[redacted]

PETRO-CANADA

Report on the
GEOPHYSICAL EXPLORATION SURVEY

PROGRAM No. 9229-P28-6E

in

FORT SIMPSON
NORTHWEST TERRITORIES

Exploration Agreement No. 166

APRIL, 1986

PROJECT ACTION SHEET

RESOURCE EVALUATION BRANCH

PROJECT NUMBER: 9229-P28-GE

COMPANY: P.E.A.

REPORT TITLE:

The following action has been taken:

Receipt acknowledged ... APRIL 16/86

Reports and maps date-stamped ... ✓

Memo sent to Land Management ...

Reports for review list edited ... ✓

Inventory sheet made ... ✓

Mylar ...

REVIEW AND APPROVAL made by: Laura Richards May 1/86

COMMENTS:

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PETRO-CANADA

March 31, 1986

Canada Oil and Gas Land Administration
355 River Road
Ottawa, Ontario
K1A OE4

Attention: Mr. Don Sherwin
Director Resource Evaluation

Dear Sir:

Re: PROGRAM #9229-P28-6E
FORT SIMPSON 1984/85
PCI File: NOR Program 9229-P28-6E

Please find enclosed in triplicate, copies of the final report for the Fort Simpson Seismic Program No. 9229-P28-6E, 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 Fort Simpson Seismic Report
Transmittal List No. 000002

x.c.: Westcoast Petroleum Attention: Mr. D. MacQuarrie
(one copy of report and transmittal list 000002)

TRANSMITTAL LIST

№ 005092

DATE 26 MARCH 19 [illegible]

TO	FROM
JAMES MAXIM 1008 PCCW	BERNIE TAYLOR [illegible] PCCW

☑ ENCLOSED AS FOLLOWS ☐ UNDER SEPARATE COVER

SENDER'S SIGNATURE Bettie [illegible]

REFERENCE

NO	ITEM
3	COGLA REPORTS [illegible] LA 166 1984/85 9229 - P 28 - 6/E

REMARKS

RECEIVED BY [illegible] DATE [illegible]

PLEASE ACKNOWLEDGE RECEIPT BY SIGNING AND RETURNING ATTACHED COPY

PROGRAM NUMBER: 9229-P28-6E

YEAR: 1985

Filed under same Project Number YES or _____

(a) **WRITTEN REPORTS:**

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

OPERATION-PROCESSING-INTERP ALL IN ONE REPORT

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

(b) **MAPS:**

(1) **Shotpoint Maps** Number: 4

SEISMIC BASE MAP

(2) **Interpretation Maps** Number: 11

-DEPTH MAP TOP LOWER MEMBER KEG RIVER FM(LONELY BAY FORMATION)
-ISOCHRON MAP TOP HORN RIVER FM-TOP LOWER MEMBER KEG RIVER FM (2)
-ISOCHRON MAP TOP LOWER MEMBER KEG RIVER FM-PRECAMBRIAN (2)
-T.S.M. TOP HORN RIVER FM(MUSKWA MEMBER SHALE)
-T.S.M. TOP OF HORN RIVER FORMATION MUSKWA MEMBER SHALE
-T.S.M. TOP LOWER MEMBER KEG RIVER FM(LONELY BAY FM)
-T.S.M. TOP OF LOWER KEG RIVER FORMATION LONELY BAY FORMATION
-T.S.M. PRECAMBRIAN (2)

(3) **Other Maps** Number: 9

-SYNTHETIC SEISMOGRAM H-28,E-07
-RESIDUAL BOUGUER GRAVITY (2)
-BOUGUER GRAVITY (4)
-GRAVITY DATA INDEX MAP

(c) **SEISMIC SECTIONS** Number: 12

8100
8101
8102
8103
8104
8106
8108
8110
8112
8114
8116
8118

9229-P28-6E

PROGRAM NUMBER 9229-P28-6E

GEOPHYSICAL EXPLORATION REPORT [redacted]

FORT SIMPSON SURVEY

NORTHWEST TERRITORIES

EXPLORATION AGREEMENT NO. 166

by

PETRO-CANADA INC.
April, 1986

Land Use Permit No.:	N84B272
Area Co-ordinates:	Lat: 61°00'00"-61°55'00" Long: 119°07°30'-121°45'00"
Prime Contractors: Seismic: Gravity:	 Enertec Geophysical MWH Geophysics Ltd.
Field Work Period:	March 1985 - April 1985

Submitted by:

Alim Ghasnavi, P. Geoph.
Senior Geophysicist
N.W.T. Region

B. Taylor
Project Geophysicist
N.W.T Region

PROFESSIONAL ENGINEER
J.B. HENRY
N.W.T.

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GEOPHYSICAL MATERIAL
TRANSMITTED UNDER SEPARATE COVER
Map Scale 1:100,000

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1. Seismic Shot Point Location Map - NTS 85E, 95H
   1 mylar; 2 prefold paper prints each

2. Seismic Sections:
   Lines 8100, 8101, 8102, 8103, 8104, 8106, 8108, 8110, 8112, 8114, 8116, 8118
   36 Traces per inch; 10.0 inch/sec.
   Normal and Reverse Polarities
   1 mylar; 2 prefold paper prints each.

3. Gravity Station Map
   Posted Bouguer Gravity
   1 mylar; 2 prefold paper prints

4. Bouguer Gravity Fence Diagram
   2 prefold paper prints

5. Residual Gravity Fence Diagram
   2 prefold paper prints

6. Bouguer Gravity Map
   2 prefold paper prints

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SECTION ONE

INTRODUCTION

The primary objective of acquiring the Fort Simpson area under Exploration Agreement 166 was to explore potential Middle Devonian reef plays. A geophysical study consisting of 400 kilometres of seismic and gravity data was acquired by Petro-Canada Inc. during the 1984-85 winter season. Vibrator and conventional seismic crews were deployed simultaneously in the two blocks of the Fort Simpson E.A.

The study area lies between 61°-62° N latitude and 119°-122° W longitude in the southern Northwest Territories (Figure 1.1). Fort Simpson is located 75 kilometres northwest of the study area.

The study, which produced structure and isochron maps, was based on the analysis of twelve seismic sections, four well log sections, seismic well synthetics, gravity data, and both published and unpublished geological reports of the region.

The purpose of this report is partially to fulfill the requirements of the Exploration Agreement. It describes the objectives of the acquisition program and summarizes field operations, data processing procedures and results of the interpretation. Supporting documents in the form of maps, statistical summaries, figures and sections are integrated into this report. Other data such as mylar and paper copies of shot point base maps, seismic sections, and gravity maps have been forwarded to COGLA under separate cover.

SECTION TWO

ENVIRONMENTAL CONSIDERATIONS

2.1 Study Area Environments

During November and December of 1984, Petro-Canada Inc. representatives held meetings with Deh Cho Regional Council and members of Trout Lake, Fort Liard and Nahanni Butte communities to discuss seismic procedures and concerns of local residents. Major aspects of consideration at these meetings were trap and trapline damages and compensation, employment opportunities, training for the northern people who were to be employed, and an overall general concern that the communities and local authorities be kept up-to-date regarding the program progression and any problems arising as a direct result of the seismic operations.

