Mapping and Measurement of Noise on 3-D Seismic Data from the Campos Basin.

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Abstract

Quality control is crucial to seismic data processing. In this paper we will show examples where an application which estimates and maps signal to noise ratio (S/N) was applied on a 3-D seismic survey from the Campos Basin. This measurement allows for the identification of noisy lines and allows us to focus on these during data processing. After each of the main steps in the processing sequence, quality control (QC) is performed. Global root mean squared (RMS) amplitude and estimates of signal to noise ratio (S/N) are captured and presented as spatial maps and histograms. These measurements can also be compared with similar metrics from earlier and later in the processing flow to determine when we have improved or degraded the result.

Introduction

Metrics analysis is a suite of procedures which involves the collection of various statistics from the seismic data volume and their subsequent analysis. One of these procedures, which utilize an amplitude attribute, was used during testing and production phases of processing to QC the results. The process utilizes a measurement of the RMS amplitude from each input trace over a user specified time gate. Multiple time gates can be selected for analysis however in the examples shown here we have utilized a single gate from 6 to 8 seconds to assure a consistent measurement.

These analyses will be displayed after each sequence in the processing flow to demonstrate the changes observed.

Data Processing

Metrics analysis was performed after each main step in seismic data processing sequence. These steps were:

- RESAMPLE
- LOW CUT FILTER
- DESPIKE
- Seismic Interference (SI) REMOVAL
- Surface Related Multiple Elimination (SRME)
- FX-decon, Tau p Decon (FX – TD)
- Water Velocity (WV) - RADON
- Multiple Diffraction Attenuation (MDA)

RESAMPLE

The first processing step was RESAMPLE, where the Designature Filter, De-Bubble and Zero Phase Filter, were applied. In the figure 1 we see an amplitude map produced from the stack cube.

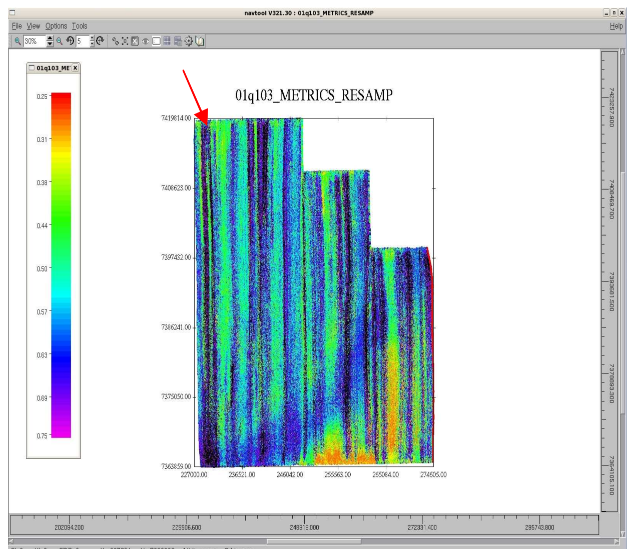

Figure 1: Resample Amplitude Map, gate 6 -8 seconds. The red arrow indicates a noise line.

LOW CUT FILTER

In this step a low cut filter was applied to remove low frequency noise prevalent on the recorded data. In figure 2, we see an amplitude map produced from the stack cube after applying the filter.

