FINAL REPORT

EL# 09-101-01-RS

MUNSIST Seismic Source Test - Five Mile Road

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Earth Sciences Dept.
Memorial University
Sept. 2009

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Memorial University
Final Report

Executive Summary

A production test of the MUNSIST seismic source in the Five Mile Road area was successfully completed in June 2009. Although only 2 km of data were collected, the production test clearly demonstrates the ability of the MUNSIST source to provide seismic images comparable to and exceeding those resulting from conventional Vibroseis under the conditions presented by the Five Mile Road area. The test also demonstrates that the MUNSIST source is capable of transmitting higher frequencies than Vibroseis but due to the relatively low power of the source, CMP fold is critical to maintaining image quality.

The MUNSIST source has significant potential to provide an alternative to conventional explosive and Vibroseis sources that may be attractive in terms of both operational cost and environmental impact if a suitably low environmental impact carrier can be identified. Further development of the source to allow simultaneous operations of multiple MUNSIST sources (in the same fashion that multiple vibrators are the norm) would very likely increase overall source power and significantly increase production rate.

Introduction

The MUNSIST source consists of a commercially available (mid-range) hydraulic rock breaker that is combined with a custom designed control valve and control software. The rock breaker is conventionally mounted on a back-hoe or excavator but there is significant potential for development of a wide-tracked low impact carrier that would allow off road and rough terrain operations. The MUNSIST source operates by applying a sweep of multiple impacts to the ground in which the rate of impact increases throughout the duration of the sweep. A shot point consists of the summation of multiple sweeps with the rate of impact (sweep frequency) changing for each sweep. In typical operation the final summed shot point would consist of 300-700 impacts on the ground surface. The recorded signal is then collapsed or decoded either by cross correlation or a shift and sum process and the resulting shot records summed to produce the final shot record for a specific shot point. The result of the decoding process is an impulsive signal which takes advantage of the multiple impacts to increase the S/N by increasing total energy input into the ground and by cancellation of random noise. Unlike Vibroseis, the frequency spectrum of the source is dictated by the impact of the hammer on the ground (not the bump rate of the extended signal) so the MUNSIST system does not require continuous ground compliance and has significant potential to produce frequencies up to 200 Hz.

Field test

Source Parameters

- shot point (SP) spacing - 20 m
- 9 sweeps per SP consisting of 3 sets of 3 sweeps
- sweep sets 2-3 Hz
  2-5 Hz
  2-7 Hz
- sweep length - 20 s

Receiver Parameters

- receiver spacing - 10 m
- geophones - single 14 Hz geophones
- # of channels - 120
- near offset - 20 m
- far offset - 1210 m

Recording Parameters

- recording system - ARAM Aries
- sample rate - 1 ms
- record length - 23 s reduced to 3 s after correlation
- data channels - 1-120
- aux. channels - 121 - predicted time break
  - 122 - baseplate accelerometer
  - 123 - field time break

Processing stream for final stack

- edit missed/incomplete shots
- whole trace agc for lateral trace balance
- cross correlation
- vertical stack - 9 ensembles/120 traces per ensemble
- geometry application
- refraction statics - GLI3d
- AGC - 100 ms, mean
- bandpass filter - 10/20-150/250
- mute - first breaks
- sort to CMP gathers
- velocity analysis
- NMO correction
- 5 trace array simulation - weights 1,2,3,2,1
- CMP stack
- F-k filter on forward and backscattered noise
- 7 trace array simulation - weights - 1,2,3,4,3,2,1
- migration - Kirchoff

Data Comparison

Figure 1 shows a comparison between the results of the MUN Five Mile Road Survey and a segment of a coincident Vibroseis survey (Humber Arm 89-2). The source for the Five Mile Survey was a single MUNSIST source with the source parameters shown in the preceding table (20 s sweeps and 9 sweeps per shot point). The Vibroseis data shown for comparison were acquired using four full-sized vibrators using 12 s sweeps (10-96 Hz) and 8 sweeps per shot point. Note that only the middle portion of the MUN profile reaches the nominal 30 fold (as indicated by the box) while the entire segment of the Vibroseis profile reaches nominal 28 fold.

