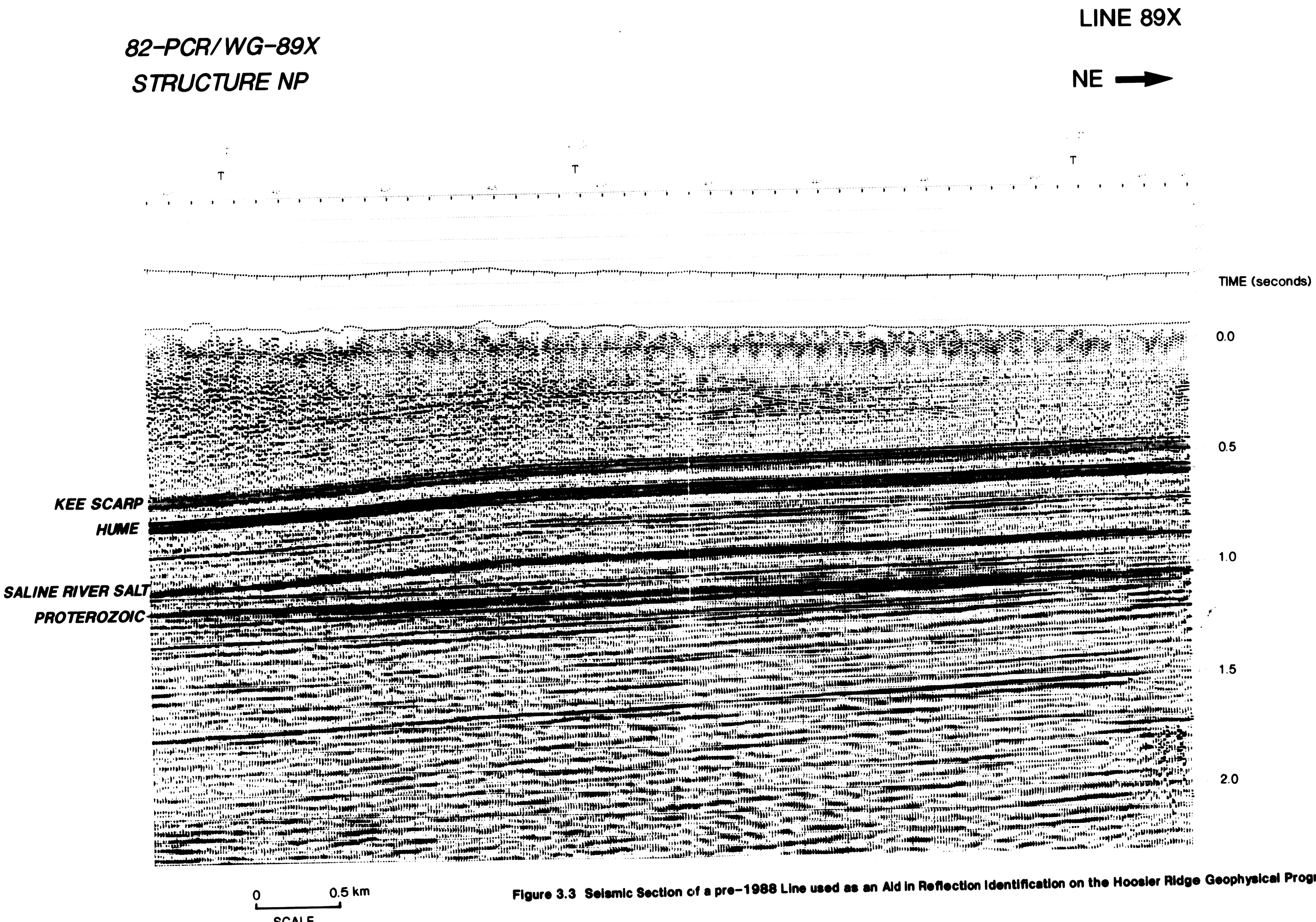

Figure 3.3 Seismic Section of a pre-1988 Line used as an Aid in Reflection Identification on the Hoosier Ridge Geophysical Program.

