PETRO-CANADA

[redacted]

92[illegible] - P28 - 14[illegible]

9220 - P[illegible]8 - 156

Approved. Nov 27/86
L. Richards

PROGRAM NUMBER: 9229-P28-14E

YEAR: 1986

Filed under same Project Number _______ **or** ____________

(a) WRITTEN REPORTS:

(1) Operations Report — Number: 1

OPS, PROCESSING + INT. COMBINED

(2) Interpretation Reports — Number: ______

(b) MAPS:

(1) Shotpoint Maps — Number: 2

96G, 96F 1:100,000

(2) Interpretation Maps — Number: 10

- ISOCHRON (FROM TOP OF MT. CAP TO PROT.) 96G, 96F CAMBRIAN CLASTICS
- TSM (TOP OF CARBONATES) 96G, 96F
- TSM (TOP OF MT. CAP) 96G, 96F
- TSM (TOP OF PROTEROZOIC) 96G, 96F
- BOUGUER GRAVITY MAP
- TRUE + RELATIVE DIPS OF PROTEROZOIC BEDS

(3) Other Maps — Number: 8

- SYNTHETIC SEISMOGRAMS G-22, F-62
- RESTORED SECTIONS FOR LINES: 7002, 8444, 8418, 8410, 8503
- GEOLOGICAL / GEOPHYSICAL MODEL

(c) SEISMIC SECTIONS — Number: 12

(~~Final Stack~~ and Migrated)

8403	8510
8405	8512
8446	8518
8450	8520
8452	8525
8458	8527

GREAT BEAR & BLACKWATER LAKE

N.W.T.

E.A. #161 and #162

Program No.'s 9229-P28-14E
9229-P28-15E

REPORT ON THE
GEOPHYSICAL EXPLORATION SURVEY

PROGRAM NO. 9229-P28-14E and 9220-P28-15E

IN THE

GREAT BEAR AND
BLACKWATER LAKE AREAS
NORTHWEST TERRITORIES

EXPLORATION AGREEMENT NOS. 161 AND 162

BY

PETRO-CANADA INC.
SEPTEMBER 1986

FIELD WORK PERIOD: 31st December 1985 to 29th March 1986

LAND USE PERMIT NOS.: N85-B474 and N85-B473

AREA CO-ORDINATES: Latitude 64° 00' - 66° 10'
Longtitude 121° 30' - 124° 45'

DATA ACQUISITION: Seiscom Delta United

SUBMITTED BY

Patrick Wu
Project Geophysicist

B. Palmiere, P. Geoph.
Exploration Manager
N.W.T. Region

CONTENTS

Page

CONTENTS

Page

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

SECTION ONE

INTRODUCTION

A dynamite seismic reflection survey was conducted by Seiscom Delta United on behalf of Petro-Canada Inc. in the Great Bear and Blackwater Lake areas of the Northwest Territories during the 1985/86 winter season. This report summarizes the work done during this period and the results obtained. The submission of the report is in partial fulfillment of COGLA requirements for the Blackwater Lake E.A. No. 161, Program No. 9229-P28-15E and the Great Bear E.A. No. 162 Program No. 9229-P28-14E. The location of the survey area is given in Figure 1.1.

The purpose of the survey was primarily to delineate anomalies mapped from the 1984/85 seismic program.

This report comprises a statistical summary of the data acquisition, a discussion on the processing and an interpretation of the data. All maps produced during the work period of April, 1986 to September, 1986 are included in the report. Other data required to fulfill the exploration agreement were sent separately. These items include one mylar copy and two paper copies of each seismic section and the seismic base maps of the areas.

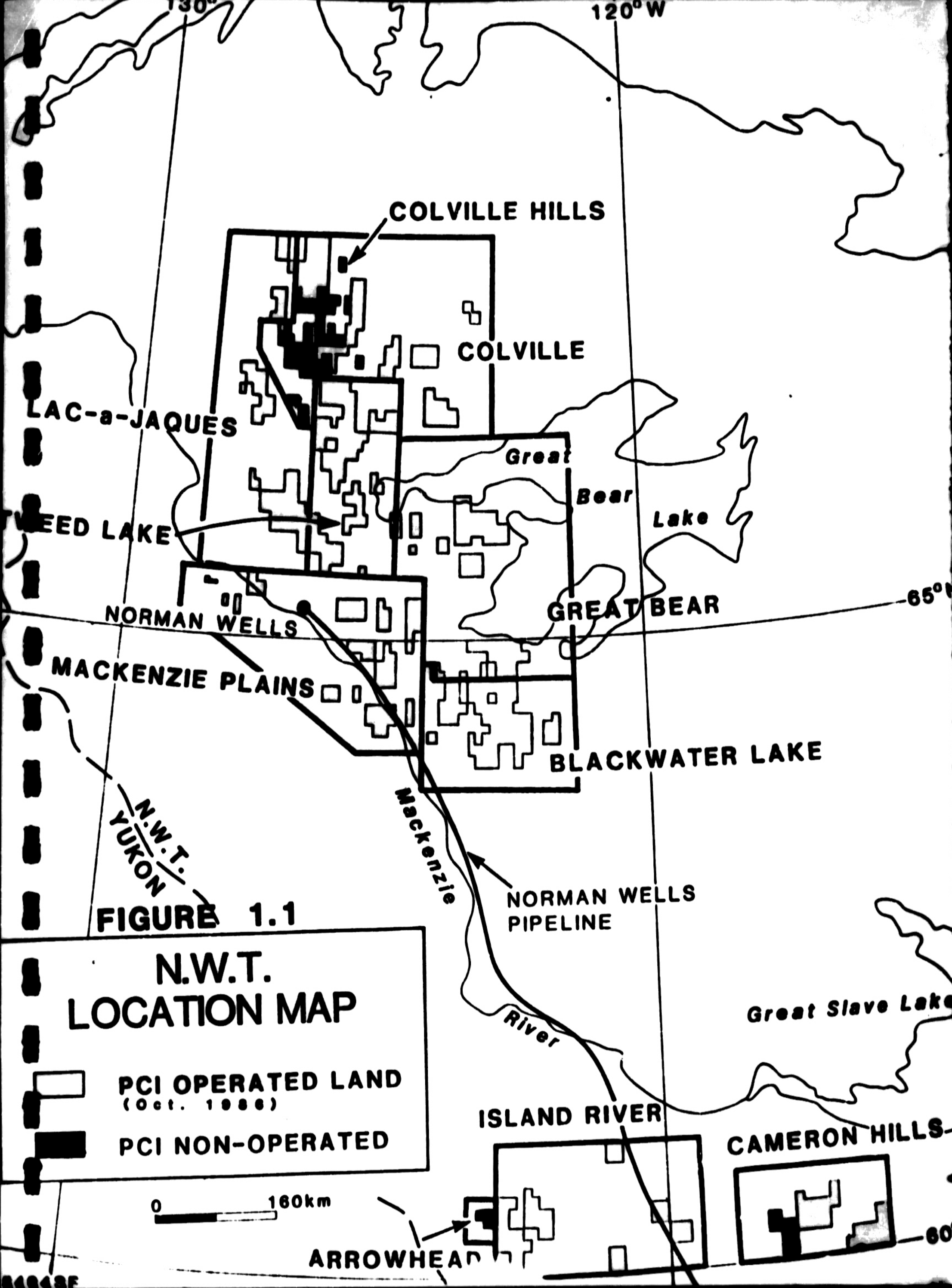

130°
120°W
COLVILLE HILLS
COLVILLE
LAC-a-JAQUES
WEED LAKE
Great Bear Lake
GREAT BEAR
65°
NORMAN WELLS
MACKENZIE PLAINS
BLACKWATER LAKE
N.W.T.
YUKON
Mackenzie River
NORMAN WELLS PIPELINE
Great Slave Lake
N.W.T. LOCATION MAP
PCI OPERATED LAND
PCI NON-OPERATED
0 160km
ISLAND RIVER
CAMERON HILLS
ARROWHEAD
60°

FIGURE 1.1

SECTION TWO

DATA ACQUISITION AND REDUCTION

2.1 Instrumentation

A set of 120 channel DFS-V's was used to collect the seismic data. Further details regarding instrumentation can be found in Tables 2.1 and 2.2.

SEISMIC RECORDING

Amplifiers	Texas Instruments . . . DFS V
Tape Systems	Texas Instruments . . . DFS V
Camera	S.I.E. ERC-10C
Remote Firing System . .	Input-Output Encoder/Decoder
Cables	S, D, V 460 m
Geophone Strings	Mark Products 14HZ

TABLE 2.1 DESCRIPTION OF INSTRUMENTS UTILIZED ON THE 1985/86 BLACKWATER AND GREAT BEAR GEOPHYSICAL SURVEY.

SURVEYING

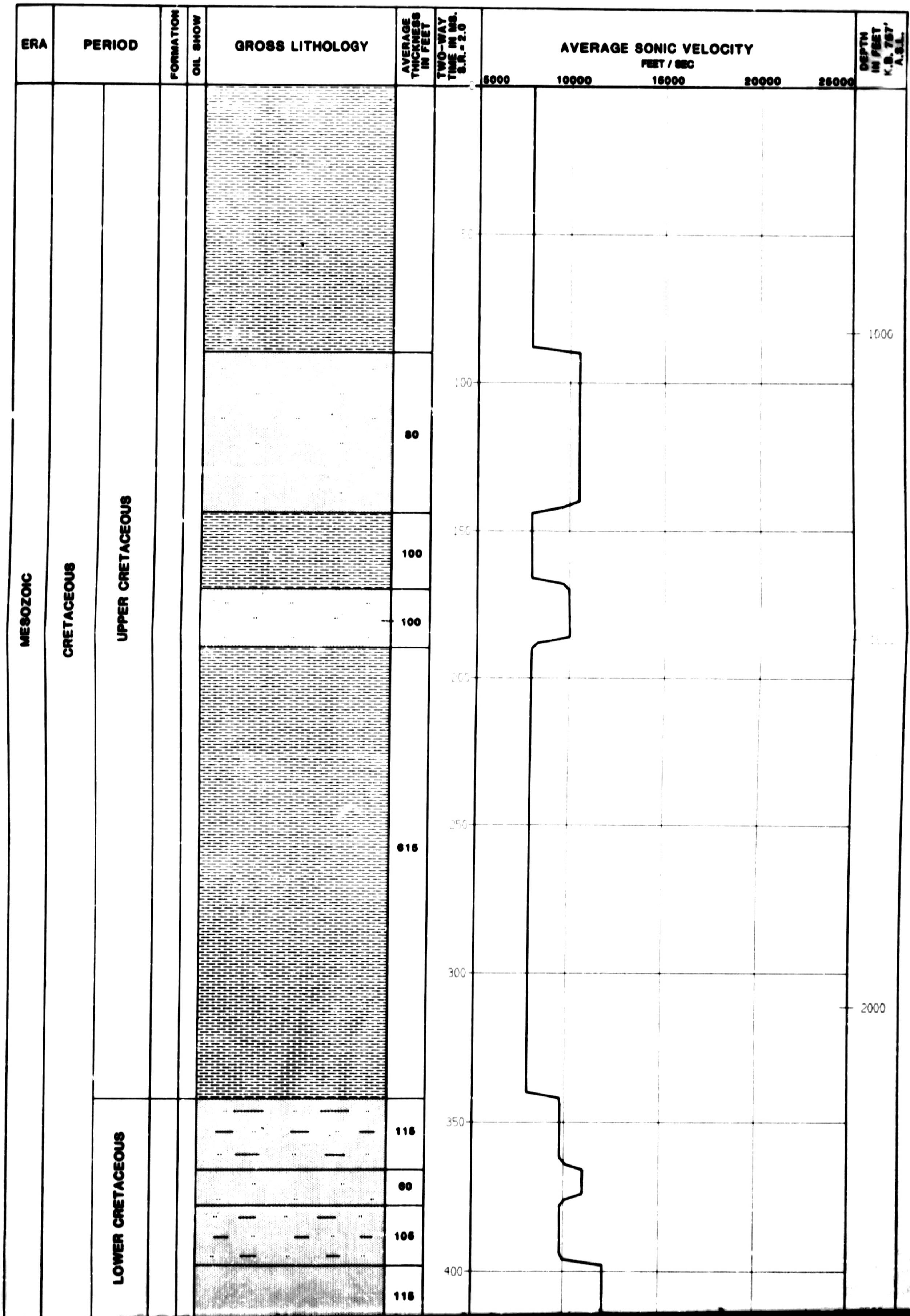
Wilde T-16 Theodolite . . .	2
D14L Distomat	1

