

~~CONFIDENTIAL~~

PETRO-CANADA  
MONKMAN COAL PROJECT

PEACE RIVER LAND DISTRICT  
NTS 93I/15

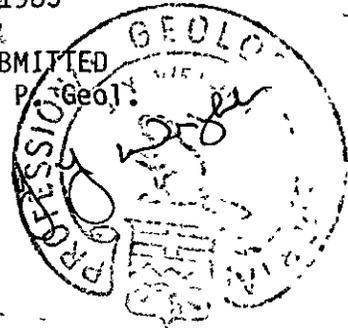
1984

Lat. 54°46' N-54°50' N  
Long. 120°39' W-120°45' W

COAL LICENCES:	3226	3232	3954
	3227	3233	3955
	3228	3947	3957
	3229	3948	3959
	3230	3949	3960
	3231		

WORK DONE: Summer 1984  
REPORT DATE: October 1984  
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SUBMITTED: April 1985

AMENDED AND RE-SUBMITTED  
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Petro-Canada  
July 1986



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SUMMARY

The Monkman Coal Project is a joint venture of Petro-Canada, Canadian Superior Exploration Ltd., McIntyre Mines Ltd. and Sumitomo Corporation. Petro-Canada is the operator.

Exploration has been carried out each year on the Monkman property since 1975, primarily at the north end, in the block of licences known as the Duke Mountain Block. Drilling and mapping have defined major open pit coal resources within this block.

The 1984 field project comprised geological mapping of the Quintette Syncline and a trial of ground electromagnetic surveying as a means of defining coal seam subcrops.

## 1.0 INTRODUCTION

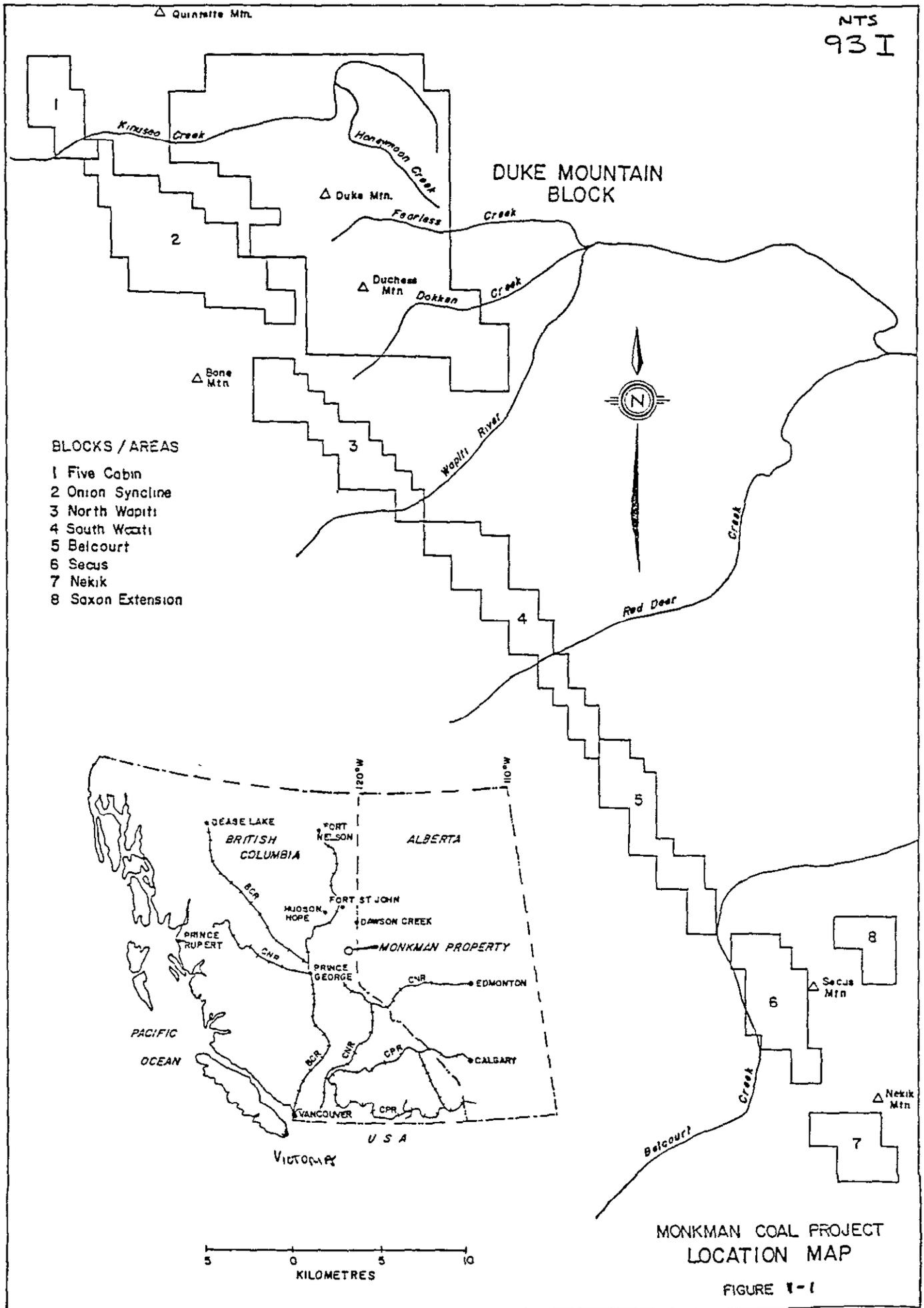
### 1.1 Location and Means of Access

The Monkman Property is located in the southern part of the Peace River Coalfield, approximately 630 km northeast of Vancouver, British Columbia (Fig. 1-1).

The property is more or less equidistant, by all-weather loose surface roads, from Beaverlodge, Alberta and Tupper, British Columbia, both of which are situated on Highway No. 2 which connects Grande Prairie and Dawson Creek. The camp is 11 km west of Stony Lake on the Kinuseo Falls road and is approximately 125 km from pavement. A third route, the Fellers Heights road from Dawson Creek, is also passable most of the year. The Quasar airstrip near Thunder Mountain permits year-around access by light plane. This airstrip is 16 km from the camp.

### 1.2 History of Land Tenure

In 1970, McIntyre Mines Ltd. acquired 134 coal licences from the Government of British Columbia. In 1975, Canadian Superior Exploration Ltd. acquired a 66 2/3% interest in the property, which was reduced to 119 licences. Pacific Petroleum Ltd. entered into an option agreement with McIntyre and Canadian Superior in 1976 and by the end of



BLOCKS / AREAS

- 1 Five Cabin
- 2 Orion Syncline
- 3 North Wapiti
- 4 South Wapiti
- 5 Belcourt
- 6 Secus
- 7 Nekik
- 8 Saxon Extension

MONKMAN COAL PROJECT  
LOCATION MAP

FIGURE 1-1

1978 had earned a 50% interest in the property, the shares of the partners being reduced to 16 2/3% and 33 1/3% respectively. In 1978, 31 licences were added to the property and a further 12 licences were added in 1979, bringing the total to 162 and the area to 37,492 hectares.

