Mn-MT-SPIEKER 78(1)A

MT. SPIEKER COAL PROJECT

GEOLOGICAL REPORT OF THE
1978 EXPLORATION PROGRAMME

PREPARED FOR: RANGER OIL (CANADA) LIMITED

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ROBERTSON RESEARCH

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SECTION 1

SUMMARY

The exploration programme carried out by Ranger Oil (Canada) Ltd. on the Mt. Spieker Coal Project during the 1978 summer field season has advanced the stratigraphic and structural knowledge of the property and confirmed the presence of in excess of 100 million tonnes of coal which are possible to be mined. The field programme consisted of geological mapping, drilling a total of almost 4000 metres in 18 diamond drill holes, cutting of 24 trenches to expose the coal seams and driving three adits a total distance of 180 metres to obtain bulk samples. The geological evaluation and analytical data which has resulted from the exploration is to be used as a foundation for a pre-feasibility mining study under preparation by Intermin Consultants Ltd.

Approximately 300 metres of the Minnes Group Nikanassin Formation forms the base of stratigraphic section within the Mt. Spieker property. The Cadomin and Gething Formations, comprising the Bullhead Group, are fully exposed within the mapped area; the two formations are 50 metres and 300 metres thick respectively. The only seam in the Gething Formation which has been found to attain an economic thickness is the Bird Seam.

The Fort St. John Group is represented by the Bluesky, Moosebar and Commotion Formations. Within the 170 metre thick Gates Member of the Commotion Formation are the coal seams of economic interest, the Gates Seams A, B, C and D. A partial section of the Shaftesbury Formation represents the uppermost unit outcropping on the property.

The major structural elements of the Mt. Spieker property consists of a large anticlinal box fold lying adjacent to and east of a broad concentrically folded syncline. The axes of these structures trend in a northwesterly direction.

The upper strata of box folds are characteristically flat-lying and are bounded by steeply dipping, relatively planar limbs. The junctions between the steeply dipping and the flatlying strata form abrupt monoclines. The Main Syncline portion of the property is a very regular concentric fold unlike the Mt. Spieker box anticline. It is common for such regularly folded strata to be located immediately adjacent to box folds in the Foothills.

A series of small scale tight folds lie sub-parallel to the Main Syncline as parasitic structures at the far western margin near the Syncline outcrop. These parasitic structures are chevron style folds with inclined axial planes dipping at approximately sixty degrees towards the east. At several locations, thrust faults on various scales have been mapped in the field and observed in drill cores.

The Mt. Spieker property has been sub-divided into several areas on the basis of geological structure. This sub-division highlights those areas which are considered to be especially suitable for mining. These areas are:

a) Mt. Spieker Ridge;
b) EB 1 Pit;
c) Main Syncline:
d) Bird Seam Underground Area; and
e) Bird Seam Pit Areas.

The Mt. Spieker Ridge and the EB 1 Pit are both essentially flatlying areas where economic thicknesses of Gates Member coal seams exist.

On the basis of geologic structure, the Main Syncline Area is divided into two regions. Within the northern portion, the strata are structurally continuous and nearly flatlying. The area is bounded on the east by a major thrust fault. South of this area the Syncline proper develops with steeper dipping strata, generally ranging between 15° and 20°.

The Bird Seam Underground Area is composed of strata which are almost flatlying. A thrust fault forms the eastern limit to this potential mining area while the western limit is a monoclinal hinge. No data are presently available with regard to the internal structure of either the South Bird Area or the West Bird Seam.

On the Mt. Spieker property the Bird Seam occurs as two splits, referred to as the Upper and Lower Bird Seams. The two splits are separated by an average of 2.5 metres of interseam strata. The Upper Bird Seam attains an average true thickness of 3.50 metres and varies from 2.43 metres to 3.64 metres. The average true thickness of the Lower Bird Seam is 1.75 metres, with maximum and minimum values of 1.98 metres and 1.49 metres, respectively.

The two Bird Seams are similar in quality with the exception of their sulphur content. A predicted product, after washing at a specific gravity of 1.50, would be approximately 7% ash, 20.3% volatile matter (d.m.m.f.), F.S.I. of 7½ and a theoretical washing yield of approximately 90%. The sulphur content of the Lower Bird Seam appears to be between 0.70% and 0.80% in the clean coal. The clean coal from the Upper Bird contains around 1.8%, and 2.3% in the raw coal.

The four coal seams of the Gates Member are termed the Gates Seams A, B, C and D in ascending stratigraphic order. Seam A is fairly uniform in thickness ranging from 0.8 metres to 1.2 metres. Approximately 10 metres to 15 metres above Seam A, the Gates Seam B occurs, varying in thickness from 2.5 metres to 6.0 metres. With an average thickness of 4.5 metres throughout most of the property, this seam constitutes the principal economic unit.

Twenty-five (25) metres above Seam B, the Gates Seam C occurs although it is not represented on Mt. Spieker Ridge due to erosion. The seam varies from a coaly horizon of no economic interest in the northwest of the property to a maximum of 4.23 metres within the EB 1 Pit Area. The uppermost seam in this geological unit is the *Gates Seam D*, separated by 15 metres of interseam sediments from Seam C. Like Seam C, this seam tends to thicken toward the southeast and attains its maximum thickness of 3.5 metres in the EB 1 Pit. In the northwest its thickness is 1.4 metres.

On a clean coal basis, the coal within the four Gates Member seams are similar in chemical composition, containing generally less than 10% ash, between 25% and 27% volatile matter (d.m.m.f.) and F.S.I. of 6 or higher. The sulphur content is consistantly low in Seams B, C and D, ranging from 0.27% to 0.65% in both the as-mined coal and the clean coal. An average of approximately 1% sulphur occurs in Seam A in the raw coal; this value is reduced to less than 0.60% after washing, except on Mt. Spieker Ridge where the sulphur content averages 0.93% in the clean coal.

Reserves of coal in the four potential mining areas have been calculated and categorised using the standard definitions of Proven, Indicated and Inferred. All figures quoted are *in situ*. The total resource base which is considered to be extractable by various mining methods is *approximately 120 million tonnes of coal in situ*, in all reserve categories. Approximately 10% of this tonnage is regarded as oxidised.

In the Gates Seams A and B on Mt. Spieker Ridge are 7.66 million tonnes. The Bird Seam Underground Area contains 29.2 million tonnes of which 19.7 million tonnes exist in the thicker Upper Bird Seam. Even considering the higher sulphur content, this seam is more ammenable to mining, than the Lower Bird Seam. A washed product from the Upper Bird Seam could be blended with the Gates B Seam to produce a clean coal product with acceptable sulphur content.

The Main Syncline Area total tonnage of 65.2 million tonnes has been divided into two areas on the basis of internal structure. This tonnage is contained within Seam B. The flatter "Conventional Mining Potential" area contains 18.2 million tonnes. The reserve blocks in the southern portion of the syncline, termed "Non-conventional Mining Potential", contains 47.0 million tonnes. These reserves have a lower priority of extraction.

Two sets of reserve figures are included for the EB 1 Pit Area, dependent on the overburden ratio at the highwall of a theoretical open pit. Within the four Gates Member Seams present in the pit area, 19.32 million tonnes and 13.74 million tonnes are believed to exist at limiting highwall ratios of 8.5 to 1 and 12 to 1, respectively. The ratio is cubic metres of overburden to one tonne of coal.

Section 7 of the Report contains recommendations for an exploration programme aimed at up-grading the inferred and indicated reserve categories, and refining the structural interpretation where there is a paucity of data.

G. R. Wallis, P. Geol.

SECTION 2

INTRODUCTION

2.1 OBJECTIVES

This geological report has been compiled as a result of an exploration programme carried out on behalf of Ranger Oil (Canada) Ltd. during the 1978 summer field season on that company's Mt. Spieker Coal Property in north east British Columbia; see Figure 2.1. In general terms, the investigations have as their ultimate objective a completed final feasibility study by May, 1980. Hence the 1978 programme had to identify sufficient coal reserves, define the geologic structure and the coal quality to such a degree that a 1979 programme could provide the data required to complete the final feasibility study. Further, the results of the 1978 programme were to be used as a basis for a pre-feasibility mining study to be prepared by Intermin Consultants Ltd.

In May 1978, Robertson Research (RRNA), in conjunction with Ranger Oil (ROCL) and Intermin Consultants (ICL), refined a tentative exploration programme outlined by Ranger Oil. The objectives of the final programme were to investigate six principal areas of the property such that a reserve base of approximately 45 million tonnes of coal could be identified. These areas, illustrated in Figure 2.2, were:

- two Gates Seam open pits, Mt. Spieker Ridge and EB 1;
- an underground potential in the "Main Syncline Area";
- an underground potential in the Gething Formation Bird Seam;

- two Bird Seam open pit areas; the West Bird Area and the South Bird Seam.

It was predicted that the resource base of 45 million tonnes would fall into the following categories:

"a) at least 15 million tonnes of open pit clean coal in place coming from both Gething and Gates coal seams. The reserve category will be partially "Proven" and partially "Indicated".

"b) approximately 9 million tonnes of underground mineable coal in place located at the northern end of the Main Syncline. These reserves will be located in Gates Member Seam B only and will have a reserve category of Proven".

"c) approximately 15 million tonnes of underground mineable coal in place located at the eastern side of the Main Syncline adjacent to the EB 1 Pit. These reserves will lie within Gates Seams B, C and D and will have a reserve category of "Proven".

"d) approximately 6 million tonnes of underground mineable tonnes of Bird Seam coal in place located beneath Mount Spieker Ridge. These reserves will be partially "Proven" and partially "Indicated"."

In designing the drilling programme, particular importance was attached to both identifying the geologic structure and establishing sufficient reserves in the "Proven" and "Indicated" categories.

2.2 LOCATION

The Mt. Spieker Property is 65 kilometres in a direct line south of Chetwynd, B.C. and 115 kilometres by lumber road. See Figure 2.1 and the 1:250 000 topographic map in map pocket for the location of the property. The property rises in elevation from 1021 metres above sea level (a.s.l.) at Bullmoose Breek to 1978 metres a.s.l. on Mt. Spieker. The terrain is generally mountainous with small plateaus at higher elevations.

2.3 PREVIOUS INVESTIGATIONS

The 28 coal licences are currently held by Brameda Resource Limited of Vancouver, B.C., which carried out reconnaissance exploration work in the early 1970's.

During the 1975 to 1977 field seasons, Nichimen Resources Ltd., in conjunction with Ranger Oil, under the terms of an option from Brameda Resources, upgraded the knowledge of the property by additional geological exploration. The evaluation was carried out by geologists from Mitsui Mining Co. Ltd. of Japan. This work demonstrated the presence of both Commotion Formation and Gething Formation coal seams on the property in mineable thicknesses. The coal seams on this property are tectonically disturbed, as are the seams on all other coal properties in north east British Columbia.

This previous exploration work lead to the conclusion that 197 million tonnes of mineable reserves in place existed on the property. Of this tonnage 124 million tonnes were located within Gates Member coal seams and 53 million tonnes within Gething Formation seams under less than 1500 feet (457 metres) of cover.

2.4 THE 1978 EXPLORATION PROGRAMME

To achieve the objectives of the exploration programme as set out in Section 2.1, an integrated programme of geological mapping, diamond drilling and trenching was carried out. Each phase of that programme is described below.

2.4.1. Programme Supervision and Logistics

Overall supervision of the field logistics and geological exploration was under the control of Mr. M. A. Mitchell (ROCL). Operating as an integrated team, Mr. G. R. Jordan (Under contract to RRNA) and Mr. F. M. Dawson (RRNA), in conjunction with Mr. Mitchell, undertook the responsibility for ensuring that the geological data was collected and collated according to well defined systems and stringent standards. A field camp was established by ROCL on the Mt. Spieker Property to accomodate field crews and contractor's personnel.

Support, communications to the field camp, routing facilities for data and coal samples were supplied from the offices of RRNA, under the supervision of Mr. G. R. Wallis.

2.4.2. Geological Mapping

To complement and to validate the mapping carried out by Mitsui Mining Co. Ltd., and to extend knowledge of the stratigraphy and structure of the property, further geological mapping of the coal licenses was carried out. The mapping was also extended into previously un-mapped coal licenses.

The surface mapping methods employed consisted of both the reconnaissance style incorporating aerial photographic interpretation and detailed mapping involving a chain and compass modification of plane tabling; a method rapid enough to allow significant areas of the property to be covered while maintaining a high level of accuracy. Each of these mapping methods was employed in different parts of the property as was found necessary.

Detailed mapping, especially of areas of the Rocky Mountain foothills above tree line, resolves many of the stratigraphic and structural problems which are encountered, thus excluding the requirement for a "blanket coverage" approach to drilling. This invariably means that drilling can be most effectively employed in a discretionary manner to solve geological problems which the mapping method is unable to resolve as well as to obtain coal samples. This approach to exploration leads to significant savings on drilling costs and makes the requirement for an extensive grid approach to drilling redundant when knowledge of geological structure is the only objective.

Geological maps at a scale of 1:5 000 for the Mt. Spieker Ridge and the EB 1 Pit Area, Maps 2 and 10, are included in the map pocket. Map 1 at 1:10 000 scale summarises the geology of the coal licenses held by ROCL. Geological cross sections further illustrate the stratigraphy and structure.

2.4.3. Diamond Drilling

To enable the data forthcoming from the exploration programme to be properly organised and assessed, a 500 metre grid was established over the area of activity. Consequently this grid was used as the first level determinant for drill site selection when considering the need for categorising the coal reserves. The second level of decision was the need for special data, that is, structural data or increased density of drilling in a potential open pit. Existing geological data was, at all times, taken into consideration.

During the planning phase of the programme it was decided that a sufficiently high geological confidence level could only be achieved by employing the full diamond core method of drill sampling. Table 2.1 summarizes the extent to which this method of testing in each of the areas was carried out during 1978.

The drilling was contracted to Connors Drilling Ltd. of Vancouver. Appendix A summarises the drill hole intersection, core recoveries, etc., and complete drill logs and sections,both stratigraphic and seam, for each drill hole are included in Appendix D.

The original programme called for a total of 31 drill holes, with a cumulative footage of 5105 metres (16,750 feet). This footage was not achieved due to a slower than predicted drilling rate effected by the contractor.

Timing, and budgetary constraints only allowed for a limited amount of work to be undertaken in the lower priority West Bird and South Bird Areas. Further work on these areas will be deferred until the 1979 programme.

TABLE 2.1

DRILLHOLE SUMMARY SHEET

DDH HOLE	TOTAL DEPTH	LOCATION
MS 16	328 m (1077')	Main Syncline
MS 17	161 m (527')	EB 1 Pit
MS 18	246 m (807')	EB 1 Pit
MS 19	161 m (527')	EB 1 Pit
MS 20A	321 m (1052')	Mt. Spieker Ridge
MS 21	107 m (351')	EB 1 Pit
MS 22	430 m (1412')	Main Syncline
MS 23	70 m (230')	Mt. Spieker Ridge
MS 24	57 m (186')	Mt. Spieker Ridge
MS 25A	386 m (1267')	Main Syncline
MS 26	49 m (161')	~~Main Syncline~~ Mt Spieker Ridge
MS 27	416 m (1367')	Main Syncline
MS 28	225 m (737')	Main Syncline
MS 29	310 m (1017')	Main Syncline
MS 30	138 m (453')	Main Syncline
MS 31	187.5 m (615')	Main Syncline
MS 32	118 m (287')	Main Syncline
MS 33	252 m (827')	Main Syncline

Total holes drilled: 18

Total footage drilled: 3963.4 m (13,000')

2.4.4. Trenching

The presence of surface seam exposures was used as much as possible to complement the drill core information and to provide as much detail of lateral seam variations as could be gained. Two methods of trench construction were employed; hand trenching and mechanised back-hoe trenching.

In general, it was found that above tree line hand trenches could be constructed more rapidly in a wider variety of locations than would have been possible by mechanized methods, and at a considerably lower cost. The construction of hand trenches, as opposed to mechanised trenches, is especially desirable, where possible, since the extent of environmental damage is negligible and reclamation is easily achieved.

The location of the trenches is shown on Map 1, and the seam sections measured in those trenches are included in Appendix E.

2.4.5. Adit Driving

To allow bulk sampling for washability and coking tests three adits, involving some 180 metres of total drivage, were constructed during 1978. The work was carried out under contract by Target Tunnelling Ltd.

Two adits in the EB 1 Pit Area in the Gates B and C Seams were driven 74.5 metres and 63.0 metres respectively. These adits are referred to as "Seam B - Adit 1" and "Seam C - Adit 1", respectively. The third adit, "Seam B - Adit 2", was driven a distance of 42.0 metres in the Gates B Seam to the east of the potential "Main Underground Mining Area".

Throughout the construction work,channel samples of the total various seam plies, excluding rock bands, were taken at 1.5 metre intervals along the drivage for field testing of the free swelling index (F.S.I.). A sample of the seam above the roof of the adit was collected by drilling into the roof coal, since the adit was not driven the full seam height throughout its total length. By this procedure the degree and depth of oxidation were continuously monitored. Plans 1 to 3 show details of the three adits, seam sections and F.S.I. results.

Sampling, either by blasting or cutting a channel, was carried out after the full height of the seam had been exposed at the sample location.

2.4.6. Testing, Analysis and Data Evaluation

An extensive programme of geophysical borehole logging, visual logging of both stratigraphy and coal seams, and coal analysis was carried out during 1978.

Geophysical logging using caliper, gamma ray and neutron tools, in conjunction with both general and detailed focussed resistance and density tools, was carried out on all holes drilled. Diamond drill hole MS 11, formerly EB 11 drilled in 1977, was reamed out to enable geophysical logging to be undertaken. The geophysical logging was contracted to Roke Oil Enterprises Ltd. of Calgary.

The geophysical logs have been extensively incorporated with geologists' detailed core logs to prepare the log summaries, included in Appendix A, as well as to determine seam thicknesses for reserve calculations and to prepare geological correlation diagrams.

The coal core, after detailed logging and subsequent comparison with the geophysical logs, was sampled and forwarded to Warnock Hersey Professional Services Ltd. for analysis. Similarly, the adit bulk samples were forwarded to Birtley Coal and Minerals Testing Ltd. for washability tests. The complete results of these analytical programmes have been compiled into one volume by Intermin Consultants Ltd. who are also carrying out an evaluation of the coal quality and washability characteristics.

2.4.7. Report Preparation

Following the completion of the field activities on September 24th, 1978, the data evaluation phase of the programme concentrated on producing the necessary maps and cross-sections to enable Intermin Consultants Ltd. to commence their pre-feasibility study of the mining potential of the property. Throughout the field activities data processing was undertaken at various stated intervals as small data packages were completed.

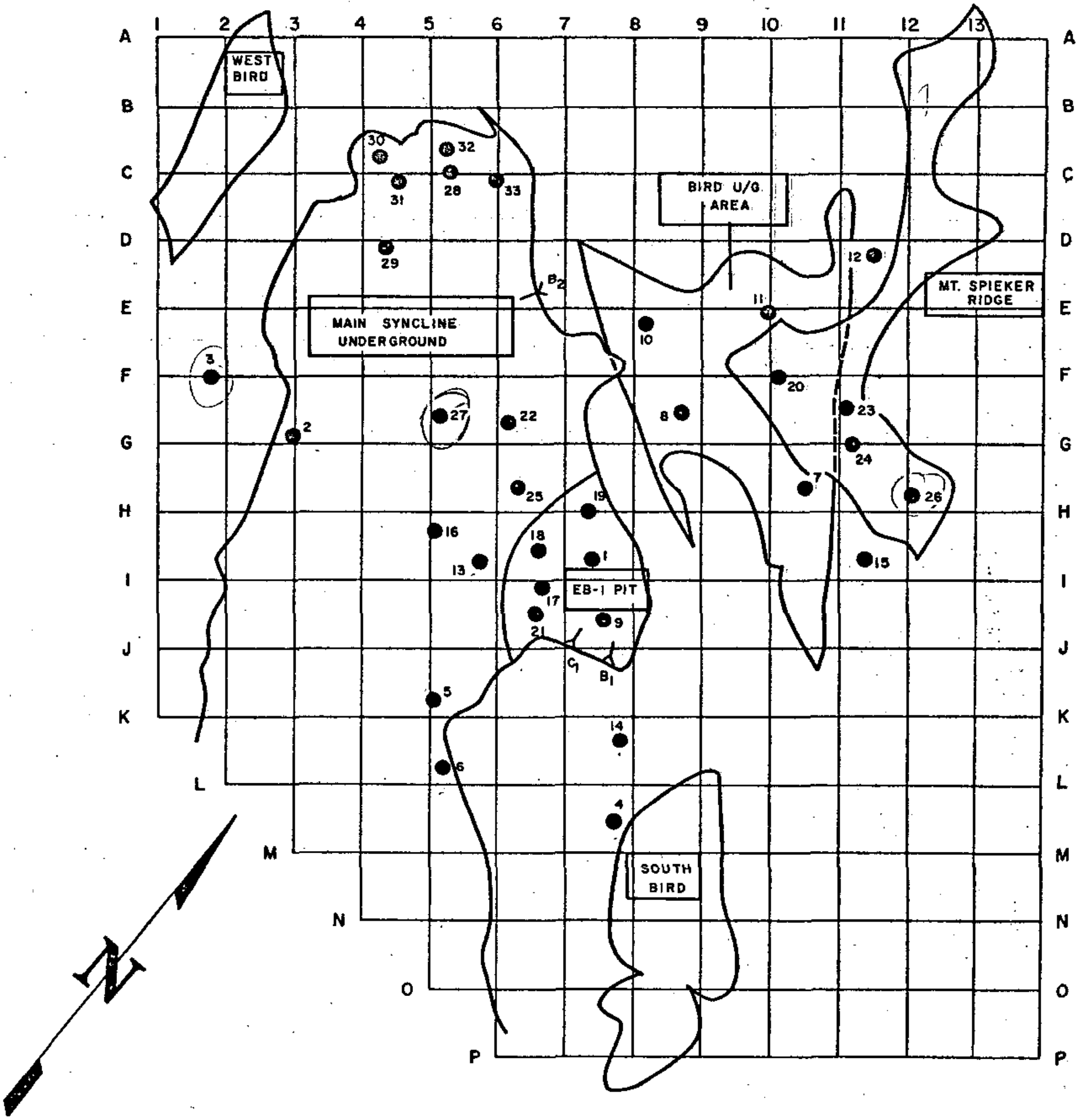
The Table of Contents for this report illustrates the format and scope of data included in the final report. In essence, the text of the report is supported by some 40 maps, 25 geological cross-sections and 8 plans at scales of 1:5 000 and 1:10 000. For convenience of reading, pertinent maps are reproduced as 1:50 000 scale figures for inclusion within the text.

