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Canada

HIGH-RESOLUTION, MULTICHANNEL, MARINE SEISMIC SURVEYING USING A SMALL AIRGUN SOURCE

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Section des sciences de la Terre


MV *J. Ross Mackay* heading out to survey on Lake Simcoe.


MV *J. Ross Mackay*


Sunset over Lake Simcoe


Down time!


Capt. Good


A. Pugin

R.A. Burns

Poster presented at SAGEEP'99 (Symposium on the Application of Geophysics to Environmental and Engineering Problems), March 14-18, 1999, Oakland, CA.

See also: Pugin, A., Pullan, S.E., Burns, R.A., Douma, M., and Good, R.L.: High-resolution, multichannel, marine seismic surveying using a small airgun; in Proceedings, SAGEEP'99, Symposium on the Application of Geophysics to Environmental and Engineering Problems, March 14-18, 1999, Oakland, CA, p. 255-264.

Summary

This poster presents results from a high-resolution, multichannel, CMP, marine seismic reflection survey using a small (1 cubic inch) airgun as a source. Considerable care was taken to ensure that the airgun was fired accurately on distance (5 m spacing). This was accomplished by integrating a real-time DGPS with a computer-driven triggering system which adjusts the firing rate depending on the ship's velocity.

The small airgun source combined with multichannel digital recording and processing provides very high-resolution, stacked (6-fold) seismic sections with significant energy to frequencies of 2000 Hz. These high-frequency signals are combined with greatly enhanced depth penetration over that achievable with single-channel subbottom profilers. In this survey, the bedrock surface can be observed at depths of ~40 m below bottom, even though part of the overlying sedimentary section includes thick, high-velocity tills. Penetration is reduced in areas where these tills exceed ~20 m in thickness.

The high resolution on the processed sections depends on careful data processing, particularly on spectral whitening and on accurate, closely-spaced velocity determinations. The velocity information and the full-waveform recording allow additional data processing (e.g. migration) to be applied. These results demonstrate that high-resolution, multichannel, CMP, marine seismic surveys are a viable and potentially useful technique where detailed information on the shallow subbottom (to 10's ofmetres below bottom) is required.

Acknowledgments

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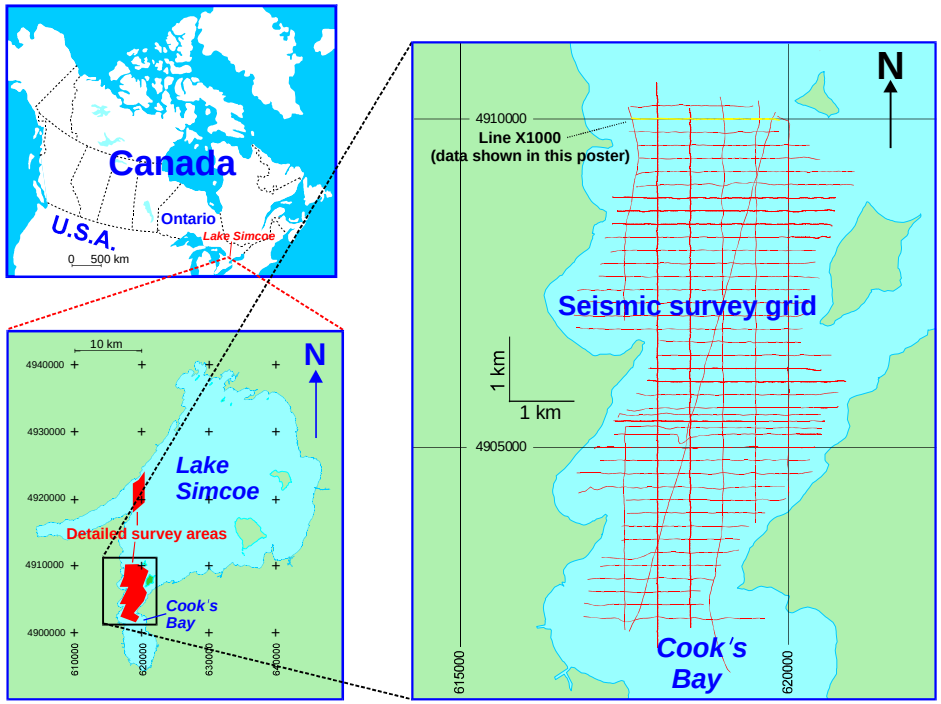
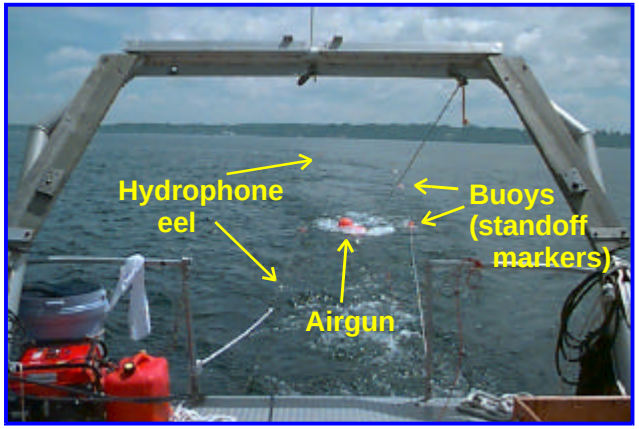
Data Acquisition