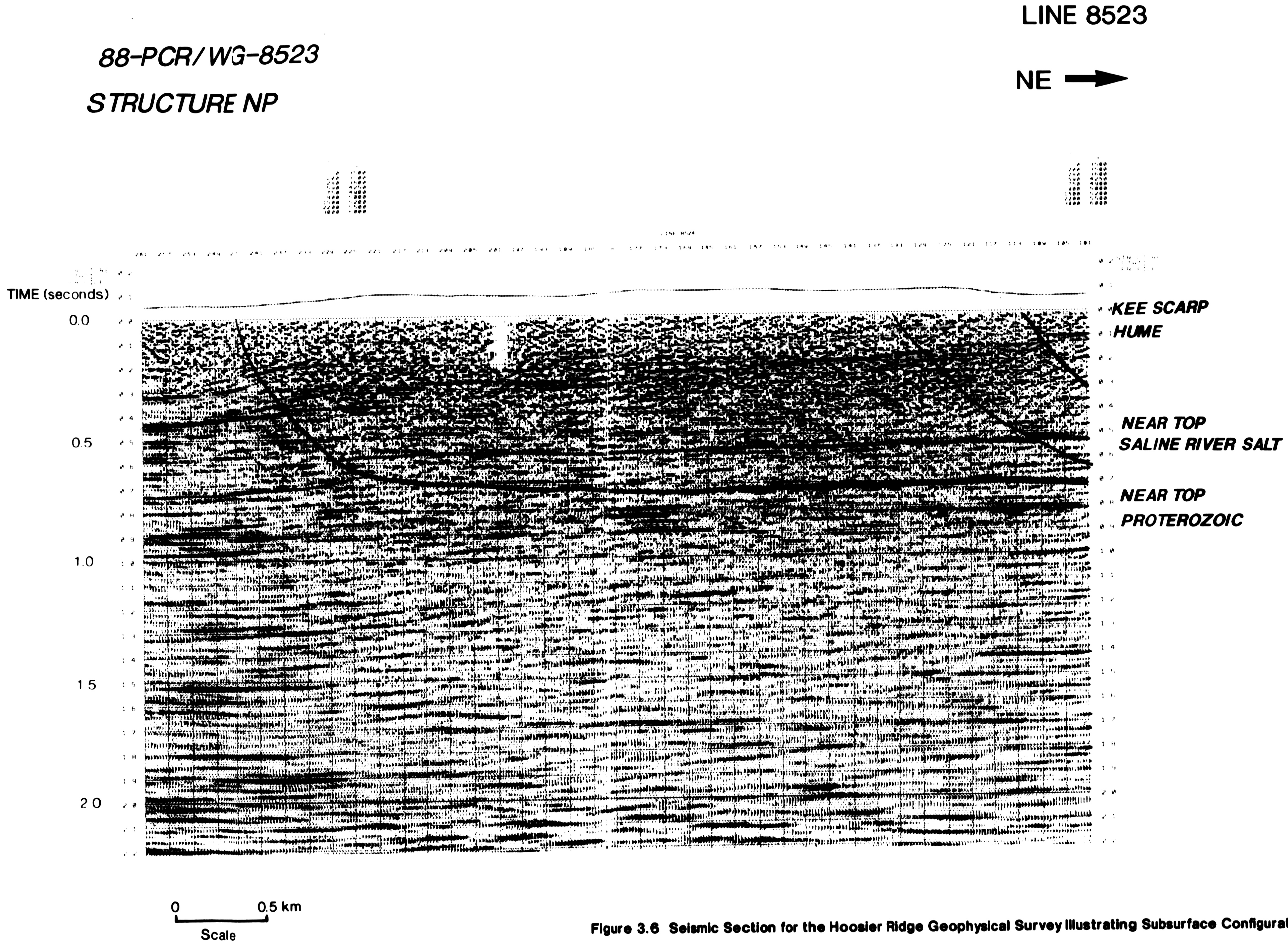

Figure 3.6 Seismic Section for the Hoosier Ridge Geophysical Survey Illustrating Subsurface Configuration.

