WHITEHORSE TROUGH PROCESSING REPORT

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INTRODUCTION

The following is a report on the seismic data processing (vertical component only) of two seismic lines acquired in southern Yukon in the winter of 2004 as part of the Whitehorse Trough Seismic Survey. The seismic survey was designed to transect three distinct geological terranes, the Yukon-Tanana terrane, the Boswell assemblage and Stikinia, which envelops the Whitehorse Trough. Two regional profiles were acquired. Line GSC-001-04 (referred to as CARM1 during processing) is a 117 km east-west transect across the northern Whitehorse Trough, along the Robert Campbell Highway, beginning at the midpoint of Little Salmon Lake and ending 13 km west of the town of Carmacks on Mt. Nansen road. Line GSC-002-04 (referred to as CARM2 during processing) is 53 km in length, starting 35 km north of Carmacks and ending 18 km south of the town, entirely along the western edge of the Whitehorse Trough on the North Klondike Highway.

Field Crew	Kinetex Inc., Calgary.
Date	February-April, 2004
Clients	Geological Survey of Canada / Yukon Geological Survey
Instrumentation	I/O Vectorseis® System IV
Traces/Record	600
Record Length	33 seconds
Sample Rate	2 ms
Anti-alias Filter	½ Nyquist
Nominal CDP Fold	100
Source Type	4 Vibrators (IVI Y2400 Buggy Mount)
Source Array	4 Vibrators In-line
Pattern Length	12000 m
VP Interval	60 m
# Sweeps/VP	6 or 10 (with 3 vibrators operational)
Sweep Length	24 seconds
Sweep Type	Linear upsweep
Sweep Frequency	10-84 Hz
Group Interval	20 m
Geophones/group	1 (3C Sensor Buried)

Table 1 - Data acquisition parameters

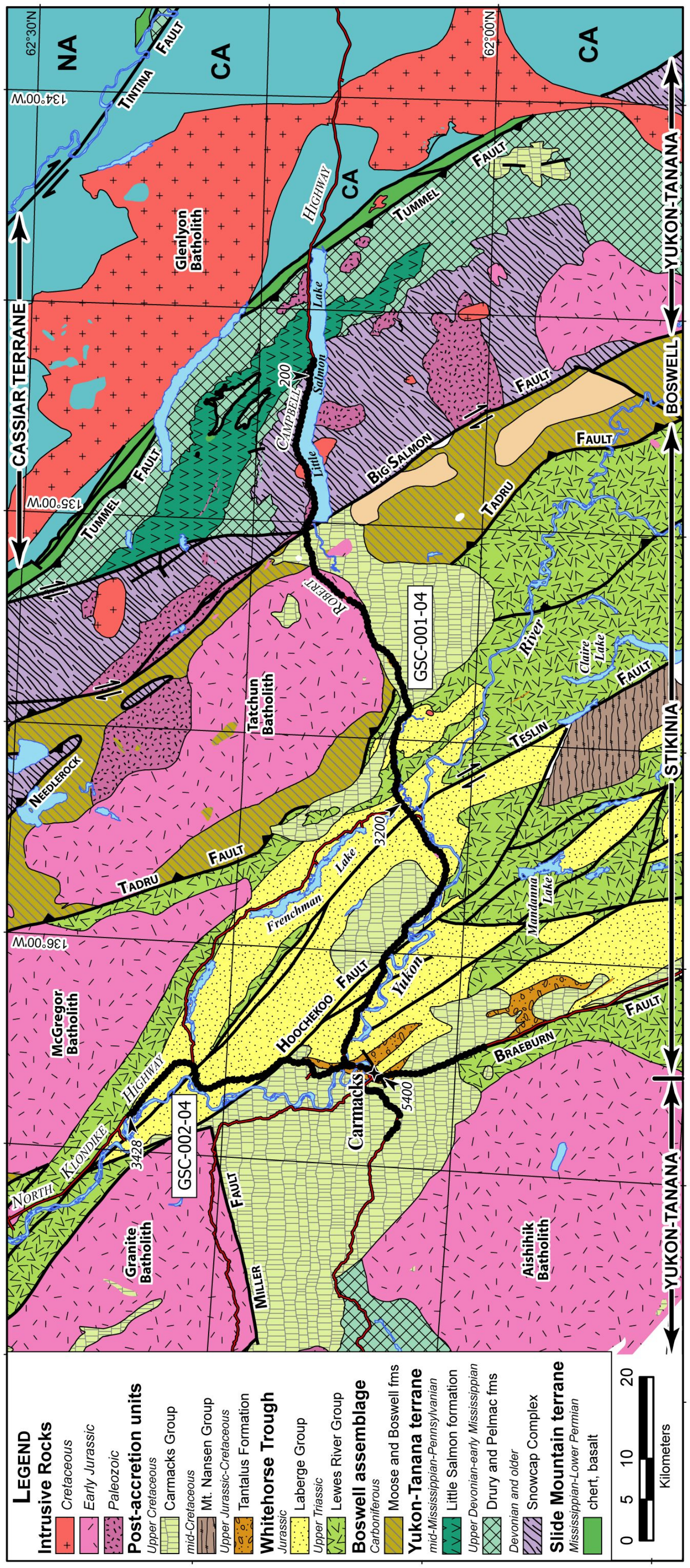

Figure 1 - Geological Setting/Survey Design

STAGE 1: PRE-PROCESSING

INITIAL DATA INPUT AND SORTING

Before standard seismic data processing could commence, several data integrity issues needed to be addressed. Notably, the raw data delivered from the contractor (Kinetex) were replete with inconsistencies. For instance, some uncorrelated shot records contained no auxiliary traces by which to correlate the data. In addition, there were missing data traces, which caused disagreement with the compiled geometry information. Ultimately, some replacement data were delivered on Maxtor external hard drives, which addressed these problems somewhat. However, the FFID (Field File Identification) numbers for this data shipment were re-ordered sequentially. This introduced the problem of having to laboriously match data from the Maxtor drives with the original data procured on DLT IV tape. Consequently, considerable time was spent ensuring the correctness of the compiled dataset. The problems with CARM1 were exacerbated further when it was discovered that all 3 components (vertical, inline, crossline) were contained for each FFID as one file and not as individual datasets. Also, there was no header word that identified the three different components. Based on the assumption that the first component was the vertical dataset (based mainly on strong first-break energy relative to other components) the files were exported to Insight format and separated using a UNIX script which counted the number of traces, divided by 3 and thus allowed separation of each 1/3 of that dataset. These files were then read back into Promax and appended to allow further processing. Once all raw data were compiled in a useable format, correlation of the datasets could be completed.

CREATING CRUSTAL RECORDS

Although standard, 9-second correlation was done in the field, it was necessary to generate crustal scale sections. This was done by taking the 32 sec raw data, correlating and truncating it to 14 seconds; a usable crustal two-way-time. Again, obstacles were encountered due to data inconsistencies in the data delivered on DLT tape and those delivered on Maxtor hard drives. Some of the uncorrelated Maxtor hard drive data were corrupt. Consequently, some data from tape were merged with the hard drive data to generate 14-second records. The data from tape, however may not have contained auxiliary traces and thus, the following steps were taken to create 14-second correlated records under the assumption that all sweep auxiliary traces were identical:

1) Vertical component of tape data was isolated
2) Vertical component was merged with auxiliary traces from FFID 34
3) Data were correlated.
4) Trace length was reduced from 32000ms to 14000ms.
5) Traces were renumbered within the correlated records as 1-600
6) Auxiliary trace FFID was removed
7) Correlated dataset is merged with non-corrupt Maxtor data files.

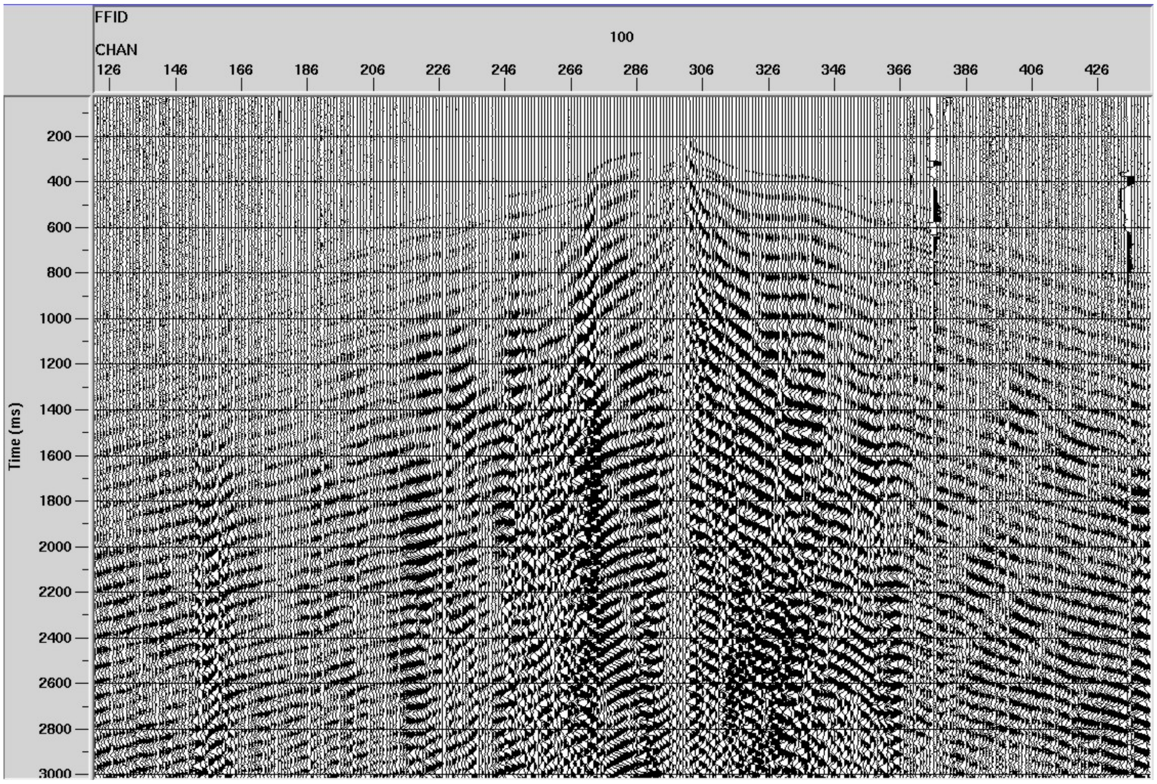

Figure 2- the first 3 sec of an uncorrelated shot record (FFID 100, CARM 1)

VIBROSEIS CORRELATION

The files were first correlated individually within Promax, nominally using trace number "-3" of the uncorrelated dataset. This trace corresponds to the sweep signal generated in the field to be used for this purpose. Some files did not have auxiliary traces from which to correlate, so it was necessary to use the sweep signal from an adjacent shot record with the assumption that it was valid. Data correlated using this method were checked for inconsistencies; none were found. After correlation, the auxiliary traces were excluded and each dataset merged by appending to the previous.

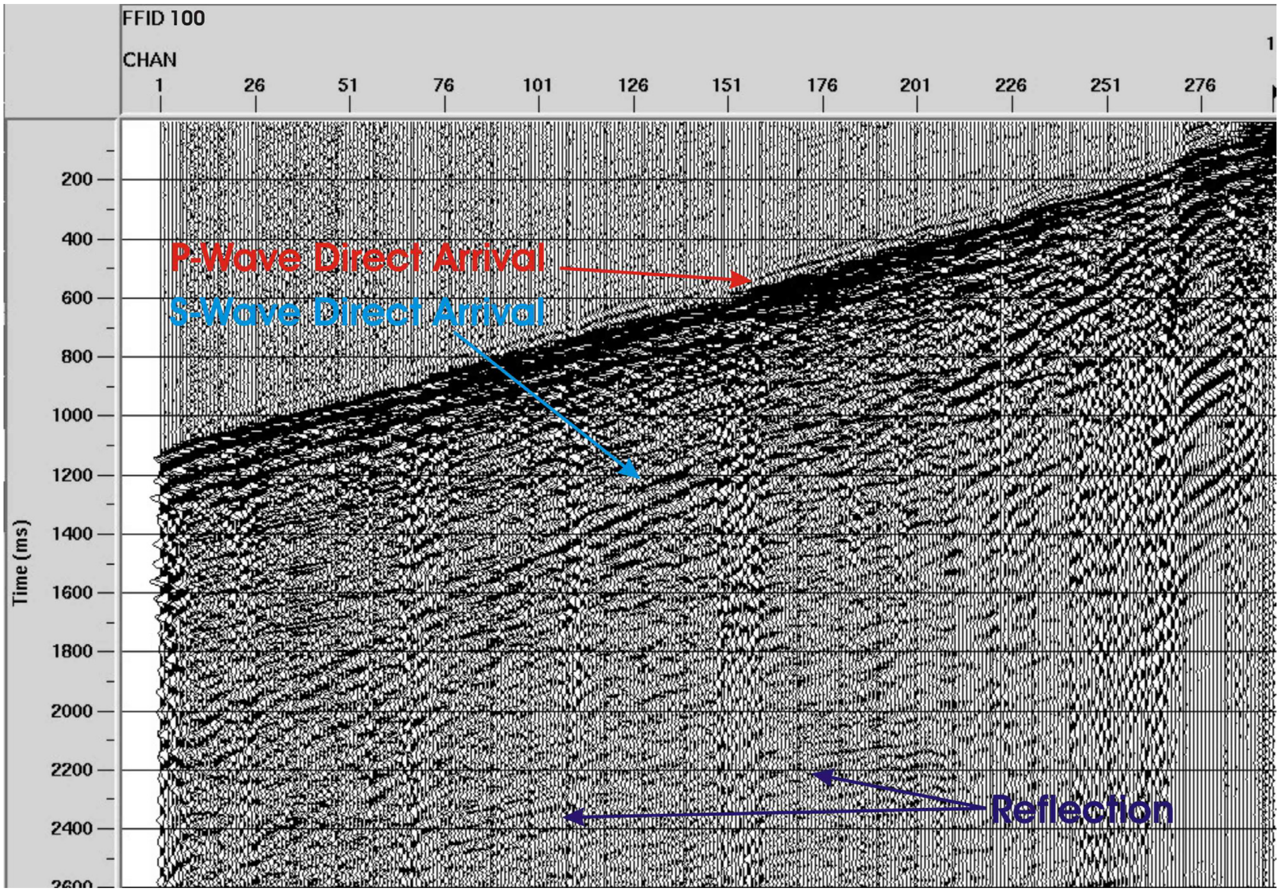

Figure 3 - FFID 100 (CARM1), after Vibroseis correlation

STAGE 2: GEOMETRY DEFINTION

CROOKED LINE GEOMETRY SPREADSHEET
Further problems regarding geometry were found to do with spread definition patterns. A pattern spreadsheet is used internally within Promax to generate patterns to define station (geophone) layout for individual shots. Geographical survey data was directly imported into the SRF, SIN or PAT ordered parameter files (OPFs). This was done by running *crooked line geometry spreadsheet* as a standalone process and setting up the dataset with the appropriate information.

Step 1: Run the crooked line geometry spreadsheet in Promax.

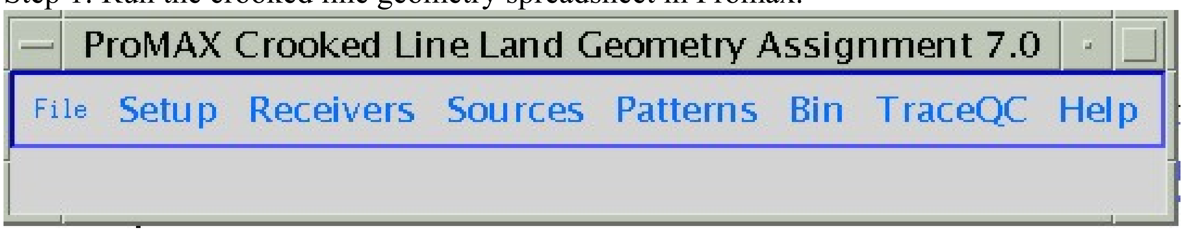

Figure 4 – Promax Crooked Line Geometry Module

Step 2: Fill in the *SETUP* section of the crooked line geometry spreadsheet.

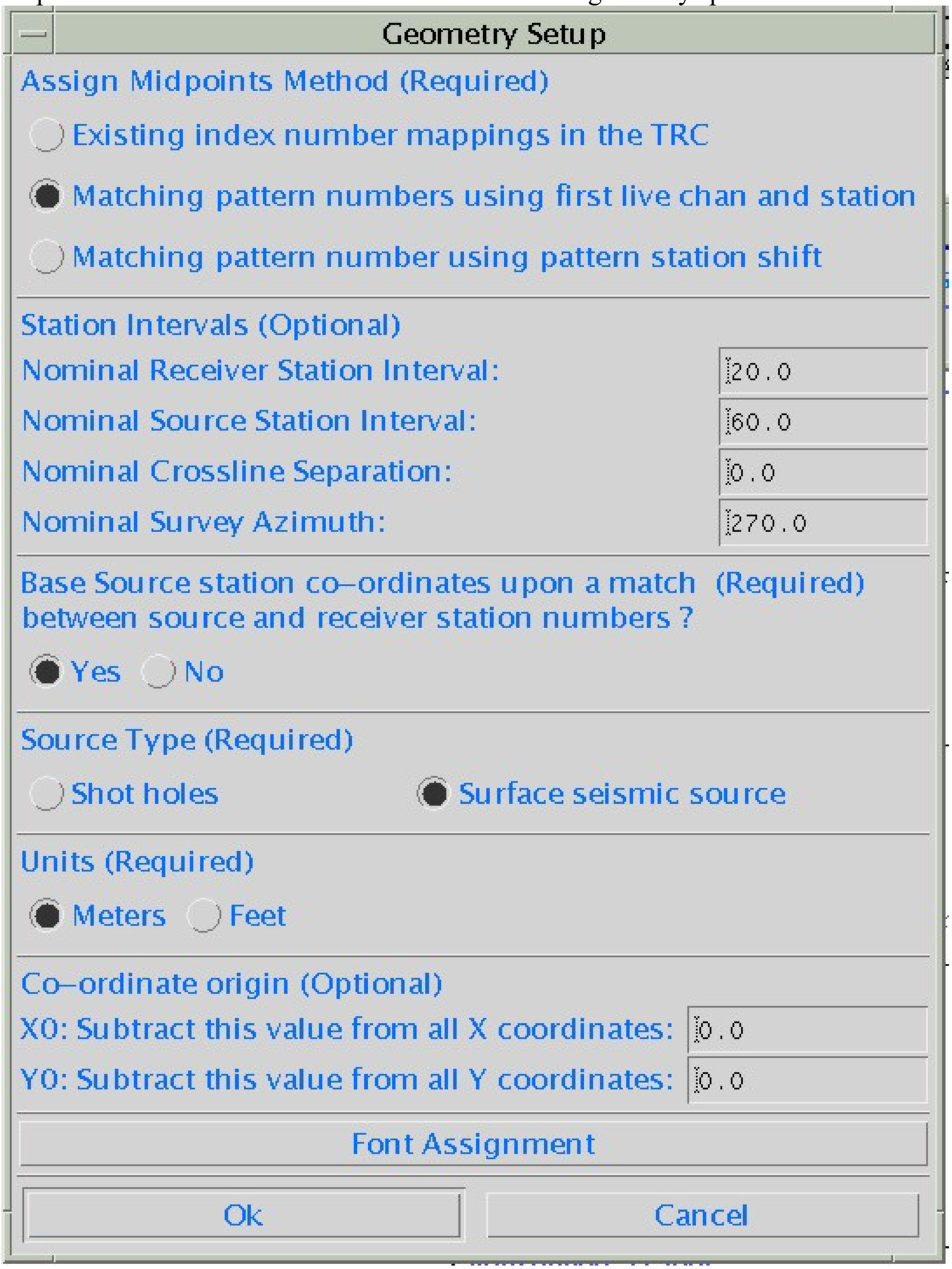

Figure 5 – Promax Geometry Setup

Step 3: Complete the SRF ordered parameter file. This file contains the station number and geographical coordinates of the geophone group.

SRF Ordered Parameter File

File Setup Edit View Help

Mark Block	Station	X	Y	Elev	Static
1	101	519830.0	6895539.5	643.0	19.9
2	102	519810.4	6895534.5	643.3	19.9
3	103	519790.9	6895530.5	643.8	20.4
4	104	519771.1	6895526.5	644.3	21.4
5	105	519751.4	6895523.5	644.9	22.4
6	106	519731.8	6895521.5	645.6	23.5
7	107	519711.7	6895520.0	646.5	24.9
8	108	519691.5	6895519.5	647.5	25.8
9	109	519671.7	6895520.0	648.5	27.1
10	110	519651.9	6895521.5	649.4	27.7
11	111	519631.6	6895523.5	650.3	28.2
12	112	519612.4	6895525.5	651.1	28.4
13	113	519592.3	6895528.0	651.7	28.4
14	114	519572.4	6895529.5	652.2	28.4
15	115	519552.6	6895532.0	652.4	28.3
16	116	519532.1	6895533.5	652.4	28.1
17	117	519512.1	6895535.5	652.2	27.7
18	118	519492.9	6895536.0	651.8	27.2
19	119	519472.7	6895537.0	651.3	26.8
20	120	519452.8	6895537.5	650.8	26.1
21	121	519433.2	6895537.5	650.4	25.6
22	122	519412.7	6895539.5	649.6	25.1
23	123	519391.8	6895540.0	649.5	24.7
24	124	519372.3	6895541.0	649.5	24.4
25	125	519353.0	6895541.5	649.7	24.3
26	126	519333.5	6895541.5	650.0	24.2

Figure 6 - Receiver (SRF) Ordered Parameter file for geometry definition

Step 4: Complete the SIN ordered parameter file. This file contains the station numbers occupied as source points and their geographical coordinates.

SIN Ordered Parameter File

File Setup Edit View Help

Mark Block	Source	Station	X	Y	Z	FFID	Offset	Skid	Pattern	Num Chn	Shot Fold*	1st Live Sta	1st Live Chn	Gap Chan Dlt	Gap Size Dlt	Static
1	1	101	519830.0	6895539.0	643.0	1			1	300	300	101	1		0	20.9
2	2	104	519771.0	6895527.0	644.0	2			2	303	303	101	1		0	20.3
3	3	107	519712.0	6895520.0	646.0	3			3	306	306	101	1		0	22.1
4	4	110	519652.0	6895521.0	649.0	4			4	309	309	101	1		0	24.3
5	5	113	519592.0	6895528.0	652.0	5			5	312	312	101	1		0	25.5
6	6	116	519532.0	6895534.0	652.0	6			6	315	315	101	1		0	28.6
7	7	119	519473.0	6895537.0	651.0	7			7	318	318	101	1		0	25.5
8	8	122	519413.0	6895539.0	650.0	8			8	330	330	101	1		0	24.0
9	9	125	519353.0	6895541.0	650.0	9			9	324	324	101	1		0	24.1
10	10	128	519293.0	6895544.0	651.0	10			10	327	327	101	1		0	24.6
11	11	131	519233.0	6895546.0	652.0	11			11	330	330	101	1		0	21.5
12	12	134	519174.0	6895551.0	653.0	12			12	333	333	101	1		0	20.1
13	13	137	519116.0	6895567.0	654.0	13			13	336	336	101	1		0	21.2
14	14	140	519062.0	6895593.0	655.0	14			14	339	339	101	1		0	19.5
15	15	143	519014.0	6895628.0	656.0	15			15	342	342	101	1		0	21.1
16	16	146	518966.0	6895664.0	656.0	16			16	345	345	101	1		0	21.4
17	17	149	518918.0	6895700.0	654.0	17			17	348	348	101	1		0	20.1
18	18	152	518872.0	6895736.0	653.0	18			18	351	351	101	1		0	21.2
19	19	155	518822.0	6895773.0	653.0	19			19	354	354	101	1		0	21.0
20	20	158	518773.0	6895808.0	654.0	20			20	357	357	101	1		0	21.7
21	21	161	518720.0	6895837.0	655.0	21			21	360	360	101	1		0	21.8
22	22	164	518662.0	6895855.0	654.0	22			22	363	363	101	1		0	18.5
23	23	167	518603.0	6895861.0	653.0	23			23	366	366	101	1		0	19.2
24	24	170	518545.0	6895865.0	651.0	24			24	369	369	101	1		0	18.5
25	25	174	518465.0	6895871.0	648.0	25			25	372	372	101	1		0	21.7
26	26	176	518425.0	6895874.0	646.0	26			26	375	375	101	1		0	24.2

MB1=edit current value MB2=clear/enter value MB3=interpolate value

Figure 7 - Source Index Number (SIN) Ordered Parameter file for geometry

Step 5: Complete the PAT ordered parameter file. This file defines which geophone groups were "live" for each shot.