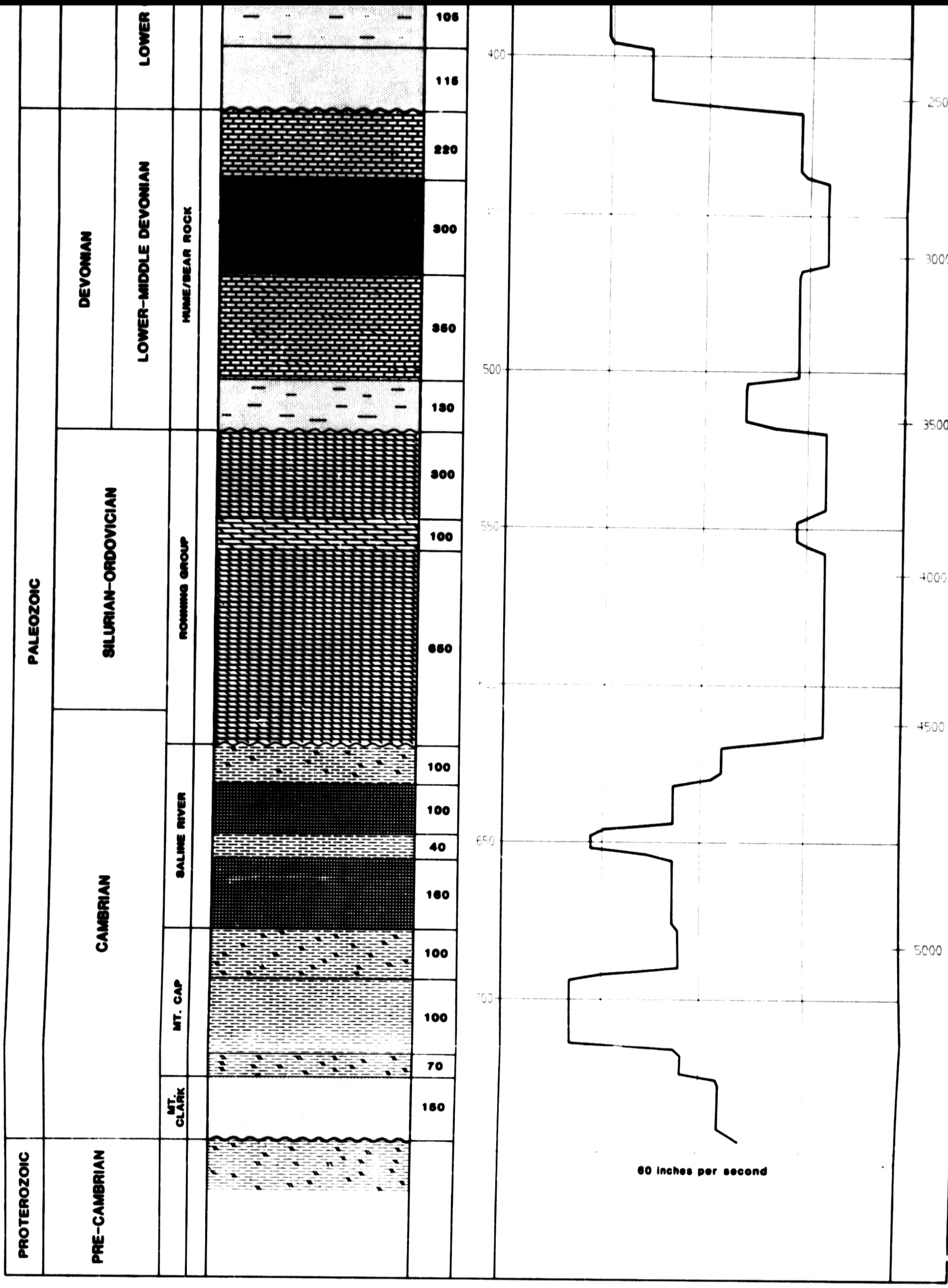
TABLE 2.2 DESCRIPTION OF INSTRUMENTS UTILIZED ON THE 1985/86 BLACKWATER AND GREAT BEAR GEOPHYSICAL SURVEY

2.2 Seismic Data Acquisition

The data in the Blackwater Lake and Great Bear area was acquired by Seiscom Delta United in one operation.

FIGURE N° 3.9
NWT - Great Bear / Blackwater
GEOPHYSICAL / GEOLOGICAL MODEL



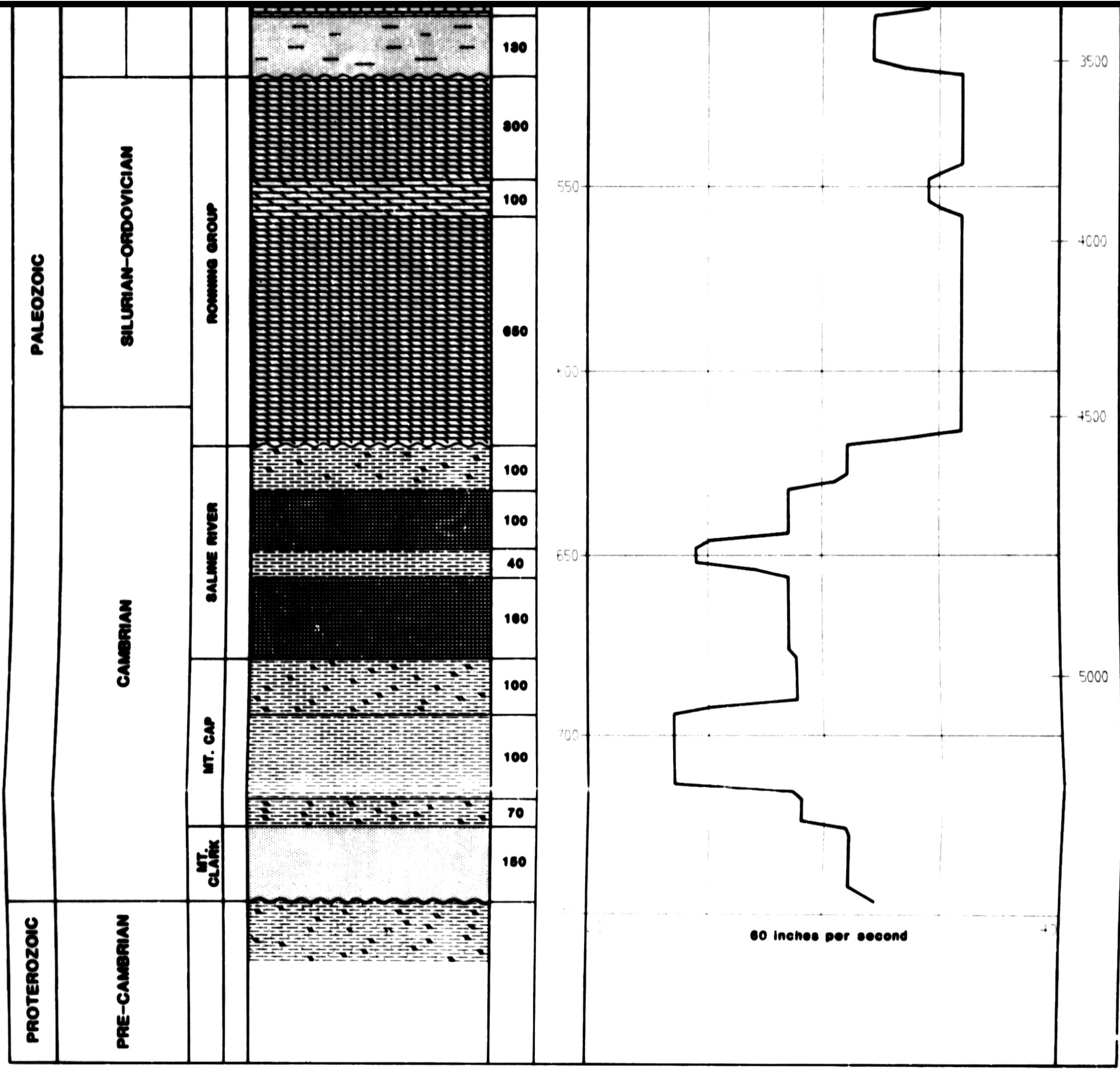


Average Velocity and Formation Thicknesses are taken from 4 wells:
SINCLAIR WHITEFISH RIVER K-76
WEST WHITEFISH RIVER H-34
BP ET AL LOST LAKE G-22
ARCO LOST HILL LAKE F-62

LEGEND

- Shale
- Sandstone
- Siltstone
- Limestone
- Anhydrite
- Dolomite
- Porous Dolomite
- Salt
- Dolomite Stringers
- Anhydrite Stringers

FILE No: 4848



Average Velocity and Formation Thicknesses are taken from 4 wells:
SINCLAIR WHITEFISH RIVER K-76
WEST WHITEFISH RIVER H-34
BP ET AL LOST LAKE G-22
ARCO LOST HILL LAKE F-62

FILE No: 4248

2.2.1 Seismic Parameters

The interval between geophone groups was 20 metres. The source-detector geometry was a 1200-20-0-20-1200 balanced spread with shot points located at the group flags. A 20 metre gap was used on either side of the shot point. Other parameters are given in Table 2.3.

The uphole geophone was placed 3 metres from the shot hole. Trace 1 was always to the northeast or southeast on each line. All shots were detonated by radio signals from a master unit in the recording truck. The start and finish of each time was started with 120 traces alive and leaving center gap in between group number 60 and 61.

Sample Rate.	2 milliseconds
Record Length.	4 seconds
Recording Filter	low cut 18 Hz high cut 128 Hz
Subsurface Coverage.	1000%/1200%
Seismometers per Group	9
No. of Groups.	120
Group Interval	20 metres
Geophone Array (Great Bear) . .	9 over 20 metres (2.5 m)
Shot Point Location Interval . .	120 metres/ 100 metres/40
Holes per location	1
Hole Depth	14 metres/10 metres
Dynamite Charge	2 kilograms

TABLE 2.3 RECORDING PARAMETERS FOR THE 1985/86 GREAT BEAR AND BLACKWATER LAKE SEISMIC SURVEYS

2.2.2 Surveying

Shot point and geophone group distances were measured with a steel chain. Pin flags marked the geophone and shot point locations. Chainage notes were kept for each line and forwarded to Petro-Canada with the record shipments.

New cut lines were started using topographic features and sun shots as a guide. When a helicopter was available it was used for giving a "line of sight" to set off the bulldozers. Station elevations were computed by stadia and horizontal locations by latitudes and departures. The lines were plotted on Petro-Canada base maps and the original survey notes, location sheets, closure sheets, and base maps were forwarded to Petro-Canada by Seiscom Delta United.

The final horizontal positions were given in the U.T.M. coordinate system. All survey work was performed in the metric system.

2.2.3 Shot Hole Drilling - Blackwater Lake

There were eight drilling rigs on the crew, six TF-110 Mayhew Air Drills (two with air/water), one TF-110 Mayhew Air Drill with downhole hammer and one TF-110 Top Drive air/water with down-hole hammer.

Except for line 8436, most shots were single holes with a depth of 14 metres and shot point intervals of 120 metres. Production holes were preloaded with two kilograms of Geogel 60 and tamped with the cuttings. Line 8436 has three hole patterns with holes 2 metres apart and centered at the shot point. The charge size was 1.5 kilograms per hole.

No holes were drilled on lakes or near water-courses. The drilling condition varied from sticky clay to gravel, rock and boulders.

2.2.4 Shot Hole Drilling Great Bear

The same drilling equipment that was used in Blackwater Lake was used for the Great Bear Seismic Survey.

Except for Line 8452, most shots were single holes with a depth of 14 metres and charged with 2 kilograms of Geogel. Shot point interval of 100 metres were used on most of these lines except for lines 8405 and 8446 where shot point interval of 120 metres were used. For line 8452, a three hole pattern was used. The holes were 3 metres deep and 2 metres apart with the centre at the shot point. Each hole was charged with 1.5 kilograms of Geogel.

The drilling conditions started out poor, gravel and boulders, but improved to clay and rocks.

2.2.5 Line Cutting

Seven bulldozers were assigned to the operation. The lines were cut to a width of 8 metres except for a 3 kilometre section of hand cut line criss crossing a small creek as per land use regulations.