Points of comparison

The MUNSIST source resulted in significantly better imaging of the shallow geology (0-1.0 s / 0-2000 m) with clear definition of dips in both the upper and lower plate of the thrust sheet. However, signal coherence below 1.0 s is poorer than the Vibroseis data and is very poor in the low fold zones. This suggests a limit of signal penetration for the single MUNSIST source. Both the stack and the shot records indicate that most of the signal was concentrated in the mid to far offsets (400-1200 m) with significant contributions from the near offsets limited to reflections from less than 0.5 s (< 900 m).

The frequency content of the MUNSIST data ranges from 15 to 200 Hz (Fig. 2) but the spectrum is strongly peaked in the 40-70 Hz range. The narrow peak is reflected in the fairly monotonic look of the data. At present it is not entirely clear why the spectrum is so strongly peaked but we suspect that it is due to ground conditions and the size/weight of the present baseplate. We are actively investigating this issue.

Technical Issues Encountered

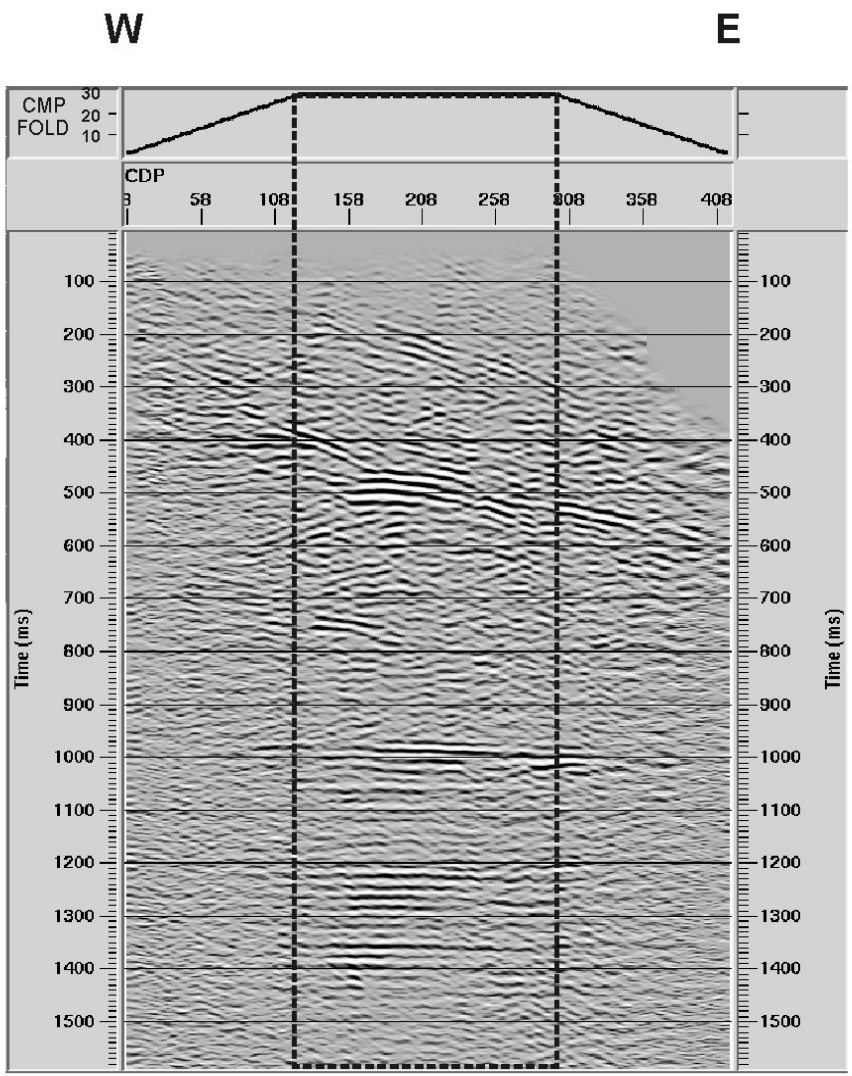
The major technical issue that arose from this test was in driving the sources over the optimal range of frequencies. Although the backhoe hired for the job met specs on paper, it was not able to deliver a flow rate high enough to reach the high end of the planned sweep program. As a result we used a 3 sweep group rather than the planned 5 sweep group and the sweep frequencies were adjusted to match the range available from the backhoe pump. This resulted in an increase in amplitude of the correlation side lobes by about 3dB. Correlation side lobes are evident in the shot records but do not strongly manifest in the stack.