PAT Ordered Parameter File

File Setup Edit Help

Mark Block	Pattern	Min Chan	Max/Gap Chan	Chan Inc	Rcvr MinChan	Rcvr MaxChan	Rcvr Inc	Error
1	1	1	300	1	101	400	1	
2	2	1	303	1	101	403	1	
3	3	1	306	1	101	406	1	
4	4	1	309	1	101	409	1	
5	5	1	312	1	101	412	1	
6	6	1	315	1	101	415	1	
7	7	1	318	1	101	418	1	
8	8	1	330	1	101	430	1	
9	9	1	324	1	101	424	1	
10	10	1	327	1	101	427	1	
11	11	1	330	1	101	430	1	
12	12	1	333	1	101	433	1	
13	13	1	336	1	101	436	1	
14	14	1	339	1	101	439	1	
15	15	1	342	1	101	442	1	
16	16	1	345	1	101	445	1	
17	17	1	348	1	101	448	1	
18	18	1	351	1	101	451	1	
19	19	1	354	1	101	454	1	
20	20	1	357	1	101	457	1	
21	21	1	360	1	101	460	1	
22	22	1	363	1	101	463	1	
23	23	1	366	1	101	466	1	
24	24	1	369	1	101	469	1	
25	25	1	372	1	101	472	1	
26	26	1	375	1	101	475	1	

Figure 8 - Pattern (PAT) Ordered Parameter file for geometry

All of the crooked line geometry ordered parameter files were completed by directly importing the survey data into the appropriate spreadsheet. To do this, the following steps were implemented:

1) In the file menu of each OPF, click on *file>import* and select the correct survey data file to include.
2) Specify the correct column range for each UTM coordinate to properly import it into the appropriate spreadsheet column and click "apply".
3) Check the imported spreadsheet for consistency. Manual changes can then be made to the spreadsheet to properly complete the geometry.

This method worked well for predictable spread patterns, however for areas of the line with data gaps (due to physical obstructions or arbitrary missing channels) several patterns need to be defined to account for missing channels. A script was written using FORTRAN to verify the integrity of each pattern definition, whereby one could complete the geometry midpoint assignment.

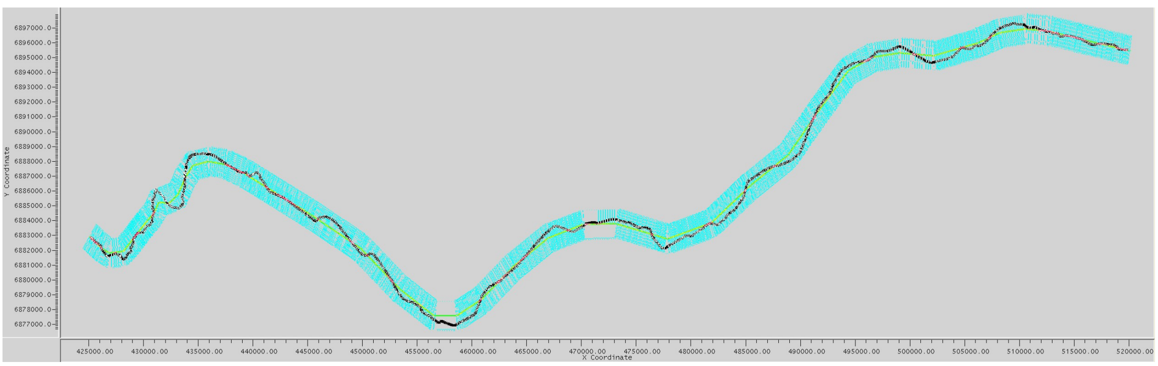

Figure 9 - Crooked Line Geometry – CARM 1 (GSC-001-04) Black line indicates the location of seismic line; Green line is the 'slalom line' which was interactively drawn through the midpoint distribution and about which the bins are generated. The blue boxes are the 10m x 2300m mid point bins.

ASSIGNING MIDPOINTS

Before defining a midpoint grid the midpoints need to be assigned based on "matching pattern numbers using first live channel and station". Simply clicking on the OK button while the option is selected does this. A note of caution however, that once this step is executed, all trace headers stored in the previous geometry database are erased. So, certain information may need to be backed up (ie. first breaks, mutes...) before re-binning.

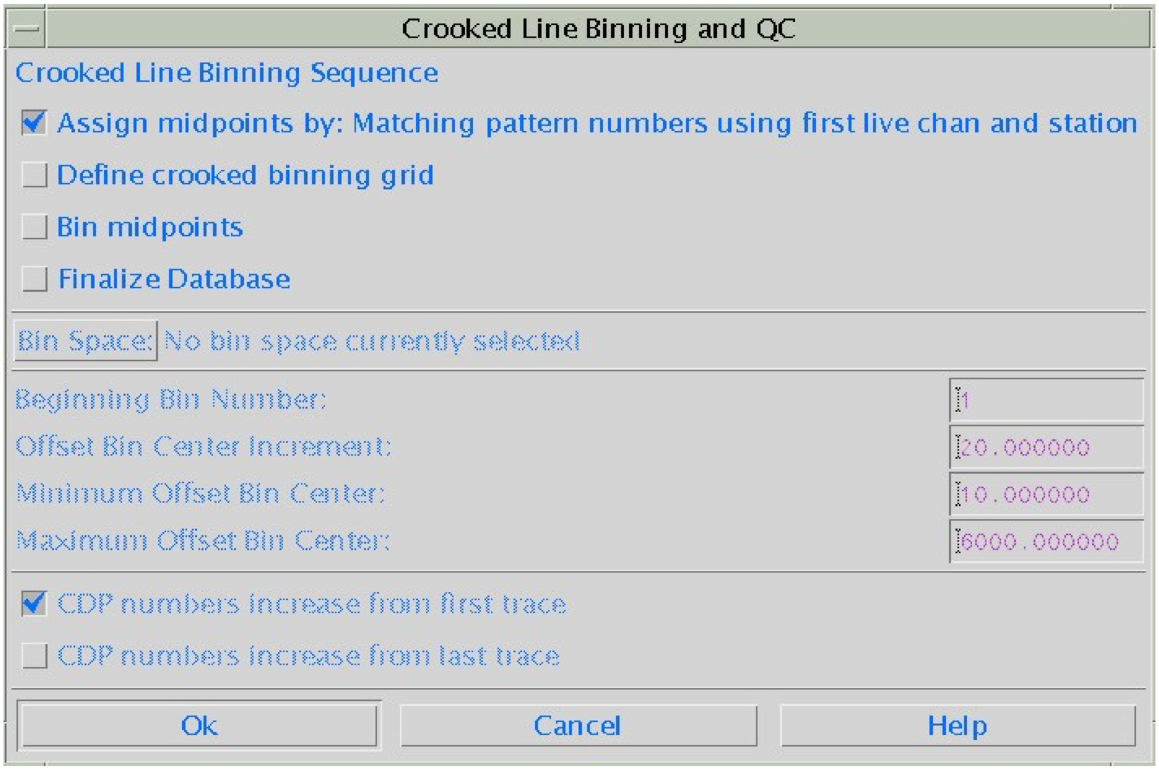

Figure 10 - Assigning Midpoints

MIDPOINT BINNING GRID DEFINITION

The next step involved midpoint binning. Midpoint bins were chosen manually within Promax by defining a crooked binning grid. Three bin definition methods are available. The midpoint 'follow' method was chosen since it included the most midpoints and was robust for binning around bends in the line. All methods of bin definition are generated by first defining a 'track' or 'slalom-line' through the midpoint distribution. Bin size was chosen to be 10 m by 2300 m such as to include all midpoints. The value of 10 m was chosen as the bin width (in-line direction) since it is equivalent to the cdp interval. The bin length (cross-line direction) was chosen as 2300m to accommodate all midpoints. Once the bins are defined, the third step in the Crooked Line Binning Sequence can be implemented: Midpoint Binning. All midpoints found along its distribution are assigned to their associated bin as per the previous step.

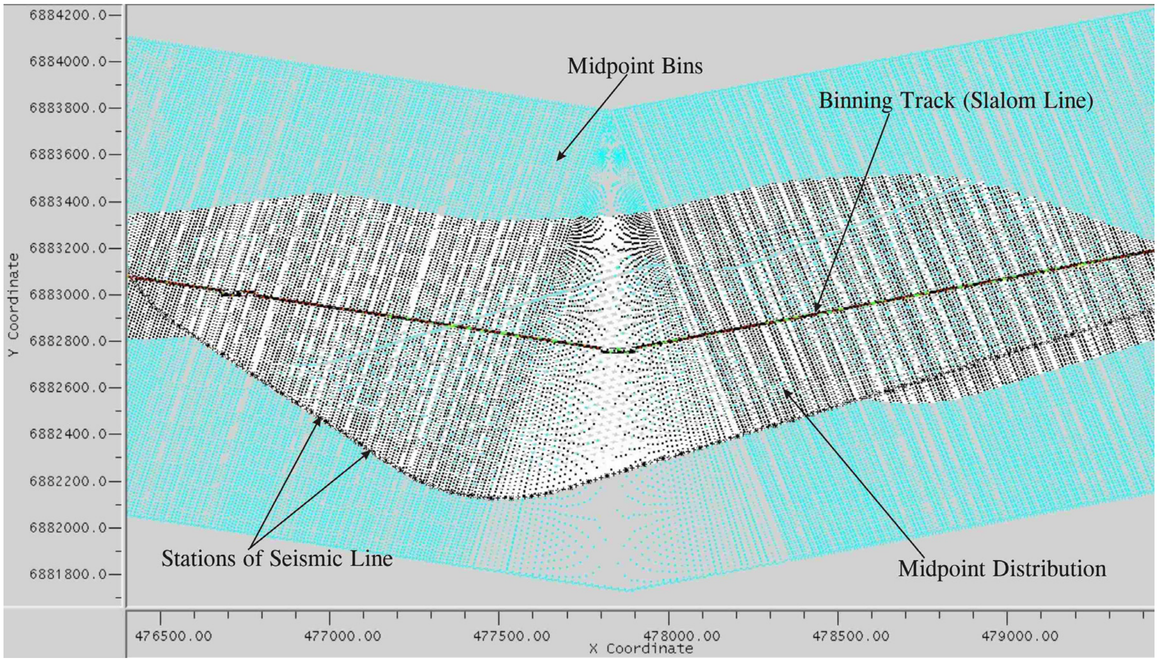

Figure 11 - Midpoint Binning Definition

Figure 11 depicts the process of defining the bins in which to assign midpoints. Here, the X and Y-axis represent UTM coordinates and the seismic line is indicated as shown. The Midpoint Distribution is plotted in Promax and a Binning Track (Slalom Line) is manually picked, centered within the midpoint distribution. Bins are designed around the chosen track and are large enough such as to include the midpoint distribution.

BINNING THE MIDPOINTS AND FINALIZING THE DATABASE

Next, the midpoints are assigned to the previously defined bins by running the third step in *Crooked Line Binning and QC*. Finally, the last step is run which finalizes the geometry database. At this point, the crooked line binning job can be closed.

LOADING GEOMETRY INTO TRACE HEADERS

Next, the finalized geometry database is loaded into the correlated raw shot records. That is, the geometry information calculated in the Promax database is applied to the headers of the correlated raw shots records. This is done using “INLINE GEOM HEADER LOAD” (see appendices 2 and 3).

GEOMETRY QC

Upon loading geometry into traces headers it is checked for reliability by observing the correct position of the shot point flag. Producing a stacking chart permits further verification:

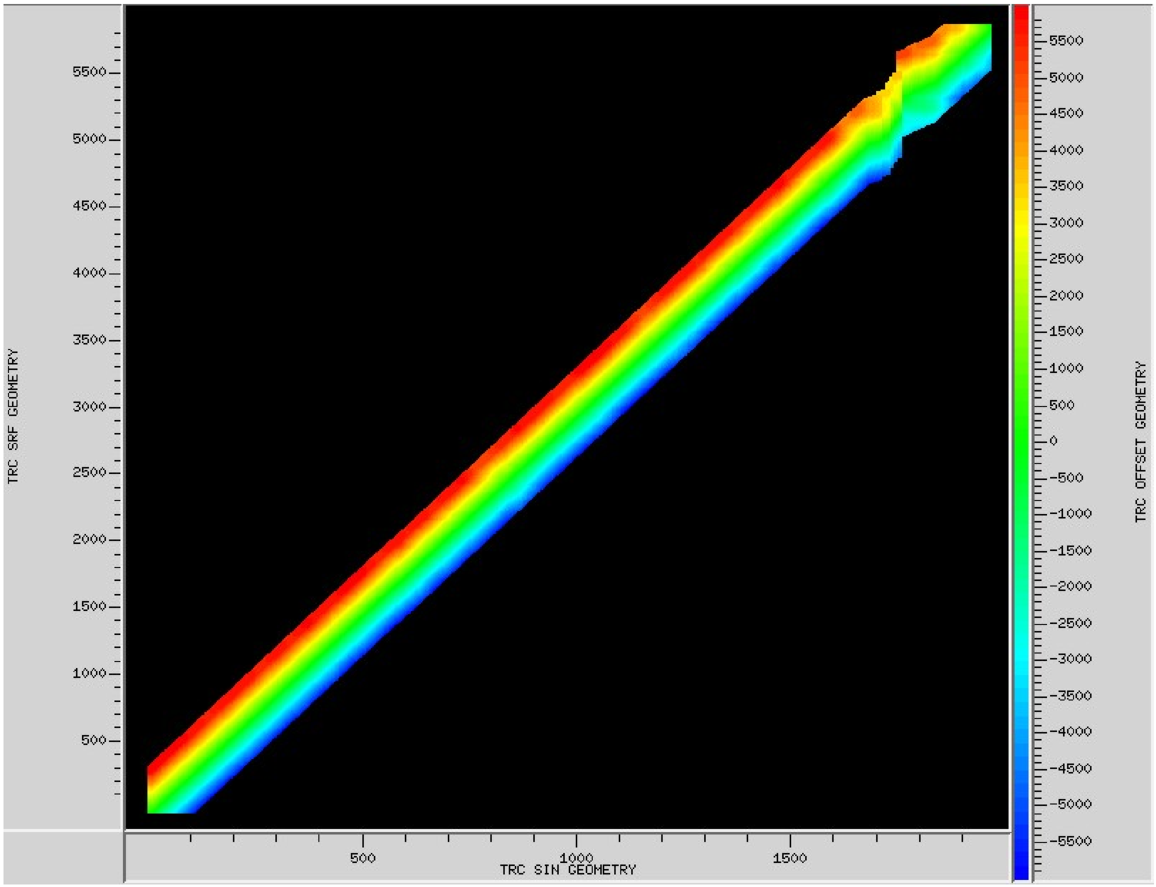

Figure 12 - Stacking Chart

Sheriff (1991) defines a stacking chart as a diagram, which displays the interrelationships among the traces from common-midpoint surveying. By plotting SRF (Receiver number) against SIN (source index number) and offset (colour), one can easily observe an incorrect geometry assignment by observing vertical 'shifts' where any particular SIN value is not at the correct SRF location. The change in continuity at the upper right of the figure is due to missing shot points near the end of the line as there were no Vibroseis shaking operations through the town of Carmacks.

STAGE 3: PRE-STACK PROCESSING

AUTOMATIC GAIN CONTROL

AGC, or Automatic Gain Control is an amplitude scaling function, which varies the gain applied to trace samples as a function of the sample amplitude within a sliding time window. The AGC operator length defines the length of the time window. The value chosen for processing of these data was 500 ms. The type of AGC scalar used was a 'mean' scalar, which bases the scaling on the mean value of the samples in the sliding time window. The basis for scalar application was 'centered', meaning the computed gain is applied using the middle sample in the sliding time gate.

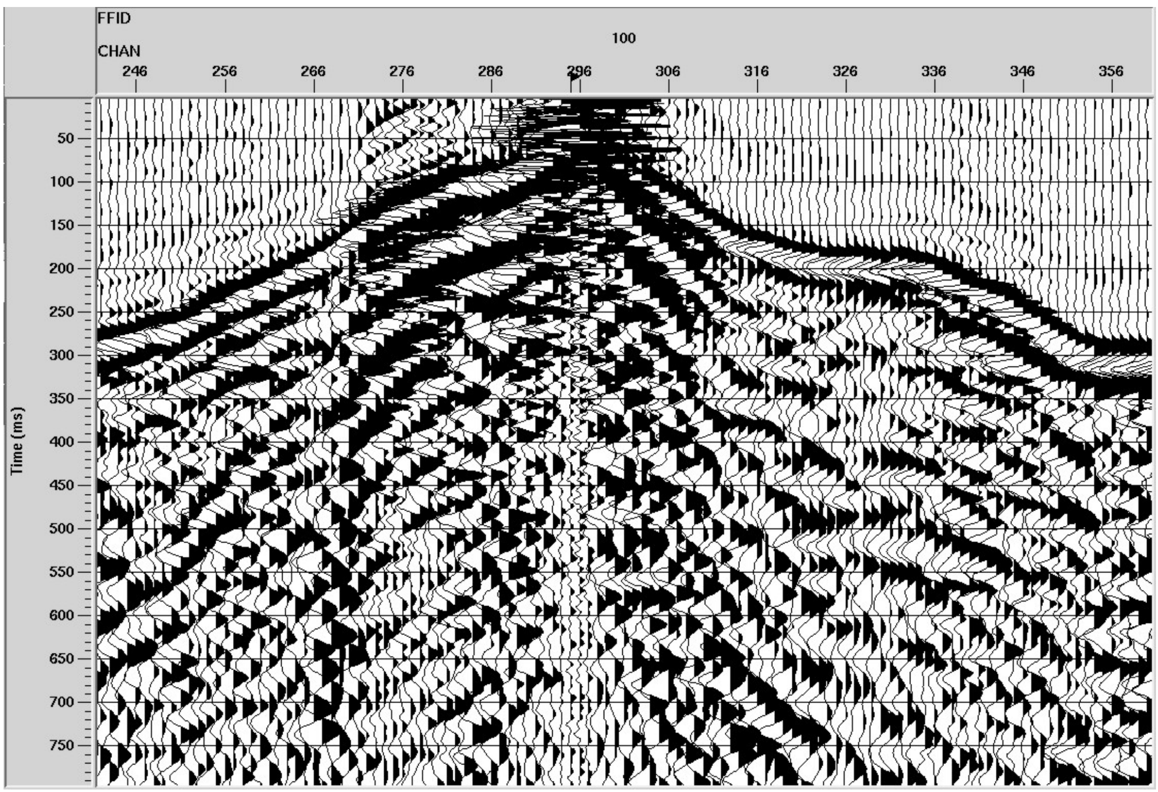

Figure 13 - Portion of a shot record before AGC

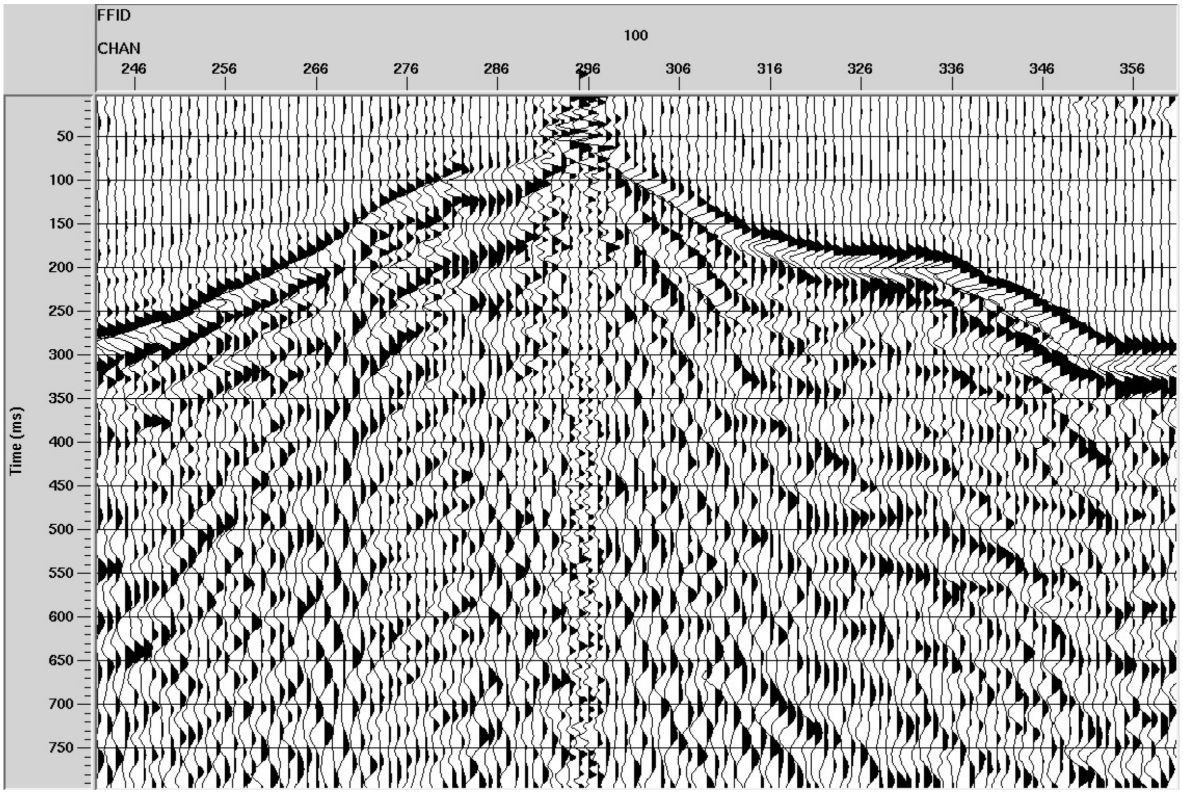

Figure 14 - Portion of a shot record after AGC

In reference to figures 13 and 14, the effect of AGC is demonstrably to balance amplitudes across a chosen time window (in this case, 500 ms). Low amplitude wavelets are enhanced, while anomalously high amplitudes are reduced.

PREDICTIVE DECONVOLUTION

Deconvolution is a signal-processing operation, which seeks to improve the temporal resolution of a seismic trace by compressing the basic seismic wavelet (Yilmaz, 1987). In principal, deconvolution works by applying an inverse filter to the input seismic trace, to yield the earth's impulse response.

For these datasets, the Predictive Deconvolution algorithm yielded the best results. The parameters to choose from are:

Operator Length: Short operator lengths tend to give spikes with smaller amplitudes and noisier, high-frequency tails, while longer operators whiten the spectrum further, approximating better, the spectrum of the impulse response (Yilmaz, 1987). Tests of operator lengths on Whitehorse Trough data concluded that an operator length of 120 ms was optimal.

Operator Prediction Lag (Gap): This value is the time difference between an input value and the prediction based on it (Sheriff, 1991). The shorter the prediction gap, the more the deconvolution attempts to compress the wavelet and thus, the "whiter" the spectrum (ie., higher frequencies are typically enhanced). A value of 32 ms was chosen. Shorter gaps were tested but resulted in noisy-looking data. A gap length of 0 ms corresponds to spiking deconvolution.

Operator White Noise Level: Deconvolution will attempt to boost the amplitudes of frequencies, which are absent from the spectrum in addition to real values. Hence, to ensure numerical stability, an artificial amount of ‘white noise’ is added to the spectrum before deconvolution. This ‘pre-whitening’ value was chosen at 1.0%.

Data windows used for design of the deconvolution operator were chosen on shot records based on three criteria: 1) selecting the top of the window to follow after the first break energy, 2) designing the gate such that noisy data regions – such as samples at depths greater than several seconds - are excluded and 3) choosing the gate such that it includes prominent reflectivity.