Appendices A, B and C summarise the Drill Hole Data, Coal Quality Data and Reserve Calculations, respectively. Appendix D in 3 volumes contains the stratigraphic and seam sections and the written descriptive logs of each drill hole. Appendix E contains the trench seam section graphic logs.

International System (S.I.) weights and measures have been used throughout this report. British standards together with S.I. units have been stated in some instances for comparative purposes. Similarly, all maps and diagrams are prepared according to S.I. standards, except that degrees of dip rather than grads are used on geological maps.


YUKON
NORTHWEST TERRITORIES
BRITISH COLUMBIA
ALBERTA
PACIFIC OCEAN
UNITED STATES OF AMERICA
JUNEAU
FORT NELSON
LAKE CLAIRE
LAKE ATHABASCA
FORT McMURRAY
WILLISTON LAKE
FORT ST. JOHN
CHETWYND
DAWSON CREEK
LESSER SLAVE LAKE
GRANDE PRAIRIE
PRINCE RUPERT
MT. SPIEKER AREA
HANSARD
PRINCE GEORGE
WHITECOURT
EDMONTON
LLOYDMINSTER
BRÛLÉ
RED PASS
JASPER
RED DEER
GOLDEN
BANFF
CALGARY
REVELSTOKE
KAMLOOPS
MEDICINE HAT
LETHBRIDGE
FORT MACLEOD
FERNIE
BRITANNIA BEACH
HOPE
VANCOUVER
VICTORIA
LEGEND
PROVINCIAL BOUNDARY
INTERNATIONAL BOUNDARY
GEOGRAPHICAL LOCATIONS
CAPITAL CITIES
RAILWAY LINES
MILEAGES BETWEEN POINTS
kilometers
50 0 50 100 150 200 250
miles
50 0 50 100 150
RANGER OIL LTD.
CALGARY ALBERTA
Location Map
MT. SPIEKER AREA

FIGURE 2.1



LEGEND

●15 D.D.H. MS 15

B1 ADIT

EXPLORATION TARGET AREA

SCALE

0 500 1000 1500 2000 (METERS)

1 : 50,000

RANGER OIL (CANADA) LTD.

MT. SPIEKER PROJECT

EXPLORATION TARGET AREAS

NOV. 1978	FIG. 2.2

SECTION 3

REGIONAL GEOLOGY AND STRUCTURAL SETTING

The Mt. Spieker property is located within the Rocky Mountain Foothills coal belt of Northeastern British Columbia. This portion of the foothills strata has been subjected to extensive exploration for coal, oil and gas during the last decade and, in fact, is one of the major coking coal prospects, on a world-wide basis, which has been evaluated within that time span.

The Cretaceous and Jurassic strata, which contains the economic coal seams were deposited upon older marine sediments. The whole of this sequence was subsequently uplifted during the mountain building phase of the Laramide Orogengy. Thrust faulting and intense folding were deformation mechanisms which strongly affected the Foothills strata during the mountain building phase. Subsequent erosion of the highland areas has left the mountainous coal-bearing sequences, trending in a northwesterly direction, sandwiched between the extremely high relief Palaeozoic sediments to the west and the undisturbed and flatlying strata of the British Columbia and Alberta Plains. During the on-going erosional period, a series of major and deeply incised rivers has developed throughout the western Foothills regions. These rivers, flowing in a easterly direction and usually cutting the Foothills ranges in a northeasterly direction, have developed passes by which access to the inner, high relief areas has been gained.

During Jurassic and Cretaceous times a shallow marine sea existed between the eastern stable shelf area and the actively developing uplift area presently occupied by exposed Palaeozoic sediments of the main Rocky Mountain ranges. Eroded material from the western highlands was transported along rivers and streams towards the east and deposited at the margins of the uplift area,possibly in an extensive deltaic environment. Large accumulations of plant debris formed within this region at that time between phases of deposion of continental sands and muds. This trend of sedimentation was interrupted from time to time by periods of subsidence which allowed transgression of the continental sediments by the marine sea. Consequently periods of marine mudstone deposition interrupted the accumulation of continental sediments. Finally, strong uplift, accompanied by intense thrust faluting and folding, joined the uplift area to the main continental land mass.

The most significant coal accumulations are found within the Minnes Group to Gething Formation and the Gates Member of the Commotion Formation, covering a time span from Jurassic to Lower Cretaceous. Those two phases of continental sedimentation are separated by the marine deposits of the Moosebar Sea, with a second marine cycle of deposition being represented by Hulcross sediments at the top of the coal-bearing sequence.

The Mt. Spieker property is located to cover part of this sequence of strata in the Rocky Mountain Foothills between Bullmoose and Perry Creeks, some 115 kilometres south of Dawson Creek, British Columbia. The most important coal seams are located within the Gates Member of the Commotion Formation, although some of the Gething Formation seams are of commercial importance where they are located sufficiently close to the surface to be mined. The mineable portions of the seams occur within the two major structural features on the property: A major anticlinal box fold in the east and a concentrically folded syncline in the west, which lie adjacent to each other and trend in a northwesterly direction. These two mega structures are typical of the main tectonic features developed throughout the Foothills region during deformation and uplift. Such structures are currently being extensively explored for coking coal throughout the Foothills coal belt.

SECTION 4

STRATIGRAPHY

4.1 GENERAL STATEMENT

The Mt. Spieker property lies within the tectonically disturbed foothills strata of northeastern British Columbia. The property contains strata of the Lower Cretaceous, Bullhead and Fort St. John Groups, as shown on the stratigraphic column included as Figure 4-1.

The Minnes Group forms the base of the geological section within the Mt. Spieker property. Overlying the Minnes Group are the Cadomin, Gething, Moosebar and Commotion Formations with an eroded section of Shaftesbury Formation lying at the top of the sequence. The Commotion Formation includes the Gates, Hulcross and Boulder Creek Members.

The Gething Formation and the Gates Member of the Commotion Formation are the principal coal-bearing units on the property.

4.2 MINNES GROUP (NIKANASSIN FORMATION)

An incomplete section of Minnes Group strata is exposed at the northern edge of the Mt. Spieker property. Erosion has exposed only the top 300 metres of the Minnes Group section which is known to have a total thickness of approximately 2000 metres in this area.

Although the Minnes Group is a coal-bearing sequence of strata, very little exploration work has been carried out to define

FIGURE 4.1

STRATIGRAPHIC COLUMN

PERIOD	GROUP	FORMATION		LITHOLOGY	UNIT THICK'N (m)
LOWER CRETACEOUS	Fort St. John	Shaftesbury		Dark grey marine mudstone; sideritic concretions; some sandstone grading to silty dark grey marine mudstone, siltstone and sandstone in lower part, minor conglomerate at base.	+ 250
LOWER CRETACEOUS	Fort St. John	Commotion	Boulder Creek	Fine-grained, well-sorted, non-marine sandstone, mudstone carbonaceous claystone, and conglomerate; few thin coal seams towards base.	200
LOWER CRETACEOUS	Fort St. John	Commotion	Hulcross	Dark grey marine mudstone interlayered with strongly bioturbated fine-grained sandstone and siltstone.	130
LOWER CRETACEOUS	Fort St. John	Commotion	Gates	Fine-grained non-marine sandstone; conglomerate, major coal seams, siltstone, and mudstone.	170
LOWER CRETACEOUS	Fort St. John	Moosebar		Dark grey marine mudstone with sideritic concretions; gradational increase in sandstone and siltstone at top.	220
LOWER CRETACEOUS	Fort St. John	Bluesky		Glauconitic fine-grained sandstone.	
LOWER CRETACEOUS	Bullhead	Gething		Fine to coarse brown calcareous sandstone, coal, carbonaceous mudstone and conglomerate.	300
LOWER CRETACEOUS	Bullhead	Cadomin		Massive conglomerate containing chert and quartzite pebbles interbedded with quartzose sandstone.	50
LOWER CRETACEOUS	Minnes	Nikanassin		Conglomerate, carbonaceous, claystone, thin-bedded grey and brown sandstone; contains numerous coal seams.	+ 2000

the nature of this stratigraphic unit on the Mt. Spieker property. More information will be required concerning the numerous coal seams within the Minnes Group before their economic significance can be assessed.

The Minnes Group as a whole consists of coarse-grained continental sandstones and conglomerate interbedded with abundant plant-bearing siltstone, carbonaceous mudstone and coal seams throughout the upper two-thirds of the sequence. The lower third of the Minnes Group section includes an increasing abundance of marine bioturbated sandstones and marine mudstones.

4.3 CADOMIN FORMATION

The Cadomin Formation is the oldest fully-exposed formation on the Mt. Spieker property. Outcrops of the Cadomin Formation are exposed on either side of Bullmoose Creek northwest of Mt. Spieker.

The Cadomin Formation is approximately 50 metres thick and unconformably overlies the Minnes Group strata. This formation consists of conglomerate interbedded with coarse-grained quartzose sandstones. The conglomerate contains clasts of chert and quartzite ranging in size from 1 centimetre to 20 centimetres included within a sandstone matrix. The sandstone matrix and the intraformational sandstone beds and lenses appear to be similar to the clasts in lithology, consisting mainly of chert and quartz grains.

The Cadomin Formation forms a pronounced topographic expression since it is especially resistant to erosion. As a result, this unit has been utilized in aerial photograph interpretation to define geological structures that occur at depth within the Mt. Spieker property.

4.4 GETHING FORMATION

The non-marine sedimentary rocks of the Gething Formation conformably overlie the Cadomin Formation. The approximate thickness of the Gething Formation is 300 metres on the Mt. Spieker property. The formation consists of brown-coloured calcareous lithic sandstone ranging from fine to coarse in grain size, interbedded with conglomerate, carbonaceous shale and coal seams. Rocks of the Gething Formation are exposed at the surface over much of the Mt. Spieker property.

Three principal coal seams lie within the Upper Gething sequence. These are the Chamberlain, Skeeter and Bird Seams (see Gething Stratigraphic Column, Figure 4.2). Additional coal zones occur within the Lower Gething sequence.

Only the Bird Coal Seam at the top of the Gething Formation appears to be of economic thickness within the Mt. Spieker property. This seam can be divided into the Upper Bird Seam (3 metres) and the Lower Bird Seam (1.5 metres), which are separated by 2.5 metres of strata. Intersections of the Skeeter and Chamberlain Seams were encountered in several drill holes, D.D.H.'s MS 1 and MS 3, where the seams were found to be less than one metre in thickness. Trenched sections indicate that the Upper Bird Seam becomes very thin and decreases in quality in the northwest portion of the Mt. Spieker property. Further north on the Sukunka property the two splits of the Bird Seam merge. The Chamberlain and Skeeter Seams thicken on the Sukunka property and become the main seams of economic interest.

4.5 MOOSEBAR FORMATION

The Gething Formation is overlain by the marine Bluesky and Moosebar Formations. The poorly developed Bluesky Formation consists of up to one metre of glauconitic sandstone overlying the non-glauconitic sandstone of the Gething Formation. The Bluesky Formation is abruptly overlain by the dark grey mudstone of the Moosebar Formation.

The lower two-thirds of the Moosebar Formation consists of a monotonous sequence of recessive dark grey marine mudstone containing sideritic concretions. Two bentonitic bands, each about 20 centimetres thick, are found near the contact with the Bluesky Formation. The lower band lies about 20 centimetres above this glauconitic horizon, and the upper band lies an additional 20 centimetres above the lower band.

The upper portion of the Moosebar Formation is characterized by increasing amounts of interbedded siltstone and sandstone as the gradational contact with the overlying non-marine Commotion Formation is approached. As a whole, the Moosebar Formation is about 220 metres thick within the Mt. Spieker property.

4.6 COMMOTION FORMATION

The Commotion Formation contains the coal seams of principal economic interest on the Mt. Spieker property. This formation has been divided into three members, these being the coal-bearing Gates Member, the marine Hulcross Member, and the non-marine Boulder Creek Member. The total formation is about 500 metres thick and the thicknesses of the Gates, Hulcross and Boulder Creek Members are 170 metres, 130 metres and about 200 metres respectively.

4.6.1. Gates Member

This unit is of non-marine origin and consists mainly of brown-weathering sandstone interbedded with mudstone, siltstone, conglomerate and coal seams of economic interest. Geological mapping in recent years has provided data which justifies raising the Gates Member to Formational status.

The mesa-like topography and well-exposed strata on Mt. Spieker Ridge allowed detailed mapping of indivual units of the lower Gates Member to be carried out as is shown on Map No. 2. Relatively poor exposure throughout the remaining project area has only allowed the Gates Member to be mapped as a single unit, as shown on the Geological Map of the property, Map 1.

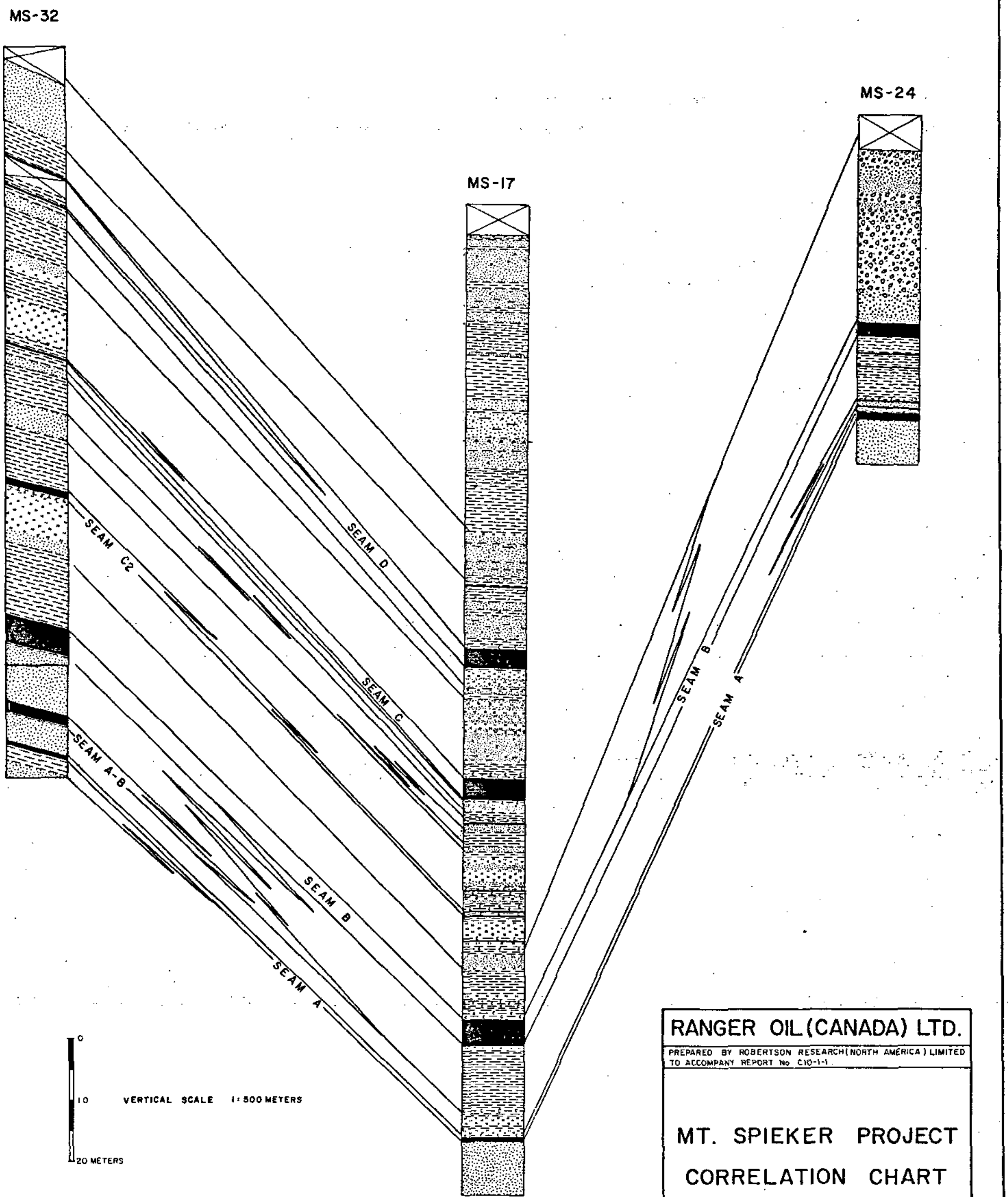
The upper contact of the Gates Member with the Hulcross Member is a thin argillaceous pebble-conglomerate from 0.1 metres to 0.3 metres in thickness overlain by a massive sandstone and several thin coal seams.

The basal unit of the Gates Member is a resistant, massive sandstone referred to as the "Torrens Member". This unit is approximately 25 metres thick and conformably overlies the interbedded mudstone, siltstone and sandstone of the Moosebar Formation. The "Torrens Member" is an especially distinct unit which has been mapped consistantly throughout the Foothills coal belt of northeastern British Columbia, and now warrants Member status, within a redefined "Gates Formation".

Several stratigraphic marker horizons are present within the Gates Member. Approximately 3 metres below the upper contact of the Gates Member, there are several thin (0.1 metres to 0.5 metres) coal seams. These seams are present throughout the property and have been located in outcrop as well as being observed in diamond core. Twenty-six metres below these seams lies a fossil bed horizon which contains freshwater pelecypods. A further marker horizon, characterised by worm burrows and a glauconitic sandstone bed, lies approximately 25 metres lower in the section. The glauconite is easily recognised in outcrop, weathering to a bright green colour.

Four potentially economic coal seams, labeled A, B, C and D, with a total average thickness of 13 metres, are found towards the base of the Gates Member. These seams are shown on the Gates Member Correlation Chart, Figure 4.2. Seam B is found to be of economic thickness throughout the property, while Seams A, C, and D are of economic importance in isolated areas. Two smaller coal horizons, Seams A-B and C_2, develop towards the northwest but are of no economic significance.

The interseam stratigraphy is relatively uniform for all seams consisting of interbedded sandstone and mudstone. The variations are illustrated on Plan Nos. 5 and 6 in the map pocket. On Mt. Spieker Ridge, however, several thick tabular beds of conglomerate overlie Seam B and Seam C_2 as is shown on Plan No. 7. The conglomerate units are wedge shaped with thickness variations from 1 metre to 110 metres over a distance of 1000 metres. The upper section of the Gates Member has been eroded from Mt. Spieker Ridge, leaving the thick conglomerate mantle to cap Seams A and B.



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MT. SPIEKER PROJECT CORRELATION CHART

DRAWN BY: F.M.D. DEC. 1978 | FIG.: 4.2

Within the Main Syncline and the EB 1 Pit Area a complete section of Gates Member is present.

Seam A occurs at the base of the coal-bearing strata within the Gates Member. This seam is 0.8 metres to 1.4 metres thick and immediately overlies the basal "Torrens Member".

A small coaly horizon, *Seam A-B*, is located 3 metres to 8 metres above Seam A in the northwest part of the property. This zone is very thin having thicknesses ranging from 0.5 metres to 0,8 metres, and is discontinuous throughout the property.

