14-2	C	12.20	50	1.34	0.069	1.23	B−
14-3	C	78.00	50	1.28	0.066	1.18	B+
14-4	C	85.00	50	1.21	0.051	1.12	B−
14-5	C	109.80	50	1.27	0.088	1.15	B=
14-6	C	117.30	50	1.34	0.088	1.23	B−
14-7	C	131.90	50	1.27	0.068	1.16	B=
14-8	C	159.10	50	1.15	0.078	1.09	B=
14-9	C	222.80	50	1.18	0.045	1.12	B=
14-10	C	298.30	50	1.14	0.068	1.05	B+
Section 15	**TeePee Mountain**						
15-1	C	—8.50*	50	0.90	0.049	0.71	B=
15-2	C	1.00*	50	1.18	0.065	1.08	B−
15-3	C	13.20*	51	1.30	0.058	1.23	B=
Section 16	**Crown Mountain**						
16-1	C	19.60	50	1.63	0.051	1.50	B−
16-2	C	56.90	50	1.29	0.089	1.20	B+

C Channel sample
G Grab sample
B− Biaxial negative
B= Biaxail even
B+ Biaxail positive
* Position with respect to base of Mist Mountain Formation
** cannot be interpreted

TABLE 13
SUMMARY OF REFLECTANCE PARAMETERS — DRILL-CORE SAMPLES

Sample Number	Depth (m)	No. of Readings	$\bar{R}$max	Standard Deviation	$\bar{R}$m	RIS Shape	Rmax	Rint	Rmin	Rev	$\bar{R}$m/Rev	Rst	Ram
	MBE-101												
A-1	207.83	50	1.42	0.028	1.31	B−	1.46	1.34	1.12	1.297	1.010	−8.689	0.0507
A-2	188.20	50	1.38	0.058	1.27	B−	1.48	1.30	1.06	1.268	1.005	−4.714	0.0634
A-3	74.69	50	1.39	0.042	1.30	B−	1.45	1.32	1.14	1.293	1.002	−4.715	0.0468
A-4	55.12	50	1.34	0.040	1.27	B=	1.41	1.28	1.15	1.272	0.995	0.624	0.0399
	EP-102												
B-1	259.00	50	1.31	0.028	1.23	B−	1.35	1.25	1.09	1.225	1.004	−7.589	0.0410
B-2	248.20	50	1.29	0.043	1.20	B=	1.37	1.22	1.05	1.203	1.002	−1.526	0.0517
B-3	157.70	50	1.28	0.028	1.21	B−	1.32	1.22	1.07	1.197	1.007	−7.098	0.0412
B-4	144.60	50	1.19	0.058	1.13	B=	1.27	1.14	1.00	1.126	1.007	−1.225	0.0459
B-5	134.10	50	1.24	0.038	1.17	B−	1.30	1.18	1.01	1.154	1.015	−5.033	0.0491
B-6	108.50	50	1.25	0.042	1.18	B−	1.30	1.19	1.05	1.170	1.005	−3.963	0.0410
B-7	74.70	50	1.20	0.026	1.15	B=	1.26	1.16	1.05	1.148	1.000	−1.575	0.0351
B-8	64.30	50	1.18	0.044	1.11	B=	1.24	1.12	0.98	1.105	1.004	−1.871	0.0460
B-9	47.80	50	1.17	0.040	1.11	B=	1.22	1.11	0.98	1.096	1.010	−2.111	0.0411
	EP-105												
C-1	233.95	50	1.26	0.039	1.17	B−	1.31	1.20	0.99	1.157	1.008	−9.223	0.0536
C-2	221.00	50	1.18	0.038	1.11	B−	1.24	1.13	0.96	1.100	1.008	−8.213	0.0491
C-3	134.50	50	1.21	0.046	1.15	B=	1.28	1.15	1.03	1.147	1.002	0.675	0.0409
C-4	105.73	50	1.12	0.032	1.07	B=	1.17	1.07	0.98	1.067	1.001	0.000	0.0342
C-5	74.32	50	1.11	0.025	1.06	B−	1.15	1.08	0.96	1.057	1.007	−7.994	0.0339
C-6	12.09	50	0.95	0.037	0.90	B=	1.01	0.92	0.82	0.908	0.996	−1.741	0.0401
	EV-151												
D-1	376.31	37	1.40	0.042	1.32	B+	1.45	1.32	1.21	1.318	1.003	2.755	0.0350
D-2	367.20	50	1.46	0.030	1.38	B−	1.52	1.42	1.22	1.376	1.005	−10.893	0.0426
D-3	334.49	50	1.36	0.035	1.28	B=	1.41	1.29	1.16	1.279	1.000	−0.649	0.0382
D-4	300.63	50	1.27	0.039	1.21	B−	1.31	1.21	1.09	1.198	1.013	−3.670	0.0361
D-5	295.05	50	1.23	0.032	1.18	B+	1.28	1.17	1.09	1.177	1.000	5.209	0.0311
D-6	231.47	50	1.38	0.040	1.31	B−	1.43	1.32	1.18	1.304	1.005	−4.531	0.0376
D-7	216.04	50	1.21	0.024	1.15	B−	1.25	1.17	1.04	1.147	1.003	−9.367	0.0356
D-8	166.48	50	1.28	0.042	1.20	B−	1.35	1.23	1.06	1.204	1.000	−5.209	0.0455
D-9	89.19	50	1.27	0.036	1.21	B−	1.34	1.22	1.08	1.204	1.005	−2.543	0.0415
D-10	69.59	50	1.24	0.036	1.17	B−	1.30	1.19	1.04	1.167	1.005	−5.076	0.0429
D-11	42.98	50	1.15	0.028	1.09	B−	1.19	1.10	0.96	1.076	1.010	−6.587	0.0404
D-12	35.36	50	1.18	0.025	1.12	B−	1.22	1.13	1.02	1.117	1.003	−4.950	0.0345
D-13	12.19	50	1.19	0.043	1.12	B=	1.26	1.14	0.99	1.123	0.998	−2.449	0.0461
D-14	6.71	50	1.11	0.043	1.06	B+	1.16	1.06	0.97	1.057	1.004	2.543	0.0354
	EV-150												
E-1	290.02	51	1.43	0.053	1.33	B=	1.51	1.34	1.14	1.320	1.005	−1.787	0.0536
E-2	257.86	44	1.37	0.024	1.30	B−	1.42	1.33	1.17	1.299	0.999	−8.709	0.0366
E-3	221.29	50	1.27	0.030	1.19	B−	1.31	1.21	1.07	1.192	1.001	−5.496	0.0388
E-4	217.87	50	1.26	0.028	1.21	B+	1.31	1.21	1.12	1.208	0.998	2.680	0.0295
E-5	201.48	50	1.31	0.032	1.23	B−	1.36	1.25	1.09	1.225	1.006	−5.397	0.0432
E-6	187.45	50	1.24	0.046	1.17	B=	1.30	1.16	1.03	1.158	1.009	1.225	0.0447
E-7	119.33	50	1.26	0.041	1.18	B=	1.32	1.19	1.04	1.173	1.007	−2.361	0.0458
E-8	77.88	50	1.24	0.033	1.17	B−	1.29	1.18	1.03	1.159	1.012	−4.531	0.0423
	BM81-1												
F-1	511.30	49	1.47	0.021	1.36	B−	1.50	1.41	1.15	1.341	1.017	−16.537	0.0520
F-2	461.90	50	1.36	0.036	1.27	B−	1.42	1.29	1.08	1.252	1.011	−7.365	0.0516
F-3	445.51	50	1.43	0.028	1.35	B−	1.48	1.39	1.17	1.337	1.011	−14.614	0.0459
F-4	428.74	50	1.43	0.030	1.34	B−	1.49	1.37	1.20	1.341	0.998	−6.812	0.0416
F-5	408.02	50	1.45	0.032	1.36	B−	1.50	1.40	1.20	1.361	1.003	−10.893	0.0430
F-6	405.03	50	1.32	0.034	1.23	B−	1.36	1.26	0.99	1.193	1.031	−14.857	0.0612
F-7	310.80	50	1.38	0.040	1.28	B−	1.44	1.29	1.11	1.270	1.009	−2.543	0.0490
F-8	301.17	50	1.24	0.038	1.16	B−	1.29	1.18	1.02	1.156	1.004	−6.587	0.0459
F-9	190.07	50	1.17	0.052	1.10	B=	1.24	1.11	0.97	1.098	1.005	−0.624	0.0462
F-10	181.76	50	1.15	0.035	1.08	B−	1.21	1.10	0.95	1.078	0.999	−4.531	0.0454
F-11	161.51	50	1.20	0.043	1.13	B−	1.25	1.15	1.02	1.133	1.001	−5.734	0.0391
F-12	130.78	50	1.20	0.027	1.15	B=	1.24	1.15	1.07	1.146	1.000	1.945	0.0285
F-13	102.27	50	1.10	0.028	1.05	B−	1.13	1.06	0.95	1.041	1.007	−6.234	0.0343
F-14	75.88	50	1.13	0.030	1.08	B−	1.18	1.09	0.98	1.077	1.000	−4.950	0.0356
F-15	63.18	50	1.12	0.024	1.07	B−	1.16	1.08	0.97	1.073	1.005	−5.209	0.0343
F-16	55.00	50	1.08	0.044	1.03	B+	1.13	1.02	0.93	1.023	1.003	3.304	0.0376
F-17	43.86	50	1.05	0.038	1.00	B=	1.10	1.00	0.90	0.995	1.006	−0.848	0.0376
F-18	20.76	50	1.15	0.023	1.09	B−	1.18	1.10	0.96	1.072	1.012	−8.401	0.0388

TABLE 13
SUMMARY OF REFLECTANCE PARAMETERS — DRILL-CORE SAMPLES — *Continued*

Sample Number	Depth (m)	No. of Readings	R̄max	Standard Deviation	R̄m	RIS Shape	Rmax	Rint	Rmin	Rev	R̄m/Rev	Rst	Ram
	BM81-2												
G-1	529.00	50	1.50	0.043	1.40	B−	1.56	1.44	1.22	1.396	1.007	−9.033	0.0479
G-2	512.06	50	1.47	0.030	1.35	B−	1.51	1.40	1.12	1.328	1.013	−14.126	0.0578
G-3	497.60	50	1.41	0.036	1.30	B−	1.46	1.34	1.11	1.295	1.006	−10.284	0.0525
G-4	475.95	50	1.35	0.042	1.25	B=	1.44	1.27	1.09	1.253	0.995	−0.945	0.0534
G-5	466.80	50	1.35	0.066	1.25	B=	1.46	1.26	1.04	1.241	1.009	−1.575	0.0645
G-6	399.00	50	1.43	0.031	1.34	B−	1.48	1.37	1.18	1.332	1.008	−8.753	0.0436
G-7	380.60	50	1.36	0.051	1.26	B−	1.45	1.29	1.08	1.264	1.000	−4.461	0.0561
G-8	339.40	50	1.36	0.031	1.28	B−	1.40	1.30	1.11	1.263	1.011	−9.049	0.0446
G-9	330.40	50	1.31	0.049	1.21	B−	1.38	1.24	1.02	1.200	1.004	−6.766	0.0585
G-10	320.04	50	1.37	0.054	1.28	B−	1.43	1.29	1.10	1.263	1.012	−4.570	0.0494
G-11	300.00	50	1.34	0.032	1.26	B−	1.41	1.28	1.12	1.259	1.000	−3.418	0.0442
G-12	298.68	30	1.35	0.045	1.27	B−	1.43	1.29	1.12	1.271	0.997	−2.709	0.0460
G-13	267.80	50	1.23	0.025	1.18	B−	1.27	1.19	1.07	1.174	1.005	−6.587	0.0329
G-14	251.46	50	1.38	0.048	1.30	B=	1.47	1.32	1.16	1.307	0.996	−0.542	0.0477
G-15	211.77	50	1.30	0.036	1.21	B−	1.36	1.25	1.05	1.210	0.997	−10.550	0.0499
G-16	198.12	50	1.29	0.029	1.20	B−	1.34	1.22	1.04	1.192	1.005	−7.250	0.0478
G-17	190.11	50	1.38	0.034	1.28	B−	1.43	1.33	1.04	1.255	1.018	−15.710	0.0616
G-18	112.28	50	1.20	0.037	1.13	B−	1.25	1.14	1.00	1.123	1.009	−4.531	0.0436
G-19	99.06	50	1.17	0.032	1.11	B=	1.22	1.12	1.01	1.108	1.005	−1.575	0.0364
G-20	93.60	50	1.14	0.033	1.08	B=	1.19	1.09	0.98	1.082	0.996	0.000	0.0372
G-21	90.97	50	1.18	0.049	1.12	B+	1.25	1.12	1.00	1.117	1.001	2.644	0.0429
G-22	51.20	50	1.18	0.034	1.11	B+	1.24	1.11	1.00	1.107	1.004	2.755	0.0416
	SR-7												
H-1	239.67	50	1.13	0.035	1.07	B=	1.19	1.08	0.97	1.074	0.998	−0.735	0.0402
H-2	218.94	50	1.13	0.037	1.07	B+	1.18	1.08	0.99	1.077	0.995	2.680	0.0330
H-3	201.20	50	1.11	0.034	1.06	B+	1.17	1.06	0.97	1.059	1.000	3.304	0.0363
H-4	174.44	50	1.08	0.028	1.02	B=	1.12	1.02	0.92	1.015	1.000	1.654	0.0378
H-5	158.86	50	1.00	0.036	0.94	B=	1.05	0.95	0.84	0.939	1.002	−0.769	0.0439
H-6	152.89	50	1.10	0.045	1.03	B+	1.18	1.03	0.94	1.040	0.988	8.213	0.0447
H-7	139.78	50	1.03	0.034	0.97	B=	1.08	0.98	0.88	0.975	0.999	1.654	0.0394
H-8	123.75	50	1.06	0.023	0.97	B−	1.10	1.00	0.79	0.953	1.022	−10.550	0.0631
H-9	114.82	50	0.98	0.024	0.92	B−	1.02	0.93	0.82	0.917	1.001	−2.543	0.0408
H-10	47.18	50	1.02	0.041	0.96	B=	1.07	0.97	0.85	0.956	1.005	−2.204	0.0451
H-11	41.88	30	1.02	0.037	0.95	B−	1.07	0.97	0.83	0.952	1.001	−5.496	0.0485
H-12	32.64	50	1.00	0.044	0.94	B+	1.06	0.95	0.86	0.950	0.994	4.028	0.0415
H-13	27.28	50	1.02	0.027	0.97	B−	1.07	0.98	0.87	0.965	1.003	−3.304	0.0398
	SR-12												
I-1	181.82	50	1.41	0.035	1.31	B−	1.45	1.34	1.15	1.306	1.003	−7.672	0.0444
I-2	168.10	50	1.45	0.034	1.34	B−	1.50	1.39	1.14	1.335	1.002	−12.654	0.0529
I-3	157.64	50	1.36	0.044	1.28	B=	1.43	1.29	1.13	1.277	0.999	−2.204	0.0450
I-4	146.40	50	1.38	0.042	1.28	B−	1.44	1.30	1.09	1.268	1.009	−6.587	0.0531
I-5	131.37	50	1.33	0.048	1.26	B+	1.40	1.26	1.15	1.261	0.997	3.372	0.0372
I-6	114.18	50	1.43	0.041	1.31	B−	1.51	1.33	1.11	1.306	1.000	−3.304	0.0586
I-7	97.99	50	1.42	0.038	1.31	B−	1.48	1.35	1.09	1.313	1.013	−10.893	0.0585
I-8	91.72	50	1.37	0.035	1.24	B=	1.41	1.25	1.09	1.241	1.001	−0.509	0.0501
I-9	83.21	50	1.33	0.041	1.24	B−	1.37	1.25	1.11	1.234	1.009	−2.543	0.0404
I-10	66.72	50	1.35	0.032	1.26	B−	1.40	1.29	1.08	1.248	1.006	−10.893	0.0492
I-11	59.07	50	1.33	0.023	1.25	B−	1.37	1.28	1.09	1.239	1.009	−10.513	0.0440
I-12	46.63	50	1.27	0.036	1.19	B=	1.33	1.19	1.04	1.181	1.006	−1.141	0.0470
I-13	33.83	50	1.31	0.044	1.21	B=	1.38	1.22	1.05	1.206	1.003	−2.004	0.0524
I-14	15.73	50	1.24	0.031	1.15	B=	1.29	1.15	1.02	1.154	1.010	1.225	0.0453
	SR-2												
J-1	153.77	50	1.43	0.064	1.32	B=	1.53	1.32	1.13	1.317	1.004	1.654	0.0580
J-2	123.32	50	1.41	0.055	1.32	B=	1.48	1.32	1.16	1.314	1.002	0.000	0.0467
J-3	101.80	50	1.41	0.056	1.30	B=	1.51	1.32	1.11	1.303	0.995	−1.654	0.0586
J-4	75.10	50	1.52	0.051	1.40	B−	1.59	1.41	1.19	1.387	1.007	−3.304	0.0552
J-5	63.25	50	1.48	0.048	1.35	B−	1.55	1.38	1.15	1.350	0.998	−4.950	0.0568
J-6	60.35	50	1.41	0.058	1.30	B=	1.50	1.30	1.07	1.278	1.014	−2.307	0.0642
J-7	58.22	50	1.46	0.058	1.34	B=	1.57	1.36	1.17	1.357	0.988	1.654	0.0564
J-8	15.18	50	1.46	0.047	1.35	B−	1.55	1.38	1.11	1.334	1.010	−7.475	0.0634
J-9	6.55	50	1.49	0.048	1.40	B−	1.56	1.41	1.24	1.394	1.004	−3.098	0.0441

TABLE 13
SUMMARY OF REFLECTANCE PARAMETERS — DRILL-CORE SAMPLES — *Continued*

Sample Number	Depth (m)	No. of Readings	$\overline{R}$max	Standard Deviation	$\overline{R}$m	RIS Shape	Rmax	Rint	Rmin	Rev	$\overline{R}$m/Rev	Rst	Ram
	BRE-3												
K-1	402.71	50	1.23	0.027	1.15	B−	1.27	1.17	0.97	1.128	0.000	−9.826	0.0516
K-2	354.35	50	1.50	0.061	1.40	B−	1.59	1.41	1.19	1.387	0.000	−3.304	0.0552
K-3	343.80	50	1.36	0.042	1.29	B−	1.41	1.30	1.15	1.277	0.000	−5.076	0.0392
K-4	316.76	50	1.36	0.038	1.30	B=	1.42	1.31	1.19	1.302	0.000	0.000	0.0339
K-5	305.65	50	1.40	0.042	1.32	B+	1.46	1.31	1.20	1.317	0.000	4.361	0.0387
K-6	285.95	50	1.36	0.023	1.30	B=	1.40	1.31	1.20	1.299	0.000	−1.654	0.0296
K-7	276.80	50	1.33	0.028	1.27	B−	1.37	1.27	1.14	1.253	0.000	−3.514	0.0361
K-8	264.95	50	1.26	0.032	1.20	B−	1.31	1.21	1.06	1.189	0.000	−6.587	0.0406
K-9	255.20	50	1.31	0.043	1.25	B−	1.37	1.26	1.12	1.242	0.000	−5.278	0.0388
K-10	248.00	50	1.34	0.037	1.27	B−	1.39	1.29	1.13	1.262	0.000	−7.098	0.0390
K-11	242.30	50	1.30	0.031	1.24	B=	1.34	1.24	1.13	1.230	0.000	−0.769	0.0336
K-12	236.16	50	1.30	0.017	1.24	B−	1.33	1.25	1.14	1.234	0.000	−6.930	0.0298
K-13	225.40	50	1.28	0.021	1.23	B=	1.32	1.24	1.16	1.234	0.000	−1.002	0.0256
K-14	209.45	50	1.23	0.027	1.18	B−	1.29	1.20	1.07	1.180	0.000	−5.132	0.0367
K-15	187.85	50	1.18	0.027	1.13	B−	1.23	1.13	1.01	1.118	0.000	−3.670	0.0387
K-16	176.70	50	1.27	0.028	1.19	B−	1.31	1.21	1.06	1.187	0.000	−5.278	0.0405
K-17	164.60	50	1.32	0.030	1.25	B−	1.37	1.26	1.13	1.246	0.000	−4.128	0.0370
K-18	156.07	50	1.26	0.046	1.21	B+	1.31	1.21	1.13	1.211	0.000	4.461	0.0294
K-19	125.73	50	1.24	0.031	1.19	B−	1.29	1.19	1.07	1.180	0.000	−3.004	0.0358
K-20	117.80	50	1.19	0.029	1.11	B−	1.24	1.13	0.99	1.114	0.000	−2.640	0.0431
K-21	113.00	50	1.21	0.044	1.15	B=	1.27	1.15	1.04	1.150	0.000	1.438	0.0384
K-22	71.60	50	1.22	0.025	1.17	B−	1.27	1.18	1.07	1.165	0.000	−3.304	0.0330
K-23	58.00	50	1.37	0.035	1.24	B=	1.42	1.25	1.09	1.243	0.000	1.526	0.0501
K-24	52.00	50	1.22	0.036	1.16	B+	1.27	1.16	1.07	1.159	0.000	3.304	0.0332
K-25	38.40	50	1.20	0.034	1.13	B−	1.24	1.15	1.01	1.128	0.000	−8.033	0.0386
K-26	19.30	50	1.14	0.032	1.10	B=	1.19	1.11	1.02	1.101	0.000	−0.945	0.0305

on Mount Michael, Mount Banner and Ewin Creek contains mainly high-volatile rank.

The slopes of reflectance *versus* stratigraphic position graphs for measured sections containing a reasonable amount of section (Figure 30) range from 0.053 to 0.119 per cent per 100 metres, with an unweighted average gradient of 0.073 per cent per 100 metres (Table 14). One section, No. 11 (Mount Michael upper sheet), displays no systematic relationship between reflectance and stratigraphic position. The values of the down-hole reflectance gradients (Figures 31 to 41) range from 0.031 to 0.178 per cent per 100 metres with an unweighted average of 0.079 per cent per 100 metres (Table 15). In one drill hole, SR-2, there is no systematic relationship betweem reflectance and depth.

Individual examples of Mist Mountain Formation surface and subsurface coal-rank distributions and gradients at specific locations within the study area are discussed separately below, beginning at the south end. The areas of the coalfield discussed under each heading are indicated on Figure 5.

Crown Mountain

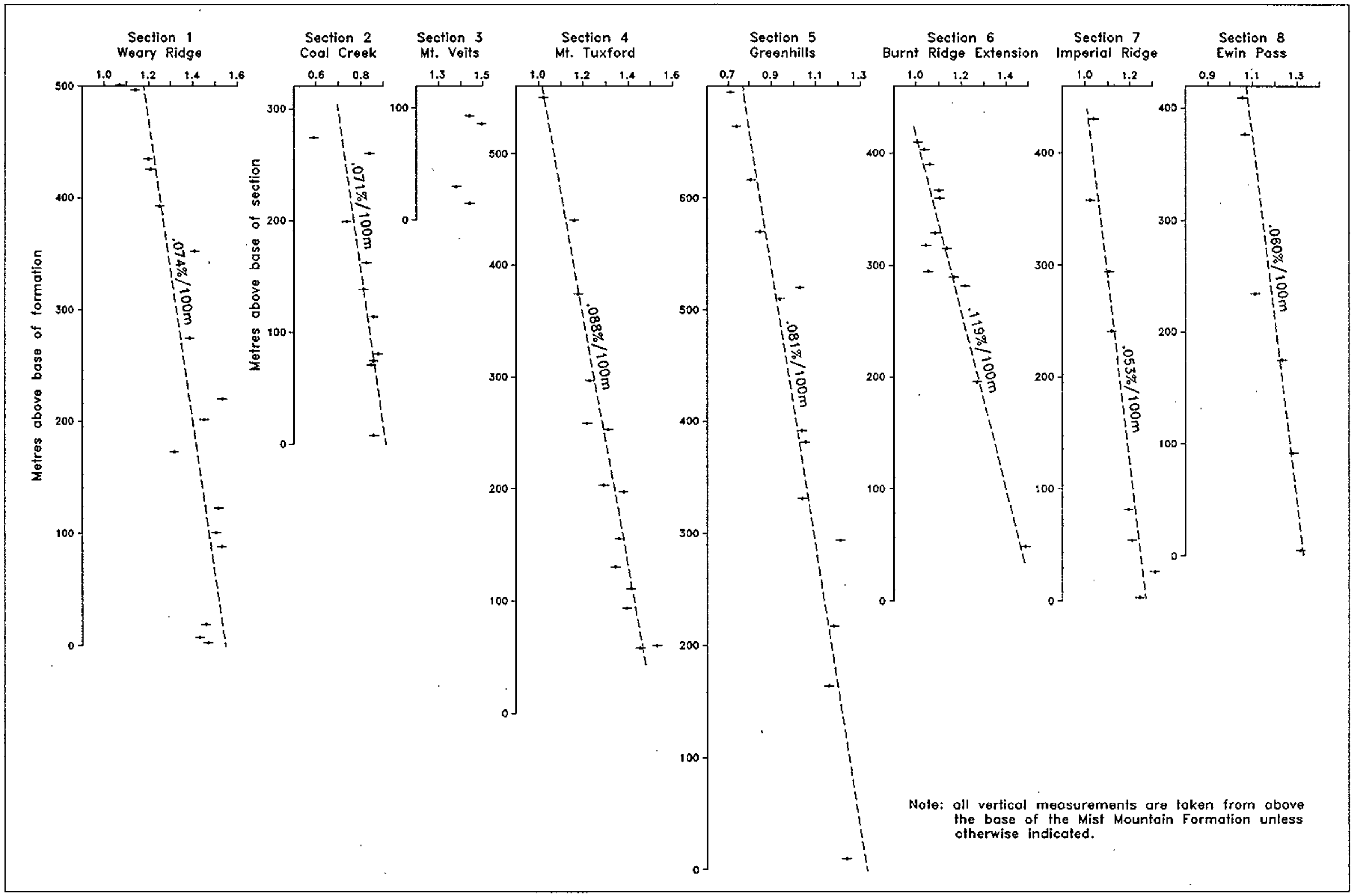
Vitrinite reflectance values at Crown Mountain are among the highest in the study area. Low-volatile bituminous rank characterizes the basal coal zone in the footwall of the Crown Mountain thrust, while the hangingwall of the thrust, and the remainder of the formation in the footwall, contains medium-volatile coals (Figure 5). Highest reflectance values obtained are in excess of 1.6 per cent, in the basal coal zone of the thrust footwall (Figures 7 and 30; *see also* Grieve and Fraser, 1985, Sheets 1 to 3). Overlying strata in the footwall, although limited in total thickness (Figure 7), have reflectance values ranging from 1.47 to 1.25 per cent. Reflectance values in the hangingwall strata, again limited in thickness, range from 1.47 per cent (basal coal zone) to 1.33 per cent.

Tee Pee Mountain

Reflectance values of coals on Tee Pee Mountain suggest medium-volatile rank for the limited amount of the stratigraphic section preserved. Values range from 1.35 to 1.18 per cent (Figures 5, 7 and 30; Grieve and Fraser, 1985, Sheet 4), although the poor quality of outcrop at this location makes some of the readings suspect. An interesting observation is that a thin coal seam in the Moose Mountain Member of the Morrissey Formation has a reflectance of 0.90 per cent, that is, it is of high-volatile rank. Its low reflectance is consistent with the observations of Pearson and Murchison (1990) concerning the influence of roof-rock lithology on coal rank. They observed that the rank of a seam with a sandstone roof is lower than the rank of the same seam in locations where the roof is a finer grained rock. No one specific factor was identified to account for this phenomenon.

Horseshoe Ridge – Line Creek Ridge

Reflectance values of coals from Horseshoe Ridge and the northern portion of Line Creek Ridge (Line Creek Extension) suggest that the ranks here vary from medium volatile at the base of the formation to high volatile in the upper part (Figure 5). Highest individual reflectance values are obtained in the basal coal zone, and are between 1.3 and


Section 1
Weary Ridge
Section 2
Coal Creek
Section 3
Mt. Veits
Section 4
Mt. Tuxford
Section 5
Greenhills
Section 6
Burnt Ridge Extension
Section 7
Imperial Ridge
Section 8
Ewin Pass
Metres above base of formation
Metres above base of section
.074%/100m
.071%/100m
.088%/100m
.081%/100m
.119%/100m
.053%/100m
.060%/100m
Note: all vertical measurements are taken from above the base of the Mist Mountain Formation unless otherwise indicated.

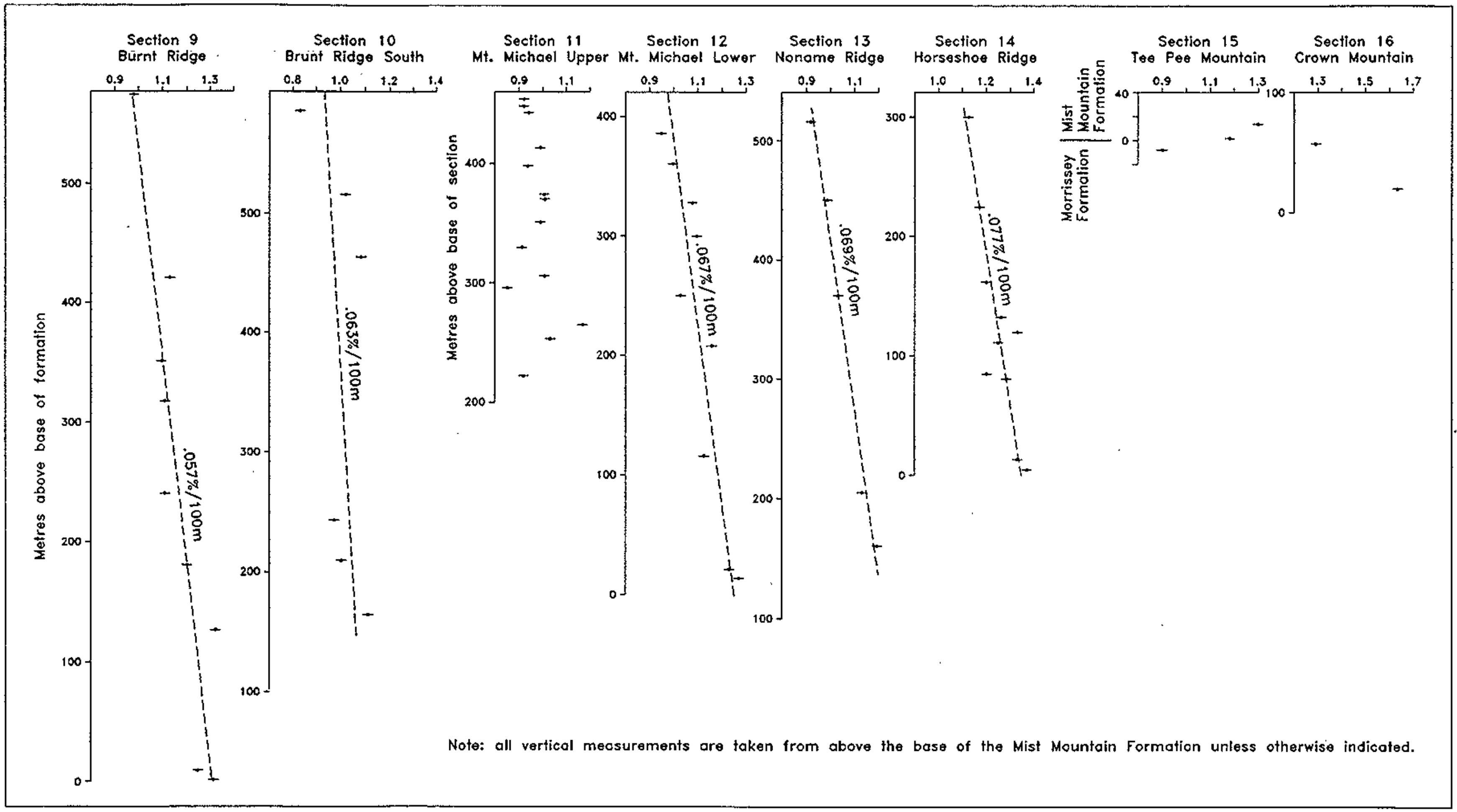


Figure 30. Variations in $\bar{R}_{max}$ with position in measured stratigraphic sections. Error bars represent ± 0.02 per cent reflectance. Line of best fit is shown where applicable.

TABLE 14
GRADIENTS AND VALUES OF REGRESSION COEFFICIENTS FOR LINES OF BEST FIT THROUGH MAXIMUM VITRINITE REFLECTANCE DATA — OUTCROP SAMPLES

Section Number	Location	Reflectance Gradient (decrease in $\bar{R}max$/100m upsection)	r^2
1	Weary Ridge	0.074%	0.7230
2	Coal Creek	0.071	0.4937
3	Mt. Veits	Minimal section — apparent up-section increase	
4	Mt. Tuxford	0.088	0.9230
5	Greenhills	0.081	0.8765
6	Burnt Ridge Extension	0.119	0.8671
7	Imperial Ridge	0.053	0.8686
8	Ewin Pass	0.060	0.8647
9	Burnt Ridge	0.057	0.7840
10	Burnt Ridge South	0.063	0.6404
11	Mt. Michael Upper Sheet	No systematic variation	
12	Mt. Michael Lower Sheet	0.067	0.8367
13	Noname Ridge	0.069	0.9854
14	Horseshoe Ridge	0.077	0.6822
15	TeePee Mountain	Minimal section — two readings only	
16	Crown Mountain	Minimal section — two readings only	

1.4 per cent (Figures 5 and 7; Grieve and Fraser, 1985, Sheet 5). Lowest values are near and below 1.0 per cent, and represent strata in the upper (but not uppermost) Mist Mountain Formation. The average reflectance gradient through the Horseshoe Ridge measured section is 0.077 per cent per 100 metres (Figure 30).

Hacquebard and Donaldson (1974) gave a reflectance range of 1.49 to 0.97 per cent for Line Creek Ridge, and a calculated reflectance gradient of 0.164 per cent per 100 metres. This gradient is much higher than the one calculated here, but the reason for this contrast is not known.

Mount Michael

The two sequences of Mist Mountain Formation exposed on Mount Michael, corresponding with the footwall and hangingwall of the Ewin Pass fault, have contrasting rank distributions. Rank values in the footwall sheet range from medium volatile to high volatile (Figure 5). Reflectance values range from approximately 1.35 per cent in the lower part of the formation, down to values of approximately 1.0 per cent in the uppermost part (Figures 5 and 7; Grieve and Fraser, 1985, Sheets 5 and 6). The average reflectance gradient through the Mount Michael lower sheet measured section is 0.067 per cent per 100 metres (Figure 30).

Rank values in the hangingwall of the Ewin Pass fault are mainly high volatile, with the exception of a relatively thin zone of medium-volatile coal near the base of the sequence (Figure 5). Even this medium-volatile coal, however, is of lower rank than corresponding strata on Line Creek Ridge to the south (B. Ryan, personal communication, 1988; Grieve and Fraser, 1985, Sheet 5). Reflectance values for the coals in the Mount Michael upper sheet measured section range from 1.17 to 0.92 per cent (Figure 7). Data of reflectance *versus* stratigraphic position (Figure 30) are extremely scattered, and there is no systematic relationship between reflectance and stratigraphic position.

Burnt Ridge – Burnt Ridge South – Noname Ridge

Rank values on Burnt Ridge and areas to the south referred to as Burnt Ridge South and Noname Ridge, range from medium volatile in the lower part of the formation to high volatile in the upper part (Figure 5). Reflectance values range from slightly over 1.3 per cent down to slightly less than 1.0 per cent (Figures 5 and 7; Grieve and Fraser, 1985, Sheets 5 and 6). Reflectance gradients for measured sections are: Burnt Ridge, 0.057 per cent per 100 metres; Burnt Ridge South, 0.063 per cent per 100 metres; and, Noname Ridge, 0.069 per cent per 100 metres (Figure 30).

Ewin Pass

Rank distribution on Ewin Pass is similar to that on the lower sheet of the Mount Michael property, that is, the lower part of the formation is characterized by medium-volatile coals, while the upper part contains high-volatile coals (Figure 5). Reflectance values on the basal coal zone range from 1.26 to 1.42 per cent, with a general increase from south to north over the property. This trend continues northward into the Mount Banner property, where the basal coals are low volatile (Grieve and Fraser, 1985, Sheet 6). Uppermost seams in the formation have reflectances near or below 1.0 per cent (Figures 7 and 8). Reflectance gradient for the Ewin Pass measured section is 0.060 per cent per 100 metres. Down-hole reflectance gradients for the two sampled cores are 0.060 per cent per 100 metres in hole EP-102 (Figure 32), and 0.112 per cent per 100 metres in EP-105 (Figure 33).

Mount Banner

The northward rank increase observed in Ewin Pass continues into Mount Banner, where the basal and lower coals of the formation are low-volatile bituminous, and even the highest stratigraphic seams are medium volatile (Figure 5).

TABLE 15
GRADIENTS AND VALUES OF REGRESSION COEFFICIENTS FOR LINES OF BEST FIT THROUGH MAXIMUM VITRINITE REFLECTANCE DATA — DRILL-CORE SAMPLES

Drillhole I.D.	Drillhole Number	Location	Reflectance Gradient (increase in $\bar{R}max$/100m depth)	r^2
A	MBE-101	Mt. Banner	0.031%	0.5175
B	EP-102	Ewin Pass	0.060	0.7665
C	EP-105	Ewin Pass	0.112	0.7855
D	EV-151	Ewin Creek	0.060	0.6593
E	EV-150 (below thrust)	Ewin Creek	0.178	0.8451
F	BM81-1	Bare Mountain	0.079	0.8876
G	BM81-2 (above thrust)	Bare Mountain	0.069	0.7187
H	SR-7	Weary Ridge	0.055	0.5932
I	SR-12	Weary Ridge	0.088	0.5846
J	SR-2	Weary Ridge	No systematic variation	
K	BRE-3	Burnt Ridge Extension	0.061	0.5410

Reflectance in the basal coal zone reaches a maximum of 1.58 per cent, while at the same location a coal seam immediately below the Elk contact has a reflectance of 1.30 per cent (Grieve and Fraser, 1985, Sheet 7). The down-hole reflectance increase for drill core MBE-101 is 0.031 per cent per 100 metres (Figure 31), although this is based on only four readings.

The upper sheet of the Ewin Pass thrust is also exposed in the Mount Banner area. As was the case on Mount Michael, this sheet is characterized by lower rank coals, chiefly high-volatile (Figure 5), although only a portion of the upper part of the formation is preserved (Grieve and Fraser, 1985).

Strata of the upper part of the formation exposed in the core of the anticline in the western part of the Mount Banner area also appear to be of lower rank than corresponding strata in the main part of the Mount Banner property (Figure 5).

EWIN CREEK – IMPERIAL RIDGE – TODHUNTER CREEK

Ranks of coals in the vicinity of Ewin Creek and Imperial Ridge are medium volatile in the lower part of the formation and high volatile in the upper part (Figure 5). Reflectances in the basal coal zone range from 1.30 per cent on Imperial Ridge, to in excess of 1.4 per cent in drill cores EV-150 and EV-151 (Figures 5, 7 and 8). The uppermost seams in the formation have reflectances of approximately 1.0 per cent (Grieve and Fraser, 1985, Sheet 8). Reflectance gradient for the Imperial Ridge measured section is 0.053 per cent per 100 metres (Figure 30). The down-hole gradient for drill core EV-151 is 0.060 per cent per 100 metres (Figure 34), and the gradient for the portion of drill core EV-150 below the thrust fault is 0.178 per cent per 100 metres (Figure 35).

Coals in the hangingwall of the Ewin Pass fault at Ewin Creek are all of high-volatile rank (Figure 5).

Burnt Ridge Extension

The lower part of the formation on Burnt Ridge Extension is characterized by medium-volatile coals, while the upper part contains high-volatile coals (Figure 5). Reflectances in coals in the measured section range from 1.47 per cent to 1.01 per cent, with the former representing a seam roughly 50 metres above the base of the formation, and the latter a seam in the upper, but not the uppermost, part (Figure 7). Reflectance gradient for the section is 0.119 per cent per 100 metres (Figure 30). Reflectances in the basal coal zone at surface range from 1.36 to 1.45 per cent (Grieve and Fraser, 1985, Sheets 7 and 8). In drill core BRE-3 reflectances range from 1.50 (basal coal zone) to 1.14 per cent (Figure 8). The down-hole reflectance gradient is 0.061 per cent per 100 metres, omitting sample K-1 which is from the Morrissey Formation (Figure 41). As was the case of the surface sample from the Morrissey Formation at Tee Pee Mountain, this sample has an anomalously low reflectance (1.23 per cent) for its stratigraphic position, consistent with the observations of Pearson and Murchison (1990) concerning the influence of a sandstone roof on coal rank.

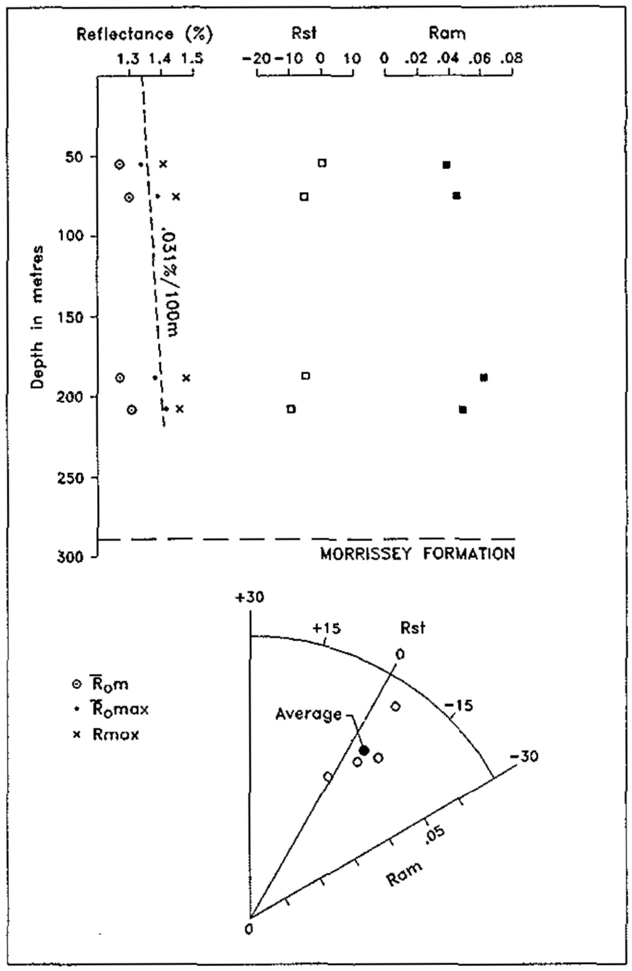


Figure 31. Variations in reflectance parameters in drill hole A (MBE-101). Line of best fit through $\bar{R}_{max}$ data is shown.

Greenhills

Rank values in the south and west part of the Greenhills Range are somewhat lower than in the adjacent part of the coalfield. The lower part of the formation is medium volatile, while the rest is high volatile (Figures 5 and 7). Reflectance values in the basal coal zone range from 1.20 to 1.27 per cent, while the uppermost part contains coals with reflectances less than 0.8 per cent. The average reflectance gradient for the Greenhills measured secton is 0.081 per cent per 100 metres (Figure 30).

Coals in the Bingay Creek syncline are of similar rank to those in the west part of the Greenhills Range (Figure 5).

As mentioned earlier, these values for Greenhills reflectances are somewhat higher than those published previously (Pearson and Grieve, 1980; Grieve and Pearson, 1983), but are believed to be more accurate.

Bare Mountain – Castle Mountain

Coal ranks in the lower part of the formation on Bare and Castle mountains are medium volatile, while those in the upper part are high volatile (Figure 5). Reflectances in the basal coal zone range from 1.34 to 1.39 per cent in outcrop

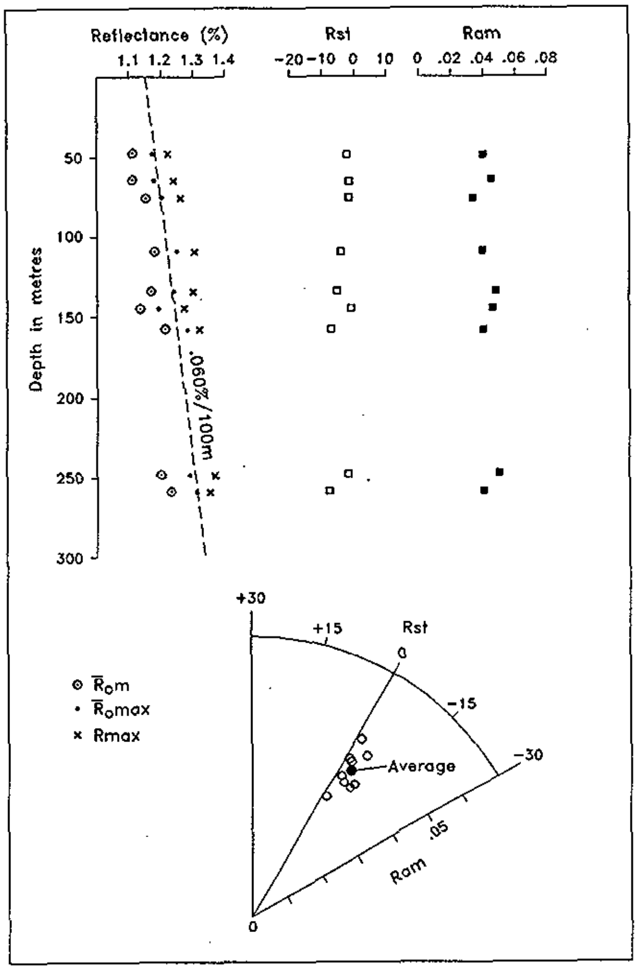


Figure 32. Variations in reflectance parameters in drill hole B (EP-102). Line of best fit through $\bar{R}_{max}$ data is shown.

(Figure 5; Grieve and Fraser, 1985, Sheets 8, 9 and 10), and up to 1.50 per cent in drill core BM-81-2. Reflectances in the uppermost part of the formation are less than 1.0 per cent. A thrust fault in drill hole BM-81-2 duplicates part of the lowermost part of the formation. There does not appear to be any significant difference between reflectance values of corresponding stratigraphic positions in the two fault slices. Down-hole reflectance gradient for core BM-81-1 is 0.079 per cent per 100 metres (Figure 36), and for the portion of BM-81-2 above the thrust fault it is 0.08 per cent/100 metres (Figure 37).

Hacquebard and Donaldson (1974) gave a reflectance range of 1.43 to 1.13 per cent for a partial Mist Mountain section on Eagle Mountain to the north of Castle Mountain. Their calculated gradient was 0.092 per cent per 100 metres.

Henretta Ridge – Mount Tuxford

Coal ranks on Henretta Ridge and Mount Tuxford are medium to low volatile in the lower part of the formation and high volatile in the upper part (Figures 5 and 7). Maximum reflectance values associated with basal and lower portions of the formation are in excess of 1.5 per cent, while lowest values are near 1.0 per cent (Morris and Grieve, 1990, Sheets 1 and 2). The reflectance gradient of the Tuxford measured section is 0.088 per cent per 100 metres (Figure 30).

Mount Veits

Coal ranks on Mount Veits are transitional between those on Mount Tuxford and the anomalously high values on Weary Ridge to the north. Low-volatile ranks are associated with the lowest part of the formation, and high-volatile ranks with the uppermost part (Figure 5). Reflectance values of 1.56 and 1.59 per cent were obtained on lower section coals north of the measured section (Morris and Grieve, 1990, Sheet 3). Values for samples from within the measured section, which contains only the lower part of the Mist Mountain Formation, range from 1.38 to 1.49 per cent.

Weary Ridge – Weary Creek

Coal ranks in the vicinity of Weary Ridge and Weary Creek are the highest in the coalfield, with the exception of parts of Crown Mountain. The lower part of the formation contains low-volatile coals, while most of the remainder is

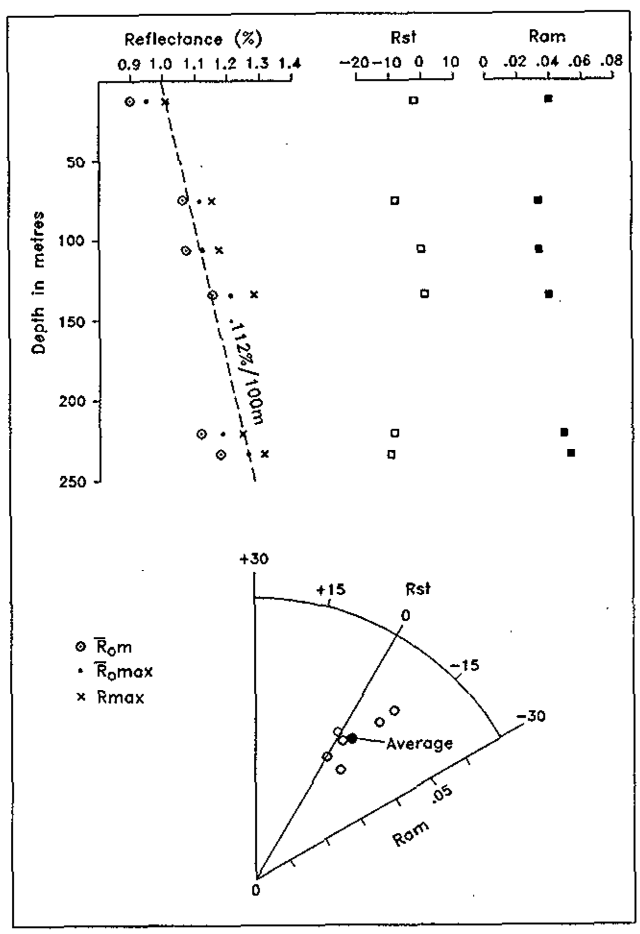


Figure 33. Variations in reflectance parameters in drill hole C (EP-105). Line of best fit through $\bar{R}_{max}$ data is shown.

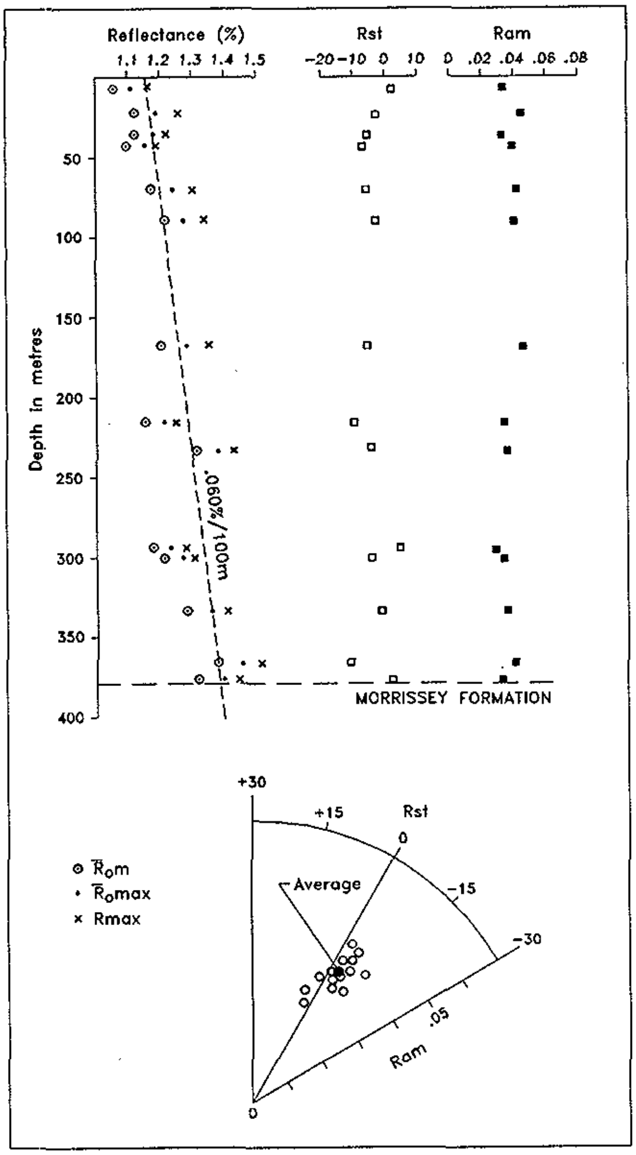


Figure 34. Variations in reflectance parameters in drill hole D (EV-151). Line of best fit through $\bar{R}_{max}$ data is shown.

medium volatile, with some high volatile corresponding with the uppermost seams (Figures 5, 7 and 8). Reflectance values as high as 1.53 per cent were obtained from the basal coal zone, but at most locations the highest reflectances are from the lower part of the formation but above the basal coal zone (*i.e.* the gradient steepens in the lowermost part of the section). Highest reflectance values are in excess of 1.6 per cent (Morris and Grieve, 1990, Sheet 4). The lowest values are in the vicinity of 1.0 per cent. The measured section reflectance gradient is 0.074 per cent per 100 metres (Figure 30).

Cameron and Kalkreuth (1982) gave a reflectance range of 1.56 to 1.04 per cent for Weary Ridge, and Cameron (1984) calculated a gradient of 0.123 per cent per 100 metres. This gradient is higher than the one determined in this study. This discrepancy is partly accounted for by differences in section thicknesses; Cameron's section, which was a generalized one, provided to him by the exploration company, was roughly 100 metres thinner than the one measured and used in this study. Some differences in reflectance values determined for some of the seams may also have contributed to this contrast.

Cameron (1984) also noted that the gradient steepens near the base of the section. He suggested a possible explanation for this is a higher percentage of sandstone in the lower part of the Mist Mountain Formation, but the Weary Ridge section, as noted in Chapter 2, contains very little sandstone, and less than some other sections in which there is no such steepening of gradient.

Down-hole reflectance gradients for Weary Ridge are: SR-7, 0.055 per cent per 100 metres (Figure 38); SR-12, 0.088 per cent per 100 metres (Figure 39); and SR-2, no systematic relationship between depth and reflectance (Figure 40).

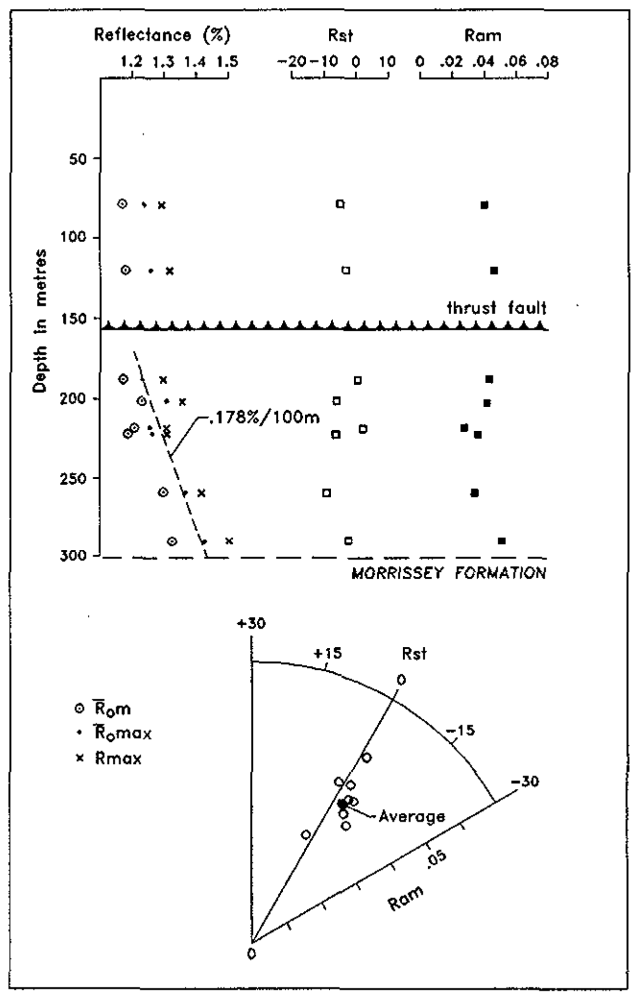


Figure 35. Variations in reflectance parameters in drill hole E (EV-150). Line of best fit through $\bar{R}_{max}$ data is shown.

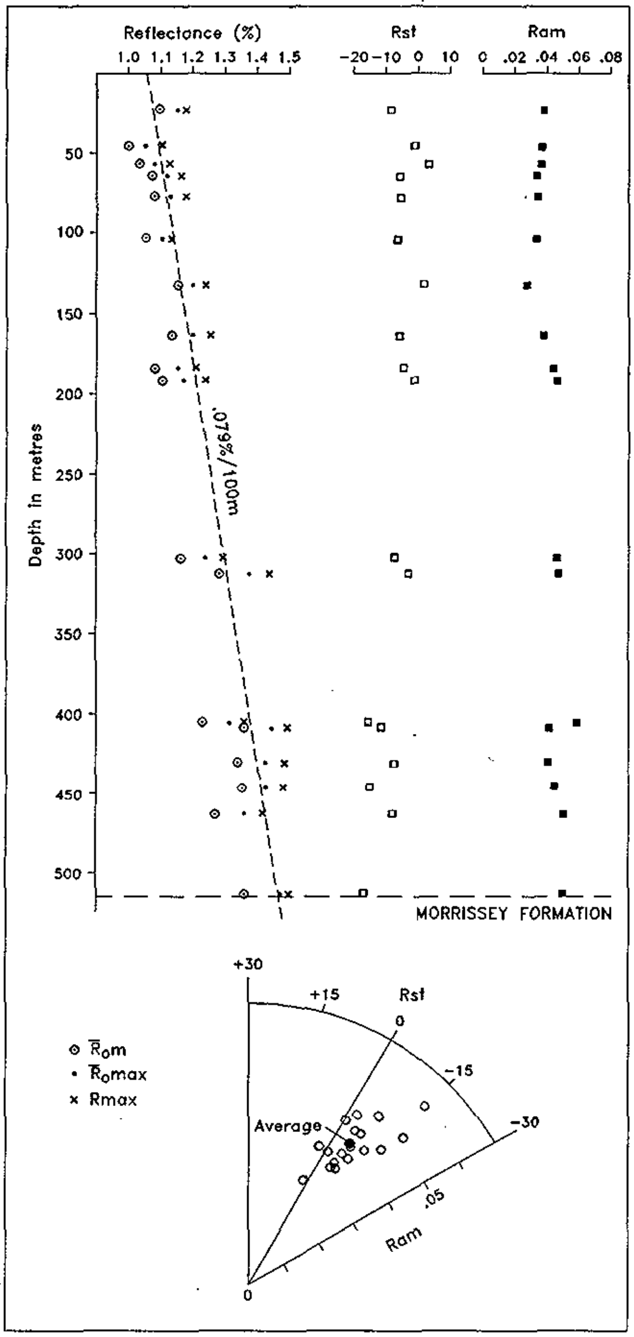


Figure 36. Variations in reflectance parameters in drill hole F (BM81-1). Line of best fit through $\bar{R}_{max}$ data is shown.

Coal Creek – Bleasdell Creek

In marked contrast with the high-rank coals near Weary Creek are the anomalously low-rank coals on the west limb of the syncline, immediately to the west, in the vicinity of Bleasdell Creek. At this location all coals in the section are high volatile in rank, with a reflectance gradient of 0.071 per cent per 100 metres (Figures 5, 7 and 30), although the data scatter is considerable ($r^2<0.5$) [Hacquebard and Cameron (1989) report little or no measureable gradient at this location]. The highest reflectance value obtained in this area is 1.00 per cent, but most seams have associated values of less than 0.90 per cent (Morris and Grieve, 1990, Sheet 4). The lowest values are less than 0.7 per cent (high-volatile B bituminous) which makes these the lowest rank Mist Mountain coals in southeastern British Columbia.

Cadorna Creek to Elk Pass

The northern part of the coalfield is characterized by sparse outcrop. Consequently very few coal samples were obtained from this area, and some of these were of poor quality. Based on these limited data, it is believed that much of the northernmost part of the coalfield contains coals of relatively low rank (Figure 5). The west limb of the Alexander Creek syncline is assumed to contain high-volatile coals. This is based on the occurrence of five readings below 0.8 per cent for coals in the upper part of the formation roughly 5 kilometres north of Cadorna Creek (Morris and Grieve, 1990, Sheet 6).

The east limb contains medium-volatile coals in the lower part of the formation, and high-volatile coals in the remainder (Figure 5). Compared with most other parts of the coalfield, however, the rank at any given position is probably relatively low, and the transition from medium to high volatile is at a relatively lower stratigraphic position. This assumption is based on reflectance values ranging from 1.06 to 0.69 per cent in the Tobermory Ridge - Elk Pass area (Morris and Grieve, 1990, Sheets 7 and 8). The highest of these values, 1.06 per cent, represents a position in the lower, but not basal, part of the formation, while the lowest values are from the upper part. Direct evidence for the existence of medium-volatile coals in the lowermost part of the section is provided by Graham *et al.* (1977), who report that reflectance values as high as 1.16 per cent were determined for basal zone coals in drill cores in the Elk Pass area. Down-hole reflectance gradients in these cores average 0.079 per cent per 100 metres.

Down-dip Rank Gradients

Pearson and Grieve (1985) observed down-dip increases in reflectance on individual coal seams at several locations in the Crowsnest coalfield. The rate of increase, or reflectance gradient, ranges from 0.02 per cent per 100 metres at the north end of the coalfield, to 0.065 per cent per 100 metres at the south end. The locations where these increases were observed were on the sides of large creek valleys, which cut perpendicular to strike. This configuration allowed outcropping coal to be sampled through large vertical intervals (exceeding 600 metres in some cases).