Three licences (899 hectares) were added to the Duke Mountain Block in 1980 and four (1196 hectares) were added in 1981. The total area of the Monkman Property as of December 31, 1981 was 39,587 hectares of which 20,745 hectares were contained within the Duke Mountain Block. The composition of the property has not changed since this date.

### 1.3 Topography

The Monkman Property is situated within the Inner Foothills of the Rocky Mountains in an area of rugged topography. The property is approximately 80 km long, extending from the southern slopes of Quintette Mountain in the northwest to the Narraway River south of Nekik Mountain in the southeast. The property is situated on a dissected belt of highlands which rises from a valley floor elevation of 950 m at Kinuseo Creek to a maximum of 2250 m on Secus Mountain. The highlands are cut by seven water courses which are, from north to south, Kinuseo Creek, Fearless Creek, Dokken Creek, the Wapiti River, Red Deer Creek, Belcourt Creek and the Narraway River.

The Duke Mountain Block, 17 km in length and 10 km in width, includes Kinuseo, Fearless and Dokken Creeks and Duke and Duchess Mountains. Its southerly limit is the Wapiti River and the highest point is 1791 m, on Duchess Mountain. The valleys and lower slopes are heavily forested with spruce and jackpine up to the treeline which is 1400 m above sea level.

#### 1.4 Exploration History

- 1968 Regional Mapping by D.F. Stott, G.S.C.
- 1970 Initial licences acquired by McIntyre Mines
- 1973 Geological reconnaissance, trenching
- 1975 Canadian Superior drilled three diamond holes
- 1976 Pacific Petroleum drilled twelve diamond holes, mapped
- 1977 Pacific drilled eight diamond holes, mapped
- 1978 Pacific drilled 24 diamond holes, 22 hammer holes and drove two adits on the Duke Mountain Block and drilled six diamond holes elsewhere

1979 Pacific drilled 18 diamond holes, 35 hammer holes and drove four adits on Duke Mountain Block.

1980 Petro-Canada drilled 11 diamond holes and 77 hammer/rotary core holes and drove three adits - all on Duke Mountain Block.

1981 Petro-Canada drilled 17 diamond holes and 8 hammer/rotary core holes on the Duke Mountain Block and 2 diamond holes on the Nekik Block.

In addition to drilling, mapping was carried out on the Duke Mountain, Five Cabin, Onion Syncline Blocks and Wapiti Dip Slope areas.

1982 Petro-Canada drilled 6 hammer/rotary core holes to test the Gething Formation on the Duke Mountain Block and 10 other hammer holes in the pit areas for engineering purposes.

1983 Petro-Canada commissioned a study of the structural geology of the Duke Pit area using computer techniques.



## 2.0 1984 SUMMER FIELD PROGRAM

### Objectives

1. To test the theory of Quintette syncline east flank development and associated coal reserve potential.
2. To test ground resistivity geophysical methods for coal exploration.
3. To gain onsite experience by Engineering staff members.

The initial planning of the 1984 summer field program indicated that a month of field work at Monkman was required to carry out mapping and ground geophysics in the Duke East Flank area. This field work was to verify previous limited mapping information in the area and to conduct a more detailed study of the geology than had been carried out in the general reconnaissance coverage in the past. The mapping program was to be augmented by ground geophysical resistivity survey work to test the application of this method to coal exploration. (Figure 2.0 shows the location of the study area)

During this planning stage of the program, it was decided that the timing would present an ideal opportunity for members of the Engineering Group to gain some hands-on experience by their participation in the actual field work in July. In this way, they would be able to better appreciate the problems and discrepancies between planning and actual field conditions.

The old exploration camp site was used as a base of operations because of its location and hook-up facilities. A small (6 man) staff trailer was brought in from Ft. St. John. Tom Covert acted as project co-ordinator and was on site for the duration of the

field work. The various engineering staff members were used as assistants, rotating on a weekly basis from Calgary, flying in and out of Dawson Creek on the company scheduled flights.

Supplies were purchased in Tumbler Ridge and Dawson Creek as required. Two field vehicles were used for transportation to various parts of the property.

The overall arrangements and planning worked well and the program was completed without any major problems. One minor mishap occurred on the return trip to Calgary after the program was completed. One field vehicle went off the highway near Tumbler Ridge and received fairly substantial damage to the front end and drive train. However, no personal injuries were received and the vehicle has since been repaired.

## 2.1 Geological Studies

Geological mapping was carried out in the Duke pit and Duke East Flank. Traverses were done throughout the East Flank area, making use of old sawmill and drill roads, seismic trails and streams which have cut down through the unconsolidated glacial tills, sands and clays.

Outcrop data from previous exploration programs was checked and verified. This information has been updated and augmented by new data obtained in the field. The results of this summer's mapping confirms that there is definite east limb development to the Quintette Synclinal structure and that the strata in this area are more gently dipping than the strata on the west (Duke pit) limb.

These new findings also suggest that there is some potential for coal seam development in the East Flank area although no actual coal seam outcrops were seen in the field. The major constraint on

this development is the presence and location of the Quintette Thrust fault, a major displacement which crosses the area from west to east.

Although the presence of the thrust faults will limit the extent of coal seam development, these same faults could possibly offset the coal seams in a way which might cause them to be repeated in the east flank area. The true potential of this area can only be outlined by drilling.

## 2.2 Engineering Studies

The week long visits by the Engineering Group personnel proved to be useful in a number of ways. The various aspects of the overall project were addressed by the individuals concerned. Duke and Honeymoon pit areas, new proposed plant site location, rail alignment, tailings pond site, haulage road access locations, dump site areas, diversion channel route and general property layout were some of the aspects which were looked at from various perspectives. Use of personnel as assistants in the actual field program will help give a firmer and more concrete base for any new ideas which are developed in the planning of the mining operation and other associated studies.

## 2.3 Geophysical Studies

The use of ground resistivity geophysics was tested during the 1984 summer field program. This method has not been widely used in foothills coal exploration but it was felt that, if successful, this type of survey could provide useful low cost information on coal seam subcrop locations in areas where surface exposures are lacking.

The 1984 field program made use of a Geonics EM 16-16R resistivity instrument utilizing Cutler, Maine as a transmitting station. This station gave the best signal for the particular regional structural orientation (strike and dip) of the rocks at Monkman.

One test profile was run along the Duke Mountain road from its junction with Route 66 as far as the B1 adit site and a second profile was run along the Kinuseo Falls road from Honeymoon Creek across Honeymoon East pit. Subsequent profiles were run across the structural trend of the Duke East Flank area to try and pick up responses from any underlying coal seams.