Seam B is between 10 metres and 15 metres above Seam A, and averages 12 metres on Mt. Spieker as shown on Map 8. Its thickness ranges from 2.5 metres on Mt. Spieker to 6 metres in the EB 1 Pit Area. Drill hole intersections indicate Seam B is of relatively uniform thickness throughout the Main Syncline area, and contains few rock bands. This seam is the principal economic seam on this property.

A small coal horizon, *Seam* C_2, lies 15 metres above Seam B. This coal zone attains a maximum of 1.5 metres in the northwest portion of the property. Throughout the remainder of the property the seam is represented by thin coal partings.

Approximately 10 metres below Seam C_2 *Seam C* occurs. This seam is similar to Seam D in that it contains several rock partings. The seam thins towards the northwest and attains its maximum thickness within the EB 1 Pit Area. Seam thicknesses range from 0.5 metres in the northwest to 4.2 metres in the EB 1 Pit Area. Seam C is very distinct in that the roof of the seam is overlain by approximately 2.0 metres of fossiliferous carbonaceous shale.

Seam D, the uppermost economic coal seam within the Gates Member, is 15 metres above Seam C and approximately 25 metres below the worm burrow and glauconite marker horizon. The seam ranges in thickness from 0.8 metre in the northwest to 3.5 metres in the EB 1 Pit Area and contains several rock partings with thicknesses ranging from 0.1 metre to 0.3 metre. This is illustrated on the Seam Correlation Chart, Plan No. 7, in the map pocket.

4.6.2. Hulcross Member

The recessive Hulcross Member conformably overlies the Gates Member on the property. The Hulcross Member is overlain by the resistant beds of the Boulder Creek Member. The contact between these two units is gradational, but is occasionally marked by a thin glauconitic sandstone horizon. The Hulcross Member is approximately 130 metres thick and consists of marine siltstone and mudstone. The member is easily recognisable on the Mt. Spieker property; in cores, the Hulcross Member consists of thinly laminated interbeds of mudstone, siltstone and fine-grained sandstone. The beds are usually highly bioturbated and tend to become more arenaceous towards the base. Occasional thin bentonite beds are present throughout.

4.6.3. Boulder Creek Member

The Boulder Creek Member is the youngest, completely exposed unit on the property. The Boulder Creek Member and several small erosional remnants of Shaftesbury Formation outcrop in the eastern portion of the property. Within the Main Syncline the resistant nature of the Boulder Creek Member lithologies results in large cliffs overhanging the recessive underlying Hulcross Member. A complete section of the Boulder

Creek Member has not been measured on the Mt. Spieker property but the thickness of this member is estimated to be on the order of 200 metres.

The Boulder Creek Member consists of fine- to medium-grained, well-sorted, non-marine sandstone, containing phases and interbeds of mudstone, carbonaceous shale and conglomerate. A few thin and discontinuous coal seams have been intersected towards the base of the unit, but these seams have proven to be of no economic significance.

The upper 25 metres of the Boulder Creek Member is believed to consists of carbonaceous claystone, mudstone and some siltstone containing numerous thin coal bands. The contact between the Boulder Creek Member and the overlying Shaftesbury Formation is thus placed at the contact between the predominantly marine and non-marine strata.

4.7 SHAFTESBURY FORMATION

The youngest stratigraphic unit on the Mt. Spieker property is the Shaftesbury Formation which disconformably overlies the Boulder Creek Member. This formation is present only within the northeastern portion of the property. Erosion has left an incomplete sequence of Shaftesbury Formation on the Mt. Spieker property, but at other locations in the foothills this formation has a thickness of approximately 250 metres.

The Shaftesbury Formation consists of dark grey marine shale containing sideritic concretions and some sandstone phases. In the lower portion of the formation these lithologies grade into silty dark grey marine shale and siltstone, with sandstone and minor conglomerate near the base.

SECTION 5

STRUCTURAL GEOLOGY

5.1 MAJOR STRUCTURAL ELEMENTS

The Mt. Spieker Property consists of a large anticlinal box fold lying adjacent to and east of a broad concentrically folded syncline. The axes of these structures trend in a northwesterly direction. Map No. 1 illustrates these features.

C.D.A. Dahlstrom (1970) described the box fold style of crustal shortening, and suggested that this shortening mechanism was typical of many folded sequences in the Rocky Mountain Foothills. One of the examples of this type of structure cited by Dahlstrom is Babcock Mountain, which is currently being explored and developed as a coal property by Denison Mines Limited. A further example is Duke Mountain, where Pacific Petroleums Limited is currently developing their Monkman Pass coal property.

The upper strata of box folds are characteristically flat-lying and are bounded by steeply dipping, relatively planar limbs. The junctions between the steeply dipping and the flatlying strata form abrupt monoclines. The geometry of such folding requires that the monoclinal axes approach each other at depth, so that disharmonic folding and high angle reverse faulting are typical of the deformation of the older strata lying within the core of the anticline. Text figure 5.1 is a diagrammatic illustration of the nature of the deformation that is found within an anticlinal box fold.

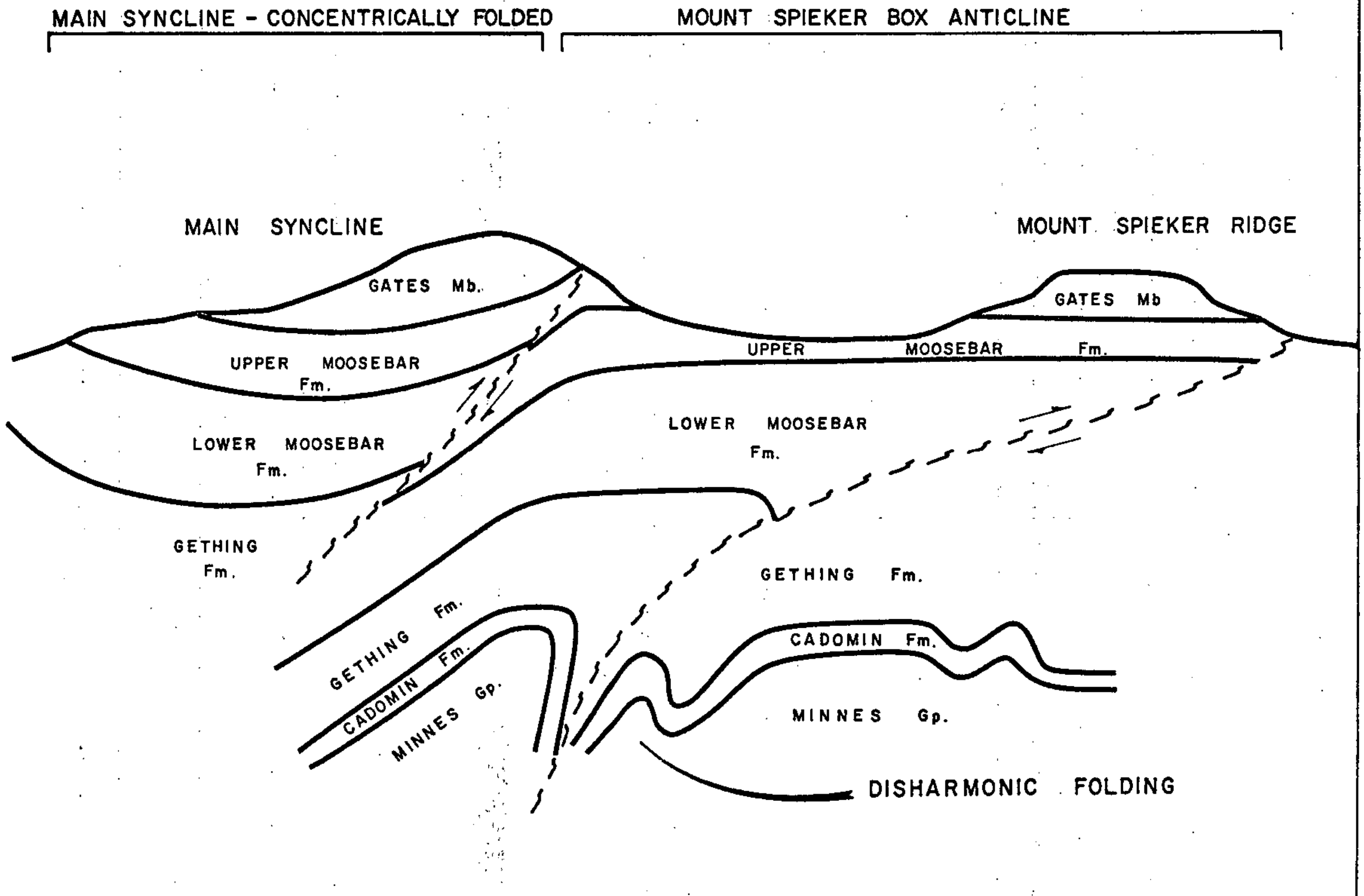


FIGURE 5.1: GENERALIZED CROSS-SECTION THROUGH THE MOUNT SPIEKER PROPERTY

The youngest strata of the Mt. Spieker box anticline consist of the Commotion Formation, while the Cadomin Formation and Minnes Group comprise the oldest units exposed at the core of the structure. It is most apparent when observing Mt. Spieker from a distance that very large disharmonic folds occur within the Cadomin Formation. It can clearly be seen that these fold core structures do not penetrate to the well-exposed overlying Commotion Formation strata. The simple anticlinal box fold of the Commotion Formation at Mt. Spieker is truncated by a large thrust fault along the eastern flank.

The Main Syncline portion of the property is a very regular concentric fold unlike the Mt. Spieker box anticline. It is common for such regularly folded strata to be located immediately adjacent to box folds in the Foothills.

A series of small scale tight folds lie sub-parallel to the Main Syncline as parasitic structures at the far western margin near the Syncline outcrop. These parasitic structures are chevron style folds with inclined axial planes dipping at approximately sixty degrees towards the east.

At several locations, thrust faults on various scales have been mapped in the field and observed in drill cores. These structures will be described in detail in a subsequent section of this report.

5.2 DEFINITION OF POTENTIAL MINING AREAS

The Mt. Spieker Property has been subdivided into several areas on the basis of geological structure. This subdivision highlights those areas which are considered to be especially suitable for mining. These areas are:

a) Mt. Spieker Ridge;
b) EB 1 Pit;
c) Main Syncline;
d) Bird Seam Underground Area; and
e) Bird Seam Pit Areas.

Definitions of these structural areas are given below. Text figure 2.2 shows their location.

5.2.1. Mt. Spieker Ridge Area

The Mt. Spieker Ridge Area is a mesa-like topographic feature consisting of the eastern portion of the main Mt. Spieker anticlinal box fold. The strata of the Gates Member of the Commotion Formation are exposed on the flat top of the mesa and lie well above treeline. Well-exposed sequences of the underlying Moosebar Formation and the upper part of the Gething Formation outcrop along the steep slopes of the western and northern edges of the ridge.

5.2.2. EB 1 Pit Area

The EB 1 Pit Area covers a flatlying portion of exposed Gates Member strata located on the central eastern margin of the Main Syncline Area. Although this area lies below treeline the considerable amount of road construction and other exploration activities conducted in this area have provided many stratigraphic sections which have been mapped in detail. This flatlying area does not truly represent the western area of of the Mt. Spieker box anticline but appears to be the erosional remnant of a similar *en echelon* structure which achieved its maximum development in a southeasterly direction. The steeply dipping eastern boundary of the EB 1 Area is part of the western monoclinal limb of the Mt. Spieker box anticline. The western limit of the EB 1 Pit Area is also formed by a monocline of steeply inclined west dipping strata. The latter steeply dipping beds are structurally separated from the Main Syncline Area by a northwesterly trending thrust fault. The northern limit of the EB 1 Pit Area occurs at the point where the monoclinal axes of the eastern and western flanks converge. To the north of this point only a continuous limb of steep west dipping strata exists. The enclosed cross-sections and structure contour maps, Maps 11 to 14, illustrate these features.

5.2.3. Main Syncline Area

The Main Syncline Area occupies the large mass of high ground adjacent to Mt. Spieker Ridge. The concentric folding of the strata of the Main Syncline develops at a point approximately half way through the main high ground mass and extends in a southerly direction from there across the southern property boundary. North of the Syncline proper, the strata are structurally continuous and nearly flatlying; Map 27* illustrates these features. This structural unit is bounded to the east by a northwesterly trending and westerly dipping thrust fault, and to the west by erosion. The northern limit is formed by the eroded north facing slope of Mt. Spieker.

* Map 27 is reproduced as Figure 5.2, page 5-10, herein.

5.2.4. Bird Underground Area

The Bird Seam Underground Area is located within the Gething Formation, underlying the Gates Member sequence of the Mt. Spieker Ridge structure. The Bird Seam Underground Area lies somewhat farther towards the west in the central portion of the Mt. Spieker anticlinal box fold.

5.2.5. South Bird Pit Area

The South Bird Pit is located near the southeastern margin of the Main Syncline Area. Little exploration has been conducted in this low lying, heavily vegetated area to date but the South Bird Pit Area appears to be the southern structural extension of the EB 1 Pit Area at the Gething Formation stratigraphic level.

5.2.6. West Bird Pit Area

The West Bird Pit Area is located at low topographic elevations along the south fork of Bullmoose Creek. Lower Moosebar Formation and Gething Formation strata are exposed along a broad eroded anticline which trends sub-parallel to the Main Syncline. Very little exploration has been carried out in this low priority area to date. One trench constructed over the Bird Seam indicates uneconomic coal thicknesses, although further exploration work is required before a final assessment can be made.

5.3 STRUCTURAL GEOLOGY OF MINING AREAS

5.3.1. The Mt. Spieker Ridge Area

The Mt. Spieker Ridge Area is a sequence of relatively flatlying strata. Broad, shallow dipping folds cause the strata to be undulatory. The trends of the fold axes are sub-parallel in a northwesterly direction. The maximum dip measured on the limbs of these folds to date is nineteen degrees with the average dip being approximately seven degrees.

Only the lowest portion of Gates Member strata remains at the surface following erosion of younger units with Gates Seams "C_2" through A being present. Map 2 illustrates these units. The roof of Seam B is a massive chert pebble conglomerate which has formed the mesa cap. This unit forms cliffs which provide continuous exposure around the ridge. A thorough examination of this completely-exposed unit shows that no structural discontinuities such as normal or reverse faults penetrate the conglomerate. This indicates that Seam B exists as a continuous structural block throughout the area. However, a normal fault has been mapped within the highest remaining stratigraphic units. The normal fault trends parralel to the most prominent of the broad anticlinal structures along its western limb. This fault appears to be the result and "crimping" of the upper strata along the axis of a synformal monocline at the junction between the anticlinal limb and flatlying beds to the west.

Coal exposures and drill cores of Seams A and B showed well-developed cleat sets oriented perpendicular to each other. The absence of shear failure planes or bedding plane shear zones was especially noticeable. In addition, the maximum coal core recovery for any area on the property was attained in Seams A and B. These facts indicate that the seams in this area have been subjected to a minimal amount of internal tectonic deformation, no doubt as a result of the presence of the thick conglomerate roof unit which either protected the seams or absorbed much of the tectonic stresses by shortening and thickening without failure. It can be inferred that this area will have a minimum of small scale structures in the Seam B roof, and probably at the Seam B floor. Such structures may also be minimal in the Seam A roof and floor. At this time no small scale tectonic structures have been located in this area within the well-exposed Seam B roof.

5.3.2. EB 1 Pit Area

The strata in the EB 1 Pit Area are exposed by erosion to a far lesser extent than those on Mt. Spieker Ridge, but the extensive drilling and road cut surface exposures have allowed the structure of this area to be examined in detail. The strata are flatlying and appear to be almost free of the broad fold structures which are present in the Mt. Spieker Ridge Area. Map 10 is the Geological Map of this area.

Two thrust faults have been identified and shown to trend across the EB 1 Area. These structures are relatively small scale. Throws of less than 20 metres have been found in drill holes, at trenched seam-repeated sections, and in Adit B2.

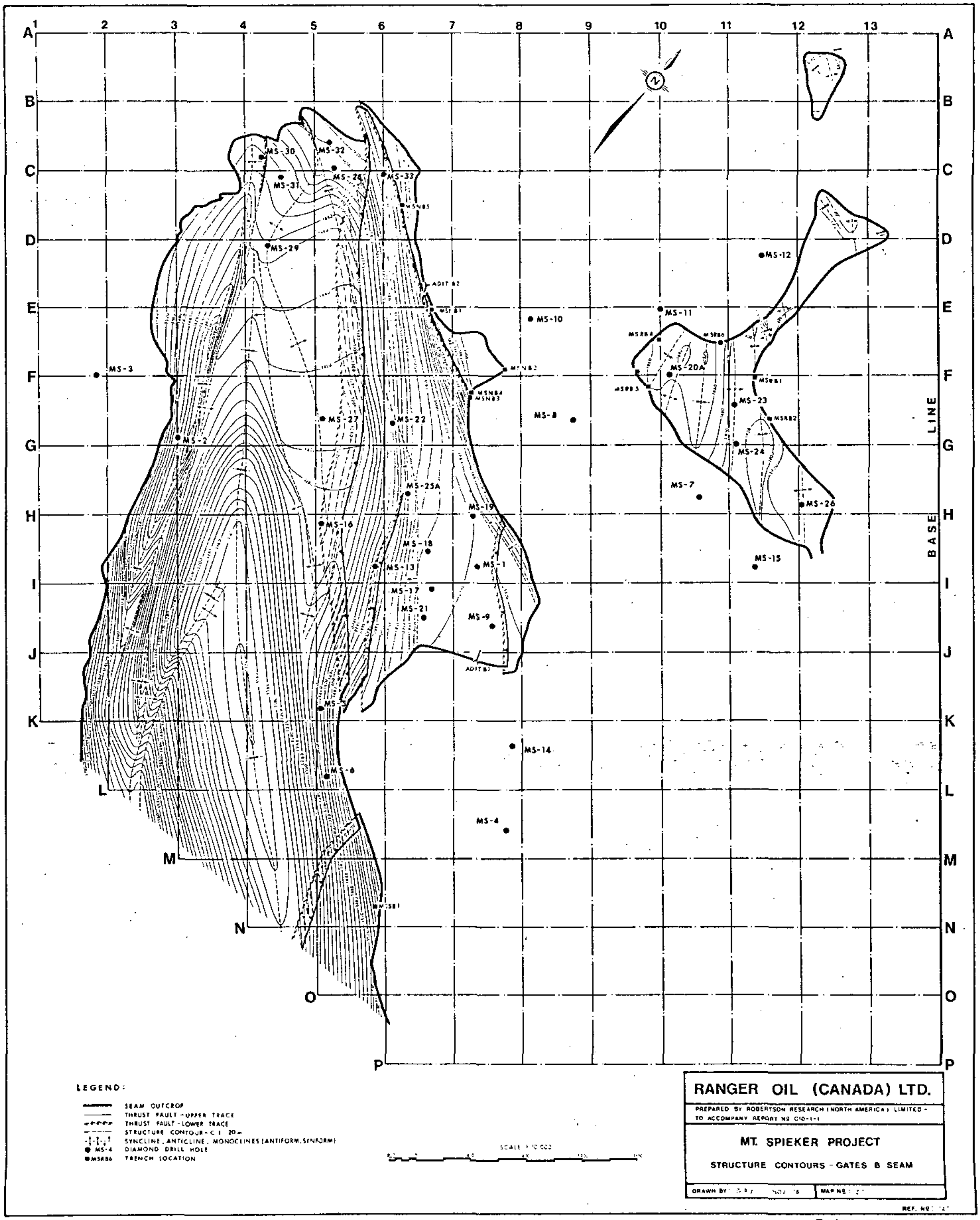
The adit and surface exposures show that Seams A, B and C are breached by both of these faults. Seam D appears to be broken only by the eastern thrust fault and this seam may act as the locus for bedding plan termination of the western fault.

The two faults trend sub-parallel in a northwesterly direction and dip towards the west. The dip of the faults is shown on the cross-sections included in the map pocket. Where the beds are flatlying, the faults dip 15° to 20° towards the west, and in the strata in the vicinity of the western margin of EB 1 Pit Area, which dip approximately 50° towards the west, faulting is shown to dip at approximately 65° in the same direction. At this time there is insufficient data to positively establish the dip of these faults. However, the orientations inferred on the cross-sections agree with established fault patterns on adjacent coal properties. This aspect will be further discussed in a following section of this report.

5.3.3. The Main Syncline Area

The Main Syncline Area consists of flatlying strata in the north from which a large concentrically folded syncline develops towards the south. This area also contains several smaller scale structural features. Along the western margin, an anticline and syncline pair exists, which trends in a northwesterly direction. Unlike the concentric folding of the Main Syncline, these structures are clearly chevron folds with very abrupt fold axes and long, straight limbs. These two fold styles commonly exist within the same structural regime and represent buckle folding or brittle deformation at relatively shallow depths of cover. A structure Contour Map on the floor of the Gates Seam B is included as Map 27, and reproduced herein as Text figure 5.2.

