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PETRO-CANADA

April 2, 1986

Canada Oil and Gas Lands Administration
Administration du pétrole et du gaz des terres du Canada
APR AVR 14 1986
To:
File #:

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-P28-7E
TWEED LAKE 1984/85
PCI File: NOR Program 9229-P28-7E

Please find enclosed in triplicate, copies of the final report for the Tweed Lake Seismic Program No. 9229-P28-7E 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 Tweed Lake Seismic Report
Transmittal List No. 005756

MYLAR + SECTION ALREAD HERE

PETRO-CANADA

TRANSMITTAL LIST

№ 005756

DATE March 19 19 86

TO:	FROM:
COGLA attn:	K.N-Davies Recieved R. Hepburn?

☒ ENCLOSED AS FOLLOWS ☐ UNDER SEPARATE COVER

SENDER'S SIGNATURE [signature]

REFERENCE

NO.	ITEM
	3 copies of the Cogla Reports for EA. 158
	Program. No. 9229-P28-1E.

REMARKS

RECEIVED BY: M. McIntosh DATE: APRIL 16/86 19

176-8411 PLEASE ACKNOWLEDGE RECEIPT BY SIGNING AND RETURNING ATTACHED COPY

Report on the
Geophysical Exploration Survey

PROGRAM NO. 9229-P28-7E

Tweed Lake Survey
Northwest Territories
EXPLORATION AGREEMENT NO. 158

by

Petro-Canada Inc.
April 1986

FIELD WORK PERIOD: January - April, 1985

LAND USE PERMIT NO.: N84B276

AREA COORDINATES: Latitude 66° 10' - 67° 10' North
Longitude 125° 15' - 126° 45' West

DATA ACQUISITION: Reflection Seismograph (Vibroseis) by Western Geophysical Company of Canada Ltd.

Submitted
By

K.N. Davies
Project Geophysicist
NWT Region

J.B. Henry, P. Geoph.
Regional Geophysicist
NWT Beaufort Region

CONTENTS

LIST OF TABLES

LIST OF DATA TRANSMITTED UNDER SEPARATE COVER

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1. 1 Mylar Shot Point Map: 96K, L, M, and N (composite)

2. 15 Seismic Sections: 8600, 8601, 8602, 8603, 8604, 8605, 8606, 8607, 8609, 8610, 8611, 8612, 8613, 8614

   1 mylar and 2 paper copies of each section,(normal and reverse polarities at 7.5 inch/second, 12 traces/inch)

LIST OF FIGURES

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SECTION ONE

INTRODUCTION

Petro-Canada Inc. conducted a geophysical survey over the central part of the Northern Interior Plains in the Northwest Territories during the 1984-1985 winter season. The lands involved were operated by PCI under Exploration Agreement number 158, known as Tweed Lake. See Figure 1.1 for the location of the Exploration Agreement.

The survey was a detailed program designed to obtain subsurface information to delineate features with hydrocarbon potential. A total of 463 kilometres of seismic data were shot.

This report, submitted to COGLA as required by the Exploration Agreement, summarizes the procedures of data acquisition, processing, and the results of the interpretation.

The interpretation of this data incorporated Petro-Canada's existing seismic data. Seismic time structure and isochron maps were produced and are enclosed in the report.

Data which has been sent separately from this report includes mylar copies of the seismic base map and seismic sections, and paper copies of each seismic section.

