G E O L O G I C A L S U R V E Y O F C A N A D A.

ATLANTIC GEOSCIENCE CENTRE

OPEN FILE REPORT

SEISMIC DATA FROM THE HUDSON 88-020 CRUISE, JUNE 1988, MONTAGNAIS, NOVA SCOTIA.

by

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July, 1989.

INTRODUCTION.

This report covers the acquisition and processing of marine reflection seismic data acquired on Hudson Cruise 88-020 between June 15 and June 28, 1988 (Loncarevic et. al., 1988). The purpose of this cruise was to investigate a unique structural feature located on the edge of the Scotian Shelf which had been interpreted as being the result of a meteorite impact (Jansa and PePiper, 1987, Jansa et. al. 1989). Two record lengths of seismic data were acquired, the bulk of the data was recorded to 3 seconds (TWT) and a small portion to 15 seconds (TWT).

The report is divided into four sections, the first deals with the field recording operation. The second with the processing of the 15 second data by the Centre for Earth Resources Research, Memorial University of Newfoundland. The third section covers the processing of the three second record data by Western Geophysical, a Division of Western Atlas, Calgary, Alberta. The final section provides a list of all the sections processed and displayed under the two processing schemes.

REFERENCES

Jansa, L.F. and Pe-Piper, G., 1987, Identification of an underwater extraterrestrial impact crater; Nature v. 327, no. 6/23, p. 612-614.

Jansa, L.F., Pe-Piper, G., Robertson, B. and Friedenreich, O., 1989, Montagnais: a submarine impact structure on the Scotian Shelf, eastern Canada; Geological Society of America Bulletin, v. 101, p. 450-463.

Loncarevic, B.D., Edwards, A. and the Shipboard Scientific Party, 1988, "Cruise report, CSS Hudson 88-020, June 13-28, 1988", AGC Internal Report, 80 p.p.

SEISMIC REFLECTION SURVEY

T. Edwards, F.K. Learning and M.E. Best

OBJECTIVES

Available industry seismic data in the area of the Montagnais structure consist of recent data on the slope and a number of older seismic lines on the shelf. The older data is of poor quality (at least that available to AGC) and our attempts to acquire the original data from the petroleum companies for re-processing has had limited success. For example, Shell Canada Limited could not read their original field tapes so gave us a stacked tape for re-processing. There was marginal improvement of the post stack re-processed line, but not enough for improving the interpretation.

The main objective of the seismic program was to supplement the good reflection data on the slope with modern multi-channel seismic data on the shelf. This data would be used to make a detailed interpretation of the area around the structure. The lines were arranged to cross the structure in a radial pattern, particularly covering the northern (shelf) portion of the expected structure (Fig. 1.). The lines were recorded to 3 seconds two way time to ensure they penetrated the basement. A shot spacing of 25 m was selected to obtain good spatial resolution along line while the temporal sampling interval was 2 ms to ensure high resolution in the vertical direction.

Another objective of the program was to obtain seismic data over several survey sites in preparation for possible ODP drilling when the ship returns to the North Atlantic. Reflection data were obtained on several seismic lines that tied at the proposed site locations. As well, several seismic lines were selected to pass over the Montagnais I-94 and Mohawk B-93 wells for calibration of specific reflectors with the known lithologies in the wells.

Finally, deep seismic data were acquired on a seismic line directly over the Montagnais I-94 well. This data was shot and recorded to 15 seconds two way time. All other parameters were the same, except the airgun volume. One objective was to see if reflection energy could be recorded to the Moho using a relatively small airgun source. Both 1000 and 2000 cubic inches of air guns were compared during this line. This was strictly experimental; the processing of this data will be carried out jointly with Jeremy Hall of Memorial University. The second objective was to investigate if there was any structural changes in the Moho under the area of the Montagnais structure.
An impact may be expected to affect the crust right to the Moho.

