Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources
Hon. Jack Davis, Minister

MINERAL RESOURCES DIVISION
Geological Survey Branch

GEOLOGY AND COAL RESOURCES OF THE DOMINION COAL BLOCK, SOUTHEASTERN BRITISH COLUMBIA

By D.A. Grieve
W.F. Kilby

PAPER 1989 - 4

MINERAL RESOURCES DIVISION
Geological Survey Branch

Canadian Cataloguing in Publication Data
Grieve, David Austin, 1952-
Geology and coal resources of the Dominion Coal Block, southeastern British Columbia

(Paper, ISSN 0226-9430 ; 1989-04)

Includes bibliographical references.
ISBN 0-7718-8895-3

1. Coal - Geology - British Columbia - East Kootenay. 2. Geology, Economic - British Columbia - East Kootenay. I. Kilby, Ward E., 1954- II. British Columbia. Geological Survey Branch. III. Title. IV. Series: Paper (British Columbia. Ministry of Energy, Mines and Petroleum Resources) ; 1989-04.

TN806.C32B72 1989 553.2'4'0971165 C89-092278-0

VICTORIA
BRITISH COLUMBIA
CANADA
March 1990

ABSTRACT

The objectives of this paper are to summarize available geological and coal quality information concerning the Dominion Coal Block, and to present newly developed computer models of the geology of the Coal Block, along with resource calculations derived from the models.

The coal-bearing Mist Mountain Formation of the Jurassic-Cretaceous Kootenay Group crops out in three general areas within the Dominion Coal Block: i) the western half of Parcel 73 on the north end of Hosmer Ridge and the south end of Sparwood Ridge; ii) the southwestern edge of Parcel 82 on Flathead Ridge; iii) the northeastern part of Parcel 82 in the vicinity of Mount Taylor.

Potentially economic coal occurrences in Parcel 73 are in the hangingwall of the Lookout thrust fault. Rocks in this structural block are essentially monoclinal, with a mean bedding orientation of $182^{\circ}/13.5^{\circ}$ (dip-direction/dip). Seven seams are found within a stratigraphic section between 475 and 500 metres in thickness. The major seam, 9-seam or Lookout seam, is near the base of the section, and has a combined thickness of 19 metres in three separate benches. Coals are medium to high-volatile bituminous in rank, and for a given stratigraphic position are somewhat lower in rank than those in the surrounding areas. The deposit contains *in situ* resources of 76 million tonnes at an overall waste-to-coal ratio of 4.7:1 bank cubic metres per tonne. Open pit mining of Parcel 73 appears to be feasible.

Coal occurrences on Flathead Ridge in Parcel 82 are on the west limb of the McEvoy syncline. The structure of the upper part of the Mist Mountain Formation, the only portion of the section modelled here, is monoclinal, with an average bedding orientation of $040^{\circ}/20^{\circ}$. Ten seams occur within a section approximately 400 metres in thickness. A and B-seams, at the top of the Mist Mountain Formation, were the focus of most exploration efforts and of our model. Coals on Flathead Ridge are medium and low-volatile bituminous in rank, and this area in general contains coals of higher rank for a given stratigraphic position than any other part of southeastern British Columbia. Both A and B-seams contain, for the most part, very high quality medium to low-volatile coking coal. Seams lower in the section are of lower quality, including some which have only thermal potential. The deposit, consisting of A and B-seams and their associated riders, contains 230 million tonnes of *in situ* coal, 17.5 million tonnes of which falls into the measured category. Underground mining is probably the only feasible approach to exploiting the bulk of this resource.

Coal occurrences on Mount Taylor in Parcel 82 are affected by complex structural geology, including north-trending folds and low-angle normal faults. The 400-metre thick stratigraphic section contains 10 coal seams, the thickest of which, U2-seam, ranges from 5.5 to 11 metres. Coal rank varies from medium to high-volatile bituminous, with one small zone of low-volatile rank. The deposit model, which is based on the five thickest seams, predicts *in situ* coal resources of 613 million tonnes, and identifies no sites with significant open pit mine potential.

INTRODUCTION

BACKGROUND AND CURRENT STATUS

The federally-owned Dominion Coal Block consists of two separate parcels of land totaling 20 235 hectares in area, in the East Kootenay coalfields of southeastern British Columbia (Figures 1 and 2). The block was initially part of the Canadian Pacific Railway's construction land grant acquired from the British Columbia government in 1905 under the terms of the Crows Nest Pass Act of 1897. The specific land areas were selected by the Director of the Geological Survey of Canada, based on reconnaissance surveys by government geologists (McEvoy, 1901; Leach, 1902).

The rationale for creating the block was to secure a supply of coal to the public at a price not exceeding $2Cdn per short ton. This proviso was eliminated in 1983 when the Western Grain Transportation Act (Bill C-155) was enacted to replace the Crows Nest Pass Act. This removed an anachronistic obstacle to development of the block, leaving only the issue of jurisdiction to be settled between the Canadian and British Columbia governments. Recent signs of cooperation between the two levels of government suggest that a mechanism may soon be found to issue coal rights for exploration and development in the block to the private sector.

LOCATION AND PHYSIOGRAPHY

Crowsnest coalfield, which contains the Dominion Coal Block, is one of three separate East Kootenay coalfields. It lies in the general vicinity of the Crowsnest Pass and the towns of Fernie and Sparwood (Figure 1). Currently operating surface mines in the coalfield are located near Sparwood on Harmer and Natal ridges (Westar Mining Ltd.'s Balmer Operations) and at Coal Mountain near Corbin (Byron Creek Collieries). In the past, underground mines were operated at Michel, Hosmer, Coal Creek, Morrissey and Corbin (Figure 2).

Parcel 73, with an area of 2023.5 hectares, is the smaller and more northerly of the two parcels (Figure 2). It is roughly rectangular with approximate dimensions of 6 by 3.5 kilometres. It lies between the valleys of the Elk River and Michel Creek, and includes the south end of Sparwood Ridge and the north end of Hosmer Ridge (Figure 3). Elevations range from 1325 metres in the extreme southwest corner, to 2260 metres at the Natal forestry lookout. The steep west-facing slopes of Sparwood and Hosmer Ridges in the western third give way to a more subdued topography with a general eastern exposure over the remainder of the parcel. Parcel 73 is accessible by four-wheel-drive vehicle from Highway 3 and from the Byron Creek Collieries access road along Michel Creek.

Parcel 73 is completely surrounded by District Lot 4589, and borders freehold land where coal rights are held by Westar Mining Ltd. (Figure 2). It lies immediately north of Westar's proposed Hosmer-Wheeler project, which was dormant at press time (March 1990).

The southern parcel, 82, comprises an area of 182 11.5 hectares. It extends roughly 28 kilometres in a southwest to northeast direction, and is 8 kilometres across at its widest point (Figure 2). It straddles an area between the Elk River and Lodgepole Creek valleys in the southwest and the Michel Creek valley in the northeast, and is cut by the valleys of Leach Creek and Flathead River (Figures 4 and 5). It is partly bounded by Morrissey Creek on the southwest. In general the highest elevations and strongest relief occur at the extreme southwest and northeast ends of the parcel. Flathead Ridge, in the southwest, has a maximum elevation in the Coal Block of 2225 metres, while Michel Ridge, in the northeast, reaches an elevation of 2290 metres. Mount Taylor, at the north end of Michel Ridge is 2250 metres high. The intervening area, including the northeast-facing slope of Flathead Ridge, has moderate relief, and only locally exceeds 2000 metres in elevation.

Access to Parcel 82 is generally difficult. Secondary roads branch off the Lodgepole forestry road in the Flathead Ridge area and the Byron Creek Collieries road near Mount Taylor area (Figures 4 and 5). With the exception of the Morrissey Creek road, however, most of these are not maintained and are only passable, if at all, by four-wheel-drive vehicle. Parcel 82 is traversed by a buried natural gas pipeline.

Parcel 82 also lies within District Lot 4589. Along its northwestern boundary it borders freehold land where coal rights are held by Crows Nest Resources Ltd., and along its eastern and southeastern boundaries it is bounded by freehold land with coal rights held by Westar Mining Ltd., and Crown land, part of which is covered by coal licences also belonging to Westar Mining (Figure 2).

PREVIOUS WORK

British Columbia coal licences covering the Dominion Coal Block were granted beginning in 1964 and were revoked, at the request of the Canadian govern-

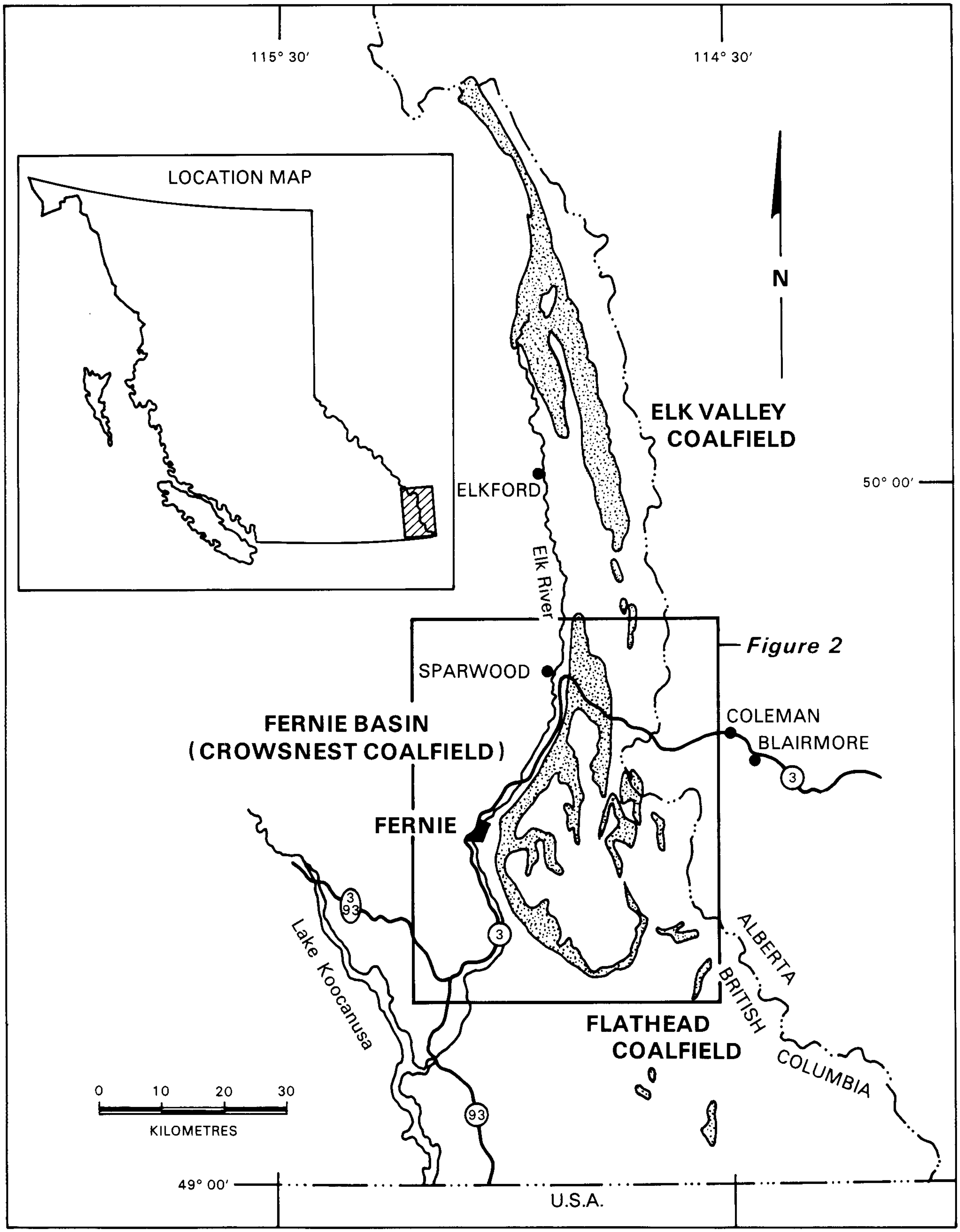


Figure 1. Location of the East Kootenay coalfields.

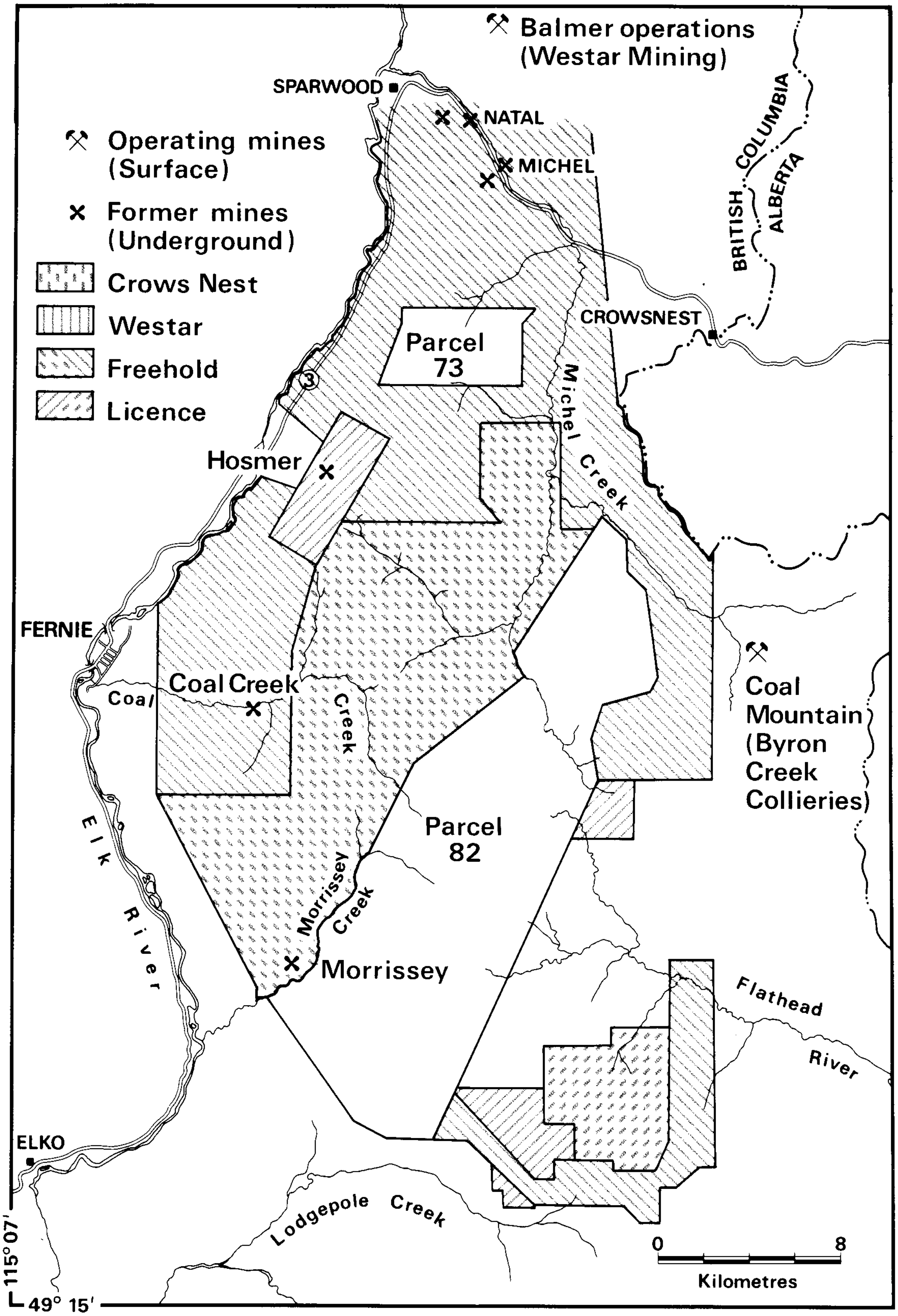


Figure 2. Coal tenure map of Crowsnest coalfield showing location of the Dominion Coal Block and current and former mines in the vicinity.

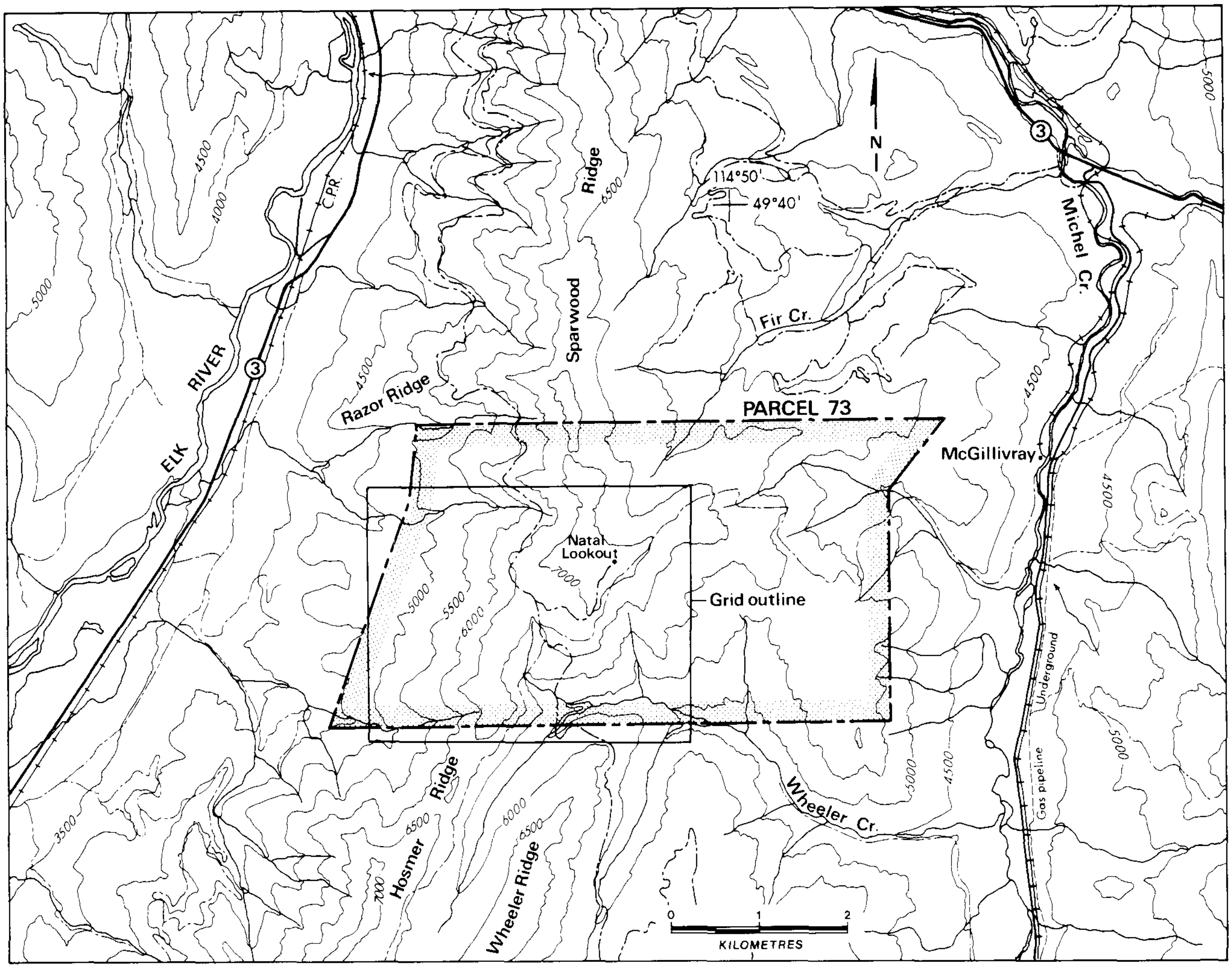


Figure 3. Topography of Parcel 73, Dominion Coal Block, with outline of model grid superimposed.

ment, in 1972. Licences were concentrated in three general areas (Figures 6 and 7): licences in Parcel 73 were first held by Crows Nest Industries Ltd. and later sold to Kaiser Resources Ltd. (now Westar Mining Ltd.); licences covering the Flathead Ridge portion of Parcel 82 were held by Pacific Coal Ltd.; and licences covering the Mount Taylor portion were held by the Fernie Coal Mine Co. Ltd.

Exploration on Parcel 73 was carried out between 1969 and 1971 by Kaiser Resources, and included geological mapping, eight rotary-drill holes, twelve adits and two test pits. Only a small portion of the results of this work, specifically the results of analyses on adit bulk samples, are on file with the British Columbia government (Anonymous, 1974). It is certain, however, that the company was not assessing Parcel 73 in isolation, but rather as an integral part of a larger planned mining area, including the area immediately to the south, the Hosmer-Wheeler proposal (Latour, 1970).

The Pacific Coal property on Flathead Ridge in Parcel 82 was referred to as the "Fernie Coal mine". Pacific Coal was funded by Japanese interests; their objective was to establish reserves of low-volatile coking coal for the Japanese steel industry. The first year of exploration, 1964, was supervised by consultant D.D. Campbell and focused on the Morrissey valley. Ten diamond-drill holes were completed, totalling approximately 1675 metres. This program apparently continued into 1965 with the drilling of two additional holes totalling 300 metres. These results are not on file with the British Columbia government. Subsequent work, beginning in 1965, was carried out by Nittetsu Mining Consultants Co. Ltd. (Nakayama *et al.*, 1966). Adits were driven for bulk samples in two of the lower seams along Morrissey Creek (Figure 4), and surface mapping was carried out along Flathead Ridge. Exploration in 1966 and 1967 was concentrated on A and B-seams on Flathead Ridge (Harada *et al.*, 1967, 1968). Work was done by Nittetsu Mining Co. Ltd. and Toyo Menka Kaisha Ltd. Seven drill holes were cored for a total of 1599 metres, nine adits were driven in A and B-seams (Figure 4 for locations), and more than 29 kilometres of new road were built; most roads were along the traces of A and B-seams. Detailed mapping, supplemented by trenching, was carried out over the entire property. Drill-core and bulk samples were provided to several Japanese steel com-

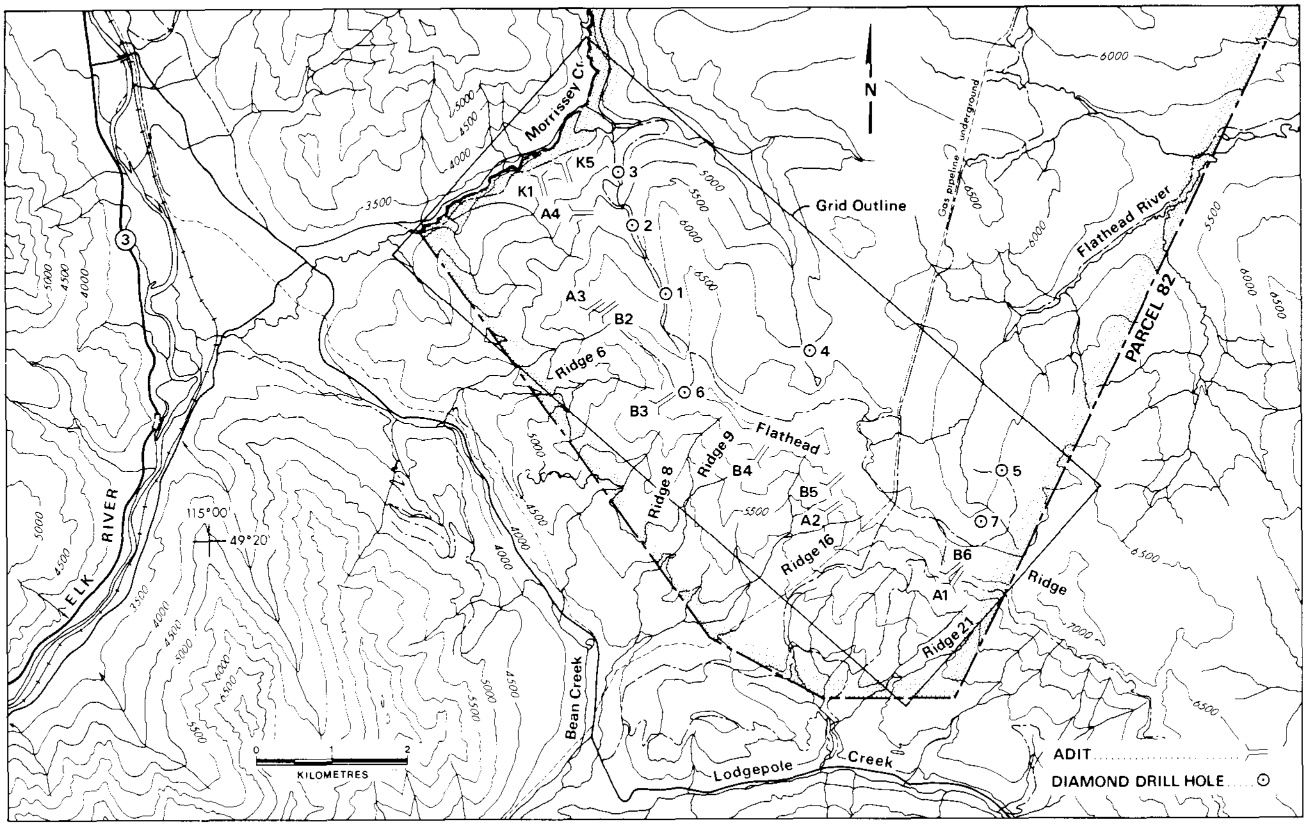


Figure 4. Topography of Flathead Ridge in Parcel 82, Dominion Coal Block, with outline of model grid superimposed, and exploration adit and drillhole sites located.

panies for testing of washability and coking potential. A feasibility study (Shiokawa, 1968) stated that the coal was economically mineable and equal in quality to other western Canadian coking coals entering Japan at the time. Shortly afterward, however, the operators withdrew from the project, and Mitsui Mining Co. Ltd. obtained permission from Pacific Coal to further evaluate the property. A geological survey was completed in 1969 (Aihara, 1970) in which a few differences in structural interpretation and seam correlation were noted. Further exploration was proposed but never carried out.

