[redacted]

PETRO-CANADA

Report on the GEOPHYSICAL EXPLORATION SURVEY

PROGRAM No. 9229-P28-5E

in

BLACKWATER/GREAT BEAR
NORTHWEST TERRITORIES

Exploration Agreement No. 161, 162

APRIL, 1986

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PETRO-CANADA

April 2, 1986

Canada Oil and Gas Land Administration
355 River Road
Ottawa, Ontario
K1A 0E4

Attention: Mr. Don Sherwin
Director Resource Evaluation

Dear Sir:

Re: PROGRAM #9229-P28-5E
BLACKWATER LAKE 1984/85
PCI File: NOR Program 9229-P28-5E

Please find enclosed in triplicate, copies of the final report for the Blackwater Lake Seismic Program No. 9229-P28-5E 1984/85.

Please acknowledge receipt of the final report and return one copy of the transmittal list to the attention of the writer.

Thank you.

Sincerely,

PETRO-CANADA INC.

K.N. Johnstone
Land Manager

James M. Maxim
Regional Land Representative

JMM/kcb
enclosure: 1984/85 Blackwater Lake Seismic Report
Transmittal List No. 006457
x.c.: Westcoast Petroleum Attention: Mr. D. MacQuarrie
(One copy of report and transmittal list 006458)

WE HAVE MYLARS + SECTIONS.

TRANSMITTAL LIST

PETROCANADA № 005457

DATE March 31st 19 86

TO	FROM
James Maxim 1008 PCCW	E Lamesche 709 PCCW

☒ ENCLOSED AS FOLLOWS ☐ UNDER SEPARATE COVER

SENDER'S SIGNATURE Lamesche

REFERENCE

NO	ITEM
	Blackwater / Great Bear Area - NWT
	- 3 Reports on the Geophysical Exploration Survey
	- Forward to COGLA.

REMARKS

RECEIVED BY M. McKeith

DATE March 31/86

PLEASE ACKNOWLEDGE RECEIPT BY SIGNING AND RETURNING ATTACHED COPY

1985 GREAT BEAR AND BLAC
LAKE AREAS N.W.T.

PROGRAM NUMBER: 9229-P28-5E

YEAR: 1985

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

(a) WRITTEN REPORTS:

(1) Operations Report **Number:** 1

OPERATIONS-PROCESSING-INTERP ALL IN ONE REPORT

(2) Interpretation Reports **Number:** ______

(b) MAPS:

(1) Shotpoint Maps **Number:** 5

-96B,96B/C
-fig. 3.3,3.3.2,3.3.1

(2) Interpretation Maps **Number:** ~~7~~ 10

-T.S.M. TOP OF PROTEROZOIC (2)
-T.S.M. PRE-CRETACEOUS UNC. (2)
-T.S.M. MOUNT CAP SHALE MARKER/PROTEROZOIC (2)
-T.S.M. TOP OF DEVONIAN CARBONATES
-ISOCHRON (FROM TOP OF MT. CAP TO PROT.) 96F
-ISOCHRON (BETWEEN MT. CAP + PROT.) 96B
-ISOCHRON (FROM TOP OF MT. CAP TO PROT) 96C

(3) Other Maps **Number:** 10

-SYNTHETIC SEISMOGRAMS G-52,G-22,F-62,I-54
-BOUGUER GRAVITY (2)
-RESIDUAL BOUGUER GRAVITY (4)

(c) SEISMIC SECTIONS **Number:** 24

8400	8500	14X
8401	8501	32X
8402	8502	56X
8404	8503	58X
8406	8504	60X
8408	8505	
8410	8506	
8412	8507	
8414		
8416		
8418		

PROJECT ACTION SHEET

RESOURCE EVALUATION BRANCH

PROJECT NUMBER: 9229-P28-SE

COMPANY: PETRO CANADA INC

REPORT TITLE: REFLECTION SEISMIC PROGRAM - GREAT BEAR LAKE

The following action has been taken:

Receipt acknowledged	✓
Reports and maps date-stamped	✓
Memo sent to Land Management	
Reports for review list edited	
Inventory sheet made	✓
Mylar	✓

REVIEW AND APPROVAL made by:

COMMENTS:

Report on the
Geophysical Exploration Survey

PROGRAM NO. 9229-P28-5E
in the

Great Bear and
Blackwater Lake Areas
Northwest Territories
EXPLORATION AGREEMENT NOS. 161 AND 162

by

Petro-Canada Inc.
April 1986

9229 - P28 - 5E

FIELD WORK PERIOD:	January - April, 1985
LAND USE PERMIT NOS.:	N84B-269, N84B-270
AREA COORDINATES:	Latitude 64°00' - 66°10' Longtitude 121° 30' - 124°45'
DATA ACQUISITION:	Western Geophysical Company of Canada Ltd. Airborne Geophysical Surveys Ltd. Seiscom Delta United

Submitted
By

R. Niederauer
Project Geophysicist
NWT Region

R. Singh
Project Geophysicist
NWT Region

PROFESSIONAL ENGINEER ALBE[RTA] J.B. HENRY

J.B. [illegible]
Regiona[illegible]sicist
NWT/Beau[illegible] Region

CONTENTS

CONTENTS (Cont'd)

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

REFERENCES

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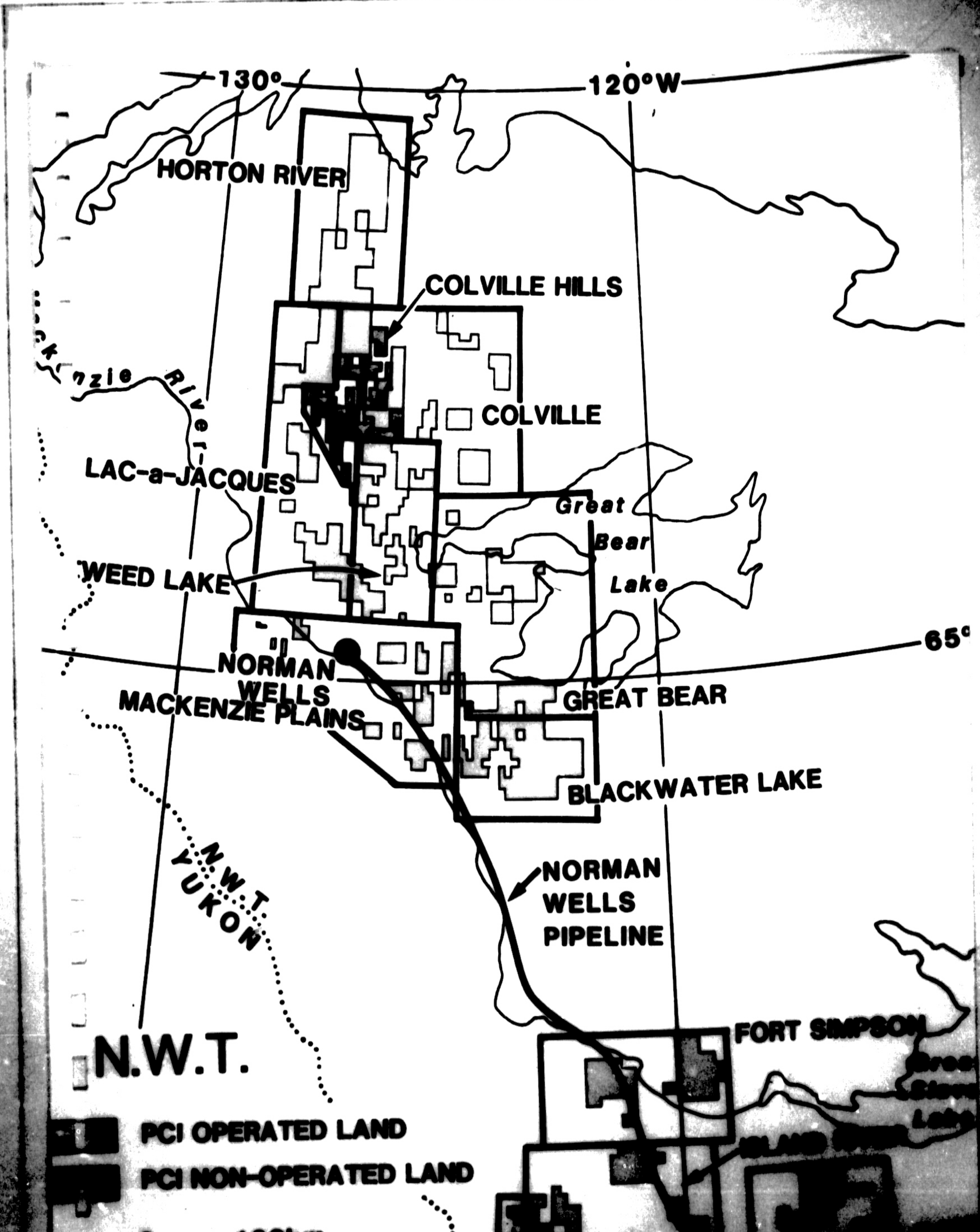
SECTION ONE

INTRODUCTION

A geophysical survey was conducted by Petro-Canada Inc. in the Great Bear and Blackwater Lake areas of the Northwest Territories during the 1984/85 winter season. This report summarizes the work done during this period and the results obtained from the two surveys. The submission of the report is in partial fulfillment of COGLA requirements for the Blackwater Lake E.A. No. 161, and the Great Bear E.A. No. 162 Program No. 9229-P28-5E. The location of the survey area is given in Figure 1.1.

The southern part of the Great Bear area adjoins the Blackwater Lake area and in this report is considered part of the Blackwater Lake survey. Both areas were shot by Western Geophysical Co. The northern Great Bear survey was acquired by a Seiscom Delta United crew. Each geophysical program consisted of a seismic and gravity survey.

The purpose of the Blackwater survey was primarily to delineate anomalies mapped using data from the 1983/84 seismic program whereas the Great Bear survey intended to gather regional seismic information.



130°
120°W
65°
HORTON RIVER
COLVILLE HILLS
COLVILLE
LAC-a-JACQUES
WEED LAKE
Great
Bear
Lake
Mackenzie River
NORMAN WELLS
MACKENZIE PLAINS
GREAT BEAR
BLACKWATER LAKE
N.W.T.
YUKON
NORMAN WELLS PIPELINE
FORT SIMPSON
N.W.T.
PCI OPERATED LAND
PCI NON-OPERATED LAND
0
160km

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 June, 1985 to March, 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.

SECTION TWO

DATA ACQUISITION AND REDUCTION

2.1 Instrumentation

A set of 96 channel DFS-V's was used to collect the seismic data. The gravity information was gathered using a Lacoste-Romberg gravimeter. 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 . . . DSF V
Oscillograph	Tektronic
Camera	S.I.E. ERC-10C
Remote Firing System . .	Input-Output Encoder/Decoder
Cables	Mark Products: 430 m, 16.7m take-outs per cable
Geophone Strings	Geosource: 10HZ, 9 per string

GRAVITY RECORDING

Three LaCoste & Romberg 'G' type land gravity meters.

Meter	Range	Constant
G-232	5600	1.05526
	5700	1.05517
G-442	5600	1.04650
G-732	5700	1.02101

SURVEYING

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

TABLE 2.1 DESCRIPTION OF INSTRUMENTS UTILIZED ON THE 1984/85 GREAT BEAR GEOPHYSICAL SURVEY.

SEISMIC RECORDING

Amplifiers	Texas Instruments . . . DFS V
Tape Systems	Texas Instruments . . . DSF V
Oscillograph	Tektronic
Camera	S.I.E. ERC-10C
Remote Firing System . .	Input-Output...Encoder/Decoder
Cables	Geospace Canada Ltd., 660 ft. with 55 ft. group interval, 12 outlets per cable
Geophone Strings	LRS model 1011 - 14 HZ, 420 OHM coil, 9 per string

GRAVITY RECORDING

Four LaCoste & Romberg G-meters. . .	#232, 387, 442, 732
Conversion constants	1.0553, 1.0711, 1.0465, 1.0212

SURVEYING

Wilde T-16 Theodolite . . .	2
Sokkiska Red II E.D.M. . .	1

TABLE 2.2 DESCRIPTION OF INSTRUMENTS UTILIZED ON THE 1984/85 BLACKWATER LAKE GEOPHYSICAL SURVEY.

2.2 Seismic Data Acquisition

The data in the Blackwater Lake and Southern Great Bear area was acquired by Western Geophysical and in the Northern Great Bear area by Seiscom Delta United.