2.3 Field Operations

Since the survey in Great Bear was a continuation of the survey in Blackwater Lake, the two operations will be considered and reported as one. The mobilization date of the crew was December 31, 1985. On January 9 the bulldozers started plowing in Blackwater. Recording began January 12. All aspects of the project operations were completed by March 29, 1986. A summary of the pertinent dates is given in Table 2.4

Mobilization date	Drill Camp	December 31, 1985
	Recording Camp	January 2, 1986
Start Cutting		January 9, 1986
Start Recording		January 12, 1986
Finish Cutting		March 20, 1986
Completion of Drilling		March 21, 1986
Completion of Recording		March 25, 1986
Demobilization Date		March 29, 1986
Total Recording Days		70
Total Moving Days		17
Total Weather Days		2
Total Down Days		0

TABLE 2.4 CHRONOLOGY OF MAJOR EVENTS FOR THE 1985/86 BLACKWATER LAKE AND GREAT BEAR SEISMIC SURVEY

PETRO-CANADA FIELD SUPERVISOR

SEISCOM DELTA UNITED FIELD SUPERVISOR

PARTY MANAGER

Recording

Observer	1
Jr. Observer	1
Shooter	1
Shooter's Helper	1
Cable Truck Drivers	4
Recording Helpers	8

Surveying

Surveyors	2
Survey Computor	1

Bulldozing

Operators	8
Cook	1
Cat Push	1
Fuel Camp Operators	1

Drilling

Drillers	8
Helpers	8
Water Truck Drivers	2
Drill Push	1

Catering

Cooks	2
Assistant Cooks	2
Attendants	2

Support Staff

Party Managers	2
Clerk	1
Mechanics	2
Mechanics Helper	1
Expediters	2
Monitor	1
Survey Helpers	2

TABLE 2.5 ORGANIZATION CHART FOR THE 1985/86 BLACKWATER AND GREAT BEAR GEOPHYSICAL SURVEY

The seismic crew was composed of four separate and self-contained camp operations. The cat and survey camp led the operation, surveying, cutting and cleaning the lines. The surveyors then laid out the spread configuration on the lines for the drills and recorders. The drill camp was the next group to travel the lines, they drilled and loaded the shot points marked by the surveyors with flags and tags. Next came the recording camp and crew to detonate and record the seismic waves. As each of these three camps were constantly on the move, a fourth camp, the base camp, was included in the operation. This camp, which was located near a large lake on which an airstrip was plowed, supplied the other camps with fuel, food, personnel and parts through supply vehicles. Ideally this camp was to be centrally located so that other camps would pass it periodically for fuel; thus the length of stay and the position of the base camp was dependent on the progress of the other camps and limited to the availability of suitable lakes for airstrips.

Table 2.5 shows the organization chart for the project. Of the 66 positions in the chart, 42 were filled by residents from the Northwest Territories (i.e. 65%) and 24 by Canadians from the south.

2.3.1 Producton Statistics

Table 2.6 provides a summary of the seismic data acquired as well as data pertinent to shot hole drilling.

SEISMIC RECORDING

Production profiles shot (Approx.)	5,293
Total number of lines in Blackwater	14
Great Bear	12
Kilometers Shot in Blackwater Lake	294
GreatBear	262
Average Number of Recorded Shots per production day	76
Average Kilometres per production day	7.95

DRILLING

Number of holes drilled	6,355
Total metres drilled	64,803
Average hole depth (meters)	10
Total powder consumed (kilograms)	10,460
Average charge per hole (kilograms)	2

TABLE 2.6 NUMERICAL SUMMARY OF PRODUCTION FOR THE 1985/86 BLACKWATER AND GREAT BEAR SURVEY

2.3.2 Terrain and Weather Conditions

Terrain in the Blackwater area varied from muskeg flats to rolling hills, with many small lakes which had to be detoured because of thin ice due to deep snow and mild temperatures. Arctic Ice Builders were contracted to flood the ice to a desired thickness capable of supporting the camps. Numerous breakdowns were encountered on the camps while moving over the summit of the McConnel Range: trailers were winched over the hills which resulted in a broken hitch pin, the Borek survival shack was damaged and there were problems with the sleighs. Because of mild temperature and deep snow there were problems with cats breaking through and getting stuck.

In the Great Bear area, the terrain varied from gentle rolling hills with many small lakes to short steep hills requiring a tow cat for some of the equipment.

2.4 Seismic Processing

The seismic data in both areas were processed by Geophysical Services Incorporated. The processing procedures were as follows.

1. Demultiplex
2. Trace Editing
3. Statics Computations
4. True Amplitude Recovery - 7db/sec from 0 to 3.0 sec
5. First Break Noise Suppression
6. Spiking Deconvolution -
   - a) operator length: 80 msec
   - b) prewhitening: 1%
   - c) design window: 200-1800 msec near trace
900-1950 msec far trace
7. Equalization
8. Velocity Analysis: surface referenced (type: VELSCAN)
9. Residual Statics Analysis - Surface Consistent Automatic Statics (HSTATC)
10. Velocity Analysis: VELSCAN, relative and residual statics applied
11. Mean Datum Statics Applications
12. Trim Statics
13. Stack muting - Offsets (m) 20, 260, 500, 1200
- Time (msec) -50, 0, 400, 1000
14. CDP Stack: 12/10/30 fold
15. Migration
16. Time Invariant Filter: 13/23 - 50/60 Hz
17. Time Variant Scaling - (10 x 100) 200, 200, 300, 500 msec gates, start time 0 msec.
18. Display to Film: Scale sent to COGLA (normal polarity)
    - vertical: 3.75 inches/sec in Blackwater and southern Great Bear and 7.5 inches/sec. in northern Great Bear
    - horizontal: 36 traces/inch

Corrections were made for elevation and shot depth. A surface consistent automatic residual statics routine was run on the data. The datum chosen was 305 metres above sea level and the replacement velocity used was 2450 metres per second.

Moveout velocities were picked from semblance plots. The velocity functions were checked using common offset stacks. A mute pattern was then chosen for the CDP stack.

A time variant scaling was applied to the data after stacking as well. The filter used was 13-60 Hertz and a roll-off of 120 decibels/octave at each end. All the data were migrated.

SECTION THREE

INTERPRETATION AND PRESENTATION OF RESULTS

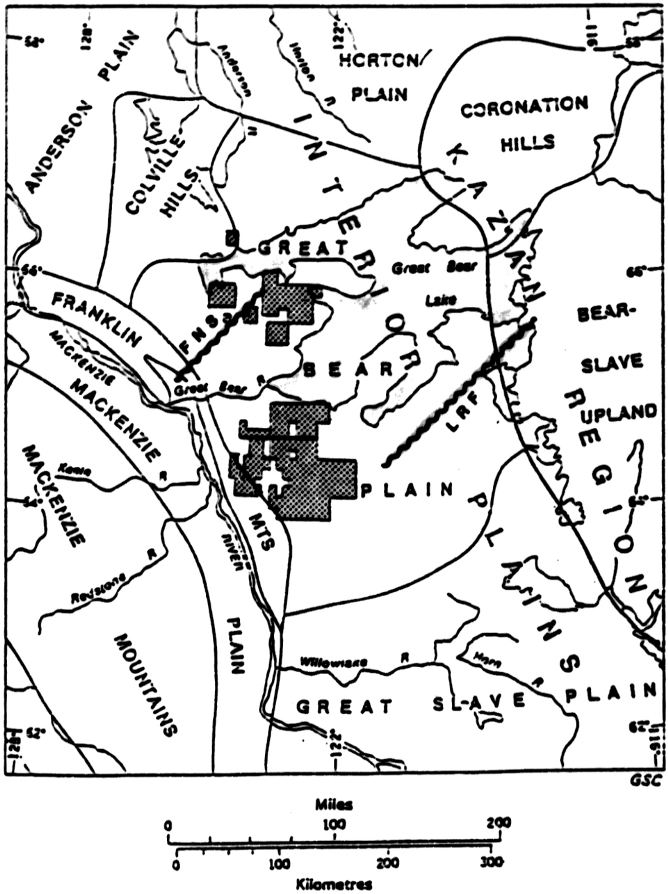
3.1 Regional Physiography and Geology

The survey area is located within the Northern Interior Plain of the Northwest Territories and lies to the southwest and west of Great Bear Lake. The town of Norman Wells is west of the area on the Mackenzie River. The location of the project area is shown in Figure 1.1.

The survey area is bounded by the following co-ordinates: 122°15' - 124° 45' west and 64° 00' - 66° 10' north. The project area is within the physiographic sub-province of Great Bear Plain as shown in Figure 3.1.

The project area is composed of two topographically different zones. The western zone is located in the Franklin Mountains where elevations vary from 240 to 900 metres above sea level. The eastern zone is relatively low in relief with elevations that range from 230 to 260 metres above sea level. The latter contains many lakes and rivers.

A major structural feature in the Blackwater Lake area is the Cap Thrust which brings lower Paleozoic and Proterozoic rocks to the surface. The Cap Thrust, which is situated at the eastern edge of the Franklin Mountains, passes through the southwest corner of the Blackwater Lake area and strikes northwesterly and is found west of the Great Bear project area. The surface location of the fault is shown in Figure 3.2.1.



FNS — FORT NORMAN STRUCTURE

LRF — LEITH RIDGE FAULT

GREAT BEAR & BLACKWATER LAKE E.A (July 1986)

Fig.3.1 Map of the physiographic provinces in the Blackwater Lake and Great Bear Lake areas. Major structural features are also shown (modified from Bostock,1970)

East of the Cap Thrust is the Wolverine Arch which has no surface expression. Subsurface information from the Wolverine Creek D-61 and Mahoney Lake I-74 wells shows that the rocks of the Cambrian Saline River Formation lie directly on top of the Proterozoic rocks and the Lower Cambrian Clastics of the Mount Cap and Mount Clark Formations are missing on this ancient structural high. The approximate location of the arch is given in Figure 3.2.1 (see also Section 4).

Another feature in the Blackwater Lake area is the fault zone A in Figure 3.2.1. Although not seen on the surface, it manifests itself as two thrust faults in the Blackwater Lake G-52 well. One of the thrusts gives a repeated high gamma ray sequence in the Mount Cap Formation while the other gives a repeated Mount Kindle sequence. The thrusting reverses its direction several times along the fault zone as it strikes northeastwards into the southern part of the Great Bear area. At several places along the fault zone, thrusting even turns into normal faulting with the downthrown side to the west and northwest.

Sub-parallel to fault zone A is fault D which is a normal fault and is downthrown to the east and southeast. Between these two fault zones is a graben which is further divided by the fault zones B and C.

In the Great Bear area, Aitken and Pugh (1984) reported two northeast trending structures: the Leith Ridge fault and the Fort Norman structure (see Fig. 3.1). The Leith Ridge fault is a northwest-side-down fault that runs on the northwest flank of the Leith Ridge, a high, linear ridge of Aphebian crystalline rocks that crosses the base of the Leith Peninsula on Great Bear Lake. The Leith Ridge fault probably crosses the southeast part of the Great Bear and Blackwater Lake

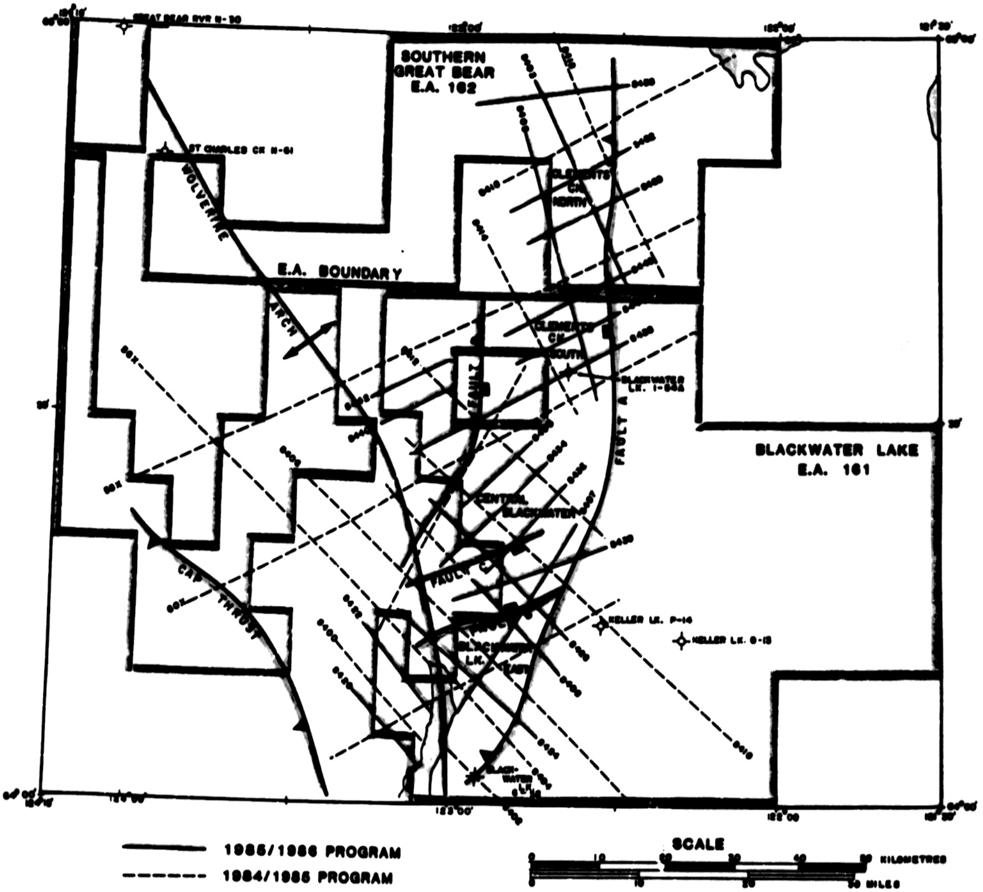


FIGURE 3.2.1. Locality map of the 1985/1986 geophysical program and 1984/1985 data in the Blackwater Lake and Southern Great Bear area showing major structures