Partially as a result of these meetings, Petro-Canada Inc. was awarded its Land Use Permit to commence operations in the Northwest Territories on December 21st, 1984. The Regional Council monitored the performance of the seismic survey with special emphasis being given to socio-economic commitments made during the meetings.

2.2 Personnel Training

Except for trained equipment operators and experienced personnel required in this particular operation, most of the labour force was hired locally. Although most had no previous experience, this was not a handicap as training was provided through actual field experience.

2.3 Line Clean-up and Restoration

The Jean-Marie Band of Jean-Marie and Digga Enterprises of Fort Providence, Northwest Territories carried out the line clean-up and restoration to meet the standards set out by Forestry and Northern Affairs. All personnel employed for this prospect were hired locally.

SECTION THREE

1984-85 GEOPHYSICAL PROGRAM

3.1 Field Operations

A program to record 400 kilometres of seismic as well as gravity data was proposed by Petro-Canada and partners for the Fort Simpson E.A. 166 to delineate the Horn Plateau reef growth over the Lonely Bay Middle Devonian carbonate platform. The study area is split into two blocks four kilometres apart. The west block program was located 75 kilometres south of Fort Simpson. The Norman Wells pipeline traverses through the eastern extremity of the west block (Figure 3.1).

3.1.1 Field Conditions and Access

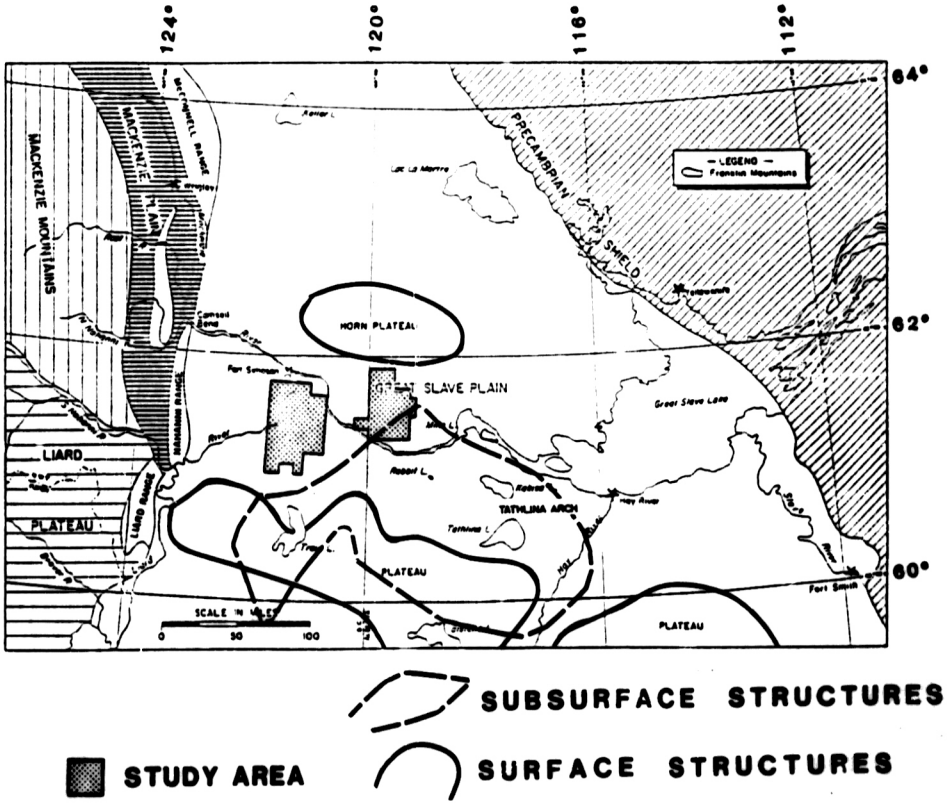
The Exploration Agreement land boundaries were outlined by the following coordinates (Figure 3.2):

East Block

Latitude 61°20'00" - 61°55'00" North
Longitude 119°07'30" - 120°15'00" West

West Block

Latitude 61°00'00" - 61°45'00" North
Longitude 120°45'00" - 121°45'00" West



PHYSIOGRAPHIC PROVINCES OF SOUTHERN N.W.T.

(Modified from deWit et al 1971)

Figure 3.2

Terrain in the study area varies from extreme muskeg flats with minimal elevation change to lightly wooded areas and gently rolling hills. Seismic lines were rough due mostly to small frozen muskeg hummocks. Numerous bodies of water both large and small were found throughout the project area. Elevations ranged from 190-400 metres in the west and 170-250 metres in the east with mean elevations of 300 and 214 metres respectively.

Weather conditions during March and April were normal with temperatures ranging from +7° C to -46° C and calm to moderate winds with occasional gusts. Overcast days with occasional snowfalls were infrequent allowing production to continue with no time lost because of poor weather conditions.

Drilling was hampered by the presence of surface rocks, gravel, muskeg, sandy clay, limestone, shales, and shattered hard grey sandstone.

Access to each camp was obtained by plowing from nearby existing roads and accesses.

3.1.2 Seismic Operations

Enertec Geophysical, the prime contractor for seismic acquisition, deployed DFS-V recorders with 120 channel symmetrical split spreads designed to record both shallow and deep events in the most economic and efficient manner possible. A NE/SW line orientation was considered optimum for delineating the reef and mapping shelf edges.

A total of 48 residents of the Northwest Territories were hired for this project - 27 in the East Fort Simpson block and 21 in the west.

Tables 3.1, 3.2, 3.3, 3.4A and 3.4B summarize project chronology, production, drilling, and organization.

	EAST	WEST
Mobilization date:	March 7, 1985 (Camp & Surveyors) March 9 (Recording Crew)	March 20, 1985
Recording start up:	March 11	March 20
Recording completion:	April 3	April 3
Surveying start up:	March 11	March 12
Surveying completion:	March 28	April 1
Bulldozing start up:	March 1	March 1
Bulldozing completion:	April 4	March 31
Drilling start up:	N/A	March 15
Drilling completion:	N/A	April 3
Demobilization date:	March 30 (Surveying) April 6 (Recording)	April 4, 5, 6

TABLE 3.1 SEISMIC PROJECT CHRONOLOGY

	EAST	WEST
Total recording days:	23	15
Total weather days:	Nil	Nil
Total moving days:	Nil	Nil
Total equipment malfunction days:	Nil	1
Total programme standby days:	Nil	Nil
Total testing days:	1	Nil
Total equipment down days:	Nil	Nil
Total kilometres shot:	219.85	182.15
Average kilometres shot per recording day:	9.55	12.14
Total days mobilization:	2	0.5 (Moved from Island R. E.A.)
Total days demobilization:	3	3

TABLE 3.2 SEISMIC PRODUCTION

Total drilling days:	20 days
Total weather days:	Nil
Total number of metres drilled:	21,858 metres
Total number of hours drilling:	*1,332 hours
Average number of metres drilled per hour:	16.40 metres
Total days mobilization:	Moved from Island River E.A.
Total days demobilization:	2 days

NOTE: * This figure includes driving time, which was very high due to the logistics of the programme and the limited day light.