2.2.1 Seismic Parameters

The interval between geophone groups was 33 metres. The source-detector geometry was a 1617-66-0-66-1617 balanced spread with shot points located at the group flags. A 132 metre gap was used, usually 66 metres 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 north or east on each line. All shots were detonated by radio signals from a master unit in the recording truck. Flagging was removed from all lines. All tags indicated the land use number, line number and shot point.

Sample Rate.	2 milliseconds
Record Length.	6 seconds
Recording Filter	8/18-128/72
Subsurface Coverage.	1200%
Seismometers per Group	9
No. of Groups.	96
Group Interval	33 Metres
Geophone Array (Great Bear) . . .	9 over 66 metres, 9 over 33 metres
Geophone Array (Blackwater) . . .	9 over 60 metres
Shot Point Location Interval . .	132 metres
Holes per location	1
Hole Depth	18 metres
Dynamite Charge	2 kilograms

TABLE 2.3 RECORDING PARAMETERS FOR THE 1984/85 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 Western Geophysical and 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 - Great Bear

There were nine drills on the crew, seven TF-110 Mayhew Air Drills (2 with air/water), one TF-110 Mayhew Air Drill with down-hole hammer and one TF-110 Top Drive air/water with down-hole hammer. All shots were single holes with an average depth of 18 metres. Production holes were preloaded with two kilograms of Geogel 60 and tamped with the cuttings. There were no holes drilled on lakes or near water-courses. The drilling formations were primarily wet clay and rocks with some areas of gravel and extremely hard formations. There were no major drilling problems. The combination drill with top-drive was useful in the wet clay formations.

2.2.4 Shot Hole Drilling - Blackwater Lake

There were eight drills on the crew, seven conventionals (6 air; 1 air/water combination), and 1 air/water combination top drive. All shots were single holes with an average depth of 18 metres. Each production hole was loaded with 2 kilograms of geogel 60 and tamped with the cuttings. No holes were drilled on lakes or near water-courses.

Drilling formations varied from mostly clay and rocks to some soft shale and wet sand.

2.2.5 Line Cutting

Eight bulldozers were assigned to the operation. The lines were cut to a width of 10 meters. The slash was windrowed to one side, compacted by the bulldozers and broken into piles where necessary.

2.3 Gravity Data Acquisition

The data was acquired in both areas by two crews from Airborne Resource Developments Ltd.

2.3.1 Field Survey Technique and Parameters

Field operations for the gravity survey in the Great Bear area were initiated on February 26th, 1985 and were terminated on March 29. Field operations for the Blackwater Lake area were initiated on January 12th, 1985 and were terminated on March 17. The operators returned to the prospect from April 2nd to April 5th to pick up stations previously forgotten.

The bases in the prospect area were tied to Norman Wells I.G.S. Base # 9549-59 with a value of 982,228.39 milligals. The base station network was accomplished by the "step-by-step" method in which each previous base station was used as the reference for the next base station. To increase the accuracy of the network, the last base was tied back to the primary field base.

The gravity values were observed along the seismic lines every 264 metres, that is every other shotpoint. Three instrument readings were taken at each station. Repeat measurements were made on a minimum of 5% of the gravity stations.

2.3.2 Accuracy of the Gravity Data

The elevation and coordinates of each shot point were provided by the survey groups of Western Geophysical and Seiscom Delta United. The vertical control has an absolute accuracy of +/- 0.55 metres, and the horizontal control is believed to have an accuracy of +/- 10 metres. The elevation correction is based on a vertical gradient of 0.30845 milligals per metre. The latitude correction is based on the 1967 International Gravity Formula and the 1866 Clarke spheroid.

The accuracy of the Bouguer gravity is a final indicator of the quality of the survey and is affected by the accuracy of:

Base network	**+/- 0.05 mgal**
Observed gravity	**+/- 0.04 mgal**
Elevation	**+/- 0.55 m or +/- 0.17 mgal (at 0.3086 mgal/m)**
Positioning	**negligible**
Terrain and tidal corrections. . .	**negligible**

The total absolute accuracy is calculated as the square root of the sum of squares of all the above RMS accuracies, and is equal to +/- 0.18 milligals.

2.4 Field Operations - Great Bear Survey

2.4.1 Project Chronology

The mobilization date of the crew was February 8th, 1985. On February 16th the bulldozers started plowing, followed a day later by the commencement of drilling. Recording on line 8504 began on February 23rd. All aspects of the project operations were completed by March 30, 1985. A summary of pertinent dates is given in Table 2.4.

Mobilization date	February 8, 1985
Start Cutting	February 16, 1985
Start of Drilling	February 17, 1985
Finish Cutting	March 26, 1985
Completion of Drilling	March 27, 1985
Completion of Recording	March 28, 1985
Demobilization date	April 4, 1985
Total recording days	33
Total moving days	13
Total weather days	0
Total testing days	0
Total down days	7

TABLE 2.4 CHRONOLOGY OF MAJOR EVENTS FOR THE 1984/85 GREAT BEAR SEISMIC SURVEY.

2.4.2 Project Organization

The major contractor on the project was Seiscom Delta United. Airborne Resource Developments Ltd. was contracted by

Petro-Canada to carry out the gravity acquisition. Two gravity operators were used throughout the survey and a third, a temporary one, was used to loop the base.

Table 2.5 shows the organization chart for the project. A total of 67 persons were employed under this contract. Of the 67, 39 were residents of the Northwest Territories.

2.4.3 Production Statistics

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

2.4.4 Weather Conditions

Weather conditions during the course of the program were normal for the season. The average temperature in February was about -40° C. In March and April temperatures were not as low due to the increased amount of sunlight. No recording or drilling production was lost due to weather conditions.

Petro Canada Field Supervisor

Siescom Delta United Field Supervisor

Party Manager

Recording	Surveying	Gravity	Bulldozing	Drilling	Catering	Support Staff
1 Observer	2 Surveyors	2 Observers	6 Operators	8 Drillers	2 Cooks	2 Party Managers
1 Asst.observer	2 Rodmen	1 Temporary Observer	1 Cook	8 Helpers	2 Assistant Cooks	1 Clerk
1 Shooter			1 Cat Push	2 Water Truck Drivers	2 Attendants	2 Mechanics
1 Shooter's Helper			2 Full Camp Operators	1 Drill Push		1 Mechanics Helper
4 Cable Truck Drivers						2 Expediters
8 Recording Helpers						1 Monitor

TABLE 2.5 ORGANIZATION CHART FOR THE 1984/85 GREAT BEAR GEOPHYSICAL SURVEY.

SEISMIC RECORDING

Production profiles shot (Approx.)	2,244
Total number of lines	8
Line Numbers	8500, 8501, 8502, 8503, 8504, 8505, 8506, 8507
Kilometers Shot	341
Average Profiles per day	68
Average Kilometres per production day	8.97

GRAVITY

Total number of stations	1109
Total number of lines	8
Line numbers	8500, 8501, 8502, 8503, 8504, 8505, 8506, 8707
Total distance covered (kilometers)	337
Total number of bases	45

DRILLING

*Number of locations drilled	2,743
Average hole depth (meters)	18.05
*Average holes per day	68
Total metres drilled	49,511.15
Average charge per hole (kilograms)	2
Total powder consumed (kilograms)	5,480

* Useable locations only

TABLE 2.6 NUMERICAL SUMMARY OF PRODUCTION FOR THE GREAT BEAR SURVEY

2.5 Field Operations - Blackwater Lake Survey

2.5.1 Project Chronology

The mobilization date of the crew was January 1st, 1985. People were flown in by helicopter to set up camp on Blackwater Lake. Soon after, the bulldozers started snow plowing on line 32X which was the line left from last winter's work. Drilling commenced on January 6th and recording began on January 14th. On March 16th, the bulldozers started snow plowing off the northern end of line 8414 towards a winter road for the move to the Brackett Lake project. The drilling and recording crews followed on March 17th, 1985 at which time the project operations for the Blackwater Lake area were completed. A summary of pertinent dates is given in Table 2.7.

Mobilization date	January 1, 1985
Start of Drilling	January 6, 1985
Start of Recording	January 14, 1985
Finish Cutting	March 15, 1985
Completion of Drilling	March 16, 1985
Completion of Recording	March 17, 1985
Demobilization date	60
Total recording days	69
Total drilling days	1
Total moving days	1
Total weather days	0
Total testing days	0
Total down days	0

TABLE 2.7 CHRONOLOGY OF MAJOR EVENTS FOR THE 1984/85 BLACKWATER LAKE SEISMIC SURVEY.

2.5.2 Project Organization

The major contractor on the project was Western Geophysical. Airborne Resource Development Ltd. was contracted by Petro-Canada to carry out the gravity acquisition. A single gravity operator was used throughout the survey.

Table 2.8 shows the organization chart for the project. A total of 60 persons were employed under this contract. Approximately 45% - 50% were residents of the Northwest Territories.

Petro Canada Field Supervisor

Western Geophysical Field Supervisor

Party Manager

Recording
- 1 Observer
- 1 Asst.observer
- 1 Shooter
- 1 Shooter's Helper
- 3 Cable Truck Drivers
- 9 Helpers

Surveying
- 1 Surveyor
- 2 Rodmen
- 1 Cat Push

Gravity
- 1 Operator

Bulldozing
- 6 Operators
- 1 Foreman
- 1 Cook
- 2 Monitor (Native)

Drilling
- 8 Drillers
- 8 Helpers
- 1 Mechanic
- 1 Water Hauler

Catering
- 2 Cooks
- 2 Assistant Cooks
- 1 Attendant

Support Staff
- 1 Party Manager
- 1 Assistant Manager
- 1 Clerk
- 1 Mechanics
- 1 Mechanics Helper
- 1 Expediter
- 1 Expediter's Assistant

TABLE 2.8 ORGANIZATION CHART FOR THE 1984/85 BLACKWATER LAKE GEOPHYSICAL SURVEY.

2.5.3 Production Statistics

Table 2.9 provides a summary of the seismic data acquired, the amount of gravity obtained as well as data pertinent to shot hole drilling.

SEISMIC RECORDING

Total Operating Days	75
Production profiles shot	3,216
Total number of lines	13
Line Numbers	8400, 8401, 8402, 8404, 8406, 8408, 8410, 8412, 8414, 8416, 8418, 32X, 58X
Kilometers Shot	422.83
Average Profiles per day	53.60
Average Kilometres per production day	7.05

GRAVITY

Total number of stations	1,467
Total number of lines	13
Line numbers	8400, 8401, 8402, 8404, 8406, 8408, 8410, 8412, 8414, 8416, 8418, 32X, 58X
Total distance covered (kilometers)	409
Total number of bases	25

DRILLING

*Number of locations drilled	3,216
Average hole depth (meters)	14.82
*Average holes per day	46.61
Total metres drilled	47,662.40
Average charge per hole (kilograms)	2.1
Total powder consumed (kilograms)	6,765.5

* Useable locations only

TABLE 2.9 NUMERICAL SUMMARY OF PRODUCTION FOR THE BLACKWATER LAKE SURVEY.

2.5.4 Weather Conditions

Weather conditions during the course of the program were normal. The average temperature was -40°C in February.

Temperatures moderated in March. Recording operations were down for 1 day due to adverse weather conditions.

2.6 Data Reduction

2.6.1 Seismic Processing

The seismic data in both areas were processed by Geophysical Services Incorporated in May and June of 1985. 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: 300-1600 msec
      950-2250 msec
7. Equalization
8. Residual Statics Analysis - Surface Consistent Automatic Statics (HSTATC) Plus Trim Statics
9. Relative Statics - Residual Statics Applications
10. Normal Moveout Correction - Velocity Analysis from VELSCANS (Before and after Automatic Statics)
11. Mean Datum Statics Applications
12. Stack muting - Distance (m) 66 264 495 1617
    - Time (msec) -50 0 400 1100
13. CDP Stack: 1200%
14. Migration
15. Time Invariant Filter: 10/20 - 50/60 Hertz
16. Time Variant Scaling - (10 x 100)200, 200, 300, 500 msec Gates, Start time 0 msec.
17. Display to Film: Scale sent to COGLA (normal polarity)
    Great Bear - vertical: 7.5 inches/sec
    - horizontal: 16 traces/inch
    - CDP interval: 16.6 metres
    Blackwater Lake - vertical: 3.75 inches/sec.
    - horizontal: 36 traces/inch
    - CDP interval: 16.5 metres

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 10-60 Hertz and a roll-off of 120 decibels/octave at each end. All the data were migrated.

2.6.2 Gravity Processing

Field processing was done by the contractor and included the conversion of the meter readings to milligals and the calculation of drift and earth tidal corrections. The loops used in the calculations of drift did not exceed six hours in length, and the drift during the loop did not exceed 0.4 milligal. Data quality was controlled by repeat observations on a daily basis. The inner zone terrain corrections were estimated by the operator in the field.

