2D MARINE SEISMIC
PROCESSING REPORT

OF

LITHOPROBE

FOR

ATLANTIC GEOSCIENCE CENTRE

BY

WESTERN GEOPHYSICAL, A DIVISION
OF WESTERN ATLAS CANADA LTD.

CALGARY DIGITAL CENTRE - JULY 1988

CONTRACT NUMBER - 2275

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LIST OF ENCLOSURES

Line 4A, Stacked Panel:

1. No Shot F-K
2. With Shot F-K
3. With DMO
4. With Shot F-K and DMO

Line 5C Stacked:

5. Stack Only
6. Differential Trace Weighting
7. F-K Domain Multiple Attenuation
8. Wave Equation Multiple Attenuation

8a. Fast Version of (8)

9. (6) + (7)
10. (7) + (8)
11. (6) + (8)
12. (6) + (7) + (8)

Line 5C, Deconvolution After Stack:

13. 12 ms. Prediction Distance
14. 24 ms. Prediction Distance
15. 48 ms. Prediction Distance
16. 60 ms. Prediction Distance

17. Shallow W.B. Filter Panels (Line 1A)
18. Deep W.B. Filter Panels (Line 5C)
19. Shallow W.B. F-K Migration (Line 2B)
20. Deep W.B. F-K Migration (Line 5C)
21. Shallow W.B. Finite Difference Migration (Line 2B)
22. Deep W.B. Finite Difference Migration (Line 5C)

INTRODUCTION

The processing of seismic data from offshore Newfoundland was performed by Western Geophysical, A Division of Western Atlas Canada Ltd. for the Atlantic Geoscience Centre as part of the Canadian Lithoprobe Project. Approximately 800 kilometers of deep seismic data (20 second records) was collected in the spring of 1987 (by G.S.I.) with the processing completed in the spring of 1988.

This report details the processing methods and parameters used as well as providing a summary of the testing that lead to the selection of this processing sequence. Also provided is a statement of the products generated and their final disposition, along with a list of the personnel involved in this project.

ACQUISITION PARAMETERS

ACQUISITION DATES: Lines 3B,3D,1A,2B,2C,4,4A,4B May 1987
Lines 5,5A,5B,5C,1C June 1987

VESSEL: M/V FRED AGNICH - Party 2995
Shot by G.S.I.

SOURCE:

Energy Source	AIR GUN
Gun Array Volume	7780 CU. IN.
Gun Pressure	2000 P.S.I.
Gun Depth	11 M
Shotpoint Interval	50 M
Source-Antenna Distance	80 M

CABLE:

Centre Near Group to Centre Far Group	2975 M
Cable Depth	VARIES
Offset Centre Guns to Centre Near Group	VARIES
Group Interval	25 M
Number of Groups Recorded	120