### 3.0 RESULTS OF FIELD INVESTIGATIONS

The 1984 summer field program at Monkman enabled the accomplishment of a number of tasks. New geological data was gathered. Engineering staff members were given the opportunity to gain first hand experience about actual field conditions and a new exploration tool was used on the property for the first time, a tool which could have potential for the tracing of coal seam subcrops at a cost much lower than drilling.

#### 3.1 Geological Studies

The results of the geological mapping have been plotted on a 1:10,000 scale map (Figure 3.1.1 in folder) and six cross sections have been generated to illustrate the development of the Quintette Syncline east limb in the Duke East Flank area (Figures 3.1.2 - 3.1.7).

Use has been made of air photos, drill hole data and previous geological mapping results to augment the 1984 field program information.

Figure 3.1.1 shows the results of the geological mapping program. It can clearly be seen from the outcrop data accumulated in the field that there is definite east limb development to the Quintette synclinal structure. The mapping also shows that the attitudes of the strata in the East Flank area are much gentler than the west or Duke pit side of the structure. This fact suggests that, if the coal seams are developed on the east limb of the structure, the coal may be more easily extracted than in the Duke pit area. Results of the mapping and subsequent interpretation also suggest that the coal seams developed on the east limb of the structure may be structurally thickened due to the thrust faulting.

The map also shows the presence of the Duke and Quintette Thrust Faults. It appears as though these faults were initiated in the Minnes Formation as a single major thrust (Quintette Thrust) with the Duke Thrust spalying off some one and one half kilometres to northwest of the study area.

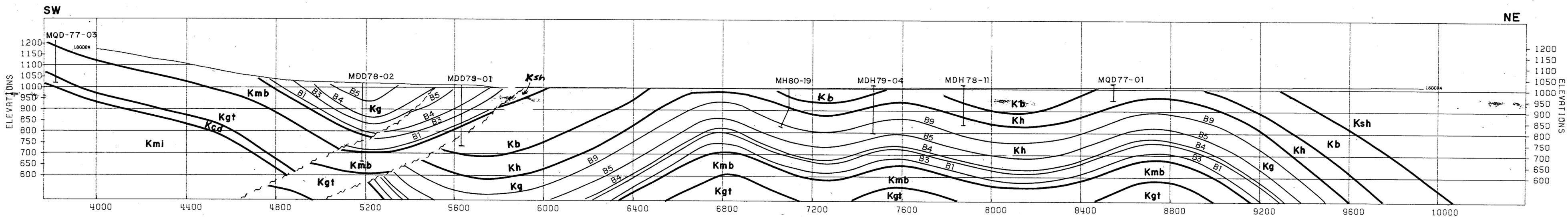
The stratigraphic throw on the Quintette thrust is estimated to be in the order of 400 to 500 metres. This fault developed early in the structural history of the area and subsequently folded during later structural deformation. It has probably originated as a splay from a deeper seated sole fault that may be located in the underlying Fernie Formation.

Information from drillhole MDD 78-12 suggests that the Quintette Thrust Fault is a major structure separating the Duke and Honeymoon areas.

The Duke thrust fault has probably developed as a splay from the Quintette Thrust. The stratigraphic throw on this fault is estimated to be approximately 100 metres at the north end and totally disappears into the overlying Hulcross Formation to the south.

The structural interpretation of the Quintette Syncline development is shown by Figures 3.1.2. - 3.1.7. These sections illustrate the tightness of the structure at the north end (16,000N) which is caused by the displacement of the strata by the two closely spaced thrust faults. Proceeding south from section 15,500 N to section 13,500 N, the structure opens up because the separation between the two faults becomes greater and the effects of the thrusting movement is less pronounced. It is anticipated that the Duke Thrust dies out somewhere south of section 13,500 N and the more major Quintette Thrust further southeast, possibly near section 10,000 N. The exact extent of the displacement of these structures can only be determined by drilling. The same holds true for outlining the East Flank area for potential coal seam development.

The results of the mapping program confirmed that there is extensive development of an east limb to the structure, the exact extent of which is unknown because it cannot be determined from surface mapping where this limb is cut out by the Quintette Thrust.



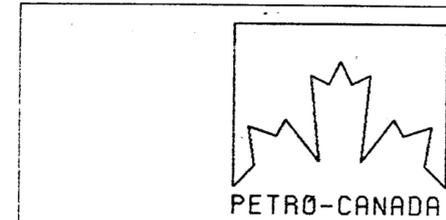
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FINAL X CO-ORD = 649215.000  
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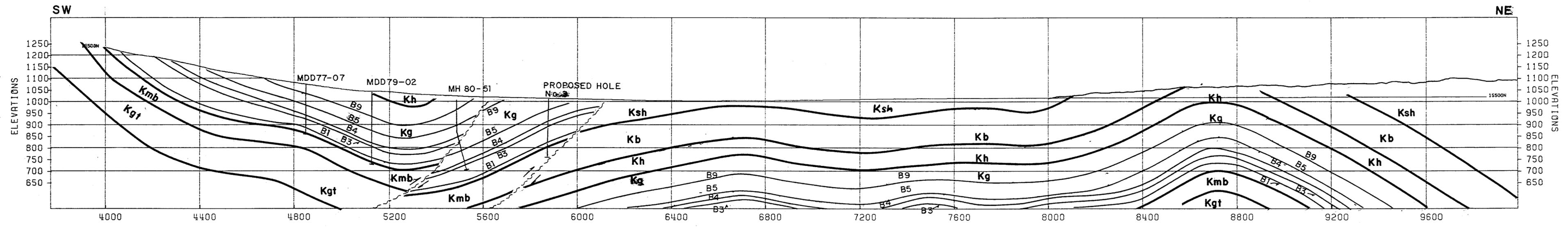
**GEOLOGICAL LEGEND**

<b>LOWER CRETACEOUS</b>		} FORT ST. JOHN GROUP
Ksh	SHAFTESBURY FM.	
Kb	BOULDER CREEK FM.	
Kh	HULCROSS FM.	
Kg	GATES FORMATION	
Kmb	MOOSEBAR FM.	} BULLHEAD GROUP
Kgt	GETHING FM.	
Kcd	CADOMIN FM.	



**16000N XSEC MAP  
 MONKMAN COAL PROJECT**

DRAWING NO.: 1	DATE: SEP 26/84
REVISION NO.: 0	REQ. BY: COAL DIV.
VERT. SCALE 1:10000	APP. BY: T. COVERT
HORZ. SCALE 1:10000	FIG. 312



**GEOLOGICAL LEGEND**

LOWER CRETACEOUS		FORT ST. JOHN GROUP
Ksh	SHAFTESBURY FM.	
Kb	BOULDER CREEK FM.	
Kh	HULCROSS FM.	
Kg	GATES FORMATION	
BULLHEAD GROUP		BULLHEAD GROUP
Kmb	MOOSEBAR FM.	
Kgt	GETHING FM.	
Kcd	CADOMIN FM.	