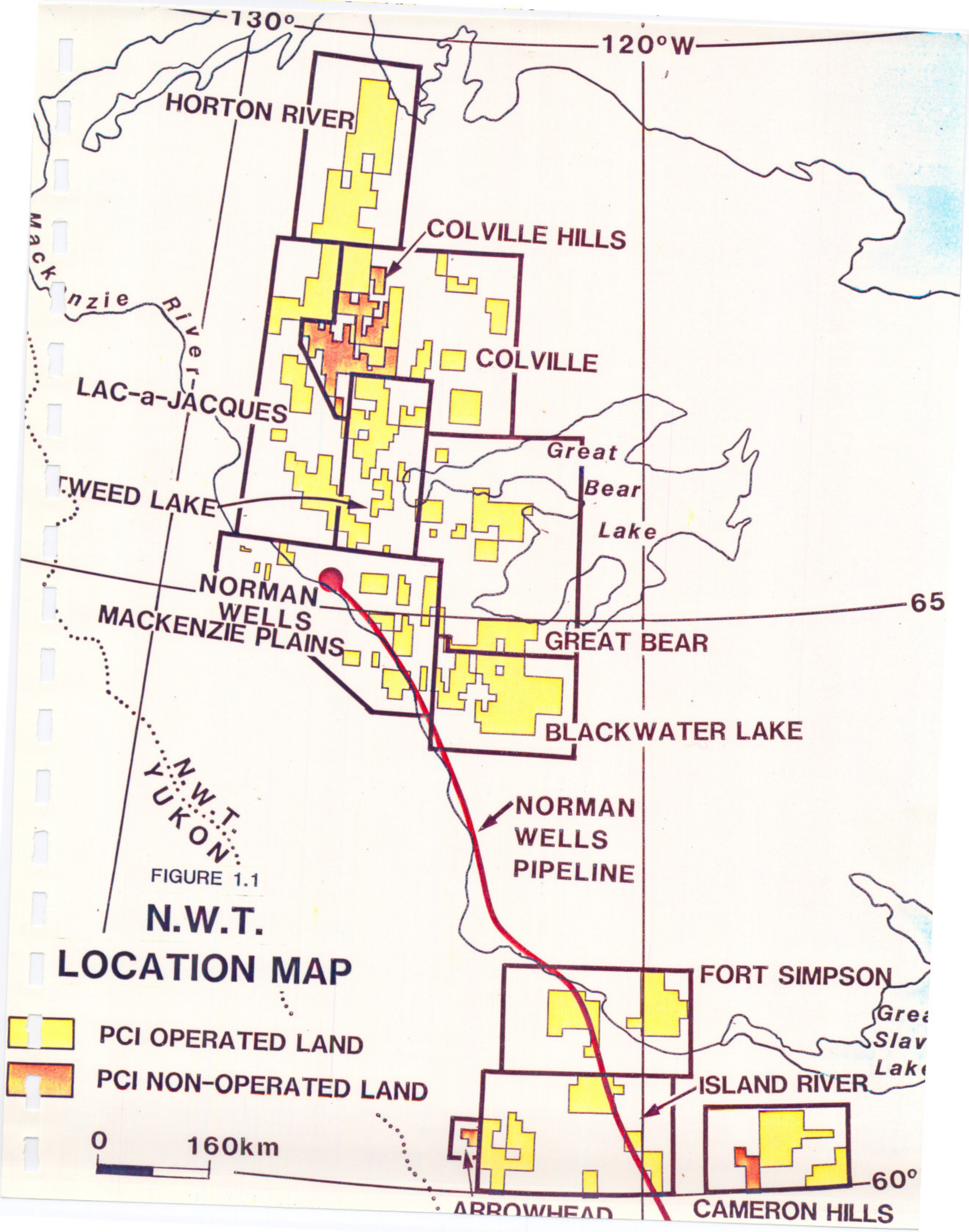

FIGURE 1.1

N.W.T.

LOCATION MAP

SECTION TWO

DATA ACQUISITION AND REDUCTION

2.1 Field Operations Summary

2.1.1 Field Conditions

The Tweed Lake project is characterized by elevations varying from 200-370 metres above sea level. The region contained numerous lakes with a majority being in the southeast portion of the area. The timber was generally of small size.

Weather conditions during the course of the program were normal with temperatures in the -40°C range in February, and moderating into March and April.

2.1.2 Seismic Operations

The survey was conducted by Western Geophysical Company of Canada Ltd. A total of 46 people were employed, of which 44% of the field personnel were native residents.

Two drills accompanied the vibroseis crew to provide refraction data. This program was cancelled on February 8, 1985 due to the slow down it caused in field production.

Tables 2.1, 2.2, and 2.3 summarize the project chronology, production and organization.