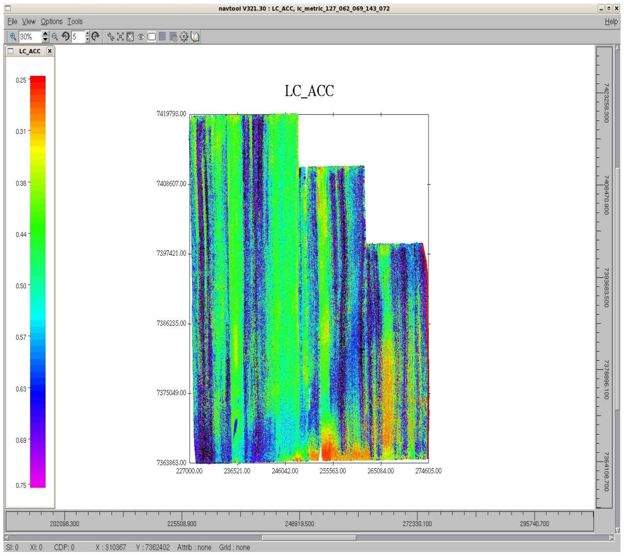

Figure 2: Low Cut Amplitude map, gate 6-8 seconds

DESPIKE

Despike was applied to detect and remove anomalous amplitude events. This process will zero the gated window if RMS levels fall outside a user-defined tolerance range based on an analysis within a given trace. In figure 3, we see an amplitude map produced from the stack cube after application of this process.

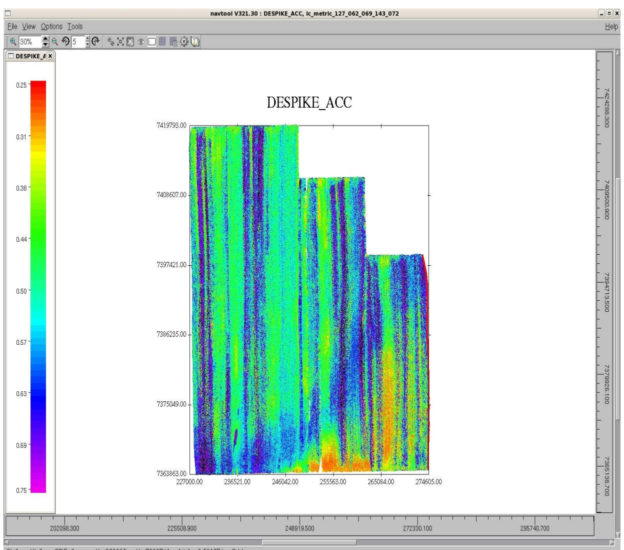

Figure 3: Despike Amplitude Map, gate 6-8 seconds

SI REMOVAL

Seismic interference was removed using a noise attenuation technique performed on shot ensembles. This process uses a multichannel technique which analyses amplitude statistics from multiple time and spatial gates to detect anomalous amplitude events. When detected, these individual gates are then scaled to reduce the noise present within them. This process is performed to remove seismic interference and swell noise from the records. In figure 4, we have an amplitude map created from the stack cube at this stage in the processing.

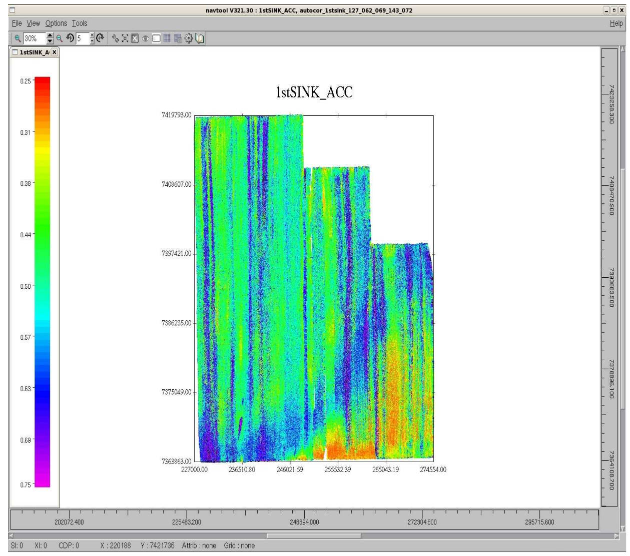

Figure 4: SI REMOVAL Amplitude Map, gate 6 – 8 seconds.