SURVEY EQUIPMENT

The contract to provide multi-channel seismic recording equipment aboard the CSS Hudson was awarded to Earth and Oceans after a competitive bidding process. The proposal called for the installation and operation of the equipment, AGC was to provide a seismic streamer which was obtained on loan from the US Geological Survey,Woods Hole,U.S.A. The contractor was also

required to provide navigation interface between shipboard Bionav and the DFS V. This software was called BIOSEIS.

a) System configuration

The seismic system consists of four main subsystems, namely;

1 Recorder
2 Hydrophone Array
3 Source
4 Navigation Interface

Details of each subsystem are listed below. Figure 2. shows the system interconnections.

1 Recorder

The primary instrument is a Texas Instruments DFS V configured for 48 channels, 8 hz. lo-cut and 128 hz. anti alias filters, 2 ms. sample rate, SEG B, 1600 BPI Phase Encoded tape format. Major components of the system are:

TI DFS V Controller module
TI DFS V Analog module
Dual TI 10", 9 track tape transports
Tektronics 465 monitor oscilloscope
Geosource SDW 400B Recording Oscillograph
EPC Labs EPC 3200S Near Trace Recorder

2 Hydrophone Array

The hydrophone array used was custom manufactured by Seismic Engineering Inc. for Texas A&M University and the U.S. Geological Survey. Basic subsystem components are as follows;

- Active Section, 12 in total, 2 channels per section, 50 meter group interval, 30 hydrophones/group.
- Isolation section, 50 meter length
- Extender section, 50 meter length
- Depth Transducer Section, 4 in total
- Armoured Lead-in, 200 meter length
- Patch panel/interface box
- 10 HP electric winch

Ancillary equipment to the hydrophone array:

- Syntron RCL 2 remotely controllable cable levellers,(birds), 4 in total
- Syntron RCL 2 Command Unit
- Syntron RCL 2 Battery Charger
- Seismic Engineering DDI-100 Depth Display
- Teledyne Depth Transducer Calibrator
- Aluminum Tailbouy

Figure 3. illustrates the hydrophone array configuration as used on 88-020.

3 Source

The source used consists of an array of six Bolt PAR airguns on an 8' x 21' tow frame constructed of 3" schedule 80 steel pipe. The array was supported by four 1 meter plastic buoys and towed at a depth of 5 meters. Figures 4 (a. and b.) illustrate

the airgun spacings within the array and the volume of the individual airguns for both array configurations used.

The airgun array is triggered by an Input/Output Inc. AIRCON II airgun controller system which enabled individual delay of airgun fire times to from 1 ms. to 99 ms.

A Mark Products hydrophone was installed in the array airline bundle 10 meters from the tow frame and was used to monitor array output and sync on a Gould OS 4040 Digital Storage Oscilloscope.

4 Navigation Interface

An IBM AT clone computer with "BIOSEIS" software provided an interface between the vessel's BIONAV system and the seismic system. The computer received all available raw navigational data from BIONAV via an RS-232 interface. A smoothed position was then calculated and a closure generated to trigger the seismic system on a predetermined distance interval.

SYSTEM MOBILIZATION AND FIELD PERFORMANCE

The seismic electronics were all housed in a 7' by 8' by 11' steel container which was situated on the helicopter deck overlooking the stern of the vessel. This afforded the operators a good view of the streamer and airgun array whilst in towing position and enabled problems with the towing arrangements to be identified quickly.

Mobilization commenced with the arrival of the vessel on June 9th. By 0800 local time, June 13th, all equipment was in place and fine tuning of the instruments was well underway.