Unfortunately there are no similar locations in the Elk Valley coalfield. The Line Creek mine, however, offers an opportunity to sample one seam, the 8-seam, through a vertical interval of over 350 metres, and four other seams, 10A, 10B, 9 and 7, through smaller intervals. Results are illustrated by Figure 42, and are inconclusive. Seams 10B, 9 and 7 exhibit no change other than that allowed for under assumed experimental error (0.02 per cent). The 10A-seam shows a reflectance increase of 0.08 per cent over a vertical interval of 211 metres, but this is not believed to represent a *down-dip rank increase* because the samples were collected in close proximity to the 10B, 9 and 7-seam samples. This increase probably represents errors or variation not accounted for in the assumed experimental error.

Seam 8 also exhibits no significant reflectance change over 200 metres, but over the entire sampling interval, 356 metres, its reflectance increases from 1.31 to 1.39 per cent. This represents an average reflectance gradient of approximately 0.02 per cent per 100 metres, equivalent to the gradient at the north end of the Crowsnest coalfield. Whether this increase is real, or is merely due to data variation, is not clear. Therefore, given the amount of reflectance data scatter observed in down-hole rank profiles in this study (*e.g.* Figures 31 to 41) this is not believed to represent conclusive proof of down-dip rank increase. A larger difference in sampling elevations would be desirable, but is not available at this location.

Other data were made available by Fording Coal. These allow comparison of reflectance of samples taken from drill core within one structural block on Eagle Mountain at different elevations on four separate coal seams. Graphs were constructed showing reflectance *versus* elevation for each seam, of which one example is reproduced here (Figure 43). Reflectance values range from 1.27 to 1.44 per cent, but despite an elevation range of over 650 metres, there is no obvious systematic variation of reflectance with elevation, and thus no discernable down-dip rank gradient. This again reflects a high degree of data scatter or variation. In one case, two samples of the same seam from the same elevation, and separated by only 150 metres along strike, have reflectance values which differ by 0.11 per cent.

Further attempts to identify down-dip reflectance changes were made, using data obtained from individual seams sampled in outcrop and nearby drill core in the course of this study. Only surface samples directly up-dip from the drill-core sample were used, in order to avoid the effects of rank changes along strike. For example, a sample from the basal coal zone in drill-hole BRE-81-3, on Burnt Ridge Extension, has a reflectance of 1.44 per cent, compared with two outcrop samples from the same part of the property with reflectances of 1.36 per cent (Figure 31). Based on an elevation difference of 450 metres, this represents an apparent down-dip reflectance gradient of just under 0.02 per cent per 100 metres, or roughly equivalent to the gradient observed in the northern part of the Crowsnest coalfield. The question of how much faith to put in a calculation like this is a difficult one to answer. To begin with, surface and subsurface samples may not be directly comparable, because of the relatively greater amount of weathering in the surface samples. Furthermore, the degree of data scatter observed in most of the drill cores (Figures 31 to 41), and the Eagle Mountain example (Figure 43), makes it very difficult to assign exact reflectance values with any degree of confidence.

Other similar attempts at documenting down-dip rank changes were frustrated by the possible influence of gradients along strike. For example, the basal coal on Imperial Ridge has a reflectance of 1.30 per cent (Figure 5), while in drill cores EV-150 and EV-151 it has an average value of 1.43 per cent (average of three values; *see* Figure 8).

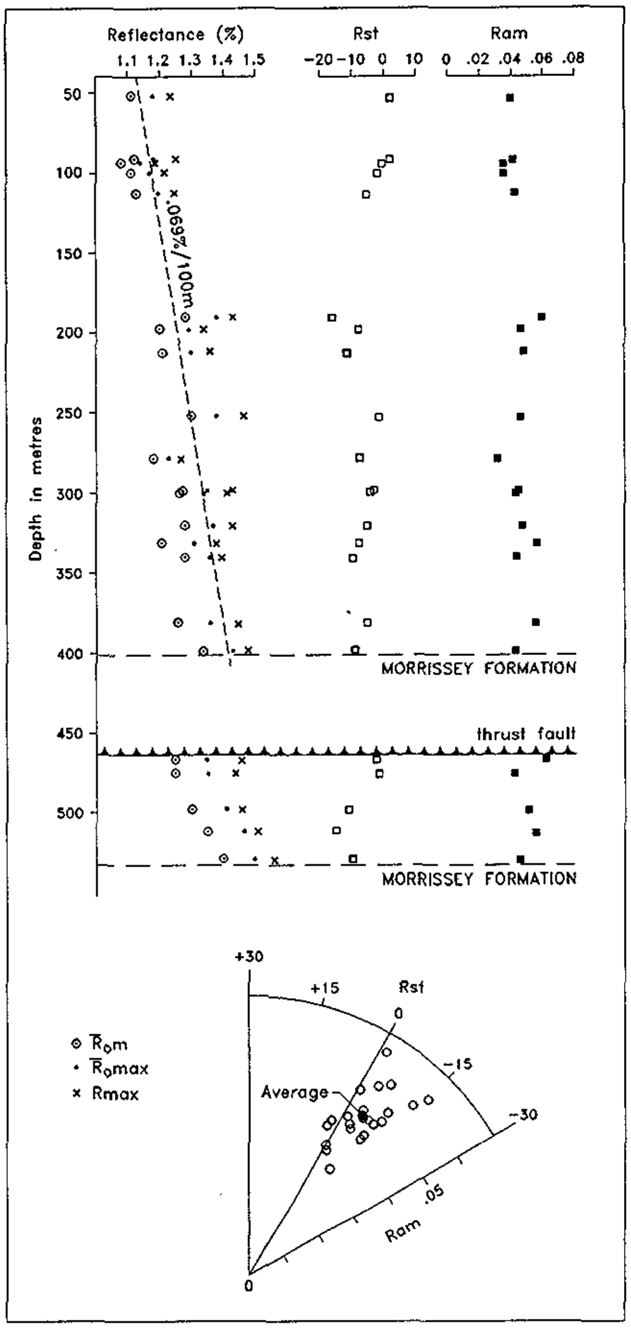


Figure 37. Variations in reflectance parameters in drill hole G (BM81-2). Line of best fit through R_{max} data is shown.

However, it is also known that reflectance values are increasing to the south between Imperial Ridge and Mount Banner (Figure 5), and so the increase observed in the drill cores may be largely due to a lateral gradient.

In summary, no conclusive evidence for down-dip rank gradients was found in the Elk Valley coalfield. Either no gradient exists, or it exists but is too low to detect given the sampling conditions. The implications of this will be discussed later.

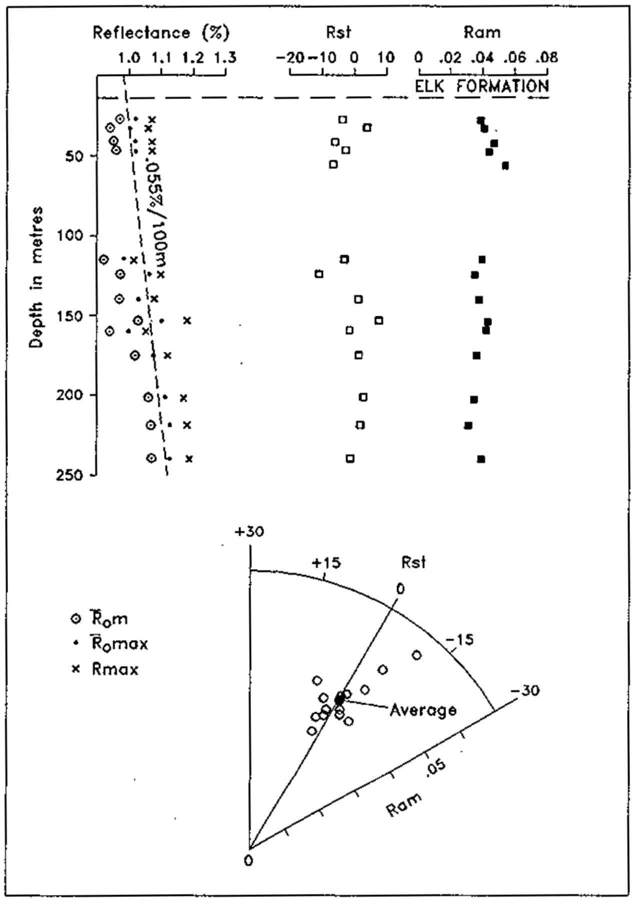


Figure 38. Variations in reflectance parameters in drill hole H (SR-7). Line of best fit through $\bar{R}_{max}$ data is shown.

REFLECTANCE INDICATING SURFACE (RIS) ANALYSIS

All subsurface grab sample reflectance results were subjected to further analysis designed to calculate the three major axes (R_{min}, R_{int}, and R_{max}) of their reflectance indicating surfaces (RIS). The cross-plot methodology for particulate samples as outlined in Kilby (1988) was utilized; it is summarized in Chapter 1. The objectives of this analysis are: to derive the reflectance parameters R_{ev}, R_{st} and R_{am} from the values of the three major axes, and to classify the RIS of each sample. The reasons for selecting only subsurface samples for rigorous analysis were outlined earlier: the subsurface samples are mainly taken from thin coal bands, and so any variations present within seams are avoided; and, the subsurface samples are relatively fresh.

Examples of cross-plots for samples used in this study are shown in Figure 44. Results of RIS analysis for each separate drill core are shown in Table 13 and Figures 31 to 41. In the diagrams, both R_{st} and R_{am} are plotted against depth and on a triangular graph. All the R_{st} and R_{am} data are plotted on the triangular graph in Figure 45, together with the average position of each drill core. In theory, a biaxial negative RIS would have an R_{st} of less than zero. For purposes here, however, samples classified as biaxial negative (B−) have R_{st} values less than −2.5, biaxial even (B=) samples have R_{st} values between −2.5 and +2.5, and samples classified as biaxial positive (B+) have R_{st} values greater than +2.5.

The most striking and significant feature of these data is that they suggest that all the samples analyzed are biaxial. R_{st} values range from −16.537 to +5.209, with an average of −3.750 (Figure 45); a uniaxial negative RIS has an R_{st} value of −30. R_{am} values range from 0.0285 to 0.0645, with an average of 0.0435; an isotropic RIS would have an R_{am} value of zero.

The averages of the RIS data for each drill hole (Figure 45) are reasonably close to each other and do not suggest any systematic variation with structural or geographic position. Moreover, there is no apparent systematic variation with stratigraphic or structural position within each drill hole (Figures 31 to 41), with a few possible exceptions. For example, R_{st} values for samples collected from within the basal coal zone of the Mist Mountain Formation may be distinctive. Five out of the ten samples have R_{st} values less than −8.0, compared with only 18 per cent for the remainder of the formation. Also of possible significance is the fact that the highest R_{am} value in the entire population (0.0645) is associated with a sample from immediately beneath the large thrust fault in drill core BM81-2 (Figure 37).

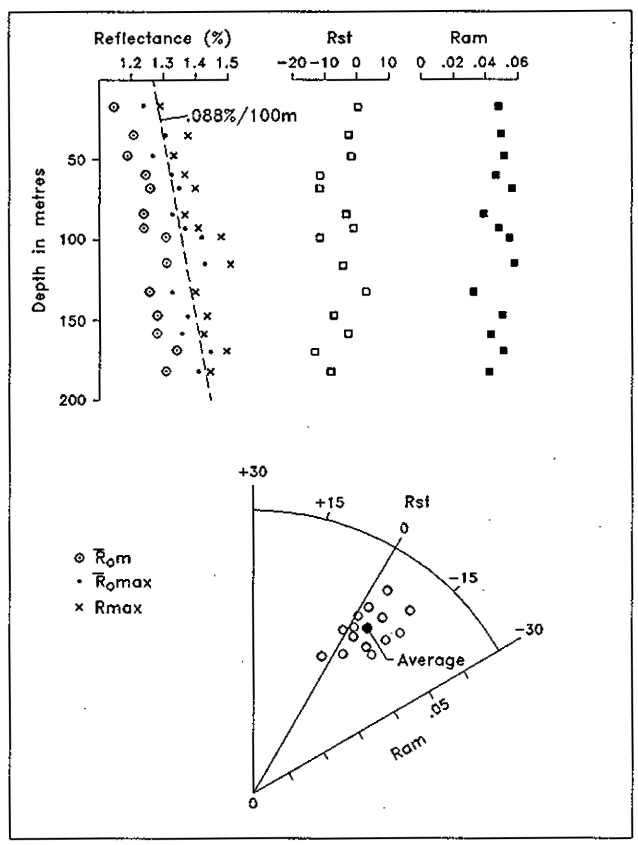


Figure 39. Variations in reflectance parameters in drill hole I (SR-12). Line of best fit through $\bar{R}_{max}$ data is shown.

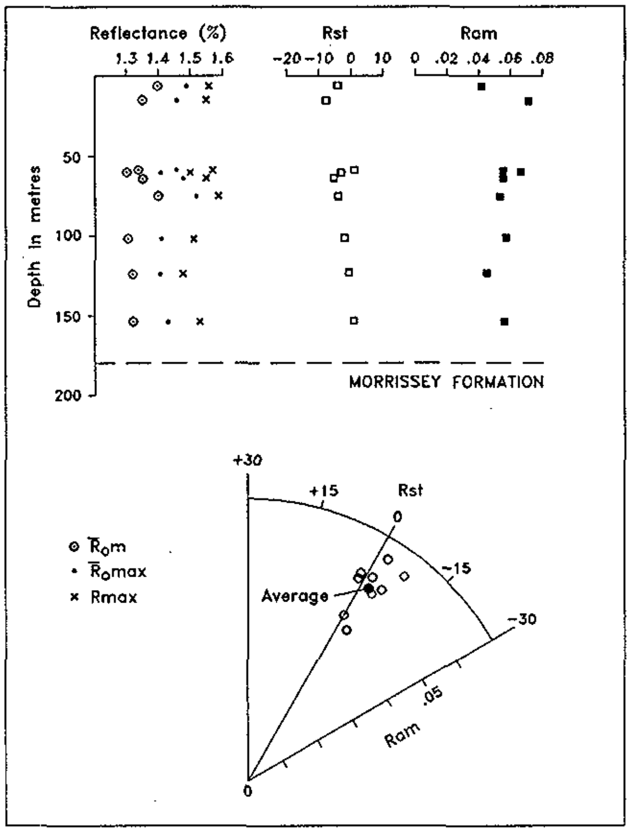


Figure 40. Variations in reflectance parameters in drill hole J (SR-2).

Correlations between the various reflectance parameters are listed in Table 16. The matrix indicates strong correlations (r>0.9) between all combinations of $\bar{R}_{max}$, R_m, R_{max}, R_{int}, R_{min} and R_{ev}. On the other hand, correlations between all combinations involving R_{st} and R_{am} are not pronounced (r<0.5).

DISCUSSION

Rank Gradients

There is considerable variation in coal rank, as measured by the maximum vitrinite reflectance method, throughout the study area. In order to attempt interpretation of observed rank distributions, these variations have been quantified in terms of gradients. For example, the reflectance *versus* stratigraphic position graphs for measured sections (Figure 30) suggest average gradients in the neighbourhood of 0.07 per cent per 100 metres of section (Table 14). However, the variation in these gradients does not appear to be related to geographic position or to the absolute values of reflectances at any location. The same is true for the reflectance *versus* depth plots for subsurface samples (Figures 31 to 41; Table 15). This is consistent with observations by Hughes and Cameron (1986) for the Kootenay Group in general.

Lateral rank gradients also occur in the Elk Valley coalfield, although they are not as pronounced as those in the Crowsnest coalfield (Pearson and Grieve, 1985). An example is the rank increase between Ewin Pass and Mount Banner, as evidenced by reflectance values in the basal coal zone, which increase from 1.26 per cent to 1.58 per cent. This represents an average lateral gradient of greater than 0.06 per cent per kilometre.

As mentioned in a previous section, down-dip rank gradients were not positively detected in this study as they were in the case of the Crowsnest coalfield.

There is an across-structure rank gradient between Weary and Bleasdell creeks in the north half of the study area. In this case reflectances on roughly stratigraphically equivalent horizons decrease by as much as 0.7 per cent over a horizontal distance of 4.5 kilometres.

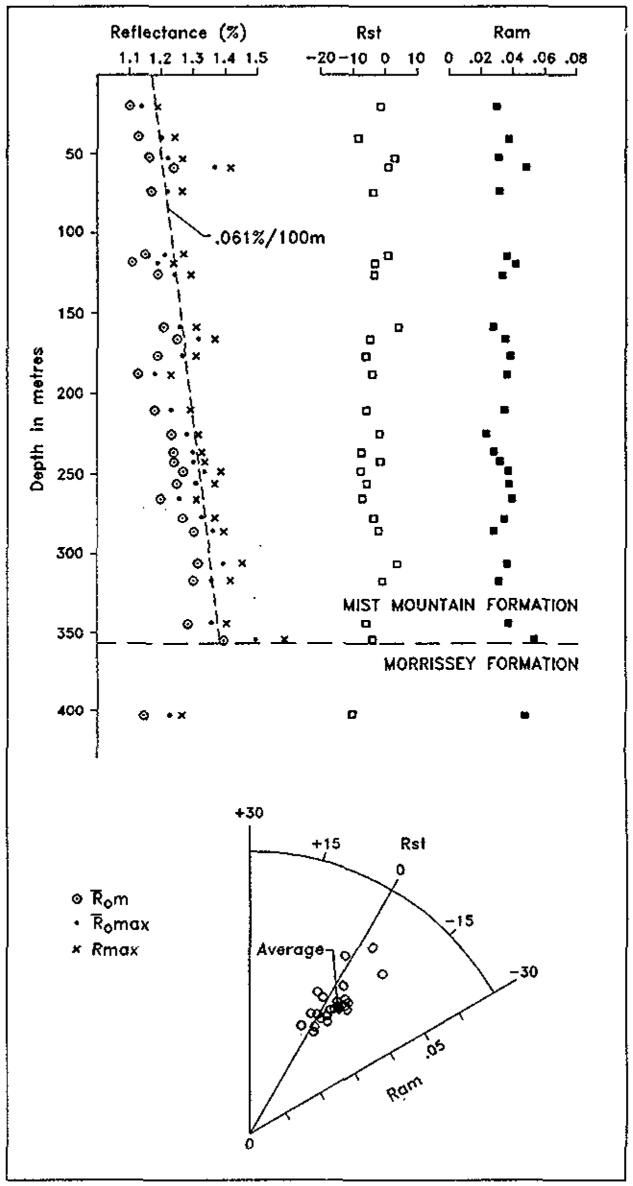


Figure 41. Variations in reflectance parameters in drill hole K (BRE-3). Line of best fit through $\bar{R}_{max}$ data is shown.

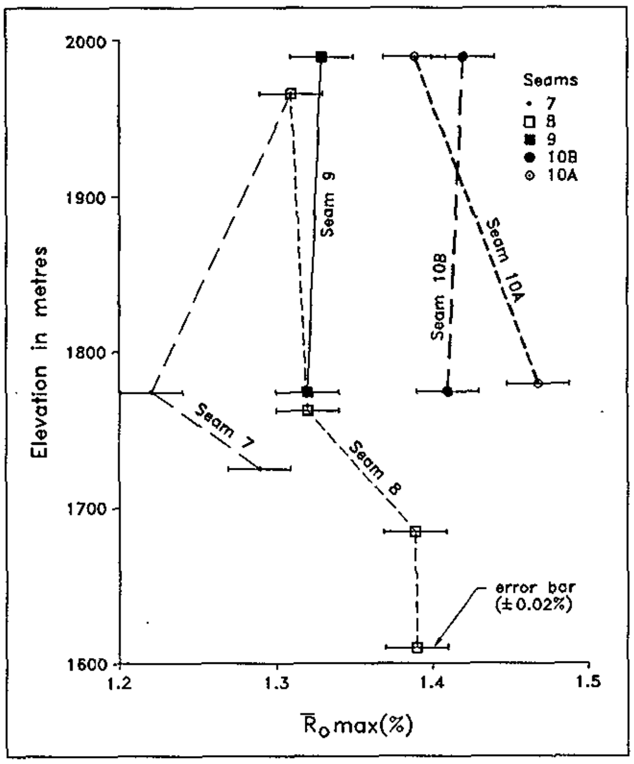


Figure 42. Variations in vitrinite reflectance ($\bar{R}_{max}$) with elevation for four coal seams at Line Creek mine.

Tectonic Implications of Rank Distributions

The timing of coalification relative to structural events has been interpreted for the Crowsnest coalfield (Pearson and Grieve, 1985) and, by extrapolation, is believed to apply to all of southeastern British Columbia, including the Elk Valley coalfield. The most notable of the conclusions of the earlier study were that coalification occurred both before and after folding and thrust faulting and was complete prior to normal faulting. Hughes and Cameron (1986) and Hacquebard and Cameron (1989) corroborated the first conclusion for Kootenay Group occurrences in general.

One line of evidence used to establish the timing of coalification relative to folding and thrust faulting in the Crowsnest coalfield was the observation that coal seam reflectances increase down-dip. As outlined above, there are no clearcut examples of this in the current study. Another line of evidence involved comparison of reflectances of coals in the hangingwall and footwall of major thrust faults: samples of coal from the hangingwall of major thrusts in the Crowsnest coalfield have lower reflectances than samples from corresponding stratigraphic positions in the footwall. This appears to be the case for coals above and below the Ewin Pass thrust at Mount Michael, Mount Banner and Ewin Creek (Figures 5 and 7). The thrust fault in drill hole BM-81-2, on the other hand, does not show this relationship, presumably because its displacement is too small.

In the case of the timing of coalification relative to normal faulting, the evidence used in the Crowsnest coalfield depended on the observation that coals from the hangingwall of a major normal fault are of lower reflectance than those from the footwall, assuming that the normal fault was initially a thrust. The Erickson fault is the only large-scale normal fault in the study area, and it is believed to have initially been a thrust fault (Dahlstrom *et al.*, 1962). Strata in its hangingwall comprise the Greenhills Range. Pearson and Grieve (1980) noted that coals from the Greenhills Range are typified by somewhat lower reflectance values than those from the adjacent parts of the coalfield. Greenhills samples were re-analyzed for this paper, and the results indicate that although the difference is smaller than that previously published, they are of relatively low rank. A typical value for the basal coal zone at the south end of the Greenhills Range is 1.21 per cent; in contrast, the same stratigraphic position on Burnt Ridge Extension, immediately to the east and on the other side of the Erickson fault, has a typical reflectance of 1.36 per cent. This is believed to constitute evidence for the completion of coalification prior to normal faulting.

The tectonic significance of lateral rank gradients is not clear; in the case of the Crowsnest coalfield (Pearson and Grieve, 1985), it was noted that the areas with the highest absolute rank values tended to have the largest contribution of postfolding coalification. Verification of this observation is not possible in this study, because of the lack of detectable down-dip rank increases. Hughes and Cameron (1986) also noted that on a more regional scale, rank gradients do not vary consistently with geographic position in the Koote-

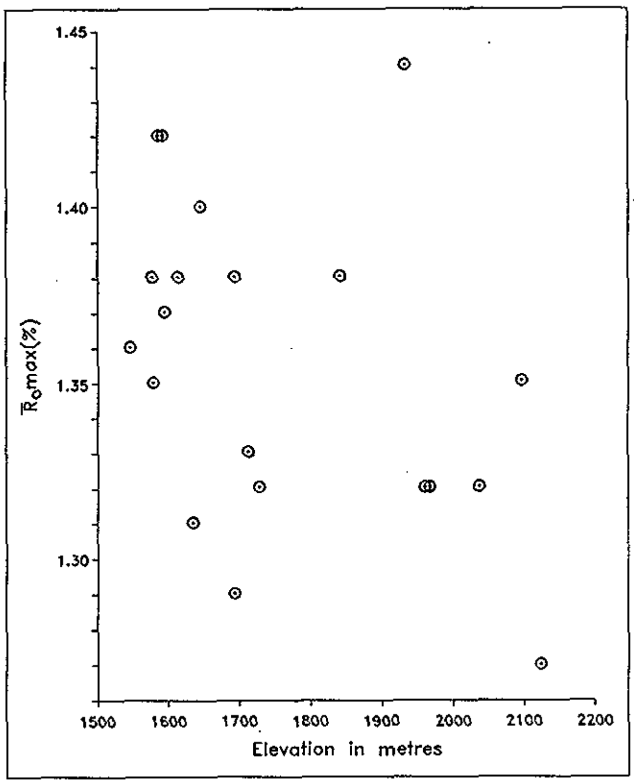


Figure 43. Vitrinite reflectance ($\bar{R}_{max}$) *versus* elevation for a single coal seam within one structural block on Eagle Mountain in the Fording River operations.

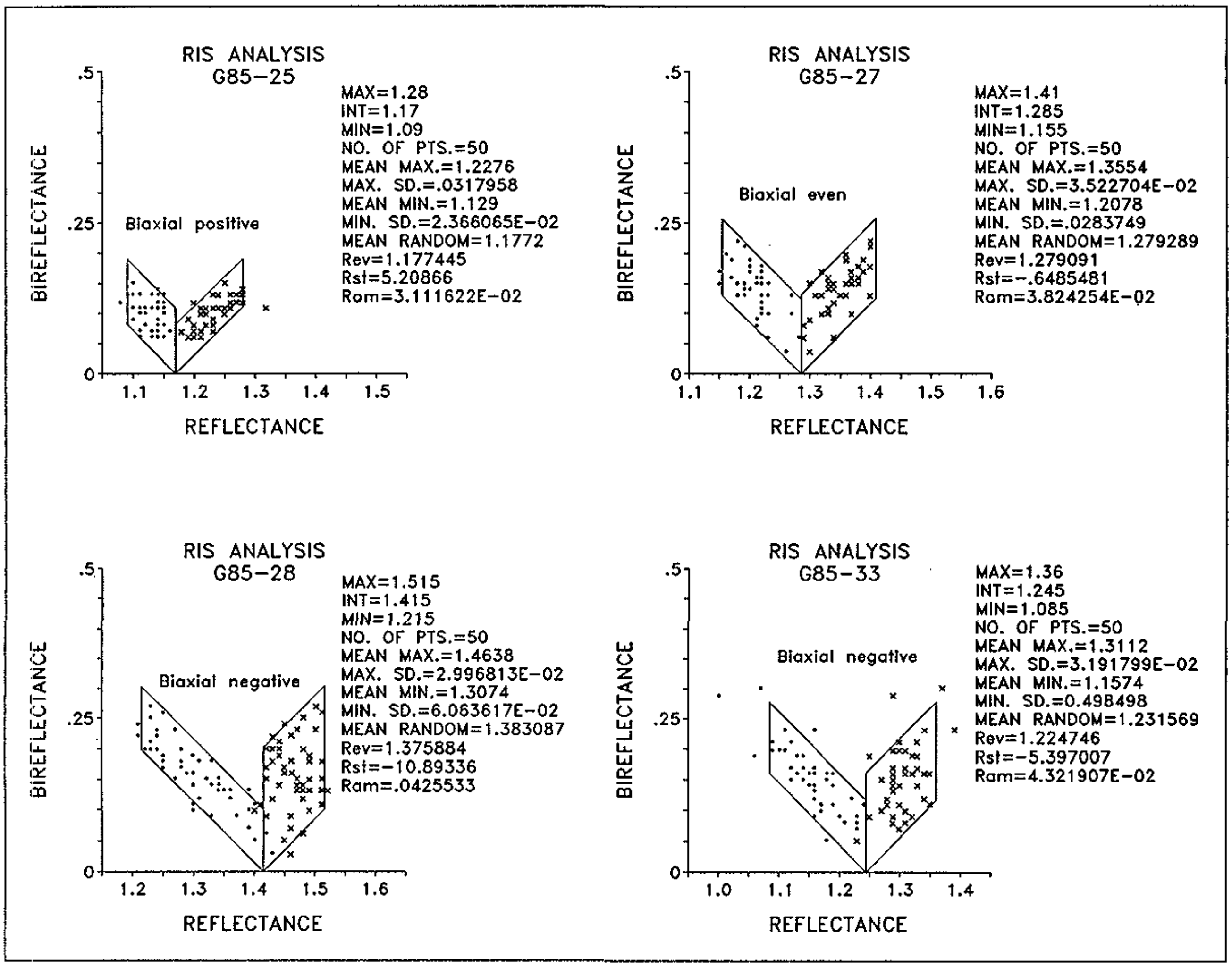


Figure 44. Examples of vitrinite reflectance cross-plots used in this study. See text for explanation.

nay Group. They concluded that "differences in absolute rank between localities with similar geological settings are related to differences in maximum depth of burial". This seems a very reasonable conclusion.

The dramatic rank contrast between Weary Creek on the east limb of the Alexander Creek syncline and Bleasdell Creek on the west limb is probably of tectonic significance. After modelling the time-temperature history of this occurrence and two similar occurrences involving overturned synclines adjacent to large thrust faults in southern Alberta, Hughes and Cameron (1986) concluded that compressional deformation began during the Late Cretaceous, before deposition of since-eroded younger strata over the Kootenay Group. In other words, early, incipient thrusting created a regional warping with an axis perpendicular to the direction of compressional stress. The amount of warping was great enough to allow a thicker blanket of younger sediment to accumulate over strata now underlying Weary Creek than over those underlying Bleasdell Creek. An important implication of this model is that Laramide deformation spanned a period of at least 10 million years.

Also of interest in the Weary Creek - Bleasdell Creek area is the observation that, although a reflectance gradient was calculated for the Bleasdell Creek area, there is a great deal of data scatter and a corresponding low regression coefficient. Hacquebard and Cameron (1989) report no discernible gradient in this area, and therefore conclude that a "substantial component" of the coalification was postfolding.

The last line of evidence for the timing of coalification relative to structural events is the reflectance indicating surface (RIS) analysis. To summarize, all samples for which the RIS parameters were determined in this study are biaxial. This implies that a secondary stress field existed during coalification that was not perpendicular to bedding, that is, not parallel to overburden pressure (Kilby, 1988). A likely candidate for this secondary stress field is horizontal stress corresponding to compressional forces present during deformation of a fold and thrust belt, therefore implying that coalification was in part concurrent with folding and thrusting.

In summary, available reflectance data for the Elk Valley coalfield appear to be consistent with the conclusions regarding the timing of coalification relative to tectonic events in the Crowsnest coalfield (Pearson and Grieve, 1985). Coalification is believed to have begun prior to

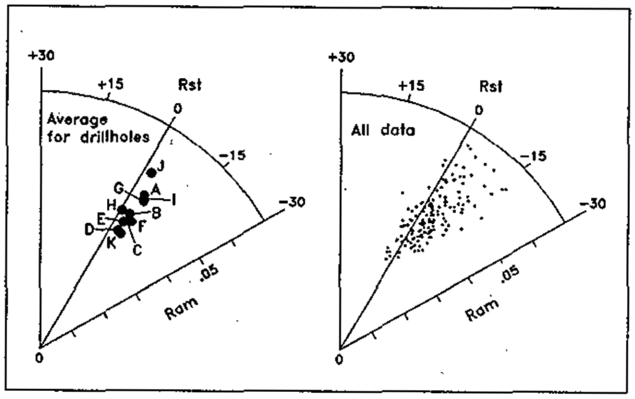


Figure 45. R_{st} *versus* R_{am} for all data and position of average Rst-Ram values of each drill hole.

TABLE 16
CORRELATION MATRIX OF REFLECTANCE PARAMETERS, DRILL-CORE SAMPLES

$\bar{R}m$	Rmax	Rint	Rmin	Rev	$\bar{R}m$/ Rev	Rst	Ram	
.992	.993	.991	.91	.989	0	.125	.414	$\bar{R}$max
	.982	.993	.946	.997	0	.11	.319	$\bar{R}$m
		.979	.894	.983	.1	0	.457	Rmax
			.922	.991	0	.178	.361	Rint
				.956	0	0	0	Rmin
					0	0	.299	Rev
						0	.207	$\bar{R}$m/Rev
							.224	Rst

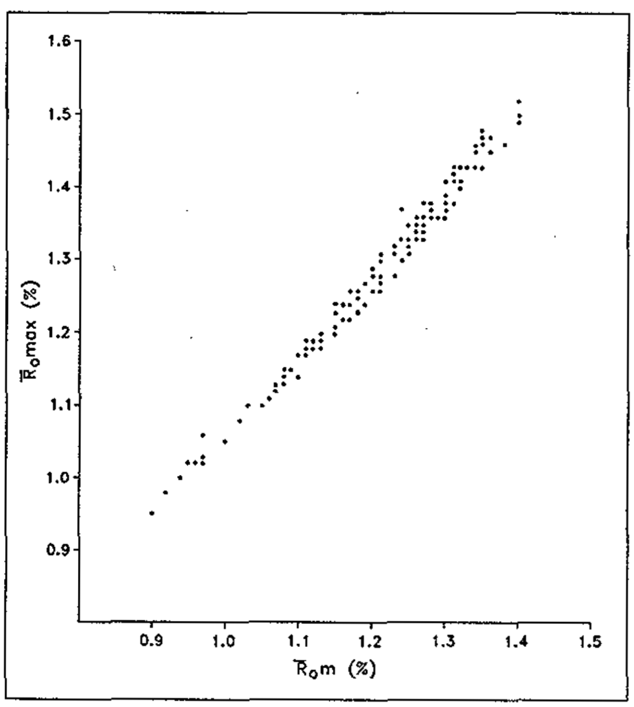


Figure 46. $\bar{R}_{max}$ *versus* $\bar{R}_m$ (all data).

compressional deformation, and to have continued until some time after compression ended, but prior to extensional deformation.

Use of Reflectance Parameters

In biaxial coals, the value of $\bar{R}_{max}$ is smaller than the length of the maximum axis of the RIS, R_{max}. Therefore, the conclusion derived from RIS analysis that all the samples examined, and by extrapolation all the coals in the study area, are biaxial, raises the question of which reflectance parameter best characterizes coal rank. Some of the choices are: mean maximum reflectance or $\bar{R}_{max}$, which is used throughout this study; mean random reflectance or $\bar{R}_m$;

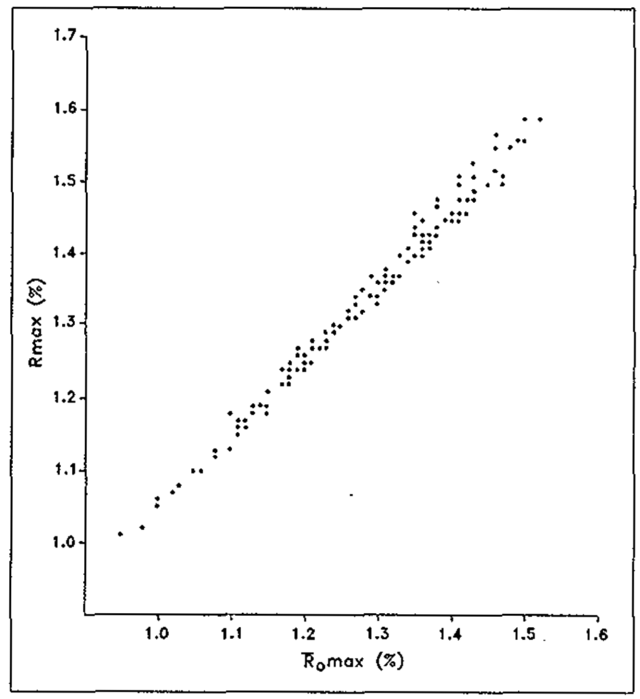


Figure 47. R_{max} *versus* $\bar{R}_{max}$ (all data).

R_{max}, R_{int}, and R_{min}, the determined lengths of the principal axes of the RIS; and R_{ev}, the radius of a sphere of equal volume as the RIS ellipse. All are listed in Table 13, together with the ratio of R_m to R_{ev}. The first three are plotted, with respect to depth, on Figures 31 to 41. Relationships between the various parameters are indicated in the correlation matrix (Table 16), and were described in an earlier section. The relationship between $\bar{R}_{max}$ and $\bar{R}_m$ for all subsurface samples is plotted on Figure 46, and that between R_{max} and $\bar{R}_{max}$ on Figure 47.

The first observation is that R_{ev} provides a very close approximation of $\bar{R}_m$, with $\bar{R}_m$ generally being slightly larger than R_{ev}. For example, the ratio $\bar{R}_m/R_{ev}$ ranges from 0.994 to 1.031, and averages 1.004. These two parameters are therefore believed to be interchangeable. Both are smaller in value than $\bar{R}_{max}$, which is an expected outcome, considering the definitions of $\bar{R}_m$ and $\bar{R}_{max}$. Based on the graph of $\bar{R}_{max}$ *versus* $\bar{R}_m$ (Figure 46), the relationship of the two is $\bar{R}_{max} = 1.064\bar{R}_m$. This compares very well with previously published relationships of $\bar{R}_{max} = 1.066\bar{R}_m$ (Ting, 1978) and $\bar{R}_{max} = 1.061\bar{R}_m$ (Hoover and Davis, 1980, in Davis, 1984).

Secondly, R_{max} is always larger than $\bar{R}_{max}$, which is again the expected relationship. The difference $R_{max} - \bar{R}_{max}$ ranges from 0.03 to 0.11 per cent, with a mean of approximately 0.06 per cent, and a mode of 0.05 per cent. Based on the graph of R_{max} *versus* $\bar{R}_{max}$ (Figure 47), the relationship of the two is $R_{max} = 1.044\bar{R}_{max}$.

When depth profiles of $\bar{R}_{max}$, $\bar{R}_m$ and R_{max} are compared (Figures 31 to 41), there does not appear to be much variation in their overall relative shape. Neither the slopes of the lines nor the degree of scatter about the lines are different; only the absolute values vary, as already noted. This is consistent with their strong intercorrelations (Table 16). Therefore, for the purposes of demonstrating relative rank distributions and calculating gradients, none appears to have particular advantage. In this study $\bar{R}_{max}$ was used, mainly because of its precedence in studies of the Kootenay Group, and its generally wide acceptance among coal geologists and petrographers. However, either $\bar{R}_m$ or R_{max}, together with R_{ev}, R_{int} and R_{min}, would have been equally effective in demonstrating rank variations in the study area.

For application of the reflectance data to coal quality predictions $\bar{R}_{max}$ certainly has precedence, especially in the field of petrographic prediction of coke-making potential. However, where many of the coals are apparently biaxial, such as in the study area, $\bar{R}_{max}$ is lower in value than R_{max}, the maximum reflectance axis of the RIS. This can be expected to have some impact on the prediction process, but the size of the impact has not yet been studied.

CHAPTER 7: COAL QUALITY

INTRODUCTION

This chapter briefly summarizes some of the available data concerning the quality of coal in the Elk Valley coalfield. Further information, on a seam-by-seam basis for some of the properties in the coalfield, may be found in the "British Columbia Coal Quality Catalog" (British Columbia Ministry of Energy, Mines and Petroleum Resources, 1992).

Large amounts of relevant coal-quality analytical data are available in coal-property assessment reports on file with the Ministry of Energy, Mines and Petroleum Resources. Comprehensive tabulation and interpretation of these data are not within the scope of this study, but are being included within the context of other Ministry studies.

Vitrinite reflectance distribution and coal maceral compositions in the study area are covered in earlier chapters. In combination, they can be used to make general, qualitative assumptions concerning quality characteristics.

Coal-quality data summarized here are grouped into three categories: a) analysis of raw, whole-seam, bulk-sampled coal from the Elk River, Burnt Ridge and Ewin Pass properties; these data are from assessment reports; b) product specifications from each of the three producing mines in the coalfield, Line Creek, Greenhills and Fording; and, c) proposed product specifications of the "Elco" mine on the Elk River property. These are discussed separately below.

BULK SAMPLES

Bulk samples are in the minority of coal analyses reported in assessment reports, but as they are the most representative samples, they have been chosen for inclusion. Analyses of raw, bulk (adit) samples of several seams on each of three properties, two from the south half of the coalfield (Burnt Ridge and Ewin Pass) and one from the north half (Elk River), are shown in Table 17 (data on clean coals are for the most part confidential, and so can not be included here). Data are taken from coal company assessment reports. Adit locations are shown on Figure 48. The approximate stratigraphic positions of coal seams are shown on Figure 7. At two of the locations, Burnt Ridge and Elk River, coal seams are numbered upward from "1" at the base of the formation, but no correlation on a seam-by-seam basis is implied. At the Ewin Pass property, seam numbers decrease from 10 at the base to 4 near the top of the formation.

These data are not intended to represent the range of coal quality over the coalfield, nor should they be considered representative of coal seams within each property away from the actual sample locations. They are reproduced here for general discussion and comparison only.

BURNT RIDGE

Data for Burnt Ridge in Table 17 are presented on a dry basis. Ash values range from 9.3 per cent to 33.1 per cent, volatile matter contents (daf) from 23.6 to 30.9 per cent and

TABLE 17
SUMMARY OF QUALITY OF RAW BULK SAMPLES FROM ELK RIVER, BURNT RIDGE AND EWIN PASS PROPERTIES

Property	Adit	Seam	Sample Type	Basis	Moisture (%)	Ash (%)	Volatile Matter (%)	Fixed Carbon (%)	S (%)	FSI	Calorific Value (kcal/kg)	Assess. Report No.
Elk River	2	B(2)	—	AD	0.72	16.36	18.85	64.77	0.6	7	8080	266
	3	C(3)	—	AD	0.66	8.49	20.14	71.37	0.5	8	7910	266
	4	D(4)	—	AD	0.67	25.14	15.47	58.72	0.33	4	6490	266
	7	F(7)	—	AD	0.44	14.46	17.85	67.25	0.59	4.4	7145	266
	8	F(8)	—	AD	0.51	11.34	19.34	68.81	0.41	5.4	7515	266
	9	G(9)	—	AD	0.68	13.66	19.27	66.39	0.42	3.8	7190	266
	S-1	Q(15)	—	AD	1.50	9.19	26.60	64.21	0.68	8.5	8070	266
Burnt Ridge	EV-2	6	—	Dry	—	9.3	24.5	66.2	0.56	NC	—	262
	EV-3	7	—	Dry	—	33.1	20.7	46.2	0.70	6.5	—	262
	EV-4	4	—	Dry	—	19.3	20.7	60.0	0.48	1	—	262
	EV-5	2	—	Dry	—	15.7	19.9	64.4	0.43	2.5	—	262
	EV-6	8(?)	—	Dry	—	9.4	26.6	64.0	0.41	NC	—	262
	EV-7	1	—	Dry	—	19.2	20.1	60.7	0.39	1.5	—	262
Ewin Pass	1	7	Cross-cut Channel	AD	0.62	7.87	27.23	64.28	—	7.5	—	396
	2	4	Cross-cut Channel	AD	0.60	6.47	27.16	65.77	—	7.5	—	396
	3	8	Cross-cut Channel	AD	0.86	28.80	18.29	52.05	—	1.0	—	396

AD = Air dried
NC = Non-caking

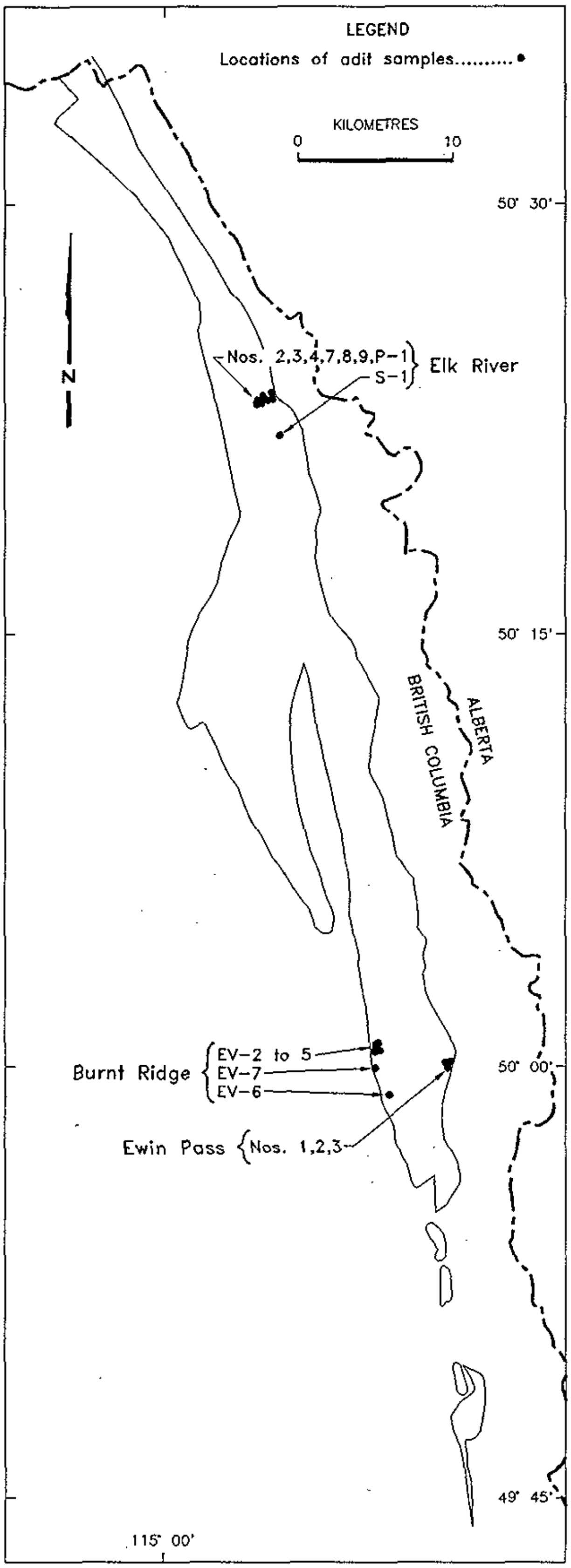


Figure 48. Locations of adit-sample sites for bulk sample data described in this study.

sulphur contents range from 0.39 to 0.70 per cent. The generally low free swelling index values (non-caking to 6.5) are not typical of the coalfield, and suggest that most of the samples were oxidized.

Ewin Pass

Ewin Pass data in Table 17 are presented on an air-dried basis. Only three seams are represented, for which ash contents range from 6.47 to 28.80 per cent and volatile matter (daf) from 26.0 to 29.8 per cent. Two of the three samples have free swelling index values of 7.5.

Elk River

With one or two possible exceptions data are presented on an air-dried basis (Table 17). Ash contents range from 8.49 to 25.14 per cent. Dry, ash-free volatile matter contents range from 20.9 to 29.3 per cent and sulphur values range from 0.33 to 0.68 per cent. Free swelling index values range from 2.5 to 8.5, and calorific values (air-dried) from 6495 to 8085 kilocalories per kilogram.

PRODUCT SPECIFICATIONS

Each of the three mines in the coalfield processes and ships a range of products of differing specifications which are dependent mainly on user requirements. Current products include coking coal of differing volatilities, semicoking coal and thermal coal. Most of the coal falling into the last category is oxidized and is therefore not suitable for coking purposes.

Product specification data are summarized in Table 18. These are all taken from the 1988 TEX Coal Manual (Horie, 1988) and represent specifications stipulated in contracts between Elk Valley mines and Japanese steel mills and utilities.

Fording River

Fording Coal's Fording River operation ships three types of coking coal (Table 18). The differing specifications are met by mining seams from different parts of the stratigraphic section. The "standard product" has an air-dried volatile matter content of 21 to 24 per cent. In contrast, the air-dried volatile matter content of the "medium volatile" and "high volatile" products are 25 to 28 per cent and 30 to 33 per cent, respectively. Air-dried moisture is 1.0 per cent in all three cases, ash content varies from 6.5 to 9.5 per cent, and sulphur values range from 0.45 to 0.85 per cent. Calorific values (daf) all exceed 8340 kilocalories per kilogram.

Fording's semicoking products fall into "high volatile" and "low volatile" categories (Table 18). Ash values are slightly higher and free swelling index values are lower than in the coking coals.

The thermal coal product specifications require 7.0 per cent ash and a calorific value (daf?) of 7595 kilocalories per kilogram.

TABLE 18
SPECIFICATIONS OF PRODUCT COALS FROM MINES IN THE ELK VALLEY COALFIELD

Product	Total moisture (%)	Air-dried moisture (%)	Ash (%)	Volatile matter (%)	Fixed carbon (%)	Sulphur (%)	Calorific value (daf) (kcal/kg)	FSI	Fluidity (ddpm)
Fording									
Coking — standard	8.0	1.0	9.5	21–24	65.5–69	0.45	8335+	6–8	—
Coking — medium volatile	8.0	1.0	8.0	25–28	62–65.5	0.85	8335+	6.4–8.5	—
Coking — high volatile	8.0	1.0	6.5	30–33	59–62.5	0.55	8335+	6–8	—
Semi-coking	9.5	—	10.0	26–28	—	0.6	—	4–6	—
Semi-coking	8.0	—	10.5	21–25	—	0.45	—	4–6	—
Thermal	—	1.0	7.0	32.0	60.0	0.5	7590	—	—
Greenhills									
Coking *"guaranteed specifications"*	8.0	—	7.0	24	—	0.5	—	7–8	—
Coking — base product 1990	—	—	7.0	28.1	—	0.58	—	—	156
Coking — high volatile 1990	—	—	6.5	32.0	—	0.56	—	—	250
Thermal	10.0	1.5	16.0	25–28	54.5–57.5	0.5	6900	—	—
Line Creek									
Coking	8.0	1.2	9.5	19.5–22.5	—	0.5	—	5–6.5	—
Thermal — unwashed	6.0	—	23	17–20	—	0.5	6400	—	—
Thermal — washed	8.0	—	10–12	19.5–22.5	—	0.5	6400	—	—

(From Horie, 1988.)

Greenhills

Westar Mining's Greenhills operation produces a "base metallurgical" product and a "high-volatile metallurgical" product for the Japanese steel industry (Horie, 1988). The former has 1990 specifications (air-dried?) of 7.0 per cent ash, 28.1 per cent volatile matter, 0.58 per cent sulphur, and a fluidity of 156 dial divisions per minute (Table 18). The high-volatile product, which is mined from stratigraphically higher coal seams, contains 6.5 per cent ash, 32.0 per cent volatile matter, 0.56 per cent sulphur and has a fluidity of 250 dial divisions per minute.

Greenhills thermal coal contains, on an air-dried basis, 16.0 per cent ash, 25.0 to 28.0 per cent volatile matter, 0.5 per cent sulphur, and a calorific value (air-dried) of 6900 kilocalories per kilogram.

Line Creek

Line Creek's coking coal specifications (air-dried) are 9.5 per cent ash, 19.5 to 22.5 per cent volatile matter and 0.5 per cent sulphur (Table 18). Clean thermal coal specifications (also air-dried) are 10 to 12 per cent ash, 19.5 to 22.5 per cent volatile matter, 0.5 per cent sulphur and a calorific value of 6405 kilocalories per kilogram.

PROPOSED PRODUCT SPECIFICATIONS - ELK RIVER PROJECT

The only inactive property in the Elk Valley coalfield to have gone through the Ministry's Mine Development Review Process for development approval is the Elk River property in the northern part of the coalfield. The proposed "Elco" minesite is north of Weary Creek, centred on Little Weary Ridge on the east limb of the Alexander Creek syncline. The project is currently dormant, and the 50 per cent interest in the property held by Elco Mining Ltd. at the time the proposal was made is now owned by Fording Coal.

Coal-quality specifications (Table 19) were based on a mine plan which would have involved continuous blending of coal from seams throughout the stratigraphic section. Seams were divided into three general quality types, and the proportions of each type were to remain constant during production. Product specifications (dry basis) included 9.5 per cent ash, 20.4 per cent volatile matter, 0.6 per cent sulphur, a free swelling index of 6 and fluidity of 5 to 18 dial divisions per minute.

DISCUSSION

Tables 17 to 19 demonstrate in a simplistic way the potential of coals within the Elk Valley coalfield, and indeed within the entire southeastern British Columbia region, to meet a range of quality requirements. Taken in concert with petrographic data given in earlier chapters, they allow comparision with the petrographically based coking coal classification cited by Pearson (1980; see also Table 20).

The coals for which quality parameters are tabulated mainly belong to Group G3 which encompasses low to medium-volatile coking coals, typified by Balmer coal from Westar's Balmer operation at Sparwood in the Crowsnest

TABLE 19
SPECIFICATIONS OF PROPOSED PRODUCT COAL FROM "ELCO" MINE, ELK RIVER PROPERTY

Volatile matter	20.4%
Ash	9.5%
Sulphur	0.6%
Phosphorus	0.03–0.04%
Fluidity	5–18 ddpm
FSI	6
Coke Stability Index (petrographic)	56.5–57.1

(From Elco Mining Ltd., 1978.)

TABLE 20
COKING COAL CLASSIFICATION

Group Name	Group No.	Rank ($\bar{R}max$ %)	Inert Content (%)	Max. Dilatation (%)	Max. Fluidity (ddpm)	FSI	Volatile Matter (%)	Coke Strength JIS D^{30}_{15}	Coke Strength ASTM 25mm
Keystone	G1	>1.50	8-30	0 to 70	5-100	6-9	16-19	92-93.5	50-65
Pittston	G2	1.0-1.4	8-30	80 to 260	1500-30000	7-9+	22-34	91-94	48-65+
Balmer	G3	1.2-1.5	25-45	−10 to 100	3-1500	5-8	19-26	90.5-93.5	40-62
Moura	G4	0.9-1.2	25-45	−10 to 100	3-2500	5-8	25-32	90-92.5	45-57
Kellerman	G5	0.8-1.0	0-25	100 to 300	1500->30000	7-9+	32-38	75-90.5	20-48
Big Ben	G6	<0.9	5-20	−10 to 100	3-1000	5-7	37-40	50-80	0-30

(From Pearson, 1980.)

coalfield. Some of its characteristics include: $\bar{R}_{max}$, 1.2 to 1.5 per cent; inert content, 25 to 45 per cent; volatile matter, 19 to 26 per cent; FSI, 5 to 8; and maximum dilatation, −10 to 100. This category probably includes: Fording's standard product; Greenhills' base metallurgical product; Line Creek's metallurgical product; and coal from the proposed Elk River project. Bulk-sampled coals on Burnt Ridge and on the east side of the Elk River within the Elk River property would probably also fit within this classification.

Another coking coal classification represented by these coals is Group G4. This group includes relatively high-inert, medium to high-volatile coking coals, with typical properties including: $\bar{R}_{max}$, 0.9 to 1.2 per cent; inert content, 25 to 45 per cent; volatile matter, 25 to 32 per cent; FSI, 5 to 8; and maximum dilatation, −10 to 100. This category may include some of the seams from Greenhills and other areas.

Some high-volatile, upper-section coals from Greenhills, Fording and other areas are expected to fall into the G5 group. This group includes relatively low-inert, high-volatile coking coals, with typical properties including: $\bar{R}_{max}$, 0.8 to 1.0; inert content, up to 25 per cent; volatile matter, 32 to 38 per cent; FSI, 7 to 9+; maximum dilatation, 100 to 300; maximum fluidity, 1500 to >30 000. The expected fluidity, however, is probably unreasonably high for the Elk Valley coals. Fluidity measurements, as a rule, are not a valid assessment of western Canadian coking coals.

Other coking groups are expected to occur within the coalfield, although definitive evidence in the form of analytical results from exploration samples does not exist. One area expected to have anomalous coal-quality characteristics is the Bleasdell Creek - Coal Creek area in the north part of the coalfield. The low rank of coals in this area might place them in the G5 or G6 categories. Their relatively high liptinite contents would contribute to fluidity, although the actual extent of this contribution is unknown.

Some of the upper-section (low-inert) coals from areas where overall rank is elevated, such as at Weary Creek and Mount Banner, might fall into Group G2. Again, however, it is doubtful that the high fluidity values which are characteristic of this group of coals would be met by Elk Valley coals.

In terms of thermal utilization potential, the generally high calorific values and low sulphur contents found in these coals are very attractive characteristics. The relatively high inertinite contents, which are typical of most coals from southeastern British Columbia, are generally not detrimental to combustion or other utilization processes, as a larger portion of semi-inertinites (that is, semifusinite) are more reactive than is typical in many coalfields throughout the world (Pearson, 1980).

CHAPTER 8: CONCLUSIONS

The Elk Valley coalfield is one of three coalfields in southeastern British Columbia. Exploration dates back to the turn of the century, and actual production began in 1972, on the Fording River property of Fording Coal Limited. There are three producing mines in the coalfield (1991), Fording River, the Greenhills Operations of Westar Mining Ltd., and Manalta Coal Ltd.'s Line Creek mine, which had a combined 1988 production of 11.1 million tonnes. Total potential *in situ* coal resources are a minimum of 7.8 billion tonnes.

In the study area the coal-bearing Mist Mountain Formation of the Jurassic-Cretaceous Kootenay Group ranges from less than 425 to approximately 700 metres in thickness. An average of approximately 10 per cent of its total thickness is composed of coal seams which range in thickness up to 13 metres. Coal seams between 1 and 2 metres thick are the most common and, on a qualitative basis, also appear to account for the most volume. The second largest contribution to coal volume is from seams in the 5 to 6-metre thickness range.

Seam correlation is generally difficult in the study area. However, the basal 20 metres of the formation, referred to informally as the "basal coal zone", consistently contains coal and other carbonaceous strata, in some instances in contact with the underlying Morrissey Formation. A thick coal seam in the lower half of the formation, referred to as the "Imperial seam", has been correlated laterally in drill core and surface exposures over a distance of approximately 17 kilometres.

Lithologies in the Mist Mountain Formation form a Markov chain. The data confirm a general fining-upward sequence typical of fluvial-alluvial depositional systems. Within a sequence, point-bar or channel sandstone deposits give way up-section to intermixed shale and sandstone units, which probably represent levee and/or crevasse-splay deposits, which in turn are overlain by floodplain shales. The sequence may continue upward into intermixed shale and sandstone units or to coal. The coal-forming environment is believed to have been relatively isolated from sources of clastic material. Coal deposition was generally terminated by drowning of the swamp, accompanied by deposition of fine-grained sediments. The portions of the Mist Mountain Formation above and below 200 metres above the base are not significantly different from each other in terms of their statistical sequence models.

Tonsteins are found throughout the Mist Mountain Formation, from the basal coal zone to the uppermost part. Lateral continuity of 1.4 kilometres is demonstrated for two individual tonstein bands. Based on their petrographic textures, chemistry and mineralogy, they are believed to be primarily of volcanic or reworked volcanic origin. Essentially all are kaolinite rich, but one example, from Ewin Pass, is poor in kaolinite and rich in the phosphate mineral gorceixite.

Vitrinite, with a range of 51 to 93 per cent of total organic material, is the maceral of greatest abundance in all channel samples collected, while semifusinite is the second most abundant, and the most abundant intertinite maceral. In general, the amount of vitrinite increases up-section, with the exception of the basal coal zone which often contains some of the more vitrinite-rich seams in the section. Liptinite is generally rare or absent, although sections of predominantly high-volatile rank contain a range of about 1 to 5 per cent liptinite. Maceral contents and derived petrographic parameters suggest that the height of the water table probably increased up-section.

The Elk Valley coalfield is part of the Lewis thrust sheet. Major structures influencing distribution of the Kootenay Group are the Alexander Creek and Greenhills synclines, which are separated by the Erickson normal fault, and the Bourgeau thrust fault, which marks the western boundary of the north half of the coalfield. The Alexander Creek syncline is the dominant structure, and hosts coal deposits more or less continuously throughout its length. Overall the Alexander Creek syncline has a north-northwest trend, and no net plunge. Locally its plunge is subhorizontal to gentle, resulting in a series of depressions and culminations. It is generally asymmetric (with the west limb being the shorter), open, and has an upright to steeply inclined axial plane. The instances where the fold is overturned are close to the Bourgeau fault. Thrust faults affecting the Mist Mountain Formation are more common on the east limb than on the west limb. The most important example is the Ewin Pass fault, which has the effect of repeating the Mist Mountain Formation at some locations, most notably on Mount Michael.

Coal ranks, based on the maximum vitrinite reflectance method, range from low-volatile to high-volatile B bituminous. Reflectance gradients within stratigraphic sections range from 0.057 to 0.119 per cent per 100 metres, with no systematic variations with geographic or structural position. At most locations, the lower part of the Mist Mountain Formation contains coals of medium-volatile bituminous rank, typically with reflectance values of 1.3 to 1.4 per cent, while the upper part contains coals of high-volatile rank, with values of approximately 1.0 per cent or less. At three locations, Crown Mountain, Mount Banner and Weary Creek, the coals of the lower part of the formation are of low-volatile rank. At one location, namely near Bleasdell Creek, the entire formation contains coals of high-volatile rank.

Analysis of the reflecting indicating surface (RIS) of subsurface grab samples suggests that all the coals in the study area are biaxial. Several reflectance parameters generated during this analysis, including $\bar{R}_{max}$, $\bar{R}_m$, R_{max}, and R_{ev}, are strongly intercorrelated, and any one would be an acceptable indicator of rank variations. The R_{st} values, representing the style of the RIS, range from -16.537 (biaxial negative) to $+5.209$ (biaxial positive). Neither R_{st} nor R_{am} (am=reflectance anisotropy) appear to vary systematically, with the possible exceptions that R_{st} values on basal section coals may have anomalously high negative values, and one R_{am} value from the immediate footwall of a thrust fault is unusually high.

Evidence for the timing of coalification relative to structural deformation is not as marked in the Elk Valley coalfield as it is in the Crowsnest coalfield. For example, there is no firm evidence for down-dip rank increases in the Elk Valley coalfield. On the other hand, coal seams in the hangingwall of the Ewin Pass thrust fault have lower reflectances than those at corresponding stratigraphic positions in the footwall. Moreover, the reflectances of coals at the south end of the Greenhills Range, in the hangingwall of the Erickson normal fault, are slightly lower than those in the adjacent part of the Alexander Creek syncline structural block. The RIS analysis suggests that coalification was at least partly concurrent with compressional deformation. Taken overall, it is believed that coalification began before compressional deformation and continued until after compression ceased, but was completed before the later extensional phase, consistent with conclusions reached in the Crowsnest coalfield.