SRME

The Surface Related Multiple Estimation (Verschuur, D.J., and Kelamis, P.G., 1997), procedure generates a model of multiple events that would be generated by the wave fields reflection off the surface of the water. To generate these multiples, this method requires only the recorded seismic data and a simple assumption of the source wavelet. Since no additional information about the subsurface is required, this process can be performed efficiently, early in the processing flow. In figure 5, we have the amplitude map created from the stack cube after application of the SRME.

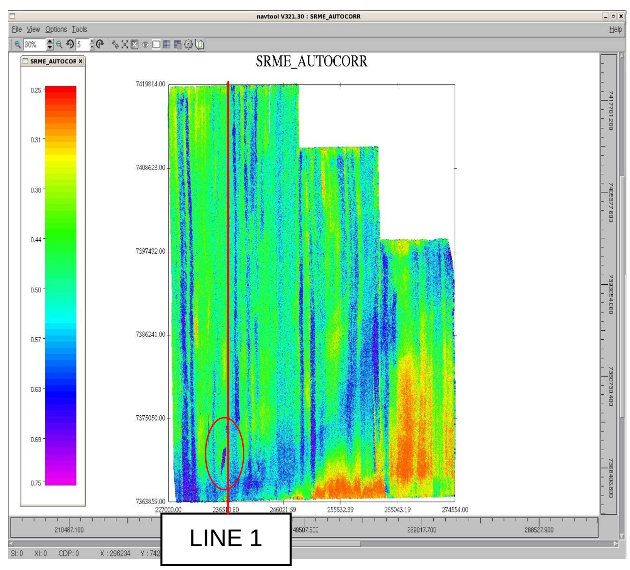

Figure 5: SRME Amplitude Map, gate 6 – 8 seconds. Anomaly enhanced by the circle. The stack of this area is showed bellow.

FX-TD

FX-Decon is designed to enhance signal continuity in seismic data. Parameters describe a temporal and spatial analysis gate, where the traces are transformed from time to frequency domain. This process removes noise by predicting the signal from the input data and attenuating energy which does not match.

Tau P Decon is used to perform noise attenuation and removal of shorter period reverberation in the data. The data is first transformed into Tau P domain where the periodicity of the reverberations is better behaved and can be addressed with the application of decon. Additionally areas in the transform domain that lie outside possible signal areas can be gained down or muted to remove unwanted noise events still present in the data. In figure 6, we have the amplitude map derived from the stack cube after application of these processes.

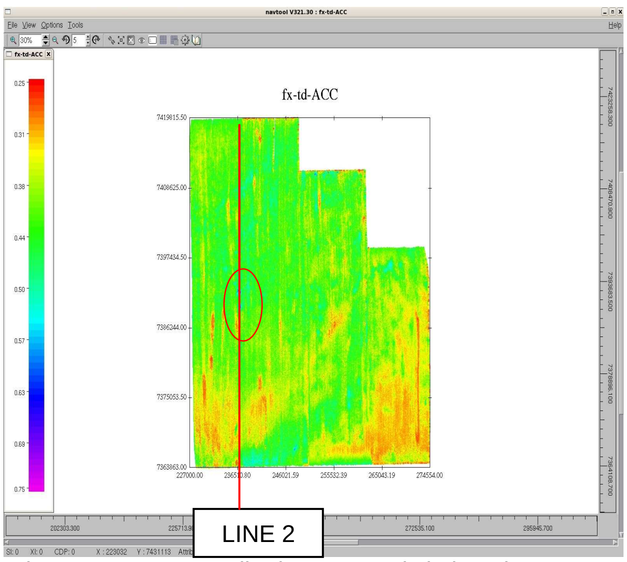

Figure 6: FX-TD Amplitude Map. Red circle enhance two anomalies, caused by inter bed reverberations, gate 6 -8 seconds.

WV- RADON

The "WV-RADON" procedure is another pre-stack noise attenuation program which is performed in the “parabolic” tau-p domain. In this step, CDP gathers are moveout corrected with a water velocity, and then the process applied and appropriate parameters selected to remove any remaining multiple events associated with the water layer. In figure 7, we have the amplitude map derived after this step.

