Oil & Natural Gas Technology

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Quarterly Research Performance Progress Report (Period ending 04/31/2013)

Structural and Stratigraphic Controls on Methane Hydrate occurance and distribution: Gulf of Mexico, Walker Ridge 313 and Green Canyon 955

Project Period: 10/01/2012 – 09/30/2015

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Executive Summary

This quarterly progress summarizes the progress made towards Phase 1, Subtask 2.1 (Data Processing) and Subtask 2.2 (Stacking and Picking). Seismic profile under consideration is a 2D line extracted from 3D survey. We report that we have fully completed Subtask 2.1 and partially completed Subtask 2.2. The progress is as per the original schedule.

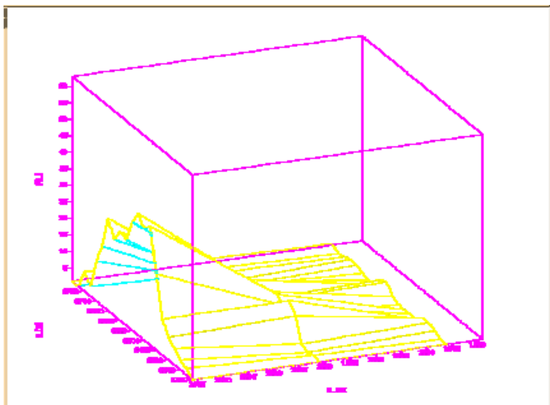
Background

The overall objective is to identify and understand structural and stratigraphic controls on hydrate accumulation and distribution in leased blocks WR313 (WR: Walker Ridge) and GC955 (GC: Green Canyon) in the Gulf of Mexico using seismic and well data. The effort shall be completed in three phases. In the first phase, the objective is to create a large-sale (resolution in the order of Fresnel zone) P-wave velocity model using traveltime inversion and a corresponding depth image using pre-stack depth migration (PSDM). In the second phase, the objective is to refine the resolution of the P-wave velocity model created in the first phase to the order of seismic wavelength using full-waveform inversion and simultaneously create P-wave attenuation model. The third phase has two objectives. The first objective is to create a hydrate distribution map with the help of P-wave velocity and attenuation model created in the second phase and standard rock physics modeling method. The second objective is to jointly interpret the saturation map, Full-Waveform Inversion (FWI) velocity and attenuation, and the PSDM image to determine the structural and stratigraphic controls on hydrate occurrence and distribution.

Phase1: Subtask 2.1 (Data Processing)

The data used in this project were donated by CGG Veritas. The data have been extracted from a rather large 3D volume. Only selected gathers that stack along an oblique 2D profile were given to us. First and foremost the data were meticulously studied in the SEGY viewer, to corroborate proper byte locations for different headers. Source-Receivers were plotted in MESA. Knowledge of source-receiver distribution is essential for the success of this project because data are subset of a larger 3D volume. They were also critical in ensuing that the seismic data are loaded properly and processing procedures are adequately chosen. One of the key steps before applying any kind of processing module is to create database of the important headers, constituting the data, to be modified later such that the 3D gathers can be processed in a 2D style. We are using the industry standard processing software ProMAX. After loading the headers in ProMAX conventional processing has been performed up to the stage of creating stack. Module “Header Range Scan” was repeatedly carried out to confirm that the headers have been accurate transformation from the CGG database into ProMAX.

In the end the following header were loaded: Trace Number, Inline, X-line, CDP Number, and Source Index Number. Figure 1 is the display of the fold. It shows that the maximum fold is along inline 1495 and 1500. Also maximum fold of 60 corresponds to CDP`s ranging from 47900000 to 48500000.



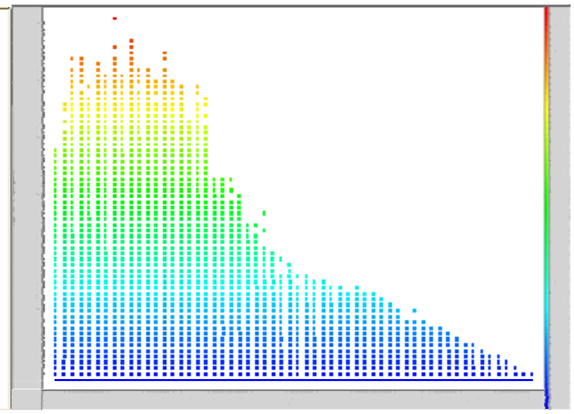


Fig.1 Fold Distribution along Inline and Cross line.