In Calgary, the contractor sorted the field data by lines instead of by loops and calculated Bouguer gravity using a crustal density of 2.35 grams/cc. The final values were transcribed onto magnetic tape (9 tracks, 1600 BPI, EBCDIC) by Digitech Systems and it was then delivered to the Gravity and Magnetics Group of Petro-Canada Resources.

The final processing consisted of the following steps:

1. Merging the line oriented data into the merged survey file (MSF).

2. Correcting discrepancies at line intersections by systematic adjustments.

3. Low-pass filtering of Bouguer anomalies.

4. Plotting of the gravity profiles, index maps, fence diagrams and contour maps.

5. Indexing the gravity data.

6. Calculating residual gravity using upward continuation on a line-by-line basis.

7. Plotting of the residual fence diagrams and contour maps.

Upward continuation was calculated at a distance of 2 kilometers above the point of observation. The residual gravity was obtained by subtracting the upward-continued gravity from the Bouguer gravity.

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 60 kilometres to the southwest 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 coordinates: 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 Franklin Mountains border the western edge of the prospect.

The project area is composed of two topographically different zones. The western zone is located in the Franklin Mountains where elevations vary from 250 to 600 meters above sea level. The timber is primarily pine and spruce. The other zone is relatively low in relief with elevations that range from 230 to 260 meters above sea level. This area is lightly timbered and contains many lakes and rivers.

3.1.1. Stratigraphic Column

The stratigraphic column of the area includes Proterozoic, Cambrian, Ordovician, Silurian, Devonian, Cretaceous and Quaternary units. The stratigraphic units of the Great Bear Plain are shown in Table 3.1.

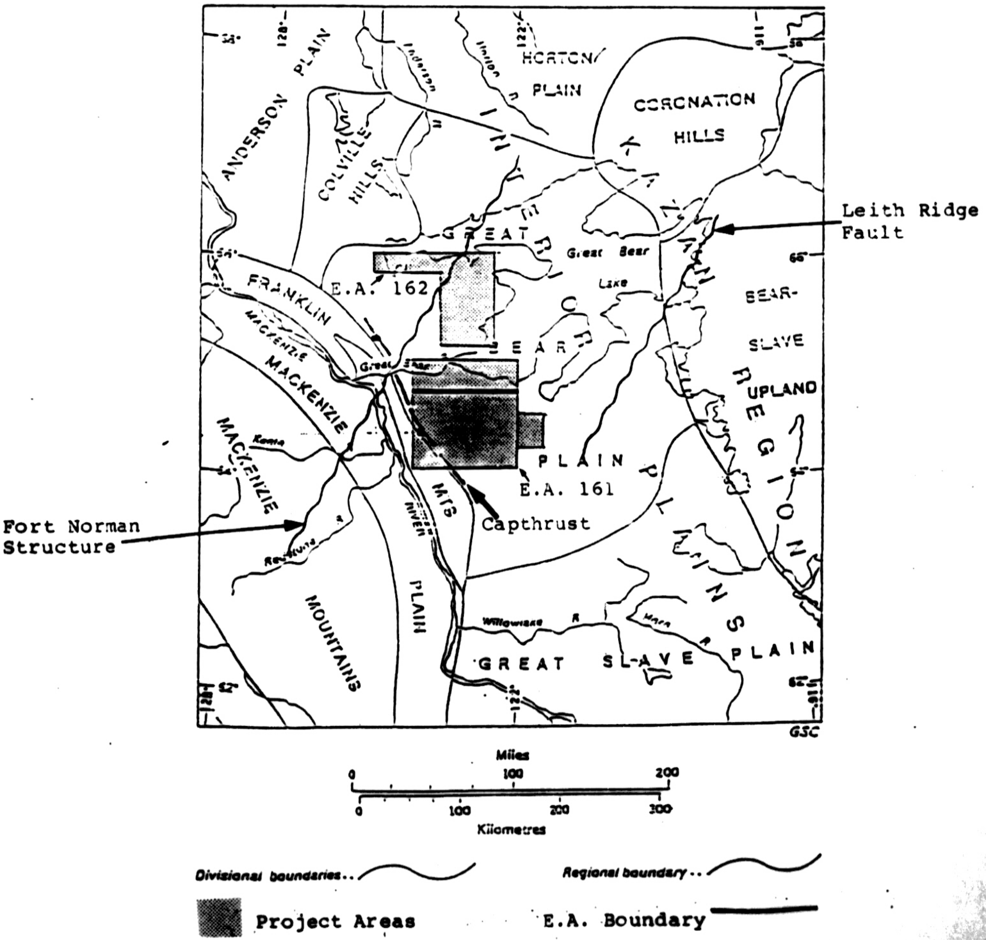


FIGURE 3.1 Map of the physiographic provinces in the Blackwater Lake and Great Bear Lake areas. Major structural features are also shown (modified from Bostock, 1970).

System or Series		Map-unit	Lithology
QUARTERNARY		Q (undivided)	Unlithified gravel, sand, silt, clay; till
Unconformity			
LOWER AND UPPER CRETACEOUS		K (undivided)	Partly bentonitic, black and grey, papery shale, blocky mudstone; siltstone; lignite; minor sandstone
Unconformity			
LOWER AND (?) MIDDLE DEVONIAN		BEAR ROCK FORMATION	Brecciated grey-brown dolomite; anhydrite; red and green shale and siltstone at base
Probable Unconformity			
UPPER ORDOVICIAN AND (?) LOWER SILURIAN	RONNING GROUP	MOUNT KINDLE FM.	Medium to dark brownish grey dolomite; silicified fossils; chert
	RONNING GROUP	Unconformity	
LOWER ORDOVICIAN (?), UPPER AND (?) MIDDLE CAMBRIAN	RONNING GROUP	'Rhythmic unit'	Alternating beds of brownish grey and greyish orange dolomite; indistinct oolitic textures
MIDDLE AND (?) UPPER CAMBRIAN	RONNING GROUP	'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 FORMATION	red, green, grey shale and siltstone; glauconitic sandstone; brown dolomite
(?) LOWER AND MIDDLE CAMBRIAN		MOUNT CLARK FORMATION	Grey, white, pink, friable sandstone; minor pebble beds
Unconformity			
(?) HADRYNIAN, NEOHELIKIAN, OR PALEOHELIKIAN		Gabbro sills and dykes	Dark green to black, partly diabasic gabbro
		Large quartz veins	White to pink quartz
Intrusive Contact			
PALEOHELIKIAN		HORNBY BAY GROUP	Upper part: brown stromatolitic dolomite; chert Lower part: white, buff, pink, maroon quartzite
Unconformity			
APHEBIAN		Granite	Pink, equigranular and porphyritic granite
		Intrusive Contact	
		Feldspar porphyries	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).

The Proterozoic rocks are thought to consist of predominantly clastic sequences. The overlying Cambrian units are composed of a mixed lithology of clastics, evaporites and carbonates. The Lower Cambrian Mount Clark (Old Fort Island) Formation consists of quartz sandstones which lie unconformably on the Proterozoic. Shales, siltstones and carbonates of the Mount Cap Formation, followed by siltstones, dolomites and gypsum of the Saline River Formation overlie the Mount Clark sandstones. The Cambro-Ordovician carbonates of the Franklin Mountain Formation overlie these Cambrian formations. Upper Ordovician-Lower Silurian carbonates of the Mount Kindle Formation rest uncomformably on the Cambro-Ordovician Franklin Mountain Formation. The Devonian section, which consists of carbonates of the Bear Rock and Hume Formations, lie uncomformably on the Mount Kindle Formation. Upper Cretaceous shales, siltstones and basal sandstones lie uncomformably on the Devonian. The Quaternary rocks, composed of gravel, sand, clay and glacial till, lie unconformably on the Cretaceous. Thicknesses of the Quaternary section range from nil to over 200 metres.

The main differences between the geology of the Great Bear and Blackwater Lake areas is that the Saline River Formation consists predominantly of salt in the north and siltstone, dolomite and gypsum in the south. Also, in the south, a shale marker usually occurs between the Mount Kindle and Franklin Mountain Formations of the Ronning Group, which are composed of carbonates. This shale produces a relatively good seismic reflection. Another difference is that the Bear Rock Formation appears to be more anhydrous in the south and a carbonate marker within this formation can be mapped throughout most of the Blackwater Lake area.

3.1.2 Structural Aspects

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 originated during the Laramide Orogeny, strikes northwest and cuts through the southwest corner of the project area. It occurs to the west of the Great Bear area. The thrust is situated at the eastern edge of the Franklin Mountains. The surface location of the fault is shown in Figures 3.1 and 3.2.1. In the study area there are thrust faults in the Paleozoic and Mesozoic rocks which are probably related to the major Laramide faults in the area. In the well Blackwater Lake G-52, there is a thrust fault within the Mount Kindle Formation. Seismic evidence of the fault may be seen on line 8402 around shot point 135. In the west of the Great Bear area there is a northwest-striking thrust fault.

On the east side of the Cap Thrust Cretaceous clastics are covered by thick glacial drift deposits. Subsequently there is no surface expression for many structures in the area. From subsurface information, the Wolverine Arch is interpreted to trend in a southeasterly direction from the Wolverine Creek D-61 well, where rocks of the Saline River Formation lie directly on Proterozoic rocks, through the western part of the Blackwater Lake area. In the area of this ancient structure, there are no Cambrian rocks present. The approximate location of this arch is given in Figure 3.2.1. The southern extension of this structure is not known for certain due to the poor quality of the seismic data in the south.

In the Great Bear Plain there are two major northeast trending structures, the Leith Ridge fault to the east and the Fort Norman structure which cuts through the Great Bear project area (Aitken and Pugh, 1984). No direct seismic evidence of these structures occurs in the prospect areas. The approximate subsurface locations of these faults are shown in Figure 3.1. In the project area, the basement is characterized by a northeasterly trending structural grain (Balkwill, 1971). Most faults have a northeasterly trend and are probably related to the larger structures in the Great Bear Plain. These major structures are likely a result of orogenic activity in Proterozoic or Cambrian time and could have involved tear-faulting and strike-slip motion characteristic of wrench tectonics.

Another major structural feature in the Great Bear area is a northeast trending fault. The location of this fault, labelled fault A, is shown in Figure 3.2. Other faults in the area are also shown. This fault A appears to have undergone two, and in some places three, different stages of activity. It originated in Cambrian time, probably as a normal planar fault, downthrown to the southeast, it was later rejuvenated during the Laramide Orogeny and then thrusting occurred. The base or sole of the thrust is the salt of the Saline River Formation.

In the Blackwater Lake area there are three major fault zones. Their locations are given in Figure 3.2.1. Fault A' is a complex fault zone whose characteristics change along its length. This fault appears to have undergone at least two different phases of activity, probably originating in the Cambrian or Pre-Cambrian. The affects of the Laramide Orogeny are also evident. Fault zones B' and C' are closely related to Fault A'. The resulting structure is a graben-like feature. These fault zones appear to have the characteristics of wrench tectonics and will be discussed in more detail in section 5.