15500N XSEC MAP  
MONKMAN COAL PROJECT

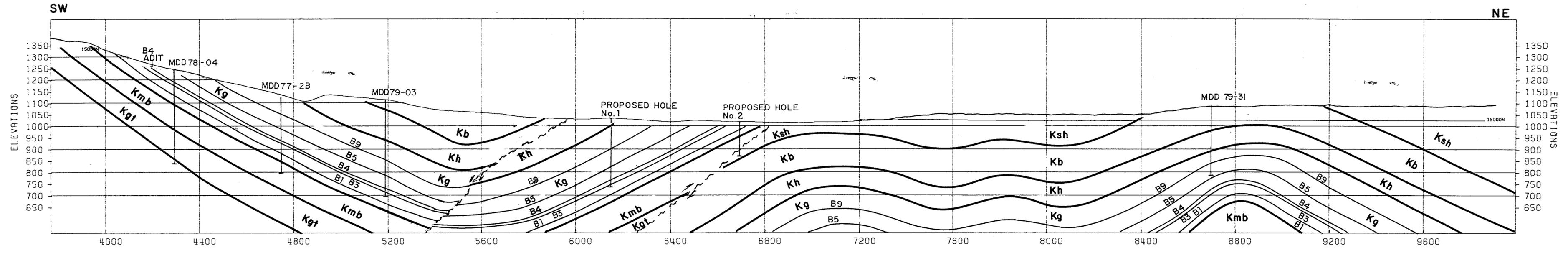
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DISTANCE/ 400

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REVISION NO.:	0	REQ. BY:	COAL DIV.
VERT. SCALE	1:10000	APP. BY:	T. COVERT
HORZ. SCALE	1:10000		

FIG. 3.13



**GEOLOGICAL LEGEND**

LOWER CRETACEOUS		FORT ST. JOHN GROUP
Ksh	SHAFTESBURY FM.	
Kb	BOULDER CREEK FM.	
Kh	HULCROSS FM.	
Kg	GATES FORMATION	
Kmb	MOOSEBAR FM.	BULLHEAD GROUP
Kgt	GETHING FM.	
Kcd	CADOMIN FM.	



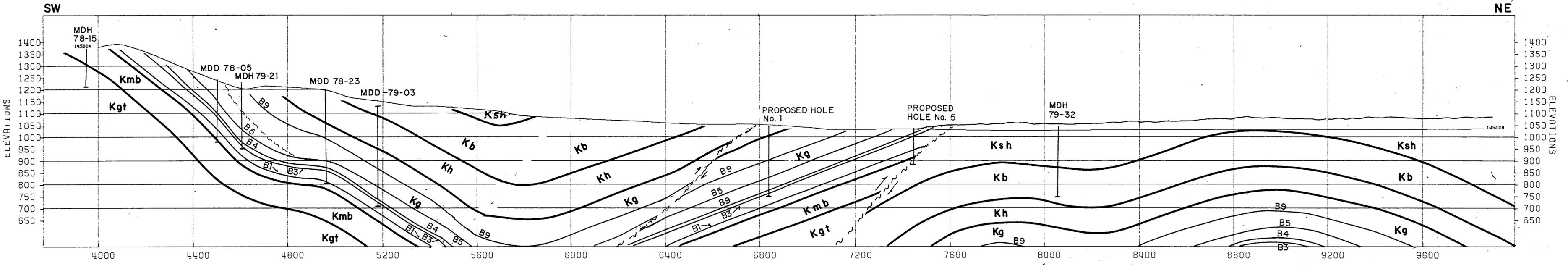
15000N XSEC MAP  
MONKMAN COAL PROJECT

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DISTANCE / 400

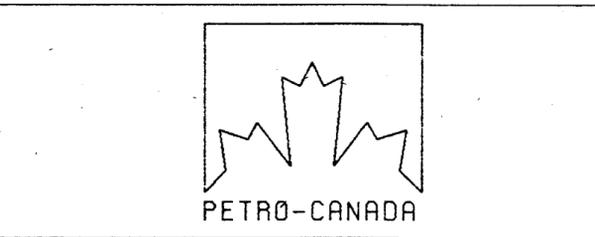
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DRAWING NO.:	1	DATE:	SEP 26/84
REVISION NO.:	0	REQ. BY:	COAL DIV.
VERT. SCALE	1:10000	APP. BY:	T. COVERT
HORZ. SCALE	1:10000		



**GEOLOGICAL LEGEND**

LOWER CRETACEOUS		FORT ST. JOHN GROUP
Ksh	SHAFTESBURY FM.	
Kb	BOULDER CREEK	
Kh	HULCROSS	
Kg	GATES FM.	
Kmb	MOOSEBAR FM.	
BULHEAD GROUP		BULHEAD GROUP
Kgt	GETHING FM.	
Kcd	CADOMIN FM.	



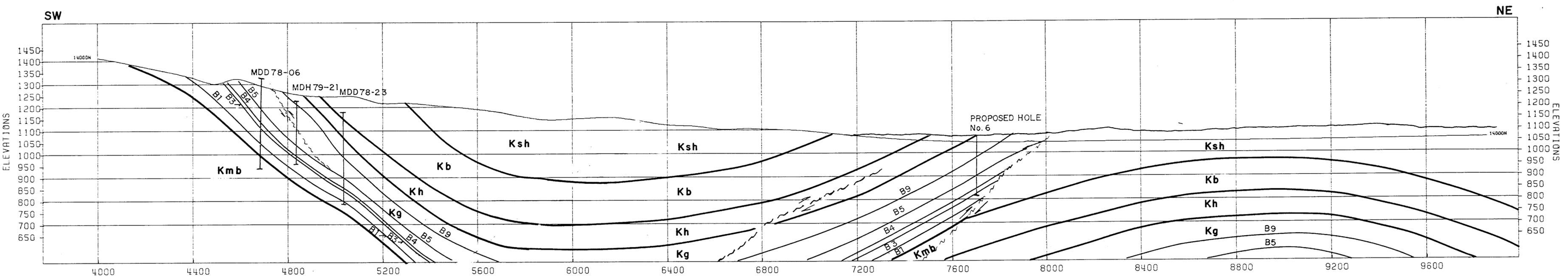
14500N XSEC MAP  
MONKMAN COAL PROJECT

INITL X CO-ORD = 645466.000  
INITL Y CO-ORD = 6071234.000

DISTANCE/ 400

FINAL X CO-ORD = 650050.000  
FINAL Y CO-ORD = 6075090.000

DRAWING NO.:	1	DATE:	SEP 26/84
REVISION NO.:	0	REQ. BY:	COAL DIV.
VERT. SCALE	1:10000	APP. BY:	T. COVERT
HORZ. SCALE	1:10000	FIG 3.15	



**GEOLOGICAL LEGEND**

LOWER CRETACEOUS		] FORT ST. JOHN GROUP
<b>Ksh</b>	SHAFTESBURY FM.	
<b>Kb</b>	BOULDER CREEK	
<b>Kh</b>	HULCROSS	
<b>Kg</b>	GATES FM.	
<b>Kmb</b>	MOOSEBAR FM.	
<b>Kgt</b>	GETHING FM.	] BULHEAD GROUP
<b>Kcd</b>	CADOMIN FM.	