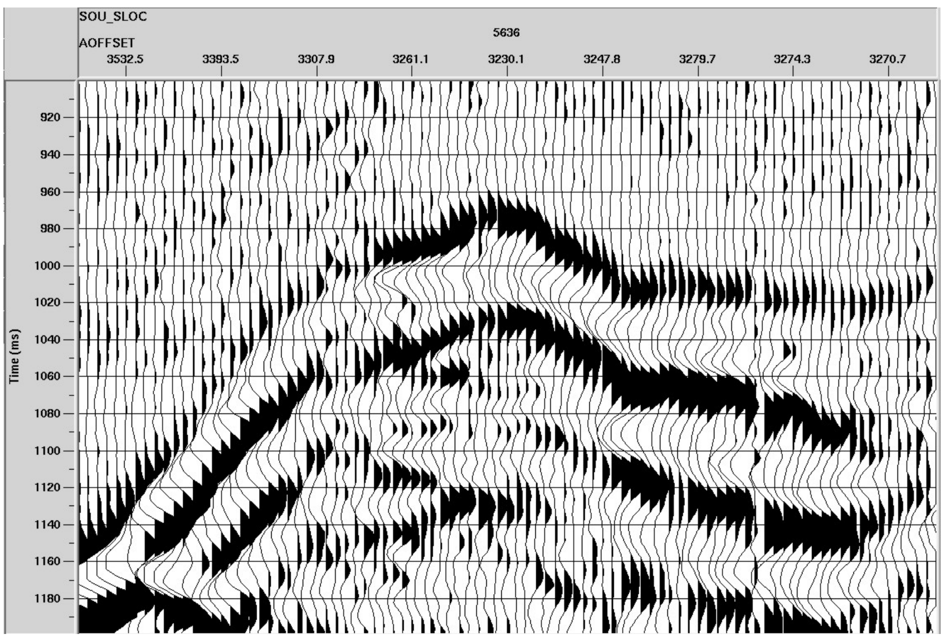

Figure 16 - Traces from shot station 5636 (CARM 1) before predictive deconvolution

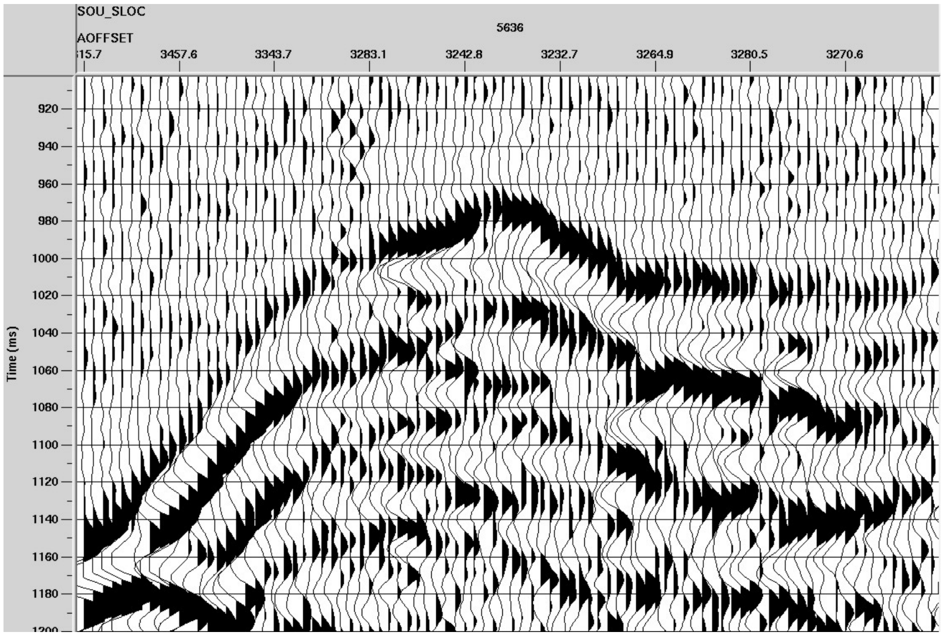

Figure 17 - Traces from shot station 5636 (CARM 1) after predictive deconvolution

Note the distinct change in frequency content of the two sections. After deconvolution, higher frequencies are boosted and hence resolution is increased.

The following amplitude spectra further illustrate the point. Note, that the 32 ms prediction gap chosen does not over accentuate the higher frequencies.

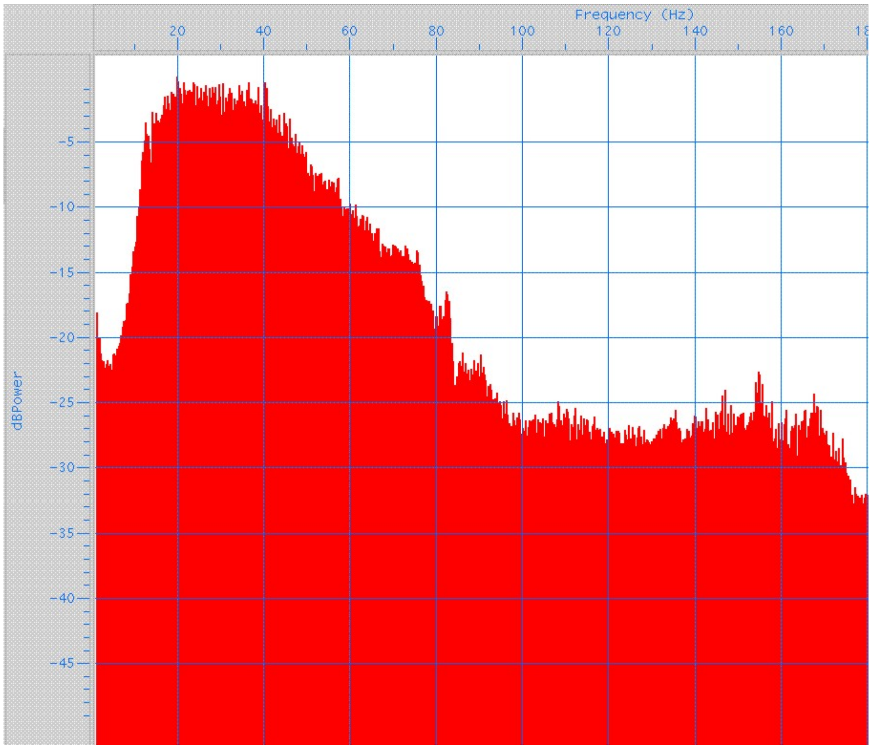

Figure 18 - Amplitude Spectra before deconvolution

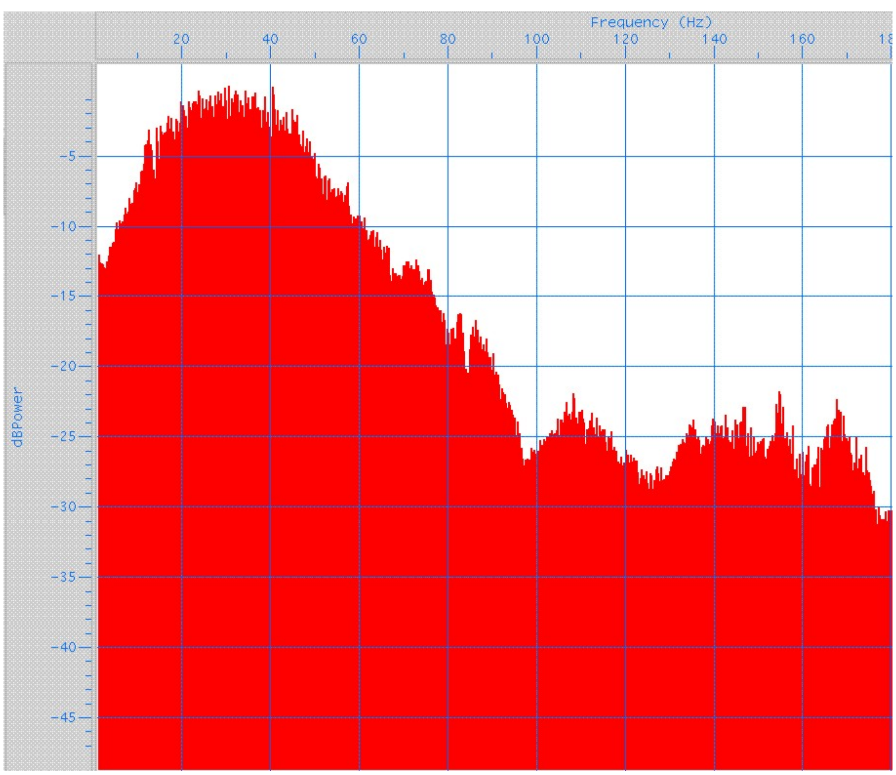

Figure 19 - Amplitude Spectra after deconvolution

TRACE MUTING

Trace mutes are simple functions used to remove coherent first break energy and other refracted waves that would otherwise contaminate the stacked section. Trace mutes can be picked on shot gathers or CDP gathers and are generally picked 50-100 milliseconds after the first arrival. For both seismic sections, mutes were picked on each shot record using ‘Trace Display’.

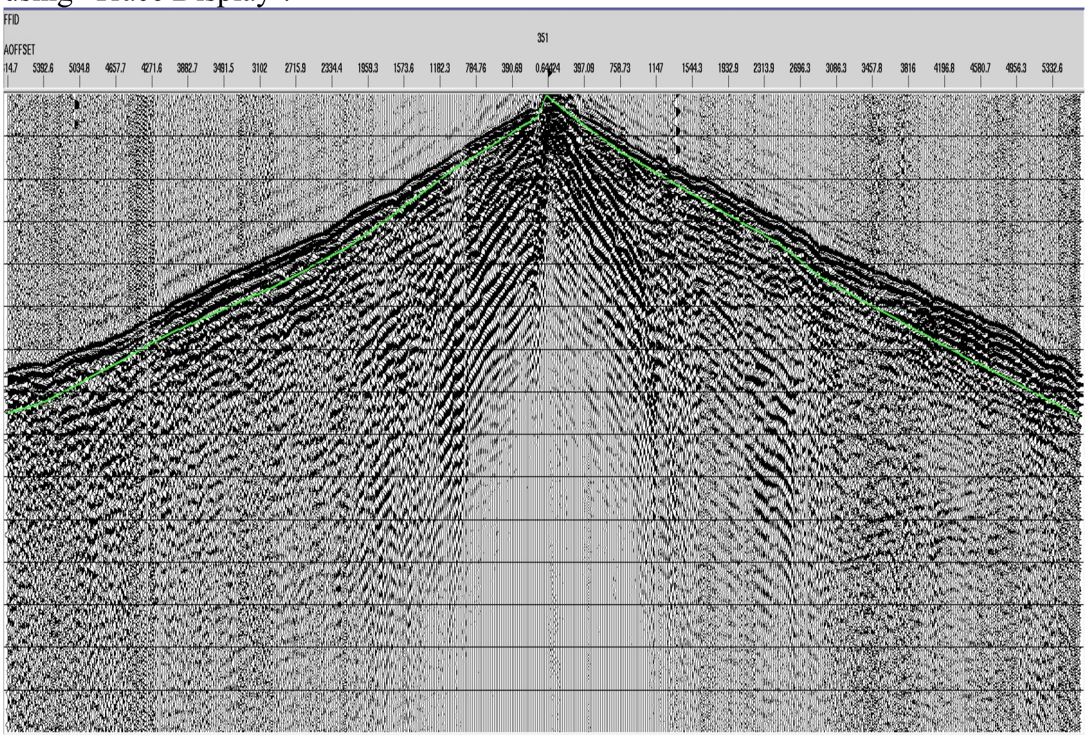

Figure 20 - Location of top mute for CARM2 (picked to eliminate refraction energy)

REFRACTION STATICS
Some problems were encountered with the Promax Refraction Statics algorithm in that anomalously large offsets are displayed within the program and thus suggest uncertainty in the accuracy of statics solutions. The maximum offset for this data set is 6000m, whereas Promax displays a maximum offset of 66000m. This problem first originated in early testing of refraction statics and was presumed to be due to the current geometry errors however. Ultimately, after geometry correction, this algorithm was abandoned and the problem presumed to be an internal programming bug. Refraction Analysis in Insight commenced in its place using first breaks picked in Promax's Trace Display.

First Arrival Analysis
Further to the completion of an accurate geometry assignment, first breaks (the first recorded signal from a known source) were manually picked on every shot gather from zero to maximum offset using Trace Display. First Breaks are 'snapped to peak' and manually adjusted to correct for small misalignments. Completed picks are transferred to the trace header of an assigned dataset for later use in Refraction Analysis.

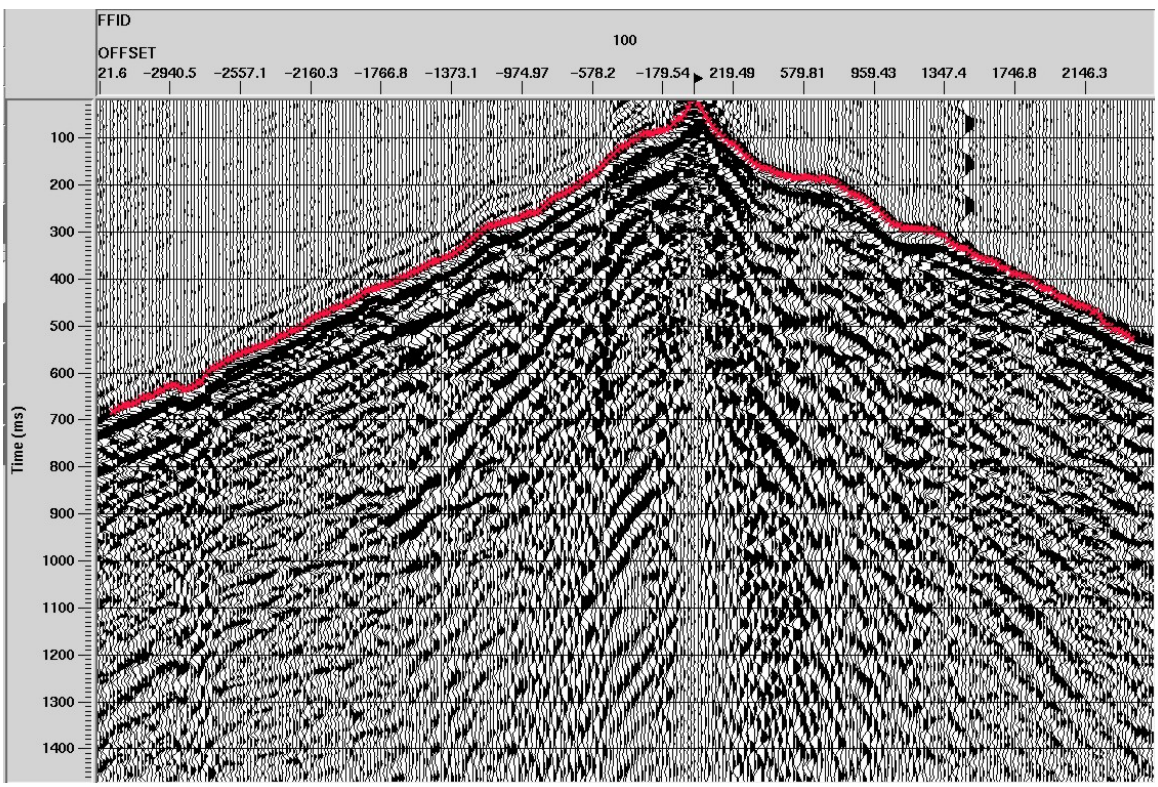

Figure 21 - First break definition on FFID 100 (CARM 1)

Inspection of the receiver and cdp linear moveout stacks (see appendix 4) of line CARM2 shows that after application of refraction statics, only the area between stations 4600-5400 looks like long-wavelength statics may still be an issue. Outside of this region, there are some very long-wavelength statics that may remain, but over the length of the spread, these are likely gradual enough that they wouldn't completely degrade the stack. This is corroborated by the shot gather inspections; the Moho reflections that are clear at the start of the line should certainly be visible although with a smooth long-wavelength variation; in fact, they are not visible.

It was at first uncertain whether the poor quality of the linear moveout receiver and cdp stacks in the station range of 4600-5400 was due to a poor statics solution or perhaps due to the moveout velocity used being inappropriate. After some investigation, it was observed that the first break stack through this region is quite good when the variable refractor velocities generated by refraction statics calculations are used in the linear moveout (lmo) processing flow. Application of surface consistent residual statics to the first breaks after lmo, however, degraded the first break stacks, introducing long wavelength statics. The conclusion that follows is that refraction statics produce comparably good results along the line. The following images show a portion of line GSC-001-04 (CARM1) before and after application of refraction statics:

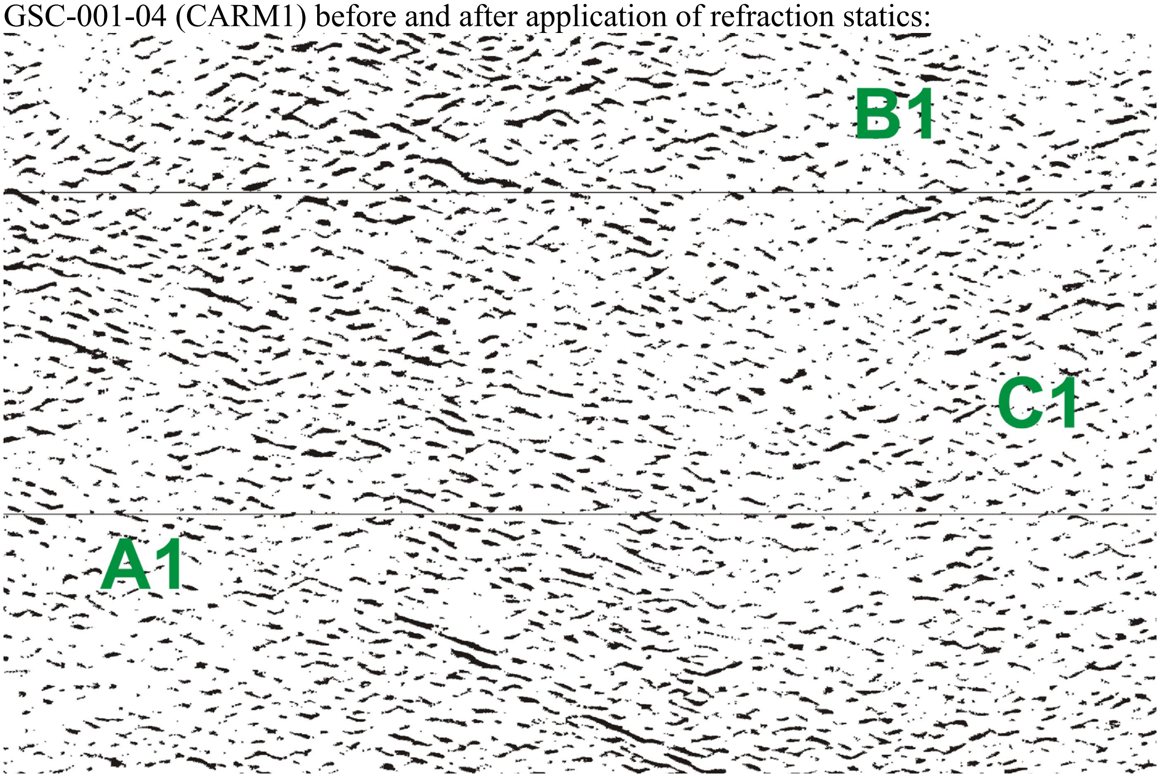

Figure 22 - A selected seismic section before refraction statics (compare lateral coherency between A1, B1 and C1 with A2, B2, C2 in Figure 23).

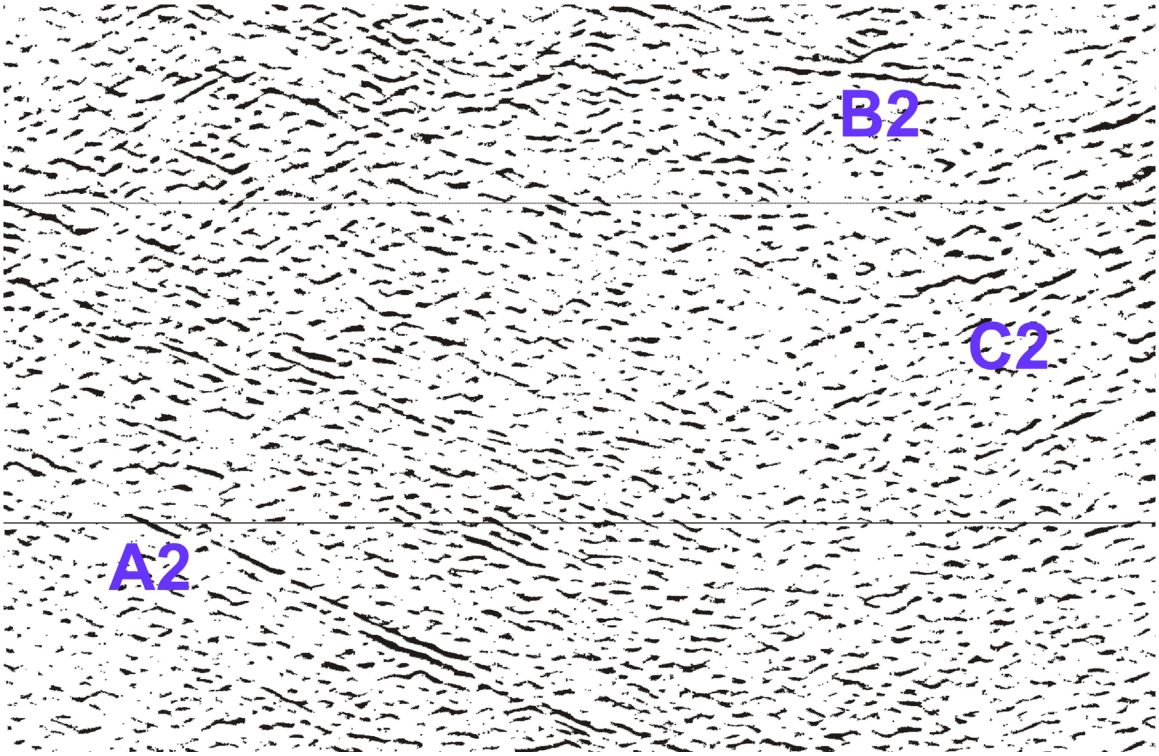

Figure 23 - The same section after refraction statics (compare lateral coherency between A1, B1 and C1 in Figure 22 with A2, B2, C2).

Of note when comparing the previous two images (before and after refraction statics) is the improvement in lateral coherency after application. Events are more delineated and continuous across the seismic section. This illustrates the effectiveness of refraction statics in correcting long-wavelength statics problems. Any shorter wavelength statics should be resolved by later residual or trim statics.

VELOCITY ANALYSIS
Velocity Analysis is an important interactive step in seismic data processing. It represents an approximation of the variation in seismic velocity with depth and as such provides an estimate of changing lithology. Although a sonic log represents a direct measurement of velocity as a function of depth, seismic velocity analysis can only provide an indirect method of estimating a velocity function. In this sense, velocity analysis is inherently an iterative process of velocity adjustment, quality control, re-adjustment and further quality control to produce the best stack response (coherency).

Given a particular dataset, the shot records are sorted by common midpoint, where the time difference between a given characteristic wavelet at zero offset and another at a non-zero offset is called *normal moveout* (NMO). In a horizontal, isotropic medium, this NMO is hyperbolic on a common midpoint gather (CMP), where the NMO velocity is equal to the velocity of the medium above the reflector. However, for a dipping interface, this NMO velocity is equal to the velocity of the said medium divided by the cosine of the dip angle. Furthermore, changes in rock properties within a medium (pore shape, pore pressure, pore fluid saturation, confining pressure, temperature), that is, heterogeneity, all modify the true NMO velocity. Finally, static time shifts caused by near surface velocity variations can also cause traveltimes to deviate from a true hyperbola.

In practice, NMO velocity is not known exactly, but, instead is estimated by picking ‘stacking velocities’, that is, interactive, velocity adjustments to yield the best stacking response (coherency). The NMO velocity is based on the small-spread hyperbolic traveltime, while stacking velocity is based on the hyperbola that best fits the data over the entire spread length (Yilmaz, 1987, pp155-156).

For both Whitehorse Trough datasets, stacking velocities were picked using *Velocity Analysis* in Promax. This processing flow was set up such that a pre-computed dataset was generated composed of ‘supergathers’ that allow for faster interactive picking in *Velocity Analysis*. The pre-compute processing flow is shown in appendices 2 and 3.