The seismic recorder and its primary monitor, an oscillographic recorder, required extensive work to get running after loading on the vessel, even to the point of delaying departure by 48 hours. The DFS V was reconfigured from 48 channels to 24 channels prior to installation on the vessel but would not operate in 24 channel configuration. Consultation with the manufacturer suggested problems most likely originated in the programming plugs and technicians from AGC and Earth and Ocean Research verified the correct wiring of the plugs on three occasions. Finally the Canadian representive for Texas Instruments Field Service was brought in from Calgary to assist on Tuesday the 14th. The program plug settings were verified by him as correct for the desired configuration but he was unable to bring the system up for 24 channels. The system was then put back to 48 channel configuration and powered up successfully. The oscillographic recorder supplied proved to be too unreliable and another unit was rented from a local seismic contractor about 3 hours prior to departure. This unit required manufacture of interface cables for the DFS V and experienced some start up problems of its own but proved reliable once it was made operational.

The airgun array was assembled ashore and was tested alongside. When deployed at sea however the hose used to feed high pressure air to the guns began failing at an alarming rate. At the suggestion of the Chief Scientist, all the hose on the frame itself was replaced and no further problems of that nature

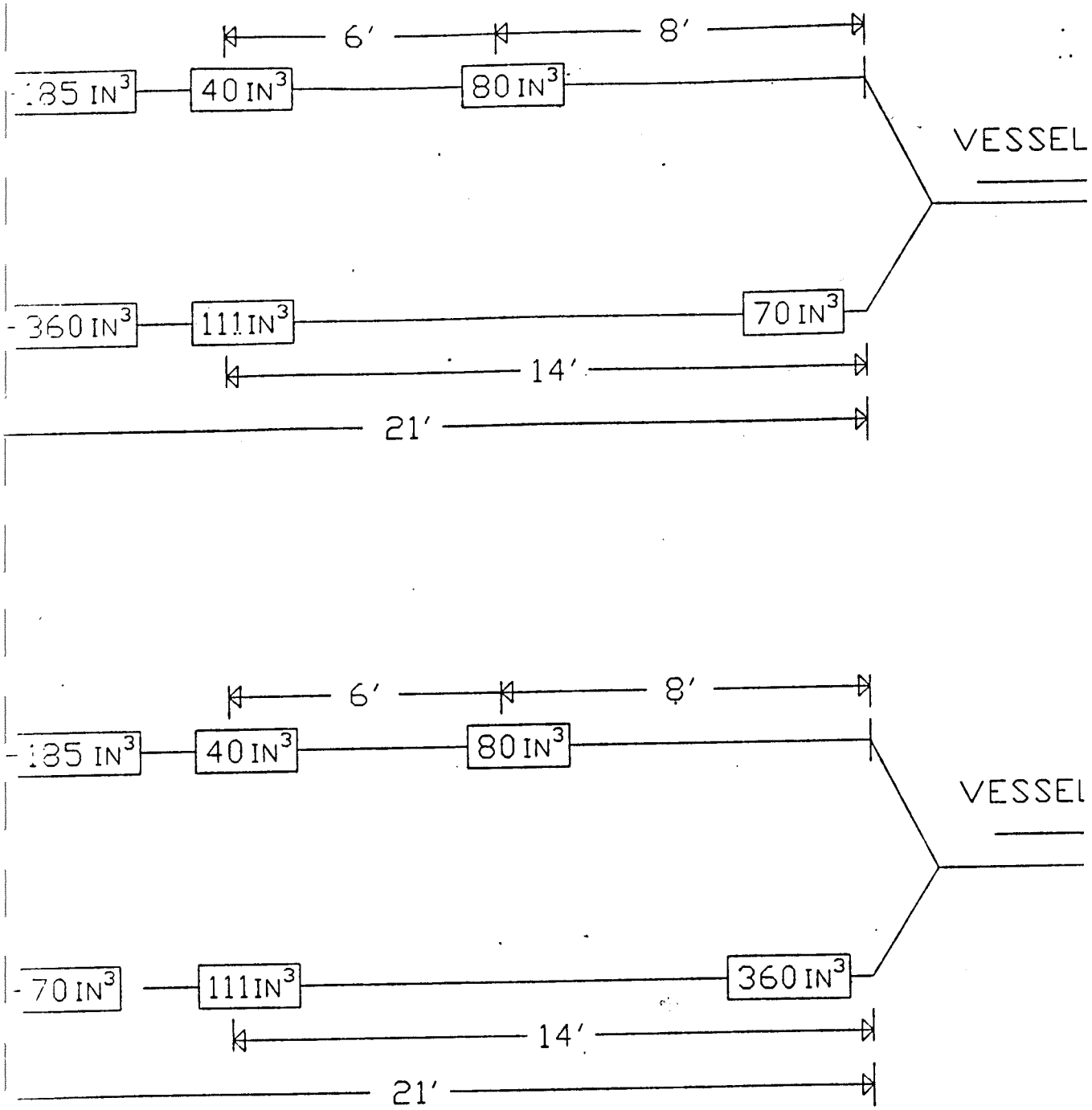
6′
8′
185 IN3
40 IN3
80 IN3
VESSEL
360 IN3
111 IN3
70 IN3
14′
21′
6′
8′
185 IN3
40 IN3
80 IN3
VESSEL
70 IN3
111 IN3
360 IN3
14′
21′

