



RANGER OIL LIMITED

9229-R36-1E/2E

REPORT ON SEISMIC SURVEYS

CONDUCTED ON

EL 372, EL 377, EL 390

NORMAN WELLS AREA, N.W.T.

COVERING PROGRAMS CONDUCTED BETWEEN


JANUARY 1996 – JANUARY 1997

SUBMITTED TO THE NATIONAL ENERGY BOARD

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by



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NEB AUTHORIZATION #s - #9229-R36-1E and #9229-R36-2E

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I ABSTRACT

Two separate seismic surveys were conducted across Ranger's EL 372, 377 and 390 in January – March 1996. The 1996 program consisted of 156 km of 2D seismic, 129 km of which was with a dynamite source and 27 km of which was a vibroseis source. The December 1996 seismic program consisted of one 15 km vibroseis sourced 2D seismic line. During both seismic programs gravity data was collected along the seismic lines.

The seismic and gravity programs were designed to evaluate potential plays in several formations including the Mt Clark S.S., Mt Kindle dolomite, Franklin Mtn, Bear Rock, cretaceous sandstone and of course the Kee Scarp. In addition to our own proprietary seismic acquisition Ranger Oil Limited participated in 63 km of participation survey data acquired in 1996 and 1997, purchased 662 km of 1983 vintage trade data, purchased and reprocessed 240 km of 1968-1972 vintage trade data. Purchase of a scanned data set allowed the loading of the non reprocessed trade data plus about an additional 500 km of data into a Photon geophysical workstation where all the interpretation was completed.

Two previously unidentified regional geological features have been documented by our work. first a bad data region paralleling the Little Bear River southwest of Tulita is being interpreted as a Saline River formation salt wall initiated by Devonian Age strike slip movement. The second is a regional basement graben with at least a 1000m of down throw and a minimum 30 km of strike length paralleling the Norman Range. Ranger is planning to drill 3 wells during the 1998 winter season. C-17 (65° 06', 126° 03') is a test of the Mt Clarke sandstone in an updip position against the regional graben mentioned above. O-20 (65° 00', 125° 47') is a test of the Bear Rock formation in an area where it has limited closure but exhibits anomalous seismic signature suggesting brecciation in the vicinity of a fault or faults. M-39 (64° 48', 126° 23') is a test of an amplitude anomaly in the Devonian Imperial section that exhibits a strong AVO response. Our interpretation is the amplitude anomaly is coming from a low impedance highly porous sand encased in the higher impedance Devonian shales.