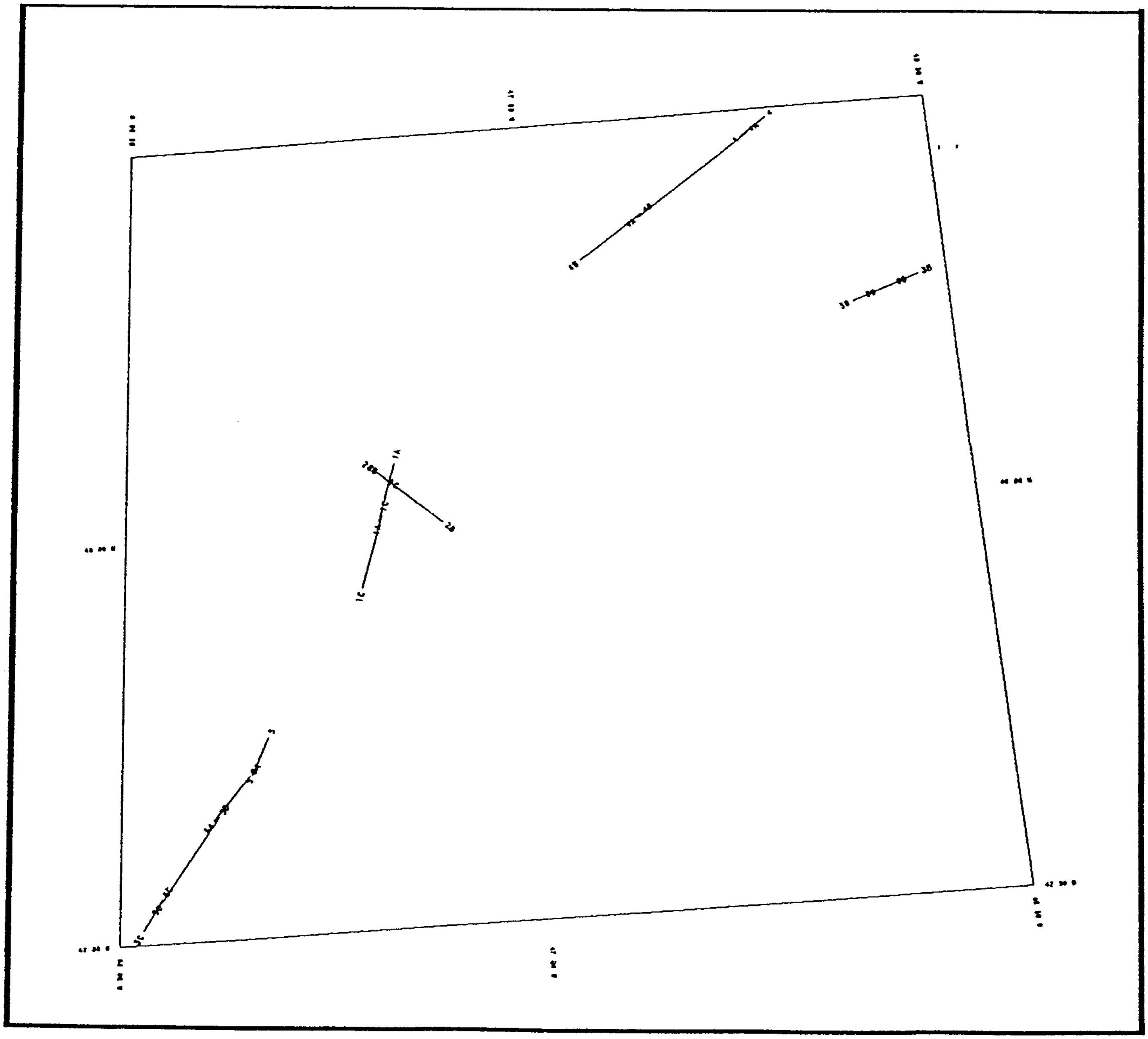
INSTRUMENTS:

Recording System	DFS V
Filter	LOW CUT 5.3 HZ, 18 db/oct HIGH CUT 64 HZ, 72 db/oct
Sampling Interval	4 MS
Record Length	VARIES
Format	MULTIPLEXED SEG-B
Primary Nav. System	LORAN-C
Secondary Nav. System	GPS

LINE LIST

LINE	S.P. ACQUIRED	FINAL PROCESSED S.P. RANGE
1	101-413 (NO OB's)	
1A	101-1369	101-1345
1B	1322-1524 (NO OB's)	
1C	1525-3123	3123-1525
2	101-168(NO OB's)	
2A	101-307 (NO OB's)	
2B	101-1936	101-1708
2C	1937-2167	1937-2167
3	101-135 (NO OB's)	
3B	101-1003,1004-1575	101-800,1004-1575
3D	1576-1882	1576-1835
4	101-678	101-598
4A	679-3751	679-3607
4B	3756-5445	3756-5445
5	101-1056	101-938
5A	1057-2341	1057-2299
5B	2342-5377	2342-4509
5C	5378-6248	5378-6248