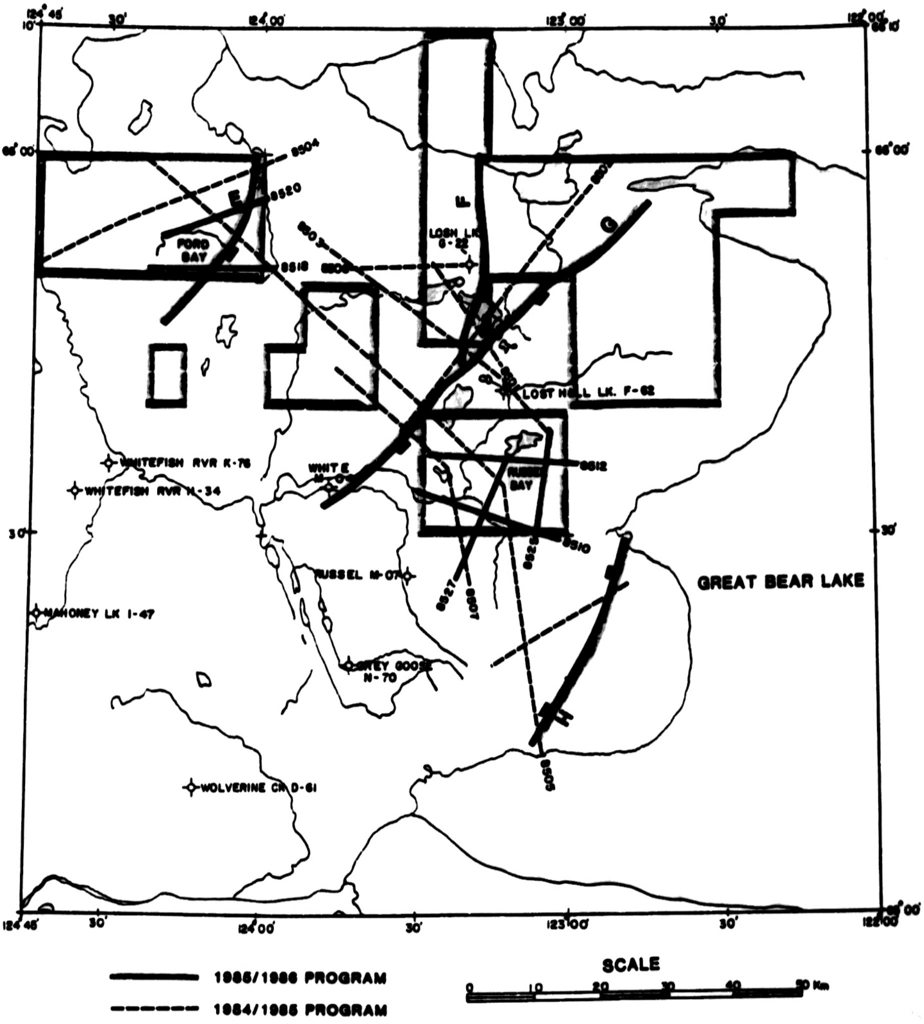


FIGURE 3.2.2 Locality map of the 1985/86 geophysical program in the Great Bear E.A. showing some interpreted faults in the area.

area and fault zone A may be a southern extension of this fault.

The Fort Norman structure is a Proterozoic structure that is not seen on the surface. Northwest of the structure, in Mahoney Lake I-74, the Lower Cambrian sandstones rest unconformably upon various formations of the 'Mackenzie Mountains Supergroup' (Aitken et.al. 1982). Southeast of the structure, the unconformity is even more profound: the Lower Cambrian sandstones are underlain by the Hornby Bay-Dismal Lakes Group (Kerans et.al. 1981). The 'Mackenzie Mountain Supergroup', which overlay the Dismal Lakes-Hornby Bay Groups in the Coppermine Homocline northeast of Great Bear Lake and the Cap Mountain in the south, is missing. This means that the region was a late Precambrian high relative to the northwest.

Several other faults are found in the Great Bear area. They are shown as faults E, F, G and H in Figure 3.2.2. Fault F and G are normal faults while faults E and H have thrust components. A more detailed discussion on these structures can be found in Sections 3,4 and 5.

3.1.1 Overview of Stratigraphy and Well Geology

The stratigraphic column of the area includes Proterozoic, Cambrian, Ordovician, Silurian, Devonian, Cretaceous and Quaternary units. The stratigraphic units are shown in Table 3.1, and the wells are listed in Table 3.2.

System of Series	Group	Map-unit	Lithology
QUARTERNARY		Q (undivided)	Unilithified gravel, sand, silt, clay, till
Unconformity			
LOWER AND UPPER CRETACEOUS		K (undivided)	Partly bentonitic, black and gray, papery shale, blocky mudstone, siltstone, lignite, minor sandstone
Unconformity			
LOWER AND (?) MIDDLE DEVONIAN		BEAR ROCK FORMATION	Brecciated gray-brown dolomite: anhydrite, red and green shale and siltstone at base
Probable Unconformity			
UPPER ORDOVICIAN & (?) LOWER SILURIAN	RONNING GP.	MOUNT KINDLE FM.	Medium to dark brownish gray dolomite, silicified fossils, chert
	RONNING GP.	Unconformity	
LOWER ORDOVICIAN (?), UPPER AND (?) MIDDLE CAMBRIAN	RONNING GP. / FRANKLIN MT.	Rhythmic unit	Alternating beds of brownish gray and grayish arange dolomites indistinct oolitic textures
MIDDLE AND (?) UPPER CAMBRIAN	RONNING GP. / FRANKLIN MT.	'Cyclic unit'	Dolomite: repetitions of laminated, oolitic, conglomeratic, stromatolitic beds, green and maroon shale
(?) LOWER, MIDDLE AND UPPER (?) CAMBRIAN		SALINE RIVER FM.	red and green shale, buff dolomite, pink gypsum
		MOUNT CAP FM.	red, green, gray shale and siltstone, glauconitic sandstone, brown dolomite
(?) LOWER AND MIDDLE CAMBRIAN		MOUNT CLARK FM.	Gray, white, pink, friable sandstone, minor pebble beds
Unconformity			
(?) HADRYNIAN OR NEOHELIKIAN OR PALEOHELIKIAN	MACKENZIE MT. SUPER GP.	Katherine	Gray orthoquartzite, beds of dolomitic sandstone
	MACKENZIE MT. SUPER GP.	Tsezotene	black, siliceous argillite, minor chert and orthoquartzite
	MACKENZIE MT. SUPER GP.	H1	micro crystaline to aphanitic dolomite, vari-colored, Pale chert, interbedded siltstone, shale and dolomite
Intrusive Contact			
PALEOHELIKIAN		Dismal Lake Gp.	Brown stromatolitic dolomite, chert
		Hornby Bay Group	White, buff, pink, maroon quartzite
Unconformtly			
APHEBIAN		Granite	Pink, equigranular and porphyritic granite
		Intrusive Contact	
		Feldspar porhyries	Pink, brown, black dacite and quartz latite
		Intrusive Contact	
		SNARE, ECHO BAY AND CAMERON BAY GROUPS	Partly to intensely metamorphosed conglomerate, sandstone, argillite, andesite

TABLE 3.1 STRATIGRAPHIC UNITS OF THE GREAT BEAR PLAINS (MODIFIED FROM BALKWILL, 1971 AND PUGH, 1983)

Well Name	Devon.	Sil-Ordov.	Saline River	Mt. Cap	Mt. Clark	Prot.
Blackwater I-54A	Y	Y	Y	-	-	-
Blackwater G-52	Y	Y	Y	Y	Y	Y
Great Bear Rv. N-30	Y	-	-	-	-	-
Grey Goose N-70	Y	-	-	-	-	-
Keller Lake O-13	Y	Y	-	-	-	-
Keller Lake P-14	Y	-	-	-	-	-
Losh Lake G-22	-	Y	Y	Y	Y	Y
Lost Hill Lake F-62	Y	Y	Y	Y	-	-
Mahoney Lake I-74	Y	Y	Y	-	-	Y
Russel M-07	Y	-	-	-	-	-
St. Charles Ck. H-61	Y	Y	-	-	-	-
White M-04	Y	-	-	-	-	-
Whitefish Rv. H-34	Y	Y	Y	-	-	Y
Whitefish Rv. K-76	Y	Y	Y	Y	Y	-
Wolverine Ck. D-61	Y	Y	Y	-	-	Y

TABLE 3.2 WELLS WITHIN THE STUDY AREA AND THE FORMATIONS WHICH THEY PENETRATE (INDICATED BY Y)

There are only 5 wells in the area that penetrate the Proterozoic. They are the Blackwater G-52, Loch Lake G-22, Mahoney Lake I-74, Whitefish River H-34 and the Wolverine Creek D-61 wells. In Blackwater G-52, the Proterozoic consists of shales, siltstones and dolomites. Further to the north in Loch Lake G-22 and Wolverine Creek D-61, it is predominantly shales of the Horny Bay-Dismal Lake Group. However, across the Fort Norman Structure, in Mahoney Lake I-74 and Whitefish River H-34, the Proterozoic contains dolomites of the 'Mackenzie Mountain Supergroup' Unit H1 (Aitken and Pugh, 1984).

The overlying Cambrian units are composed of clastics, evaporites and carbonates. The Lower Cambrian Mount Clark (Old

Fort Island) Formation, which consists of a light grey, medium to fine grained quartzitic sandstone, is the primary exploration target. At Loch Lake G-22 it is 60 metres thick and has a porosity of 6% (unfortunately it is wet). At Blackwater G-52, the sand is only 45 metres thick, and since the grains have sutured contacts, the porosity is close to zero. The existence of such sutured grains in the G-52 well is probably due to the lower thrust, which lies only 30 metres above the Mount Clark. In the Blackwater E-11 well, which lies outside and to the south of the area, the Mount Clark is only 20 metres thick and the porosity is about 5%. To the west, the Mount Clark thins more rapidly. In Whitefish River H-34 it is only 30 metres thick, at K-76, it decreases to 15 metres, and over the Wolverine Arch at Wolverine Creek D-61 and Mahoney Lake I-47 the Mount Clark no longer exists.

The Mount Clark Formation is overlain by the Mount Cap shales, siltstones and dolomites. In Loch Lake G-22 and Lost Hill Lake F-62 in northern Great Bear, the Mount Cap consists of 25 metres of low velocity shale overlying 10 metres of dolomite and 40 metres of high gamma ray shale. In the Blackwater G-52 well the low velocity shale is missing and the Mount Cap is only 45 metres thick. The Mount Cap shale also thins to the west, disappearing over the Wolverine Arch in the Wolverine Creek D-61 and Mahoney I-74 wells.

Above the Mount Cap lies the siltstones, dolomites and gypsum of the Saline River Formation. In northern Great Bear, there is 145 metres of halite sandwiched between the siltstones, dolomites and gypsum, and within the salt, there is a shale marker of 15 metres thick. The thick salt layer provides an excellent seal for the Cambrian sandstones. In Blackwater G-52, the salt is completely missing and the Saline River Formation is only 35 metres thick.