The Fernie Coal Mine Co. Ltd. property in the Mount Taylor area of Parcel 82 was also referred to as the "Fernie Coal mine". Like Pacific Coal, this company was funded by Japanese interests hoping to prove up economic reserves of coking coal. The property was operated by Marubeni-Iida Co. Ltd. Exploration was carried out in 1966 and 1967 (Ohtaki, 1967) but never advanced beyond the preliminary phase. One adit was driven in each year and other work included bulldozer and hand-trenching, road-building and geological mapping.

Federal government surveys of the Dominion Coal Block date to the initial selection of the boundaries of the block (McEvoy, 1901; Leach, 1902). More recent Geological Survey of Canada mapping encompassing the Block includes the Fernie East-half map area (Price, 1962). Mapping specific to the Block was undertaken in 1970 (Latour, 1970) and between 1975 and 1979 (Ollerenshaw, 1977, 1981b). The Geological Survey Branch of the British Columbia Ministry of Energy, Mines and Petroleum Resources carried out detailed mapping studies of Parcel 73 in conjunction with the Geological Survey of Canada in 1976 (Ollerenshaw *et al.*, 1977), and independent studies of Parcel 82 in 1977 and 1978 (Gigliotti and Pearson, 1979; Pearson and Grieve, 1981). Petrographic coal rank and composition of coal samples from the block and surrounding areas were also determined (Pearson and Grieve, 1985).

OBJECTIVES OF THE STUDY

The objectives of the current study are: to construct digital deposit models of the three areas in the Block where coal is exposed at surface, namely the western part of Parcel 73 and the Flathead Ridge and Mount Taylor portions of Parcel 82, utilizing existing data supplemented by minor field work; to use the models to calculate coal resource values for those areas; and to summarize known stratigraphic, structural, coal quality and mineability information for the same areas.

In all cases we have been selective in choosing stratigraphic intervals and structural blocks on which to

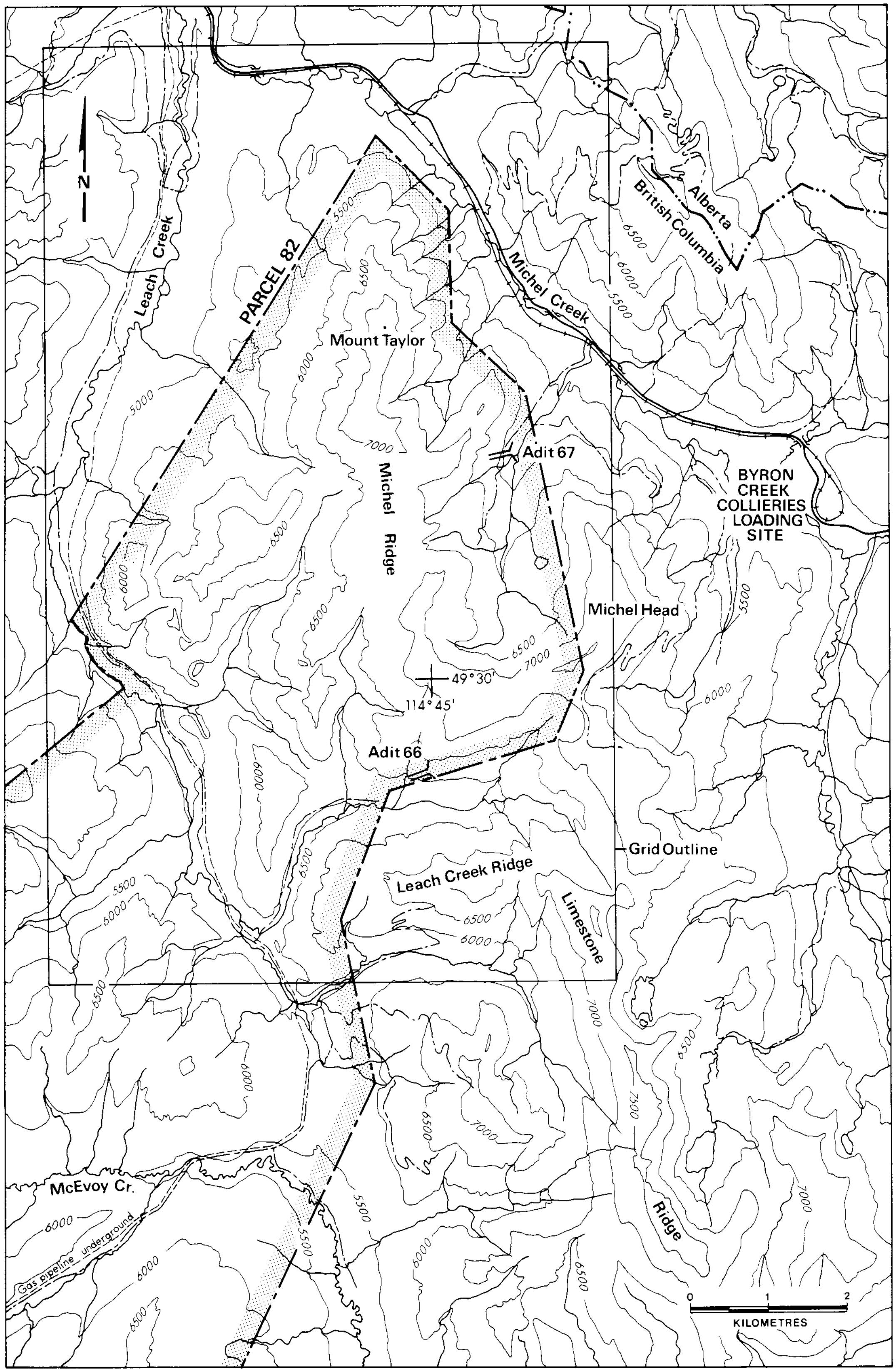


Figure 5. Topography of Mount Taylor in Parcel 82, Dominion Coal Block, with outline of model grid superimposed, and exploration adit sites located.

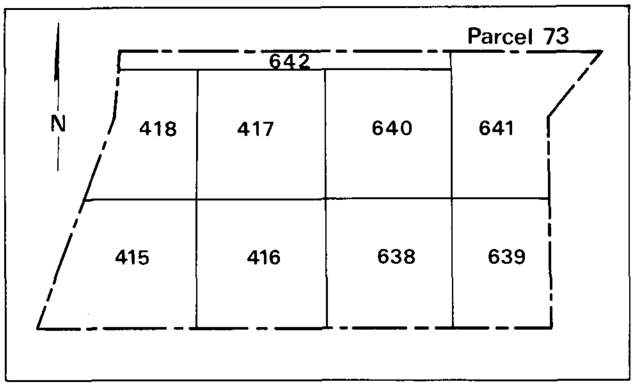


Figure 6. Former coal licences in Parcel 73.

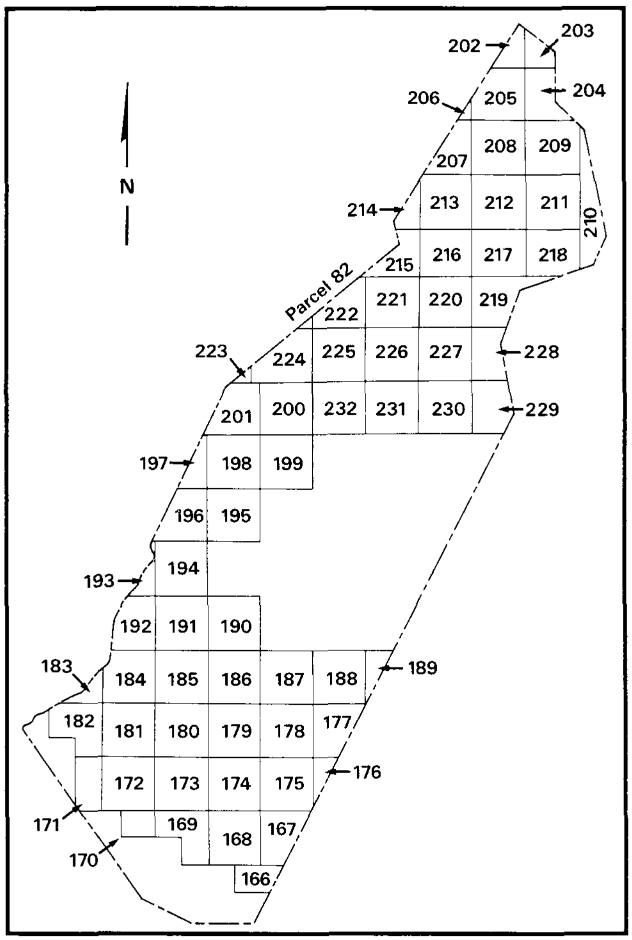


Figure 7. Former coal licences in Parcel 82.

focus. This was in large part forced on us by the limited scope of much of the reference material available.

The constructed models are supplied in digital form (Appendix 2, diskette) and programs are provided to allow the reader to perform additional calculations on the three deposit models. Appendix 1 contains a brief description of the digital models, analysis programs and their usage.

REGIONAL GEOLOGICAL SETTING

STRUCTURE

The East Kootenay coalfields lie in the Front Ranges of the Rocky Mountains. The Front Ranges at this latitude are characterized by north to northwest-trending concentric folds and west-dipping thrust faults, associated with the Laramide orogeny. Tertiary post-Laramide normal faults, some of which are listric and probably occupy earlier thrust surfaces, are also a major feature.

The Crowsnest coalfield, which contains the Dominion Coal Block, is formed by the Fernie basin, a complex synclinorium in the Lewis thrust sheet. The major compressional features of the basin are a series of synclines, the most notable being the McEvoy syncline, linked en echelon by low-amplitude anticlines (Price, 1962). A series of west-dipping thrust faults, including the Dominion and Lookout faults, dominate the structure of the north half of the basin (Figure 8). The major extensional feature of the Fernie Basin is the Flathead fault system. The Flathead fault enters the Basin in the southeast, where it has a northwest strike, cuts through the coalfield as its strike tends more northerly, and actually

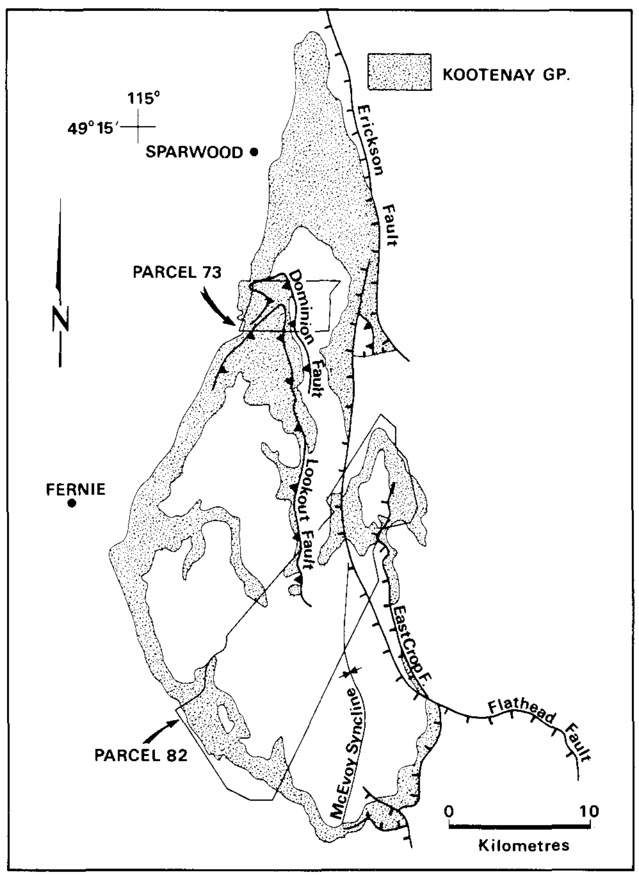


Figure 8. Generalized geology of the Crowsnest coalfield (modified after Price, 1962).

forms the eastern boundary of the northern part of the coalfield. The East Crop normal fault is responsible for thinning the Kootenay Group over much of the eastern edge of the coalfield.

STRATIGRAPHY

The Dominion Coal Block is underlain by a succession of Mesozoic sedimentary rocks including the coal-bearing Mist Mountain Formation of the Kootenay Group. Brief descriptions of all units are given here. Only the Mist Mountain Formation will be discussed under the heading of each of the modeled areas.

FERNIE FORMATION (JURASSIC)

With the exception of two very small occurrences of the Triassic Spray River Group within Parcel 82, the marine Fernie Formation is the oldest stratigraphic unit in the block. It is primarily a recessive unit, in contrast to the overlying Kootenay Group. Its base is marked by a thin band of phosphorite and phosphatic shale, which gives way to dark gray shale, overlain by the Rock Creek member, which is composed of brownish silty shale with thin black limestone beds. The overlying Grey Beds consist of medium brownish grey shale with interbeds of calcareous sandstone and impure limestone (Price, 1962). A glauconitic sandstone or shale unit (Green Beds) immediately underlies the uppermost unit, the Passage Beds, which is a coarsening-upward sequence of interbedded shale and sandstone transitional to the Morrissey Formation of the overlying Kootenay Group.

KOOTENAY GROUP (LATE JURASSIC TO EARLY CRETACEOUS)

The base of the Kootenay Group is marked by the Morrissey Formation (formerly the Basal Sandstone member), which is resistant and easily mapped in most areas of its occurrence. It averages 40 metres in thickness in the study area, and consists of two members (Gibson, 1985). The lower Weary Ridge member is predominantly a fine-grained, quartzose, argillaceous, calcareous and ferruginous sandstone. The upper Moose Mountain member is the more resistant and consists predominantly of medium-grained quartz-chert sandstone. Thin interbeds of carbonaceous shale and coal occur locally within the Moose Mountain member.

The economically important Mist Mountain Formation (formerly the Coal-bearing member) conformably overlies the Morrissey Formation. It is moderately recessive to moderately resistant depending on the proportion of resistant sandstone or conglomerate beds it contains. It averages 500 metres in thickness in the Crowsnest coalfield; generalized sections of Mist Mountain Formation from different parts of the study area are shown in Figures 18, 23 and 29. Mist Mountain Formation in the Crowsnest coalfield consists of an interbedded sequence of siltstone, sandstone, mudstone, shale, coal and conglomerate of predominantly nonmarine origin. Correlation of individual units is made difficult by lateral facies changes over relatively short distances. Coals in the Mist Mountain Formation are almost exclusively humic. Original banding has often been destroyed by shearing associated with Laramide deformation. They form an average of 10 per cent of the total thickness of the formation in seams which range from less than one to greater than 15 metres in thickness. Coal seams do not tend to cluster in any part of the stratigraphic section, and the only horizon which is consistently coal-bearing is the basal 20 to 25 metres of the formation or "basal coal zone". Fine-grained clastic rocks tend to be dark grey because of their carbonaceous content, while the sandstones, which contain grains of quartz, chert and quartzite (Gibson, 1985), tend to be somewhat lighter in colour.

The Elk Formation (formerly the Elk member), which gradationally overlies the Mist Mountain Formation, is the uppermost formation in the Kootenay Group. It is a relatively resistant nonmarine unit dominated by coarse clastic rocks and in the Crowsnest coalfield it varies in thickness from a maximum of 482 metres on Sparwood Ridge (Gibson, 1985) to 155 metres near McLatchie Creek (Grieve and Ollerenshaw, 1989). Thicknesses of 327.0 metres (Grieve and Ollerenshaw, 1989) and 253.5 metres (Gibson, 1985) have been recorded at Flathead Ridge and Mount Taylor, respectively. In general it decreases in thickness from west to east. It is composed of sandstone, siltstone, mudstone, shale, coal and, locally, conglomerate. Sandstone units tend to be more numerous and laterally continuous than those in the Mist Mountain Formation. Conglomerates are associated with sandstone units, and achieve their greatest concentration and thickness within the thickest sections, that is, at the western edge of the coalfield. Siltstones are generally similar to those in the Mist Mountain Formation, with the exception of the light grey weathering, well-indurated "needle siltstones" (Gibson, 1977). Coal occurs in laterally discontinuous seams generally less than one metre thick, and is of both humic and sapropelic types. The sapropelic coals are thin (less than 0.6 metre) and include the so-called "needle coals" of uncertain origin (Snowdon *et al.*, 1986).

BLAIRMORE GROUP (EARLY CRETACEOUS)

The Kootenay-Blairmore contact occurs at the base of the Cadomin Formation, the basal unit of the nonmarine Blairmore Group. In the Crowsnest coalfield this contact is abrupt and scoured, but may be conformable, at least in the western part of the coalfield (Gibson, 1979; Ricketts and Sweet, 1985). The Cadomin Formation in the Crowsnest coalfield consists of one or more thick cliff-forming chert-pebble to cobble conglomerate beds separated by recessive greenish and maroon mudstone units with a locally developed thin bed of light grey, nodular-weathering micrite. For example, Ollerenshaw

(1981a) described a 75.5-metre section of Cadomin Formation on Flathead Ridge containing four conglomeratic units, including a basal conglomerate unit 15 metres thick. The Cadomin Formation is gradationally overlain by the Lower Blairmore, which in the Crowsnest coalfield is a 455 metre thick recessive sequence of greenish grey, grey and maroon mudstone, with interbedded siltstone, cherty sandstone, conglomerate and minor limestone (Ollerenshaw, 1981a).

The conformably overlying Beaver Mines-Mill Creek Formation in the Crowsnest coalfield is a sequence of greenish grey and maroon mudstone, sandstone and conglomerate 1875 metres thick. Some of the sandstones contain feldspar and some of the conglomerates contain igneous pebbles (Ollerenshaw, *op. cit.*).

ALBERTA GROUP (LATE CRETACEOUS)

Unconformably overlying the Blairmore in the core of the McEvoy syncline are two marine shales (Blackstone and Wapiabi formations) separated by nonmarine(?) sandstone and shale (Cardium Formation) of the Alberta Group.

COAL PETROGRAPHY

Samples of coals from the Crowsnest coalfield were collected during British Columbia Ministry of Energy, Mines and Petroleum Resources surveys (*see* Previous Work), and were analyzed petrographically.

RANK

Mist Mountain Formation coals range from low-volatile to high-volatile A bituminous in rank. Reflectance values ($\bar{R}_o max$) on the basal coal zone range from 1.00 per cent on Razor Ridge, immediately north of Parcel 73, to 1.85 per cent near Morrissey Creek inside Parcel 82 (Figure 9). A "typical" value in Crowsnest coalfield for this particular horizon is 1.3 to 1.4 per cent; variations are related to structural position as well as regional rank variations. Seams higher in the section have progressively lower ranks (Hilt's law), with the vertical rank gradient varying locally. Reflectance values on seams from the uppermost Mist Mountain Formation range from 0.85 per cent to greater than 1.5 per cent (Pearson and Grieve, 1985) although values are generally in the high-volatile range ($\bar{R}_o max < 1.12\%$).

A significant portion of the coalification in Crowsnest coalfield was bracketed between the compressional and extensional structural phases (Pearson and Grieve, 1985). As alluded to above, this has resulted in several distinctive rank distribution patterns. For example, rank increases down-dip on individual seams. Moreover, there is no discernible rank discontinuity across some thrust faults, including the Dominion thrust, but there is a very marked gap in rank values across large normal faults such as the East Crop fault.

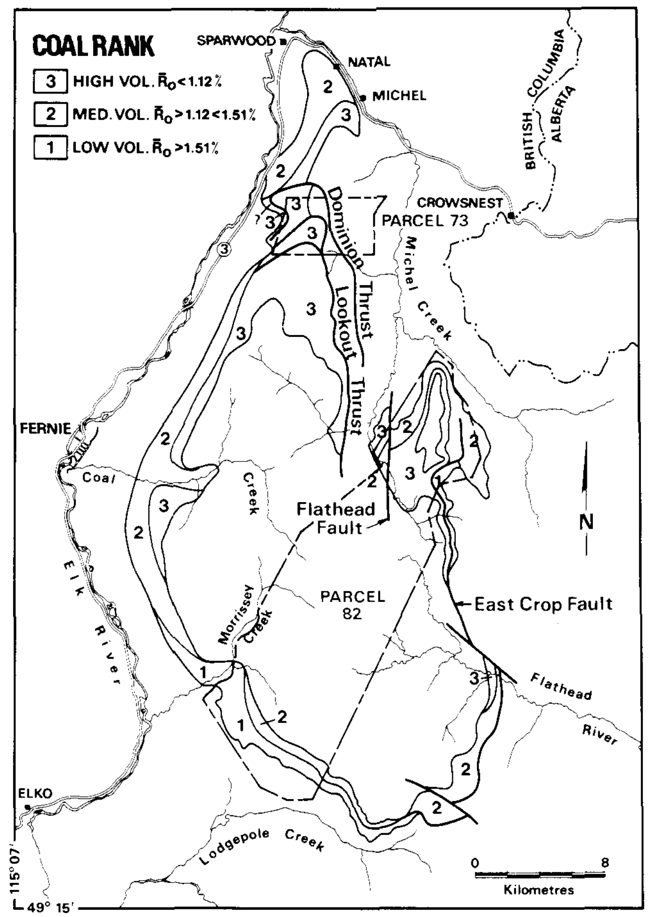


Figure 9. Distribution of coal rank in Crowsnest coalfield, based on reflectance values of grab samples of coal collected in the field (from Pearson and Grieve, 1985).

COMPOSITION

Mist Mountain Formation coals in the Crowsnest coalfield show a definite trend of increasing reactive macerals (predominantly vitrinite), with corresponding decreasing inertinite content, from the lower to upper part of the formation (Cameron, 1972; Pearson and Grieve, 1985). Vitrinite content of coal seams ranges from less than 50 per cent to greater than 80 per cent of the organic portion of the coal. Semifusinite is the most common of the inertinite group macerals, and in some of the seams in the lower part of the formation it forms more than 40 per cent of the organic portion. Lesser amounts of the other inertinite macerals, fusinite, marcrinite and inertodetrinite, are found in all seams. Liptinite macerals are rare; sporinite and cutinite are the most common types.

PREDICTED QUALITY

Knowledge of rank distribution and maceral composition allows prediction of certain coal-quality characteristics (Pearson, 1980). Quality predictions based on samples collected in Crowsnest coalfield are shown in

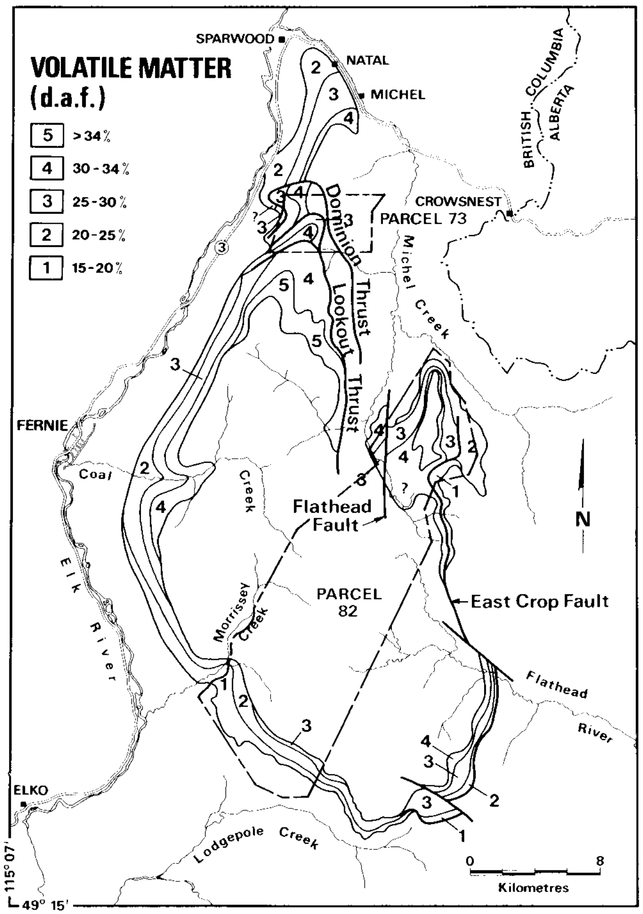


Figure 10. Predicted volatile matter for Crowsnest coalfield based on petrography of coal channel samples (Pearson, unpublished).