PETRO-CANADA

GEOPHYSICAL EXPLORATION SURVEY REPORT

PROGRAM NO. 9229-P28-18E

HOOSIER RIDGE

NORTHWEST TERRITORIES

Exploration License No. 303

July, 1988

Submitted by

K. Davies

Geophysicist

Canadian Frontier Exploration Petro-Canada Resources

PROJECT ACTION SHEET

RESOURCE EVALUATION BRANCH

PROJECT NUMBER: 9229-P28-18E

COMPANY: PETRO-CANADA RESOURCES

REPORT TITLE: HOOSIER RIDGE GEOPHYSICAL SURVEY N.W.T.

The following action has been taken:

Receipt acknowledged: AUG 22/88

Reports and maps date-stamped: ✓

Reports for review list edited: ✓

Inventory sheet made: ✓

Mylar: ✓

REVIEW AND APPROVAL MADE BY: L. Richards Feb 28/89

COMMENTS: 3 COPIES of REPORTS AND MAPS. 2 COPIES of SECTIONS.

* ONE COMPUTER TAPE *

PROGRAM NUMBER 9229-P28-18E AREA Hoosier Ridge N.W.T.

YEAR 1988 E.A. 303

FILED UNDER: SAME

REPORTS

OPERATIONS REPORT: NUMBER 1

- GEOPHYSICAL EXPLORATION SURVEY REPORT

INTERPRETATION REPORT: NUMBER

(COMBINED IN OPERATION REPORT)

MAPS

SHOTPOINT MAPS NUMBER 2

- LOCATION MAP

INTERPRETATION NUMBER 1

- HUME TIME STRUCTURE MAP

OTHER NUMBER

SECTIONS NUMBER 6

MIGRATED SECTIONS

NORMAL POL	REVERSE POL.
8524	8523
8523	8524
8525	8525

HOOSIER RIDGE GEOPHYSICAL SURVEY

N.W.T.

Program No. 9229-P28-18E

Report On The
Geophysical Exploration Survey

Program No. 9229-P28-18E

HOOSIER RIDGE
Northwest Territories
Exploration Licence No. 303

9229-P28-18E

by
Petro-Canada Inc.
June, 1988

Field Work Period:	March, 1988
Land Use Permit No:	N88-B888
Area Co-ordinates:	65°22' - 65°26'N 127°11' - 127°24'W
Data Acquisition:	Reflection Seismograph (Dynamite) by Western Geophysical, A Division Of Western Atlas Canada Ltd.

Submitted by:

K. N. Davies
Geophysicist
N.W.T.

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LIST OF TABLES

LIST OF FIGURES

LIST OF DATA TRANSMITTED UNDER SEPARATE COVER

1. 1 Mylar Shotpoint Map: 96E (Partial)

2. 3 Seismic Sections: 8523
   8524
   8525

   1 Mylar And 2 Paper Copies Of Each Section (Normal And Reverse Polarities At 5.0 Inch/Second And 24 Traces/Inch)

3. 1 Digital Shotpoint Location Tape

SECTION ONE
INTRODUCTION

Petro-Canada Inc. conducted a geophysical survey 20 km northwest of Norman Wells in the central Northwest Territories in March, 1988. The program was carried out on the PCI operated Exploration Licence Number 303, referred to as Hoosier Ridge. Figure 1.1 indicates the location of the Exploration Agreement.

The seismic program, consisting of three lines totaling 20 km of data, was designed to determine if prospective Kee Scarp Formation reefal buildups, similar to that producing at the Norman Wells field, were present on this portion of the E.L.

This report summarizes the procedures of data acquisition, processing, and the results of the geophysical interpretation. A seismic time structure map is enclosed.

Mylar copies of the seismic base map and seismic sections, as well as paper copies of the sections, were sent separately from this report.