The Five Mile Road area is characterized by a cover of 10-20 m of glacial till containing cobble to boulder sized hard rock inclusions in an unconsolidated, clay-rich matrix. The inclusions result in significant forward and backscatter of the refracted waves which is evident in the stacked data. Because the data were acquired with single geophones, we used array simulation (trace mixing) at several levels in the processing sequence to attenuate the scattered waves. The scattered waves are not source dependent as there is good evidence that the Vibroseis data encountered the same problem.

We also encountered technical problems centered around the supply of power to the source control system and the radio firing system. These problems resulted in a relatively low per day production rate. We have already successfully tested a modified power system that alleviates this set of problems.

Summary

A single MUNSIST source provides high resolution seismic data for depths on the order of 2-2.5 km but data quality deteriorates below that depth. The quality and coherence of the data are very dependent on CMP fold. The most likely ways of increasing the source power are increasing the size (output energy) of the hydraulic hammer and by utilizing multiple sources. Due to the light weight of the source and control system, mounting a MUNSIST style source on a wide-tracked carrier has high potential for providing a relatively cheap, portable, low environmental impact seismic source. Additional development of the control and processing systems would be required to implement an multiple source array.



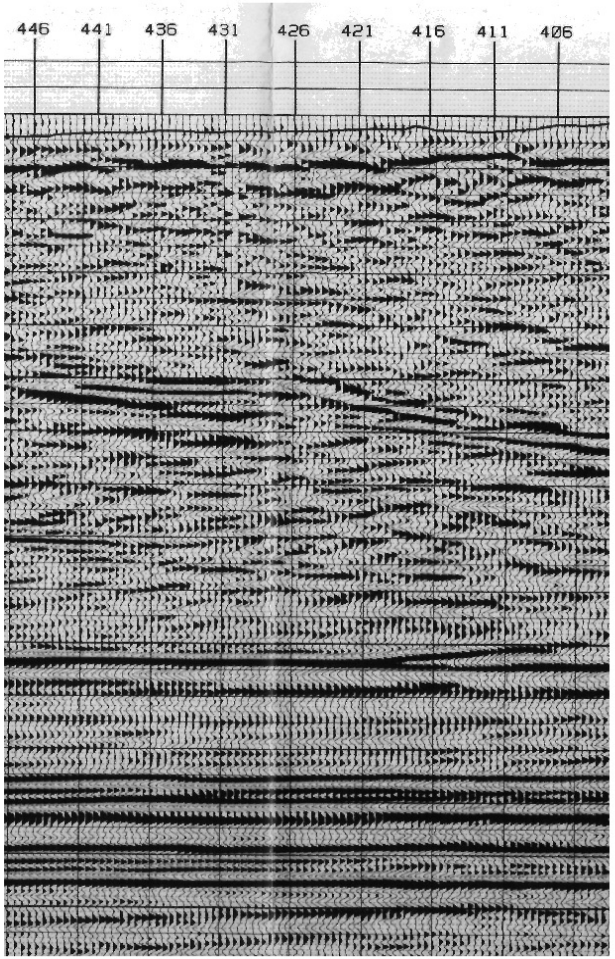


Fig. 1

1 MUNSIST
unmigrated stacked

4 Vibrators
migrated stacked

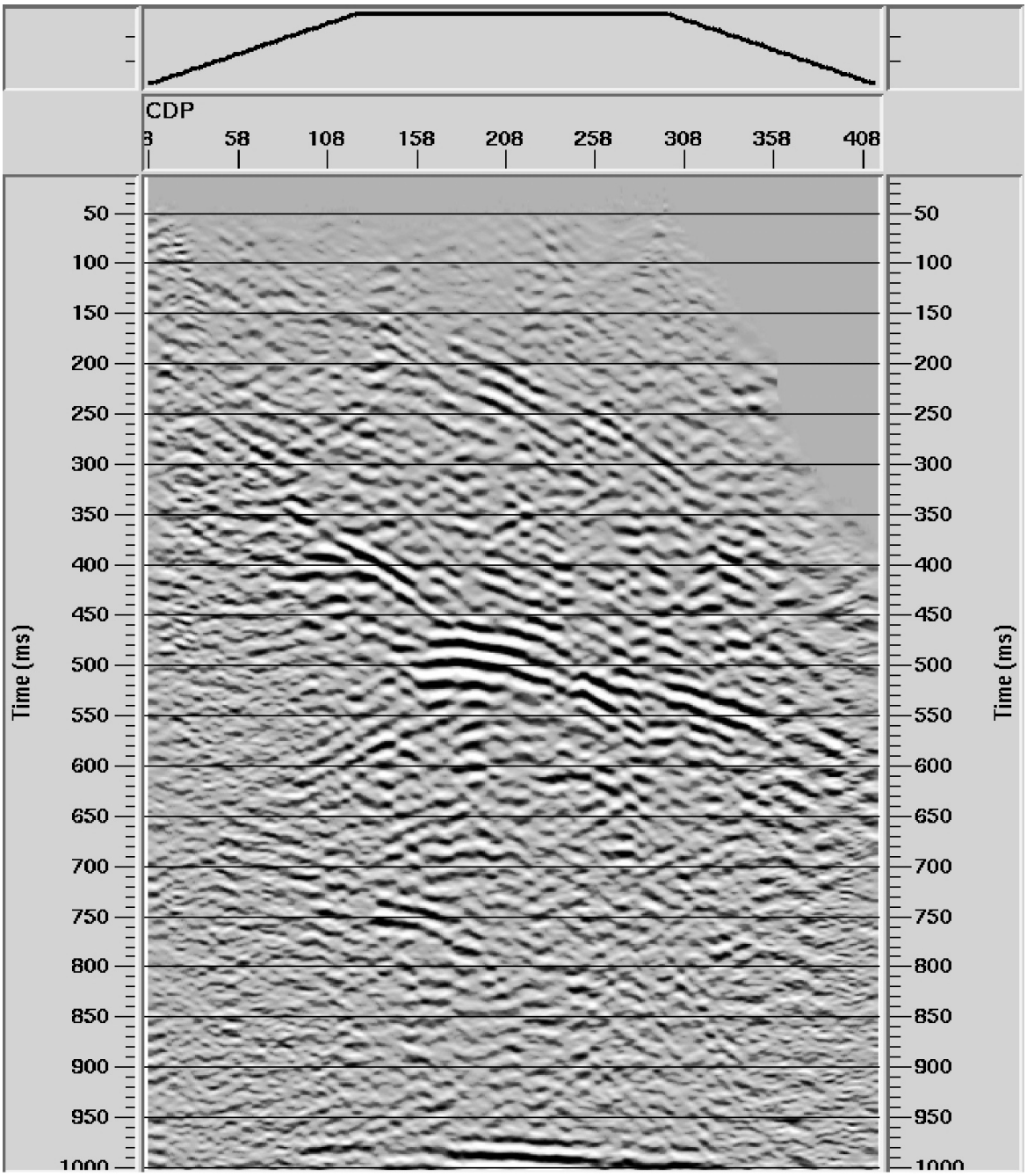


Fig. 1a 0-1.0 S MUNSIST Source

Fig. 2 Average Amplitude Spectrum - Stacked data 0-2.0 s

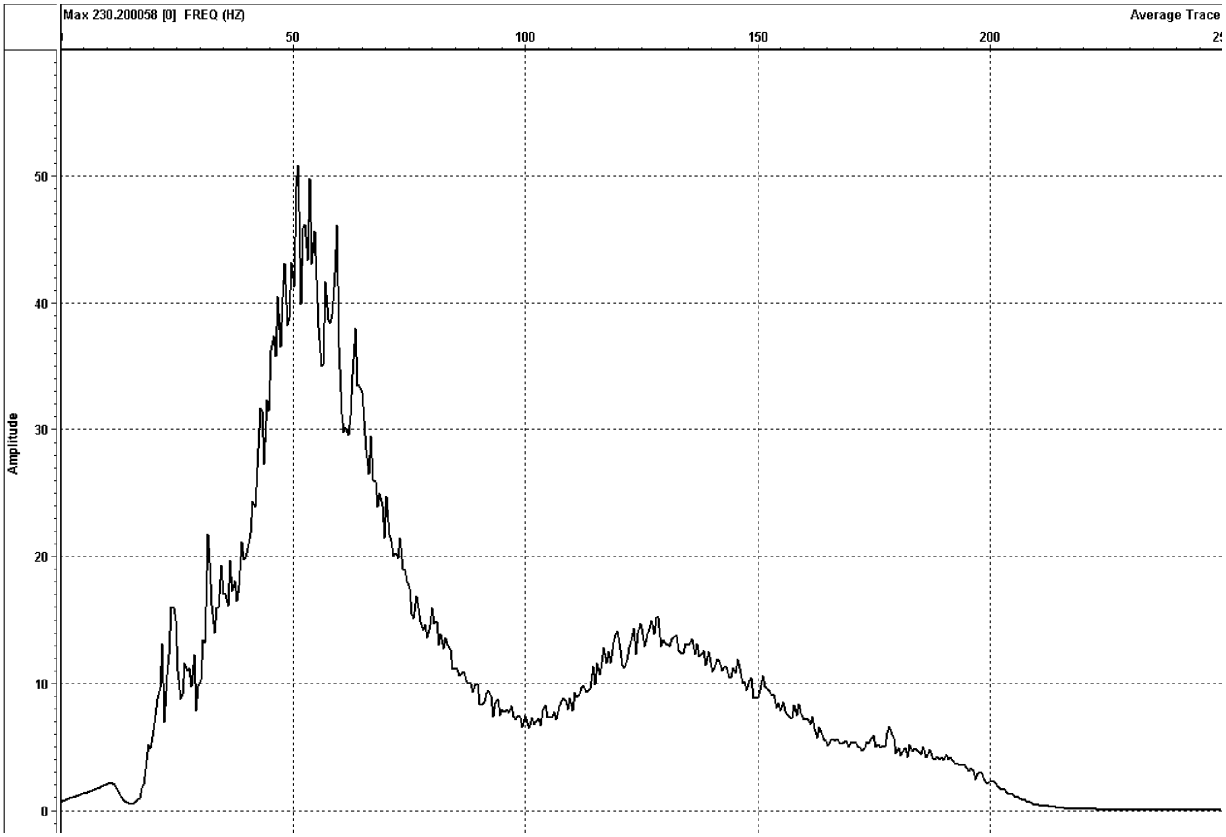
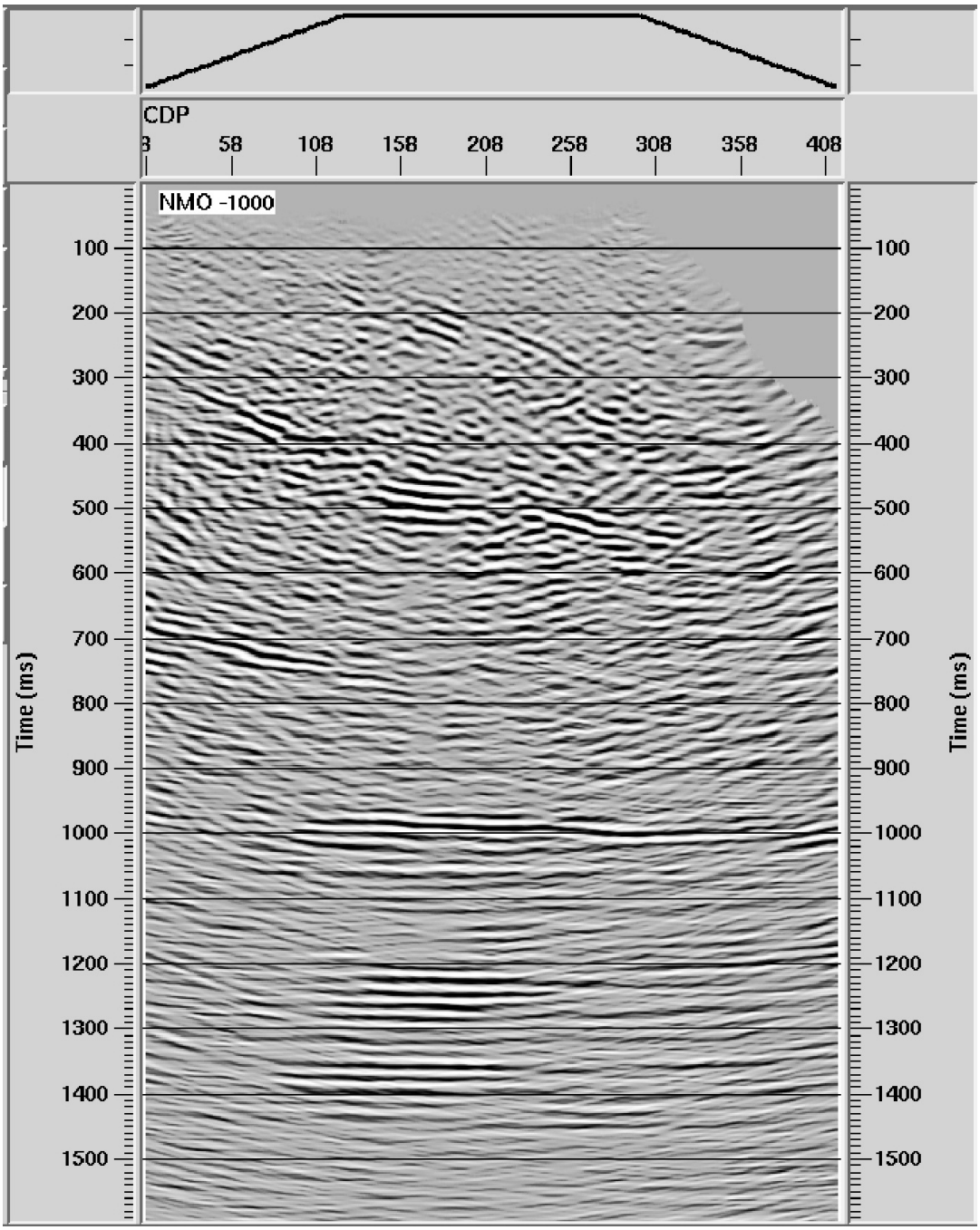
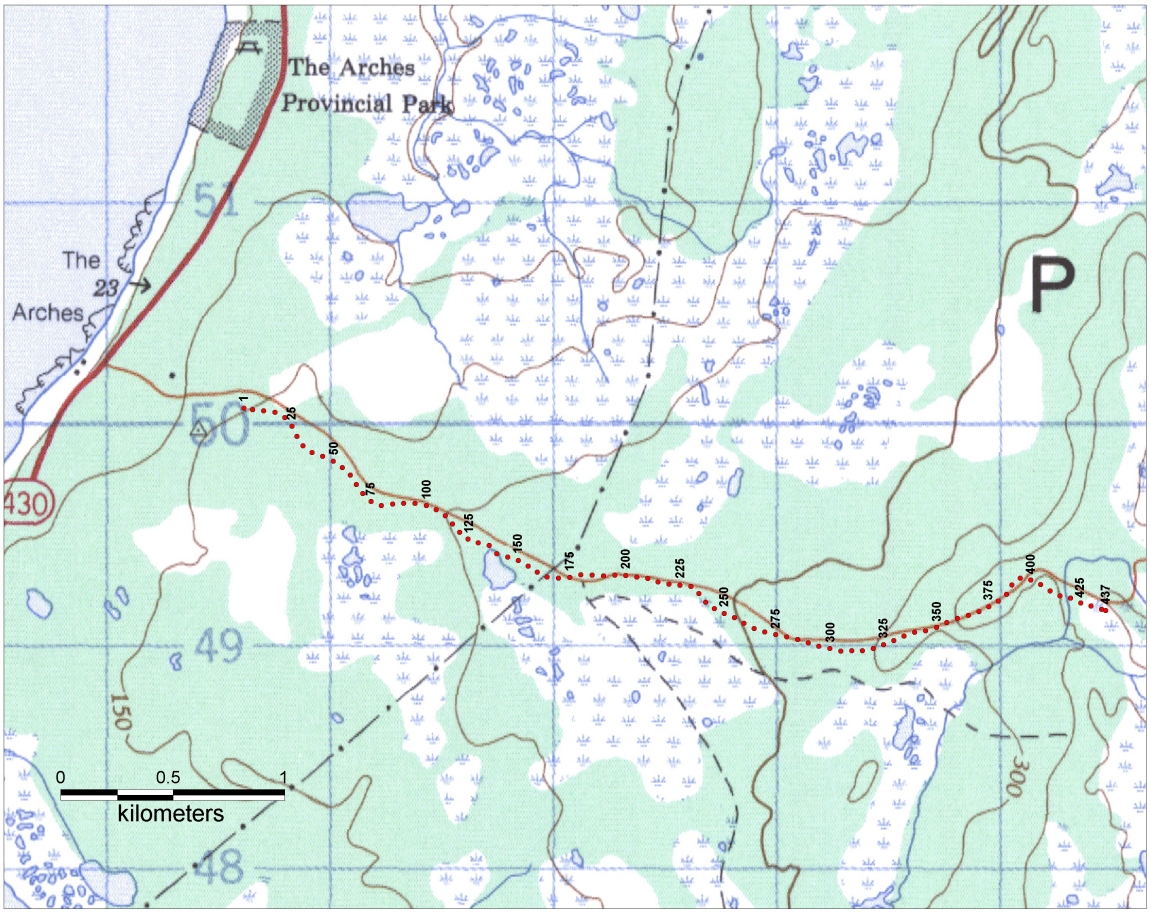