A second chevron fold syncline and anticline pair lies near the southern property boundary immediately east of the structures described above. This pair of structures is also



MS-30
MS-32
MS-31
MS-28
MS-33
MS-29
MS-12
ADIT B2
MS-10
MS-11
MS-20A
MS-3
MS-23
MS-27
MS-22
MS-2
MS-24
MS-7
MS-25A
MS-26
MS-19
MS-16
MS-18
MS-13
MS-15
MS-1
MS-17
MS-21
MS-9
ADIT B1
MS-5
MS-14
MS-6
MS-4
LINE
BASE
LEGEND:
SEAM OUTCROP
THRUST FAULT - UPPER TRACE
THRUST FAULT - LOWER TRACE
STRUCTURE CONTOUR - C.I. 20 m
SYNCLINE, ANTICLINE, MONOCLINES (ANTIFORM, SYNFORM)
MS-4 DIAMOND DRILL HOLE
MSRB6 TRENCH LOCATION
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MT. SPIEKER PROJECT
STRUCTURE CONTOURS - GATES B SEAM

FIGURE 5.2

located on the east dipping western limb of the Main Syncline. However, towards the northern limit of the Main Syncline, the trend of this pair of chevron folds changes to a northerly direction and the folds appear to terminate near the Main Syncline fold axis. It is possible that these structures developed in this orientation to accomodate problems of geometry and volume distribution generated by the obvious difference in the amount of deformation and shortening experienced by the northern and southern portions of the Main Syncline.

Within the relatively flatlying strata at the northern end of the Main Syncline, the axes of several small and broad parasitic folds approach each other. At the point of overlap it is anticipated that small scale thrust faults have been developed. Some such structures are shown on the structure contour maps at a scale of 1:10 000. In some instances drill results were used to establish the presence of these structures. The drill holes towards the north of the Main Syncline area show a greater degree of tectonic disturbance than those on Mt. Spieker Ridge or in the EB 1 Pit Area. This indicates that the required amount of structural shortening has taken place principally by the mechanism of small scale faulting rather than by folding as is the case farther south. Thus it should be anticipated that small scale faulting adjacent to the seam in this area may often be encountered. One thrust fault was observed at the southern end of the Main Syncline. However, that structure dips towards the west and appears to be related to the series of thrust faults which separate the Main Syncline Area from the southern structural extension of the EB 1 Pit Area.

5.3.4. The Bird Seam Underground Area

Drill holes completed in the Bird Seam Underground Area indicate that the strata are almost flatlying. Natural exposures of this sequence are insufficient to establish the presence of the broad warp folding observed in the overlying Gates Member strata; it is not known whether the soft mudstone of the Moosebar Formation has accommodated the warp fold structures. However, the structures observed within the Gates Member have necessarily been extrapolated to depth.

During the exploration of this area in 1977, the thrust fault forming the eastern limit of the Bird Seam Underground Area was mapped and intersected in drilling. That exploration showed that, at the Gates Member level, the thrust fault dipped at approximately 15° towards the west and truncated the eastern limb of the Mt. Spieker box anticline. Subsequent work has shown that this structure greatly increases in dip with stratigraphic depth and is almost vertical at the Cadomin Formation. The extension of this structure onto BP Canada Limited's Bullmoose Block can be readily observed.

Only one other thrust fault has been encountered in the Bird Seam Underground Mining Area. That structure has been projected parallel to the major eastern limiting fault and in fact is located close to the latter structure.

The most prominent fold structures in this area consist of two tight, horizontally oriented chevron folds which form a "Z" shape. The axial planes of these structures have a very shallow westerly dip. These structures have been observed at the upper Moosebar Formation stratigraphic level and thus are projected to be present at the Bird Seam level. The relative displacement at either side of these flatlying folds at the Bird Seam level can only be estimated at about 10 metres.

5.3.5. The Bird Seam Open Pit Areas

The South Bird Area and the West Bird Area respectively constitute the Bird Seam Pit Areas. As discussed above, the South Bird Area is structurally equivalent to the EB 1 Pit Area but is located at the Gething Formation stratigraphic level. The internal structure of this block is unknown at the present time. However, it must be anticipated that the main structural features of the EB 1 Pit Area will affect this area, at least in a similar if not more intense manner. The reason why structures affecting the Gates Member strata may be more strongly developed in the Gething Formation are discussed in Section 5.6 of this report.

No information is presently available with regard to the internal structure of the West Bird Pit Area.

5.4 FAULTING

The location of faults on the Mt. Spieker property have been fully described in the previous sections of this report. Only mechanisms and theories of fault orientation which have been used to aid cross-section construction will be discussed.

It can be seen from the cross-section that, in flatlying areas of strata intersected by thrust faults, the faults are shown to have a westerly dip to 15° to 20°. The direction of the dip of these structures have been assumed to lie in the same direction as that of the major structures mapped on the property for the reasons described below. The smaller scale structures are also assumed to have this orientation.

Small scale structures which have been proven by drilling on both the Sukunka property to the north and the Babcock property to the south have similar orientations to those proposed for the Mt. Spieker property. In addition, studies in rock mechanics conducted on the failure of rocks by brittle deformation under compression indicate that failure planes are generated at approximately 26° to the direction of maximum principal stress. Further, given a pronounced, suitably oriented anisotropy such as bedding, the angle between failure planes and the maximum principal stress direction can be reduced to as little as 10°. Hence, it is only necessary to demonstrate that the maximum principal stress direction was sub-horizontal at the time of deformation for the proposed fault orientations to become those most likely to be present.

Detailed studies at Sukunka indicate that the remnant principal tectonic stress direction is sub-horizontal. Mining conditions encountered during trial mining have confirmed this stress orientation. Since the remnant principal stress direction can only reflect the direction of maximum principal stress at the time of failure, the conclusion must be drawn that the maximum principal stress had a horizontal orientation at deformation. Consequently, it must be anticipated that the small scale structures, and indeed the large scale thrust faults, will be oriented between 10° and 26° to the orientation of bedding.

A similar orientation of faulting with respect to steeply dipping beds has been observed in the field on the Mt. Spieker property as well as other coal properties along the Rocky Mountain Foothills trend, that is, the bedding dips at an angle of, say, 50° while thrust faults penetrate these beds at 15° degrees. It is not known at Mt. Spieker whether this faulting originally developed in a near horizontal orientation and was later folded to a steeper orientation, or whether the anisotropy of the rocks was sufficiently great to cause a local modification of the deformation stress field parallel to bedding. Such a local rotation of the stress field would also produce thrust failure planes which are steeply dipping but which have an orientation of 10° to 20° with respect to bedding.

Only one fault has been observed to have a different orientation to those described above. That fault lies near the centre of the Mt. Spieker box anticline where the Cadomin Formation is folded disharmonically. As this fault continues upwards stratigraphically the dip flattens to assume an orientation of 15° with respect to the flatlying beds. It is assumed that this fault originated at a steep angle during the disharmonic folding phase, and was later propagated at the expected shallower angle as a response to further deformation.

5.5 FOLDING

A variety of fold styles have been observed on the Mt. Spieker property including concentric folding, chevron folding, and box folding. Box and chevron folding are both related, being formed by buckle fold mechamisms during brittle deformation. Concentric folding is commonly encountered during brittle deformation. Thus it should be expected that these fold styles will all be encountered in strata such as those which have been subjected to brittle failure. In fact, these fold styles are common to all strata situated along the Rocky Mountain Foothills coalfields of northeastern British Columbia.

5.6 RELATIVE DEFORMATION OF COMMOTION FORMATION AND GETHING FORMATION STRATA

On the nearby Sukunka coal property it has been clearly demonstrated that the Gething Formation has been subjected to a greater amount of faulting than the overlying Commotion Formation. In fact numerous thrust faults intersected in the Gething Formation were found not to penetrate throughout the mudstone of the Moosebar Formation into the overlying Gates Member. It can only be assumed that the soft and monotonous mudstone of the Moosebar Formation absorbed much of the strain energy.

At Mt. Spieker, a similar contrast of deformation between the Cadomin Formation and the Gates Member can be observed. Thus it should be anticipated that the Gething Formation strata will display a greater degree of tectonic deformation, by either large or small scale thrust faulting, than the overlying Gates Member.

SECTION 6

ECONOMIC APPRAISAL

6.1 GENERAL STATEMENT

This section provides an appraisal of the currently known potential of the Gates Member A, B, C and D Seams and a small area of Gething Formation Upper and Lower Bird Seams, as they apply to the Mt. Spieker Property.

The variations in the seam continuity and thickness, and the coal quality are discussed in Sections 6.2 and 6.3, respectively, and the resource base is documented in Section 6.4. Comments of a geological nature relating to mining conditions are included as Section 6.5; these are intended as guides only since categoric data will only become available after mining has commenced.

Physiographic features, structural controls or potential mining methods allow a natural sub-division of the property into four principal areas for ease of map display and discussion. These are:

- i) Mt. Spieker Ridge (1:5 000 scale maps)
- ii) EB 1 Open Pit (1:5 000 scale maps)
- iii) Main Syncline Underground Area (1:10 000 scale maps)
- iv) Bird Seam Underground Area (1:10 000 scale maps)

The maps included in the map box are grouped according to the above sub-division and in the same order. The List of Contents provides a full tabulation of all maps and plans accompanying this report.

The data presented in this report, and summarised in Appendices A to C, has resulted from detailed visual logging, both of the lithologies and of the coal seams, correlated with the detailed or expanded geophysical logs. Analysis of the coal is a natural corollory to this work. Unless attention is paid to those finer details of seam variation, mis-correlations of coal seams occur with consequent affect on the economic evaluation of the property.

Similarly, only by a developing a detailed knowledge of the "petrographic characteristics" of a coal seam, can sample intervals be defined and economic mining sections determined. "Petrographic characteristics", in this sense, refers to the visual observations of the relative percentage composition of the bright and dull macerals, and the associated non-coal constituents. The correlation between the coal macerals and the bright - dull ratio is shown on the Legend accompanying Appendix D, Ref. No. 162.

6.2 SEAM THICKNESS AND DISTRIBUTION

6.2.1. Bird Seam

Exploration of the Bird Seam to date has been concentrated within the Bird Underground Area where the depth of cover is relatively shallow and reasonable access to the seam can be gained. Maps 34 and 35, also Figures 6.6 and 6.7, the Isopach and Reserve Category Maps of the Upper and Lower Bird Seams, respectively, show the relatively small area of the property where data are available to provide a basis for evaluation. Based upon projections from drill holes completed during the 1978 programme, the Bird Seams are believed to lie under approximately 800 metres of cover within the Main Syncline Area. Little information is available for the West and South Bird reserve areas, as shown in Figure 2.2.

The Upper Bird Seam attains an average true thickness of 3.50 metres and varies in thickness from 2.43 metres to 3.64 metres in the Bird Underground Area, as illustrated on Map 34.

The Correlation Chart, Plan 8, illustrates the relationship between the Upper and Lower Bird Seams. An average of 2.5 metres of interseam strata separates the two coal seams.

The Lower Bird Seam has been intersected in diamond drill holes throughout the property, and has been observed in outcrop on Bullmoose Creek. The seam has an average true thickness of 1.75 metres, with maximum and minimum values of 1.98 metres to 1.49 metres, respectively. It should be noted that several of the intersections reported from the pre-1978 drill holes are based upon visual logging core recovery only, with no geophysical logs for verification.

6.2.2. Gates Member Seams

i) Gates Seam A

Seam A represents the lowest coal seam within the Gates Member stratigraphic sequence. The seam is continuous throughout the Mt. Spieker property, and serves as a distinctive marker horizon, lying immediately above the "Torrens Member". Seam intersections are fairly uniform ranging from 0.8 metre to 1.2 metres. This seam typically is composed of dull banded to dull and bright coal with several claystone partings toward the floor of the seam. On Mt. Spieker Ridge thin sandstone partings are occasionally present.

ii) Gates Seam B

The Gates Member Seam B lies approximately 10 metres to 15 metres above Seam A and is the most economically significant coal seam on the Mt. Spieker property. The seam is continuous throughout the main coal reserve areas, including the Main Syncline, EB 1 and Mt. Spieker Ridge. Seam thicknesses vary from 2.5 metres on Mt. Spieker Ridge to 6.0 metres in D.D.H. MS 25A. An average thickness for the Gates Seam B is approximately 4.5 metres within the EB 1 Pit and Main Syncline Areas.

Seam B is usually clean and contains only a few small rock partings. The seam can be divided into three main plys. The upper ply, 1.5 metres thick, consists of dull and bright coal which is often sheared. The middle ply is defined by the first bone coal parting and usually consists of dull to dull banded coal with several bone coal and claystone partings. The bottom ply, 1.3 metres thick, is bright banded or bright coal with a sharp floor contact.

iii) Gates Seam C

The Gates Member Seam C lies approximately 25 metres above the Gates Member Seam B and is included within mineable reserves only in the Main Syncline and EB 1 Pit Areas. Seam C varies from a coaly horizon of no economic interest in the northwest to a maximum of 4.23 metres thickness within the EB 1 Pit Area. The seam contains several rock partings, with a distinctive band 0.25 metres thick lying 1.5 metres above the seam floor.

iv) Gates Seam D

The Gates Member Seam D lies 15 metres above the Seam C. Seam D, like Seam C, tends to thicken towards the southeast and attains its maximum thickness in the EB 1 Pit Area. This seam also contains several rock partings. Seam D varies in thickness from 1.4 metres in the northwest to 3.5 metres in the EB 1 Pit Area.

6.2.3. TRENDS OF SEDIMENTATION OF MT. SPIEKER COAL SEAMS

Development of seam splits and changes in seam thicknesses occur, according to gradual trends throughout the Mt. Spieker property. There is no evidence to suggest any rapid development of seam splits or of major changes in seam thicknesses over short distances. No channel deposits or washouts have been located in the seams of the Mt. Spieker property and, in fact, none have been identified in the Foothills coal belt to date.

Gates Member Seam A tends to be consistent in thickness throughout the Mt. Spieker Property, except in the north-eastern portion of the Mt. Spieker Area where a split has developed. The roof of Seam A is a mudstone with occasional thin bands of coaly material. The basal "Torrens Member" of the Gates, a massive sandstone, forms the seam floor.

Gates Member Seam B is also reasonably consistant in thickness. On Mt. Spieker Ridge, however, the Seam B roof strata and the upper portion of the seam were evenly removed by, pene-contemporaneous erosion,and a tabular unit of conglomerate deposited over the remainder of the seam. This conglomerate has been completely exposed by erosion along the cliffs of Mt. Spieker Ridge, where drilling and trenching has shown that

a) the seam thickness is fairly constant;
b) the contact with the conglomerate roof is planar; and
c) it is apparent that no washouts of channels have developed in the seam.

The thicknesses of *Gates Member Seams C and D* vary from north to south across the Mt. Spieker property. The total section of coaly strata remains fairly constant for each seam, but the mining sections are reduced toward the north because of the gradual increase of boney coal and claystone within each seam. Reference to Plan 7 illustrates this feature.

The Bird Seam of the Upper Gething Formation is consistently divided into two splits, the *Upper and Lower Bird Seams,* throughout the Mt. Spieker property, although these splits gradually merge to form one seam on the Sukunka property to the north. Several thin coaly partings of variable thickness are consistently present beneath the Lower Bird Seam, as illustrated in Plan 8 in the map pocket.

There is no indication that further exploration activities on the Mt. Spieker property will cause a major revision of these trends of sedimentation decribed above. In fact, the patterns observed are consistant with these encountered throughout Lower Cretaceous strata of the northeastern Foothills coal belt. It is most notable that the sedimentation within these coal measures is unusually consistant over an exceptionally large areal extent.

6.3 COAL QUALITY

6.3.1. Data Sources

Warnock Hersey Professional Services, under instruction from Intermin Consultants (I.C.L.) and R.R.N.A., provided analyses of the raw coal plies as samples by R.R.N.A. in the field. The division of each seam intersection into sub-samples or plies for analysis was based on both detailed visual inspection and analysis of the geophysical logs, in particular the density and focussed beam resistivity logs. Special attention was paid to the percent recovery of the particular intersection under consideration. Rock bands greater than 2 centimetres were sampled separately from the adjacent coal plies.

Composites of the plies in each seam sampled were prepared by Warnock Hersey for washability testing; the results, and a discussion of the coal cleaning characteristics of the coal seams, are the subject of a separate study by I.C.L..

The three volume Appendix D accompanying this geological evaluation, containing the drill hole data, illustrates the seam sections in graphic form in conjunction with the analysis of the individual raw coal plies, as sampled. Appendix C in this volume summarises, for each of reference, the coal quality data. The spatial variation of specific quality parameters are illustrated in text figure form.

The analytical data previously reported by Mitsui (1977), Table 7, were used in the calculation of means, etc., for Gates C and D Seams, and the Bird Seams, since limited intersections were forthcoming from the 1978 programme. Since the 1978 programme was directed principally toward evaluating the Gates B Seam, adequate new data of a known standard was available on which to base conclusions.

In this section the following standard abbreviations are used:

- d.a.f. - dry ash free
- d.m.m.f. - dry mineral matter free
- V.M. - volatile matter
- F.C. - fixed carbon
- F.S.I. - free swelling index

TABLE 6.1

COMPARATIVE COAL QUALITY DATA

(See Appendix C for Summarised Coal Quality Data)

SEAM	AREA	RAW COAL (a.d.b.) Ash %	V.M. %	S %
A	All values	17.7	21.4	1.09
	Mt. Spieker Ridge	24.0	20.3	0.95
B	All values	13.8	23.0	0.42
	Mt. Spieker Ridge	10.6	23.6	0.59
	E.B. 1 Pit	16.7	22.2	0.37
C	All excl. MS 22 & 29	30.5	19.5	0.42
D	All excl. MS 18	28.2	21.0	0.54
	E.B. 1 Pit	31.2	20.0	0.38
Bird				
Upper	All values	10.9	*19.8	*2.33
Lower	All values	9.8	*19.8	*0.72

ø Composite of 1.50 S.G. Float + Frot washability test.

* One value only from MS 20A.

6.3.2. Gething Coal Seams

The two splits of the Bird Seam have similar quality characteristics, with the exception of the sulphur content. Refer Appendix C, page (vi) for summarised quality data and Table 6.1 herein.

In the raw coal state, they both contain approximately 10% ash and 20% volatile matter on an air dried basis, (a.d.b.). In the clean coal product, the dry ash free (d.a.f.) volatile matter is between 21.5% and 22%, and averages 20.3% (d.m.m.f.) in both seams. The ash content is reduced to approximately 7% (a.d.b.), after washing at a specific gravity of 1.50. The free swelling index (F.S.I.) is 7½ or higher in the clean coal product.

The A.S.T.M. Classification of the two splits of the Bird Seam is low volatile bituminous.

The principal deleterious feature of the Upper Bird Seam, the sulphur content, will necessitate blending of the clean coal product with products from other seams to increase its marketability. In the raw coal, the sulphur content can be as high as 2.33%, cleaning to 1.8%. As an example, mathematically blending 20% of the Upper Bird Seam 1.8% sulphur content coal with 80% Gates B Seam coal with 0.5% sulphur, would produce a final product with a sulphur content of 0.75%.

In comparision, the sulphur content of the clean coal from the Lower Bird Seam is predicted to be approximately 0,8%, a.d.b.. Only one raw coal sulphur value of 2.33% is available for the Upper Bird Seam, D.D.H. MS 20A, however seven values from the Mitsui (1977), reproduced in Appendix C, page (vii) to this report, are available to support the clean coal value. Results from previous exploration programmes suggest values as high as 2.20% sulphur in the clean coal, but it is noted that the sampled interval in some instances included basal sections of the seam which normally would be excluded from the mining section.

6.3.3. Gates Member Coal Seams

The variations in the physical character observed within each of the four Gates Member coal seams, as discussed in Section 6.2 above, is confirmed by the analytical data. For example, the raw or as-mined ash content (a.d.b.) ranges from 10.6% in the Gates Seam B to in excess of 30% in the Gates Seam C. Table 6.1 contains the mean values of the salient quality parameters for the four seams and Appendix C, pages (i) to (v) summarises the quality data for each seam.

On a clean coal basis, however, the coal within the four seams are similar in chemical composition, containing generally less than 10% ash (a.d.b.) and between 25% and 27% volatile matter (d.m.m.f.). Figures 6.1 and 6.2 illustrate the spatial variation of the ash and volatile matter, respectively, of the Gates Seam B throughout the project area. The A.S.T.M. classification of these coals is medium volatile bituminous. The average mean maximum reflectance of the Gates Seams A, B and C is 1.21%, and 1.17% for the Gates Seam D.