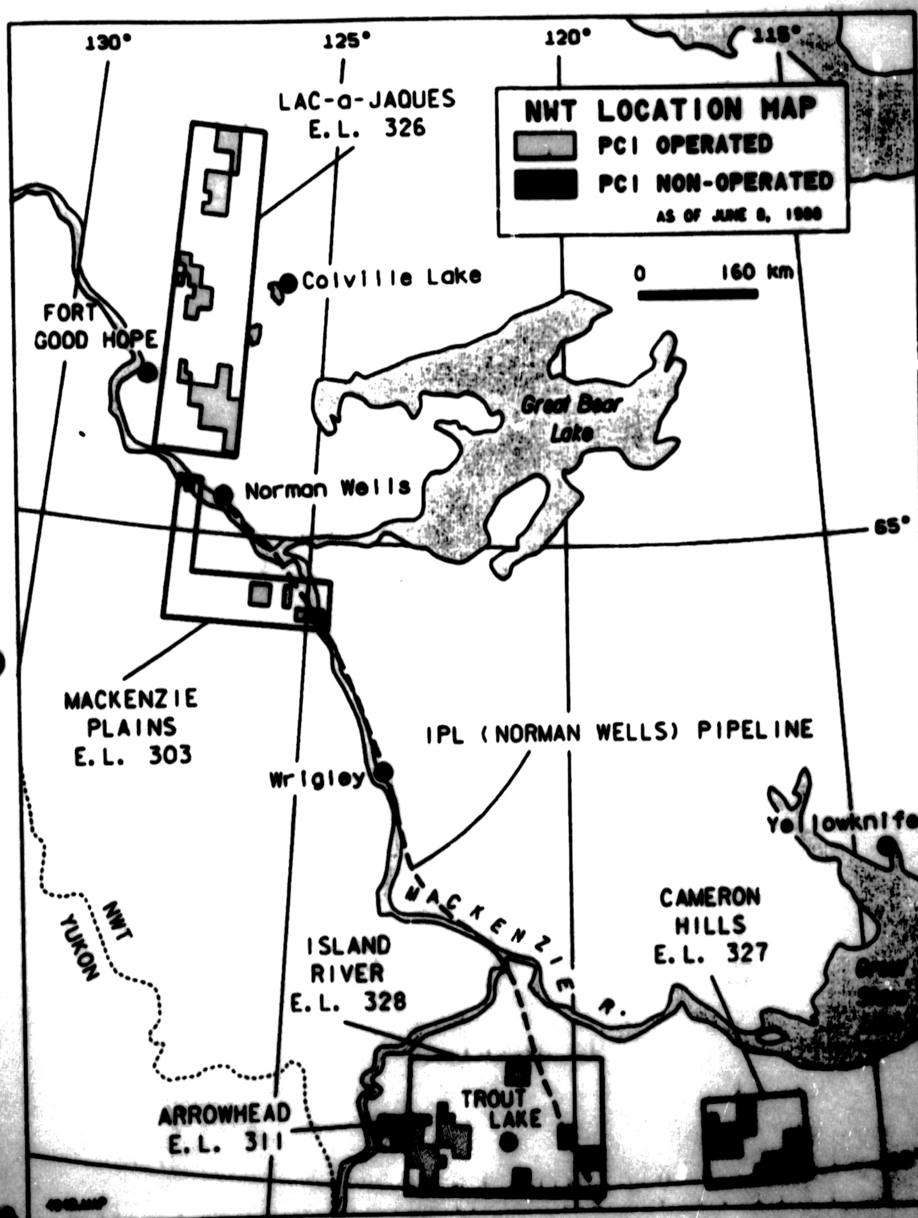
130°
125°
120°
115°
65°
LAC-a-JAQUES
E.L. 326
NWT LOCATION MAP
PCI OPERATED
PCI NON-OPERATED
0 160 km
Colville Lake
FORT
GOOD HOPE
Great Bear
Lake
Norman Wells
MACKENZIE
PLAINS
E.L. 303
IPL (NORMAN WELLS) PIPELINE
Wrigley
Yellowknife
NWT
YUKON
MACKENZIE R.
CAMERON
HILLS
E.L. 327
ISLAND
RIVER
E.L. 328
TROUT
LAKE
ARROWHEAD
E.L. 311

Figure 1.1 [illegible]

SECTION TWO
DATA ACQUISITION AND REDUCTION

2.1 Field Operations Summary

2.1.1 Field Conditions

The Hoosier Ridge area lies just north of the Mackenzie River and the seismic data was acquired over fairly unconsolidated surface material which may be representative of an abandoned river bed. Tree cover was relatively dense although not of a large size. Weather conditions were normal with temperatures in the -30° range.