After generating the velocity pre-compute dataset, it then, becomes the input to *Velocity Analysis*: This flow will generate the following interactive display:

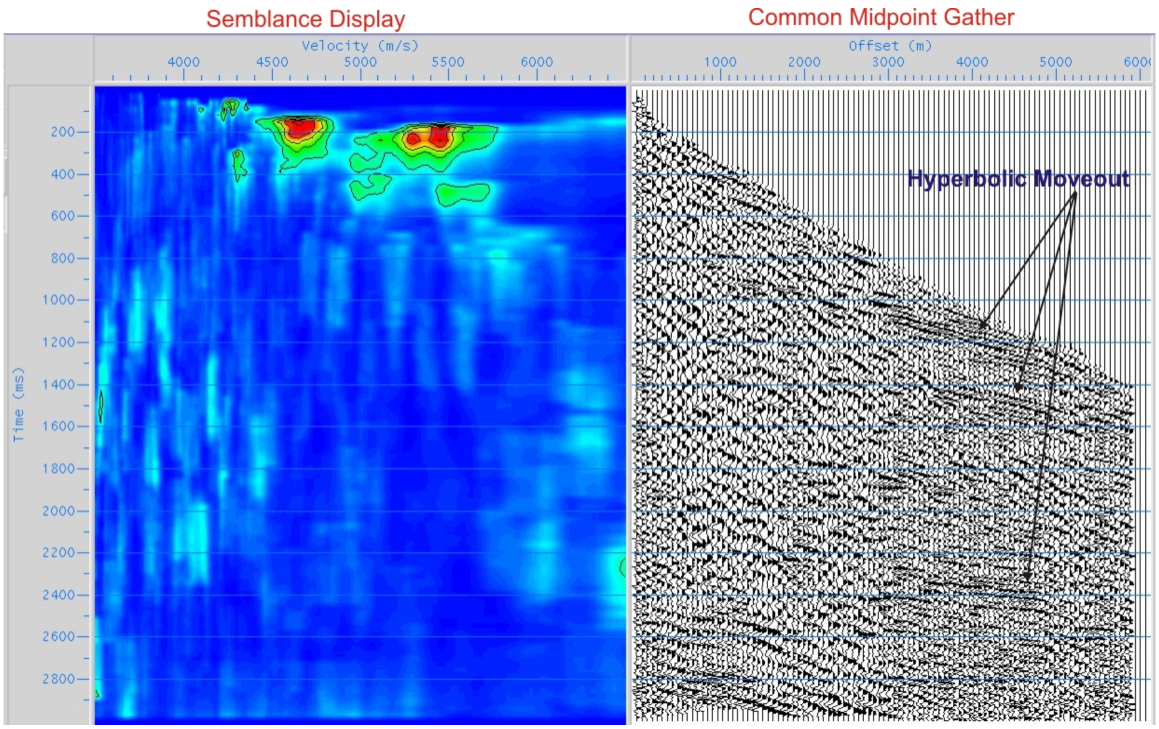

Figure 24 - No NMO Correction

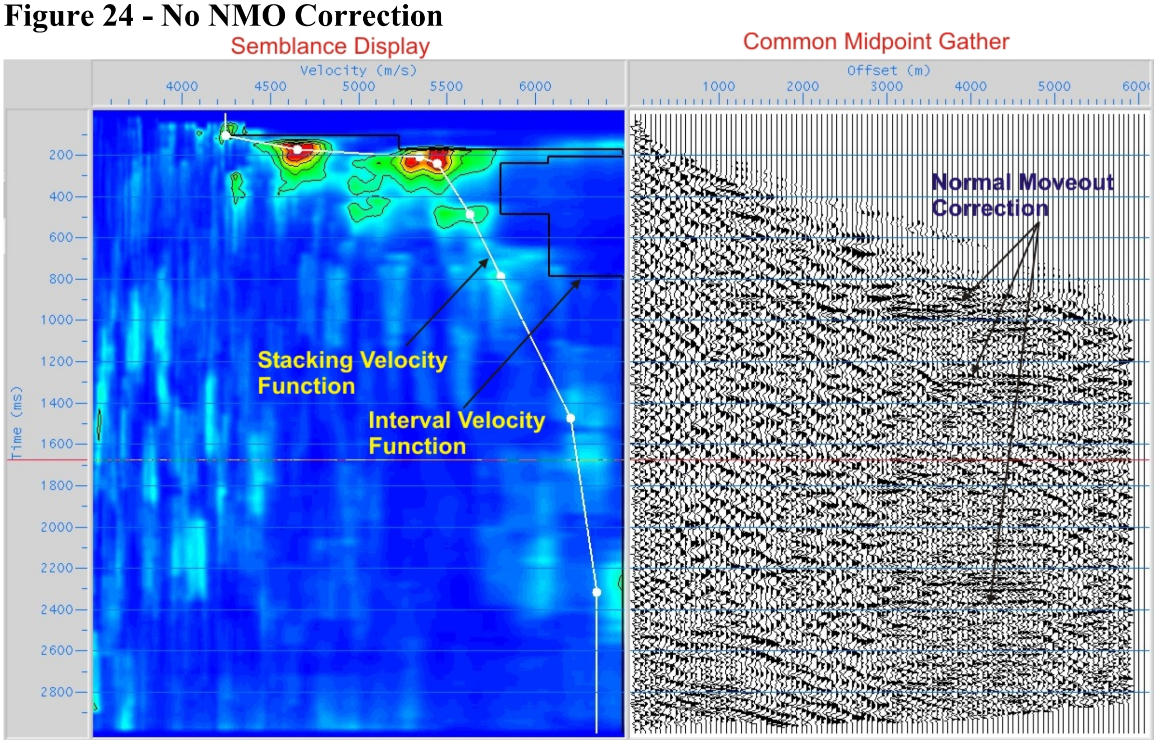

Figure 25 - Properly NMO Corrected

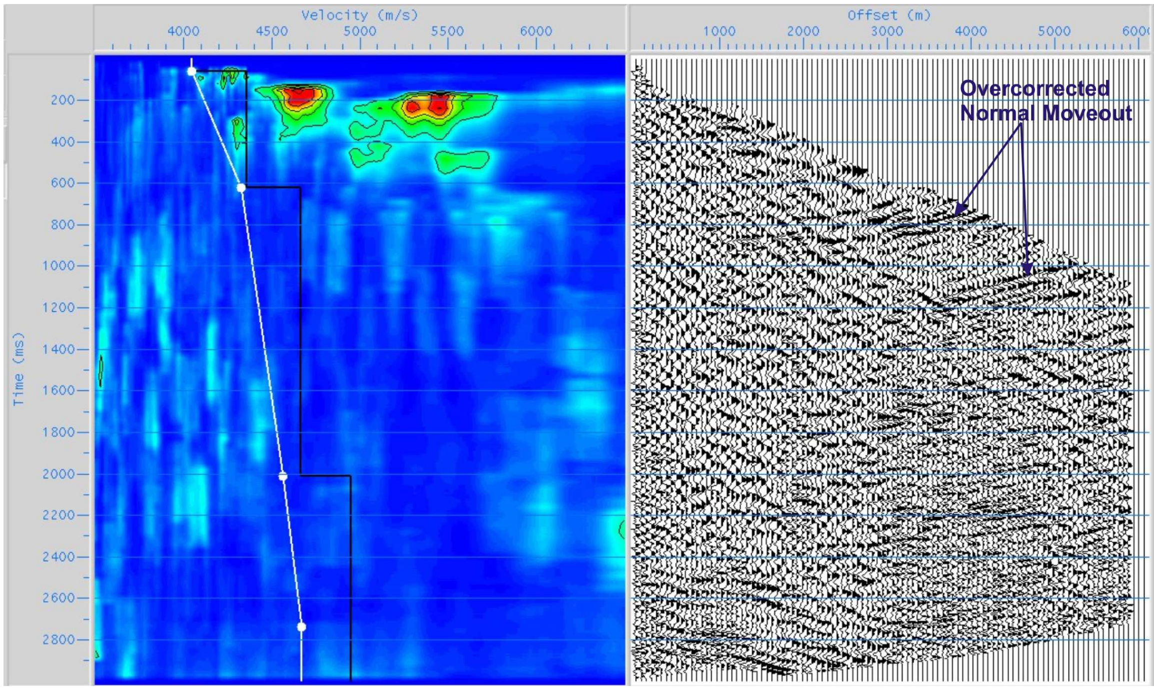

Figure 26 - Over corrected NMO (stacking velocities too low)

NORMAL MOVEOUT CORRECTION

After a stacking velocity function is defined interactively using semblance velocity analysis. These velocities were applied to a CDP sorted gather to correct for the effect of hyperbolic moveout due to the travel time delay inherent with reflected energy reaching larger offset seismometers. Since the gather of traces at the right of the velocity analysis figures is a "common-midpoint gather", the underlying assumption being that with traces having a common-midpoint, the source-receiver traveltime is equal. Thus, traces should line-up to create an approximation of a zero-offset section. NMO correction, however, introduces a NMO stretch effect, which is a frequency distortion that causes mainly large offset and shallow time events to manifest themselves as lower frequencies. This problem is resolved by muting the frequency stretched data. In this case, applying a NMO stretch mute. For this dataset, the stretch mute used was 50%, meaning any sample stretched more than this percentage will be automatically muted.

RESIDUAL STATICS CORRECTIONS

Residual statics corrections seek to maximize the horizontal alignment of individual reflection events prior to stacking by applying small time-shifts. The calculated time shifts are required to be “surface consistent”. That is, a single time-shift for each station source and each receiver is determined from the multiplied data. As opposed to long-wavelength refraction statics, residual statics do not depend on an earth model, but rather, are small-wavelength adjustments to improve signal coherency. Residual statics calculation is completed by choosing an autostatics horizon on a cdp stacked section and defining a time-window about this horizon such as to include the maximum signal-to-noise ratio. A cdp trace ‘smash gate’ is also chosen to sum a number of gathers to improve the signal-to-noise ratio prior to calculating the static values. This autostatics information is then used to calculate residual statics on NMO corrected cdp gathers. The output statics results are stored in Promax’s internal database and applied to the cdp stacked section. Next, the chosen processing flow is executed with residual statics corrections applied to NMO corrected cdp gathers. The following figures illustrate the improvement of residual statics corrections:

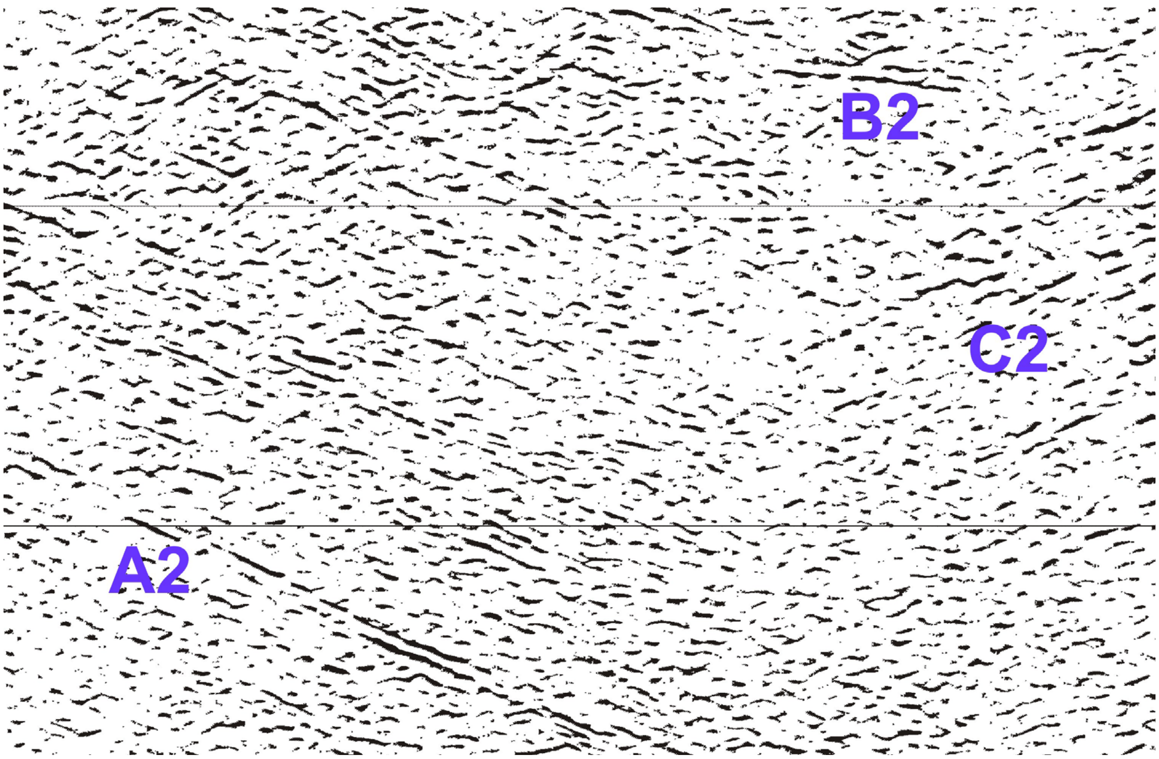

Figure 27 - Selected stack with only refraction statics applied (from figure 23)

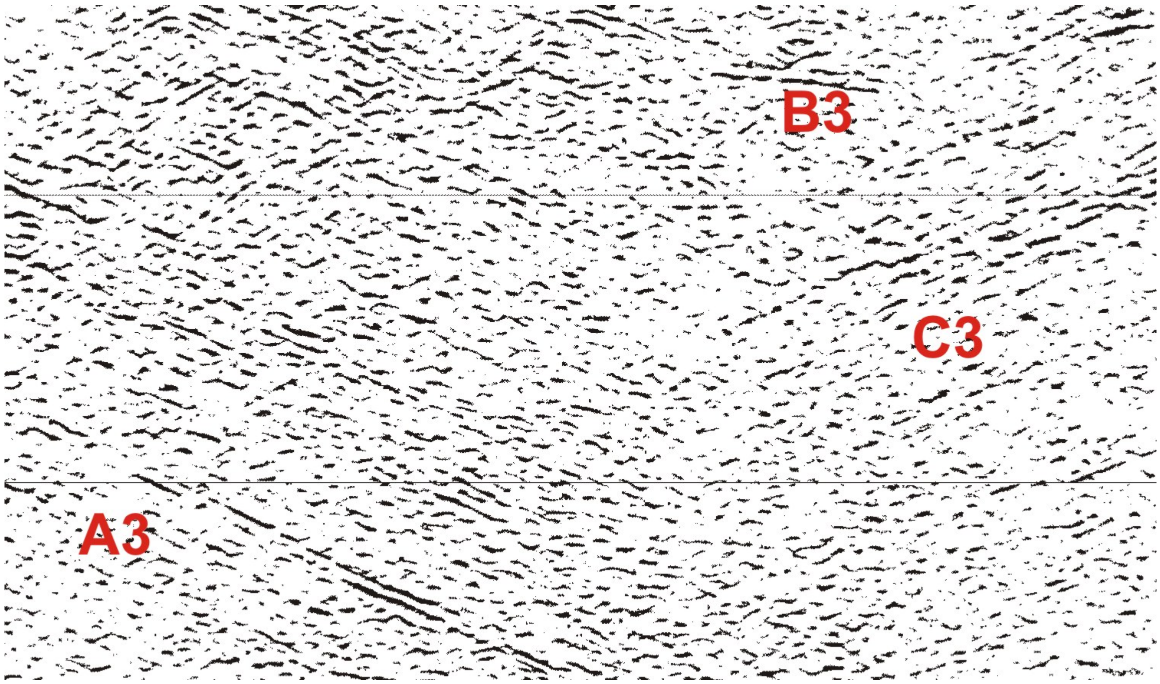

Figure 28 - Same stack with refraction statics and additional residual statics applied. All events, A3, B3 and C3 are more laterally coherent.

DIP MOVEOUT (DMO) ANALYSIS

The presence of reflected/diffracted energy on the stacks with a variety of dips suggested that application of DMO might improve the quality of the stack. Toward this end, a number of DMO tests were implemented on segment 2 (CDPS 6800-9430) of CARM1. However, the conclusion reached at the end of this analysis is that the structure stack (i.e., without DMO) is better (based on lateral coherency) than any of the DMO test sections. The only perceivable advantage of applying DMO is that the stacking velocities are lower (<6000 m/s) and thus more likely representative of the actual rock velocities.

Prior to running DMO, the prestack data were processed using the same flow (excluding stack) as used to produce the structure stack. DMO stacks were produced at various stages. Offset bin intervals of double and quadruple the shot spacing (i.e., 120 and 240 m, respectively) were tested with very little difference in the results. Also, residual statics were calculated after NMO using the DMO-based velocities with marginal change in the stack quality.

For comparison, plots of the various test stacks are included below.

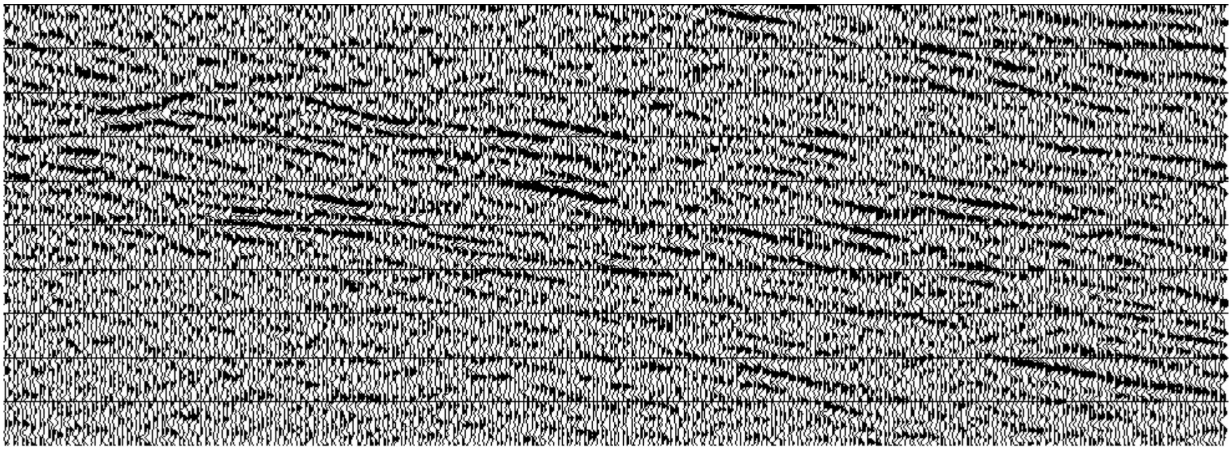

Figure 29 - Structure stack – standard processing flow (without DMO)

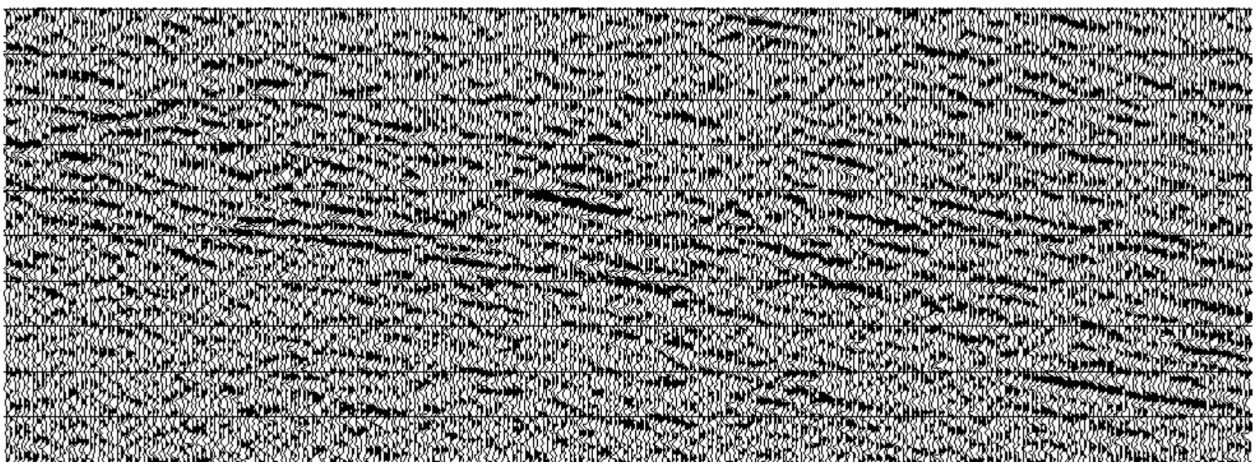

Figure 30 - DMO stack 1: DMO applied to data using original velocities, then stacked

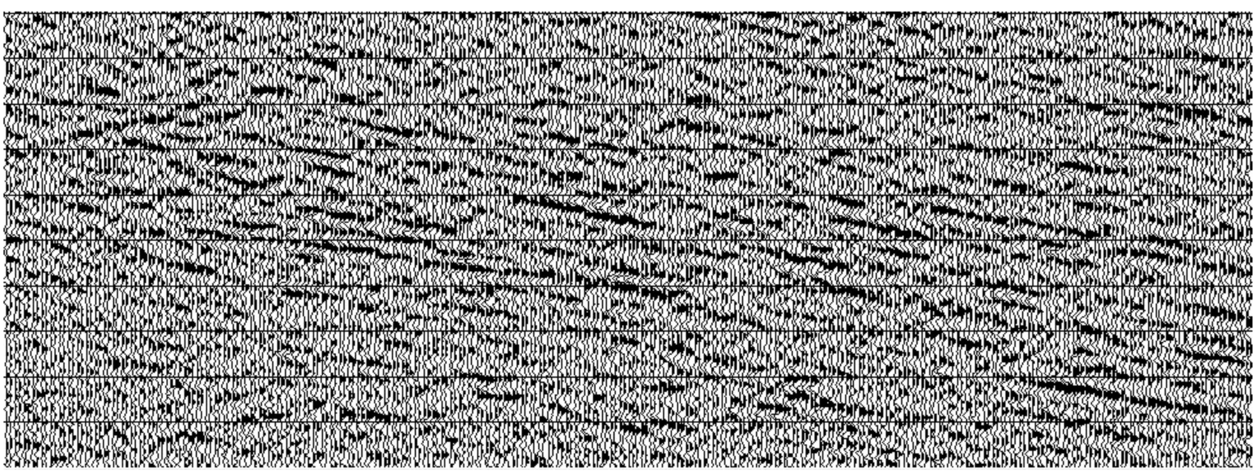

Figure 31 - DMO stack 2: DMO applied to data using original velocities
-inverse nmo applied after DMO
-new velocity analysis
-nmo using new velocities applied to existing DMO data, then stacked

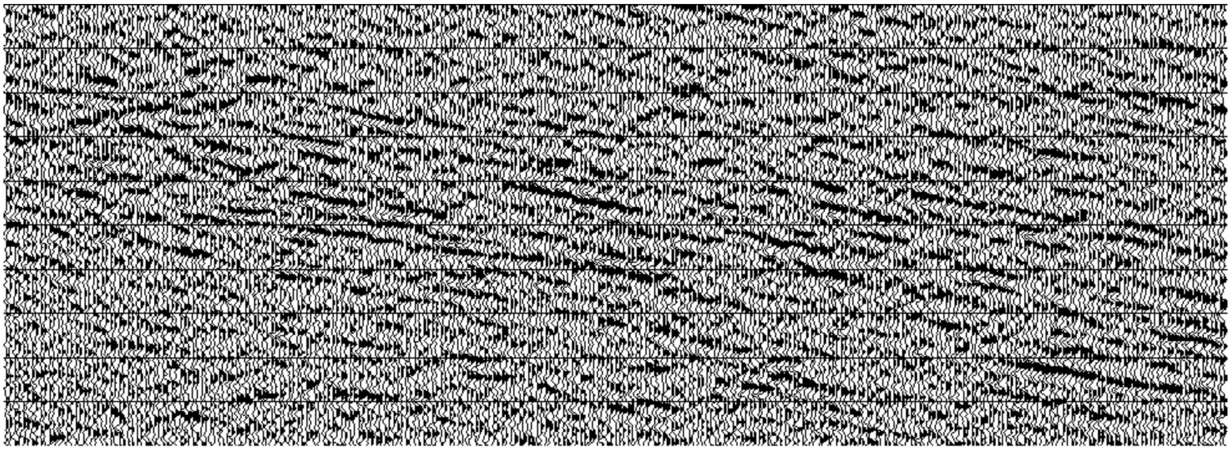

Figure 32 - DMO stack 3: DMO applied to data using original velocities
-inverse nmo applied after DMO
-new velocity analysis
-nmo using new velocities
-DMO using new velocities, then stacked

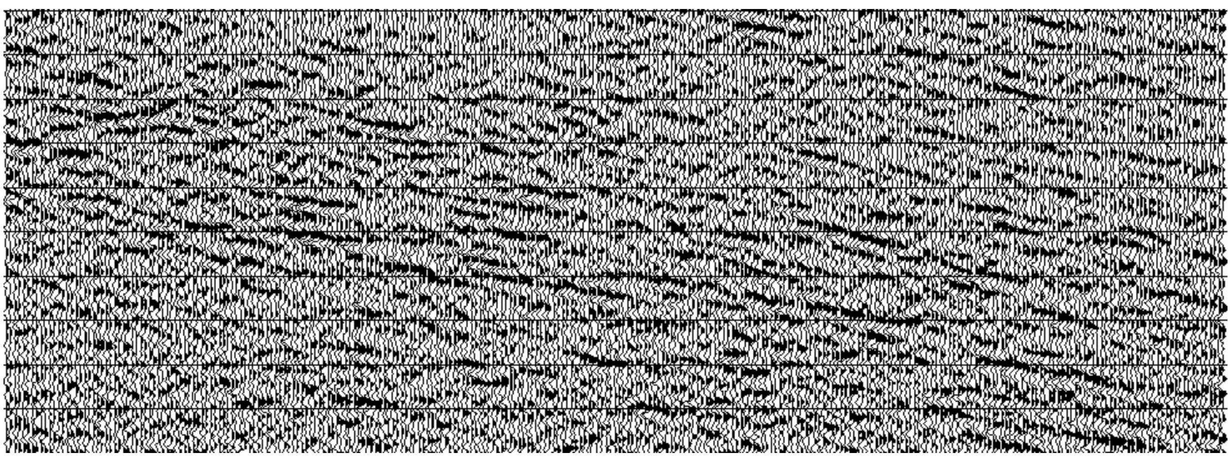

Figure 33 - DMO stack 3a: same as 3, but picked lower velocities during semblance analysis

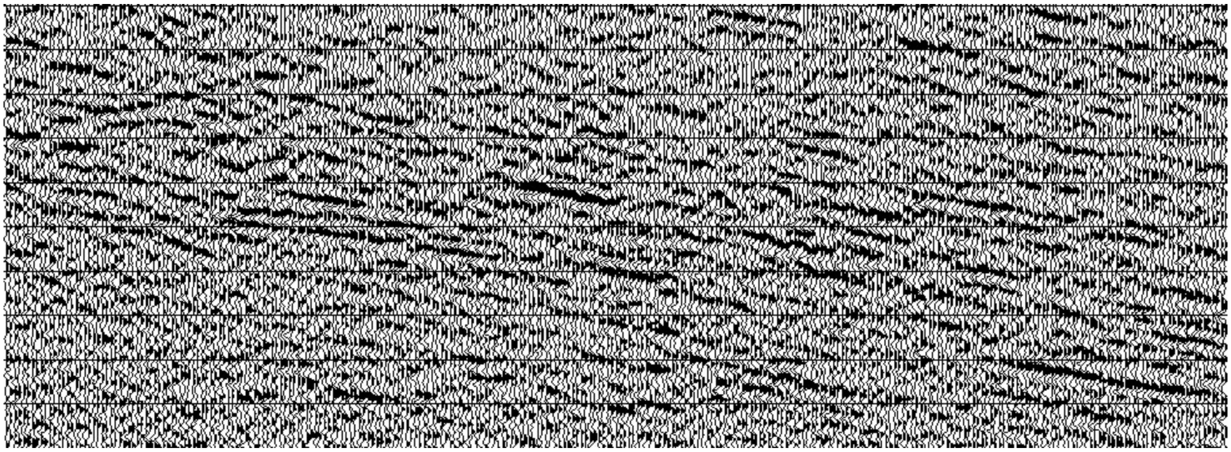

Figure 34 - DMO stack 4: as DMO stack 1, but 120 m bin width for common offset bins