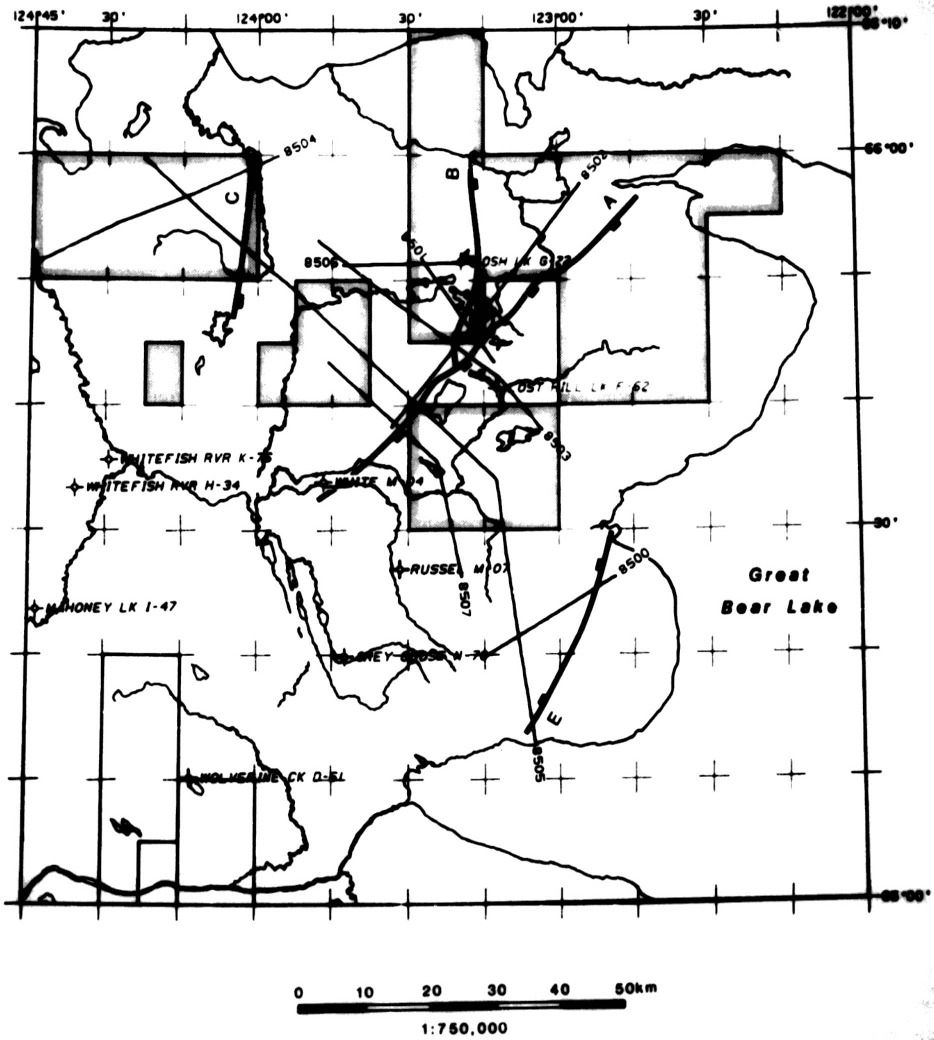


FIG. 3.2 LOCALITY MAP OF THE 1984/85 GEOPHYSICAL PROGRAM IN THE GREAT BEAR E.A. SHOWING SOME INTERPRETED FAULTS IN THE AREA.

3.1.3 The Target; General Distribution and Control

The basal Cambrian sand of the Mount Clark Formation is the primary exploration target. These sands are widespread in the area and are thought to be derived from the Precambrian shield to the east. The Mount Clark sandstone is typically a very light grey, fine to medium-grained quartzitic sandstone. The thickness of the Cambrian Mount Clark varies from about 60 to 0 metres from east to west in the Great Bear area. In the Blackwater Lake area, the greatest thickness occurs to the west of fault A' (Figure 3.2.1.) and may reach up to 125 metres. To the east of this fault, thicknesses can only be estimated but are probably not as great. Toward the west the Cambrian sediments thin to zero due to erosion or non-deposition on the Wolverine Arch, especially on the western flank of the structure.

Structures in the Precambrian basement, such as ridges or troughs, had a profound influence on Cambrian sedimentation. Precambrian highs acted as local source areas and topography of the erosional surface controlled the Cambrian sedimentation. In some areas the Cambrian sands may be confined to depressions in the Precambrian surface.

3.2 Correlations Between Well Data and Seismic Data

3.2.1 Great Bear

The map in Figure 3.2 gives the location of the seismic lines and wells in the Great Bear Lake E.A. The seismic base map of the area is shown in Figure 3.3. The scale of this map is 1 : 150,000.

Correlations from geology to geophysics were based on the wells BP et al Losh Lake G-22 and ARCO et al Lost Hill Lake

F-62. Line 8506 ties to the G-22 at shot point 109 and F-62 is located at about 1.3 km southwest of shot point 170 on line 8503. The G-22 well penetrates the Proterozoic rocks whereas F-62 well stops within Mt. Cap formation. Information from other wells which helped the interpretation include Sinclair Whitefish River K-76, Arco West Whitefish River H-34, BP et al White M-04, BP et al Russel M-07 and, BP et al Grey Goose N-70. Except for the two Whitefish River wells which penetrated the Proterozoic rocks, none of the remaining wells were drilled deeper than the Bear Rock formations. Synthetic seismograms for the wells G-22 and F-62 are shown in Figures 3.4 and 3.5 and, an example of the BP Losh Lake G-22 synthetic tie with line 8506 is also shown in Figure 3.6.

An example of an interpreted seismic line is given in Figure 3.7. The line shown is 8505. The seismic events that were correlated in the project area are, the top of Lower Cretaceous, Pre-Cretaceous Unconformity, top of Silurian- Ordovician Carbonates, Shale marker within the salt of Saline River formations, the shale marker within the Mount Cap formation and the top of the Proterozoic. Truncations within the Proterozoic as well as Fault C are also shown. Another example of the interpreted horizons and a similar fault A are shown in Figure 3.8.

The quality of the 1984/85 seismic data varies from good to very good. Most of the interpreted events were continuous throughout the prospect, except for the shale marker within the salt of the Saline River Formation and the Lower Cretaceous which are more difficult to interpret in the western part of the area. The seismic event at the Pre-Creteous Unconformity is the strongest reflector in the geologic sequence. Because the Cambrian and Proterozoic are clastics, the reflectivity coefficient of this interface is not sufficient to produce a good seismic reflection. However, the Proterozoic unconformity can be interpreted because of the nature of the erosional surface. The Proterozoic sediments are usually truncated by the overlying Paleozoic beds and it is these truncations that can be seen on the sections.

3.2.2 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 3.3.1 and 3.3.2.

Correlations from geology to geophysics were based on the wells Buttes et al Blackwater Lake I-54A and Shell Blackwater Lake G-52. The I-54A well is about 3.5 kilometres north of shot point 360 on line 60X and 2 kilometres to the east of shot point 145 on line 8414. The G-52 well is located about 0.5 kilometres south of shot point 134 on line 8402. The I-54A well penetrates the Saline River formation and the G-52 well penetrates Proterozoic rocks. The data from this latter well is not of much use because of its position in the fault zone A'. The data from other wells which provided some information in the area include SOBC CS St. Charles Creek H-61, Keller Lake P-14, Keller Lake O-13, Union Blackwater E-11 and Sinclair Wolverine Creek D-61. None of these wells penetrated deeper than the Franklin Mountain Formation except for D-61 which penetrated Proterozoic rocks. There is no Mount Cap or Mount Clark in this well which is situated near the Wolverine Arch. Synthetic seismograms for the wells I-54A and G-52 are shown in Figures 3.5.1. and 3.5.2.

An example of the interpreted seismic is given in Figure 3.8.1. The line shown is 8406. The seismic events that were correlated in the project area are; the top of the Devonian carbonates (Pre-Cretaceous unconformity), a marker in the

Bear Rock, the top of the Mount Kindle, the Franklin Mountain, and the Saline River Formations, a Mount Cap shale marker and the top of the Proterozoic.

The quality of the 1984/85 seismic data varies from good to poor. Most of the interpreted events were continuous throughout the prospect, except for the Saline River Formation, the Bear Rock marker and the Proterozoic event. The amount of data is not sufficient to map the entire prospect area with confidence and in some cases it was difficult to correlate horizons from line to line.

Because the Cambrian and Proterozoic are clastics, the reflectivity coefficient of this interface is not sufficient to produce a good seismic reflection. However, the Proterozoic unconformity can be interpreted in most cases because of the nature of the erosional surface. The Proterozoic sediments are usually truncated by the overlying Paleozoic beds and it is these truncations that can be seen on the sections. The best example of this is found at the northern end of line 8416. Very poor reflections from the Proterozoic do occur, especially in the south on lines 8400, 14X, 8402, 8404, 8401 and at the western end of line 60X. In some cases the Proterozoic could not be interpreted. In 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 Mt. Formation overlie the Proterozoic clastics which results in a strong reflection coefficient. A good example of this is at the western end of line 56X and 58X.

The Saline River Formation is relatively thin in the area and is composed of rocks which, at times, are similar to the overlying Franklin Mt. Formation and the underlying Mount Cap Formation. The seismic event is, therefore, not always mappable. In the area the base of the Saline River Formation is an unconformity and, because the Saline River is thin, this horizon gives a good representation of the erosional surface at the top of the Mount Cap Formation.

The Bear Rock Marker is a limestone unit within the anhydrous Bear Rock Formation. It is discontinuous due to erosion and the marker subcrops under the Pre-Cretaceous unconformity surface toward the east.

The seismic data from the 1983/84 program was reprocessed by G.S.I. and the result was an improvement in the quality of most of the data. Some of the interpretation on these five lines has been changed from last year due to the better data quality.

The Mount Cap shale marker is usually a strong event in the area and a structure map of this horizon was produced (Figures 3.14 and 3.15). This map is a combination of the Proterozoic structure in the west and the shale marker to the east. The nature of the two events in the differenet areas made it necessary to make this kind of map. The structure of the Proterozoic in the east is probably very similar to that of the Mount Cap shale marker.

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.

3.2.3 Velocity Information

Velocity information was obtained from three sources, sonic logs, seismic velocity analyses obtained from seismic data and first break diagrams. Tables 3.2 and 3.3 give average velocities for certain formations and intervals in the areas. Included also in Figure 3.9, is the 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 3.2 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 - Proterozoic	6300

TABLE 3.3 APPROXIMATE VELOCITIES OF FORMATIONS IN THE BLACKWATER LAKE AREA.

3.3 Presentation of Seismic Results

Migrated, normal polarity seismic sections for the Great Bear and Blackwater Lake 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 the Great Bear area that were sent are 1 : 10,394 (horizontal) and 7.5 inches/sec (vertical). The scales for the Blackwater Lake sections are 1 : 23,386 (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 Great Bear area:

(i) Top of Proterozoic (Figures 3.10 and 3.11)
(ii) Pre-Cretaceous unconformity (Figures 3.12 and 3.13)

In the Blackwater Lake map area, the following time structure maps were made:

(i) Top of Mount Cap shale marker/Proterozoic (Figures 3.14 and 3.15)

(ii) Top of Devonian carbonates (Figure 3.16)

The structure of the Mount Cap shale marker and the structure on the Proterozoic event is on the same map. The two structure maps are separated by a line to the west of which there is no Mount Cap present. This line is the approximate location of the western limit of Cambrian sediments. The map will be discussed in more detail in section 4.

3.4 Presentation of Gravity Results

For both the Great Bear and the Blackwater/Southern Great Bear areas, the following maps were made:

sections in the Great Bear area that were sent are 1 : 10,394 (horizontal) and 7.5 inches/sec (vertical). The scales for the Blackwater Lake sections are 1 : 23,386 (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 Great Bear area:

(i) Top of Proterozoic (Figures 3.10 and 3.11)
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In the Blackwater Lake map area, the following time structure maps were made:

(i) Top of Mount Cap shale marker/Proterozoic (Figures 3.14 and 3.15)

(ii) Top of Devonian carbonates (Figure 3.16)

The structure of the M unt Cap shale marker and the structure on the Proterozoic event is on the same map. The two structure maps are separated by a line to the west of which there is no Mount Cap present. This line is the approximate location of the western limit of Cambrian sediments. The map will be discussed in more detail in section 4.

3.4 Presentation of Gravity Results

For both the Great Bear and the Blackwater/Southern Great Bear areas, the following maps were made:

A) Contour Map

(i) Bouguer Gravity (Figure 3.17 - Great Bear, Figure 3.20 - Blackwater)
(ii) Residual Gravity (Figure 3.18 - Great Bear, Figure 3.22 - Blackwater)

B) Fence Diagram

(i) Residual gravity (Figure 3.19 - Great Bear, Figure 3.21 - Blackwater)

The scale of all the maps is 1:100,000. The vertical gravity scale for the fence diagrams is 2.0 milligals/inch and the base line or zero-level is 0.0 milligals. The 1983/84 gravity data in the Blackwater Lake area was merged with the 1984/85 data in the same area.

SECTION FOUR

DISCUSSION OF RESULTS GREAT BEAR AREA

4.1 The Proterozoic

4.1.1 Present Morphology

In the project area the relief of the Proterozoic is moderate and varies between highs and lows by about 450 metres. The Proterozoic unconformity and the overlying Paleozoic strata dip gently to the west with an average dip of 1.32 degrees.

4.1.2 Proterozoic Structures

Several Proterozoic faults were interpreted from the data. Many of them have a northeasterly trend. Most faults cut the lower Paleozoic strata and the larger ones cut all overlying rocks. The most significant fault trends northeast and is down thrown to the southeast. This fault may be seen on line 8501 (S.P. 128) and on line 8505 (S.P. 505) on the Proterozoic map, Figure 3.11. In Figure 3.8 of line 8501, the fault is labelled A. There is no surficial evidence of the structure due to the glacial cover but the entire stratigraphic column, including the upper Proterozoic rocks, appears to be cut by the fault. The top of the Silurian-Ordovician carbonates and Proterozoic unconformity are structurally higher on the northwest side of the fault. There may be some thrusting associated with the structure but the data quality is insufficient to prove this. The structure may have originated during orogenic activity in the Proterozoic, with reactivation of this ancient fault during the Late Cretaceous. Regional tectonic movements during the Laramide Orogeny resulted in uplift of the Paleozoic and Cretaceous rocks along the fault. Figure 3.8 shows a similar fault but probably with lesser thrusting activity and is labelled B.