II INDEX MAPS

N.W.T.-

Fort Norman



Ranger Lands



Oil Field



1996 Seismic



1997 Seismic



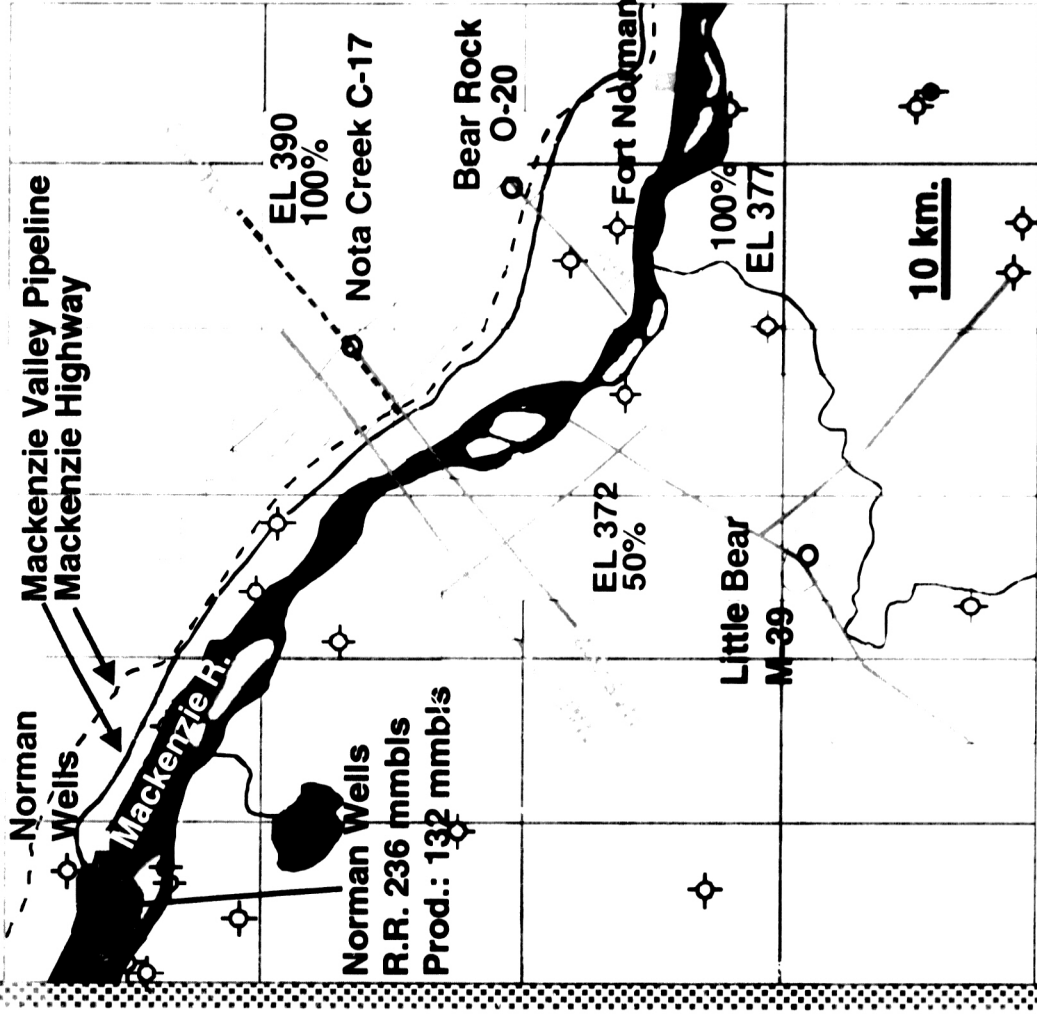
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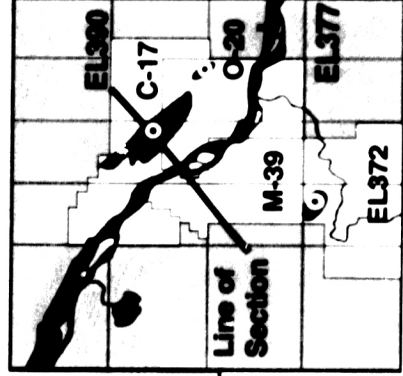
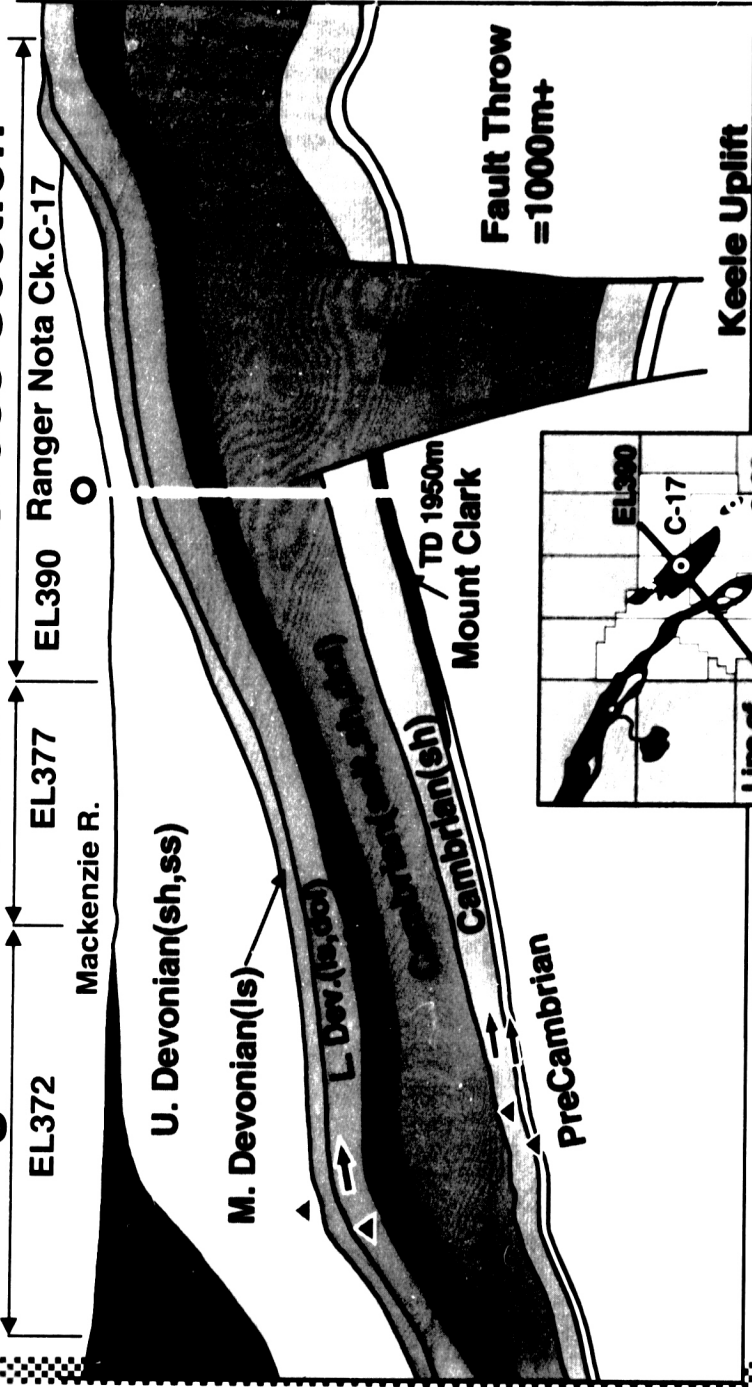
Prop. Location



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Ranger Nota Creek C-17 Cross Section