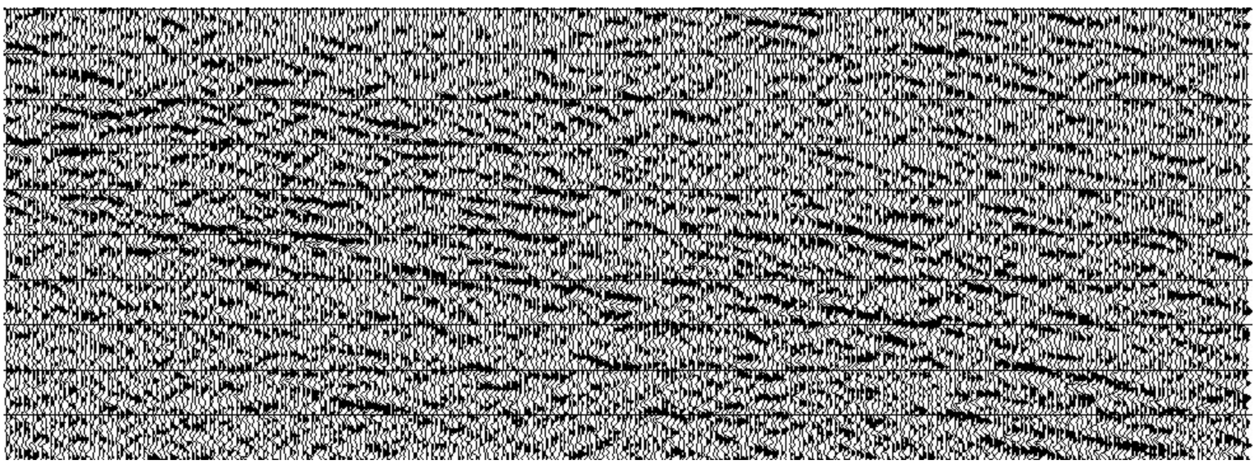

Figure 35 - DMO stack 5: same as DMO stack 3a, but with 120 m bin width for common offset bins

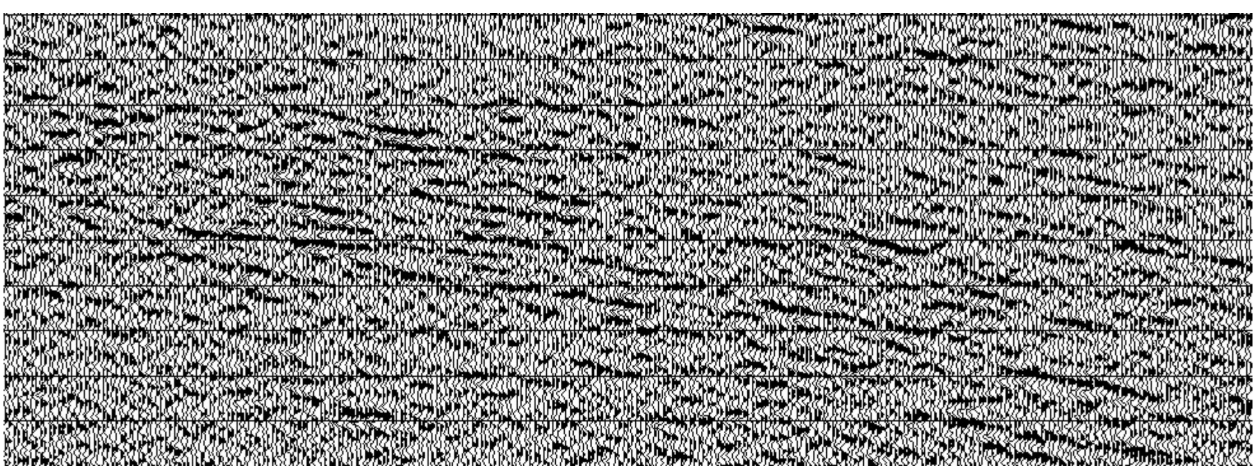

Figure 36 - DMO stack 5a: same as DMO stack 5, but with residual statics applied after NMO, but prior to DMO

FILTER TESTS
Several sections of the seismic lines were tested for appropriate frequency content by analyzing paper raw shot records with different bandpass filters applied. The bandpass filter decided upon was a time-variant filter with an open bandpass in the upper crustal section (3000ms) and overlapping panels of progressively lower high-cut and high-truncation frequency in the deep crust:

0-3000 ms: 10/14-80/84 Hz
2500-8000 ms: 10/14-60/70 Hz
7500-20000 ms: 10/14-70/80 Hz

CDP STACKING
After NMO correction, cdp gathers[1] are "stacked" (or summed) to produce an interpretable cdp stacked section. Traces within each cdp gather are summed to produce a single 'stacked trace'. A cdp-stacked trace should approximate the earth response as if recorded from zero-offset.

Although common mid-point stacking normally assumes all input traces in a given cdp gather are of equal value and are thus given equal weight in the contribution to the stack, the algorithm can accommodate for weighted trace stacking where one can assign more importance to better (usually, less noisy) traces. For instance, it is common for one to weight traces for stacking based on offset. This may produce a better stack.

---

[1] **The use of the term cdp refers to "common depth point" and although in the case of dipping reflectors this is not strictly true, the abbreviation 'cdp' is commonly used in reflection seismology to refer to common-midpoint or, cmp**

STAGE 4: POST-STACK PROCESSING

POST-STACK PHASE SHIFT MIGRATION

Migration moves dipping reflectors to their true subsurface position and collapses diffractions, hence delineating subsurface features (Yilmaz, 1987). Whereas deconvolution increases temporal resolution, migration boosts spatial resolution, yielding an interpretable seismic section. Migrations can be performed pre- or post-stack, with pre-stack being more complex and CPU intensive. Two post-stack migrations were tested: Kirchhoff Time Migration and Phase-Shift Time Migration. Both were tested on the same input dataset, an unmigrated, cdp stacked section. In general, while the Kirchhoff migration results were comparable, the Phase-Shift migration performed better. The following is an example of part of a dataset before and after phase-shift migration:

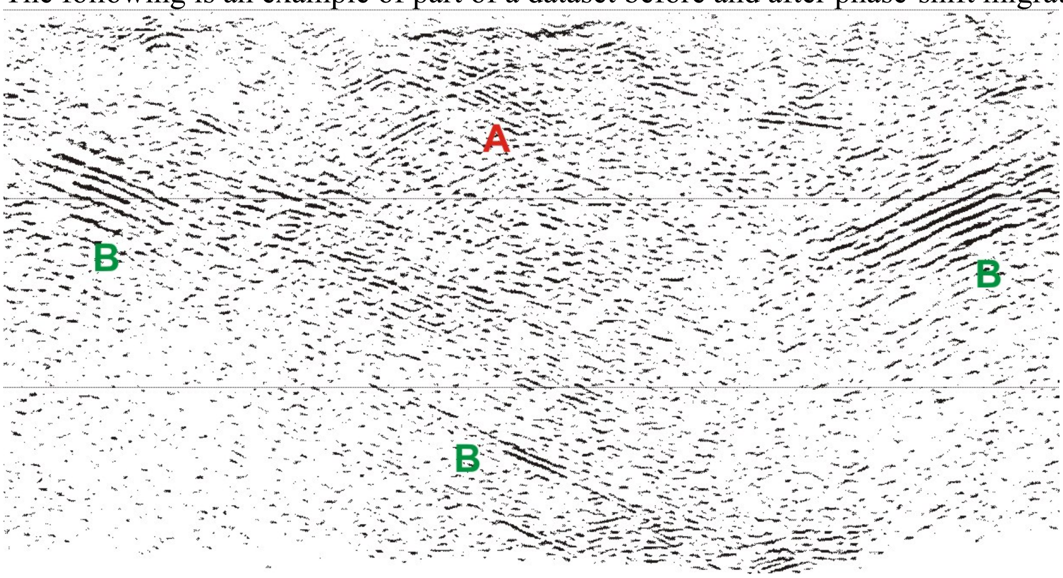

Figure 37 - Before Phase-Shift Migration

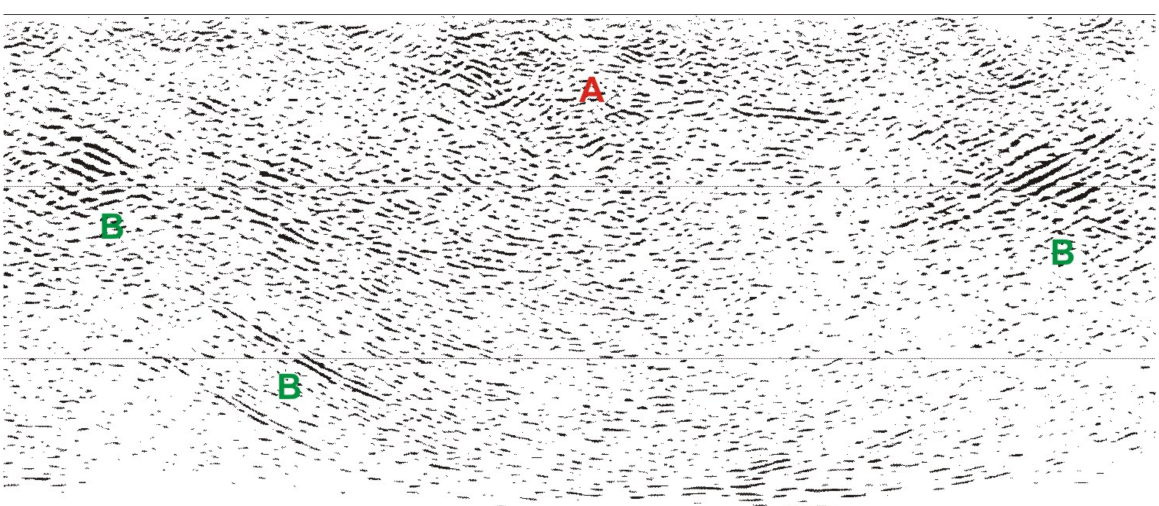

Figure 38 - After Phase-Shift Migration

In the first seismic section (before phase-shift migration) there are noticeable diffraction hyperbolae (A) – due to energy scattering at edges. The result of migration is to collapse these diffractions to their apex and create a more easily interpretable seismic section. Migration also steepens dipping events and moves them up-dip (B). Migration parameters included use of 100% interval velocities and the algorithm only migrated dips up to and including 90° using the full 10-84 Hz frequency spectrum.

PRESTACK PHASE SHIFT MIGRATION

Insofar as the assumption that a stacked section is an appropriate representation of a zero-offset section is correct, one can have confidence in a poststack migration algorithm. In such cases of severe conflicting dips, where an accurate velocity model cannot be established, it may not be possible to approximate a zero offset section from a simple cdp stack. In these cases, prestack migration may provide a more accurate interpretive model. This method was tested on a partial dataset (an area of strong conflicting dips) and was deemed to only be a marginal improvement over the poststack dataset. In fact, some areas were over-smoothed and higher frequency events present in the poststack section were eliminated. Given the high confidence level in the poststack section and the considerably longer processing times inherent in prestack migration, the method was abandoned.

SEMBLANCE SMOOTHING

The semblance smoothing algorithm (smb_smooth) is a coherency filter that was written at the GSC and calculates semblances based on a slant stack approach over a lateral trace window. Coherences are calculated by taking the semblance value and raising it to an exponent. The input data are then smoothed by taking the average value in the direction of the maximum semblance. The smoothed data are then multiplied by the calculated coherency to produce the filtered section.

PLOT THRESHOLD

Plot threshold is an algorithm (plot_thresh) run as a UNIX script on an INSIGHT/ITA file. Its function is to assign shading to peaks based on a predetermined minimum amplitude. Below this threshold amplitude trace peaks are not shaded black. Plot_thresh scans the data to determine the rms amplitude and the amplitude range for a user specified window within the data file. It also produces a profile of the data (it determines the percentage of data within a set of amplitude ranges). This information can then be used to determine an appropriate threshold level to apply to the data for plotting.

APPENDIX 1 – DELIVERABLES RECEIVED FROM KINETEX INC.

Data Tapes

Tape 1:
Label: Carmacks Line 1, Reel 1, Files 1-275, SHOT ID: 1078422708-1079104606

Tape 2:
Label: Carmacks Line 1, Reel 2, Files 276-524, SHOT ID: 1079104355-1079289548
Splits file 524 @ trace 1259

Tape 3:
Label: Carmacks Line 1, Reel 3, Files 524-800, SHOT ID: 1079289548-1079789700
Split trace 869-870

Tape 4:
Label: Carmacks Line 1, Reel 4, Files 800-1068, SHOT ID: 1079789700-1079975678
Split @ trace 159-160

Tape 5:
Label: Carmacks Line 1, Reel 5, Files 1068-1315, SHOT ID: 1079975678-1080157187

Tape 6: Correlated Field Data (9sec)
Label: DT24630
Density: 10GIG, Uncompressed
Client: Kinetex Inc.
Date: May 7, 2004
Data Type: SEGY Field Data
S.I.: 2ms; R.L. 9sec

Line#/Filename	File #
CARM2_3428-4283_vertical_corr_sgy	1-157500
CARM2_4286-4661_vertical_corr_sgy	157201-170296
CARM2_4661-4868_vertical_corr_sgy	170297-212633
CARM2_4871-5172_vertical_corr_sgy	212634-286425
CARM2_5221-5459_vertical_corr_sgy	286426-330702
CARM2_5462-5891_vertical_corr_sgy	330703-415014
CARM2_5894-6080_vertical_corr_sgy	415042-440119

8,218 MB

Tape 7: Uncorrelated Field Data (9sec)
Label: DT24631
Density: 40GIG, Uncompressed
Client: Kinetex Inc.
Date: May 7, 2004
Data Type: SEGY Field Data
S.I.: 2ms; R.L. 9sec

Line#/Filename	File #
CARM2_3428-4283_vertical.sgy	1-309
CARM2_4286-4661_vertical.sgy	310-450
CARM2_4661-4868_vertical.sgy	451-535
CARM2_4871-5172_vertical.sgy	536-667
CARM2_5221-5459_vertical.sgy	678-759
CARM2_5462-5891_vertical.sgy	760-913
CARM2_5894-6080_vertical.sgy	914-977

34,188 MB

Tape 8:
Label: 3884 to 5951 Vertical.sgy
Contains: `vertical component data for stations 3884-5951, line CARM1(GSC-001-04)`

Tape 9:
Label: 3884 to 5951 Crossline.sgy
Contains: `crossline component data for stations 3884-595, line CARM1(GSC-001-04)`

Tape 10:
Label: 3428-3719 (401)
3722-3899 (402)
3902-4283 (403)
Contains:
```
Carm2_3428-3719_crossline.sgy
Carm2_3428-3719_inline.sgy
Carm2_3428-3719_vertical.sgy
Carm2_3428-3719_vert_corr.sgy
Carm2_3722-3899_crossline.sgy
Carm2_3722-3899_inline.sgy
Carm2_3722-3899_vertical.sgy
Carm2_3722-3899_vert_corr.sgy
Carm2_3902-4283_crossline.sgy
Carm2_3902-4283_inline.sgy
Carm2_3902-4283_vertical.sgy
Carm2_3902-4283_vert_corr.sgy
```

Tape 11:
Label: 4286-4661 (404)
4661-4868 (405)
Contains:
```
Carm2_4286-4661_crossline.sgy
Carm2_4286-4661_inline.sgy
Carm2_4286-4661_vertical.sgy
Carm2_4286-4661_vert_corr.sgy
Carm2_4661-4868_crossline.sgy
Carm2_4661-4868_inline.sgy
Carm2_4661-4868_vertical.sgy
Carm2_4661-4868_vert_corr.sgy
```

Tape 12:
Label: 4871-5172 (406)
5221-5459 (407)
Contains:
```
Carm2_4871-5172_crossline.sgy
Carm2_4871-5172_inline.sgy
Carm2_4871-5172_vertical.sgy
Carm2_4871-5172_vertical_corr.sgy
Carm2_5221-5459_crossline.sgy
Carm2_5221-5459_inline.sgy
Carm2_5221-5459_vertical.sgy
Carm2_5221-5459_vertical_corr.sgy
```

Tape 13:
Label: 5894-6080 (409)
5462-5891 (408)
Contains:
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Carm2_5462-5891_crossline.sgy
Carm2_5462-5891_inline.sgy
Carm2_5462-5891_vertical.sgy
Carm2_5462-5491_vertical_corr.sgy
Carm2_5894-6080crossline.sgy
Carm2_5894-6080inline.sgy
Carm2_5894-6080vertical.sgy
Carm2_5894-6080vertical_corr.sgy
```

External Hard Drives

Maxtor Drive 1:
Software Label: Carmacks Correlated Data
Contents: *Folder: CARM1 CORR REGENERATED NOV1*
```
CARM1_File1_to_20_Vert_corr.sgy
CARM1_File21_to_200_Vert_corr.sgy
CARM1_File201_to_339_Vert_corr.sgy
CARM1_File340_to_490_Vert_corr.sgy
CARM1_File491_to_642_Vert_corr.sgy
CARM1_File643_to_780_Vert_corr.sgy
CARM1_File781_to_847_Vert_corr.sgy
CARM1_file897-996_VERTICAL_CORR.sgy
CARM1_file997-1096_VERTICAL_CORR.sgy
CARM1_file1097-1196_VERTICAL_CORR.sgy
CARM1_file1197-1296_VERTICAL_CORR.sgy
CARM1_file1297-1345_VERTICAL_CORR.sgy
```

Folder: CARM2 CORR REGENERATED NOV2
```
CARM2_FILE1_TOFILE128_Vert_corr.sgy
CARM2_FILE129_TOFILE280_Vert_corr.sgy
CARM2_FILE281_TOFILE420_Vert_corr.sgy
CARM2_FILE421_TOFILE570_Vert_corr.sgy
CARM2_FILE571_TOFILE720_Vert_corr.sgy
CARM2_FILE721_TOFILE889_Vert_corr.sgy
```

Maxtor Drive 2:
Software Label: Carm1_3884_5951
Contents: *Folder: CARM1 3884-5951 CROSSLINE*

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carm1_file1346_to_1394_crossline.sgy
carm1_file1395_to_1443_crossline.sgy
carm1_file1444_to_1490_crossline.sgy
carm1_file1491_to_1541_crossline.sgy
carm1_file1542_to_1593_crossline.sgy
carm1_file1594_to_1640_crossline.sgy
carm1_file1641_to_1685_crossline.sgy
carm1_file1686_to_1730_crossline.sgy
carm1_file1731_to_1776_crossline.sgy
carm1_file1777_to_1822_crossline.sgy
carm1_file1823_to_1862_crossline.sgy
carm1_file1863_to_1909_crossline.sgy
carm1_file1910_to_1948_crossline.sgy
carm1_file1949_to_1988_crossline.sgy
carm1_file1949_to_1988_crossline.sgy
```

Folder: CARM1 3884-5951 INLINE

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carm1_file1346_to_1394_inline.sgy
carm1_file1395_to_1443_inline.sgy
carm1_file1444_to_1490_inline.sgy
carm1_file1491_to_1541_inline.sgy
carm1_file1542_to_1593_inline.sgy
carm1_file1594_to_1640_inline.sgy
carm1_file1641_to_1685_inline.sgy
carm1_file1686_to_1730_inline.sgy
carm1_file1731_to_1776_inline.sgy
carm1_file1777_to_1822_inline.sgy
carm1_file1823_to_1862_inline.sgy
carm1_file1863_to_1909_inline.sgy
carm1_file1910_to_1948_inline.sgy
carm1_file1949_to_1988_inline.sgy
carm1_file1989_to_2035_inline.sgy
```

Folder: CARM1 3884-5951 REPORTS

```
MissingReport_CARM1_3884_5951_final.txt
ShotLog_File1346_to__2035.txt
ShotLog_File1346_to__2035.xls
```

Subfolder: CARM1 3884-5951 OB'S

```
VIBES-032504_NOV20.xls
VIBES-032604_NOV20.xls
VIBES-032704_NOV20.xls
VIBES-032804_NOV20.xls
VIBES-032904_NOV20.xls
VIBES-033004_NOV20.xls
VIBES-033104_NOV20.xls
```

Folder: CARM1 3884-5951 VERT CORRELATION

```
carm1_file1346_to_1445_vertical_corr.sgy
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carm1_file1546_to_1645_vertical_corr.sgy
carm1_file1646_to_1745_vertical_corr.sgy
carm1_file1746_to_1845_vertical_corr.sgy
carm1_file1846_to_1945_vertical_corr.sgy
carm1_file1946_to_2035_vertical_corr.sgy
```

Folder: CARM1 3884-5951 VERTICAL

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carm1_file1346_to_1394_vertical.sgy
carm1_file1395_to_1443_vertical.sgy
carm1_file1444_to_1490_vertical.sgy
carm1_file1491_to_1541_vertical.sgy
carm1_file1542_to_1593_vertical.sgy
carm1_file1594_to_1640_vertical.sgy
carm1_file1641_to_1685_vertical.sgy
carm1_file1686_to_1730_vertical.sgy
carm1_file1731_to_1776_vertical.sgy
carm1_file1777_to_1822_vertical.sgy
carm1_file1823_to_1862_vertical.sgy
carm1_file1863_to_1909_vertical.sgy
carm1_file1910_to_1949_vertical.sgy
carm1_file1950_to_1988_vertical.sgy
carm1_file1989_to_2035_vertical.sgy
```

Maxtor Drive 3:

Software Label: Carmacks

Contents: *Folder: CARM1 2630-3881 CORR*

```
CARM1_file897-996_VERTICAL_CORR.sgy
CARM1_file942-986_CROSSLINE.sgy
CARM1_file987-1031_CROSSLINE.sgy
CARM1_file997-1096_VERTICAL_CORR.sgy
CARM1_file1097-1196_VERTICAL_CORR.sgy
CARM1_file1197-1296_VERTICAL_CORR.sgy
CARM1_file1297-1345_VERTICAL_CORR.sgy
```

Folder: CARM1 CROSSLINE STACK

```
CARM1_file1-100_CROSSLINE.sgy
CARM1_file85-130_CROSSLINE.sgy
CARM1_file131-172_CROSSLINE.sgy
CARM1_file173-217_CROSSLINE.sgy
CARM1_file218-264_CROSSLINE.sgy
CARM1_file265-309_CROSSLINE.sgy
CARM1_file310-353_CROSSLINE.sgy
CARM1_file354-400_CROSSLINE.sgy
CARM1_file401-445_CROSSLINE.sgy
CARM1_file446-490_CROSSLINE.sgy
CARM1_file491-535_CROSSLINE.sgy
CARM1_file536-578_CROSSLINE.sgy
CARM1_file579-623_CROSSLINE.sgy
CARM1_file624-664_CROSSLINE.sgy
CARM1_file665-710_CROSSLINE.sgy
CARM1_file711-755_CROSSLINE.sgy
CARM1_file756-801_CROSSLINE.sgy
CARM1_file802-847_CROSSLINE.sgy
CARM1_file897-941_CROSSLINE.sgy
CARM1_file1032-1076_CROSSLINE.sgy
CARM1_file1077-1116_CROSSLINE.sgy
CARM1_file1117-1160_CROSSLINE.sgy
CARM1_file1161-1209_CROSSLINE.sgy
CARM1_file1210-1255_CROSSLINE.sgy
CARM1_file1256-1300_CROSSLINE.sgy
CARM1_file1301-1345_CROSSLINE.sgy
```

Folder: CARM1 INLINE STACK

CARM1_file1-84_INLINE.sgy
CARM1_file85-130_INLINE.sgy
CARM1_file131-172_INLINE.sgy
CARM1_file173-217_INLINE.sgy
CARM1_file218-264_INLINE.sgy
CARM1_file265-309_INLINE.sgy
CARM1_file310-353_INLINE.sgy
CARM1_file354-400_INLINE.sgy
CARM1_file401-445_INLINE.sgy
CARM1_file446-490_INLINE.sgy
CARM1_file491-535_INLINE.sgy
CARM1_file536-578_INLINE.sgy
CARM1_file579-623_INLINE.sgy
CARM1_file624-664_INLINE.sgy
CARM1_file665-710_INLINE.sgy
CARM1_file711-755_INLINE.sgy
CARM1_file756-801_INLINE.sgy
CARM1_file802-847_INLINE.sgy
CARM1_file897-941_INLINE.sgy
CARM1_file942-986_INLINE.sgy
CARM1_file987-1031_INLINE.sgy
CARM1_file1032-1076_INLINE.sgy
CARM1_file1077-1116_INLINE.sgy
CARM1_file1117-1160_INLINE.sgy
CARM1_file1161-1209_INLINE.sgy
CARM1_file1210-1255_INLINE.sgy
CARM1_file1256-1300_INLINE.sgy
CARM1_file1301-1345_INLINE.sgy