TABLE 3.3 SEISMIC DRILLING (WEST FORT SIMPSON)

RECORDING:	
Crew Manager	1
Observer	1
Junior Observer	1
Vibrator Operators	4
Line Truck Drivers	4
Vibrator Technician	1
Line Helpers	12
Mechanic	1
Supply Driver	1

SURVEYING:	
Surveyors	2
Chainmen	2
BULLDOZING:	
Cat Supervisor	1
Cat Operators	10
Skidder Operators	2
CATERING:	
Cooks	2
Camp Attendant	1

TABLE 3.4A PROJECT ORGANIZATION (EAST FORT SIMPSON)

RECORDING:	
Crew Manager	1
Observer	1
Junior Observer	1
Shooter	1
Shooter's Helper	1
Line Truck Drivers	4
Line Helpers	8
Clerk	1
Mechanic	1
Supply Driver	1
Gravity Operator	1
Environmental Monitor	1
DRILLING:	
Drill Push	1
Drillers	6
Driller's Helpers	6
Water Truck Drivers	2

SURVEYING:	
Surveyors	2
Chainmen	2
BULLDOZING:	
Cat Supervisor	1
Cat Operators	5
CATERING:	
Cooks	2
Camp Attendant	1
FIRST AID:	
Attendant	1

TABLE 3.4B PROJECT ORGANIZATION (WEST FORT SIMPSON)

3.1.3 Gravity Operations

Land gravity data were also collected simultaneously by two contractors: MWH Geophysics for the east block, and Murex Gravity Surveys for the west.

Table 3.5 summarizes project chronology and production for each area.

	EAST	WEST*
PROJECT CHRONOLOGY		
Mobilization Crew 1	3 days - March 5, 6, 10	N/A
Mobilization Crew 2	1.5 days - March 22, 23	N/A
Demobilization Crews 1 & 2	3 days - April 2, 3, 4	N/A
Standby Days	1 day - March 11	N/A
Base Ties	1 day - March 11, 12	N/A
PRODUCTION		
Total number of stations	2418	1448
Total number of lines	5	7
Total distance run	224.5 km	182 km

TABLE 3.5 GRAVITY PROJECT CHRONOLOGY AND PRODUCTION

* Note: Murex Gravity Surveys did not submit a report with details of its field data acquisition. Production figures were calculated from the actual number of data points on the field tapes.

3.2 Seismic Data Acquisition

3.2.1 Land Survey System

Land surveying was carried out by four-man crews in each block using a Theodolite and an EDM. In the west block, use of a skidoo was found most convenient as a means of transportation because of terrain and climatic conditions.

Vertical and horizontal surveys controlled inaccuracies in elevations, and the coordinates of existing wellsite locations within the program area required the development of a satellite positioning system. Satellite receivers aided in establishing the horizontal points, improving the accuracy of the surveying considerably.

Newly cut line locations were determined from stadia distances from the already established points.

3.2.2 Equipment, Instruments and Calibration

Hemi-5000 Vibrator equipment, mounted on 1984 International Paystar 5070 6x6 trucks, was used for the first time as a surface energy source by Petro-Canada. The production and data quality obtained met Petro-Canada's expectations for seismic data from a comparatively shallow zone (200-500 msec two-way time).

For the conventional crew (west block), buggy and wheeled top drive drills were used.

Tables 3.6A and 3.6B list equipment and instruments used in each area.

RECORDING INSTRUMENTATION		
Amplifiers	Texas Instruments	DFS-V
Tape System	Texas Instruments	DFS-V
Camera	S.I.E.	ERC-10
Oscilloscope	Tektronics	
Correlator	Real Time	Input/Output
Computer	Max Advance I	
Vibrator Electronics	Pelton Advance 1-5	
Cables	Mark Productions	433 metres in length with 55 group intervals Terra-Con heads
Geophones	Mark Products	L-28-14 Hz. 710 OHM Coil - 60% dampening
Vibrators	Hemi-5000	4
SURVEYING		
1	Wilde Theodolite	
1	EDM	

TABLE 3.6A SEISMIC AND SURVEY INSTRUMENTS
(EAST FORT SIMPSON)

RECORDING INSTRUMENTATION

Amplifiers	Texas Instruments	DFS-V
Tape System	Texas Instruments	DFS-V
Camera	S.I.E.	ERC-10
Cables	Mark Products	400 metre cable
Geophone strings	Mark Products L-28	14 Hz.
Geophone Type	Mark L-28	14 Hz.

SURVEYING

1	Wilde Theodolite
1	Skidoo
1	EDM

DRILLING

ARDCC INDUSTRIES	
3	Wheeled top drive drills
1	Buggy Sewel drill
4	4 x 4 Support Trucks
LANDMARK DRILLING	
1	Buggy top drive drill
1	4 x 4 Support Truck
ELGIN EXPLORATIONS	
1	Wheeled top drive drill
1	4 x 4 Support Truck
BARRET DRILLING	
1	Wheeled top drive drill
1	4 x 4 Support Truck

TABLE 3.6B SEISMIC AND SURVEY INSTRUMENTS
(WEST FORT SIMPSON)

3.2.3 Recording Parameters

Source-detector geometry for the vibrator crew (east block) was 1008-64-X-64-1008 (m) with a group interval of 16 metres.

and a vibrating interval of 96 metres (Figure 3.3). The detector array geometry used was 9 geophones in line over 16 metres.

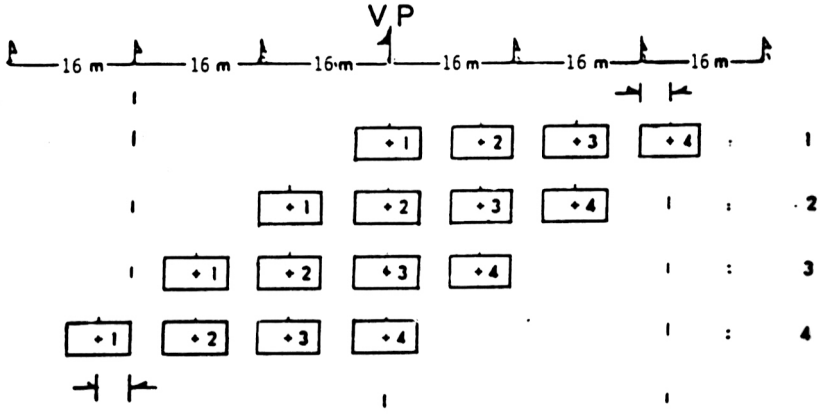
For the conventional crew (west), the source-detector geometry was 1500-25-X-25-1500 (m) with a group interval of 25 metres. The detector array geometry used was 9 geophones in line over 25 metres.

Tables 3.7A and 3.7B list the final recording parameters used by each crew. Because vibrators had not been used previously in this area, extensive testing was carried out to determine these parameters.