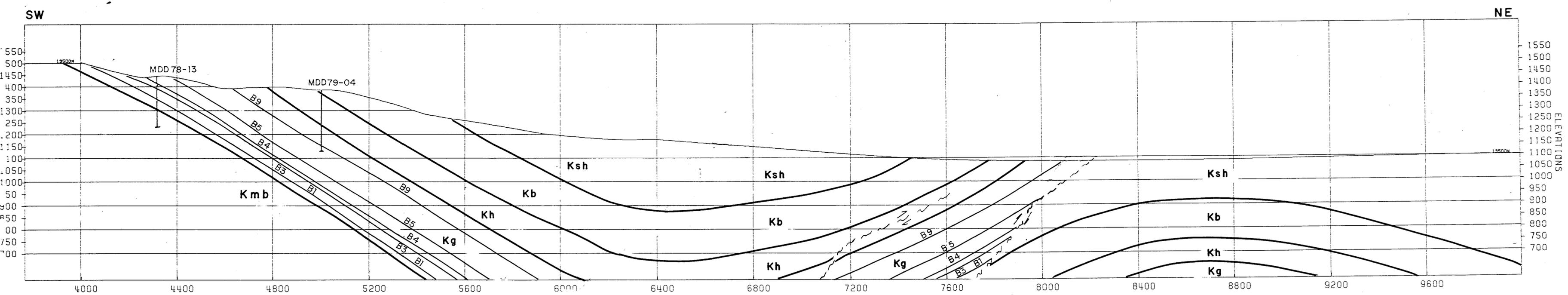
14000N XSEC MAP  
MONKMAN COAL PROJECT

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INITL Y CO-ORD = 6070851.000

DISTANCE/ 400

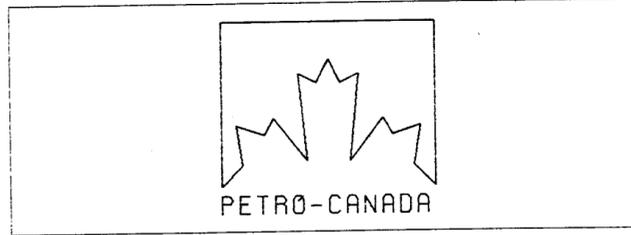
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FINAL Y CO-ORD = 6074714.000

DRAWING NO.: 1	DATE: SEP 26/84
REVISION NO.: 0	REQ. BY: COAL DIV.
VERT. SCALE 1:10000	APP. BY: T. COVERT
HORZ. SCALE 1:10000	FIG 3.1.6



GEOLOGICAL LEGEND

LOWER CRETACEOUS		] FORT ST. JOHN GROUP
Ksh	SHAFTESBURY FM.	
Kb	BOULDER CREEK	
Kh	HULCROSS	
Kg	GATES FM.	
Kmb	MOOSEBAR FM.	
] BULHEAD GROUP		
Kgt	GETHING FM.	
Kcd	CADOMIN FM.	



13500N XSEC MAP  
MONKMAN COAL PROJECT

INITL X CO-ORD = 646109.000  
INITL Y CO-ORD = 6070468.000

DISTANCE/ 400

FINAL X CO-ORD = 650695.000  
FINAL Y CO-ORD = 6074335.000

DRAWING NO.:	1	DATE:	SEP 26/84
REVISION NO.:	0	REQ. BY:	COAL DIV.
VERT. SCALE	1:10000	APP. BY:	T. COVERT
HORZ. SCALE	1:10000		FIG 3.17

The cross sections give a preliminary interpretation and can only be substantiated by more detailed investigations, i.e., by drilling. A number of holes have been proposed for this area to outline both the reserve potential and structural geology of the east limb of the Quintette Synclinal structure and Quintette Thrust Fault.

### 3.2 Engineering Studies

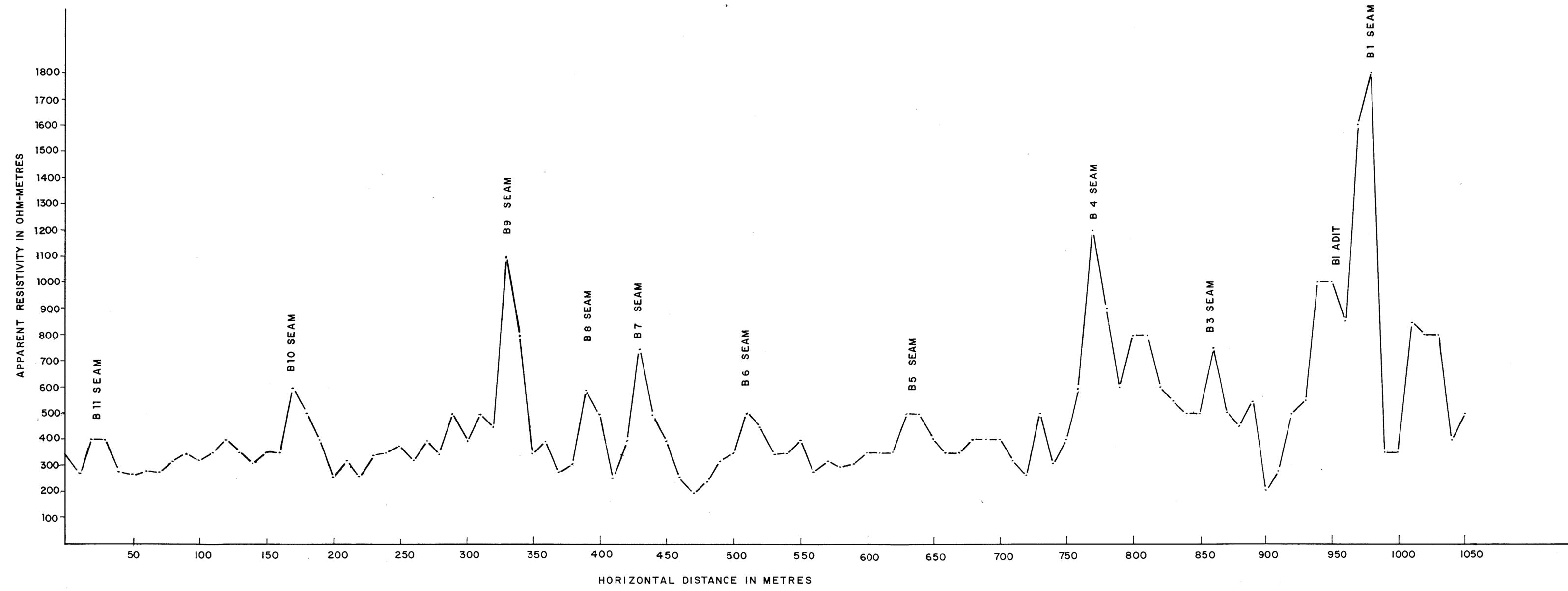
The involvement of the Engineering staff members in the actual field study worked out very well. Each individual had a chance to observe his particular area of interest, dump areas, pit outlines and plantsite locations. From these studies I think they will be better able to address the problems to be faced in the mine planning and pit design work ahead.