The sulphur content in the Gates Seams B, C and D is consistantly low, ranging from 0.27% to 0.65%, in both the total seam and the clean coal. Sketch iso-sulphur lines for the Gates Seam B are shown in Figure 6.3.

A slight increase of between 0.05% and 0.10% sulphur content is not uncommon in the clean coal fraction of the Seams B, C and D after washing. In the absence of analytical data on the various forms of sulphur present, this increase in sulphur content is interpreted to mean that the sulphur is present in the coal in the organic form rather than the pyritic form.

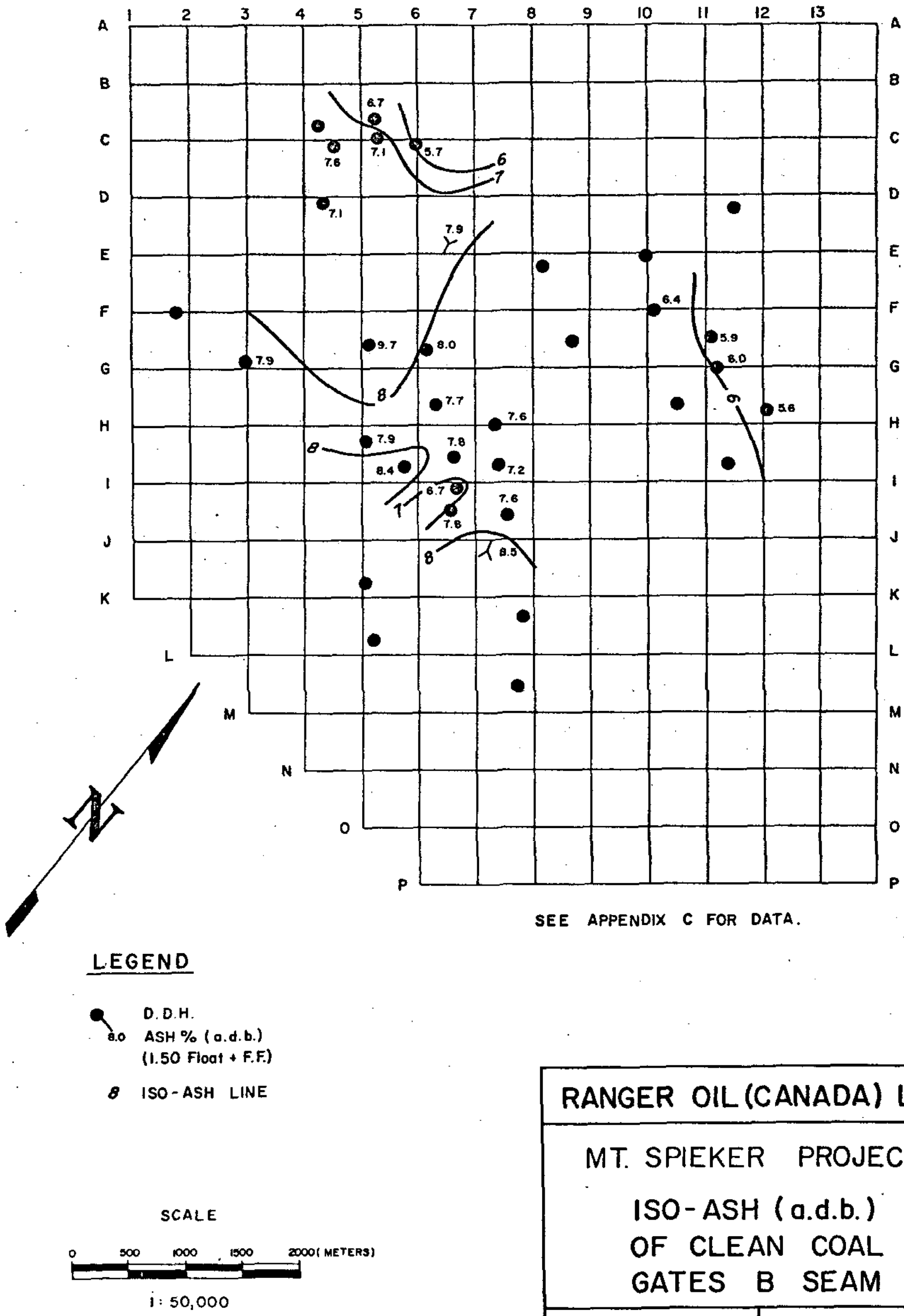
The Gates Seam A contains a higher percentage of sulphur than the other three Gates Member seams, averaging approximately 1%. However, washing the seam reduces the content to an acceptable level of less than 0.60% except on Mt. Spieker Ridge. In the northwest sector of the property, a minor marine incursion during formation of the seam has resulted in an increase in the sulphur content to between 1.5% and 2.0%. These high levels again are reduced by washing to less than 0.60%.

Variations in the ash and sulphur content *throughout the property* are not great, with the exception of the Gates Seams A and B on Mt. Spieker Ridge. In this area the mean of both parameters is higher than for the property as a whole, as shown in Table 6.1.

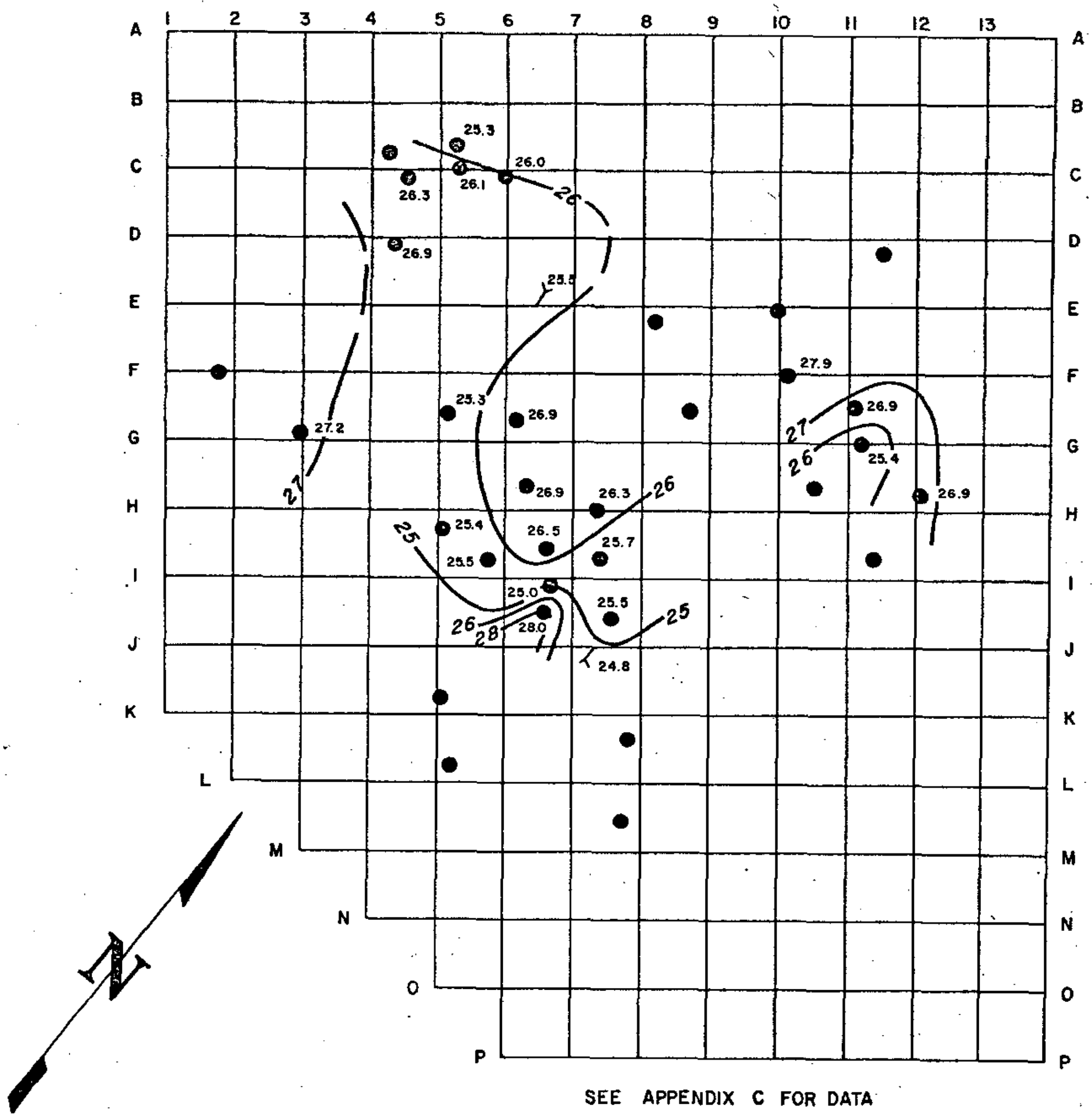
In the EB 1 Pit Area, Seams B and D are of similar quality to the remainder of the property. Insufficient data are available to make separate statements relating to the Seams A and C in this area.

Throughout the property, the free swelling index (F.S.I.) of the clean coal in all Gates seams is consistantly 6 or higher and ranges up to 8.

Six phosphorous determinations were carried out on seam composites from the Seam B (3 samples), Seam C (2 samples) and the Seam D (1 sample). The results were all acceptable, ranging from 0.050% to 0.074%.



RANGER OIL (CANADA) LTD.	
MT. SPIEKER PROJECT ISO-ASH (a.d.b.) OF CLEAN COAL GATES B SEAM	
NOV. 1978	FIG. 6.1



SEE APPENDIX C FOR DATA

LEGEND

D.D.H.
25.4 V.M.% (d.a.f.)
(1.50 Float + F.F.)

25 ISO-VOLATILE LINE

SCALE

0 500 1000 1500 2000 (METERS)

1: 50,000

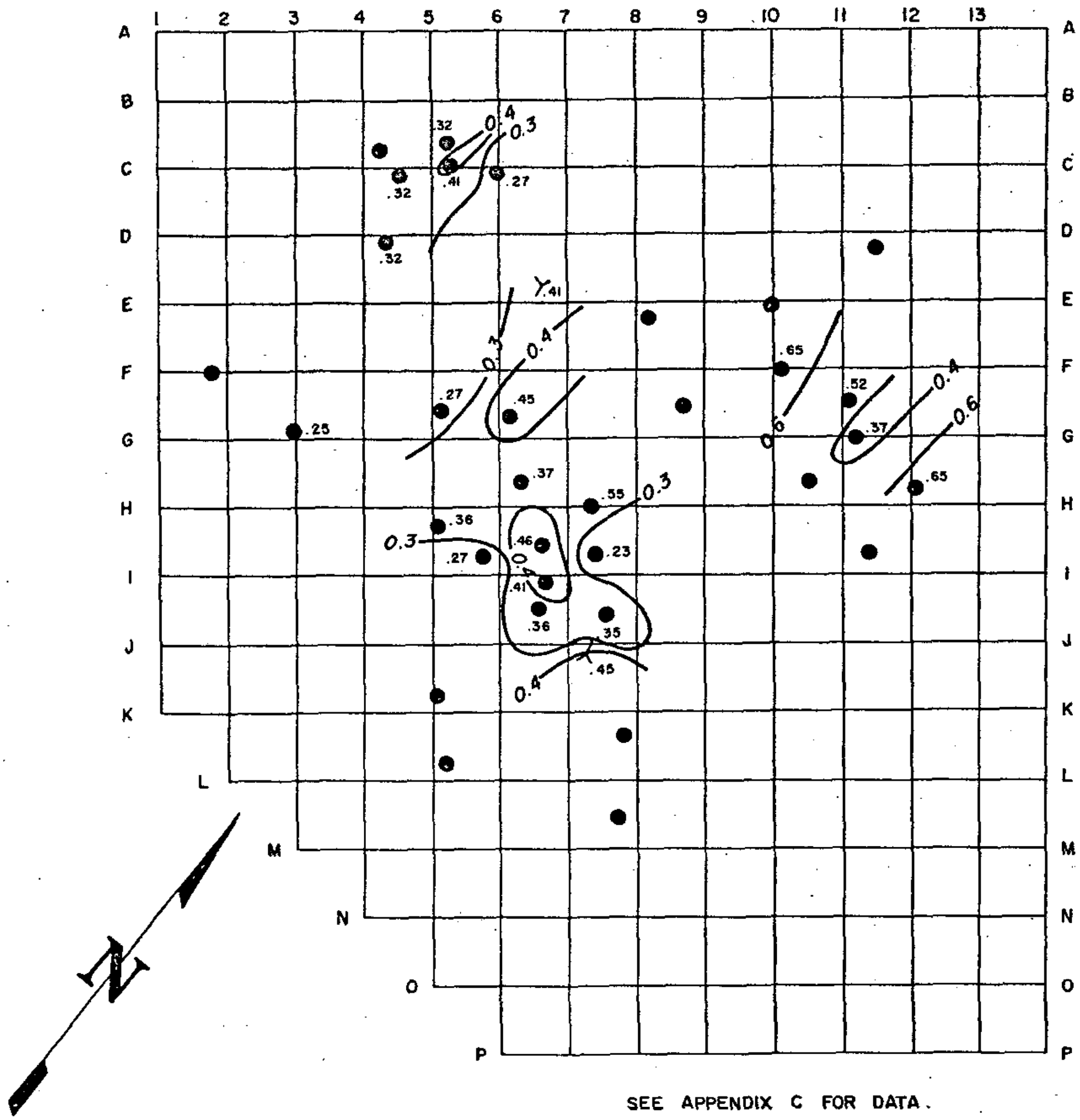
RANGER OIL (CANADA) LTD.

MT. SPIEKER PROJECT

ISO-VOLATILE MATTER (d.a.f.) OF CLEAN COAL GATES B SEAM

NOV. 1978

FIG. 6.2



SEE APPENDIX C FOR DATA.

LEGEND

- ● D.D.H.
- .23 SULPHUR % (1.50 Float + F.F.)
- *0.3* ISO-SULPHUR LINE

SCALE

0 500 1000 1500 2000 (METERS)

1 : 50,000

RANGER OIL (CANADA) LTD.	
MT. SPIEKER PROJECT ISO-SULPHUR (a.d.b.) OF CLEAN COAL GATES B SEAM	
NOV. 1978	FIG. 6.3

6.4 COAL RESOURCES

6.4.1. Reserve Calculations

The reserves of coal in the Mt. Spieker property have been calculated using the method described below. The detailed results of the calculations, on a seam by seam basis, for the various potential mining areas are tabulated in Appendix B, Tables B-2 to B-5; Table B-1 of the same appendix summarises those figures. All figures are *IN SITU* tonnes, i.e. metric.

The standard reserve categories of *Proven, Indicated and Inferred* have been used throughout as defined in the Notes to Accompany Appendix B.

The *reserve blocks*, as defined by areas of average dip between significant structural discontinuities, are shown on the relevant maps accompanying this report and reproduced as text figures in this section for ease of reference. It will be seen from these maps that the boundaries of some adjacent reserve blocks overlap due to the displacement by a thrust fault. On some maps the reserve block symbol is replaced by the upper and lower traces of the bounding thrust fault.

6.4.2. Method of Reserve Calculations

Reserves on the Mt. Spieker property have been determined by the planimetric method of calculation for plan areas rather than the cross-section method. Although the plan method is more time consuming to calculate it is felt that this technique allows the most accurate results to be gained from the available data.

The plan area method, if undertaken in a series of steps, as described below:

1) The seam sections determined from drill core and geophysical logs or seam trenches are analysed to determine mining seam sections. This analysis takes into consideration such factors as the minimum mineable seam height, in this case judged to be 1.5 metres, roof and floor conditions, the presence of rock bands which are too thick to allow economic mining, and the evaluation of a reasonable wash plant yield.

2) The true thickness of the mining sections is calculated.

3) Mining section isopach maps are prepared which include suitable barriers to allow for areas of oxidized coal. Those barriers are considered to occur at a 15 metre minimum overburden limit within strata dipping in excess of 10° and increase to as much as 30 metres in flatlying strata. The available quality data tends to support these oxidation limits.

4) A series of structure contour maps is prepared for each seam for which reserves are to be calculated. The structure contour maps are then subdivided into a series of smaller blocks each of which has a consistent internal dip. Those blocks, termed Reserve Blocks in this report, and the isopachs are illustrated on the various reserve maps included in this report.

5) A correction factor to allow for the dip of each block is then calculated. That factor, the secant of the dip, is also shown on the included reserve maps.

6) To determine the area occupied by each seam, a planimeter is calibrated to a standard map area, in this case 1 X 10^6 square metres, to give a planimeter function.

7) The area of each seam block is then determined by dividing the seam area as measured with the planimeter by the planimeter function, and multiplying by the secant of the dip for each block:

$$\text{Area} = \frac{\text{Planimeter Area}}{\text{Planimeter Function}} \times \text{Dip Secant}$$

8) The calculation of coal volume for each block is gained by multiplication by the seam thickness, which gives the volume of coal in millions of cubic metres.

9) This volume is multiplied by the specific gravity of the raw coal, assumed to be 1.35 where analytical data is inadequate, to determine the weight of raw coal in millions of metric tonnes.

10) The results of calculations for each block are then tabulated to determine the total mineable reserves for the property or individual potential mining areas.

6.4.3. Total Resource Base

The total resource base of coal which is considered to be extractable by various mining methods are 121.34 million tonnes in situ in all reserve categories, on the assumption that an overburden ratio of 12 cubic metres of overburden to 1 tonne of coal at the highwall of EB 1 Pit can be

TABLE 6.2

TOTAL RESOURCE BASE

(Refer to Section 6.4.3. for dicsussion)

LOCATION & RESERVE CATEGORY	SEAM	IN SITU TONNES X 10^6		
		UNOXIDISED	OXIDISED	TOTAL
ALL AREAS - all reserve categories				
Mt. Spieker Ridge	A	2.034	0.660	2.964
	B	3.035	1.662	4.697
Subtotal:		5.339	2.322	7.661
Main Syncline	B	16.022	0.288	16.310
	D	1.846	-	1.846
	B	45.765	1.257	47.022
Subtotal:		63.633	1.545	65.178
Bird Seam Underground				
	Upper	15.454	4.215	19.669
	Lower	7.533	0.598	9.519
Subtotal:		22.987	6.201	29.188
E.B. 1 Pit (Ratio 12:1)	A	1.924	0.387	2.311
	B	6.460	0.888	7.348
	C	4.167	1.063	5.230
	D	3.438	0.990	4.428
Subtotal:		15.989	3.328	19.317
TOTAL:		107.948	13.396	121.344

economically mined. Should it be necessary to reduce this ratio to 8.5:1, the in situ resource base would be reduced to *115.77 million tonnes.* This is discussed below in more detail. The dispersion of this tonnage throughout the property in the various seams is included in Table 6.2, broken down by potential mining areas. Table B-1 in Appendix B provides a breakdown of the reserve figures by mining area, seam and reserve category. Note that all figures are *in situ* tonnages. Approximately 10% of the total reserves are regarded as potentially oxidised.

Within the oxidised Gates Seam B tonnage of 1.66 million tonnes on Mt. Spieker Ridge, 0.29 million tonnes are designated "partially oxidised", based on analytical data and structural geology. This area is shown on Map 9 and in Figure 6.4. Not all this tonnages may be oxidised but in the absence of additional definitive data it should be regarded as such at this time. The bulk of the Mt. Spieker Ridge reserves are contained in the thicker Gates Seam B. Further, it is reasonable to expect that the 1.83 million tonnes of *indicated and inferred* reserves in this seam can be upgraded to *proven* with little difficulty.

Approximately 50% of the total resource base of 121.34 million tonnes occurs in the Gates Seam B in the Main Syncline Area; 27.59 million tonnes of this figure are categorised as *proven* and *indicated.*

The "conventional mining potential" reserves of 16.3 million tonnes of the Gates Seam B in this area are virtually all regarded as unoxidised and 12.5 million tonnes are proven and indicated. These reserve categories are illustrated on Map 33, Blocks F and G, and Figure 6.5. This area is regarded as being amenable to mining by "continuous miner" type operations, since the gradients present are reasonably low.

Reserve blocks A, D, E and O on Map 33 and Figure 6.5 have been designated "non-conventional mining potential", due to structural complications, and are regarded as being possible to be mined by longwall or hydraulic methods, for example. Attention is drawn to the fact that of the 47 million tonnes calculated as existing in this area, 15 million tonnes fall into the *proven* and *indicated* categories. A considerable amount of additional exploration will be necessary to upgrade the *inferred* reserve category to verify the current structural interpretation.

Maps 34, and Figures 6.6 and 6.7, illustrate the reserve categories for the 29 million tonnes of coal existing in place in the Upper and Lower Bird Seams, respectively. These are regarded as extractable by underground mining methods. The thicker, higher sulphur content Upper Bird Seam contains approximately 60% of the total tonnage.