- ▲ Source Bed
- Migration Path



Ranger Nota Creek C-17

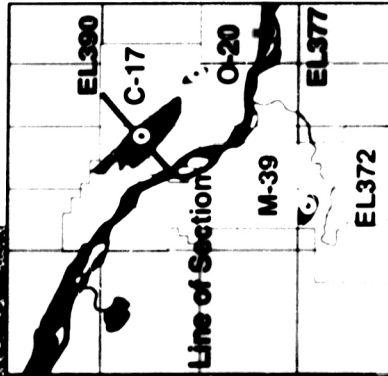
SW



NE



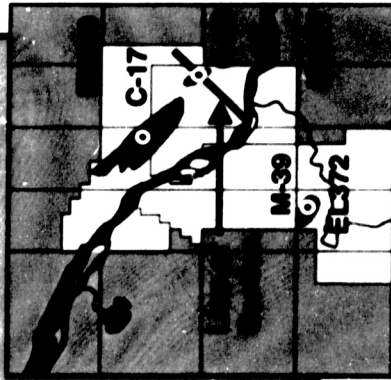
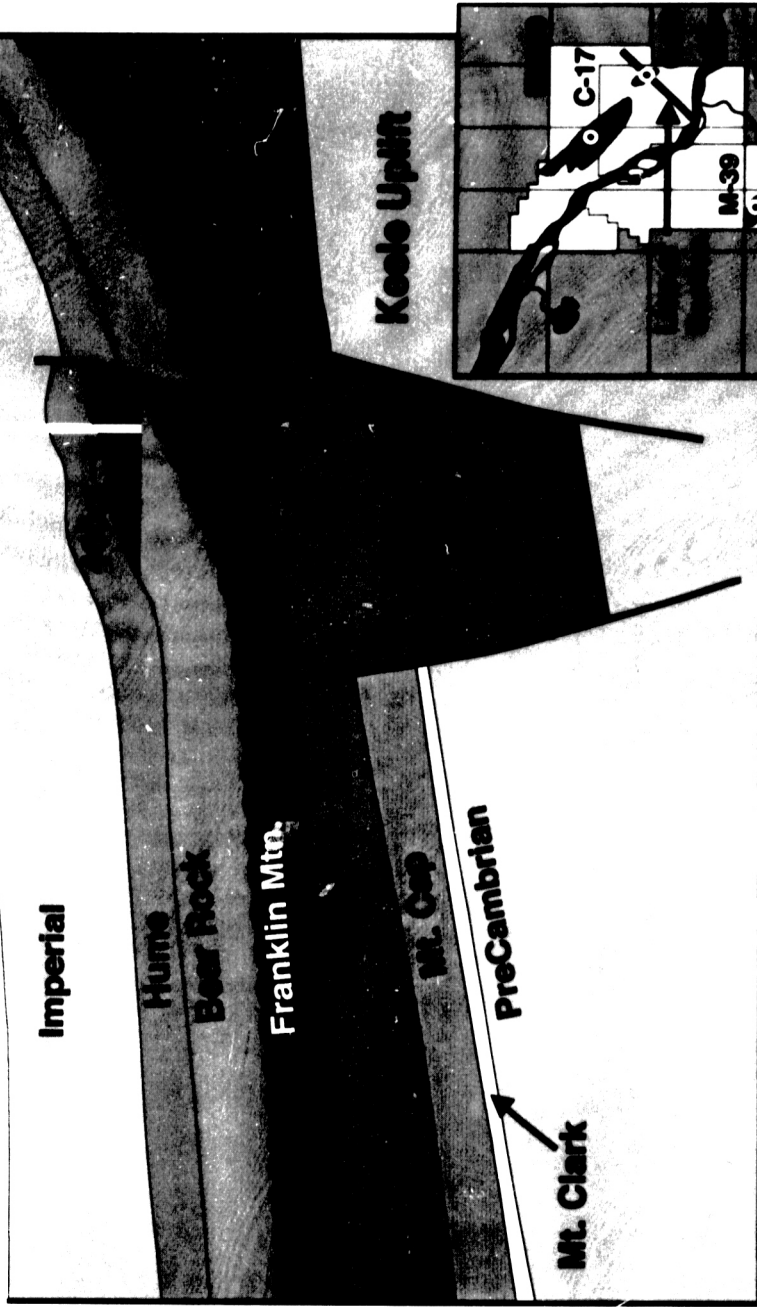
Line NAF-002E/
NAL-002



Ranger Bear Rock O-20

N.E.

S.W.