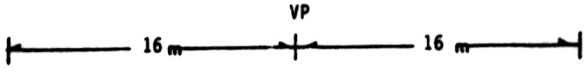
Sample rate:	2 milliseconds
Record length:	2 seconds
Recording Filter	Low cut-18 Hz., high cut-128 Hz.
Sub-surface Coverage	1000%
No. of Groups	120
Group Interval	16 metres
Group Array	Inline array over 16 metres
Seismometres per Group	9
Vibrating Interval	96 metres
Spread Length	1008-64-X-64-1008
Energy Source	4 Hemi 5000 Vibrators
Number of Sweeps & Sweep Lengths	4 sweeps at 12 seconds, 0.30 Taper
Sweep	Non-linear, 0.3 db/octave pre-emphasis
Sweep Frequency	14-96 Hz.
Total Drag/ Total Array Length	36 metres/72 metres

TABLE 3.7A RECORDING PARAMETERS (EAST FORT SIMPSON)

VIBRATORS ON ONE VIBE POINT



VIBRATORS stacked Bumper-to-Bumper, IN-LINE, Maximum distance = 2 meters.



1 DRAG COVERS 72 METERS

Figure 3.3

Sample rate:	2 milliseconds
Record length:	4 seconds
Recording Filter	Low cut-18 Hz., high cut-128 Hz.
Sub-surface Coverage	1200%
No. of Groups	120
Group Interval	25 metres
Group Array	Inline array over 25 metres
Seismometres per Group	9
Shot point Interval	125 metres
Spread Length	1500-25-X-25-1500
Energy Source	1 kilogram of dynamite
Holes per Shot Location	1 or 3 hole pattern
Average Hole Depth	15 metres

TABLE 3.7B RECORDING PARAMETERS (WEST FORT SIMPSON)

3.3 Gravity Data Acquisition

The initial gravity base for the East Fort Simpson survey was established from Government station #9178 at the Fort Simpson airport. Four additional base stations were established in the field with double run base loops from the government base.

Gravity was observed at every shot point (96 metres) along the seismic lines. Eighty (80) repeat readings were made from which an RMS mistie of 0.02 mgals was determined. Gravity readings were taken to the nearest 0.01 mgal and inner zone terrain corrections were estimated in the field to a distance of 600 feet (183 metres) around the station where the terrain dictated.

Table 3.8 summarizes instruments and equipment used in the eastern gravity survey.

1 Lacoste and Romberg G-Meter #332
(Conversion Constant = 1.06251)

1 Lacoste and Romberg G-Meter #725
(Conversion Constant = 1.02040)

2 Hewlett-Packard 72B portable computers

1 Jeep 4 x 4 truck

2 Toyota 4 x 4 trucks

2 all terrain vehicles

TABLE 3.8 GRAVITY INSTRUMENTS AND SUPPORT EQUIPMENT
(EAST FORT SIMPSON)

In the western block gravity was observed at every other shot point (every 250 metres) using Lacoste and Romberg 'G' type land gravity meters.

3.4 Geophysical Data Processing

3.4.1 Seismic

Seismograph Service Corporation of Canada was contracted by Petro-Canada Inc. to process the seismic data comprising 12 lines totalling 403.1 kilometres. The final processing format used in each area is given in Tables 3.9A and 3.9B.

Line Numbers	8103, 8106, 8108, 8110, 8112
1. Demultiplex	2 msec sample rate
2. Trace Edit	
3. Phase Compensation	Geophones
4. Gain Recovery	
5. CDP Sort	
6. Minimum Phase Spiking Deconvolution:	
a) Operator length	48 msec.
b) Prewhitening	0.1%
c) Design Window	200-600 msec @ 64 metres offset 500-800 msec @ 1008 metres offset
7. Trace Equalization	
8. Refraction (Drift/Datum) Statics	
a) Datum	250 metres
b) Replacement velocity	3100 metres/second
c) Weathering velocity	700 metres/second
9. Velocity Analysis	Constant velocity stacks
10. Normal Moveout Correction	
11. First Break Mute	Offset (m) 290 310 1008 Time (msec) 0 200 500
12. Residual Surface Consistent Statics:	200-600 msec window
13. CDP Trim Statics	200-600 msec window
14. CDP Stack	1000%
15. Final Filter	Ormsby 14/18-128/150 Hz.
16. Trace Amplitude Equalization	Window 1: 0-200 msec Window 2: 200-600 msec
17. Display to Film	Scale-horizontal -36 traces /inch -vertical -10 inches /second -CDP interval-8 metres

TABLE 3.9A PROCESSING PARAMETERS (EAST FORT SIMPSON)

Line Numbers	8100, 8101, 8102, 8104, 8114, 8116, 8118
1. Demultiplex	2 msec sample rate
2. Trace Edit	
3. Phase Compensation	Instrument & Geophone
4. Gain Recovery	
5. CDP Sort	
6. Minimum Phase Spiking Deconvolution:	
a) Operator length	48 msec.
b) Prewhitening	0.1%
c) Design Window	200-1100 msec @ 25 metres offset 900-1400 msec @ 1500 metres offset
7. Trace Equalization	
8. Refraction (Drift/Datum) Statics	
a) Datum	250 metres
b) Replacement velocity	3100 metres/second
c) Weathering velocity	700 metres/second
9. Velocity Analysis	Constant velocity stacks
10. Normal Moveout Correction	Offset (m) 250 275 1500 Time (msec) 0 300 700
11. First Break Mute	
12. Residual Surface Consistent Statics:	250-900 msec window
13. CDP Trim Statics	200-800 msec
14. CDP Stack	1200%
15. Final Filter	Ormsby 10/24-80/90 Hz.
16. Trace Amplitude Equalization	Window 1: 0-300 msec Window 2: 300-700 msec
17. Display to Film	Scale-horizontal -36 traces /inch -vertical -10 inches /second -CDP interval-12.5 metres

TABLE 3.9B PROCESSING PARAMETERS (WEST FORT SIMPSON)

The data were tested using a variety of spiking and predictive deconvolution operators. Test stacks were created to compare chosen deconvolution types with raw stacks. A spiking deconvolution operator designed primarily over the shallow data zone proved to best compress the signal and enhance resolution, and was used in both the dynamite and vibroseis surveys.

For refraction statics, first breaks were picked automatically but were closely monitored by the analyst. Static calculations were based on deviations of individual picks from best fit velocity curves for a two layer case.

Vibrator lines presented problems with statics, most likely the result of apparent phase distortions seen in the first breaks (a problem common to vibroseis data). Although first break picking was carefully guided so as not to leg jump, some static busts and cycle skips did occur when passing through the automatic statics routine. In these areas shot and receiver statics were hand-picked and put through automatic statics again.

Permafrost created several bad static patches, most noticeably in the dynamite data. First break arrivals deemed to be permafrost direct arrivals had to be discarded from the useable refraction picks for use in the statics routine. Again, shot and receiver statics were hand-picked and corrections applied.