2.1.2 Seismic Operations

The survey was conducted by Western Geophysical, a division of Western Atlas Canada Ltd. Twenty kilometres of reflection seismograph data was obtained over three days.

The total crew consisted of 41 people, including a native monitor. Native residents comprised 51% of field personnel.

Tables 2.1 and 2.2 summarize the seismic production and organization.

Start Recording	March 17, 1988
Complete Recording	March 20, 1988
Number of kilometres shot	20.196
Number of records taken	153
Number of stations	612
Days lost to poor weather	Nil
Days lost to equipment failure	Nil
Days moving on program	Nil

TABLE 2.1 SEISMIC PRODUCTION

Misc. Personnel 5 people

Party Manager
Clerk
Mechanic
Supplyman
Native Monitor

Data Acquisition
21 people

Observors
Junior Observer
Cable Truck Drivers
Recording Helpers
Shooter
Shooter's Helper
Drillers
Drill Helpers

Catering 4 people

Cooks
Cook's Helper
Camp Attendent

Line Cutting, Clearing 7 people

Cat Skinners
Cat Foreman

Surveying 4 people

Surveyor
Helper
Chainer
Helper

TOTAL PERSONNEL 41 people

TABLE 2.2 PROJECT ORGANIZATION

2.2 Seismic Data Acquisition

2.2.1 Instruments and Parameters

The seismic data was acquired with 15 fold common depth point coverage. The cable layout was a split spread of 1980 metres with a 33 metre detector spacing and a 132 metre shot spacing.

Tables 2.3 and 2.4 list the acquisition equipment and recording parameters employed for the survey.

Recording Instruments	Texas Instruments DFS-V
Geophone Strings	LRS 14 hz
Energy Source	2 kg Geogel 60
Number of Traces	120
Number of Cables	30
Length of Cable	1320 m
Number of Geophones per Station	9
Number of Geophone Strings	300

TABLE 2.3 ACQUISITION EQUIPMENT

C.D.P. Coverage	1500%
Shot Hole Depth	18 m single
Shot Hole Distance	132 m
Geophone String Length	3.67 m
Geophone Array	9 over 33 m
Sample Rate	2 millisec.
Record Length	3 sec.
Filters	8 - 128 Hz
Spread Layout	1980-30x30-1980 m

TABLE 2.4 RECORDING PARAMETERS

2.2.2 Survey System

Two Wild T-16 theodolite survey instruments were employed for horizontal and vertical control. Two Sekkisha Red II E.D.M. instruments were also used for additional control.

Shotpoint and geophone group location distances were derived using a surveyor's steel road chain. New cut line locations were derived from topographic features and sun shots. A helicopter was employed for a "line of sight", to set off the bull dozers, when available.

Station elevations were computed by E.D.M. and horizontal locations by latitudes and departures. Accuracy of positioning was ± 1 metre in elevation and less than ± 10 metres in horizontal distance.

2.3 Geophysical Data Processing

The seismic data was contracted out to Veritas Geophysical for processing. The raw data was extremely poor in quality and required extensive efforts to produce the final sections.

Two factors likely account for the abysmal data quality recorded. Firstly, the area consists of carbonates overlain by a variable thickness of drift and lower velocity unconsolidated material, and secondly, the target event lies from 0 to about 450 metres below surface in the program area.

Due to 'soft' material at surface, considerable ground roll and other destructive waveforms obscure the reflection data. As well, the C.D.P. coverage at this shallow zone of interest is only about 200 percent reducing the statistical advantage of multifold stacking and exhibiting little normal movement to aid in velocity/statics analysis. Future seismic acquisitions in this area would likely benefit from employing short spreads, a maximum of

500 metres split, and low charge (less than one kilogram total) multiple hole source arrays to possibly reduce shot generated noise.