Fig.2 Fold Distribution along CDP`s

Processing QC:

For generation of the brute stack for QC purposes, alternated traces were dropped and the data are re-sampled to 8ms. Individual shot gathers were displayed for a general QC. Although the geometry is loaded a display ensured that there were no mismatches between header in the trace geometry and header in the database. Individual gathers were also checked for any bad and erroneously reversed traces. The trace headers are read using interactive ProMax tool, from different shot gathers. This has given insight about the original 3D acquisition and parameters. After a general header QC, the dataset is ready for initial processing. The header database and QC of datasets assisted in parameter selection of initial processing which is discussed in ensuing paragraphs.

Processing Parameterization:

The following seismic modules were applied to the data for preparing a brute stack:

1. Top Mute
2. De-convolution
3. Band-pass filter
4. Velocity Analysis (1st Iteration)
5. Stacking
6. Gains (for display only).

Top Mute:

In order to avoid pre-seafloor reflection noise at the hydrophone, the data is muted at the top of shot gathers. This will ensure removal of in-coherent noise before actual data begins to record. Figure 3 shows top mute applied to shot gathers. The mute is applied and QC, so that the seafloor reflection is not muted. For top mute, troughs in the seafloor reflection wavelet are snapped. The top mute widow is placed 50ms above the snapped pick.

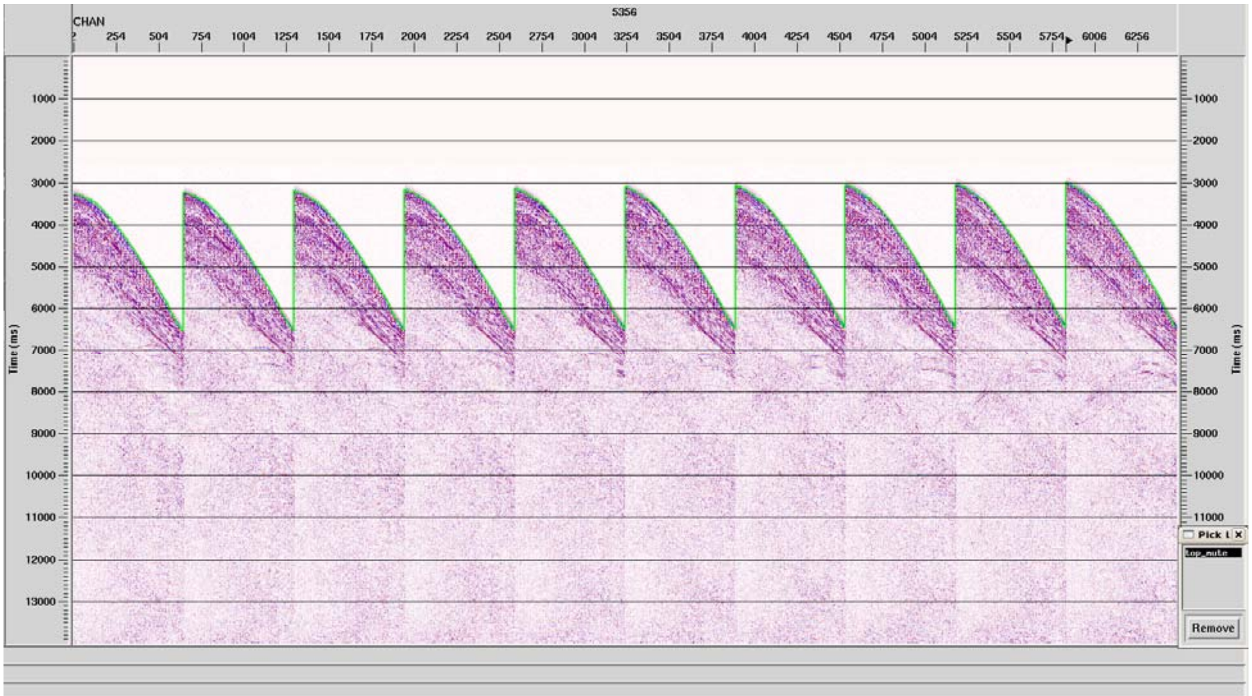


Fig.3 Top Mute Applied to Shot

Predictive De-convolution:

Predictive de-convolution is applied to shot gathers for enhancing the temporal resolution of the data by attenuated source reverberations. In essence it also attenuates the short period multiples, but at this stage we are unable to comment on that aspect. The periodicity in the traces can be estimated using autocorrelation which implies correlating the trace with itself at different time lags. The correlation is a maximum at zero-lag. In principle, assuming a random reflectivity series, the correlation must be near-zero at all other lags. In practice, however, when the source wavelet is not a spike or peg-leg multiples are present in the data the autocorrelation values could be significant at other lags as well.