Another major fault occurs approximately 38 km NW of fault "A", trends almost N-S and dips towards the east. In Figure 3.7 the fault is labelled fault "C" and seems to follow a similar configuration as fault "A". It has been shown on line 8505 at shot point 801. A closed Proterozoic high has been interpreted on the upthrown side of the fault around S.P. 850 on line 8505 and S.P. 154 on line 8504. The Paleozoic sediments thin on the west side of this fault, suggesting a high of Precambrian origin.

Another significant fault occurs in the extreme SE part of the project area and is located on line 8505 at S.P. 128 and on line 8500 at S.P. 120. It is interpreted to be downthrown to the northwest and is illustrated in Figure 4.1 and labelled fault E in Figure 3.2. This fault is also trending NE-SW and seems to have penetrated the section from Proterozoic to the Cretaceous.

Cambrian age faulting occurs throughout the area. An example of one such fault is illustrated in Figure 4.1 on line 8505 at S.P. 169 and is labelled "D". This fault appeared to have only d' cated the sediments up to the end of Cambrian. The thicker section of the younger sediments towards the downthrown side of the fault is good evidence for that.

4.2 Mount Clark Formation

The Mount Clark Formation consists entirely of sandstones in the G-22 well where it is about 65 metres thick. The sands tend to thicken in Proterozoic lows and thin across highs. However, the top of the Mount Clark is not a seismically resolvable event and the exact distribution of the sands cannot be determined. In the D-61 well to the southwest of the Great Bear Lake E.A. there is no Mount Clark or Mount Cap. There may be local areas, in and around the project area, where lower Cambrian sediments were not deposited.

4.3 Mount Cap Formation

The distribution of the Mount Cap shales appears to be affected by Proterozoic structures as is the Mount Clark sands. There is 119 metres of Mount Cap in the G-22 well. The interval from the top of the Mount Cap to the Proterozoic thins from east to west especially in the southern part of the project area. Along line 8502 the interval thins from a two-way time of approximately 105 msec in the east to 80 msec in the west within a distance of 46 km, or from 184 metres encountered in the Losh Lake G-22 well in the east to 55 metres in the Whitefish K-76 well in the west.

4.4 Saline River Formation

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

4.5 The Ronning Group (Silurian-Ordovician Carbonates)

The carbonates of this group consists of two formations, the Mount Kindle and the Franklin Mountain formation. It seems to thicken towards the east. This change appears to have been caused by the thinning of the Franklin Mountain formation which underlies unconformably on the Mt. Kindle formation to the west. On the other hand, the Mt. Kindle formation appears to be of relatively uniform thickness. On line 8502 the isochron of Top of Ronning to the Top of Saline River Salt thins from a two-way time of approximately 195 msec in the east to approximately 150 msec in the west, or 624 metres in the east to 480 metres in the west.

4.6 Devonian Carbonates

The interval from the top of the Devonian carbonates to the top of the Ronning Group thickens from northeast to southwest in the area. Thicknesses vary from 80 to 110 msec on line 8504 or about 179 to 327 metres.

The interval from the top of the Devonian carbonates to the top of the Proterozoic also thickens from the northeast to the southwest in the Great Bear Lake area. The change in two-way time taken from the reference line 8504 is 400 to 485 msec, is equivalent to about 1200 to 1528 metres.

4.7 Cretaceous

The Cretaceous clastics thicken toward the west in the study area where the top of the Paleozoic rocks are structurally deeper. The Cretaceous section was not studied in detail but the seismic data suggests that there are depositional features in the clastics, such as paleo-river channels.

4.8 Results from Gravity

The gravity gathered along the seismic lines is insufficient for a regional interpretation. The regional interpretation was made from the Bouguer Gravity Map of the Northwest Territories (Department of Energy Mines and Resources, 1969 Gravity Map Series, Map No. 118). Generally, the gravity trends on the seismic lines conform with the trends depicted on the regional gravity map.

4.8.1 Bouguer Gravity

Two features of note on the regional gravity map are:

1. A northeast trending gravity high and low associated with Fault A.
2. Another low in gravity on the downside (northwest) side of Fault E.

These features can be correlated with the Bouguer gravity on the seismic lines, Figure 3.17.

On all lines the gravity tracks the top of the Devonian carbonates. Most of the gravity highs and lows are associated with the structural features present in the carbonates. The data does not show the regional effect of the southwest dipping Devonian carbonates.

4.8.2 Residual Gravity

The residual gravity is shown in Figure 3.18. Residuals associated with the regional features are obvious, however many small amplitude gravity highs and lows are present. These small anomalies are considered to represent undulations on the top of the Paleozoic carbonates. A gravity high indicates a carbonate high whereas a gravity low represents a carbonate low.

The best illustration of the residual gravity mirroring the carbonate top occurs between S.P. 600 to S.P. 700 on line

8505. An examination of Figure 4.1 and Figure 3.19 show a good correlation between the seismic and gravity.

SECTION FIVE

DISCUSSION OF RESULTS BLACKWATER LAKE AREA

5.1 The Proterozoic

5.1.1 Present Morphology

In the project area the relief of the Proterozoic is usually moderate and varies between highs and lows by about 300 metres. In the area of major fault zones the relief may be as high as 750 metres. Toward the west, near the Cap Thrust, the Proterozoic is structurally deeper than in the east.

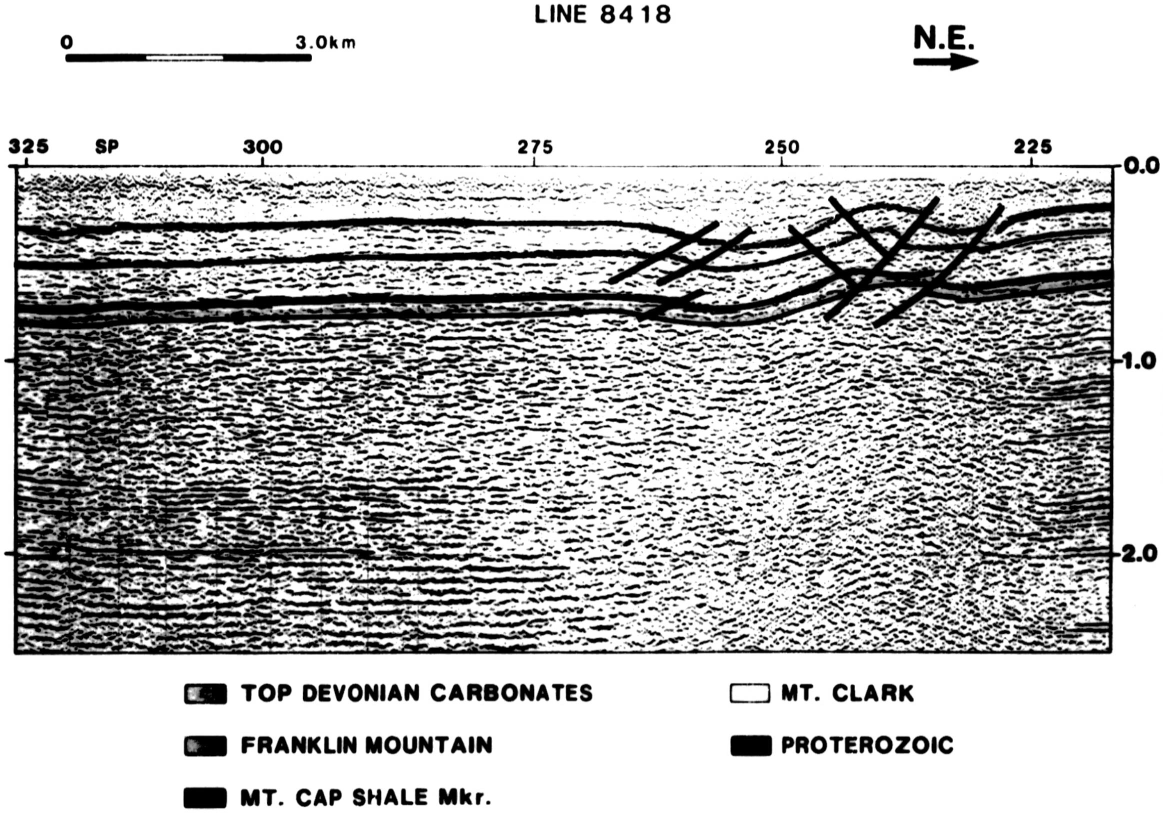
5.1.2 Proterozoic Structures

Some changes have been made in the structural interpretation of the area since last year due to the increase in seismic data. More faults have been mapped in the area and some faults already interpreted in the area have been mapped in more detail. The major Proterozoic high which was mapped previously, has been broken up and other structural highs have been interpreted.

The major fault in the area, labelled fault A' in Figure 3.2.1, is a north-south trending fault zone. The characteristics of this fault complex change along its length. A close examination of the seismic which crosses the fault zone illustrates this. The fault has been interpreted as being a normal fault, down thrown to the west; however, in some areas the fault more resembles a complicated thrust fault. The fault zone A' is shown on lines 8406 and 8418 in Figures 4.2 and 4.3 respectively. Another major fault complex occurs in

CLEMENTS CREEK

LINE 8418



AR-85-10-298

Figure 4.3 Line 8418 showing Proterozoic structures and fault zone A'.

the area which is closely related to fault A'. Its location is shown in Figure 3.2.1. The fault complex consists of two normal fault zones, labelled B' and C'. These faults result in a graben-like structure which trends in a northeasterly direction. Line 8406, seen in Figure 3.8.1, shows the two fault zones. The time structure map of the Mount Cap shale marker and Proterozoic events is given in Figures 3.14 and 3.15 and shows the major fault zones in the area.

These major faults appear to affect all of the rocks except fault C' which doesn't cut through the Devonian carbonates. Faults A' and B' are therefore at least Laramide in age. Fault C' is at least Silurian to Lower Devonian in age. It is likely that these faults were active in the past, possibly originating in the Proterozoic or Cambrian, with some activity and movement through Paleozoic time. The data quality in the fault zones is often poor and a clear idea of what is happening structurally within this area cannot always be obtained.

The characteristics of certain portions of the fault zone A' is evidence that there has been some rejuvination in more recent times, probably a result of the Laramide Orogeny. As previously mentioned, fault A' is mapped as a normal fault. These characteristics were probably a result of ancient tectonic activity in the area. The same orogenic event probably caused the formation of the Leith Ridge and Fort Norman structures, which are down thrown to the northwest fault zones (Balkwill, 1971). Often the events within the Proterozoic appear to be discontinuous across the fault zone A' which may be evidence of movement in Proterozoic or Cambrian time (Figure 4.2). Most seismic lines that cross fault A' show some evidence of normal faulting and some lines show evidence of both normal faulting and thrust faulting. On line 8418 (Figure 4.3) the fault resemble a complex thrust zone. On other seismic lines, such as line 60X, the fault zone resembles a flower structure closer to the surface. These complex structural features are the result of compressional forces which are related to the Laramide Orogeny.

The fault zones B' and C' are probalby closely related to fault A' and were active during the same period of time. The faults B' and C' appear to split off of fault A' in the vicinity of lines 8410 and 8412. To the south of the area where the faults seem to join the deformation of the rocks around fault A' is not as great as the deformation to the north. Instead, fault B' shows most of the deformation in this area. The throw on this normal fault is enormous in places, especially near line 8406 (Figure 3.8.1). The faults B' and C' form a graben-like structure to the west of fault A'. The thickness of the Devonian rocks is greater in the graben than on either side which indicates this area was structurally lower at least at the time of the Pre-Cretaceous erosional event also. The exact time of origin of this graben cannot be estimated.

There are some other minor faults in the project area of which most are Cambrian in age. The location of most of the interpreted faults in the area are shown in Figures 3.14 and 3.15. An example of a Cambrian fault occurs on line 60X and is shown in Figure 4.4. The surface at the base of the Saline River Formation is an unconformity in the area which is evident from this example. Most of these older faults trend toward the north or northeast.