MAP OF SURVEY



PROCESSING FLOWCHARTS

I PRE STACK PROCESSING

FIELD TAPE

SEG-Y------------1. DEMULTIPLEX/FORMAT CONVERSION
TAPES

2. F-K DOMAIN VELOCITY FILTER

3. WAVE EQUATION MULTIPLE ATTEN. (WHERE REQUIRED)

4. INSTRUMENT PHASE COMPENSATION

5. GEOMETRIC SPREADING GAIN

6. PRESTACK DECONVOLUTION

7. TRACE BALANCE

8. CDP SORT

9. PRELIMINARY VELOCITY ANALYSIS------9a. BRUTE STACK

SEG-Y-------------10. F-K DOMAIN MULTIPLE ATTEN.
TAPES

11. FINAL VELOCITY ANALYSIS

12. STACK (TRACE WEIGHTS/DMO WHERE REQUIRED)

II POST STACK PROCESSING

13. WATER BOTTOM MUTE

14. 2:1 TRACE SUM

15. GAIN (VARIOUS ALGORITHMS)

16. POST STACK DECONVOLUTION

17. TIME-VARYING FILTER

SEG-Y TAPES---------------18. MIGRATION

19. 2:1 TRACE SUM

20. LOW-CUT FILTER

21. GAIN (VARIOUS ALGORITHMS)

23. 2:1 TRACE SUM--------22. 5 TRACE MIX

FILM/PRINT FILM/PRINT

SEISMIC DATA PROCESSING

1. FORMAT CONVERSION/EDIT

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 60th shot record were displayed for quality control and subsequent parameter selection. Data was processed to a record length of 20 seconds. The tiger firing delay of 51.2 milliseconds was also compensated for in this processing step.

2. FK DOMAIN NOISE FILTER

Dipping events that overlap in the TX domain can be separated in the FK domain. This separation enables us to filter out events with unwanted dips. First the data are transformed from the TX domain to the FK domain. Next, regions of the FK domain (see below) corresponding to unwanted dips are attenuated. Finally, the data are transformed back to the TX domain to obtain the filtered result.

FK Filter Zones

Pass -10 to +10 ms/trace
Pass -6.25K to +6.25K

FK filtering was performed on all lines.

3. WAVE EQUATION MULTIPLE ATTENUATION (W.E.M.A.)

In this method, the wave equation is used to extrapolate the record wave field from the water surface back to the water-bottom. The influence of the water-bottom shape is properly taken into account. Each repeat of the multiple series is predicted from the previous repeat and is subtracted from the total data.

Performed on lines 4A, 4B, 5C and 5B (SP 2452 - 4509)

4. INSTRUMENT PHASE COMPENSATION

The phase response of the recording system (as obtained from Texas Instruments DFS-V specifications) was used to design an inverse operator, which when convolved with the data, transferred the system's response to a zero-phase bandpass filter.

FK Filter Zones

Pass -10 to +10 ms/trace
Pass -6.25K to +6.25K

FK filtering was performed on all lines.

5. GAIN COMPENSATION FOR SPHERICAL SPREADING

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. These were obtained from the prints of each line supplied to Western Geophysical by Atlantic Geoscience Centre.

Note: In cases where wave equation multiple attenuation (W.E.M.A.) was performed, this process was done post W.E.M.A. (4A, 4B, 5C and 5B (SP 2452 - 4509).

6. 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:

Minimum Prediction Distance	12 ms
Maximum Prediction Distance	600 ms
Percent White Noise	0.1%
Autocorrelation Averaging	1 Trace
Autocorrelation Windowing	One window beginning at 200 ms directly below direct arrival or in deep water at water bottom reflection

7. TRACE BALANCE

Each trace was scaled to a fixed root mean square value (2000) to remove source and receiver induced amplitude differences between traces. Minimizing large amplitude differences between traces in this manner was essential for optimizing the autocorrelation averaging performed in the following step.

9. VELOCITY ANALYSIS

Velocity analyses were performed at an interval of .3 km. Eleven adjacent common midpoint gathers with common offset traces summed together provided the input. A cross correlation based technique was used to determine stacking velocities by searching for coherence (semblance) along hyperbolic trajectories.

Conventional gained and filtered stacked sections were produced for subsequent velocity residualizing.

10. FK DOMAIN MULTIPLE ATTENUATION

The preliminary velocity analysis (step 9) provided the multiple velocities with sufficient accuracy to determine intermediate velocity functions with which to temporarily NMO correct the data. These gathers with over-corrected primary (negative dip) and under-corrected multiple (positive dip) were then transformed into the FK domain where all positive dips were removed. An inverse FK transform was then applied and the temporary velocity correction removed.

F-K demultiple was performed on all times.

11. FINAL VELOCITY ANALYSIS

When FK demultiple was performed, a second set of velocity analyses was done, providing a better estimate of primary velocities as the multiple interference had been removed.