### 3.3 Geophysical Studies

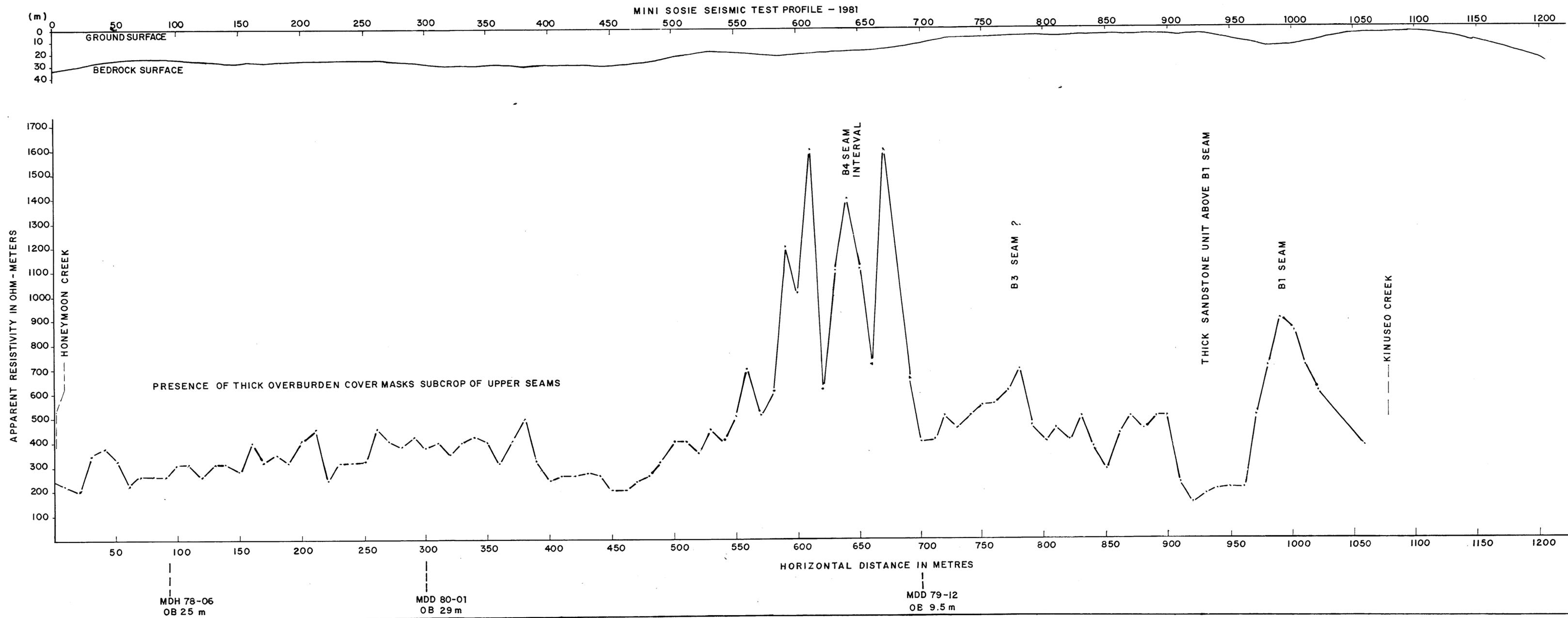
The resistivity survey went quite well. The signal received from the selected transmitting station was strong and usually easy to null. The locations of the test runs and subsequent profiles across the East Flank area are shown on Figure 3.3.1 (in folder).

Actual results for coal seam definition and differentiation were quite variable. The accuracy of this method seems to be highly dependent upon a number of factors, the most important being thickness of overburden above the coal seam subcrop, orientation of the receiver (instrument) from the transmitting station, composition of the strata above the coal, quality of the coal seams themselves and thickness of the seams which subcrop below surface.

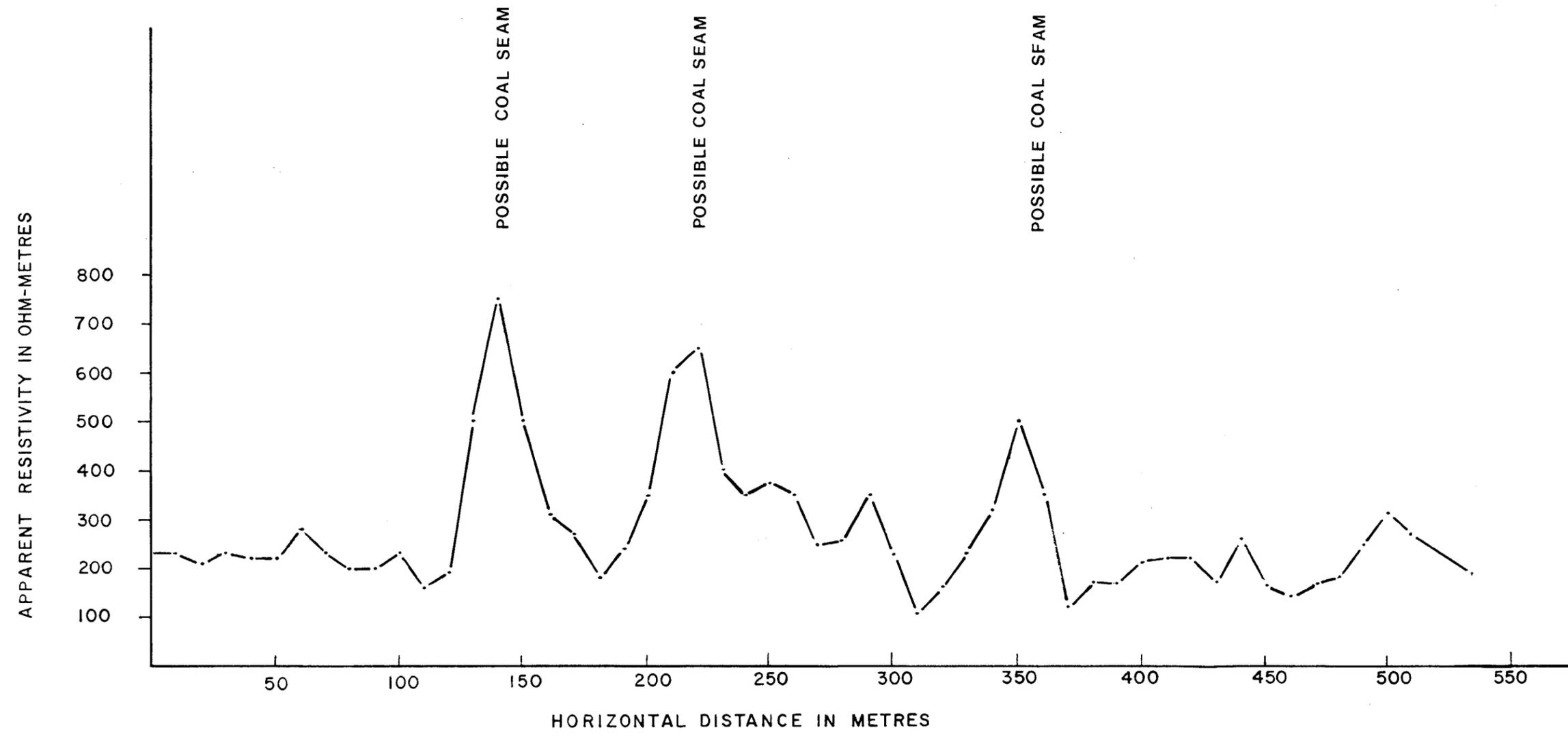
The results of the resistivity survey work are illustrated in Figures 3.3.2 - 3.3.5 (following page). These plots are attempts to show the correlation between known coal seam intersections and the anomalous readings picked up from the resistivity survey.



