Tom Schroeter

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MOUNT KLAPPAN ANTHRACITE, THE OTHER COAL

PREPARED FOR THE CIMM

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1.0 SUMMARY

The Mount Klappan Anthracite Property, in Northwestern British Columbia, ranks as a world class resource in terms of its size and its potential to be a competitive source of surface mined anthracite.

Preliminary geological exploration has identified a sedimentary coal bearing sequence approximately 900 metres thick. Several anthracite seams each in excess of 5 metres thick and other additional thinner seams have been drilled to date. Although the seams are folded and faulted, the geological structure in certain parts of the property, where the coal seams are brought to the surface, is favourable for open pit mining.

The Mount Klappan property has an inferred resource of 900 million tonnes of anthracite in place which would be capable of sustaining an open pit mine producing 5 million tonnes per year, of mixed products, for more than 20 years. The actual level of initial production would be determined by market and economic conditions prevailing at the time that a decision is made to bring the property into production.

The anthracite quality is suitable for potential markets in North America, Europe and Asia. The ash content of the anthracite products, that can be produced from this property, ranges from a low of 5% to a high of 25%. This range of products meets the diverse user requirements of the consuming countries.

2.0 INTRODUCTION

2.1 Location and Physiography

The Mount Klappan coal licences are located in northwestern British Columbia, approximately 150 kilometres northeast of Stewart (population 1 445) and 530 kilometres northwest of Prince George (population 69 300). The nearest community is the village of Iskut (population 500) which lies 100 kilometres to the northwest on the Stewart-Cassiar Highway (Figure 2.1).

The property is located in the Skeena Mountains physiographic region at the headwaters of the Little Klappan and Skeena Rivers between 57° 06' and 57° 22' north latitude and 128° 37' and 129° 09' west longitude. Locally, the topography is characterized by broad open valleys and generally subdued mountains, with elevations ranging from 1100 to 2000 metres above sea level. Scattered coniferous forest interspersed with grass, shrubs, meadows and shallow bogs occur below the tree line, which is at 1500 metres of elevation. Above the treeline, alpine meadows give way to weathered bedrock at higher elevations.