FIG. 4

represent the feature quite well. The monitor records are obviously not of sufficient quality to make any meaningful comment or interpretation at this time. The line recorded to 15 seconds could only be displayed on the near trace for the first 8 seconds and therefore does not show if we recorded Moho or deep crustal reflections. Monitoring of the oscilloscope did show energy returns at late arrival times which may indicate that we were receiving primary signal.

PROCESSING REPORT - DSS Contract No. 23420-8-C607/01-OSC

PROCESSING OF MONTAGNAIS DEEP SEISMIC LINE

BY

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Brian Roberts
Seismological Analyst

Processing Sequence:

Pre-Stack

1) Demultiplex into 24 channel shot records stored in a SEG Y format

2) Resample to 4 ms from the original 2 ms.

The shot records were examined at this point to flag bad shots and noisy traces. It was at this point that significant coherent noise was noticed between shot points 400 and 550 on line M901. The noise source is suspected to have been from a passing ship since the apparent velocity varies gradually from negative to positive values as measured in the direction of steaming.

3) Burst removal; done as a routine process to remove the few noise bursts occuring in the data set.

4) FK filtering to remove the dipping coherent noise present in the centre part of line M901.

Tests were performed on the effectiveness of the FK filter in removing the coherent noise noted in 2) above. It was found that the filter was effective in removing the noise on the shot gathers but could only be used on the positive dipping events since a negative attenuation fan also began to distort reflections in the upper section. The filter was applied to the whole of line M901.

5) CDP Gather

6) Pre-stack predictive deconvolution

Pre-stack deconvolution tests were performed on shot gathers with panels of shot gathers and short stack sections generated in order to pick the best deconvolution operator . A minimum phase predictive deconvolution operator with a maximum lag of 140 ms and a prediction lag of 28 ms was chosen as doing the best job of pulse compression without adding any serious high frequency noise to the data.

7) NMO correction

Velocity Analyses (1 per tape) were used to derive a useful velocity function for the application of the NMO correction.
Velocities for the shallow section were derived from only a small set of high quality picks from the velocity analyses. On the photocopied semblance plots those picks are highlighted . A contour plot showing the velocity profile used in the upper section for line 901 was produced along with a similiar plot showing the high quality picks mentioned above which could be overlain on the contoured plot if desired.

12) Migration

A finite difference time migration using the 15 degree approximation was performed for each line using interval velocities derived from the stacking velocities previously picked. Prior to migration the data was rsampled to 8 ms in order to reduce computation time.

Both migrated and unmigrated sections were forwarded.

13) Expanding gain; the following gain function was applied:

+10 dB/sec, expanded 0.8 sec to 1.5 sec
+8 dB/sec, expanded 1.5 sec to 3.0 sec
+6 dB/sec, expanded 3.0 sec to 6.0 sec
+2 dB/sec, expanded 6.0 sec to 12.0 sec

14) Automatic gain equalization was done using an AGC algorithm with a one second balancing window.