A potentially wide variety of bituminous coal quality types is available in the Elk Valley coalfield. Volatile matter contents (dry, ash-free) of selected, raw bulk samples from three properties range from 20.9 to 30.9 per cent. Ash contents, on a dry basis, range from 6.5 to 33.1 per cent and sulphur contents are all less than or equal to 0.7 per cent.

Specifications of product coals from mines in the Elk Valley coalfield also show a variety of coal-quality characteristics. Volatile matter contents (air-dried) of coking coals range from 21 to 33 per cent, ash contents range from 6.5 to 9.5 per cent and sulphur contents are generally less than 0.6 per cent. Free swelling index values of coking coals range from 5 to 8.

Semicoking coal from the Fording River mine (two products) has 10 to 10.5 per cent ash and 21 to 28 per cent volatile matter.

Volatile matter in thermal coal ranges from 17 to 32 per cent, while ash contents range from 7 to 23 per cent. Specified sulphur values are 0.5 per cent, and calorific values, where reported, are close to 7200 kilocalories per kilogram.

REFERENCES

Beavan, C.R. (1981): Ewin Pass Coal Property; *Crows Nest Resources Limited,* open file assessment report, 43 pages.

Bouroz, A. (1962): Sur la Pluralité d'Origine des Tonsteins (A Propos d'une Cinérite Oligocène du Japon); *Annales de la Société Géologique du Nord,* Volume 82, pages 77-94.

British Columbia Ministry of Energy, Mines and Petroleum Resources (1992): British Columbia Coal Quality Catalog, Information Circular 1992-20, 51 pages.

Bustin, R.M., Cameron, A.R., Grieve, D.A. and Kalkreuth, W.D. (1985): Coal Petrology – Its Principles, Methods and Applications; *Geological Association of Canada,* Short Course Notes, Volume 3, 230 pages.

Cameron, A.R. (1972): Petrography of Kootenay Coals in the Upper Elk River and Crowsnest Areas, British Columbia and Alberta; *in* Proceedings of the First Geological Conference on Western Canadian Coal, Mellon, G.B., Kramers, J.W. and Seagel, E.J., Editors, *Alberta Research Council,* Information Series, No. 60, pages 31-46.

Cameron, A.R. (1984): Comparison of Reflectance Data for Various Macerals from Coals of the Kootenay Group, Southeastern British Columbia; *in* Proceedings of the 1984 Symposium on the Geology of Rocky Mountain Coal, Bismarck, North Dakota, October 2-4, 1984, Houghton, R.L. and Clausen, E.N., Editors, *North Dakota Geological Survey,* Publication 84-1, pages 61-75.

Cameron, A.R. and Babu, S.K. (1968): The Petrology of the No. 10 (Balmer) Coal Seam in the Natal Area of the Fernie Basin, British Columbia; *Geological Survey of Canada,* Paper 68-35.

Cameron, A.R. and Kalkreuth, W.D. (1982): Petrological Characteristics of Jurassic-Cretaceous Coals in the Foothills and Rocky Mountains of Western Canada; *in* Proceedings of the Fifth Symposium on the Geology of Rocky Mountain Coal, 1982, Gurgel, K.D., Editor, *Utah Geological and Mineral Survey,* Bulletin 118, pages 163-167.

Cant, D.J. and Stockmal, G.S. (1989): The Alberta Foreland Basin: Relationship Between Stratigraphy and Cordilleran Terrane-accretion Events; *Canadian Journal of Earth Sciences,* Volume 26, pages 1964-1975.

Coal Association of Canada (1989): 1989 Directory, 62 pages.

Dahlstrom, C.D.A., Daniel, R.E. and Henderson, G.G.L. (1962): The Lewis Thrust at Fording Mountain, British Columbia; *Alberta Society of Petroleum Geology,* Journal, Volume 10, pages 373-395.

Davis, A. (1978): The Reflectance of Coal; *in* Analytical Methods for Coal and Coal Products, Volume 1, Karr, C., Editor, *Academic Press,* New York, pages 27-81.

Davis, A. (1984): Coal Petrology and Petrographic Analysis; *in* Coal Geology and Coal Technology, Ward, C.R., Editor, *Blackwell Scientific Publications,* pages 74-112.

Davis, J.C. (1973): Statistics and Data Analysis in Geology; *John Wiley and Sons,* New York, 550 pages.

Diessel, C. (1982): An Appraisal of Coal Facies Based on Maceral Characteristics; *Australian Coal Geology,* Volume 4, Part 2, pages 131-146.

Diessel, C. (1986): The Correlation Between Coal Facies and Depositional Environments; *in* Advances in the Study of the Sydney Basin, Proceedings of the 20th Symposium, *The University of Newcastle,* pages 19-22.

Donald, R.L. (1984): Sedimentology of the Mist Mountain Formation in the Fording River Area, Southeastern Canadian Rocky Mountains; unpublished M.Sc. thesis, *The University of British Columbia,* 180 pages.

Dunlop, R.L. and Bustin, R.M. (1987): Depositional Environments of the Coal-bearing Mist Mountain Formation, Eagle Mountain, Southeastern Canadian Rocky Mountains; *Canadian Petroleum Geology,* Bulletin, Volume 35, pages 389-415.

Eden, R.A., Elliot, R.W., Elliott, R.E. and Young, B.R. (1963): Tonstein Bands in the Coalfields of the East Midlands; *Geological Magazine,* Volume 100, pages 47-58.

Elco Mining Ltd. (1978): Stage II Report, prepared for the Environment and Land Use Committee, as prescribed by the Guidelines for Coal Development, British Columbia.

Gibson, D.W. (1979): The Morrissey and Mist Mountain Formations – Newly Defined Lithostratigraphic Units of the Jura-Cretaceous Kootenay Group, Alberta and British Columbia; *Canadian Petroleum Geology,* Bulletin, Volume 27, pages 183-208.

Gibson, D.W. (1985): Stratigraphy, Sedimentology and Depositional Environments of the Coal-bearing Jurassic-Cretaceous Kootenay Group, Alberta and British Columbia; *Geological Survey of Canada,* Bulletin 357.

Goodarzi, F. (1987): Trace Element Concentration in Canadian Coals, II. Byron Creek Collieries, British Columbia; *Fuel,* Volume 66, pages 250-254.

Goodarzi, F., Grieve, D.A. and Labonté, M. (1990): Petrological, Mineralogical and Elemental Composition of Tonsteins in Relation to the Origin and Degree of Physical and Chemical Alteration in the East Kootenay Coalfields, Southeastern British Columbia; *Energy Sources,* Volume 12, pages 265-295.

Graham, P.S., Gunther, P.R. and Gibson, D.W. (1977): Geological Investigations of the Coal-bearing Kootenay Formation in the Subsurface of the Upper Elk River Valley, British Columbia; *in* Report of Activities, Part B, *Geological Survey of Canada,* Paper 77-1B, pages 203-210.

Grieve, D.A. (1984): Tonsteins: Possible Stratigraphic Correlation Aids in East Kootenay Coalfields; *in* Geological Fieldwork 1983, *B.C. Ministry of Energy, Mines and Petroleum Resources,* Paper 1984-1, pages 36-41.

Grieve, D.A. (1985): Coalfields of the East Kootenay Region, Southeastern British Columbia; *in* Coal in Canada, Patching, T.H., Editor, *Canadian Institute of Mining and Metallurgy,* Special Volume 31, pages 203-211.

Grieve, D.A. (1989): Stratigraphy of the Mist Mountain Formation (Jurassic-Cretaceous Kootenay Group) in the Elk Valley Coalfield, Southeastern British Columbia; *in* Advances in Western Canadian Coal Geoscience – Forum Proceedings, *Alberta Research Council Information Series,* Number 103, pages 24-41.

Grieve, D.A. and Elkins, P.R. (1986): Correlation and Comparison of Two Coal-bearing Zones Between Ewin Pass and Bare Mountain, Elk Valley Coalfield, Southeastern British Columbia; *in* Geological Fieldwork 1985, *B.C. Ministry of Energy, Mines and Petroleum Resources,* Paper 1986-1, Pages 17-23.

Grieve, D.A. and Fraser, J.M. (1985): Geology of the Elk Valley Coalfield, Southern Half (Kilmarnock Creek to Alexander Creek); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Preliminary Map 60.

Grieve, D.A. and Ollerenshaw, N.C. (1989): Stratigraphy of the Elk Formation in the Fernie Basin, Southeastern British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Paper 1989-2.

Grieve, D.A. and Pearson, D.E. (1983): Geology of the Greenhills Range, Elk Valley Coalfield; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Preliminary Map 51.

Grieve, D.A. and Price, R.A. (1985): Geological Setting of the South Half of the Elk Valley Coalfield, Southeastern British Columbia (Parts of 82G/15 and 82J/2); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Preliminary Map 63.

Hacquebard, P.A. and Cameron, A.R. (1989): Distribution and Coalification Patterns in Canadian Bituminous and Anthracite Coals; *International Journal of Coal Geology,* Volume 13, pages 207-260.

Hacquebard, P.A. and Donaldson, J.R. (1974): Rank Studies of Coals in the Rocky Mountains and Inner Foothills Belt, Canada; *in* Carbonaceous Materials as Indicators of Metamorphism, Dutcher, R.R., Hacquebard, P.A., Schopf, J.M. and Simon, J.A., Editors, *Geological Society of America,* Special Paper 153, pages 75-94.

Horie, H. (Editor) (1988): 1988 Coal Manual; *The TEX Report, Ltd.,* 528 pages.

Hughes, J.D. and Cameron, A.R. (1986): Modelling Maturation Regimes in the Kootenay Group, Alberta and British Columbia (abstract); *in* Proceedings, Western Canada Coal Geoscience Forum, Calgary, Alberta, November 1986, page 29.

Huryn, J.A. (1982): Ewin Creek Coal Licences, Exploration Progress Report; *B.C. Coal Ltd.,* open file assessment report, 22 pages.

ICCP (International Committee for Coal Petrology) (1963): Handbook of Coal Petrography, Second Edition; *Centre National de la Récherche Scientifique,* Paris, France.

Irvine, J.A. (1972): Exploration Techniques, Upper Elk Coal Field, British Columbia; *in* Proceedings of the First Geological Conference on Western Canadian Coal, Mellon, G.B., Kramers, J.W. and Seagel, E.J., Editors, *Research Council of Alberta,* Information Series, No. 60, pages 9-24.

Jansa, L. (1972): Depositional History of the Coal-bearing Upper Jurassic–Lower Cretaceous Kootenay Formation, Southern Rocky Mountains, Canada; *Geological Society of America,* Bulletin, Volume 83, pages 3199-3222.

Kilby, W.E. (1986a): British Columbia coal resource calculations, unpublished data.

Kilby, W.E. (1986b): Some Chemical and Mineralogical Characteristics of Tonsteins and Bentonites in Northeast British Columbia (93O,P,I;94A); *in* Geological Fieldwork 1985, *B.C. Ministry of Energy, Mines and Petroleum Resources,* Paper 1986-1, pages 139-149.

Kilby, W.E. (1988): Recognition of Vitrinite with Non-uniaxial Negative Reflectance Characteristics; *International Journal of Coal Geology,* Volume 9, pages 267-285.

Kilby, W.E. and Oppelt, H.P. (1985): Numerical Depositional Modelling – Gething Formation Along the Peace River; *in* Geological Fieldwork 1984, *B.C. Ministry of Energy, Mines and Petroleum Resources,* Paper 1985-1, pages 233-249.

Langenberg, W., MacDonald, D. and Kalkreuth, W. (in press): Sedimentological and Tectonic Controls on Coal Quality of a Thick Coastal Plain Coal in the Foothills of Alberta, Canada; *Geological Society of America,* Special Paper.

Leech, G.B. (1979): Kananaskis Lakes; *Geological Survey of Canada,* Open File 634.

Levine, J.R. and Davis, A. (1989): Reflectance Anisotropy of Upper Carboniferous Coals in the Appalachian Foreland Basin, Pennsylvania, U.S.A.; *International Journal of Coal Geology,* Volume 13, pages 431-373.

McCabe, P.J. (1984): Depositional Environments of Coal and Coal-bearing Strata; *in* Sedimentology of Coal and Coal-bearing Sequences, Rahmani, R.A. and Flores, R.M., Editors, *International Association of Sedimentologists,* Special Publication No. 7, pages 13-42.

McCabe, P.J. (1987): Facies Studies of Coal and Coal-bearing Strata; *in* Coal and Coal-bearing Strata, Scott, A.C., Editor, *Geological Society,* Special Publication No. 32, pages 51-66.

Mériaux, E. (1972): Les Tonsteins de la Veine de Charbon No. 10 (Balmer) à Sparwood Ridge dans le Bassin de Fernie (Columbie Britannique); *in* Report of Activities, *Geological Survey of Canada,* Paper 72-1B, pages 11-22.

Mériaux, E. (1974): A Propos de Quelques Tonsteins Observes dans les Veines de Charbon de la Formation de Kootenay en Colombie Britannique et en Alberta (Canada); *in* Report of Activities, *Geological Survey of Canada,* Paper 74-1, Part A, Page 7.

Moore, L.R. (1968): Some Sediments Closely Associated with Coal Seams; *in* Coal and Coal-bearing Strata, Murchison, D. and Westoll, S.T., Editors, *Oliver and Boyd,* Edinburgh, pages 105-123.

Morris, R.J. and Grieve, D.A. (1990): Geology of the Elk Valley Coalfield, Northern Half (Henretta Creek to Elk Lakes); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Preliminary Map 68.

Pearson, D.E. (1980): The Quality of Western Canadian Coking Coal; *Canadian Institute of Mining and Metallurgy,* Bulletin, Volume 73, pages 70-84.

Pearson, D.E. and Duff, P.McL.D. (1977): Studies in the East Kootenay Coalfields; *in* Geology in British Columbia 1975, *B.C. Ministry of Energy, Mines and Petroleum Resources,* pages G94-G99.

Pearson, D.E. and Grieve, D.A. (1980): Elk Valley Coalfield; *in* Geological Fieldwork 1979, *B.C. Ministry of Energy, Mines and Petroleum Resources,* Paper 1980-1, pages 91-96.

Pearson, D.E. and Grieve, D.A. (1985): Rank Variation, Coalification Pattern and Coal Quality in the Crowsnest Coalfield, British Columbia; *Canadian Institute of Mining and Metallurgy,* Bulletin, Volume 78, pages 39-46.

Pearson, J. and Murchison, D.G. (1990): Influence of a Sandstone Washout on the Properties of an Underlying Coal Seam; *Fuel,* Volume 69, pages 251-253.

Poulton, T.P. (1988): Major Interregionally Correlatable Events in the Jurassic of Western Interior, Arctic, and Eastern Offshore Canada; *in* Sequences, Stratigraphy, Sedimentology: Surface and Subsurface, James, D.P. and Leckie, D.A., Editors, *Canadian Society of Petroleum Geologists,* Memoir 15, pages 195-206.

Price, N.B. and Duff, P.McL.D. (1969): Mineralogy and Chemistry of Tonsteins from Carboniferous Sequences in Great Britain; *Sedimentology,* Volume 13, pages 45-69.

Price, R.A. (1962a): Geological Structure of the Central Part of the Rocky Mountains in the Vicinity of Crowsnest Pass; *Alberta Society of Petroleum Geology,* Journal, Volume 10, No. 7, pages 341-351.

Price, R.A. (1962b): Fernie East-half Map-area, Alberta and British Columbia; *Geological Survey of Canada,* Preliminary Paper 61-24, Report and Map 35-1961.

Price, R.A. (1980): The Cordilleran Foreland Thrust and Fold Belt in the Southern Canadian Rocky Mountains; *Geological Society of London,* Special Publication 9, 22 pages.

Price, R.A. and Grieve, D.A. (in press, a): Tornado Mountain (82G/15); *Geological Survey of Canada,* Map.

Price, R.A. and Grieve, D.A. (in press, b): Fording River (82J/2); *Geological Survey of Canada*, Map.

Rapson, J.E. (1965): Petrography and Derivation of Jurassic-Cretaceous Clastic Rocks, Southern Rocky Mountains, Canada; *American Association of Petroleum Geologists*, Bulletin, Volume 49, pages 1426-1452.

Ricketts, B.D. and Sweet, A.R. (1986); Stratigraphy, Sedimentology and Palynology of the Kootenay-Blairmore Transition in Southwestern Alberta and Southeastern British Columbia; *Geological Survey of Canada*, Paper 84-15.

Ruby, C.M., Horne, J.C. and Reinhart, P.J. (1981): Cretaceous Rocks of Western North America – A Guide to Terrigenous Clastic Rock Identification; *Research Planning Institute, Inc.*, 100 pages.

Schuller, A. and Hoehne, K. (1956): Petrographie, Chemismus und Facies der Tonsteine des Saargebiets; *Geologie*, Volume 5, pages 695-755.

Siemers, C.T. (1978): Generation of a Simplified Working Depositional Model for Repetitive Coal-bearing Sequences Using Field Data: An Example from the Upper Cretaceous Menefee Formation (Mesaverde Group), Northwestern New Mexico; *in* Proceedings of the Second Symposium on the Geology of Rocky Mountain Coal, Hodgson, H.E., Editor, *Colorado Geological Survey*, pages 1-22.

Smith, G.G. (1989): Coal Resources of Canada; *Geological Survey of Canada*, Paper 89-4, 146 pages.

Spears, D.A. and Kanaris-Sotiriou, R. (1979): A Geochemical and Mineralogical Investigation of Some British and Other European Tonsteins; *Sedimentology*, Volume 26, pages 407-425.

Spears, D.A., Duff, P.McL.D. and Caine, P.M. (1988): The West Waterberg Tonstein, South Africa; *International Journal of Coal Geology*, Volume 9, 221-233.

Stott, D.F. (1984): Cretaceous Sequences of the Foothills of the Canadian Rocky Mountains; *in* The Mesozoic of Middle North America, Stott, D.F. and Glass, D., Editors, *Canadian Society of Petroleum Geologists*, Memoir 9, pages 85-107.

Ting, F.T.C. (1978): *in* Analytical Methods for Coal and Coal Products, Volume 1, Karr, C., Editor, *Academic Press*, New York, pages 3-26.

Walker, R.G. and Cant, D.J. (1984): Sandy Fluvial Systems; *in* Facies Models, Second Edition, Walker, R.G., Editor, *Geoscience Canada*, Reprint Series 1, pages 71-89.

Williamson, I.A. (1961): Tonsteins: A Possible Additional Aid to Coalfield Correlation: *Mining Magazine*, Volume 104, pages 9-14.

Williamson, I.A. (1967): Coal Mining Geology; *Oxford University Press*, 266 pages.

APPENDIX 1
MEASURED SECTIONS – ELK VALLEY COALFIELD

Section 1

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SILTSTONE	Fining upward; base of unit is top of Morrissey Formation	0.0	0.5
COAL		0.5	1.1
INTERBEDDED SHALE AND COAL		1.1	1.6
MUDSTONE	Silty	1.6	2.9
COAL		2.9	3.6
MUDSTONE	Silty	3.6	4.2
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: fine grained; unit fines to siltstone at top	4.2	5.0
SILTSTONE OVERLAIN BY MUDSTONE	Siltstone: dark grey; mudstone: black; fining-upward unit	5.0	5.4
COAL WITH SHALE BANDS	Shale rare, in thin bands	5.4	9.5
INTERBEDDED SILTSTONE AND SANDSTONE	Siltstone: platy; sandstone: very fine grained	9.5	10.7
SILTSTONE WITH SANDSTONE INTERBEDS	Sandstone: very fine grained; orange weathering	10.7	15.2
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: carbonaceous; black; siltstone: blocky	15.2	17.2
COAL		17.2	19.0
MUDSTONE	Dark grey; rubbly	19.0	20.3
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; fining-upward unit	20.3	22.7
SILTSTONE	Dark grey; recessive	22.7	27.1
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: fine grained; siltstone: thin bedded	27.1	27.9
SILTSTONE	Calcareous and orange weathering at top of unit	27.9	29.0
MUDSTONE	Dark grey; rubbly; recessive	29.0	34.5
SILTSTONE	Calcareous and orange weathering at top of unit	34.5	35.8
INTERBEDDED MUDSTONE AND SILTSTONE	Recessive	35.8	39.3
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	39.3	40.3
SILTSTONE WITH SANDSTONE INTERBEDS	Recessive; sandstone: fine grained	40.3	44.6
SILTSTONE	Carbonaceous; black	44.6	45.8
PARTLY COVERED	Predominantly silty mudstone	45.8	47.8
MAINLY COVERED	Carbonaceous interval, probably mainly coal in uppermost 1 m	47.8	49.3
SHALE	Carbonaceous	49.3	49.7
MUDSTONE WITH SILTSTONE AND SANDSTONE	Mudstone: concretionary; siltstone and sandstone: two coarsening-upward sequences	49.7	53.7
INTERBEDDED SANDSTONE AND SILTSTONE	Coarsening-upward sequences of siltstone to fine-grained sandstone	53.7	55.7
SANDSTONE	In part ripple crosslaminated, in part flaggy	57.7	60.7
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; calcareous, orange-weathering siltstone at top	60.7	64.5
PARTLY COVERED	Predominantly siltstone	64.5	72.0
INTERBEDDED MUDSTONE AND SILTSTONE	Mudstone: black; siltstone: orange weathering	72.0	75.0
PARTLY COVERED	Predominantly siltstone; some interbedded fine-grained sandstone near top	75.0	76.5
INTERBEDDED SILTSTONE AND MUDSTONE		76.5	84.0
MUDSTONE WITH COAL BANDS	Mudstone: black; rubbly	84.0	86.2
INTERBEDDED COAL AND SHALE	Shale: carbonaceous	86.2	86.8
COAL	Hard; dull	86.8	90.0
SANDSTONE WITH SILTSTONE INTERBEDS	Fining-upward unit; sandstone: fine grained	90.0	92.4
SILTSTONE	Some distinct orange-weathering bands	92.4	94.2
MUDSTONE WITH COAL BANDS	Mudstone: black; rubbly; coal: bright	94.2	95.8
SILTSTONE	Dark grey	95.8	96.8
MUDSTONE	Dark grey; carbonaceous	96.8	97.8
COAL	Hard; mudstone parting 30 cm below roof	97.8	100.1
SILTSTONE	Dark grey	100.1	101.4
COAL	Dull; hard	101.4	105.8

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SILTSTONE WITH MUDSTONE INTERBEDS	Mudstone: rubbly	105.8	107.1
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: fine grained	107.1	108.2
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: silty	108.2	109.7
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	109.7	112.5
MUDSTONE	Silty; partly carbonaceous	112.5	114.2
SILTSTONE	Orange-weathering bed at base	114.2	114.9
SANDSTONE WITH SILTSTONE INTERBEDS		114.9	115.6
INTERBEDDED MUDSTONE AND SILTSTONE	Mudstone: carbonaceous	115.6	117.1
MUDSTONE	Carbonaceous in part	117.1	121.1
COAL	Hard; dull	121.1	122.7
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: grey; rubbly; siltstone: orange weathering	122.7	127.7
SANDSTONE	Very fine grained; orange weathering	127.7	128.3
MUDSTONE	Dark grey; rubbly	128.3	130.8
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine grained	130.8	132.1
SILTSTONE	Dark grey	132.1	134.6
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; dark grey; carbonaceous; siltstone: light grey weathering; iron stained	134.6	139.6
INTERBEDDED MUDSTONE AND SILTSTONE	All dark grey; mudstone at base, siltstone at top	139.6	143.0
SILTSTONE	Orange-weathering beds	143.0	145.3
SANDSTONE	Lower contact scoured; fines upward, medium to fine grained	145.3	148.3
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	148.3	155.7
INTERBEDDED SILTSTONE AND MUDSTONE		155.7	160.2
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: rubbly; dark grey	160.2	167.2
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: very fine grained	167.2	168.5
MAINLY COVERED	Probably mudstone	168.5	170.3
PARTLY COVERED	Predominantly coal	170.3	176.3
INTERBEDDED MUDSTONE AND SILTSTONE		176.3	181.2
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	181.2	182.7
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine grained	182.7	187.0
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	187.0	191.5
SILTSTONE		191.5	193.5
INTERBEDDED SILTSTONE AND SANDSTONE	Sandstone: fine grained	193.5	198.0
MUDSTONE WITH COAL BANDS	Mudstone: carbonaceous; black; coal: bright	198.0	201.0
COAL		201.0	204.1
SILTSTONE	Light grey weathering	204.1	205.5
LIMESTONE	Lenticular pod; orange weathering	205.5	206.4
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine grained	206.4	207.1
SILTSTONE WITH SANDSTONE INTERBEDS	Siltstone: light grey weathering; sandstone: fine grained	207.1	213.2
INTERBEDDED SILTSTONE AND MUDSTONE		213.2	216.0
INTERBEDDED MUDSTONE AND SHALE	Mudstone: dark grey	216.0	218.5
COAL	Very hard; two 1 to 2 cm thick tonsteins, 50 and 60 cm below roof; both sampled	218.5	221.7
MUDSTONE WITH COAL BANDS	Mudstone: black; friable; coal: bright; tonstein (?) 30 cm above base	221.7	223.2
INTERBEDDED SILTSTONE AND MUDSTONE		223.2	227.7
PARTLY COVERED	Predominantly siltstone	227.7	230.7
COAL	Hard; bright	230.7	231.5

Lithology	Description	Base of Interval (m)	Top of Interval (m)
MUDSTONE	Rubbly; some concretionary, orange-weathering layers	231.5	232.3
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; ripple crosslaminated; siltstone: fissile	232.3	233.0
SILTSTONE	Brownish grey	233.0	234.0
PARTLY COVERED	Predominantly dark grey and black, rubbly mudstone	234.0	246.0
SILTSTONE WITH SANDSTONE AND MUDSTONE INTERBEDS	Siltstone: grey brown; sandstone: very fine grained; mudstone: dark grey	246.0	249.5
MUDSTONE	Dark grey; rubbly	249.5	250.9
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: very fine grained	250.9	252.6
INTERBEDDED SANDSTONE, SILTSTONE AND MUDSTONE	Sandstone: very fine grained; siltstone: brown; mudstone: black	252.6	258.1
MUDSTONE	Black; rubbly	258.1	259.2
COAL		259.2	261.0
MUDSTONE WITH COAL INTERBEDS	Mudstone: black	261.0	262.5
MUDSTONE WITH SILTSTONE INTERBEDS		262.5	266.5
INTERMIXED MUDSTONE AND SILTSTONE	Chaotic mixture of over and underlying units	266.5	267.9
SILTSTONE	Orange weathering; calcareous	267.9	269.4
MUDSTONE	Dark grey; rubbly	269.4	270.4
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: very fine grained	270.4	271.9
MUDSTONE	Grey; rubbly	271.9	273.4
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	273.4	274.3
COAL		274.3	277.1
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: brown; silty	277.1	284.4
SILTSTONE WITH MUDSTONE AND SANDSTONE INTERBEDS	Sandstone: very fine grained	284.4	291.7
PARTLY COVERED	Exposures of siltstone and mudstone	291.7	295.7
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: fine grained	295.7	297.4
INTERBEDDED MUDSTONE AND SILTSTONE	Recessive unit; mudstone: in part silty; siltstone: in part orange weathering	297.4	316.9
COAL		316.9	317.0
INTERBEDDED MUDSTONE AND SILTSTONE	Mudstone: in part black and carbonaceous, in part silty; siltstone: orange weathering	317.0	326.9
SILTSTONE	In part fissile, in part orange weathering	326.9	327.8
MUDSTONE AND SILTSTONE	Same as unit underlying previous	327.8	329.0
INTERBEDDED SILTSTONE, MUDSTONE AND SANDSTONE	Sandstone: very fine grained	329.0	330.4
INTERBEDDED SILTSTONE, MUDSTONE AND SANDSTONE	Sandstone: fine grained; restricted to upper portion of unit	330.4	343.9
MUDSTONE	Black; carbonaceous	343.9	345.4
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	345.4	346.9
COVERED	Evidence of carbonaceous material (coal?)	346.9	348.4
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	348.4	351.0
SHALE	Carbonaceous	351.0	351.4
COAL		351.4	358.9
MUDSTONE	Silty; carbonaceous at top	358.9	363.4
SILTSTONE WITH SANDSTONE INTERBEDS	Siltstone: orange weathering; crosslaminated; sandstone: fine grained; crosslaminated	363.4	366.6
PARTLY COVERED	Predominantly dark grey/brown siltstone with dark grey mudstone interbeds	366.6	378.5
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	378.5	381.2
SANDSTONE	Fine grained; crosslaminated	381.2	383.5
SILTSTONE	Dark grey; blocky	383.5	383.9
INTERBEDDED SILTSTONE AND MUDSTONE		383.9	388.3
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	388.3	391.2
INTERBEDDED MUDSTONE AND SHALE	Mudstone: black; rubbly; concretionary layers; forms base of unit; shale: black; coal banded; at top	391.2	392.0
COAL		392.0	396.5
INTERBEDDED COAL AND SHALE	Coal: 10 to 20 cm thick bands	396.5	399.5
MUDSTONE	Silty; rubbly	399.5	402.5

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SILTSTONE	Contains 1 m diameter irregular bodies of orange-weathering, calcareous siltstone	402.5	404.0
SILTSTONE	Contains orange-weathering, calcareous layers	404.0	411.5
SILTSTONE WITH MUDSTONE INTERBEDS	Mudstone: silty	411.5	420.5
MUDSTONE WITH SILTSTONE INTERBEDS		420.5	422.4
SHALE WITH COAL BANDS	Shale: carbonaceous	422.4	422.9
INTERBEDDED SHALE AND COAL	Shale: carbonaceous; coal: beds up to 20 cm thick	422.9	423.8
INTERBEDDED SHALE AND SILTSTONE	Shale: black; carbonaceous; siltstone: dark grey; fissile	423.8	424.3
COAL		424.3	428.7
INTERBEDDED COAL AND SHALE	Coal: beds up to 5 cm thick	428.7	429.8
MUDSTONE	Silty	429.8	431.3
INTERBEDDED SHALE AND COAL		431.3	432.1
COAL		432.1	433.1
MUDSTONE	Rubbly	433.1	433.9
COAL WITH SHALE BANDS		433.9	434.6
COAL		434.6	437.2
SILTSTONE		437.2	437.8
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: fine grained; orange weathering	437.8	438.7
SILTSTONE	Contains orange-weathering layers	438.7	444.5
SILTSTONE	Bluff forming; buff to orange weathering; calcareous, especially in uppermost 1 m	444.5	449.7
INTERBEDDED MUDSTONE AND SILTSTONE	Mudstone: silty; siltstone: thin bedded; similar to underlying unit	449.7	453.9
SANDSTONE	Fine grained	453.9	454.7
INTERBEDDED MUDSTONE AND SILTSTONE	Mudstone: silty	454.7	456.9
SILTSTONE	Resistant; similar to 444.5 to 449.7	456.9	458.6
MUDSTONE	Dark grey; rubbly	458.6	460.1
SILTSTONE	Resistant	460.1	461.1
MUDSTONE	Dark grey; rubbly	461.1	468.6
SILTSTONE	Resistant; orange weathering; similar to 444.5 to 449.7	468.6	469.4
MAINLY COVERED	Siltstone ?	469.4	476.7
SANDSTONE WITH SILTSTONE INTERBEDS		476.7	478.9
MAINLY COVERED	Siltstone and mudstone ?	478.9	487.4
MUDSTONE	Carbonaceous zones	487.4	490.3
COAL WITH SHALE BAND	Shale band near top	490.3	490.9
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: fine grained; thin bedded	490.9	492.4
COAL		492.4	499.6
INTERBEDDED SHALE AND MUDSTONE	Shale: carbonaceous	499.6	501.6
COAL WITH SHALE BAND	Shale band 10 cm thick	501.6	503.4
MUDSTONE	Silty	503.4	507.9
SANDSTONE	Bluff forming; medium and coarse grained; large-scale crossbedded; thickness a minimum	507.9	513.0

Section 2

Lithology	Description	Base of Interval (m)	Top of Interval (m)
INTERBEDDED MUDSTONE, SHALE AND COAL	Shale: carbonaceous; coal: beds to 20 cm thick; base does not correspond with base of formation	0.0	4.1
COAL	Contains a 5 cm thick siderite band and 10 cm thick shale bed	4.1	5.3
INTERBEDDED SHALE AND COAL	Shale: carbonaceous; unit contains a 3.5 cm thick tonstein	5.3	6.5
COAL		6.5	9.1
SHALE	Carbonaceous	9.1	9.7
COAL		9.7	12.4
SANDSTONE	Medium to fine grained; thin bedded to flaggy; low-angle, large-scale crossbedded	12.4	16.6
INTERBEDDED SANDSTONE AND SILTSTONE	Bedding thickness 10 to 40 cm; sandstone: fine grained	16.6	31.4
SILTSTONE WITH MUDSTONE PARTINGS	Spheroidal weathering	31.4	33.2
MUDSTONE	Medium and dark grey	33.2	43.2
INTERBEDDED SANDSTONE AND SILTSTONE	Thin bedded; sandstone: fine grained	43.2	45.9
INTERBEDDED SILTSTONE AND MUDSTONE		45.9	49.6
SANDSTONE WITH SILTSTONE AND COAL PARTINGS	Sandstone: fine grained; coal: concentrated near top of unit	49.6	56.6
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	56.6	58.4
SILTSTONE WITH SANDSTONE AND MUDSTONE INTERBEDS	Sandstone: very fine grained	58.4	61.1
INTERBEDDED MUDSTONE, SHALE AND COAL	Shale: carbonaceous	61.1	65.8
COAL		65.8	66.3
MUDSTONE WITH COAL STRINGERS	Mudstone: carbonaceous near top; coal: concentrated near top	66.3	67.2
INTERBEDDED COAL AND SHALE	Coal: in beds up to 25 cm thick	67.2	68.4
COAL		68.4	68.8
SHALE	Carbonaceous	68.8	69.2
MUDSTONE	Orange weathering	69.2	70.3
COAL		70.3	72.5
SANDSTONE	Fine grained; small-scale crosslaminated; silty at top	72.5	73.9
COAL	Hard; blocky; sheared	73.9	75.1
MUDSTONE	Fe-rich near base	75.1	76.2
COAL		76.2	77.0
MUDSTONE WITH COAL STRINGERS	Mudstone: orange weathering; concretionary; coal: top 40 cm of unit	77.0	80.0
COAL		80.0	81.7
MUDSTONE WITH SHALE INTERBEDS	Shale: carbonaceous	81.7	83.2
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine grained; crosslaminated; flaggy	83.2	83.7
SILTSTONE WITH MUDSTONE PARTINGS		83.7	85.7
SANDSTONE WITH SILTSTONE INTERBEDS		85.7	88.2
SANDSTONE	Fine grained; orange weathering; fines upward into overlying unit	88.2	90.9
INTERBEDDED SILTSTONE, MUDSTONE AND SHALE	Shale: carbonaceous	90.9	95.6
SHALE WITH COAL STRINGERS	Shale: black; carbonaceous	95.6	97.9
INTERBEDDED MUDSTONE AND SILTSTONE	Coarsening-upward unit; mudstone overlies siltstone	97.9	99.1
INTERBEDDED SANDSTONE AND SILTSTONE	Fining-upward unit; sandstone: very fine grained; forms base of unit; siltstone: forms top of unit	99.1	102.2
INTERBEDDED SILTSTONE AND MUDSTONE	Bedding thickness 20 to 70 cm	102.2	107.7
SANDSTONE	Medium grained; tree casts; calcareous	107.7	108.7
SILTSTONE WITH MUDSTONE INTERBEDS	Mudstone: light grey weathering; occurs at top of unit; unit contains large ironstone concretions	108.7	111.0
MUDSTONE WITH COAL INTERBEDS	Coal: occurs near top of unit	111.0	113.5

Lithology	Description	Base of Interval (m)	Top of Interval (m)
INTERBEDDED SANDSTONE AND SILTSTONE	Light grey weathering; fining-upward unit; sandstone: fine grained; occurs at base of unit	113.5	114.2
COAL		114.2	116.2
INTERBEDDED SILTSTONE AND MUDSTONE	Orange weathering; same unit across creek has sand lenses and beds	116.2	130.7
INTERBEDDED SHALE AND COAL	Shale: carbonaceous; coal: one 50 cm thick bed	130.7	132.7
MUDSTONE		132.7	138.1
COAL		138.1	140.0
MUDSTONE	Dark grey	140.0	140.7
INTERBEDDED SILTSTONE AND MUDSTONE		140.7	145.6
INTERBEDDED SILTSTONE AND SHALE	Shale: black; some carbonaceous	145.6	152.4
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: very fine grained	152.4	155.4
MUDSTONE WITH SILTSTONE INTERBEDS		155.4	157.8
SILTSTONE WITH MUDSTONE INTERBEDS		157.8	161.4
MUDSTONE	Dark grey	161.4	161.9
COAL		161.9	164.6
MUDSTONE	Dark grey	164.6	164.8
SILTSTONE WITH MUDSTONE PARTINGS	Siltstone: thin bedded	164.8	168.2
INTERBEDDED SANDSTONE AND SILTSTONE	Fining-upward unit; well laminated and cross laminated; sandstone: very fine grained; occurs at base	168.2	171.2
MUDSTONE	Black at top	171.2	172.0
INTERBEDDED COAL AND SHALE		172.0	175.2
INTERBEDDED SANDSTONE AND SILTSTONE	Fining-upward unit; orange weathering; sandstone: very fine grained; forms base of unit	175.2	179.1
INTERBEDDED MUDSTONE AND SHALE	Shale: carbonaceous	179.1	186.6
INTERBEDDED SILTSTONE AND MUDSTONE	Siltstone: blocky; calcareous, orange weathering at top of unit	186.6	191.3
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: in part carbonaceous	191.3	194.5
COAL		194.5	195.3
MUDSTONE WITH SILTSTONE INTERBEDS		195.3	196.8
SILTSTONE WITH SHALE INTERBEDS		196.8	198.6
MUDSTONE	Concretionary layer at base	198.6	199.6
COAL	Apparent faulting at footwall	199.6	204.0
SILTSTONE WITH MUDSTONE PARTINGS	Siltstone: in beds up to 40 cm thick	204.0	216.9
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	216.9	217.9
MUDSTONE WITH SILTSTONE INTERBEDS		217.9	219.3
SILTSTONE WITH MUDSTONE INTERBEDS AND PARTINGS	Orange weathering	219.3	221.3
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: dark grey	221.3	223.8
SILTSTONE WITH SHALE PARTINGS		223.8	224.7
MUDSTONE	Dark grey; fissile	224.7	225.8
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: very fine grained	225.8	226.7
SILTSTONE WITH MUDSTONE INTERBEDS	Mudstone: concretionary	226.7	228.7
SANDSTONE WITH SHALE PARTINGS	Sandstone: very fine grained	228.7	230.7
PARTLY COVERED	Siltstone	230.7	231.8
COVERED	Some siltstone exposed	231.8	238.8
PARTLY COVERED	Shale exposed, in part carbonaceous	238.8	244.1
SANDSTONE	Very fine grained; orange weathering	244.1	245.2
INTERBEDDED SILTSTONE AND MUDSTONE	Siltstone beds up to 80 cm	245.2	249.9
INTERBEDDED SILTSTONE, MUDSTONE, SHALE AND COAL	Shale: carbonaceous; coal: 3 beds, 10 to 30 cm thick	249.9	255.9
COAL	Shaly at top and base	255.9	256.4
INTERBEDDED SILTSTONE, SANDSTONE, MUDSTONE & SHALE		256.4	257.5
SANDSTONE	Bluff-forming; buff weathering; massive; calcareous	257.5	259.5

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COAL	Very bright; gouge zone at lower contact	259.5	261.4
MUDSTONE		261.4	262.5
INTERBEDDED SILTSTONE AND MUD-STONE		262.5	263.8
SILTSTONE WITH MUDSTONE PART-INGS	Siltstone: medium bedded	263.8	266.8
MUDSTONE	Silty; rubbly	266.8	267.8
SILTSTONE WITH MUDSTONE INTER-BEDS AND PARTINGS		267.8	271.2
INTERBEDDED COAL AND MUDSTONE		271.2	272.8
SILTSTONE	Orange weathering; calcareous	272.8	273.9
COAL	Gouge zone at base	273.9	274.9
SILTSTONE	Orange weathering; calcareous	274.9	276.2
COAL	Interbedded shale in basal half metre	276.2	279.5
PARTLY COVERED	Interbedded siltstone and mudstone	279.5	284.2
SANDSTONE	Fine grained; thin to medium bedded; silty partings near top	284.2	287.7
COVERED	Semi-recessive	287.7	293.2
SANDSTONE	Medium grained	293.2	302.2
MUDSTONE		302.2	304.2
SANDSTONE	Thickness a minimum	304.2	307.0

Section 3

Lithology	Description	Base of Interval (m)	Top of Interval (m)
INTERBEDDED SHALE AND MUD-STONE	Brown	0.0	7.8
SHALE WITH SILTSTONE INTERBEDS	Shale: black and brown; siltstone: ironstone concretions	7.8	10.4
SHALE	Black; carbonaceous	10.4	11.6
SILTSTONE	Fe-rich	11.6	12.3
SHALE WITH SILTSTONE INTERBEDS	Shale: black	12.3	14.5
COAL	Bright	14.5	16.4
INTERBEDDED SHALE AND SILT-STONE	Shale: black	16.4	17.6
COAL		17.6	18.3
SHALE	Black and brown	18.3	20.9
SANDSTONE	Fine to medium grained; brown; laminated	20.9	21.5
SILTSTONE	Carbonaceous; in part Fe-rich	21.5	24.4
SILTSTONE	Brown to black	24.4	26.1
SHALE	Carbonaceous	26.1	30.3
COAL		30.3	32.0
SHALE	Black	32.0	33.7
INTERBEDD SILTSTONE AND MUD-STONE	Brown yellow	33.7	34.1
SHALE	Black	34.1	37.0
SANDSTONE WITH SILTSTONE INTER-BEDS	Sandstone: fine grained; laminated; thin bedded; brown	37.0	40.0
SANDSTONE	Medium to coarse grained; grey salt and pepper	40.0	43.4
SHALE	Black	43.4	46.6
INTERBEDDED SANDSTONE AND SILT-STONE	Laminated; brown	46.6	58.1
SHALE	Black; carbonaceous	58.1	60.9
SANDSTONE	Medium-coarse grained; light grey; salt and pepper; thin bedded; laminated; erosional lower contact	60.9	65.9
INTERBEDDED SANDSTONE AND SILT-STONE		65.9	68.9
SHALE	Black	68.9	69.2
INTERBEDDED SANDSTONE AND SILT-STONE		69.2	76.7
INTERBEDDED SANDSTONE AND SILT-STONE		76.7	81.6
SHALE	Black	81.6	82.3
SANDSTONE		82.3	82.6
SHALE	Black	82.6	86.0
COAL	Hard	86.0	87.5
SHALE	Black	87.5	88.6
INTERBEDDED SANDSTONE AND SILT-STONE		88.6	89.3
INTERBEDDED SANDSTONE AND SILT-STONE		89.3	91.1
SHALE	Black	91.1	92.7
COAL		92.7	95.2
SHALE	Black	95.2	99.9
INTERBEDDED SANDSTONE AND SILT-STONE		99.9	102.5
SHALE	Black; carbonaceous	102.5	104.0
SANDSTONE		104.0	104.9
SHALE WITH MINOR COAL INTER-BEDS		104.9	106.7
SANDSTONE	Fines upward; coarse grained at base	106.7	119.2
SILTSTONE		119.2	120.1
SHALE	Black	120.1	121.7
SANDSTONE	Coarse grained	121.7	127.7

Section 4

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COVERED		0.0	9.0
INTERBEDDED SHALE AND SILT-STONE	Brown	9.0	14.0
COVERED		14.0	22.4
SHALE	Black and brown	22.4	24.3
SANDSTONE	Medium grained; laminated; grey brown	24.3	27.5
COVERED		27.5	35.5
COVERED	Fine-grained sandstone float; brown; laminated	35.5	43.7
SANDSTONE	Fine grained; laminated; grey brown	43.7	46.7
SANDSTONE		46.7	47.3
SHALE	Black	47.3	48.1
COAL		48.1	48.5
SHALE	Black	48.5	49.2
SANDSTONE	Fine grained; medium bedded; grey	49.2	51.6
INTERBEDDED SILTSTONE AND SAND-STONE		51.6	53.8
INTERBEDDED SHALE AND SILT-STONE		53.8	56.2
SANDSTONE	Fine grained; grey; thin bedded; laminated	56.2	57.5
INTERBEDDED SHALE AND SILT-STONE	Black	57.5	61.0
SILTSTONE	Rusty	61.0	61.4
INTERBEDDED SHALE AND SILT-STONE	Black	61.4	63.2
COAL		63.2	64.1
SHALE	Black; carbonaceous	64.1	66.1
COAL		66.1	66.9
SHALE	Brown	66.9	68.6
SANDSTONE	Brown and grey	68.6	73.9
INTERBEDDED SILTSTONE AND SHALE	In part black	73.9	78.0
SANDSTONE WITH MINOR SILTSTONE INTERBEDS	Sandstone: fine to medium grained; thin bedded; grey	78.0	88.4
INTERBEDDED SHALE AND SILT-STONE	Dominantly black	88.4	93.5
INTERBEDDED SHALE AND SILT-STONE	Black	93.5	96.0
SANDSTONE	Fine grained; grey	96.0	96.5
INTERBEDDED SHALE AND SILT-STONE	Shale: black	96.5	98.5
COAL		98.5	99.5
SHALE	Black	99.5	102.0
COAL		102.0	103.0
INTERBEDDED SHALE AND SILT-STONE		103.0	108.3
SHALE	Black	108.3	110.7
SANDSTONE	Fine grained; sandstone	110.7	112.6
SILTSTONE	Grey	112.6	113.6
SHALE	Black	113.6	116.1
COAL		116.1	117.0
INTERBEDDED SILSTSONE AND SHALE	Black and brown	117.0	118.3
SANDSTONE	Fine grained; grey	118.3	121.9
SANDSTONE		121.9	123.1
INTERBEDDED SILTSTONE AND SAND-STONE		123.1	129.7
SHALE	Brown	129.7	131.8
SHALE	Black; very coaly	131.8	134.7
SHALE	Black	134.7	135.5
COAL	Very dirty	135.5	136.4
SHALE	Black; brown	136.4	139.1

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SANDSTONE		139.1	144.0
INTERBEDDED SHALE AND SILT-STONE		144.0	148.0
INTERBEDDED SILTSTONE AND SAND-STONE		148.0	150.1
SHALE	Black	150.1	152.2
INTERBEDDED SILTSTONE AND SAND-STONE		152.2	153.9
SHALE	Black	153.9	159.4
COAL		159.4	164.2
SHALE	Black; brown	164.2	167.2
SANDSTONE		167.2	176.1
SANDSTONE	Fine grained; thin bedded; grey	176.1	188.1
SHALE	Black	188.1	203.1
COAL		203.1	204.7
SHALE	Black	204.7	207.9
COAL WITH SHALE INTERBEDS		207.9	210.6
SANDSTONE		210.6	211.7
SHALE	Black	211.7	213.3
SANDSTONE	Fine grained; brown	213.3	215.4
SHALE	Black to brown	215.4	219.7
SANDSTONE		219.7	224.0
INTERBEDDED SHALE AND SILT-STONE	Shale: brown	224.0	231.9
COAL		231.9	232.4
SHALE	Black; carbonaceous	232.4	238.7
INTERBEDDED SILTSTONE AND SNDSTONE	Rusty	238.7	239.8
SANDSTONE	Rusty brown	239.8	245.8
COVERED	Float of siltstone and black shale	245.8	254.8
INTERBEDDED SILTSTONE AND SAND-STONE		254.8	258.6
COVERED		258.6	259.5
COAL		259.5	260.9
SHALE	Black; carbonaceous	260.9	263.4
COAL		263.4	265.1
INTERBEDDED SILTSTONE AND SHALE	Brown	265.1	268.9
INTERBEDDED SILTSTONE AND SAND-STONE	Brown	268.9	277.2
SHALE	Black	277.2	281.7
INTERBEDDED SILTSTONE AND SAND-STONE	Brown; rusty	281.7	288.6
SHALE	Black	288.6	300.6
COAL		300.6	305.8
SHALE	Black	305.8	307.9
INTERBEDDED SILTSTONE AND SAND-STONE	Laminated	307.9	318.4
INTERBEDDED SHALE AND SILT-STONE	Brown and black	318.4	321.7
INTERBEDDED SHALE AND SILT-STONE	Grey black	321.7	338.0
SHALE	Black; some rusty siltstone	338.0	344.0
COAL		344.0	346.9
INTERBEDDED SILTSTONE AND SAND-STONE		346.9	348.6
SHALE	Black	348.6	351.5
INTERBEDDED SILTSTONE AND SAND-STONE		351.5	353.2
SHALE	Black to brown	353.2	354.9
INTERBEDDED SHALE AND SILT-STONE		354.9	357.8
INTERBEDDED SILTSTONE AND SAND-STONE		357.8	368.2
SANDSTONE	Fine grained; brown; laminated	368.2	372.2
SANDSTONE		372.2	375.1
INTERBEDDED SILTSTONE AND SHALE		375.1	378.0
SANDSTONE	Fine to medium grained; laminated; brown	378.0	381.5

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COAL		381.5	383.2
SANDSTONE	Contains some chert pebbles	383.2	388.5
SANDSTONE	Medium to coarse grained; grey	388.5	403.0
SANDSTONE	Very coarse grained; red stained	403.0	417.5
COVERED	Sandstone float	417.5	424.8
COVERED	Siltstone and shale float	424.8	432.9
COVERED	Shale debris	432.9	444.3
COAL		444.3	449.5
COVERED	Possibly coal	449.5	451.7
SANDSTONE	Laminated; brown	451.7	453.8
INTERBEDDED SILTSTONE, SHALE AND MINOR SANDSTONE		453.8	465.8
INTERBEDED SILTSTONE AND SAND-STONE		465.8	468.2
SANDSTONE	Brown and grey	468.2	480.2
SANDSTONE		480.2	487.8
INTERBEDDED SILTSTONE AND SHALE		487.8	492.0
COVERED		492.0	494.5
COVERED	Float of shale and siltstone	494.5	496.9
INTERBEDDED SILTSTONE, SAND-STONE AND MINOR SHALE		496.9	509.4
SHALE	Black	509.4	510.8
COAL		510.8	512.2
SANDSTONE	Fine to medium grained; medium bedded; grey; minor black shale near top	512.2	523.5
INTERBEDDED SILTSTONE, SAND-STONE AND SHALE		523.5	532.9
COAL		532.9	533.3
INTERBEDDED SHALE AND SILT-STONE		533.3	535.9
SANDSTONE		535.9	537.3
SHALE		537.3	543.6
SHALE	Black; very carbonaceous	543.6	548.0
SANDSTONE		548.0	551.8
SHALE	Brown	551.8	554.0
SANDSTONE		554.0	555.3
COAL		555.3	557.5
SANDSTONE WITH SHALE INTERBEDS	Base of unit = Elk/Mist Mountain contact	557.5	564.0

Section 5

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COAL	Base of unit = top of Morrissey Formation	0.0	1.0
SILTSTONE WITH SANDSTONE INTERBEDS		1.0	10.7
COAL		10.7	11.1
COVERED INTERVAL		11.1	65.3
SANDSTONE	Locally coarse grained; well crosslaminated	65.3	96.3
SILTSTONE		96.3	115.0
INTERBEDDED SANDSTONE AND SILTSTONE		115.0	129.0
SANDSTONE WITH MINOR SILTSTONE INTERBEDS	Resistant	129.0	157.0
SILTSTONE		157.0	162.5
COAL		162.5	165.9
SILTSTONE		165.9	171.9
SANDSTONE		171.9	200.0
SANDSTONE	Interbedded, fine and medium grained	200.0	206.0
INTERBEDDED SANDSTONE AND SILTSTONE		206.0	211.0
SILTSTONE		211.0	218.0
COAL		218.0	219.8
SANDSTONE	Resistant	219.8	235.0
INTERBEDDED SILTSTONE AND SANDSTONE		235.0	238.0
COVERED INTERVAL		238.0	257.0
SANDSTONE	Dark grey; fine grained	257.0	266.0
SANDSTONE		266.0	280.0
SILTSTONE	Orange weathering	280.0	281.0
SILTSTONE	Grey	281.0	285.0
SILTSTONE	Orange weathering	285.0	286.0
SILTSTONE		286.0	296.0
COAL		296.0	297.5
COVERED INTERVAL	Siltstone?	297.5	303.5
COVERED INTERVAL		303.5	330.0
SANDSTONE	Fine grained	330.0	333.0
COAL		333.0	335.2
COVERED INTERVAL		335.2	365.0
SANDSTONE WITH SILTSTONE INTERBEDS		365.0	379.0
SILTSTONE		379.0	381.5
COAL		381.5	382.8
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; thinly interbedded unit	382.8	384.8
SILTSTONE		384.8	391.0
COAL		391.0	393.4
SILTSTONE		393.4	394.0
SANDSTONE		394.0	454.5
SANDSTONE	Fine grained	454.5	457.0
SILTSTONE		457.0	464.0
SANDSTONE	Fine grained	464.0	468.0
SILTSTONE		468.0	469.0
SHALE	Carbonaceous	469.0	469.3
COAL		469.3	470.0
COVERED INTERVAL		470.0	483.0
SANDSTONE	Interbedded coarse grained and fine grained	483.0	494.0
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	494.0	498.0
SILTSTONE	Orange weathering	498.0	498.7
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	498.7	502.0
SILTSTONE		502.0	502.5

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COAL		502.5	502.8
INTERBEDDED SILTSTONE AND COAL		502.8	503.8
SILTSTONE		503.8	506.6
COAL		506.6	506.9
SHALE	Carbonaceous	506.9	507.6
COAL		507.6	510.4
SHALE		510.4	516.0
MUDSTONE	Orange weathering	516.0	516.8
SILTSTONE		516.8	519.8
COAL		519.8	521.0
SHALE	Carbonaceous	521.0	522.0
COAL		522.0	523.4
SHALE	Carbonaceous	523.4	523.6
COAL		523.6	524.0
INTERBEDDED SANDSTONE AND SILT-STONE		524.0	533.0
SANDSTONE	Medium and fine grained	533.0	546.0
SILTSTONE	Orange weathering	546.0	546.8
SILTSTONE		546.8	549.0
SANDSTONE		549.0	552.0
COVERED INTERVAL		552.0	565.0
SHALE	Carbonaceous	565.0	565.3
COAL		565.3	566.0
SHALE		566.0	566.3
COAL		566.3	570.3
SILTSTONE WITH MINOR SANDSTONE INTERBEDS		570.3	600.0
SANDSTONE	Fine grained	600.0	601.0
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	601.0	603.0
SILTSTONE		603.0	604.0
SANDSTONE		604.0	610.7
SHALE		610.7	614.4
COAL		614.4	615.0
SHALE	Carbonaceous	615.0	615.6
COAL		615.6	618.6
INTERBEDDED SILTSTONE AND SHALE	Siltstone: orange weathering; blocky; shale: carbonaceous	618.6	621.0
COVERED INTERVAL		621.0	639.0
SANDSTONE		639.0	661.0
COAL		661.0	664.5
SANDSTONE WITH MINOR SILTSTONE INTERBEDS	Sandstone in part carbonaceous; some sapropelic coal	664.5	690.0
SANDSTONE		690.0	692.0
SILTSTONE		692.0	694.0
COAL		694.0	695.0
SILTSTONE		695.0	695.5
COAL		695.5	696.0
SANDSTONE	Basal unit of Elk Formation	696.0	700.0

Section 6

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COAL	Base of unit corresponds with the top of the Morrissey Formation	0.0	0.3
INTERBEDDED SILTSTONE AND MUDSTONE	Siltstone: laminated; dark grey; mudstone: dark grey; friable	0.3	8.9
COAL		8.9	9.4
SILTSTONE	Part carbonaceous; part blocky, fissile and dark grey	9.4	11.8
COAL		11.8	12.1
MUDSTONE WITH SHALE INTERBED	Mudstone: very friable; thinly bedded; 25 cm thick concretionary layer; shale: carbonaceous	12.1	15.3
COAL		15.3	15.5
SANDSTONE	Medium grained (coarse at base); medium to thick bedded; medium to large-scale crossbedded; tree casts	15.5	31.8
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: very fine grained; dark grey; laminated; blocky; thick bedded; siltstone: orange weathering	31.8	38.8
MUDSTONE	Friable; carbonaceous	38.8	39.6
COAL		39.6	40.4
INTERBEDDED SILTSTONE & SHALE WITH COAL STRINGERS	Siltstone and shale: dark grey to black	40.4	42.5
PARTLY COVERED	Coal	42.5	50.1
INTERBEDDED SILTSTONE AND MUDSTONE	Siltstone: dark grey; mudstone: vitrain stringers; large, orange-weathering concretions	50.1	52.6
COAL		52.6	52.8
INTERBEDDED MUDSTONE AND SHALE WITH COAL BANDS	Mudstone and shale: carbonaceous; coal: bright; up to 5 cm thick	52.8	53.5
SILTSTONE WITH SANDSTONE "CONCRETION"	Siltstone: grey/brown; rubbly; sandstone: very fine grained; convoluted bedding; rooted?	53.5	56.2
SANDSTONE	Medium & coarse grained (fine near top); cross & parallel bedded and massive; thin to medium bedded; plant casts	56.2	71.7
SILTSTONE	Blocky; dark grey	71.7	76.0
SILTSTONE	Dark grey; friable	76.0	77.1
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	77.1	80.1
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: silty; dark grey; friable	80.1	81.6
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	81.6	86.4
MUDSTONE	Dark grey and carbonaceous at base; brownish grey and friable at top	86.4	96.9
COVERED	Float of fine-grained sandstone at top of interval	96.9	105.4
SANDSTONE	Fine grained; orange/grey weathering; platy and flaggy; blocky	105.4	108.9
MUDSTONE	In part carbonaceous	108.9	113.5
MAINLY COVERED	Recessive; friable siltstone and mudstone; locally carbonaceous (no coal); possible fault at top	113.5	141.0
INTERBEDDED SILTSTONE AND SANDSTONE	Siltstone: firable; sandstone: fine grained; blocky	141.0	144.9
INTERBEDDED SILTSTONE, SHALE AND COAL	Shale: carbonaceous; coal: bright; beds up to 10 cm thick	144.9	157.2
COAL WITH SHALE INTERBEDS	Shale: carbonaceous; abundant in lower half of unit	157.2	158.0
INTERBEDDED MUDSTONE, SHALE AND SILTSTONE	Mudstone and shale: carbonaceous; siltstone: blocky; occurs near top of unit	158.0	166.2
COAL		166.2	166.5
INTERBEDDED MUDSTONE, SHALE AND COAL	Mudstone: very carbonaceous; locally concretionary; shale: carbonaceous; coal: in beds up to 10 cm	166.5	169.3
INTRERBEDDED SANDSTONE AND SILTSTONE	Fining-upward unit; sandstone: fine grained; occurs at base of unit	169.3	171.3
INTERBEDDED MUDSTONE AND SILTSTONE WITH COAL BANDS	Mudstone and siltstone: carbonaceous; coal: bright	171.3	172.3
INTERBEDDED SANDSTONE AND SILTSTONE	Beds up to 0.5 m thick; sandstone: fine grained; siltstone: part carbonaceous	172.3	184.3
COVERED	Float of fine-grained sandstone, similar to that in underlying unit	184.3	188.8
SILTSTONE	Blocky	188.8	190.0
INTERBEDDED COAL, MUDSTONE AND SHALE	Coal: beds up to 20 cm thick; mudstone and shale: carbonaceous	190.0	193.2

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COAL		193.2	196.2
SILTSTONE		196.2	200.8
INTERBEDDED SANDSTONE AND SILTSTONE	Thin to medium bedded; sandstone: fine grained	200.8	207.8
INTERBEDDED SILTSTONE AND MUDSTONE	Recessive	207.8	218.3
COVERED		218.3	220.4
COAL		220.4	221.7
MUDSTONE		221.7	221.9
COAL		221.9	223.4
MUDSTONE		223.4	224.6
SILTSTONE WITH SANDSTONE INTERBEDS	Sandstone: very fine grained	224.6	227.6
INTERBEDDED SHALE AND COAL	Shale: carbonaceous; coal: beds up to 15 cm thick	227.6	228.4
MUDSTONE		228.4	229.3
SANDSTONE	Very fine grained	229.3	230.3
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: carbonaceous near top	230.3	234.8
SANDSTONE WITH SILTSTONE AND SHALE INTERBEDS	Vitrain bands; sandstone: very fine grained; shale: carbonaceous	234.8	238.8
SANDSTONE	Fine grained	238.8	239.8
SANDSTONE	Medium grained; large tree casts; thin bedded and flaggy near top	239.8	244.8
COVERED	Medium-grained sandstone float; part recessive interval?	244.8	247.1
COVERED		247.1	248.6
SANDSTONE	Fine to medium grained; thin bedded; flaggy; cross-laminated	248.6	252.1
MAINLY COVERED	Recessive; upper 50% has float of siltstone and mudstone and a few exposures of siltstone	252.1	275.6
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	275.6	279.6
COAL		279.6	283.1
INTERBEDDED SILTSTONE AND SHALE	Minor vitrain bands; shale carbaonaceous	283.1	284.8
INTERBEDDED SHALE AND COAL	Shale: carbonaceous; coal: in beds up to 50 cm thick	284.8	287.0
COAL		287.0	288.9
SANDSTONE	Fine grained	288.9	291.9
SILTSTONE	Carbonaceous	291.9	292.4
COAL		292.4	294.9
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: very fine grained	294.9	300.2
INTERBEDDED COAL AND SHALE	Shale: carbonaceous	300.2	301.8
SHALE	Carbonaceous	301.8	303.1
COAL		303.1	304.0
SILTSTONE	Blocky	304.0	314.0
COAL		314.0	316.0
SILTSTONE	Carbonaceous	316.0	317.0
COAL		317.0	317.9
SANDSTONE	Very fine grained	317.9	319.1
SILTSTONE		319.1	325.5
COAL		325.5	330.0
INTERBEDDED SHALE AND COAL	Shale: carbonaceous; coal: bright	330.0	330.5
SILTSTONE		330.5	340.5
INTERBEDDED MUDSTONE AND SILTSTONE	Mudstone: silty	340.5	351.0
INTERBEDDED MUDSTONE AND SHALE	Shale: carbonaceous; minor vitrain bands	351.0	357.4
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	357.4	357.9
COAL		357.9	359.7
INTERBEDDED SHALE AND COAL	Shale: carbonaceous; coal: bright	359.7	360.8
INTERBEDDED SANDSTONE AND SILTSTONE	Thinly interbedded; sandstone: very fine grained	360.8	365.5
COAL		365.5	367.1
INTERBEDDED MUDSTONE AND SILTSTONE	Mudstone: rubbly; dark grey weathering; siltstone: dark grey weathering	367.1	371.6
SILTSTONE	Blocky; orange weathering	371.6	373.0
MUDSTONE	Friable; dark grey; in part carbonaceous	373.0	375.6
INTERBEDDED SILTSTONE AND SANDSTONE	Sandstone: very fine grained	357.6	378.0