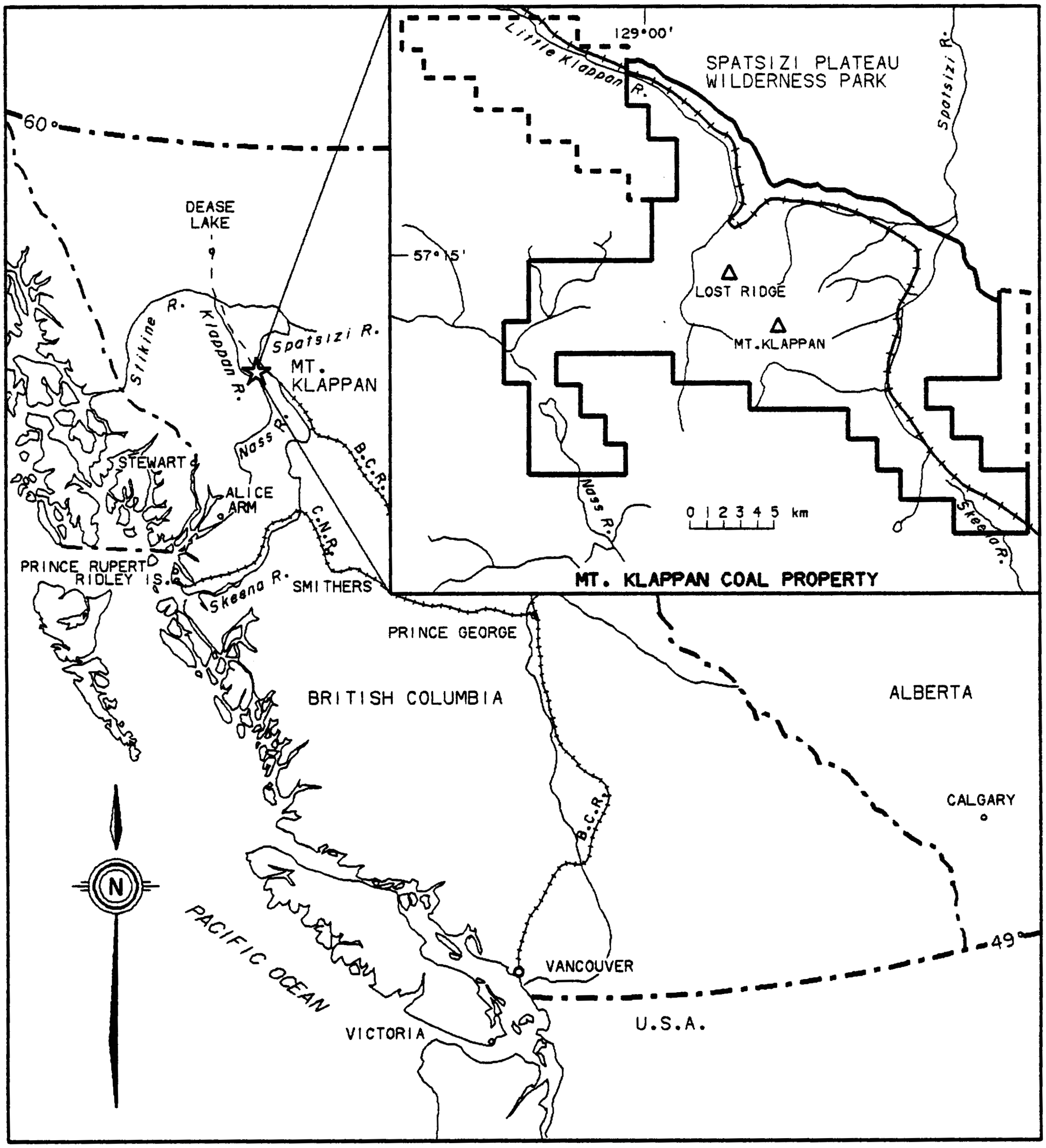
2.2 Climate

The area is situated in the interior transitional climatic zone. Indications are that precipitation is on the order of 300 millimetres per year. The average yearly minimum temperature is on the order of -41°C and the average yearly maximum temperature is about 26°C, values which are approximately equivalent to those of Calgary, Alberta.

FIGURE 2.1

MT. KLAPPAN COAL PROPERTY

LOCATION MAP



——— MT. KLAPPAN LICENCE AREA - - - - - LICENCES UNDER APPLICATION	GULF CANADA RESOURCES INC. 09/01/84

2.3 Property Description

The property comprises a total of 50 470 hectares, of which 12 332 hectares are currently under coal licence application to the Government of British Columbia. The Mount Klappan licences are for the coal rights on crown land and are held by Gulf Canada Resources Inc. of Calgary, Alberta.

2.4 Access

The Mount Klappan property straddles the partially completed British Columbia Railway line between Prince George and Dease Lake. Prior to cessation of work on the construction of the line, steel was laid to within 85 kilometres of the property, and, with the exception of a short stretch south of the licences, the subgrade was constructed through and beyond the property to the Stikine River just south of Dease Lake.

At present, road access is possible from the Stewart-Cassiar Highway (Highway 37) via the Ealue Lake road along the British Columbia Railway subgrade, or by air, to a 1000 metre gravel airstrip on the licences. The road distances from Stewart and Terrace to the south are 380 and 650 kilometres respectively.