3.4.2 Gravity

Field processing was done by the contractor and included conversion of meter readings to milligals, plus drift and tidal

corrections. Inner zone terrain corrections were estimated by the field operator. In Calgary Bouguer gravity was calculated using a crustal density of 2.35 grams/cc, to which was added outer zone terrain corrections. The contractor supplied Petro-Canada Inc. with the following data on magnetic tape:

Bouguer gravity
Free-air gravity
Observed gravity meter reading
Tidal and drift corrections
Elevations and elevation correction
Latitude and longitude, UTM N&E
Inner zone terrain corrections
Line number and station number
Time and date of meter reading

Final processing by Petro-Canada's Gravity and Magnetics group was as follows:

1. Merging line oriented data into the Merged Survey File (MSF).

2. Correcting for discrepancies at line intersections using systematic adjustments.

3. Low-pass filtering of the Bouguer anomalies.

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

SECTION FOUR

INTERPRETATION OF RESULTS

4.1 Regional Geology

4.1.1. Physiography

The Fort Simpson Study area is located in the Great Slave Plain, the southernmost physiographic province of the Northern Interior Plains (Figure 3.2). Locally the terrain varies from flat and lightly wooded areas to gently rolling hills having average elevations ranging between 200 and 300 metres above sea level. To the north and south of the study area, the flats are interrupted by plateaus which rise to elevations of more than 600 metres. The entire plain drains into the Great Slave Lake, the Mackenzie River or the Liard River.

4.1.2 Structural Setting

The area was relatively stable during the Paleozoic and Mesozoic Eras. Paleozoic strata dip very gently to the southwest within the study area. The Precambrian, which is generally flat except for minor faults and folds, largely determines the structural configuration of the overlying sedimentary sequence. Major structural movements during late Silurian/Lower Devonian time (Caledonian epeirogeny) and late Cretaceous /early Tertiary time (Laramide orogeny) resulted in uplift, deformation, and erosion of all units.

Glaciation from the east and south occurred several times during the Pleistocene Epoch leaving varying thicknesses of glacial drift over the Interior Plains. A maximum of 120 metres of drift has been recorded in wells within the Fort Simpson area.

Figure 3.2 shows prominent local features such as the Tathlina Arch and Horn Plateau.

4.1.3 Stratigraphy

The stratigraphic succession ranges from Precambrian to Upper Devonian and possibly Cretaceous with an overlying glacial till of varying thickness (Figure 4.1).

During Paleozoic time, carbonates, clastics, and evaporites were deposited in predominantly marine environments. In Lower Devonian times the stable shelf was emergent, resulting in erosion of strata of Cambrian, Ordovician and Silurian ages over a widespread area. Thus Middle Devonian Bear Rock anhydrites of the Chinchaga Formation were deposited over basal clastics and Proterozoic rocks. Following a regional regression the detrital shale of the Ebbutt Member was deposited. The dolomitized Willow Lake Member of the Upper Chinchaga Formation was laid over this and a second regression occurred along with gentle subsidence. This resulted in an unconformable contact with the overlying Lonely Bay limestone, a widespread carbonate unit deposited over a shallow shelf or platform in relatively quiet waters. Stratigraphic equivalents of this limestone - the lower member Keg River and Nahanni Formations - served as carbonate platform units for pinnacle reef development of the Horn Plateau Formation.

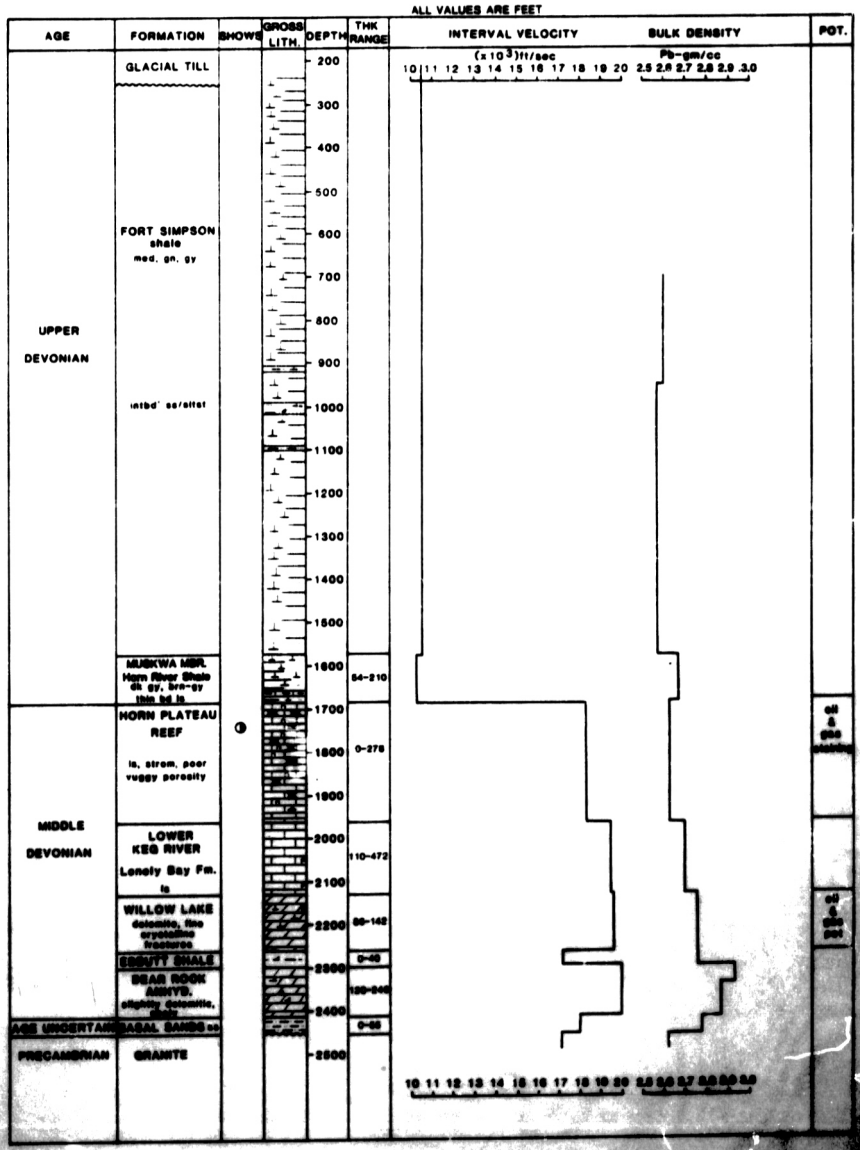
Figure 4.1

SONIC/DENSITY STRATIGRAPHIC COLUMN MODEL

FORT SIMPSON

SOUTHERN NORTHWEST TERRITORIES

REFERENCE WELLS: RABBITSKIN I-08, REDKIFE H-28,
JEAN-MARIE N-73, SIMPSON O-24A



A change in the depositional environment during Upper Devonian time resulted in deposition of clastics - mainly marine shales and sandstones. The Muskwa Member (Horn River Shale) is a clean, highly organic, radioactive shale which conformably overlies the Horn Plateau Reef Formation. The remainder of the stratigraphic sequence generally consists of Upper Devonian Fort Simpson shales with interbedded sands and siltstones and the Jean-Marie Limestone Member. These units are unconformably overlain by glacial drift.

Although post-Devonian sediments do not appear in wells examined for this report, Cretaceous sediments outcrop just north and west of the Fort Simpson E.A., suggesting they may occur within this area as well.

4.1.4 The Prospect

Exploration of the Horn Plateau reef as a primary hydrocarbon target in the Fort Simpson area was based on the geological history of the region and past drilling results. Early drilling from 1967-1970 first revealed the presence of the reef.

Studies done in this area suggest the possibility of reef development in a northeast-southwest trend, possibly along a major regional fault.