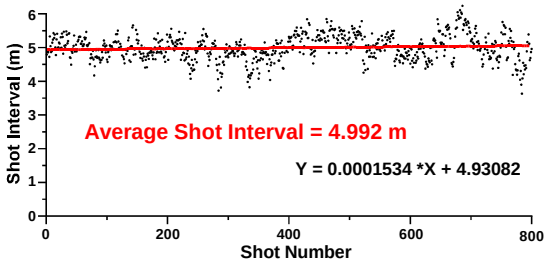


Recording Parameters

Survey area:	Lake Simcoe
Survey vessel:	*MV J. Ross Mackay* 46-foot, aluminum workboat
Avg. Speed:	4 knots (7 km/hr)
Receiver array:	24-channel, oil-filled eel (2 hydrophones/channel)
Group spacing:	5 m
Seismic source:	1 cu. in. Airgun (~1500 psi)
Air supply:	on-board compressor feeding air bottles
Firing interval:	2.2-3 s
Source offset:	10 m
Recorder:	Geometrics R-24 Strataview



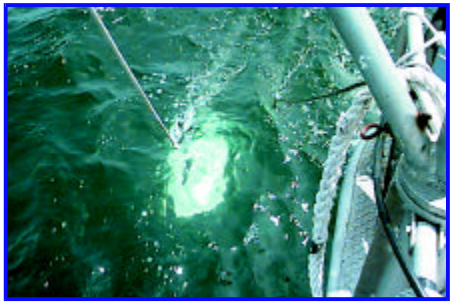
The airgun source was fired accurately at 5 meter horizontal intervals by integrating a real-time DGPS (Differential Global Positioning System) and a computer-driven triggering system which adjusted the firing rate depending on the ship's velocity.



Accuracy of firing-on-distance system (Line X1000).

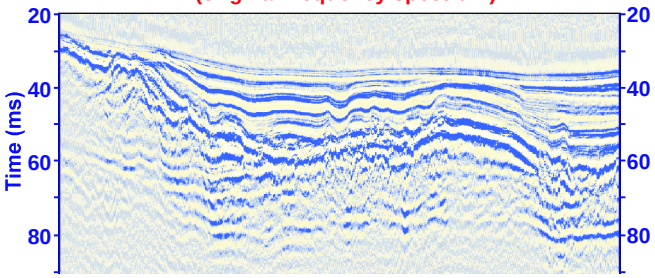
Data Processing

The high resolution on the processed sections depends on careful processing, particularly on spectral whitening (accomplished here with a zero-phase spiking deconvolution), and on accurate, closely-spaced velocity determinations.

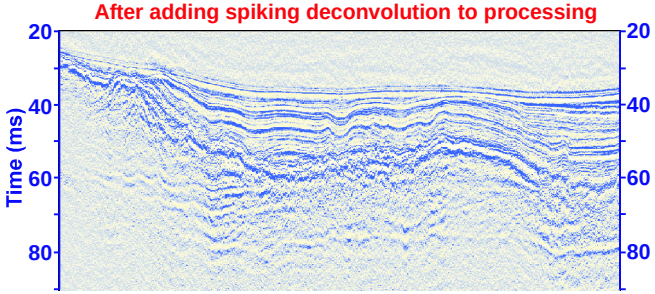


Datasonics Chirp II subbottom profiler (sonar sweep 2-7 kHz)