The Cambro-Ordovician carbonates of the Franklin Mountain Formation overlies these Cambrian formations and the Upper Ordovician-Lower Silurian carbonates of the Mount Kindle Formation rest unconformably on top. The color of the carbonates are light brown in both formations. Vuggy porosities do exist in these dolomites, but they are all wet. In Lost Hill Lake F-62, some dead oil staining (pyrobitumen) is found in the Mount Kindle Formation. In the south, a shale marker usually occurs on the boundary between the two formations, providing a good seismic reflection. However, this is not true for the north.

The Devonian section, which consists of carbonates and anhydrites of the Bear Rock Formation, lies unconformably on the Mount Kindle Formation. The anhydrites provide an excellent seal for the vuggy limestone units within the Bear Rock, which unfortunately are wet. In Blackwater I-54A, the Bear Rock is about 400 metres thick but it thins towards the north. In the Lost Hill Lake F-62 well the Bear Rock is made up of 40 metres of shale, siltstone and dolomite. In Losh Lake G-22, the Bear Rock is completely gone.

Upper Cretaceous shales, siltstones and basal sandstones lie unconformably on the Devonian section. At Losh Lake G-22 and Lost Hill Lake F-62 the basal Cretaceous sandstone is approximately 50 metres thick and is overlain by thick units of shale. The Quaternary rocks, composed of gravel, sand, clay and glacial till, lie unconformably on the Cretaceous. Thickness of the Quaternary section ranges from zero to over 200 metres.

The Mount Clark sandstone is the primary target in this area. The vuggy limestones and dolomites of the Bear Rock, Mount Kindle and Franklin Mountain, the basal sandstones of the

Cretaceous, and the Proterozoic are all potential secondary targets.

3.2 Correlations Between Well Data and Seismic Data

3.2.1 Blackwater Lake

The map in Figure 3.2.1 gives the location of the seismic lines and wells in the Blackwater/Southern Great Bear area. The seismic base maps are shown in Figures 3.3.

Correlations from geology to geophysics were based on the Buttes et al Blackwater Lake I-54A and Shell Blackwater Lake G-52 wells. The I-54A well is located just north of shot point 187 on Line 8438. The G-52 well is located about 0.5 kilometres south of shot point 145 on Line 8418, which was shot in last year's program. Synthetic seismograms were used to tie the well to the seismic data (Figures 3.4, 3.5). The I-54A well penetrates down to the Saline River Formation only and thus provides no correlation for the Mount Cap, the Mount Clark and the Proterozoic. The G-52 well provides no further information because of its position in the fault zone A. Other wells provide little help because of their shallow depth or because they are not close to any of our seismic lines.

The seismic events that were correlated in the project area are: the top of the Devonian carbonates (Pre-Cretaceous unconformity), the top of the Mount Kindle, the Franklin Mountain, the Saline River Formation, the Mount Cap and the top of the Proterozoic. An example of the interpreted events is given in Figure 3.8.1 for Line 8438.

The quality of the 1985/86 seismic data are generally good, however, there are some problems with surveying and statics,

LINE 8438

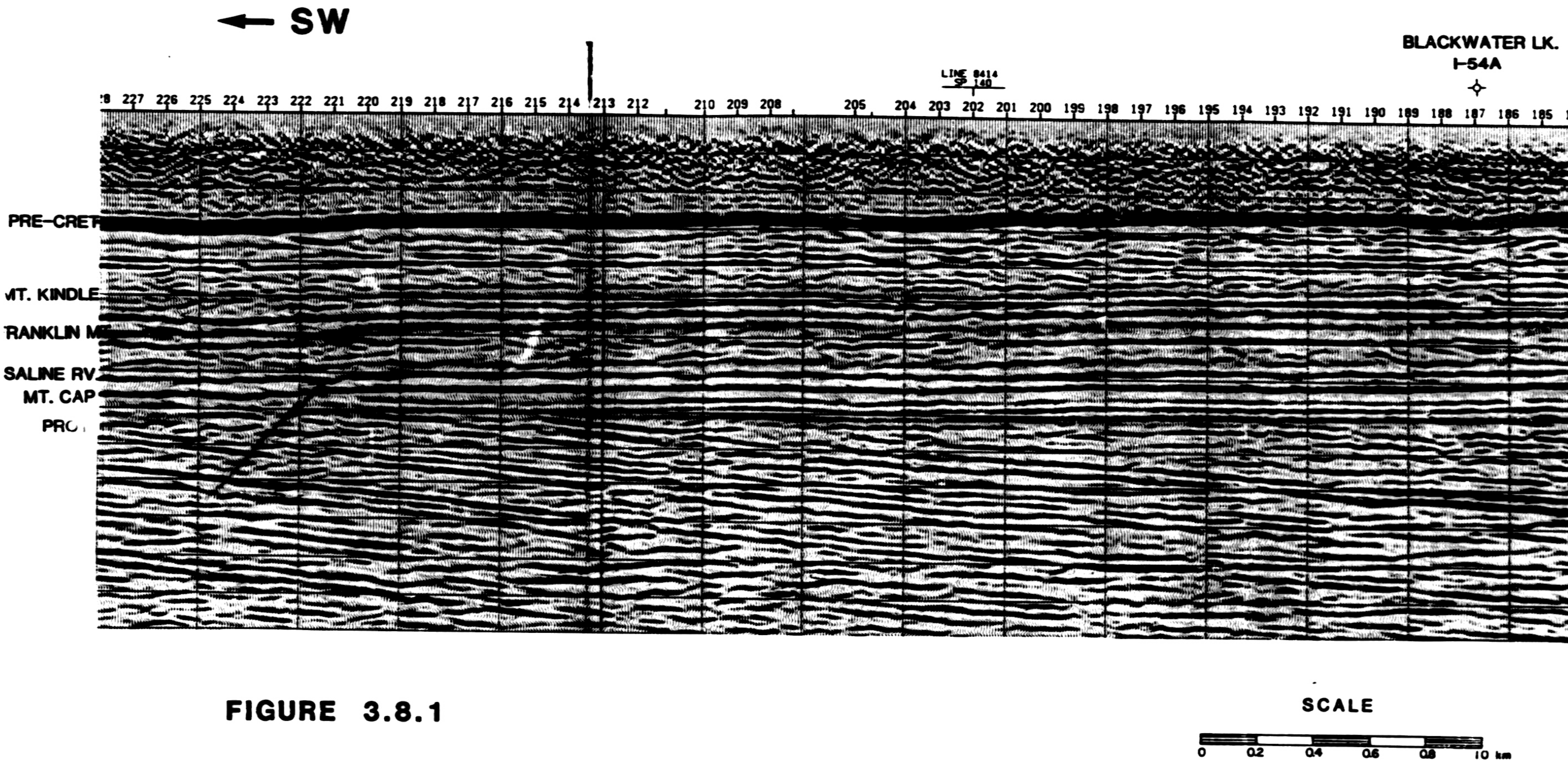


FIGURE 3.8.1

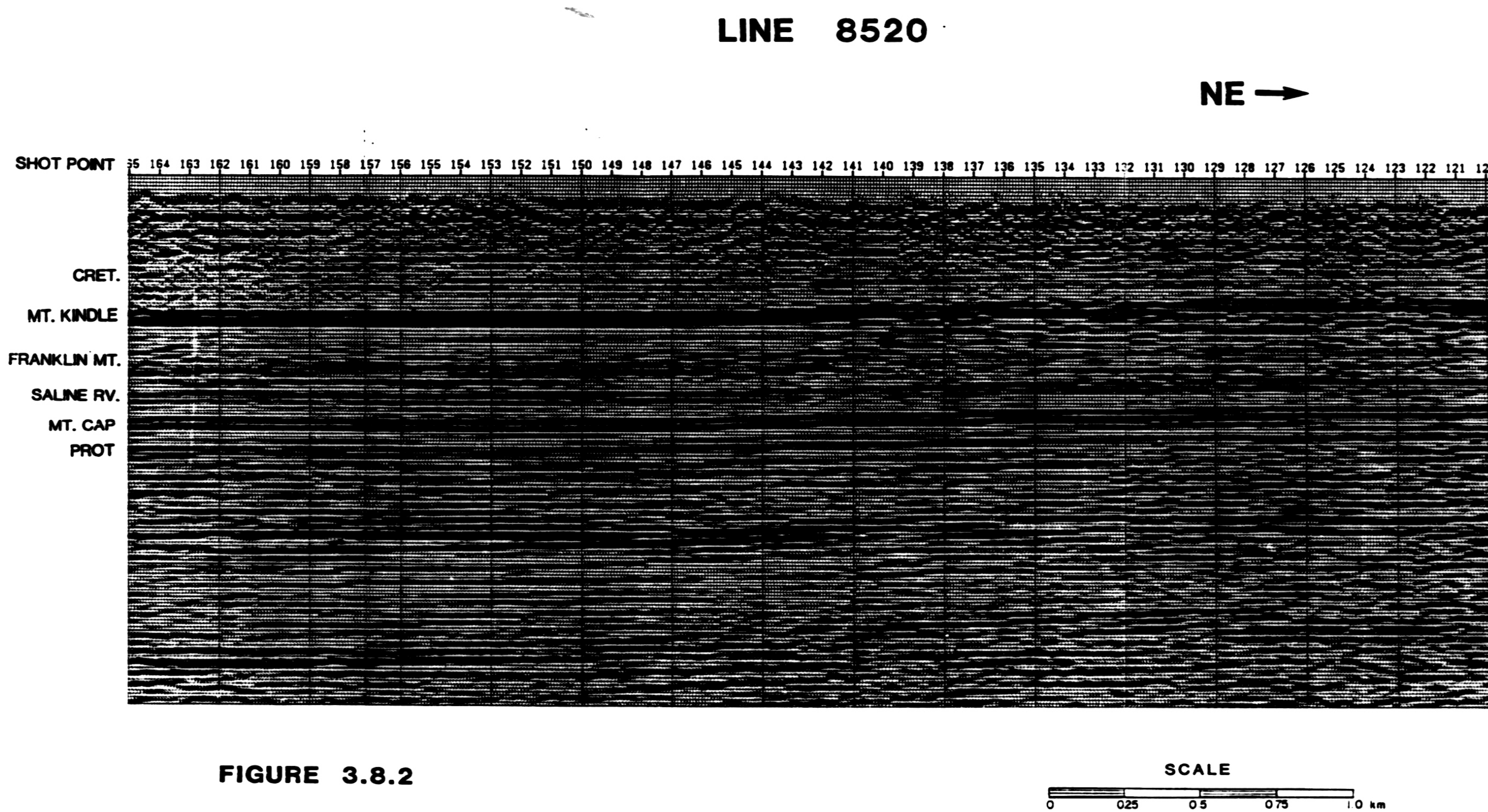
and as a result, seismic sections have to be shifted by various amounts to make them tie at intersections. Fortunately most of the shifts are less than 25 msec.

Because the Cambrian and Proterozoic markers are both clastics, the reflectivity coefficient of this interface is not sufficient to produce a good seismic reflection. However, the Proterozoic/Cambrian contact can be interpreted in most cases because the interface is usually an angular unconformity. An example of this is around shot point 215 of Line 8438 (Fig. 3.8.1). Very poor reflections from the Proterozoic do occur, especially in the southwest, where the Cambrian clastics begin to thin (eg. Line 8424). However, on the western part of the project area, where it has been interpreted that no Cambrian sediments occur, the Proterozoic event is usually strong. This is because carbonates of the Franklin Mountain Formation overlie the Proterozoic clastics and this results in a strong reflection coefficient (see for example Lines 56X and 58X of last year's program). The Proterozoic is correlated and mapped, the result is shown in Figure 3.10.

The top of the Mount Clark sandstone cannot be correlated because its impedence contrast with the Mount Cap shale is small and it is rather thin.

The mapped Mount Cap shale marker is a strong event in the area (Figure 3.12). An isochron map between the Mount Cap and the Proterozoic is produced in Figure 3.16. This map not only tells us how the sandstone reservoir varies in thickness laterally but the topography of the Proterzoic at Cambrian time can be inferred from it.

The Saline River Formation is relatively thin in the area and is composed of rocks which have only a small contrast in im-



LINE 8520
NE
SHOT POINT
165 164 163 162 161 160 159 158 157 156 155 154 153 152 151 150 149 148 147 146 145 144 143 142 141 140 139 138 137 136 135 134 133 132 131 130 129 128 127 126 125 124 123 122 121 120
CRET.
MT. KINDLE
FRANKLIN MT.
SALINE RV.
MT. CAP
PROT
SCALE
0 0.25 0.5 0.75 1.0 km

FIGURE 3.8.2

pedence with the overlying Franklin Mountain Formation. The seismic event is, therefore, not always mappable.