The major Proterozoic and Cambrian structures in the area are located to the west of fault zone A' and are primarily a result of the Laramide Orogeny. These are shown in Figure

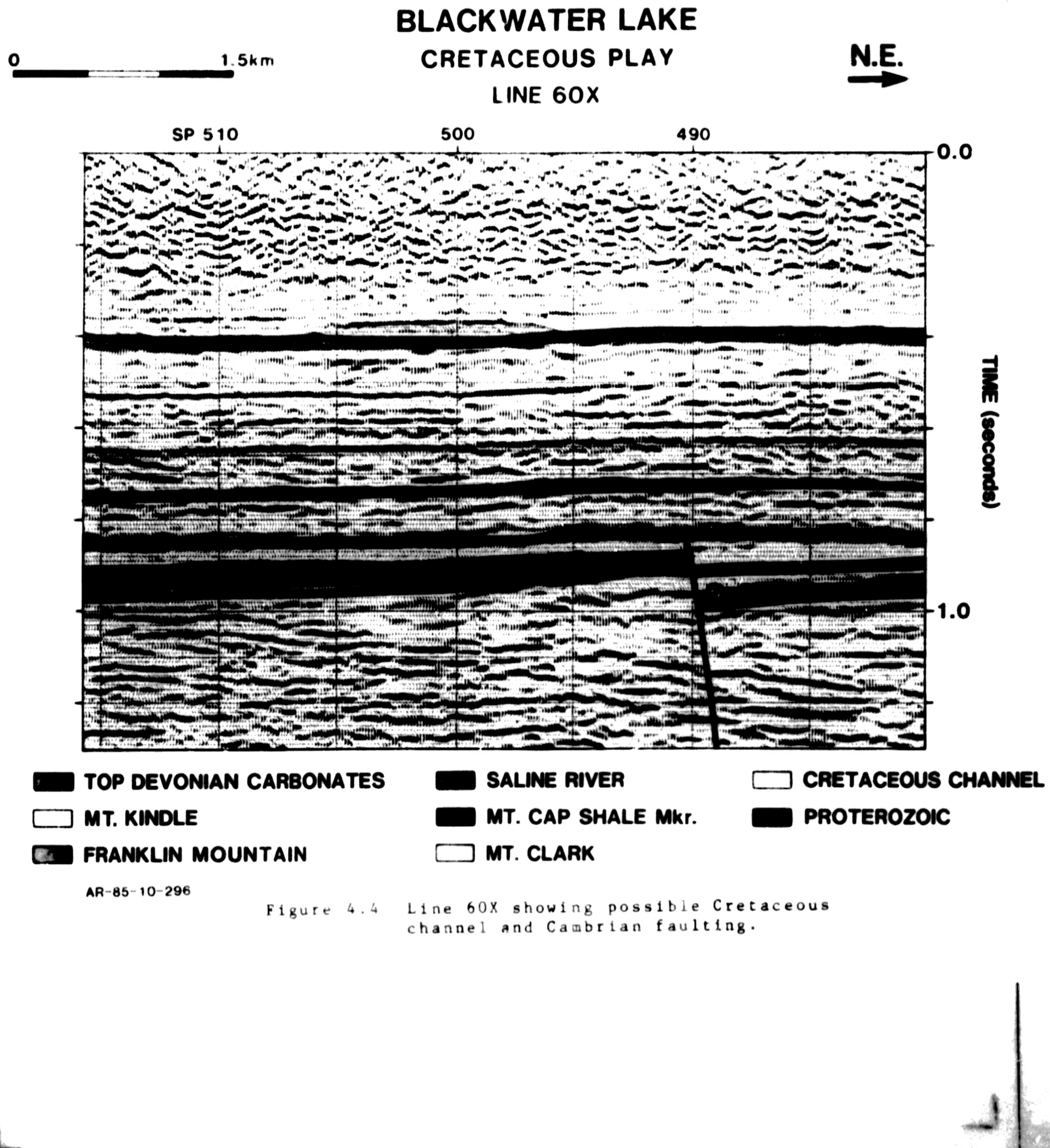


Figure 4.4 Line 60X showing possible Cretaceous channel and Cambrian faulting.

3.14. The northern structures are located in the vicinity of lines 8418, 58X and 60X. Figure 4.3 shows part of a major structure on line 8418 from shot point 260 to 320. In the southern part of the project area there is another structural high on the Proterozoic which is located between fault zones A' and B' around lines 8406, 8404, 8402 and 32X. Figure 4.2 shows part of this structure on line 8406 from shot point 300 to 350.

There are other smaller structures in the Cambrian and Proterozoic further to the west of the major structures just mentioned. One such structure occurs on line 56X from shot point 915 to 950. Another is located near line 8408 around shot point 190 to 215. Some of these minor structures may be of Laramide age while others may be a result of tectonic activity that occurred at sometime between Proterozoic and Devonian time.

Some of the structures in the Blackwater Lake area may be a result of tectonic activity during the Caledonian epeirogeny. This epeirogeny occurred near the end of Silurian time and may have resulted in faulting or changes in depositional environments.

The major structural feature in the area is the Proterozoic Wolverine Arch. The approximate location of this arch is shown in Figure 3.2.1. The beds within the Proterozic form an anticlinal feature which has affected Cambrian sedimentation. The crest of this anticline is located near shot point 875 on line 58X and shot point 610 on line 60X. Very close to the apex of this ancient anticline the edge of Cambrian sediments occurs. The Cambrian also does not occur to the west of the arch in the project area until they are brought to surface in the area of the Cap Thrust. The Cambrian was probably not deposited on this old high. The Cambro-Ordovician Franklin Mountain Formation also thins toward the west across this arch. At the western end of lines 58X and 56X, just to the east of the Cap Thrust, the Franklin Mountain carbonates are very thin as compared to the rest of the project area.

5.2 Mount Clark Formation

The Mount Clark Formation consists entirely of sandstones in the G-52 well where it is about 40 metres thick. This is the only well in the area that penetrates the lower Cambrian.

The sands tend to thicken in Proterozoic lows and thin across highs. However, the top of the Mount Clark is not a seismically resolvable event and the exact distribution of the sands cannot be determined. As previously mentioned, in the D-61 well to the northwest of the Blackwater Lake E.A. there is no Mount Clark or Mount Cap. The well is situated in the vicinity of the Wolverine Arch. There may be local areas, in and around the project area, where lower Cambrian sediments were not deposited.

A general observation in the area is that the Cambrian section is thicker in the east, especially to the west of fault A'. The Cambrian sediments thin to the west toward the Wolverine Arch. The approximate edge of the Cambrian is shown in Figure 3.14. From a study of the seismic data in the area the greatest thickness of the Mount Clark Formation is estimated to be approximately 125 metres.

Localized areas of thicker Cambrian sediments occur on the down thrown side of normal faults in the project area which are Cambrian in age (Figure 4.4).

5.3 Mount Cap Formation

The distribution of the Mount Cap shales appears to be affected by Proterozoic structures as was the Mount Clark sands. There is about 50 metres of Mount Cap in the G-52 well. The interval from the top of the Mount Cap to the Proterozoic thins from east to west toward the Wolverine Arch.

5.4 Saline River Formation

The thickness of the Saline River Formation was not determined with certainty in the area because of the poor resolution of the interval.

5.5 Franklin Mountain Formation

As mentioned previously, the carbonates of the Franklin Mountain Formation thin toward the west of the project area toward the Wolverine Arch. The thickness of the Franklin Mountain decreases from a two-way time of approximately 120 msec in most of the area 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.

5.6 Mount Kindle Formation

The thickness of the Mount Kindle Formation is relatively constant throughout the project area at about 80 msec two-way time. This is equivalent to approximately 200 metres.

5.7 Devonian Carbonates

The top of the carbonates and anhydrites of the Devonian Bear Rock Formation is the strongest reflector in the project area except on the east side of fault A' where the carbonates are very close to the surface. The seismic data could not sample this horizon at a close enough interval in some places and the event is therefore not as continuous. The time structure map of the top of the Devonian carbonates is given in Figure 3.16.

In general the Devonian carbonates thicken to the southwest. The thickness of the carbonates vary from approximately 350 metres on the east side of fault A' near line 60X to 625 metres near the I-54A well and to about 1,000 metres at the western end of lines 60X and 58X. The top of the carbonates deepens to the southwest as well.

As previously mentioned, the carbonates are deeper as well as thicker in the graben between faults B' and C' than the adjacent areas. In the graben thicknesses may reach 1,000 metres.

The carbonates are also higher in the areas of the major Proterozoic structures as may be seen by comparing Figures 3.14 and 3.16. The carbonates are also higher in the northwestern part of the project area at the end of line 56X.

5.8 Cretaceous

The Cretaceous section thickens towards the west in the study area, especially in the west near the Cap Thrust and in the graben bounded by faults B' and C'. The Cretaceous also thins towards the northwest end of line 56X.

A channel at the base of the Cretaceus was interpreted in the vicinity of lines 60X and 8401. An example of this channel is shown in Figure 4.4. The map of the Devonian carbonates (Figure 3.16) gives the location of some interpreted seismic anomalies at the base of the Cretaceous which include some possible off-shore sandbars and the stream channel.

5.9 Results from Gravity

The gravity data gathered along the seismic lines is sufficient to map major trends and to make correlations between the gravity and the seismic data. Generally, the gravity trends on the Bouguer gravity map (Figure 3.20) correlate with the regional trends from the Bouguer Gravity Map of the Northwest Territories (Department of Energy, Mines and Resources, 1969 Gravity Map Series, Map No. 118). The residual trends on the residual gravity map (Figure 3.22) and fence diagram (Figure 3.21) correlate well with the structure on the top of the Devonian carbonates (Figure 3.16).

In general, a gravity low occurs in areas where the Cretaceous section is thicker or the top of the Devonian carbonates is structurally lower. The gravity is affected by the densi-ty contrast between the Cretaceous shales and Devonian carbonates. The carbonates are more dense and therefore when they are close to the surface will result in a gravity high. Where the more dense Cambrian and Proterozoic rock outcrop at the Cap Thrust the result also is a gravity high.

To a lesser extent the gravity may be affected by the thickness of the Devonian carbonates so that in areas where the carbonates are thin the gravity will be lower.

5.9.1 Bouguer Gravity

Four features of note on the regional gravity map and the Bouguer gravity map of the project area are:

1. A northwest trending gravity high associated with the Cap Thrust.
2. A gravity high striking in a northerly direction related to fault zone A'.
3. A general decrease in gravity toward the west from Blackwater Lake associated with the increase in thickness of the Cretaceous.
4. A more gentle gravity decrease on the east side of fault zone A' related to areas where the Devonian carbonate interval is thin.

The gravity highs in some areas along fault A' are a result of the Devonian being structurally higher in the fault zone. A major gravity low occurs in the area of the graben between faults B' and C'. This is because the top of the Devonian carbonates is structurally lower in this area.

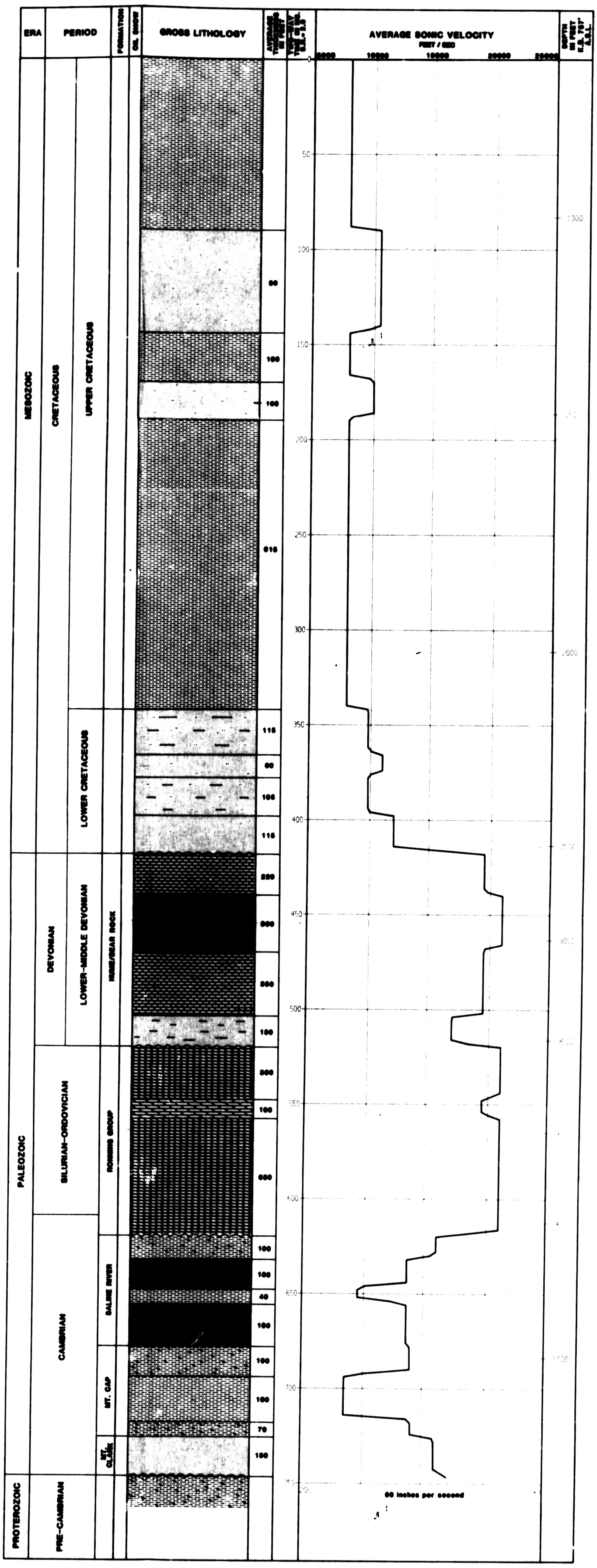
A comparison between the Bouguer gravity map (Figure 3.20) and the Devonian carbonates map (Figure 3.16) shows correlations between the major structural and gravity trends in the area.