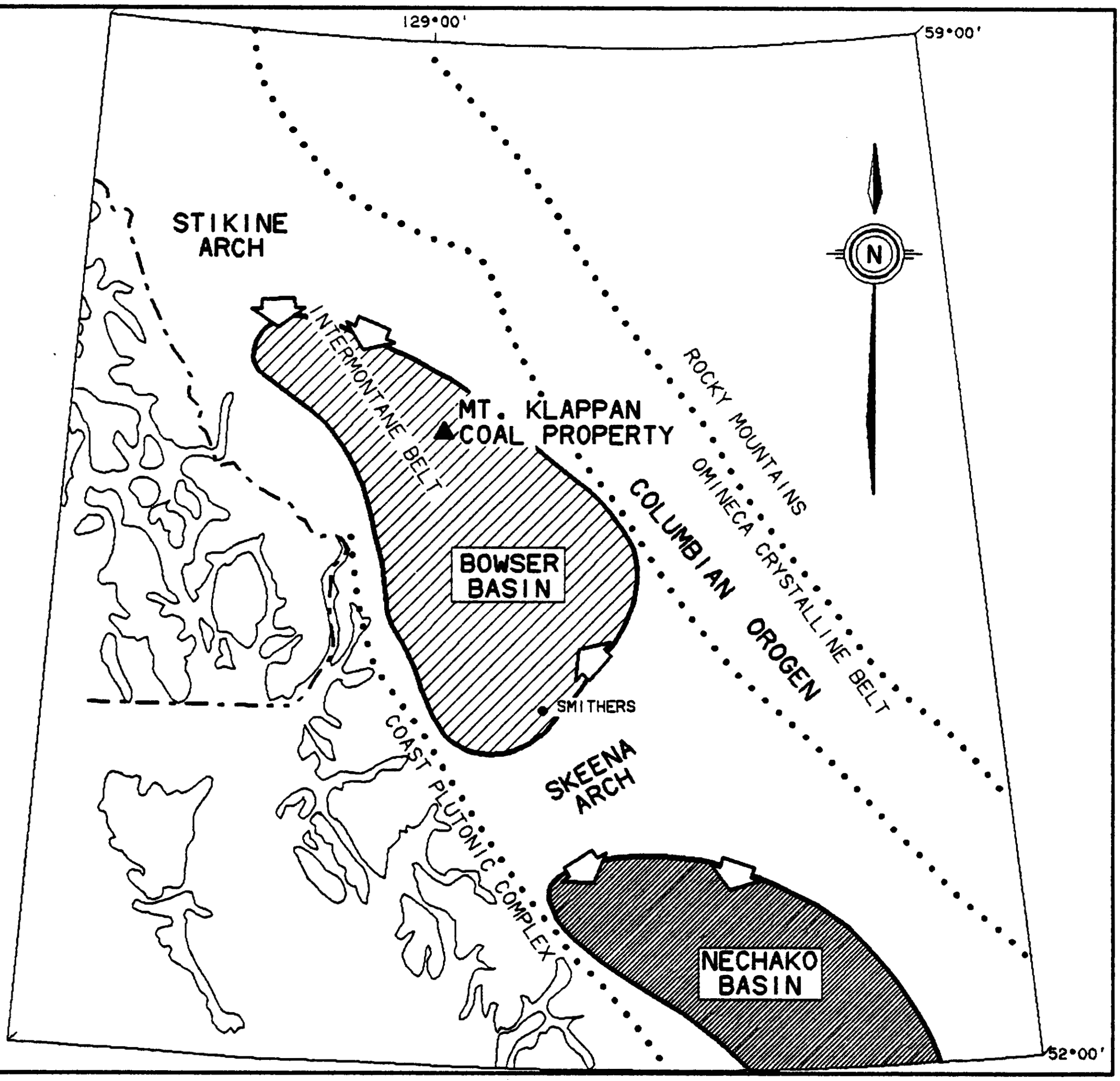
3.0 REGIONAL GEOLOGICAL SETTING

The coal measures of the Mount Klappan Property are contained within a series of sediments ranging in age from Middle Jurassic to early Cretaceous. These sediments were deposited in the Bowser Basin, a

FIGURE 3.1

MT. KLAPPAN COAL PROPERTY

JURASSIC-CRETACEOUS BOWSER BASIN



LEGEND

BOWSER BASIN

NECHAKO BASIN

(AFTER TIPPER AND RICHARDS, 1976)

SCALE

0 100 200 km

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successor basin to the volcanogenic Hazelton Trough (Tipper and Richards 1976). The Bowser Basin is bounded to the north and south by the Stikine and Skeena arches respectively, and to the east by the Columbia Orogen (Omineca Crystalline Belt). The western margin is thought to have been open to the sea at the time of Bowser sediment deposition (Figure 3.1)

The formation and development of the Bowser Basin was controlled by the "collision and subsequent isostatic uplift of several crustal blocks in the Cordilleron Orogen of western Canada" (Eisbacher, 1981). These crustal blocks include the Stikine Terrane (volcanic arc complex) which directly underlies the Bowser sediments, the Atlin Terrane (remnant oceanic crust) and the Omineca Crystalline Belt (western margin of the North American Craton).

During the Middle Jurassic the Skeena arch was uplifted and the subsidence of the Stikine Terrane divided the Hazelton Trough into the Bowser Basin to the north and the Nechako Basin to the south. Uplift of the Atlin Terrane to the north and northeast of the Bowser Basin, coupled with continued subsidence of the Stikine Terrane and collision and suturing of both these terranes with the Omineca Crystalline Belt (Eisbacher, 1981) resulted in a progradation of nonmarine over marine sediments within the basin.

Paleocurrent measurements indicate a centripetal flow into the Bowser Basin from highlands to the north, northeast, and south.

Bowser sediment source rocks originate within the Atlin Terrane (high chert low volcanic content) for the north and northeastern margins of the Basin, and from the remnant volcanic arc assemblage of the Stikine Terrane, (high volcanic, low chert content) for the southern portion of the Basin. Sediments from early Cretaceous (youngest marine succession of the Bowser Basin) through to the Paleocene are found only on the eastern, and in part, the southern margins of the Basin.

3.1 Stratigraphy

In the southern portion of the Bowser Basin, the assemblage has been subdivided into three groups by Tipper and Richards (1976). These groups, in ascending order are: the Early Jurassic to Middle Jurassic Hazelton Group; the Upper Jurassic Bowser Lake Group, and the Early Cretaceous Skeena Group. In the area discussed by Tipper and Richards (1976), the Skeena Group contains the major coal occurrences with some coal occurring at the top of the Bowser Lake Group.

In the Northern Bowser Basin no such comprehensive work has been done and the sedimentary package associated with the coal in the Klappan-Groundhog Area has been variously named: the Skeena Series (Malloch, 1914); Upper Hazelton (Buckham and Latour, 1950); Groundhog-Gunanoot (Eisbacher, 1974a), and has been dated as Lower Cretaceous (Malloch, 1914; Buckham and Latour, 1950) and Upper Jurassic to Lower Cretaceous (Eisbacher, 1974a).

In the Mount Klappan area, the Upper Jurassic to Lower Cretaceous sediments have been subdivided into four sequences for exploration purposes. Three of the sequences, which in ascending order are the Klappan, Malloch and Rhondda Sequences, occur on the property. The fourth, and lowest sequence of marine sediments, is not discussed in this paper. The Klappan sequence is the main coal bearing unit.

3.1.1 Klappan Sequence

The Klappan Sequence consists of sandstone, siltstone, mudstone, coal and conglomerate. Sandstone is the dominant lithotype comprised mainly of detrital chert, with some quartz and minor feldspar. Interbedded siltstones and mudstones are generally dark grey to brown weathering, display low angle cross laminations, ripple marks, and occassional varved bedding. These finer grained units have been found to contain several species of pelecypods, as well as rare ammonites and belemites.

The Klappan Sequence is estimated to be in the order of 900 metres thick and it contains up to 16 seams. Seam thicknesses range from less than 0.5 metres to a maximum of 7.21 metres. The thickest accumulation of coal drilled in one area is 34 metres occurring in 8 seams over a 320 metre interval.