Based on two preliminary open pit mine designs for the EB 1 Pit Area, in situ reserves are calculated for the four Gates Member Seams at two overburden ratios. The reserve categories are shown on Maps 23 to 26, and the reserve figures tabulated in Appendix B, Tables B-1 and B-5.

Table 6.3, below, summarises the differing tonnages of coal mineable from the two preliminary open pit designs supplied by Intermin Consultants Ltd.

TABLE 6.3

EB 1 PIT RESERVES

	DESIGN 1	DESIGN 2
OVERBURDEN RATIO (1)		
- High Wall (2)	8.5:1	12:1
- Total (approx.)(3)	n.a.	7.5:1
GATES SEAM RESERVES (4) - ($X\ 10^6$ tonnes)		
A	1.925	2.311
B	5.535	7.348
C	3.263	5.230
D	3.021	4.428
TOTALS:	13.744	19.317

Notes:

(1) This ratio is in cubic metres of overburden to 1 tonne of coal.

(2) The ratio at the high wall of an open pit.

(3) The *approximate* overall ratio of total overburden to total tonnes of coal, run of mine.

(4) Total reserves in all categories, in million tonnes.

In the above two designs, unoxidised coal constitutes approximately 76% and 83% of the total tonnages for the 8.5 to 1 and 12 to 1 ratio pit designs, respectively. For both pit designs, approximately 96% of the reserves are categorised as *proven and indicated*.

n.a. - not available at time of writing

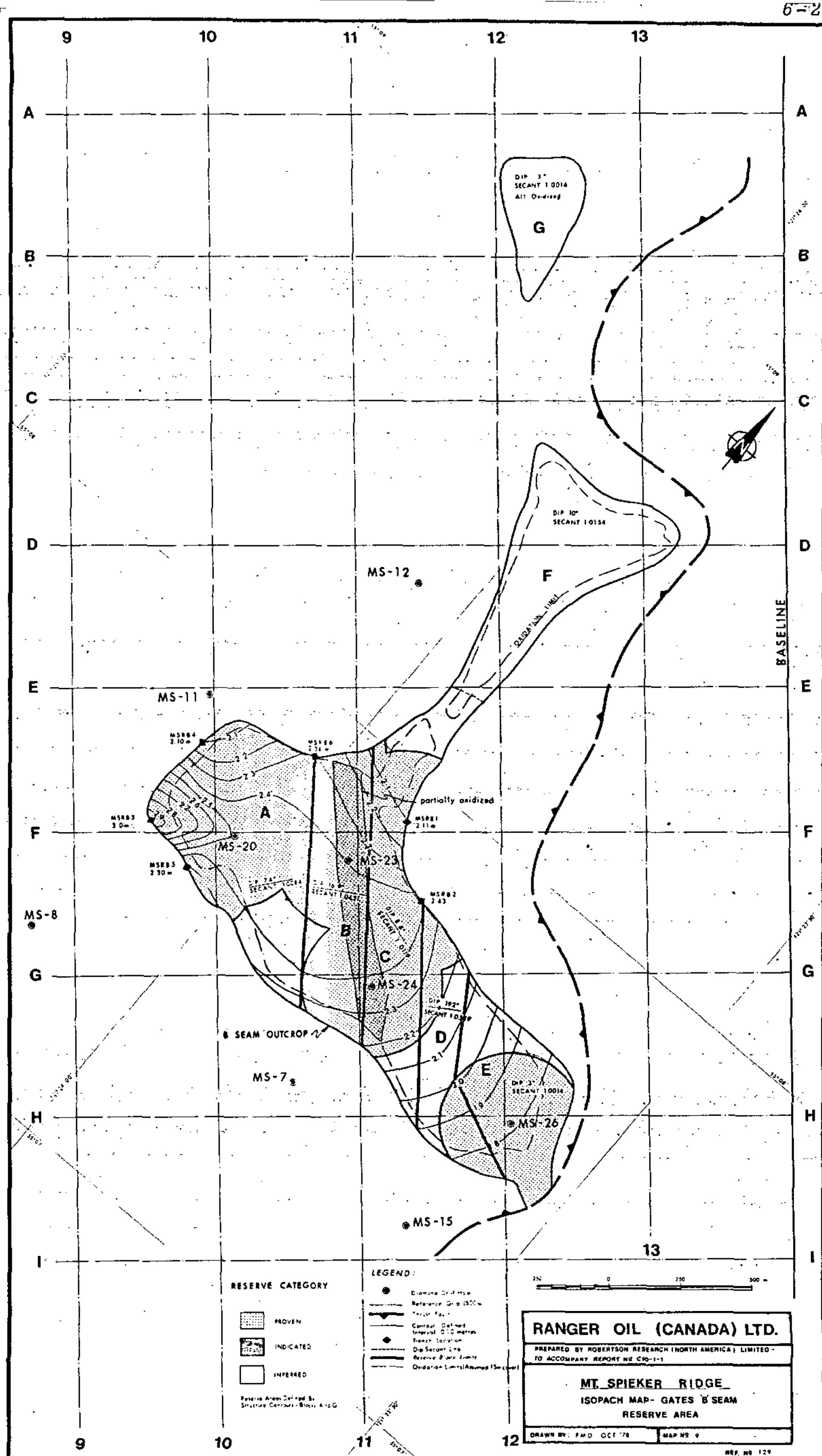
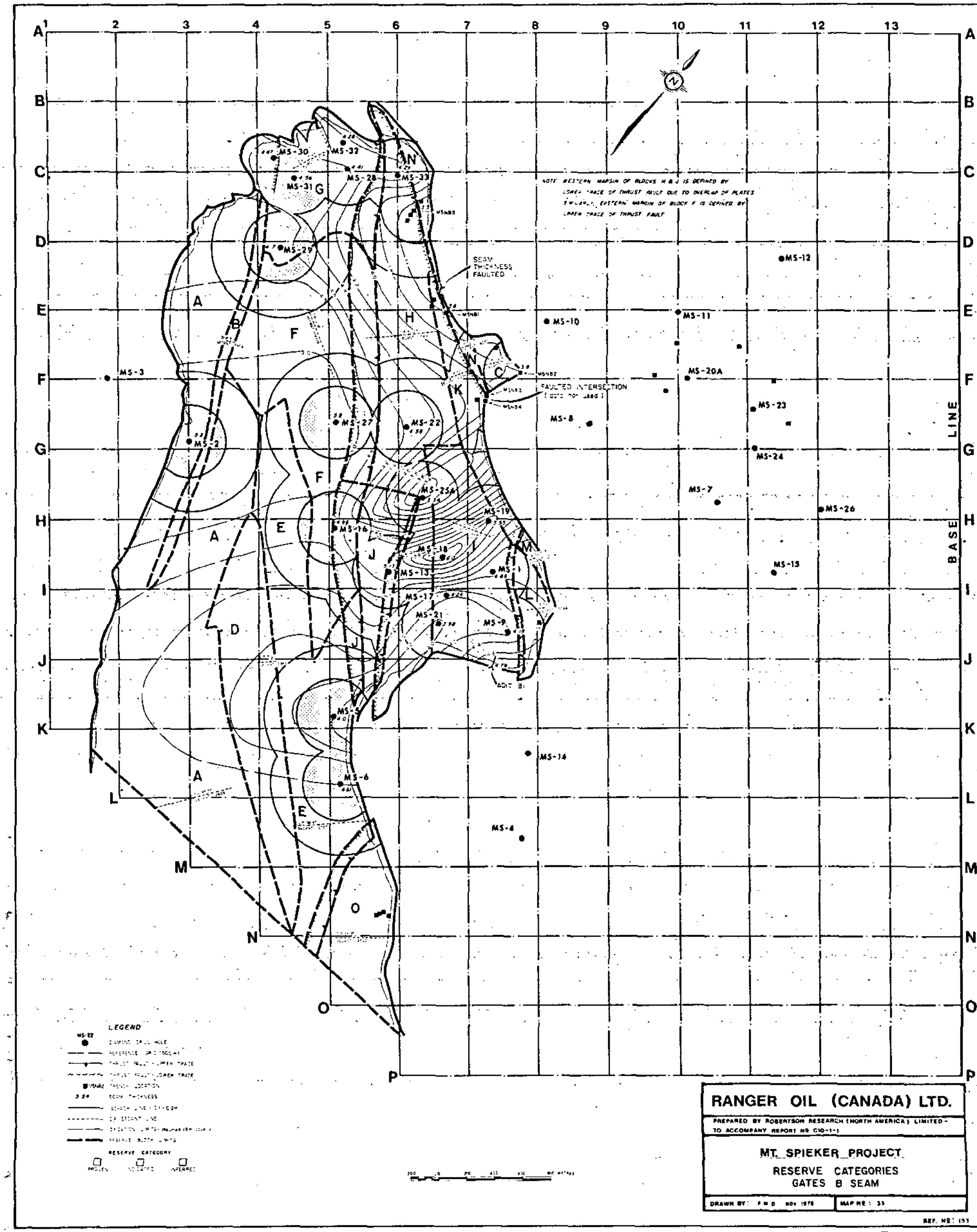

RANGER OIL (CANADA) LTD.
PREPARED BY ROBERTSON RESEARCH (NORTH AMERICA) LIMITED - TO ACCOMPANY REPORT NO C10-1-1
MT. SPIEKER RIDGE
ISOPACH MAP- GATES 'B' SEAM
RESERVE AREA
DRAWN BY: FMD OCT '78
MAP NO 9
REF. NO 129
RESERVE CATEGORY
PROVEN
INDICATED
INFERRED
LEGEND:
Diamond Drill Hole
Thrust Fault
Trench Location
Oxidation Limits
BASELINE
MS-7
MS-8
MS-11
MS-12
MS-15
MS-20
MS-23
MS-24
MS-26
B SEAM OUTCROP
partially oxidized
OXIDATION LIMIT
A
B
C
D
E
F
G
H
I
9
10
11
12
13

FIGURE 6.4



RANGER OIL (CANADA) LTD.
PREPARED BY ROBERTSON RESEARCH (NORTH AMERICA) LIMITED - TO ACCOMPANY REPORT NO C10-1-1
MT. SPIEKER PROJECT
RESERVE CATEGORIES
GATES B SEAM
DRAWN BY: F M D NOV 1978
MAP NO: 33
LEGEND
RESERVE CATEGORY
SEAM THICKNESS FAULTED
FAULTED INTERSECTION
ADIT B
BASE LINE
MS-3
MS-2
MS-10
MS-11
MS-12
MS-20A
MS-23
MS-24
MS-8
MS-7
MS-26
MS-15
MS-14
MS-4
MS-6
MS-5
MS-9
MS-21
MS-17
MS-13
MS-18
MS-1
MS-19
MS-25A
MS-16
MS-27
MS-22
MS-29
MS-30
MS-31
MS-32
MS-28
MS-33

FIGURE 6.5

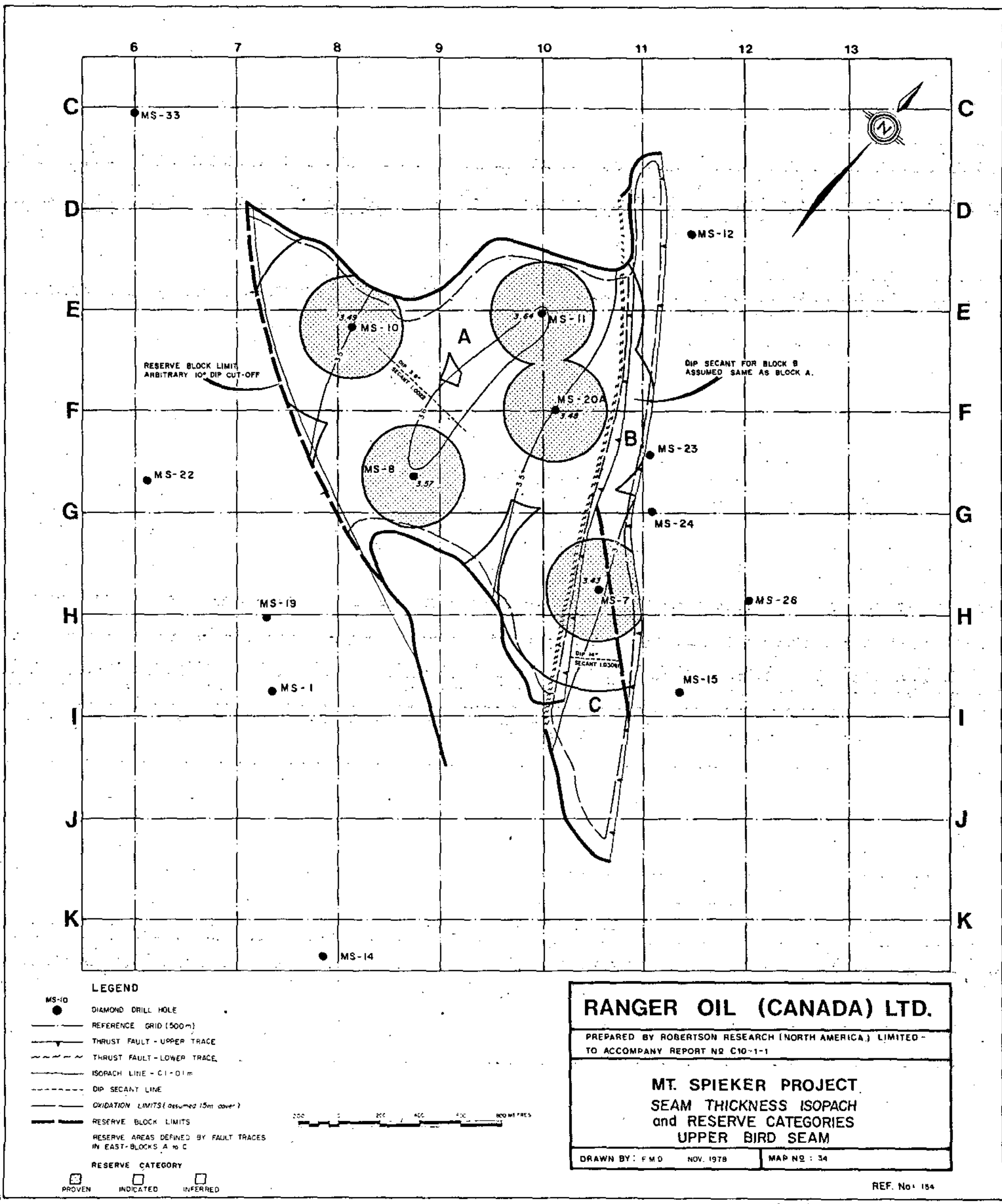
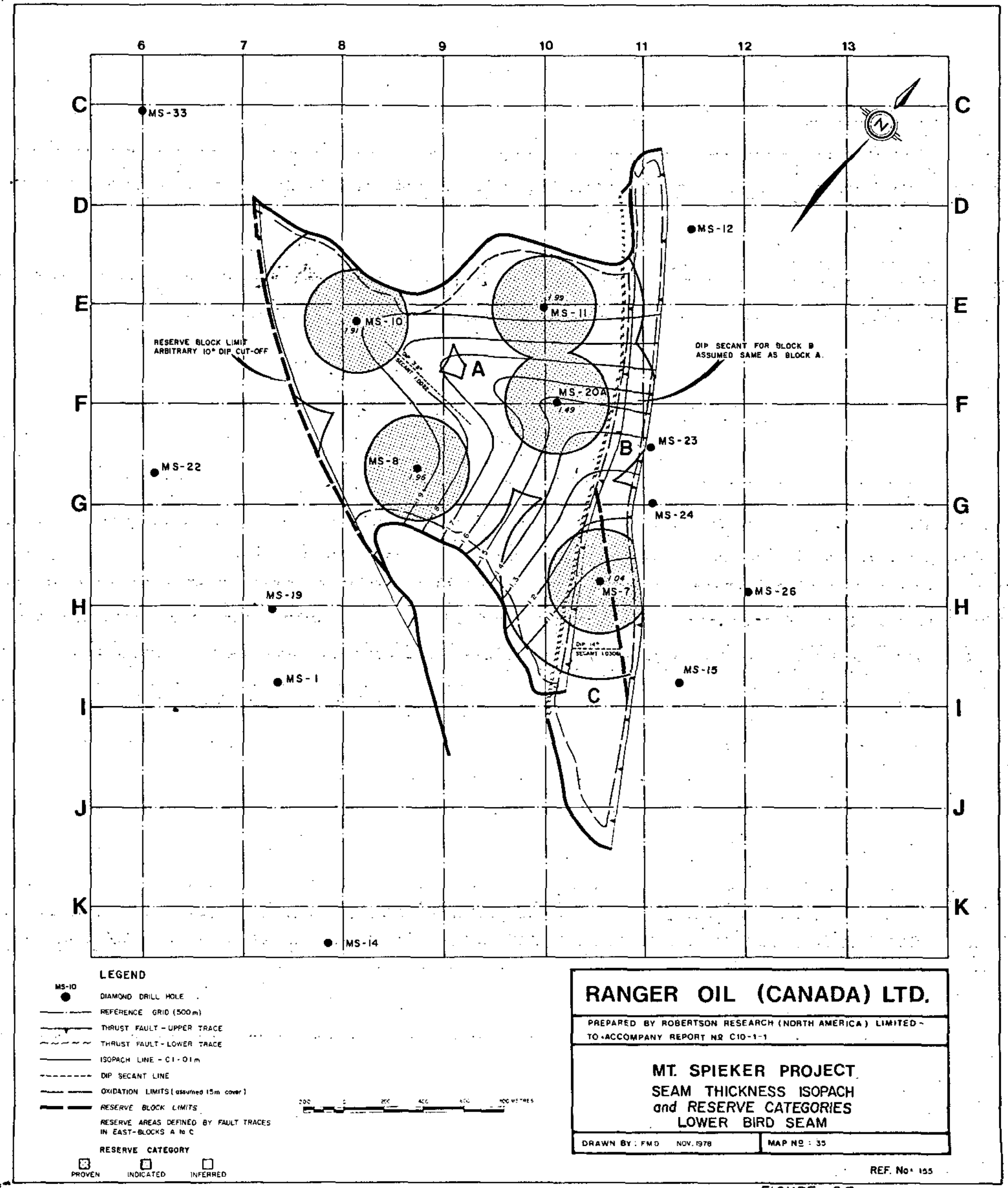

MS-33
MS-12
MS-10
MS-11
MS-20A
MS-8
MS-22
MS-23
MS-24
MS-7
MS-19
MS-26
MS-1
MS-15
MS-14
A
B
C
RESERVE BLOCK LIMIT ARBITRARY 10° DIP CUT-OFF
DIP SECANT FOR BLOCK B ASSUMED SAME AS BLOCK A.
LEGEND
DIAMOND DRILL HOLE
REFERENCE GRID (500m)
THRUST FAULT - UPPER TRACE
THRUST FAULT - LOWER TRACE
ISOPACH LINE - C.I. - 0.1 m
DIP SECANT LINE
OXIDATION LIMITS (assumed 15m cover)
RESERVE BLOCK LIMITS
RESERVE AREAS DEFINED BY FAULT TRACES IN EAST-BLOCKS A to C
RESERVE CATEGORY
PROVEN
INDICATED
INFERRED
800 METRES
RANGER OIL (CANADA) LTD.
PREPARED BY ROBERTSON RESEARCH (NORTH AMERICA) LIMITED - TO ACCOMPANY REPORT Nº C10-1-1
MT. SPIEKER PROJECT
SEAM THICKNESS ISOPACH
and RESERVE CATEGORIES
UPPER BIRD SEAM
DRAWN BY: FMD NOV. 1978
MAP Nº : 34
REF. No: 154

FIGURE 6.6



MS-33
MS-12
MS-10
1.91
MS-11
1.99
RESERVE BLOCK LIMIT
ARBITRARY 10° DIP CUT-OFF
DIP SECANT FOR BLOCK B
ASSUMED SAME AS BLOCK A.
A
MS-20A
1.49
MS-8
1.96
B
MS-23
MS-22
MS-24
MS-7
1.04
MS-19
MS-26
DIP 14°
SECANT 1.0306
MS-15
MS-1
C
MS-14
LEGEND
DIAMOND DRILL HOLE
REFERENCE GRID (500 m)
THRUST FAULT - UPPER TRACE
THRUST FAULT - LOWER TRACE
ISOPACH LINE - C.I. - 0.1 m
DIP SECANT LINE
OXIDATION LIMITS (assumed 15m cover)
RESERVE BLOCK LIMITS
RESERVE AREAS DEFINED BY FAULT TRACES IN EAST-BLOCKS A to C
RESERVE CATEGORY
PROVEN
INDICATED
INFERRED
RANGER OIL (CANADA) LTD.
PREPARED BY ROBERTSON RESEARCH (NORTH AMERICA) LIMITED - TO ACCOMPANY REPORT Nº C10-1-1
MT. SPIEKER PROJECT
SEAM THICKNESS ISOPACH
and RESERVE CATEGORIES
LOWER BIRD SEAM
DRAWN BY: FMD
NOV. 1978
MAP Nº : 35
REF. No: 155

FIGURE 6.7

6.5 GEOLOGICAL FACTORS AFFECTING MINING

Although no detailed investigations of seam mining conditions have as yet been undertaken, some general aspects of the geology of the seams have been observed and these are expected to have a significant influence on mining. Some of these geological factors are discussed below.