5.9.2 Residual Gravity

The residual gravity is a more sensitive measurement of the structure of the Devonian carbonates as well as the thickness of the carbonate interval. The faults and major structural features in the area are also more clearly represented. A close association exists between the residual gravity and the structure of the carbonates which may be shown by comparing the residual fence diagram (Figure 3.21) and the Devonian carbonate structure map (Figure 3.16).

A residual gravity high occurs in the areas of the major Proterozoic structures. This is because the Devonian carbonates are also structurally higher in these areas and the Cretaceous interval is thinner.

FIGURE NO. [illegible]
NWT - [illegible] / Blackwater
GEOPHYSICAL / GEOLOGICAL MODEL

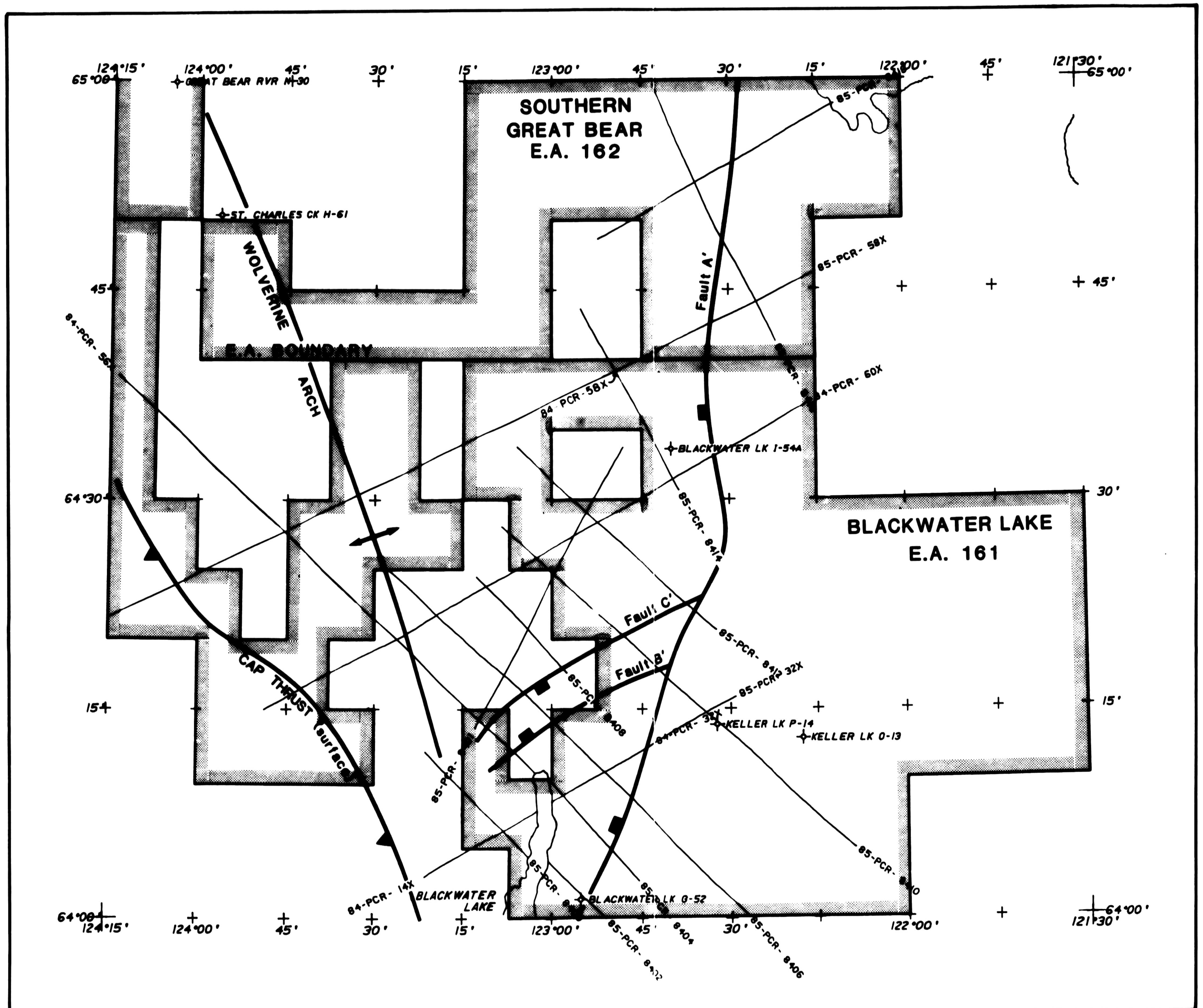


Average Velocity and Formation Thicknesses are taken from 4 wells:
SINCLAIR WHITEFISH RIVER K-76
WEST WHITEFISH RIVER H-84
BP ET AL LOST LAKE G-22
ARCO LOST HILL LAKE F-62

LEGEND

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

FILE No: 4848



BLACKWATER LAKE AND SOUTHERN GREAT BEAR - NTS 096A,B,C

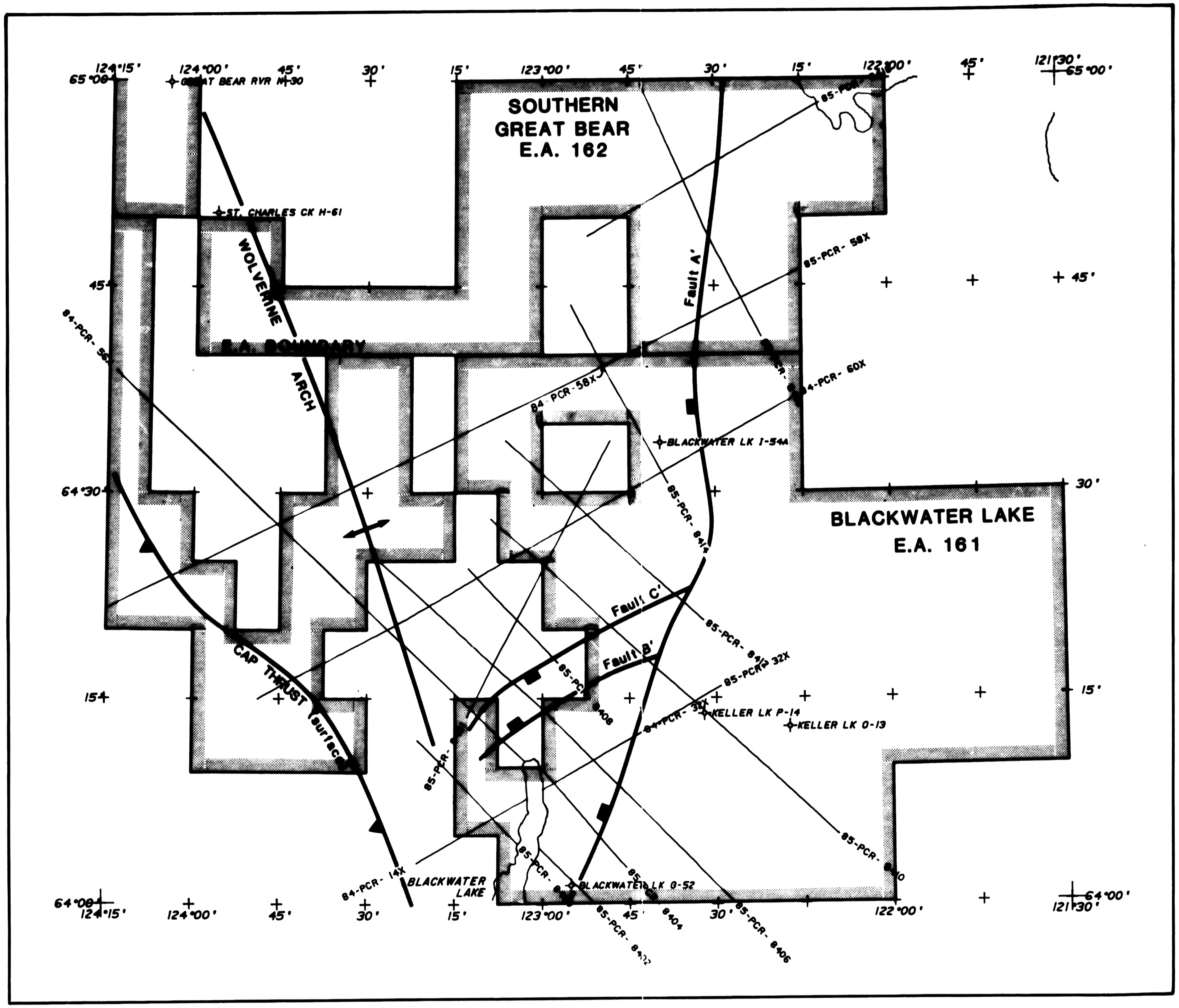
KILOMETRES 10 0 10 20 30 40 50 60 KILOMETRES

MILES 10 0 10 20 30 40 MILES

FIGURE 3.2.1

LOCALITY MAP OF THE 1984/1985 GEOPHYSICAL PROGRAM AND 1983/1984 DATA IN THE BLACKWATER LAKE AND SOUTHERN GREAT BEAR AREA SHOWING MAJOR STRUCTURES

AUTHOR: R.Niederauer DATE: 01-86 FILE: 4888 SF



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AUTHOR: R.Niederauer DATE: 01-86 FILE: 4888 SF