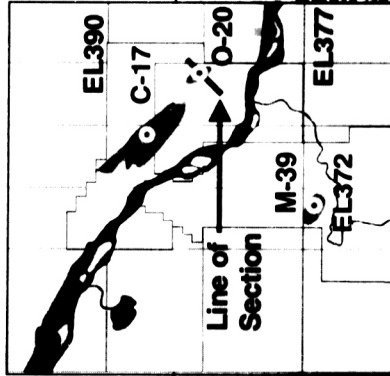
Line NAF-005

Ranger Bear Rock O-20

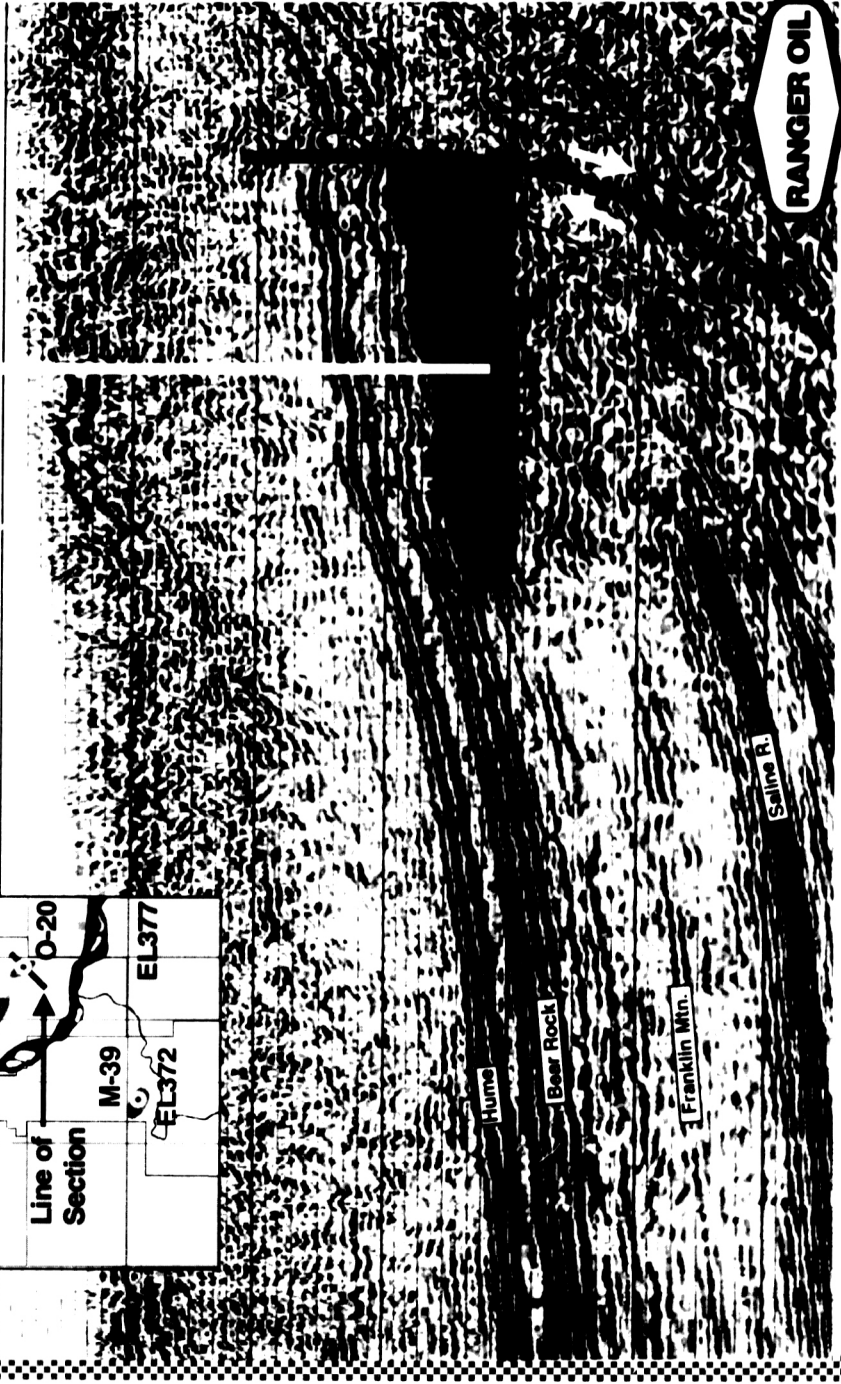
Line NAF-005



NE



SW

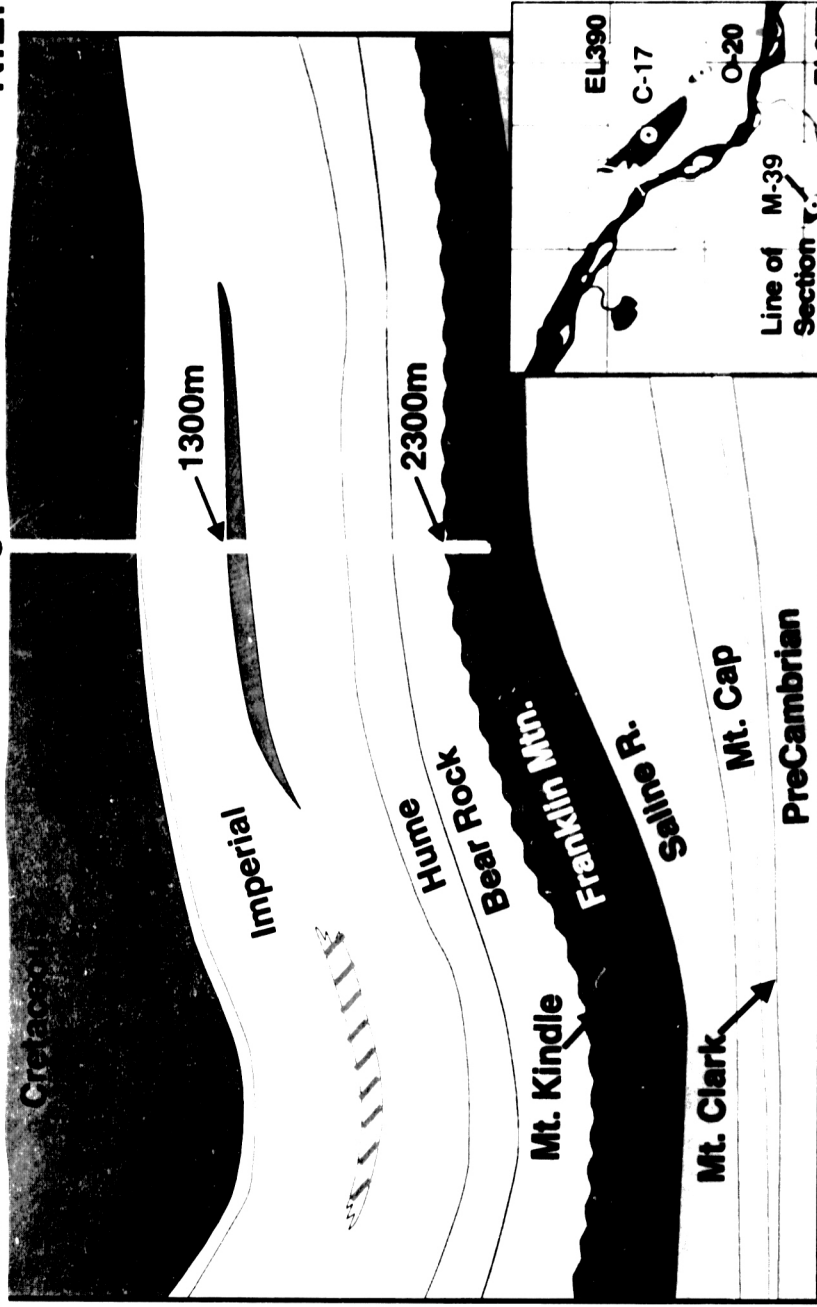


RANGER OIL

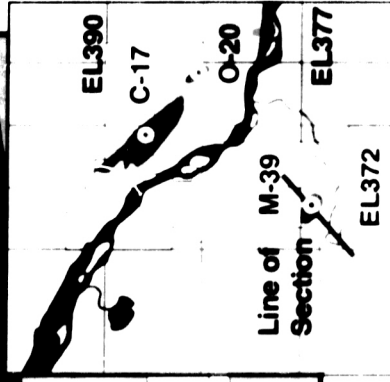
Ranger Little Bear M-39

S.W.

N.E.