Figure 3 - Migration

Except for the first 0.3-0.4 s, the profile is too short to produce a complete migrated image. However, we include the migration for those that are interested.



Shot Point Map



Acknowledgments

Funding for this test was provided through the Petroleum Exploration Enhancement Program operated by the Government of Newfoundland and Labrador. We wish to thank David McCallum (Energy Branch) and Ian Atkinson (NALCOR) for support during the funding process and during application for the exploration license.

The data were acquired by Memorial University through the Land and Seabed Imaging Facility with the support of Chris Byrne (Seismic Manager) and Dan Blackmore (Project Engineer). Dr. Sharon Deemer processed the data in Memorial University's Computing, Visualization and Simulation Laboratory with software provided by Landmark Graphics.

Appendices

A)

- weekly report
- Exploration Survey cost summary
- Exploration Survey equipment inventory
- Exploration survey employment summary

B)

- correlated shot records
- stack
- migration

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NEWFOUNDLAND AND LABRADOR
Department of
Natural Resources

Exploration Survey Equipment Inventory

Description	Newfoundland Based	Other
Vibrators:	1 MUNSIST source	
Drills:		
Rental cars / pickups:	4	
Semi-trailors:		
Bombardiers:		
ATVs:		
Snowmobiles:		
Tractors:	Contacted backhoe & op	
Cables:	38 Aeries cables	
Geophones:	420 singe 14 Hz	
Helicopters:		
Snowplows:		
Survey Instruments:	Aeries Recording System	
Recording Trucks:		
Gravity Meters:		
Magnetometers:		
Other:		