The shale marker between the Franklin Mt. and the Mount Kindle allow the unconformity to be mapped. However above the dolomites of the Mount Kindle Formation, the Bear Rock varies between anyhydrites and dolomite and the unconformity is not always mappable.

The strongest, most continuous event in the area is the top of the Devonian carbonates because of the strong reflection coefficient between the low velocity Cretaceous clastics and the high velocity carbonates.

3.2.2 Great Bear

The map in Figure 3.2.2 gives the location of the seismic lines and wells in the Great Bear E.A. The seismic base maps of the area are shown in Figure 3.3.1 and 3.3.2. The scales of these maps are 1:100,000.

Correlations from geology to geophysics were based on the BP et al Losh Lake G-22 and Arco et al Lost Hill Lake F-62 wells via synthetic seismograms. The seismic events that were correlated in the project area are: the top of the Pre-Cretaceous Unconformity, the salt member in the Saline River Formation, the Mount Cap and the top of the Proterozoic. An example of an interpreted seismic line is given in Figure 3.8.2.

The quality of the 1985/86 seismic data is good, however, in order to tie with last year's data, the datum have to be shifted by as much as 40 msec in the northwest. The Pre-Cretaceous and the Mount Cap seismic events are easy to interpret because of their strong amplitude and continuity.

However the seismic event at the Proterozoic Unconformity and at the top of the salt are more difficult to interpret because of the weak character of the reflectors. Fortunately for the Proterozoic, there are angular unconformities at various places, and at these places the Proterozoic can be interpreted.

Although the seismic coverage is not continuous from Northern Great Bear to Southern Great Bear, the seismic events can be jump correlated without much problem.

3.2.3 Velocity Information

Velocity information was obtained from three sources, sonic logs, seismic stacking velocity analyses and first break diagrams. Tables 3.3 and 3.4 give average velocities for certain formations and intervals in the areas. Included also in Figure 3.9, is a geological/geophysical model showing the stratigraphic column along with respective interval velocities.

Formations	Interval Velocity (m/sec)
Quaternary	2100
Cretaceous	3100
Devonian carbonates	5950
Silurian-Ordovician carbonates	6400
Saline River	4600
Mount Cap and Mount Clark	4300
Proterozoic	5200
Dev. carbonates - Proterozoic	6300

TABLE 3.3 APPROXIMATE VELOCITIES OF FORMATIONS IN THE GREAT BEAR AREA

Formations	Interval Velocity (m/sec)
Quaternary	2100
Cretaceous	2900
Devonian carbonates	6000
Mount Kindle and Franklin Mt	6400
Saline River	5800
Mount Cap and Mount Clark	5400
Proterozoic	5500
Dev. carbonates - Protorozoic	6300

TABLE 3.4 APPROXIMATE VELOCITIES OF FORMATIONS IN THE BLACKWATER LAKE AREA

3.3 Presentation of Seismic Results

Migrated, normal polarity seismic sections for the Blackwater Lake and Great Bear areas were sent separately from this report. One mylar copy and two paper copies of each section as well as for each base map were included. The scales of the sections in Northern Great Bear area are 1:6289 (horizontal) and 7.5 inches/sec (vertical). The scales for the Blackwater Lake and Southern Great Bear are 1:11,765 (horizontal) and 3.75 inches/sec (vertical). The Interpretive maps made in the areas are at a scale of 1:100,000.

The following time structure maps were made for the Blackwater Lake and Great Bear areas:

(i) Top of Proterozoic (Figures 3.10 and 3.11)
(ii) Top of Mount Cap (Figures 3.12 and 3.13)
(iii) Top of Devonian Carbonates for the Blackwater Lake and Southern Great Bear area (Figures 3.14)
(iv) Pre-Cretaceous unconformity for Northern Great Bear (Figure 3.15)

Isochron maps of the Cambrian clastics (i.e. between the top of the Mount Cap and the top of the Proterozoic) are also made for the areas. (See Figures 3.16 and 3.17). Faults that have existed before the Mount Cap was laid down are also marked on these maps.

3.3.1 Dip Angle Maps

In order to study paleo-structures in the Proterozoic, dip angle maps for both areas are generated (Figures 3.18 and 3.19). Marked along the seismic lines on these maps are the apparent dip angles of the Proterozoic beds which lie near the top of the unconformity. These angles are apparent dips because they are angles measured along the seismic lines. The true dip and the direction of true dip can be calculated wherever two seismic lines intersect. If A is the angle of intersection between the two seismic lines, B is the angle of apparent dip as seen in Line 1 and C is the apparent dip measured in Line 2, then according to Ragan (1985, p.11-15), the true dip angle D and the direction of true dip measured with respect to Line 1 (angle E) are given by the following relationships:

$$\tan E = \tan C/(\tan B * \sin A) - \cot A$$

and

$$\tan D = \tan B/\cos E$$

The arrows on the dip angle maps are the directions of true dip, and the angles beside the words "dip=" are the true dip angles.

From Figure 3.18, it can be seen that the direction of true dip is to the west on the western part of the Blackwater area and to the east on the eastern part. The dividing line probably represents the Proterozoic Wolverine Arch. From the apparent dips, two more ancient arches can be identified -

one of them strikes southwest and merges with the Wolverine Arch; the other is located northeast of Blackwater Lake and strikes to the northwest.

3.3.2 Restored Sections and Faults Interpretation

Several restored sections, with reflectors restored to the top of the Pre-Cretaceous unconformity, the top of the Franklin Mountain and to the top of the Saline River Formations, were produced (Figures 3.20, 3.21, 3.22, 3.23). These restored sections show the history of the structure and faulting. For example, from line 8402 (Figure 3.20a), the evolution of Fault A can be reconstructed as follows. During Mount Cap time there were no faults to influence the deposition of the sediments. However, from Ordovician to Pre-Cretaceous times, the northwestern part was faulted down, resulting in a thicker section across the fault. During the Laramide Orogeny this fault was re-activated but the direction of throw was reversed. At the present it remains a thrust fault. In Figure 3.21, the restored sections along line 8418 also show that Fault A has a similar history there.

The above examples show the history of Fault A at its extreme north and south ends. Between them, the development of fault A is different and can be summarized as follows: During Proterozoic to Cambrian times, a series of local, normal faults were formed where Fault A now lies. These faults were downthrown to the northwest. In Southern Great Bear, these faults remained active until the present. This is illustrated in Figure 3.22 where the section thickens across Fault A. In the southern part of Blackwater, these normal faults were active until around Silurian time. Elsewhere, the faults were inactive until the Laramide Orogeny when all parts of Fault A were rejuvenated and some parts became thrusts.

Fault B was normal fault downthrown to the northwest during the Proterozoic. It was rejuvenated during the Devonian and was active into the tertiary.

Fault C, a normal fault, only moved from the Proterozoic to Silurian time.

Fault D was active as a normal fault from the Proterozoic to late Cambrian time. The middle part was rejuvenated during the Laramide Orogeny. (Figure 3.22).

In Northern Great Bear, Fault E was downthrown to the southeast from Ordovician to Devonian time. During the Laramide Orogeny, it reversed its direction of throw and became a thrust fault.

Fault F was initiated after Silurian time and remained active into the Tertiary (Figure 3.23).

Fault G was initiated in the Proterozoic as a small normal fault. Figure 3.23 shows that it remained active into the Tertiary, however other parts were rejuvinated during the Laramide Orogeny and contain thrust components.

Fault H was downthrown to the southeast around Silurian to Devonian time, but reversed its direction during the Laramide Orogeny.

From the above discussion, we have seen that many of the mapped faults changed from normal faulting to thrust faulting during the Laramide Orogeny, this indicates that the tectonic forces changed from tensional to compressional.

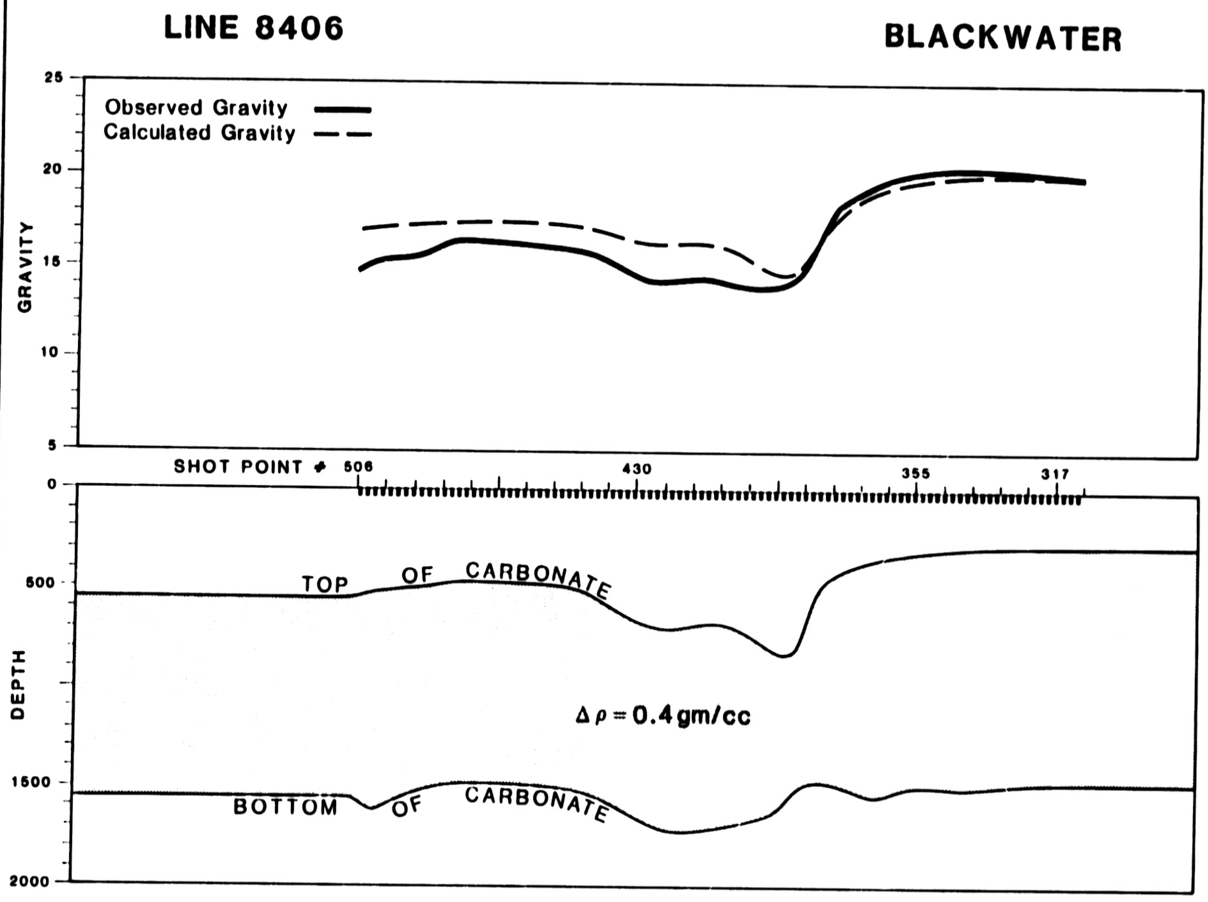
Figure 3.22 shows that a rollover was developed between Fault A and Fault D around Ordovician time. Figure 3.20b shows that a small rollover at South Clement Creek was in place during late Cambrian to Ordovician time. This rollover increased in amplitude during the Laramide Orogeny. Similar inferences can be made on the other structural anomalies in the area and it turns out that most of them were already in place before or around Ordovician time. This is important because they could act as reservoirs for hydrocarbons that migrated into the Mount Clark after Ordovician time.

3.4 Gravity Modelling and Interpretation

No gravity survey was conducted in the 1985/86 program. The 1984/85 gravity was re-interpreted in order to confirm the structures inferred from the dip angle map.

The Bouger gravity (Fig. 3.24 and 3.25) correlates with the topography and thickness of the Pre-Cretaceous to Franklin Mountain carbonates. Where the carbonates are deep (ie. where the lower density Cretaceous section is thick), a gravity low is observed and where the carbonates are closer to the surface, a gravity high usually occurs. The thickness of the carbonates also affects the gravity; where the carbonates are thin, the gravity will be lower. These behaviors are expected because carbonates are denser than the clastics around them. Exceptions to the above generalizations do exist. For example, in the western part of Blackwater Lake, around shot point 580 of line 60X, a gravity low is observed over a thick and shallow carbonate (see Figure 3.27). In the Great Bear area, the regional effect of the southwest dipping carbonate is not seen in the gravity data.