The lines processed were 8523, 8524 and 8525. Petro-Canada processed 8523 as well. The seismic datum is sea level and the replacement velocity is 3506 m/s. The data was processed to 3 seconds using a 2 millisecond sample interval.

The following sequence was used for the processing:

1. Demultiplex
2. Amplitude Recovery - Exponential Function
3. Geometry
4. Instrument and Geophone Dephasing
5. Deconvolution - Time Domain Spiking
   a) Operator: 80 ms
   b) Pre-whitening: 1%
6. Residual Amplitude Analysis and Application
7. Structure Statics - 2 Layer Drift
8. Trace Gather
9. Velocity Analysis/Normal Moveout
10. First Break Mutes
    Distance: 265 266 528 1980 m
    Time: 0 200 300 1000 ms
11. Noise Attenuation (Radon Transform)
    Window: 0-3000 ms
12. Amplitude Equalization - AGC
13. Statics - Trim
    Window: 200-1000 ms
14. Stack
15. Filter: 10/15-80/90 Hz
16. Amplitude Equalization - Mean Scaling
    Window: 0-200/200-1500 ms
17. Finite Difference Migration
18. Fk-Powering
    Powering Exponent: 1.4

SECTION THREE

INTERPRETATION OF RESULTS

3.1 Regional Geology

The geophysical survey (Figure 3.1) was conducted on the Mackenzie Plains, a physiographic province situated between the prominent Mackenzie Mountains to the west, the Franklin Mountains to the east and bisected by the Mackenzie River. The survey site was located on the east side of the river. The Hoosier Ridge anticline lies directly opposite on the west side of the river and the Norman Wells oil field is about 20 km to the south.

3.1.1 Stratigraphy

A stratigraphic column for the Mackenzie Plains area is shown in Figure 3.2

The Proterozoic section is overlain unconformably by Middle Cambrian clastics. The succeeding Upper Cambrian Saline River Formation consists of shale and dolomite with varying amounts of ductile salt. Silurian to Lower Devonian deposition consists predominantly of carbonates.

The Middle Devonian section (from oldest to youngest) contains the limestone Hume Formation, the shale Hare Indian Formation and the limestone Kee Scarp Formation. The Kee Scarp Formation exists as a limestone platform with localized reefal buildups.