12. NMO STACK (DMO, OPTIMUM WEIGHTS WERE INDICATED

All of the following operations were performed in this single major processing step:

i) Normal Moveout Correction
ii) Trace Muting
iii) Dip Moveout Correction and Common Reflection Point Stack
iv) Optimum Trace Weighting

i) Normal Moveout Correction

Based on the final interpolated velocities, the component of arrival time associated with shot to receiver offset for each trace sample was removed (NMO.)

ii) Trace Muting

After NMO correction, but before the application of the dip moveout correction, the data was muted to remove stretching effects and unwanted refractions.

iii) Dip Moveout (DMO)

This conditioning of the data specifically addresses several problems with conventional stacking and migrating such as:

a) DMO followed by conventional post stack migration is equivalent to full prestack migration.

b) Dip and azimuth dependency of the stacking velocity - all zero-offset time concurrent events stack-in with the same velocity (i.e. the RMS velocity of the medium at that time.) Therefore, no dips are discriminated against by the stack and the 'dip bandwidth' is increased.

c) Linear diagonal noise on the stack - this effect produced by near surface diffractions now have moveout characteristic of the lower medium in which they propagate. This results in their being stacked out at later times in much the same way as slower velocity multiples are attenuated by stacking.

d) Midpoint smear - moveout curves from dipping events represent reflections from a single point rather than from a region on the dipping interface as is the case without DMO correction.

DMO was performed on all of line 2.

iv) Optimum Trace Weighting

Offset dependent weights were designed to aid in multiple suppression by weighting down the near offsets where the multiple exhibited little residual moveout after correction with the primary velocity. The weights were designed using the velocities of primary and multiple reflections at specific times.

Optimum trace weighting was performed on lines 3, 4 and 5C.

14. ARRAY FORM

A 1:1 array form is applied to the data. A 2:1 trace decimation is also performed.

15. GAIN

a) Reflection Strength Gain
RMS Amplitude - 2000
Maximum Standout after Gain - 4

b) RAC
Residual Amplitude Compensation

LINE	TIME (MSEC)	SCALER
1	0	1.4
	20,000	1.6
2	0	0.35
	3,750	1.00
	7,100	1.30
	20,000	1.80
3	5,700	0.5
	20,000	1.5
4	3,800	0.5
	20,000	1.2
5	SHALLOW	
	0	1.4
	20,000	1.6
	DEEP	
	4,000	0.5
	20,000	1.5

16. MULTI-CHANNEL FREQUENCY DOMAIN DECONVOLUTION

Minimum phase predictive deconvolution was applied in the frequency domain using the Wiener-Levinson algorithm.

The design parameters were as follows:

Number of Windows .... (from water bottom to water bottom plus 4,000 ms)	1
Minimum Prediction Distance	48 ms
Maximum Prediction Distance	400 ms
Percent White Noise	0.1%
Autocorrelation Averaging	101 Trace Running Average

17. TIME VARIANT FILTER

The data was filtered with zero-phase bandpass filters having time and space dependent 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 separately. The cutoff frequency is specified at -3 db. (Times vary relative to water bottom.)

Time	Low Cut	High Cut
WB	4 hz, 18 db/oct	50 hz, 36 db/oct
WB +4000	4 hz, 18 db/oct	40 hz, 36 db/oct
WB +8000	4 hz, 18 db/oct	30 hz, 36 db/oct
20,000 ms	4 hz, 18 db/oct	20 hz, 36 db/oct

18. MIGRATION

All data was migrated using the 'Finite Difference Solution' to the scalar wave equation. Smoothed stacking velocities were used for the migration velocity field.

19. ARRAY FORM

A 1:1 array form was applied to the data. A 2:1 trace decimation is also performed.

20. LOW CUT FILTER

The data was filtered with zero-phase bandpass filters having time and space dependent passbands. The filter used was 4Hz, slope of 18. The cutoff frequency is specified at -3 db.

21. GAIN
REFLECTION STRENGTH GAIN

RMS Amplitude - 2000
Maximum standout after Gain - 4

22. ARRAY FORM

A 1:2:3:2:1 array form trace mix was applied to the data.

23. ARRAY FORM

A 1:1 array form was applied to the data. A 2:1 trace decimation is also performed to facilitate the set of condensed displays.

PROCESSING TESTS

INTRODUCTION:

This section describes and discusses the testing performed for the determination of the processing parameters and processing sequence that was employed for this survey. Extensive testing had previously been done on Lithoprobe lines 2A + 2B, 3B and 85-2 for which a separate report has been written.

The basic processing approach is based largely on the results of this earlier testing. Besides the routine parameter selection the emphasis was placed on establishing techniques for multiple attenuation and maximizing the coherency of deeper primary reflections.