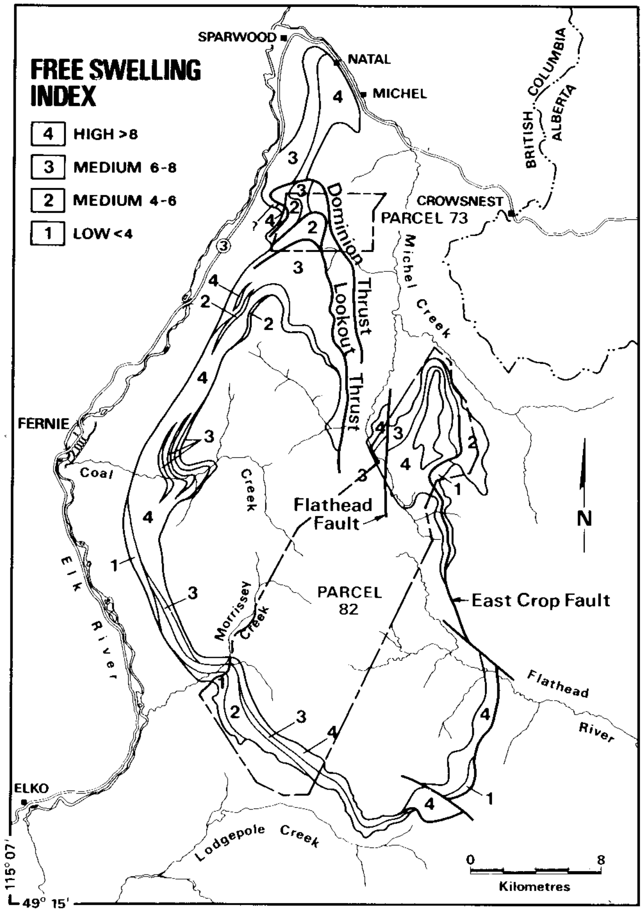


Figure 11. Predicted FSI for Crowsnest coalfield based on petrography of coal channel samples (Pearson, unpublished).

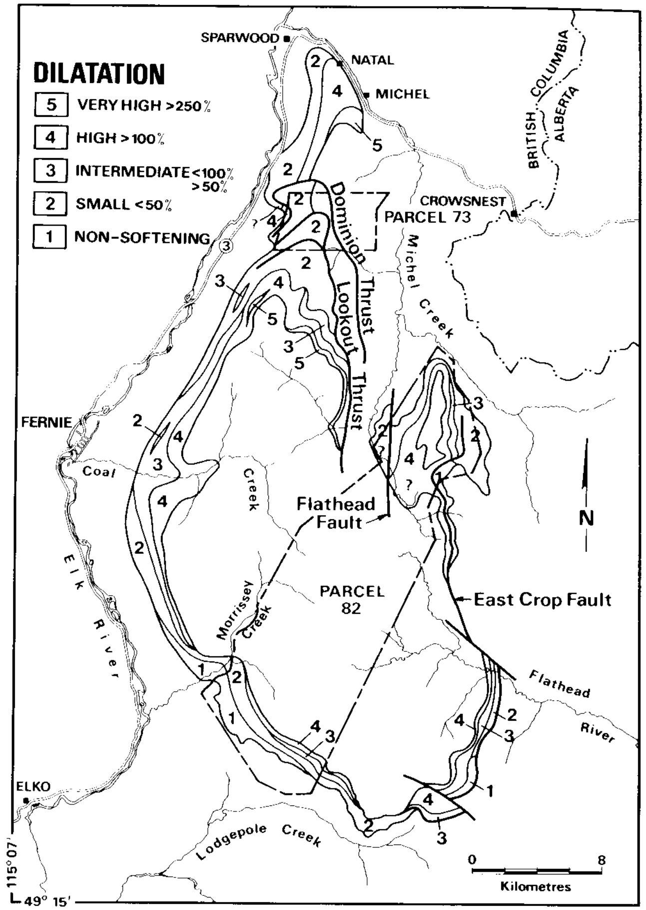


Figure 12. Predicted dilatation for Crowsnest coals based on petrography of coal channel samples (Pearson, unpublished).

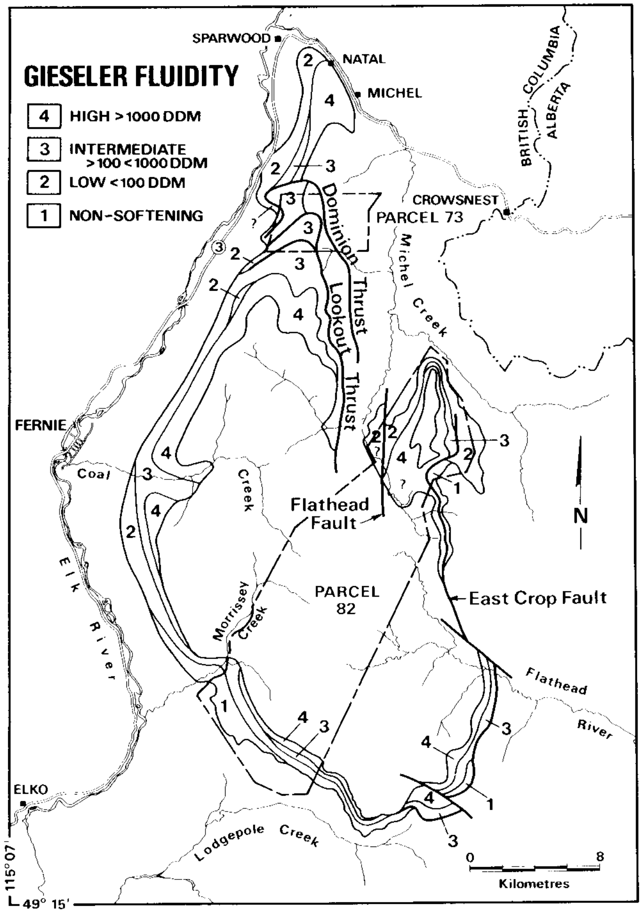


Figure 13. Predicted fluidity for Crowsnest coals based on petrography of coal channel samples (Pearson, unpublished).

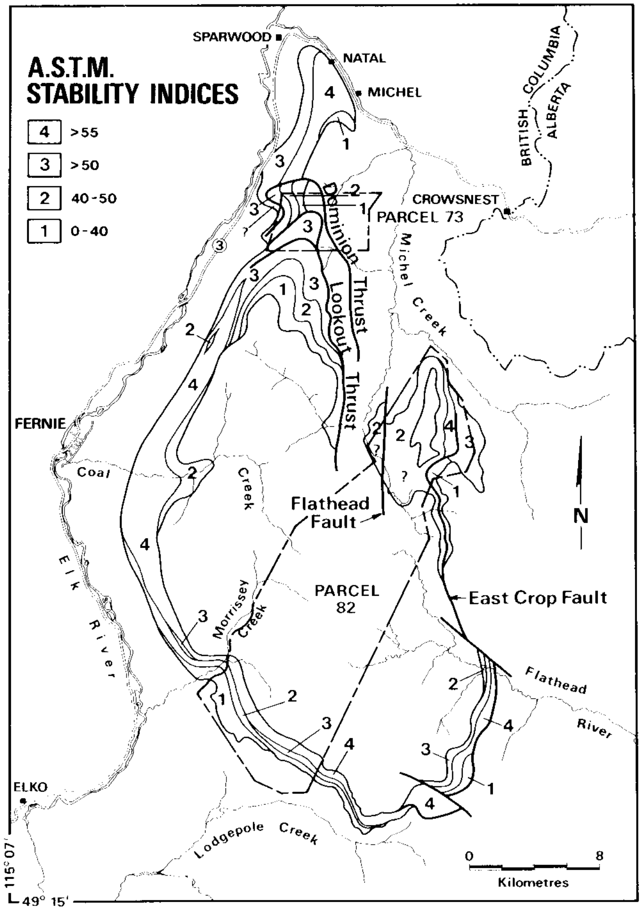


Figure 14. Predicted ASTM coke stability for Crowsnest coals based on petrography of coal channel samples (Pearson, unpublished).

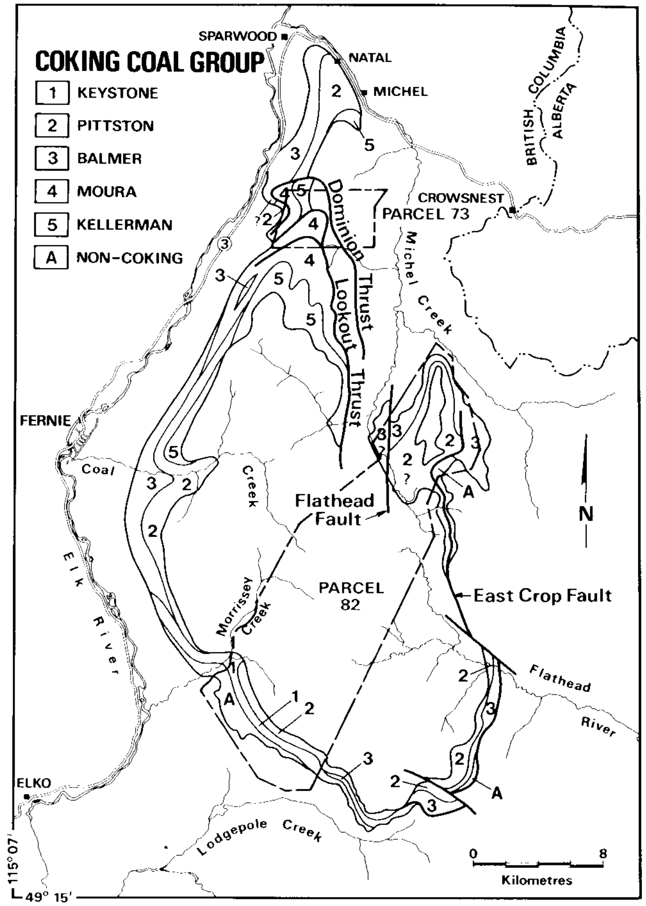


Figure 15. Predicted coking coal groups for Crowsnest coals based on petrography of coal channel samples (Pearson and Grieve, 1985). *See* Table 1 and Figure 16 for characteristics of the groups.

TABLE 1
CHARACTERISTICS OF COKING COAL GROUPS[a]

GROUP NO.	RANK (Ro MAX %)	INERT CONTENT (%)	MAX. DILATATION (%)	MAX. FLUIDITY (ddpm)	FSI	VOLATILE MATTER (%)	COKE STRENGTH JIS D $^{30}_{15}$	COKE STRENGTH ASTM 25mm
G1	>1.50	8-30	0 to 70	5-100	6-9	16-19	92-93.5	50-65
G2	1.0-1.4	8-30	80 to 260	1500-30000	7-9+	22-34	91-94	48-65+
G3	1.2-1.5	25-45	-10 to 100	3-1500	5-8	19-26	90.5-93.5	40-62
G4	0.9-1.2	25-45	-10 to 100	3-2500	5-8	25-32	90-92.5	45-57
G5	0.8-1.0	0-25	100 to 300	1500-30000	7-9+	32-38	75-90.5	20-48
G6	<0.9	5-20	-10 to 100	3-1000	5-7	37-40	50-80	0-30

[a]*From Pearson, 1980, Table 3.*

Figures 10 to 15. The petrographic coking coal group classification corresponding to Figure 15 (Pearson, 1985) is shown in Figure 16 and characteristics of the coking coal groups are listed in Table 1. Specific coal-quality predictions will be discussed later under each area within the Dominion Coal Block. To summarize, a wide variety of coking coal types, including Groups G1 to G4, and non-coking coal, is predicted to occur within the block.

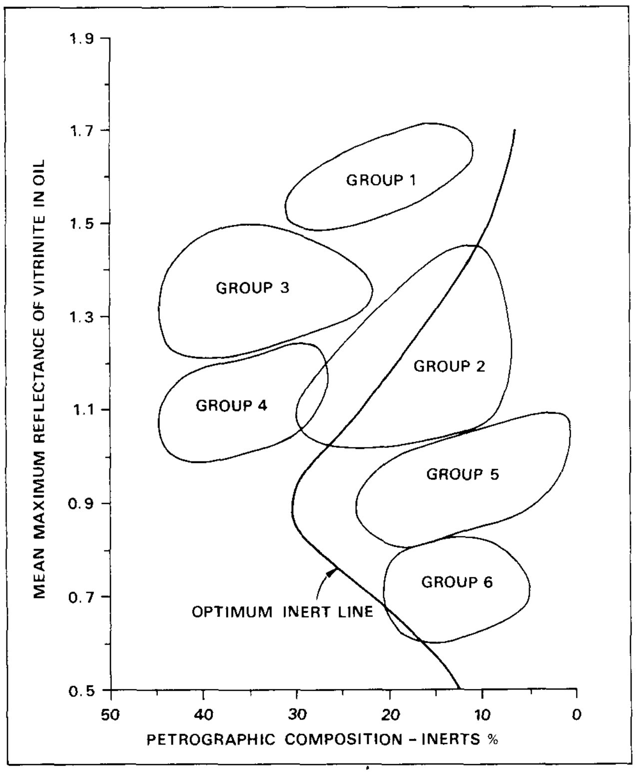


Figure 16. Positions of coking coal groups listed in Table 1 relative to reflectance and inert contents (from Pearson, 1980).

COMPUTER MODELLING TECHNIQUE

Computer-based deposit modeling of the three areas within the Dominion Coal Block was performed using the gridded-surface technique. This method of describing the geology of a deposit is readily achieved on a microcomputer. Microcomputers enable the techniques to be applied in the field for data collection and analysis. Their present computation power and the interactive nature of most software also makes them the logical choice for office-based data processing.

The study required the compilation of all existing geological data describing the deposits as well as any new data collected from the field. This information was used to describe positional and quality parameters of the coal seams of interest within the three deposits.

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 took the form of a network of regularly spaced points, grid nodes, covering the deposit. The value of the parameter of interest was determined and recorded at each grid node. All digital surfaces for a single deposit are of equal size and configuration, so that the corresponding grid nodes for each surface have the same lateral coordinates. Grid node values may equal the value of the parameter at that geographic location, matching the grid node location, or be some average value which better describes the whole grid cell, depending upon the type of parameter being described. A grid cell is the area around a grid node which is assumed to be represented by the value at the grid 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. 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 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.

GRID-SURFACE DESIGN

Grid design is the first requirement in constructing a digital deposit model. The following grid parameters must be defined based on available data and end-use of the model:

(1) model boundary locations;
(2) grid orientation; and
(3) grid-node spacing.

Grid location is dictated by the area of interest and will be a compromise between areas with the best data distribution and the area for which analysis is required. Grid orientation is selected on the basis of ease of model construction and use. This may depend on the source of data (*e.g.* company grid) or some geological control such as a regional strike. The orientation should be chosen in a way that minimizes the size of the grid which will completely cover the area of interest once the previous two concerns have been addressed. Grid-node spacing is dependent upon the required resolution of the model. Desire for the best possible resolution will be tempered by the availability of computer memory and the computation time required in dealing with large grids. Small grid-node spacings will result in a smooth grid but the validity of the surface does not increase greatly beyond a grid-node spacing equal to the average data spacing across features of interest.

GRIDDED-SURFACE CONSTRUCTION

There are an infinite number of ways to construct a gridded surface; the choice is dependent upon the type and format of data being described. Some methods produce an exact replica of the input data, while other techniques allow for geologic input by the user, and yet others are based on some mathematical weighting function. The actual methods used in this study will be discussed in a later section, but the following is a partial list of some broad categories of techniques:

(1) moving weighted average (inverse distance, kriging);
(2) trend surface;
(3) down-plunge projection; and
(4) direct translation.

MODEL FORMAT AND ANALYSIS

A 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 "TOPO". Model analysis is accomplished with a series of programs which access the required gridded surface files and perform simple arithmetic functions to obtain 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.

The specific grid parameters, data, construction techniques and results will be discussed in the individual sections dealing with the three deposits examined during this study. Appendix 1 contains a description of the models and the analysis programs and Appendix 2 (diskette) contains the actual digital deposit models and analysis programs.

STRUCTURE

Parcel 73 can be divided into three distinct structural blocks (Figure 17). The eastern one-third to one-half lies in the footwall of the Dominion thrust, and is underlain by gently folded Blairmore Group strata. The second block, a structural horse lying between the Dominion thrust and its splay, the Lookout thrust, is characterized by a tight overturned syncline predominantly in Elk, Cadomin and Lower Blairmore strata, with some Mist Mountain Formation exposed near the northwest corner of the parcel. The third block has by far the highest economic potential of the three and comprises the area covered by resource calculations presented in this report. It consists of the hanging-wall of the Lookout thrust, and occurs in the southwest corner of Parcel 73, underlying Lookout Hill at the south end of Sparwood Ridge, and the north end of Hosmer Ridge (Figures 3 and 17).

Strata on the north end of Hosmer Ridge are folded into a broad southwest-plunging syncline, but the regional calculated fold axis has an orientation of $165^{\circ}/12^{\circ}$ (trend/plunge). Rocks on Lookout Hill have a general southwesterly dip. For the purposes of modeling, however, strata above the Lookout thrust can best be described as monoclinal with a mean orientation of $182^{\circ}/13.5^{\circ}$ (dip-direction/dip). The southwest-dipping Lookout thrust (mean orientation $216^{\circ}/17^{\circ}$) appears to splay into a series of imbricate thrusts which repeat the basal Kootenay Group (Figure 17). The uppermost of these, the Saddle thrust, passes between Lookout Hill and Hosmer Ridge and affects the strata involved in the resource calculation. However, its movement appears minor enough to be ignored for our purposes. Smaller-scale thrust faults which cut the stratigraphy underlying Lookout Hill suggest the pattern of imbrication is repeated.

STRATIGRAPHY OF THE LOOKOUT THRUST SHEET

The Lookout sheet within Parcel 73 contains a preserved thickness of between 475 and 500 metres of Mist Mountain Formation strata (Figure 18), compared with a total of 600 metres in uneroded sections in the surrounding area (Gibson, 1985). The section description here is based on only one measured section (Pearson, 1977). A total of 45 metres of coal is contained in seven seams, numbered consecutively upward from 10 to 3. The major seam is 9-seam or "Lookout" seam (Ollerenshaw, 1977). With a combined thickness of 19 metres and a wider geographic distribution than the other major seams, 9-seam forms the bulk of resources in Parcel 73. It consists of an upper and lower bench separated by 14 metres of interbedded shale and coal; the upper bench is itself split by a shaley parting 2 metre thick (Figure 18). Analytical results for Parcel 73 (Table 2) refer to samples from 9-lower, middle and upper, although exact correlation of these subseams with the section shown here is not certain. The base of a prominent series of sandstone beds overlies the Lookout seam by an average of 10 metres throughout the Lookout plate. This unit, dubbed the "Lookout sandstone" by Ollerenshaw (1977) forms the cap of Lookout Hill and has protected the Lookout seam from erosion.

The other seams are thinner and occur only above the Saddle thrust; 8-seam contains a total of 11.3 metres of coal in two benches, while 7-seam is 1.5 metres thick, 6-seam is 1.8 metres thick, and 3-seam is 6.1 metres thick.

TABLE 2
SUMMARY OF TEST RESULTS ON PARCEL 73 ADIT SAMPLES[a]

SEAM	RAW ASH (%)	YIELD (%)	SPECIFIC GRAVITY (%)	VOLATILE MATTER (%)	FIXED CARBON	ASH (%)	MOISTURE (%)	SULPHUR (%)	FLUIDITY (ddpm)	FSI	COKE STABILITY ASTM
10-lower	27.5	58.2	1.42	27.9	64.5	6.0	1.6	0.69	710	7	-
10-upper	19.2	71.0	1.42	26.4	66.2	6.3	1.1	0.56	108	8	54.4
9-lower	17.4	71.7	1.45	27.8	61.4	9.2	1.6	0.33	51.5	5	48.2
9-lower	24.5	-	-	28.0	58.5	4.9	1.6	-	0.7	5	53.7
9-lower	22.4	-	-	27.1	64.1	7.7	1.1	0.39	391.1	6	51.8
9-middle	26.5	55.0	1.45	27.4	61.6	9.0	2.0	0.39	310	5	-
9-upper	17.0	81.8	1.50	26.9	62.8	9.0	1.3	0.27	66	5	56.5
9-upper	16.0	-	-	28.8	61.6	8.2	1.4	-	50.7	6	-
9-upper	13.8	-	-	25.5	66.1	7.2	1.2	0.30	45.5	5	44.5
9-upper	17.8	-	-	28.6	61.0	9.2	1.2	-	51.5	5	45.5
8-lower(8)	13.0	88.2	1.50	26.8	63.5	8.5	1.2	0.33	0	3	-
8-upper(7)	25.2	59.1	1.42	29.1	60.9	8.2	1.8	0.59	20.9	3	48.2
6(5)	15.7	79.4	1.44	28.4	61.4	8.6	1.6	0.47	7.5	5	45.4
3(4)[b]	20.6	72.5	1.50	28.8	60.8	8.8	1.6	0.39	3.2	3	49.0

[b]*Numbers in parantheses are seam numbers used in report (Anonymous, 1974) and are assumed to correspond with seam numbers indicated.*
[a]*From Anonymous, 1974. Results reported on an air-dried basis. Adit locations are not known.*

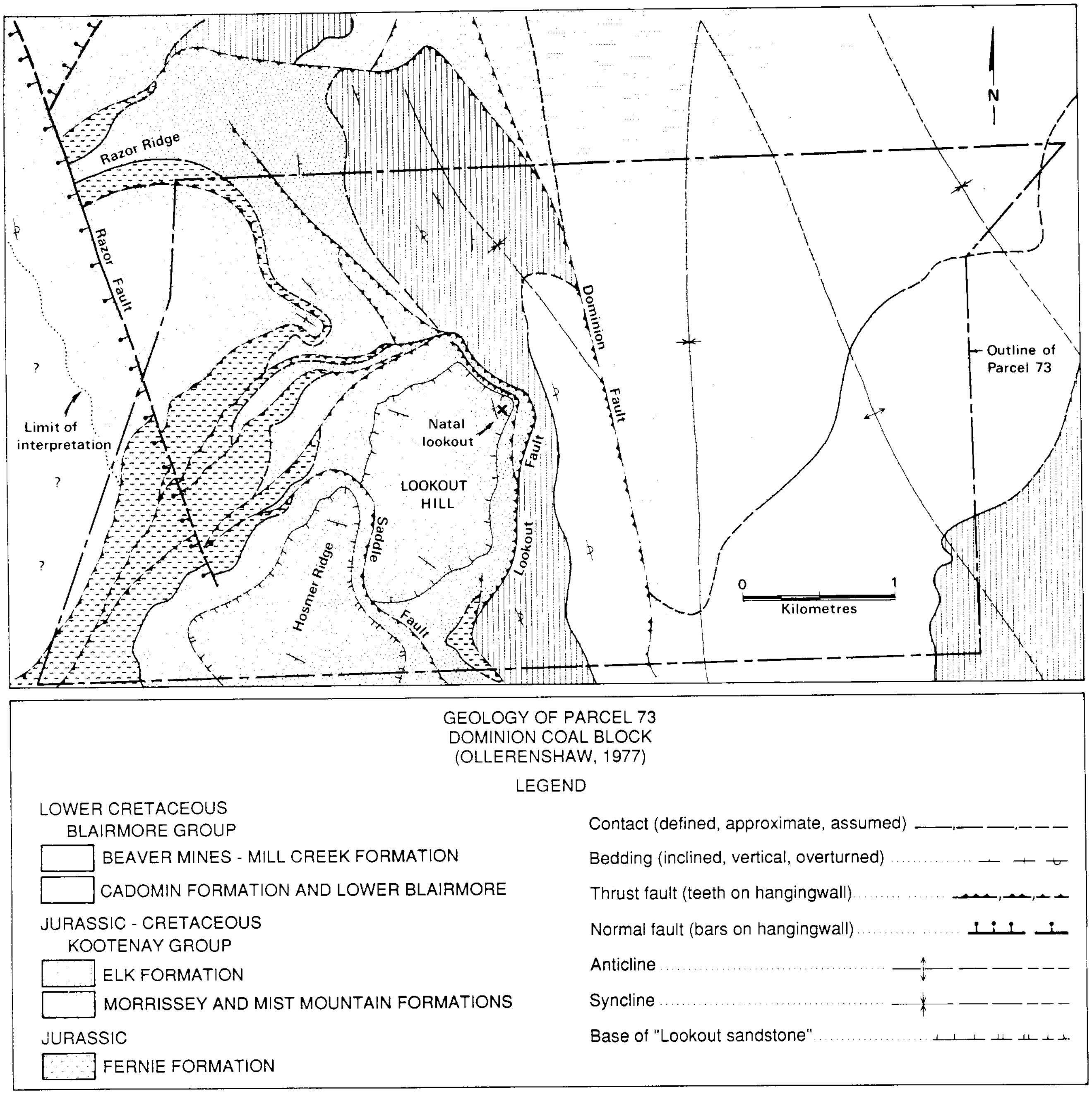


Figure 17. Geology of Parcel 73 (modified after Ollerenshaw, 1977).