Prepared by: Dr. Charles Hurlich Prof. Memorial Univ.
(Name and Position)

Charles Hurlich
(Signature)

Exploration Licence #: 09-101-01-RS **Date:** Oct 19 2009

GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
Department of Natural Resources

Weekly Report - Geophysical Exploration

Exploration Licence #: 09-101-01-RS Report Period: June 7-14, 2009

Licensee: Memorial Univesity Contractor:

Area: Five Mile Road – North of Parson's Pond

	TO DATE	REMAINING
Number of km: Cut		
Chained		
Surveyed	4	0
Drilled		
Layed Out	4	0
Recorded	2	0
Reclaimed		

CURRENT EMPLOYMENT	RESIDENTS	OTHER
Party Manager	1	
Observers	2	
Junior Observers		
Line Cutters		
Surveyors		
Surveyors Helpers		
Drilling Supervisors		
Drillers		
Driller's Helpers		
Cat Operators		
Pilots		
Juggies	4	
Security Guards		
Blasters		
Mechanics		
Other:		

CURRENT EMPLOYMENT	RESIDENTS	OTHER
	7	

EQUIPMENT IN USE	NEWFOUNDLAND BASED	OTHER
Vibrator Trucks		
Rental Cars/Trucks	4	
Semi-Trailers		
Snowmobiles		
ATVs		
Drills		
Bull Dozers		
Helicopters		
Cables	36	
Geophones	420	
Survey Instruments		
Gravitymeters		
Magnetometers		
MUNSIST source	1	

COMMENTS:

Report Prepared by: Dr. Charles Hurich (Print Name) 709-737-2384 (Telephone) _____ (Fax)

Prof. Memorial University (Position & Company)

(Signature) Oct 19, 2009 (Date)

Please attach a page size map illustrating the line sections that have been (where applicable) cut, chained, surveyed, recorded and reclaimed.

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NEWFOUNDLAND AND LABRADOR
Department of
Natural Resources

Exploration Survey Employment Summary

Occupation	Number of Employees		Person Days		Total Person Days
	Residents	Non-residents	Residents	Non-residents	
Project Supervisor:	1		7		7
Line Cutters:					
Surveyors:					
Surveyor's Helpers:					
Drillers:					
Driller's Helpers:					
Juggies:	4		7		28
Line-truck Drivers:					
Cat Operators:					
Pilots:					
Mechanics:					
Security Guards:					
Blasters:					
Observors:	2		2		14
Jr. Observors:					
Other:					
TOTAL:					

Prepared by: Dr. Charles Hurich Professor
(Name and Position)
Charles Hurich
(Signature)

Exploration Licence #: 09-101-01-RS **Date:** Oct 19 2009

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NEWFOUNDLAND AND LABRADOR
Department of
Natural Resources

Exploration Survey Cost Summary

(Estimate where necessary)

Mobilization:	$2,189
Drilling[1]:	
Salaries: Residents:	$10,000
Non-Residents:	
Accommodations:	$8,940
Surveying:	
Equipment Rental:	$11,500
Helicopter Time:	
Dynamite:	
Food:	$2,000
Fuel:	$1,200
Recording[1]:	
Processing:	$3,500
Miscellaneous:	
Other:	
Total Cost of Program: (not including overhead)	$39,329

I Charles Hurich of Charles Hurich Memorial University
(Name and Position) *(Company Name)*

do hereby certify that the information contained herewithin is, to the best of my knowledge, accurate.

Charles Hurich
(Signature of Company Representative)

Sharon Deemer, Memorial University
(Witness Name and Position)

Sharon Deemer
(Witness Signature)

Exploration Licence #: 09-101-01-RS **Date:** Oct 19 2009

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[10] State contract rate per day or per km, where applicable.

Additional data listed below is available through email requests to petroleum_development@gov.nl.ca

- Correlated shot records - SEGY format
- Final Processed Stack - SEGY format
- Final Processed Migration - SEGY format