Line NAF-004

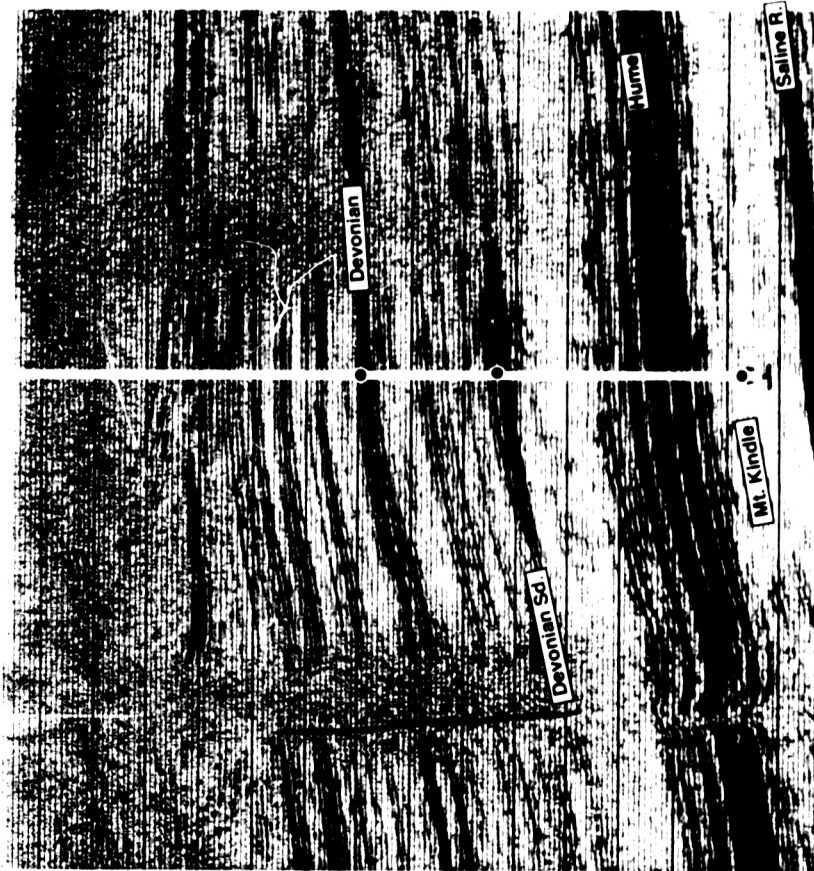


Ranger Little Bear M-39

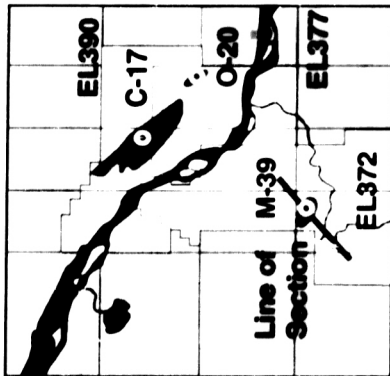
SW



NE



Line NAF-004



- Prospective Horizon



III OPERATIONS REPORT FOR LINES

NAF - 001E, 001W, 002E, 002W, 003, 004, 005, 006

(SHOT IN JANUARY/MARCH 1996)

1. Introduction

NEB authorization #9229-R36-1E

In January 1996 a seismic survey for Ranger Oil/Unocal was undertaken by Western Geophysical in the Fort Norman area of the Northwest Territories. Coincident with the seismic operations gravity data was collected along the seismic lines by MWH Geo-Surveys Ltd. This section covers pertinent operational information from the survey required by the Canada Oil and Gas Geophysical Operations Regulations.

The seismic survey consisted of 6 loosely spaced 2D lines totalling 156 km. The survey covered lands on both sides of the Mackenzie River. The terrain was generally level with elevations ranging from 100 to 500 metres above sea level. Steep slopes were encountered on creek and river crossings. Vegetation generally consisted of 5-10m high Spruce, some areas of the seismic program were affected by the 1994 forest fire. Because of the sensitive nature of the muskeg and permafrost which underlies most of the program area care was taken to minimize the disturbance of the upper turf layer when clearing lines.

The operation consisted of three phases, each phase having its own camp. First phase consisted of line clearing and surveying. Second phase was drilling of the shot holes. Third phase was the recording of the seismic data. The gravity operator generally was with the seismic recording crew in the third camp. All camps were sled mounted and all vehicles were tracked Nodwells or Foremost Delta buggy vehicles. Several snowmobiles were also utilized by recording line checkers and the gravity operator.

Vibrators were used as a seismic source on Lines NAF - 001E and 002E as a way of getting data on the Mackenzie River itself which the 2 lines crossed. Data quality was excellent with both dynamite and vibroseis sources. Frequency content up to 90 hz down to 1 second and up to 70 hz at 2 seconds

2. Equipment

Seismic Recording Equipment

- Vision-1000 Digital Telemetry system
- 11 kilometres recording cable
- 720 sets of LRS-1011 14 hz geophones with 9 geophones per string

Survey Equipment

- Trimble 4000SSE used in setting 11 GPS control points
- 3 FN60 tracked Nodwells
- 2 Leica Theodolites

Gravity Recording Equipment

- Lacoste and Romberg G Model Gravity Meter
- Suunto inclinometer
- Laptop computer
- 1 VHF radio

Drilling Equipment

- 3 radio equipped tracked conventional rigs
- 2 radio equipped tracked top drive rigs
- 1 tracked water hauling unit
- 1 tracked mounted mobile shop unit
- 1 powder custodian supply unit
- 1 tracked radio equipped party manager unit
- 1 tracked radip equipped mechanic unit

Vehicles

- 1 tracked recording unit
- 1 tracked shooting unit
- 4 tracked line units
- 1 Bell 206 helicopter
- 1 Delta III fuel storage buggy unit
- Delta II fuel storage buggy unit
- 1 tracked fuel unit
- 1 tracked party manager unit
- 1 tracked crew personnel carrier
- 1 tracked mechanics unit
- 3 snowmobiles
- 6 D7 cats for line clearing and camp moves
- 4 buggy mounted Litton 315 vibrators 47500 lb peak force

3. Camps

Recording Camp

- 6 sleighs accommodation minimum 40 people
- 1 power plant sleigh with spare generator
- 1 maintenance and repair sleigh
- 2 fuel sleighs with capacity of 12500 litres each
- 1 first aid station sleigh