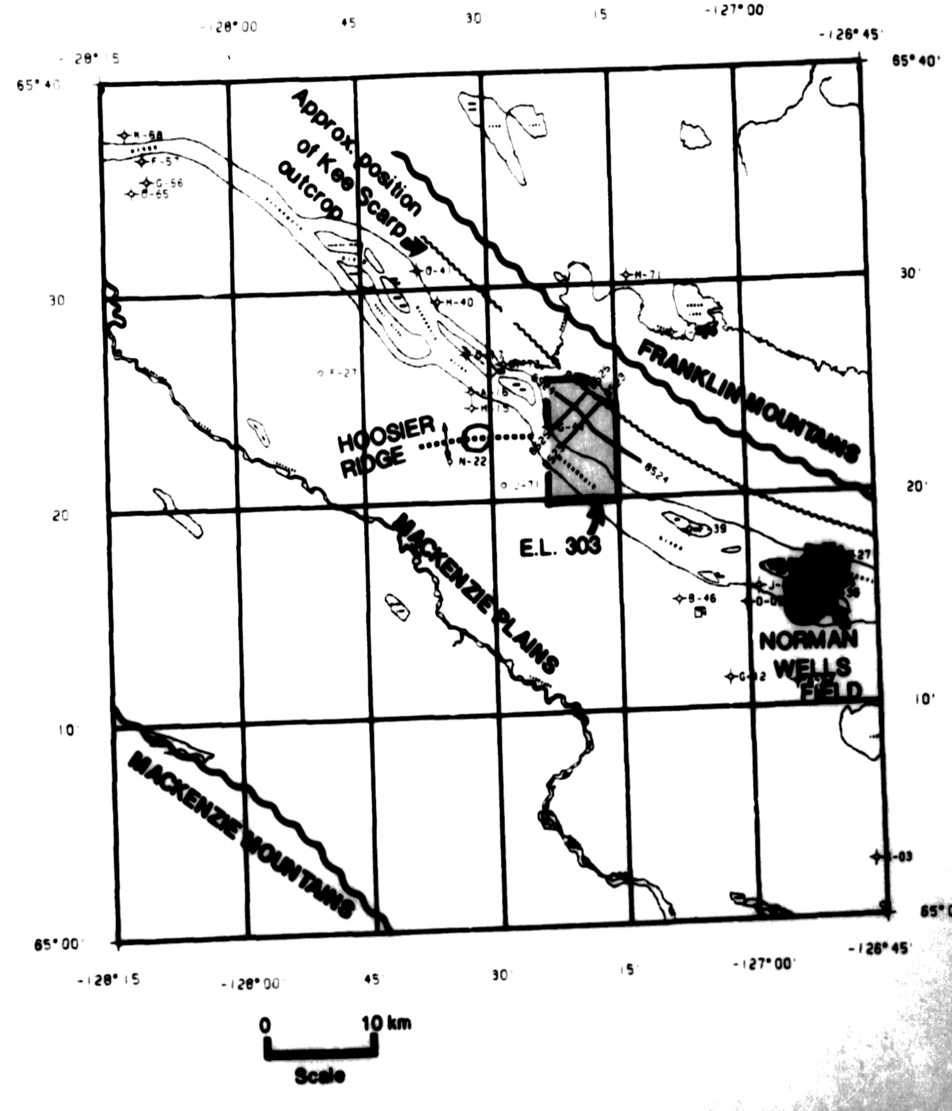

Figure 3.1 Location Map of the 1988 Geophysical Program in the Hoosier Ridge Area.

The Kee Scarp Formation is encased by the Canol Formation, an organic rich shale, which may lie directly on the Hare Indian Formation if the Kee Scarp Formation is absent. The Canol Formation is topped by the shales of the Imperial Formation of Upper Devonian age. Sedimentation concluded with Cretaceous clastics which overlay Devonian strata with pronounced unconformity. Due to the shallowness of the Devonian section in the survey area proper, it is unlikely that any Cretaceous material is present.

3.1.2 Structural Geology

A relatively stable large shallow basin existed throughout the Paleozoic until the end of the Devonian resulting in extensive carbonate deposition. This stability was terminated by uplift in the pre-Cretaceous and Cretaceous. At the end of the Cretaceous, the Laramide Orogeny shaped the terrain to its present configurations.

The Laramide Orogeny was characterized by extensive thrusting which produced the Mackenzie and Franklin Mountains and intervening anticlines. The Mackenzie Mountains appear to have formed primarily as a result of thrusting penetrating into the Proterozoic. Interpretation of older PCI seismic data suggests part of the narrower Franklin Mountains formed as a result of decollement in the Saline River Formation salt. Tear faulting is also evident from PCI seismic data obtained from the Hoosier Ridge anticline.

Age	Formation	Lithology
QUATERNARY	Q (undivided)	till, gravel, sand, clay; unconsolidated
Unconformity		
TERTIARY	Summit Creek	sandy conglomerate, mudstone, coal
Unconformity		
CRETACEOUS	East Fork	shale
	Little Bear	sandstone, siltstone, mudstone
	Slater River	shale
	Basal K SS	conglomerate chert-rich sandstone
Unconformity		
UPPER DEVONIAN	Imperial	shale, siltstone, limestone MBR
	Canol	shale
Disconformity		
MIDDLE DEVONIAN	Kee Scarp	limestone
	Hare Indian	shale
	Hume	limestone, minor shale
LOWER DEVONIAN	Bear Rock	dolomite, anhydrite
Unconformity		
UPPER ORDOVICIAN LOWER SILURIAN	Mt. Kindle	dolomite
Unconformity		
UPPER CAMBRIAN LOWER ORDOVICIAN	Franklin Mtn.	dolomite
UPPER CAMBRIAN	Saline River	shale, salt, siltstone, dolomite
Unconformity		
MIDDLE CAMBRIAN	Mt. Cap	shale, dolomite
	Mt. Clark	sandstone
Unconformity		
PROTEROZOIC	Undivided	shale, sandstone, dolomite, intrusives

Figure 3.2 Stratigraphic Column for the Hoosier Ridge Area.