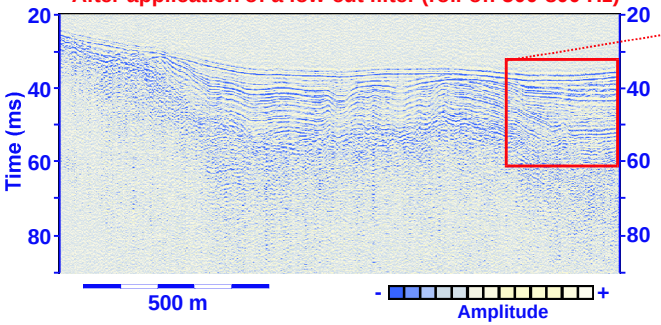
Stacked section (6-fold) using unfiltered data (original frequency spectrum)

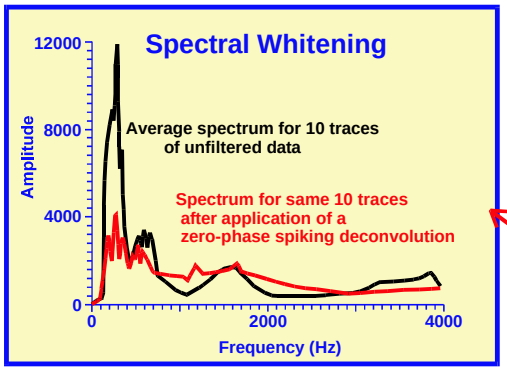


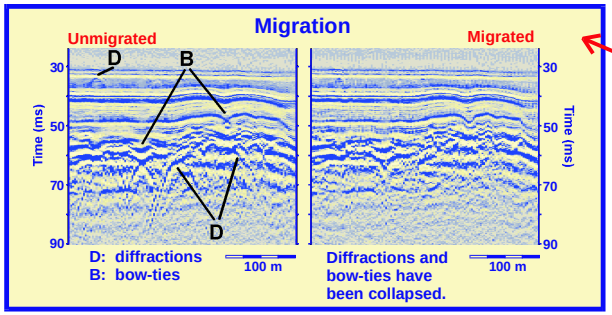
After adding spiking deconvolution to processing



After application of a low-cut filter (roll-off 500-800 Hz)

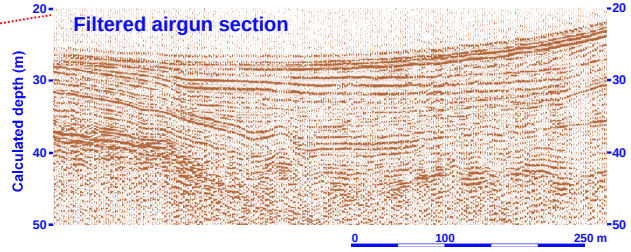


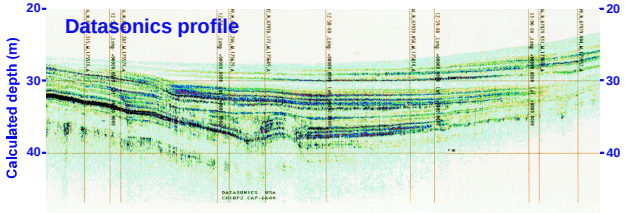




Seismic data processing flow chart.