Folder: CARM1 VERTICAL STACK

CARM1_file1-84_VERTICAL.sgy
CARM1_file85-130_VERTICAL.sgy
CARM1_file131-172_VERTICAL.sgy
CARM1_file173-217_VERTICAL.sgy
CARM1_file218-264_VERTICAL.sgy
CARM1_file265-309_VERTICAL.sgy
CARM1_file310-353_VERTICAL.sgy
CARM1_file354-400_VERTICAL.sgy
CARM1_file401-445_VERTICAL.sgy
CARM1_file446-490_VERTICAL.sgy
CARM1_file491-535_VERTICAL.sgy
CARM1_file536-578_VERTICAL.sgy
CARM1_file579-623_VERTICAL.sgy
CARM1_file624-664_VERTICAL.sgy
CARM1_file665-710_VERTICAL.sgy
CARM1_file711-755_VERTICAL.sgy
CARM1_file756-801_VERTICAL.sgy
CARM1_file802-847_VERTICAL.sgy
CARM1_file897-941_VERTICAL.sgy
CARM1_file942-986_VERTICAL.sgy
CARM1_file987-1031_VERTICAL.sgy
CARM1_file1032-1076_VERTICAL.sgy
CARM1_file1077-1116_VERTICAL.sgy
CARM1_file1117-1160_VERTICAL.sgy
CARM1_file1161-1209_VERTICAL.sgy
CARM1_file1210-1255_VERTICAL.sgy
CARM1_file1256-1300_VERTICAL.sgy
CARM1_file1301-1345_VERTICAL.sgy

Folder: CARMACKS1 REPORTS

MissingReport_101_to_2627.txt
ShotLog_File1_to_847.txt
ShotLog_File1_to_847.xls
VIBES-030904_OCT30.xls
VIBES-031004_OCT30.xls
VIBES-031104_OCT30.xls
VIBES-031204_OCT30.xls
VIBES-031304_OCT30.xls
VIBES-031404_OCT30.xls
VIBES-031504_OCT30.xls
VIBES-031704_OCT30.xls
VIBES-031804_OCT30.xls
VIBES-031904_OCT30.xls
VIBES-032004_OCT30.xls
VIBES-032104_OCT28.xls
VIBES-032204_OCT28.xls
VIBES-032304_OCT28.xls
VIBES-032404_OCT28.xls

Paper Deliverables/Compact Discs

Acquisition Report (paper)

Observer's Notes (paper)

Chaining Notes (paper)

CD A: Tape Logs: Crossline, Inline, Vertical

autoTapeLog,inline1001.xls
autoTapeLog.crossline2001.xls
autoTapeLog.vert1.xls

CD B: Observer Reports, Tape Logs

Folder: CROSSLINE TAPELOGS

autoTapeLog.crossline2001.xls
autoTapeLog.crossline2002.xls
autoTapeLog.crossline2003lastpart.xls
autoTapeLog.crossline2003partial.xls
autoTapeLog.crossline2004.xls
autoTapeLog.crossline2005,partial.xls

Folder: INLINE TAPELOGS

autoTapeLog,inline1001.xls
autoTapeLog.inline1002.xls
autoTapeLog.inline1003lastpart.xls
autoTapeLog.inline1003part.xls
autoTapeLog.inline1004.xls
autoTapeLog.INLINE1005.xls
autoTapeLog.INLINE1006.xls

Folder: OBSERVOR REPORTS

1ST DAY TEST,OB LOGS-030404.xls
2ND DAY TESTS,Vibe OBs-030504.xls
OBS-031404corrected.xls
OBS-031504,correted.xls
OBS-031704,corrected.xls
OBS-031804,corrected.xls
OBS-031904,corrected.xls
OBS-032004,corrected.xls
OBS-032104,corrected.xls
OBS-032204,corrected.xls
OBS-032304,corrected.xls
OBS-032404,corrected.xls
Vibe OBs-030904,CORRECTED.xls
Vibe OBs-031004,CORRECTED.xls
Vibe OBs-031104,CORRECTED.xls
Vibe OBs-031204corrected.xls
Vibe OBs-031304,corrected.xls

Folder: VERTICAL TAPELOGS

autoTapeLog.vert1.xls
autoTapeLog.vert2.xls
autoTapeLog.VERT3lastpart.xls
autoTapeLog.vert3partial.xls
autoTapeLog.vert4.xls
autoTapeLog.vert5.xls
autoTapeLog.VERT6.xls

CD C: Observer Reports (GSC-002-04)

OBS-040204_WITH FILE NUMBER.XLS
T2OBS-040104_WITH FILE NUMBER.XLS
V2OBS-040304.XLS
V2OBS-040404.XLS
V2OBS-040504.XLS
V2OBS-040604.XLS
V2OBS-040704.XLS
V2OBS-040804.XLS
V2OBS-040904.XLS

CD D: Observer Reports (GSC-001-04)

Folder: OBSERVER REPORTS

1ST DAY TEST,OB LOGS-030404.xls
2ND DAY TESTS,Vibe OBs-030504.xls
OBS-031404corrected.xls
OBS-031504,correted.xls
OBS-031704,corrected.xls
OBS-031804,corrected.xls
OBS-031904,corrected.xls
OBS-032004,corrected.xls
OBS-032104,corrected.xls
OBS-032204,corrected.xls
OBS-032304,corrected.xls
OBS-032404,corrected.xls
Vibe OBs-030904,CORRECTED.xls
Vibe OBs-031004,CORRECTED.xls
Vibe OBs-031104,CORRECTED.xls
Vibe OBs-031204corrected.xls
Vibe OBs-031304,corrected.xls

CD E: Topographic GPS Survey (GSC 00104 Seg1, GSC 00204, Seg1)

```
GSC00104.SEG
GSC00204.SEG
```

CD F: Observer Reports, Tape Logs, Missing Trace Reports

Folder: Carmacks Line 1 - Final Reproduction

```
MissingReport_101-3881.txt
MissingReport_Test Data.txt
MissingTracescompleteline.txt
TapeLog SP101-1607.xls
TapeLog SP1610-3881.xls
VIBES-030904.xls
VIBES-031004.xls
VIBES-031104.xls
VIBES-031204.xls
VIBES-031304.xls
VIBES-031404.xls
VIBES-031504.xls
VIBES-031704.xls
VIBES-031804.xls
VIBES-031904.xls
VIBES-032004.xls
VIBES-032104.xls
VIBES-032204.xls
VIBES-032304.xls
VIBES-032404.xls
VIBES-032504.xls
VIBES-032604.xls
VIBES-032704.xls
VIBES-032804.xls
VIBES-032904.xls
VIBES-033004.xls
VIBES-033104.xls
WriteSplitShotDetails.txt
```

APPENDIX 2 - PROCESSING FLOW FOR CARM 1 VERTICAL COMPONENT (FROM PROMAX)

1) Data Input
  - Uncorrelated Raw Shot Records

2) Vibroseis Correlation
  - Location of sweep trace: very first input trace
  - Start time for sweep: 0
  - Length of sweep: 24576 ms
  - Output trace length: 20000 ms

3) Crooked Line Geometry Application
  - Setup: Matching pattern numbers using first live chan and station
    - Nominal receiver station interval: 20.0 m
    - Nominal source station interval: 60.0 m
    - Nominal crossline separation: 0.0
    - Nominal survey azimuth: 270.0°
    - Base Source station co-ordinates upon a match between source and receiver station numbers? YES
    - Source type: Surface seismic source
    - Units required: Meters
  - Midpoint Binning
    - Assign midpoints by: matching pattern numbers using first live chan and station
    - Define crooked binning grid: Track #: 'brtrack'; bin# 'brbin'
    - Bin Size: 10 m by 2300 m
    - Beginning Bin number: 1
    - Offset Bin Center Increment: 20.000000
    - Minimum Offset Bin Center: 10.000000
    - Maximum Offset Bin Center: 6000.000000
    - CDP numbers increase from first trace: YES
  - Loading Geometry into Trace headers
    - Disk Data Input: All Correlated Raw Shots
    - Inline Geom Header Load
      - Primary header to match database: FFID
      - Secondary header to match database: none
      - Match by valid trace number: NO
      - Drop traces with NULL CDP headers: NO
      - Drop traces with NULL receiver headers: NO
      - Verbose diagnostics: NO
    - Disk Data Output: Shots With Geometry

4) Geometry Quality Control
  - Checking geometry for errors using stacking chart and flag position of shot records

5) First Arrival Analysis
  - Snap picks to peak

6) Automatic Gain Control (AGC)
  - Application mode: APPLY
  - Scalar Type: Mean
  - AGC Operator Length: 500 ms
  - Basis for scalar operation: Centered
  - Exclude hard zeros: YES
  - Robust scaling: NO

7) Spiking/Predictive Deconvolution
  - Type of deconvolution: Minimum phase predictive
  - Decon Operator Length: 120 ms
  - Operator Prediction Distance: 32 ms
    - Is prediction distance water relative: NO

Apply prediction filter correction: NO
- Operator White Noise Level: 1.0%
- Window rejection factor: 2
- Time gate reference: Time 0
- Get decon gates from database: NO
    Select Primary decon gate header word: Source index number (internal)
    Select secondary decon gate header word: Absolute value of offset
    Specify decon gate parameters: 369: 20:150-2400/369:5500:1600-2800
- Output traces or filters: Normal decon output
- Apply a bandpass filter after decon: NO
- Re-apply trace mute after decon: NO

8) Trace Muting (Picked on every shot record to mute refraction energy)
- Re-apply previous mutes: NO
- Mute time reference: Time 0
- Type of mute: TOP
    Starting ramp: 30
    Extrapolate mute times: YES
- Get mute file from database: YES
    Select mute parameter file: topmute2

9) Apply User Statics (Refraction Statics Application from Insight)
- Final Datum Elevation: 750 m
- Replacement Velocity: 4800 m/s
- NMO static method: Elevations
- Length of smoother: 1201 cdps
- Database math file: /net/logan/logansw/promax7.0/port/misc/user_stat_math

10) Velocity Supergather Precompute
Supergather Formation
    Read data from other lines/surveys: NO
    Dataset: appropriate shots_with_geometry file
        Presort in memory or on disk: Memory
    Maximum CDP fold: 1000
    Minimum CDP number: first CDP of line
    Maximum CDP number: last CDP of line
    CDP increment: 50
    Number of CDPs to combine: 11
Automatic Gain Control
    Application mode: APPLY
    Type of AGC Scalar: MEAN
    AGC operator length: 500 ms
    Basis for scalar application: centered
    Exclude hard zeros: YES
    Robust Scaling: NO
Trace Muting
    Re-apply previous mutes: NO
    Mute time reference: Time 0
    Type of Mute: TOP
    Starting Ramp: 30
    Extrapolate mute times: YES
    Get mute file from database: YES
    Select mute parameter file: topmute2
Apply User Statics (Refraction Statics generated from INSIGHT)
    Final Datum Elevation: 750 m
    Replacement Velocity: 4800 m/s
    NMO static method: Elevations
    Length of Smoother: 1201 cdps
    Database math file: /net/logan/logansw/promax7.0/port/misc/user_stat_math

- Apply Residual Statics
    - Normal Database Naming Mode: YES
    - Source residual statics database parameter: SIN STATICS SPWR???? (appropriate to segment)
    - Receiver residual statics database parameter: SRF STATICS SPWR???? (appropriate to segment)
- Velocity Analysis Pre-compute
    - Number of cdps in supergather: 11
        - Apply partial NMO-to-binning: NO
        - Apply differential statics: NO
        - Absolute offset of first bin center: 0
        - Bin size for vertically summing offsets: 60
        - Maximum offset: 6000
        - Use absolute value of offset for stacking: YES
        - Maximum stretch percentage for NMO: 30%
    - Minimum semblance analysis velocity: 3500 m/s
    - Maximum semblance analysis velocity: 3500 m/s
    - Number of semblance analysis velocities: 500
    - Semblance sample rate: 30 ms
    - Semblance calculation window: 25 ms
    - Method of computing stack velocity functions: Top/Base range
        - Number of Velocity Functions: 21
        - Minimum time velocity function variation: 5000 m/s
        - Maximum time velocity function variation: 5000 m/s
        - Velocity guide function table name: choose most recent velocity table
- Disk Data Output
    - Output Dataset Filename: choose appropriate name
    - New or Existing File: NEW
    - Record length to output: choose appropriately
    - Trace sample format: 16 bit
    - Skip primary dish storage: NO

11) Velocity Analysis

- Disk Data Input
    - Read data from other lines/surveys: NO
    - Select Dataset: select output from velocity pre-compute flow
    - Trace Read option: SORT
    - Interactive Data Access: YES
    - Select primary trace header entry: USER header word: SG_CDP (that is, supergather_cdp)
    - Select secondary header entry: NONE
    - Sort order list for dataset: CDP range of line or segment of line
    - Presort in memory or on disk: MEMORY
    - Read the data multiple times: NO
    - Process trace headers only: NO
    - Override input data's sample rate: NO
- Automatic Gain Control
    - Application mode: APPLY
    - Type of AGC Scalar: MEAN
    - AGC operator length: 500 ms
    - Basis for scalar application: centered
    - Exclude hard zeros: YES
    - Robust Scaling: NO
- Velocity Analysis
    - Select display device: This Screen
    - Set Supergather parameters: YES
        - Display gather panel: YES
        - Is the incoming data pre-computed: YES
        - Maximum stretch percentage for NMO: 70%
    - Set semblance parameters: YES
        - Display Semblance Panel: YES
        - Display Semblance Contours: YES
        - Display Stack Velocity Functions: NO
        - Display guide function: NO

Display interval velocity function: YES
Semblance normalization mode: Scale Panel
Contrast power factor: 1
Contrast noise factor: 0.1
Maximum Velocity change for snapping: 5%
Maximum time change for snapping: 20 ms
Set Stack parameters: YES
Display velocity functions stack panel: YES
Display dynamic stack panel: YES
Display flip stacks panel: NO
Display velocity colour background: YES
Display velocity colour key: YES
Set Velocity Parameters: YES
Table to store velocity picks: choose appropriately
Velocity guide function name: choose appropriately
Interval Velocity below last knee: 0 (option off)
Communicate with Volume Viewer/Editor using PD: NO
Set Horizon Parameters: NO
Use Neural Network Velocity picker: NO

12) Time Variant Bandpass Filter
0-3000 ms: 10 / 14 – 80 / 84 Hz
2500-8000 ms: 10 / 14 – 60 / 70 Hz
7500-20000 ms: 10 / 14 – 50 / 60 Hz

13) Normal Moveout Correction
Direction for NMO application: FORWARD
Stretch Mute Percentage: 50%
Apply any remaining static during NMO: NO
Apply partial NMO: NO
Get velocities from database: YES
Select velocity parameter file: Velocities Derived From Velocity Analysis
cdp range: 26-2099: seg0_v1
cdp range: 2100-4800: seg1_v1
cdp range: 4801-6800: seg2_v1a3
cdp range: 6801-9450: seg3_v1
cdp range: 9451-10668: seg4_v1

14) Residual Statics Application
Maximum Power Autostatics Calculation
Select Trace data file: nmo corrected cdp gathers
Select autostatics horizon file: picked on cdp stack in trace display
RMS static change convergence criteria: 0.05
Maximum number of iterations: 6
Minimum live samples in a gate: 60%
Maximum static allowed: 50 ms
Compute statics for whole line: YES
Create a NEW database entry for each run: YES
Report static values after each iteration: NO
- Apply residual statics
Normal database entry naming mode: NO
Source residual statics database parameter: SIN STATICS SPWR9838 (cdp range: 26-2099)
Receiver residual statics database parameter: SRF STATICS RPWR9838 (cdp range: 26-2099)
Source residual statics database parameter: SIN STATICS SPWR1181 (cdp range: 2100-4800)
Receiver residual statics database parameter: SRF STATICS RPWR1181 (cdp range: 2100-4800)
Source residual statics database parameter: SIN STATICS SPWR9086 (cdp range: 4801-6800)
Receiver residual statics database parameter: SRF STATICS RPWR9086 (cdp range: 4801-6800)
Source residual statics database parameter: SIN STATICS SPWR4167 (cdp range: 6801-9450)
Receiver residual statics database parameter: SRF STATICS RPWR4167 (cdp range: 6801-9450)
NO STATICS APPLIED (cdp range: 9451-10668)

15) CDP/Ensemble Stack

- Sort order of input ensembles: CDP
- Method for Trace Summing: Mean
- Root power scalar for stack normalization: 0.5
- Apply final datum statics after stack: NO
- Has NMO been applied: YES

16) Phase Shift Time Migration

- Minimum CDP to migrate: 26
- Maximum CDP to migrate: 10668
- CDP interval: 9.33466 m
- Minimum frequency to migrate: 10 Hz
- Maximum frequency to migrate: 84 Hz
- Get interval-velocity-versus-time function from database: NO
- INTERVAL-velocity-versus-time for migration: 1:0-4000, 3000-5000
- Percent velocity scale factor: 100%
- Migrate dips: up to 90° only
- Maximum amount of memory (in Mbytes): 2048
- Change default tapering: NO
  - Bottom taper: 200 ms
  - Upper edge taper: 2 traces
  - Lower edge taper: 20 traces
- Re-apply trace mutes: YES
- Re-kill dead traces: YES

APPENDIX 3 - PROCESSING FLOW FOR CARM 2 VERTICAL COMPONENT (FROM PROMAX)

1) Data Input

   Uncorrelated Raw Shot Records

2) Vibroseis Correlation

   Location of sweep trace: very first input trace
   Start time for sweep: 0
   Length of sweep: 24576 ms
   Output trace length: 20000 ms

3) Crooked Line Geometry Application

   Setup: Matching pattern numbers using first live chan and station
      Nominal receiver station interval: 20.0 m
      Nominal source station interval: 60.0 m
      Nominal crossline separation: 0.0
      Nominal survey azimuth: 270.0°
      Base Source station co-ordinates upon a match between source and receiver station numbers? YES
      Source type: Surface seismic source
      Units required: Meters
   Midpoint Binning
      Assign midpoints by: matching pattern numbers using first live chan and station
      Define crooked binning grid: Track #: 'brtrack'; bin# 'brbin'
      Bin Size: 10 m by 2300 m
      Beginning Bin number: 1
      Offset Bin Center Increment: 20.000000
      Minimum Offset Bin Center: 10.000000
      Maximum Offset Bin Center: 6000.000000
      CDP numbers increase from first trace: YES
   Loading Geometry into Trace headers
      Disk Data Input: All Correlated Raw Shots
      Inline Geom Header Load
         Primary header to match database: FFID
         Secondary header to match database: none
         Match by valid trace number: NO
         Drop traces with NULL CDP headers: NO
         Drop traces with NULL receiver headers: NO
         Verbose diagnostics: NO
      Disk Data Output: Shots With Geometry

4) Geometry Quality Control

   - Checking geometry for errors using stacking chart and flag position of shot records

5) First Arrival Analysis

   - Snap picks to peak

6) Automatic Gain Control (AGC)

   - Application mode: APPLY
   - Scalar Type: Mean
   - AGC Operator Length: 500 ms
   - Basis for scalar operation: Centered
   - Exclude hard zeros: YES
   - Robust scaling: NO

7) Spiking/Predictive Deconvolution

   - Type of deconvolution: Minimum phase predictive
   - Decon Operator Length: 120 ms
   - Operator Prediction Distance: 32 ms
      Is prediction distance water relative: NO

Apply prediction filter correction: NO
- Operator White Noise Level: 1.0%
- Window rejection factor: 2
- Time gate reference: Time 0
- Get decon gates from database: NO
    Select Primary decon gate header word: Source index number (internal)
    Select secondary decon gate header word: Absolute value of offset
    Specify decon gate parameters: 5636: 20:200-2400/5636:20:1700-2800
- Output traces or filters: Normal decon output
- Apply a bandpass filter after decon: NO
- Re-apply trace mute after decon: NO

8) Trace Muting (Picked on every shot record to mute refraction energy)
- Re-apply previous mutes: NO
- Mute time reference: Time 0
- Type of mute: TOP
    Starting ramp: 30
    Extrapolate mute times: YES
- Get mute file from database: YES
    Select mute parameter file: topmute2

9) Apply User Statics (Refraction Statics Application from Insight)
- Final Datum Elevation: 750 m
- Replacement Velocity: 4800 m/s
- NMO static method: Elevations
- Length of smoother: 1201 cdps
- Database math file: /net/logan/logansw/promax7.0/port/misc/user_stat_math

10) Velocity Supergather Precompute
Supergather Formation
    Read data from other lines/surveys: NO
    Dataset: appropriate shots_with_geometry file
        Presort in memory or on disk: Memory
    Maximum CDP fold: 1000
    Minimum CDP number: first CDP of line
    Maximum CDP number: last CDP of line
    CDP increment: 50
    Number of CDPs to combine: 11
Automatic Gain Control
    Application mode: APPLY
    Type of AGC Scalar: MEAN
    AGC operator length: 500 ms
    Basis for scalar application: centered
    Exclude hard zeros: YES
    Robust Scaling: NO
Trace Muting
    Re-apply previous mutes: NO
    Mute time reference: Time 0
    Type of Mute: TOP
    Starting Ramp: 30
    Extrapolate mute times: YES
    Get mute file from database: YES
    Select mute parameter file: dw_tmute2
Apply User Statics (Refraction Statics generated from INSIGHT)
    Final Datum Elevation: 750 m
    Replacement Velocity: 4800 m/s
    NMO static method: Elevations
    Length of Smoother: 1201 cdps
    Database math file: /net/logan/logansw/promax7.0/port/misc/user_stat_math

Apply Residual Statics
- Normal Database Naming Mode: YES
- Source residual statics database parameter: SIN STATICS SPWR???? (appropriate to segment)
- Receiver residual statics database parameter: SRF STATICS SPWR???? (appropriate to segment)

Velocity Analysis Pre-compute
- Number of cdps in supergather: 11
  - Apply partial NMO-to-binning: NO
  - Apply differential statics: NO
  - Absolute offset of first bin center: 0
  - Bin size for vertically summing offsets: 60
  - Maximum offset: 6000
  - Use absolute value of offset for stacking: YES
  - Maximum stretch percentage for NMO: 30%
- Minimum semblance analysis velocity: 3500 m/s
- Maximum semblance analysis velocity: 3500 m/s
- Number of semblance analysis velocities: 500
- Semblance sample rate: 30 ms
- Semblance calculation window: 25 ms
- Method of computing stack velocity functions: Top/Base range
  - Number of Velocity Functions: 21
  - Minimum time velocity function variation: 5000 m/s
  - Maximum time velocity function variation: 5000 m/s
  - Velocity guide function table name: choose most recent velocity table

Disk Data Output
- Output Dataset Filename: choose appropriate name
- New or Existing File: NEW
- Record length to output: choose appropriately
- Trace sample format: 16 bit
- Skip primary dish storage: NO

11) Velocity Analysis

Disk Data Input
- Read data from other lines/surveys: NO
- Select Dataset: select output from velocity pre-compute flow
- Trace Read option: SORT
- Interactive Data Access: YES
- Select primary trace header entry: USER header word: SG_CDP (that is, supergather_cdp)
- Select secondary header entry: NONE
- Sort order list for dataset: CDP range of line or segment of line
- Presort in memory or on disk: MEMORY
- Read the data multiple times: NO
- Process trace headers only: NO
- Override input data's sample rate: NO

Automatic Gain Control
- Application mode: APPLY
- Type of AGC Scalar: MEAN
- AGC operator length: 500 ms
- Basis for scalar application: centered
- Exclude hard zeros: YES
- Robust Scaling: NO

Velocity Analysis
- Select display device: This Screen
- Set Supergather parameters: YES
  - Display gather panel: YES
  - Is the incoming data pre-computed: YES
  - Maximum stretch percentage for NMO: 70%
- Set semblance parameters: YES
  - Display Semblance Panel: YES
  - Display Semblance Contours: YES
  - Display Stack Velocity Functions: NO
  - Display guide function: NO

Display interval velocity function: YES
Semblance normalization mode: Scale Panel
Contrast power factor: 1
Contrast noise factor: 0.1
Maximum Velocity change for snapping: 5%
Maximum time change for snapping: 20 ms
Set Stack parameters: YES
Display velocity functions stack panel: YES
Display dynamic stack panel: YES
Display flip stacks panel: NO
Display velocity colour background: YES
Display velocity colour key: YES
Set Velocity Parameters: YES
Table to store velocity picks: choose appropriately
Velocity guide function name: choose appropriately
Interval Velocity below last knee: 0 (option off)
Communicate with Volume Viewer/Editor using PD: NO
Set Horizon Parameters: NO
Use Neural Network Velocity picker: NO

12) Time Variant Bandpass Filter
0-3000 ms: 10 / 14 – 80 / 84 Hz
2500-8000 ms: 10 / 14 – 60 / 70 Hz
7500-20000 ms: 10 / 14 – 50 / 60 Hz