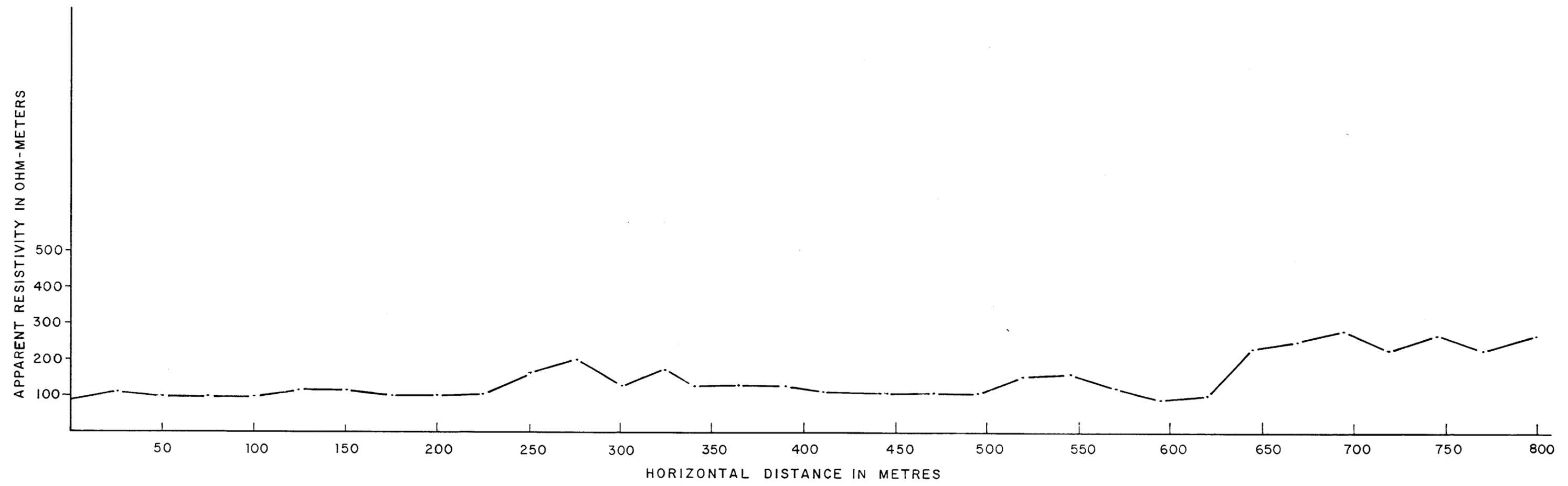
 PETRO-CANADA COAL DIVISION	<b>MONKMAN COAL PROJECT</b>
DATE <b>OCTOBER 1984</b> REVISED	<b>EM-16R RESISTIVITY SURVEY</b>
AUTHOR <b>T. COVERT</b> DRAFTED	
SCALE <b>1:2000</b>	
<b>FIGURE 3.3.2</b>	<b>PROFILE ALONG MOUNTAIN ROAD IN DUKE PIT AREA</b>



	<b>MONKMAN COAL PROJECT</b>	
	DATE <b>OCTOBER 1984</b>	<b>EM-16R RESISTIVITY SURVEY</b>
	REVISIONS	
	AUTHOR <b>T. COVERT</b>	
	DRAFTED	
SCALE <b>1:2000</b>	TEST PROFILE ALONG KINUSEO FALLS ROAD ACROSS HONEYMOON EAST PIT AND COMPARISON WITH 1981 MINI SOSIE SEISMIC TEST PROFILE OF SAME AREA	
<b>FIGURE 3.33</b>		



 PETRO-CANADA COAL DIVISION	<b>MONKMAN COAL PROJECT</b>
	<b>EM-16R RESISTIVITY SURVEY</b>
	<b>PROFILE ALONG SAWMILL ROAD IN DUKE EAST FLANK AREA</b>
	DATE <b>OCTOBER 1984</b>
	REVISOR
AUTHOR <b>T. COVERT</b>	
DRAFTED <b>1:2000</b>	
SCALE	
<b>FIGURE 3.3.4</b>	



 <b>PETRO-CANADA</b> COAL DIVISION	<b>MONKMAN COAL PROJECT</b>
	<b>EM-16R RESISTIVITY SURVEY</b>
	<b>PROFILE ALONG SEISMIC LINE IN DUKE EAST FLANK AREA</b>
	DATE <b>OCTOBER 1984</b>
	REVISIONS
	AUTHOR <b>T. COVERT</b>
DRAFTED	
SCALE <b>1:2000</b>	
<b>FIGURE 3.35</b>	

#### 4.0 CONCLUSIONS

The results of the 1984 summer field program at Monkman have been very positive. The mapping studies have proven that there is definite development of an east limb to the Quintette Syncline in the Duke East Flank area. The studies have also indicated that there is potential for coal seam development and that the major constraint to the potential of the area is the location of the Quintette Thrust Fault, i.e. where it cuts off the coal seams.

The use of low-cost ground geophysical resistivity methods as an exploration tool was successful to the extent that we now know that this type of survey can locate coal seam subcrops if the conditions are favourable - thin (less than 20 m) overburden cover and good receiver-to-transmitting station orientation.