Surveyors commenced	January 11, 1985
Drills commenced	January 18, 1985
Recorders left base (Norman Wells)	January 11, 1985
Recording commenced	January 22, 1985
Recording completed	April 3, 1985
Vehicles released on	April 7, 1985

Table 2.1 Project Chronology

Number of kilometres shot	458.66
Number of shots taken	11,466
Number of geophone stations	22,932
Number of recording days	71
Average daily production:	
- kilometres recorded	6.46
- V.P. recorded	162
Days lost due to weather conditions	Nil
Days lost due to equipment failure	1
Total days - mobilization	6
- demobilization	7

Table 2.2 Seismic Production

Misc. Personnel		Catering	
Party Manager	1	Cook	1
Clerk	1	Assistant Cook	1
Mechanic	1	Camp Attendant	1
Mechanic's Helper	1		
Expediter	1	**Line Cutting**	
Expediter Assistant	1	Machine Operators	6
		Foreman	1
Data Acquisition		Cook	1
Vibrator Operators	4	Native Monitor	1
Vibrator Mechanic	1		
Observer	1	**Drilling**	
Assistant Observer	1	Drillers	2
Cable Truck Drivers	4	Driller's Helpers	2
Recording Helpers	9		
Surveying		**N.W.T. Residents**	
Surveyors	2	43	
Rodmen	2		

Table 2.3 Project Organization

2.2 Seismic Data Acquisition

2.2.1 Instruments

Table 2.4 summarizes equipment used for recording, detection, and for the seismic source.

Amplifiers, Tape System	Texas Instruments DFSV
Geophone Strings	Geo-space 20-D 14 Hz.
Energy Source	4 Y-900 MERTZ Vibrators mounted on buggies

Table 2.4 Seismic Instrumentation

2.2.2 **Parameters**

An 80 metre gap on either side of the vibrator point was used, with a cable layout of 1020-80-0-80-1020. The vibrators vibrated continously along the line.

Refraction seismic work for weathering corrections was eliminated part way through the program in an attempt to increase production.

Table 2.5 lists the recording parameters used.

Number of Traces	96
C.D.P. Coverage	2400%
No. of Detectors per Station	9
Geophone Spacing	2.5 metres
Geophone Array	9 over 20 metres
Distance Between Stations	20 metres
Distance Between Vibrator Points	40 metres
Drag Length	40 metres
No. of Sweeps	6
Sweep Frequency	20/100 upsweep
Sweep Length	4 seconds
Sample Rate	2 msec
Record Length	7 seconds
Filter	8 Hz. @ 18db-128 Hz.
Spread Layout	1020-80-0-80-1020

Table 2.5 Recording Parameters

2.2.3 **Survey System**

Two Wild T-16 Theodolite survey instruments were used for horizontal and vertical control, backed by two Sokkisha Red II E.D.M. instruments.

Vibrator point and geophone group location distances were measured using a surveyor's steel road chain.

New cut line locations were derived from topographic features and sun shots. Station elevations were computed by E.D.M. and horizontal locations by latitudes and departures. The survey was tied internally by loops.

2.3 Geophysical Data Processing

The seismic data was processed by Veritas Seismic Ltd. The following processing sequence was used:

1. Demultiplex/Display - 2 ms Sample Rate
2. Correlation
3. Amplitude Recovery - Exponential Function
4. F-K Filtering - Reject = 5 msec/trace
5. Geophone Dephasing
6. Frequency Deconvolution - a) Autocorrelation: 120 msec
   b) Pre-Whitening: 1%
   c) Design Window: 150-800 msec at 80 metres
   300-900 msec at 1020 metres
7. Residual Amplitude Analysis
8. Structure Statics - Elevation Only
9. Trace Gather
10. Normal Moveout
11. Statics - Automatic Surface Consistent
    - Windows: 300-900 msec
12. First Break Mutes - 200 msec at 240 metres
    - 500 msec at 1020 metres
13. Trim Statics - Correlation Window: 300-900 msec
14. Stack
15. Filter - Digital Bandpass - 30/35 - 90/100 Hz
16. Amplitude Equalization - Mean Scale
    - Windows: 250-1000 msec Appl. Point 900 msec
    1000-2000 msec Appl. Point 1100 msec
17. Display to Film - Scale - a) Horizontal: 24 traces/inch
    Vertical: 7.5 inches/sec
    b) Horizontal: 12 traces/inch
    Vertical: 15 inches/sec
    Normal and Reverse Polarities for a)
    Reverse Polarity Only for b)

Drift corrections were not applied as the processor was unable to determine the base of weathering from the vibrator first breaks.

SECTION THREE

INTERPRETATION OF RESULTS

3.1 Regional Geology

The Tweed Lake survey was conducted in the southern portion of the Colville Hills physiographic province, 160 km north of Norman Wells, Figure 3.1.