A bed of soft white "bentonitic" clay is located within the first metre of the roof of the *Upper Bird Seam*. Although this layer is termed "Bentonitic", the actual clay mineral composition has not yet been determined. Analysis of that material will have to be undertaken during exploration studies prior to the completion of a final feasibility study. If the clay minerals in this bed are established to be expanding or mixed layered clays, including minerals such as bentonite or montmorillonite, it should be anticipated that roof support difficulties will be experienced while mining the Upper Bird Seam. Since the *Lower Bird Seam* is located several metres below the Upper Bird Seam it is not expected that the "bentonitic" layer will be exposed to air during the underground mining of the Lower Bird Seam. Therefore, roof support problems created by the presence of the distant "bentonitic" layer may not be significant for the Lower Bird Seam extraction. Map 36 is an isopach map of the interseam sediments between the Upper and Lower Bird Seams.

The mining section for the *Gates Member Seam B* consists of the full seam height in all instances. Hence it can be anticipated that relatively competent strata at the roof and floor will be encountered for this seam in all underground and open pit mining situations. The Seam B to Seam C inter-seam strata forming the roof of Seam B consists predominantly of a mudstone and siltstone sequence; refer also the isopach maps of this interval, Map 8 and 21. Although the rock strength of this material is expected to be similar to that forming the Chamberlain Seam roof on the Sukunka property, the overall rock strength for Seam B on the Mt. Spieker property is expected to be considerably greater. The thin-bedded strata of the Chamberlain Seam roof have been subjected to a distinctive style of stratigraphically bounded tectonic deformation which has caused a significant reduction of the seam roof strength. Those structures are particularly distinct in drill core and none of them has been observed during the exploration of the Mt. Spieker property.

The selected mining sections for both Seams C and Seam D do not constitute of full coaly horizon section. Thus coal and rock bands are proposed to be left unmined at both the roof and floor of these seams. It should be anticipated that the inter-layering of these materials may require a more elaborate method of roof support to be employed other than the methods that would normally be used.

The depth of cover over the seams is shown on the relevant area maps as listed in the Contents Pages to this report. Similarly, the Contents lists the isopach maps of the inter-seam thicknesses between adjacent seams for specific areas.

Throughout virtually the whole of the Main Syncline the depth of cover is less than 400 metres (1300 feet) whereas previous exploration results has suggested that a proportion of the reserves of coal were under greater than 457 metres (1500 feet). From an underground mining standpoint the shallower depth of cover can only be advantageous, and further, means that no coal is sterilised because of excessive depths of mining.

SECTION 7

RECOMMENDATIONS

As a result of the work completed to date an exploration programme for 1979 is recommended with the aim of further delineating potential flat-lying coal reserves within the Gates Member and the Upper Gething Formation coal seams. Emphasis will be directed towards upgrading Probable and Inferred coal reserves into the Proven category. Reserve blocks, as defined by previous exploration programmes, are concentrated within the following areas:

South Bird Pit Area
E.B. 1 Pit Area
West Bird Pit Area
Mt. Spieker Ridge Area
Bird Seam Underground Area
Main Synclinde Underground Area

Drilling in the specific areas is discussed in the following sub-sections, and illustrated in Figure 7.1. Table 7.1 lists the depths of the drill holes recommended.

Additional extensive exploration, necessary to refine the structural interpretation, and to upgrade the reserve categories in that part of the Main Syncline designated and as "Non-Conventional Mining Potential" is not included in these recommendations.

Additional bulk sampling is considered necessary to determine coking characteristics but the design of such a programme is dependent upon recommendations forthcoming from the coal quality evaluation being conducted by Intermin Consultants Ltd.

In order to acquire the maximum amount of information while minimising expenditure, a combinations of drilling techniques is proposed for use. Two types of drill rigs would be needed to carry out the programme in its present configuration. A percussion, or down-hole hammer, drill rig with the capability of coring designated sections, using a VTM core barrel, would be needed for 2960 metres. This type of drill rig has the advantage of high penetration rates at a cost less than diamond drilling, and further, has no necessity for water.

The use of a diamond drill rig for obtaining full core is essential if structural data is to be obtained. Consequently, this type of drill rig is recommended for 920 metres of drilling in holes where the estimated depth is less than 300 metres. For holes where this depth is exceeded, principally where the upper 200 metres are non-coal bearing, a combination of pre-collaring by percussion drilling and completion by diamond drilling is recommended.

7.1 SOUTH BIRD PIT AREA

During the summer of 1978 the access road to the potential pit area was constructed. Since geological mapping to date has not revealed any coal exposures throughout the area, two exploratory drill holes are recommended to locate the coal seams. These holes would be drilled early in the programme in order to establish the coal thicknesses present and depth of cover. If results are favourable the number of drill holes in the South Bird Pit Area should be expanded. It is recommended that these two holes be drilled with a percussion drill rig utilizing a VTM core barrel.

7.2 EB 1 PIT AREA

The EB 1 Pit Area has been extensively drilled during the 1978 exploration programme. The coal sampled in the drill holes and adits is of varying coal quality, and further quality information should be obtained.

Four percussion drill holes are planned for this pit area. As with the South Bird Pit Area, a VTM barrel should be utilized for coring the coal seams.

7.3 WEST BIRD PIT AREA

Mapping conducted during the summer of 1978 within the West Bird Pit Area indicates the coal seams are of insufficient thickness to warrant a large scale exploratory programme in this area. It is recommended that further mapping and perhaps several "Winkie" drill holes be completed to confirm the preliminary indications.

7.4 MT. SPIEKER RIDGE AREA

Seven percussion drill holes are proposed, which would place most of the coal reserves of the Gates Seam B in to the Proven category. Seam B appears to be partially oxidized within specific areas, three of the proposed shallow drill holes would enable coal quality variations to be outlined more thoroughtly. Two drill holes, L and N should be extended to intersect the Bird Seam as well.

7.5 BIRD SEAM UNDERGROUND AREA

The Bird Seam Underground Area has had some exploratory drilling conducted on the fringes of the reserve area. Five diamond drill holes are proposed, enabling most of the reserve area to be placed in the Proven category. Two additional drill holes, L and N, would be drilled from Mt. Spieker Ridge. It is possible that all these drill holes could be completed, utilizing a percussion drilling rig and a VTM core barrel. Significant budget and time savings would be achieved by using this technique. Since the drill holes would be relatively deep, the ability of the VTM core barrel to obtain good core recovery must be assessed. If good core recovery was in doubt, the percussion drill rig could pre-drill to the top of the Gething Formation and the drill holes completed using a diamond drill rig.

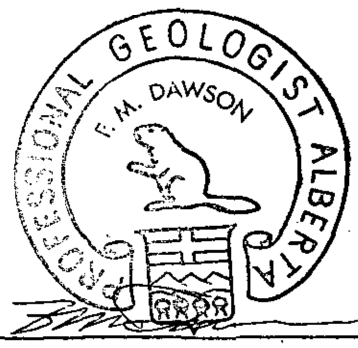
7.6 MAIN SYNCLINE AREA

The emphasis in the proposed exploration programme for 1979 in this area would be to delineate the remaining relatively flatlying coal reserves within the Main Syncline area. This would involve extending the grid drilling pattern established in 1978. If further interest is expressed in exploration of the potential "non-conventional mining areas", the programme could be expanded to include the limbs of the Main Syncline to the south of the principal reserve block.

The majority of the proposed diamond drill holes in the Main Syncline area are expected to be in excess of 400 metres in depth. It should be noted that the upper 200 metres are non-coal bearing. It is therefore recommended that the upper portion of these drill holes be pre-drilled using a percussion drilling rig. These would decrease the total diamond drilling footage by 2000 metres.

Four diamond drill holes at locations S, T, CC and KK are recommended for coring throughout their entire depth. Information obtained is essential in interpreting the structural complications expected on the east limb of the Main Syncline.

It is expected that the main entry to the Main Syncline underground mine will be north of D.D.H. MS 32 on the Seam B outcrop. Four diamond drill holes are recommended along the line of mine headings to define any structural or stratigraphic complications that may be encountered. The location of the drill holes would be feasible depending upon the placement of the main entry.



G. R. Jordan, P. Geol.

F. M. Dawson, P. Geol.

TABLE 7.1

RECOMMENDED DRILLING PROGRAMME

AREA	HOLE DESIGNATION	ESTIMATED DEPTH (metres)	RECOMMENDED TYPE OF DRILLING
South Bird Pit Area	II	100	Percussion with VTM core barrel
South Bird Pit Area	JJ	100	Percussion with VTM core barrel
Subtotal:		200	
EB 1 Pit Area	A	150	Percussion with VTM core barrel
	B	180	Percussion with VTM core barrel
	C	150	Percussion with VTM core barrel
	D	150	Percussion with VTM core barrel
Subtotal:		630	
West Bird Pit Area - Winkie Drill and geological mapping			
Mt. Spieker Ridge	E	60	Percussion with VTM core barrel
Mt. Spieker Ridge	F	60	Percussion with VTM core barrel
Mt. Spieker Ridge	G	60	Percussion with VTM core barrel
Mt. Spieker Ridge	H	60	Percussion with VTM core barrel
Mt. Spieker Ridge	I	60	Percussion with VTM core barrel
Mt. Spieker Ridge	J	60	Percussion with VTM core barrel
Mt. Spieker Ridge	K	60	Percussion with VTM core barrel
Subtotal:		420	
Bird Underground Area	L	300	Percussion with VTM core barrel
Bird Underground Area	M	270	Percussion with VTM core barrel
Bird Underground Area	N	300	Percussion with VTM core barrel
Bird Underground Area	O	170	Percussion with VTM core barrel
Bird Underground Area	P	270	Percussion with VTM core barrel
Bird Underground Area	Q	150	Percussion with VTM core barrel
Bird Underground Area	R	250	Percussion with VTM core barrel
Subtotal:		1710	

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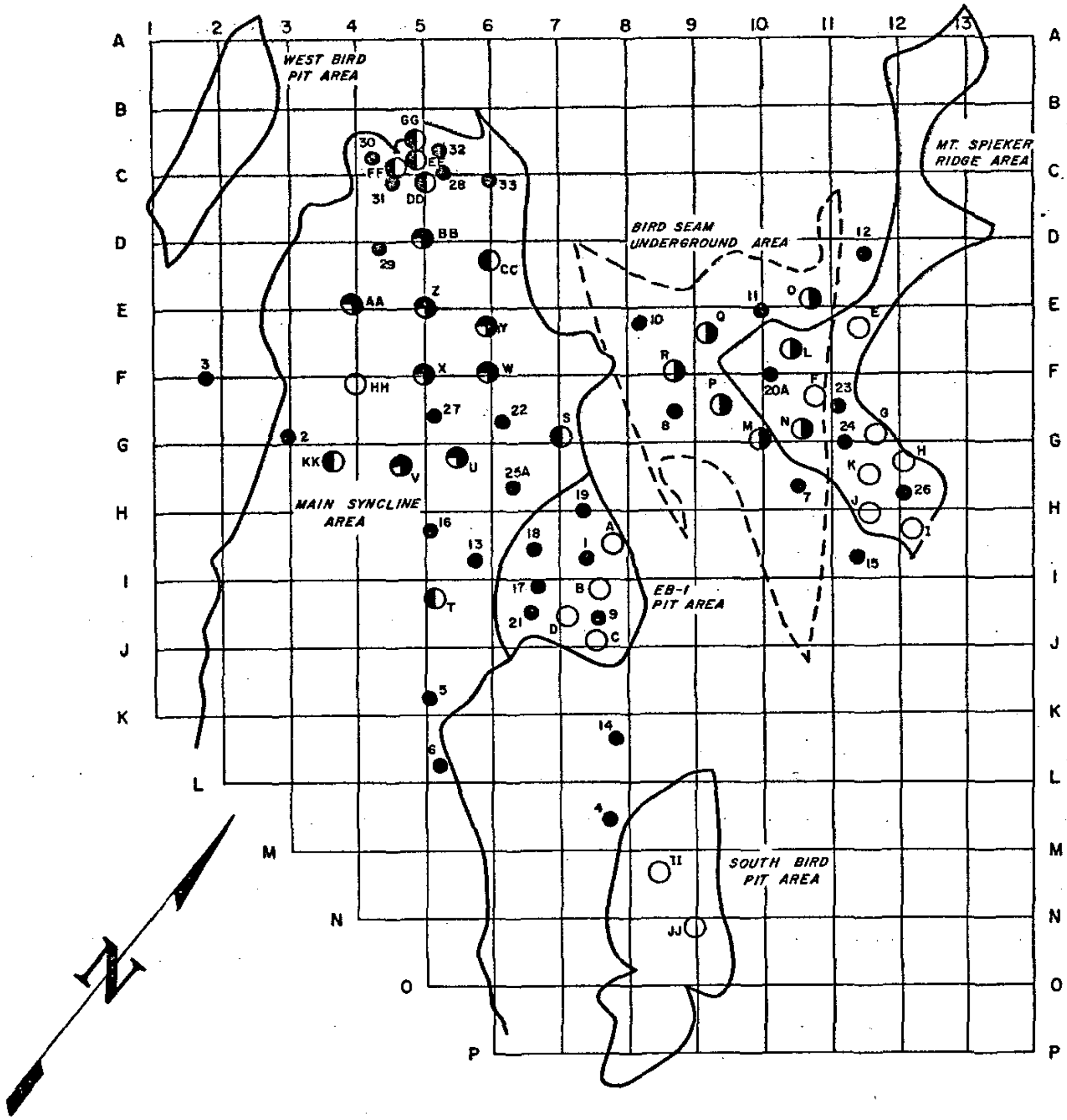
Summary of Drill holes (cont'd)

AREA	HOLE DESIGNATION	ESTIMATED DEPTH (metres)	RECOMMENDED TYPE OF DRILLING
Main Syncline	S	250	Diamond drill throughout
Main Syncline	T	300	Diamond drill throughout
Main Syncline	U	400	Predrill percussion, diamond drill Gates
Main Syncline	V	350	Predrill percussion, diamond drill Gates
Main Syncline	W	450	Predrill percussion, diamond drill Gates
Main Syncline	X	450	Predrill percussion, diamond drill Gates
Main Syncline	Y	450	Predrill percussion, diamond drill Gates
Main Syncline	Z	450	Predrill percussion, diamond drill Gates
Main Syncline	AA	450	Predrill percussion, diamond drill Gates
Main Syncline	BB	450	Predrill percussion, diamond drill Gates
Main Syncline	CC	250	Diamond drill throughout
Main Syncline	DD	150	Diamond drill throughout
Main Syncline	EE	100	Diamond drill throughout
Main Syncline	FF	60	Diamond drill throughout
Main Syncline	GG	60	Diamond drill throughout
Main Syncline	HH	350	Diamond drill throughout
Main Syncline	KK	450	Diamond drill throughout
Subtotal:		5420	
Total Metreage:		8380	



LEGEND

- ● 15 EXISTING DRILLHOLES
- ○ PERCUSSION D.H. + V.T.M. CORE BARREL
- ◐ PERCUSSION D.H. + V.T.M. CORE BARREL OR DIAMOND CORING
- PRE - COLLAR AND DIAMOND CORING
- DIAMOND CORE STRUCTURAL DRILLHOLE
- POTENTIAL RESERVE AREA

SCALE

0 500 1000 1500 2000 (METERS)

1 : 50,000

RANGER OIL (CANADA) LTD.	
MT. SPIEKER PROJECT	
1979 PROPOSED EXPLORATION PROGRAMME	
NOV. 1978	FIG. 7.1

SECTION 8

REFERENCES

DAHLSTROM, C. D. A., 1970. Structural Geology in the Eastern Margin of the Canadian Rocky Mountains. *Bull. Can. Pet. Geol., 18(3), pp. 332 - 406. (Sept. 1970).*

MITSUI MINING CO. LTD., 1977. Report on the Geological Exploration of the Mt. Spieker Area. November 1977. Confidential Report prepared for Nichiman Resources Ltd. and Ranger Oil (Canada) Ltd.

MT. SPIEKER COAL PROJECT

APPENDIX A

SUMMARISED DRILL HOLE DATA

Note: The pre-1978 drill holes, MS 1 to MS 15, were formerly prefixed as EB 1 to EB 15.

DECEMBER 15, 1978

ROBERTSON RESEARCH NORTH AMERICA LTD.
CALGARY

P/C

ATTENTION: MR. F. A. DAWSON

BELOW ARE THE DRILL HOLE COORDINATES FOR RANGER OIL LTD. AS REQUESTED BY MR. R. MITCHELL.

APOLOGISE FOR LATE SUBMISSION DUE TO WORKLOAD AND COMPUTING DELAYS.

COORDINATES IN METRIC, IN UTM ZONE 10 AND GEODETIC DATUM.

	EAST	NORTH	ELEVATION
ADIT C 1	602219.5	6107560.5	1665.9
ADIT B 1	602351.4	6107525.1	1625.5
ADIT B 2	600248.5	6109197.0	1731.7
MS 24	602620.8	6109990.9	1944.9
MS 26	603338.7	6109894.3	1929.2
MS 7	602688.9	6109475.3	1807.1
MS 15	603315.9	6109361.7	1821.9
MS 14	602861.5	6107196.5	1462.1
MS 3	598843.8	6107187.3	1359.7
MS 2	599593.9	6107211.8	1553.5
MS 16	600742.7	6107470.1	1689.9
MS 13	601283.6	6107505.4	1686.5
MS 9	602210.5	6107782.7	1708.9
MS 1	601842.1	6108018.4	1767.7
MS 18	601463.0	6107830.9	1827.4
MS 17	601662.3	6107636.7	1747.1
MS 4	603275.4	6106819.9	1443.7
MS 5	601663.8	6006463.9	1534.5
MS 6	602040.7	6106267.9	0502.6
MS 29	599108.4	6108551.5	1766.5
MS 31	598576.7	6109071.9	1583.1
MS 30	598540.6	6109184.5	1560.8
MS 32	598859.7	6109590.3	1666.0
MS 28	599022.6	6109440.1	1750.1
MS 33	599364.2	6109654.2	1793.2
MS 10	600917.3	6109593.2	1675.6
MS 22A	600694.9	6108472.4	1930.3
MS 8	601635.7	6109272.3	1722.3
MS 11	601554.3	6110294.8	1760.7
MS 20A	601970.8	6110002.5	1904.8
MS 23	602369.2	6110182.9	1941.7
MS 19	601605.5	6108274.4	1751.9
MS 22	600789.6	6108240.1	1875.9
MS 25A	601089.8	6107975.8	1857.6
MS 27	600386.8	6108024.6	1806.7
MS 21	601791.2	6107504.6	1702.3
MS 12	601836.8	6111067.1	1722.4

REGARDS

JOHN GROENEVELT
MCELHANNEY SURVEYING AND ENGINEERING LTD.
TELEX: 04-51474
TELEPHONE: 683-8521

ROBERTSON RESEARCH

MT. SPIEKER PROJECT

SUMMARISED DRILL HOLE DATA

GATES A SEAM

DDH NO.	COLLAR ELEVATION (m)	CORE ANGLE (°)	DEPTHS TO		TOTAL SEAM THICKNESS		CORE RECOVERY %	MINING SECTION	
			ROOF (m)	FLOOR (m)	APP'T (m)	TRUE (m)		APP'T (m)	TRUE (m)
1	1769.8	5	161.54	162.76	1.22	1.22	98	-	1.22
2	1554.9	37	179.53	180.90	1.37	1.09	87	-	-
5	1537.5	33	136.73	138.53	1.80	1.51	32	-	1.49
6	1532.6	33	152.40	153.94	1.54	1.28	47	-	-
9	1712.5	10	104.30	105.92	1.62	1.60	23	-	1.28
		11	122.93	127.25	4.32	4.24	82	-	4.24
13	1686.0	19	270.81	271.88	1.07	1.01	100	-	1.00
16	1685	0	320.57	321.79	1.22	1.220	88.5	1.22	1.22
17	1741	0	150.82	151.69	0.87	0.870	77.0	0.87	0.87
19	1759	2	152.004	153.134	1.13	1.129	58.4	1.13	1.13
20	1902	6	51.48	52.62	1.14	1.134	66.7	1.14	1.13
21	1695	0	101.44	102.56	1.12	1.120	73.2	1.12	1.12
22	1875	35	425.77	426.47	0.70	0.573	45.7	0.70	0.57
23	1940	15	62.72	63.61	0.89	0.860	67.4	0.89	0.86
24	1890	2	48.43	49.57	1.14	1.139	100	1.14	1.14
25A	1890	15	375.05	375.97	0.92	0.889	63.0	0.92	0.89
26	1925	3	41.97	43.08	1.11	1.108	100	1.11	1.11
27	1811	0	409.11	410.08	0.97	0.970	29.9	0.97	0.97