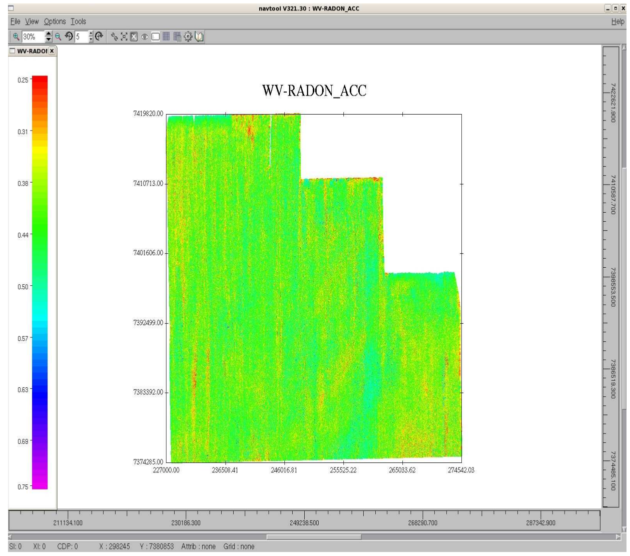

Figure 7: WV-RADON Amplitude Map, gate 6-8 seconds.

MDA

Multiple diffraction attenuation is a processing technique designed to attenuate high-energy reverberations of near-surface diffractions. Such reverberations are commonly seen on deep-water datasets with complex, shallow sub-seabed topography. In figure 8, we have the amplitude map after application of this process.

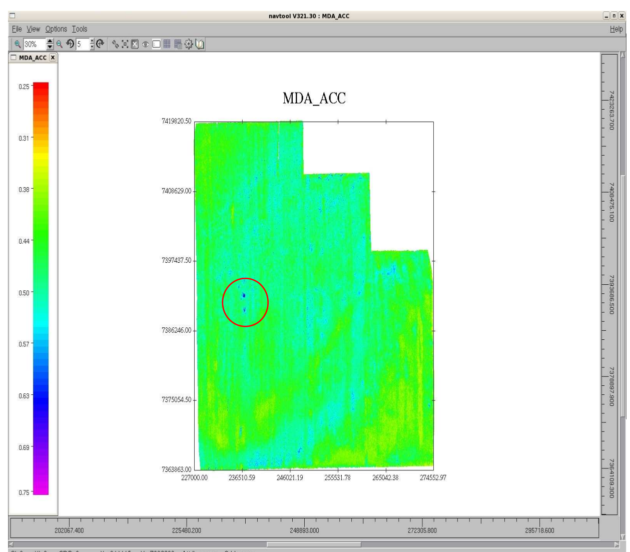

Figure 8: MDA amplitude map, gate 6-8 seconds.

Amplitude Histograms

The following graphs are histograms constructed from the individual amplitude maps. Their purpose is to monitor the overall behavior in the amplitude distribution in the data volume. Since most noise tends to be of higher amplitude than the surrounding signal, we expect the histograms to reflect the attenuation of such noise by a reduction in the number of hits in the higher amplitude ranges.