3.1.1 Structural Geology

A massive sedimentary sequence was deposited in a wedge thickening to the southwest during the Proterozoic. These units were uplifted and eroded prior to deposition of Paleozoic sediments. Later uplifts and movements occurred during Phanerozoic time with major erosional cycles in post-Devonian period, the Laramide Orogeny being the most severe.

The project area is characterized by rolling hills and sharp linear ridges. The most pronounced of these surface features occur at the western boundary of the program area. The Belot Ridge strikes north-south predominantly, while the Tunago Ridge below it is oriented northeast-southwest. Topography on the project's eastern boundary reverses rapidly to trend northwest to southeast, as at the Tweed Lake Dome east of Lac Belot.

Figure 3.2 shows the location of prominent features such as the Belot Ridge and the Tunago Ridge.

3.1.2 Stratigraphy

The stratigraphic column includes rocks ranging in age from Pre-Cambrian to Recent as shown in Figure 3.3.

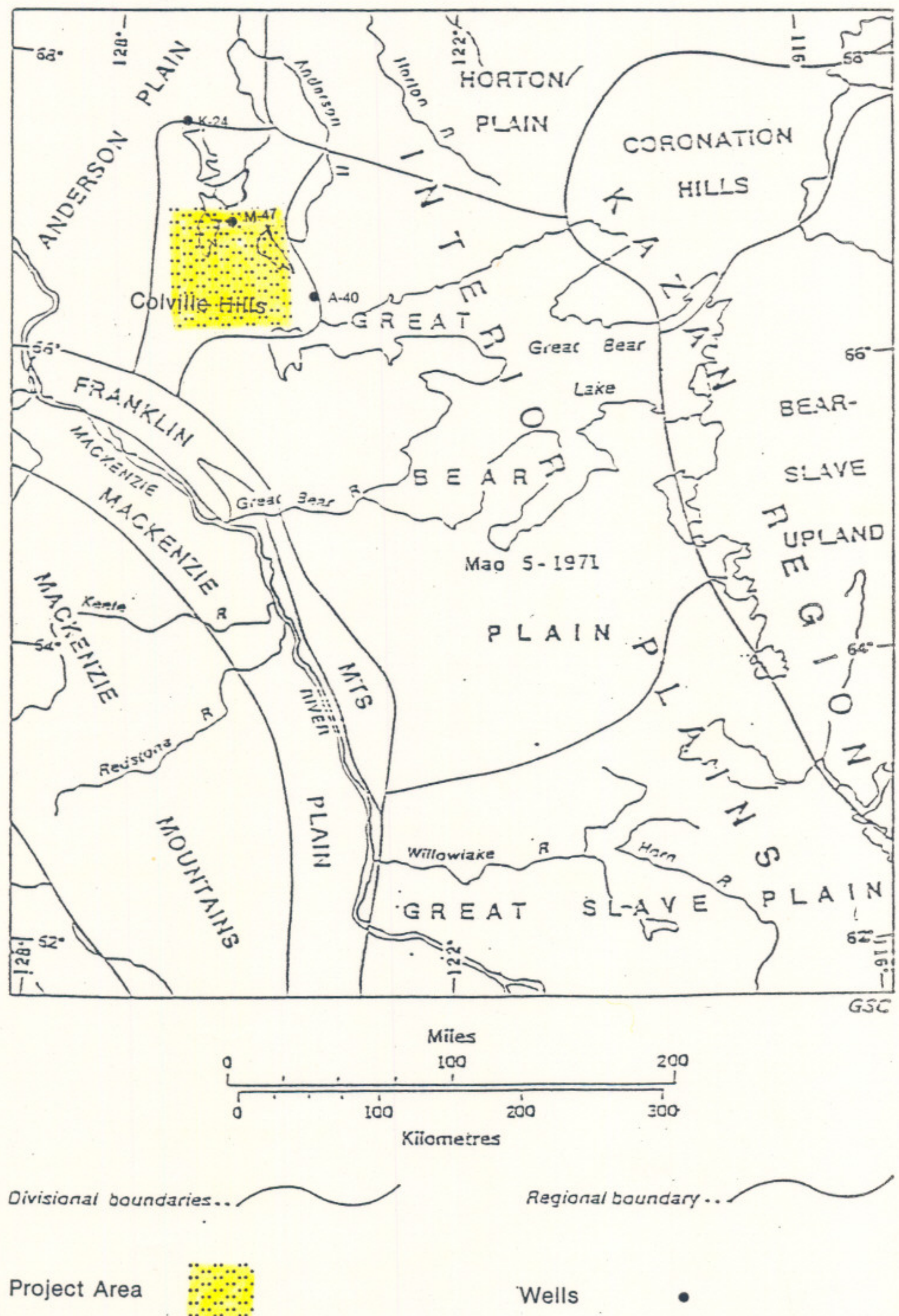

Figure 3.1 Map of the physiographic provinces and well control in the Tweed Lake area (modified from Bostock, 1970).