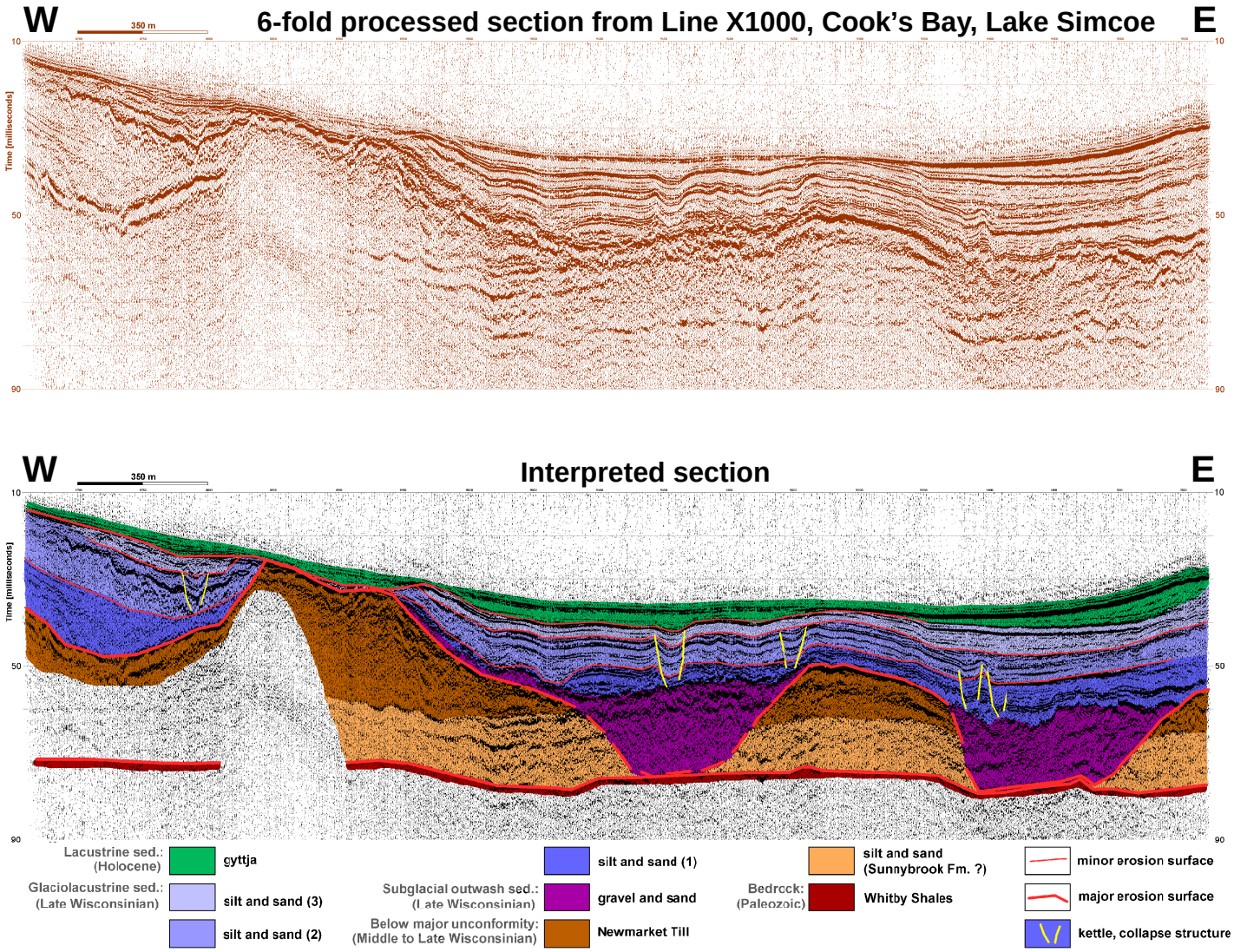
data format conversion
trigger delay corrections
edition of the geometry
CMP sorting
band pass filter
predictive deconvolution
(to remove bubble pulse)
zero-phase spiking deconvolution
(to whiten frequency spectrum - see figure)
velocity analysis
normal moveout corrections
stack of corrected CMP's
phase shift migration
(to reduce diffractions and improve interpretation of subbottom structure - see figure)





Comparison of high-frequency components of airgun data and Datasonics records.

Interpretation



Lake Simcoe is underlain by a sequence of Pleistocene sediments over Paleozoic black shales (Whitby Shales).

Two groups of lithologies are separated by a major regional unconformity (highly-reflective surface):

1) a lower unit, characterized by relatively low-frequency reflections (orange/browns). This unit is interpreted to consist of Middle Wisconsinan silts and sands deposited in a prograding glacial environment, overlain by the high-velocity Newmarket Till.

2) an upper unit, characterized by low-frequency reflections (purple; interpreted to be gravels) and very-high frequency reflections (blues; interpreted to be sands and silts), interspersed with three small-scale erosion surfaces. These sediments are interpreted to be deposited in subglacial and proglacial environments. The presence of kettles (collapse structures) indicates that ice was originally trapped in these sediments.

The major regional unconformity is interpreted to represent erosion by large-scale, subglacial sheet flooding. The downcutting of tunnel channels would be related to the waning stages of this event. The channel features are partly filled with gravels or diamicton.

For further information:
Pugin, A., Pullan, S.E., And Sharpe, D.R. (1999) Seismic facies and regional architecture of the Oak Ridges Moraine area, southern Ontario; Canadian Journal of Earth Sciences, 36, p. 409-432.