Drill Camp

- 4 sleighs accommodation minimum 30 people
- 1 power plant sleigh with spare generator
- 2 fuel sleighs with a capacity of 12500 litres each
- 1 powder/cap magazine sleigh mounts

Line Clearing & Survey Camp

- 4 sleighs accommodation minimum 30 people
- 1 power plant sleigh with spare generator
- 2 fuel sleighs with a capacity of 12500 litres each

4. Statistical Data

Personnel

26	Recording crew
5	Vibrator operators and technician
14	Drill operators Supervisor, mechanic, water haulers
8	Cat operators, supervisor, mechanic
6	Surveyors and helpers
1	Environmental Monitor
1	Safety Advisor
4	Slashers
8	Camp cooks and helpers
2	Clerks
1	Medic
76	Total Personnel

Throughout the 3 month duration of the field work 88 people from the communities of Tulita, Norman Wells, Decline, and Fort Good Hope were employed at various times and for various durations.

Production Statistics

Jan 12/96 Line clearing commenced
Jan 15/96 Drilling commenced
Jan 22/96 Recording commenced
Mar 3/96 Recording completed

Total Profiles Recorded	2305
Vibroseis profiles Recorded	634
Dynamite Profiles Recorded	1671
Kilometres Recorded	156
Weather Days	0
Total Days	51
Total Recording Days	41

5. Field Parameters

Seismic

Instrument Type	Vision-1000 digital telemetry
Field filters	Out/Out
Record length	4 sec
Sample Rate	1 msec
Group interval	15 m
Geophones/group	9
Geophone type	LRS-1011 14 hz
No. of traces	360
Spread	1 - 180 - x - 181 - 360 2700 - 15 - 0 - 15 - 2700m

LINE NAF - 001E (S.P. 228 to 1169)

LINE NAF - 002E (S.P. 101 to 983)

Source Vibroseis, 3 vibrators, 45m drag

Sweep 10 - 100 hz Linear

6 sweeps, 8 second length

Source Interval 45 m

Fold 60

LINE NAF - 001W (S.P. 816 to 1969)

LINE NAF - 002W (S.P. 949 to 1901)

LINE NAF - 003 (S.P. 101 to 1369)

LINE NAF - 005 (S.P. 146 to 1013)

Source Dynamite, 2 kg @ 18m

Source Interval 60 m

Fold 45

LINE NAF - 004 (S.P. 101 to 2557)

Source Dynamite, 2 kg @ 18m

Source Interval 90 m S.P. 101-917

120 m S.P. 925-2557

Fold 30 to 22.5

LINE NAF - 006 (S.P. 99 to 2241)

Source Dynamite, 2 kg @ 18m

Source Interval 90 m

Fold 30

NOTE: The reason for the variable shot point interval was to maintain a similar fold at the Hume interval. The Hume formation's depth varied considerably over the extent of the seismic program. For example the Hume is at a time of 1.7 seconds on the west end of Line NAF-004 but outcrops on the east end of Line NAF-005.

Gravity

Station Interval	90 to 120m subject to shot point spacing on seismic lines
Survey	Seismic survey for shot points was used for elevations and horizontals
Terrain Corrections	Inner zone terrain correction determined by operator measuring slopes and distances with an inclinometer and range finder

Survey

- 11 GPS control points set by Nehpets Holdings Ltd. report enclosed.
- Optical survey using Leica theodolites referenced to GPS points.

6. Data Processing Parameters

Seismic Data Processing Sequence

The field seismic data was processed by Veritas Seismic. Processing flow used was:

Demultiplex
Amplitude Recovery: Exponential Function

Minimum Phase Surface Consistent Deconvolution

Operator length 80 msec
Prewhitening 0.1%

Zero Phase Deconvolution

Operator length 80 msec
Prewhitening 0.1%

Refraction Statics

Datum Elevation 500m ASL
Replacement Velocity 3048 m/s
Weathering Velocity 900 m/s
Processing Datum Surface

Manual Trace Edits

Trace Gather
Velocity Analysis
Residual Statics
Type Automatic Surface Consistent
Correlation Window 400-2800 msec
Maximum shift $\pm/30$ msec
No. of traces in model 11

First Break Mutes

Statics
CDP trim

Stack
Migration
Type Finite Difference
Velocity 90% of stacking velocities

Filter
Type Bandpass 10/15 - 80/95

Amplitude Equalization
Type Mean scaling

Display Parameters
Film Display Vertical 7.5 inches/second
Horizontal 36 traces/ inch
Lines NAF-004 and 006 were filmed with a 2 to 1 trace sum after migration

Lines NAF-004 and 006 also had a DMO version run before migration followed by a Migration pass using only 70% of the stacking velocities.

IV OPERATIONS REPORT FOR LINE NAL - 002

(SHOT IN JANUARY 1996)

1. Introduction

NEB authorization #9229-R36-2E

In December 1996 a seismic survey for Ranger Oil Limited was conducted by Western Geophysical in the Fort Norman area of the Northwest Territories. Coincident with the seismic operations gravity data was collected along the seismic line by MWH GeoSurveys Ltd. This section covers pertinent operational information from the survey as required by the Canada Oil & Gas Operations Regulations.

The seismic survey consisted of one 15km vibroseis line extending from the northeast end of the 1996 line NAF-002E. A significant 4km overlap allowed proper imaging of the graben which this line was designed to cross. The line was laid out to cross the Norman Range in a low elevation saddle which allowed conventional acquisition.

The operation consisted of two phases, each phase having its own camp. This single line was acquired in conjunction with a much larger participation survey commissioned by GSI/Western Geophysical. The first phase consisted of line clearing and surveying. Second phase was the recording of the vibroseis seismic data and collection of the gravity data. A helicopter assisted in cable and geophone pickup and layout.