LINE 8501

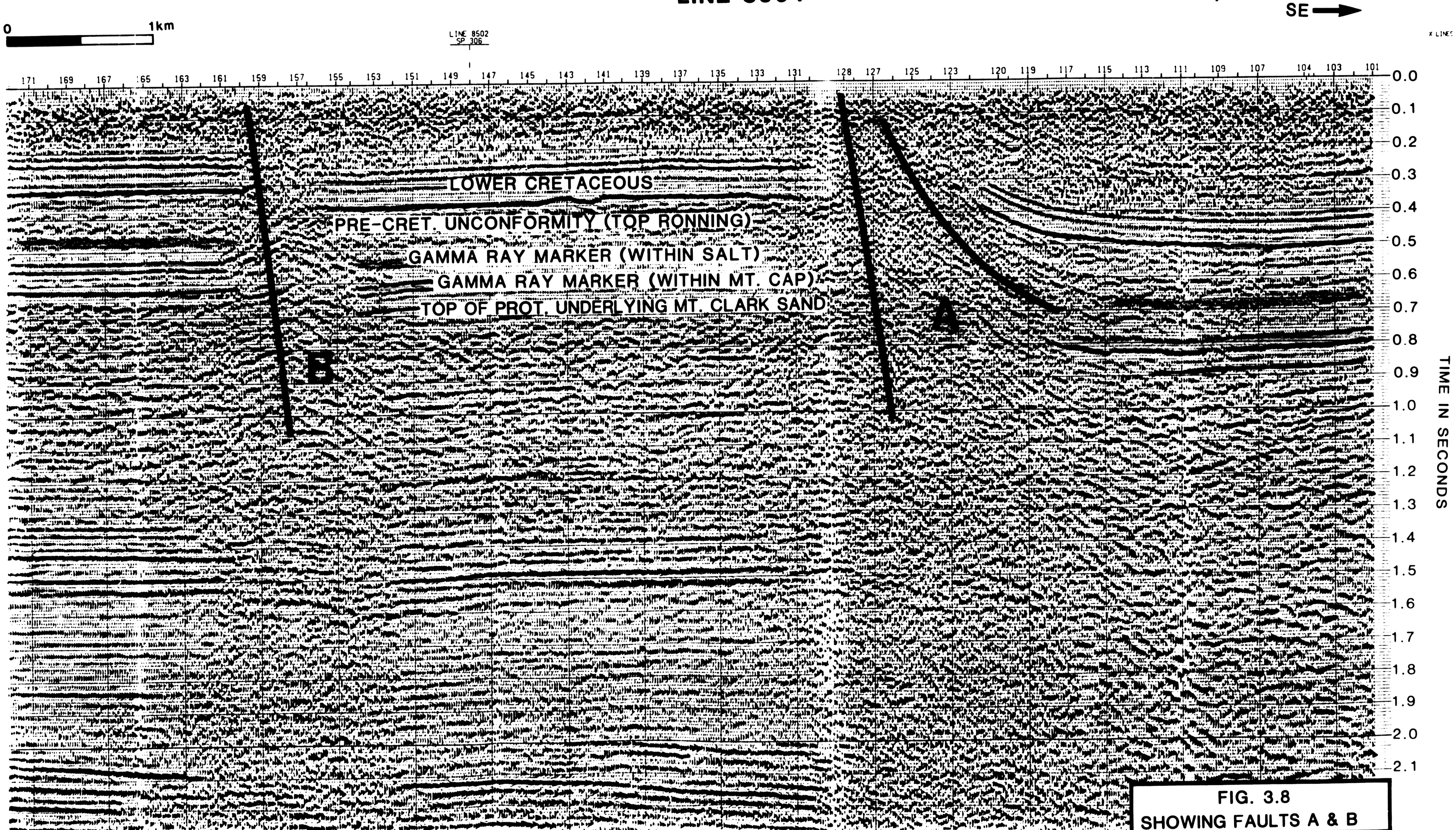


FIG. 3.8
SHOWING FAULTS A & B

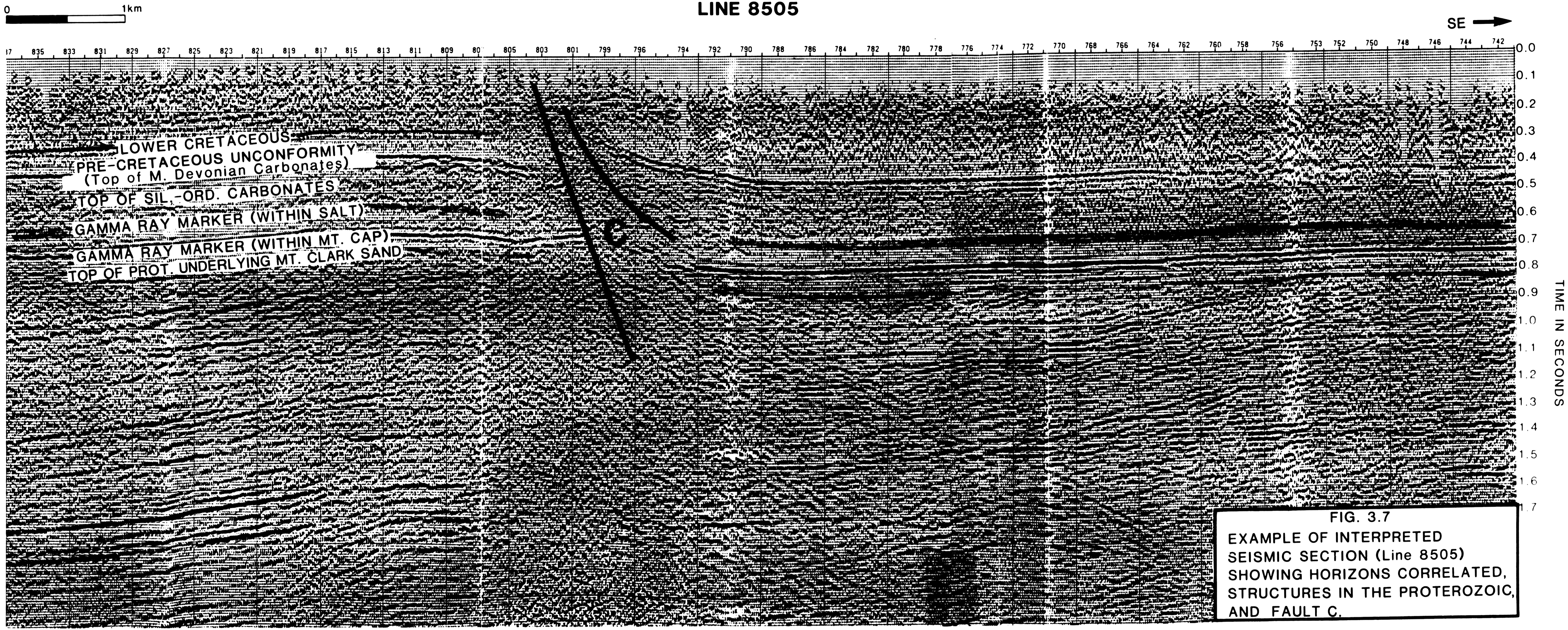


FIG. 3.7
EXAMPLE OF INTERPRETED SEISMIC SECTION (Line 8505) SHOWING HORIZONS CORRELATED, STRUCTURES IN THE PROTEROZOIC, AND FAULT C.

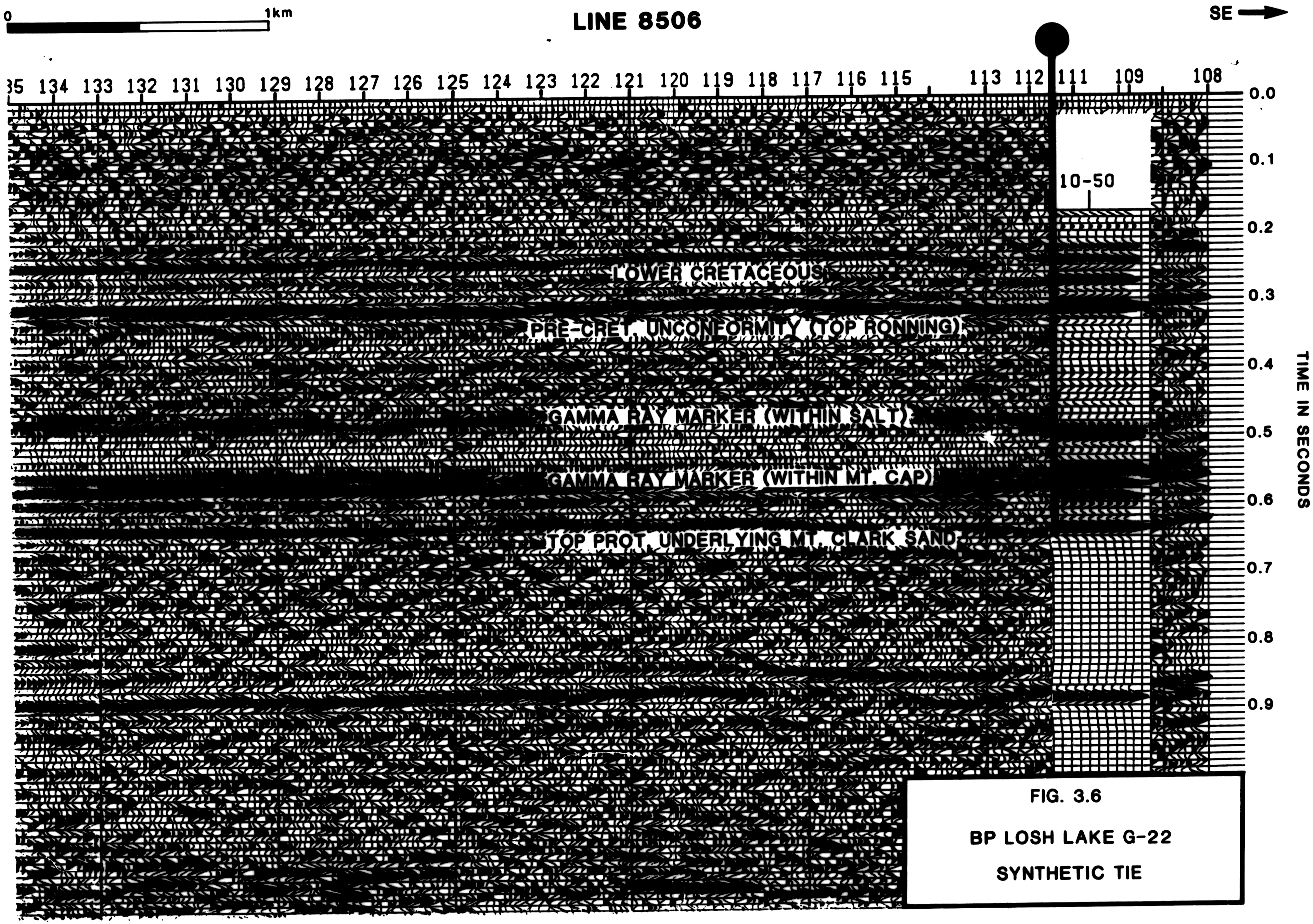
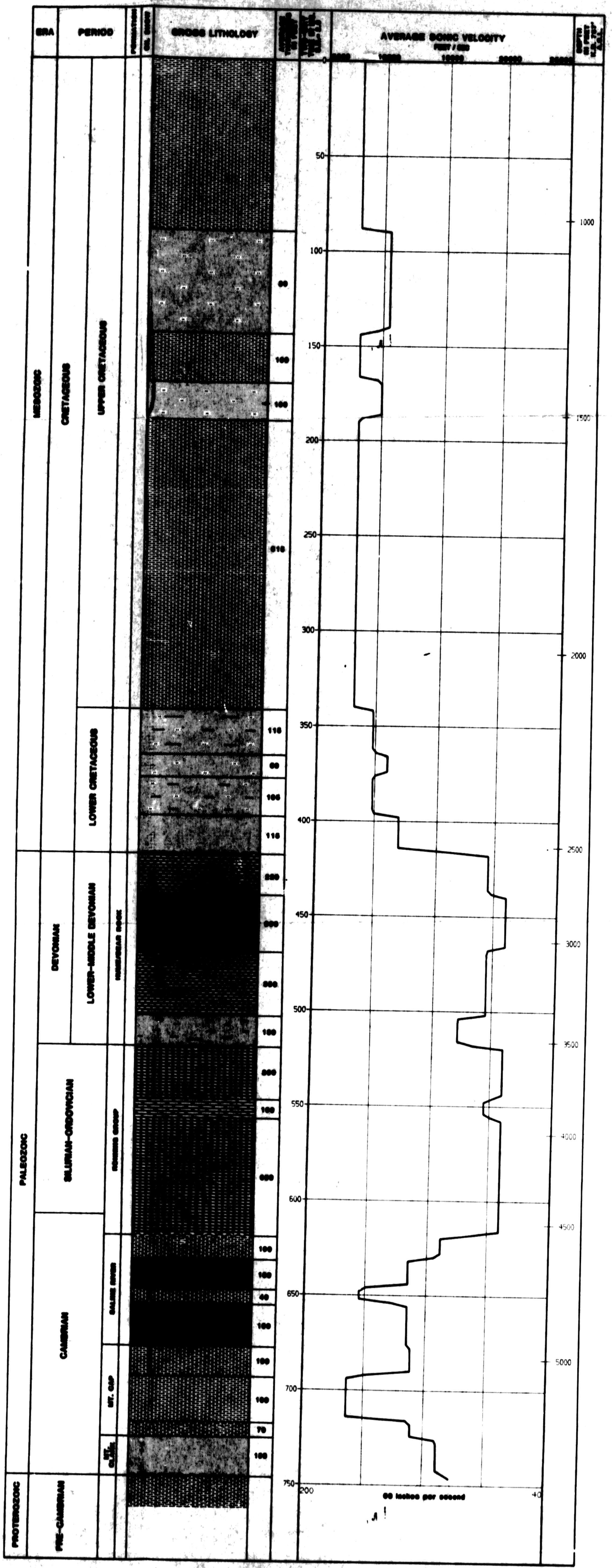


FIG. 3.6

BP LOSH LAKE G-22

SYNTHETIC TIE

GEOPHYSICAL / GEOLOGICAL MODEL



Average Velocity and Formation Thicknesses are taken from 4 wells:
SINCLAIR WHITEFISH RIVER K-70
WEST WHITEFISH RIVER H-34
BP ET AL LOST LAKE G-22
ARCO LOST HILL LAKE F-62

FIGURE 3.8.1 Example of interpreted seismic section (Line 8406) showing horizons correlated and fault zones B' and C'.

FILE 5218