COAL QUALITY

Data from tests on adit samples are contained in an anonymous report by a third party (Anonymous, 1974) on file with the British Columbia government.

ADIT SAMPLES

Partial results of 14 bulk sample tests are listed in Table 2. Clean coal volatile matter contents (dry, ash-free) range from 27.8 per cent (one sample of 9-upper) to 32.4 per cent (one sample of 9-lower). Most of the samples, therefore, have volatile matter contents near the boundary between medium and high-volatile bituminous (approximately 32.5% on a dry, ash-free basis). The range in volatiles in the cases of multiple samples (9-upper and 9-lower) suggests possible rank variation over the property. For example, values for 9-lower range from 28.3 to 32.4 per cent volatile matter. Unfortunately we do not know the adit locations, and so are unable to compare proximate analytical variations with geographic position or observed vitrinite reflectance variations.

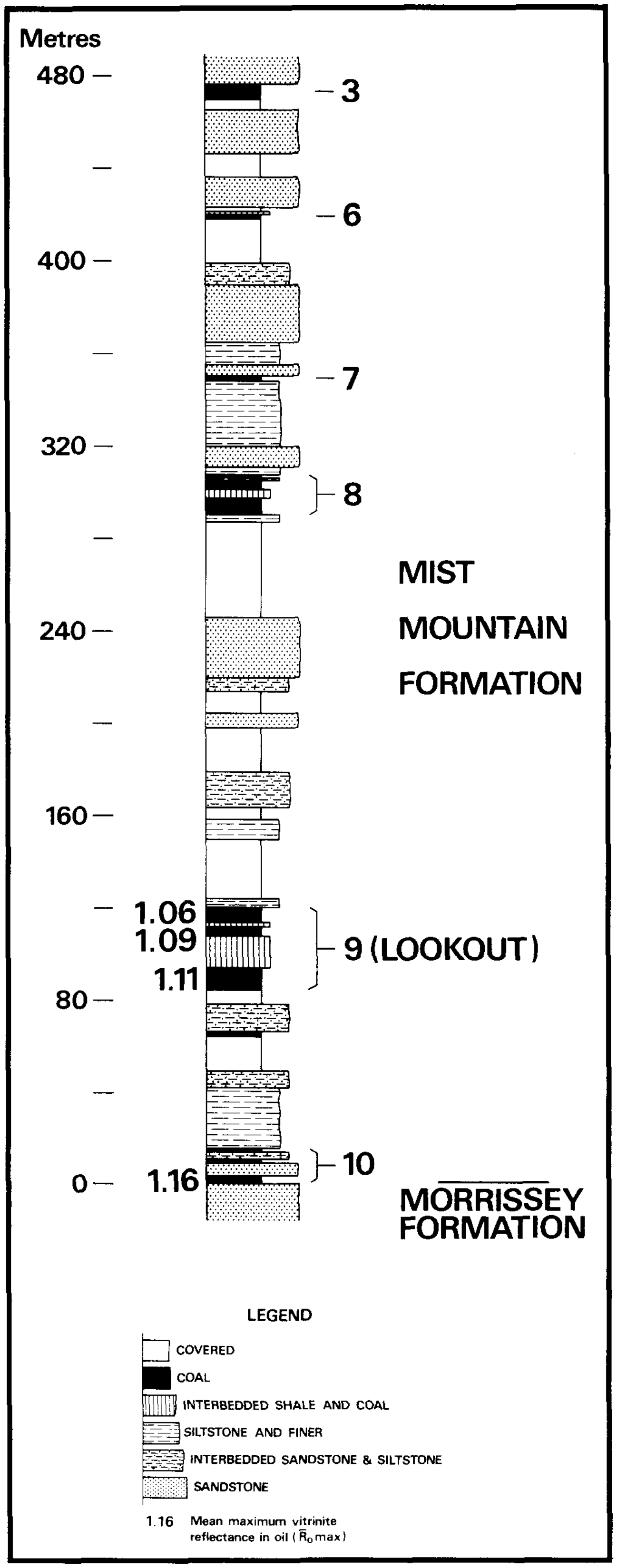


Figure 18. Generalized measured stratigraphic section from Parcel 73 with coal rank values (from Pearson, 1977).

Clean-coal ash ranges from 6.0 to 9.2 per cent, while sulphur values are in the range of 0.27 to 0.69 per cent. Free swelling index is highest in the two 10-seam bench samples (7 1/2 and 8), and is lowest in the samples from seams 8-upper, 8-lower and 3 (3 1/2). The 9-seam samples are all in the range of 5 to 6. Fluidity values appear to decrease up section. For example, the highest fluidity value, 710 dial divisions per minute (ddpm), occurs in 10-lower, while three of the four seams above 9-seam have values less than 10 ddpm associated with them. The three samples of 9-lower show a range of 0.7 to 391.1 ddpm, the 9-middle sample has a value of 310 ddpm, and the four samples of 9-upper show a range of 45.5 to 66 ddpm.

Coke stabilities (ASTM) range from a high of 54.4 (10-upper) to a low of 44.5 (one 9-upper sample). There is no stratigraphic trend evident in coke stability values.

Rank Distribution

Rank values for specific sample sites, expressed as $\bar{R}_o$max, are plotted on Figures 18 and 19. Regional rank distributions are indicated on Figure 9. On Hosmer Ridge $\bar{R}_o$max values range from 1.16 per cent for the seam immediately overlying the Morrissey Formation to 1.06 per cent for the uppermost bench of the Lookout seam (Figure 18) to values ranging from 0.99 to 1.04 per cent for seams higher in the stratigraphy (not shown on Figure 18, as sample sites do not correspond with the measured section). Thus the Lookout seam at the location of the measured section falls near the boundary between high and medium-volatile bituminous rank as determined petrographically (1.12%). The upper seams on Hosmer Ridge are all of high-volatile bituminous rank.

Within the study area the rank of the Lookout seam appears to decrease toward the northeast and increase toward the southwest (Figure 19). For example, reflectance of a sample of the Lookout seam from the north spur of Lookout Hill is 0.91 per cent, and increases to 1.09 per cent at the position of the measured section. Further to the southwest, the basal seam in the Mist Mountain Formation at a point 650 metres south of the southwest corner of Parcel 73 (outside of the area shown on Figure 19) has a reflectance of 1.26 per cent. In the latter case the Lookout seam might reasonably be expected to have a reflectance in the neighbourhood of 1.2 per cent. The difference in elevation between these two points is approximately 770 metres, suggesting that the contrast is partly due to down-dip rank increases (Pearson and Grieve, 1985). This change in rank with elevation (0.038%/100 metres) is, in fact, only slightly higher than that established at Coal Creek, 15 kilometres to the south, for purely down-dip rank increase (0.035%/100 metres).

The relatively low rank of coals above the Dominion thrust fault compared with adjacent areas was noted by Pearson and Grieve (1985). The Balmer seam, which is

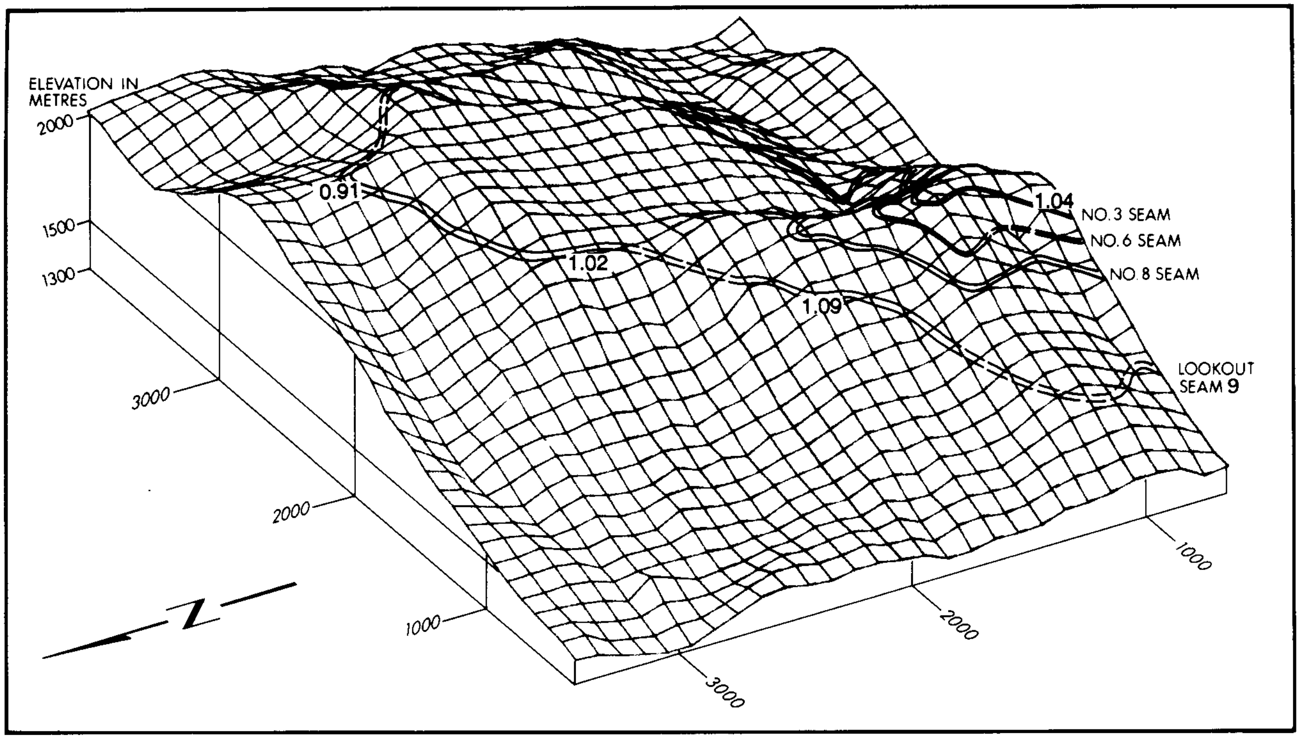


Figure 19. Isometric diagram of the surface topography of Parcel 73 with coal seams and reflectance values displayed. Each net square is 100 metres on a side. The view is that seen by looking down on the deposit in a southeasterly direction.

of great economic importance in the Sparwood area and which lies at approximately the same stratigraphic position as the Lookout seam, has reflectance values of approximately 1.4 per cent on Sparwood Ridge. The structural position of the Lookout seam, however, is the key to understanding its relatively low rank. As demonstrated by Pearson and Grieve (1985, Figure 9) there is no discernible rank discontinuity across the trace of the Dominion thrust and thus lower section seams from above the thrust have rank values equivalent (or lower) to upper section seams from beneath it.

Predicted Coal Quality

Coals from the Lookout sheet in Parcel 73 are predicted to fall mainly, if not entirely, into coking coal Group G4 (Figure 15). Table 1 gives the general characteristics of this classification. More precise limits on predicted quality parameters are given in Figures 10 to 14. Volatile matter (daf) is predicted to lie between 30 and 34 per cent with the exception of the lowest seams on Lookout Hill which will be less than 30 per cent. Free swelling index is predicted to be 6 to 8 on Hosmer Ridge and 4 to 6 on Lookout Hill. Maximum dilatation is predicted to be less than 50 per cent and fluidity to be between 100 and 1000 ddpm. Coke stability values are predicted to be generally greater than 50 per cent, especially in the lower seams.

Comparisons with Table 2 indicate significant differences between some of the predicted and actual properties determined on adit samples. For example, the FSI values on the seams above 9-seam are lower than predicted (3 1/2 to 5, compared with 6 to 8). Likewise, most of the actual fluidity values are below the predicted range.

DEPOSIT MODEL

Objectives

The objective of the Parcel 73 study was to use available orientation, seam position and seam thickness data to construct a digital deposit model to assist in resource estimation and illustrate the geometry of the deposit. Total coal resources as well as mining factors such as overburden ratios were required to assess the resource potential of the deposit.

Grid Specifications

The grid area (Figure 3) was selected to cover the most economically interesting part of Parcel 73. It encompasses a 2.9 by 3.7 kilometre area including Hosmer Ridge and Lookout Hill. The grid is oriented parallel to the UTM grid in the area. The orientation was selected to facilitate topographic data collection and transferring mapping data. This grid-node spacing was used for ease of calculation and because a finer grid was not warranted with the given data distribution. The grid nodes are 100 metres apart. The grid contains 29 rows (east-west) and 37 columns (north-south) for 1073 grid nodes per surface.

Data Sources

Geologic and topographic information are available in various forms for use in the construction of the deposit model. Topographic values were taken from a National Topographic System 1:50 000 scale map with a 100-foot contour interval. Geologic information came from an existing geological map (Ollerenshaw *et al.*, 1977), and fieldwork completed during this project. Information from boreholes and adits exists but was not available. Strata orientations were collected from the geological map and from field measurements during this project. A total of 33 orientation data points were obtained from these sources. The surface traces of coal seams were obtained from the geological map and field mapping. Stratigraphic and seam thickness values were obtained from Ollerenshaw (1977), together with past and present Ministry work. All the collected information were entered into computer files using the Cal Data Ltd. Geological Analysis Package software.

GRID CONSTRUCTION

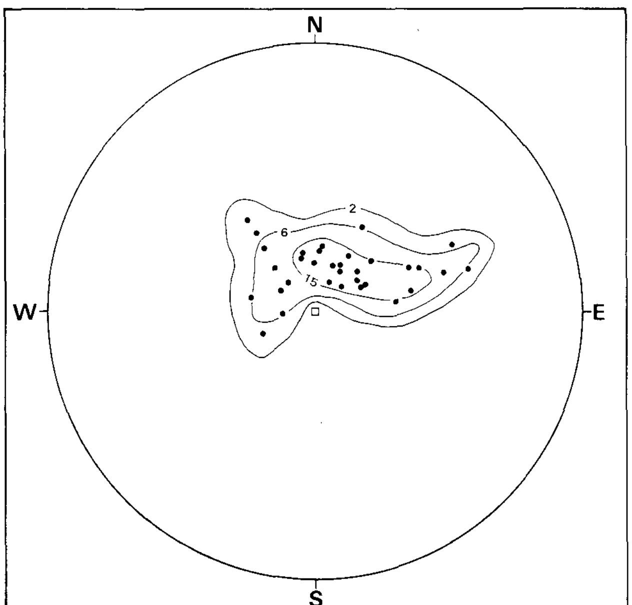
A single grid surface was constructed to describe each deposit variable investigated during this study (Table 3). The method used was dependent in large part on the type of data being gridded. During the course of a model investigation a large number of grid surfaces are constructed, but only a few are considered to be primary grids. Those describing the topography, seam positions and seam thicknesses are primary, others describing interseam thicknesses and mining ratios are secondary grids as they are derived from the primary surfaces. Methods used to construct the primary grids will be discussed here while the construction of secondary grids will be addressed later (*see* Analysis).

Manual digitizing was used to translate the topographic data into a computer-processable format. A network of grid nodes coinciding with the model grid was superimposed on the 1:50 000 topographic map. The surface elevation at each grid node was interpolated between the 100-foot contour lines. These values were then converted to metres and entered into a computer grid file. The resulting file, TOPOLOOK.P73, is presented in Appendix 2.

Down-plunge projection was used to construct a cross-section defining the position of coal seam tops. Extending the trace of seams on the cross-section parallel to the selected projection direction over the model area determines the position of the seam or horizon within the model. The surface trace of the coal seams provided the only absolute seam-location data. Analysis of bedding attitudes showed the mean bedding orientation in the grid area to be $210^{\circ}/15^{\circ}$ (Figure 20). An interactive method was used to draw down-plunge projection cross-sections of the seam surface-trace data. The projection direction was varied interactively in a plane parallel to the mean bedding orientation until data for the seam under consideration lined up in a geologically acceptable fashion on the cross-section. Once this best projection direction was identified and the seam trace on the profile was interpreted, this seam trace was projected over the whole grid area parallel to the selected projection direction. The elevation of the seam was calculated at each grid node within the model to arrive at the gridded surface for the location of the particular seam. Seam-position grids were constructed for seams 3, 6, 8-upper, 8-lower, Lookout-upper and Lookout-lower. These six surfaces, together with the topographic grid, comprise the seven primary grids used in this model. Due to the lack of areally distributed seam thickness data each seam was characterized by a average seam thickness, corresponding with the thickness of the seam in the measured section (Figure 18). The positions of the seam bottoms were calculated from the seam top elevations and the average seam

TABLE 3
LIST OF GRIDS IN THE PARCEL 73 MODEL

GRID NAME	GRID DESCRIPTION
TOPOLOOK.P73	Topography elevation
3-SURF.P73	3-seam top elevation
6-SURF.P73	6-seam top elevation
8L-SURF.P73	Lower 8-seam top elevation
8U-SURF.P73	Upper 8-seam top elevation
9L-SURF.P73	Lower 9-seam top elevation
9U-SURF.P73	Upper 9-seam top elevation



PARCEL 73

EIGENVAL./N	TREND	PLUNGE
.8897	30.3	74.6
.0947	269.2	8
.0156	177.3	12.9

POLES TO BEDDING (33 POINTS).......•

Figure 20. Plots of poles to bedding in Parcel 73 (Wulff projection) with associated eigenvectors and eigenvalues.

thickness. These calculations and others will be discussed in the model analysis section.

MODELLING

The basic model consists of seven primary grid-layers (Table 3; Appendix 1 and 2). Numerous other secondary layers were constructed by simple layer-to-layer manipulations of single grids. The computer program G-CALC (Appendix 2) was used to produce secondary grids required for specific calculations. The topographic layer remained unchanged from its input through the final deposit analysis. Seam-top position grids, once constructed with the down-plunge projection technique, were used to calculate the seam bottom layers. This was accomplished by subtracting the average seam thicknesses from the appropriate seam top grid-nodes to determine the values at the nodes on the new surface. Once the seam top and bottom layers were established they required modification to reflect the erosional edge of the seam. The trim function in G-CALC was used for this purpose.

ANALYSIS

Analysis of the digital deposit model took several forms. Straightforward displays of maps and perspective views were often adequate to assess specific features. The computer program G-PLOT (Appendix 2) produces a line-printer map of the gridded surfaces. G-CALC performs grid manipulations and calculations.

An example of an important analysis question would be, "What is the total-coal-thickness distribution?". To answer this question the trimmed seam-thickness grids are added together to form a new grid and then plotted with PLOTTER to show the total coal thickness distribution over the deposit. If total tonnage of contained coal is required, the grid would be multiplied by the grid-cell area (10 000 square metres) and the specific gravity of the coal (say 1.32 gram/cubic centimetre). The result is the total *in situ* coal resource. If the distribution of waste-to-coal ratios is required an additional secondary grid is needed. The thickness of strata between the topography and the base of the lowest seam is calculated. Once a grid of this parameter has been constructed total waste in the section can be derived by subtracting the total coal grid from the total section grid, and then dividing the total waste grid by the total coal grid to obtain the waste-to-coal ratio (Figure 21).

There are countless variations to the analysis problem. We have applied a few basic assumptions and parameters to establish a basic analysis of the coal resource and reserve potential of the deposit. Tables 4 and 5 summarize the coal quantities and vertical waste-to-coal ratios of the deposit given the selected parameters. The model and programs included in Appendix 2 allow additional analysis and parameter selection to be made.

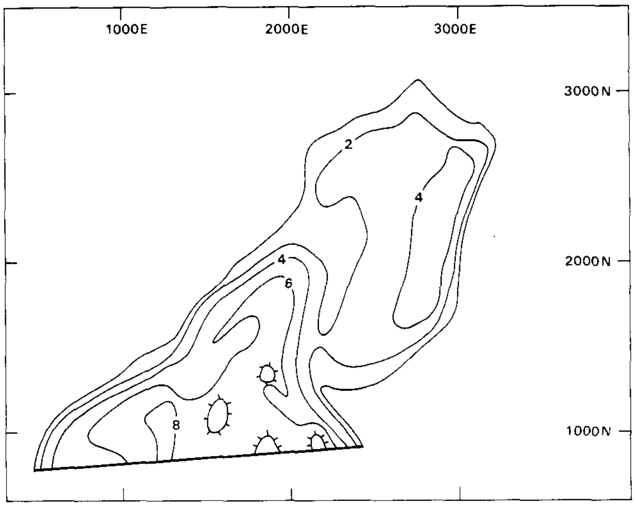


Figure 21. Distribution of waste-to-coal ratios over Parcel 73 as derived from the model.

Following are a list of interpretation and calculation assumptions which were made by the authors. Several of these assumptions could be modified in subsequent analysis, but the positions of the seam tops and topography are fixed.

- The Saddle thrust is not incorporated in the model because, at the resolution of the model, its effect on the geology and resource calculations is insignificant.
- The Lookout seams are assumed to be continuous in the northeast and southwest portions of the grid area even though complications are apparent on the published geology map. In both cases faulting is indicated and the seams are not represented on the map (Ollerenshaw *et al.*, 1977), but in both areas the seam would probably be present with some displacement due to the faulting. Thus the total coal calculation would appear similar in any event.
- All seams are considered to be of a uniform thickness. The thickness values used were those obtained from the measured section (Figure 18).
- It is assumed that the coal seam positions can be described by a line moving parallel to the projection direction, 115°/0°, and joining all known outcrops of a seam. The projection direction does not correspond with the fold-axis orientation for the area, but with the data available the chosen direction most accurately describes the known position of the seams. The coal seam positions will require modification when additional information from the interior of the deposit becomes available.
- The coal is assumed to be of constant specific gravity in each seam and across the deposit. No

information is available to allow assessment of this assumption.
- No dilution or recovery factors are assumed, all calculations are strictly on an in-place basis.

Resource Calculations

Coal resource calculations were performed on the deposit using the gridded surfaces previously described. The calculated volumes must be categorized as resources due to the lack of adequate geological control on seam thicknesses and positions. This data exists but is not available to the Ministry. Tonnage values are obtained by determining the surface area underlain by a seam, its thickness and its density. Within these three variables lies a very large scope for error in the resource calculation. The calculations summarized in Tables 4 and 5 are therefore very preliminary. The potential error and refinements to the calculations are discussed below.

A variety of potential errors are present in the calculations but they were determined in such a manner that alternative values can easily be substituted by the reader for variables such as density, seam thickness and coal content of a seam. All of these assumptions are obviously idealistic. Ash content and seam parting material will reduce the total coal volume, raise the density and increase the run-of-mine tonnage. Dilution during extraction will aggravate this trend but has not been considered here. The reader is advised to use the calculation values with caution. Table 3 illustrates the errors associated with minor variations in seam area and seam thickness. Effects of density variation are obvious but remain one of the major sources of concern in coal tonnage calculations.

Values presented in Table 4 were obtained using the program G-CALC and seam-top position grids of the deposit model. The position grids had valid values only where coal was present within the deposit. Each grid node represented an area of 10 000 square metres thus it was a simple task to multiply the number of valid grid nodes by this value to obtain the surface area underlain by the seam. Locally errors associated with this procedure may be great but when the whole deposit is considered they tend to average out satisfactorily. Some 76 million tonnes of coal are suggested by our calculations.

Open pit waste-coal ratios are vital in assessing the potential of a deposit. Table 5 contains the deposit-wide ratio values for the six seams. Figure 21 illustrates the distribution of vertical waste-to-coal ratios over the deposit area based on the assumption that all six seams are extracted. These individual seam calculations and the cumulative calculations were obtained by calculations using G-CALC and grids from the model. The results are in tonnes of coal per bank cubic metre of waste. The required calculations are simple but require multiple calculations. The results of the calculations show that the deposit has an overall waste-coal ratio of 4.7:1, although it must be remembered that this is based on the assumption that seams maintain a specific gravity of 1.32 which is idealistic. This ratio would be less if typical run-of mine densities are employed but compensation for recovery factors would offset this decrease somewhat.