3.1.2 Malloch Sequence

The majority of this sequence comprises interbedded siltstone, mudstone, thick bedded to massive conglomerates, sandstone, and coal. The upper portion of the Malloch is predominantly dark grey weathering siltstones and mudstones, interbedded with sandstone and occassional conglomerate beds. These units may contain orange weathering siliceous nodules. The abundance of sandstone, conglomerates, and minor coal seams increases towards the base of the sequence. Thin coal seams occur within the lower portion of the Malloch Sequence. The thickness of the unit is in the order to 800 metres.

3.1.3 Rhondda Sequence

The Rhondda Sequence overlies the Malloch Sequence and is comprised of massive chert pebble conglomerates, grits, and conglomeratic sandstones. Occassional thin beds of siltstone and mudstone are found associated with coal seams in the order of a few centimetres thick. The thickness of the Rhondda Sequence has not, as yet, been determined.

3.2 Structure

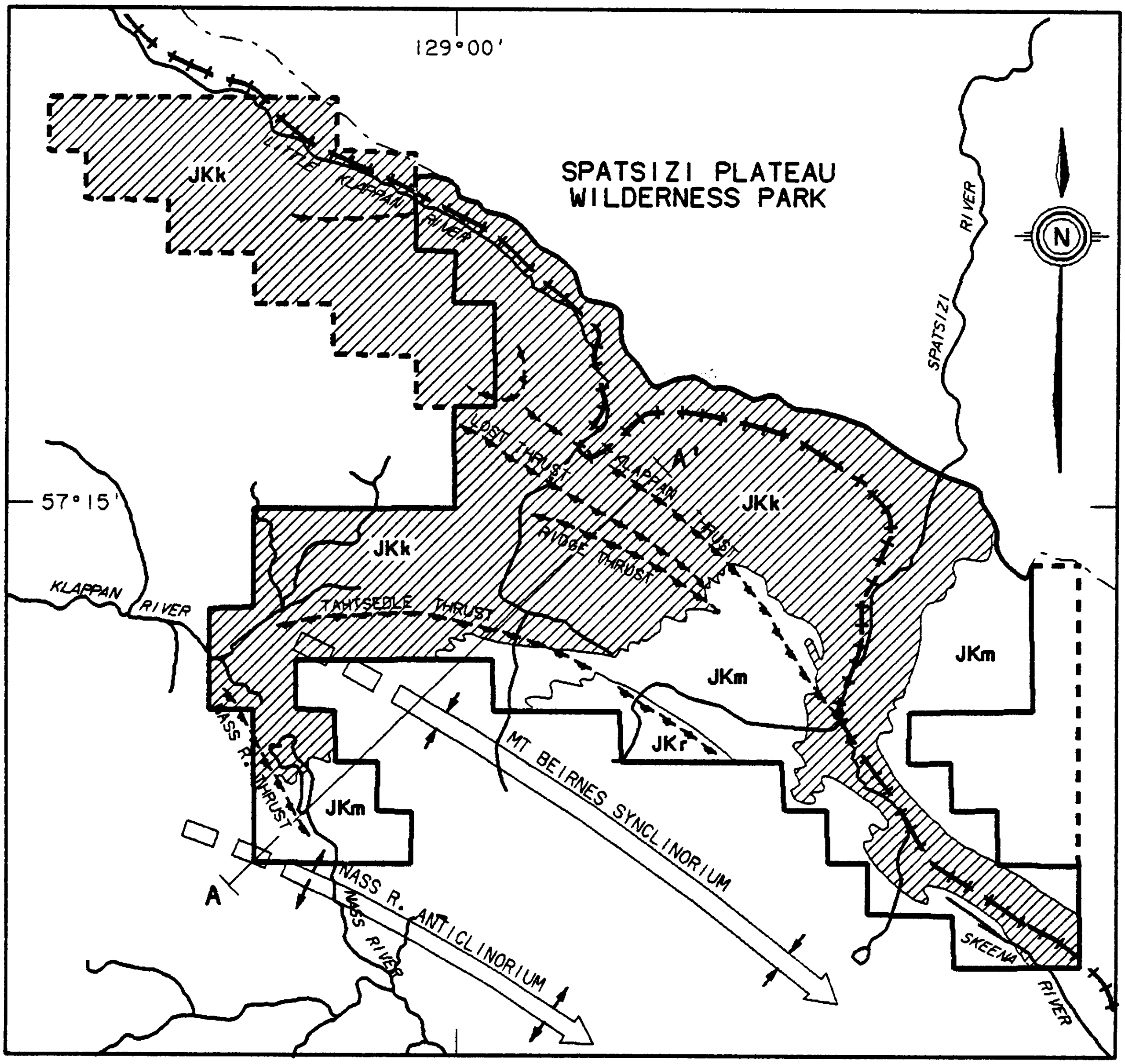
The Klappan Area is dominated by a synclinorium - anticlinorium pair trending northwest - southeast. Both the Mt. Beirnes Synclinorium (Richards and Gilcrist, 1979) and the Nass River Anticlinorium (Moffat and Bustin in press) are located almost exclusively to the south of the property. The bulk of the Mount Klappan Property covers the eastern limb of the synclinorium (Figures 3.2 and 3.3).

The area has been subjected to two phases of deformation. The original compressional event resulted in the development of first phase folds trending in a northwest to southeast direction.