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SILTSTONE	Fissile	378.0	378.4
COAL WITH SHALE PARTINGS		378.4	379.9
INTERBEDDED SILTSTONE AND COAL	Siltstone: carbonaceous; coal: bright	379.9	381.1
INTERBEDDED SHALE AND SILTSTONE	Shale: carbonaceous	381.1	382.6
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	382.6	383.9
COAL	Contains 3 to 4 cm thick tonstein	383.9	386.7
MUDSTONE	Friable	386.7	387.8
SILTSTONE	Crosslaminated	387.8	396.9
SILTSTONE		396.9	399.9
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	399.9	401.5
COAL		401.5	402.0
SHALE	Carbonaceous	402.0	402.4
COAL		402.4	403.2
SILTSTONE	Crosslaminated	403.2	408.8
COAL		408.8	413.4
SILTSTONE	Carbonaceous at top	413.4	418.0
COAL		418.0	418.9
SILTSTONE	Thin to medium bedded; in part crosslaminated	418.9	430.4
SILTSTONE	Carbonaceous at base; crosslaminated	430.4	435.0
INTERBEDDED SHALE, MUDSTONE AND COAL	Shale and mudstone: carbonaceous; coal: bright	435.0	437.5
SANDSTONE	Very fine grained	437.5	438.0
SANDSTONE	Medium to coarse grained	438.0	440.0
MUDSTONE	Friable; dark grey; slightly carbonaceous	440.0	441.5
SANDSTONE	Coarse to medium grained; crossbedded; tree casts at base	441.5	444.5
INTERBEDDED SANDSTONE AND SILTSTONE	Bluff forming; sandstone: fine grained; platy; crosslaminated	444.5	449.2
COAL		449.2	449.7
SANDSTONE	Thickness a minimun	449.7	453.0

Section 7

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SILTSTONE WITH COAL BANDS	Siltstone: carbonaceous	0.0	1.5
SILTSTONE	Grey; friable	1.5	7.9
SANDSTONE	Fine grained; fissile	7.9	8.8
COAL		8.8	12.0
SILTSTONE	Fissile	12.0	13.5
SANDSTONE WITH SILTSTONE INTERBEDS	Thin bedded; sandstone: fine and medium grained	13.5	20.0
SILTSTONE	Carbonaceous at top	20.0	21.0
COAL		21.0	24.1
SILTSTONE		24.1	31.1
SANDSTONE	Flaggy; fine grained	31.1	31.6
SILTSTONE		31.6	37.4
SANDSTONE	Flaggy; fine grained	37.4	38.4
SILTSTONE		38.4	43.7
SILTSTONE	In part carbonaceous	43.7	49.4
COAL		49.4	50.1
SHALE	Carbonaceous	50.1	51.0
COAL		51.0	53.3
SILTSTONE		53.3	56.1
SANDSTONE	Fine grained; flaggy	56.1	56.5
SILTSTONE		56.5	68.3
SANDSTONE	Fine grained; flaggy	68.3	69.0
SILTSTONE		69.0	76.4
SILTSTONE WITH COAL INTERBEDS		76.4	78.4
COAL WITH SHALE BANDS	Shale: bands of 2 and 6 cm	78.4	81.9
SILTSTONE	Grey; in part orange weathering; friable	81.9	87.1
SANDSTONE	Fine grained; thin bedded	87.1	87.8
SILTSTONE	Dark grey	87.8	90.4
COAL		90.4	90.9
SILTSTONE	Dark grey	90.9	93.4
SANDSTONE	Medium grained; bedding thickness 5 to 20 cm; resistant	93.4	125.5
SANDSTONE	Fining-upward unit; fine to very fine grained	125.5	128.2
SILTSTONE		128.2	130.5
SANDSTONE	Medium grained; crosslaminated	130.5	134.3
SILTSTONE	Grey	134.3	137.5
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	137.5	139.3
SILTSTONE	Grey	139.3	143.7
SANDSTONE	Fine grained; thin bedded	143.7	145.2
INTERBEDDED SILTSTONE AND SANDSTONE	Siltstone: carbonaceous at base; sandstone: fine grained; thin bedded except in upper 2.5 m (up to 0.75 m)	145.2	157.2
SILTSTONE		157.2	162.1
SILTSTONE	Carbonaceous	162.1	163.4
COAL WITH SHALE INTERBANDS		163.4	167.5
COAL		167.5	173.9
SILTSTONE	Dark grey; friable	173.9	184.8
SANDSTONE	Medium grained; thin bedded; crossbedded; resistant	184.8	214.4
SANDSTONE OVERLAIN BY SILTSTONE	Fining-upward unit; sandstone: fine grained	214.4	216.7
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	216.7	219.3
SILTSTONE	Dark grey	219.3	223.5
SANDSTONE	Fine grained	223.5	223.8
SILTSTONE	Grey and orange weathering	223.8	232.4
SANDSTONE	Fine grained; thin bedded	232.4	233.4
SILTSTONE		233.4	235.9
SILTSTONE	Carbonaceous	235.9	237.1
COAL		237.1	238.6
INTERBEDDED COAL AND SILTSTONE	Siltstone: carbonaceous	238.6	240.4

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COAL		240.4	241.7
INTERBEDDED COAL AND SILTSTONE	Coal: bands up to 20 cm	241.7	242.4
SANDSTONE	Medium grained; bluff-forming	242.4	256.7
SANDSTONE	Medium grained; thin bedded	256.7	266.2
SANDSTONE	Medium grained; channel crossbedded	266.2	275.9
SILTSTONE	Orange and grey weathering	275.9	278.7
SILTSTONE		278.7	287.7
INTERBEDDED COAL AND SILTSTONE		287.7	289.1
COAL		289.1	289.9
SILTSTONE		289.9	290.6
COAL		290.6	291.0
INTERBEDDED COAL AND SILTSTONE	Coal: bright; siltstone: carbonaceous	291.0	292.5
SILTSTONE		292.5	292.9
COAL WITH SILTSTONE INTERBANDS		292.9	294.9
SILTSTONE		294.9	296.1
SANDSTONE	Fine grained	296.1	303.0
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	303.0	307.2
INTERBEDDED SILTSTONE AND SANDSTONE		307.2	311.6
INTERBEDDED COAL AND SHALE		311.6	312.6
SILTSTONE		312.6	314.6
SANDSTONE	Fine grained	314.6	315.6
SILTSTONE		315.6	322.1
INTERBEDDED COAL AND SHALE		322.1	323.6
SILTSTONE		323.6	325.6
SILTSTONE	Orange weathering	325.6	327.0
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; beds up to 1.5 m thick	327.0	338.2
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; 2 m bed at base, 1 m bed at top of unit	338.2	348.3
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	348.3	350.7
SILTSTONE	Grey-brown and orange weathering	350.7	356.6
COAL WITH SHALE BANDS	Best coal at top and bottom 1 m	356.6	360.1
SILTSTONE		360.1	362.1
SANDSTONE	Fine grained; thin bedded	362.1	364.1
SILTSTONE	Some orange-weathering beds	364.1	376.2
SILTSTONE	Grey; friable	376.2	381.7
SILTSTONE		381.7	402.0
SANDSTONE	Fine grained	402.0	403.2
MAINLY COVERED	60 cm coal exposed in small trench	403.2	410.1
SANDSTONE	Fine grained	410.1	413.5
SILTSTONE	Friable; orange and brown weathering	413.5	425.7
INTERBEDDED COAL AND SILTSTONE		425.7	426.9
COAL		426.9	432.2
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	432.2	444.8
SANDSTONE	Fine grained	444.8	445.5
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	445.5	453.5
SILTSTONE		453.5	456.5
SANDSTONE	Fine grained	456.5	457.8
SILTSTONE		457.8	459.8
COAL		459.8	460.2
SILTSTONE WITH COAL BANDS	Siltstone: carbonaceous	460.2	462.2
SILTSTONE		462.2	463.7
COAL		463.7	464.4
SANDSTONE	Thin bedded; bluff forming	464.4	477.8
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	477.8	486.0
SANDSTONE	Medium grained; thin bedded; bluff forming	486.0	495.8
INTERBEDDED SANDSTONE AND SILTSTONE	Fining-upward unit	495.8	500.0
INTERBEDDED SANDSTONE AND SILTSTONE	Fining upward unit	500.0	506.2

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SHALE		506.2	506.9
COAL		506.9	507.5
SHALE		507.5	508.2
SANDSTONE	Coarse and medium grained	508.2	511.0
SANDSTONE	Medium grained; thin bedded	511.1	514.2
PARTLY COVERED	Predominantly brown-weathering siltstone	514.2	525.6
SILTSTONE WITH COAL BANDS	Siltstone: carbonaceous; coal: bright	525.6	527.6
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	527.6	557.5
SANDSTONE	Medium and coarse grained; thin bedded	557.5	561.3
SANDSTONE	Medium grained; fining upward; flaggy near top	561.3	563.8
SANDSTONE	Fine grained	563.8	565.8
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	565.8	568.4
SILTSTONE		568.4	576.4
SANDSTONE	Medium grained; thin bedded	576.4	585.7
MAINLY COVERED	Exposures of siltstone; carbonaceous zone	585.7	591.7
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	591.7	597.1
PARTLY COVERED	Exposures of fine-grained sandstone and siltstone	597.1	612.1
MAINLY COVERED	Small exposures of fine-grained sandstone	612.1	629.1
SANDSTONE	Fine grained	629.1	630.6
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	630.6	638.6
SANDSTONE	Fine grained; thin bedded	638.6	641.0

Section 8

Lithology	Description	Base of Interval (m)	Top of Interval (m)
MUDSTONE	Dark grey; orange weathering; rubbly	0.0	2.5
INTERBEDDED COAL AND SHALE	Shale: carbonaceous	2.5	3.5
MUDSTONE	Carbonaceous	3.5	4.2
COAL		4.2	9.1
INTERBEDDED SHALE AND MUDSTONE WITH COAL BANDS	Shale: dark grey; carbonaceous; fissile; coal: bright	9.1	13.0
SHALE WITH COAL INTERBEDS	Shale: dark grey; carbonaceous; fissile; coal: beds up to 10 cm thick	13.0	15.7
COAL		15.7	21.0
COVERED	Coal bloom	21.0	22.1
COVERED		22.1	23.1
PARTLY COVERED	Exposures of rubbly siltstone	23.1	24.6
COVERED		24.6	35.8
INTERBEDDED SANDSTONE AND SILTSTONE	Orange weathering; bed thickness 2 to 20 cm; sandstone: fine grained	35.8	40.1
COVERED		40.1	41.8
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: fine grained; fissile to flaggy; laminated and crosslaminated	41.8	44.7
SILTSTONE	Dark brown to grey; thin bedded; rubbly	44.7	46.5
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	46.5	47.5
INTERBEDDED SILTSTONE AND MUDSTONE	Mudstone: in part concretionary, orange weathering	47.5	51.9
SILTSTONE	Blocky	51.9	52.8
SHALE	Carbonaceous; dark grey; fissile	52.8	53.0
SILTSTONE	Dark grey; orange weathering; concretionary; spheroidal weathering	53.0	54.6
INTERBEDDED SHALE AND MUDSTONE		54.6	55.8
SILTSTONE	Dark grey to brown	55.8	58.0
SILTSTONE	Dark grey; rubbly	58.0	62.6
SILTSTONE	Dark grey to brown; medium bedded; blocky	62.6	63.6
MUDSTONE	Dark grey	63.6	64.1
INTERBEDD SHALE AND COAL	Shale: carbonaceous	64.1	64.8
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: medium grained	64.8	65.4
SANDSTONE	Medium grained; laminated and crosslaminated	65.4	66.1
INTERBEDDED SANDSTONE AND SILTSTONE		66.4	67.4
SANDSTONE	Bed thickness 5 cm to 1 m; variable grain size; medium grained: laminated; fine grained: flaggy	67.4	70.0
SILTSTONE	Orange weathering; concretionary	70.0	70.8
SANDSTONE	Fine grained; thin bedded	70.8	72.2
SANDSTONE	Medium grained	72.2	72.9
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: medium grained	72.9	75.9
INTERBEDDED SANDSTONE AND SILTSTONE	Orange weathering; sandstone: fine grained	75.9	79.1
SILTSTONE	Dark grey; orange weathering	79.1	80.9
COVERED		80.9	83.0
INTERBEDDED SANDSTONE AND SILTSTONE	Orange weathering; blocky; sandstone: fine grained	83.0	86.3
SILTSTONE	Dark grey; orange weathering; blocky	86.3	89.8
INTERBEDDED SHALE AND SILTSTONE	Shale: carbonaceous	89.8	91.6
COAL		91.6	93.1
SILTSTONE		93.1	93.5
PARTLY COVERED	Coal bloom; close to in-place	93.5	99.5
COVERED		99.5	113.4
MUDSTONE	Fissile; dark brown; rubbly	113.4	115.3
SANDSTONE	Coarse to very coarse grained; plant casts and coal stringers; trough crossbedding; medium bedded	115.3	120.7

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SANDSTONE	Coarse grained; carbonaceous; plant casts and coal stringers; thin bedded	120.7	124.5
SANDSTONE	Coarse grained; laminated; thick bedded	124.5	127.0
SANDSTONE	Medium grained; flaggy	127.0	129.2
SANDSTONE	Medium grained; massive	129.2	131.1
SANDSTONE	Fine to medium grained; flaggy	131.1	132.4
SANDSTONE	Medium and fine grained; thick bedded	132.4	136.5
SANDSTONE	Medium and fine grained; thin and medium bedded	136.5	139.6
INTERBEDDED SANDSTONE AND SILTSTONE		139.6	143.2
SILTSTONE	Part concretionary, orange weathering	143.2	143.8
SANDSTONE	Fine grained	143.8	144.1
MUDSTONE	Rubbly; concretionary layers	144.1	145.9
SANDSTONE	Fine to medium grained; orange weathering	145.9	146.7
INTERBEDDED SILTSTONE AND MUDSTONE	Part concretionary, orange weathering	146.7	151.6
INTERBEDDED MUDSTONE, SHALE AND COAL	Thin bedded; shale: carbonaceous	151.6	153.7
COAL WITH SHALE BANDS	One siderite layer	153.7	155.5
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	155.5	156.9
MUDSTONE	Dark grey; rubbly	156.9	157.9
INTERBEDDED SHALE, SILTSTONE AND COAL	Shale: carbonaceous; coal: bed thickness up to 20 cm	157.9	162.5
MUDSTONE	Dark grey; orange weathering; part concretionary	162.5	168.9
INTERBEDDED SANDSTONE AND MUDSTONE	Sandstone: blocky; mudstone: rubbly	168.9	173.3
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	173.3	173.6
COAL		173.6	176.4
MAINLY COVERED	Coal bloom	176.4	181.8
MUDSTONE		181.8	183.5
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: ripple crosslaminated	183.5	185.7
SILTSTONE WITH MUDSTONE INTERBEDS		185.7	187.8
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; crosslaminated	187.8	194.8
SANDSTONE	Coarse grained; trough crossbedded	194.8	198.5
SANDSTONE	Fine and medium grained; flaggy to crosslaminated	198.5	206.2
SANDSTONE	Fine grained; flaggy	206.2	210.0
SANDSTONE	Medium grained; thin bedded; laminated	210.0	216.5
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: fine grained	216.5	223.8
PARTLY COVERED	Exposures of siltstone	223.8	225.7
COVERED		225.7	226.8
SILTSTONE	Rubbly	226.8	227.5
COVERED		227.5	228.0
SHALE WITH COAL INTERBED	Shale: carbonaceous; coal: 10 cm thick bed	228.0	229.0
SILTSTONE	Orange weathering; fissile; rubbly	229.0	231.0
SHALE	Carbonaceous; fissile	231.0	232.6
COAL	Very poorly exposed	232.6	237.0
COVERED		237.0	239.3
SILTSTONE	Dark grey	239.3	240.1
SANDSTONE	Medium grained	240.1	240.6
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	240.6	244.7
COVERED	Float of material similar to underlying unit	244.7	254.3
INTERBEDDED SANDSTONE AND SILTSTONE	Thinly bedded unit; sandstone: fine grained	254.3	257.3
PARTLY COVERED	Exposures of interbedded siltstone and mudstone; >20 cm thick coal seam roughly 1 m below top of unit	257.3	262.3
INTERBEDDED SILTSTONE AND MUDSTONE	Orange weathering; rubbly	262.3	266.8
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; crosslaminated	266.8	269.4
INTERBEDDED SILTSTONE, MUDSTONE AND SANDSTONE	Sandstone: fine grained	269.4	279.4
MAINLY COVERED	Exposures of fine-grained sandstone and siltstone	279.4	285.9
SILTSTONE		285.9	287.2

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COVERED		287.2	290.7
INTERBEDDED SANDSTONE AND CONGLOMERATE	Sandstone: coarse grained; conglomerate: pebble clasts	290.7	291.4
SANDSTONE	Coarse grained; thin to medium bedded; in part massive, in part laminated	291.4	295.9
SANDSTONE WITH CONGLOMERATE LENSES	Sandstone: coarse grained; carbonaceous; conglomerate: pebble clasts	295.9	298.6
SANDSTONE	Coarse grained; thin bedded; trough crosslaminated; parallel-laminated near top	298.6	300.5
SANDSTONE	Medium grained	300.5	305.4
MAINLY COVERED	Small exposures and float of siltstone	305.4	307.2
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine grained; thin bedded	307.2	312.2
MUDSTONE	Carbonaceous	312.2	314.3
COAL		314.3	315.8
SILTSTONE	In part carbonaceous	315.8	316.2
COAL		316.2	317.5
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine grained; thin bedded; crosslaminated	317.5	318.5
SILTSTONE		318.5	320.2
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	320.2	321.8
INTERBEDD SHALE AND COAL	Thinly bedded unit; shale: carbonaceous	321.8	322.8
COAL		322.8	323.5
INTERBEDDED SILTSTONE AND MUDSTONE	Dark grey	323.5	324.6
MUDSTONE		324.6	326.0
INTERBEDDED SILTSTONE AND MUDSTONE		326.0	327.7
SANDSTONE	Fine grained	327.7	332.4
MUDSTONE	Orange weathering; concretionary	332.4	332.9
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: medium grained, with some fine-grained sandstone partings; crosslaminated	332.9	333.4
SILTSTONE WITH SANDSTONE INTERBEDS	Sandstone: fine grained; thin beds	333.4	336.8
INTERBEDDED MUDSTONE AND COAL	Mudstone: carbonaceous	336.8	341.0
SILTSTONE		341.0	341.9
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine to medium grained; thin bedded; crosslaminated	341.9	342.8
SILTSTONE	Dark grey; orange weathering	342.8	348.3
COAL		348.3	350.1
PARTLY COVERED	Some rubbly mudstone exposed	350.1	360.3
SANDSTONE WITH SILTSTONE PARTINGS		360.3	364.5
COVERED	Float of siltstone and mudstone	364.5	371.5
SILTSTONE		371.5	376.5
COAL		376.5	379.0
PARTLY COVERED	Exposures of rubbly mudstone	379.0	384.5
SILTSTONE	Orange weathering	384.5	386.0
PARTLY COVERED	Exposures of rubbly mudstone	386.0	392.0
SILTSTONE	Dark grey; blocky	392.0	393.3
COVERED	Float of fine-grained rocks	393.3	403.8
COAL		403.8	416.8
MUDSTONE WITH COAL STRINGERS	Mudstone: rubbly; coal: confined to top of unit	416.8	418.8
INTERBEDDED SANDSTONE AND SILTSTONE	Graded unit; dark grey; sandstone: fine grained	418.8	420.6
COAL		420.6	422.1
SHALE WITH COAL INTERBEDS	Shale: carbonaceous	422.1	425.7
SANDSTONE WITH SILTSTONE PARTING (ONE)	Sandstone: fine grained	425.7	426.3
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	426.3	426.6
SANDSTONE	Very fine grained; orange weathering; ripple crosslaminations	426.6	429.5
SHALE	Carbonaceous	429.5	430.3
SILTSTONE	Orange weathering	430.3	431.3
SHALE	Carbonaceous	431.3	431.8
MUDSTONE WITH SILTSTONE INTERBEDS	Grey; orange weathering	431.8	446.4
SANDSTONE	Very fine grained; crosslaminated	446.4	447.7

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SILTSTONE	Dark brown	446.6	448.1
SHALE	Carbonaceous	448.1	448.5
SILTSTONE	Mainly massive; some laminated	448.5	450.2
MUDSTONE	In part carbonaceous; fissile to thin bedded	450.2	451.5
SILTSTONE	Orange weathering; plant fossils	451.5	452.1
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	452.1	452.6
MUDSTONE		452.6	453.0
SHALE WITH COAL INTERBEDS	Shale: carbonaceous	453.0	453.7
SANDSTONE	Very fine grained; crosslaminated	453.7	454.3
MUDSTONE	Dark grey to brown; fissile	454.3	455.0
INTERBEDDED SILTSTONE AND MUDSTONE	Siltstone: blocky	455.0	457.3
SHALE WITH COAL INTERBEDS		457.3	457.9
MUDSTONE	Rubbly	457.9	459.6
MUDSTONE	Orange and red weathering; concretionary	459.6	462.6
SHALE WITH COAL INTERBEDS	Shale: carbonaceous; coal: beds up to 20 cm thick	462.6	465.1
SILTSTONE	Dark grey to brown	465.1	466.4
SANDSTONE	Medium grained; ripple crosslaminated	466.4	467.7
SILTSTONE	Carbonaceous	467.7	468.0
COAL		468.0	468.3
SILTSTONE		468.3	469.0
SILTSTONE WITH SANDSTONE INTERBEDS	*Sandstone: fine grained*	469.0	469.7
SANDSTONE	Medium grained; thin bedded	469.7	471.1
SILTSTONE	Carbonaceous	471.1	472.3
MUDSTONE	Part concretionary	472.3	473.2
INTERBEDDED SANDSTONE AND SILTSTONE	Thinly bedded unit; sandstone: fine grained	473.2	474.2
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	474.2	475.0
SANDSTONE	Medium grained; fines upward; crossbedded; coal stringers	475.0	477.6
INTERBEDDED SANDSTONE AND SILTSTONE	Fining upward unit; sandstone: fine grained	477.6	478.5
SILTSTONE	Dark grey	478.5	479.1
SILTSTONE	Carbonaceous; dark grey; white weathering; contains rootlets	479.1	479.4
COAL		479.4	480.0
INTERBEDDED SILTSTONE AND MUDSTONE	Thinly bedded	480.0	481.5
SILTSTONE		481.5	482.9
MUDSTONE	Fissile	482.9	484.1
SANDSTONE	Very fine grained	484.1	484.4
SILTSTONE	Dark grey	484.4	484.6
SHALE	Carbonaceous	484.6	486.8
SANDSTONE	Medium to coarse grained; trough crossbedded; plant casts; coal stringers; thickness a minimum	486.8	490.0

Section 9

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COAL		0.0	0.9
SILTSTONE		0.9	2.6
COAL		2.6	3.6
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	3.6	4.2
COAL		4.2	4.5
SILTSTONE		4.5	4.7
INTERBANDED COAL AND SHALE	Shale: carbonaceous	4.7	5.0
SHALE	Carbonaceous	5.0	5.2
COAL	Contains two siderite bands	5.2	10.2
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	10.2	10.7
SHALE	Carbonaceous; thin bedded	10.7	11.6
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: dark grey to brown weathering; strongly fractured; siltstone: near base of unit	11.6	17.3
SILTSTONE	Orange weathering	17.3	17.5
INTERBEDDED SILTSTONE AND MUDSTONE		17.5	18.7
MUDSTONE WITH SILTSTONE BAND (ONE)	Siltstone: orange weathering	18.7	22.0
MUDSTONE	Orange weathering; concretionary	22.0	22.5
INTERBEDDED MUDSTONE AND SILTSTONE		22.5	24.0
MUDSTONE		24.0	26.0
INTERBEDDED SILTSTONE AND MUDSTONE	Siltstone: crosslaminated	26.0	28.1
INTERBEDDED SANDSTONE AND SILTSTONE	Fining-upward unit; sandstone: medium grained at base; *crosslaminated*	28.1	28.8
MUDSTONE WITH SILTSTONE INTERBED (ONE)		28.8	29.5
MUDSTONE	Includes orange-weathering, concretionary bands	29.5	32.6
INTERBEDDED SANDSTONE AND SILTSTONE	Fining-upward unit; sandstone: medium grained at base	32.6	34.0
MUDSTONE		34.0	34.3
SILTSTONE WITH MUDSTONE INTERBEDS	Siltstone: orange weathering; blocky	34.3	36.3
COVERED		36.3	39.8
SANDSTONE	Medium grained; crosslaminated	39.8	40.5
PARTLY COVERED	Coaly interval; coal bloom; about 1 m coal exposed at top of unit	40.5	43.5
SANDSTONE WITH SHALE INTERBEDS	Fine grained; flaggy; shale: carbonaceous	43.5	45.0
SANDSTONE	Coarse grained; carbonaceous	45.0	45.8
SILTSTONE	Friable	45.8	47.7
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: very fine grained	47.7	49.2
SANDSTONE	Fine grained; flaggy	49.2	55.2
SANDSTONE	Medium grained at base, fine grained at top; crosslaminated	55.2	58.1
COVERED	Float of clean, medium-grained, massive sandstone; coal bloom at top of interval; equivalent to sandstone cliff	58.1	84.1
MAINLY COVERED	Exposures of sandstone in uppermost few metres of interval	84.1	97.6
INTERBEDDED SILTSTONE AND MUDSTONE		97.6	98.8
SILTSTONE	Orange weathering	98.8	99.5
SILTSTONE	Dark grey; orange weathering; intensely fractured	99.5	105.3
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: medium grained; crosslaminated	105.3	106.3
MUDSTONE	Part carbonaceous, part concretionary	106.3	108.5
INTERBEDDED MUDSTONE AND COAL	Mudstone: carbonaceous; coal: in beds up to 15 cm thick	108.5	109.6
MUDSTONE	Concretionary; orange weathering	109.6	110.0
INTERBEDDED SILTSTONE AND MUDSTONE	Fining-upward unit; siltstone at base	110.0	112.0
COAL WITH SHALE BANDS	Shale: carbonaceous; up to 0.2 m thick	112.0	113.1
SILTSTONE	Brown; orange weathering	113.1	115.2

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SILTSTONE	Dark grey; orange weathering; in part carbonaceous	115.2	121.4
COAL WITH SHALE INTERBEDS	Shale: carbonaceous; mainly at base of unit	121.4	124.4
INTERBEDDED SILTSTONE AND COAL	Siltstone: carbonaceous; blocky	124.4	125.3
COAL		125.3	128.0
COVERED	Coal?	128.0	129.5
MUDSTONE	Dark grey; carbonaceous at top of unit	129.5	135.6
INTERBEDDED SANDSTONE AND SILTSTONE	Several fining-upward sequences; overall unit is fining upward	135.6	137.9
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: dark grey; rubbly	137.9	143.8
SILTSTONE WITH MUDSTONE INTERBEDS	Siltstone: blocky	143.8	144.7
MUDSTONE	Dark grey-yellow to orange weathering	144.7	150.1
MUDSTONE WITH COAL INTERBEDS	Mudstone: carbonaceous	150.1	152.4
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; crosslaminated; bed thickness up to 0.25 m	152.4	154.7
INTERBEDDED SANDSTONE AND SILTSTONE	Composed of three or four fining-upward sequences; sandstone: medium grained; crosslaminated	154.7	156.6
MUDSTONE	Dark grey; orange, concretionary layer at base	156.6	158.0
INTERBEDDED SANDSTONE AND SILTSTONE	Fining-upward sequences; sandstone: medium grained; trough crosslaminated; beds up to 40 cm; siltstone: dark grey	158.0	159.4
SHALE	Carbonaceous	159.4	160.1
COAL		160.1	160.8
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	160.8	162.6
MAINLY COVERED	Exposures of siltstone	162.6	166.0
SANDSTONE	Fining-upward unit; medium grained at base, very fine grained at top; crosslaminated	166.0	167.2
INTERBEDDED COAL AND SHALE	Shale: carbonaceous	167.2	168.1
MUDSTONE	Dark grey; rubbly	168.1	169.4
INTERBEDDED SHALE AND COAL	Shale: carbonaceous; coal: forms top 40 cm of unit	169.4	170.7
MUDSTONE	Brownish grey; rubbly	170.7	174.9
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	174.9	175.7
COAL		175.7	176.6
MUDSTONE	In part carbonaceous	176.6	179.2
COAL		179.2	183.1
INTERBEDDED COAL AND SHALE	Beds up to 40 cm thick; shale: carbonaceous	183.1	185.4
COAL WITH SHALE BANDS	Shale: bands from 2 to 5 cm thick	185.4	186.8
MUDSTONE WITH COAL BANDS	Mudstone: carbonaceous; dark grey to black; coal: bright	186.8	187.8
SILTSTONE WITH MUDSTONE INTERBEDS	Dark brown; orange weathering	187.8	190.8
MUDSTONE	Fissile; dark grey	190.8	193.6
SILTSTONE	Brownish grey; thin bedded	193.6	197.5
SILTSTONE	Orange weathering; part crosslaminated; bed thickness up to 50 cm	197.5	203.5
MUDSTONE	Part carbonaceous; dark grey	203.5	204.8
INTERBEDDED SHALE AND MUDSTONE WITH COAL	Shale: carbonaceous	204.8	207.4
MUDSTONE	Brownish grey; rubbly; massive; silty near top	207.4	214.6
SANDSTONE	Medium to coarse grained; crosslaminated in lower portion; tree casts and coal stringers near base	214.6	220.9
COVERED		220.9	227.9
SANDSTONE	Very fine grained; greyish brown	227.9	228.4
COVERED		228.4	231.3
INTERBEDDED SILTSTONE AND MUDSTONE	Fining-upward unit; all dark grey	231.3	234.3
COVERED		234.3	235.2
COAL		235.2	235.5
INTERBEDDED SILTSTONE AND SHALE	Shale: carbonaceous	235.5	237.4
COAL		237.4	246.3
SHALE	Carbonaceous	246.3	246.5
COAL		246.5	247.9
SILTSTONE	Laminated	247.9	250.2
MUDSTONE	Dark grey	250.2	250.7
INTERBEDDED SILTSTONE AND MUDSTONE	Thinly bedded; finer at top; well laminated	250.7	257.5
SILTSTONE	Orange weathering; thin to thick bedded	257.5	259.7

Lithology	Description	Base of Interval (m)	Top of Interval (m)
INTERBEDDED SILTSTONE AND MUDSTONE	Fining-upward unit; siltstone: thin bedded	259.7	263.9
INTERBEDDED SANDSTONE AND SILTSTONE	Fining-upward unit; laminated and crosslaminated; sandstone: fine grained	263.9	265.9
INTERBEDDED SILTSTONE AND MUDSTONE	Mudstone: fissile; siltstone: orange weathering; parallel-laminated	265.9	270.2
SILTSTONE	Laminated; greyish brown	270.2	271.9
MUDSTONE WITH COAL BAND (ONE)		271.9	273.1
SILTSTONE	Parallel and crosslaminated; orange weathering	273.1	274.1
INTERBEDDED MUDSTONE AND SHALE WITH COAL BANDS	Shale: carbonaceous	274.1	279.6
MUDSTONE WITH COAL BANDS	Mudstone: carbonaceous; coal: in bands up to 10 cm thick	279.6	280.5
COAL		280.5	281.5
MUDSTONE WITH COAL INTERBEDS	Mudstone: carbonaceous	281.5	283.3
MUDSTONE WITH COAL INTERBEDS	Mudstone: carbonaceous	283.3	284.4
MUDSTONE	Dark grey	284.4	287.4
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: medium grained; laminated and crosslaminated	287.4	290.0
COVERED		290.0	293.0
MAINLY COVERED	Exposures of dark grey siltstone	293.0	294.3
INTERBEDDED SANDSTONE AND SILTSTONE	Fining-upward sequences; both types dark grey; sandstone: very fine grained; crosslaminated	294.3	295.6
SILTSTONE	Dark grey	295.6	296.5
INTERBEDDED SANDSTONE AND SILTSTONE	Fining-upward unit; sandstone: orange weathering; fine grained; crosslaminated; siltstone: dark grey	296.5	298.9
COVERED		298.9	299.8
SILTSTONE WITH MUDSTONE INTERBEDS	Recessive; siltstone: dark grey; mudstone: orange weathering; concretionary	299.8	310.9
MUDSTONE	In part carbonaceous; dark grey; fissile	310.9	315.8
MAINLY COVERED	Coal seam included	315.8	320.8
MAINLY COVERED	Exposures of interbedded siltstone and mudstone	320.8	324.7
SILTSTONE	Dark grey; fissile	324.7	326.0
INTERBEDDED SILTSTONE AND SANDSTONE	Coarsening-upward unit; siltstone: dark grey; part fissile; sandstone: fine grained; laminated	326.0	328.7
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: mainly medium grained; carbonaceous at base of unit; laminated; siltstone: dark grey	328.7	335.5
SANDSTONE	Very fine grained; thin bedded; dark grey	335.5	336.9
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: medium grained; resistant; outcrop weathers red; thin bedded; vitrain partings	336.9	346.7
COVERED		346.7	347.2
COAL		347.2	354.6
MUDSTONE	Fissile	354.6	355.6
COAL	Bright; well banded	355.6	356.7
SILTSTONE	Grayish brown; thin to medium bedded	356.7	358.0
COAL		358.0	359.4
PARTLY COVERED	Exposures of carbonaceous siltstone, siltstone and mudstone (ascending order)	359.4	372.7
INTERBEDDED SILTSTONE AND MUDSTONE		374.1	373.9
SILTSTONE WITH COAL INTERBEDS	Siltstone: carbonaceous	373.9	374.6
MUDSTONE	Part carbonaceous; part concretionary and orange weathering; fissile	374.6	382.2
SILTSTONE	Well laminated; orange weathering	382.2	383.7
SANDSTONE	Medium grained; thin bedded to flaggy; ripple drift crosslaminated	383.7	386.1
INTERBEDDED SANDSTONE AND SILTSTONE	Fining-upward unit; orange weathering; sandstone: fine grained	386.1	388.2
PARTLY COVERED	Predominantly siltstone	388.2	390.8
PARTLY COVERED	Carbonaceous zone; about 60 cm of coal at top of interval	390.8	392.3
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	392.3	393.3
COVERED		393.3	396.2
SANDSTONE	Medium to coarse grained; trough crossbedded; plant casts and coal stringers near base	396.2	398.6
SANDSTONE	Medium grained; thin bedded	398.6	403.0
SANDSTONE	Fine grained, orange weathering at base; medium grained overlying; crosslaminated	103.0	405.9
COVERED	Fine grained rocks in top of unit?	405.9	420.7
COAL WITH SANDSTONE INTERBED (ONE)	Sandstone: fine grained; 25 cm thick bed, 2 m above base	420.7	432.5

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SILTSTONE	Dark brown; carbonaceous at base	432.5	433.2
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; laminated and crosslaminated; 4 to 20 cm thick beds	433.2	437.2
SANDSTONE	Medium grained; crosslaminated; thin to medium bedded	437.2	442.1
SANDSTONE	Medium grained; thin bedded; ripple crosslaminated	442.1	449.9
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: fine grained	449.9	457.4
COVERED		457.4	463.1
SILTSTONE	Crosslaminated	463.1	465.8
COVERED		465.8	491.3
COVERED	Carbonaceous bloom at top	491.3	495.3
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: medium grained to fine grained (gradational); thin bedded to flaggy; siltstone: near top	495.3	499.7
SILTSTONE	Blocky	499.7	503.6
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: fine grained; crosslaminated	503.6	505.0
COVERED	Coal bloom in top 5 m	505.0	523.7
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine grained; thin bedded	523.7	534.8
SILTSTONE	Thin bedded; orange weathering	534.8	538.9
COVERED		538.9	540.2
COAL		540.2	545.1
MAINLY COVERED	Coal uncovered at three locations	545.1	548.1
INTERBEDDED MUDSTONE AND SILTSTONE	Mudstone: carbonaceous	548.1	549.8
COVERED	Float of siltstone	549.8	553.7
MUDSTONE	Fissile; dark grey; some orange weathering and concretionary	553.7	561.5
SHALE	Carbonaceous; fissile	561.5	562.2
COAL	Dull; dirty	562.2	568.9
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine grained; crosslaminated; blocky	568.9	573.4
COVERED		573.4	576.4
SANDSTONE	Medium grained; thin bedded to flaggy; crosslaminated	576.4	579.4

Section 10

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COVERED	Recessive; carbonaceous material in burrow; Moose Mountain Member	0.0	3.0
SANDSTONE	Medium grained; well laminated; thin to medium bedded; upper Moose Mountain Formation	3.0	11.0
COAL		11.0	12.1
SHALE WITH COAL INTERBEDS	Shale: carbonaceous	12.1	19.5
COAL		19.5	20.8
SHALE WITH COAL INTERBEDS	Shale: carbonaceous; coal: thin beds	20.8	22.5
PARTLY COVERED	Predominantly coal	22.5	26.1
COVERED		26.1	38.1
SANDSTONE	Bluff-forming unit; medium/coarse grained; trough and planar crossbedded; flaggy near top	38.1	51.6
COVERED	Float of fine-grained sandstone in lowest portion	51.6	71.1
PARTLY COVERED	Float of siltstone and shale; shale: carbonaceous; concentrated in upper part of interval	71.1	83.1
SANDSTONE	Medium to coarse grained; medium bedded; well laminated and low-angle crosslaminated; plant casts	83.1	93.6
COVERED		93.6	137.1
MAINLY COVERED	Siltstone exposures; carbonaceous at base and top of interval	137.1	140.6
COAL		140.6	142.9
COVERED	Carbonaceous material (shale and coal?) dug out	142.9	144.6
SANDSTONE	Fine to medium grained; thin bedded; laminated and crosslaminated	144.6	157.5
SILTSTONE	Recessive	157.5	163.1
INTERBEDDED SANDSTONE AND SILTSTONE	Fining-upward unit; sandstone: very fine grained; dark grey; siltstone: dark grey; friable near top	163.1	169.4
COAL		169.4	172.4
COAL	Alternating dull (dirty) and bright	172.4	172.8
COAL	Dull; thin banded	172.8	174.6
COAL	Alternating dull (dirty) and bright	174.6	175.3
SILTSTONE	Dark grey; friable	175.3	177.2
COAL	Alternating dull (dirty) and bright	177.2	178.6
SILTSTONE	Dark grey; friable; carbonaceous in lower portion	178.6	186.2
COAL		186.2	188.0
COAL	Alternating dull (dirty) and bright	188.0	188.4
COAL		188.4	189.9
COAL	Dull (dirty)	189.9	190.6
COAL		190.6	193.0
COAL	Alternating dull (dirty) and bright	193.0	193.9
SILTSTONE	Semirecessive; in part friable	193.9	205.9
SILTSTONE	Recessive; in part friable	205.9	214.4
COAL WITH SHALE INTERBEDS	Shale: carbonaceous; beds up to 10 cm thick	214.4	219.2
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	219.2	221.1
SANDSTONE WITH SILTSTONE INTERBEDS	Fining-upward unit; sandstone: fine grained; cross laminated; siltstone: in part calcareous	221.1	237.4
SILTSTONE	Friable; dark grey	237.4	240.1
SANDSTONE	Very fine grained; dark grey; thin bedded	240.1	240.9
SILTSTONE WITH SANDSTONE INTERBEDS	Sandstone: very fine grained; concentrated near top of unit; siltstone: friable; dark grey	240.9	244.4
INTERBEDDED SANDSTONE AND SILTSTONE	Fining-upward unit; sandstone: very fine grained; medium to thin bedded	244.4	248.4
SILTSTONE WITH SANDSTONE INTERBEDS	Siltstone: dark grey; friable; sandstone: very fine grained	248.4	249.8
SHALE	Carbonaceous	249.8	250.2
COAL		250.2	252.3
SHALE WITH COAL PARTINGS	Shale: carbonaceous; coal: bright	252.3	252.9
COAL	Clean; bright; thin siderite and clay bands	252.9	256.9
COAL	Alternating dull (dirty) and bright	256.9	258.6
SHALE WITH COAL INTERBEDS	Shale: carbonaceous	258.6	259.6
COAL WITH SHALE INTERBEDS	Shale: carbonaceous	259.6	261.1

Lithology	Description	Base of Interval (m)	Top of Interval (m)
MUDSTONE	Friable; dark grey	261.1	265.5
COAL		265.5	265.9
MUDSTONE	Dark grey; friable	265.9	269.4
COAL		269.4	271.1
SILTSTONE	Friable; dark grey; brown and orange weathering; part carbonaceous	271.1	272.7
SANDSTONE WITH SILTSTONE PARTING (ONE)	Fine/medium grained; bluff forming	272.7	282.2
COVERED	Float of siltstone and fine-grained sandstone	282.2	286.2
SANDSTONE	Medium to coarse grained; plant casts; small scale cross-bedding	286.2	292.2
COVERED	Recessive	292.2	297.7
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: very fine grained; small-scale crosslaminated	297.7	305.2
MUDSTONE	Friable; grey brown; silty	305.2	313.4
SILTSTONE	Carbonaceous at base; friable; dark grey	313.4	316.8
SANDSTONE	Thin bedded; very fine grained	316.8	318.0
SILTSTONE WITH SHALE INTERBEDS	Shale: carbonaceous	318.0	320.7
COAL		320.7	321.5
SILTSTONE WITH SHALE INTERBEDS	Shale: carbonaceous	321.5	323.7
INTERBEDDED SILTSTONE AND MUDSTONE	Recessive unit; mudstone: silty	323.7	330.6
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; crosslaminated; siltstone: grey and/or grey brown	330.6	342.8
SANDSTONE	Medium grained; thin and medium bedded; well cross-bedded; resistant	342.8	349.1
SILTSTONE	Grey brown; friable; rubbly; recessive	349.1	355.1
SILTSTONE	Calcareous; thin bedded; orange weathering	355.1	356.6
SANDSTONE	Very fine grained; thin bedded; small scale cross-laminations	356.6	359.6
SILTSTONE	Dark grey; friable; recessive	359.6	361.0
SILTSTONE	Fissile; carbonaceous	361.0	362.2
COAL WITH SHALE PARTINGS		362.2	363.5
MAINLY COVERED	Semirecessive; carbonaceous siltstone at base; small exposures of very fine grained sandstone; siltstone float	363.5	372.0
PARTLY COVERED	Exposures and float of dark grey siltstone; carbonaceous shale and 20 cm coal at base	372.0	378.0
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: fine and very fine grained; thin bedded; cross-laminated	378.0	380.6
MAINLY COVERED	Siltstone float in lower part; very fine grained sandstone exposures in upper part	380.6	404.6
SANDSTONE	Fine grained; thin bedded; crosslaminated; semiresistant	404.6	413.6
COVERED	Float of fine-grained sandstone (underlying unit) and siltstone	413.6	419.6
SILTSTONE	Brownish; rubbly; dark grey and carbonaceous at top of unit	419.6	431.6
COAL WITH SHALE PARTINGS	Partings: restricted to lower one half of unit	431.6	434.1
SILTSTONE WITH SANDSTONE INTERBEDS	Sandstone: fine grained	434.1	440.6
COAL		440.6	441.4
SILTSTONE	Dark grey; friable	441.4	442.7
SANDSTONE	Fine grained; thin bedded; semiresistant	442.7	448.7
SILTSTONE	Mainly dark grey and brown grey; rubbly; two beds of orange-weathering, calcareous siltstone	448.7	453.7
COAL		453.7	455.2
SILTSTONE	Dark grey and brown grey; rubbly	455.2	456.7
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	456.7	463.2
SANDSTONE	Fine grained; thin bedded; in part carbonaceous	463.2	465.5
SILTSTONE	Grey; friable	465.5	467.3
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: very fine grained; carbonaceous shale at top	467.3	471.3
COAL WITH SHALE PARTINGS		471.3	472.3
SHALE	Carbonaceous	472.3	474.1
COAL		474.1	475.1
COVERED	Some siltstone float	475.1	491.1
SANDSTONE	Fine grained; thin bedded	491.1	501.6
INTERBEDDED SANDSTONE AND SILTSTONE		501.6	506.1

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COVERED		506.1	516.6
INTERBEDDED SHALE AND COAL	Shale: carbonaceous; coal: beds up to 30 cm	516.6	518.5
SILTSTONE	Dark grey; in part brown	518.5	525.7
SANDSTONE	Fine grained; thin bedded	525.7	527.5
SILTSTONE WITH SHALE INTERBEDS	Siltstone: friable; dark grey; shale: carbonaceous; mainly near top of unit	527.5	535.0
MAINLY COVERED	Coal dug up at three places; one seam?	535.0	538.0
COVERED		538.0	546.4
SANDSTONE	Fine grained; thin bedded	546.4	568.7
SILTSTONE	Dark grey; recessive	568.7	571.7
SANDSTONE	Fine grained; thin bedded; light grey weathering	571.7	576.2
SILTSTONE	Dark grey; recessive	576.2	585.5
INTERBEDDED SHALE AND COAL	Shale: carbonaceous; coal: hard; bright; beds up to 10 cm thick	585.5	587.0
SANDSTONE	Coarse and medium grained; channel structures; thickness arbitrary	587.0	590.0

Section 11

Lithology	*Description*	Base of Interval (m)	Top of Interval (m)
SANDSTONE	Medium grained; thin bedded	0.0	9.0
SILTSTONE	Concretionary, orange-weathering siltstone layers interbedded	9.0	15.5
SILTSTONE		15.5	26.5
SILTSTONE	Grey and brown; locally dark grey; locally orange weathering and concretionary; fissile; recessive	26.5	44.5
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; crosslaminated; thin bedded	44.5	55.0
INTERBEDDED SILTSTONE AND SHALE	Carbonaceous zone; siltstone: dark grey; shale: carbonaceous with vitrain bands	55.0	62.8
INTERBEDDED SANDSTONE AND SILTSTONE	Fining-upward unit; sandstone: fine grained; siltstone: dark grey	62.8	63.6
MUDSTONE WITH COAL INTERBED (ONE)	Dark grey; silty	63.6	70.6
SANDSTONE	Medium grained; medium bedded	70.6	73.1
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	73.1	92.2
SILTSTONE WITH SANDSTONE INTERBEDS	Sandstone: fine grained	92.2	96.5
SILTSTONE WITH SHALE INTERBEDS	Shale: carbonaceous; contains one coal band	96.5	100.8
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine grained; gradational to partings	100.8	107.3
SILTSTONE WITH SANDSTONE INTERBEDS	Sandstone: fine grained	107.3	111.3
SILTSTONE	Orange weathering	111.3	111.9
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine grained; thin bedded	111.9	122.4
SILTSTONE	Dark grey; recessive	122.4	128.2
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	128.2	133.6
MUDSTONE WITH SHALE INTERBEDS	Mudstone: silty; dark grey; friable; shale: carbonaceous	133.6	151.6
SANDSTONE	Fine and medium grained; well laminated and crosslaminated; crossbedded; thin and medium bedded	151.6	168.8
SANDSTONE WITH SILTSTONE INTERBEDS	Sandstone: fine grained	168.8	179.1
MUDSTONE	Dark grey; friable	179.1	189.6
SILTSTONE		189.6	190.4
SANDSTONE	Coarse to medium grained	190.4	191.6
COAL WITH SHALE PARTING		191.6	192.2
SANDSTONE	Medium and fine grained	192.2	202.0
SILTSTONE	Dark grey	202.0	207.0
SILTSTONE	Dark grey	207.0	212.4
SILTSTONE WITH COAL BANDS	Siltstone: in part carbonaceous	212.4	215.1
INTERBEDDED COAL AND SHALE	Shale: carbonaceous	215.1	216.2
INTERBEDDED SHALE AND SILTSTONE	Shale: carbonaceous	216.2	218.3
COAL		218.3	225.4
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: silty; friable; dark grey	225.4	231.4
SILTSTONE	Orange weathering; laminated	231.4	232.0
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: silty; dark grey; friable	232.0	237.5
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine grained to very fine grained; fining upward; thin bedded	237.5	248.0
MAINLY COVERED	Probably siltstone	248.0	249.5
INTERBEDDED SHALE AND SILTSTONE	Shale: carbonaceous	249.5	250.6
COAL		250.6	252.0
INTERBEDDED SHALE AND MUDSTONE	Shale: fissile; carbonaceous	252.0	253.3
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: very fine grained	253.3	254.6
COAL		254.6	255.6
SILTSTONE	In part blocky, laminated; in part dark grey, friable	255.6	260.6

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SHALE	Carbonaceous	260.6	261.3
COAL		261.3	263.4
INTERBEDDED COAL AND SHALE	Shale: carbonaceous	263.4	265.0
COAL WITH SHALE PARTING		265.0	267.1
COVERED	Siltstone?	267.1	267.8
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine grained; parallel and crosslaminated; in part flaggy	267.8	272.1
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: very fine grained; crosslaminated	272.1	275.6
PARTLY COVERED	Showings of rubbly siltstone	275.6	278.5
INTERBEDDED SANDSTONE AND SILSTONE	Sandstone: very fine grained; siltstone: rubbly; in part calcareous and orange weathering	278.5	285.2
SILTSTONE	Friable; dark grey; in part carbonaceous	285.2	287.4
MUDSTONE	Dark grey to black; friable; in part silty; in part concretionary and orange weathering	287.4	294.6
COAL		294.6	297.3
INTERBEDDED MUDSTONE AND SHALE	Mudstone: fissile; shale: carbonaceous	297.3	304.1
COAL		304.1	307.1
INTERBEDDED SILTSTONE AND MUDSTONE	Fining-upward unit	307.1	315.6
COAL		315.6	317.3
SILTSTONE WITH SANDSTONE INTERBEDS	Sandstone: very fine grained; siltstone: grey brown weathering	317.3	321.8
SANDSTONE	Fine grained; thin bedded; small crosslaminations; platy to flaggy	321.8	324.8
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: very fine grained	324.8	328.3
COAL		328.3	329.8
INTERBEDDED SILTSTONE AND COAL	Siltstone: carbonaceous	329.8	332.3
SILTSTONE	Dark grey; friable; in part blocky	332.3	334.3
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine and very fine grained; thin bedded	334.3	337.3
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: very fine grained	337.3	346.1
SILTSTONE WITH SANDSTONE INTERBEDS	Siltstone: dark grey to brown; friable; sandstone: very fine grained	346.1	349.6
COAL		349.6	351.9
SHALE WITH COAL INTERBED (ONE)	Shale: carbonaceous	351.9	352.9
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: very fine grained; thin bedded	352.9	355.4
SILTSTONE WITH SANDSTONE INTERBEDS	Siltstone: grey brown; weathers brown; sandstone: very fine grained	355.4	367.6
INTERBEDDED SILTSTONE AND SHALE	Siltstone: dark grey; friable; shale: carbonaceous	367.6	369.1
COAL		369.1	371.4
SILTSTONE	Greyish brown	371.4	373.2
COAL		373.2	374.5
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: very fine grained	374.5	377.5
SILTSTONE	Dark grey; friable	377.5	379.8
COAL		379.8	380.2
SILTSTONE	Grey brown; friable	380.2	381.9
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine to very fine grained; thin bedded; laminated	381.9	384.4
INTERBEDDED SILTSTONE, MUDSTONE AND SHALE	Shale: carbonaceous; siltstone: grey brown; mudstone: silty	384.4	388.6
INTERBEDDED SANDSTONE AND SILTSTONE	Thin-bedded unit; sandstone: very fine grained; crosslaminated; siltstone: grey brown	388.6	392.1
MUDSTONE	Silty; dark grey; some orange-weathering strata	392.1	396.8
COAL		396.8	398.1
SILTSTONE	Carbonaceous	398.1	398.7
SANDSTONE	Very fine grained; thin bedded; crosslaminated	398.1	399.4
SILTSTONE	In part blocky, in part friable; latter is grey brown	399.4	402.4
SANDSTONE	Fine and medium grained; thin bedded; crosslaminated; platy	402.4	405.7
COAL		405.7	406.4
INTERBEDDED SANDSTONE AND SILTSTONE	Coarsening-upward unit; siltstone: dark grey; sandstone: very fine grained; grey brown	406.4	407.7
SILTSTONE	Dark grey; shaly	407.7	409.1

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COAL		409.1	410.6
SILTSTONE	Carbonaceous	410.6	411.1
COAL WITH SHALE INTERBEDS		411.1	413.9
SILTSTONE	Carbonaceous	413.9	414.1
COAL		414.1	414.6
SHALE	Carbonaceous	414.6	415.1
COAL WITH SHALE PARTING		415.1	416.4
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; carbonaceous; contains plant fragments and casts	416.4	417.9
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine to medium grained; siltstone: friable; dark grey	417.9	426.2
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; dark grey	426.2	427.4
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: dark grey; silty; locally orange weathering	427.4	439.9
SHALE WITH MUDSTONE INTERBEDS AND COAL BANDS	Shale: carbonaceous; coal: bright	439.9	441.4
COAL WITH SHALE PARTINGS	Coal: hard; bright	441.4	443.9
SHALE	Carbonaceous	443.9	444.4
SILTSTONE	Thin bedded	444.4	445.7
INTERBEDDED SILTSTONE, SHALE AND COAL	Shale: carbonaceous	445.7	447.9
COAL		447.9	448.9
MUDSTONE	Silty; dark grey; in part carbonacoues; in part concretionary	448.9	453.7
COAL		453.7	455.1
SANDSTONE	Fine to medium grained; thin to medium bedded; parallel and crosslaminated	455.1	468.1

Mist Mountain Formation - Mount Michael Lower Sheet

Section 12

Lithology	Description	Base of Interval (m)	Top of Interval (m)
INTERBEDDED SILTSTONE AND MUDSTONE	Non-carb; beds 10-20 cm thick; siltstone: laminated; weathers yellow/brown; mudstone: concretionary	0.0	4.5
INTERBEDDED MUDSTONE AND SHALE WITH COAL BANDS	Shale: carbonaceous; coal: bright	4.5	9.0
COAL	Siderite bands in upper 2 m	9.0	15.6
INTERBEDDED MUDSTONE AND SHALE WITH COAL BANDS	Shale: carbonaceous; coal: bright; restricted to upper 40 cm of unit	15.6	18.0
COAL	Siderite bands throughout	18.0	23.8
INTERBEDDED MUDSTONE AND SHALE	Shale: carbonaceous	23.8	25.7
COAL		25.7	26.4
INTERBEDDED MUDSTONE AND SHALE	Shale: carbonaceous	26.4	28.5
COAL		28.5	31.0
INTERBEDDED SILTSTONE AND SHALE	Siderite bands; shale: carbonaceous	31.0	34.0
COAL	Total thickness unknown	34.0	35.5
COVERED		35.5	40.0
COAL		40.0	44.0
COVERED		44.0	49.0
PARTLY COVERED	Exposures of siltstone and fine-grained sandstone	49.0	51.5
COVERED		51.5	74.6
MUDSTONE	Thin bedded; rubbly; in part concretionary	74.6	79.1
COVERED		79.1	88.1
SILTSTONE	Dark grey; carbonaceous	88.1	89.1
COVERED		89.1	103.1
COAL		103.1	105.3
MAINLY COVERED	Exposures of very fine grained sandstone and siltstone	105.3	112.3
COAL		112.3	121.8
COVERED		121.8	134.6
INTERBEDDED SANDSTONE AND SILTSTONE	Bedding thickness 5 to 25 cm; sandstone: fine grained; crosslaminated	134.6	149.1
SILTSTONE WITH MUDSTONE INTERBEDS	Thin bedded unit; siltstone: laminated	149.1	156.6
MUDSTONE WITH SHALE AND SILTSTONE INTERBEDS (RARE)	Mudstone: in part orange weathering and concretionary; shale: carbonaceous	156.6	174.6
SILTSTONE WITH MUDSTONE INTERBEDS	Thinly bedded	174.6	175.6
SHALE WITH COAL INTERBED (ONE)	Shale: carbonaceous; coal: bed 30 cm thick	175.6	176.6
INTERBEDD SILTSTONE AND SANDSTONE	Coarsening-upward unit; thinly bedded; sandstone: fine grained	176.6	179.1
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine to medium grained; thin to medium bedded; ripple marks; crosslaminated	179.1	182.5
INTERBEDDED SILTSTONE, MUDSTONE AND SHALE	Bed thickness 10 cm to 1 m; siltstone: laminated; shale: carbonaceous; contains vitrain partings	182.5	195.5
INTERBEDDED SHALE AND COAL	Shale: carbonaceous; coal: in bands up to 15 cm thick	195.5	198.0
MUDSTONE WITH COAL BANDS	In part carbonaceous	198.0	200.8
SANDSTONE WITH SILTSTONE PARTINGS	Fining-upward unit	200.8	201.9
INTERBEDDED SILTSTONE AND MUDSTONE	Siltstone: orange weathering; crosslaminated; blocky	201.9	206.4
COAL		206.4	210.7

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SILTSTONE	Fissile; dark grey	210.7	213.4
INTERBEDDED SANDSTONE & SILTSTONE W. MUDSTONE PTGS	Thin to medium bedded; sandstone: very fine grained	213.4	217.1
SANDSTONE WITH SILTSTONE PARTINGS	Fining-upward unit; sandstone: medium to fine grained; crosslaminated; siltstone: near top of unit	217.1	221.8
SANDSTONE	Very fine grained; thin bedded; burrowed; crosslaminated	221.8	223.5
MUDSTONE WITH SILTSTONE INTERBEDS	Siltstone: beds up to 5 cm thick	223.5	228.5
SANDSTONE	Medium grained; plant debris in lowest 30 cm; crossbedded and crosslaminated	228.5	230.1
SILTSTONE	Dark grey; thin bedded; blocky	230.1	232.5
COVERED	Fine-grained sandstone near in place; float of siltstone, mudstone; carbonaceous shale float near top	232.5	248.5
COAL		248.5	249.5
INTERBEDDED MUDSTONE AND SHALE	Shale: carbonaceous	249.5	251.3
COAL		245.1	252.5
INTERBEDDED SHALE AND COAL	Shale: carbonaceous; coal: in beds up to 30 cm thick	252.5	254.7
COAL		254.7	257.1
MUDSTONE WITH SILTSTONE INTERBEDS	Mudstone: in part silty; rubbly; siltstone: thin to medium bedding thickness	257.1	263.9
SILTSTONE WITH MUDSTONE PARTINGS	Thin to medium bedded; siltstone: crosslaminated; blocky	263.9	272.9
INTERBEDDED SILTSTONE AND MUDSTONE	Thin-bedded unit; siltstone: dark grey; mudstone: in part concretionary	272.9	283.4
COVERED	Float of blocky, orange-weathering siltstone	283.4	288.2
MUDSTONE	Thin bedded	288.2	290.4
SANDSTONE WITH SILTSTONE INTERBEDS AND PARTINGS	Fining-upward unit; bed thickness thins upward; sandstone: fine to very fine grained; crosslaminated	290.4	295.1
INTERBEDDED MUDSTONE & SHALE WITH COAL STRINGERS	Mudstone: dark grey to black; carbonaceous; shale: carbonaceous; coal: restricted to shale; bright	295.1	298.6
COAL		298.6	300.9
SILTSTONE WITH MUDSTONE PARTINGS AND INTERBEDS	Thin to thick-bedded unit; greyish brown	300.9	306.9
MUDSTONE	Rubbly	306.9	310.7
SANDSTONE WITH SILTSTONE PARTINGS (LOCAL)	Sandstone: medium to dark grey; fine to medium grained; medium bedded; laminated and crosslaminated	310.7	326.2
COAL	Bright; well banded	326.2	331.7
SILTSTONE WITH MUDSTONE PARTINGS	Thin to medium bedded; siltstone: dark grey brown; blocky; in part crosslaminated	331.7	335.4
INTERBEDDED MUDSTONE, SHALE AND COAL	Mudstone and shale: carbonaceous; coal: beds up to 15 cm thick	335.4	338.9
MUDSTONE	Orange weathering; concretionary	338.9	339.9
COVERED		339.9	341.9
MUDSTONE WITH COAL STRINGERS	Mudstone: locally black and carbonaceous; coal: bright	341.9	345.1
COAL		345.1	345.8
INTERBEDDED SILTSTONE AND MUDSTONE	Thinly bedded unit	345.8	348.5
SHALE WITH COAL PARTINGS	Shale: carbonaceous; coal: bright	348.5	349.5
INTERBEDDED SILTSTONE AND MUDSTONE	Thin to medium-bedded unit	349.5	361.0
COAL		361.0	362.5
SANDSTONE	Medium to coarse grained; medium to thick bedded; medium grey; crossbedded; plant casts; resistant	362.5	377.5
INTERBEDDED SANDSTONE AND SILTSTONE	Thin-bedded unit; fining upward; sandstone: fine grained	377.5	379.0
MUDSTONE WITH SILTSTONE INTERBEDS	Carbonaceous in part	379.0	385.0
SHALE WITH COAL PARTINGS	Shale: carbonaceous; coal: bright	385.0	386.0
COAL	Contains 10 to 20 cm thick siderite band	386.0	387.3