2. Equipment

Seismic Recording Equipment

- Vision-1000 Digital Telemetry system
- 11 kilometres recording cable
- 750 sets of LRS-1011 14 hz geophones with 6 geophones per string

Survey Equipment

- Trimble 4000SSE used in setting 11 GPS control points
- 3 FN60 tracked Nodwells
- 2 Leica theodolites

Gravity Recording Equipment

- Lacoste and Romberg G Model Gravity Meter
- Suunto inclinometer
- Laptop computer
- 1 VHF radio

Vehicles

- 1 Van
- 1 Mechanic's truck
- 1 Vib Tech's truck
- 4 buggy mounted Litton 315 vibrators 47500 lb peak force
- 1 tracked recording unit
- 4 tracked cable units
- 1 Crew cab 4x4
- 2 tracked Party Manager units
- 5 snowmobiles
- 3 water haulers
- 2 D6 cats
- 1 977 cat
- 2 D7 cats
- 1 Astar helicopter
- 1 Delta II
- 1 Delta III

3. Camps

Recording Camp

- 6 sleighs accommodation minimum 40 people
- 2 power plant sleighs
- 1 first aid station sleigh
- 2 sleigh mechanic unit
- 2 fuel sleighs with capacity of 13500 litres each

Line Clearing & Survey Camp

- 4 sleighs accommodation minimum 30 people
- 1 power plant sleigh
- 4 fuel sleighs with a capacity of 13500 litres each

4. Statistical Data

Personnel

- 19 Recording crew
- 5 Vibrator operators and technician
- 1 Party Manager
- 2 Safety Advisors
- 1 Environmental Monitor
- 1 Native liaison
- 3 Mechanics

- 1 Delta 3 Driver
- 1 Helicopter pilot
- 7 Cat operators, supervisor, mechanic
- 4 Surveyors and helpers
- 2 Slashers
- 6 Camp cooks and helpers
- 2 Clerks
- 2 Medic
- 57 Total Personnel

A total of 22 residents of the N.W.T. were hired by Western Geophysical for this program.

Production Statistics

Dec 14/96 Line clearing commenced
 Dec 16/96 Recording commenced
 Dec 18/96 Recording completed

Total Profiles Recorded	251
Kilometres Recorded	15
Weather Days	0
Total Days	6
Total Recording Days	3

5. Field Parameters

Seismic

Instrument Type	Vision-1000 digital telemetry
Field filters	Out/Out
Record length	4 sec
Sample Rate	1 msec
Group interval	20 m
Geophones/group	9
Geophone type	LRS-1011 14 hz
No. of traces	240
Spread	1 - 120 - x - 121 - 240 2440 - 60 - 0 - 60 - 2440

Source	3 vibrators. 25m drag
Sweep	8 - 96 hz NON-LINEAR 6 sweeps, 8 second length
Source Interval	60 m
Fold	40

Gravity

Station Interval 100m

Survey Seismic survey for shot points was used for elevations and horizontals

Terrain Corrections Inner zone terrain correction determined by operator measuring slopes and distances with an inclinometer and range finder

Survey

- 11 GPS control points set by Nehpets Holdings Ltd. report enclosed.
- Optical survey using Leica theodolites referenced to GPS points.

6. Data Processing Parameters**Seismic Data Processing Sequence**

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Minimum Phase Surface Consistent Deconvolution

Operator length 80 msec
Prewhitening 0.1%

Zero Phase Deconvolution

Operator length 80 msec
Prewhitening 0.1%

Refraction Statics

Datum Elevation 500m ASL
Replacement Velocity 3048 m/s
Weathering Velocity 900 m/s
Processing Datum Surface

Manual Trace Edits

Trace Gather

Velocity Analysis

Residual Statics

Type Automatic Surface Consistent

Correlation Window 400-2800 msec

Maximum shift ± 30 msec

No. of traces in model 11

First Break Mutes

Statics

CDP trim

Stack

Migration

Type Finite Difference

Velocity 90% of stacking velocities

Filter

Type Bandpass 10/15 - 80/95

Amplitude Equalization

Type Mean scaling

Display Parameters

Film Display Vertical 7.5 inches/second
Horizontal 36 traces/ inch

V INTERPRETATION

1. Data Quality

All data acquired by these two seismic programs were of excellent quality. Frequency content up to 90 hz was not uncommon. Very little discernible difference could be distinguished between the vibroseis and dynamite data. Future seismic work will be conducted using vibroseis because it makes for a more efficient field operation, one less camp and reduced costs.

Even the 1968 vintage 4 fold dynamite trace data when reprocessed provided excellent quality data.

2. Reflection Identification

Throughout the area of the seismic program there are 11 wells penetrating the Hume formation with sonics. Of these only 4 penetrated the Saline River formation: A-49, A-53, K-03, O-33. Synthetics generated from these wells tied well with the seismic data and allowed reliable marker identification down to the Saline River formation. The Hume and Saline River formations provided the most continuous and reliable reflectors. Below the Saline River marker identification was much less reliable. The B-62 and C-21 wells located in the Brackett Lake basin to the east of the Keele Arch were the closest wells with sonics penetrating the PreCambrian section. The Vermillion N-28 well drilled in 1944 provided sample top depths for the Saline River and Mt Cap formations. The Mt Cap correlation was based on the first regional seismic reflector below the massive nature of the Saline River interval. The top of PreCambrian or basement reflector was based on an angular unconformity as seen on the middle of Line NAF-004 at a time of 1.9 to 2.0 seconds. The PreCambrian section as described in outcrop in the Mackenzie Mountains to the west are layered clastics and carbonates giving rise to a PreCambrian seismic signature that exhibits strong bed forms. The Mt Clarke sandstones if present would be sitting directly on the PreCambrian unconformity and their presence was inferred rather than interpreted from the seismic.