Traces from the entire data are selected and are auto-correlated. The short period reverberations are estimated by measuring time between 0 and 1^{st} lag. Figure 4 displays trace No. 11127 and Figure 5 is its auto-correlation at various lags. The trace appears to have repeatability at a log of 16 ms. Operator length of 160 ms is chosen for application. For application of predictive decon, time windows are selected in the original shot gathers. The time gates are selected keeping in mind the primary energy and our zones of interest.

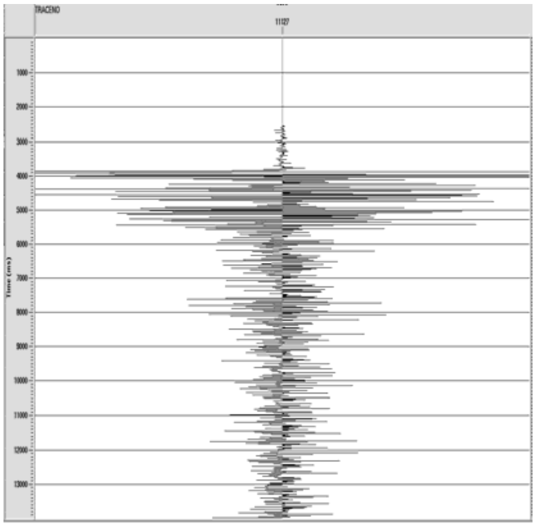


Fig.4 Trace No. 11127 Selected for Auto-Correlation

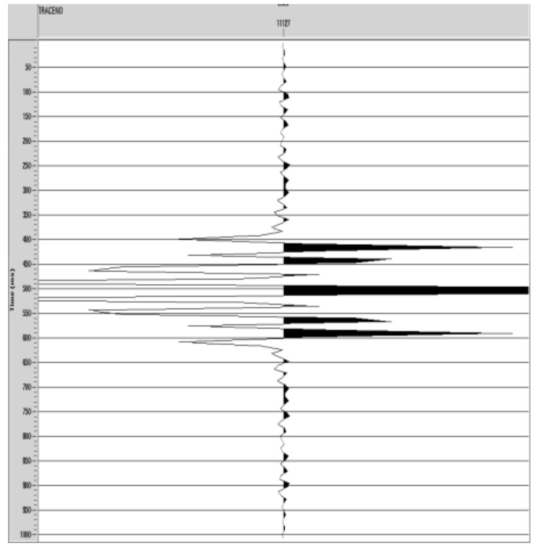


Fig.5 Auto-Correlated Trace. 16 msec predictive distance and 160 msec operator length is selected

Band-pass Filter:

It is essential to select optimum range of frequencies which is subject to processing. Spectral Analysis of shot gathers are carried out as shown in the figure 6. The time-offset domain in shot gathers are transformed into frequency and phase domain. Those frequencies are selected which are prevalent in the entire dataset from shallower times to deeper. This will give smooth visualization of the geological features which are resolved at particular frequencies. The selected bands of frequencies are also tapered at the end for smooth transition. A frequency range of 8-12.5-40-80Hz is selected after observing frequency spectrum of shot gathers selected randomly in the entire dataset. An Ormsby band pass filter operator is used for passing the aforementioned frequency range and filtering the rest.

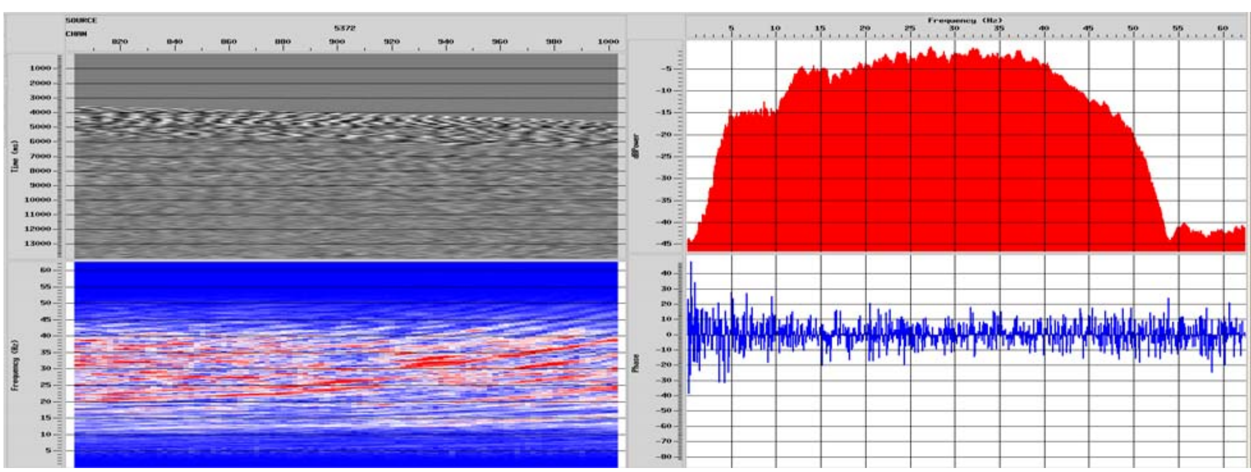


Fig.6 Spectral Analysis of Shot Gather showing Frequency and Phase of shot gathers. Frequency range of 8.5-12-45-50 Hz is selected for processing.