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SILTSTONE WITH MUDSTONE PARTINGS	Thin-bedded unit; siltstone: dark grey	387.3	388.6
PARTLY COVERED	Exposures of blocky siltstone	388.6	393.1
INTERBEDDED SHALE, MUDSTONE AND COAL	Shale: carbonaceous; coal: bright	393.1	394.0
SILTSTONE	Laminated; blocky; thick bedded	394.0	396.6
INTERBEDDED COAL AND SHALE	Coal: in part shaly; shale: carbonaceous	396.6	397.6
INTERBEDDED SILTSTONE AND MUDSTONE	Thin to medium bedded; laminated	397.6	404.1
SANDSTONE	Fine grained; crosslaminated	404.1	404.9
PARTLY COVERED	Exposures of interbedded siltstone and mudstone; thin bedded; carbonaceous in upper 1 m	404.9	412.4
SANDSTONE WITH SILTSTONE PARTINGS (MINOR)	Fining-upward unit; sandstone: medium-fine grained; medium-thick bedded; crosslaminated near base	412.4	414.7
MAINLY COVERED	Outcrop of dark grey siltstone and concretionary mudstone	414.7	417.5
SANDSTONE WITH SILTSTONE PARTINGS (MINOR)	Sandstone: fine to medium grained; trough crossbedded at base; crosslaminated throughout	417.5	418.8
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; crosslaminated	418.8	419.3
INTERBEDDED SANDSTONE, SILTSTONE AND MUDSTONE	Thin to medium-bedded unit; sandstone: very fine grained; medium bedded; crosslaminated	419.3	422.2
INTERBEDDED MUDSTONE AND COAL	Mudstone: carbonaceous	422.2	422.7
SANDSTONE	Medium and coarse grained; medium to thick bedded; medium gray; cross bedded and crosslaminated	422.7	430.2

Section 13

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COAL	Base of unit corresponds with top of Morrissey Formation; coal is in part mineral-matter rich	0.0	1.8
INTERBEDDED SHALE AND COAL	Thinly bedded unit; shale: carbonaceous; coal: in beds up to 30 cm thick	1.8	3.3
INTERBEDDED SILTSTONE AND SHALE	Shale: carbonaceous	3.3	4.7
COVERED	Possible local float of fine-grained sandstone; recessive?	4.7	7.7
INTERBEDDED SILTSTONE AND SHALE	Siltstone: dark grey; friable; shale: fissile	7.7	9.4
COAL		9.4	10.8
PARTLY COVERED	Exposures of friable, grey and brown siltstone	10.8	15.3
COAL WITH SHALE PARTINGS		15.3	16.8
INTERBEDDED SHALE AND COAL	Coal: beds up to 30 cm thick	16.8	18.4
SILTSTONE	Dark grey; friable	18.4	19.5
COVERED	Recessive	19.5	22.6
MAINLY COVERED	Small exposures of thin-bedded, fine-grained sandstone; probably an interbedded sandstone\siltstone	22.6	25.5
COVERED	*Recessive; sandstone float (probably not local)*	25.5	38.0
INTERBEDDED SILTSTONE AND SANDSTONE	Sandstone: very fine grained; confined to top of unit	38.0	45.3
SANDSTONE	Very fine to fine grained; crosslaminated; orange weathering; semiresistant	45.3	48.1
SILTSTONE	Dark grey; friable	48.1	50.3
PARTLY COVERED	Carbonaceous unit; includes 0.5 m coal bed	50.3	51.3
PARTLY COVERED	Exposures of friable, dark grey siltstone; interbeds of fine-grained sandstone occur near top	51.3	61.8
SANDSTONE	Medium and coarse grained; medium bedded; thinner bedded near top; crossbedded; very resistant	61.8	94.3
COVERED	Semirecessive	94.3	97.3
SANDSTONE WITH SILTSTONE INTERBEDS NEAR TOP	Sandstone: medium grained near base; becomes finer grained and thin bedded near top; crosslaminated	97.3	105.8
INTERBEDDED SANDSTONE AND SILTSTONE	Thin bedded, fining-upward unit; sandstone: fine to very fine grained; siltstone: dark grey	105.8	107.8
INTERBEDDED SANDSTONE AND SILTSTONE	10 to 20 cm thick beds; sandstone: very fine grained	107.8	110.3
COVERED	Coal float roughly 5.5 m below top of unit	110.3	119.3
COAL	Thickness a minimum	119.3	126.8
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: very fine grained; siltstone: friable	126.8	136.2
INTERBEDDED SANDSTONE AND SILTSTONE	Thin to medium-bedded unit; sandstone: very fine grained	136.2	146.7
SILTSTONE	Dark grey; friable; recessive	146.7	154.4
COAL	Hard and blocky	154.4	162.4
INTERBEDDED CARBONACEOUS SHALE AND SILTSTONE	Carbonaceous	162.4	164.2
COAL	Hard and blocky; minor partings near base	164.2	169.8
SILTSTONE	Recessive	169.8	172.8
SANDSTONE	Fine grained; thin bedded; semiresistant	172.8	178.3
MAINLY COVERED	Dark grey siltstone predominantly; fine-grained sandstone float in one zone	178.3	202.8
COAL		202.8	204.1
SHALE WITH COAL PARTINGS	Shale: carbonaceous	204.1	205.4
COAL	One siderite band	205.4	208.8
SHALE WITH COAL INTERBEDS	Shale: carbonaceous	208.8	210.1
PARTLY COVERED	Siltstone exposures	210.1	219.6
COAL		219.6	220.1
SILTSTONE		220.1	220.8
COAL		220.8	221.0
MAINLY COVERED	Siltstone float, locally carbonaceous; recessive	221.0	229.0
SANDSTONE WITH SILTSTONE INTERBEDS	Semiresistant; sandstone: fine grained; thin bedded; siltstone: orange weathering; cross & convoluted laminations	229.0	240.3
COVERED	*Probably continuation of underlying unit*	240.3	241.7
SILTSTONE	Friable; grey/brown	241.7	244.4
SILTSTONE	Thin bedded; in part blocky; semirecessive	244.4	251.9

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COVERED	Carbonaceous spoil; up to 0.5 m coal	251.9	253.4
INTERBEDDED SANDSTONE AND SILTSTONE	Bed thickness up to 15 cm; evidence of faulting; sandstone: very fine to fine grained;	253.4	267.0
INTERBEDDED SILTSTONE AND SANDSTONE	Thin-bedded unit; sandstone: fine grained	267.0	289.0
SANDSTONE	Fine grained; thin bedded; crosslaminated	289.0	292.0
INTERBEDDED SILTSTONE AND SHALE	Recessive unit; siltstone: grey-brown; friable; shale: carbonaceous; fissile	292.0	296.5
COAL		296.5	297.8
INTERBEDDED SHALE AND SILTSTONE	Shale: dark grey; carbonaceous	297.8	299.3
SANDSTONE WITH SILTSTONE PARTINGS	Coarsening-upward unit; sandstone: very fine to fine grained; siltstone: occurs near base	299.3	301.5
SILTSTONE	Semirecessive	301.5	310.2
MAINLY COVERED	Float and pothole exposures of grey-brown siltstone; local carbonaceous shale	310.2	328.7
SANDSTONE	Fine grained; thin bedded; evidence of faulting	328.7	335.4
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; thin bedded	335.4	356.1
SILTSTONE	Recessive; friable; grey brown; locally orange weathering, calcareous and nodular	356.1	362.8
SANDSTONE WITH SILTSTONE INTERBEDS AND PARTINGS	Fining-upward unit; sandstone: fine to very fine grained	362.8	367.3
INTERBEDDED SILTSTONE AND SHALE	Siltstone: dark grey; shale: carbonaceous; black	367.3	368.3
COAL WITH SILTSTONE PARTING (ONE)	Siltstone: 20 cm parting in lowest 0.5 m	368.3	370.1
SHALE	Carbonaceous	370.1	371.4
COAL		371.4	375.4
INTERBEDDED SHALE (BASE) AND SILTSTONE	Shale: carbonaceous; siltstone: grey brown; friable	375.4	378.6
SANDSTONE WITH SILTSTONE PARTINGS	Semiresistant unit; sandstone: fine grained; thin bedded; crosslaminated	378.6	391.6
SILTSTONE	Grey brown; friable; recessive	391.6	393.1
SANDSTONE	Fine grained	393.1	394.1
PARTLY COVERED	Float and pothole exposures of friable, dark grey siltstone	394.1	406.2
SANDSTONE	Fining-upward unit; semiresistant; fine to very fine grained; thin bedded	406.2	409.5
SILTSTONE	Gradationally overlies previous unit	409.5	410.0
COAL		410.0	411.2
SILTSTONE	Semirecessive unit	411.2	428.8
SILTSTONE WITH SANDSTONE INTERBEDS	Thickly bedded unit; siltstone: dark grey; friable; sandstone: very fine grained	428.8	438.4
SANDSTONE	Fining-upward unit; bedding thickness thins upward; fine to very fine grained; well crosslaminated	438.4	445.4
SILTSTONE	Recessive unit; dark grey; friable	445.4	446.9
SANDSTONE	Fine grained; thin bedded	446.9	447.4
SILTSTONE	Recessive unit; dark grey; friable; locally blocky	447.4	451.0
COAL	10 cm thick parting 15 cm below top	451.0	452.5
SHALE	Carbonaceous; recessive unit	452.5	454.0
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: fine grained; thin bedded	454.0	458.3
SILTSTONE	Dark grey; fissile; recessive	458.3	466.3
SANDSTONE	Fine grained; thin to medium bedded; well crosslaminated	466.3	468.9
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained	468.9	473.4
SILTSTONE	Dark grey	473.4	474.5
COAL		474.5	474.7
SHALE	Carbonaceous	474.7	475.0
COAL	Hard; bright	475.0	

Lithology	Description	Base of Interval (m)	Top of Interval (m)
			476.0
SANDSTONE	Fine grained; thin bedded; well laminated and cross-laminated	476.0	479.3
SILTSTONE WITH SANDSTONE PARTINGS	Siltstone: friable; grey brown; sandstone: fine grained	479.3	482.3
SANDSTONE	Resistant, fining-upward unit; medium to fine grained; crossbedded and crosslaminated; plant casts	482.3	492.8
MAINLY COVERED	Siltstone float	492.8	494.3
COAL WITH SHALE PARTINGS	Shale: carbonaceous; concentrated in lowest 1.5 m	494.3	498.7
INTERBEDDED SILTSTONE AND SHALE	Shale: carbonaceous	498.7	501.7
SANDSTONE	Fining upward; medium grained at base, fine at top; cross-bedded, including trough; medium to thin bedded	501.7	507.7
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: fine grained; thin bedded; crosslaminated	507.7	517.7
COAL		517.7	518.3
SILTSTONE WITH SANDSTONE INTERBEDS	Recessive unit; siltstone: dark grey; carbonaceous at base and top; sandstone: very fine grained	518.3	527.1
SANDSTONE	Very resistant; medium grained; large scale crossbeds at base; thin to medium bedded; basal Elk	527.1	550.1

Section 14

Lithology	Description	Base of Interval (m)	Top of Interval (m)
SHALE	Carbonaceous	0.0	3.0
COAL		3.0	4.5
SHALE	Very carbonaceous	4.5	9.0
COAL		9.0	10.4
SHALE	Carbonaceous	10.4	12.2
COAL	Contains siderite	12.2	13.4
COVERED	Siltstone float	13.4	14.4
SILTSTONE		14.4	18.4
SHALE	Carbonaceous	18.4	20.4
INTERBEDDED SILTSTONE AND SANDSTONE	Sandstone: fine grained; beds 25 to 50 cm thick; crosslaminated; siltstone 5 to 15 cm beds	20.4	25.7
INTERBEDDED MUDSTONE, SILTSTONE AND SANDSTONE	Thin-bedded unit; sandstone: very fine grained	25.7	27.7
INTERBEDDED SILTSTONE AND SHALE	5 to 25 cm thick beds	27.7	32.9
SHALE	Carbonaceous in lower half	32.9	41.9
SANDSTONE WITH SILTSTONE PARTINGS	Sandstone: very fine grained; crosslaminated	41.9	43.5
INTERBEDDED SHALE AND SILTSTONE		43.5	48.5
SHALE WITH MUDSTONE PARTINGS	Shale: carbonaceous; mudstone: silty	48.5	56.8
SANDSTONE WITH MUDSTONE PARTINGS	Sandstone: very fine grained	56.8	57.5
COAL		57.5	57.7
INTERBEDDED SILTSTONE AND SANDSTONE	5 to 50 cm thick beds; coarsening-upward unit; sandstone: very fine grained; crosslaminated	57.7	65.9
SANDSTONE	Fine grained; thin bedded; laminated and crosslaminated; dark grey; weathers brownish grey	65.9	73.8
SHALE	Part carbonaceous	73.8	78.0
COAL		78.0	79.0
SHALE		79.0	85.0
COAL		85.0	86.0
SHALE		86.0	88.8
SANDSTONE	Medium grained; medium grey; thinly laminated; bed thickness 5 to 10 cm; abundant wood casts	88.8	96.3
PARTLY COVERED	Exposures of very fine grained sandstone and siltstone	96.3	106.3
MAINLY COVERED	Exposures of carbonaceous shale and siltstone	106.3	109.8
COAL	Shaly	109.8	112.8
SILTSTONE	Carbonaceous	112.8	117.6
COAL WITH SHALE PARTINGS AND INTERBEDS		117.6	123.0
SHALE	Carbonaceous	123.0	128.4
INTERBEDDED SHALE AND SILTSTONE		128.4	131.9
COAL		131.9	133.3
SHALE	Carbonaceous	133.3	134.1
SANDSTONE	Very fine grained; thinly laminated; thin bedded; crosslaminated; orange weathering	134.1	142.4
COAL		142.4	143.1
SANDSTONE	Fine grained; medium grey; thin bedded	143.1	147.9
SANDSTONE WITH SILTSTONE INTERBEDS	Fine grained; thinly laminated; medium bedded	147.9	156.1
MAINLY COVERED	Siltstone exposures	156.1	159.1
COAL		159.1	165.1
SHALE	Carbonaceous	165.1	168.0
MAINLY COVERED	Exposures of siltstone and shale	168.0	177.3
SANDSTONE	Fine grained; medium grey; thinly bedded	177.3	189.3
COVERED		189.3	221.8
SHALE	Carbonaceous	221.8	222.8
COAL WITH SHALE PARTINGS	Shale: carbonaceous	222.8	227.4
SHALE	Carbonaceous	227.4	229.8

Lithology	Description	Base of Interval (m)	Top of Interval (m)
INTERBEDDED SILTSTONE AND MUDSTONE WITH SHALE	1 to 20 cm thick beds; shale: carbonaceous	229.8	247.8
SANDSTONE	Medium to coarse grained; fines upward to fine grained; laminated; planar crossbedded; tree casts	247.8	257.8
COVERED		257.8	292.8
SILTSTONE WITH MUDSTONE INTERBED (ONE)		292.8	295.7
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	295.8	298.3
COAL		298.3	302.0
INTERBEDDED MUDSTONE AND SILTSTONE	Carbonaceous in upper 2 m; 5 to 10 cm thick beds	302.0	311.0

Section 15

Lithology	Description	Base of Interval (m)	Top of Interval (m)
COAL		0.0	2.0
SANDSTONE	Moose Mountain Member	2.0	8.5
SHALE	Carbonaceous	8.5	9.5
COAL		9.5	10.7
INTERBEDDED MUDSTONE AND SHALE	Carbonaceous	10.7	13.7
SILTSTONE		13.7	16.7
SHALE	Carbonaceous	16.7	21.7
COAL WITH SHALE PARTING		21.7	25.9
INTERBEDDED SHALE AND MUD-STONE		25.9	30.9

Section 16

Lithology	*Description*	*Base of* Interval (m)	*Top of* Interval (m)
COVERED		0.0	7.0
SANDSTONE	Fine grained; thin bedded	7.0	10.3
COAL WITH SHALE INTERBEDS	Shale: carbonaceous	10.3	11.6
MUDSTONE	Friable; dark grey	11.6	12.8
MUDSTONE	Grey brown weathering; thin bedded	12.8	18.6
SILTSTONE	Dark grey; carbonaceous at top	18.6	19.6
COAL		19.6	21.1
INTERBEDDED SHALE AND COAL		21.1	22.6
MUDSTONE	Dark grey; thin bedded	22.6	25.7
INTERBEDDED SILTSTONE AND MUDSTONE		25.7	29.1
INTERBEDDED SANDSTONE AND SILTSTONE	Sandstone: very fine grained	29.1	30.4
MAINLY COVERED	Carbonaceous zone	30.4	31.9
COVERED		31.9	54.9
INTERBEDDED SHALE AND COAL	Shale: carbonaceous	54.9	56.9
COAL		56.9	59.9
SANDSTONE	Medium to coarse grained; large scale crossbedded; plant casts	59.9	72.4

APPENDIX 2
DRILL-CORE LOGS – ELK VALLEY COALFIELD

Explanation of Drill Core Descriptions

Based on the method of the Research Planning Institute Inc. (Ruby et al., 1981)

LITHOLOGICAL CODES

700 Series (conglomerates)

742 - Shale pebble conglomerate
745 - Lithic pebble conglomerate

500 Series (sandstones)

5X1 - Crossbedded sandstone
5X2 - Flat-bedded sandstone
5X3 - Flaser-bedded sandstone
5X4 - Massive sandstone
5X5 - Churned sandstone
5X7 - Rooted sandstone
Where X=4, rock is a lithic arenite
X=5, rock is a quartz arenite

300 Series (intermixed shales and sandstones or ISAS)

3X1 - Wavy-bedded sandstone with interbedded shale
3X2 - Lenticular-bedded sandstone with interbedded shale
3X3 - Shale with lenticular-bedded sandstone streaks
3X4 - Massive ISAS
3X5 - Churned ISAS
3X6 - Completely bioturbated ISAS
3X7 - Rooted ISAS
3X8 - Intensely burrowed ISAS
Where X=1, rock is black
X=2, rock is dark grey
X=3, rock is light grey-green
X=4, rock is green
X=9, rock is brown

100 Series (shales)

1X2 - Laminated shale
1X3 - Coal-streaked shale
1X4 - Massive shale
1X5 - Churned shale
1X6 - Completely bioturbated shale
1X8 - Intensely burrowed shale
Where X=1, rock is black
X=2, rock is dark grey
X=3, rock is light grey-green
X=9, rock is brown

020 Series (coal)

021 - Common banded coal
022 - Coal interbedded with bone
024 - Massive dull coal
027 - Coal interbedded with shale
028 - Coal streaked with shale

000 - Missing or unlogable core

Suffix Modifiers

COLSPR	Coal spar
COLBND	Coal banding
CO3CMT	Calcite cement
SLP	Slumped
DST	Distorted or convoluted bedding
MFT	Microfaulting
MXT	Mixed deformation
FLT	Flat bedded
RIP	Rippled
BUR	Slightly burrowed
LRG	Large scale
RTD	Rooted

(Intervals converted to true thickness)

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
290.14	289.84	124	CO3CMT
289.84	287.68	321	RIP SLP CO3CMT
287.68	287.40	124	CO3CMT
287.40	286.99	321	RIP CO3CMT
286.99	285.93	124	
285.93	285.65	000	
285.65	285.49	321	RIP SLP CO3CMT
285.49	285.09	000	
285.09	283.84	000	
283.84	284.74	000	
282.74	282.36	321	RIP
282.36	281.27	114	COLSPR
281.27	280.99	321	SLP CO3CMT
280.99	280.29	124	CO3CMT
280.29	280.15	322	RIP BUR DST CO3CMT
280.15	279.99	114	COLSPR
279.99	279.84	321	RIP CO3CMT
279.84	279.51	124	CO3CMT
279.51	279.46	322	DST CO3CMT
279.46	278.47	124	
278.47	278.35	323	DST CO3CMT
278.35	274.44	000	
274.44	273.70	112	COLBND
273.70	268.04	000	
268.04	267.83	113	COLBND
267.83	266.88	323	FLT DST
266.88	266.43	321	FLT DST CO3CMT
266.43	266.24	323	FLT BUR
266.24	265.93	321	RIP
265.93	264.54	323	FLT
264.54	264.44	322	FLT
264.44	264.07	323	FLT
264.07	263.65	122	
263.65	262.83	112	COLSPR COLBND
262.83	261.67	000	
261.67	259.62	122	COLSPR COLBND
269.62	258.85	323	FLT BUR CO3CMT
258.85	258.12	114	COLSPR COLBND
258.12	258.06	027	
258.06	257.36	112	COLSPR COLBND
257.36	257.10	122	COLSPR
257.10	256.89	112	COLBND
256.89	256.31	122	FLT
256.31	256.19	127	MFT
256.19	255.82	323	CO3CMT
255.82	253.68	122	COLSPR
253.68	253.43	197	DST CO3CMT
253.43	253.05	122	COLSPR
253.05	251.54	323	FLT BUR CO3CMT
251.54	249.72	122	COLSPR
249.72	249.67	021	
249.67	248.92	127	DST CO3CMT
248.92	248.21	323	RTD DST CO3CMT
248.21	246.80	127	COLSPR
246.80	246.40	323	DST CO3CMT
246.40	245.73	321	RIP DST COLSPR
245.73	245.50	322	RIP
245.50	245.27	553	RIP CO3CMT
245.27	245.04	323	RIP
245.04	243.40	122	
243.40	242.01	114	COLSPR
242.01	241.01	122	CO3CMT
241.01	240.62	124	
240.62	240.10	114	COLSPR
240.10	239.55	124	
239.55	239.40	124	COLSPR
239.40	231.35	000	
231.35	230.74	122	COLSPR
230.74	230.59	027	
230.59	230.14	114	COLBND
230.14	228.93	122	RTD
228.93	228.14	554	
228.14	227.86	323	COLSPR
227.86	227.62	321	RIP
227.62	226.84	323	SLP
226.84	226.30	321	COLSPR RIP
226.30	225.80	553	RIP RTD
225.80	225.31	323	DST
225.31	225.27	114	COLBND
225.27	225.08	027	
225.08	224.57	114	COLBND
224.57	224.24	325	COLBND
224.24	223.74	553	RIP
223.74	223.41	323	COLBND
223.41	223.25	553	
223.25	223.04	323	
223.04	222.76	557	COLBND
222.76	222.07	321	RIP
222.07	221.88	323	COLBND
221.88	221.17	321	RIP RTD
221.17	220.74	322	FLT
220.74	220.49	322	RTD COLBND
220.49	219.93	321	RIP RTD COLSPR

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
219.93	219.58	323	COLBND RTD
219.58	219.11	321	RIP
219.11	218.78	323	COLSPR
218.78	218.24	321	RIP RTD
218.24	216.99	323	RIP RTD
216.99	216.17	117	COLBND COLSPR
216.17	212.18	323	RTD
212.18	211.81	557	COLSPR CO3CMT
211.81	210.87	321	COLBND FLT RIP BUR
210.87	210.01	323	COLSPR RTD
210.01	208.29	124	COLSPR
208.29	207.12	324	
207.12	206.59	322	RIP
206.59	206.08	321	RIP BUR RTD
206.08	205.99	323	
205.99	205.72	321	RIP
205.72	204.72	541	COLSPR
204.72	204.37	321	COLSPR
204.37	203.95	334	
203.95	203.82	322	
203.82	202.37	542	COLSPR
202.37	200.13	544	
200.13	197.83	322	RIP DST SLP
197.83	195.90	323	COLSPR MFT
195.90	195.22	122	COLSPR
195.22	191.54	325	COLSPR
191.54	190.79	321	RIP BUR DST
190.79	190.60	323	
190.60	189.87	124	
189.87	188.97	000	
188.97	187.50	000	
187.50	185.99	000	
185.99	185.73	000	
185.73	183.43	321	RIP BUR
183.43	182.26	553	RIP
182.26	181.78	552	COLSPR
181.78	181.43	542	
181.43	180.34	544	COLSPR COLBND
180.34	180.23	323	
180.23	179.97	541	
179.97	177.55	323	SLP
177.55	175.37	124	
175.37	173.89	323	RTD
173.89	173.51	325	COLBND
173.51	173.23	324	RTD
173.23	173.02	322	DST RTD
173.02	172.20	323	COLBND
172.20	172.00	321	RIP DST COLSPR
172.00	171.86	325	COLSPR
171.86	171.66	321	RIP
171.66	171.27	323	COLBND
171.27	171.21	322	COLBND RIP DST CO3
171.21	164.19	323	COLBND RIP DST MFT
164.19	163.25	124	COLBND COLSPR
163.25	155.86	000	
155.86	155.65	114	COLBND
155.65	155.51	124	COLBND
155.51	154.59	124	
154.59	154.23	323	
154.23	149.71	124	
149.71	149.08	325	RTD
149.08	148.49	124	
148.49	148.26	322	DST
148.26	147.89	323	RIP
147.89	147.37	322	DST
147.37	147.10	197	
147.10	147.03	322	DST
147.03	146.92	321	RIP
146.92	146.35	547	
146.35	145.42	321	DST MFT
145.42	144.88	322	RIP DST
144.88	144.16	323	
144.16	143.97	325	
143.97	143.48	541	RTD
143.48	143.05	324	
143.05	142.76	322	RIP
142.76	142.25	324	COLSPR
142.25	141.45	323	DST
141.45	141.05	322	RIP DST
141.05	140.68	323	
140.68	140.33	321	RIP DST
140.33	139.79	324	
139.79	139.64	321	DST COLSPR
139.64	139.54	544	
139.54	139.44	323	COLSPR RTD
139.44	139.25	544	
139.25	139.21	541	
139.21	139.14	544	
139.14	138.82	321	RIP
138.82	138.52	543	COLSPR
138.52	137.77	541	COLBND
137.77	136.72	323	DST
136.72	136.55	321	
136.55	136.24	542	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
136.24	135.98	541	
135.98	134.80	541	COLSPR
134.80	133.12	541	COLBND
133.12	132.15	323	DST
132.15	131.23	124	
131.23	130.69	124	COLSPR COLBND
130.69	129.66	323	COLBND RIP
129.66	129.28	123	
129.28	129.00	325	
129.00	126.99	123	
126.99	126.90	322	DST
126.90	126.56	122	
126.56	126.51	323	
126.51	125.68	124	
125.68	125.61	323	
125.61	124.22	124	
124.22	124.03	114	COLSPR
124.03	123.99	024	
123.99	123.80	113	COLBND
123.80	123.45	000	
123.45	123.36	113	COLSPR
123.36	121.37	325	COLSPR
121.37	121.06	541	
121.06	120.95	543	
120.95	119.84	321	RIP BUR DST
119.84	119.57	323	RIP
119.57	119.43	113	COLBND
119.43	118.46	323	
118.46	118.30	322	DST
118.30	117.51	124	
117.51	117.29	325	
117.29	117.05	324	
117.05	116.08	323	
116.08	115.88	321	RIP CO3CMT
115.88	115.16	325	
115.16	114.90	322	DST
114.90	114.35	321	RIP CO3CMT
114.35	114.06	323	
114.06	113.46	322	RIP DST CO3CMT
113.46	112.99	323	DST COLSPR
112.99	112.52	321	DST CO3CMT
112.52	112.34	324	
112.34	111.81	322	RIP DST
111.81	111.36	321	RIP COLSPR
111.36	110.47	543	COLSPR
110.47	110.23	543	COLBND
110.23	109.83	321	COLSPR
109.83	109.47	544	COLSPR COLBND
109.47	108.97	323	RIP DST COLSPR
108.97	108.61	324	CO3CMT
108.61	108.34	325	COLSPR
108.34	107.93	324	COLSPR
107.93	107.75	321	RIP
107.75	107.28	323	COLSPR
107.28	106.82	123	
106.82	105.36	124	COLSPR
105.36	105.32	027	
105.32	104.55	021	
104.55	104.06	113	
104.06	102.71	124	COLBND
102.71	102.66	021	
102.66	102.37	124	COLSPR
102.37	102.15	123	RTD
102.15	102.06	322	RIP
102.06	101.10	323	RIP
101.10	100.58	321	FLT DST CO3CMT
100.58	100.26	323	FLT DST
100.26	99.84	122	
99.84	99.50	114	COLBND
99.50	99.44	027	
99.44	98.59	124	
98.59	98.47	322	RIP RTD
98.47	98.06	323	RIP RTD MFT CO3CMT
98.06	97.25	124	CAL VEINS
97.25	97.05	323	RIP
97.05	95.54	122	RTD COLSPR
95.54	95.30	114	COLBND
95.30	94.02	122	COLSPR
94.02	91.91	123	
91.91	91.10	000	
91.10	86.83	000	
86.83	85.95	122	BUR RTD COLSPR
85.95	83.22	124	
83.22	83.07	127	
83.07	82.93	323	RIP CO3CMT
82.93	82.69	124	
82.69	82.59	323	RIP
82.59	82.54	124	
82.54	82.27	122	COLSPR
82.27	82.18	000	
82.18	81.82	321	RIP
81.82	81.13	000	
81.13	79.32	000	
79.32	78.41	000	
78.41	78.33	323	RIP
78.33	78.17	322	FLT CO3CMT
78.17	78.02	321	RIP CO3CMT
78.02	77.80	323	
77.80	77.68	321	RIP CO3CMT
77.68	77.60	323	DST
77.60	77.53	321	CO3CMT
77.53	76.97	124	
76.97	76.59	323	
76.59	76.21	324	
76.21	75.89	323	
75.89	75.42	321	DST SLP
75.42	74.04	542	DST
74.04	73.14	541	COLBND
73.14	72.98	322	FLT
72.98	72.05	544	COLBND
72.05	71.93	124	
71.93	71.82	544	COLBND
71.82	71.51	543	FLT
71.51	71.39	544	COLBND
71.39	71.25	542	
71.25	70.44	122	
70.44	70.35	322	
70.35	69.51	122	
69.51	69.38	197	
69.38	67.37	123	COLBND
67.37	67.33	325	CO3CMT
67.33	67.18	124	
67.18	67.11	321	RIP RTD CO3CMT
67.11	66.71	123	
66.71	66.47	197	
66.47	65.98	123	
65.98	65.85	323	FLT
65.85	64.71	123	
64.71	64.67	322	RIP
64.67	63.87	123	
63.87	63.38	122	
63.38	63.06	322	RIP CO3CMT
63.06	62.22	124	
62.22	61.82	122	BUR
61.82	61.57	325	
61.57	61.21	122	DST BUR
61.21	61.06	197	
61.06	60.41	124	COLSPR
60.41	60.33	194	
60.33	59.67	325	
59.67	59.52	197	
59.52	58.56	123	
58.56	57.90	122	COLSPR
57.90	57.70	321	RIP CO3CMT
57.70	57.62	323	
57.62	57.20	124	COLSPR
57.20	56.59	124	
56.59	56.17	322	RIP DST CO3CMT
56.17	55.72	323	COLSPR
55.72	55.38	321	RIP CO3CMT
55.38	55.26	323	DST
55.26	54.91	123	
54.91	54.75	325	
54.75	53.65	124	
53.65	53.38	322	DST
53.38	52.12	323	DST BUR
52.12	51.92	321	DST BUR CO3CMT
51.92	51.82	323	
51.82	51.73	195	
51.73	50.85	323	
50.85	50.64	321	CO3CMT
50.64	50.02	323	BUR
50.02	49.94	321	RIP BUR
49.94	49.83	122	
49.83	49.55	321	DST MFT
49.55	49.38	323	FLT
49.38	49.27	321	RIP
49.27	48.98	323	DST
48.98	48.76	322	RIP
48.76	48.33	321	RIP
48.33	47.86	323	DST SLP
47.86	47.23	322	DST FLT
47.23	46.77	122	
46.77	45.64	124	
45.64	45.53	124	
45.53	44.95	323	DST
44.95	44.60	122	
44.60	44.19	124	
44.19	43.66	553	COLSPR COLBND
43.66	41.98	000	
41.98	41.43	113	
41.43	41.15	124	COLSPR
41.15	39.93	000	
39.93	38.98	113	
38.98	38.48	114	COLBND
38.48	35.86	000	
35.86	34.97	122	
34.97	34.57	323	
34.57	34.22	124	
34.22	34.19	114	COLBND
34.19	33.40	000	
33.40	33.16	112	COLSPR
33.16	32.88	325	
32.88	32.27	322	RIP DST
32.27	31.66	000	
31.66	31.39	114	COLSPR
31.39	31.04	323	DST
31.04	30.77	000	
30.77	30.37	122	
30.37	29.96	323	
29.96	29.56	000	

(Intervals converted to true thickness)

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
256.41	256.19	122	RIP
256.19	255.59	124	
255.59	254.67	321	RIP BUR MFT
254.67	254.35	122	
254.35	254.24	322	RIP MFT BUR
254.24	254.07	541	DST
254.07	253.67	325	DST COLSPR
253.67	253.36	323	DST BUR COLSPR
253.36	253.01	325	BUR
253.01	252.90	323	DST RIP
252.90	252.49	322	
252.49	252.41	321	RIP
252.41	251.83	323	DST
251.83	251.51	321	DST
251.51	251.46	544	
251.46	251.10	321	COLSPR
251.10	250.41	544	COLSPR
250.41	249.87	542	
249.87	248.83	544	
248.83	248.06	542	RTD COLSPR COLBND
248.06	247.75	322	
247.75	247.53	542	COLSPR DST RTD
247.53	246.80	122	
246.80	245.96	542	
245.96	254.00	544	COLSPR
245.00	244.61	542	
244.61	244.47	322	RIP CO3CMT
244.47	244.38	544	CO3CMT
244.38	243.86	544	COLSPR RTD CO3CMT
243.86	243.81	745	CO3CMT
243.81	243.51	542	COLSPR CO3CMT
243.51	243.46	323	COLSPR CO3CMT
243.46	243.31	745	COLSPR CO3CMT
243.31	243.23	542	COLSPR CO3CMT
243.23	242.64	542	CO3CMT
242.64	242.53	745	CO3CMT
242.53	241.66	544	CO3CMT
241.66	241.55	542	CO3CMT
241.55	241.22	322	COLSPR RTD CO3CMT
241.22	240.36	322	RIP CO3CMT
240.36	240.07	544	CO3CMT
240.07	240.03	542	BUR CO3CMT
240.03	239.23	542	CO3CMT
239.23	238.02	745	CO3CMT
238.02	237.07	122	
237.07	236.97	112	
236.97	231.84	122	COLSPR
231.84	231.64	323	COLSPR CO3CMT
231.64	231.12	122	COLSPR BUR CO3CMT
231.12	230.91	323	RIP BUR DST COLSPR
230.91	230.82	322	RIP CO3CMT
230.82	230.41	323	COLSPR RTD FLT CO3
230.41	230.31	325	COLSPR C03CMT
230.31	230.23	323	FLT RTD COLSPR CO3
230.23	230.03	323	BUR COLSPR RTD CO3
230.03	229.57	324	COLSPR DST CO3CMT
229.57	229.06	324	FLT CO3CMT
229.06	228.84	323	BUR FLT CO3CMT
228.84	228.77	321	BUR CO3CMT
228.77	228.69	323	BUR FLT CO3CMT
228.69	228.25	122	FLT BUR CO3CMT
228.25	227.53	323	COLSPR FLT CO3CMT
227.53	227.08	128	COLBND CO3CMT
227.08	226.64	324	COLBND CO3CMT
226.64	226.37	322	CO3CMT
226.37	225.88	323	BUR RTD CO3CMT
225.88	225.53	122	RTD CO3CMT
225.53	225.43	322	CO3CMT
225.43	225.20	323	RTD MFT CO3CMT
225.20	224.18	122	BUR RTD COLSPR DST
224.18	223.86	322	BUR RIP CO3CMT
223.86	223.64	122	BUR C03CMT
223.64	223.50	323	BUR CO3CMT
223.50	222.80	122	CO3CMT
222.80	222.52	324	C03CMT
222.52	222.15	323	COLSPR CO3CMT
222.15	222.00	324	CO3CMT
222.00	221.58	323	CO3CMT
221.58	220.99	322	RIP LRG CO3CMT
220.99	220.78	323	RTD COLSPR CO3CMT
220.78	219.79	322	RIP RTD BUR COLSPR
219.79	219.61	323	COLSPR RIP RTD BUR
219.61	219.10	322	COLSPR RTD CO3CMT
219.10	218.54	122	CO3CMT
218.74	218.39	124	DST CO3CMT
218.39	217.88	324	DST
217.88	216.97	323	RIP BUR
216.97	216.84	122	
216.84	216.59	323	
216.59	216.38	322	RIP
216.38	215.86	122	BUR
215.86	215.79	322	RIP
215.79	215.66	124	BUR COLSPR

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
215.66	214.85	122	RIP COLSPR DST
214.85	214.72	323	DST
214.72	214.46	322	RIP RTD BUR
214.46	213.39	122	RTD COLSPR DST
213.39	213.23	000	
213.23	212.54	122	RTD COLSPR COLBND
212.54	197.72	000	
197.72	196.92	122	
196.92	196.69	021	
196.69	196.46	124	
196.46	195.59	122	RIP RTD MFT DST
195.59	195.31	324	COLSPR RTD
195.31	195.06	327	DST COLSPR
195.06	194.16	322	COLSPR CO3CMT
194.16	193.99	122	RTD
193.99	193.94	321	RTD CO3CMT
193.94	193.38	122	COLSPR
193.38	193.05	322	DST RTD
193.05	192.91	323	
192.91	192.48	322	RTD MRT RIP COLSPR
192.48	192.40	122	
192.40	191.73	322	RTD COLSPR
191.73	191.17	122	
191.17	191.12	321	RTD RIP
191.12	190.97	122	BUR
190.97	190.86	321	RIP COLSPR
190.86	190.18	122	
190.18	189.89	194	
189.89	189.64	122	
189.64	189.05	112	
189.05	187.71	122	
187.71	187.55	322	DST RTD COLSPR
187.55	187.48	122	COLSPR
187.48	187.39	322	COLSPR DST RTD
187.39	187.22	114	
187.22	186.70	324	RTD COLSPR
186.70	186.19	112	COLBND
186.19	184.85	324	COLSPR
184.85	182.75	114	RTD
182.75	180.32	124	RTD CO3CMT
180.32	179.88	324	CO3CMT
179.88	179.63	322	RIP LRG CO3CMT
179.63	179.49	122	CO3CMT
179.49	179.25	323	FLT CO3CMT
179.25	178.46	122	BUR CO3CMT
178.46	178.02	323	RIP CO3CMT
178.02	177.03	323	FLT BUR CO3CMT
177.03	176.88	392	RIP BUR MFT CO3CMT
176.88	176.33	323	FLT CO3CMT
176.33	176.10	322	RIP CO3CMT
176.10	176.04	112	CO3CMT
176.04	175.57	322	BUR RIP CO3CMT
175.57	175.33	122	FLT CO3CMT
175.33	175.13	322	RTD BUR CO3CMT
175.13	174.90	322	FLT CO3CMT
174.90	173.85	322	RIP CO3CMT
173.85	173.40	322	FLT CO3CMT
173.40	172.89	544	CO3CMT
172.89	172.73	322	FLT CO3CMT
172.73	172.67	322	RIP CO3CMT
172.67	172.00	544	CO3CMT
172.00	171.35	541	CO3CMT
171.35	170.64	542	COLSPR RTD DST CO3
170.64	169.76	541	LRG COLSPR CO3CMT
169.76	169.57	542	COLBND CO3CMT
169.57	169.20	541	COLSPR CO3CMT
169.20	167.44	542	CO3CMT
167.44	166.89	122	COLSPR CO3CMT
166.89	166.71	194	COLSPR RTD CO3CMT
166.71	165.90	122	CO3CMT
165.90	165.64	122	COLSPR CO3CMT
165.64	165.10	122	COLSPR CO3CMT
165.10	165.01	192	
165.01	164.54	122	
164.54	164.42	192	
164.42	164.07	122	
164.07	163.97	112	COLSPR
163.97	161.42	124	
161.42	161.20	114	
161.20	161.02	122	
161.02	160.20	541	
160.20	169.91	124	
159.91	159.46	122	
159.46	158.33	114	COLSPR
158.33	158.21	542	DST COLSPR
158.21	157.95	323	
157.95	157.72	112	COLSPR
157.72	157.26	322	COLSPR RIP
157.26	157.17	122	
157.17	157.12	321	COLSPR RIP
157.12	155.45	112	
155.45	155.07	122	
155.07	152.97	112	
152.97	152.77	021	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
152.77	150.73	112	COLBND
150.73	150.55	134	RTD COLSPR CO3CMT
150.55	150.37	124	CO3CMT
150.37	149.99	132	COLSPR CO3CMT
149.99	149.87	124	CO3CMT
149.87	149.79	132	COLSPR CO3CMT
149.79	148.53	122	CO3CMT
148.53	148.31	323	RIP CO3CMT
148.31	148.03	324	CO3CMT
148.03	147.83	323	CO3CMT
147.83	147.55	322	CO3CMT
147.55	147.44	323	CO3CMT
147.44	147.30	122	CO3CMT
147.30	147.10	324	CO3CMT
147.10	146.15	322	CO3CMT
146.15	145.77	321	CO3CMT
145.77	145.66	122	CO3CMT
145.66	145.12	322	RIP CO3CMT
145.12	144.97	122	CO3CMT
144.97	144.90	127	COLSPR CO3CMT
144.90	144.84	322	RIP CO3CMT
144.84	144.66	323	CO3CMT
144.66	144.53	322	CO3CMT
144.53	144.47	122	CO3CMT
144.47	144.22	322	DST CO3CMT
144.22	144.17	122	RTD CO3CMT
144.17	143.97	321	CO3CMT
143.97	143.72	122	CO3CMT
143.72	143.50	323	DST BUR CO3CMT
143.50	143.09	124	CO3CMT
143.09	143.01	322	RIP CO3CMT
143.01	142.73	323	RIP CO3CMT
142.73	141.59	321	RIP CO3CMT
141.59	141.45	124	CO3CMT
141.45	141.34	321	RIP CO3CMT
141.34	141.14	321	BUR DST CO3CMT
141.14	140.82	122	CO3CMT
140.82	140.48	323	RIP CO3CMT
140.48	140.08	122	RIP CO3CMT
140.08	139.75	124	CO3CMT
139.75	139.56	321	RIP CO3CMT
139.56	139.32	122	CO3CMT
139.32	139.28	322	RIP CO3CMT
139.28	138.72	324	CO3CMT
138.72	138.25	124	CO3CMT
138.25	138.18	322	CO3CMT
138.18	138.06	122	CO3CMT
138.06	137.79	323	DST CO3CMT
137.79	137.02	322	RIP LRG CO3CMT
137.02	136.88	323	FLT CO3CMT
136.88	136.29	322	RIP BUR CO3CMT
136.29	136.14	321	RIP CO3CMT
136.14	135.94	323	RTD CO3CMT
135.94	135.30	324	CO3CMT
135.30	135.19	322	RIP CO3CMT
135.19	134.83	323	FLT CO3CMT
134.83	134.41	322	RIP CO3CMT
134.41	134.13	122	CO3CMT
134.13	133.78	323	RIP RTD CO3CMT
133.78	133.65	322	DST CO3CMT
133.65	133.56	324	CO3CMT
133.56	132.79	321	RIP DST CO3CMT
132.79	132.60	122	CO3CMT
132.60	132.55	323	RIP CO3CMT
132.55	132.40	122	CO3CMT
132.40	132.28	323	RIP CO3CMT
132.28	131.30	122	RTD COLSPR
131.30	131.24	324	
131.24	131.18	122	
131.18	131.12	323	SLP
131.12	130.61	122	
130.61	130.45	324	
130.45	130.26	124	
130.26	130.02	323	COLSPR DST BUR
130.02	129.02	122	COLSPR
129.02	128.75	112	COLBND
128.75	128.36	122	
128.36	128.16	112	
128.16	117.88	000	
117.88	117.22	112	COLBND
117.22	116.83	323	DST
116.83	116.68	122	
116.68	116.62	324	
116.62	116.16	122	COLBND
116.16	115.69	322	
115.69	115.30	112	COLBND
115.30	115.23	323	
115.23	114.85	112	
114.85	114.64	192	
114.64	113.37	112	COLSPR COLBND
113.37	112.10	000	
112.10	111.88	112	COLBND COLSPR
111.88	110.34	122	COLBND
110.34	110.21	192	RTD
110.21	109.37	122	COLSPR COLBND
109.37	109.24	112	COLBND COLSPR
109.24	108.53	124	COLSPR
108.53	108.07	134	
108.07	104.67	112	COLSPR COLBND
104.67	102.57	000	
102.57	101.76	112	COLSPR COLBND
101.76	101.33	124	
101.33	101.16	324	
101.16	100.30	124	
100.30	99.67	324	RTD
99.67	99.14	323	RIP
99.34	97.84	322	FLT
97.84	97.12	322	RIP
97.12	94.18	122	MFT
94.18	93.96	324	
93.96	93.54	334	
93.54	93.35	124	
93.35	92.64	542	
92.64	92.44	122	
92.44	91.83	544	
91.83	91.65	542	RIP
91.65	91.07	323	DST
91.07	91.02	541	
91.02	90.79	323	
90.79	90.76	324	MFT LRG
90.76	90.69	122	
90.69	90.44	323	RTD
90.44	90.10	122	DST
90.10	89.93	322	RIP
89.93	89.72	541	
89.72	89.45	122	
89.45	88.56	122	COLSPR
88.56	88.26	322	DST BUR
88.26	88.10	323	RIP DST
88.10	87.86	541	
87.86	87.78	544	RTD
87.78	87.39	541	
87.39	85.55	544	
85.55	84.72	543	RTD FLT COLBND
84.72	84.40	542	
84.40	82.29	544	
82.29	81.65	541	COLBND COLSPR
81.65	81.55	544	MFT DST RTD COLSPR
81.55	80.96	542	COLSPR
80.96	74.40	544	
74.40	74.14	541	COLBND
74.14	73.83	545	COLBND
73.83	73.58	122	
73.58	73.52	323	RIP
73.52	73.46	122	
73.46	73.36	322	RIP
73.36	73.19	323	FLT
73.19	72.44	122	
72.44	72.25	322	RIP
72.25	72.16	323	
72.16	72.05	322	RIP
72.05	71.85	323	
71.85	71.73	542	
71.73	71.21	323	RIP LRG
71.21	70.31	543	COLBND
70.31	69.76	323	
69.76	69.65	322	RIP
69.65	69.37	122	
69.37	68.98	322	RIP
68.98	68.01	541	COLSPR RTD DST
68.01	67.79	122	
67.79	67.74	322	FLT DST
67.74	67.66	323	FLT
67.66	67.54	543	RTD COLSPR
67.54	67.38	323	FLT
67.38	67.29	322	RIP
67.29	67.17	323	FLT
67.17	66.92	122	
66.92	66.74	323	FLT
66.74	66.62	322	RIP
66.62	66.37	122	
66.37	66.31	323	FLT
66.31	65.46	324	
65.46	65.40	322	RIP
65.40	64.42	324	FLT
64.42	64.33	322	FLT
64.33	64.12	324	
64.12	63.96	321	DST FLT
63.96	63.84	323	FLT
63.84	63.73	321	
63.73	63.43	543	COLSPR
63.43	62.86	324	FLT
62.86	57.79	542	FLT COLBND
57.79	57.61	542	COLBND FLT
57.61	56.63	542	FLT
56.63	55.17	324	DST RTD
55.17	54.64	541	
54.64	54.36	544	COLBND RTD
54.36	54.26	542	
54.26	53.21	544	COLBND RTD
53.21	52.97	322	RIP
52.97	52.77	122	
52.77	52.41	322	RIP
52.41	52.10	542	FLT
52.10	51.83	322	RIP
51.83	51.65	323	
51.65	51.34	321	
51.34	50.87	543	
50.87	50.46	543	FLT
50.46	50.21	542	
50.21	50.07	542	
50.07	49.79	543	RIP
49.79	49.11	544	
49.11	48.96	544	
48.96	48.88	544	
48.88	48.45	542	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
48.45	48.27	544	
48.27	48.14	542	
48.14	47.91	544	
47.91	47.58	544	
47.58	46.93	544	
46.93	46.56	544	COLBND
46.56	46.10	122	
46.10	46.03	544	
46.03	45.24	122	
45.24	45.00	542	
45.00	44.94	122	
44.94	44.61	542	
44.61	44.07	542	
44.07	43.87	543	
43.87	41.60	544	RTD COLSPR COLBND
41.60	40.89	322	RIP
40.89	40.81	124	
40.81	40.60	322	RIP
40.60	40.45	323	SLP
40.45	40.20	124	
40.20	40.00	541	
40.00	39.80	124	
39.80	39.73	323	RIP
39.73	39.54	124	
39.54	39.43	322	
39.43	39.23	124	
39.23	38.33	323	RIP RTD COLSPR
38.33	37.80	322	FLT
37.80	37.49	323	
37.49	37.37	122	
37.37	36.84	323	FLT DST RTD COLSPR
36.84	36.54	324	
36.54	36.40	122	
36.40	35.07	323	
35.07	33.92	122	
33.92	33.82	322	FLT
33.82	32.74	122	
32.74	32.69	322	
32.69	32.43	122	
32.43	32.17	323	FLT
32.17	32.04	541	
32.04	31.82	122	
31.82	31.72	323	
31.72	31.57	122	
31.57	31.47	322	RIP
31.47	30.81	323	FLT RTD
30.81	30.33	324	
30.33	30.09	112	COLSPR
30.09	21.17	000	
21.17	20.63	112	
20.63	18.05	122	
18.05	17.93	192	
17.93	17.57	122	
17.57	15.57	000	
15.57	15.39	112	
15.39	15.14	122	
15.14	14.80	323	FLT RTD DST
14.80	14.71	541	
14.71	14.39	122	
14.39	14.34	321	RIP
14.34	14.27	122	
14.27	14.15	323	BUR
14.15	14.07	122	BUR
14.07	13.98	321	RTD RIP
13.98	13.71	323	BUR
13.71	13.66	324	
13.66	13.56	122	
13.56	13.46	321	FLT
13.46	13.42	122	
13.42	13.37	321	
13.37	13.31	122	
13.31	13.21	541	
13.21	12.93	122	
12.93	12.88	321	
12.88	12.81	122	
12.81	12.76	322	
12.76	12.52	122	
12.52	12.44	322	
12.44	12.31	122	
12.31	12.16	323	
12.16	12.05	321	RIP
12.05	11.93	122	
11.93	11.80	322	RIP BUR
11.80	11.59	122	
11.59	11.34	321	
11.34	11.16	122	
11.16	10.93	321	RIP BUR RTD
10.93	10.84	122	
10.84	10.65	321	RIP
10.65	10.47	122	
10.47	10.39	322	
10.39	10.30	122	
10.30	10.26	321	
10.26	10.03	122	
10.03	9.81	324	DST
9.81	9.44	122	
9.44	9.37	322	
9.37	9.29	122	
9.29	9.23	323	
9.23	9.00	122	
9.00	8.76	321	DST CO3CMT
8.76	8.64	122	
8.64	8.27	192	DST
8.27	8.13	323	
8.13	7.40	122	
7.40	7.00	323	RIP
7.00	6.04	122	COLSPR
6.04	5.01	000	
5.01	3.22	112	COLBND COLSPR
3.22	2.26	322	RIP DST
2.26	2.08	324	
2.08	2.02	323	FLT RTD
2.02	1.56	124	COLSPR
1.56	1.36	194	
1.36	1.17	124	
1.17	0.96	323	RIP
0.96	0.72	323	DST
0.72	0.40	323	RTD RIP DST
0.40	0.00	324	

(Intervals converted to true thickness)

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
193.78	192.57	124	RTD
192.57	191.73	322	RIP RTD
191.73	190.96	324	
190.96	188.61	124	RTD
188.61	188.15	122	
188.15	187.74	027	
187.74	187.33	124	RTD
187.33	186.72	123	
186.72	186.14	324	CO3CMT
186.14	185.97	124	RTD
185.97	185.69	323	FLT CO3CMT
185.69	184.33	124	RTD CO3CMT
184.33	184.14	194	RTD
184.14	183.90	124	CO3CMT
183.90	182.79	124	
182.79	182.14	123	
182.14	182.01	027	
182.01	181.66	123	
181.66	181.20	124	
181.20	180.98	323	
180.98	180.40	324	
180.40	178.34	124	
178.34	177.71	324	
177.71	177.26	323	CO3CMT
177.26	176.64	324	CO3CMT
176.64	176.20	124	COLSPR
176.20	176.08	322	RTD CO3CMT
176.08	175.88	324	CO3CMT
175.88	175.69	322	CO3CMT
175.69	175.40	324	CO3CMT
175.40	175.13	122	CO3CMT
175.13	174.71	124	RTD CO3CMT
174.71	174.62	322	BUR CO3CMT
174.62	174.16	323	RIP CO3CMT
174.16	173.87	124	DST COLSPR
173.87	173.24	324	DST CO3CMT
173.24	172.03	322	RIP MXT CO3CMT SLP
172.03	171.94	323	CO3CMT
171.94	171.59	114	COLBND
171.59	171.22	324	RTD CO3CMT
171.22	171.05	322	CO3CMT
171.05	170.96	122	
170.96	170.68	322	RIP BUR DST C03CMT
170.68	170.48	322	BUR RIP DST CO3CMT
170.48	170.31	122	CO3CMT
170.31	169.86	123	CO3CMT
169.86	169.30	322	CO3CMT
169.30	168.91	324	CO3CMT
168.91	168.15	124	
168.15	166.65	122	CO3CMT
166.65	166.13	324	CO3CMT
166.13	165.79	124	CO3CMT
165.79	165.52	324	BUR CO3CMT
165.52	165.07	122	CO3CMT
165.07	164.59	124	BUR CO3CMT
164.59	164.09	324	RTD CO3CMT
164.09	163.78	322	BUR CO3CMT
163.78	163.16	324	BUR CO3CMT
163.16	161.40	124	CO3CMT
161.40	161.26	124	CO3CMT
161.26	161.10	113	
161.10	160.64	324	RTD CO3CMT
160.64	160.13	322	RIP BUR RTD
160.13	159.55	323	BUR DST CO3CMT
159.55	158.83	324	COLSPR CO3CMT
158.83	158.45	324	RTD CO3CMT
158.45	157.43	124	RTD CO3CMT
157.43	157.31	322	RIP BUR CO3CMT
157.31	157.17	124	RTD CO3CMT
157.17	156.97	113	
156.97	156.58	124	RTD CO3CMT
156.58	156.27	113	
156.27	155.48	124	COLSPR CO3CMT
155.48	155.00	324	CO3CMT
155.00	154.60	322	DST CO3CMT
154.60	153.03	321	RIP CO3CMT
153.03	152.29	543	FLT+RIP CO3CMT
152.29	151.90	323	FLT
151.90	151.62	113	COL BND
151.62	151.31	322	FLT MXT CO3CMT
151.31	149.82	124	
149.82	148.35	322	RIP
149.35	148.93	122	
148.93	147.61	000	
147.61	147.30	324	
147.30	146.37	324	RTD
146.37	146.12	321	RIP
146.12	145.88	324	
145.88	145.55	321	RIP
145.55	145.51	324	COL SPR
145.51	137.78	000	
137.78	137.65	000	
137.65	137.42	324	
137.42	137.15	323	RIP BUR
137.15	136.80	322	FLT
136.80	136.08	112	COLBND
136.08	135.79	122	
135.79	135.60	324	
135.60	135.44	323	DST
135.44	135.17	123	
135.17	134.63	122	
134.63	134.34	114	COLBND
134.34	133.60	122	
133.60	133.49	324	
133.49	133.41	323	BUR
133.41	132.68	122	
132.68	132.50	113	COLBND
132.50	132.17	113	
132.17	132.03	124	
132.03	131.73	322	DST BUR
131.73	131.64	324	
131.64	131.57	322	DST
131.57	130.80	114	COL SPR
130.80	130.71	324	
130.71	128.92	322	DST RTD
128.92	128.17	321	RIP
128.17	128.02	324	
128.02	127.87	321	RIP
127.87	127.73	324	
127.73	127.00	323	
127.00	125.68	124	
125.68	124.31	322	DST BUR CO3CMT
124.31	123.90	124	
123.90	123.72	321	DST CO3CMT
123.72	123.57	324	
123.57	123.52	122	
123.52	123.29	321	RIP DST COLSPR CO3
123.29	122.31	122	DST
122.31	121.81	322	RIP DST CO3CMT
121.81	121.34	122	CO3CMT
121.34	120.69	134	RTD COLSPR CO3CMT
120.69	120.40	324	CO3CMT
120.40	119.69	321	MXT RIP BUR CO3CMT
119.69	119.23	322	RIP DST CO3CMT
119.23	119.12	324	CO3CMT
119.12	118.50	323	DST CO3CMT
118.50	118.42	324	CO3CMT
118.42	118.32	321	RIP CO3CMT
118.32	117.23	122	
117.23	117.14	194	
117.14	115.86	122	
115.86	113.47	000	
113.47	112.67	113	
112.67	112.37	324	RTD
112.37	112.06	322	RTD DST
112.06	111.96	324	
111.96	111.85	322	RTD DST
111.85	111.47	324	
111.47	111.03	322	DST
111.03	110.81	124	COLSPR
110.81	110.51	113	
110.51	110.38	113	COL BND
110.38	108.08	113	
108.08	107.90	113	COLBND
107.90	107.27	113	RTD
107.27	107.04	323	DST RTD
107.04	105.82	124	
105.82	105.63	322	SLP CO3CMT
105.63	105.13	123	RTD
105.13	105.03	194	RTD
105.03	104.73	124	
104.73	104.53	322	RIP BUR CO3CMT
104.53	103.27	114	COLSPR
103.27	103.01	124	
103.01	101.58	324	
101.58	99.58	124	
99.58	92.73	113	
92.73	92.57	112	
92.57	91.77	113	
91.77	90.95	124	
90.95	90.73	323	BUR
90.73	90.04	122	
90.04	89.80	124	BUR
89.80	89.34	322	RIP
89.34	89.15	323	RIP
89.15	88.25	122	
88.25	88.12	114	COL SPR
88.12	87.17	000	
87.17	87.04	114	COLBND
87.04	86.53	124	
86.53	86.40	322	BUR
86.40	84.16	114	COLBND
84.16	83.82	124	
83.82	82.50	324	
82.50	81.89	323	
81.89	81.55	322	RIP