3.1.3 The Play

Kee Scarp reefs are the major play in the area. The Norman Wells oilfield (270 MM barrels recoverable) produces light crude from a Kee Scarp reef which is up to 100 metres thick. The field is stratigraphically sealed updip to the east by a permeability barrier. Production occurs from only 300-400 metres below the surface and the Kee Scarp Formation actually outcrops about 3 km to the east of the field where oil seeps are evident. Other reefs tested in the area, such as at the Hoosier Ridge Anticline and further west, are wet.

The Kee Scarp Formation lies within 400 metres of the surface in the survey area after rising from the basin centre west of the Mackenzie River. The eastern portion of the seismic survey closely approaches the outcropping Kee Scarp Formation. A viable prospect would require a reefal buildup with structural or stratigraphic trapping. To date, the Kee Scarp platform has been unproductive and typically is tight.

3.2 Geophysical Methodology

3.2.1 Data Quality

The seismic data quality is poor to very poor on the three seismic lines. The data is severely contaminated with noise, probably due for the most part, to the presence of unconsolidated material at surface and relatively shallow carbonates below this drift.

3.2.2 Correlation of Stratigraphy to Seismic Profiles

The Imperial Morrow Creek No. 1 (G-44) well is the only well in the survey with which a direct correlation of geology to seismic reflectors can be made. It was drilled in 1944 and no logs were run, therefore a synthetic seismograph could not be produced. Knowing the formation tops and typical velocities (from refraction and PCI's Hoosier Ridge N-22 and Morrow Creek J-71 to the west) reflection times for the Kee Scarp and Hume Formations could be estimated.

Morrow Creek No. 1 Formation Depth (metres bsl)		Approx. Interval Velocity (m/s)	Two-Way Time (sec.)
Kee Scarp	246.4	3300	.150
Hare Indian	280.9	5000	.164
Hume	435.2	3350	.256

The well is about 300 metres off Line 8525. The tops are about 30 ms lower on the seismic section than the above times.

The Kee Scarp and Hume Formations usually produce a pronounced reflection response. This is due to the sharp velocity contrasts resulting from the transition from overlying uniform thick shales into carbonates. Figure 3.3 shows a seismic profile, acquired in an earlier survey, that is approximately two kilometres southwest of the Hoosier Ridge survey. This section illustrates the reflection character of the Kee Scarp and Hume Formations as well as allowing tentative identification of the Saline River salt and near top of Proterozoic reflectors.

3.2.3 Seismic Mapping

The Kee Scarp, Hare Indian and Hume Formations, as well as Saline River salt and near top of Proterozoic were correlated as well as possible. The seismic base map is shown in Figure 3.4. A Hume time structure map is shown in Figure 3.5. A Kee Scarp to Hume isochron map would have been produced if any significant variability had been observed.

3.4 Discussion of Results

A thickening of the Kee Scarp Formation or Kee Scarp to Hume Formations interval, which is indicative of prospective reefal development, was not observed. While the seismic data quality is often very poor, it is likely sufficient to conclude that reefs are not present on the seismic lines.

The Hume time structure map indictes that regional dip is strongly to the southwest. Back thrusting is evident, see Figure 3.6, and is possibly a result of decollement from the Saline River salt, which in turn is likely adjusting to major northeastward directed thrusting from the Proterozoic. A normal fault, mapped perpendicular to the thrust orientation, may be interpreted as a tear fault. Alternatively, it may represent a thrust plane cut at an oblique angle.