TABLE 5
INDIVIDUAL AND CUMULATIVE WASTE-COAL RATIOS, PARCEL 73

SEAM	TOTAL COAL BY SEAM (tonnes)	TOTAL WASTE ABOVE SEAM (BCM) (cumulative)	WASTE TO COAL RATIO (cumulative)
No. 3	563 640	760 502	1.35
No. 6	285 000	5 082 400	5.5
No. 8-upper	2 164 800	29 752 400	9.67
No. 8-lower	3 950 760	33 001 700	4.4
Lookout (U)	35 664 525	306 976 000	7.08
Lookout (L)	33 419 496	389 799 000	4.7

MINING METHOD AND LOGISTICS

The portion of Parcel 73 modeled here clearly lends itself to open pit mining. An overall stripping ratio of less than 5:1 is coupled with a gentle dip-slope mining situation and other favourable topographic characteristics which appear to make uphill haulage of coal or waste largely unnecessary. A potential problem might be siting of waste dumps. Dumps on the west-facing slopes above the Elk River would be visible from Highway No. 3 and

TABLE 4
POTENTIAL COAL RESOURCES IN PARCEL 73

SEAM	AREA (hectares)	THICKNESS (metres)	S.G.	TONNES	RANGE PER 10 CM THICKNESS	RANGE PER GRID SQ.
No. 3	7	6.1	1.32	563 640	9 240	80 250
No. 6	19	1.5	1.32	285 000	25 080	19 800
No. 8-upper	41	4	1.32	2 164 800	54 120	52 800
No. 8-lower	41	7.3	1.32	3 950 760	54 120	96 360
Lookout (U)	277	9.754	1.32	35 664 525	365 640	128 752
Lookout (L)	277	9.14	1.32	33 419 496	365 640	120 648
Total	-	-	-	76 048 221		

might be difficult to contain within the boundary of Parcel 73. The south-facing slope above Wheeler Creek and its tributary, on the other hand, appears to offer sufficient room and suitable slopes for a wrap-around dump system well within the boundary of the parcel. Settling ponds near the mouth of Wheeler Creek would probably be necessary to ensure maintenance of water quality in Michel Creek. An advantage of this plan is that dumping would be taking place on uneconomic Elk and Blairmore strata.

Road and service access would appear to be easiest and most direct following Fir Creek to the northeast. General access to the west would be very difficult because of the steep slopes. Rail load-out facilities within Parcel 73 are probably not feasible, but the property is well placed with respect to rail transportation and a spur-line to the chosen load-out site would probably not have to be long.

PARCEL 82 - FLATHEAD RIDGE

STRUCTURE

Flathead Ridge lies near the south end of the Fernie basin on the west limb of the McEvoy syncline, which plunges northward in this general area (Figure 8 and Figure 22 in pocket). Ollerenshaw (1981a) noted a regional décollement or "preferred detachment interval" within the Mist Mountain Formation which effectively divides the area of coal exposure on Flathead Ridge into two domains. The strata below this interval are affected by "tight, low amplitude folds of relatively short wavelength, cut by numerous thrust faults", while those above are characterized by "broader, gentle folds of low amplitude cut by fewer thrust faults but numerous normal faults". Within the study area this décollement was identified as the Flathead Ridge normal fault by Pearson and Grieve (1981, Sheet 3) and the Morrissey retrothrust by Ollerenshaw (1981a). In both studies the northeast-dipping fault was traced from Morrissey Creek southeastward along the face of Flathead Ridge to a point roughly halfway between the creek and the southeastern boundary of Parcel 82 (Figure 22). Ollerenshaw (1981a, p. 151) speculated that the fault continues through to the boundary, but is hidden in bedding of the Mist Mountain Formation. Pearson and Grieve concluded that the fault changes orientation and cuts rapidly up-section, affecting the lateral continuity of strata. In the present study we found no field evidence to support the latter interpretation and we lean to the interpretation of Ollerenshaw.

The structure of the upper part of the Mist Mountain Formation (above the Flathead Ridge fault), including the important A and B-seams considered at length here, is monoclinal. On the southwest face of the ridge the average bedding orientation is $040^{\circ}/20^{\circ}$ (dip direction/dip). In the area behind (northeast of) the ridge line, the dip flattens to 10 degrees (Figure 22). Minor structures include predominantly small-scale, low-displacement northeast-dipping thrust and normal faults. In contrast, strata beneath the Flathead Ridge fault are intensely folded, with fold axes trending northeast; these rocks are also affected by northeast-dipping thrust faults.

Normal movement on the Flathead Ridge fault has had the effect of reducing the apparent thickness of Mist Mountain Formation along parts of the ridge. Apparent thickness of strata below the fault has been increased by folding and thrusting (Pearson and Grieve, 1981, Sheet 3).

STRATIGRAPHY

A generalized measured section of Mist Mountain Formation from the gas pipeline right-of-way (Ridge 16, Fig. 4) is shown in Figure 23. The Mist Mountain Formation on Flathead Ridge is approximately 400 metres thick, and on average contains 10 coal seams. During the initial exploration, seams were numbered upward from K1, K2, K3 *etc.*, but seams in the upper part of the section were later renamed A, B, C and D, leaving K designations in the lower part of the section only (Figure 23). This change arose partly because of the difficulty encountered by Pacific Coal in correlating seams from Morrissey Creek, where the nomenclature was first established, southeastward along the ridge. The only seam below A-seam correlated with any degree of confidence was K1-seam, within the basal coal zone. It ranges in thickness from greater than 15 metres in Morrissey Creek to 2.7 metres at the pipeline (Figure 23). In the pipeline section four coal zones occur between K1 and A-seams. The three in the basal 120 metres range from 2.7 to 5.1 metres thick; the uppermost of these may be correlative with K5-seam, which in Morrissey Creek has a thickness of greater than 5 metres. A thick siltstone-dominant interval overlies this seam in the pipeline section, followed by a split seam totalling 6 metres in thickness.

The majority of exploration effort was directed at seams A and B, near the top of the Mist Mountain Formation (Figure 23). Consequently, correlation and thickness variations of these seams are well established. Both are characterized by rapid thickness changes and variations in the number and thickness of partings. A-seam, for example, ranges from 3.5 to greater than 13 metres total thickness in outcrop at the northwestern end of Flathead Ridge (Ridge 3 to Ridge 8 and 9); it is from 2.6 to 7.7 metres thick at the southeastern end (Adit TA-2 to Ridge 21). Between it is less than 1.6 metres thick with numerous partings. In drill core it ranges from 2.68 (J-6) to 17.77 metres wide (J-3). The proportion of coal in A-seam varies from 60 to 100 per cent of total seam thickness, but is generally greater than 90 per cent, omitting the central area just mentioned. Lower splits of A-seam exist in the area southeast of Ridge 16. The upper of these (A1) is up to 3.05 metres in thickness, while the lower (A2) is up to 3.36 metres; both appear to be increasing in thickness to the southeast. The Al-seam is located just below A-seam in the northwest part of the

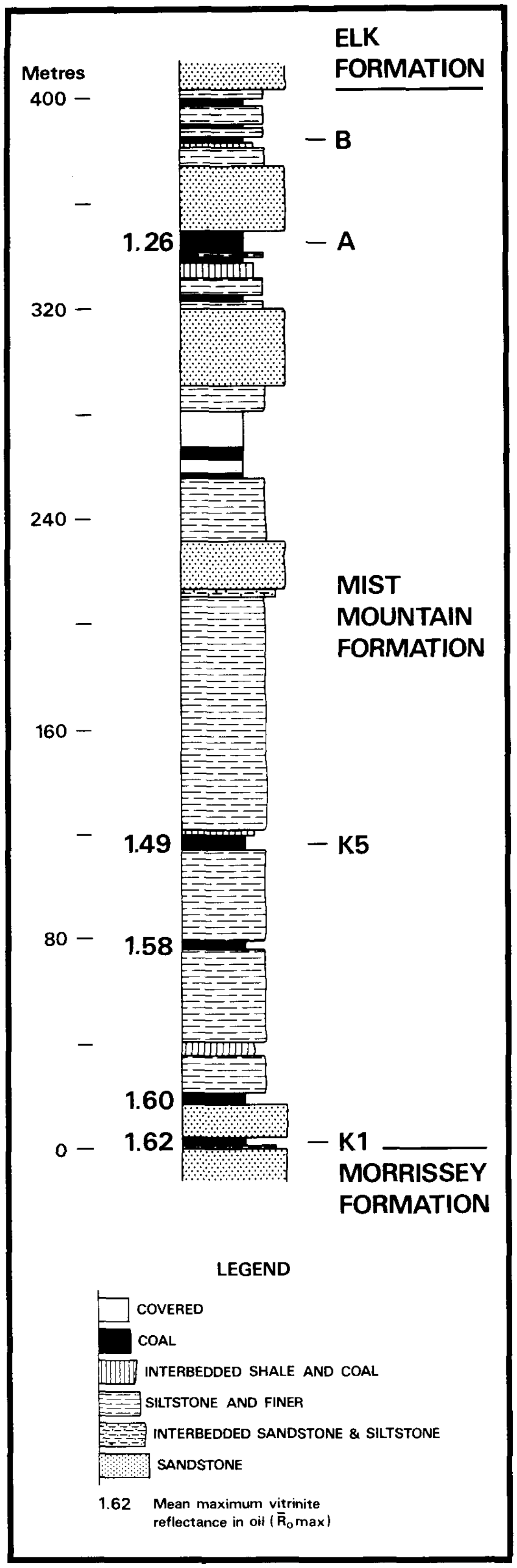


Figure 23. Generalized measured stratigraphic section from Flathead Ridge in Parcel 82 with coal rank values (from Pearson and Grieve, 1981).

study area. Al-seam thickness varies from 2.0 to 6.0 metres.

B-seam overlies A-seam by 25 to 45 metres. Its thickness in outcrop ranges from 1.73 to 5.86 metres, and in drill-core from 3.64 (J-2) to 7.32 metres (J-3). An upper split, named Bu, crops out on Ridge 11 and extends southeastward; it is up to 2.51 metres in thickness. Thickness of B-seam coal is generally greater than 80 per cent, but varies down to less than 60 per cent of the total seam thickness.

COAL QUALITY

WASHABILITY

Float-sink tests of bulk samples were performed in conjunction with both the Nittetsu and Mitsui studies (*see* Previous Work). Data in Table 6 are summarized from the latter source (Aihara, 1970), and deal with B-seam only. The reader is referred to Harada *et al.* (1968) for original float-sink data and washability curves from the Nittetsu studies, including results on A, B, K1 and K5-seams.

Results in Table 6 represent bulk samples TB-2, 3, 4 and 6 combined. Yields were calculated on the assumption that the +0.5-millimetre fractions would be washed with heavy medium cyclones and the -0.5 millimetre fraction by froth flotation. As Table 6 shows, yields of 70.0, 75.0 and 77.0 per cent are calculated based on clean-coal ash contents of 7.0, 8.0 and 9.0 per cent, respectively. Allowing for 5 per cent dilution during mining, the yields reduce to 65.0, 70.0 and 72.0 per cent, respectively.

TABLE 6
COMBINED RESULTS OF FLOAT-SINK TESTS OF B-SEAM FLATHEAD RIDGE[a]

Raw-coal Ash (%)	23.2	23.2	23.2
Clean-coal Ash (%)	7.0	8.0	9.0
S.G. (g/cc)	1.53	1.60	1.68
Calculated yield (%)	70.0	75.0	77.0
Revised yield[b] (%)	65.0	70.0	72.0

[a]*Based on samples TB-2, TB-3, TB-4, and TB-6 from Aihara, 1970.*
[b]*Allowing 5% dilution during mining.*

STEEL MILL TESTS

Six Japanese steel mills were provided with cleaned bulk samples for testing; the results recorded in the Nittetsu reports were later reproduced in the Mitsui report. Summaries for B and A-seam samples are presented in Tables 7 and 8, respectively. The reader is referred to Harada *et al.* (1968) for original data.

Clean B-seam coal (Table 7) has average volatile matter contents (air-dried basis) ranging from 23.3 to 19.2 per cent, decreasing from southeast (Adit TB-6) to northwest (TB-2). On a dry, ash-free basis the average volatile matter contents vary from 25.4 per cent in the

TABLE 7
SUMMARY OF CLEAN B-SEAM TEST RESULTS AT JAPANESE STEEL MILLS[a]

ADIT	MOISTURE (%)	ASH (%)	VOLATILE MATTER (%)	FIXED CARBON (%)	S (%)	CALORIFIC VALUE (kJ/kg)	FSI	DRUM INDEX (+15mm)	FLUIDITY (ddpm)
TB-6	1.8 (avg)	6.8	23.3	68.4	0.48	33432	7.5-8.5	93.9	186
	1.7-1.9 (range)	6.7-7.2	22.3-24.06	67.8-69.21	0.44-0.56	33076-33787		93.0-95.4	66-412
TB-5	1.3	6.3	21.0	71.8	0.50	33787	8-9	94.0	336
	1.2-1.37	6.1-6.73	20.1-21.71	71.3-72.1	0.48-0.53	33453-34081		93.5-94.8	206-758
TB-4	1.3	6.8	21.9	70.3	0.40	33549	8-9	94.3	708
	1.1-1.5	6.6-6.9	21.3-22.8	70.0-70.5	0.38-0.42	33201-33829		93.3-94.9	390-1235
TB-3	1.5	6.2	20.6	72.0	0.50	33817	7-8	94.0	98
	1.3-1.7	6.0-6.4	20.2-20.91	71.6-72.74	0.49-0.52	33285-34415		93.4-94.4	52-220
TB-2	1.1	7.0	19.2	72.7	0.57	33465	6.5-7.5	92.8	48
	0.6-1.4	6.4-7.9	18.4-20.1	71.9-73.2	0.54-0.60	33034-33871		91.4-94.7	2.9-113

[a]*From Aihara, 1970. Results reported on an air-dried basis.*

southeast to 20.9 per cent in the northwest. Lowest FSI values (6.5 to 7.5) are associated with TB-2, while other sites tend to be in the order of 8.0. Lowest average fluidity also occurs at TB-2 (48 ddpm) with the highest being at TB-4 (708 ddpm). Sulphur values are all around 0.5 per cent, and calorific values are near 14 400 Btu/lb (33 500 kilojoules per kilogram). Drum-index values are all above 92 per cent. The Nittetsu reports conclude that B-seam is a superior coking coal.

Clean A-seam coal (Table 8) has average volatile matter contents (air-dried) ranging from 21.2 to 17.4 per cent, decreasing from southeast (TA-1) to northwest (TA-4). On a dry, ash-free basis the average volatile matter contents vary from 22.5 per cent in the southeast to 18.8 per cent in the northwest. FSI, at 3 and 4.5, and fluidity values are low at TA-3 and TA-4 relative to TA-1, where FSI is 6 to 7.5. Sulphur and calorific values are very similar to those of B-seam. Drum-index values are low at TA-3 and TA-4, but are equivalent to B-seam at TA-1. The conclusion was drawn that superior quality coking coal could be found in A-seam at the southeast end of the ridge, but that A-seam coal at the northwest end is semi-coking coal. Unfortunately TA-2 results were not reported. It was suggested that A-seam coal from the northwest might be blended with B-seam from the central or southeast part of the ridge to increase reserves of acceptable quality coking coal.

Two other seams, K1 and K5, were bulk sampled at Morrissey Creek. Clean coal volatile matter content of K1 averaged 14.4 per cent at 8.5 per cent ash, while K5 averaged 16.1 per cent at 8.8 per cent ash. FSI values of K1 ranged from 3 to 4, while those of K5 ranged from 3.5 to 5. Calorific values of K1 and K5 averaged 32 860 kilojoules per kilogram (14 126 Btu/lb), and 32 640 kilojoules per kilogram (14 035 Btu/lb), respectively. Average drum indices of 54.2 and 84.6 per cent respectively were obtained. This material appears to be potential semi-coking coal at best; it might be better described as thermal coal, especially in the case of K1.

RANK DISTRIBUTION

The Japanese survey reports concluded that the tendency of clean coal volatile matter contents and related coking properties to decrease from southeast to

TABLE 8
SUMMARY OF CLEAN A-SEAM TEST RESULTS AT JAPANESE STEEL MILLS[a]

ADIT	MOISTURE (%)	ASH (%)	VOLATILE MATTER (%)	FIXED CARBON (%)	S (%)	CALORIFIC VALUE (kJ/kg)	FSI	DRUM INDEX (+15mm)	FLUIDITY (ddpm)
TA-1	1.3 (avg)	4.5	21.2	73.0	0.41	34240	6-7.5	91.9	47
	1.0-1.5 (range)	4.15-4.8	20.75-21.8	72.0-73.6	0.38-0.42	33746-34843		89.9-94.4	1.95-225
TA-3	1.1	6.5	20.0	72.8	0.28	33566	3.5-4	58.0	6
	0.8-1.4	6.4-6.6	19.5-20.9	71.3-73.9	0.27-0.29	33076-34457		50.0-63.9	2.4-9
TA-4	1.2	6.6	17.4	74.8	0.45	33348	3-4.5	49.1	11
Upper	0.8-1.4	6.4-6.8	17.2-17.7	74.4-75.0	0.41-0.50	33201-33453		36.0-70.2	1.48-20
TA-4	1.2	5.8	17.5	75.6	0.36	33607	3-4.5	44.2	4
Lower	0.8-1.4	5.1-6.3	17.4-17.6	74.9-76.7	0.34-0.40	33536-33704		(only value)	1.6-7

[a]*From Aihara, 1970. Results reported on an air-dried basis.*

northwest (toward Morrissey Creek) in all seams represents a definite trend in coalification. This trend, or rank gradient, is corroborated by the work of Pearson and Grieve (1981, 1985). Vitrinite reflectance values of coal samples collected from this vicinity follow the same trend and are highest at the north end of Flathead Ridge (Figure 24). Rank values in the Morrissey Creek section are further enhanced by down-dip increases noted in the Crowsnest coalfield (Pearson and Grieve, 1985). The down-dip rank gradient at this point is 0.065 per cent per 100 metres of elevation. The net result is that essentially the entire Mist Mountain Formation section at Morrissey Creek contains coals of low-volatile bituminous rank ($\bar{R}_{o}$max >1.51%). A value of 1.85 per cent was obtained on the basal seam on Ridge 3, near the adit in K1-seam. $\bar{R}_{o}$max decreases to 1.69 per cent for the same horizon on Ridge 5, and to 1.62 per cent near the pipeline (Figures 23 and 24). In other words, at least some exposed Mist Mountain coals are low-volatile in rank throughout the length of the study area.

Reflectance of A-seam coals ranges from approximately 1.26 per cent at the pipeline to 1.39 per cent on Ridge 6, to 1.56 per cent in Morrissey Creek valley (Figure 24). B-seam values are very similar (Pearson and Grieve, 1981). Therefore, these seams are predominantly medium-volatile bituminous at their outcrop locations, except at the extreme northwest end of the property, where, because of the regional rank gradient and down-dip rank increases, A and B-seams are low-volatile. Down-dip rank increases are predicted to boost the rank of these seams at all locations along Flathead Ridge into the low-volatile category at some point.

The high rank of coal in Morrissey Creek was a major contributary factor to the permanent closure of Morrissey Colliery in 1909, and this is important to consider when evaluating the Flathead Ridge resource.

Predicted Coal Quality

Flathead Ridge is predicted to contain a significant amount of non-coking coal (Figure 15), encompassing only the basal Mist Mountain Formation at the southeast end, but gradually taking in an increasing proportion of the total section in a northwesterly direction. Non-coking coals are predicted to be overlain by coking coal Group 1 coals. The part of the section corresponding with A and B-seams is predicted to fall into coking coal Group 2 throughout most of the length of Flathead Ridge. At the northwest end of the ridge, the Morrissey valley, these seams are predicted to fall into Group 1. This change is related to regional rank gradients and down-dip rank increases. Down-dip extensions of the ridge exposures of A and B-seams are predicted to become Group 1 coals

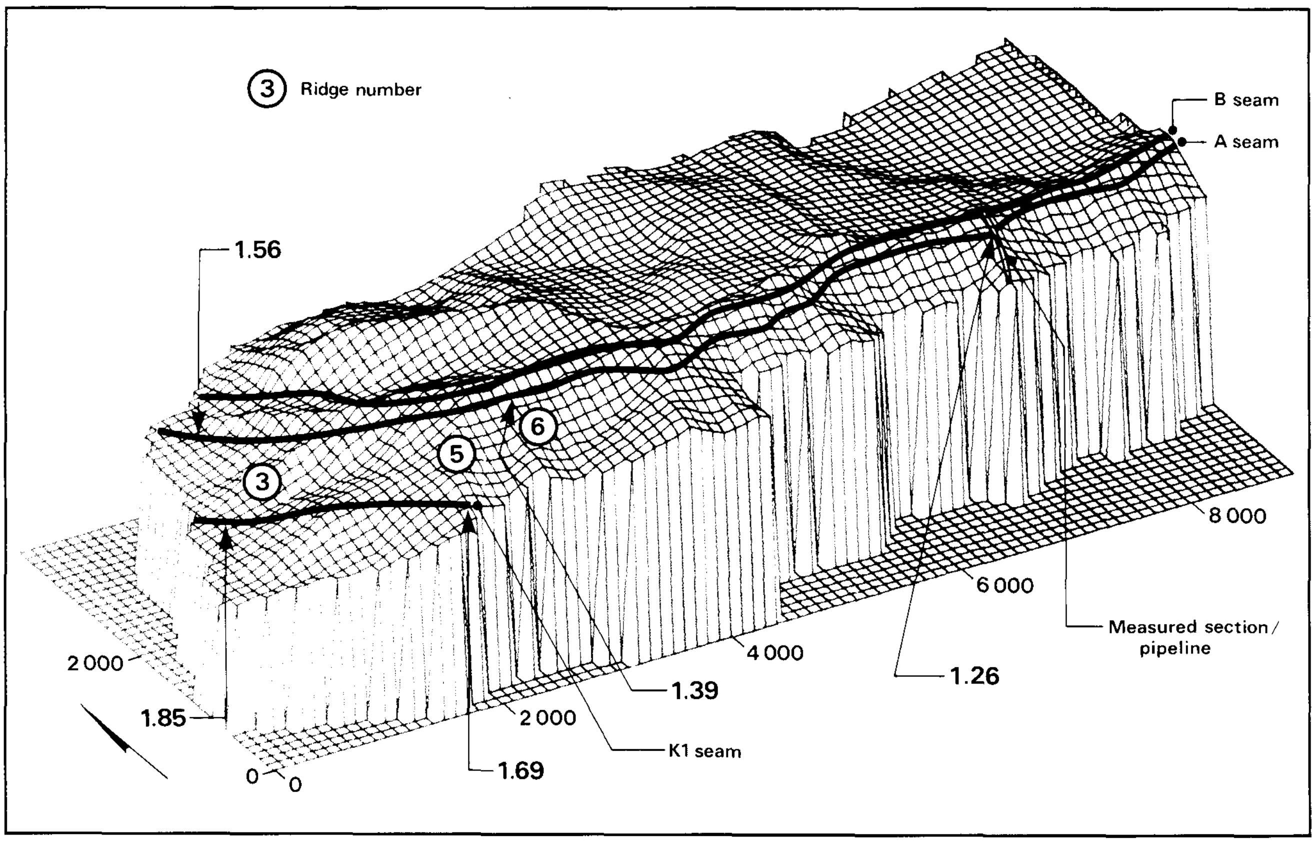


Figure 24. Isometric diagram of the surface topography of Flathead Ridge in Parcel 82 with major contacts, coal seams and B and reflectance values displayed. The view is looking down on the deposit in a grid-northeasterly direction.

at some point and perhaps eventually non-coking coals. Some of the characteristics of Group 2 coals, including 1500 to 30 000 ddpm fluidity, are higher than results actually reported for A and B-seams (Tables 1, 7, 8) and A and B-seams appear to be more similar to Group 1 coals or intermediate between the two groups. The separate quality prediction maps (Figures 10 to 14), however, appear to give realistic values, including generally 20 to 25 per cent volatile matter and FSI generally above 6, although actual fluidity values are lower than predicted. High predicted ASTM stability factors coincide with the high drum- index values (Tables 7, 8). Predicted dilatation of A and B-seams ranges from less than 50 per cent at Morrissey Creek to intermediate to high at the southeast boundary, but there are not enough dilatation values in the assessment reports to evaluate this prediction. The prediction maps have insufficient resolution to predict the contrast between A and B-seams, in particular the manner in which A-seam quality deteriorates in the vicinity of adits TA-3 and TA-4 (Table 7).

DEPOSIT MODEL

OBJECTIVES

The purpose of the digital deposit model of A and B coal zones in the Flathead Ridge area is to assess the coal resource associated with these seams. Outcrop as well as subsurface data are available which provide the ability to model seam thicknesses and distributions, and apply confidences to resource estimates to a greater extent than with Parcel 73.

GRID SPECIFICATIONS

The grid area was selected to best cover the area of interest within the smallest possible area. A 39 row by 90 column grid (3510 grid nodes) with a node spacing of 100 metres was used. The grid was rotated from true north to run parallel to Flathead Ridge. Grid north is 41 degrees east of true north. All data were collected or transformed to be relative to this new north reference.