Last year's interpretation used the upwards continuation method. The Bouger gravity was upward continued to 2 kilo-

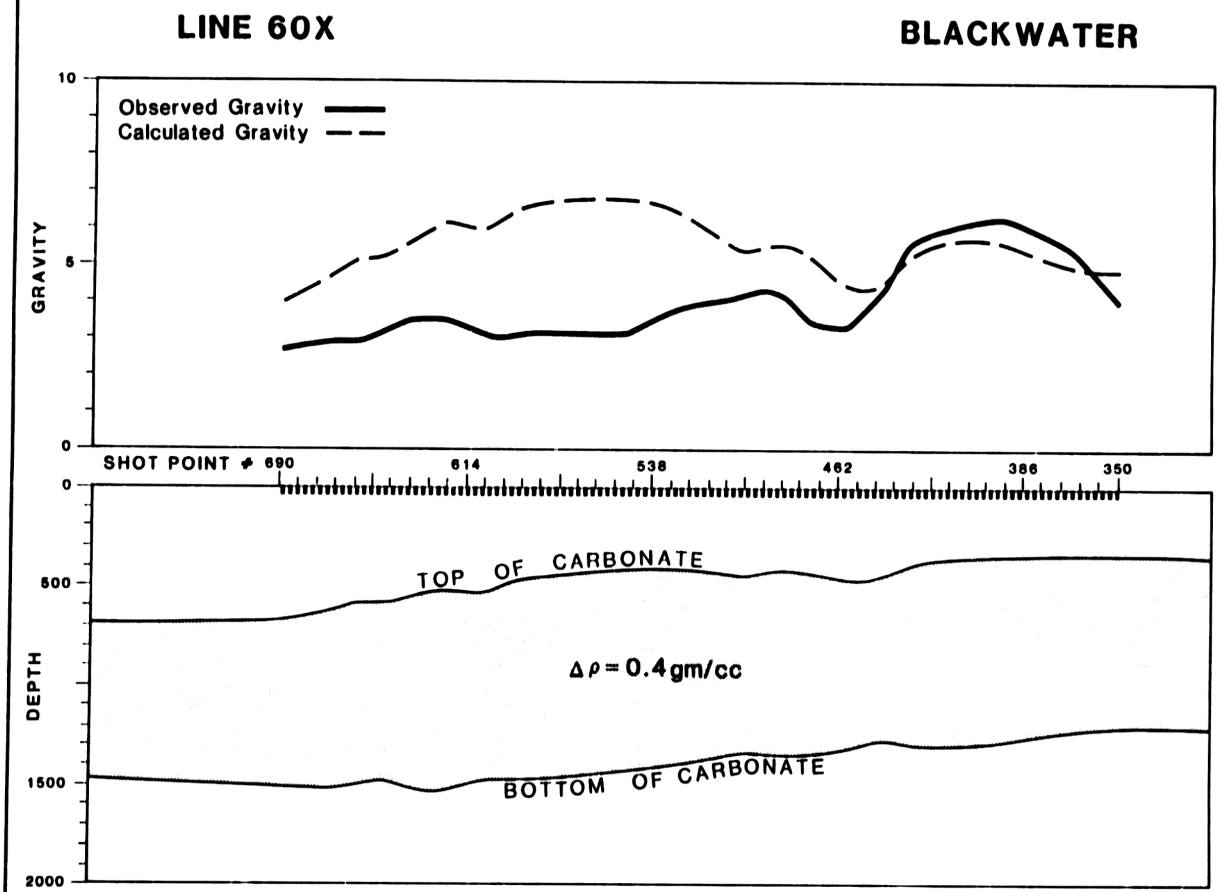


5487 11 of 11

Figure 3.26

metres above the observation, and the residual gravity is the difference between this upward continued gravity and the Bouger gravity. The residual gravity was found to correlate with the carbonate topography and yield no information on the Proterozoic. In order to see below the carbonates, the gravity field has to be continued upwards to a higher elevation. However this is limited by the short length of some lines in the survey where end effects distort the survey data. Another limitation of the upward continuation method is that it assumes a separation of wavelength between the regional and the local anomalies and it achieves this separation by acting as a low pass filter. However, as we see, the carbonate topography also contains long wave length variations and thus this method cannot separate the long wave length gravity due to the carbonates from that of the Proterozoic structure. Thus upward continuation will not be used in this study.

One way to see below the carbonates is to model its effect and then remove it from the Bouger gravity. Now the two way reflection time to the top and bottom of the carbonates can be measured, and by assuming the average interval velocity in the Cretaceous section to be 2.2 km/sec and that in the carbonates to be 6.4 km/sec, the depth and thickness of the carbonates can be obtained. Since the difference in density is about 0.4 gm/cc, the gravity anomaly produced by the carbonates can be calculated. This is illustrated in Figure 3.26. The lower part of the figure shows the depth and the thickness of the carbonates as deduced from the seismic data along line 8406. The Bouger gravity observed above the corresponding shot points are plotted as a solid line in the upper part of the figure and is seen to correlate with the topography of the carbonates. The contribution due to the carbonates is calculated and plotted as a dashed line. It can be seen that the Bouger gravity can be explained to a large extent by the presence of the carbonates. A small increase in density con-



5487 10 of 11

Figure 3.27

trast may even give a better fit. The residual gravity, obtained by taking the difference between the curves, is small except around shot points 420.

Another example is shown in Figure 3.27 for line 60X. Again, the lower figure shows the topography and the thickness of the carbonates. The Bouger gravity (solid line) is seen not to correlate with the carbonates around shot point 580. The effect of the carbonates is plotted as a dash line. It can be seen that the Bouger gravity high around shot point 400 can probably be explained by the carbonates but the gravity low around shot point 580 must be due to some mass deficiency lying below the carbonates. The maximum possible depth for this mass deficiency can be estimated from the half width of the residual anomaly and is found to be around 10 km. The interesting point is that the location of this residual anomaly corresponds to the centre of the Wolverine arch as deduced from the Dip Angle map (Figure 3.18). The small divergence seen in line 8406 also coincides with the location of the arch.

The above exercise illustrates that if the residual gravity is calculated for every line in the area and then contoured, then structures in the Proterozoic may be revealed.

SECTION FOUR

DISCUSSION OF RESULTS IN BLACKWATER LAKE AREA

4.1 The Proterozoic

4.1.1 Present Morphology

In the project area, the relief of the Proterozoic unconformity is moderate and varies between highs and lows by 400 metres. Along Fault A, between the South Clement Creek anomaly and the Blackwater Lake anomaly, the relief is as high as 1000 metres. West of these structures, the Proterozoic dips gently to the west.

Some changes have been made in the interpretation of the area since last year. More faults have been mapped and the location and extent of other faults are better defined. The major Proterozoic highs, that were mapped previously, have been broken up and the areas of closure that is independent of faulting are reduced. Other structural highs have also been interpreted.

The depth and the area of closure of the major anomalies are listed in Table 4.1. All of these anomalies are rollovers found on the downthrown side of a fault.

Name of Prospect	Depth (metres)	Area of Closure (hectares)
Clement Creek South	1700	4500 (fault indep)
		25500 (fault dependent)
East Blackwater Lake	1900	3200 (fault indep)
Central Blackwater	2200	5800 (fault indep)

TABLE 4.1 STRUCTURAL ANOMALIES IN BLACKWATER LAKE E.A.

4.1.2 Proterozoic Structures

A. The Wolverine Arch

As discussed in Sections 3.3.1 and 3.4, the location of the Wolverine Arch can be inferred from the Dip Angle Map (Figure 3.18) and this location is confirmed by the gravity data. Section 3.4 also shows that the arch is associated with a mass deficiency which may be as deep as 10 kilometres. Perhaps this ancient structural high has a low density core or has a low density root lying underneath.

The presence of the Wolverine Arch did affect the deposition of sediments during Cambrian time. An inspection of the Cambrian clastics isochron map (Figure 3.16) shows that the Cambrian clastics thin westwards towards the Wolverine arch, and, except for a few undulations, the 40 msec isochron runs parallel to the Wolverine Arch (Beyond the 40 msec isochron the Mount Clark sandstone becomes so thin that it cannot be resolved by the seismic method). No Mount Clark sandstone exist on the crest of the arch and west of the arch.

The present morphology of the Proterozoic Unconformity however do not remember the presence of the Wolverine Arch. The only exception is in the south over Blackwater Lake where an anomaly is on trend with and lies on top of this southern portion of the Arch.

B. Other Arches

Other Proterozoic arches are also observed in the Dip Angle map. One of them strikes southwest and merges with the Wolverine Arch. On top of this arch lies the Central Blackwater anomaly. A third arch is located beneath the East Blackwater Lake anomaly and strikes in a northwest direction. Cambrian sediments are thickest on the eastern side of these anomalies and become very thin on top.

C. Faults and Topography at Cambrian Time

From the discussion of 3.3.2 it can be seen that the fault complexes that we see on the present morphology map were built up at different stages. At Proterozoic to early Cambrian time, a number of local normal faults were present and thick Cambrian clastics are usually found on the downthrown side of these faults (Fig. 3.16), indicating that places with thick Cambrian sediments were probably topographic lows in early Cambrian time. Thus the isochron map can be used to infer the topography of the Proterozoic Unconformity during early Cambrian time.

4.2 Mount Clark Formation

The isochron map shows that the Mount Clark Formation thins westwards and disappears completely before reaching the Wolverine Arch. Its thickness is also determined by the topography of the Proterozoic at early Cambrian time. Over ancient arches it thins, while on top of topographic lows, it thickens (See also Section 3.1.1).

The exact thickness cannot be determined with certainty but can be estimated. In the G-52 well, the Mount Clark and the Mount Cap are both approximately 45 metres thick. If this ratio in thickness is maintained in the area, then the Mount Clark can have a maximum thickness of 120 metres and averages around 50 metres. Over the structural anomalies in the south, the thickness may be less than the average value. In fact, the isochron map indicates that there may not be any reservoir on the western side of the East Blackwater Lake anomaly and the Central Blackwater anomaly. This results in a reduced reserve estimate for these anomalies.

4.3 Mount Cap Formation

The structural map of the Mount Cap is shown in Figure 3.12. There is a strong resemblence between this map and the Proterozoic structure map (Figure 3.10).

The distribution of the Mount Cap is similar to the Mount Clark. It thins westwards over the Wolverine Arch and disappears west of it. This also implies that the source of the sediment is from the east.

In Section 3.1.1, it was pointed out that in northern Great Bear, the Mount Cap contains 25 metres of low velocity shale which is thought to provide the hydrocarbon source to the Mount Clark sandstones. This low velocity shale is absent in the G-52 well.

Although the low velocity shale is thin, the large velocity contrast produces a strong tuning effect which can be detected most of the time. This can be seen in Figure 3.8.1. However when the shale gets really thin, then it cannot be detected. The edge where the low velocity shale becomes undetected from seismic is marked in Figure 3.12. This edge lies south of the South Clement Creek Anomaly. In the eastern part of the triangular region between Fault A and Fault B, the low velocity shale is also detected in the seismic. It should be noted that the shale can still exist in places where it is not detected seismically, no detection just means that the low velocity shale is very thin.

4.4 Saline River Formation

In Northern Great Bear, this formation contains 145 metres of halite and by the time it reaches the G-52 well, the halite is completely gone (The I-54A well, which lies between them, do not penetrate deep enough into the Saline River to encounter the salt.). Since the salt can provide an excellent seal for hydrocarbons, it is of interest to know its lateral extent. Again, seismic data can provide some help because within the salt there is a thin layer of low velocity shale. The presence of this shale marker is seen over the southern part of the South Clement Creek anomaly in Figure 3.12. Thus the salt extends at least this far to the south.

It should be noted that the absence of this shale marker does NOT necessarily mean that the salt is also absent, it may mean that the shale marker is too thin to be detected or that the salt does not contain the shale marker. Neither is it true that places with no salt cannot have a good sealing rock, in fact, a good seal may exist if the shale section over the sandstone reservoir is thick enough.

4.5 Franklain Mountain Formation

The carbonates of the Franklain Mountain Formation thin toward the west over the Wolverine Arch. The thickness of the Franklain Mountain decreases from a two way time of approximately 120 msec in most areas to almost zero in the west. This is equivalent to a change in thickness from about 300 metres to near zero from east to west.