It is possible that the Horn River reef may have acted as both source and reservoir with the Muskwa shale providing a seal. A deeper source is also possible since oil stains and gas bleeding have been recorded in the Lonely Bay, Keg River, and Horn River Formations. Unfortunately, stratigraphic analyses of well data indicate poor porosity associated with salt water in the Horn Plateau Formation. Wells with hydrocarbon shows are indicated in Figure 4.2.

Secondary targets might be Horn River reef development along the flank of the Tathlina Arch.

4.2 Correlation of Geology to Geophysics

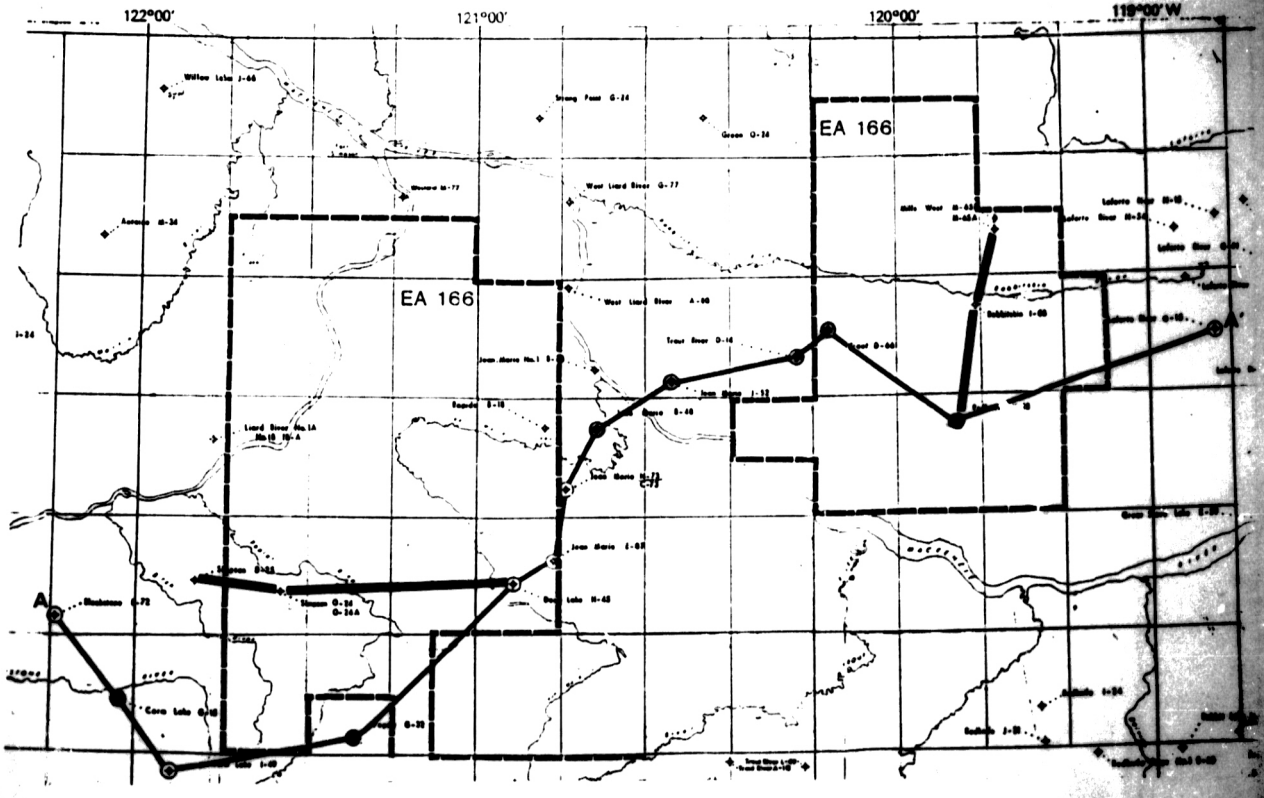
4.2.1 Velocity Information

Velocity analysis for data processing was carried out at 2 kilometre intervals through a constant velocity stack program. For a general estimate of interval velocities in the Fort Simpson area, four representative wells were analyzed: Rabbitskin I-08, Redknife H-28, Jean-Marie N-73, and Simpson O-24A (Figure 4.2). Interval velocities, which were quite similar, were averaged and represented by a single curve (Figure 4.1).

A similar method was used to calculate an average velocity for time to depth conversions since again the values were consistent from well to well.

4.2.2 Seismic Correlation

Seismic reflections were identified by correlating sections with synthetic seismograms from local wells. Synthetic seis-



● HYDROCARBON SHOWS

SONIC/DENSITY LOG (Sections Studied)

0 10 20km

Figure 4.2

mic packages for the Redknife H-28 and Jean-Marie N-73 wells are included with this report (Figures 4.3 and 4.4).

Due to limited data resolution and a narrow vertical zone of interest (100 msec two-way time), only five horizons were interpreted and mapped with a high degree of accuracy. These are:

1. Precambrian
2. Lower Member Chinchaga Formation (Bear Rock Anhydrite)
3. Lower Member Keg River Formation (Lonely Bay carbonate platform)
4. Horn River Formation (Muskwa Member shale)
5. Jean-Marie Limestone Member

Correlation of the Precambrian with synthetics is not straightforward as only a few wells penetrated the basement. Hence the next closest marker which can be reliably correlated is the top of the Bear Rock Anhydrite. The overlying Ebbut Member Shale provides a considerable impedance contrast thus the Bear Rock Formation is a distinct and almost consistent reflector.

The top of the carbonate deposition - the dolomitized Willow Lake Formation and the Lonely Bay Limestone platform member - is very distinctly identified by a strong continuous reflector due to a velocity contrast with the overlying Horn River shale on the order of 19,500 feet/sec (5945 metres/sec) to 12,000 feet/sec (3658 metres/sec).

There is little contrast in velocities of the Horn River Shale (Muskwa Member) and the overlying Fort Simpson shale. However, the top of the Horn River Shale can be identified on gamma ray logs due to its highly radioactive nature and hence correlated with the synthetics.

The Jean-Marie Limestone Member of Upper Devonian age, a strong reflector rapidly outcropping along a NW/SE trend, is easily identified and correlated on the synthetics as well.

4.3 Presentation of Results

4.3.1 Data Quality

Overall data quality was excellent. Problem areas occurred near creeks, streams, and lakes where the signal-to-noise ratio decreased dramatically. Vibrator lines presented some problems with statics due to first break phase distortions, while dynamite lines had several bad static patches due to permafrost.

4.3.2 Seismic

The Fort Simpson project involves NTS grids 85E and 95H. Figures 4.5A and 4.5B are seismic base maps for the two blocks showing the location of the 1984/85 seismic surveys and wells in the area.