FIGURE 3.2

MT. KLAPPAN COAL PROPERTY

GEOLOGY



LEGEND

┼┼┼ ┼┼┼	PREPARED RAIL BED
— · — · —	PROVINCIAL PARK BOUNDARY
———	LICENCE AREA
- - - - - -	LICENCES UNDER APPLICATION
JKr	RHONDDA SEQUENCE
JKm	MALLOCH SEQUENCE
JKk	KLAPPAN SEQUENCE

SCALE

0 1 2 3 km

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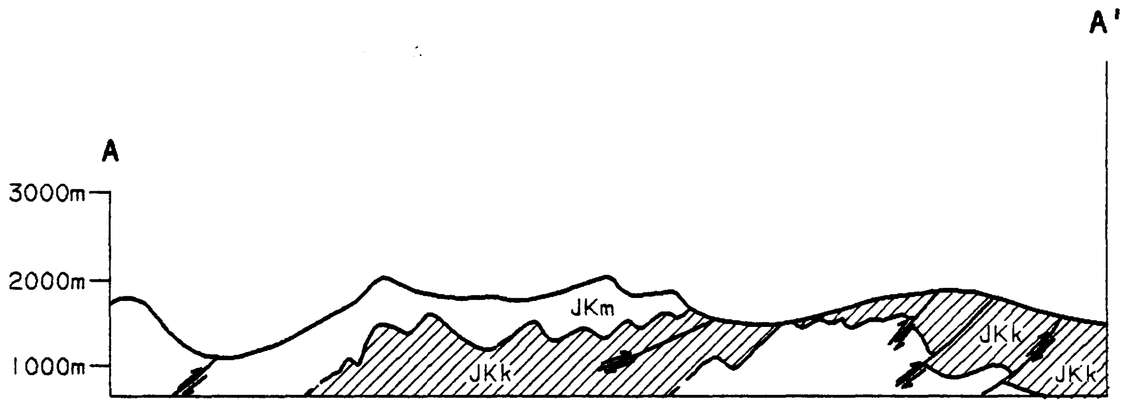
FIGURE 3.3

MT. KLAPPAN COAL PROPERTY

CROSS SECTION



LEGEND

JKr	RHONDDA SEQUENCE
JKm	MALLOCH SEQUENCE
JKk	KLAPPAN SEQUENCE

SCALE

0 2 4km

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Geometry of these folds range from broad and upright, to overturned megascopic Z folds with axial planes inclined as much as 45° to the northeast. Faulting related to this phase of deformation includes thrust faults with displacements in the order of several hundred metres.

A second stage of deformation, resulted in the formation of broad open folds trending in a northeast - southwest direction. The imprint of these folds on the first phase folds is seen as a series of plunge changes approaching maximum values of between 45° north and 21° south.

4.0 RESOURCES

The Klappan Sequence, underlying the Mount Klappan Property, is estimated to have an in situ inferred resource of 967 million tonnes.

The resources are contained within 4 areas (Figure 4.1). The Hobbit-Broatch area contains 620, the Lost-Fox area 330 and the Summit north and south areas 17 million tonnes.