Eight test sites were selected by the Scientific Authority for parameter studies as follows:

Line	Shotpoint Range
1A	295-400
2B	200-700
3B	500-900
4A	1100-1500
4B	4300-4700
5B	3008-3709
5C	5800-6200

Extensions or subsets of these shotpoint ranges and other portions of the survey were also incorporated into the testing sequence.

TESTING SEQUENCE:

1. Velocity Filtering

   By inspection of preliminary shot records an F-K domain filter passing apparent dips of -10 ms/tr to +10 ms/tr with a centered roll off of 8 ms/tr was chosen to test. This filter was applied to every 200th shot record of lines 1A and 2B and provided to the Scientific Authority with and without gaining.

   In shallower reflection data the preferred alternative to velocity filtering of common shot data is to dip-moveout (DMO) correct the common offset data to more selectively remove the steeply dipping linear noise. The difficulty with this approach for Lithoprobe deep reflection times is that the DMO-operator is tapered increasingly with time resulting in little or no attenuation at greater times (i.e. below 10 seconds).

To compare the action of F-K filtering of shot records and DMO correction; stacked panels of lines 4A and 5C were generated as follows:

a) No filtering
b) F-K filtering
c) DMO-correction
d) F-K filtering and DMO-correction

These results are supplied as enclosures (1) through (4) for Line 4A.

Through consultation with the Scientific Authority, F-K filtering alone was chosen.

2. PRE-STACK DECONVOLUTION

Predictive deconvolution tests were first conducted on representative shallow and deep (with respect to waterbottom arrival time) data types on lines 1 and 3B. The parameter allowed to vary for these tests was prediction distance holding the operator length constant at 600 ms and designing over a single window spanning the record (excluding direct arrivals). The prediction distances used were 12, 24, 36 and 48 ms.

From analysis of these results, it was determined in consultation with the Scientific Authority that a 12 ms prediction distance would be used, subject to confirming tests on lines 2B, 4A, 4B, 5B and 5C which were subsequently conducted.

3. MULTIPLE ATTENUATION

The dominant multiple interference present in this survey resulted strictly from reverberation in the water layer, but can be placed into several distinct types, with the performance of the multiple attenuation routine applied dependent on the type of multiple as follows:

Type 1: Flat shallow waterbottom (i.e. less than 500 ms)

Type 2: Flat intermediate waterbottom (i.e. W.B. between 500 ms & 2500 ms)

Type 3: Flat deep waterbottom (i.e. greater than 2500 ms)

Type 4: Irregular shaped waterbottom

The following multiple attenuation routines were tested for the above conditions:

1. Differential trace weighing.
2. F-K domain demultiple.
3. Wave equation multiple attenuation.

*See Processing section for algorithmic descriptions of these techniques.

The results of this suite of tests based on multiple type are as follows:

Type 1: Flat Shallow Waterbottom

For this situation, later orders of multiple were discriminated adequately from primary during the NMO-stacking stage. Earlier orders of multiple received some attenuation action from F-K domain demultiple. The techniques of differential trace weighting and WEMA were considered not applicable in this case.

Type 2: Flat Intermediate Waterbottom

All the techniques tested performed well in this situation with differential trace weighting providing comparable results at no additional processing cost. Higher orders of multiple, although having relatively little residual moveout after correction with the stacking velocity, were again sufficiently attenuated by the NMO stacking stage.

Type 3: Flat Deep Waterbottom

These high amplitude multiples (relative to time concurrent primary reflections) occuring at later reflection times exhibit very little normal moveout and hence even less residual moveout for the NMO-stacking stage. The limited amount of moveout based separability inhibits the action of differential trace weights and FK domain dumultiple, although both techniques when applied, produced some attenuation of the multiple.

WEMA which is not based on moveout discrimination (it locates, estimates and subtracts the multiple) performed best for this category of multiple. Although when the amplitudes at depths were restored, the weakened multiple still dominated at the times it occurred on the stacked output.

Type 4: Irregular Shaped Waterbottom

In this situation, the multiple fails to display the typical hyperbolic moveout curve on which differential trace wights and FK domain demultiple are based, although again when applied during our tests some attenuation resulted. It was for this case that the WEMA program was developed and as expected, produced the best results.

All of the multiple attenuation routines were applied over all portion of Line 5C (S.P. 5378 to 6284), each alone and in combination with the others for comparison purposes. Also included for benchmarking purposes is a newer, more economical version of WEMA not available at the time of processing. These are provided as enclosures (5) through (12).