The following maps were produced at a scale of 1:100,000 for each block:

1. Precambrian Time Structure — Figures 4.6A & 4.6B

2.	Top Lower Member Keg River Fm. (Lonely Bay Fm.) Time Structure	Figures 4.7A & 4.7B
3.	Top Horn River Fm. (Muskwa Member Shale) Time Structure	Figures 4.8A & 4.8B
4.	Top Lower Member Keg River Fm. to Precambrian Isochron Map	Figures 4.9A & 4.9B
5.	Top Horn River Formation to Top Lower Member Keg River Fm. Isochron Map	Figures 4.10A & 4.10B

In addition, a depth structure map was generated for the Top Lower Member Keg River Formation at a scale of 1:250,000 (Figure 4.11). A constant average velocity of 10,450 feet/sec (3,185 metres/sec) was determined by studying eight wells in the area. By incorporating depth values from the wells it was possible to generate a map including the area between the two Fort Simpson blocks. All the above maps were generated by a computer mapping program.

Note: Land shown on these maps (and in Figure 1.1) are boundaries after 1985 land relinquishments. Other figures in the text use 1984/85 land boundaries.

4.5.3 Gravity

The following gravity maps were produced at a scale of 1:100,000 for each Fort Simpson block using data from the 1984/85 geophysical survey:

1.	Gravity Station Index Map	Figures 4.12A & 4.12B
2.	Bouguer Gravity Contour Map	Figures 4.13A & 4.13B
3.	Bouguer Gravity Fence Diagram	Figures 4.14A & 4.14B
4.	Residual Gravity Fence Diagram	Figures 4.15A & 4.15B

4.4 Discussion of Results

4.4.1 Precambrian and Devonian Morphology

The structural maps show a gentle southwesterly regional dip which is interrupted twice over the east block by flattening of the formations, in particular across Rabbitskin I-08 and northwest of Redknife H-28 (Figures 4.6-4.8).

The sub-surface is characterized by broad and gentle folds, mostly in the east block. Except for a few minor basement faults which hardly extend above the evaporites, the faults at Rabbitskin I-08 and Redknife H-28 extend up to the Horn River Shale Formation.

The uniformity of structural configuration is broken on a minor scale by faulting of the basement. The Bear Rock Formation, which almost directly overlies the Precambrian, is therefore invariably but only minutely affected.

The absence of major faulting in the area along with deposition during Middle Devonian time in a relatively quiet environment suggest that the sedimentary sequence is generally determined by the structural configuration of the Precambrian basement.

A considerable exception, however, is due to the growth of pinnacle reefs such as that found over the Redknife H-28 well. The reef, developed on the Lonely Bay Platform results in draping of the Horn River Formation over the reef. Porosity pockets which develop can be observed on the seismic.

4.4.2 Isochrons

The isochron maps, particularly the Horn River Shale to the Top of Lonely Bay Platform, indicate thinning of the shale section over reef occurrences (Figure 4.10). Otherwise, the two isochron maps represent identical features (cf Figure 4.9).

4.4.3 Geophysical Anomalies

Several 'leads' based upon pinnacle reef occurrences are indicated by the seismic, most noteable of these are observed at the following locations:

Line 8106 SP 448
Line 8108 SP 1504 and SP 2176
Line 8112 SP 800 and SP 1232

It may also be noted that shelf edges can be traced from changes in the regional southwesterly dip of the Lonely Bay platform, which could be favourable locations for reef growth.

Interpretation of the present study has, however, resulted in the mapping of three anomalies - two based on reefs with porosity development, the third on a structural high. These anomalies are described as follows:

Redknife

The Redknife Anomaly, located 3 kilometres southwest of the intersection of lines 8103 and ~~8016~~ 8106 (in the east block) is an anticlinal feature with its axis laid in a northwest - southeast direction (Figure 4.7A).

The feature is based on a huge reefal buildup over the Lonely Bay carbonate platform and is flanked by two normal faults along its strike. Seismic indicates the development of porosity. Aerial closure over the Lonely Bay Structure is approximately 5 square kilometres corresponding to a seismic closure of forty msec.

Seismic lines 8103 and 8106 cross over this feature as indicated in figures 4.16 and 4.17.

Redknife H-28 well, drilled over the southern flank on the downthrown side of the fault, shows 423 feet of reef with spotted oil staining in the Keg River Formation. The quality of this reservoir is marred by poor vuggy porosity and the presence of salt water.

Further to the northwest and southwest of the anticlinal axis, there is no seismic control.

Rabbitskin

The Rabbitskin Anomaly also in the east block, is based on a comparatively smaller reef development as seen on line 8103, just south of the intersection of lines 8103 and 8110. The anomalous feature is flanked by two minor faults as shown in Figure 4.7A.

Rabbitskin I-08 well was drilled over this feature, producing 20 metres of reef without any hydrocarbon shows.

The structural configuration of this anomaly is highly speculative because of lack of seismic control; and therefore no statistics for this anomaly are available.

Fort Simpson

A third feature, called the Fort Simpson Anomaly, is a structural high with one of its noses plunging over SP 1024 of line 8104 (Figure 4.7B). Again due to lack of seismic control, the configuration and orientation of this feature cannot be envisaged with certainty. The isochron map of the Horn River Shale shows general thinning in a northwest-southeast direction (Figure 4.10).

Gravity Results

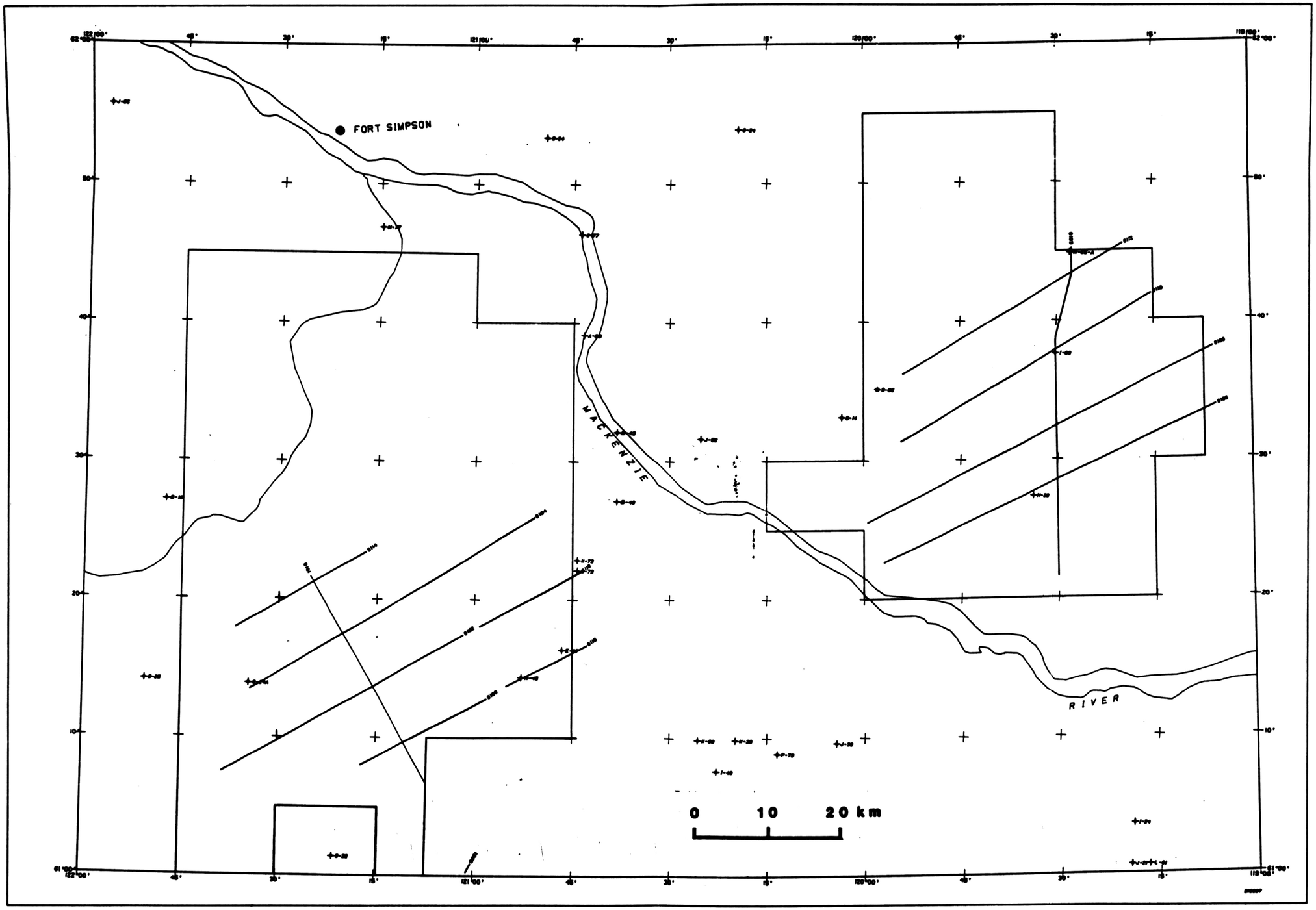
The density of the Lonely Bay carbonate platform is almost identical to the overlying Horn River Shale. Hence small pinnacles show up as very small gravity anomalies (+ .2 to .3 mgal) and are hard to estimate at profile scale.