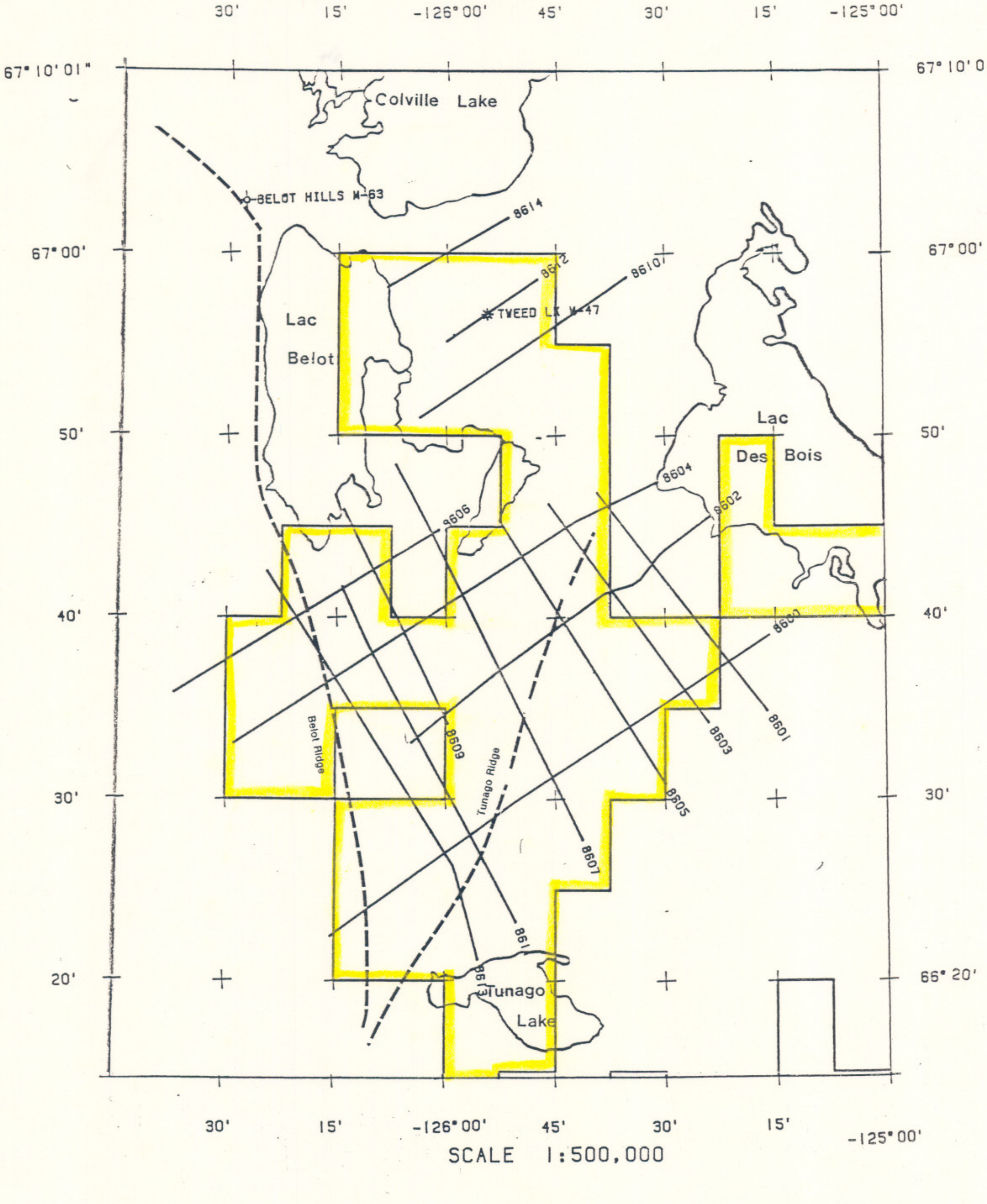

Figure 3.2 Location map of the 1984-85 geophysical program in the Tweed Lake area.