5.0 COAL QUALITY

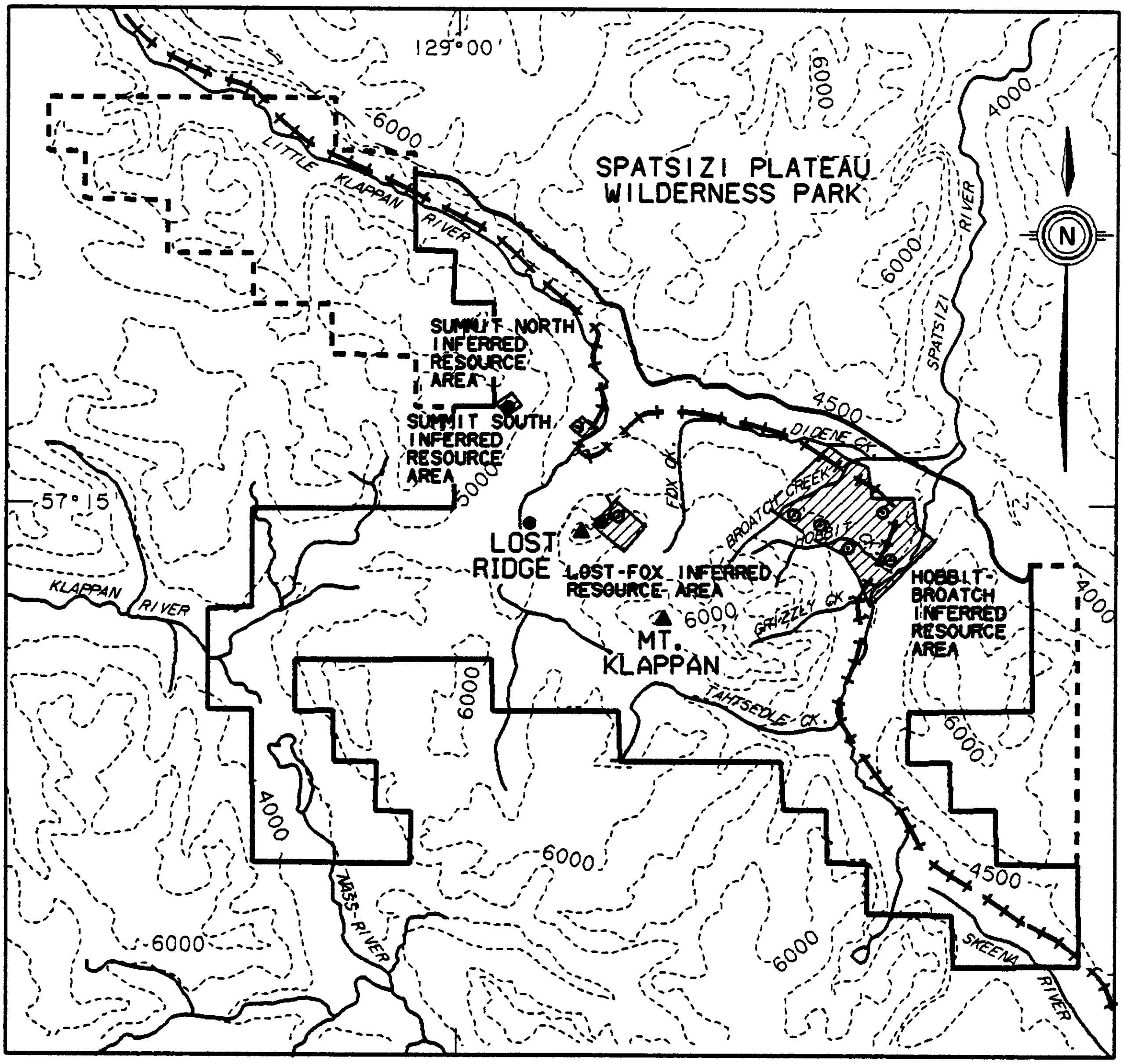
5.1 Introduction

The Mount Klappan coal is a low sulphur anthracite from which sized products can be produced to satisfy most market requirements identified to date. Products ranging in size from 0 to 50 millimetres at 5% and 10% ash levels, and 0 to 25 millimetres at ash contents of between 20 and 25% can be produced. Table 5.1 and 5.2 compare Mount Klappan anthracite products with Hongay #4 from Vietnam and Pennsylvania 10% ash anthracite, respectively.

FIGURE 4.1

MT. KLAPPAN COAL PROPERTY

INFERRED RESOURCE AREAS



LEGEND:

- PREPARED RAIL BED
- PROVINCIAL PARK BOUNDARY
- LICENCE AREA
- LICENCES UNDER APPLICATION
- INFERRED RESOURCE AREAS

SCALE:

0 1 2 3 4 5km

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Table 5.1

	Seam I Mt. Klappan	Hongay #4 (Vietnam)
Size	35 x 15 mm	35 x 15 mm
Residual Moisture	1.9	1.2
Ash	4.2	4.2
Volatile Matter	6.5	5.8
VM (d.m.m.f.)	6.4	5.6
Fixed Carbon	87.4	88.8
CV (cal./g.)	7,830	8,250
Sulphur	0.5	0.4
Nitrogen	0.9	1.0

(analysis on an air dried basis)

Table 5.2

	Mt. Klappan	Pennsylvania
Size	6 x 1 mm	6 x 1 mm
Residual Moisture	1.1	1.8
Ash	8.9	9.8
Volatile Matter	5.4	4.3
VM (d.m.m.f.)	5.0	3.8
Fixed Carbon	84.6	84.1
CV (cal./g.)	7,430	7,170
Sulphur	0.50	0.57
Nitrogen	0.8	0.6

(analysis on an air dried basis)

5.2 Rank

Anthracite, as defined by the Americian Society for Testing and Materials, has a fixed carbon content of between 92 and 98% and volatile matter of between 2 and 8%, both determined on a dry mineral matter free basis (Table 5.3).