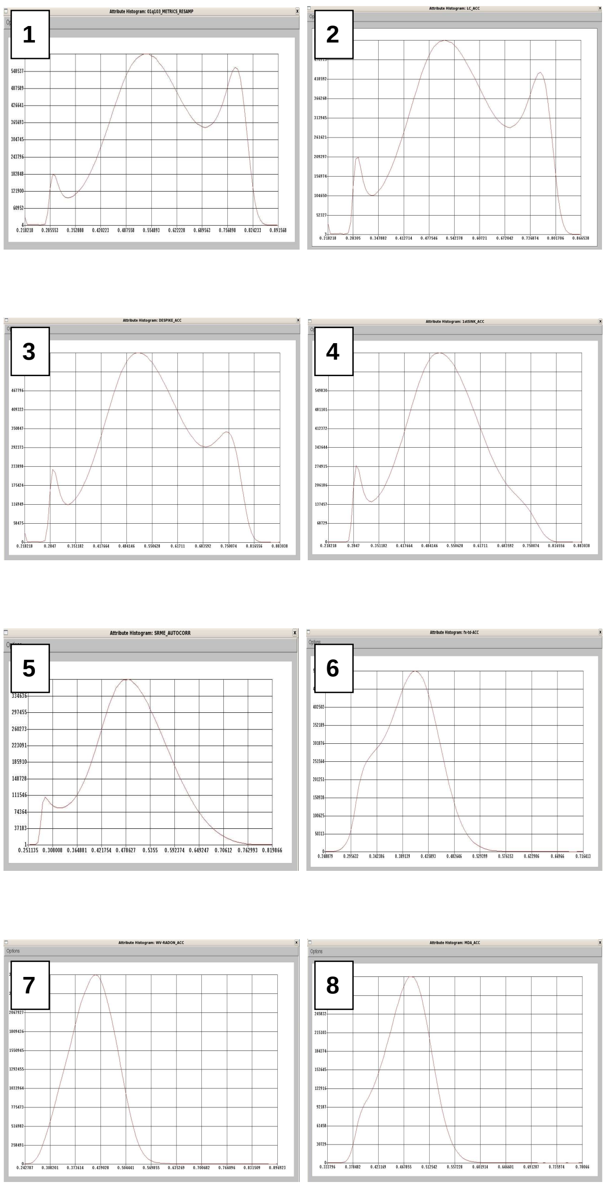

Figure 9: Amplitude Histograms: 1-RESAMPLE, 2-LC, 3-DESPIKE, 4-SINK, 5-SRME, 6-FX-TD, 7-WV-RADON and 8- MDA.

Stacks

The following stacks relate to the anomalies highlighted in the amplitude map figures. The arrows highlight the offending noise event or events which produced the anomaly in the RMS amplitude maps. Underneath the seismic portion of the display is a graph of the RMS statistics from the current processing step in addition to one of the other processing steps to highlight the changes which occurred.

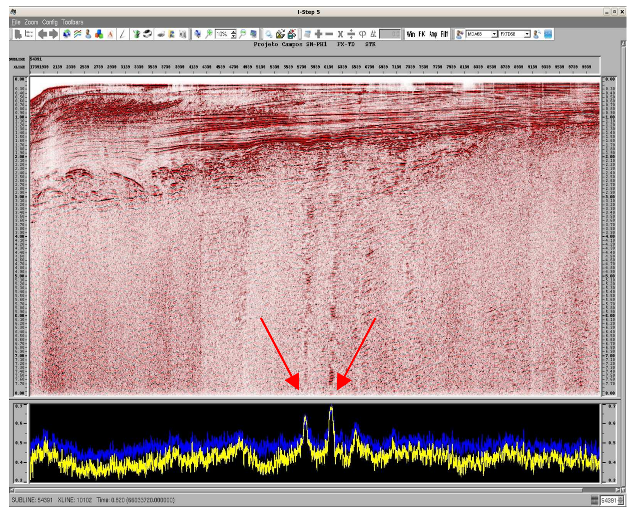

Figure 10: Line 2, FX-TD stack. Graph blue MDA, graph yellow FX-TD. Red arrows enhance inter bed reverberations problems. Anomalies observed in figure 6 and 8.