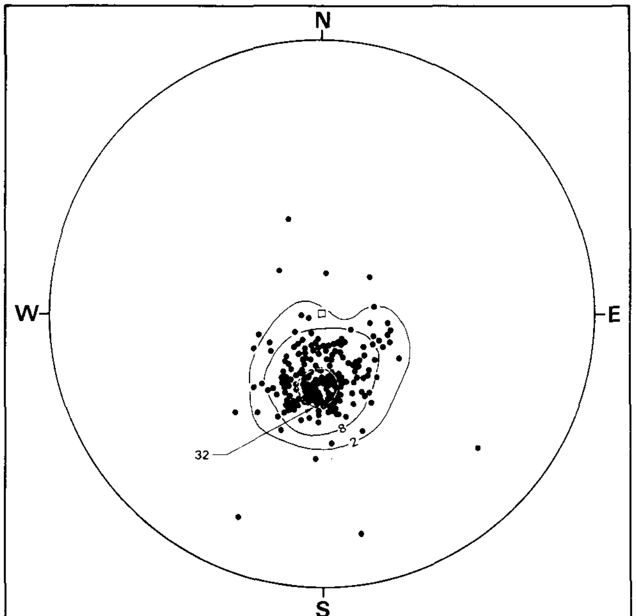
DATA SOURCES

The geologic and stratigraphic information used for the model were collected from a variety of existing sources as well as from field mapping in conjunction with this project. Topographic values were taken from a 1:5000 map with 5-metre contour intervals (Harada *et al.*, 1968). Orientation data from outcrops were obtained from existing geological maps using the computer program COD (Coal Outcrop Digitizer) and from field measurements. Seam position and thickness measurements were obtained from outcrops, trenches and boreholes. Seam position and thickness information was collected for six seams in two zones. A and B-seams are found throughout the entire model area. The other four seams, Al (A-lower), Bu (B-upper), A1, and A2, are of limited extent.

GRID CONSTRUCTION

The topographic grid, due to its large size, was generated using a semi-automated data collection technique. A digitizing tablet and an IBM-XT were used to record the raw elevation data from the topographic map. Lines joining the columns of grid nodes (north-south) were drawn on the map. A digitizing program (TOPOLINE) was written and used to digitize the contour intersections with each of these lines. A 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 resulting series of elevations along the 90 column lines were then placed in the Cal Data Ltd. grid format. The digitizing process required about 16 hours of work. The advantage of collecting the raw data electronically is that if the grid-node spacing is ever changed, the original raw data need only be reprocessed rather than recollected.

Positions of the coal seams within the deposit were calculated relative to the position of the B-seam. B-Seam



FLATHEAD RIDGE

EIGENVAL. N	TREND	PLUNGE
.9476	179.2	70.4
.0295	32.6	16.4
.0229	299.7	10.1

POLES TO BEDDING (223 POINTS)..........•

Figure 25. Plot of poles to bedding on Flathead Ridge in Parcel 82 (Wulff projection) with associated eigenvectors and eigenvalues.

is continuous over the whole deposit and has more positional data than any of the other seams. By positioning the other seams relative to B-seam a better stratigraphic relationship was maintained than by positioning each seam independently.

B-seam was positioned using a modification of the down-plunge projection technique. Selection of the initial projection orientation was based on the analysis of the outcrop orientation data plotted on a pi-diagram (Figure 25). The projection direction should be parallel to the fold-axis or 90 degrees away from the maximum concentration of poles to bedding. After initial selection of the projection direction, minor orientation adjustments were made on a trial-and-error basis to minimize the scatter of B-seam position data points. Following selection of the best projection orientation, which was 80°/0° (trend/plunge), the position of the seam was manually traced onto the profile (Figure 26a). This line was then digitized and projected parallel to the selected projection direction so that its position at each grid centre could be calculated. The result is a surface (Figure 26b) which has the cross-sectional shape of the seam trace on the profile and is oriented parallel to the projection direction. This surface reflects the general structure of the seam but, because it is artificial, does not necessarily honour any of the B-Seam positional data. To solve this problem a residual grid of the distances between the raw positional data and the projected grid was constructed (Figure 26c). An inverse distance-squared moving average algorithm was used to generate the grid. The grid of residuals was subtracted from the projected grid to yield a new seam-position grid which retained the geologist's overall structural interpretation, yet honoured the raw data (Figure 26d).

A-seam was positioned by determining a grid of A-seam to B-seam distances and subtracting this grid from the B-seam position grid. Only four widely spaced boreholes provide useable information for this purpose; a grid was constructed from these raw data using an inverse distance-squared moving average technique.

Once these two seam-position grids were constructed they were trimmed by removing those grid nodes which represented seam positions above the present topographic surface.

The four minor seam position grids were obtained in a similar manner except that constant interseam thicknesses were used for each seam. These interval thicknesses were 1, -1, -8 and -16 metres for B-Bu, A-Al, A-A1 and A-A2 respectively. The grids were trimmed at the topographic surface. The trim lines used were the same for the minor seams as the lines used for the associated major seam. The 100-metre grid-node spacing and the steep face of the ridge made use of these common trim lines acceptable, as additional grid nodes would not be included by the lower seam traces. In the subsurface,

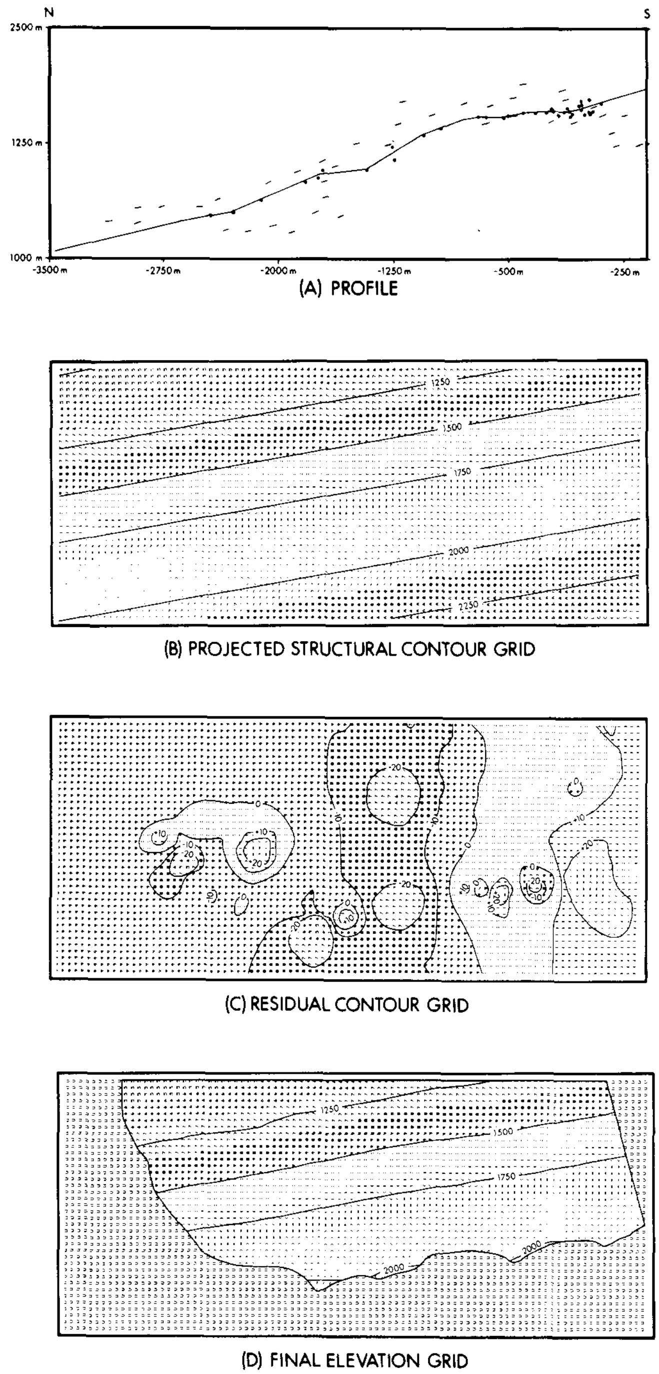


Figure 26. (a) Down-plunge projection profile of B-seam data (dots) and selected outcrop orientation data (pitch lines). Interpreted B-seam position also shown; (b) B-seam structural contour grid obtained by projecting interpreted B-seam position line from (a) parallel to the projection direction; (c) Residual grid, obtained by gridding the difference between B-seam positional data and the B-seam structural contour grid; (d) Final B-seam position grid obtained by subtracting the residual grid from the grid displayed in (b). This grid has been trimmed at outcrop and property boundaries.

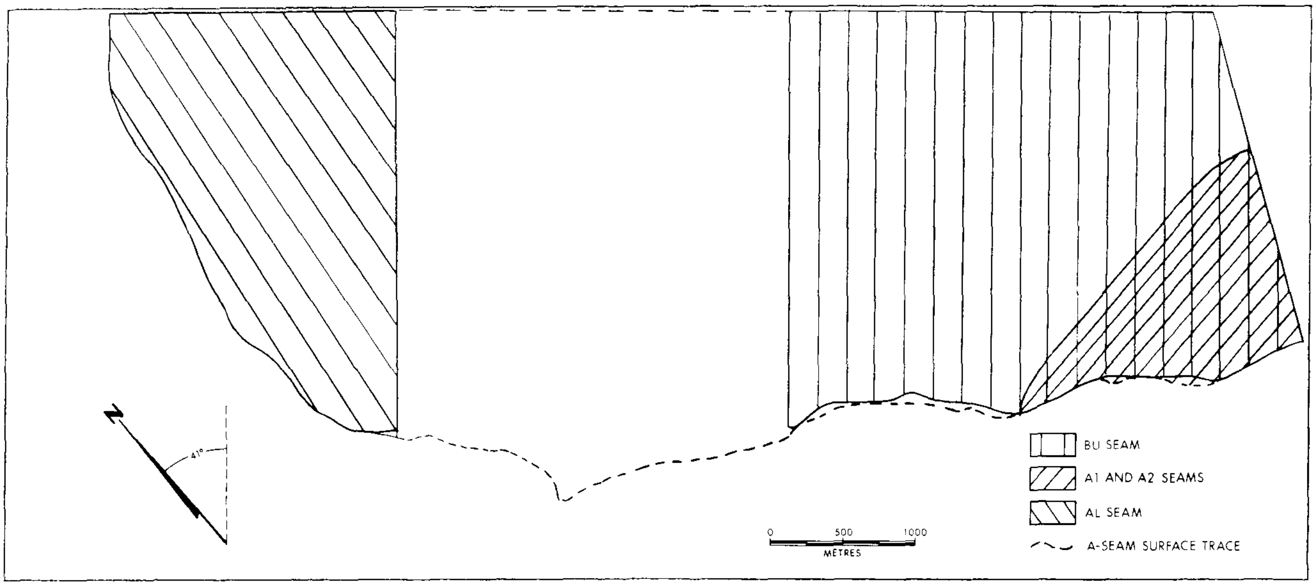


Figure 27. Areal distribution of seams used in the digital deposit model. A and B-seams are found over the whole area with only minor differences in outcrop traces.

seams A1, A2 and Bu were trimmed along interpreted pinchout lines (Figure 27).

Seam-thickness grids for all the seams were obtained by a $1/d^2$ moving average algorithm. Total coal thickness within seams, rather than actual seam thicknesses, were used in these calculations. Semi-variograms were constructed for the thickness data, but due to the limited number and poor distribution of the data points these plots were of little use. The method used actually generates a smooth version of the results obtained by the polygon method. In one borehole an exceedingly thick B-seam intersection of 17.11 metres was arbitrarily reduced to 10 metres as it was felt that this anomalous thickness was not depositional, but due to local structure and should not influence too great an area of the model. Some trenches did not expose the entire seam and thicknesses are reported as a value followed by a plus sign. Only the reported thickness was used; thus seam thickness values are on the conservative side.

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 because geostatistical parameters such as those in Kilby and McClymont (1985) were unobtainable; the quality of the raw data was inadequate to define these parameters.

Modelling and Analysis

The basic model consists of 19 primary grids (Table 9; Appendix 2). These primary grids are used to construct secondary grids to answer deposit related questions (Table 9).

Analysis of the model concentrated on the definition of the coal resource as to its potential exploitation. Important calculations are:

(1) the total coal resource;

(2) resource by confidence category; and

(3) the waste-to-coal ratio distribution.

Assesment of the total coal resource of the model area is possible on a seam-by-seam basis or on a total cumulative basis. The individual seam-thickness grids can be plotted to illustrate the various thickness distributions. The total volume of coal associated with each seam can

TABLE 9
LIST OF GRIDS IN THE FLATHEAD RIDGE MODEL
PARCEL 82

GRID NAME	GRID DESCRIPTION
FLATOPO.FLT	Topography elevation
BU-Final.FLT	Upper B-seam top elevation
B-Final.FLT	B-seam top elevation
A-Final.FLT	A-seam top elevation
AL-Final.FLT	Lower A-seam top elevation
A1-Final.FLT	A1-seam top elevation
A2-Final.FLT	A2-seam top elevation
BU-THIKS.FLT	Upper B-seam thickness
B-THIKS.FLT	B-seam
A-THIKS.FLT	A-seam
AL-THIKS.FLT	Lower A-seam
A1-THIKS.FLT	A1-seam
A2-THIKS.FLT	A2-seam
BU-DIST.FLT	Upper B-seam distance to data pt.
B-DIST.FLT	B-seam distance to data pt.
A-DIST.FLT	A-seam distance to data pt.
AL-DIST.FLT	Lower A-seam distance to data pt.
A1-DIST.FLT	A1-seam distance to data pt.
A2-DIST.FLT	A2-seam distance to data pt.

TABLE 10
RESERVES AND RESOURCES, FLATHEAD RIDGE, PARCEL 82

SEAM	MEASURED (tonnes)	INDICATED (tonnes)	INFERRED (tonnes)	TOTAL (tonnes)
A	6 286 130	12 815 100	86 778 000	105 879 000
AL	1 023 340	3 253 450	17 920 200	22 197 000
A1	673 532	1 067 230	3 283 410	5 024 170
A2	634 593	1 052 550	3 472 390	5 159 530
B	8 390 460	11 628 200	69 645 700	89 664 300
BU	463 211	351 411	1 040 260	1 854 880
Total	17 471 266	30 167 941	182 139 960	229 778 880

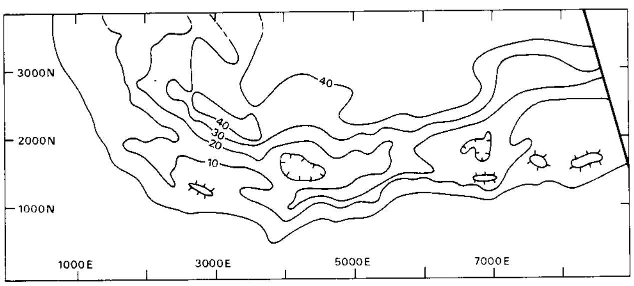


Figure 28. Distribution of waste-to-coal ratios over Flathead Ridge in Parcel 82, as derived from the model.

be calculated by multiplying the appropriate thickness grid by 10 000 (100 by 100 metres grid cell) and by 1.32 grams/cubic centimetre (specific gravity of coal). Placement of these resources into the various confidence categories can be achieved by reference to the distance-to-data grids. Table 10 illustrates the breakdown of the coal resources into the categories of measured, indicated and inferred based on the distance-to-data intervals of 0-150, 150-300 and greater than 300 metres. These values could be further defined by determining the tonnage of the resource within specific categories and having specific waste-to-coal ratios. Figure 28 illustrates the distribution of total waste-to-coal ratios for the entire model area. As would be expected, the majority of the low-ratio coals are along the ridge face where the seams crop out. An area of low-ratio coal is shown behind the ridge crest at the southern end of the model. This occurrence is very possibly due to the calculation method and data spacing; this problem cannot be resolved without additional subsurface data.

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

- B-seam position is cylindrically folded about a horizontal axis with a trend of grid 080 degrees;
- all seams are subparallel to B-seam;
- there are no major structural complications in the subsurface;
- all coal in the deposit has a specific gravity of 1.32 grams/cubic centimetre;
- all tonnage calculations are strictly on an *in-situ* basis.

RESOURCE CALCULATIONS

The coal resource potential of Flathead Ridge was calculated using all available data for the six seams examined in the study. A significant number of bedding orientations, seam surface-trace positions and seam positions in the subsurface are available from boreholes and adits. This quality of data allows categorization of the resources based on a strict distance-to-data basis. Although this method is somewhat arbitrary it does provide a standard format for reporting tonnages when the data are insufficient to complete a geostatistical evaluation. As in the calculations performed on Parcel 73 there are several significant sources of error in these results.

Errors associated with positioning of the seam surface-traces and the inclusion or exclusion of specific grid nodes are felt to be minimal due to the offsetting nature of these errors. Significant errors may be present in the areal distribution of the seams due to the location of seam pinchouts. Pinchout locations are based largely on outcrop evidence as there is little subsurface control to assist in determining the orientation of these features; therefore they were oriented parallel to the grid (Figure 27). The use of a single cross-section and one projection to define the entire deposit may cause local errors in vertical seam positioning. The large area of low mining-ratio coal at the southeast corner of the deposit may have been influenced by this type of problem but the total tonnage in the deposit is not greatly affected. The calculations used to derive the data in Table 10 assume:

- seam thickness is total coal within the seam interval
- all seams have a constant density of 1.32 grams/cubic centimetre
- minimum seam thickness to be considered is 1.3 metres.

Unlike the Parcel 73 calculations, the reduction of seam thickness to match the total coal within the seam interval reduces the calculated tonnage and reflects only the coal in place. The run-of-mine tonnages required to remove this resource would be much larger, including seam partings and roof and floor dilution.

Tonnage calculation methodology used on this deposit was very similar to that used on Parcel 73 with the exception that variable seam thicknesses were used in some cases and distance-to-data categories were applied. The calculations were all made using the grids contained in Appendix 2 and the program G-CALC. Table 9 illustrates that approximately 230 million tonnes of *in situ* coal is contained within the study area and about 17.5 million of this falls in the measured category.

There is very little low-ratio coal in the deposit, most being along the steep southern face of Flathead Ridge. Figure 28 shows several areas north of the ridge which contain ratios of 20:1 or less. As discussed earlier, caution must be used when assessing these areas because of the long projection distances and smoothing nature of the gridding alogrithims, illustrated in Figure 26, may result in the seams being positioned above their true location in some cases. These moderate-ratio areas offer the best potential for better mining ratios and warrant additional investigation.

MINING METHODS AND LOGISTICS

The feasibility report concerning underground mining of the Pacific Coal Ltd. property by Nittetsu Mining Co. Ltd. (Skiokawa, 1968) was submitted at the end of four years of exploration. The mining plan envisaged the main mine entrance to be at an elevation of 1160 metres on the southeast side of Morrissey Creek, with the main level developed along the strike of the seam. Longwall mining was selected as the most feasible method to exploit the dip of the seams (10 to 20 degrees) and to ensure maximum recovery, ventilation and productivity. Working faces were planned to be 80 metres long. The estimated amount of drifting required for the development of the first panel, with two faces, was 10 030 metres, of which 1420 metres would be through rock. Normal annual production rate was projected to be 1 million tonnes.

The Mitsui report (Aihara, 1970) presented an alternative development scenario based on the application of room-and-pillar mining where possible, especially in areas of low dip coinciding with seam thickness of greater than 3.0 metres.

The property is very close to rail transportation; the proposed underground mine entrance is less than 6 kilometres east of the Canadian Pacific Railway. There is a large area of flat land, which is not coal-bearing, near the confluence of Morrissey Creek and Elk River suitable for a rail loop and loading facilities (the same site assessed by Sage Creek Coal Ltd. for the same purpose), and also for a preparation plant and other facilities.

PARCEL 82 - MOUNT TAYLOR

STRUCTURE

The Mount Taylor area is on the east side of the Fernie basin. Exposed coal-bearing strata in this vicinity lie east of the trace of the west-dipping Flathead normal fault (Figure 22). The dominant structure is the north-trending, locally overturned Taylor syncline, which is flanked by converging fold structures. The most important of these flanking folds is the Barnes anticline or anticlinorium (Ollerenshaw, 1981a), with its axis trending northwesterly to where it disappears underneath the East Crop normal fault. This latter structure, termed the McEvoy retrothrust by Ollerenshaw, is a low-angle, west-dipping splay of the Flathead fault. It was initially a thrust fault, but net movement after extension was normal (Ollerenshaw, 1981a; Pearson and Grieve, 1985). Within Parcel 82 the East Crop fault has had the effect of thinning the exposed Kootenay Group on the east limb of the Taylor syncline. At several locations the Cadomin Formation rests in fault contact with lower Mist Mountain Formation strata, with an estimated net stratigraphic displacement of greater than 550 metres (Figure 22). The East Crop fault appears to die out to the north.

Structural data taken from the geological maps provide 94 stations which yield a deposit-wide fold axis orientation of 188°/03°. Two major structures occur within the deposit area: the Taylor syncline and the Barnes anticline. Analysis of the structural data from these two areas provides fold axis orientations of 186°/04° and 338°/08°, respectively. The two structures are separated by the East Crop fault which, as mapped, is an unusual feature, with displacement varying from zero in the north to a significant displacement within 2000 metres to the south. In addition the close association of compressional and extensional structures along this fault trace make structural interpretation, let alone modeling, difficult. Fieldwork was not a part of the analysis of this deposit with the result that some mapped features such as tentative seam correlations were modified where their position was incongruous with the major structures as mapped.

The structure of the Mount Taylor deposit area is complex. The complexities are obvious from field mapping and will undoubtedly be severe locally and extremely confusing when subsurface information becomes available.

STRATIGRAPHY

A generalized section of Mist Mountain Formation on the east side of Mount Taylor is shown in Figure 29. It was modified after Gibson (1985, Figure 5) using infor-

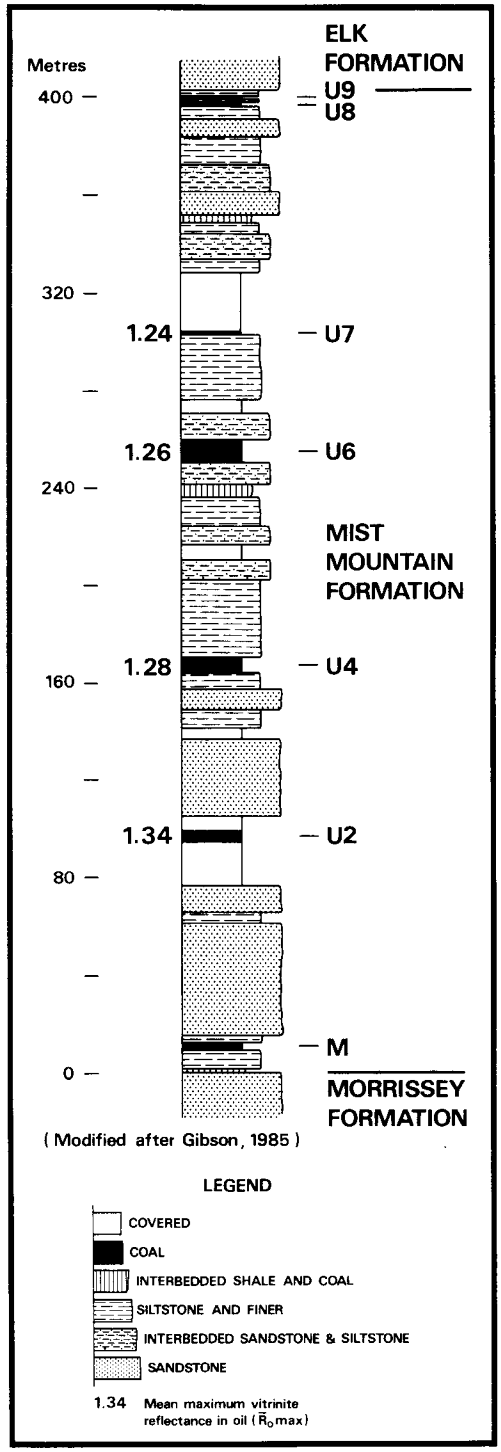


Figure 29. Stratigraphic section from Mount Taylor, Parcel 82, with coal rank values. (Section modified after Gibson, 1985, Fig. 5).

mation in the Mount Taylor assessment report (Ohtaki, 1967). The Mist Mountain Formation at Mount Taylor is approximately 400 metres thick and contains ten seams of which seven are shown in the generalized section. They are named upward from M at the base, L (not shown), U2 (usually accompanied by lower and upper splits U1 and U3, respectively), U4, U5 (discontinuous and not shown), U6, U7, U8 and U9. The last two are close enough together to be considered as one seam (Figure 29). On the property the major seams are M, U2, U4 and U6. They range in thickness as follows: M-seam, 5.5 to 11 metres; U2-seam, 4.3 to 16.7 metres; U4-seam, 1.5 to 8.5 metres; and U6-seam, 4.6 to 6.7 metres.

Two very thick sandstone units occur in the lower part of the Mist Mountain Formation, the more prominent of which occurs between M and U2-seams.