Table 5.3

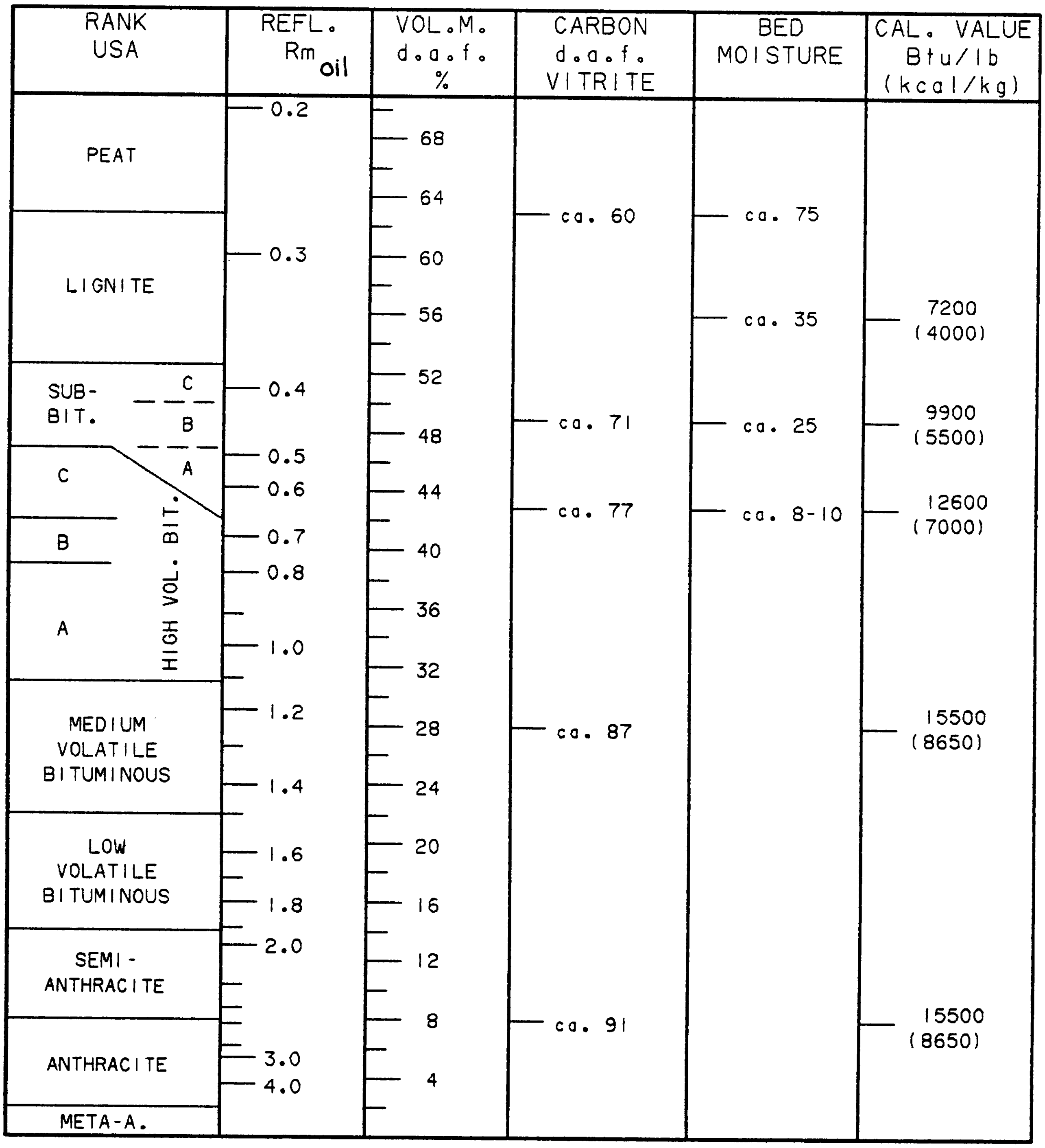
ANTHRACITE (A.S.T.M.)

Volatile matter (d.m.m.f.)	2% - 8%
Fixed Carbon (d.m.m.f.)	92% - 98%

In applying the ASTM parameters to coal in the northern Bowser Basin, earlier workers may have been confused by the inclusion of carbon dioxide and other gases, generated by carbonates and clays present in the seam partings during testing, with the measured volatile percentage for the coal portion of the seam. This sometimes results in d.m.m.f. volatile matter analysis in excess of the defined range for anthracite.

Reflectance has proved to be a much more reliable indicator of rank. The lower mean maximum reflectance limit for anthracite (measured in oil) is 2.5%. (Stach 1975).

FIGURE 5.1
RELATIONSHIP BETWEEN MEAN MAXIMUM REFLECTANCE AND COAL RANK



After Stach, 1975

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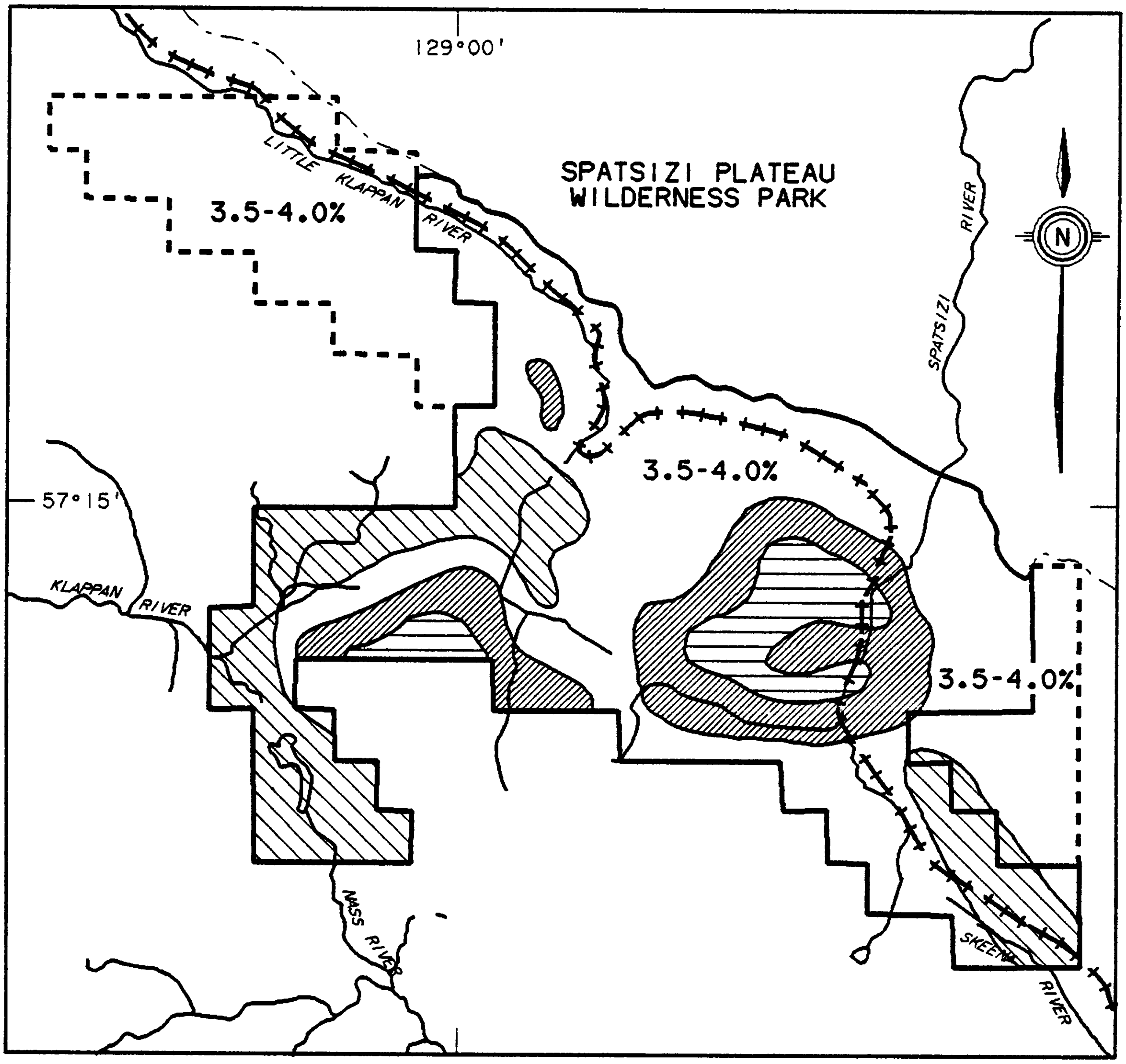
FIGURE 5.2