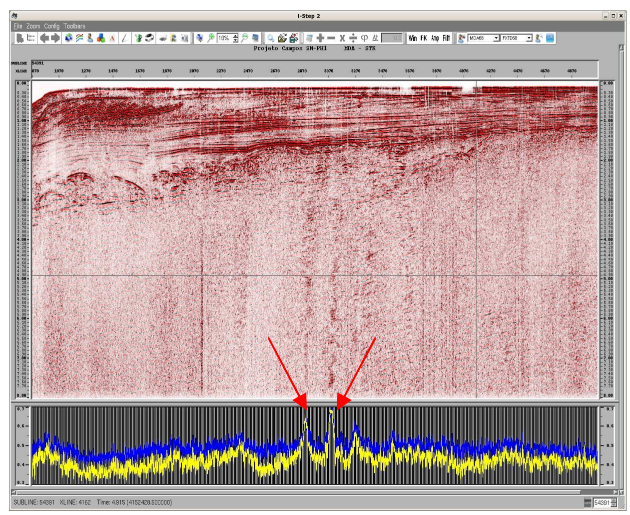

Figure 11: Line 2, MDA stack. Graph blue MDA, graph yellow FX-TD. Anomalies observed in figure 8.

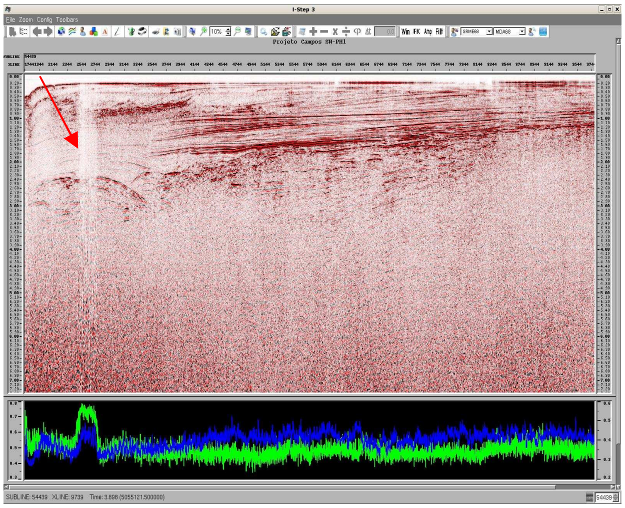

Figure 12: Line 1, SRME stack. Graph blue MDA, graph green SRME. Strong anomaly indicated by red arrow. Anomaly observed in figure 5.

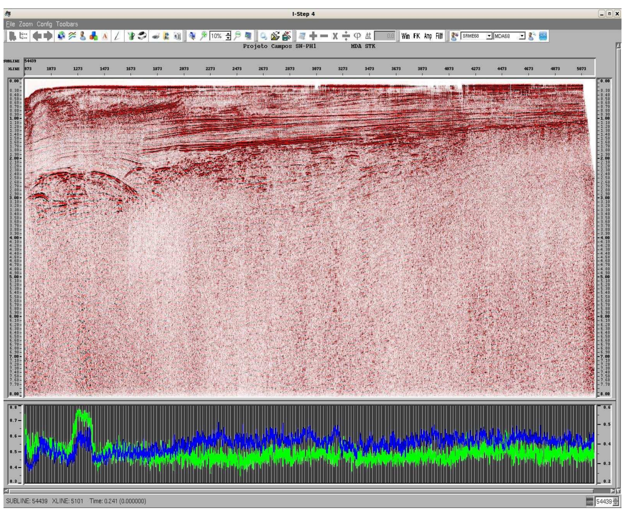

Figure 13: Line 1, MDA stack. Graph blue MDA, graph green SRME. Anomaly removed.

Conclusions

The application of quality control procedures were directly related to the improved quality of the 3D seismic data processing. The global amplitude maps allowed for rapid identification of noisy areas and subsequently a rapid solution to the problems. Also of note was the validation of reduced noise levels in the data volume after each processing step as evidenced on both the amplitude maps and the histograms.

Acknowledgments

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References

Verschuur, D.J., and Kelamis, P.G., 1997, Surface-related multiple elimination on 3-D land data, 67th Ann. Internat. Mtg., Soc. Expl. Geophys., Expanded Abstracts, 1383-1386.