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
81.55	81.23	321	RIP
81.23	81.09	122	
81.09	80.77	322	BUR
80.77	80.54	122	
80.54	80.36	322	RIP
80.36	79.94	323	
79.94	79.58	122	
79.58	79.52	323	RIP
79.52	79.38	322	RIP
79.38	78.96	122	
78.96	78.42	322	RIP
78.42	77.63	324	
77.63	77.18	322	CO3CMT
77.18	76.05	321	RIP CO3CMT
76.05	75.97	322	
75.97	75.91	324	
75.91	75.73	321	
75.73	75.64	324	
75.64	73.41	321	RIP CO3CMT
73.41	73.09	544	CO3CMT
73.09	72.99	321	SLP
72.99	72.70	323	FLT
72.70	72.47	122	
72.47	72.04	321	
72.04	71.78	544	CO3CMT
71.78	71.17	323	
71.17	70.97	322	FLT CO3CMT
70.97	70.45	323	
70.45	70.23	322	FLT CO3CMT
70.23	69.85	321	FLT
69.85	69.24	321	COLBND
69.24	68.86	324	
68.86	68.22	322	
68.22	68.14	324	
68.14	67.89	322	
67.89	67.76	323	
67.76	67.53	324	
67.53	67.47	322	
67.47	67.24	324	
67.24	67.04	323	FLT
67.04	66.71	324	
66.71	66.51	321	FLT
66.51	65.22	544	
65.22	64.51	544	COLSPR
64.51	64.27	324	
64.27	64.20	544	
64.20	63.55	324	
63.55	63.35	544	COLSPR
63.35	63.08	322	
63.08	63.00	541	
63.00	62.55	745	COLSPR
62.55	62.02	544	
62.02	61.56	542	
61.56	61.42	543	COLBND
61.42	61.30	544	COLSPR
61.30	60.93	745	
60.93	60.76	544	COLSPR
60.76	60.73	745	
60.73	60.68	544	
60.68	60.22	542	COLSPR
60.22	60.13	745	
60.13	60.09	544	COLSPR
60.09	59.95	542	
59.95	59.71	544	COLSPR
59.71	59.54	745	
59.54	59.49	544	
59.49	59.14	745	
59.14	58.88	544	COLSPR
58.88	58.61	542	
58.61	58.44	541	
58.44	58.31	542	
58.31	57.81	541	
57.81	57.45	543	FLT
57.45	57.08	542	
57.08	54.85	543	FLT COLBND
54.85	54.54	542	CHAOTIC
54.54	54.33	745	
54.33	53.90	542	
53.90	52.06	542	COLSPR
52.06	51.98	541	LRG
51.98	51.67	544	COLSPR
51.67	51.57	745	
51.57	51.22	544	COLSPR
51.22	50.76	745	COLSPR
50.76	50.36	543	FLT COLBND
50.36	50.16	745	
50.16	50.03	541	COLSPR
50.03	49.94	745	
49.94	49.85	541	
49.85	49.71	745	
49.71	49.44	541	COLSPR
49.44	49.32	745	
49.32	48.56	543	FLT COLBND
48.56	48.41	745	
48.41	47.47	544	COLSPR
47.47	47.04	544	
47.04	45.60	541	COLBND
45.60	45.16	544	COLSPR
45.16	44.51	124	
44.51	44.30	323	BUR
44.30	43.94	122	
43.94	42.18	124	
42.18	41.78	122	
41.78	40.71	323	RIP BUR CO3CMT
40.71	40.18	122	
40.18	38.93	323	RIP CO3CMT
38.93	38.50	322	RIP CO3CMT
38.50	38.16	323	CO3CMT
38.16	37.55	322	DST CO3CMT
37.55	37.27	321	CO3CMT
37.27	36.73	322	RIP CO3CMT
36.73	36.02	323	DST CO3CMT
36.02	35.81	322	RIP MFT CO3CMT
35.81	35.20	323	CO3CMT
35.20	34.84	322	RIP
34.84	34.70	122	
34.70	34.22	322	RIP CO3CMT
34.22	34.13	122	
34.13	33.82	322	RIP CO3CMT
33.82	33.50	323	
33.50	33.38	321	RIP CO3CMT
33.38	33.15	323	CO3CMT
33.15	32.81	321	RIP CO3CMT
32.81	32.66	324	
32.66	32.53	322	CO3CMT
32.53	32.24	124	
32.24	32.05	544	SLP DST
32.05	31.67	541	RIP CO3CMT
31.67	31.46	124	
31.46	31.04	321	RIP CO3CMT
31.04	30.55	124	
30.55	30.36	321	RIP BUR CO3CMT
30.36	30.10	324	CO3CMT
30.10	29.96	124	
29.96	29.88	544	CO3CMT
29.88	29.34	124	
29.34	28.79	321	RIP CO3CMT
28.79	27.87	124	
27.87	27.75	122	
27.75	27.47	322	RIP CO3CMT
27.47	26.83	124	
26.83	26.66	322	RIP BUR CO3CMT
26.66	25.63	122	BUR
25.63	24.84	123	
24.84	24.28	114	COLSPR COLBND
24.28	14.97	000	
14.97	14.07	114	COLBND COLSPR
14.07	13.88	122	COLBND
13.88	13.60	114	
13.60	13.15	124	
13.15	12.99	000	
12.99	12.13	322	BUR RIP
12.13	11.96	124	BUR RTD
11.96	11.78	021	
11.78	10.32	114	COLSPR
10.32	10.04	124	
10.04	9.15	114	COLSPR
9.15	8.68	124	BUR CO3CMT
8.68	8.36	322	BUR CO3CMT
8.36	7.93	323	RIP
7.93	7.69	321	RIP BUR CO3CMT
7.69	7.32	114	
7.32	7.22	021	
7.22	6.88	114	COLSPR
6.88	6.57	122	
6.57	6.35	323	RIP BUR CO3CMT
6.35	6.24	322	BUR RIP CO3CMT
6.24	6.16	122	
6.16	5.90	322	RIP BUR CO3CMT
5.90	5.37	122	
5.37	4.78	321	RIP
4.78	4.42	543	FLT
4.42	3.15	122	
3.15	2.29	114	
2.29	1.79	114	COLBND COLSPR
1.79	0.72	124	
0.72	0.29	324	BUR
0.29	0.00	322	

(Intervals converted to true thickness)

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
353.65	351.76	124	
351.76	350.69	323	DST
350.69	350.15	124	
350.15	349.10	113	COLBND
349.10	345.26	000	
345.26	343.82	113	COLBND
343.82	343.36	112	COLSPR
343.36	343.15	321	DST
343.15	340.51	122	COLSPR
340.51	336.86	000	
336.86	336.76	113	
336.76	336.51	321	MXT RTD
336.51	336.32	113	
336.32	336.02	321	CO3CMT
336.02	335.49	124	COLSPR
335.49	335.03	322	DST CO3CMT
335.03	334.24	321	RTD CO3CMT
334.24	332.96	122	DST
332.96	332.40	323	BUR
332.40	331.89	112	
331.89	331.76	122	BUR
331.76	331.64	321	RTD CO3CMT
331.64	330.21	323	
330.21	329.43	000	
329.43	328.98	322	COLSPR FLT
328.98	328.91	321	FLT
328.91	328.00	323	COLSPR
328.00	327.71	321	RTD COLSPR
327.71	327.35	123	
327.35	326.76	321	CO3CMT FLT DST
326.76	326.27	322	COLSPR
326.27	325.54	322	COLSPR SLP RTD
325.54	325.16	324	
325.16	324.25	113	COLBND
324.25	322.66	323	COLSPR RTD
322.66	321.74	122	
321.74	321.32	322	FLT BUR CO3CMT
321.32	319.24	122	
319.24	318.45	323	DST CO3CMT
318.45	318.13	321	RIP BUR CO3CMT
318.13	317.84	322	RIP BUR CO3CMT
317.84	316.59	113	COLBND
316.59	315.97	000	
315.97	315.30	112	COLSPR
315.30	314.68	321	RIP BUR CO3CMT
314.68	314.41	323	
314.41	313.42	122	COLSPR
313.42	312.12	324	RTD
312.12	311.72	322	
311.72	311.12	543	RIP
311.12	309.80	541	COLSPR CO3CMT
309.80	309.48	323	COLSPR FLT
309.48	309.02	543	RTD BUR FLT CO3CMT
309.02	308.79	324	COLSPR
308.79	308.26	321	DST CO3CMT
308.26	307.31	323	DST
307.31	305.49	321	DST BUR COLSPR
305.49	305.14	324	COLSPR
305.14	302.02	321	RTD DST COLSPR CO3
302.02	301.59	322	RTD
301.59	301.49	543	RIP BUR CO3CMT
301.49	301.09	322	BUR FLT DST CO3CMT
301.09	300.67	321	BUR RTD CO3CMT
300.67	300.49	323	RTD BUR COLSPR
300.49	299.38	123	
299.38	298.85	000	
298.85	298.62	113	
298.62	298.16	323	BUR CO3CMT
298.16	296.98	122	
296.98	296.06	321	RIP CO3CMT
296.06	295.12	122	
295.12	295.07	113	
295.07	295.01	099	COLBND
295.01	294.67	021	
294.67	294.38	114	
294.38	293.80	323	RIP
293.80	293.58	321	BUR
293.58	292.15	324	BUR
292.15	291.17	323	RIP
291.17	289.14	122	RTD
289.14	288.57	323	DST
288.57	287.90	321	BUR DST
287.90	285.93	322	DST
285.93	285.82	321	RIP
285.82	285.43	322	RIP
285.43	285.03	122	
285.03	284.81	322	BUR
284.81	284.70	124	
284.70	283.58	323	
283.58	280.68	000	
280.68	279.09	113	COLBND
279.09	278.75	323	
278.75	278.26	322	RTD
278.26	277.71	323	COLSPR
277.71	277.28	027	
277.28	276.87	123	
276.87	275.11	113	COLBND
275.11	274.70	323	
274.70	273.79	123	
273.79	273.60	113	
273.60	273.50	027	
273.50	273.11	123	
273.11	272.98	113	COLBND
272.98	272.79	124	
272.79	272.20	322	BUR
272.20	271.06	122	
271.06	270.42	322	FLT RIP
270.42	269.69	122	
269.69	268.55	000	
268.55	268.33	113	
268.33	268.05	324	RTD
268.05	267.59	322	RIP RTD
267.59	265.55	124	COLSPR
265.55	265.19	124	
265.19	265.08	324	
265.08	264.73	322	RIP
264.73	264.53	321	RIP
264.53	264.38	324	
264.38	263.75	321	BUR
263.75	263.39	324	
263.39	262.10	543	RIP
262.10	261.69	542	MFT
261.69	260.34	321	COLSPR
260.34	259.94	324	
259.94	258.10	321	COLSPR
258.10	256.05	542	COLSPR
256.05	252.94	542	
252.94	252.17	541	RIP
252.17	251.20	542	
251.20	250.32	541	RIP CO3CMT
250.32	249.02	541	LRG CO3CMT
249.02	246.55	544	COLSPR
246.55	246.41	124	
246.41	245.37	544	COLSPR
245.37	243.29	541	LRG RTD COLSPR
243.29	242.76	544	COLSPR
242.76	241.21	544	COLSPR
241.21	240.87	742	
240.87	239.92	541	
239.92	237.29	124	
237.29	237.15	322	BUR
237.15	236.87	123	
236.87	236.71	194	
236.71	235.05	123	
235.05	233.13	544	
233.13	233.10	123	BUR
233.10	232.94	124	BUR
232.94	230.72	544	
230.72	229.56	541	LRG
229.56	228.80	544	COLSPR
228.80	228.52	542	
228.52	228.05	324	
228.05	227.63	321	CO3CMT RIP
227.63	227.45	324	
227.45	227.27	542	
227.27	224.77	541	RIP SLP
224.77	223.88	322	RTD DST
223.88	223.45	541	
223.45	223.27	544	COLSPR
223.27	223.18	193	
223.18	222.89	544	COLSPR
222.89	222.02	124	
222.02	221.92	543	SLP
221.92	221.70	542	
221.70	221.35	541	LRG
221.35	220.26	543	FLT
220.26	219.72	544	
219.72	217.11	544	
217.11	216.41	324	
216.41	215.91	542	
215.91	215.38	541	
215.38	214.96	544	COLSPR
214.96	214.25	124	COLSPR
214.25	214.09	322	RIP
214.09	213.77	323	RIP
213.77	212.59	122	
212.59	212.27	193	
212.27	210.74	122	COLSPR
210.74	210.27	321	RIP
210.27	209.58	323	
209.58	208.65	321	BUR
208.65	208.41	123	
208.41	207.68	123	
207.68	207.55	193	RTD
207.55	206.99	123	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
206.99	204.14	114	COLSPR COLBND
204.14	203.35	000	
203.35	202.92	123	RTD
202.92	202.66	324	RTD
202.66	200.69	322	RTD COLSPR
200.69	200.34	324	
200.34	200.12	193	RTD
200.12	198.99	124	BUR
198.99	198.41	542	
198.41	196.88	543	
196.88	196.41	124	RTD
196.41	195.88	544	RIP
195.88	195.48	323	RIP
195.48	195.14	322	DST BUR RIP
195.14	194.77	323	
194.77	193.53	124	RTD
193.53	193.39	124	RTD CO3CMT
193.39	193.24	193	RTD
193.24	192.97	123	RTD CO3CMT
192.97	192.74	323	DST
192.74	189.74	541	LRG
189.74	189.52	544	
189.52	188.00	541	MUD CHIPS
188.00	187.14	543	FLT COLBND
187.14	185.94	541	
185.94	185.78	544	
185.78	185.66	543	COLBND FLT
185.66	184.79	541	
184.79	183.01	544	COLSPR RTD
183.01	181.58	541	COLSPR
181.58	181.33	544	COLSPR
181.33	180.90	321	RIP
180.90	180.30	543	RIP
180.30	179.53	544	
179.53	178.22	323	
178.22	177.61	124	
177.61	176.95	323	RIP
176.95	176.78	124	
176.78	176.58	322	RIP
176.58	175.77	324	
175.77	175.13	322	RIP
175.13	174.08	321	RIP BUR
174.08	173.31	543	RIP
173.31	172.57	322	RIP DST
172.57	170.42	323	
170.42	169.96	321	RIP
169.96	169.79	323	
169.79	169.53	543	RIP
169.53	169.02	323	
169.02	168.93	321	RIP
168.93	168.64	321	
168.64	166.72	122	RTD COLSPR
166.72	166.29	323	BUR
166.29	163.90	322	RIP BUR
163.90	163.50	124	COLSPR
163.50	163.38	194	
163.38	162.95	321	RIP
162.95	161.94	122	
161.94	161.53	113	COLBND
161.53	146.59	000	
146.59	145.91	113	COLBND
145.91	145.34	112	
145.34	145.29	027	
145.29	144.52	324	RTD
144.52	144.31	321	RIP
144.31	144.15	324	
144.15	143.98	193	RTD
143.98	142.87	323	RIP
142.87	142.19	324	
142.19	141.87	323	RIP
141.87	141.32	122	
141.32	139.74	113	COLBND
139.74	139.64	113	
139.64	138.39	324	
138.39	138.22	321	RIP
138.22	137.87	323	RIP
137.87	137.28	122	
137.28	135.83	122	
135.83	135.02	323	DST
135.02	133.79	126	RTD COLSPR
133.79	133.66	322	RIP
133.66	132.85	324	
132.85	132.47	324	COLSPR
132.47	132.27	394	RTD
132.27	131.86	324	
131.86	130.99	541	RIP
130.99	130.42	324	
130.42	129.37	322	RIP
129.37	129.03	124	RTD
129.03	128.47	543	RIP COLBND BUR
128.47	127.25	322	RIP
127.25	126.80	324	RTD
126.80	126.35	321	DST BUR
126.35	125.66	324	COLSPR
125.66	123.77	323	DST RIP
123.77	122.73	322	RIP BUR
122.73	122.37	321	FLT BUR
122.37	122.03	321	RIP
122.03	121.38	543	FLT
121.38	120.11	544	COLSPR COLBND
120.11	119.49	542	COLSPR
119.49	118.63	544	COLSPR COLBND

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
118.63	118.33	544	
118.33	117.31	544	COLSPR COLBLND
117.31	117.14	321	COLSPR
117.14	116.80	544	COLSPR
116.80	116.49	541	LRG
116.49	116.23	543	FLT
116.23	114.48	541	LRG
114.48	113.69	541	SLP
113.69	113.04	544	SLP
113.04	112.20	544	COLSPR
112.20	111.75	321	MFT
111.75	111.03	544	COLSPR COLBND
111.03	110.89	124	DST
110.89	110.56	544	COLSPR COLBND
110.56	110.41	321	
110.41	110.22	544	COLSPR
110.22	109.97	544	COLSPR
109.97	109.03	541	
109.03	108.66	541	COLBND
108.66	108.21	541	LRG
108.21	105.90	541	COLSPR LRG
105.90	105.27	541	
105.27	104.79	541	RIP
104.79	104.14	323	DST
104.14	103.37	544	COLBND COLSPR
103.37	102.29	541	COLSPR
102.29	100.92	541	COLBND
100.92	100.13	541	COLBND
100.13	99.48	544	COLSPR
99.48	99.02	324	
99.02	98.23	324	DST
98.23	97.89	322	RIP
97.89	97.72	122	
97.72	97.10	124	
97.10	96.67	321	RIP
96.67	96.48	322	RIP
96.48	95.91	324	DST COLSPR
95.91	95.16	321	DST COLSPR
95.16	94.77	324	
94.77	94.54	321	RIP
94.54	91.98	544	COLBND COLSPR
93.98	93.10	122	
93.10	92.87	322	RIP BUR
92.87	91.92	124	SOME SANDY LENSES
91.92	91.40	123	
91.40	91.07	124	COLSPR
91.07	90.52	323	BUR
90.52	90.17	321	BUR RIP
90.17	89.83	122	COLBND
89.83	89.15	122	
89.15	88.96	194	DST RTD
88.96	88.62	324	RTD
88.62	87.65	321	RIP BUR
87.65	84.84	122	BUR
84.84	84.74	027	
84.74	83.96	122	BUR
83.96	83.53	323	RIP DST
83.53	83.33	122	
83.33	82.84	323	RIP
82.84	81.39	122	COLSPR
81.39	81.34	192	DST
81.34	80.72	122	RTD
80.72	78.13	124	RTD
78.13	77.42	322	RIP CO3CMT
77.42	76.16	324	BUR CO3CMT
76.16	75.12	322	BUR DST CO3CMT
75.12	74.92	122	
74.92	74.76	322	RIP CO3CMT
74.76	73.86	323	RIP CO3CMT
73.86	73.64	322	RIP CO3CMT
73.64	73.48	321	RIP CO3CMT
73.48	72.15	323	RIP BUR CO3CMT
72.15	72.07	321	RIP CO3CMT
72.07	71.90	122	
71.90	71.84	322	RIP CO3CMT
71.84	71.76	122	
71.76	71.68	321	RIP CO3CMT
71.68	71.56	124	
71.56	71.16	321	FLT
71.16	70.96	124	
70.96	70.46	321	RIP CO3CMT
70.46	70.36	124	
70.36	70.02	321	FLT RIP
70.02	69.61	122	
69.61	69.11	323	RIP DST
69.11	68.97	322	RIP BUR CO3CMT
68.97	68.56	324	
68.56	68.34	321	FLT RIP CO3CMT
68.34	67.98	323	RIP CO3CMT
67.98	67.20	122	
67.20	66.93	122	
66.93	66.59	124	
66.59	66.38	122	
66.38	66.15	124	
66.15	64.80	122	
64.80	63.79	124	DST COLSPR RTD
63.79	63.00	122	
63.00	61.82	122	BUR CO3CMT
61.82	60.91	323	RIP BUR CO3CMT
60.91	60.78	323	SLP DST
60.78	60.50	122	DST
60.50	59.93	000	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
59.93	59.30	112	RTD COLBND
59.30	54.64	000	
54.64	53.63	113	COLBND
53.63	53.39	021	
53.39	52.62	114	COLBND
52.62	51.19	123	COLSPR MFT RTD
51.19	50.89	323	DST
50.89	50.20	323	FLT
50.20	49.85	123	RTD
49.85	48.34	122	COLBND RTD
48.34	47.99	323	RIP
47.99	47.88	321	RIP
47.88	47.33	122	
47.33	47.14	323	RIP
47.14	46.45	322	RIP BUR
46.45	43.79	000	
43.79	42.56	122	DST
42.56	42.42	134	RTD
42.42	42.16	124	DST
42.16	42.04	322	RIP
42.04	41.84	194	RTD
41.84	40.41	124	COLSPR
40.41	39.66	122	
39.66	39.35	322	SLP DST
39.35	38.04	122	
38.04	36.40	124	
36.40	35.91	124	
35.91	32.25	000	
32.25	31.65	114	COLSPR RTD
31.65	28.44	000	
28.44	27.98	124	
27.98	27.16	122	
27.16	26.99	323	RIP
26.99	26.91	122	
26.91	26.66	114	COLSPR
26.66	25.93	000	
25.93	25.51	112	COLSPR
25.51	25.09	323	DST
25.09	24.69	124	
24.69	24.47	324	
24.47	24.25	323	DST
24.25	24.13	122	
24.13	24.05	321	RIP
24.05	23.69	324	DST
23.69	23.28	323	RIP
23.28	22.78	021	
22.78	22.37	114	
22.37	22.21	122	DST
22.21	21.83	122	DST
21.83	21.62	323	BUR
21.62	20.99	324	
20.99	20.19	122	
20.19	19.23	112	COLSPR COLBND
19.23	19.08	192	
19.08	18.55	027	
18.55	17.61	544	COLSPR
17.61	17.36	124	
17.36	14.82	122	BUR
14.82	14.72	122	
14.72	14.40	024	

(Intervals converted to true thickness)

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
301.67	298.90	112	COLSPR DST
298.90	298.70	394	RTD COLSPR
298.70	297.10	112	COLSPR
297.10	296.96	397	RTD COLSPR
296.96	295.61	112	COLSPR COLBND
295.61	294.87	125	
294.87	293.20	112	DST COLSPR COLBND
293.20	290.43	113	COLBND COLSPR DST
290.43	290.31	192	DST RTD COLSPR
290.31	290.25	541	COLSPR
290.25	290.08	192	DST COLSPR
290.08	287.52	323	DST FLT RIP COLSPR
287.52	287.25	541	DST COLSPR
287.25	287.06	122	COLSPR
287.06	286.93	543	COLSPR RIP RTD BUR
286.93	286.65	323	DST COLSPR
286.65	286.48	541	COLSPR
286.48	286.39	323	RIP COLSPR
286.39	285.44	541	
285.44	285.40	122	COLSPR FLT
285.40	285.27	322	RIP COLSPR
285.27	284.57	122	COLSPR
284.57	284.37	322	RIP COLSPR
284.37	283.16	122	RTD COLSPR
283.16	283.03	112	RTD COLBND COLSPR
283.03	280.01	122	RTD COLSPR
280.01	279.81	542	COLSPR
279.81	278.75	542	COLSPR
278.75	277.28	323	BUR RTD RIP
277.28	277.23	194	
277.23	275.19	323	RTD BUR RIP DST
275.19	274.98	324	
274.98	272.05	323	RTD DST BUR MFT
272.05	271.47	322	DST
271.47	270.82	542	COLSPR DST
270.82	270.19	543	RIP DST
270.19	266.87	542	FLT DST COLSPR
266.87	266.59	542	COLSPR RIP
266.59	264.35	542	FLT
264.35	262.96	541	
262.96	262.50	541	DST
262.50	259.92	544	
259.92	259.53	323	RIP FLT
259.53	259.36	322	FLT COLSPR
259.36	259.30	323	FLT
259.30	259.10	322	FLT
259.10	257.36	323	RIP BUR
257.36	257.22	112	
257.22	255.69	321	RIP BUR COLSPR
255.69	254.26	323	RIP COLSPR BUR
254.26	252.36	122	COLSPR
252.36	251.88	112	COLSPR COLBND
251.88	236.90	000	
236.90	233.96	112	COLSPR COLBND
233.96	233.53	323	DST RTD
233.53	232.94	324	
232.94	232.36	322	RIP RTD BUR
232.36	231.96	321	COLSPR BUR
231.96	231.39	323	SLP BUR COLSPR
231.39	231.26	395	COLSPR
231.26	230.97	323	RTD COLSPR FLT
230.97	229.21	112	RTD BUR COLSPR
229.21	228.75	122	COLSPR BUR
228.75	228.43	322	RTD RIP COLSPR
228.43	225.81	323	RIP COLSPR RTD BUR
225.81	225.37	312	DST RTD COLSPR COL
225.37	224.33	122	COLSPR
224.33	223.08	324	COLSPR RTD BUR SLP
223.08	222.55	122	COLSPR
222.55	220.87	323	RTD COLSPR SLP DST
220.87	219.70	322	FLT
219.70	219.21	124	COLSPR
219.21	219.03	541	RIP RTD
219.03	218.57	324	FLT
218.57	218.22	122	
218.22	217.31	324	COLSPR
217.31	216.82	323	COLSPR DST RIP
216.82	216.67	394	
216.67	216.62	321	COLSPR FLT
216.62	215.63	323	RIP BUR COLSPR
215.63	215.58	321	RIP COLSPR
215.58	215.44	323	RIP COLSPR
215.44	215.25	192	COLSPR
215.25	212.54	324	COLSPR BUR
212.54	211.62	542	BUR COLSPR
211.62	210.88	541	COLSPR
210.88	210.83	324	
210.83	210.26	541	DST COLSPR RTD
210.26	208.78	544	BUR COLSPR
208.78	208.59	542	
208.59	207.62	541	BUR
207.62	206.97	542	RIP

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
206.97	206.80	544	COLSPR
206.80	204.88	542	
204.88	204.42	542	RTD COLSPR COLBND
204.42	203.88	542	COLSPR
203.88	203.58	112	COLBND COLSPR
203.58	201.92	542	COLSPR SLP
201.92	201.01	545	SLP
201.01	199.84	542	COLBND
199.84	199.04	544	COLSPR
199.04	197.62	112	COLBND COLSPR DST
197.62	196.90	323	RIP COLSPR
196.90	196.09	112	COLBND DST
196.09	194.19	324	COLSPR DST RTD
194.19	194.10	112	
194.10	193.71	125	
193.71	192.49	324	FLT RIP RTD COLSPR
192.49	191.86	324	COLSPR BUR RIP
191.86	191.53	324	BUR COLSPR
191.53	191.36	323	RIP
191.36	190.27	324	FLT COLSPR BUR RTD
190.27	190.02	323	RIP DST
190.02	189.68	323	FLT BUR
189.68	188.93	122	COLSPR RTD
188.93	188.09	324	COLSPR DST
188.09	187.07	324	COLSPR FLT RTD
187.07	185.10	541	BUR
185.10	184.34	324	RIP COLSPR RTD
184.34	183.37	324	COLSPR
183.37	182.87	324	DST BUR COLSPR
182.87	182.73	192	COLSPR DST
182.73	182.22	324	DST COLSPR
182.22	181.46	323	COLSPR RIP DST
181.46	180.59	541	MFT DST
180.59	180.25	324	DST RTD COLSPR
180.25	179.80	322	BUR RIP COLSPR
179.80	179.34	541	COLSPR
179.34	178.46	544	
178.46	177.78	542	COLSPR CO3CMT
177.78	177.08	112	CO3CMT
177.08	176.65	324	COLSPR CO3CMT
176.65	175.85	112	COLSPR COLBND CO3
175.85	175.45	324	DST MFT CO3CMT
175.45	174.40	112	RTD COLSPR COLBND
174.40	173.36	324	DST BUR COLSPR CO3
173.36	172.64	122	BUR RTD COLSPR CO3
172.64	170.85	324	BUR RTD MXT CO3CMT
170.85	170.71	000	CO3CMT
170.71	169.66	324	BUR RTD DST CO3CMT
169.66	167.31	112	COLSPR COLBND CO3
167.31	166.12	122	RTD BUR COLSPR CO3
166.12	165.61	124	DST COLSPR RTD CO3
165.61	160.65	122	COLSPR RTD BUR CO3
160.65	159.78	324	RTD COLSPR CO3CMT
159.78	158.68	322	DST BUR RTD RIP
158.68	157.58	324	COLSPR RTD DST CO3
157.58	154.13	322	RTD BUR RIP MXT
154.13	152.48	112	CO3CMT
152.48	150.97	112	
150.97	150.76	322	DST RTD COLSPR CO3
150.76	150.48	112	
150.48	150.33	322	DST RTD CO3CMT
150.33	150.06	323	MXT SLP
150.06	149.38	322	SLP RTD DST COLSPR
149.38	148.80	323	RTD RIP
148.80	147.59	323	RTD RIP BUR COLSPR
147.59	146.82	322	DST COLSPR RTD BUR
146.82	145.65	112	COLSPR RTD DST
145.65	144.85	324	DST RTD COLSPR
144.85	142.86	321	RTD DST RIP COLSPR
142.86	140.13	324	RTD DST COLSPR
140.13	139.40	541	COLSPR
139.40	137.44	542	
137.44	135.57	542	COLSPR COLBND RTD
135.57	133.91	542	
133.91	132.14	122	RTD DST COLBND BUR
132.14	131.72	322	RTD DST COLSPR
131.72	128.73	112	RTD DST COLBND COL
128.73	127.92	323	RIP DST BUR SLP
127.92	127.22	324	RIP COLSPR BUR
127.22	126.60	122	RTD COLSPR
126.60	126.43	192	DST SLP
126.43	124.35	122	RTD RIP COLSPR COL
124.35	124.28	323	RTD RIP COLSPR BUR
124.28	123.98	322	RIP
123.98	122.81	112	RTD COLSPR
122.81	122.76	323	
122.76	121.81	122	
121.81	121.67	324	DST RIP
121.67	121.51	112	
121.51	120.29	122	RIP COLBND
120.29	119.28	112	COLSPR
119.28	118.80	112	COLSPR COLBND
118.80	118.27	122	DST FLT

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
118.27	118.14	114	
118.14	117.47	122	COLSPR RTD
117.47	116.73	324	BUR FLT RTD COLSPR
116.73	116.52	112	RTD COLBND
116.52	116.07	324	DST BUR
116.07	113.62	323	
113.62	113.06	112	RTD COLBND COLSPR
113.06	111.93	122	COLSPR
111.93	111.40	112	COLBND COLSPR
111.40	110.43	122	RTD BUR
110.43	107.17	324	
107.17	106.83	112	
106.83	105.91	323	BUR COLSPR
105.91	103.94	324	RTD COLSPR
103.94	103.34	112	
103.34	100.74	122	
100.74	99.82	322	
99.82	96.92	112	COLSPR
96.92	93.83	322	BUR RTD RIP COLSPR
93.83	93.47	322	
93.47	92.90	122	
92.90	92.03	323	RIP RTD COLSPR
92.03	91.56	122	
91.56	91.43	322	
91.43	90.37	124	
90.37	88.72	322	RTD BUR DST COLSPR
88.72	85.16	122	DST RTD COLSPR SLP
85.16	85.02	112	RTD COLSPR
85.02	79.55	000	
79.55	79.07	112	COLBND RTD DST
79.07	78.87	322	RIP RTD COLSPR
78.87	78.53	112	RTD
78.53	78.42	195	RTD
78.42	77.40	112	RTD COLSPR BUR COL
77.40	77.00	192	RTD COLSPR
77.00	75.46	122	DST
75.46	74.36	112	COLBND COLSPR
74.36	72.88	323	RTD BUR DST COLSPR
72.88	71.73	122	COLSPR RTD BUR
71.73	71.60	112	
71.60	69.94	323	DST RTD BUR COLSPR
69.94	68.81	122	COLSPR FLT
68.81	68.70	195	COLSPR
68.70	67.30	112	
67.30	67.18	325	COLSPR
67.18	66.27	112	COLSPR
66.27	65.65	323	DST BUR
65.65	65.51	114	
65.51	64.89	122	
64.89	63.43	112	
63.43	62.96	122	DST RTD
62.96	62.85	325	RTD COLSPR
62.85	62.80	000	
62.80	62.55	325	RTD COLSPR
62.55	59.21	000	
59.21	58.54	324	DST COLSPR
58.54	58.17	000	
58.17	56.95	322	DST RTD COLSPR
56.95	56.46	324	
56.46	56.21	122	
56.21	56.16	112	RTD COLSPR
56.16	54.02	000	
54.02	53.43	112	RTD DST COLSPR
53.43	53.03	122	RTD COLSPR DST BUR
53.03	52.53	323	BUR DST RTD COLSPR
52.53	52.42	122	
52.42	52.17	323	BUR RTD COLSPR DST
52.17	51.26	112	COLSPR
51.26	50.98	122	COLSPR
50.98	50.81	313	DST RTD COLSPR
50.81	49.36	324	
49.36	49.27	313	
49.27	49.02	324	COLSPR
49.02	48.74	313	BUR DST COLSPR RIP
48.74	48.19	000	
48.19	48.01	112	DST RTD COLSPR
48.01	47.90	313	
47.90	47.43	311	
47.43	46.83	313	DST BUR RTD
46.83	46.55	122	
46.55	45.46	313	
45.46	45.40	122	
45.40	44.69	000	

(Intervals converted to true thickness)

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
496.91	496.40	322	BUR DST
496.40	495.45	324	BUR COLBND CO3CMT
495.45	494.92	322	BUR
494.92	494.30	324	
494.30	493.87	323	BUR CO3CMT
493.87	493.32	322	BUR DST CO3CMT
493.32	493.24	124	
493.24	492.54	321	RIP BUR CO3CMT
492.54	491.83	323	BUR CO3CMT
491.83	491.52	322	RIP DST CO3CMT
491.52	491.28	114	
491.28	491.04	122	RTD BUR CO3CMT
491.04	490.87	323	BUR
490.87	490.65	122	
490.65	490.52	322	RIP CO3CMT
490.52	489.96	323	RIP DST CO3CMT
489.96	489.27	322	RIP CO3CMT
489.27	488.55	124	CO3CMT
488.55	488.45	323	BUR CO3CMT
488.45	488.26	322	RIP CO3CMT
488.26	488.03	323	RIP CO3CMT
488.03	487.86	322	RIP CO3CMT
487.86	487.77	324	BUR CO3CMT
487.77	487.17	322	RIP CO3CMT
487.17	486.96	323	RIP CO3CMT
486.96	486.78	122	
486.78	485.83	124	
485.83	484.63	000	
484.63	484.57	114	
484.57	484.29	324	BUR
484.29	483.79	124	COLSPR
483.79	483.40	114	COLSPR
483.40	483.18	124	COLSPR BUR
483.18	482.92	324	CO3CMT
482.92	482.78	124	
482.78	482.22	324	BUR CO3CMT
482.22	481.97	394	BUR RTD CO3CMT
481.97	481.55	323	CO3CMT
481.55	481.14	122	CO3CMT
481.14	480.93	114	
480.93	480.70	114	COLSPR
480.70	480.43	024	
480.43	480.38	114	
480.38	480.28	114	COLSPR
480.28	480.09	124	CO3CMT
480.09	478.62	124	RTD CO3CMT
478.62	478.30	124	
478.30	477.51	324	
477.51	476.90	122	CO3CMT
476.90	476.84	027	
476.84	476.71	114	COLSPR
476.71	476.18	124	COLSPR CO3CMT
476.18	475.81	323	BUR CO3CMT
475.81	475.67	323	DST CO3CMT
475.67	475.46	324	CO3CMT
475.46	475.25	124	CO3CMT
475.25	474.86	324	BUR CO3CMT
474.86	473.49	122	CO3CMT
473.49	473.36	323	BUR CO3CMT
473.36	472.88	122	CO3CMT
472.88	472.68	323	RIP CO3CMT
472.68	471.72	124	CO3CMT
471.72	471.57	124	BUR CO3CMT
471.57	471.25	323	BUR CO3CMT
471.25	471.05	322	BUR CO3CMT
471.05	470.99	124	CO3CMT
470.99	470.73	322	RTD CO3CMT
470.73	470.48	124	RIP CO3CMT
470.48	470.38	322	BUR CO3CMT
470.38	470.24	324	CO3CMT
470.24	469.27	322	BUR CO3CMT
469.27	468.62	322	RIP BUR CO3CMT
468.62	468.27	323	RIP BUR CO3CMT
468.27	468.00	324	BUR CO3CMT
468.00	467.74	322	BUR
467.74	467.27	324	CO3CMT
467.27	467.01	124	CO3CMT
467.01	466.83	324	
466.83	466.20	122	
466.20	466.12	322	RIP CO3CMT
466.12	465.16	122	CO3CMT
465.16	464.71	114	CO3CMT
464.71	464.63	322	RIP CO3CMT
464.63	464.14	323	RIP CO3CMT
464.14	463.55	122	
463.55	460.55	000	
460.55	458.67	114	COLSPR COLBND
458.67	458.44	112	RTD DST
458.44	458.00	114	COLSPR COLBND
458.00	457.95	021	
457.95	457.36	114	COLSPR COLBND
457.36	457.12	114	
457.12	456.70	122	
456.70	456.58	323	CO3CMT
456.58	456.06	124	
456.06	455.88	124	
455.88	455.74	122	
455.74	454.46	124	
454.46	454.32	322	
454.32	454.07	323	
454.07	453.32	114	
453.32	452.35	124	
452.35	451.24	000	
451.24	451.12	114	COLBND COLSPR
451.12	450.97	323	
450.97	450.78	322	DST CO3CMT
450.78	450.31	323	DST
450.31	449.96	322	DST CO3CMT
449.96	448.65	323	BUR DST COLBND CO3
448.65	448.11	122	
448.11	447.62	323	BUR
447.62	446.72	322	BUR DST
446.72	446.13	122	
446.13	446.04	114	COLBND
446.04	443.88	000	
443.88	443.71	114	COLSPR COLBND
443.71	443.53	122	
443.53	443.24	322	FLT
443.24	442.80	122	
442.80	442.68	114	COLBND
442.68	442.34	122	DST CO3CMT
442.34	441.46	122	CO3CMT
441.46	440.78	114	
440.78	440.49	122	
440.49	440.10	114	
440.10	438.05	114	COLBND
438.05	437.97	021	
437.97	437.39	122	
437.39	437.02	124	COLSPR CO3CMT
437.02	436.46	134	CO3CMT
436.46	436.29	334	RTD
436.29	435.47	124	
435.47	434.94	323	RIP BUR CO3CMT
434.94	434.81	122	CO3CMT
434.81	434.37	124	CO3CMT
434.37	433.68	122	
433.68	433.41	323	RIP CO3CMT
433.41	433.00	122	CO3CMT
433.00	431.58	112	
431.58	430.58	114	COLSPR
430.58	430.14	021	
430.14	430.04	027	
430.04	429.70	021	
429.70	429.45	114	COLBND
429.45	428.87	112	
428.87	428.42	114	COLBND
428.42	427.89	114	COLBND
427.89	427.65	124	DST
427.65	427.23	114	COLBND
427.23	426.05	113	COLBND
426.05	425.99	021	
425.99	422.33	000	
422.33	421.86	113	RTD COLSPR CO3CMT
421.86	420.14	000	
420.14	419.55	114	COLBND COLSPR
419.55	419.16	113	
419.16	418.99	324	BUR
418.99	418.53	322	BUR MFT
418.53	418.31	122	BUR
418.31	417.91	114	
417.91	416.89	324	
416.89	414.64	000	
414.64	414.03	114	
414.03	413.88	114	
413.88	412.65	122	
412.65	411.96	124	
411.96	411.64	122	
411.64	411.39	322	BUR
411.39	411.26	122	
411.26	411.17	322	
411.17	410.68	122	
410.68	410.61	322	FLT
410.61	410.04	122	BUR CO3CMT
410.04	409.91	323	FLT
409.91	408.82	122	
408.82	408.65	114	
408.65	408.33	114	COLBND COLSPR
408.33	407.17	114	
407.17	406.91	321	RIP RTD
406.91	406.50	324	RTD
406.50	406.12	194	RTD
406.12	405.05	113	
405.05	403.33	114	COLBND COLSPR
403.33	403.20	322	BUR
403.20	403.04	324	COLSPR
403.04	402.26	322	BUR RTD
402.26	402.08	123	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
402.08	401.95	322	
401.95	401.79	124	
401.79	401.33	114	COLSPR COLBND
401.33	401.22	027	
401.22	400.02	114	COLBND COLSPR
400.02	399.53	124	
399.53	399.10	323	
399.10	399.00	124	
399.00	398.39	114	
398.39	398.20	113	
398.20	397.88	000	
397.88	394.06	114	COLBND COLSPR
394.06	393.98	113	COLSPR
393.98	393.42	123	RTD
393.42	392.29	113	COLSPR
392.29	392.15	114	
392.15	391.49	122	CO3CMT
391.49	391.34	124	CO3CMT
391.34	391.08	124	CO3CMT
391.08	390.45	122	CO3CMT
390.45	389.92	122	
389.92	389.79	124	
389.79	389.25	122	CO3CMT
389.25	388.42	124	CO3CMT
388.42	387.30	122	CO3CMT
387.30	387.14	122	
387.14	386.75	122	CO3CMT
386.75	386.52	112	CO3CMT
386.52	385.76	124	CO3CMT
385.76	385.42	122	CO3CMT
385.42	384.59	124	CO3CMT
384.59	384.16	323	BUR CO3CMT
384.16	383.82	114	
383.82	383.09	114	
383.09	379.94	323	BUR CO3CMT
379.94	379.86	114	
379.86	379.19	124	CO3CMT
379.19	378.52	122	CO3CMT
378.52	378.11	124	CO3CMT
378.11	377.50	124	CO3CMT
377.50	377.19	124	CO3CMT
377.19	376.93	114	
376.93	376.81	124	CO3CMT
376.81	376.10	124	CO3CMT
376.10	375.98	122	CO3CMT
375.98	374.08	124	SLP CO3CMT
374.08	373.52	324	CO3CMT
373.52	373.36	122	CO3CMT
373.36	373.10	114	
373.10	372.88	114	COLBND
372.88	372.76	021	
372.76	372.56	114	
372.56	372.31	122	
372.31	371.28	114	COLBND COLSPR
371.28	370.82	113	RTD COLSPR
370.82	370.74	193	RTD
370.74	364.92	000	
364.92	364.04	114	COLBND
364.04	358.19	000	
358.19	356.66	113	
356.66	356.24	123	RTD DST
356.24	355.65	123	BUR MXT
355.65	348.99	000	
348.99	348.93	113	
348.93	348.63	124	QTZ-CAL VEINS
348.63	348.35	122	BUR
348.35	347.86	124	BUR RTD
347.86	347.75	113	COLSPR
347.75	347.56	193	RTD
347.56	347.33	122	RTD DST
347.33	346.75	113	COLSPR
346.75	346.60	114	COLSPR COLBND
346.60	345.77	000	
345.77	345.67	113	COLSPR
345.67	344.71	114	
344.71	344.34	122	
344.34	344.18	194	
344.18	343.63	000	
343.63	343.32	113	
343.32	343.18	027	
343.18	342.40	113	DST
342.40	342.34	114	
342.34	341.95	113	
341.95	341.63	122	RTD COLSPR
341.63	341.40	323	SLP CO3CMT
341.40	340.64	124	DST COLSPR CO3CMT
340.64	340.21	323	BUR DST CO3CMT
340.21	340.08	122	CO3CMT
340.08	339.88	323	BUR DST CO3CMT
339.88	339.44	122	CO3CMT
339.44	339.24	113	
339.24	338.64	324	CO3CMT
338.64	337.98	323	BUR DST CO3CMT
337.98	337.88	323	CO3CMT
337.88	337.04	324	
337.04	336.19	323	RIP DST CO3CMT
336.19	335.76	123	
335.76	335.26	114	COLBND COLSPR
335.26	334.57	124	
334.57	333.76	114	COLBND COLSPR
333.76	333.68	021	
333.68	333.49	113	
333.49	333.03	324	RTD
333.03	332.00	113	COLBND
332.00	330.46	114	COLBND COLSPR
330.46	328.75	113	
328.75	327.11	114	COLBND COLSPR
327.11	326.67	113	
326.67	325.72	027	
325.72	324.60	114	
324.60	324.42	323	RTD DST
324.42	324.18	114	
324.18	324.10	323	
324.10	323.78	124	
323.78	323.66	323	
323.66	323.34	113	
323.34	323.22	021	
323.22	322.94	027	
322.94	322.87	021	
322.87	322.75	114	
322.75	322.44	124	
322.44	322.28	324	
322.28	322.14	323	
322.14	322.07	122	
322.07	321.48	000	
321.48	320.75	114	
320.75	319.95	000	
319.95	319.73	113	
319.73	319.51	124	
319.51	319.21	114	COLSPR COLBND
319.21	318.53	113	
318.53	317.85	123	
317.85	317.61	193	RTD
317.61	317.20	124	
317.20	316.69	113	
316.69	316.21	123	RTD
316.21	315.32	113	
315.32	315.25	027	
315.25	314.86	114	
314.86	314.72	122	
314.72	314.50	113	
314.50	313.04	123	
313.04	312.28	114	
312.28	312.01	323	
312.01	311.27	114	
311.27	310.28	324	BUR
310.28	309.88	321	RIP BUR
309.88	309.36	323	
309.36	309.16	544	COLSPR
309.16	308.98	544	
308.98	308.42	541	COLSPR
308.42	307.43	541	COLSPR
307.43	306.97	544	COLSPR
306.97	306.29	542	
306.29	306.10	541	RIP
306.10	305.80	542	
305.80	304.56	541	
304.56	304.40	544	COLSPR
304.40	303.87	541	COLSPR
303.87	303.33	543	FLT COLBND
303.33	303.26	544	COLSPR
303.26	303.20	021	
303.20	303.01	114	COLBND COLSPR
303.01	302.69	122	
302.69	302.43	324	DST
302.43	302.06	122	COLBND
302.06	300.01	000	
300.01	298.86	114	COLBND
298.86	298.63	114	
298.63	298.27	114	COLBND
298.27	298.14	114	COLSPR COLBND
298.14	297.43	113	
297.43	295.99	124	RTD
295.99	294.94	113	
294.94	294.80	114	
294.80	294.63	194	RTD
294.63	293.15	114	
293.15	289.57	124	
289.57	289.49	114	
289.49	289.27	114	
289.27	288.54	122	
288.54	288.43	323	RIP
288.43	287.88	122	
287.88	287.77	323	
287.77	286.86	122	BUR
286.86	286.74	323	
286.74	284.53	114	
286.53	286.37	122	
286.37	286.23	323	RIP
286.23	286.04	122	
286.04	284.81	124	
284.81	284.15	122	
284.15	283.83	000	
283.83	283.67	321	
283.67	283.50	114	
283.50	283.21	122	
283.21	283.08	321	
283.08	282.91	324	RTD COLSPR
282.91	282.43	000	
282.43	281.99	543	RTD FLT RIP
281.99	281.85	124	
281.85	281.59	323	
281.59	281.43	000	
281.43	281.29	323	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
281.29	279.84	541	COLSPR
279.84	279.62	324	
279.62	279.53	323	
279.53	279.20	322	RIP
279.20	278.90	323	
278.90	278.54	000	
278.54	278.18	324	CO3CMT
278.18	278.10	114	
278.10	277.94	322	RIP
277.94	277.66	122	
277.66	275.99	123	
275.99	275.74	323	RIP CO3CMT
275.74	275.39	124	
275.39	275.15	122	
275.15	273.32	122	
273.32	271.61	114	
271.61	271.46	114	
271.46	271.20	324	COLSPR BUR
271.20	270.54	122	
270.54	269.79	114	
269.79	269.59	112	COLBND
269.59	269.27	114	
269.27	269.18	324	
269.18	269.06	112	
269.06	268.75	114	
268.75	268.67	114	
268.67	268.36	122	
268.36	267.59	123	
267.59	267.00	324	BUR CO3CMT
267.00	266.89	124	BUR
266.89	266.64	323	BUR RTD CO3CMT
266.64	266.52	122	
266.52	266.40	324	BUR RTD COLSPR CO3
266.40	266.22	323	BUR CO3CMT
266.22	265.87	324	
265.87	265.45	323	BUR
265.45	264.72	322	RIP BUR CO3CMT
264.72	263.90	124	
263.90	263.16	323	BUR MFT CO3CMT
263.16	262.74	124	
262.74	261.36	122	
261.36	261.20	324	
261.20	261.08	322	RIP
261.08	260.41	323	RIP BUR CO3CMT
260.41	260.08	122	
260.08	258.08	323	RIP BUR
258.08	257.25	541	RIP CO3CMT
257.25	256.79	322	RIP CO3CMT
256.79	255.75	541	RIP CO3CMT
255.75	255.46	322	RIP
255.46	254.52	541	RIP CO3CMT
254.52	254.37	322	RIP CO3CMT
254.37	254.25	124	
254.25	253.46	541	RIP CO3CMT
253.46	253.41	123	
253.41	252.43	547	
252.43	248.64	541	COLBND
248.64	248.48	541	SLP
248.48	247.87	553	RTD COLBND MFT
247.87	247.44	547	BUR SLP
247.44	246.59	114	COLBND
246.59	246.51	114	
246.51	245.58	113	
245.58	244.78	123	
244.78	244.05	324	
244.05	243.85	114	
243.85	242.80	122	BUR CO3CMT
242.80	242.34	323	RIP CO3CMT
242.34	241.94	122	CO3CMT
241.94	241.23	124	CO3CMT
241.23	241.02	114	
241.02	239.97	122	CO3CMT
239.97	239.80	321	RIP BUR CO3CMT
239.80	239.52	323	RIP CO3CMT
239.52	239.28	322	RIP CO3CMT
239.28	238.98	323	RIP CO3CMT
238.98	238.77	321	RIP CO3CMT
238.77	238.70	323	
238.70	237.37	541	RIP CO3CMT
237.37	236.70	321	RIP CO3CMT
236.70	236.60	323	CO3CMT
236.60	236.38	541	RIP CO3CMT
236.38	236.14	323	RIP BUR CO3CMT
236.14	235.21	541	RIP CO3CMT
235.21	234.86	321	RIP COLSPR CO3CMT
234.86	234.70	323	BUR
234.70	234.44	322	COLBND CO3CMT
234.44	233.91	323	BUR CO3CMT
233.91	233.76	321	RIP CO3CMT
233.76	233.50	323	BUR CO3CMT
233.50	233.25	321	RIP CO3CMT
233.25	233.06	122	
233.06	232.64	323	BUR CO3CMT
232.64	232.40	322	
232.40	232.10	124	
232.10	226.48	122	CO3CMT
226.48	225.76	124	
225.76	224.32	122	CO3CMT
224.32	224.19	323	DST CO3CMT
224.19	223.87	322	RIP CO3CMT
223.87	223.54	323	BUR CO3CMT
223.54	223.06	321	CO3CMT
223.06	222.62	122	BUR CO3CMT
222.62	222.57	322	RIP CO3CMT
222.57	222.20	122	CO3CMT
222.20	221.40	323	BUR CO3CMT
221.40	220.11	122	DST CO3CMT
220.11	218.60	124	CO3CMT
218.60	217.57	114	COLBND
217.57	216.72	114	COLBND
216.72	216.53	114	COLBND COLSPR
216.53	210.75	000	
210.75	210.19	114	COLBND COLSPR
210.19	210.04	122	BUR
210.04	209.72	114	COLBND COLSPR
209.72	209.42	027	
209.42	209.06	114	COLBND COLSPR
209.06	203.76	000	
203.76	202.93	122	
202.93	201.87	114	COLBND COLSPR
201.87	201.54	114	
201.54	200.64	114	COLSPR COLBND
200.64	200.55	021	
200.55	200.36	027	
200.36	200.26	114	COLSPR
200.26	199.23	000	
199.23	198.29	124	
198.29	197.78	114	
197.78	197.50	322	BUR
197.50	197.30	122	
197.30	197.22	194	RTD
197.22	196.57	122	BUR
196.57	196.51	194	
196.51	196.22	124	
196.22	196.07	114	
196.07	192.95	114	RTD
192.95	192.51	114	COLBND
192.51	192.16	114	COLBND COLSPR
192.16	191.81	114	COLSPR RTD
191.81	191.62	114	
191.62	190.58	114	COLSPR
190.58	189.31	114	COLSPR COLBND
189.31	188.98	124	COLSPR
188.98	188.46	124	
188.46	188.42	194	RTD
188.42	188.27	113	
188.27	187.95	123	
187.95	187.67	324	
187.67	187.15	124	COLSPR
187.15	186.94	194	RTD CO3CMT
186.94	186.47	193	RTD CO3CMT
186.47	185.69	124	COLSPR
185.69	185.61	02?	
185.61	185.44	194	
185.44	185.20	122	
185.20	184.01	124	
184.01	183.87	324	BUR
183.87	183.77	124	
183.77	183.49	321	RTD RIP
183.49	183.28	321	CO3CMT
183.28	183.12	322	FLT CO3CMT
183.12	182.73	324	
182.73	182.49	122	
182.49	181.98	124	
181.98	181.68	323	RIP
181.68	181.40	324	
181.40	181.01	122	
181.01	180.70	114	
180.70	179.80	124	RTD
179.80	179.64	122	
179.64	178.34	124	RTD
178.34	177.80	323	BUR
177.80	177.68	114	
177.68	177.58	122	
177.58	176.88	124	RTD
176.88	176.53	194	
176.53	176.13	122	
176.13	175.56	124	
175.56	175.18	194	RTD
175.18	174.66	124	
174.66	170.22	122	
170.22	169.44	124	RTD
169.44	169.20	124	COLBND
169.20	168.31	124	RTD
168.31	167.91	194	RTD COLBND
167.91	167.65	114	RTD
167.65	167.26	194	RTD
167.26	167.15	122	COLBND
167.15	167.03	194	RTD
167.03	166.88	122	
166.88	166.19	124	
166.19	165.75	122	
165.75	165.55	192	
165.55	165.27	113	
165.27	164.78	114	COLSPR
164.78	163.72	123	
163.72	160.87	114	
160.87	158.47	000	
158.47	158.01	114	COLSPR COLBND
158.01	157.95	194	RTD COLBND
157.95	157.83	114	COLSPR RTD
157.83	157.72	124	
157.72	157.60	324	
157.60	157.32	124	
157.32	156.55	324	BUR
156.55	155.93	123	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
155.93	155.45	323	BUR
155.45	155.25	322	BUR
155.25	155.04	321	
155.04	154.82	322	BUR
154.82	154.74	323	
154.74	154.50	114	
154.50	154.31	323	RTD
154.31	153.93	324	COLSPR
153.93	153.25	322	RTD BUR
153.25	153.03	114	
153.03	152.40	323	BUR
152.40	152.18	323	SLP DST
152.18	151.89	124	
151.89	151.51	124	
151.51	150.72	122	BUR
150.72	150.29	323	RIP BUR DST
150.29	150.14	124	BUR
150.14	149.74	324	RTD CO3CMT
149.74	149.63	122	
149.63	149.43	322	BUR
149.43	149.38	124	
149.38	149.18	322	BUR
149.18	149.02	124	
149.02	148.72	324	BUR
148.72	148.59	323	
148.59	148.49	543	
148.49	148.09	394	COLSPR
148.09	147.91	124	COLSPR
147.91	147.77	124	
147.77	147.47	323	BUR
147.47	145.14	124	
145.14	144.92	323	BUR
144.92	144.83	124	
144.83	144.62	324	RTD
144.62	144.47	124	
144.47	144.26	324	
144.26	143.90	124	
143.90	143.52	321	RTD
143.52	143.42	122	CO3 VEINS
143.42	142.88	322	RIP BUR
142.88	142.41	122	CO3 VEINS
142.41	142.29	194	
142.29	141.73	122	BUR
141.73	141.17	321	RIP
141.17	139.90	122	BUR
139.90	139.75	193	RTD
139.75	139.37	323	BUR
139.37	138.19	124	
138.19	137.78	324	DST
137.78	136.75	124	
136.75	136.39	324	DST COLSPR
136.39	136.32	122	
136.32	135.62	322	MFT SLP
135.62	135.43	324	MFT
135.43	135.09	113	
135.09	134.96	124	
134.96	134.39	123	
134.39	134.03	114	
134.03	133.88	124	
133.88	133.83	194	
133.83	133.63	122	
133.63	133.47	122	
133.47	133.37	124	
133.37	132.57	122	
132.57	132.19	324	
132.19	132.00	324	
132.00	131.84	394	
131.84	131.62	324	CO3CMT
131.62	131.54	322	FLT
131.54	129.90	124	COLBND
129.90	129.59	122	BUR
129.59	129.46	194	
129.46	128.93	322	BUR
128.93	128.83	322	
128.83	128.75	122	
128.75	128.26	323	RIP
128.26	128.13	122	
128.13	128.02	194	RTD
128.02	127.31	122	
127.31	126.73	124	
126.73	126.06	124	COLBND
126.06	125.45	324	
125.45	125.37	194	
125.37	125.27	124	
125.27	125.18	194	RTD CO3CMT
125.18	124.99	324	CO3CMT
124.99	124.92	194	CO3CMT
124.92	124.84	124	
124.84	124.64	134	RTD CO3CMT
124.64	124.27	334	RTD CO3CMT
124.27	124.23	124	
124.23	123.85	334	RTD CO3CMT
123.85	123.78	324	
123.78	123.71	394	
123.71	123.27	324	
123.27	123.14	122	
123.14	122.60	324	
122.60	122.01	124	
122.01	121.83	124	
121.83	121.37	324	BUR
121.37	121.08	324	
121.08	120.77	323	
120.77	120.55	324	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
120.55	120.14	323	
120.14	119.84	124	
119.84	119.77	323	
119.77	119.66	122	
119.66	119.19	124	
119.19	118.81	323	BUR DST
118.81	118.49	124	
118.49	118.23	323	BUR DST
118.23	117.95	124	
117.95	117.76	321	RIP
117.76	117.62	543	RIP
117.62	117.49	544	
117.49	117.24	543	COLBND
117.24	116.66	541	
116.66	116.34	542	
116.34	115.88	541	
115.88	115.72	543	FLT
115.72	114.81	541	COLSPR
114.81	114.00	544	COLSPR
114.00	113.37	124	COLBND
113.37	113.25	113	
113.25	112.87	114	COLBND COLSPR
112.87	111.51	114	RTD COLBND COLSPR
111.51	110.84	114	COLBND RTD
110.84	110.70	114	COLBND COLSPR
110.70	110.28	193	RTD
110.28	109.99	114	COLBND
109.99	109.76	122	
109.76	108.72	124	
108.72	108.55	194	RTD
108.55	108.82	194	RTD
108.82	108.07	124	
108.07	107.92	114	COLBND
107.92	107.70	027	
107.70	107.52	114	COLSPR RTD
107.52	106.36	123	
106.36	106.06	124	RTD
106.06	105.30	123	
105.30	104.95	113	RTD
104.95	104.85	124	
104.85	104.40	123	COLSPR
104.40	104.11	122	RTD BUR
104.11	103.90	123	RTD
103.90	103.46	123	RTD
103.46	103.38	122	RTD COLSPR
103.38	102.80	123	
102.80	102.63	321	RIP
102.63	102.42	322	FLT
102.42	101.38	322	RIP RTD COLBND
101.38	101.06	322	RTD DST RIP COLBND
101.06	100.89	122	COLBND
100.89	100.78	114	
100.78	100.12	324	RTD
100.12	100.08	321	
100.08	99.71	324	RTD
99.71	99.48	124	RTD COLSPR
99.48	99.18	323	DST RTD
99.18	98.90	322	FLT BUR
98.90	98.59	323	
98.59	98.26	123	RTD
98.26	97.80	113	RTD
97.80	97.23	324	
97.23	96.77	124	
96.77	96.52	321	
96.52	96.43	122	
96.43	96.34	321	
96.34	96.24	122	
96.24	95.24	541	RIP
95.24	95.16	122	
95.16	95.08	541	RIP
95.08	94.72	321	BUR RTD CO3CMT
94.72	94.13	541	RIP
94.13	94.08	322	BUR CO3CMT
94.08	93.78	323	BUR
93.78	93.28	543	RIP BUR
93.28	93.20	321	
93.20	93.14	541	RIP
93.14	92.75	321	
92.75	92.59	124	
92.59	92.24	321	RIP BUR DST
92.24	92.04	323	
92.04	91.31	124	RTD COLSPR
91.31	91.09	323	
91.09	89.84	124	
89.84	89.49	114	COLSPR
89.49	88.17	000	
88.17	87.68	114	COLSPR
87.68	87.49	021	
87.49	85.65	114	RTD COLSPR
85.65	83.85	000	
83.85	83.20	114	RTD COLBND COLSPR
83.20	82.93	022	
82.93	82.76	112	COLBND
82.76	82.64	022	
82.64	82.42	112	COLBND
82.42	82.31	027	
82.31	81.38	122	
81.38	81.28	194	
81.28	80.94	113	
80.94	80.80	114	COLBND COLSPR
80.80	80.39	000	
80.39	79.22	113	RTD
79.22	79.01	194	RTD

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
79.01	78.54	113	RTD
78.54	77.97	194	CO3CMT RTD
77.97	76.81	113	RTD
76.81	76.37	114	COLSPR
76.37	75.88	124	RTD
75.88	75.75	324	
75.75	75.21	122	
75.21	74.82	114	RTD COLSPR
74.82	74.43	124	RTD
74.43	73.92	122	
73.92	73.73	124	
73.73	73.58	323	RTD
73.58	73.04	122	
73.04	72.98	321	RIP CO3CMT
72.98	72.55	113	RTD
72.55	72.18	122	
72.18	71.72	194	RTD
71.72	71.29	114	
71.29	71.20	114	COLSPR
71.20	71.14	021	
71.14	70.86	114	COLSPR
70.86	70.27	114	COLBND
70.27	69.61	114	COLSPR
69.61	69.54	021	
69.54	68.98	114	COLSPR
68.98	68.11	122	
68.11	67.72	122	
67.72	67.49	122	
67.49	67.21	113	
67.21	67.10	114	COLBND
67.10	66.97	113	
66.97	66.89	022	
66.89	66.37	122	
66.37	64.72	114	
64.72	64.54	027	
64.54	64.29	114	COLSPR COLBND
64.29	64.21	027	
64.21	63.04	114	COLSPR
63.04	62.20	113	
62.20	60.30	124	
60.30	57.73	323	BUR DST RTD
57.73	57.10	544	COLSPR RTD
57.10	56.19	114	COLBND
56.19	55.30	114	DST
55.30	55.22	027	
55.22	55.04	114	
55.04	54.91	122	
54.91	54.40	122	
54.40	53.94	124	DST BUR
53.94	52.97	324	RTD BUR
52.97	52.21	113	
52.21	52.06	322	COLBND DST
52.06	51.92	124	DST
51.92	51.75	324	DST BUR
51.75	51.46	322	DST BUR
51.46	50.55	323	BUR DST
50.55	50.44	124	
50.44	50.19	323	BUR
50.19	49.09	122	BUR
49.09	48.69	324	
48.69	48.57	194	
48.57	48.37	113	
48.37	48.15	124	
48.15	47.95	123	
47.95	47.90	324	
47.90	45.99	122	DST BUR
45.99	45.69	323	DST BUR
45.69	45.46	322	BUR DST
45.46	45.35	323	DST BUR
45.35	45.22	328	BUR
45.22	45.14	124	
45.14	45.04	323	DST BUR
45.04	44.47	124	
44.47	44.12	122	
44.12	44.05	194	
44.05	43.13	323	
43.13	42.72	322	COLBND
42.72	42.50	323	COLBND
42.50	41.88	321	RTD COLSPR
41.88	41.58	324	COLBND DST
41.58	40.33	544	COLSPR RTD CO3CMT
40.33	39.91	541	CO3CMT
39.91	38.43	124	CO3CMT
38.43	38.26	323	CO3CMT
38.26	37.87	324	COLBND CO3CMT
37.87	37.33	124	CO3CMT
37.33	36.88	323	MXT BUR
36.88	36.69	122	CO3CMT
36.69	36.15	324	BUR RIP CO3CMT
36.15	35.81	124	
35.81	35.54	321	MXT CO3CMT
35.54	32.47	124	COLSPR
32.47	32.16	122	BUR CO3CMT
32.16	31.62	321	CO3CMT
31.62	31.55	322	CO3CMT
31.55	31.25	323	CO3CMT
31.25	30.74	124	CO3CMT
30.74	30.54	194	RTD DST
30.54	25.94	124	RTD
25.94	25.78	194	RTD CO3CMT
25.78	25.22	124	CO3CMT
25.22	24.85	114	RTD
24.85	24.29	122	RTD DST
24.29	24.20	194	DST
24.20	23.61	122	
23.61	23.39	192	DST
23.39	23.03	122	
23.03	22.55	124	
22.55	21.93	122	RTD BUR CO3CMT
21.93	21.88	321	CO3CMT
21.88	21.75	122	CO3CMT
21.75	21.69	321	CO3CMT
21.69	20.62	323	RIP BUR CO3CMT
20.62	20.57	321	RIP CO3CMT
20.57	20.49	124	
20.49	19.89	321	RIP CO3CMT
19.89	19.29	321	RIP BUR CO3CMT
19.29	18.98	322	RIP
18.98	18.89	124	
18.89	18.66	322	RIP
18.66	18.44	122	
18.44	17.30	124	
17.30	17.11	114	
17.11	13.76	000	
13.76	13.65	114	COLBND
13.65	12.30	122	
12.30	11.85	323	BUR
11.85	11.70	122	
11.70	11.54	114	
11.54	11.44	028	
11.44	11.34	114	
11.34	11.07	028	
11.07	10.96	113	RTD
10.96	10.67	323	BUR
10.67	10.00	124	DST
10.00	9.67	323	BUR
9.67	9.02	124	
9.02	8.88	122	
8.88	7.79	021	
7.79	7.54	122	
7.54	7.35	114	COLBND
7.35	6.83	028	
6.83	6.62	114	RTD
6.62	6.02	323	BUR