Display

Data was plotted on a Versatec electrostatic plotter (model #7236). Three sets of plots were produced:

1) 3 seconds of data, vertical scale - 6.35 cm/second
horizontal scale - 9 traces/cm

2) 3 seconds of data, vertical scale - 12.7 cm/second
horizontal scale - 7 traces/cm

3) 15 seconds of data, vertical scale - 3.175 cm/second
horizontal scale - 11.5 traces/cm

The polarity is positive black, with 0 % bias.

PART 3

PROCESSING OF SHALLOW DATA

TABLE OF CONTENTS

DATA ACQUISITION

ACQUISITION DATES: June 1988

VESSEL: Hudson

SOURCE:

Source	Air Gun
Energy	1500 - 2000 PSI
Gun Depth	5 M
Shotpoint Interval	25 - 50M
Source-Antenna Distance	76 M

CABLE:

Number of Groups	24
Group Interval	50 M
Average Cable Depth	10 M
Source To Near Group	59 - 84 M

INSTRUMENTS:

Recording System	DFS-V
Filter	8 Hz LOW CUT 128 Hz HIGH CUT
Sampling Interval	2 MSEC
Record Length	3 SEC
Format	SEG-B MULTIPLEXED
Primary Navigation System	Bio-Nav
Secondary Navigation System	LORAN-C

M18	113-480
M18-1	109-1541
M19	101-811
M19-1	1712-2054
M19-2	2992-3151
M19-2-A	3152-3610
M19-3	4514-5228
M20	101-671

NOTE:

** FIELD TAPE NUMBER 108 -LINE M2, COULD NOT READ TAPE.
SENT TAPE TO DYAD TO CREATE TAPE COPY.

SEISMIC DATA PROCESSING:

FORMAT CONVERSION/DEMULTIPLEX

The field tapes received in SEG-B format were converted to Western's internal Code-4 format. The near trace of each shot record and every 24th shot record were displayed for quality control and subsequent parameter selection. Data was processed to a length of 3 seconds.

FK FILTER ZONES

Pass - 15 to 5 ms/trace.

GEOMETRIC SPREADING COMPENSATION

This time and offset variant, non data amplitude dependent trace scaling compensated for amplitude loss resulting from the increasing area of the propagating wavefront. The gain correction based on the radius of the expanding wavefront was calculated as a function of offset and time dependent velocities.

PRESTACK DECONVOLUTION

Minimum phase predictive deconvolution was applied in the time domain using the Weiner-Levinson algorithm. The design parameters and windowing for autocorrelation determination were as follows:

Prediction Distance	12 MSEC.
Operator Length	300 MSEC.
Percent White Noise	0.1%
Autocorrelation Windowing	Two equal length windows between water bottom and 2900 MSEC.

MIGRATION

All data was migrated using the "STOLT MIGRATION ALGORITHM". Smoothed stacking velocities were used for migration. The input to this step was the post-stack deconvolved data.

TIME VARIANT FILTER

The data was filtered with zero phase bandpass filters having time variant passbands. The filters used are listed below. For intermediate times a weighted average was taken of the trace filtered with the earlier and later filter seperately. The cut off frequency is specified at - 3 DB.

Time (MSEC)	Low Cut (HZ)	Slope (DB)	High Cut (HZ)	Slope (DB)
Water bottom	12	18	70	96
3000	6	18	50	64

RMS GAIN

Each trace was divided into non-overlapping zones beginning with a small window and doubling to a large window. A multiplier was calculated for each zone to adjust the root-mean square to a value of 2000. The multiplier was applied at the center of each zone. The multipliers at all other times were determined by linear interpolation between zone centers.

ARRAY FORM

A 1:2:1 array form was applied to the data.