COAL QUALITY

WASHABILITY

Float-sink tests were carried out only on bulk samples from "Adit 67" in U2-seam. Results are reported on the 25 x 0.5 millimetre fraction of samples designated Fernie-A and Fernie-B (Ohtaki, 1967). This size fraction comprises 91.5 and 90.2 per cent respectively, of raw coal in the two samples. Unfortunately there is no indication what the two samples represent. Moreover, the float-sink tests did not separate specific gravity fractions greater than 1.60, which necessitated some interpolation and extrapolation in calculations. Nonetheless, we plotted cumulative float and specific gravity curves and calculated yield and specific gravity for 7, 8, 9 and 12 per cent clean-coal ash contents (Table 11). The yields of the A sample are slightly better than the B sample; yields of 77, 81 and 84 per cent were calculated for clean-coal ash contents of 7, 8 and 9 per cent respectively.

TABLE 11
MOUNT TAYLOR U2-SEAM WASHABILITY[a]

SAMPLE A				
Clean-coal ash	7	8	9	12
S.G.	1.51	1.59	1.66[b]	-
Calculated yield (%)	77	81	84	91
SAMPLE B				
Clean-coal ash	7	8	9	12
S.G.	1.50	1.59	1.66[b]	-
Calculated yield (%)	72	77	80	87

[a]*Derived from data in Ohtaki, 1967.*
[b]*Extrapolated value.*

OTHER ANALYSES

Characteristics of the clean M-seam bulk sample from Adit 66 are presented in Table 12. Adit 66 was only 11 metres long and hence this sample was oxidized (Ohtaki, 1967). The raw sample contained 16 per cent ash. The cleaned sample had a volatile matter content (daf) of 17.6 per cent and a calorific value of 32 155 kilojoules/kilogram (13 824 Btu/lb).

TABLE 12
MOUNT TAYLOR M-SEAM QUALITY[a]

RAW COAL		CLEAN COAL	
Ash (%)	15.78	Moisture (%)	1.4
Sulphur (%)	0.51	Ash (%)	9.6
		Volatile Matter (%)	15.7
		Fixed Carbon (%)	73.3
		Calorific Value (kJ/kg)	32155

[a]*From Ohtaki, 1967. Results reported on an air-dried basis.*

Characteristics of the +1.60 specific gravity fraction of the Fernie-A and Fernie-B bulk samples of U2-seam (Adit 67) are listed in Table 13. Volatile matter contents (daf) are between 22 and 23 per cent; FSI values are 5 1/2 and 7; sulphur values are both 0.4 per cent; and calorific values are both over 32 650 kilojoules/kilogram (14 040 Btu/lb).

Results of analyses on a surface (outcrop) sample of U4-seam are listed in the assessment report, but are of dubious value and are not reproduced here.

TABLE 13
MOUNT TAYLOR U2-SEAM QUALITY[a]

	SAMPLE A	SAMPLE B
Moisture (%)	1.5	1.6
Volatile Matter (%)	20.6	19.9
Fixed Carbon (%)	69.8	70.3
Ash (%)	8.1	8.2
Calorific Value (kJ/kg)	33034	32825
Sulphur (%)	0.4	0.4
FSI	7	5

[a]*From Ohtaki, 1967. All results on the +1.60 S.G. fraction. Results reported on an air-dried basis.*

RANK DISTRIBUTIONS

Vitrinite reflectance values are shown in Figures 29 and 30. In general, the area surrounding Mount Taylor contains medium-volatile coals in the lower part of the Mist Mountain section, overlain by high-volatile A coals ($\bar{R}_o max < 1.12\%$) in the upper part. For example, the M-seam immediately west of Mount Taylor has a reflectance of 1.38 per cent, while U8-seam just east of the mountain has a reflectance of 1.09 per cent (Figure 30). In general rank values increase from north to south, so that the M-seam reflectance values in the south part of the Mount Taylor grid are in excess of 1.6 per cent (Figure 30). This is manifested as a small zone of low-volatile coals ($\bar{R}_o max > 1.51\%$) in the regional rank map, Figure 9. The reflectance of U8-seam increases to 1.17 per cent over the same distance.

A gap in rank values is associated with the East Crop normal fault, with high-volatile bituminous coals occurring in its hangingwall and low-volatile coals in its footwall (Figure 9; Pearson and Grieve, 1985).

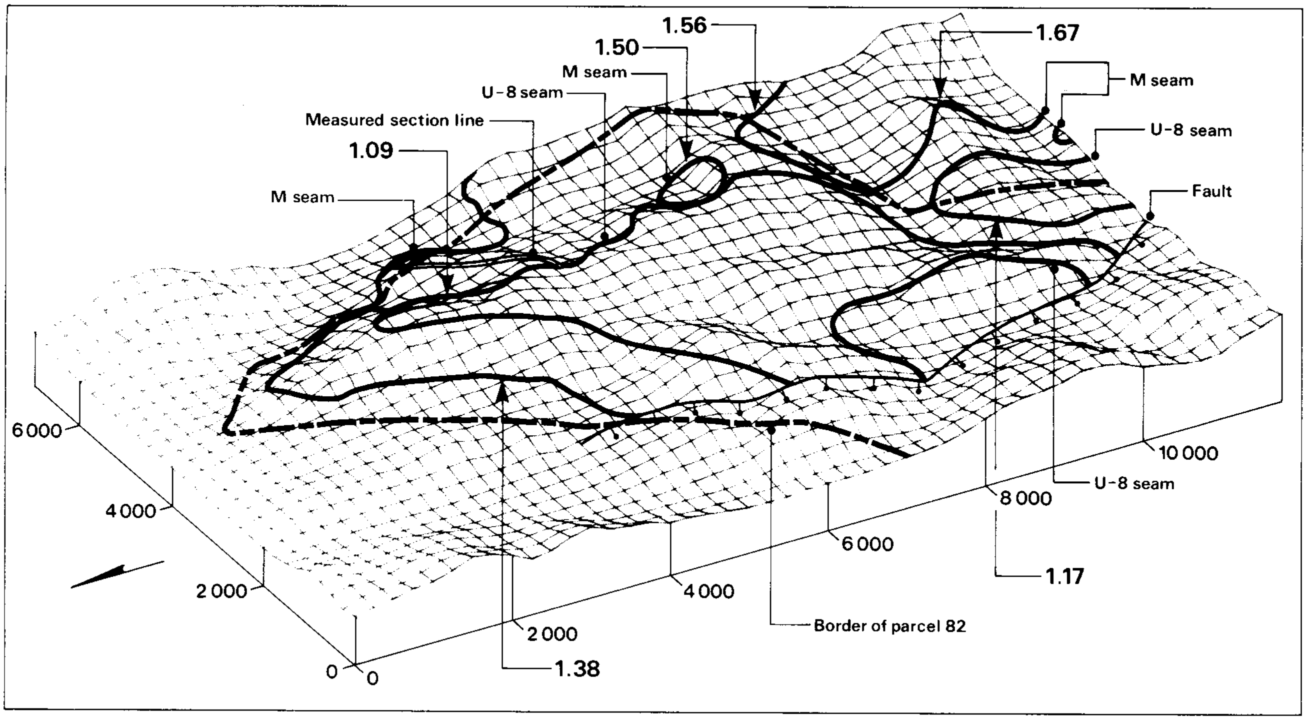


Figure 30. Isometric diagram of the surface topography of Mount Taylor in Parcel 82, selected coal seam traces and reflectance values. The view looking down on the deposit in a southeasterly direction.

PREDICTED QUALITY

In contrast with the other deposits discussed in this paper, predicted coal quality characteristics in the Mount Taylor area are fairly typical of coals currently produced in southeastern British Columbia. The small area of high rank in the south part of the area is expected to be non-coking coal (Figure 15). The remainder is predicted to contain coking coal Group 3 (Balmer type) and Group 2, with the latter corresponding with seams in the upper part of the section. This is similar, for example, to the distribution in the Sparwood-Michel area, which includes the Westar Mining Ltd. Balmer operations. There is not enough quality information from Mount Taylor available to make a rigorous comparison with the characteristics of these predicted coal groups, although the volatile contents of U2-seam (22 to 23%, daf) are within the range for Group 3 (19 to 26%). The separate quality prediction maps (Figures 10 to 14) indicate the following ranges of predicted properties from base to top of section: volatiles from 20 to greater than 30 per cent; FSI from 4 to greater than 8; dilatation from less than 50 to greater than 100 per cent; and fluidity from less than 100 to greater than 1000 ddpm. Predicted ASTM coke stability values are locally above 55 per cent and always above 40 per cent.

DEPOSIT MODEL

OBJECTIVES

The Mount Taylor area has the least available data of the three areas examined in this study. The purpose of the modeling was to use automated techniques to calculate the resource potential of the area using available information. Major geologic assumptions were made but the model duplicates the significant seam traces as located by Gigliotti and Pearson (1978).

GRID SPECIFICATIONS

The grid selected for the Mount Taylor model was oriented true north and has a grid-node spacing of 250 metres (Figure 5). The grid contains 48 rows and 29 columns of grid-nodes for a total of 1392 calculation sites. The large grid-node spacing was justified by the regional nature of our calculations and the lack of detailed geological information. The positioning and orientation of the grid were based on the 1:50 000 topographic map. The grid origin (south-west grid node) has a UTM coordinate of 658175E and 5481180N and the grid is oriented 2 degrees west of the UTM grid north.

DATA SOURCES

Topographic data were obtained from a 1:20 000 map with a 100-foot contour interval (Ohtaki, 1967). This data was only present for the area within the property boundary. Areas within the model but outside the property boundary were covered by a 1:50 000 NTS map. Unfortunately the two maps could not be joined due to significant elevation differences for the same positions. The topography was manually digitized.

Bedding orientation data from outcrops and seam surface-trace locations were collected from Gigliotti and

Pearson (1978). A combination of manual and machine-based digitizing was used to obtain this data. Seam thicknesses were assumed constant and were derived from the measured section in Gibson (1985) (Figure 29).

Grid Construction

Grids contained in the deposit model define the positions of the five major seams and the topography (Table 14). The large-scale topographic grid only covers the area within the boundaries of Parcel 82. A template grid was constructed to provide accurate boundary cutoff information. This grid contained a "1" value at each grid node which fell within the boundaries and a "0" at each node outside the boundaries. This grid was used in the analysis phase of the project and will be discussed in the appropriate section. A similar template grid was constructed to provide a cutoff on the west side of the model where the coal-bearing stratigraphy is truncated by a large fault.

TABLE 14
LIST OF GRIDS IN THE MOUNT TAYLOR MODEL
PARCEL 82

GRID NAME	GRID DESCRIPTION
TAYLOR-T.TAY	Topography elevation
U8SEAM.TAY	U8-seam top elevation
U6SEAM.TAY	U6-seam top elevation
U4SEAM.TAY	U4-seam top elevation
U2SEAM.TAY	U2-seam top elevation
MSEAM.TAY	M-seam top elevation

Construction of seam-position grids involved a combination of methods. First the structural orientation of the area was determined using the orientation data which had been collected (Figure 31). This was the starting point for an interactive down-plunge projection process which determined the best viewing direction to align the positional data from the various coal seams. Due to the scarcity of data and the possible existence of non-cylindrical folds in the area, the projection technique was of limited use, but was employed to define the position of the M-seam over the Barnes anticline.

The major part of the study area was modeled by defining the position of the best known surface and positioning the rest of the stratigraphy relative to it. The U8-seam was used due to its proximity to the overlying Cadomin conglomerate which is a reliable marker horizon throughout the area. The surface position of the conglomerate minus the appropriate stratigraphic interval modified for strata dip, was used to fix the position of the U8-seam. These locations, together with known U8 locations were plotted on a map and manually contoured to produce a structure contour map of the seam. This map was then manually digitized into the grid format in a manner similar to the topography.

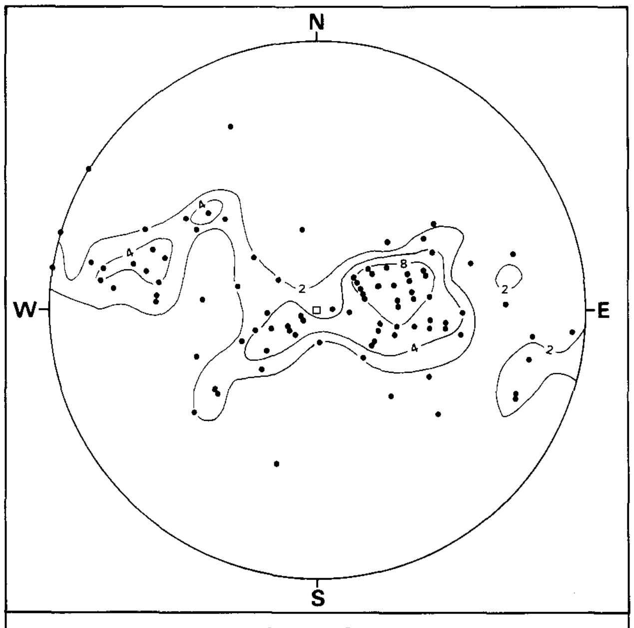
The U2-seam was modeled by two methods: down-plunge projection and conformable thickness. The seam crops out only along the northern edge of the area, with no surface expression or usable position information available elsewhere. The model fold-axis orientation was used in conjunction with the outcrop positions to construct a projected grid surface. In the areas overlain by the U8-seam a constant stratigraphic thickness was used to modify the U2-seam position. The combination of methods was required to maintain the known outcrop seam trace positions in the model and maintain the known stratigraphic thicknesses. The U6, U4 and M-seams were positioned relative to the U2-seam.

M-seam was modeled over the Barnes anticline using the down-plunge projection method, and in the rest of the area using a combination of methods as described above. The two resulting grids were then combined using prominent fault traces as the joining boundaries. The resulting discontinuity in the grid values at the joining boundary was smoothed manually by editing the combined grid file.

When all seam grid surfaces had been constructed they were trimmed against the topography, property boundary and western fault trace using the trim function of the G-CALC program.

Modelling and Analysis

The Mount Taylor model contains six gridded surfaces (Table 14). Five surfaces contain seam elevations



MT. TAYLOR

EIGENVAL./N	TREND	PLUNGE
.6329	83.3	78.4
.3061	278.5	11.1
.0610	187.8	2.9

POLES TO BEDDING (94 POINTS)........•

Figure 31. Plots of poles to bedding on Mount Taylor (Wulff projection) including associated eigenvalues and eigenvectors.

and one grid contains the topographic elevation information.

The following major assumptions were made due to the small scale of the study and limited data:

- all seams have a uniform thickness over the study area;
- two projection orientations can be used to define the seam positions, with local modifications;
- seams between U2 and U8 can be positioned on the basis of their relative stratigraphic position;
- at the scale of the model, vertical fault cutoffs can be used to define the areal extent of the seams;
- stratigraphic intervals between the seams remain constant over the model area; and
- the Cadomin Formation is a more mappable unit than the U8-seam and takes precedence over it in modeling the seam positions.

Resource Calculation

Coal resource calculations were made on the Mount Taylor deposit using a minimum of geologic data. No subsurface information is available and thickness data are insufficient to document any lateral variations. The resulting calculations are simple, as dictated by the lack of data. Grid construction was labour intensive (*see* previous section) but actual volumetrics based on the resultant grids were straightforward. Seam thicknesses used in the calculations are M-seam, 3.5 metres; U2-seam, 4.2 metres; U4-seam, 2.7 metres; U6-seam, 5 metres; and U8-seam, 3 metres. The thickness ranges of these seams has been previously noted and the present selection of thickness values is based on a somewhat arbitrary but geologically influenced best average value; the actual tonnages may vary significantly from those calculated here but could be quickly modified to reflect a different seam thickness value. Seam surface traces in the model were made to coincide as closely as possible with the traces noted on the referenced geological maps. The areal extent of the seams is considered to be acceptable at the scale of the model. The resolution along the trace and the determination that a seam is present within a given grid cell based on the relationship of grid-nodes and seam traces, is felt to be realistic. The seam configuration conforms to the mapped structures but with no subsurface control large errors in the vertical positions of seams may be present. The following assumptions were made in the tonnage calculations:

- all seams have a constant density of 1.3 grams per cubic centimetre;
- each seam has a constant thickness.

The resource values contained in Table 15 are extremely speculative. The seam thickness values are conservative so it is expected that the total tonnage in the deposit will be greater than the 613 million tonnes indicated in Table 15, but locally the variations could be extreme.

The waste-to-coal ratio distribution map (Figure 32) must be viewed with caution. Due to the many sources of errors noted, the actual values indicated on this map are expected to be dubious. The value of the map is in the relative distribution of the ratios. Ratios on the map are for the total coal section, to the base of M-seam. If only

TABLE 15
POTENTIAL COAL RESOURCES, MOUNT TAYLOR
PARCEL 82

SEAM	IN-SITU TONNES
M-seam	167 400 000
U2-seam	154 507 500
U4-seam	83 378 700
U6-seam	147 960 000
U8-seam	59 737 500
Total	612 983 700 tonnes

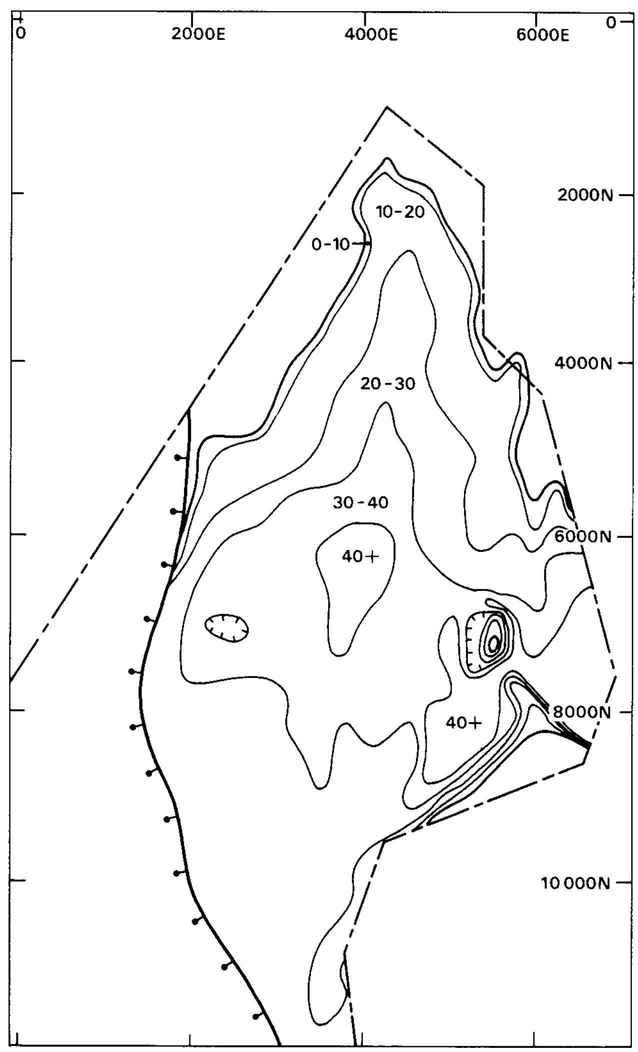


Figure 32. Distribution of waste-to-coal ratios over Mount Taylor in Parcel 82, as derived from the model.

one seam was examined it is possible that local low-ratio areas could be identified. The model in Appendix 2 allows for this type of detailed analysis to be done.

MINING METHOD AND LOGISTICS

The small amount of available data and the consequent lack of resolution of the model preclude lengthy discussion of the mineability of the Mount Taylor portion of Parcel 82. However, the waste-to-coal ratio map (Figure 32) indicates that open-pit mining is not feasible on a large scale; the mining method at Mount Taylor would have to be underground, with perhaps local small-scale open pit development to supplement production. Mining is expected to be hampered by the degree of structural complexity.

On a more positive note, the location of Mount Taylor is reasonably advantageous from a logistical point of view. The valleys of Michel and Leach creeks provide good access to both the east and west sides of Mount Taylor. The Michel valley is already the site of a major public road and a rail line, both servicing Byron Creek Collieries' Coal Mountain mine. There appears to be room for a rail loop and loading facilities, and perhaps preparation facilities as well, immediately south of the confluence of Leach and Michel creeks.

CONCLUSIONS

The coal-bearing Mist Mountain Formation is exposed in three areas within the Dominion Coal Block: Lookout Hill and Hosmer Ridge in the western portion of Parcel 73; Flathead Ridge in the southern part of Parcel 82; and Mount Taylor in the northern portion of Parcel 82. Based on structural, stratigraphic and coal quality information available in published and unpublished sources and summarized here, obvious major deterrents to the exploitation of the Coal Block are not apparent. Moreover, all three coal-bearing areas are well located with respect to topography and local infrastructure.

Our resource calculations are based on computer models of the three potentially economic portions of the Dominion Coal Block. We calculate that the western part of Parcel 73 contains 76 million tonnes of coal at a very favourable waste-to-coal ratio of 4.7:1, based on all coal seams in the section. The Flathead Ridge area of Parcel 82 contains 230 million tonnes of coal, 17.5 million of which falls in the measured category, based on only two coal zones (A and B). The waste-to-coal ratios are such that most if not all of this coal could be exploited by underground mining only. The Mount Taylor portion of Parcel 82 is estimated to contain 613 million tonnes of coal, based on the five thickest coal seams in the section. As was the case with Flathead Ridge, there does not appear to be any significant open-pit mining potential on Mount Taylor.

We predict that parts of the Dominion Coal Block will eventually be mined, and thereby benefit the local, provincial and national economies.

ACKNOWLEDGMENTS

H. Oppelt and J. Schwemler digitized the topographic data for Flathead Ridge and Mount Taylor, respectively. N. Ollerenshaw provided the originals of his published Dominion Coal Block geological maps, and allowed us to republish them.

REFERENCES

Aihara, A. (1970): The Interim Report on the Field Investigation Executed in the Flathead Ridge Pacific Coal Ltd. Property, British Columbia, Canada; *Mitsui Mining Co., Ltd.*, Open File Coal Assessment Report, *B.C. Ministry of Energy, Mines and Petroleum Resources*, 24 pages.

Anonymous (1974): Availability of Coking Coal in Western Canada - Final Report; Open File Coal Assessment Report, *B.C. Ministry of Energy, Mines and Petroleum Resources*.

Cameron, A.R. (1972): Petrography of Kootenay Coals in the Upper Elk River and Crowsnest Areas, British Columbia and Alberta; *Research Council of Alberta*, Information Series No. 60, pages 31-45.

Gibson, D.W. (1977): Sedimentary Facies in the Jura-Cretaceous Kootenay Formation, Crowsnest Pass Area, Southwestern Alberta and Southeastern British Columbia; *Canadian Petroleum Geology*, Bulletin, Volume 25, pages 767-791.

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, 108 pages.

Gigliotti, F.B. and Pearson, D.E. (1978): Preliminary Geological Map of Crowsnest Coalfield, Northeast Part; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Preliminary Map 31.

Gold, C.M., Charlesworth, H.A.K. and Kilby, W.E. (1981): Coal Resource Evaluation in Deformed Sequences using Digital Terrain Models; *Canadian Petroleum Geology*, Bulletin, Volume 29, No. 2, pages 259-266.

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 1988-2.

Harada, K., Nakamura, F. and Hayashi, S. (1967): Report on the Second Survey of Fernie Coal Mine, British Columbia, Canada; *Nittetsu Mining Co., Ltd. and Toyo Menka Kaisha, Ltd.*, Open File Coal Assessment Report, *B.C. Ministry of Energy, Mines and Petroleum Resources,* 70 pages.

Harada, K., Nakamura, F., Iwamoto, N. and Hayashi, S. (1968): Survey Report on Fernie Coal Mine, British Columbia, Canada; *Nittetsu Mining Co., Ltd. and Toyo Menka Kaisha, Ltd.*, Open File Coal Assessment Report, *B.C. Ministry of Energy, Mines and Petroleum Resources,* 98 pages.

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

Latour, B.A. (1970): Report on Coal Deposits of the Dominion Government Coal Block, Fernie Area, British Columbia; *Canada Department of Energy, Mines and Resources*, Report, 12 pages.

Leach, W.W. (1902): Crows Nest Coal Fields; *in* Summary Report, 1901, *Geological Survey of Canada*, pages 69A-81A.

McEvoy, J. (1901): Untitled report on the Crows Nest Pass Coalfield; *in* Summary Report, 1900, *Geological Survey of Canada*, pages 85A-95A.

Nakayama, K., Hatta, K. and Harada, K. (1966): Report on the Survey of Fernie Coal Mine, British Columbia, Canada; *Nittetsu Mining Consultants Co., Ltd.*, Open File Coal Assessment Report, *B.C. Ministry of Energy, Mines and Petroleum Resources,* 37 pages.

Ohtaki, T. (1967): Geological Survey Report of Fernie Coal Mine, Fernie Coalfield, B.C., Canada; *Marubeni-Iida Co., Ltd.*, Open File Coal Assessment Report; *B.C. Ministry of Energy, Mines and Petroleum Resources,* 23 pages.

Ollerenshaw, N.C. (1977): Canadian Government Coal Block, Parcel 73, Fernie Basin, British Columbia; *in* Current Research, Part A, *Geological Survey of Canada*, Paper 81-1A, pages 155-159.