(Intervals converted to true thickness)

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
506.35	505.71	323	SLP RIP BUR MFT
505.71	505.57	391	RIP
505.57	503.74	323	
503.74	502.61	122	
502.61	498.52	000	
498.52	497.72	112	
497.72	494.82	122	CO3CMT
494.82	494.70	325	CO3CMT
494.70	493.85	122	CO3CMT
493.85	493.27	134	MXT CO3CMT
493.27	492.21	122	CO3CMT
492.21	491.58	322	RTD BUR DST RIP
491.58	491.54	122	RTD DST CO3CMT
491.54	491.49	322	RIP CO3CMT
491.49	491.45	324	CO3CMT
491.45	491.38	323	FLT CO3CMT
491.38	488.99	122	FLT CO3CMT
488.99	488.30	132	MXT RTD CO3CMT
488.30	487.66	122	CO3CMT
487.66	487.62	124	DST CO3CMT
487.62	487.04	324	CO3CMT
487.04	487.00	122	CO3CMT
487.00	486.75	324	CO3CMT
486.75	482.43	122	DST BUR RTD CO3CMT
482.43	481.98	323	RIP BUR RTD CO3CMT
481.98	481.74	324	RTD COLSPR CO3CMT
481.74	481.61	323	FLT MFT CO3CMT
481.61	481.49	122	CO3CMT
481.49	481.37	323	MFT DST CO3CMT
481.37	481.26	122	CO3CMT
481.26	481.13	323	COLSPR CO3CMT
481.13	480.87	122	CO3CMT
480.87	480.81	114	CO3CMT
480.81	480.73	324	CO3CMT
480.73	480.40	122	CO3CMT
480.40	480.36	325	CO3CMT
480.36	479.44	122	CO3CMT
479.44	479.01	322	COLSPR RTD RIP CO3
479.01	478.97	124	CO3CMT
478.97	478.70	322	RIP RTD COLSPR CO3
478.70	478.48	124	CO3CMT
478.48	477.89	322	DST MXT RTD FLT
477.89	477.85	124	CO3CMT
477.85	477.76	322	FLT CO3CMT
477.76	477.58	122	CO3CMT
477.58	476.16	323	BUR CO3CMT
476.16	475.13	122	CO3CMT
475.13	475.09	324	CO3CMT
475.09	473.26	122	CO3CMT
473.26	471.67	324	CO3CMT
471.67	471.40	324	CO3CMT
471.40	469.34	122	CO3CMT
469.34	469.20	112	COLBND COLSPR
469.20	469.09	024	
469.09	468.45	112	COLBND COLSPR
468.45	466.35	000	
466.35	463.93	000	
463.93	463.51	122	LRG MFT BUR
463.51	463.25	323	MFT DST
463.25	463.18	000	
463.18	462.70	323	BUR DST CO3CMT
462.70	462.64	394	CO3CMT
462.64	461.81	324	LRG MFT BUR CO3CMT
461.81	461.60	323	MFT DST LRG CO3CMT
461.60	461.15	323	DST MFT BUR CO3CMT
461.15	460.86	323	LRG MXT CO3CMT
460.86	460.78	323	MXT CO3CMT
460.78	460.65	324	CO3CMT
460.65	459.97	122	CO3CMT
459.97	459.87	324	
459.87	459.53	324	
459.53	459.31	000	
459.31	459.12	324	
459.12	458.85	324	DST LRG MFT
458.85	458.18	323	RIP DST LRG MFT
458.18	457.41	323	LRG MFT MXT
457.41	457.15	124	MFT
457.15	456.59	334	DST MFT LRG
456.59	456.47	124	MFT
456.47	456.15	323	MXT RTD
456.15	455.48	323	RIP MXT
455.48	455.28	122	
455.28	455.20	323	FLT
455.20	455.00	122	DST
455.00	454.68	322	FLG MXT RTD
454.68	453.68	124	
453.68	453.47	321	FLT LRG MFT RTD
453.47	452.97	124	
452.97	452.84	322	MFT LRG
442.84	442.80	323	MFT
452.80	452.51	124	
452.51	542.39	322	DST MFT

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
452.39	452.33	324	MFT
452.33	452.26	322	MFT DST
452.26	452.10	122	
452.10	451.97	000	
451.97	451.62	122	
451.62	451.26	392	RTD RIP BUR DST
451.26	451.02	122	
451.02	450.89	322	
450.89	449.79	122	CO3CMT
449.79	449.69	125	CO3CMT
449.69	448.72	122	CO3CMT
448.72	448.24	322	BUR DST MFT RTD
448.24	447.89	124	CO3CMT
447.89	447.55	324	DST LRG MFT CO3CMT
447.55	447.34	323	CO3CMT
447.34	447.27	324	CO3CMT
447.27	447.14	122	CO3CMT
447.14	446.97	324	MFT CO3CMT
446.97	446.63	122	CO3CMT
446.63	445.82	322	*MXT BUR RTD RIP*
445.82	445.70	124	DST CO3CMT
445.70	444.87	324	DST RTD BUR CO3CMT
444.87	444.37	122	CO3CMT
444.37	443.68	124	DST BUR CO3CMT
443.68	443.60	000	CO3CMT
443.60	443.40	192	RTD MFT CO3CMT
443.40	442.90	122	BUR MFT CO3CMT
442.90	442.86	000	CO3CMT
442.86	442.80	124	CO3CMT
442.80	442.40	325	CO3CMT
442.40	442.20	323	*RIP* CO3CMT
442.20	442.11	124	MFT CO3CMT
442.11	441.52	124	CO3CMT
441.52	441.32	323	DST CO3CMT
441.32	439.13	122	CO3CMT
439.13	438.92	112	COLSPR CO3CMT
438.92	437.63	000	
437.63	437.21	324	COLSPR MFT CO3CMT
437.21	437.16	324	LRG MFT CO3CMT
437.16	437.08	324	CO3CMT
437.08	436.68	321	COLBND DST MFT CO3
436.68	436.38	322	RIP MFT CO3CMT
436.38	436.33	021	
436.33	436.20	124	
436.20	436.08	021	
436.08	435.97	124	
435.97	435.85	021	
435.85	435.37	322	MFT COLSPR BUR
435.37	434.95	124	COLBND
434.95	434.49	322	SLP
434.49	433.42	000	
433.42	433.27	114	COLSPR
433.27	433.13	321	RIP COLSPR
433.13	433.01	114	
433.01	432.97	021	
432.97	432.51	112	COLSPR COLBND
432.51	431.64	324	DST COLSPR
431.64	431.25	322	MFT COLSPR SLP
431.25	430.47	000	
430.47	430.08	322	COLBND COLSPR FLT
430.08	428.12	000	
428.12	427.76	321	RTD DST FLT
427.76	427.54	324	
427.54	427.01	114	COLBND COLSPR
427.01	424.98	322	RIP COLSPR
424.98	424.74	325	COLSPR
424.74	423.92	112	
423.92	423.65	323	
423.65	422.84	325	
422.84	422.30	322	RTD DST COLSPR
422.30	421.94	325	
421.94	418.10	000	
418.10	418.04	112	COLSPR
418.04	417.35	112	*COLSPR COLBND*
417.35	416.88	112	COLSPR
416.88	416.44	027	
416.44	415.20	000	
415.20	414.96	112	COLSPR
414.96	414.88	114	
414.88	414.73	323	RIP
414.73	414.61	132	MXT
414.61	414.38	112	COLSPR
414.38	414.10	322	RIP
414.10	413.92	122	COLSPR
413.92	413.45	000	
413.45	413.38	021	
413.38	412.84	112	COLBND COLSPR
412.84	412.00	122	
412.00	411.81	124	
411.81	411.61	000	
411.61	411.45	323	FLT
411.45	410.80	324	
410.80	410.69	324	MXT
410.69	410.47	322	FLT

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
410.47	410.24	321	RIP
410.24	410.18	324	
410.18	409.88	321	RIP
409.88	409.06	541	
409.06	408.27	322	FLT
408.27	408.23	544	
408.23	408.17	322	COLSPR
408.17	407.90	122	COLSPR
407.90	406.45	124	
406.45	405.42	324	DST
405.42	405.06	124	
405.06	404.93	322	RIP
404.93	404.77	323	
404.77	404.50	321	FLT COLSPR
404.50	404.21	124	
404.21	403.45	321	COLSPR COLBND
403.45	403.23	112	COLSPR COLBND
403.23	402.39	124	COLSPR COLBND
402.39	401.58	122	COLSPR
401.58	400.76	324	RTD COLSPR
400.76	400.41	114	COLBND
400.41	400.02	124	RTD DST
400.02	399.79	325	RTD DST COLSPR
399.79	399.33	122	COLSPR COLBND
399.33	398.86	124	
398.86	398.71	194	
398.71	398.19	112	COLBND
398.19	397.58	323	DST COLSPR RTD
397.58	397.42	122	
397.42	397.30	122	
397.30	397.19	323	RIP
397.19	396.55	122	RTD
396.55	396.45	125	RTD
396.45	396.38	124	
396.38	395.30	122	
395.30	394.85	122	RIP
394.85	394.80	322	RIP
394.80	394.72	122	
394.72	394.53	333	FLT
394.53	394.18	124	
394.18	393.97	323	RIP
393.97	393.65	323	FLT
393.65	393.45	392	DST
393.45	393.42	114	
393.42	392.80	323	
392.80	392.55	324	
392.55	391.54	323	COLBND BUR
391.54	391.35	322	RIP
391.35	391.20	122	
391.20	391.00	321	RIP
391.00	390.87	391	RIP
390.87	390.56	000	
390.56	390.02	122	
390.02	389.92	323	
389.92	389.04	122	
389.04	388.97	324	
388.97	388.34	324	BUR
388.34	388.28	324	
388.28	388.18	122	
388.18	387.86	323	COLSPR COLBND RTD
387.86	387.11	323	DST COLBND
387.11	387.03	322	DST COLSPR
387.03	386.03	323	DST COLSPR BUR
386.03	385.65	322	SLP CO3CMT
385.65	385.62	122	CO3CMT
385.62	385.37	325	CO3CMT
385.37	384.91	323	DST BUR CO3CMT
384.91	384.41	122	CO3CMT
384.41	384.31	322	RIP CO3CMT
384.31	384.19	323	RIP CO3CMT
384.19	383.97	322	RIP CO3CMT
383.97	383.83	124	CO3CMT
383.83	383.63	322	RIP CO3CMT
383.63	383.58	321	DST CO3CMT
383.58	383.49	324	CO3CMT
383.49	383.39	322	BUR CO3CMT
383.39	383.34	124	CO3CMT
383.34	383.04	322	DST RIP BUR CO3CMT
383.04	382.77	122	CO3CMT
382.77	382.48	322	LRG MFT CO3CMT
382.48	382.43	124	CO3CMT
382.43	382.21	322	DST CO3CMT
382.21	382.09	324	CO3CMT
382.09	381.73	322	BUR CO3CMT
381.73	381.31	323	CO3CMT
381.31	381.23	544	CO3CMT
381.23	381.12	122	CO3CMT
381.12	381.05	542	CO3CMT
381.05	380.73	125	CO3CMT
380.73	380.29	542	COLSPR COLBND CO3
380.29	379.79	122	CO3CMT
379.79	376.50	542	COLSPR COLBND CO3
376.50	376.04	114	
376.04	375.60	112	
375.60	375.33	114	
375.33	375.03	122	
375.03	374.29	132	RTD DST COLSPR BUR
374.29	372.83	122	RTD RIP COLSPR
372.83	372.56	323	BUR RIP
372.56	372.05	322	
372.05	371.95	321	RIP
371.95	371.83	323	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
371.83	371.56	541	
371.56	371.32	321	COLBND
371.32	371.19	322	COLSPR
371.19	370.81	321	COLBND COLSPR
370.81	369.94	541	
369.94	369.57	322	MFT
369.57	369.44	124	
369.44	369.37	322	DST BUR
369.37	369.29	124	
369.29	369.00	322	BUR
369.00	368.07	323	RTD BUR
368.07	367.79	127	BUR
367.79	367.23	322	RTD BUR
367.23	366.99	541	RTD COLSPR COLBND
366.99	366.40	322	BUR RTD
366.40	366.22	122	BUR
366.22	366.03	322	BUR
366.03	365.74	323	BUR
365.74	364.06	122	BUR RIP CO3CMT
364.06	363.93	124	COLSPR CO3CMT
363.93	363.69	122	COLSPR RIP CO3CMT
363.69	363.25	114	CO3CMT
363.25	361.72	122	BUR RIP CO3CMT
361.72	360.96	122	RIP CO3CMT
360.96	360.13	124	CO3CMT
360.13	389.62	122	CO3CMT
359.62	358.53	114	COLSPR CO3CMT
358.53	358.20	114	
358.20	357.05	112	COLSPR
357.05	356.82	112	COLSPR RIP
356.82	355.67	122	RIP
355.67	355.53	194	
355.53	355.15	112	COLSPR
355.15	354.96	194	DST
354.96	354.53	112	
354.53	353.89	122	RIP
353.89	353.65	124	
353.65	353.37	114	COLBND COLSPR
353.37	353.19	112	
353.19	352.86	112	
352.86	351.90	122	
351.90	351.58	112	
351.58	351.24	124	
351.24	350.91	122	
350.91	350.78	114	
350.78	349.41	122	
349.41	349.19	112	
349.19	344.83	000	
344.83	344.60	114	
344.60	344.49	027	
344.49	344.33	112	
344.33	344.18	122	RIP
344.18	343.89	112	COLBND
343.89	343.63	021	
343.63	343.51	114	
343.51	343.36	021	
343.36	343.07	114	
343.07	338.61	000	
338.61	338.52	114	COLSPR COLBND
338.52	338.11	313	RIP COLSPR
338.11	337.97	112	COLSPR FLT
337.97	337.53	313	RIP COLSPR
337.53	337.42	114	
337.42	336.94	114	COLBND COLSPR
336.94	336.83	027	
336.83	336.61	112	COLSPR
336.61	336.51	021	
336.51	336.18	112	COLBND COLSPR
336.18	336.11	027	
336.11	335.82	112	COLSPR COLBND
335.82	335.74	021	
335.74	334.80	000	
334.80	334.69	114	COLSPR
334.69	334.23	122	COLSPR
334.23	332.72	124	
332.72	331.97	324	
331.97	331.49	322	RIP BUR
331.49	330.25	122	RIP
330.25	330.11	322	RIP
330.11	330.02	324	
330.02	329.45	122	RIP
329.45	328.11	124	
328.11	327.67	114	
327.67	326.59	000	
326.59	325.84	122	
325.84	324.42	000	
324.42	324.14	124	
324.14	323.23	112	COLBND
323.23	322.53	122	COLSPR
322.53	321.43	124	
321.43	321.00	194	COLSPR
321.00	320.90	114	
320.90	320.86	323	COLSPR
320.86	320.75	164	COLSPR
320.75	319.85	124	
319.85	319.81	124	
319.81	319.55	114	
319.55	319.38	323	
319.38	318.59	124	
318.59	318.26	194	
318.26	317.68	124	
317.68	317.41	122	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
317.41	316.74	124	
316.74	316.39	114	
316.39	316.16	194	
316.16	315.82	323	RIP
315.82	315.63	122	
315.63	315.30	323	RIP
315.30	315.08	322	RIP BUR
315.08	314.27	323	RTD RIP BUR
314.27	314.02	124	
314.02	313.56	322	BUR RIP
313.56	313.26	321	RIP
313.26	312.36	122	
312.36	312.16	114	
312.16	311.93	112	
311.93	311.76	321	RIP BUR
311.76	311.40	322	RIP
311.40	311.14	321	RIP BUR
311.14	310.82	323	RIP BUR
310.82	310.64	321	RIP
310.64	310.11	323	BUR FLT COLSPR
310.11	309.78	322	FLT BUR
309.78	309.48	124	
309.48	308.94	122	
308.94	308.67	323	FLT BUR COLSPR
308.67	308.58	122	BUR FLT
308.58	308.42	323	FLT BUR DST
308.42	306.38	122	FLT
306.38	306.04	324	BUR
306.04	305.52	322	BUR DST
305.52	305.36	122	BUR COLSPR
305.36	304.95	323	RIP BUR
304.95	304.34	322	RIP BUR
304.34	303.85	122	COLSPR
303.85	303.67	323	
303.67	303.48	321	RIP
303.48	302.37	322	RIP DST BUR COLSPR
302.37	301.05	122	COLSPR
301.05	299.68	322	RIP BUR DST COLSPR
299.68	299.45	122	
299.45	299.36	322	RIP DST
299.36	299.26	122	
299.26	299.10	321	RIP
299.10	298.78	324	
298.78	298.52	322	RIP
298.52	298.39	323	FLT
298.39	298.06	322	RIP
298.06	297.37	122	COLSPR
297.37	296.68	112	COLSPR COLBND
296.68	286.14	000	
286.14	285.97	112	COLBND COLSPR
285.97	285.91	321	RIP COLSPR
285.91	285.52	112	COLBND COLSPR
285.52	284.73	122	COLSPR
284.73	284.11	324	
284.11	284.05	322	
284.05	283.56	122	
283.56	283.31	122	COLSPR DST
283.31	283.01	324	
283.01	282.91	322	
282.91	280.06	122	
280.06	279.93	324	
279.93	279.49	112	
279.49	279.34	122	
279.34	279.11	324	
279.11	278.64	124	
278.64	277.79	324	
277.79	277.70	124	
277.70	277.46	541	
277.46	277.12	323	
277.12	276.11	122	
276.11	275.99	194	
275.99	275.83	124	
275.83	275.64	544	
275.64	275.58	324	
275.58	275.18	124	
275.18	274.85	321	
274.85	272.62	541	COLSPR
272.62	272.47	122	
272.47	272.22	321	FLT
272.22	272.03	323	RIP
272.03	271.93	124	
271.93	271.60	324	COLSPR
271.60	271.17	122	
271.17	271.10	021	
271.10	270.93	122	
270.93	270.63	323	
270.63	269.62	321	MXT
269.62	269.14	323	
269.14	268.94	322	
268.94	268.88	542	RTD COLBND
268.88	268.47	321	
268.47	268.41	542	
268.41	268.20	322	COLSPR COLBND
268.20	268.07	542	
268.07	267.95	322	COLBND FLT
267.95	267.75	194	COLBND
267.75	267.34	543	COLSPR
267.34	267.11	323	COLBND
267.11	266.85	544	COLBND COLSPR
266.85	265.96	542	COLSPR
265.96	262.57	544	
262.57	262.02	542	COLBND COLSPR
262.02	260.50	542	RTD COLBND COLSPR

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
260.50	259.98	543	
259.98	259.28	544	COLBND
259.28	258.15	321	COLBND COLSPR RTD
258.15	256.77	541	COLBND COLSPR
256.77	256.18	541	COLBND
256.18	255.91	541	COLSPR
255.91	255.49	122	COLBND
255.49	255.33	541	COLBND COLSPR
255.33	254.63	541	COLSPR COLBND
254.63	254.38	321	FLT
254.38	254.11	544	COLBND COLSPR
254.11	253.90	323	
253.90	253.27	122	
253.27	253.12	192	RTD COLBND
253.12	252.92	122	
252.92	252.26	542	COLSPR
252.26	250.75	114	
250.75	248.70	000	
248.70	248.09	124	
248.09	247.97	194	
247.97	247.62	324	
247.62	247.20	332	BUR
247.20	246.44	324	DST BUR
246.44	246.32	194	RTD
246.32	245.76	323	BUR RIP
245.76	245.23	322	RTD RIP BUR
245.23	244.94	124	
244.94	244.36	322	RIP BUR
244.36	243.93	324	
243.93	243.07	114	
243.07	242.93	027	
242.93	242.45	122	COLSPR
242.45	242.29	194	COLSPR
242.29	241.86	112	
241.86	241.54	027	
241.54	239.33	112	RTD COLSPR
239.33	237.62	124	DST COLSPR
237.62	237.11	114	
237.11	236.88	323	RTD COLSPR
236.88	234.81	114	
234.81	234.51	323	COLBND RTD
234.51	233.10	321	RTD BUR RIP
233.10	232.78	122	BUR
232.78	232.14	334	COLSPR
232.14	231.76	324	DST
231.76	231.40	334	DST COLSPR RTD
231.40	230.87	124	RTD
230.87	230.72	323	RTD COLSPR DST
230.72	230.55	124	
230.55	230.44	323	FLT COLSPR
230.44	229.77	541	COLSPR
229.77	229.59	335	COLSPR DST
229.59	228.95	541	
228.95	228.53	334	COLSPR
228.53	228.49	122	MXT COLSPR
228.49	228.28	334	
228.28	228.00	323	
228.00	227.88	322	
227.88	227.67	124	
227.67	227.61	324	
227.61	224.86	124	
224.86	223.06	027	
223.06	222.57	114	
222.57	222.34	027	
222.34	221.46	122	
221.46	220.74	125	
220.74	220.36	322	DST RTD BUR
220.36	218.90	323	COLSPR
218.90	218.64	124	
218.64	218.11	122	COLSPR BUR RTD
218.11	217.83	112	RTD COLBND
217.83	217.01	116	COLBND COLSPR
217.01	216.72	114	RTD
216.72	214.13	000	
214.13	212.82	114	COLBND
212.82	212.68	194	
212.68	211.61	112	BUR COLBND COLSPR
211.61	210.70	122	COLSPR
210.70	210.38	134	
210.38	210.13	122	
210.13	209.89	122	Brown PATCHES
209.89	208.77	112	
208.77	208.37	115	
208.37	208.20	112	
208.20	208.08	115	
208.08	205.01	112	
205.01	204.83	027	
204.83	204.76	114	
204.76	204.56	027	
204.56	201.44	122	
201.44	199.57	124	
199.57	199.50	194	
199.50	198.72	122	
198.72	198.06	323	BUR RIP
198.06	197.65	321	RIP COLBND BUR
197.65	197.46	323	COLSPR
197.46	196.66	541	COLSPR
196.66	195.41	321	FLT
195.41	194.68	322	DST RTD
194.68	194.24	323	MFT
194.24	194.15	122	MFT DST
194.15	194.02	322	RIP MFT DST RTD
194.02	193.81	112	DST

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
193.81	193.69	322	MFT DST
193.69	193.43	325	DST MFT BUR
193.43	193.08	321	RIP COLSPR MFT MXT
193.08	192.62	322	RTD MXT COLSPR BUR
192.62	192.37	122	
192.37	192.21	122	
192.21	191.76	122	
191.76	191.67	122	
191.67	191.53	114	
191.53	191.33	323	MXT
191.33	189.34	122	MFT RTD BUR DST
189.34	187.39	114	
187.39	186.90	322	DST BUR RTD COLSPR
186.90	186.14	122	COLSPR RTD
186.14	185.63	322	RTD BUR RIP
185.63	185.44	325	DST
185.44	185.19	134	RTD COLSPR
185.19	183.84	114	COLSPR COLBND
183.84	183.13	124	RTD COLSPR
183.13	182.39	323	MFT FLT
182.39	182.06	124	
182.06	181.58	114	COLSPR
181.58	180.64	122	BUR FLT
180.64	180.19	134	
180.19	179.28	124	COLSPR
179.28	179.01	323	BUR COLBND
179.01	178.77	324	
178.77	176.52	321	BUR DST COLSPR
176.52	176.44	341	DST COLSPR
176.44	176.20	322	DST BUR COLSPR
176.20	175.65	114	
175.65	172.06	122	BUR FLT
172.06	171.92	192	DST RIP BUR FLT
171.92	171.69	194	
171.69	171.47	192	FLT DST
171.47	171.31	124	
171.31	171.07	323	DST BUR FLT
171.07	169.78	122	
169.78	168.32	114	COLSPR COLBND
168.32	167.82	122	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
167.82	167.63	192	
167.63	167.27	114	
167.27	167.11	124	
167.11	166.18	112	
166.18	166.12	194	
166.12	164.97	114	COLBND COLSPR
164.97	164.75	134	RTD
164.75	162.60	122	
162.60	162.17	194	
162.17	161.85	114	COLSPR COLBND
161.85	159.15	114	
159.15	158.99	124	
158.99	158.44	194	
158.44	158.20	122	DST
158.20	158.07	114	
158.07	156.44	124	RTD
156.44	156.06	114	
156.06	155.84	114	
155.84	152.48	000	
152.48	152.21	114	COLSPR
152.21	151.79	323	DST SLP BUR
151.79	150.53	122	BUR FLT COLSPR
150.53	149.30	313	FLT BUR RTD COLSPR
149.30	148.33	114	
148.33	147.83	027	
147.83	147.45	114	
147.45	147.33	122	BUR
147.33	147.01	322	DST BUR RTD
147.01	146.78	112	DST BUR
146.78	146.69	324	
146.69	146.07	112	BUR
146.07	145.85	313	BUR DST
145.85	145.61	114	
145.61	145.06	027	
145.06	144.45	124	
144.45	144.08	323	BUR
144.08	143.33	114	
143.33	143.11	021	
143.11	143.06	324	

(Intervals converted to true thickness)

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
86.05	85.03	114	
85.03	84.93	194	
84.93	84.27	114	
84.27	83.35	124	COLSPR RTD BUR CO3
83.35	81.95	114	COLSPR COLBND
81.95	81.77	021	
81.77	79.77	114	COLSPR COLBND
79.77	79.49	134	
79.49	78.50	114	
78.50	78.40	194	
78.40	77.96	114	COLSPR
77.96	77.69	027	
77.69	77.36	114	COLSPR
77.36	77.30	021	
77.30	77.22	114	
77.22	77.06	027	
77.06	76.79	114	COLSPR COLBND
76.79	79.70	028	
76.70	76.16	114	COLSPR
76.16	75.82	027	
75.82	75.45	114	COLSPR COLBND
75.45	75.09	027	
75.09	74.99	114	COLSPR COLBND
74.99	74.74	027	
74.74	74.61	114	COLSPR RTD
74.61	73.84	124	RTD
73.84	70.78	114	COLSPR COLBND
70.78	70.22	324	RTD DST COLSPR
70.22	69.92	323	FLT
69.92	69.81	323	RIP
69.81	69.43	323	BUR FLT
69.43	69.20	322	BUR
69.20	69.00	394	BUR RTD
69.00	68.72	321	DST RIP RTD
68.72	68.51	322	RIP DST
68.51	68.15	321	DST BUR RIP
68.15	68.09	324	BUR
68.09	68.04	543	RIP
68.04	67.97	324	
67.97	67.88	541	
67.88	67.68	321	BUR FLT
67.68	67.44	322	BUR RIP
67.44	67.29	394	
67.29	67.10	124	
67.10	66.78	324	RTD
66.78	66.64	321	FLT BUR
66.64	66.10	122	BUR RTD RIP FLT
66.10	65.93	323	BUR
65.93	65.35	324	BUR DST
65.35	65.25	322	FLT BUR
65.25	64.53	324	BUR
64.53	64.12	324	
64.12	64.01	124	
64.01	63.69	392	COLSPR RTD
63.69	63.55	324	COLSPR BUR
63.55	63.42	323	BUR
63.42	62.76	321	DST BUR COLSPR RTD
62.76	66.66	124	
62.66	62.16	542	BUR DST RTD
62.16	60.77	124	
60.77	60.53	125	
60.53	60.36	124	
60.36	60.26	194	
60.26	59.42	114	
59.42	58.70	321	FLT BUR DST
58.70	58.59	114	
58.59	58.36	114	COLBND COLSPR
58.36	57.63	114	COLSPR COLBND
57.63	57.46	114	
57.46	57.34	124	
57.34	56.84	114	
56.84	56.46	114	COLBND COLSPR
56.46	56.28	145	
56.28	55.80	114	COLSPR COLBND
55.80	55.66	021	
55.66	54.23	114	
54.23	54.12	027	
54.12	53.89	114	COLBND COLSPR
53.89	53.38	114	COLSPR RTD
53.38	53.31	114	COLBND
53.31	53.13	114	COLSPR
53.13	52.80	027	
52.80	51.98	114	COLSPR COLBND
51.98	50.88	124	
50.88	50.69	194	
50.69	49.95	124	COLSPR
49.95	49.84	027	
49.84	49.58	114	COLSPR
49.58	49.34	114	COLSPR COLBND
49.34	49.25	114	COLSPR
49.25	49.13	027	
49.13	48.31	114	COLSPR COLBND
48.31	48.25	194	
48.25	47.98	114	COLSPR
47.98	47.95	194	
47.95	47.33	114	COLSPR
47.33	47.17	124	
47.17	46.36	114	
46.36	46.27	027	
46.27	45.79	114	COLBND COLSPR
45.79	45.56	194	DST
45.56	45.41	134	RTD CO3CMT
45.41	44.62	124	CO3CMT
44.62	44.31	114	COLBND
44.31	43.89	124	COLBND RTD CO3CMT
43.89	43.83	132	RTD CO3CMT
43.83	42.22	124	RTD COLSPR CO3CMT
42.22	41.44	027	
41.44	40.84	114	
40.84	40.70	322	RIP CO3CMT
40.70	40.23	114	
40.23	39.75	321	RIP RTD BUR CO3CMT
39.75	39.54	124	BUR DST
39.30	38.88	322	BUR RIP COLSPR DST
38.88	38.23	321	BUR RIP RTD COLSPR
38.23	37.76	322	RTD BUR DST CO3CMT
37.76	37.63	321	BUR DST RIP CO3CMT
37.63	37.52	324	CO3CMT
37.52	37.35	322	DST BUR RIP RTD
37.35	36.67	322	DST RIP RTD BUR
36.67	36.51	324	DST CO3CMT
36.51	36.38	322	RIP CO3CMT
36.38	35.40	124	DST BUR RTD COLSPR
35.40	35.27	124	
35.27	35.23	323	RIP
35.23	35.05	124	
35.05	35.01	322	BUR DST
35.01	34.33	124	BUR DST
34.33	34.21	114	
34.21	31.48	000	
31.48	31.30	323	RTD COLSPR
31.30	31.02	124	
31.02	30.84	125	
30.84	30.69	128	
30.69	29.84	122	RTD BUR COLSPR MFT
29.84	29.76	128	
29.76	28.77	122	RTD BUR DST
28.77	28.00	122	BUR
28.00	27.97	124	
27.97	27.73	124	
27.73	27.37	114	COLSPR COLBND
27.37	26.43	124	
26.43	26.35	122	MFT
26.35	26.15	124	
26.15	25.71	323	FLT BUR RTD MFT
25.71	25.45	114	
25.45	25.11	122	BUR
25.11	24.91	124	
24.91	24.28	021	
24.28	23.94	124	
23.94	23.27	122	BUR RTD
23.37	23.13	114	
23.13	22.86	028	
22.86	22.60	114	
22.60	22.43	027	

(Intervals converted to true thickness)

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
224.86	222.57	544	
222.57	222.31	544	COLSPR
222.31	222.09	544	
222.09	221.26	544	COLSPR
221.26	220.83	541	COLSPR
220.83	220.56	544	COLSPR
220.56	220.37	541	
220.37	220.21	114	COLBND
220.21	219.83	021	
219.83	219.64	114	
219.64	219.51	322	
219.51	219.40	324	
219.40	219.05	123	
219.05	218.95	124	COLBND COLSPR
218.95	218.33	123	
218.33	218.11	124	CO3CMT
218.11	217.89	322	RIP CO3CMT
217.89	217.84	324	CO3CMT
217.84	217.59	124	CO3CMT
217.59	217.17	113	CO3CMT
217.17	217.06	197	CO3CMT
217.06	215.63	194	CO3CMT
215.63	215.41	113	RTD
215.41	215.33	127	CO3CMT
215.33	215.25	324	DST CO3CMT
215.25	214.50	124	RTD CO3CMT
214.50	214.42	324	DST BUR CO3CMT
214.42	213.74	124	RTD CO3CMT
213.74	213.67	324	CO3CMT
213.67	213.56	124	CO3CMT
213.56	213.43	322	RIP CO3CMT
213.43	213.35	124	CO3CMT
213.35	213.24	324	CO3CMT
213.24	212.76	124	RTD COLSPR CO3CMT
212.76	212.68	324	CO3CMT DST
212.68	210.93	123	RTD CO3CMT
210.93	210.12	124	COLSPR
210.12	209.76	324	SLP
209.76	209.28	124	COLSPR
209.28	208.56	124	
208.56	208.44	114	COLSPR
208.44	208.30	027	
208.30	207.41	123	RTD
207.41	206.87	122	RTD
206.87	206.48	114	COLSPR
206.48	205.86	122	
205.86	204.75	114	COLSPR
204.75	204.60	028	
204.60	204.42	113	
204.42	204.20	113	RTD
204.20	203.13	124	RTD CO3CMT
203.13	202.93	124	BUR CO3CMT
202.93	202.66	124	CO3CMT
202.66	201.98	124	COLSPR
201.98	200.83	124	CO3CMT
200.83	200.63	113	
200.63	200.22	113	COLSPR
200.22	200.02	124	BUR
200.02	199.92	113	COLSPR
199.92	199.81	028	
199.81	199.70	114	COLSPR
199.70	199.55	113	
199.55	199.25	322	BUR RIP
199.25	198.81	321	RIP
198.81	198.72	122	
198.72	198.56	124	
198.56	198.33	124	
198.33	198.14	114	COLSPR
198.14	196.47	000	
196.47	196.33	114	
196.33	196.07	113	COLSPR
196.07	195.30	124	
195.30	195.13	324	RIP CO3CMT
195.13	194.69	321	RIP CO3CMT
194.69	194.60	324	CO3CMT
194.60	194.38	124	
194.38	194.18	321	DST CO3CMT
194.18	193.96	324	RTD CO3CMT
193.96	193.68	322	CO3CMT
193.68	192.96	324	
192.96	192.82	124	
192.82	192.54	124	
192.54	192.29	113	
192.29	192.16	124	
192.16	191.71	114	COLSPR
191.71	191.57	324	
191.57	191.49	124	
191.49	191.34	028	
191.34	191.18	113	COLSPR
191.18	190.68	114	
190.68	190.38	124	
190.28	189.93	324	DST BUR
189.93	189.51	124	
189.51	189.15	324	CO3CMT
189.15	188.25	321	RIP DST CO3CMT
188.25	187.93	321	RIP CO3CMT
187.93	187.82	124	
187.82	187.63	321	RIP CO3CMT
187.63	187.40	322	FLT
187.40	187.15	324	CO3CMT
187.15	186.66	321	RIP CO3CMT
186.66	186.44	021	
186.44	186.16	114	COLSPR
186.16	184.44	123	CO3CMT
184.44	184.21	124	DST CO3CMT
184.21	184.10	322	DST CO3CMT
184.10	184.00	124	CO3CMT
184.00	183.38	122	DST CO3CMT
183.38	182.85	123	CO3CMT
182.85	181.82	021	
181.82	181.77	114	
181.77	181.58	124	
181.58	181.35	322	SLP
181.35	179.69	321	RIP BUR
179.69	179.60	324	RTD
179.60	179.30	114	
179.30	179.13	021	
179.13	178.85	124	COLSPR
178.85	178.77	021	
178.77	178.40	113	
178.40	178.26	021	
178.26	176.79	124	COLSPR
176.79	176.24	114	COLSPR
176.24	176.09	027	
176.09	176.01	114	COLSPR
176.01	172.36	000	
172.36	170.61	124	DST
170.61	170.39	194	RTD DST
170.39	170.16	122	
170.16	169.69	124	RTD
169.69	169.23	124	COLSPR
169.23	168.68	194	DST CO3CMT
168.68	168.34	114	COLSPR
168.34	168.18	124	
168.18	167.82	194	DST CO3CMT RIP
167.82	167.71	000	
167.71	167.69	194	DST CO3CMT
167.69	167.41	123	
167.41	167.27	124	COLSPR CO3CMT
167.27	166.53	114	COLSPR
166.53	166.02	124	
166.02	165.55	124	COLSPR
165.55	164.72	124	CO3CMT
164.72	164.49	193	
164.49	164.41	124	CO3CMT
164.41	164.22	323	CO3CMT RIP FLT
164.22	164.13	322	FLT CO3CMT
164.13	163.99	321	RIP CO3CMT
163.99	163.85	323	RIP CO3CMT
163.85	163.77	322	RIP CO3CMT
163.77	162.49	324	DST CO3CMT
162.49	162.29	124	
162.29	161.90	324	CO3CMT
161.90	161.56	124	DST CO3CMT
161.56	161.42	324	DST CO3CMT
161.42	161.02	124	CO3CMT
161.02	160.93	194	
160.93	160.82	000	
160.82	160.68	194	
160.68	160.17	124	
160.17	160.00	124	DST CO3CMT
160.00	159.72	544	CO3CMT
159.72	159.58	541	CO3CMT
159.58	159.32	544	CO3CMT
159.32	158.42	541	CO3CMT
158.42	158.22	544	CO3CMT
158.22	158.02	541	CO3CMT
158.02	157.54	544	CO3CMT
157.54	157.46	543	CO3CMT
157.46	157.28	544	CO3CMT
157.28	153.47	541	CO3CMT
153.47	151.61	541	CO3CMT COLSPR
151.61	151.32	541	COLSPR CO3CMT
151.32	150.09	541	LRG
150.09	149.68	543	
149.68	149.29	542	COLSPR
149.29	148.52	541	COLSPR
148.52	148.03	544	COLSPR
148.03	147.95	124	
147.95	147.79	122	RIP
147.79	147.57	124	
147.57	147.34	322	RIP
147.34	147.17	124	
147.17	146.85	122	
146.85	146.47	542	
146.47	143.54	544	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
143.54	143.37	541	
143.37	142.93	541	
142.93	142.51	544	
142.51	142.11	541	
142.11	141.92	543	
141.92	141.65	543	COLSPR
141.65	141.12	544	COLSPR CO3CMT
141.12	140.89	541	
140.89	140.47	122	
140.47	140.22	324	BUR MFT CO3CMT
140.22	139.83	324	BUR
139.83	139.66	324	BUR
139.66	138.86	324	DST
138.86	138.78	322	RIP BUR
138.78	138.56	323	FLT
138.56	138.36	321	RIP
138.36	138.15	323	FLT
138.15	138.09	122	
138.09	138.00	324	FLT
138.00	137.12	323	
137.12	137.06	322	RIP
137.06	136.85	321	RIP
136.85	136.47	324	RIP
136.47	136.03	323	
136.03	135.95	324	BUR
135.95	135.53	541	
135.53	135.44	124	
135.44	134.68	322	BUR
134.68	133.24	321	RIP
133.24	132.98	544	
132.98	132.80	324	
132.80	132.54	544	
132.54	132.28	541	
132.28	132.05	544	COLSPR
132.05	131.65	324	BUR
131.65	130.69	324	BUR COLSPR
130.69	130.46	324	
130.46	130.08	124	
130.08	129.88	324	
129.88	129.06	324	
129.06	128.69	324	MXT
128.69	128.45	324	BUR COLSPR
128.45	128.31	123	
128.31	127.84	124	
127.84	126.89	324	BUR
126.89	126.65	322	RIP DST
126.65	126.54	324	BUR
126.54	126.42	113	
126.42	126.27	027	
126.27	126.13	028	
126.13	125.70	113	
125.70	125.32	122	
125.32	125.23	027	
125.23	125.15	124	
125.15	124.91	322	MXT
124.91	124.42	000	
124.42	124.22	321	RIP
124.22	124.12	322	RIP
124.12	123.95	124	
123.95	123.75	194	
123.75	123.56	124	
123.56	123.03	000	
123.03	122.80	124	
122.80	122.63	324	DST
122.63	122.50	321	RIP DST
122.50	122.39	324	FLT
122.39	122.12	322	
122.12	122.01	000	
122.01	121.56	323	
121.56	121.45	114	
121.45	121.23	021	
121.23	120.85	114	COLSPR
120.85	120.61	194	RTD
120.61	120.26	114	COLSPR
120.26	119.82	194	
119.82	119.34	123	
119.34	118.69	124	COLSPR
118.69	118.01	123	
118.01	117.66	114	COLSPR
117.66	117.42	021	
117.42	117.30	124	
117.30	117.16	124	
117.16	117.07	321	
117.07	116.88	122	
116.88	116.68	124	
116.68	116.39	324	FLT
116.39	114.37	321	BUR
114.37	114.26	324	BUR
114.26	113.75	322	BUR
113.75	113.58	324	
113.58	113.37	124	
113.37	113.28	194	
113.28	112.63	124	
112.63	112.25	124	COLSPR
112.25	112.16	543	
112.16	111.92	542	BUR
111.92	111.51	321	MFT DST
111.51	110.73	541	RIP DST
110.73	110.05	544	COLSPR
110.05	109.65	541	RIP DST
109.65	109.40	324	DST
109.40	108.72	541	RIP
108.72	108.58	391	
108.58	107.99	541	RIP BUR
107.99	107.84	543	
107.84	107.66	544	
107.66	107.42	541	
107.42	107.13	541	RIP
107.13	106.23	542	
106.63	106.27	544	
106.27	105.77	541	RIP
105.77	105.44	542	
105.44	105.23	541	
105.23	105.09	544	COLSPR
105.09	104.61	114	COLSPR
104.61	104.01	114	COLSPR
104.01	103.62	123	RTD
103.62	103.36	197	
103.36	102.38	193	
102.38	101.75	123	
101.75	101.52	324	RTD
101.52	101.30	322	RIP RTD
101.30	101.07	114	COLSPR
101.07	100.32	123	
100.32	100.07	323	
100.07	99.75	322	RIP CO3CMT
99.75	99.44	324	BUR CO3CMT
99.44	99.20	321	RIP CO3CMT
99.20	98.97	124	CO3CMT
98.97	98.49	322	RIP BUR CO3CMT
98.49	97.52	322	RIP BUR CO3CMT
97.52	97.28	324	CO3CMT
97.28	97.20	124	
97.20	96.83	324	BUR CO3CMT
96.83	96.62	124	CO3CMT
96.62	96.29	324	BUR CO3CMT
95.29	95.14	322	RIP BUR CO3CMT
96.14	95.88	324	CO3CMT
95.88	95.79	322	RIP BUR CO3CMT
95.79	95.36	324	CO3CMT
95.36	95.16	322	RIP CO3CMT
95.16	94.56	123	
94.56	93.62	324	BUR CO3CMT
93.62	93.17	322	RIP CO3CMT
93.17	92.78	323	RIP
92.78	92.06	126	RTD
92.06	89.47	000	
89.47	89.33	114	COLSPR
89.33	89.18	322	
89.18	88.87	323	RIP BUR CO3CMT
88.87	88.70	122	
88.70	88.58	323	BUR CO3CMT
88.58	88.40	027	
88.40	88.28	021	
88.28	87.83	114	COLSPR
87.83	87.55	122	RIP
87.55	87.44	122	FLT
87.44	87.29	124	
87.29	86.92	122	RIP
86.92	86.60	114	COLSPR
86.60	85.72	114	COLSPR
85.72	83.62	000	
83.62	82.79	114	COLSPR
82.79	82.52	193	RTD
82.52	81.63	021	
81.63	81.24	114	COLSPR
81.24	81.18	021	
81.18	80.42	124	RTD
80.42	.80.30	027	
80.30	79.62	124	RTD
79.62	78.64	122	
78.64	77.18	124	
77.18	77.00	122	
77.00	76.63	122	
76.63	76.16	113	
76.16	75.38	124	RTD
75.38	73.75	122	
73.75	73.34	194	RTD
73.34	73.20	123	
73.20	72.95	124	
72.95	72.69	324	
72.69	72.61	122	
72.61	72.47	323	RIP
72.47	71.32	124	
71.32	70.89	123	
70.89	70.37	324	RIP CO3CMT RTD
70.37	70.15	124	RTD CO3CMT
70.15	69.86	324	CO3CMT
69.86	69.72	194	RTD CO3CMT
69.72	69.66	000	
69.66	69.52	124	CO3CMT
69.52	69.00	124	CO3CMT
69.00	68.71	328	CO3CMT
68.71	67.97	124	
67.97	67.71	124	
67.71	67.18	114	COLSPR
67.18	67.01	194	RTD
67.01	66.50	123	RTD
66.50	66.39	114	COLSPR
66.39	65.82	123	
65.82	65.48	122	
65.48	65.20	123	
65.20	65.03	123	DST CO3CMT RTD
65.03	64.75	323	MXT CO3CMT RIP
64.75	60.82	000	
60.82	60.45	322	RTD DST CO3CMT

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
60.45	60.36	123	
60.36	59.50	322	RTD DST CO3CMT
59.50	59.28	124	
59.28	58.13	124	CO3CMT
58.13	57.61	114	COLSPR
57.61	56.75	124	CO3CMT
56.75	56.23	324	RTD DST CO3CMT
56.23	56.01	126	RTD
56.01	55.00	124	RTD CO3CMT
55.00	54.64	324	RTD CO3CMT
54.64	53.72	322	CO3CMT
53.72	52.97	324	RTD CO3CMT
52.97	52.80	322	RTD DST CO3CMT
52.80	52.57	124	RTD BUR CO3CMT
52.57	52.37	324	CO3CMT
52.37	51.42	124	CO3CMT
51.42	51.23	324	CO3CMT
51.23	50.51	124	CO3CMT
50.51	49.48	324	DST RTD CO3CMT
49.48	49.34	322	BUR CO3CMT
49.34	48.96	324	BUR CO3CMT
48.96	48.44	322	RTD CO3CMT
48.44	48.06	324	DST
48.06	47.72	324	CO3CMT
47.72	47.37	322	RIP BUR CO3CMT
47.37	47.23	124	CO3CMT
47.23	46.77	324	BUR CO3CMT
46.77	46.60	124	CO3CMT
46.60	46.40	322	BUR DST CO3CMT
46.40	46.25	321	RIP DST CO3CMT
46.25	45.01	324	RTD DST CO3CMT
45.01	44.87	124	CO3CMT
44.87	44.61	322	DST CO3CMT
44.61	44.24	324	DST CO3CMT
44.24	42.87	124	RTD DST CO3CMT
42.87	42.70	324	CO3CMT
42.70	42.61	322	RIP CO3CMT
42.61	42.28	122	
42.28	42.22	114	COLSPR
42.22	41.39	021	
41.39	41.31	027	
41.31	40.79	114	
40.79	40.68	114	COLSPR
40.68	40.57	114	COLSPR
40.57	39.68	113	
39.68	39.26	000	
39.26	35.25	000	
35.25	34.81	114	COLSPR
34.81	34.67	027	
34.67	34.10	114	DST
34.10	33.69	122	CO3CMT
33.69	32.97	124	
32.97	32.45	322	RIP DST CO3CMT
32.45	32.19	122	CO3CMT
32.19	31.61	122	CO3CMT
31.61	30.80	124	DST
30.80	30.56	323	BUR DST
30.56	29.68	122	CO3CMT
29.68	29.23	122	CO3CMT
29.23	29.06	122	CO3CMT
29.06	28.83	124	
28.83	28.63	021	
28.63	28.52	114	COLSPR
28.52	27.78	122	DST
27.78	27.28	124	
27.28	27.08	323	DST
27.08	26.85	122	BUR
26.85	26.80	000	
26.80	26.37	122	
26.37	25.89	114	
25.89	25.72	113	
25.72	25.66	021	
25.66	25.58	124	CO3CMT
25.58	25.52	027	
25.52	24.72	124	COLSPR
24.72	24.61	323	BUR
24.61	23.98	122	
23.98	23.49	124	
23.49	19.51	000	
19.51	18.79	324	BUR DST CO3CMT
18.79	18.24	323	BUR DST CO3CMT
18.24	17.26	322	DST BUR CO3CMT
17.26	16.96	122	CO3CMT
16.96	16.30	323	BUR DST CO3CMT
16.30	16.07	122	RTD DST CO3CMT
16.07	15.55	323	BUR CO3CMT
15.55	15.35	124	CO3CMT
15.35	14.76	323	FLT RIP BUR CO3CMT
14.76	14.38	322	BUR DST CO3CMT
14.38	13.73	324	BUR DST CO3CMT RIP
13.73	13.44	323	FLT RIP BUR CO3CMT
13.44	13.12	122	CO3CMT
13.12	12.50	122	
12.50	11.79	124	
11.79	11.17	122	MXT CO3CMT
11.17	9.11	122	
9.11	8.74	124	DST
8.74	8.09	324	DST BUR CO3CMT
8.09	7.92	124	
7.92	7.62	323	RIP RTD
7.62	7.39	124	
7.39	6.83	322	RIP RTD
6.83	6.15	122	DST
6.15	5.77	124	
5.77	5.18	114	COLSPR
5.18	4.59	021	
4.59	4.50	114	COLSPR
4.50	3.91	124	
3.91	3.68	194	RTD CO3CMT
3.68	2.94	124	DST
2.94	2.70	324	DST CO3CMT

(Intervals converted to true thickness)

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
173.18	172.90	124	
172.90	172.66	124	
172.66	172.41	122	
172.41	172.32	322	BUR RIP
172.32	172.24	323	RIP
172.24	172.10	122	
172.10	171.83	122	
171.83	171.43	124	
171.43	171.20	122	
171.20	170.89	124	DST RTD
170.89	170.62	122	
170.62	170.58	114	
170.58	170.05	124	
170.05	169.16	123	
169.16	168.91	197	
168.91	168.72	113	
168.72	168.57	324	
168.57	168.40	123	
168.40	168.33	197	
168.33	168.10	123	
168.10	168.03	114	
168.03	167.92	193	
167.92	167.13	123	
167.13	165.64	114	COLSPR
165.64	165.28	123	
165.28	165.18	194	
165.18	164.96	123	
164.96	164.76	122	
164.76	164.64	324	RTD CO3CMT
164.64	164.41	322	RIP BUR CO3CMT
164.41	164.12	324	RTD BUR CO3CMT
164.12	163.94	321	BUR RIP MFT CO3CMT
163.94	163.87	323	RIP CO3CMT
163.87	163.63	122	BUR
163.63	162.21	124	
162.21	162.04	123	
162.04	161.95	193	DST RTD
161.95	161.53	124	
161.53	161.12	124	DST
161.12	161.00	324	CO3CMT
161.00	160.09	123	COLSPR
160.09	160.00	194	RTD
160.00	159.63	124	
159.63	159.43	124	COLSPR
159.43	159.06	124	DST
159.06	158.35	324	SLP CO3CMT
158.35	158.02	123	RTD
158.02	156.35	123	COLSPR DST
156.35	156.13	122	DST
156.13	155.95	124	DST
155.95	155.65	193	
155.65	154.92	124	
154.92	154.84	194	RTD
154.84	154.68	124	
154.68	154.27	113	
154.27	153.61	124	
153.61	153.06	02?	
153.06	153.01	?94	
153.01	152.86	114	COLBND
152.86	152.10	123	
152.10	151.88	123	COLSPR
151.88	151.81	?94	RTD
151.81	150.55	021	
150.55	150.35	123	
150.35	148.75	124	COLSPR
148.75	148.70	323	BUR
148.70	148.16	122	BUR
148.16	147.22	124	
147.22	146.60	122	
146.60	145.88	124	
145.88	145.75	122	
145.75	145.48	122	
145.48	145.02	122	
145.02	144.88	114	COLSPR
144.88	143.24	000	
143.24	142.92	124	DST
142.92	142.70	324	DST BUR
142.70	142.58	124	
142.58	142.36	324	MXT
142.36	141.92	124	
141.92	141.76	194	RTD
141.76	141.53	124	
141.53	141.39	324	
141.39	141.07	027	
141.07	140.81	021	
140.81	139.13	123	
139.13	138.86	122	RTD
138.86	138.52	123	COLSPR
138.52	137.59	123	
137.59	137.30	113	COLSPR
137.30	135.10	000	
135.10	134.95	124	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
134.95	134.61	324	DST
134.61	134.24	197	
134.24	134.01	113	
134.01	133.45	124	
133.45	131.35	000	
131.35	131.01	114	COLSPR
131.01	130.87	122	
130.87	130.68	324	
130.68	130.18	324	RTD COLSPR
130.18	129.98	114	COLSPR
129.98	129.90	027	
129.90	129.68	113	COLSPR
129.68	129.60	027	
129.60	129.52	114	COLSPR
129.52	129.41	021	
129.41	129.16	114	COLSPR
129.16	129.05	027	
129.05	127.90	124	
127.90	127.80	122	
127.80	127.30	324	RTD
127.30	127.22	322	RTD
127.22	126.97	324	
126.97	126.67	124	
126.67	125.99	113	
125.99	125.80	124	
125.80	125.45	122	MFT BUR
125.45	125.24	322	MXT RTD
125.24	124.11	323	
124.11	124.00	324	RTD
124.00	123.68	122	
123.68	123.57	324	
123.57	123.31	122	
123.31	122.86	124	
122.86	122.66	027	
122.66	122.24	021	
122.24	121.92	124	COLSPR
121.92	121.76	113	
121.76	118.94	000	
118.94	118.40	113	COLSPR
118.40	117.94	027	
117.94	117.37	123	COLSPR
117.37	117.29	194	RTD
117.29	117.07	324	RTD
117.07	116.96	323	RIP BUR
116.96	116.80	324	
116.80	115.66	123	
115.66	115.60	194	
115.60	115.10	123	
115.10	115.01	122	
115.01	114.94	324	
114.94	114.51	123	
114.51	114.06	124	RTD
114.06	112.45	123	COLSPR
112.45	112.36	324	COLSPR RTD MFT
112.36	110.97	124	DST
110.97	110.80	122	RTD CO3CMT
110.80	110.43	123	
110.43	109.67	124	
109.67	109.45	114	COLSPR COLBND
109.45	109.24	124	
109.24	109.07	114	COLSPR
109.07	108.46	124	RTD
108.46	108.25	122	BUR CO3CMT
108.25	107.90	123	
107.90	107.63	122	CO3CMT
107.63	107.41	124	CO3CMT
107.41	107.16	322	CO3CMT
107.16	107.67	122	
106.67	106.47	323	RIP DST
106.47	106.07	322	RIP RTD
106.07	105.82	321	RIP
105.82	105.54	322	RIP
105.54	105.04	323	RIP
105.04	103.42	124	
103.42	103.27	324	DST
103.27	102.89	122	COLSPR
102.89	102.79	113	
102.79	102.46	021	
102.46	102.21	113	RTD
102.21	101.40	123	COLSPR
101.40	101.20	323	BUR
101.20	100.97	322	BUR
100.97	100.59	323	BUR
100.59	100.04	124	BUR
100.04	99.78	324	
99.78	99.64	193	RTD
99.64	99.49	124	
99.49	99.33	324	
99.33	98.92	122	
98.92	98.76	124	
98.76	98.49	113	COLSPR
98.49	98.14	027	
98.14	97.99	114	COLBND
97.99	97.37	021	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
97.37	97.21	114	COLBND
97.21	96.38	323	BUR
96.38	96.23	124	
96.23	95.61	323	BUR CO3CMT
95.61	95.12	122	CO3CMT
95.12	94.55	323	BUR CO3CMT
94.55	92.80	122	CO3CMT
92.80	92.50	327	COLSPR CO3CMT
92.50	92.33	324	BUR CO3CMT
92.33	92.16	122	
92.16	91.94	127	COLSPR
91.94	91.71	122	
91.71	91.42	322	RIP BUR
91.42	91.18	122	
91.18	90.96	322	RTD
90.96	90.38	122	RTD
90.38	90.24	323	RIP CAL VEINS
90.24	88.91	122	
88.91	84.87	000	
84.87	84.71	028	
84.71	84.59	114	COLBND
84.59	82.68	113	COLBND
82.68	82.56	197	
82.56	81.81	113	COLBND
81.81	81.74	114	COLBND
81.74	81.33	027	
81.33	79.99	113	COLBND
79.99	77.11	124	
77.11	76.49	134	RTD CO3CMT
76.49	75.70	124	
75.70	72.96	124	
72.96	72.84	113	COL SPR
72.84	71.24	000	
71.24	71.11	027	
71.11	70.42	117	COLSPR
70.42	69.61	123	
69.61	68.77	114	COLSPR
68.77	68.16	323	RIP BUR
68.16	67.79	124	
67.79	67.49	324	
67.49	67.12	134	RTD CO3CMT
67.12	66.99	197	CO3CMT
66.99	66.85	137	CO3CMT
66.85	66.26	124	
66.26	65.67	114	COLSPR
65.67	65.57	114	COLSPR
65.57	64.75	124	
64.75	64.48	122	
64.48	64.27	113	
64.27	63.79	124	
63.79	63.65	194	
63.65	63.52	124	
63.52	63.45	194	
63.45	63.15	122	
63.15	62.82	124	
62.82	62.62	114	COLSPR
62.62	62.53	124	
62.53	62.29	113	
62.29	62.19	114	DST
62.19	60.70	124	
60.70	60.46	114	COLSPR
60.46	60.20	123	
60.20	59.35	124	
59.35	59.24	114	COLSPR
59.24	58.97	027	
58.97	58.83	114	COLSPR
58.83	56.88	124	COLSPR
56.88	56.62	324	
56.62	56.42	124	
56.42	56.16	324	BUR RTD
56.16	56.09	323	RTD RIP
56.09	55.75	124	
55.75	55.61	324	
55.61	55.46	322	RIP DST
55.46	55.39	124	
55.39	55.18	324	
55.18	54.43	124	BUR
54.43	54.26	324	BUR
54.26	53.64	124	
53.64	53.07	324	
53.07	52.80	322	MFT RTD
52.80	52.54	324	
52.54	52.15	124	
52.15	51.86	321	RIP SLP
51.86	51.19	124	
51.19	49.98	114	COLSPR
49.98	49.41	124	
49.41	49.34	122	
49.34	49.20	123	
49.20	48.86	124	COLSPR
48.86	48.76	194	RTD CO3CMT
48.76	48.59	113	
48.59	48.49	322	RTD
48.49	48.00	124	
48.00	47.65	113	COLSPR
47.65	47.32	113	
47.32	47.00	324	BUR
47.00	46.79	124	
46.79	46.61	122	CO3CMT
46.61	46.04	124	
46.04	45.83	114	COLSPR
45.83	45.66	122	
45.66	45.43	124	
45.43	45.20	322	RIP
45.20	45.15	324	
45.15	45.03	324	
45.03	44.57	124	RTD
44.57	44.30	124	SLP
44.30	44.20	324	SLP DST CO3CMT
44.20	43.78	124	
43.78	43.63	114	COLSPR
43.63	43.51	194	DST
43.51	43.16	124	DST
43.16	42.22	123	
42.22	42.05	114	COLSPR
42.05	41.85	027	
41.85	41.19	021	
41.19	41.07	124	
41.07	40.65	122	
40.65	40.53	124	COLSPR
40.53	40.41	322	RIP RTD
40.41	40.12	324	
40.12	39.64	122	
39.64	39.54	194	
39.54	39.40	124	COLSPR
39.40	39.06	322	RIP
39.06	38.67	321	RIP
38.67	38.34	324	DST
38.34	38.27	114	COLSPR
38.27	38.20	194	COLSPR
38.20	37.48	114	COLSPR
37.48	37.24	324	DST
37.24	37.00	322	RIP DST
37.00	36.60	321	RIP
36.60	36.45	114	COLSPR
36.45	36.32	027	
36.32	31.22	000	
31.22	30.85	114	COLSPR
30.85	30.75	027	
30.75	30.23	123	
30.23	28.97	114	COLSPR
28.97	28.84	027	
28.84	26.59	113	COLSPR
26.59	25.81	124	
25.81	25.21	323	MXT
25.21	25.06	124	
25.06	24.98	323	DST
24.98	24.59	124	
24.59	24.49	124	
24.49	23.38	124	
23.38	23.22	113	
23.22	23.03	124	DST
23.03	22.75	114	COLSPR
22.75	21.43	124	
21.43	21.08	114	COLSPR
21.08	20.20	124	
20.20	19.83	122	BUR
19.83	19.75	124	
19.75	19.54	124	
19.54	19.39	194	
19.39	18.99	124	
18.99	18.92	113	RTD
18.92	18.19	124	
18.19	18.00	193	
18.00	17.70	113	
17.70	16.39	113	COLSPR
16.39	15.94	124	
15.94	15.88	194	
15.88	15.27	124	
15.27	14.12	124	
14.12	13.77	324	RTD
13.77	13.42	122	
13.42	13.30	324	RIP BUR DST
13.30	13.05	322	RIP
13.05	12.73	124	
12.73	12.66	194	RTD
12.66	12.56	324	RTD
12.56	12.44	124	
12.44	5.70	000	
5.70	5.62	124	
5.62	5.53	321	
5.53	5.33	124	DST
5.33	5.26	323	
5.26	4.97	124	
4.97	4.67	324	BUR
4.67	4.37	323	SLP BUR
4.37	4.18	122	
4.18	4.03	323	RTD BUR
4.03	3.71	124	
3.71	3.47	122	
3.47	3.07	124	
3.07	2.60	122	
2.60	1.39	124	
1.39	1.09	122	
1.09	0.12	124	
0.12	0.00	123	