Paleozoic sediments are representative of marine deposition in an epicontinental basin. Of Mesozoic age, only a thin veneer of Cretaceous material is present intermittently. Post-Devonian, pre-Cretaceous, and post-Cretaceous erosional cycles truncate successively older rocks southward.

Lying unconformably on the Proterozoic strata is the basal Cambrian Mount Clark sandstone derived primarily from the Canadian Shield and possibly from the Colville High. The Mount Clark Formation is succeeded conformably by the Mount Cap Formation, a shale unit with interbedded glauconitic sands and dolomite. Above the Mount Cap Formation is the Saline River Formation, composed of shale, dolomite, and evaporites.

Siluro-Ordovician carbonates of the Franklin Mountain and Mount Kindle Formations overlie the Saline River Formation. In the extreme northern part of the project area these carbonates are capped by Devonian Bear Rock dolomite.

Cretaceous clastics and recent glacial material occur in limited areas around the lakes, especially Lac Belot and Lac des Bois, and in kharsted features of varying size.

3.1.3 **The Prospect**

The primary hydrocarbon reservoir in the region is the sand of the Mount Clark Formation. Information on sand thickness and quality is very limited due to the sparse well control. The Tweed Lake M-47 well in the northern portion of the project found 23 metres of well sorted sand, while the Good Hope A-40 well, 30 kilometers southeast of the project, encountered 40 metres of sand. Traps should be formed by blanket sands draped on present day structural highs.

A secondary target is sand stringers within the overlying Mount Cap Formation.

UPPER CRETACEOUS	Unnamed: shale	? Disconformity ?
?		
LOWER CRETACEOUS	Unnamed: sandstone	
Regional Unconformity		
MIDDLE DEVONIAN	HARE INDIAN FORMATION	
	HUME FORMATION	
	BEAR ROCK FORMATION	
Regional Unconformity		
SILURIAN UPPER ORDOVICIAN	MOUNT KINDLE FORMATION	
	Regional Unconformity	
LOWER ORDOVICIAN	FRANKLIN MOUNTAIN FORMATION	Cherty unit
? ?		Rhythmic unit
UPPER CAMBRIAN		Cyclic unit
? ?	SALINE RIVER FORMATION	
MIDDLE CAMBRIAN	MOUNT CAP FORMATION	
	MOUNT CLARK FORMATION	
Regional Unconformity		
PROTEROZOIC	DIABASE DYKES	
	COPPERMINE RIVER SERIES	
	Regional Unconformity	
	DIABASE DYKES	
	HORNBY BAY GROUP	Unnamed: stromatolitic dolomite
		Unnamed: sandstone, conglomerate, quartzite

Figure 3.3 Stratigraphic column for the Tweed Lake area

3.2 Correlation of Geology to Geophysics

Tweed Lake M-47 drilled in 1985 provided the information to tie the geological formations to seismic reflectors. The synthetic seismogram is shown in Figure 3.4. This synthetic is produced from the density and sonic logs and is corrected to the check shot survey.

Wells in the vicinity that were evaluated for the geophysical interpretation include:

Tweed Lake M-47	On line 8612 (also 116A)
Good Hope A-40	30 km southeast

The location of these wells in relation to the survey are shown in Figure 3.1.

Five events were correlated:

Near Top of Salt (shale marker)
Near Top of Mount Cap (a shale marker at the base of the salt)
An upper shale zone in the Mount Cap
Near Top of Mount Clark (a dolomite at the base of the Mount Cap)
Top of Proterozoic

The Near Top Mount Clark to Proterozoic isochron best represents the Mount Clark sand interval. An actual Mount Clark Formation thickness of only 8 milliseconds (2 way time) was encountered at the Tweed Lake well.

A sonic model, Figure 3.5, of the area illustrates the acoustic response of the correlated events.