MT. KLAPPAN COAL PROPERTY

MEAN MAXIMUM REFLECTANCE



LEGEND

- PREPARED RAIL BED
- PROVINCIAL PARK BOUNDARY
- LICENCE AREA
- LICENCES UNDER APPLICATION
- 2.5-3.0% $\overline{Ro}$ max
- 3.0-3.5% $\overline{Ro}$ max
- 3.5-4.0% $\overline{Ro}$ max
- 4.0-5.0% $\overline{Ro}$ max

SCALE

0 1 2 3 km

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Based on 146 surface coal exposures, the average reflectance for Mount Klappan coal is 3.45% and range from 2.2 to 5.0%. Much of the variation is related to stratigraphic level with average reflectances of 3.54% being recorded for the Klappan Sequence coals and 2.98% for the stratigraphically higher Malloch Sequence coals. This correlation is illustrated by comparing Figure 3.2 and Figure 5.2. On this basis, virtually all the Mount Klappan coals are classified as true anthracites. This classification is confirmed by the analyses from fresh drill core samples with 5 to 10% ash.

5.3 Products

The ability to simultaneously wash the raw mined anthracite to produce premium low and medium ash products as well as briquetting coal products is a feature of the Mount Klappan coal. Analyses of expected products for each of the three ash levels are shown in Table 5.4.

Table 5.4

	Low Ash Product	Medium Ash Product	Briquetting Product
Residual Moisture	1.5	1.5	1.5
Ash	5.1	10.3	17.9
Volatile Matter	6.2	6.8	8.0
VM (d.m.m.f.)	6.0	6.5	7.9
Fixed Carbon	87.2	81.4	72.6
Sulphur	0.5	0.5	0.7
CV (cal./g.)	7,870	7,350	6,540

6.0 MINING POTENTIAL

While no definitive mine plans have yet been prepared for the Mount Klappan anthracite resources, a number of conceptual plans and pre-feasibility studies have been considered. This work indicates that, once appropriate long term sales contracts are secured, the Mount Klappan project has the potential to be a major factor in the world anthracite market.

The studies that have been done to date indicate that much of the resource is available for conventional open pit mining using trucks and shovels. Individual pits would be capable of producing up to 5 million tonnes per year of mixed products. The nominal design, which Gulf Canada Resources is using as a base case for the assessment of the project, has a production capacity of 3.5 million tonnes per year of washed and sized products as well as unsized briquetting coal. The coal in this scenario would be mined at a strip ratio of 6.3 bank cubic metres for each tonne of mined raw coal. This plan has not been optimized and the actual strip ratios are therefore expected to be somewhat lower.

Ninety-five percent of the waste rock is expected to require drilling and blasting before being loaded by 24.5 cubic metre shovels into a fleet of 154-tonne end dump trucks. The coal would be mined by 21 cubic metre hydraulic shovels and a 15 cubic metre front-end loader. It too would be loaded into 154-tonne end dump trucks but these would be equipped with coal boxes. In this plan all of the waste would be conveyed from the pit to waste piles for 9 years when some backfilling of the pit would begin. By year 15 the conveyor would be shut down and all the waste would be backfilled. A mine of this size would initially provide some 800 direct jobs in the area and this could be expected to increase to about 1100 jobs in later years.

7.0 ACKNOWLEDGEMENTS

The authors wish to acknowledge the contribution of the Coal Division staff of Gulf Canada Resources Inc.

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