TESTING

1. DECONVOLUTION TESTS

The following tests were performed on Line M15:

DECONVOLUTION BEFORE STACK

Prediction Distance	Operator Length	% White Light	Number of Windows
2 MSEC	300 MSEC	.1	1
4 MSEC	300 MSEC	.1	1
12 MSEC	300 MSEC	.1	1
32 MSEC	300 MSEC	.1	1
64 MSEC	300 MSEC	.1	1
2 MSEC	300 MSEC	.1	2
12 MSEC	300 MSEC	.1	2

In consultation with A.G.C., the 12-300 MSEC., 2 windows was chosen.

DECONVOLUTION AFTER STACK

Prediction Distance	Operator Length	% White Light	Number of Windows
4 MSEC	300 MSEC	.1	1
12 MSEC	300 MSEC	.1	1
24 MSEC	300 MSEC	.1	1
32 MSEC	300 MSEC	.1	1
64 MSEC	300 MSEC	.1	1
2 MSEC	300 MSEC	.1	2
4 MSEC	300 MSEC	.1	2
12 MSEC	300 MSEC	.1	2
24 MSEC	300 MSEC	.1	2
32 MSEC	300 MSEC	.1	2
64 MSEC	300 MSEC	.1	2

In consultation with A.G.C., the 24-300 MSEC., 1 window was chosen.

APPENDIX 1 - HARDWARE DESCRIPTION

1 X IBM 3081 COMPUTER

32 X IBM TAPE DRIVES

16 X IBM 3480 CARTRIDGE TAPE DRIVES

1 X FPS-5505
(64 BIT FLOATING POINT ARRAY PROCESSORS)

1 X STAR ARRAY PROCESSOR

17 X IBM 3350 DISK STORAGE (34 VOLUMES)

10 X IBM 3380 DISK STORAGE (40 VOLUMES)

2 X GEOSPACE 6410 PHOTOGRAPHIC PLOTTING SYSTEMS

1 X OPS-11 WITH 36 IN. VERSATIC ELECTROSTATIC PLOTTING SYSTEM
(OFFLINE) (200 DOTS PER INCH)

1 X OPS-11 WITH 36 IN. VERSATIC ELECTROSTATIC PLOTTING SYSTEM
(ONLINE) (200 DOTS PER INCH)

1 X OPS-11 WITH 22 IN. VERSATEC ELECTROSTATIC PLOTTING SYSTEM
(ONLINE) (200 DOTS PER INCH)

1 X APPLICON COLOUR PLOTTER

2 X CRYSTAL* INERACTIVE INTERPRETATION SYSTEM

CRYSTAL* Registered Trademark and Service Mark of
Western Geophysical Company of America

LIST OF LINES

15 SECOND DATA
Available displays include 1.25"/sec and 15 seconds of data displayed for both final stack and migrated stack. At 2.5"/sec and 5"/sec for the first three seconds of data of the final stack and migrated stack versions.

Line No.	SP's
M900A	102-139
M900B	157-220
	221-319
M901	101-141
	163-203
	204-205
	206-225
	226-832
	867-922
M902	1001-1040
	1064-1202

3 SECOND DATA
Available displays include 2.5"/sec displays of the final stack and the scaled migration. In addition a 5"/sec display of the scaled migration is also available.

Line No.	SP's
M900	102-139
M900-A	157-319
M901	101-141
M901-A	164-203
M901-B	204-220
M901-C	226-832
M901-D	867-922
M902	1001-1040
M902-A	1065-1202
M1-1	101-432
M1	101-378
MA-1-A	574-1500
MA-1-B	1501-3183
MA-1	122-541
M2	101-519
M2-A	550-722
M2-A	737-777
M2-B	778-918
M2-C	1036-1341
M2-D	1353-2823
M5	101-1370
M6	101-275
M6-A	1212-1271
M6-1	1273-3030
M7	101-1447