4. STACKING VELOCITIES

For each of the eight test sites, a fanned suite of five interval velocity functions was provided by the Scientific Authority based on a preliminary interpretation of the Brute Stacks and earlier refraction studies in the area. These functions were converted to RMS velocities to conduct tests on stacking response.

From each of the test sites a centered CDP gather was chosen for NMO-correction with each of the supplied velocity functions and for coherency based velocity analysis. The supplied velocity functions were then overlayed on the velocity vrs. time correlation matrix for comparison. In addition, each of the test sites was stacked with the central and fastest of the supplied velocity functions.

From analysis of these results, it was determined to choose the correlation indicated velocity picks for the shallow sequence then adopt picks corresponding to the supplied basement velocities (from the central function) at depth.

5. POST STACK GAIN

The main objective of this step is to balance and limit the dynamic range of the stacked output to within the capabilities of the final display median. The testing for this procedure primarily occurred during and after the earlier reprocessing tests for Lithoprobe, where an approach was determined and then applied to the present survey.

The basic difficulty in determining a suitable gain for this data was to prevent shadow zones about remaining multiple energy without over-normalizing the output traces. To achieve this, a combination of two programs were applied as follows:

a) Residual Amplitude Compensation

These single functions compensated for the average amplitude decay with time for each section, resulting in an essentially flat average amplitude envelope for the entiretrace but with no significant local noramalization of amplitudes.

b) Reflection Strength Gain

This technique honors the basic trend of each traces amplitude envelope while providing for a controlled localized AGC (normalization of input amplitudes) which minimizes the gain shadowing about the high amplitude multiple still present on the stacked section. (See appendix (2) for algorithm description and numerical example).

6. DECONVOLUTION AFTER STACK

A standard suite of prediction distances were tested on stacked representations of each of the eight test sites. The parameters held fixed were as follows:

Operator length	400 ms
Traces averaged over	101
Design window	WB to WB+4 secs.
% of white noise	0.1

The prediction distances tested were:

12 ms
24 ms
48 ms
60 ms

In consultation with the Scientific Authority, the value of 48 ms was chosen. For an example of these test prediction distances applied to the test site on line 5C see enclosures (13) through (16).

7. TIME VARYING FILTER

The test sites from lines 1A and 5C were chosen to test the frequency content of the stacked data in a shallow and deep waterbottom situation respectively. The data was filtered with the following narrow band filters and displayed for S/N analysis in that passband:

Filter (specified at -3db point)		Roll Off
0 - 10	Hz	180 db/oct
10 - 20	Hz	180 db/oct
20 - 30	Hz	180 db/oct
30 - 40	Hz	180 db/oct
40 - 50	Hz	180 db/oct
50 - 60	Hz	180 db/oct

See enclosures (17) and (18) for these tests. In consultation with the Scientific Authority, the following scheme was adopted for final filtering:

W.B.	4 - 50 Hz
WB+4 secs	4 - 40 Hz
WB+8 secs	4 - 30 Hz
20 secs	4 - 20 Hz

8. MIGRATION

Shallow and deep waterbottom portions of the survey, where relatively complex subsurface structure existed were selected for testing. These test areas were line 2B SP 101 - 1700 (for shallow W.B.) and line 5C SP 3578 - 6248 (for deep W.B.). The migration algorithms tested were Stolt F-K and Finite-Difference with the smoothed stacking velocities providing the velocity field. These tests are provided as enclosures (19) through (22).

The wide aperture F-K migration basically proved unworkable in this setting since the high velocities and lengthy record time allowed this migration to swing the noise large distances without proper cancellation. The noise handling of the Finite-Difference approach (due to its limited aperture) was considered superior and in consultation with the Scientific Authority chosen.

9. ARRAY FORMING

To enhance the continuity of the deeper essentially flat events, a series of trace mixes were applied to the stacked and migrated versions of Line 5A. A 3, 5 and 7 trace running average was tested. As well, some more sophisticated algorithms were tested that involved searching for and enforcing multi-channel coherence, but the data did not respond well to these techniques. In consultation with the Scientific Authority, the 5-trace running average was chosen.