________ (1981a): Cadomin Formation, Flathead Ridge Vicinity, Southeastern British Columbia; *in* Current Research, Part A; *Geological Survey of Canada*, Paper 81-1A, pages 341-347.

________ (1981b): Parcel 82, Dominion Coal Block, Southeastern British Columbia; *in* Current Research, Part B; *Geological Survey of Canada*, Paper 81-1B, pages 145-152.

Ollerenshaw, N.C., Pearson, D.E., Gigliotti, F. and Grieve, D.A. (1977): Geology of Crowsnest Coalfield, Northwest Part; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Preliminary Map 24, Sheet 3.

Pearson, D.E. (1977): East Kootenay Coalfield; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1976, Paper 1977-1, pages 77-82.

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

Pearson, D.E. and Grieve, D.A. (1981): Geology of Crowsnest Coalfield, Southern Part; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Preliminary Map 42.

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

Price, R.A. (1962): Fernie Map-area, East Half, Alberta and British Columbia, 82G/E 1/2; *Geological Survey of Canada*, Paper 61-24 and Map 35-1961.

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, 41 pages.

Shiokawa, K. (1968): Feasibility Report, Fernie Coal Mine Project, British Columbia, Canada; *Nittetsu Mining Co., Ltd.*, Open File Coal Assessment Report; *B.C. Ministry of Energy, Mines and Petroleum Resources*, 27 pages.

Snowdon, L.R., Brooks, P.W. and Goodarzi, F. (1986): Chemical and Petrological Properties of some Liptinite-rich Coals from British Columbia; *Fuel*, Volume 65, pages 459-472.

APPENDIX 1

DISCLAIMER
The programs and files contained in this report are strictly for the use of the reader. No responsibility for financial loss incurred due to assessments based on their use is accepted. Their purpose is to illustrate specific techniques and demonstrate the findings of this report. Any attempt to obtain more detailed analysis of the deposits is at the users risk.

PROGRAM MANUAL

INTRODUCTION

Computer programs are included in this report to allow the reader to examine the constructed deposit models. The complete programs are presented in Appendix 2 together with the digital model grid files. This section will discuss the operation of these programs and the following section will describe the actual digital model grids. The programs are contained on a diskette (in pocket) formatted for MS-DOS microcomputer compatibility and containing 360 k bytes. The programs are written to make use of as little specialized hardware as possible and are in compiled BASIC (Microsoft Quickbasic). An Epson compatible dot-matrix printer is required to obtain a grid printout, otherwise only a basic IBM or compatible microcomputer system is required.

GRID SURVEY (G-SURV)

G-SURV reads the specified digital grid file and reports basic information from the file such as grid spacing, grid coordinates, grid dimensions and maximum and minimum grid-node values.

OPERATION

Type the program name, G-SURV, with the program on the active disk or diskette. The user simply replies to the queries and the summary statistics will be displayed on the screen. The screen can then be dumped to the printer with the PRINT SCREEN feature of the computer if desired.

EXAMPLE

```
***GRID SURVEY***
W.E. KILBY
B.C. GEOLOGICAL SURVEY
ENTER FILENAME? TAYLOR-T.TAY
ENTER DISK DRIVE? A
PRESS (C) WHEN DISK READY
```

PROGRAM OUTPUT

```
TAYLOR-T.TAY
GRID SCALE IS 250
ROWS= 48 COLS= 29
NW CORNER X= 0
NW CORNER Y= 0
MAX VALUE IS 2285
MIN VALUE IS 1371
PRESS (C) TO CONTINUE
```

The filename is the name of the grid which is to be examined. If the file is not present on the active disk directory, the path designation must proceed the filename (*i.e.* \TAYLOR\TAYLOR-T.TAY). **The disk designation is entered without the colon.** The grid scale in the output is the distance in map coordinates between grid nodes. The number of grid rows (E-W) and columns (N-S) are then displayed. Grid position is tied to the real world by the northwest grid node. The coordinates refer to whatever grid system is desirable. Maximum and minimum parameter values are then displayed. These are useful in picking the appropriate contour interval when using G-PLOT.

GRID PLOTTER (G-PLOT)

G-PLOT produces a printer display of digital-grid surfaces. The resulting plot contains a character at each grid-node position. The characters are coded against specific parameter values and may be manually contoured to produce a contour map of the parameter over the study area.

OPERATION

The program is run in the same manner as G-SURV, the program name is typed into the computer and it then requests certain information prior to output. The following series of questions will be displayed on the computer screen, upon completion of these questions the output will be produced on the dot-matrix printer:

EXAMPLE

```
PLOTTER
W.E. KILBY
B.C. GEOLOGICAL SURVEY
ENTER NAME OF INPUT FILE? TAYLOR-T.TAY
ENTER DATA DISK DRIVE? A
ENTER NUMBER OF STRIPS TO PLOT? 1
ENTER SPACES BETWEEN GRID VALUES? 1
ENTER MINIMUM CONTOUR LEVEL? 1000
ENTER CONTOUR INTERVAL? 100
ENTER NUMBER OF CONTOUR INTERVALS? 30
PRESS (C) WHEN DISK AND PRINTER READY
```

The program is designed to produce output on an 80-column printer, therefore if the printout is more than 80 columns wide, the plot must be split into strips. If more than one strip is specified in the third question the following additional questions are asked in order to produce the desired large plot:

```
ENTER 1st AND LAST COLUMN OF STRIP # 1
1,40
ENTER 1st AND LAST COLUMN OF STRIP # 2
40,79
ENTER 1st AND LAST COLUMN OF STRIP # 3
79,95
```

Spacing between grid values is the number of blank characters that are to appear between the characters representing the grid-node values. By adjusting this spacing the plot scale can be increased or decreased, although in coarse increments. Minimum contour interval specifies the lowest value to be represented by a valid character code. Any value below this minimum value will be treated as undefined and a **U** will be placed at that grid-node position. Contour interval is at the user's discretion, its value being dictated by the desired plot appearance. The number of contour intervals should be selected to cover the complete range of parameter values, obtainable from G-SURV.

```
5 4 5 5 5 4 4 3 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 4 4 5 5
5 5 5 5 5 4 4 3 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 5 5 6
5 5 5 5 5 4 4 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 5 5 5 5 6 6
6 5 5 5 4 4 4 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 5 6 6 6 7 7
6 6 6 5 5 4 4 4 4 4 5 5 4 5 5 5 5 5 4 4 4 4 4 5 6 7 6 8 9
7 7 6 5 5 5 4 4 4 4 5 5 4 5 5 5 5 5 5 5 4 4 4 4 5 7 7 8 9
8 7 6 6 5 4 4 4 4 5 5 5 5 5 5 6 6 6 6 5 4 4 4 4 5 7 7 8 9
7 6 6 6 5 4 4 4 4 4 5 5 5 5 6 6 7 8 7 6 5 4 4 4 5 6 7 8 8
7 6 5 5 5 4 4 4 4 5 5 5 5 5 6 7 8 8 8 7 5 5 4 4 4 5 7 7 7
5 5 5 5 4 4 4 4 4 5 5 6 6 6 6 7 8 9 8 7 6 5 4 4 4 5 6 6 7
6 5 5 4 4 4 4 4 4 5 6 6 6 6 7 7 8 : 9 7 7 6 5 4 4 5 5 5 6
7 6 5 5 4 4 4 4 4 5 6 6 6 6 7 8 9 : : 9 8 6 6 4 4 4 4 5 6
7 6 5 4 4 4 4 4 5 5 6 6 6 7 7 8 : ; ; 9 8 8 6 5 4 4 4 4 5
6 6 5 4 4 4 4 4 5 5 6 6 6 7 8 9 : ; ; : 9 7 6 5 5 4 4 4 4
6 5 4 4 4 4 4 4 5 6 6 6 6 7 8 9 : ; ; : 8 7 6 6 5 5 4 4 4
6 4 4 4 4 4 4 4 5 6 6 6 7 7 8 9 : ; ; 9.8 7 6 7 6 5 5 4 4
5 4 4 4 4 4 5 5 5 5 6 6 7 8 8 9 : ; : 9 8 7 7 8 7 6 5 4 4
5 4 4 4 4 5 5 5 6 6 6 6 7 8 9 : ; ; : : 8 7 8 9 8 6 5 5 5
5 4 4 4 5 5 6 6 6 6 6 6 7 9 9 : ; ; ; : 8 8 9 8 7 6 5 6 5
4 4 4 4 5 6 6 6 6 7 7 6 7 8 9 : ; ; ; : 9 9 9 8 6 6 6 6 6
4 4 4 4 5 6 7 6 6 7 7 7 7 7 8 9 : : ; : : : 9 7 6 6 7 7 7
4 4 4 5 5 7 7 7 7 8 8 7 8 8 9 9 9 : : : 9 9 8 7 6 6 7 8 8
4 4 4 5 5 6 7 7 8 9 9 8 9 9 9 9 9 : : : 9 8 8 8 7 7 8 9 9
4 4 5 6 6 6 6 7 8 9 : 9 : 9 8 9 : : : : 9 9 9 8 7 7 8 9 :
4 4 5 6 7 7 7 7 8 : ; : 9 8 9 9 : : ; : 9 9 8 8 7 8 9 9 ;
4 4 5 7 8 8 8 8 9 : : 9 8 8 9 9 : : ; : : : 9 8 8 8 9 9 :
4 4 5 7 8 8 9 9 : 9 8 8 8 7 8 9 : : : ; ; : : 8 8 8 9 9 :
4 4 5 7 8 8 8 8 9 8 7 7 7 8 9 : : : : ; ; : 9 8 8 8 9 : ;
5 4 5 6 7 7 7 8 8 7 6 7 8 9 9 : : : ; ; : : 9 9 8 9 9 : ;
5 4 4 5 6 6 7 8 8 7 6 7 8 9 : : 9 : : ; : : 9 9 9 9 : : ;
5 5 4 5 5 6 7 7 7 6 6 7 8 9 9 9 9 : : ; ; : 9 9 9 : ; ; <
6 6 5 4 5 5 6 7 6 5 6 7 8 9 9 9 9 : ; ; ; < ; ; ; ; < < ;
7 6 5 5 4 4 5 5 5 5 6 7 8 9 : 9 8 9 : : ; ; < < ; ; ; ; ;
7 7 6 6 5 4 5 5 5 6 6 6 7 9 9 8 9 9 9 : : ; < < ; : : : ;
8 7 7 7 6 5 5 5 5 6 7 6 7 8 9 7 8 9 : : : ; ; : : 9 : : ;
8 8 8 7 6 5 5 5 5 6 7 8 7 7 8 7 8 9 9 9 : : 9 9 9 9 : ; ;
8 8 8 7 6 6 5 5 5 5 7 8 8 7 7 7 8 8 8 8 8 8 8 8 8 9 : : ;
9 9 8 8 7 7 5 5 5 5 6 8 8 8 7 7 7 7 7 7 7 7 7 8 8 9 9 : :
9 9 9 8 7 6 5 5 5 5 7 8 8 7 6 6 6 6 7 7 7 7 7 8 8 9 9 9 :
8 9 8 7 6 6 5 5 5 5 7 8 8 6 6 7 7 7 7 8 8 8 8 8 9 9 9 9 :
7 8 7 6 5 5 5 5 5 6 7 8 7 6 7 8 8 8 8 9 9 9 9 9 9 : : : :
7 7 6 5 6 6 6 5 5 6 7 8 6 6 7 8 9 9 9 9 : : : ; : : ; : :
6 6 6 6 7 7 6 6 5 6 7 7 6 7 8 9 9 9 : : ; ; ; ; : ; ; ; ;
6 6 6 7 8 8 7 7 6 5 6 7 6 7 8 8 8 9 9 9 : : : : 9 : ; < <
6 7 8 8 9 8 8 7 6 6 5 6 6 7 8 8 8 8 8 8 8 9 9 9 8 9 : ; <
7 7 8 9 9 8 7 7 6 6 6 6 6 7 8 8 7 7 7 7 7 7 8 8 8 8 : ; <
8 8 9 9 9 8 8 6 6 7 7 6 6 7 7 7 7 7 7 7 7 7 7 7 8 8 9 : ;
9 8 9 9 9 8 7 7 7 7 7 6 6 7 6 6 7 8 8 8 8 8 8 8 8 8 9 : <
            LEGEND  TAYLOR-T
              UNITS/GRID SQUARE=  250
              X + Y ORIGIN=  0             0
              U=  LESS THAN  1000   OR UNDEFINED
              0=   1000  TO  1100
              1=   1100  TO  1200

              M=   3900  TO  4000
              *=  GREATER THAN  4000
```

GRID EDIT (G-EDIT)

G-EDIT allows the user to access the digital surface file and change specific grid-node values. A file editor may also be used to edit these files but care must be taken to accurately locate the value corresponding to a specific row and column address (*see* grid-file format below).

OPERATION

G-EDIT is run in the same manner as the preceding programs. When run the following display will appear on the screen. The user answers the appropriate questions and supplies the new grid values when requested.

EXAMPLE

```
***GRID EDIT***
W.E. KILBY
B.C. GEOLOGICAL SURVEY
FILE NAME? TAYLOR-T.TAY
ENTER DISK DRIVE? A
PRESS (C) WHEN DISK READY
TO END EDIT ENTER (999999)
ENTER ROW AND COLUMN OF VALUE TO EDIT? 12,13
ROW = 12 COL = 13 GRID VALUE = 1649
ENTER NEW VALUE FOR THIS GRID LOCATION? 2345
ENTER ROW AND COLUMN OF VALUE TO EDIT? 2,2
ROW = 2 COL = 2 GRID VALUE = 1557
ENTER NEW VALUE FOR THIS GRID LOCATION? 999999
ENTER OUTPUT FILENAME? ANYNAME
ENTER OUTPUT DISKDRIVE? ANYDISK
```

The user enters the row and column values, separated by a comma, when requested. The program returns the current value at that grid location and requests the new value. The user must enter a value, either a new value or the old value if the current value is correct. When all changes are completed, enter any valid row and column address and enter the **999999** value. The program will then request an output filename and disk location. The name may be the same as the input grid file or it could be a new name.

GRID CALCULATOR (G-CALC)

G-CALC provides the means to manipulate grid surfaces performing either single surface or multiple surface functions.

OPERATION

Filename and disk drive naming conventions are similar to those already described. The program is run by typing in the program name **G-CALC**. The program then requests operation input. The following display will then appear on the computer screen:

EXAMPLE

```
***GRID CALCULATOR***
W.E.KILBY
B.C. GEOLOGICAL SURVEY
[1] TRIM GRID
[2] GRID (+-/*) STANDARD
[3] GRID (+-/*) GRID
```

(*continued on next page*)

```
(continued from previous page)
[4] RE-INITIALIZE PROGRAM
[9] END
ENTER CHOICE
```

The user must press one of the five numerical code keys to continue to the desired function.

TRIM GRID

Trim grid is a multisurface function which modifies one grid based on the configuration of another grid. In all cases this function either leaves the current grid node unchanged or sets it to the undefined value of 9999. The following menu appears on the screen when this function is selected:

```
GRID TRIMMER
ENTER NAME OF GRID TO BE TRIMMED? TAYLOR-T.TAY
ENTER DISK DRIVE? A
ENTER NAME OF CONSTRAINING GRID? CUTTER
ENTER DISK DRIVE? A
ENTER NAME OF OUTPUT GRID? ANYNAME
ENTER DISK DRIVE? A
TRIM IF GRID (A)BOVE OR (B)ELOW OR (U)NDEF CONSTRAIN-
ING GRID? U
```

Grid naming conventions are the same as for the other programs. Neither the grid to be trimmed nor the constraining grid are affected by this function, but a new file containing the result of the trimming faction is contained in the output grid file. If **A** is pressed in response to the trim method then all values in the initial grid which are above the corresponding values in the constraining grid will be set to the undefined value. If the **B** is pressed then all the values less than the corresponding values in the constraining grid will be set to undefined. When the U is pressed the values at grid nodes which correspond to undefined grid-node locations in the constraining grid will be set to the undefined value.

GRID-STANDARD FUNCTION

This function allows an existing grid to be modified by a standard value and a simple mathematical function. The initial grid is not affected by the operation, but a new grid is created and contains the results of the operation. The following menu and questions appear when this function is selected:

EXAMPLE

```
**GRID (+-/*) STANDARD**
[1] A+ST
[2] A-ST
[3] A/ST
[4] A*ST
PRESS OPERATOR CODE
(S)UMMATION,(N)EW GRID,(B)OTH? B
IS 9999 TO CAUSE NEGATION OF CALC (Y) OR BE TREATED AS 0
(N)? Y
GRID [A] FILENAME? TAYLOR-T.TAY
GRID [A] DISK DRIVE? A
ENTER OUTPUT GRID NAME? ANYFILE
ENTER OUTPUT DISK DRIVE? ANYDISK
ENTER STANDARD VALUE? 10
```

The user selects the proper mathematical function by pressing a key from 1 to 4. The choice of creating a new grid, or making a summation of the calculations, or both, is available. The choice of how to treat undefined grid values is also available. The appropriate input and output filenames and disk drives are requested and then the user enters the value of the standard.

GRID-TO-GRID FUNCTION

Grid-to-grid function allows two grid surfaces to be used in a calculation with the result being place in a new file. When this function is selected the following menu of instructions and questions appears on the computer screen:

EXAMPLE

```
**GRID[A] (+-/*) GRID[B]**
[1] A+B
[2] A-B
[3] A/B
[4] A*B
PRESS OPERATOR CODE
(S)UMMATION,(N)EW GRID,(B)OTH? B
IS 9999 TO CAUSE NEGATION OF CALC (Y) OR BE TREATED AS 0
(N)? Y
GRID [A] FILENAME? TAYLOR-T.TAY
GRID [A] DISK DRIVE? A
GRID [B] FILENAME? ANYNAME
GRID [B] DISK DRIVE? A
ENTER OUTPUT GRID NAME? NEWGRID
ENTER OUTPUT DISK DRIVE? A
PRESS (C) WHEN DISK READY OR (A)BORT
```

The user selects the appropriate operation by pressing the proper code from 1 to 4. Selections of whether to construct a new grid and how to treat undefined data are requested. The input grid files are entered using the standard input convention described above.

DIGITAL MODEL DESCRIPTION

Digital models, in this study, are collections of digital surfaces. Each surface in the model describes a specific parameter of the model. Each surface is in a single file and all files have the same format. All surfaces within a given model have the same scale, origin coordinates and dimensions.

There are three models in this study and their digital surfaces are contained in Appendix 2 (diskette). The surfaces which belong to each model are designated by the selection of their names. An extension is added to each descriptive name to identify which model it is associated with. The three extensions used are **.P73**, **.FLT** and **.TAY** for Parcel 73, Flathead Ridge and Mount Taylor, respectively.

The formats for grided surface files are all the same and are illustrated below;

scale,row,col,origin x,origin y
value of row 1 col 1

value of row 1 col 2

value of row n col n

These files are stored in ASCII sequential file format and may be directly listed or edited with any text editor.

PARCEL 73	**.P73**
GRID NAME	**GRID CONTENTS**
TOPOLOOK.P73	Topographic elevation
3-SURF.P73	3-seam elevation
6-SURF.P73	6-seam elevation
8L-SURF.P73	Lower 8-seam elevation
8U-SURF.P73	Upper 8-seam elevation
9L-SURF.P73	Lower 9-seam elevation
9U-SURF.P73	Upper 9-seam elevation

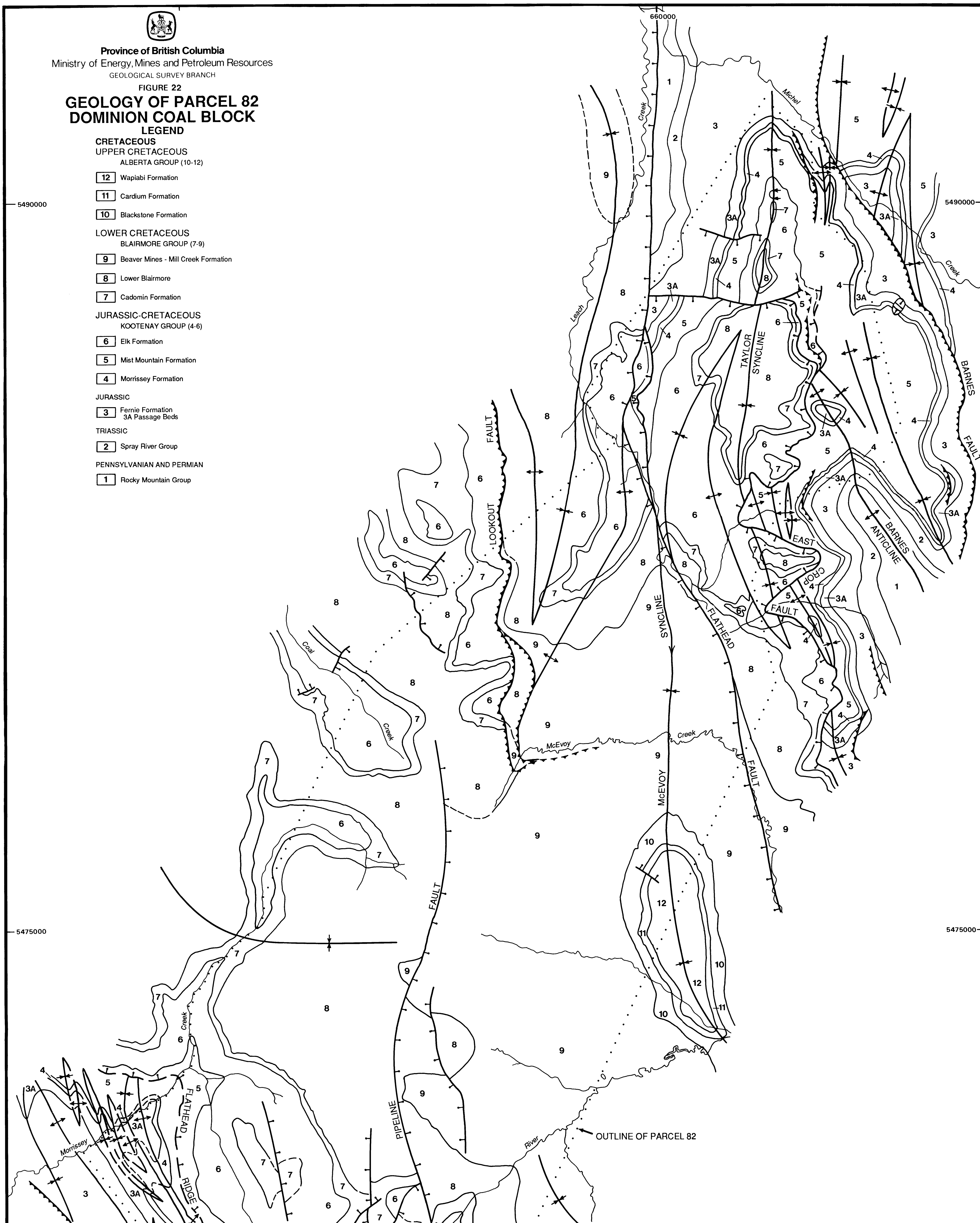
FLATHEAD RIDGE	**.FLT**
GRID NAME	**GRID CONTENTS**
FLATOPO.FLT	Topographic elevation
BU-FINAL.FLT	Upper B-seam elevation
B-FINAL.FLT	B-seam elevation
A-FINAL.FLT	A-seam elevation
AL-FINAL.FLT	Lower A-seam elevation
A1-FINAL.FLT	A1-seam elevation
A2-FINAL.FLT	A2-seam elevation
BU-THIKS.FLT	Upper B-seam thickness
B-THIKS.FLT	B-seam thickness
A-THIK.FLT	A-seam thickness
AL-THIK.FLT	Lower A-seam thickness
A1-THIK.FLT	A1-seam thickness
A2-THIK.FLT	A2-seam thickness
BU-DIST.FLT	Upper B-seam distance-to-data
B-DIST.FLT	B-seam distance-to-data
A-DIST.FLT	A-seam distance-to-data
AL-DIST.FLT	Lower A-seam distance-to-data
A1-DIST.FLT	A1-seam distance-to-data
A2-DIST.FLT	A2-seam distance-to-data

MOUNT TAYLOR	**.TAY**
GRID NAME	**GRID CONTENTS**
TAYLOR-T.TAY	Topographic elevation
U8SEAM.TAY	U8-seam elevation
U6SEAM.TAY	U6-seam elevation
U4SEAM.TAY	U4-seam elevation
U2SEAM.TAY	U2-seam elevation
MSEAM.TAY	M-seam elevation

APPENDIX 2

DISKETTE USE

The file README.1ST on the diskette contains instructions on how to load the data and programs onto a micro-computer. It also contains additional information on new programs or modifications to Appendix 2 which may have occured since press-time.



TO ACCOMPANY PAPER 1989-4