4.6 Mount Kindle Formation

The thickness of the Mount Kindle is relatively constant throughout the project ara west of Fault A. There the two way time is about 80 msec and this is equivalent to approximately 200 metres. East of Fault A, the Mount Kindle is very difficult to correlate.

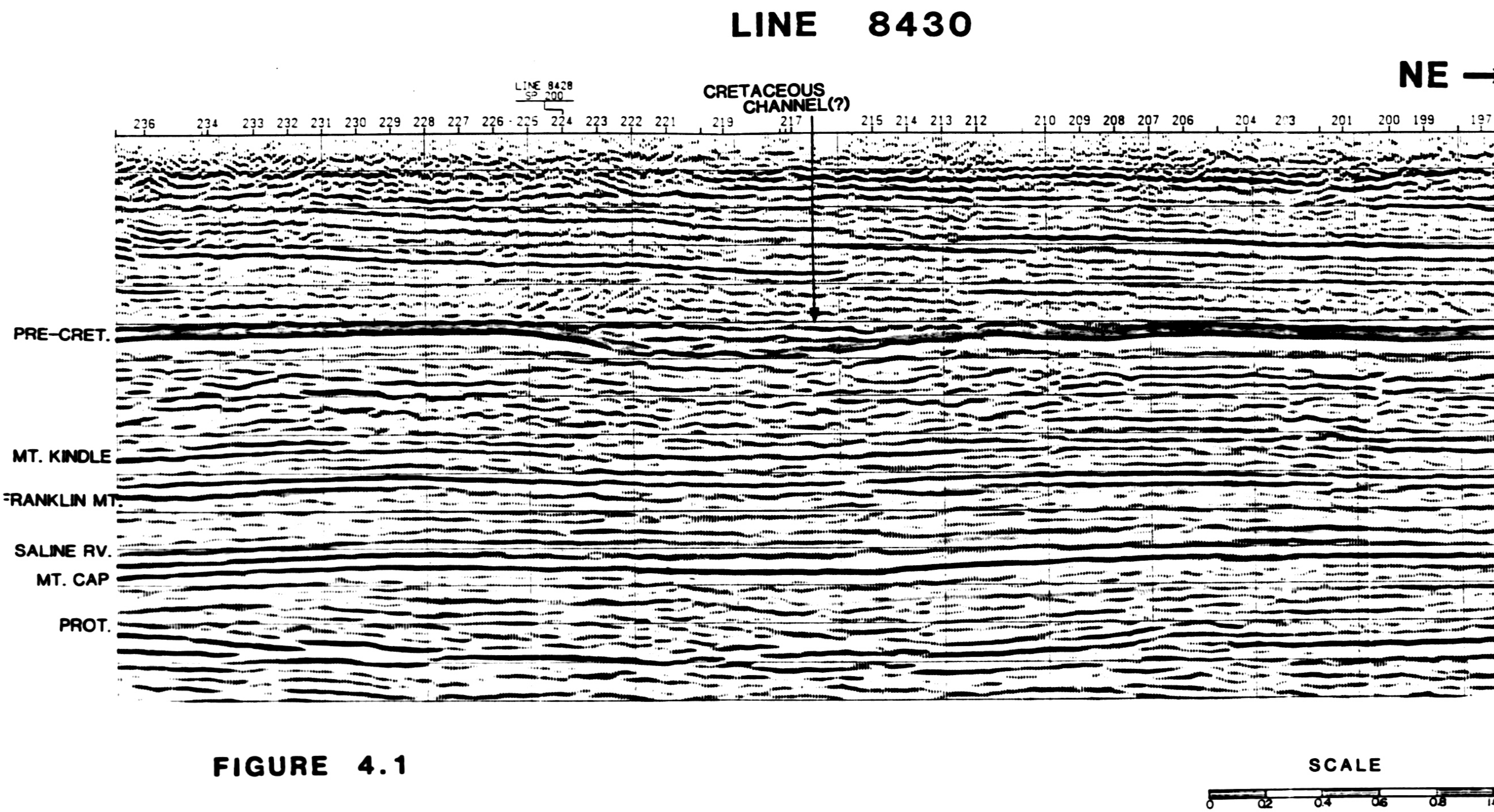
4.7 Pre-Cretaceous Unconformity

The top of the carbonates and anhydrites of the Devonian Bear Rock Formation is generally the strongest reflector in the project area The time structure map of this unconformity is shown in Figure 3.14.

In general, the Devonian carbonates thicken to the southwest. and vary from 350 metres on the east side of Fault A to 625 metres near the I-54A well to 1000 metres to the west. The top of the carbonates dips to the southwest.

4.8 Cretaceous

The Cretaceous section thickens towards the west in the study area, especially near the Cap Thrust and in the graben west of Fault A.



LINE 8430
NE —
CRETACEOUS CHANNEL(?)
LINE 8428 SP 200
236 234 233 232 231 230 229 228 227 226 225 224 223 222 221 219 217 215 214 213 212 210 209 208 207 206 204 201 200 199 197
PRE-CRET.
MT. KINDLE
FRANKLIN MT.
SALINE RV.
MT. CAP
PROT.
SCALE
0 0.2 0.4 0.6 0.8

FIGURE 4.1

Channel like features on the base of the Cretaceous were mapped last year. The new data shows more such features (Fig. 3.14). Two of them appear on line 8430 and two more appear on line 8444. These features are half a kilometre to slightly more than one kilometre wide, the length can be seven kilometres long (Figure 4.1). If these channels contain thick sand sequences as in Northern Great Bear (see section 3.1.1) then they can become secondary targets because they are overlain by thick units of shale.

4.9 Prospects

The following summarizes what is known about the major anomalies listed in Table 4.1.

All three anomalies started to develop before Ordovician time. The Central Blackwate anomaly and the East Blackwater Lake anomaly were cored by Proterozoic arches and a small rollover existed at South Clement Creek around Ordovician time. All of them were amplified during the Laramide Orogeny.

The Saline River Salt, which provides an excellent seal, is found to lie on top of the South Clement Creek anomaly. The Mount Cap shale provides seal for the other anomalies.

At the South Clement Creek anomaly 50 to 80 metres of Mount Clark sandstone has been deposited. For the other two anomalies, the Cambrian reservoir section is interpreted to be much thinner.

SECTION FIVE

DISCUSSION OF RESULTS IN GREAT BEAR AREA

5.1 The Proterozoic

5.1.1 Present Morphology

In the project area, the relief of the Proterozoic unconformity is moderate and varies by 900 m. The Proterozoic unconformity and the overlying Paleozoic strata dip gently to the west.

Some changes have been made in the interpretation of the area since last year. Fault E has been found to strike more in a southwest direction than in a north-south direction. The anomaly over Russel Bay is mapped as a rollover structure and not a fault-bounded structure.

The depth and the area of closure of the major anomalies are listed in Table 5.1 Ford Bay is a fault bounded structure, Russel Bay is a rollover anticline and Clements Creek North is a rollover anticline bounded to the east by Fault A.

Name of Prospect	Depth (m)	Area of Closure (hectares)
Ford Bay	1450	12000 (fault dependent)
Russle Bay	1500	14250 (fault dependent)
Clements Creek North	1350	26000 (fault dependent)

TABLE 5.1 STRUCTURAL ANOMALIES IN GREAT BEAR E.A.

5.1.2 Proterozoic structures

The dip angle map (Fig. 3.19) shows two ancient arches in Northern Great Bear. They are located near the Fort Norman structure and the direction of strike is probably parallel to it also. However, their relationship with the Fort Norman structure is not clear.

The presence of these ancient arches affected the deposition of sediments during Cambrian time. An inspection of the Cambrian clastics isochron map (Fig. 3.17) shows that the Cambrian clastics thin slightly over these structures.

5.1.3 Faults and topography at Cambrian time

From the discussion of 3.3.2 it can be seen that faults were active at different times. In Clements Creek North, the Fault A was only a local normal fault during the Proterozoic.

In Northern Great Bear, only fault G existed during the Proterozoic.

5.2 Mount Clark Formation

The isochron map shows that the Mount Clark Formation thins northwards across Fault G. Its thickness is also determined by the topography of the Proterozoic at early Cambrian time.

The exact thickness cannot be determined with certainty but can be estimated. In the G-22 well, the Mount Clark is 60 m thick while the Mount Cap is approximately 75 m thick. If this ratio in thickness is maintained in the area, then the Mount Clark can have an average thickness of 80 m.

In Clements Creek North, the Mount Clark probably is about 60 m thick.

5.3 Mount Cap Formation

The structural map of the Mount Cap is shown in Figure 3.13. There is a strong resemblence between this map and the Proterozoic structure map (Fig. 3.11).

The distribution of the Mount Cap is similar to the Mount Clark.

5.4 Saline River Formation

The Saline River Formation was not determined with certainty in the area but the formation probably thins to the west.

5.5 The Ronning Group (Silurian-Ordovician Carbonates)

The carbonates of this group consists of two formations, the Mount Kindle and the Franklin Mountain Formation.

The carbonates of the Franklan Mountain Formation thin toward the north in Northern Great Bear while the Mount Kindle Formation appears to be of relatively uniform thickness.

5.6 Pre-Cretaceous Unconformity

The carbonates and anhydrites of the Devonian Bear Rock subcrops in Southern Great Bear. However, the Bear Rock thins northwards and when it reached the Russel Bay anomaly, it becomes so thin that it cannot be resolved from the seismic. The Mount Kindle Formation then subcrops further the north.

5.7 Cretaceous

The Cretaceous section thickens towards the west in the study area.

5.8 Prospects

The following summarizes what is known about the major anomalies listed in Table 5.1.

All three anomalies started to develop before Silurian time. The Clements Creek North anomaly and the Russel Bay anomaly began in the Proterozoic as small rollovers while Fault E, which lie to the east of the Ford Bay structure, was initiated around Ordovician time. All structures were amplified during the Laramide Orogeny.

The low velocity shale in the Mount Cap, which is thought to provide the source is found throughout the project area.

The Saline River Salt, which provides an excellent seal, is found everywhere.

Reservoir is not a problem because the Mount Clark sand is more than 60 m thick over these anomalies.

There is a risk for the Ford Bay and the Clements Creek North structure over the sealing nature of the faults, but the Russel Bay anomaly seems to be free from such risk.

REFERENCES

Aitken, J.D. and Pugh, D.C.; 1984: The Fort Norman And Leith Ridge Structures: Major Buried, Precambrian Features Underlying Franklin Mountains And Great Bear And Mackenzie Plains; Bull. Can. Petro. Geol. Vol. 32, No. 2 (June 1984), p. 139-146.

Balkwill, H.R.; 1971; Reconnaissance Geology, Southern Great Bear Plain, District of Mackenzie; Geol. Surv. Can., Paper 71-11.

Bostock, H.S.; 1970; Physiographic Regions of Canada; Geol. Surv. Can., Map 1254A.

Dept. of Energy, Mines and Resources; 1969: Bouguer Anomaly Maps, Arctic Red River - Norman Wells, N.W.T. Gravity Map Series No. 118.

Douglas, R. J. W. and Norris, D. K.; 1963: Dahadinni And Wrigley Map Areas, Northwest Territories; Geol. Suve. Can., Paper 62-33.

Kerans C., Ross, G. M., Donaldson, J. A. and Geldsetzer, H. J.; 1981; Tectonism And Depositional History Of The Helikian Hornby Bay and Dismal Lakes Groups, District of Mackenzie. In: Campbell, F.H.A. (Ed.), Proterozoic Basins of Canada; Geological Survey of Canada, Paper 81-10, p. 157-182.

Meijer-Drees, N. C.; 1974: Geology of the "Bulmer Lake High", A Gravity Feature In The Southern Great Bear Plain, District of Mackenzie: Geol. Surv. Can., paper 74-1, part B, Report of Activities.

Pugh, D. C. 1983; Pre-Mesozoic Geology In The Subsurface Of Peel River Map-Area, Yukon Territory and District of Mackenzie; Geol. Surv. Can. Memoir 401.

Ragan D. M.; 1985; Structural Geology - An Introduction to Geometrical Techniques, 3rd Ed., Wiley & Son Inc.

Yorath, C. J. and Cook, D. G.; 1981; Cretaceous and Tertiary Stratigraphy and Paleogeography, Northern Interior Plains, District of Mackenzie. Geol. Surv. Can. Memoir 398.