FINAL PRESENTATIONS

Film Displays

1. Gained migration films at 20 tr/cm and 2.5 cm/sec for each line, normal polarity.
   Total: 5 Films

2. Gained migration films at 20 tr/cm and 5.0 cm/sec for each normal polarity.
   Total: 5 Films

3. Gained migration films at 20 tr/cm and 1.25 cm/sec for each line, normal polority.
   Total: 5 Films

4. Gained stack films at 20 tr/cm and 2.5 cm/sec for each line, normal polarity.
   Total: 5 Films

TAPE DISPOSITION

The following tapes were supplied in SEG-Y format, 6250 BPI, along with the original field reels (and paperwork) to the National Archives, Edmonton, Alberta:

1. Raw stacks.
2. Raw migrations.
3. Demultiplexed field tapes.
4. F-K multiple attenuation C.M.P. gathers

STAFFING OF PROJECT

All of the seismic processing was performed in Western Geophysical's Calgary Processing Centre.

Personnel:

Atlantic Geoscience Centre

Client Representative: Mr. Bill Kay

Western Geophysical, A Division of Western Atlas Canada Ltd.

Seismic Processing Q.C. Supervisor	- Mr. Ron Weedmark
Seismic Processing Group Leader	- Mr. Chris Heaver
Seismic Processing	- Mr. Ron Martin

This report prepared by R. Weedmark and R. Martin, June 1987.

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 IBM 3838 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. VERSATEC ELECTROSTATIC PLOTTING SYSTEM
(OFFLINE) (200 DOTS PER INCH)

1 X OPS-11 WITH 36 IN. VERSATEC ELECTROSTATIC PLOTTING SYSTEM
(ON LINE) (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* INTERACTIVE INTERPRETATION SYSTEM

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

APPENDIX 2 - REFLECTION STRENGTH GAIN

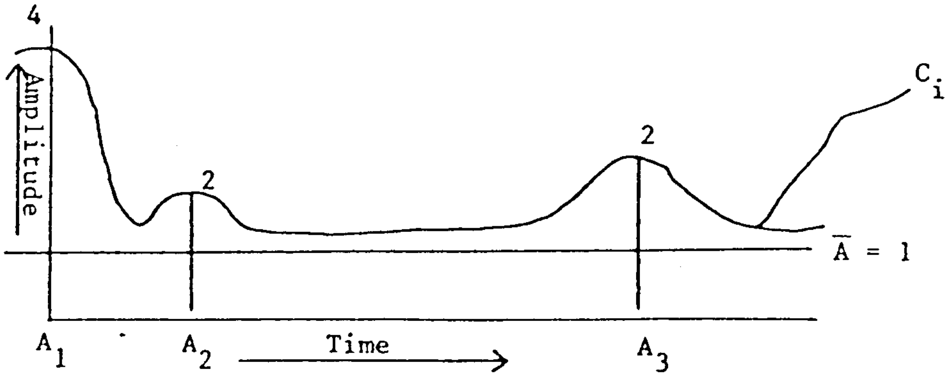
A.

1. Determine $\overline{A}$ = mean absolute value of trace
2. Determine C_i = amplitude envelope of trace (i.e. modulus of complex trace)
3. Input parameters = S and W
    - i) S called standout factor limits the amount by which an output amplitude can exceed $\overline{A}$ (can be exceeded if $W > 1$)
    - ii) W for windowing, allows C_i to be smoothed over this window length
4. If A is an input amplitude the output amplitude D_i from reflection strength gain is given by:

$$D = \frac{S.A._i}{C + (S-1)\overline{A}}$$

B.

Example (with W=1, no smoothing at C_i)



REFLECTION STRENGTH GAIN

C_i A_i for observable reflection events, hence using S=4 in the equation for D_i gives:

$$D_1 = \frac{4.4}{(4+3)1} = \frac{16}{7}$$

$$D_2 = \frac{2.4}{(2+3)1} = \frac{8}{6}$$

$$D_3 = D_2 = \frac{8}{6}$$

Observe that:

1. A_2 has not been shadowed by A_1 (i.e. $D_2 = D_3$ & $\frac{D_1}{D_2} < \frac{A_1}{A_2}$)
2. The trace has not been over normalized (i.e. although $\frac{D_1}{D_3} < \frac{A_1}{A_3}$ D_3 is still smaller than D_1)
3. The overal dynamic range of the trace has been reduced for display purposes.

C. Smoothing of C_1 over a window W will:

1. lower C_1 for strong event A
2. raise C_i for weak event A_i

Thus, diluting the action of the reflection strength gain (see the equation for D_i), leaving the trace closer to the original.