13) Normal Moveout Correction
Direction for NMO application: FORWARD
Stretch Mute Percentage: 50%
Apply any remaining static during NMO: NO
Apply partial NMO: NO
Get velocities from database: YES
Select velocity parameter file: Velocities Derived From Velocity Analysis
cdp range: 1-4744: vels9

14) Residual Statics Application
Maximum Power Autostatics Calculation
Select Trace data file: nmo corrected cdp gathers
Select autostatics horizon file: picked on cdp stack in trace display
RMS static change convergence criteria: 0.05
Maximum number of iterations: 6
Minimum live samples in a gate: 60%
Maximum static allowed: 50 ms
Compute statics for whole line: YES
Create a NEW database entry for each run: YES
Report static values after each iteration: NO
- Apply residual statics
Normal database entry naming mode: NO
Source residual statics database parameter: SIN STATICS SPWR9413 (cdp range: 1-1151)
Receiver residual statics database parameter: SRF STATICS RPWR9413 (cdp range: 1-1151)
Source residual statics database parameter: SIN STATICS SPWR5853 (cdp range: 1152-2428)
Receiver residual statics database parameter: SRF STATICS RPWR5853 (cdp range: 1152-2428)
Source residual statics database parameter: SIN STATICS SPWR5269 (cdp range: 2429-3700)
Receiver residual statics database parameter: SRF STATICS RPWR5269 (cdp range: 2429-3700)
Source residual statics database parameter: SIN STATICS SPWR4240 (cdp range: 3701-4744)
Receiver residual statics database parameter: SRF STATICS RPWR4240 (cdp range: 3701-4744)

15) CDP/Ensemble Stack
- Sort order of input ensembles: CDP
- Method for Trace Summing: Mean
- Root power scalar for stack normalization: 0.5
- Apply final datum statics after stack: NO
- Has NMO been applied: YES

16) Phase Shift Time Migration

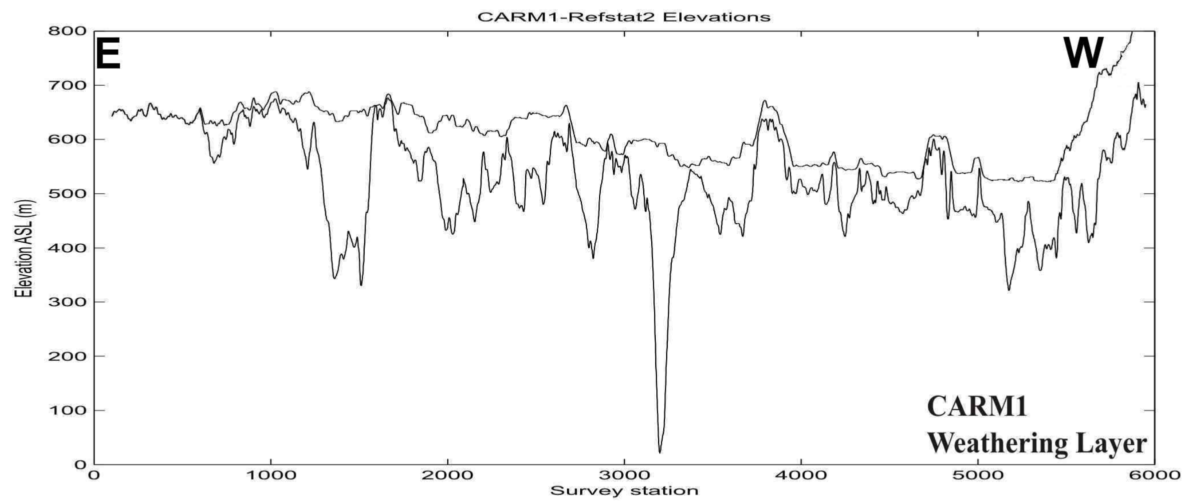
- Minimum CDP to migrate: 26
- Maximum CDP to migrate: 10668
- CDP interval: 9.33466 m
- Minimum frequency to migrate: 10 Hz
- Maximum frequency to migrate: 84 Hz
- Get interval-velocity-versus-time function from database: NO
- INTERVAL-velocity-versus-time for migration: 1:0-4000, 3000-5000
- Percent velocity scale factor: 100%
- Migrate dips: up to 90° only
- Maximum amount of memory (in Mbytes): 2048
- Change default tapering: NO
    - Bottom taper: 200 ms
    - Upper edge taper: 2 traces
    - Lower edge taper: 20 traces
- Re-apply trace mutes: YES
- Re-kill dead traces: YES

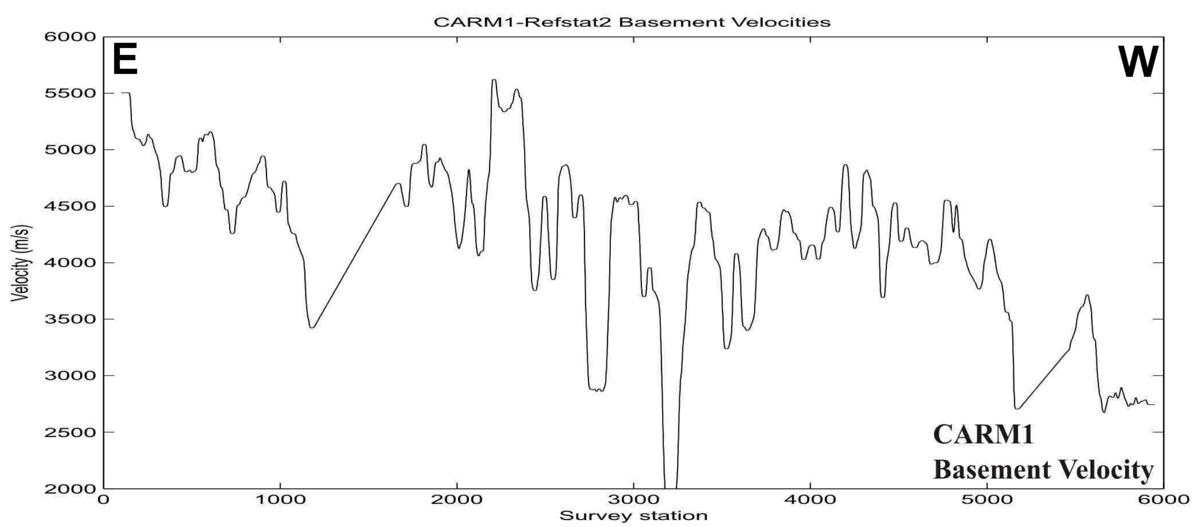
APPENDIX 4 - SIGNAL-TO-NOISE ANALYSIS

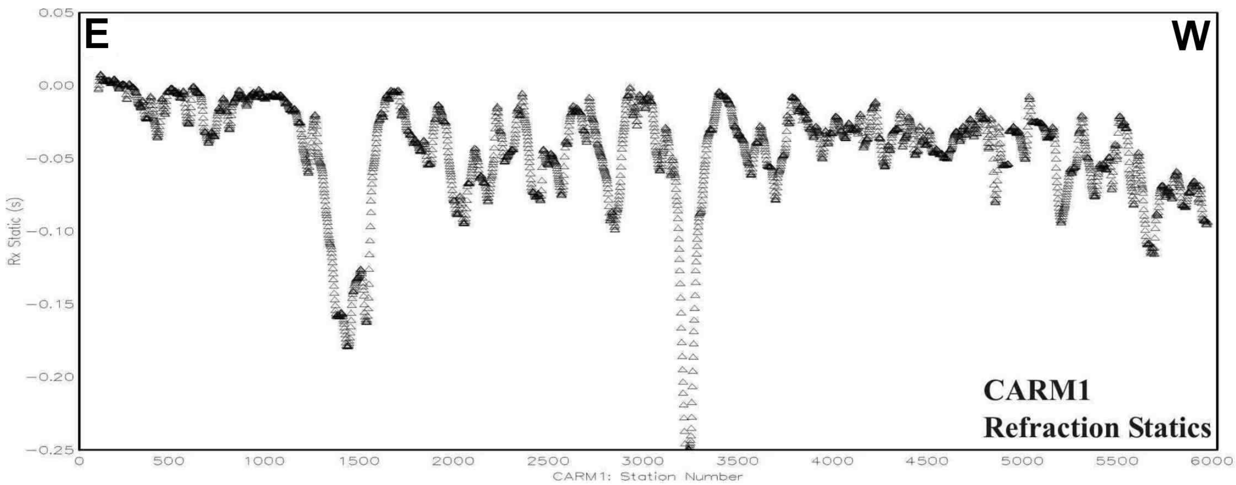
The motivation for doing this analysis was to try and isolate the cause of the reflectivity strength variations at the Moho along line CARM 2 in the stacked section (appendices 7 and 8). The question posed is: Is there truly a change in the reflectivity or is it a change in signal/noise (s/n) of the data, which can be improved by further processing? To test the s/n levels, two measures were determined: 1) first break amplitude vs. pre-first break amplitudes and 2) signal level as measured at the Moho in the raw shot gathers and then in the stack.

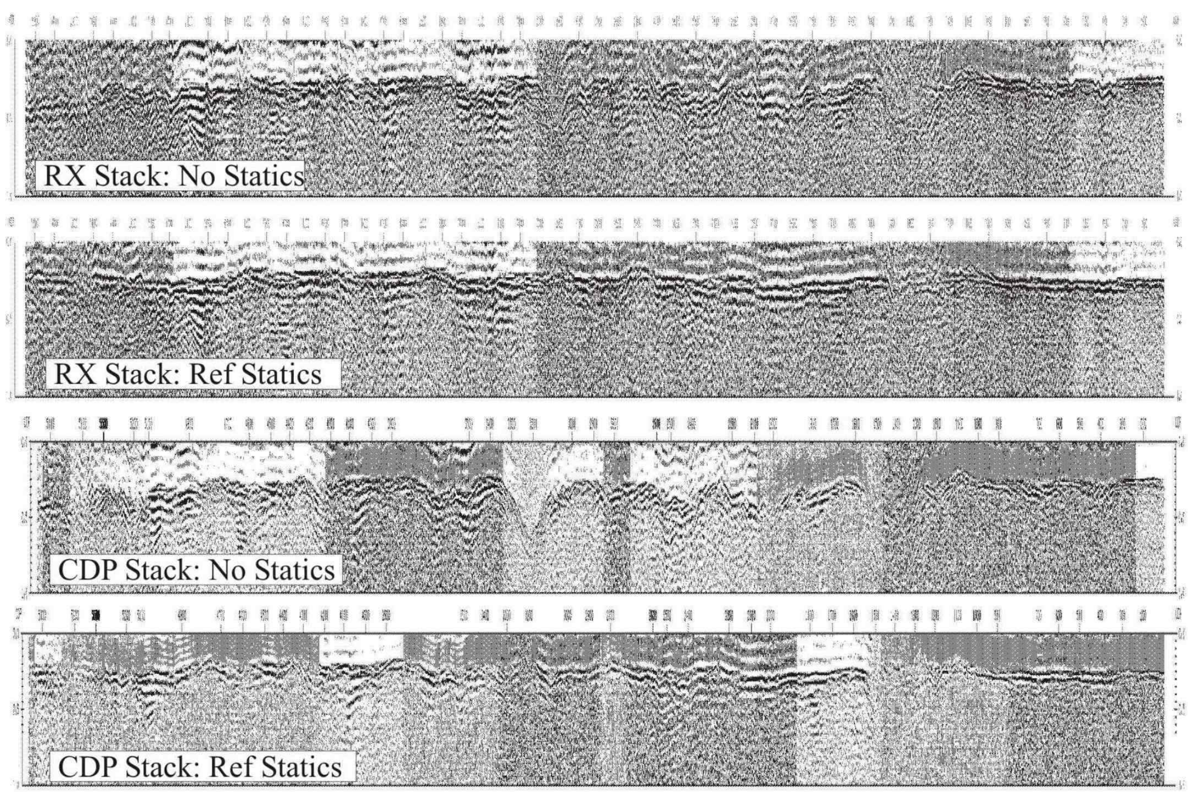
First break signal/noise

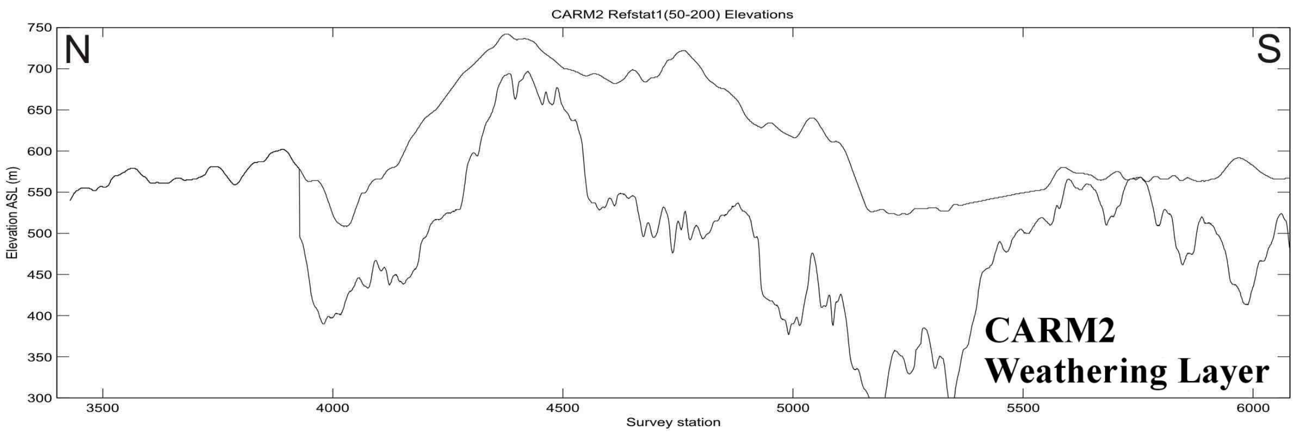
The ratio of the mean absolute amplitude for 40 ms following the first break was compared to the same in a 40 ms window preceding the first break. This s/n ratio was plotted in a stacking chart format and also as the mean value for each shot versus shot station. The highest s/n ratios obtained were ~ 15 db and s/n ratios varied by ~15 db (or a factor of 32; each 3db represents a factor of 2) excluding the nearest offsets. Variations in s/n at similar offsets varied by <9 db (a factor of 8) with most being within a range of ~3 db, although larger variations were observed at the furthest offsets. The lowest s/n values were obtained in the central part of the profile (for line CARM2, sequential shots 450-600, likely near Carmacks) where s/n falls in the range of 0-7 db. There is no obvious reduction in s/n associated with the decrease in Moho reflectivity. In fact, at the south end of the profile where Moho reflectivity increases again, the s/n levels are not high (except at near offsets). This suggests a true change in reflectivity at MOHO depths along the line.

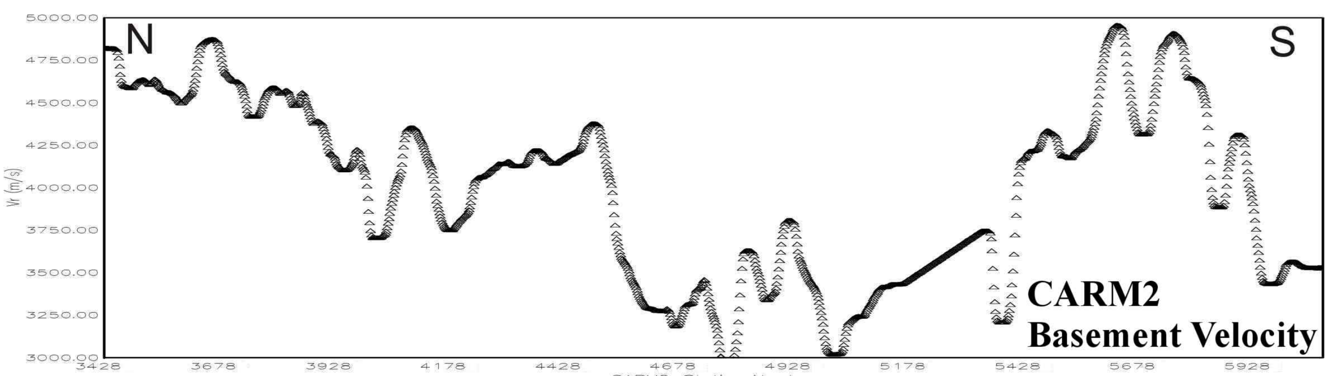

CARM1-Refstat2 Elevations
E
W
Elevation ASL (m)
Survey station
CARM1
Weathering Layer

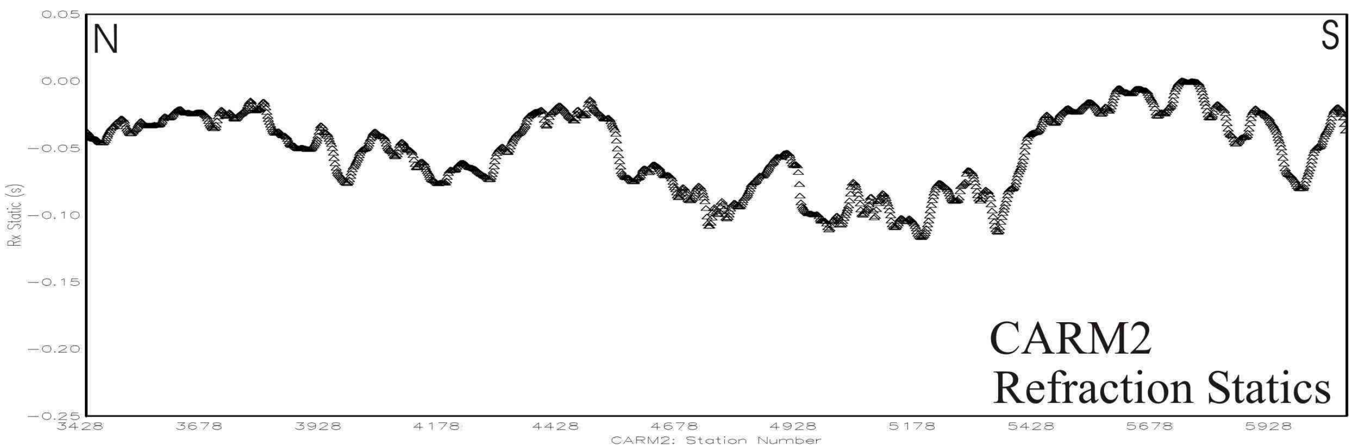

CARM1-Refstat2 Basement Velocities
E
W
Velocity (m/s)
Survey station
CARM1
Basement Velocity

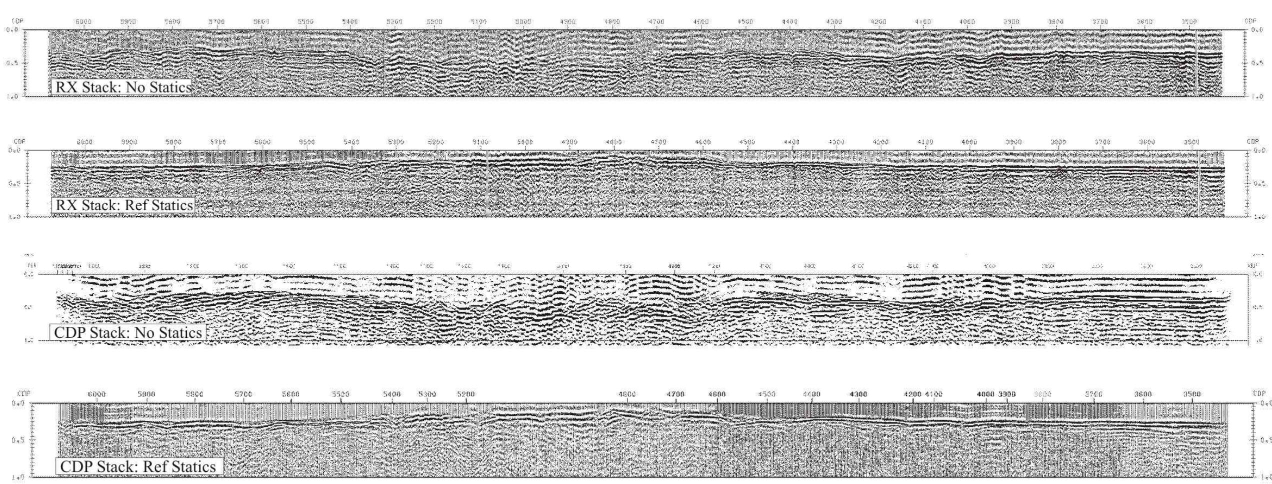

E
W
CARM1
Refraction Statics
Rx Static (s)
CARM1: Station Number
0.05
0.00
−0.05
−0.10
−0.15
−0.20
−0.25
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000


RX Stack: No Statics
RX Stack: Ref Statics
CDP Stack: No Statics
CDP Stack: Ref Statics

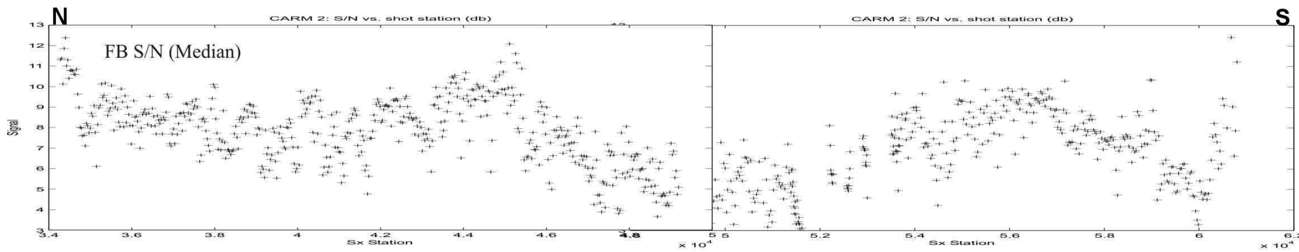

CARM2 Refstat1(50-200) Elevations
N
S
Elevation ASL (m)
Survey station
CARM2
Weathering Layer


N
S
Vr (m/s)
CARM2: Station Number
CARM2
Basement Velocity


N
S
Rx Static (s)
CARM2
Refraction Statics
CARM2: Station Number


RX Stack: No Statics
RX Stack: Ref Statics
CDP Stack: No Statics
CDP Stack: Ref Statics

Median s/n values versus shot station were plotted and fell in the range of 3-12 db. Most values were above 8 db, but dipped to 5-6 db for the station range 4400-5300. Again, there is no obvious correlation of s/n with the parts of the line where Moho reflectivity is strongest. Also, again, the median s/n values are low (< 8db) at the south end of the line where Moho reflectivity is moderately strong.

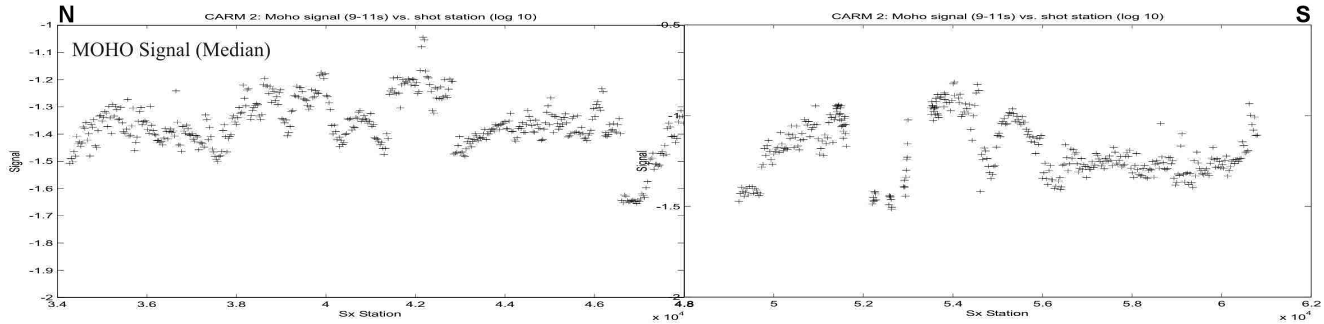


Deep signal/noise

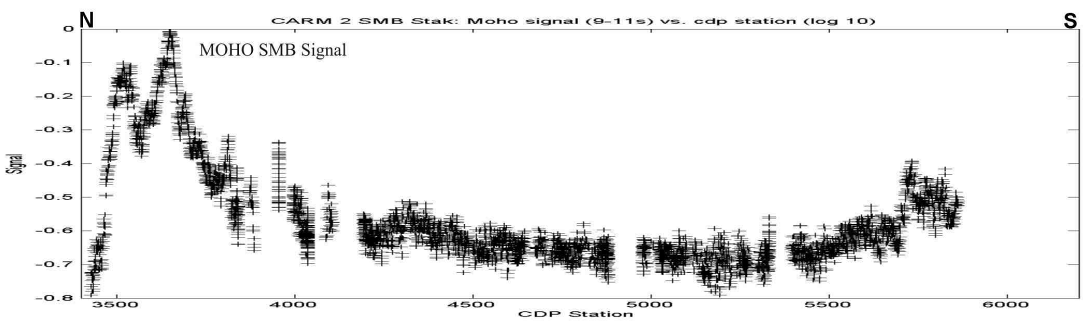
As a 2nd measure, signal values (not s/n ratios) were determined for a 2 s window from 9s to 11s two-way-time that includes the zone of prominent Moho reflectivity. This test was applied to see if there were either anomalously low or high mean signal values at the depth of the Moho in the regions where Moho reflectivity wanes. The former case (low amplitudes relative to the zone of high Moho reflectivity) might be indicative of poor signal penetration in these zones. The latter case (high amplitudes relative to the zone of high Moho reflectivity) might be indicative of high noise levels (assuming refraction statics have been successfully applied).