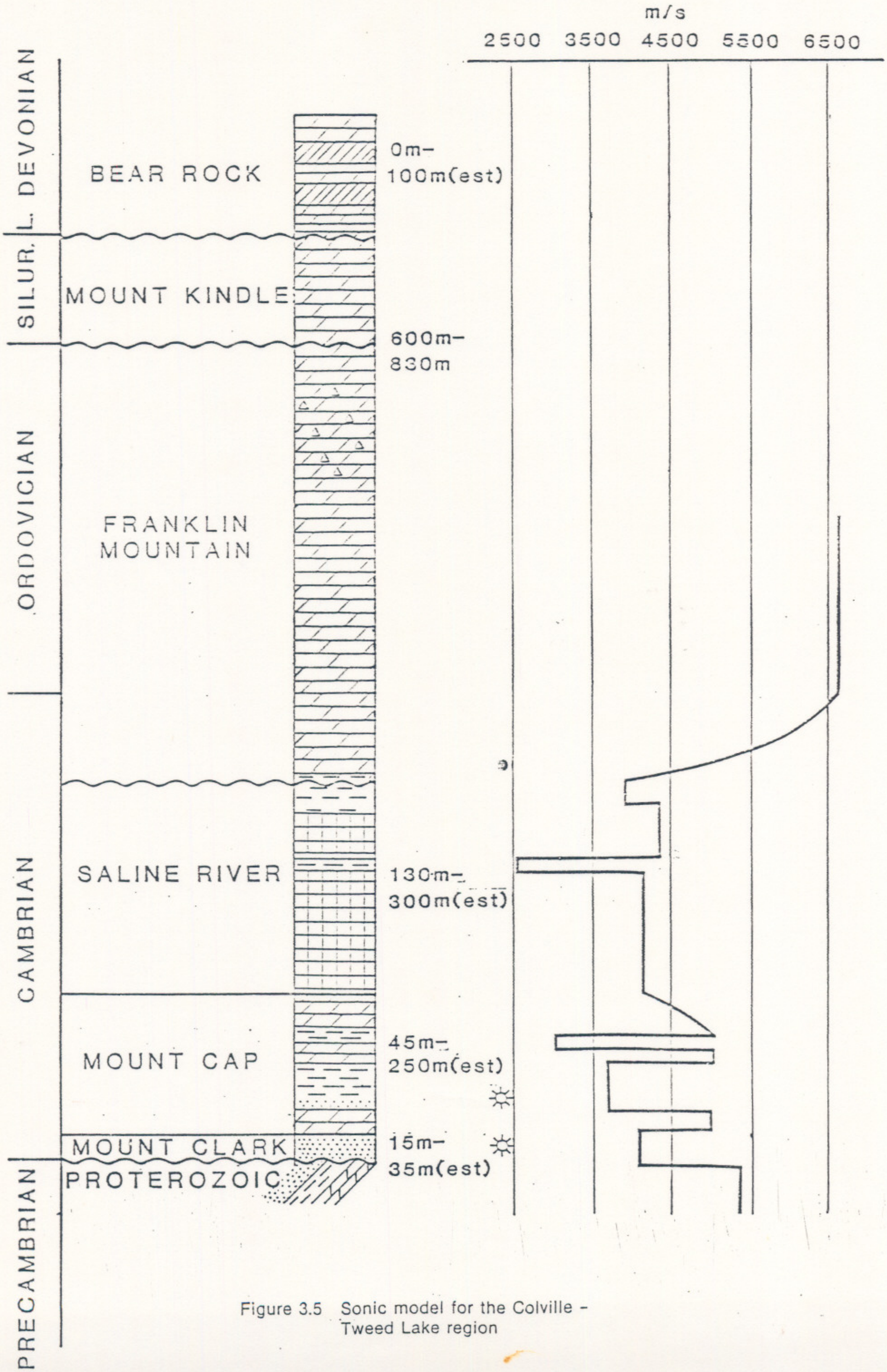

Figure 3.5 Sonic model for the Colville - Tweed Lake region

3.3 Presentation of Results

3.3.1 Data Quality

The seismic data quality is reasonably good in regions of high land with few lakes, such as in the north half of the project area. The south half of the region is characterized by numerous lakes, kharst depressions infilled with low velocity material, and more pronounced subsurface deformation with the result that the data is often very poor.

The 1985 vibrator data is superior in resolution to the older dynamite lines in the area, probably due to the shorter group interval used in acquisition. A lack of drift corrections and poor velocity analysis however, caused the vibroseis data to appear discontinuous horizontally and vertically.

3.3.2 Seismic Maps

The Tweed Lake project covers NTS grids 96K, L, M, and N. The seismic base map is shown in Figure 3.6.