Phase1: Subtask 2.2 (Stacking)

For the purpose of QC, the pre-processed data is sorted in Common Depth Point (CDP) domain. For the purposes of this report we have stacked the data with water velocity (1480 m/sec) only. A velocity profile is made, which encompasses all CDP`s along in-lines and cross-lines, along with X-Y coordinates, in the dataset. Normal Moveout correction (NMO) is applied to pre-processed data, using water velocity. NMO removes the effect of delayed time due to offset, so that the traces can be displayed in two way vertical time, which can later be converted to vertical depth. Figure 7 displays inline 1498, which one of the 6 inlines that were donated to us by CGG.

Gain (for display only):

Application of gain is an important step in processing. It enhances the energy which is attenuated over the period of recording and improved the efficiency of some seismic modules. A great deal of care is required to select gains, so it will not compromise the original signature of seismic datasets. A mean automatic gain of 500 ms is applied for display purposes only and will be removed before any further processing.

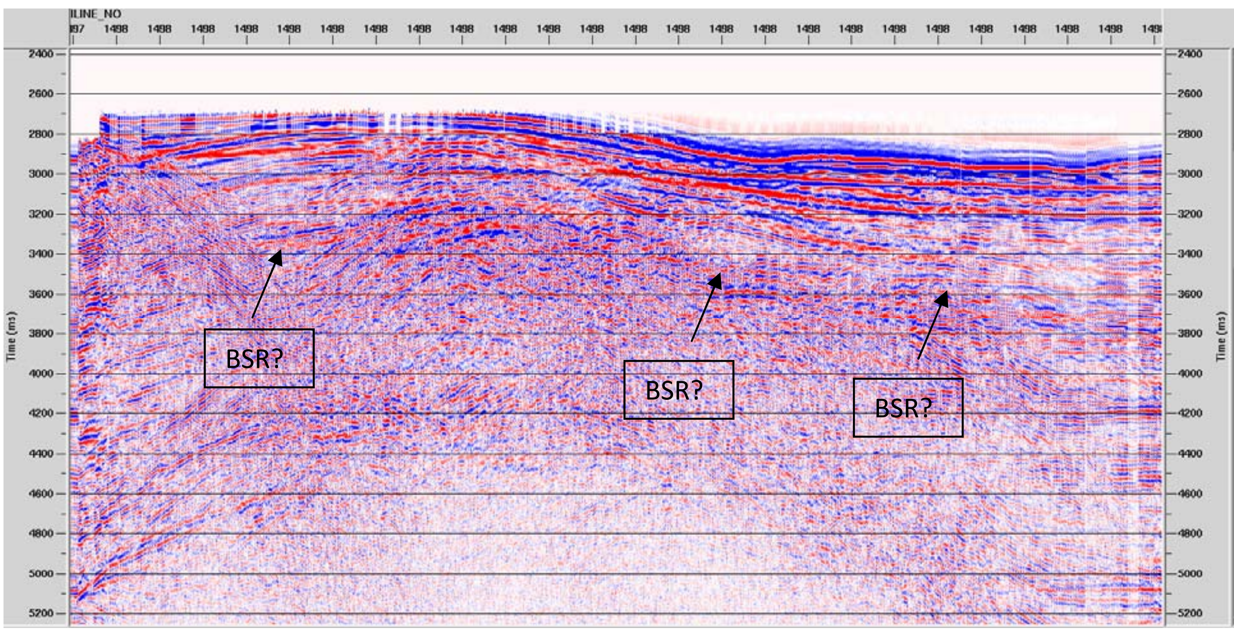


Fig 7. GC 955 Stack obtained using water velocity of 1480 m/sec of In-Line 1498

The original data has gone through these initial processing sequences. The data is now being used for is the estimation of RMS velocities. This is carried out making super gathers at a reasonable interval of CDPs in the giving volume, and estimating velocities using semblance. These velocities will be used for migrating data for removing diffracted energy. This finalizes the conventional processing. The velocity estimation and migration can be carried out in tandem with advanced travel time methods.

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