Larger features (Rabbitskin and Redknife) generally show little to no gravity anomaly, implying little to no density contrast with the Muskwa Member shale. A few small gravity anomalies (line 8106, SP 1700-1980; line 8110, SP 1056) are evident which suggest lateral porosity changes near the top of the structure, but detailed modelling would be needed to check that.

A large anomaly (3.5 mgal low) over the Redknife structure on line 8103 SP 6812 implies a huge negative density contrast in the structure (-.5 g/cc) or a large volume negative density contrast over the structure. A 10 metre dip in elevation suggests something extends to the surface.

In many cases broad gravity lows with sharp sides (shallow source) correspond to areas of obvious statics problem. In other areas direct evidence for statics problems is less evident. These shallow gravity sources could possibly be permafrost lenses. Gravity appears to be offering an independent confirmation of this sort of problem in this area.

In summary, gravity data in conjunction with seismic provides considerable additional information. Gravity alone, as an initial exploration tool, will not work in this area because there is little to no density contrast between reefs and overlying shales.



FORT SIMPSON E.A. 166
LOCATION MAP OF 1984-85 GEOPHYSICAL PROGRAM

Figure 3.1

Figure 4.16

LINE 8103

HORN PLATEAU REEF DEVELOPMENT

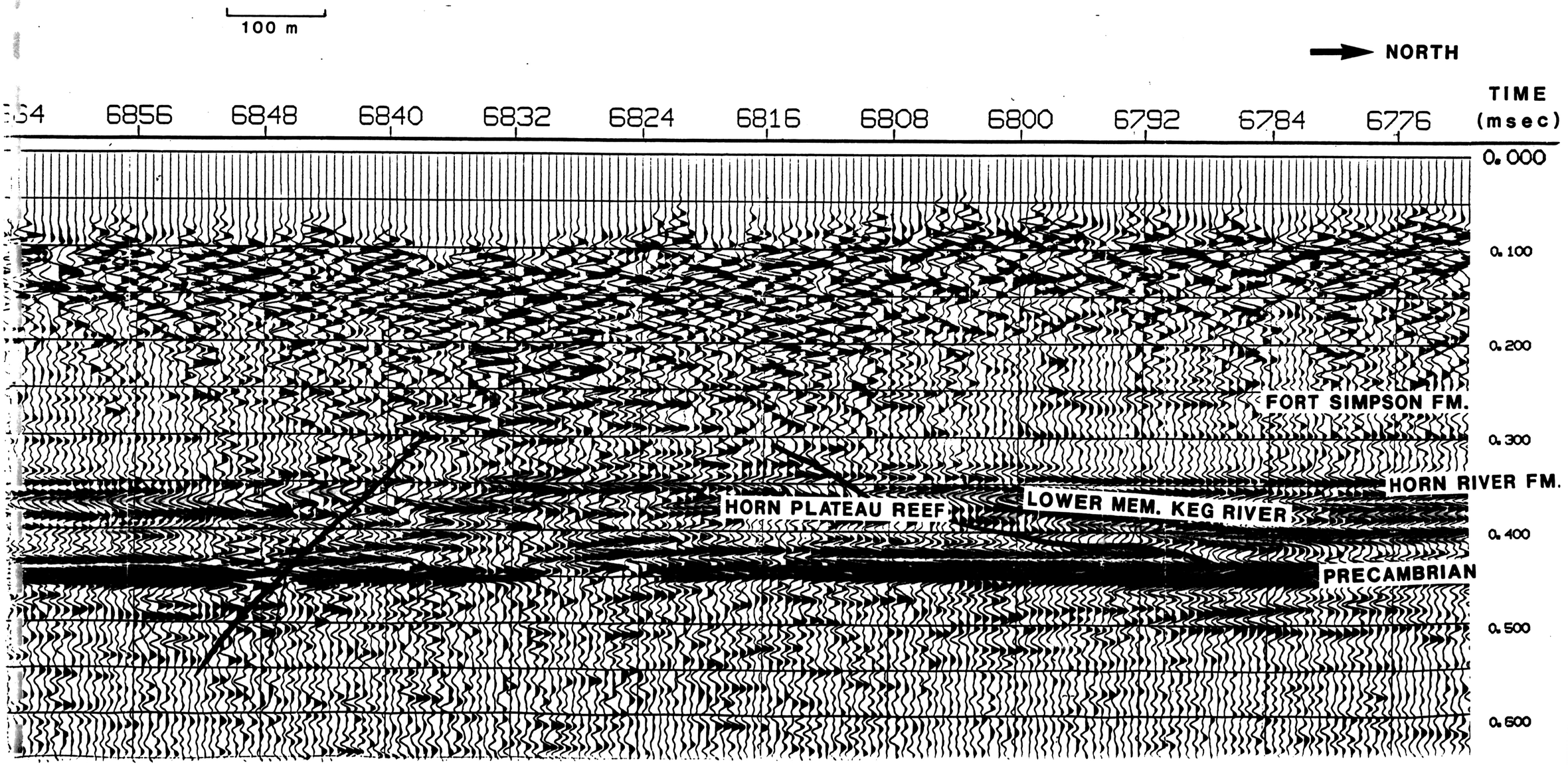


Figure 4.17

TIME	V RMS	V INT
0.000	2880	2880
0.250	3025	3025
0.350	3250	3754
0.750	3490	3687
2.000	4200	4573

3625
1813

LINE 8106

HORN PLATEAU REEF DEVELOPMENT