3. Discussion

The Mackenzie Valley Basin is bounded to the southwest by the Mackenzie Mountains and to the northeast by the Norman Range. The deepest part of the basin parallels the Mackenzie Mountain front with reflection times to the basement in the order of 2.1 seconds (about - 3200 metres subsea). From the axis of the basin the basement gently rises to the northeast where at our C-17 location the basement is at 1.05 seconds (about - 1750 metres subsea). Ranger's proprietary seismic has identified a major basement graben immediately east of our C-17 location with downward throw of at least 1000 metres. This graben is interpreted on Lines NAF - 005, NAF - 002, NAL - 002, and NAO - 015 establishing a strike length of at least 30

km and a strike direction of NW - SE. Gravity data interpretation and modelling supports a graben with Cambrian fill. The gravity profiles show up to a 5 milligal gravity low or reversal over the graben. The width of the graben appears to be 2 to 5 kilometres. The extent of the graben northwest of Line NAO - 015 has not been established. This graben is adjacent to the Keele Arch which has been documented as a regional basement uplift with movement throughout Cambrian and Devonian time. The C-17 location will test the Mt Clarke sandstones in a structurally trapped position adjacent to the graben. The Upper Saline River and younger formations lie undisturbed by the graben suggesting that the graben formation was pre Saline River or the younger formations are thrust over the graben. Other workers have suggested that the entire Norman Range is a thrust sheet with the thrust soleing out in the Saline River.

The other regional feature of great interest is the so called no-data area paralleling the Little Bear River southwest of the A-53 Windy Point well. All existing trade data in this area show a 6-8 kilometre band of non-interpretable data. Was this a surface problem or a severe structurally disturbed zone on trend with the Gambill Mountain thrust to the southwest? Line NAF - 006 was shot in an attempt to acquire better quality data in order to image this zone. Unfortunately we also encountered a virtual no data zone between S.P. 900 - 1080. But interesting structural relationships bordering this no data zone and especially the gravity data resulted in the interpretation that the no data area is a salt diapir pushing up close to the surface. Gravity data for Line NAF - 006 shows a tremendous 20 milligal low over the zone. The seismic shows the Saline River salt interval being squeezed down adjacent to the diapir. The steep dips close to surface west of the diapir on Line NAF - 006 are interpreted to be Tertiary sediments. The dip of the Tertiary beds is steeper than the underlying Cretaceous beds suggesting before the diapir formed the Saline River salt had pillowed during Tertiary time. There are well documented examples of this exact relationship in the Zechstein salt basin of Europe. Line NAF - 006 also shows major unit thickness changes from one side of the salt diapir to the other. The Hume - Saline River Isochron map shows an offset in the regional thickness across the no data area. Our interpretation is that the no data zone was a major strike slip fault during the Cambrian - Early Devonian and it was this zone of weakness which initiated the salt flowage during the late Cretaceous to Tertiary time. The no data zone is cored by a Saline River salt wall with a strike length of about 35 km. I would suggest also that the Gambill Mountain Thrust further to the southwest is likely cored by the salt wall and may not be a thrust at all.

Other less dramatic structures are influenced by the Saline River salt. A salt swell or pillow is seen at S.P. 1650 on Line NAF - 001W and S.P. 1500 on Line NAF - 002W. This pillow continues to the northwest and is mapped out on the Saline River to Mt Cap Isochron map. The timing of this salt movement appears to be younger than Cretaceous, perhaps triggered by the Laramide orogeny. Small scale thrusts at the Hume level are evidence of the compressional forces at work during this orogeny.

No evidence was found for Kee Scarp reef development anywhere on the three exploration licences. The Hare Indian to Hume Isochron map shows a dramatic thinning immediately southeast of the Norman Wells oil field and likely represents a basin edge southeast of which Kee Scarp reef development is not likely.

In the vicinity of our O-20 Bear Rock location the Bear Rock formation appears to be brecciated. In outcrop at Bear Mountain the Bear rock formation is documented as a solution collapse breccia with petroliferous odour. Line NAF - 005 shows a Bear Rock interval disturbed, locally thinner, and exhibiting a chaotic blend of high amplitude reflections some of which are horizontal. The top of the Bear Rock has limited closure but a prominent reverse fault updip may be controlling the brecciation and creating a trap for hydrocarbons.

The M-39 location is a test of a bright spot type anomaly in the middle of the Devonian Imperial section. The polarity of the seismic on Line NAF-004 suggests that the reflection bright spot is coming from a low impedance zone of about 20 metres in thickness. Common offset data for Line NAF-004 in the vicinity of the anomaly show a strong Class III type AVO anomaly, i.e., negative reflectivity increasingly negative with offset. Our interpretation is that we are dealing with a low velocity sandstone encased by higher velocity Devonian shales. The AVO response indicates that the sand is either gas bearing or high GOR oil bearing. The environment of deposition perhaps is a low stand shore face sand body.

The Mt Kindle is a secondary target at the M-39 location and we have no seismic evidence for its presence here. Further downdip west of S.P. 1590 the Hume-Saline River Isochron thickness by about 10 msec which may be indirectly indicating the eastern limit of the Mt Kindle formation.

VI CONCLUSIONS

- Reflection data quality was excellent with no quality difference between dynamite and vibroseis data.
- Vibroseis acquisition is more cost effective partly because one camp is eliminated.
- No Kee Scarp reefs were found to date on EL 372, 377, 390. Hare Indian-Hume Isochron suggests a fundamental change in the basin southeast of Norman Wells.
- New seismic and gravity confirms presence of major basement graben underlying the Norman Ranger. The northwest extent of which is undetermined.
- New seismic and gravity confirms presence of a Saline River salt wall cored by a major basement right lateral strike slip fault along the previously described no data zone southwest of the A-53 Windy Point well.
- This seismic evaluation will lead to three unique exploration wells targeting the Mt Clarke, Bear Rock and Devonian Imperial sandstone formations.

VII LIST OF ENCLOSURES

1. BASEMENT TIME STRUCTURE MAP 1:100,000
2. HUME TIME STRUCTURE MAP 1:100,000
3. SALINE RIVER TIME STRUCTURE MAP 1:100,000
4. DEVONIAN TIME STRUCTURE MAP 1:100,000
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