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MT. SPIEKER PROJECT

SUMMARISED DRILL HOLE DATA

GATES A SEAM

DDH NO.	COLLAR ELEVATION (m)	CORE ANGLE (°)	DEPTHS TO ROOF (m)	DEPTHS TO FLOOR (m)	TOTAL SEAM THICKNESS APP'T (m)	TOTAL SEAM THICKNESS TRUE (m)	CORE RECOVERY %	MINING SECTION APP'T (m)	MINING SECTION TRUE (m)
28	1790	15	216.70	217.88	1.18	1.140	67.8	1.18	1.14
30A	1620	15	120.14	130.24	1.10	1.063	66.4	1.10	1.06
A-B	1620	45	122.17	122.95	0.78	0.552	66.7	0.78	0.55
31A	1675	10	180.58	181.38	0.80	0.788	83.8	0.80	0.79
A-B			175.43	176.26	0.83	0.817	100	0.83	0.82
32A	1698	15	109.42	111.18	1.76	1.700	35.2	1.76	1.70
A-B			104.10	104.72	0.62	0.599	96.8	0.62	0.60
33A	1774	30	244.06	245.54	1.48	1.282	20.3	1.48	1.28
A-B			228.23	228.46	0.23	0.199	91.3	0.23	0.20
A-B2			242.30	243.44	1.14	0.987	13.2	1.14	0.99

MT. SPIEKER PROJECT

SUMMARISED DRILL HOLE DATA

GATES B SEAM

DDH NO.	COLLAR ELEVATION (m)	CORE ANGLE (O)	DEPTHS TO ROOF (m)	DEPTHS TO FLOOR (m)	TOTAL SEAM THICKNESS APP'T (m)	TOTAL SEAM THICKNESS TRUE (m)	CORE RECOVERY %	MINING SECTION APP'T (m)	MINING SECTION TRUE (m)
1	1769.8	6	143.50	148.16	4.66	4.63	92	-	4.66
2	1554.9	36	162.64	169.10	6.46	5.22	93	-	-
5	1537.5	37	115.70	120.70	5.00	3.99	30	-	4.00
6	1532.6	35	133.69	139.32	5.63	4.61	44	-	-
9	1712.5	9	86.87	91.14	4.27	4.22	98	-	4.18
13	1686.0	20	248.20	255.94	7.74	7.27	90	-	5.13
16	1685	0	305.59	310.48	4.89	4.890	90.6	4.96	4.96
17	1741	0	131.82	136.06	4.24	4.240	95.8	4.24	4.24
18	1833	0	223.32	229.31	5.99	5.990	58.9	5.99	5.99
19	1759	2	128.85	134.40	5.55	5.547	73.7	5.55	5.55
20	1840	0	37.09	39.60	2.51	2.510	98.8	2.51	2.51
21	1695	0	84.82	88.80	3.98	3.980	90.2	3.98	3.98
22	1875	35	401.35	407.80	6.45	5.284	62.5	5.60	4.58
23	1878	15	47.26	49.74	2.48	2.395	93.5	2.48	2.40
24	1942	2	33.72	36.10	2.38	2.379	100	2.38	2.33
25A	1890	30	354.54	358.40	3.86	3.343	83.4	3.86	3.34
26	1973	3	28.30	30.12	1.82	1.818	76.4	1.80	1.80

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MT. SPIEKER PROJECT

SUMMARISED DRILL HOLE DATA

GATES B SEAM

DDH NO.	COLLAR ELEVATION (m)	CORE ANGLE (°)	DEPTHS TO ROOF (m)	DEPTHS TO FLOOR (m)	TOTAL SEAM THICKNESS APP'T (m)	TOTAL SEAM THICKNESS TRUE (m)	CORE RECOVERY %	MINING SECTION APP'T (m)	MINING SECTION TRUE (m)
27	1811	0	393.20	298.40	5.20	5.200	70.4	5.20	5.20
28	1790	15	201.70	206.11	4.41	4.260	91.4	4.41	4.26
29	1776	0	293.00	297.70	4.70	4.700	80.2	4.70	4.70
30B_1	1620	15	107.88	112.35	4.47	4.318	86.1	4.47	4.32
B_2			114.10	115.50	1.40	1.352	25.0	1.40	1.35
31	1675	10	164.60	169.16	4.56	4.491	82.7	4.56	4.49
32	1698	15	93.12	97.40	4.28	4.134	48.6	4.28	4.13
33	1774	30	215.11	219.40	4.29	3.715	42.2	4.29	3.72

MT. SPIEKER PROJECT

Summarised Drill Hole Data

GATES C SEAM

DDH NO.	COLLAR ELEVATION (m)	CORE ANGLE (°)	DEPTHS TO ROOF (m)	DEPTHS TO FLOOR (m)	TOTAL SEAM THICKNESS APP'T (m)	TOTAL SEAM THICKNESS TRUE (m)	CORE RECOVERY %	MINING SECTION APP'T (m)	MINING SECTION TRUE (m)
1	1769.8	7	103.24	106.77	3.53	3.49	100	-	3.53
2	1554.9	44	108.90	112.04	3.14	2.26	85	-	-
5	1537.5	32	65.23	70.01	4.78	4.07	53	-	3.36
6	1532.6	35	86.50	90.83	4.33	3.55	76	-	-
9	1712.5	10	45.78	50.32	4.54	4.47	98	-	3.24
13	1686.0	25	206.38	210.31	3.93	3.56	100	-	3.56
16	1685	0	264.90	267.88	2.98	2.910	82.6	2.98	2.98
17	1741	0	92.76	96.29	3.53	3.530	95.6	3.53	3.53
18	1833	0	184.74	189.93	5.19	5.190	76.9	3.80	3.80
19	1759	2	83.00	87.19	4.19	4.160	84.2	3.80	3.80
21	1695	0	43.55	47.32	3.77	3.770	94.2	3.77	3.77
22	1875	20	360.22	364.97	4.75	4.464	46.3	4.75	4.46
25A	1890	31	299.70	301.235	1.535	1.316	16.9	1.47	1.26
27	1811	0	355.33	358.905	3.575	3.575	24.6	3.58	3.58
28C	1790	15	169.29	170.10	0.81	0.782	0	-	-
C2			181.96	182.85	0.89	0.860	100	0.89	0.86
29C	1776	0	259.80	261.40	1.60	1.600	40.6	1.60	1.60
C2			270.94	271.86	0.92	0.920	54.3	0.92	0.92

..../cont'd

MT. SPIEKER PROJECT

SUMMARISED DRILL HOLE DATA

GATES C SEAM

DDH NO.	COLLAR ELEVATION (m)	CORE ANGLE (°)	DEPTHS TO ROOF (m)	DEPTHS TO FLOOR (m)	TOTAL SEAM THICKNESS APP'T (m)	TOTAL SEAM THICKNESS TRUE (m)	CORE RECOVERY %	MINING SECTION APP'T (m)	MINING SECTION TRUE (m)
30C	1620	12	-	-	-	-	-	-	-
C2			87.10	88.96	1.86	1.819	59.1	1.59	1.56
31C	1675	15	119.04	119.19	0.15	0.145	100	-	-
C2			137.95	140.27	2.32	2.241	62.1	1.83	1.77
32	1698	25	-	-	-	-	-	-	-
C2			70.93	72.07	1.14	1.033	57.0	1.14	1.03
33C	1774	45	166.71	171.50	4.79	3.387	37.4	-	-
C2			192.96	194.21	1.25	0.884	65.6	1.25	0.88

MT. SPIEKER PROJECT

Summarised Drill Hole Data

GATES D SEAM

DDH NO.	COLLAR ELEVATION (m)	CORE ANGLE (°)	DEPTHS TO		TOTAL SEAM THICKNESS		CORE RECOVERY %	MINING SECTION	
			ROOF (m)	FLOOR (m)	APP'T (m)	TRUE (m)		APP'T (m)	TRUE (m)
1	1769.8	4	83.74	87.32	3.58	3.55	92	–	3.58
2	1554.9	46	67.30	73.49	6.19	4.30	79	–	–
5	1537.5	27	41.39	46.21	4.82	4.29	3	–	3.89
6	1532.6	34	62.73	68.03	5.30	4.37	64	–	–
9	1712.5	8	27.10	30.57	3.47	3.44	96	–	3.44
13	1686.0	26	187.18	191.08	3.90	3.51	100	–	3.54
15	1820.4	47	96.77	100.19	3.42?	2.31	58	–	–
16	1685	0	246.56	250.06	3.50	3.490	96.3	3.50	3.50
17	1741	0	72.08	75.05	2.97	2.970	83.0	2.97	2.97
18 D_1	1833	0	146.56	151.63	5.07	5.070	89.2	4.18	4.18
D_2			161.12	165.08	3.96	3.960	56.6	3.96	3.96
19	1759	0	62.39	65.92	3.53	3.530	69.1	3.53	3.53
21	1695	0	23.60	27.18	3.58	3.580	58.7	3.58	3.58
22	1875	30	341.52	344.14	2.62	2.269	46.2	1.56	1.35
25A	1890	35	282.35	286.205	3.855	3.158	69.0	1.85	1.52
27	1815	0	334.10	337.84	3.74	3.740	55.1	1.40	1.40
28 D_1	1790	15	135.10	135.28	0.18	0.174	55.5	0.18	0.17
D_2			138.90	139.80	0.90	0.869	95.6	0.90	0.87

..../cont'd

MT. SPIEKER PROJECT

SUMMARISED DRILL HOLE DATA

GATES D SEAM

DDH NO.	COLLAR ELEVATION (m)	CORE ANGLE (°)	DEPTHS TO ROOF (m)	DEPTHS TO FLOOR (m)	TOTAL SEAM THICKNESS APP'T (m)	TOTAL SEAM THICKNESS TRUE (m)	CORE RECOVERY %	MINING SECTION APP'T (m)	MINING SECTION TRUE (m)
29	1776	0	232.15	233.85	1.70	1.700	59.4	1.70	1.70
30D_1	1620	12	37.89	38.14	0.25	0.245	100	-	-
D_2			39.85	40.78	0.93	0.910	100	0.93	0.91
31D_1	1675	15	85.08	86.04	0.96	0.927	100	0.96	0.93
D_2			89.04	89.71	0.67	0.647	100	0.31	0.30
32	1698	25	17.03	19.61	2.58	2.338	55.0	-	-
33	1774	45	144.15	145.65	1.50	1.061	66.0	1.50	1.06

MT. SPIEKER PROJECT

SUMMARISED DRILL HOLE DATA

UPPER BIRD SEAM

DDH NO.	COLLAR ELEVATION (m)	CORE ANGLE (°)	DEPTHS TO ROOF (m)	DEPTHS TO FLOOR (m)	TOTAL SEAM THICKNESS APP'T (m)	TOTAL SEAM THICKNESS TRUE (m)	CORE RECOVERY %	MINING SECTION APP'T (m)	MINING SECTION TRUE (m)
1	1769.8	4	449.43	451.84	2.41	2.40	38		
3	1359.8	22	104.24	104.64	0.40	0.37	23		
4	1441.5	5	76.08	78.43	2.35	2.34	66		
		5	87.20	90.43	3.23	3.22	12		
7	1804.0	12	237.74	241.25	3.51	3.43	68		
8	1723.5	7	85.16	88.76	3.60	3.57	96		
10	1664.3	11	39.72	43.28	3.56	3.49	97		
11	1761.3	12	145.88	149.60	3.72	3.64	100		
14	1456.7	4	96.32	98.76	2.44	2.43	91		
20A	1840	0	306.10	309.58	3.48	3.48	51.7		

MT. SPIEKER PROJECT

SUMMARISED DRILL HOLE DATA

LOWER BIRD SEAM

DDH NO.	COLLAR ELEVATION (m)	CORE ANGLE (°)	DEPTHS TO ROOF (m)	DEPTHS TO FLOOR (m)	TOTAL SEAM THICKNESS APP'T (m)	TOTAL SEAM THICKNESS TRUE (m)	CORE RECOVERY %	MINING SECTION APP'T (m)	MINING SECTION TRUE (m)
1	1769.8	4	456.80	458.33	1.53	1.51	30		
3	1359.8	31	117.13	120.00	2.87	2.46	34		
4	1441.5	5	103.42	105.31	1.89	1.88	51		
7	1804.0	24	246.07	247.13	1.06	0.97	0		
8	1723.5	8	90.71	92.69	1.98	1.96	100		
10	1664.3	11	48.49	50.44	1.95	1.91	100		
11	1761.3	17	153.83	155.91	2.08	1.99	75		
14	1456.7	5	102.81	104.52	1.71	1.70	100		
20A	1840	0	312.44	313.93	1.49	1.49	85.9		

RANGER OIL (CANADA) LIMITED

MOUNT SPIEKER PROPERTY

MINEABLE SEAM THICKNESSES

Drill core logs and coal analyses were examined in order to determine mineable seam thicknesses as a basis for estimating coal reserves. The figures quoted below are for coal seams mineable by either surface or underground techniques; where no figure is given to a seam, by implication that seam is either not present or is considered not to be mineable. (For reference, in situ coal seam thicknesses are shown in these instances).

For the deep reserves (S.E.) only seam B is possibly mineable by underground hydraulic methods, in the defined 'plates' between faults. Other seams are either too thin or are affected by multiple partings. The same can be said of the deep reserves (N.W.) where only seam B is potentially mineable.

MOUNT SPIEKER AREA

DRILL HOLE NUMBER	MINEABLE SEAM THICKNESSES (m)	
	A	B
MS 20	1.14	2.51
MS 23	0.86	2.48
MS 24	1.14	2.38
MS 26	1.11	1.80

EB-1 PIT AREA

DRILL HOLE NUMBER	MINEABLE SEAM THICKNESSES (m)			
	A	B	C	D
MS 17	0.87	4.24	3.53	2.97
MS 18		5.99	3.80	4.18(D1):3.96(D2)
MS 19	1.13	5.55	3.80	3.53
MS 21	1.12	3.98	3.77	3.58
EB 1	1.22	4.66	3.53	3.58
EB 9	1.28(A1):4.24(A2)	4.18	3.24	3.44
EB 5	1.49	4.00	3.36	3.89

DEEP RESERVES (West of EB-1 Pit Area)

DRILL HOLE NUMBER	MINEABLE SEAM THICKNESSES (m)			
	A	B	C	D
MS 25A	-	3.86	1.54	-
(in situ)	0.92	3.86	1.54	1.85
EB 13	-	7.28(B1):5.13(B2)	3.56	-
(in situ)	1.00	Ditto	3.56	3.54
MS 22	-	5.60	4.75	-
(in situ)	0.70	6.45	4.75	1.56

DEEP RESERVES (Main Syncline Area)

DRILL HOLE NUMBER	MINEABLE SEAM THICKNESSES (m)				
	A	A/B	B	C	D
MS 28	-	-	4.41	-	-
(in situ)	1.18	-	4.41	0.89	0.18(D1):0.90(D2)
MS 29	-	-	4.70	-	-
(in situ)	-	-	4.70	1.60(C1):0.92(C2)	1.70
MS 30	-	-	4.47(B1) -	-	-
(in situ)	1.10	0.78	4.47(B1):1.40(B2)	1.59(C2)*	0.93
MS 31	-	-	4.56	-	-
(in situ)	0.80	0.83	4.56	1.83(C2)*	0.96(D1):0.31(D2)
MS 32	-	-	4.28	-	-
(in situ)	1.76	0.62	4.28	1.14(C2)	-
MS 33	-	-	4.29	-	-
(in situ)	1.48	0.23(A/B):1.14(A/B2)	4.29	1.25(C2)	1.50
MS 27	-	-	5.20	-	-
(in situ)	0.87	-	5.20	3.58	1.40
MS 16	-	-	4.96	-	1.66
(in situ)	1.22	-	4.96	2.98	3.50

* Indicates total seam interval, including partings.

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RANGER OIL (CANADA) LIMITED

MOUNT SPIEKER PROPERTY

MINEABLE SEAM THICKNESSES - EXPLANATORY NOTES

1.0 MAIN SYNCLINE AREA FOR UNDERGROUND MINING

(Holes 16, 27 through 33).

1.1 Seam D

At the N.W. end (holes 29 through 31), there are several shale partings in the seam, and in only one hole (29) might the coal be thick enough to mine complete with partings.

At hole 27, the total interval of 3.74 m has a 1.84 m mudstone parting, leaving the thickest coal leaf at only 1.34 m.

In hole 16, the bottom leaf is 1.66 m and may be mineable.

1.2 Seam C

As for Seam D, the mineability of this seam is strongly influenced by partings, at the N.W. end, and further S.E. in holes 27 and 16. None of this seam is considered mineable in this area.

1.3 Seam A

Consistently too thin (less than 1.5 m) and strongly influenced by partings. As with Seam C, none of the coal is considered to be mineable in this area.

2.0 AREA N.E. OF FAULT AND WEST OF EB1 PIT LIMIT

(Holes 22, 25A and 13)

This fairly extensive monocline area, featured by seam dips up to about 40°, might be mineable by underground hydraulic or steep seam longwall, and could be accessed from the highwall of the open pit.

2.1 Seam D

The bottom leaf in 25A has an intercepted thickness of 1.85 m and may be mineable, although the roof will probably be poor due to overlying coal and shale partings. In holes 22 and 13, the presence of multiple partings makes the seam unmineable.

2.2 Seam C

Despite the presence of partings, the total seam and coal thicknesses suggest the coal may be mineable. For reserves calculations, we will assume the seam is mineable.

2.3 Seam A

The seam is consistently less than 1.5 m and therefore is not considered to be mineable.

December 6, 1978

MT. SPIEKER COAL PROJECT

APPENDIX B

RESERVE CALCULATIONS

See over for List of Contents

See confidential analyses

LIST OF CONTENTS

NOTES TO ACCOMPANY APPENDIX B

This appendix contains the results of the reserve calculations for the various exploration target areas, as tabulated in the List of Contents to this Appendix. Particular attention is drawn to the notes accompanying Table B-1, which summarieses the subsequent tabulations.

The "reserve blocks" for the seams in each area, as listed in column 1 of Tables B-2 to B-5, are shown on the relevant Reserve Category Maps. The average dip shown for each of the reserve blocks was calculated from the structure contour maps. The limits to the blocks were dictated by significant changes in dip or structural features. A fuller discussion of the method used to calculate the reserve figures is included in Section 6.4 of the text to this report.

All figures quoted are In Situ tonnages and standard reserve categories of Proven, Indicated and Inferred have been used through this report; these categories are defined as follows:

> *Proven Reserves are those for which the density of points of observation is sufficient to give control on quality, thickness, depth and structure and to allow a reliable estimate of the tonnage; in this case the distance between the points of observation has been set at 250 metres or less.*

Indicated Reserves are those for which the density of points of observation is sufficient to allow a realistic estimate of the tonnage, and for which there is reasonable expectation that the reserves could be raised to the Proven category with further information; the distance between observation points has been set at 500 metres or less.

Inferred Reserves are those which are assumed to exist from a knowledge of geological conditions and for which it could be expected that most would be raised to a higher category.

TABLE B-1

SUMMARISED RESERVE FIGURES

For ease of reference Table B-1 summarises the detailed reserve figures included as Tables B-2 to B-5. The table has been sub-divided into the following areas based on possible mining methods. The maps referred to below illustrate the Reserve Blocks for each area.

- *Mt. Spieker Ridge Area - Refer Maps 5 and 9.*
- *Main Syncline Underground Area. This division is further sub-divided as per Notes (1) and (2) below; refer Map 33.*
- *Bird Seams Underground Area. Refer Maps 34 & 35.*
- *EB 1 Pit Area.*
  See also Note (3); Refer Maps 23-26.

Notes:

(1) Reserve Blocks F & G on Map 33 comprise this category and are regarded as being potentially mineable by conventional methods, e.g. continuous miner and shuttle cars.

(2) Reserve Blocks A, D, E and O on Map 33 are considered too steep for conventional mining or are in structurally complex regions but are possible to be mined by longwall or hydraulic methods, for example

(3) Reserve Blocks I, L and M shown on Map 33, Gates B Seam, and the Reserve Blocks for the EB 1 Open Pit shown on Maps 23 to 26 are included in this reserve group.

PR-MT. SPIEKER 78(4)A

MOUNT SPIEKER PROPERTY

COAL QUALITY INVESTIGATIONS

ANALYTICAL RESULTS

1978 EXPLORATION PROGRAM

Prepared for

RANGER OIL (CANADA) LIMITED

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GEOLOGICAL BRANCH
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