(Intervals converted to true thickness)

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
140.88	140.77	124	
140.77	140.55	324	DST
140.55	140.24	124	DST
140.24	140.07	114	COLBND
140.07	137.79	000	
137.79	137.17	114	COLBND
137.17	137.09	323	RIP
137.09	136.91	124	
136.91	136.63	114	COLSPR
136.63	134.04	000	
134.04	133.77	114	COLSPR
133.77	131.96	114	COLBND
131.96	131.00	124	
131.00	130.76	194	CO3CMT RTD COLSPR
130.76	130.57	124	
130.57	130.48	194	CO3CMT
130.48	130.25	123	
130.25	129.71	124	
129.71	129.39	124	
129.39	129.08	124	CO3CMT
129.08	128.50	323	DST BUR RTD
128.50	127.21	122	BUR
127.21	126.38	323	MXT BUR
126.38	123.93	122	BUR
123.93	123.54	324	MXT BUR
123.54	123.18	122	DST BUR
123.18	122.84	323	DST RTD
122.84	122.64	323	DST CO3CMT
122.64	122.42	122	DST
122.42	121.97	324	MXT RTD CO3CMT
121.97	121.67	323	MXT
121.67	120.42	122	DST
120.42	120.19	124	
120.19	118.57	124	
118.57	116.35	000	
116.35	115.98	113	COLSPR
115.98	115.70	113	
115.70	115.63	021	
115.63	115.47	114	COLBND
115.47	115.27	322	
115.27	114.39	124	
114.39	114.19	323	BUR RIP
114.19	113.08	122	
113.08	109.56	000	
109.56	109.41	124	
109.41	109.06	322	RIP RTD
109.06	108.93	324	
108.93	108.67	322	RIP RTD
108.67	108.57	122	
108.57	108.04	322	RIP RTD
108.04	107.36	122	
107.36	107.26	322	RIP RTD
107.26	107.06	122	
107.06	106.98	194	RTD
106.98	106.42	324	
106.42	106.09	322	RIP RTD
106.09	105.95	323	
105.95	105.31	124	
105.31	105.08	324	RTD DST
105.08	104.70	124	
104.70	104.20	323	FLT RIP
104.20	103.60	124	
103.60	103.48	323	RIP BUR
103.48	103.15	544	
103.15	103.02	122	
103.02	102.74	321	RIP RTD
102.74	102.64	124	
102.64	102.56	324	RTD
102.56	102.49	122	
102.49	102.35	324	RTD COLSPR
102.35	101.96	122	
101.96	101.47	122	
101.47	101.40	194	
101.40	100.91	122	
100.91	100.67	124	
100.67	99.70	000	
99.70	99.58	114	COLSPR
99.58	99.35	114	COLSPR
99.35	99.01	124	
99.01	98.57	122	BUR
98.57	98.47	324	DST
98.47	97.97	124	
97.97	97.63	027	
97.63	97.36	114	COLBND
97.36	97.02	114	COLSPR
97.02	96.72	124	
96.72	96.53	194	RTD
96.53	95.81	124	
95.81	95.64	113	COLSPR
95.64	94.40	021	
94.40	94.13	113	
94.13	93.69	544	COLSPR
93.69	93.31	124	RTD

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
93.31	92.90	324	BUR
92.90	92.01	323	DST BUR
92.01	91.81	124	
91.81	91.66	324	DST
91.66	91.32	124	
91.32	91.05	122	
91.05	90.53	323	RIP
90.53	90.16	122	RTD
90.16	89.28	322	RIP RTD
89.28	88.91	122	
88.91	88.53	324	DST RTD BUR
88.53	88.15	324	DST RTD BUR
88.15	87.48	113	
87.48	87.10	114	RTD
87.10	86.23	124	
86.23	86.10	114	COLSPR
86.10	86.01	114	COLBND
86.01	85.76	021	
85.76	85.19	114	
85.19	85.10	194	RTD
85.10	84.81	323	
84.81	82.17	122	
82.17	81.45	323	RIP BUR
81.45	81.23	122	
81.23	80.70	127	
80.70	80.38	122	
80.38	80.29	194	CO3CMT
80.29	79.90	113	
79.90	79.49	122	
79.49	79.06	323	FLT MFT
79.06	78.94	122	
78.94	78.78	124	
78.78	78.63	323	RIP
78.63	78.48	322	RTD
78.48	78.22	324	
78.22	77.55	124	
77.55	77.47	194	
77.47	77.10	124	
77.10	76.79	124	RTD COLSPR
76.79	76.49	124	RIP
76.49	76.41	323	
76.41	76.04	124	
76.04	75.27	122	
75.27	74.68	124	
74.68	74.24	114	COLSPR
74.24	74.19	194	RTD
74.19	74.05	113	RTD
74.05	70.30	000	
70.30	69.46	124	COLSPR
69.46	69.33	114	COLSPR
69.33	68.73	124	
68.73	68.42	324	RTD
68.42	67.85	322	DST RTD BUR
67.85	67.46	122	BUR
67.46	67.21	122	
67.21	67.00	124	
67.00	66.95	027	
66.95	66.38	324	COLSPR CO3CMT
66.38	66.15	124	
66.15	66.01	324	DST CO3CMT
66.01	65.56	122	CO3CMT
65.56	65.51	322	RIP RTD CO3CMT
65.51	65.43	122	CO3CMT
65.43	65.36	124	CO3CMT
65.36	65.26	322	RIP RTD CO3CMT
65.26	64.48	122	CO3CMT
64.48	64.35	322	RTD RIP CO3CMT
64.35	64.02	324	RTD
64.02	63.87	122	
63.87	63.72	124	
63.72	63.67	124	RTD CO3CMT
63.67	63.49	124	
63.49	63.00	114	COLSPR
63.00	62.39	323	RIP CO3CMT DST RTD
62.39	61.70	122	CO3CMT
61.70	61.24	324	DST COLSPR
61.24	60.86	114	
60.86	60.60	324	DST COLSPR
60.60	60.42	122	COLSPR
60.42	59.80	324	DST COLSPR
59.80	59.61	124	
59.61	59.49	324	DST COLSPR CO3CMT
59.49	59.33	124	
59.33	59.21	322	RIP CO3CMT
59.21	58.97	124	CO3CMT
58.97	58.84	324	DST COLSPR CO3CMT
58.84	58.55	114	COLSPR
58.55	58.32	124	COLSPR
58.32	57.56	324	DST
57.56	57.29	124	
57.29	56.95	124	
56.95	56.87	124	
56.87	56.74	322	RIP CO3CMT
56.74	56.47	123	

Interval Top (m)	Interval Base (m)	Lithotype Code	Suffix Modifiers
56.47	56.24	124	
56.24	55.92	123	RTD
55.92	55.59	323	RIP
55.59	55.30	124	
55.30	54.39	124	
54.39	53.09	123	RTD
53.09	52.37	124	
52.37	51.84	324	
51.84	50.40	124	
50.40	49.97	322	BUR
49.97	49.85	322	RIP RTD CO3CMT
49.85	49.13	124	RTD
49.13	48.00	323	RIP DST COLSPR
48.00	47.69	324	BUR RTD SLP
47.69	46.96	123	
46.96	46.66	123	
46.66	46.53	114	COLSPR COLBND
46.53	45.93	114	COLSPR
45.93	40.07	000	
40.07	39.71	114	COLSPR
39.71	39.37	021	
39.37	39.00	114	COLSPR
39.00	38.86	113	
38.86	38.41	114	COLSPR
38.41	38.34	021	
38.34	38.22	114	COLBND
38.22	37.75	113	
37.75	37.63	114	COLBND
37.63	37.38	124	RTD
37.38	37.13	324	
37.13	37.06	124	
37.06	36.93	194	
36.93	36.81	124	
36.81	36.74	321	BUR
36.74	36.64	324	RIP
36.64	36.30	322	RIP BUR
36.30	36.21	394	
36.21	34.99	322	RIP
34.99	34.76	194	RTD
34.76	34.41	324	RTD
34.41	33.91	324	RTD SLP
33.91	33.60	124	RTD
33.60	33.50	324	RTD
33.50	33.38	124	
33.38	33.25	323	RTD
33.25	33.09	124	SLP
33.09	32.94	194	
32.94	31.00	123	
31.00	30.85	194	
30.85	29.47	123	
29.47	26.19	000	
26.19	26.11	194	RTD COLSPR CO3CMT
26.11	25.08	113	COLBND
25.08	24.93	124	RTD
24.93	24.46	194	RTD COLSPR
24.46	24.17	113	
24.17	23.87	324	
23.87	23.48	124	
23.48	23.17	324	DST
23.17	22.96	326	BUR
22.96	22.76	124	BUR
22.76	21.97	123	RTD
21.97	21.59	123	COLSPR
21.59	20.94	123	RTD COLSPR
20.94	18.41	000	
18.41	17.97	113	
17.97	17.58	124	DST RTD
17.58	17.33	323	DST
17.33	16.57	324	DST RTD
16.57	16.17	113	
16.17	15.65	324	RTD DST
15.65	15.31	194	RTD COLSPR
15.31	15.00	324	DST SLP
15.00	14.88	124	
14.88	14.82	544	DST
14.82	14.61	543	RTD RIP
14.61	14.49	321	RIP
14.49	14.27	324	RIP RTD
14.27	14.16	124	
14.16	13.42	113	
13.42	12.71	114	
12.71	12.64	324	DST
12.64	12.50	122	
12.50	12.13	324	DST
12.13	11.57	321	RIP FLT RTD
11.57	11.32	326	RTD
11.32	10.89	324	BUR
10.89	10.34	124	
10.34	10.16	324	BUR
10.16	10.01	322	RIP RTD
10.01	9.70	323	FLT RTD DST
9.70	8.90	322	RTD
8.90	8.85	194	
8.85	8.18	323	BUR RTD
8.18	7.81	122	BUR RTD
7.81	7.76	194	CO3CMT
7.76	7.34	323	BUR RTD
7.34	6.33	322	BUR RTD
6.33	6.07	114	COLSPR
6.07	0.39	000	
0.39	0.00	113	

APPENDIX 3
DIGITAL DEPOSIT MODEL OF WEARY RIDGE

by J.D. Hunter and D.A. Grieve

INTRODUCTION

Weary Ridge is on the east side of the Elk River in the northern part of the Elk Valley coalfield, 35 to 40 kilometres north of Elkford. Strata on Weary Ridge are on the east limb of the Alexander Creek syncline and include the upper part of the Fernie Formation, the entire Morrissey and Mist Mountain formations, and the lower part of the Elk Formation. Major coal seams of the Mist Mountain Formation are included in the deposit model described here.

The model of Weary Ridge has been constructed without regard to coal property boundaries. In actual fact, coal rights on Weary Ridge are covered by parts of two properties, the Elk River property in the north and the Fording River property in the south. The boundary between them is in the vicinity of U.T.M. gridline 5 580 000 metres north. At present (April 1991) the principal owner of the Fording River property, Fording Coal Limited, also holds a 50 per cent interest in the coal rights in the Elk River property, so that at this time it is valid to consider Weary Ridge as one entity.

The seams on Weary Ridge have been modelled in two groups. The first group includes all the major seams from the base of the formation up to and including 18-seam, while the second group includes the major seams between 13 and 18 in the upper half of the formation only. The reason for calculating resource values on the latter group separately is that the measured stratigraphic section of the Mist Mountain Formation on Weary Ridge (Figure 7) suggests that this portion of the stratigraphy may be anomalously rich in coal. If this is the case throughout the grid area, there may be relatively high total tonnages and low waste-to-coal ratios associated with this part of the stratigraphy.

The computer modelling techniques applied to the Weary Ridge coal deposit are outlined briefly below. More detailed descriptions of most of the techniques are found in Kilby and McClymont (1985) and Grieve and Kilby (1990). Much of the following was extracted verbatim from the latter source.

COMPUTER MODELING TECHNIQUE

Deposit modeling of Weary Ridge was performed using the gridded-surface technique on a microcomputer. It required the compilation of existing geological data describing the deposit, as well as new data contained in this bulletin. This information was used to describe positional and thickness parameters of the coal seams of interest within the deposit, and generate resource-quantity data and rock-to-coal ratios.

GRIDDED SURFACE TECHNIQUE

In a gridded-surface digital model each parameter of interest in the deposit is described by a single **digital surface.** In this study, the digital surfaces take the form of a network of regularly spaced points, grid **nodes,** covering the deposit. A grid **cell** is the area around a grid node which is assumed to be represented by the value at the node. Gridded surfaces used in this study have square grid cells which are centred on the grid node and oriented parallel to the lines of grid nodes. All digital surfaces for the deposit are of equal size and configuration, so that the corresponding grid nodes for each surface have the same lateral coordinates.

The value of the parameter of interest is determined and recorded at each grid node. Grid-node values may be exactly equal to the value of the parameter at that exact geographic location, or may be some average value which better describes the whole grid cell, depending upon the type of parameter. Each digital surface defines the value of a single parameter over the whole model area.

Analysis of digital deposit models may be based on a single gridded surface or on multiple-surface calculations. An example of a single-surface calculation would be the total volume of coal in a single seam. The calculation would be accomplished by adding the values from each grid node of the seam thickness grid and multiplying this total by the area of the associated grid cell. An example of a multiple-surface calculation would be the calculation of overburden or intraburden associated with coal seams. This type of calculation would be accomplished by subtracting the elevations associated with the grid nodes of the lower positional-grid surface from the elevations of the corresponding grid nodes of the upper positional-grid surface. These overburden or intraburden thicknesses would then be multiplied by the associated grid-cell area to arrive at the volume of material between the two surfaces.

MODEL FORMAT AND ANALYSIS

The digital model in this study is simply a collection of gridded surfaces with identical formats. Each surface is stored in a single file with a descriptive name such as "2BASE" (elevations for the base of 2-seam). Model analysis is accomplished with a series of programs which access the required gridded-surface files and perform simple arithmetic functions to complete the required calculation. The output from these analysis programs may be a numeric value, for example, tonnage of coal in a seam, or a new grid, for example, interseam thicknesses, or both. The grids may also be displayed in the form of a line printer map, plotter contour map or perspective net diagram, which allows for hardcopy representation of the surface values.

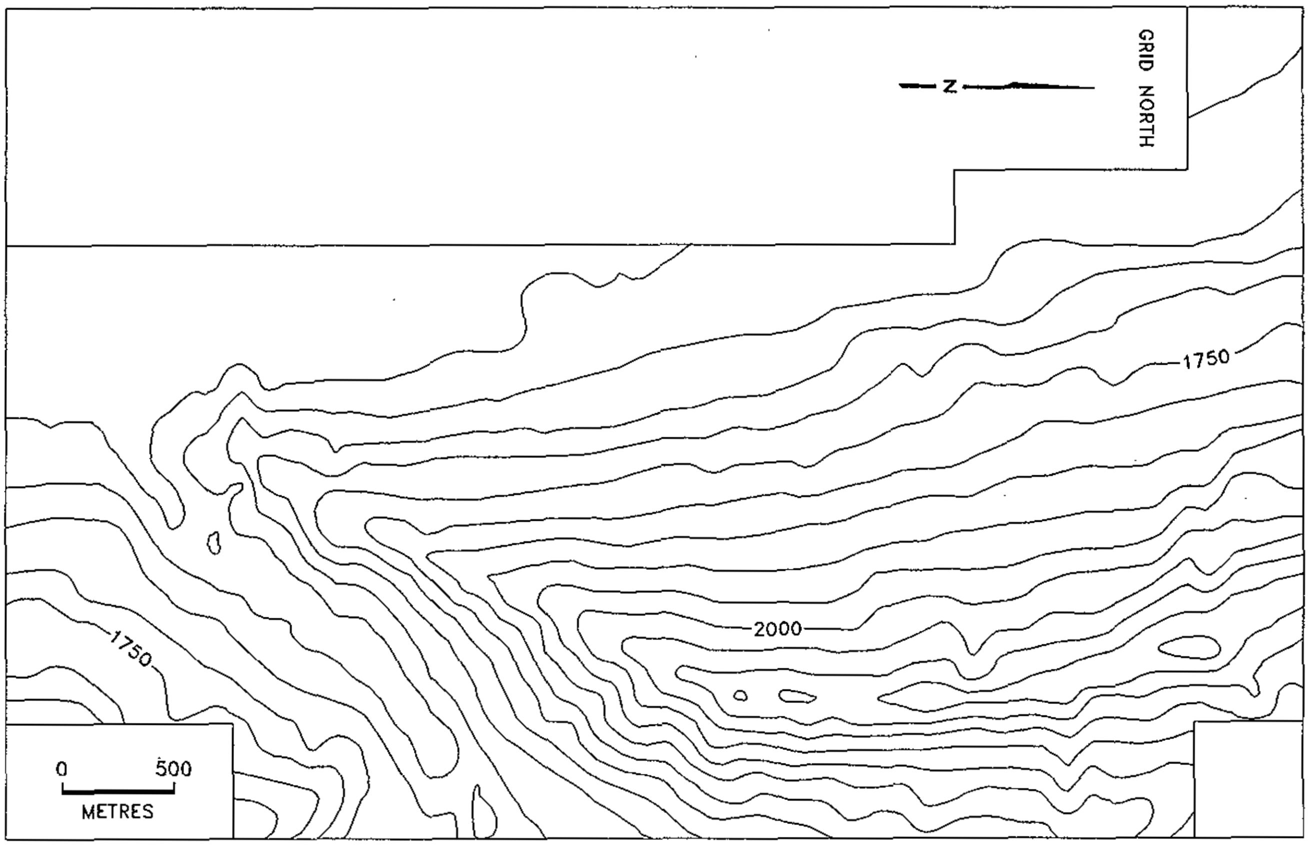


Figure A3-1. Contour map of the grid area, based on the topographic elevation grid. Contours in metres.

DEPOSIT MODEL

OBJECTIVES

The purpose of this portion of the Elk Valley coalfield study was to construct a digital deposit model of major coal seams on Weary Ridge south of U.T.M. grid line 5 584 000 metres north, utilizing all available data to assist in the coal resource evaluation. Outcrop and subsurface data were available, which provided the ability to model seam thicknesses and distributions, and apply distance-to-data resource qualifications.

GRID SPECIFICATIONS

The grid area was selected to best cover the domain of interest within the smallest possible area. This domain is bounded by U.T.M. gridlines 5 577 000 metres north and 5 584 000 metres north. Grid origin (0,0 point) is at U.T.M. 648 000 metres east, 5 577 000 metres north. A 56-row by 36-column grid with a node spacing of 100 metres was used. The grid contains only 1471 cells as its outline was trimmed to omit unnecessary areas (Figure A3-1). The grid is oriented parallel to the U.T.M. grid. Grid north is therefore 1°44′ east of true north.

DATA

The geologic and stratigraphic data used for the model were collected from a variety of existing sources, including this project. Topographic data were taken from a 1:10 000-scale map with 20-foot (6.10 m) contour intervals, contained in an exploration assessment report. Most outcrop orientation data were obtained from geological maps included in assessment reports, using the computer program COD (Coal Outcrop Digitizer). Seam position and thickness data were obtained from geological maps, trench data and interpretation of borehole geophysical logs. Information was collected for 14 coal seams. Using the Elco Mining Ltd. nomenclature system (Figure 7) these seams are, in ascending order, numbers 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 18.

A total of 113 outcrop data points were incorporated in the model, together with 34 boreholes and 35 trenches.

GRID CONSTRUCTION

Due to its large size, the topographic grid was generated using a semi-automated data collection technique. A digitizing tablet and an IBM XT computer were used to record the raw elevation data from the topographic map. Lines joining the columns of grid nodes were drawn on the map. A digitizing program called TOPOLINE was used to digitize the contour intersections with each of these lines. Another program, LINE-RED, was used to reduce the raw line data into a series of elevations which correspond to the locations of the grid nodes along each line by straight line interpolation techniques. The resultant series of elevations along the 36 column lines was then placed in the CALDATA (copyrighted software) grid format. The resultant contour map of the model area is shown on Figure A3-1. Figure A3-2 contains a three-dimensional perspective, net diagram

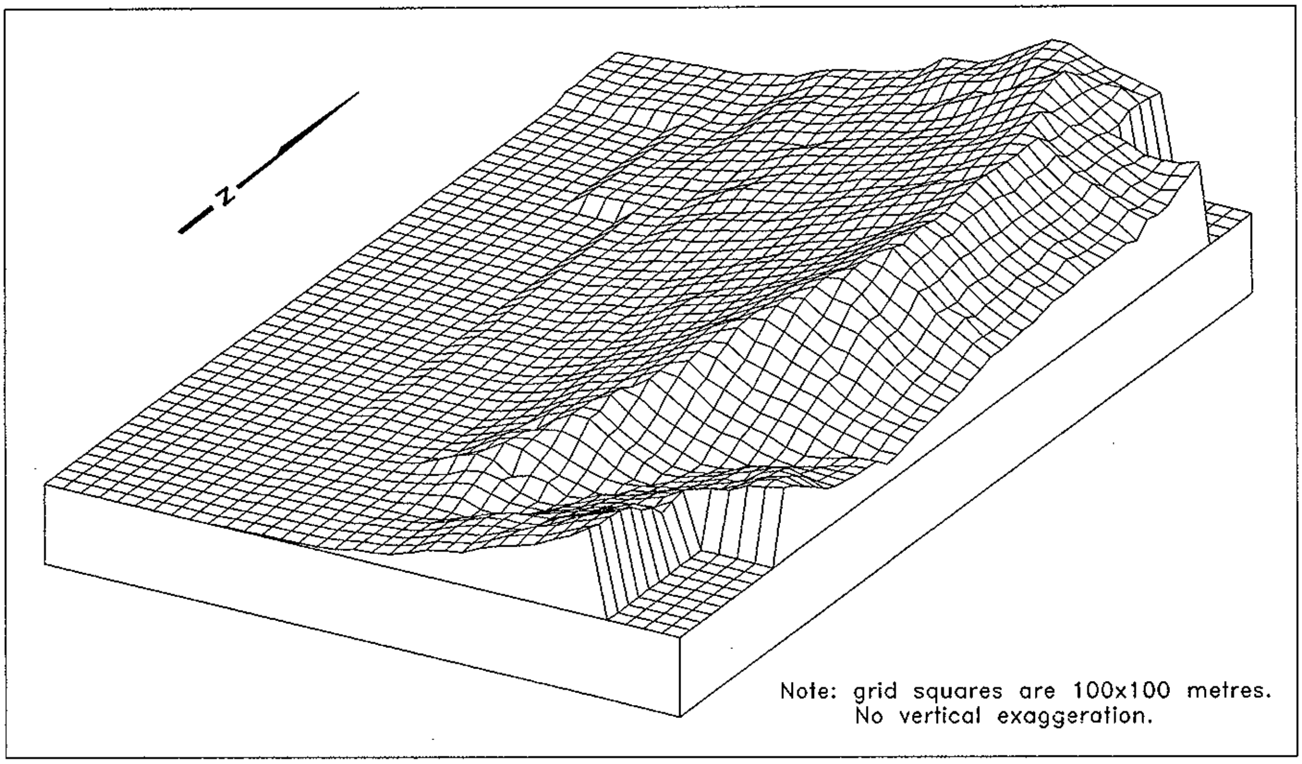


Figure A3-2. Perspective net view of Weary Ridge from the southeast, based on the topographic elevation grid.

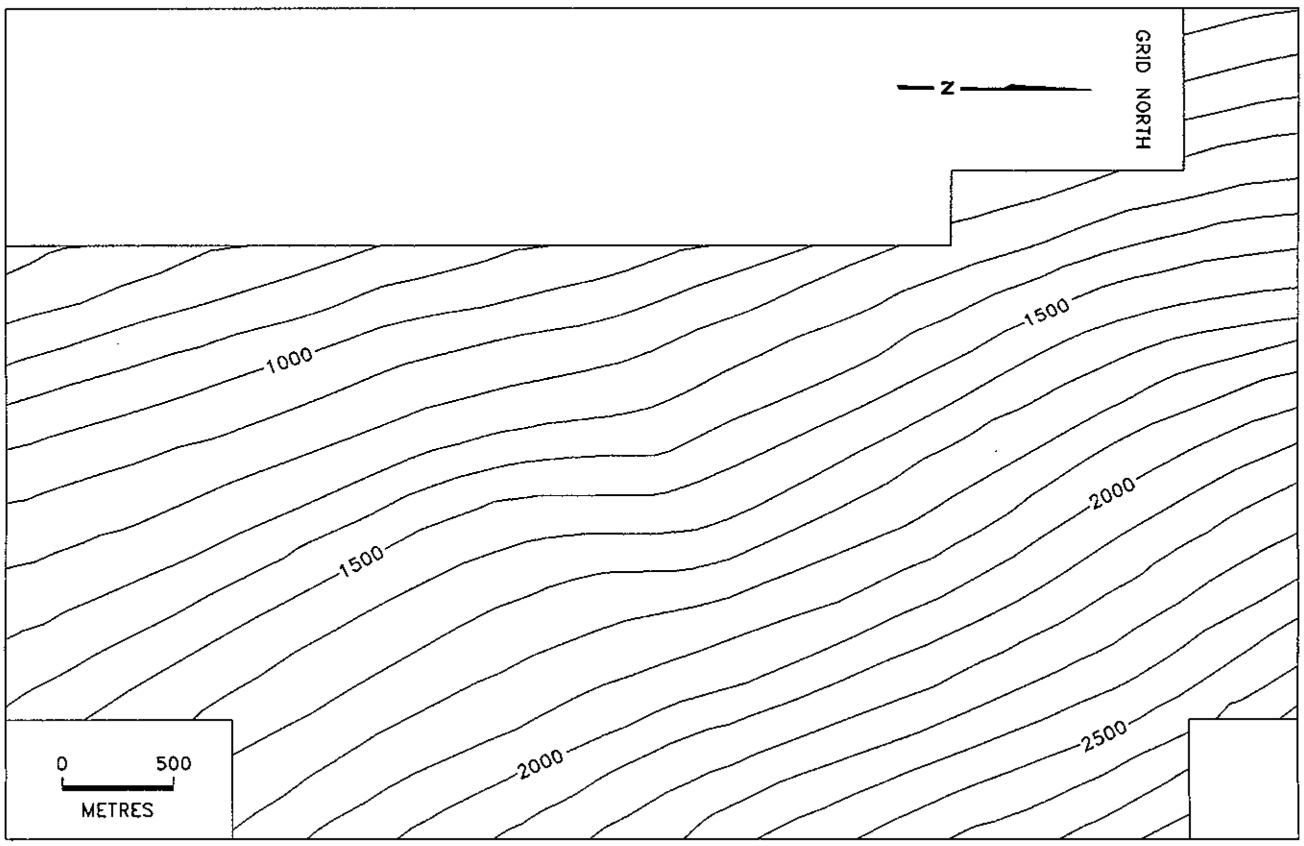


Figure A3-3. Stratum contours on the top of 10-seam on Weary Ridge, based on the 10-seam position grid. Contours in metres.

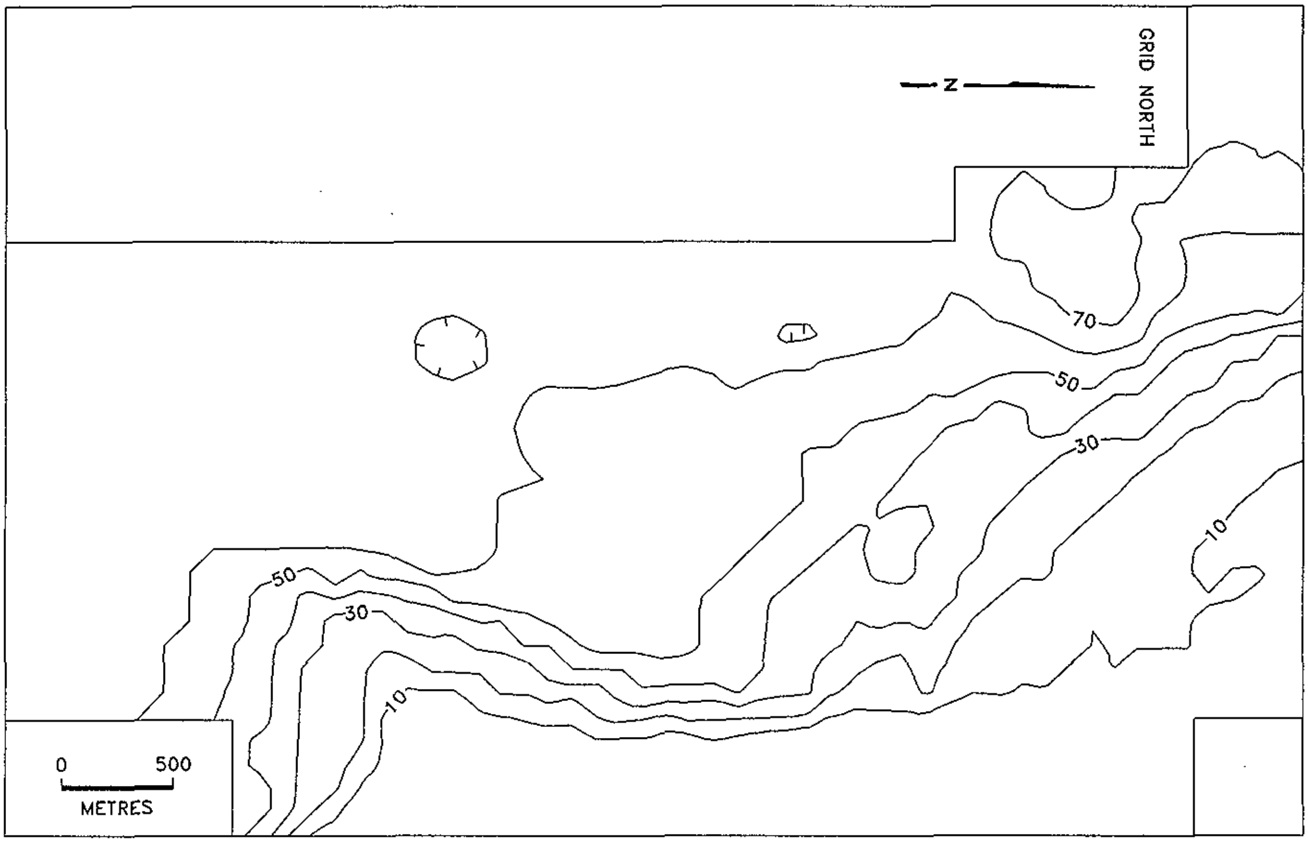


Figure A3-4. Total coal thickness over Weary Ridge, based on summation of all seam thickness grids.

of the same topographic surface, as viewed from the southeast.

Positions of the coal seams within the deposit were calculated relative to the position of 10-seam. This was necessary because very few of the boreholes penetrated the entire stratigraphic sequence. All the other seams were then positioned by adding or subtracting thicknesses to this grid.

Ten-seam was positioned by contouring borehole picks for three seams, 2, 10 and 15. This was necessary because 10-seam itself was not intersected by boreholes in all parts of the model grid. The trends of the contours for the three seams were then combined, and approximate interseam thicknesses maintained, as the 10-seam contours were expanded, by hand, to fill the model area, and then digitized. The 10-seam grid was then smoothed by using the ZGRID subroutine of PLOT88 (copyrighted software). This technique is a combination of Laplacian and spline interpolation (Young and Van Woert, 1989). The resulting stratum contour of the top of 10-seam is shown on Figure A3-3.

The inter-seam thickness and seam-thickness grids were created by using the inverse-distance-squared method, with a large search radius which filled the entire model with values. Given the relative lack of subsurface data, the effect of this was that most grid nodes at large distances from data points received an average value of all the data.

Once the seam-position grids were constructed, they were each trimmed by removing those grid nodes which represent the seam's position above the present topographic surface. These seam "templates" were also used to trim the seam-thickness grids.

Finally, a series of grids containing the distance to the nearest data point from each grid node for each seam was constructed. These grids were used to categorize tonnage values into assurance-of-existence categories.

Assumptions and Analysis

The following assumptions were made with respect to the deposit, to facilitate the model construction:

- All seams modelled are continuous over the entire grid area, unless absent from geophysical logs in specific areas.
- All seams are subparallel to 10-seam.
- There are no major structural complications in the subsurface.
- All tonnage calculations are strictly on an *in situ* basis.
- The coal has constant specific gravity of 1.45.
- Minimum seam thickness considered is 0.6 metre.

Analysis of the model concentrated on the definition of the coal resource and to its potential exploitation. Key calculations in this analysis are:

- the total coal resource;
- resource by assurance-of-existence category;
- the waste-to-coal ratio distributions.

The resource was modelled on the basis of two scenarios. The first encompassed the entire deposit, that is all of the seams in the model. The second was based on only seams 13, 14, 15 and 18 from the top of the Mist Mountain Formation.

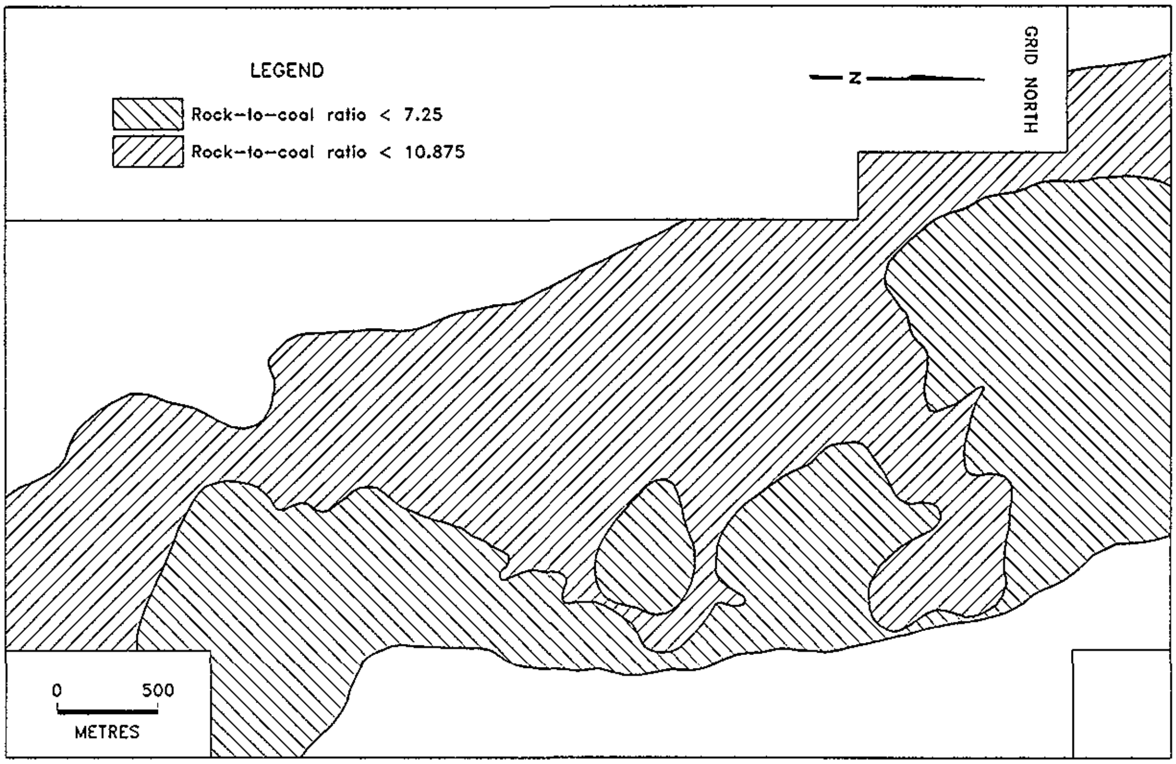


Figure A3-5. Contoured rock-to-coal ratios over the Weary Ridge model area, based on all seams in the model. Cross-hatched areas represent areas with ratios less than 10.875 (equivalent to a ratio of 7.5 bank cubic metres per tonne) and less than 7.25 (equivalent to a ratio of 5.0 bank cubic metres per tonne).

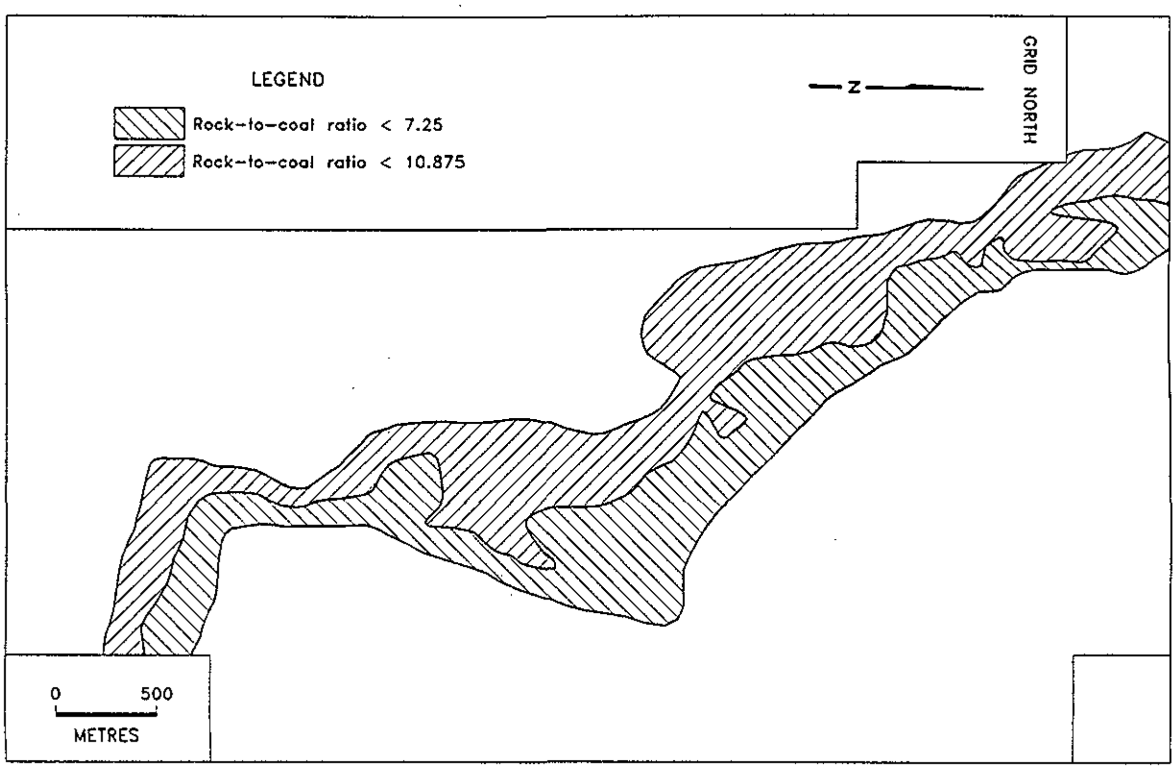


Figure A3-6. Contoured rock-to-coal ratios over the Weary Ridge model area, based on seams 13, 14, 15 and 18. *See* Figure A3-5 for significance of cross-hatching.

The individual seam-thickness grids were plotted to illustrate the various thickness distributions. The total volume of coal in each seam was calculated by multiplying the appropriate thickness grid by 10 000 (100 m by 100 m grid cell) and by 1.45 grams per cubic centimetre (assumed specific gravity of the coal). Placement of these resources into the various assurance categories was achieved by reference to the distance-to-data grids. The resource categories were delineated as follows: measured – less than 450 metres; indicated – 450 to 900 metres; inferred – 900 to 2400 metres; and possible – greater than 2400 metres. These distances are recommended by Hughes *et al.* (1989) for western Canadian coal in areas of moderate structural deformation. The last category, possible resources, was added by us.

Total rock-to-coal ratio was obtained by calculating the total volume (thickness from the base of 2-seam up to topography), and subtracting the sum of the 14 seam-thickness grids from this value. Arbitrary cut-off rock-to-coal ratios of 10.875 and 7.25 were used; these represent ratios of 5.0 and 7.5 bank cubic metres of rock per tonne of coal, using the specific gravity of coal of 1.45. Although not carried out, it is also possible to generate rock-to-coal ratios within each resource category.

RESULTS

Table A3-1 contains the breakdown of the coal resources into the categories of measured, indicated, inferred and possible for each seam. Total coal in all categories is greater than 900 million tonnes. The quantity in the measured category is approximately 250 million tonnes. Roughly 25 per cent of the total resources and 33 per cent of the measured category are contained in seams 13 to 18. Seams 8 and 10 are the most abundant individual seams, each accounting for roughly 10 per cent of the total coal in the deposit.

TABLE A3-1
CALCULATED COAL RESOURCE VALUES FOR THE WEARY RIDGE MODEL.

Seam	Measured (10^6 tonnes)	Indicated (10^6 tonnes)	Inferred (10^6 tonnes)	Possible (10^6 tonnes)	Total (10^6 tonnes)
2	21.3	14.4	22.8	20.5	78.9
3	8.6	5.8	10.4	8.9	33.7
4	18.5	13.5	21.0	18.9	71.8
6	18.3	11.5	19.6	18.3	67.8
7	10.1	6.9	13.3	12.2	42.6
8	25.3	16.3	30.2	29.1	100.9
9	16.9	10.6	18.4	20.1	66.0
10	25.8	17.0	31.2	36.0	110.1
11	9.0	9.7	14.4	15.4	48.5
12	13.1	12.9	21.9	23.2	71.1
13	16.3	15.4	22.8	15.3	69.9
14	12.6	14.0	17.9	0	44.5
15	29.6	18.8	17.0	0	65.4
18	25.7	10.0	2.7	0	38.4
Subtotals (Seams 13-18)	84.1	58.2	60.3	15.3	218.0
Totals	251.1	176.9	263.6	217.9	909.5

(Categories are as defined by Huges *et al.* (1989) for areas of moderate structural deformation.)

TABLE A3-2
TONNAGES OF COAL IN THE WEARY RIDGE MODEL IN AREAS OF LESS THAN 7.5 AND 5.0 BANK CUBIC METRES PER TONNE ROCK-TO-COAL RATIOS

bcm of rock / tonne of coal	tonnes of coal ($\times 10^6$)
Whole Sequence	
<5.0	232.0
<7.5	706.0
Seams 13-18	
<5.0	29.3
<7.5	77.5

Figure A3-4 illustrates the total coal thickness (sum of all seams) over the grid area. Figure A3-5 shows the total rock-to-coal ratio map for the entire model, while Figure A3-6 covers the upper four seams only. Quantities of coal in areas where ratios are less than 7.5:1 and 5.0:1 are summarized in Table A3-2. Over the whole deposit, 700 million tonnes of coal (all categories), or 78 per cent of the total deposit, are predicted to lie in areas where the rock-to-coal ratio is less than 7.5 bank cubic metres per tonne. A total of 232 million tonnes is located in areas where the ratio is less than 5.0:1. Essentially the entire grid encompasses the less than 7.5:1 ratio area (Figure A3-5), while the 5.0:1-and-less ratios occur mainly in two areas, one in the north and the other in the south part of the grid.

The low-ratio occurrences of the upper four seams considered as a separate group (Figure A3-6) occur as relatively thin, north-trending strips. This suggests that the apparent concentration of coal in the upper part of the formation (Figure 7) is not sufficient or widespread enough to produce large potential pit sites, given the thickness of strata above 18-seam and the dip of the beds relative to topography. The presence of coal seams above 18-seam, which were not included in the model, may extend the zone of low-ratio coal in the upper seams to the west. Clearly, however, the entire Mist Mountain Formation section is predicted to be amenable to open-pit mining over most of Weary Ridge, so this is a not a serious limitation.

REFERENCES

Grieve, D.A. and Kilby, W.E. (1990): Geology and Coal Resources of the Dominion Coal Block, Southeastern British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Paper 1989-4.

Hughes, J.D., Klatzel-Mudry, L. and Nikols, D.J. (1989): A Standardized Coal Resource/Reserve Reporting System for Canada; *Geological Survey of Canada,* Paper 88-21, 17 pages.

Kilby, W.E. and McClymont, B. (1985): An Example of Geological Modelling and Data Manipulation with a Microcomputer: Bullmoose Coal Mine, Northeastern British Columbia; *Canadian Institute of Mining and Metallurgy,* Bulletin, Volume 78, pages 37-46.

Young, T.L. and Van Woert, M.L. (1989): PLOT88 Software Library Reference Manual, Third Edition, *Plotworks Inc.,* Ramano, California.

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BULLETIN 82

Figure 5, South Half

GEOLOGY OF THE ELK VALLEY COALFIELD

NTS 82G/10, 15; 82J/2, 6, 7, 10, 11

Geology by D. Grieve

Scale 1:50 000

KILOMETRES 1 0 1 2 3 KILOMETRES

LEGEND

CRETACEOUS
BLAIRMORE GROUP

bl	Lower Blairmore: Presence inferred; no exposures
bc	Cadomin Formation: Conglomerate

JURASSIC AND CRETACEOUS
KOOTENAY GROUP

ke	Elk Formation: Sandstone, siltstone, mudstone, minor coal, conglomerate locally
kmi	Mist Mountain Formation: Siltstone, mudstone, sandstone, coal, conglomerate locally
kmo	Morrissey Formation: Sandstone, locally conglomeratic, minor carbonaceous shale and coal

JURASSIC

f	Fernie Formation: Shale, siltstone, sandstone

TRIASSIC

sr	SPRAY RIVER GROUP: Siltstone, shale, limestone

PENNSYLVANIAN AND PERMIAN

rm	ROCKY MOUNTAIN SUPERGROUP: Quartzitic, calcareous and dolomitic sandstone

MISSISSIPPIAN
RUNDLE GROUP

et	Etherington Formation: Limestone

SYMBOLS

Geological boundary:
defined, approximate, assumed, gradational

Bedding: inclined, vertical, overturned, tops unknown

Thrust fault (teeth in direction of dip):
defined, approximate, assumed

Normal fault (tic indicates downthrow side):
defined, approximate, assumed

Transverse fault (arrows indicate direction of movement):

Syncline (upright, arrow indicates direction of plunge):
defined, approximate, assumed

Syncline (overturned):

Anticline (upright, arrow indicates direction of plunge):
defined, approximate, assumed

Anticline (overturned):

Contours (100 metre interval): 600

Coal mines

High volatile bituminous

Medium volatile bituminous

Low volatile bituminous

$\bar{R}$max on sample from basal coal zone 1.29

Location of measured sections (see list below) 3

Location of drill cores used in this study (see list below) A

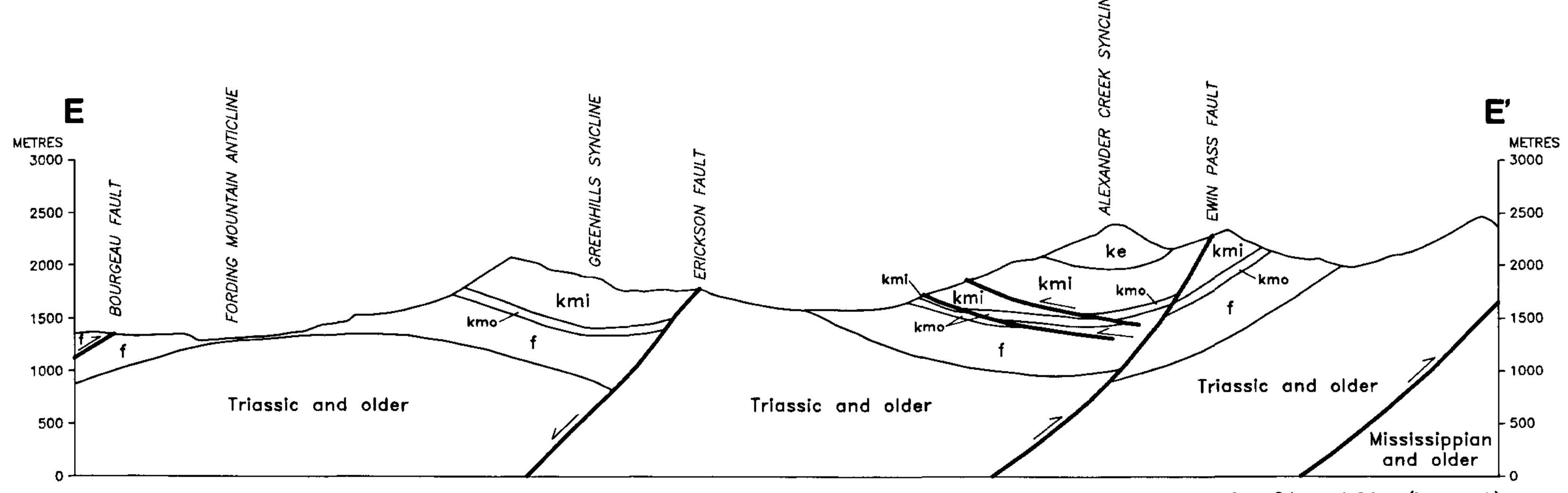
Limit of interpretation

Cross sections A A'

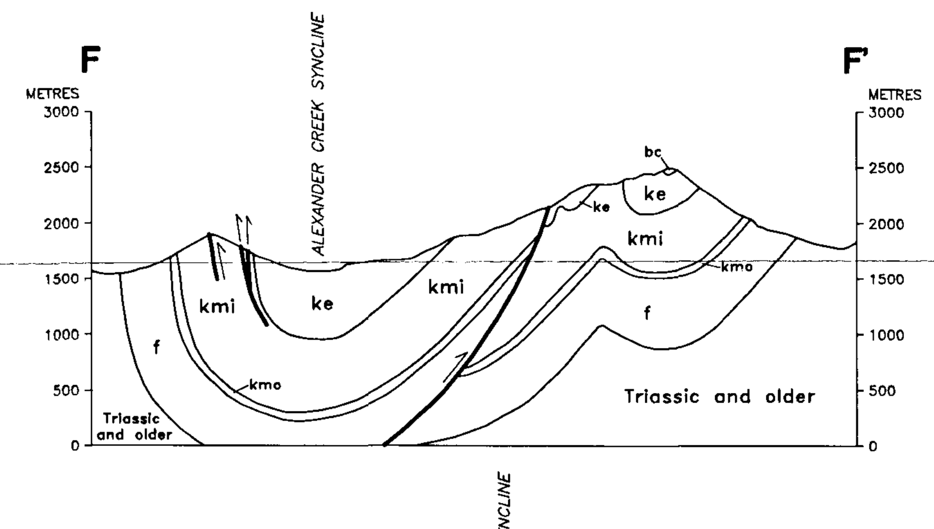
Coal property and/or area names LINE CREEK

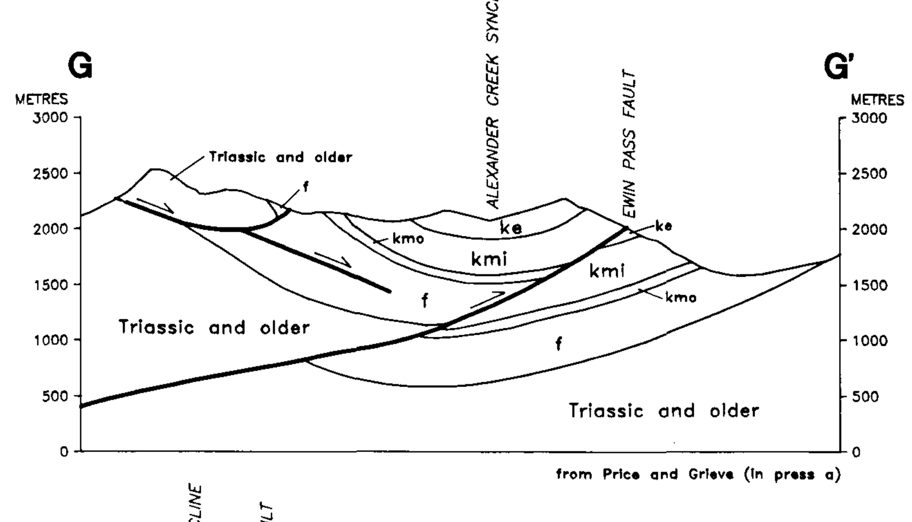
LIST OF MEASURED SECTIONS	RANGE OF $\bar{R}$max
1 Weary Ridge	1.54–1.07
2 Coal Creek	0.88–0.59
3 Mt. Veits	1.49–1.38
4 Mt. Tuxford	1.53–1.02
5 Greenhills Range	1.24–0.71
6 Burnt Ridge Extension	1.47–1.01
7 Imperial Ridge	1.29–1.02
8 Ewin Pass	1.32–1.07
9 Burnt Ridge	1.32–0.99
10 Burnt Ridge South	1.25–0.83
11 Mt. Michael upper sheet	1.17–0.92
12 Mt. Michael lower sheet	1.27–0.95
13 Noname Ridge	1.19–0.92
14 Horseshoe Ridge	1.38–1.14
15 Tee Pee Mountain	1.30–1.18
16 Crown Mountain	1.63–1.29

LIST OF DRILL HOLES	RANGE OF $\bar{R}$max
A MBE-101 (Mt. Banner)	1.42–1.34
B EP-102 (Ewin Pass)	1.31–1.17
C EP-105 (Ewin Pass)	1.26–0.95
D EV-151 (Ewin Creek)	1.46–1.11
E EV-150 (Ewin Creek)	1.43–1.24
F BM81-1 (Bare Mtn.)	1.47–1.05
G BM81-2 (Bare Mtn.)	1.50–1.14
H SR-7 (Weary Ridge)	1.13–0.98
I SR-12 (Weary Ridge)	1.45–1.27
J SR-2 (Weary Ridge)	1.52–1.41
K BRE-3 (Burnt Ridge Extension)	1.50–1.14

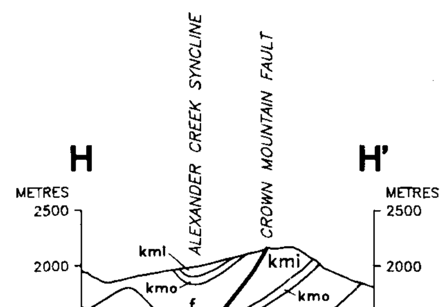


from Price and Grieve (in press b)





from Price and Grieve (in press a)



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BULLETIN 82

Figure 5, North Half

GEOLOGY OF THE ELK VALLEY COALFIELD

NTS 82G/10, 15; 82J/2, 6, 7, 10, 11

Geology by D. Grieve

Scale 1:50 000

LEGEND

CRETACEOUS
BLAIRMORE GROUP

- bl — Lower Blairmore: Presence inferred; no exposures
- bc — Cadomin Formation: Conglomerate

JURASSIC AND CRETACEOUS
KOOTENAY GROUP

- ke — Elk Formation: Sandstone, siltstone, mudstone, minor coal, conglomerate locally
- kml — Mist Mountain Formation: Siltstone, mudstone, sandstone, coal, conglomerate locally
- kmo — Morrissey Formation: Sandstone, locally conglomeratic, minor carbonaceous shale and coal

JURASSIC

- f — Fernie Formation: Shale, siltstone, sandstone

TRIASSIC

- sr — SPRAY RIVER GROUP: Siltstone, shale, limestone

PENNSYLVANIAN AND PERMIAN

- rm — ROCKY MOUNTAIN SUPERGROUP: Quartzitic, calcareous and dolomitic sandstone

MISSISSIPPIAN
RUNDLE GROUP

- et — Etherington Formation: Limestone

SYMBOLS

Geological boundary: defined, approximate, assumed, gradational

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Transverse fault (arrows indicate direction of movement):

Syncline (upright, arrow indicates direction of plunge): defined, approximate, assumed

Syncline (overturned):

Anticline (upright, arrow indicates direction of plunge): defined, approximate, assumed

Anticline (overturned):

Contours (100 metre interval): 600

Coal mines

High volatile bituminous

Medium volatile bituminous

Low volatile bituminous

$\bar{R}max$ on sample from basal coal zone: 1.29

Location of measured sections (see list below): 3

Location of drill cores used in this study (see list below): A

Limit of interpretation

Cross sections: A A'

Coal property and/or area names: LINE CREEK

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E EV-150 (Ewin Creek)	1.43–1.24
F BM81-1 (Bare Mtn.)	1.47–1.05
G BM81-2 (Bare Mtn.)	1.50–1.14
H SR-7 (Weary Ridge)	1.13–0.98
I SR-12 (Weary Ridge)	1.45–1.27
J SR-2 (Weary Ridge)	1.52–1.41
K BRE-3 (Burnt Ridge Extension)	1.50–1.14

2

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Figure 7

GENERALIZED MEASURED STRATIGRAPHIC SECTIONS OF THE MIST MOUNTAIN FORMATION IN THE ELK VALLEY COALFIELD

Sections 14 and 15 by J. Fraser
Sections 3 and 4 by R. Morris
All others by D. Grieve

LEGEND

Covered interval
Predominantly coal
Interbedded coal and shale
Predominantly siltstone or finer
Interbedded sandstone and siltstone
Predominantly sandstone

SYMBOLS

Sample number, seam designation.......(2–8)[7 or H]
Vitrinite content/semifusinite content, mean maximum vitrinite reflectance ($\overline{R}_o max$).......(75.5/15.7) 0.88
Grab sample.......*
Mist Mountain Formation/Morrissey Formation contact.... — — —
Position of the contact between the Elk Formation and Mist Mountain Formations.......◄

Cartography by P. Chicorelli

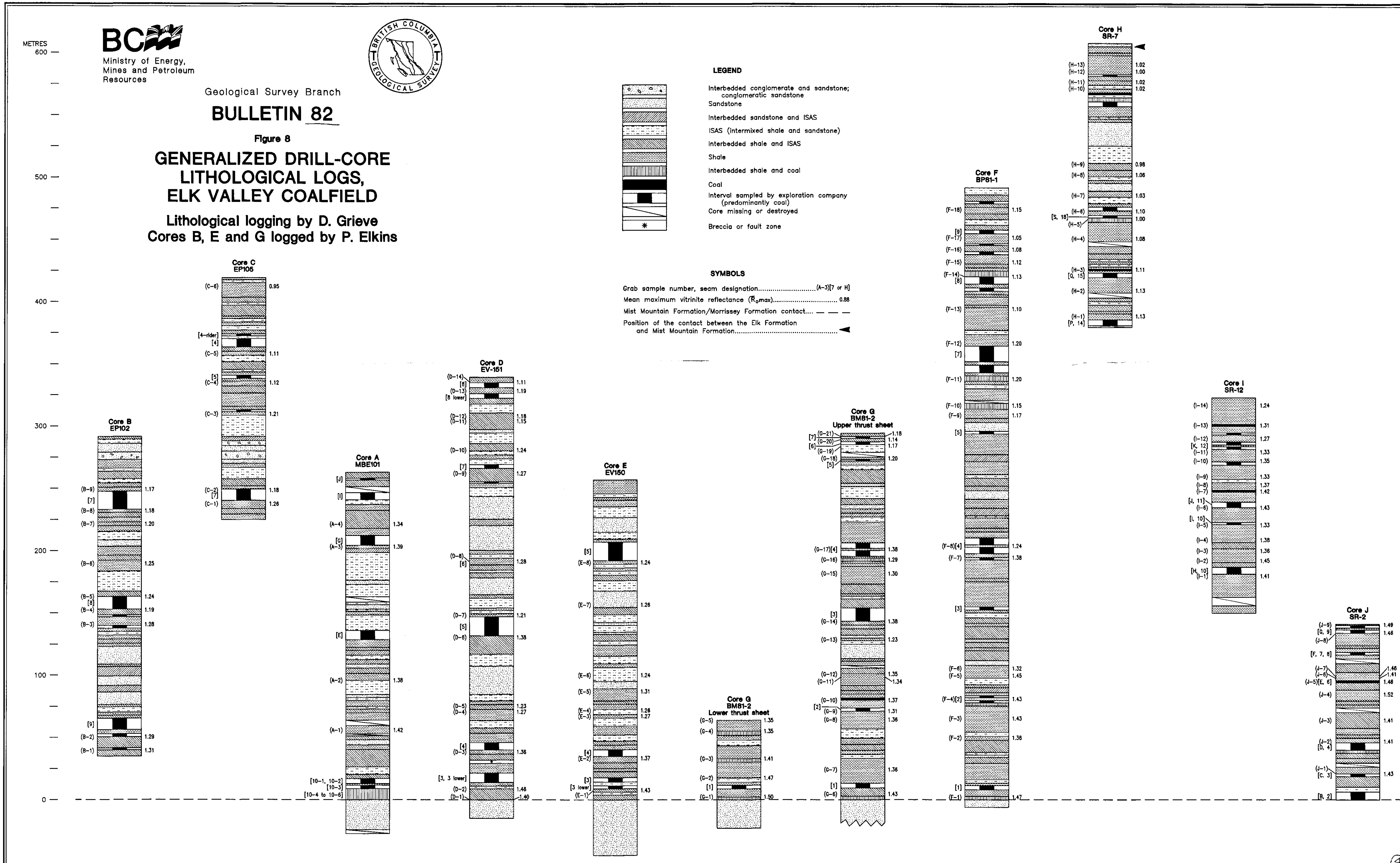

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Figure 8

GENERALIZED DRILL-CORE LITHOLOGICAL LOGS, ELK VALLEY COALFIELD

Lithological logging by D. Grieve
Cores B, E and G logged by P. Elkins

Cartography by P. Chicorelli