All earlier dynamite data in the vicinity of the 1985 program were reprocessed. These lines have been used as the standard, with the vibrator lines being adjusted to tie with them. As drift corrections were not applied to the vibrator seismic, each timed point required an individual correction factor.

The following maps at a 1:100,000 scale were produced:

1. Top Proterozoic Time Structure - Figure 3.7
2. Near Top of Salt Time Structure - Figure 3.8
3. Near Top Mount Clark to Proterozoic Isochron - Figure 3.9
4. Near Top Mount Cap to Proterozoic Isochron - Figure 3.10
5. Near Top Salt to Proterozoic Isochron - Figure 3.11
6. Top Proterozoic Depth Structure - Figure 3.12

Velocities used to convert the Proterozoic event to depth were obtained from the Tweed M-47 well check shot survey.

3.4 Discussion of Results

3.4.1 Regional Morphology

The Proterozoic and Near Top Salt time structure maps, Figures 3.7 and 3.8, as well as the Proterozoic depth map, Figure 3.12, indicate that the survey area is situated in a highland as some dip is apparent on all sides. This highland appears to be a dipping southern extension of the Colville High north of Colville Lake, separated by a minor low in the vicinity of the lake. Pronounced regional dip occurs to the southeast.

Several large structures of substantial relief, at least 200 metres, are apparent. A prominent arcuate trench, approximately 3 kilometres in width, trending primarily from northeast to southwest bisect the highland. This trench's southwestern edge coincides with the Tunago Ridge, Figure 3.2.

The Near Top of Mount Clark to Proterozoic isochron map, Figure 3.9, incorporates a dolomite unit at the bottom of the Mount Cap formation as well as the Mount Clark sands. Although the manner in which this unit might vary is unknown, the map should reflect the relative changes in the Mount Clark sand thickness. The isochron displays very minor thickening towards the southeast. Just south of the project area, Good Hope A-40 well encountered 40 metres of sand as compared to 23 metres found at Tweed Lake M-47 in the north.

The Near Top Mount Cap to Proterozoic and Near Top Salt to Proterozoic isochron maps, Figure 3.10 and 3.11, show dramatic thickening southeast into the edge of an interpreted graben. The Mount Cap Formation is primarily responsible for this effect.

3.4.2 **Depositional History**

The northern Tweed Lake area and vicinity is interpreted to have been a shallow marine basin during Early Cambrian time with its centre at the eastern limit of the survey area. A secondary low occurs off the west side. Subsidence increased during the deposition of the Mount Cap Formation, especially towards the southeast above Great Bear Lake, where a substantial graben formed. The arcuate trench previously described may represent a rift zone that failed during Early Cambrian time. For the remainder of Cambrian history, it acted as a hingeline separating a shallow near shore environment on the northwest from a deeper marine environment on the southeast. Middle Cambrian uplift produced many structures, possibly with earlier ancestry. The Saline River salt then infilled remaining depressions. Inversion of this region occurred in pre-or post-Devonian time; the exact age is uncertain due to the missing section. A final compressive stage, the Laramide Orogeny, is responsible for accentuating the structures.

There is no strong evidence showing that any unit from the Mount Cap Formation to the Proterozoic thins over highs although the salt often does. This suggests that, for the most part, structuring occurred after deposition of the Mount Cap Formation.

The Proterozoic structure map is more highly faulted than the near top of Salt structure map. This would suggest that some faulting occurred prior to or contemporaneous with salt deposition. Due to the ductility of salt, evidence of faulting within it could have been lost in flowage. However, the presence of an undisturbed shale member in the salt, the large throw on many of the faults, often comparable to the salt thickness, and evidence of other faults which obviously penetrate the entire section support an early fault theory or at least initialization.

Figure 3.13 represents the above fault style. The presence of rapid change of dip within the Proterozoic strata across the fault, and the "flower structure" in the Paleozoic section above indicate that this is probably a strike-slip fault.

Support for pre-or post-Devonian inversion is obtained from an examination of the wells outside the project proper. The Tweed Lake/Colville area is presently structurally higher than its surroundings, yet its Cambrian section is substantially thicker.

The effect of the Laramide Orogeny is particularly evident in the west. Figure 3.14 displays what appears to be thrusting on a decollement zone from the salt at the Belot Hills Ridge. Much of this ridge was probably formed by the stacking of units above the salt as neither the salt nor Proterozoic Structure maps show evidence of a linear ridge.