## 5.0 RECOMMENDATIONS

The 1984 summer field program at Monkman was carried out at low cost and provided a great deal of new and informative data for future mine planning. However, in order to fully understand the subsurface structural geological conditions of the Duke East Flank area, a drilling program will have to be undertaken to address the problems of coal reserve potential and thrust fault locations.

It is therefore recommended that a drilling program be carried out to outline the potential of the Quintette Syncline's east limb and test the possibility of coal seam repeating due to thrust faulting in the Duke East Flank area.

## APPENDIX "A"

COST BREAKDOWN AND APPLICATION OF WORK CREDITS

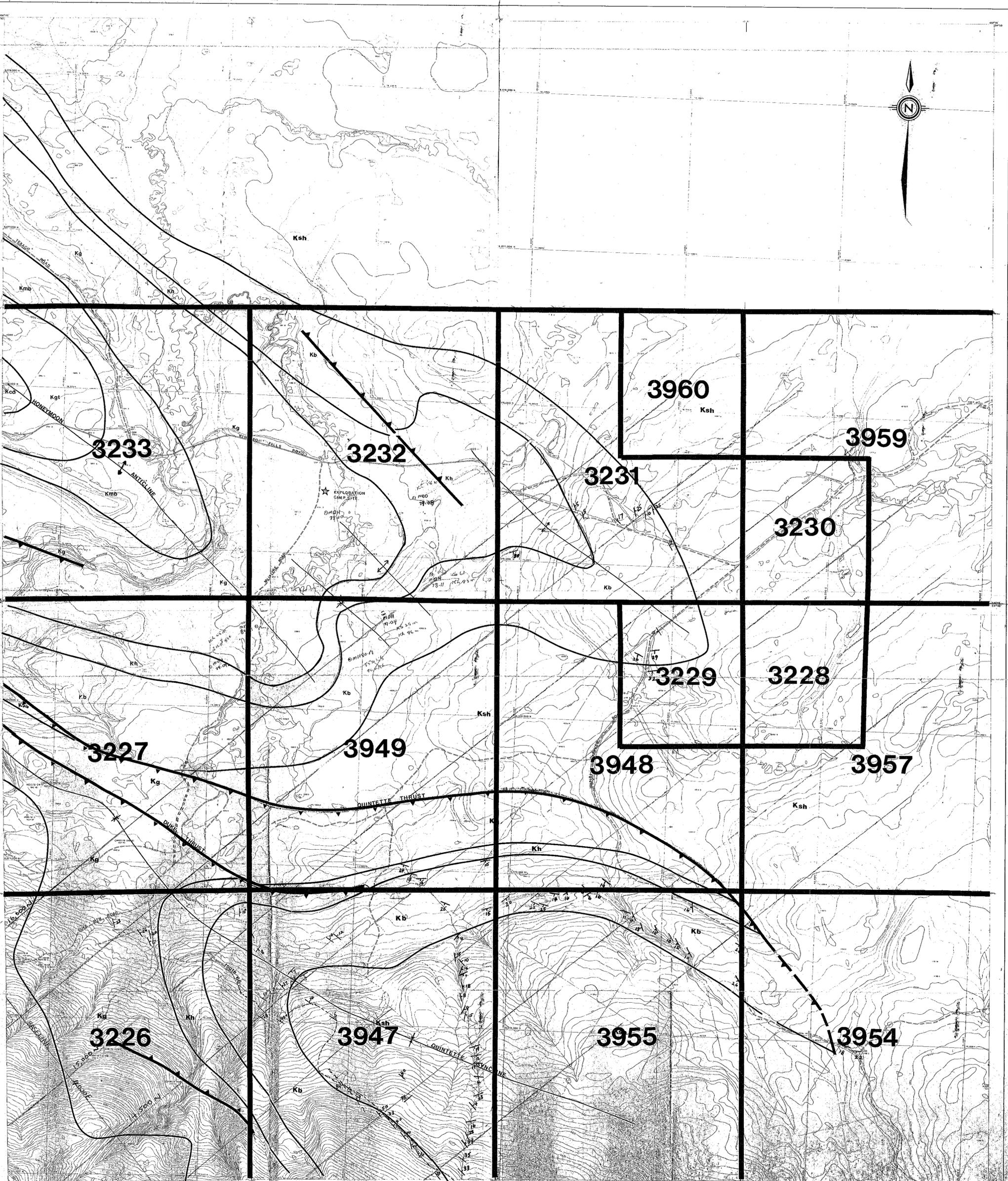
<u>GROUP NO.</u>	<u>AREA</u>	<u>WORK HECTARES</u>	<u>GEOLOGICAL MAPPING</u>	<u>RECLAMATION</u>	<u>OTHER WORK</u>	<u>OFF-PROPERTY COSTS</u>	<u>TOTAL</u>
66 172	Belcourt Red Deer Creek	3,242			60,504	13,247	88,000
67	Saxon Extension	906			500	500	1,000
68 69	Secus Nekik	3,026			8,350	8,350	30,000
163	Cabin & Duke	1,945			50,505	7,947	67,000
168 273	Onion & Boomerang North Onion	2,623			4,236	4,236	20,000
169 170S	S. Onion & Duchess North Wapiti	2,694			11,580	11,580	35,000
170S 171	North Wapiti South Wapiti	3,225			47,649	13,177	75,000
171	South Wapiti	2,248			10,924	9,185	30,000
172	Red Deer Creek	1,054			7,189	7,190	19,000
220	Nekik	607			1,167	1,167	5,000
272	Duke & Duchess	4,044	30,000	9,150	4,039	4,038	35,000
274	Onion	2,692			30,786	10,383	53,000
358	Five Cabin	3,591			62,548	14,670	93,000
359	Duke	3,277	88,750	7,400	19,808	13,390	55,000
360	Five Cabin	225			3,143	868	5,000
361	Duke	<u>4,188</u>	<u>51,250</u>	<u>9,450</u>	<u>13,072</u>	<u>13,072</u>	<u>54,000</u>
		<u>39,586</u>	<u>170,000</u>	<u>26,000</u>	<u>336,000</u>	<u>133,000</u>	<u>665,000</u>

## APPENDIX B

## BIBLIOGRAPHY

- 1977-70      Annual Exploration Reports on Monkman Coal  
Project: Pacific Petroleum Ltd.
- 1980-1982    Annual Exploration Reports on Monkman Coal  
Project: Petro-Canada
- 1983         The Structural Geology of Duke Pit by L.A.  
Smith Consulting & Development Ltd. for  
Petro-Canada





LEGEND

Topographic Contours  
 Geological Boundaries  
 Structural Features  
 Exploration Camp Site

DATE OF SURVEY: 1981-1984  
 DATE OF MAPPING: 1984

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MONKMAN COAL PROJECT

1984 GEOLOGICAL MAPPING

MONKMAN COAL PROJECT  
 WORK AREA  
 1984  
 FIG. 204