At the Moho level in the raw shot gathers away from the shortest offsets where source-generated noise is strong, the signal level (log 10) varies from ~-2 to -1 (or by a factor of 10). In general, the signal levels at the north end of the line (low stations, 3400-3800) are lower (by ~log 10=0.4 or a factor of 2.5) than further to the south. If the signal level is attributed to noise, then this allows for the possibility that the zone of enhanced reflectivity occurs where the noise level at Moho depth is lower. However, the zone of moderate Moho reflectivity at the south end of the line (high stations) is associated with moderate signal levels; i.e., the Moho reflectivity comes through even with somewhat elevated noise.

Observing the median amplitude values vs. shot station for CARM2, logarithmic signal levels are ~-1.4 for the station range of 3400 to 3800 whereas they increase to ~-1.3 from 3800 to 4200, before decreasing again to ~-1.4 to station 5000. From 5000 to 5600, they are generally elevated (-1.2 to –1.0) and then decrease again to –1.3 to the end of the line. Thus, variations of a maximum of ~2 are observed and don't likely explain the variations in observed reflectivity.



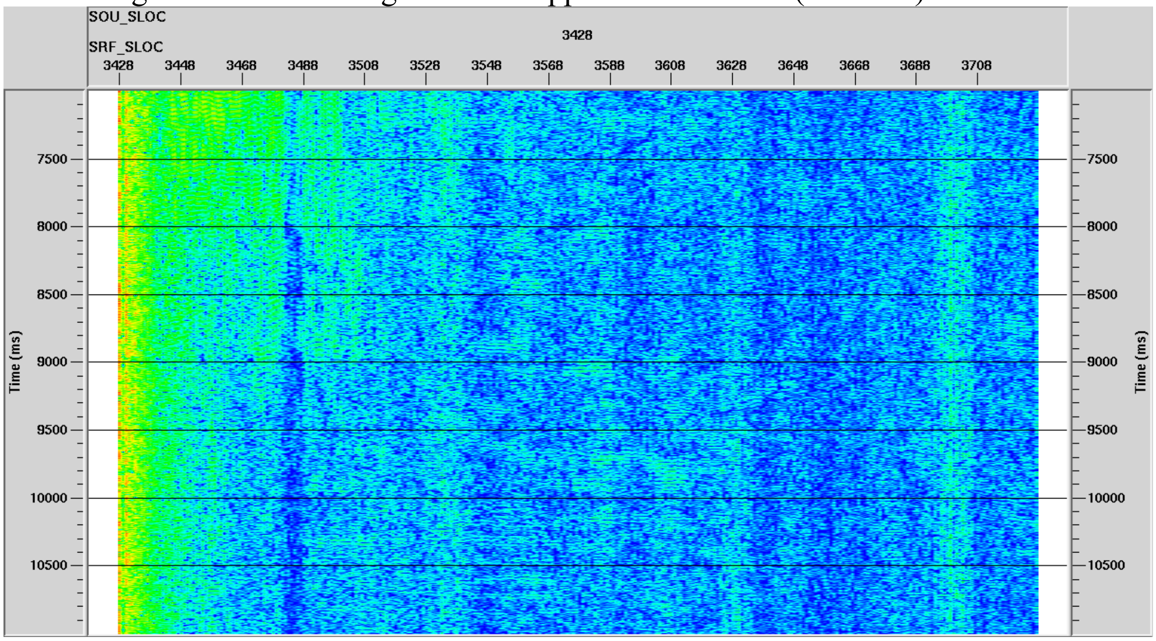
Finally, the median signal at the Moho across the stack was determined and varied from log 10 factor of 0.2 (where the reflectivity was strong) to background values of ~-0.05 to 0.05, representing a factor of ~1.5. After application of a semblance filter, the variations were from a log 10 value of 0 to a background of –0.6 to –0.7 (or a factor of 4-6).



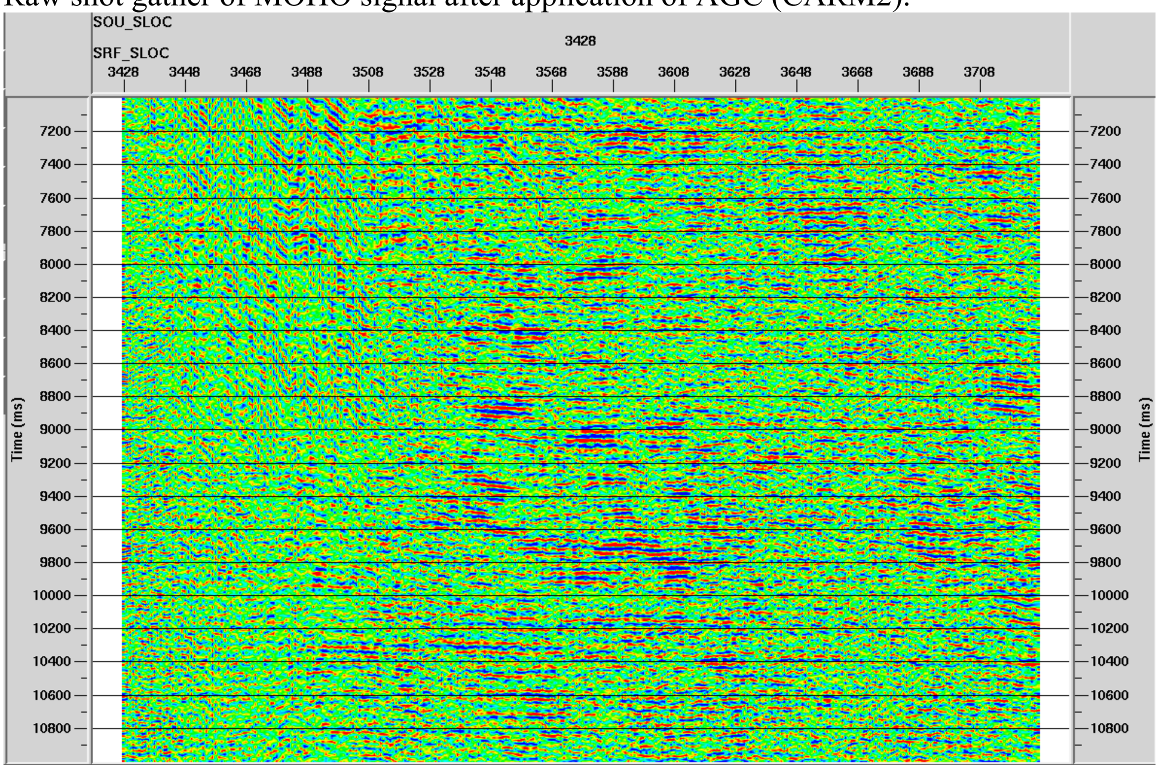
Fold considerations
For a nominal fold of 100, a s/n improvement by a factor of 10 might optimally be achieved. Given the observed signal variations along the line, it is unlikely that the observed reflectivity variations are due to variations in s/n ratio.

Raw shot gathers
Finally, raw shot gathers were visually inspected to determine whether there were obvious changes in either 1) the ambient noise level or 2) coherent noise trains (e.g., groundroll) at the Moho level in the region where the Moho reflectivity fades out in the stack in the vicinity of station 3800 on line CARM2. There are no obvious differences in the amplitude levels on the various shot gathers, suggesting that the change in reflectivity observed in the stack is not due simply to higher noise levels.

Raw shot gather of MOHO signal before application of AGC (CARM2).



Raw shot gather of MOHO signal after application of AGC (CARM2).



APPENDIX 5 – GSC-001-04 UNMIGRATED SECTION (foldout)

CARM1 FINAL STACKED CRUSTAL SECTION (CDP 26-10668)

AQUISITION PARAMETERS

SOURCE TYPE :	VIBROSEIS IVI Y2400 BUGGY MOUNT
PHASE :	ZERO PHASE
SWEEPS :	10-84 HZ LINEAR, 24 S, 6 OR 10 SWEEPS/VP
SHOTPOINT INTERVAL :	60 M
STATION INTERVAL :	20 M
RECEIVER TYPE :	I/O VECTOR-SEIS SVSM 3-COMP DIGITAL SENSOR
NOTCH FILTER:	OUT
PHONES PER GROUP :	1
NOMINAL NUMBER OF CHANNELS :	600
CENTRAL RECORDING UNIT:	I/O IMAGE VECTORSEIS SYSTEM FOUR
REMOTE ACQUISITION MODULES:	I/O VRSR 6 CHANNEL MODULE
FIELD RECORD LENGTH :	15 S UNCORRELATED
SAMPLE RATE :	2 MS

PROCESSING PARAMETERS

1) DATA READING
- -DIVERSITY STACKING OF UNSTACKED SWEEPS
- -NO RESAMPLING

2) GEOMETRY
- -CROOKED LINE GEOMETRY ALGORITHM
- -10 M BY 2300 M BINS

3) TRACE EDITING
- -FIRST BREAKS MANUALLY PICKED

4) PROCESSING SOFTWARE
- -PROMAX 7.0B
- -INSIGHT 5.1.1

5) PRESTACK PROCESSING

```
     -AUTOMATIC GAIN CONTROL (AGC)
           -SCALAR TYPE: MEAN
           -SCALAR OPERATOR LENGTH: 500 MS
     -PREDICTIVE DECONVOLUTION
           -OPERATOR LENGTH: 120 MS
           -PREDICTION GAP LENGTH: 32 MS
           -OPERATOR WHITE NOISE LEVEL: 0.1 PERCENT
     -TOP MUTE APPLICATION (PICKED EVERY GATHER: TOPMUTE2)
     -TIME-VARIANT BANDPASS FILTER
        -FILTER1: 0-3000S; 10/14-80/84HZ
        -FILTER2: 2500-8000S; 10/14-60/70HZ
        -FILTER3: 7500-20000S; 10/14-50/60HZ
     -SEMBLANCE VELOCITY ANALYSIS (SECTION 0 - SEG0_V1)
     -SEMBLANCE VELOCITY ANALYSIS (SECTION 1 - SEG1_V1)
     -SEMBLANCE VELOCITY ANALYSIS (SECTION 2 - SEG2_V1A3)
     -SEMBLANCE VELOCITY ANALYSIS (SECTION 3 - SEG3_V1)
     -SEMBLANCE VELOCITY ANALYSIS (SECTION 4 - SEG4_V1)
     -APPLY REFRACTION STATICS
           -FINAL DATUM=750 M
           -VR=4800 M/S
           -NMO METHOD=ELEVATIONS
           -SMOOTHER=1201 PTS
           -PROCESSING DATUM=NMO DATUM
     -NMO CORRECTION
           -VELOCITY FUNCTION: VELS9
           -STRETCH MUTE PERCENTAGE: 50
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 0 - CDP RANGE: 26-2099)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR9838
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR9838
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 1 - CDP RANGE: 2100-4800)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR1181
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR1181
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 2 - CDP RANGE: 4801-6800)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR9086
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR9086
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 3 - CDP RANGE: 6801-9450)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR4167
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR4167
     -NO RESIDUAL STATICS APPLIED (SEGMENT 4 - CDP RANGE: 9451-10668)

     -CDP/ENSEMBLE STACK
           -METHOD FOR TRACE SUMMING: MEAN
           -ROOT POWER SCALAR FOR STACK NORMALIZATION: 0.5
```

6) POST-STACK PROCESSING
- -SEMBLANCE SMOOTHING (31,31)
- -PLOT THRESHOLD (1.5* RMS)

PLOTTING PARAMETERS

INCHES PER SECOND :	2.0
TRACES PER INCH :	100
GAIN :	0.85 2
CLIP :	AFTER 3.0 TRACES
TYPE :	VARIABLE AREA ONLY
DECIMATION :	EVERY TRACE PLOTTED

DATA PROCESSOR

GRANT BUFFETT
CENTRAL CANADA DIVISION

APPENDIX 6 – GSC-001-04 MIGRATED SECTION (foldout)

CARM1 FINAL STACKED CRUSTAL SECTION (CDP 26-10668)
WITH POST STACK PHASE SHIFT MIGRATION (100 PER CENT VELS)

AQUISITION PARAMETERS

```
SOURCE TYPE :                VIBROSEIS IVI Y2400 BUGGY MOUNT
PHASE :                      ZERO PHASE
SWEEPS :                     10-84 HZ LINEAR, 24 S, 6 OR 10 SWEEPS/VP
SHOTPOINT INTERVAL :         60 M
STATION INTERVAL :           20  M
RECEIVER TYPE :              I/O VECTOR-SEIS SVSM 3-COMP DIGITAL SENSOR
NOTCH FILTER:                OUT
PHONES PER GROUP :           1
NOMINAL NUMBER OF CHANNELS :600
CENTRAL RECORDING UNIT:      I/O IMAGE VECTORSEIS SYSTEM FOUR
REMOTE ACQUISITION MODULES: I/O VRSR 6 CHANNEL MODULE
FIELD RECORD LENGTH :        15 S UNCORRELATED
SAMPLE RATE :                2 MS
```

PROCESSING PARAMETERS

```
1) DATA READING
     -DIVERSITY STACKING OF UNSTACKED SWEEPS
     -NO RESAMPLING

2) GEOMETRY
     -CROOKED LINE GEOMETRY ALGORITHM
     -10 M BY 2300 M BINS

3) TRACE EDITING
     -FIRST BREAKS MANUALLY PICKED

4) PROCESSING SOFTWARE
     -PROMAX 7.0B
     -INSIGHT 5.1.1

5) PRESTACK PROCESSING
     -AUTOMATIC GAIN CONTROL (AGC)
           -SCALAR TYPE: MEAN
           -SCALAR OPERATOR LENGTH: 500 MS
     -PREDICTIVE DECONVOLUTION
           -OPERATOR LENGTH: 120 MS
           -PREDICTION GAP LENGTH: 32 MS
           -OPERATOR WHITE NOISE LEVEL: 0.1 PERCENT
     -TOP MUTE APPLICATION (PICKED EVERY GATHER: TOPMUTE2)
     -TIME-VARIANT BANDPASS FILTER
        -FILTER1: 0-3000S; 10/14-80/84HZ
        -FILTER2: 2500-8000S; 10/14-60/70HZ
        -FILTER3: 7500-20000S; 10/14-50/60HZ
     -SEMBLANCE VELOCITY ANALYSIS (SECTION 0 - SEG0_V1)
     -SEMBLANCE VELOCITY ANALYSIS (SECTION 1 - SEG1_V1)
     -SEMBLANCE VELOCITY ANALYSIS (SECTION 2 - SEG2_V1A3)
     -SEMBLANCE VELOCITY ANALYSIS (SECTION 3 - SEG3_V1)
     -SEMBLANCE VELOCITY ANALYSIS (SECTION 4 - SEG4_V1)
     -APPLY REFRACTION STATICS
           -FINAL DATUM=750 M
           -VR=4800 M/S
           -NMO METHOD=ELEVATIONS
           -SMOOTHER=1201 PTS
           -PROCESSING DATUM=NMO DATUM
     -NMO CORRECTION
           -VELOCITY FUNCTION: VELS9
           -STRETCH MUTE PERCENTAGE: 50
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 0 - CDP RANGE: 26-2099)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR9838
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR9838
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 1 - CDP RANGE: 2100-4800)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR1181
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR1181
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 2 - CDP RANGE: 4801-6800)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR9086
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR9086
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 3 - CDP RANGE: 6801-9450)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR4167
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR4167
     -NO RESIDUAL STATICS APPLIED (SEGMENT 4 - CDP RANGE: 9451-10668)

     -CDP/ENSEMBLE STACK
           -METHOD FOR TRACE SUMMING: MEAN
           -ROOT POWER SCALAR FOR STACK NORMALIZATION: 0.5

6) POST-STACK PROCESSING
     -MIGRATION - TYPE: PHASE SHIFT
            - 10-84 HZ
            - INTERVAL VELOCITES OF 4000 UP TO 3SEC AND 5000 M/S AFTER
            - 100% VELS
            - MIGRATED DIPS UP TO 90 DEGREES
            - DEFAULT TAPERING
     -SEMBLANCE SMOOTHING (31,31)
     -PLOT THRESHOLD (1.5* RMS)
```

PLOTTING PARAMETERS

```
INCHES PER SECOND :   2.0
TRACES PER INCH :     100
GAIN :                0.85 2
CLIP :                AFTER 3.0 TRACES
TYPE :                VARIABLE AREA ONLY
DECIMATION :          EVERY TRACE PLOTTED
```

DATA PROCESSOR

GRANT BUFFETT
CENTRAL CANADA DIVISION

APPENDIX 7 – GSC-002-04 UNMIGRATED SECTION (foldout)

CARM2 FINAL STACKED CRUSTAL SECTION

AQUISITION PARAMETERS

```
SOURCE TYPE :                VIBROSEIS IVI Y2400 BUGGY MOUNT
PHASE :                      ZERO PHASE
SWEEPS :                     10-84 HZ LINEAR, 24 S, 6 OR 10 SWEEPS/VP
SHOTPOINT INTERVAL :         60 M
STATION INTERVAL :           20  M
RECEIVER TYPE :              I/O VECTOR-SEIS SVSM 3-COMP DIGITAL SENSOR
NOTCH FILTER:                OUT
PHONES PER GROUP :           1
NOMINAL NUMBER OF CHANNELS :600
CENTRAL RECORDING UNIT:      I/O IMAGE VECTORSEIS SYSTEM FOUR
REMOTE ACQUISITION MODULES: I/O VRSR 6 CHANNEL MODULE
FIELD RECORD LENGTH :        15 S UNCORRELATED
SAMPLE RATE :                2 MS
```

PROCESSING PARAMETERS

```
1) DATA READING
     -DIVERSITY STACKING OF UNSTACKED SWEEPS
     -NO RESAMPLING

2) GEOMETRY
     -CROOKED LINE GEOMETRY ALGORITHM
     -10 M BY 2300 M BINS

3) TRACE EDITING
     -FIRST BREAKS MANUALLY PICKED

4) PROCESSING SOFTWARE
     -PROMAX 7.0B
     -INSIGHT 5.1.1

5) PRESTACK PROCESSING
     -AUTOMATIC GAIN CONTROL (AGC)
           -SCALAR TYPE: MEAN
           -SCALAR OPERATOR LENGTH: 500 MS
     -PREDICTIVE DECONVOLUTION
           -OPERATOR LENGTH: 120 MS
           -PREDICTION GAP LENGTH: 32 MS
           -OPERATOR WHITE NOISE LEVEL: 0.1 PERCENT
     -TOP MUTE APPLICATION (PICKED EVERY GATHER: DW_TMUTE2)
     -TIME-VARIANT BANDPASS FILTER
        -FILTER1: 0-3000S; 10/14-80/84HZ
        -FILTER2: 2500-8000S; 10/14-60/70HZ
        -FILTER3: 7500-20000S; 10/14-50/60HZ
     -SEMBLANCE VELOCITY ANALYSIS (VELS9)
     -APPLY REFRACTION STATICS
           -FINAL DATUM=750 M
           -VR=4800 M/S
           -NMO METHOD=ELEVATIONS
           -SMOOTHER=1201 PTS
           -PROCESSING DATUM=NMO DATUM
     -NMO CORRECTION
           -VELOCITY FUNCTION: VELS9
           -STRETCH MUTE PERCENTAGE: 50
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 0 - CDP RANGE: 1-1151)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR9413
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR9413
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 1 - CDP RANGE: 1152-2428)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR5853
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR5853
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 2 - CDP RANGE: 2429-3700)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR5269
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR5269
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 3 - CDP RANGE: 3701-4744)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR4240
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR4240
     -CDP/ENSEMBLE STACK
           -METHOD FOR TRACE SUMMING: MEAN
           -ROOT POWER SCALAR FOR STACK NORMALIZATION: 0.5

6) POST-STACK PROCESSING
     -SEMBLANCE SMOOTHING (31,31)
     -PLOT THRESHOLD (1.5* RMS)
```

PLOTTING PARAMETERS

```
INCHES PER SECOND :   2.0
TRACES PER INCH :     100
GAIN :                0.85 2
CLIP :                AFTER 3.0 TRACES
TYPE :                VARIABLE AREA ONLY
DECIMATION :          EVERY TRACE PLOTTED
```

DATA PROCESSOR

GRANT BUFFETT
CENTRAL CANADA DIVISION

APPENDIX 8 – GSC-002-04 MIGRATED SECTION (foldout)

CARM2 FINAL STACKED CRUSTAL SECTION
WITH POST STACK PHASE SHIFT MIGRATION (100 PER CENT VELS)

AQUISITION PARAMETERS

```
SOURCE TYPE :               VIBROSEIS IVI Y2400 BUGGY MOUNT
PHASE :                     ZERO PHASE
SWEEPS :                    10-84 HZ LINEAR, 24 S, 6 OR 10 SWEEPS/VP
SHOTPOINT INTERVAL :        60 M
STATION INTERVAL :          20  M
RECEIVER TYPE :             I/O VECTOR-SEIS SVSM 3-COMP DIGITAL SENSOR
NOTCH FILTER:               OUT
PHONES PER GROUP :          1
NOMINAL NUMBER OF CHANNELS :600
CENTRAL RECORDING UNIT:     I/O IMAGE VECTORSEIS SYSTEM FOUR
REMOTE ACQUISITION MODULES: I/O VRSR 6 CHANNEL MODULE
FIELD RECORD LENGTH :       15 S UNCORRELATED
SAMPLE RATE :               2 MS
```

PROCESSING PARAMETERS

```
1) DATA READING
     -DIVERSITY STACKING OF UNSTACKED SWEEPS
     -NO RESAMPLING

2) GEOMETRY
     -CROOKED LINE GEOMETRY ALGORITHM
     -10 M BY 2300 M BINS

3) TRACE EDITING
     -FIRST BREAKS MANUALLY PICKED

4) PROCESSING SOFTWARE
     -PROMAX 7.0B
     -INSIGHT 5.1.1

5) PRESTACK PROCESSING
     -AUTOMATIC GAIN CONTROL (AGC)
           -SCALAR TYPE: MEAN
           -SCALAR OPERATOR LENGTH: 500 MS
     -PREDICTIVE DECONVOLUTION
           -OPERATOR LENGTH: 120 MS
           -PREDICTION GAP LENGTH: 32 MS
           -OPERATOR WHITE NOISE LEVEL: 0.1 PERCENT
     -TOP MUTE APPLICATION (PICKED EVERY GATHER: DW_TMUTE2)
     -TIME-VARIANT BANDPASS FILTER
        -FILTER1: 0-3000S; 10/14-80/84HZ
        -FILTER2: 2500-8000S; 10/14-60/70HZ
        -FILTER3: 7500-20000S; 10/14-50/60HZ
     -SEMBLANCE VELOCITY ANALYSIS (VELS9)
     -APPLY REFRACTION STATICS
           -FINAL DATUM=750 M
           -VR=4800 M/S
           -NMO METHOD=ELEVATIONS
           -SMOOTHER=1201 PTS
           -PROCESSING DATUM=NMO DATUM
     -NMO CORRECTION
           -VELOCITY FUNCTION: VELS9
           -STRETCH MUTE PERCENTAGE: 50
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 0 - CDP RANGE: 1-1151)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR9413
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR9413
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 1 - CDP RANGE: 1152-2428)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR5853
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR5853
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 2 - CDP RANGE: 2429-3700)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR5269
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR5269
     -APPLY MAX POWER RESIDUAL STATICS (SEGMENT 3 - CDP RANGE: 3701-4744)
           -SOURCE RESIDUAL STATICS DB PARAMETER - SIN STATICS SPWR4240
           -RECEIVER RESIDUAL STATICS DB PARAMETER - SRF STATICS RPWR4240
     -CDP/ENSEMBLE STACK
           -METHOD FOR TRACE SUMMING: MEAN
           -ROOT POWER SCALAR FOR STACK NORMALIZATION: 0.5

6) POST-STACK PROCESSING
     -MIGRATION - TYPE: PHASE SHIFT
            - 10-84 HZ
            - INTERVAL VELOCITES OF 4000 UP TO 3SEC AND 5000 M/S AFTER
            - 100% VELS
            - MIGRATED DIPS UP TO 90 DEGREES
            - DEFAULT TAPERING
     -SEMBLANCE SMOOTHING (31,31)
     -PLOT THRESHOLD (1.5* RMS)
```

PLOTTING PARAMETERS

```
INCHES PER SECOND :   2.0
TRACES PER INCH :     100
GAIN :                0.85 2
CLIP :                AFTER 3.0 TRACES
TYPE :                VARIABLE AREA ONLY
DECIMATION :          EVERY TRACE PLOTTED
```

DATA PROCESSOR

GRANT BUFFETT
CENTRAL CANADA DIVISION