Oil & Natural Gas Technology

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Quarterly Research Performance Progress Report (Period ending 06/31/2013)

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 4. Seismic profile under consideration is a 2D line extracted from 3D survey. The headers have been extracted from the SEGY headers for creating navigation database in the processing software.

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.

Phase 1, Subtask 4.1

The third quarterly report encompasses last conventional seismic processing steps. DOE was duly apprised about the data QC, geometry, header database formation and initial processing steps in 1st and 2nd quarterly reports, which were required for the ensuing advanced processing techniques. This report is the continuation of the previous processing steps, and includes successful completion of Dip Move-out and Pre–Stack Depth Migration. The final outcome is preceded by number of processing steps and data quality inspections. A velocity model is estimated after rigorous revision of velocity profile for both datasets. The data was transformed into Common-Offset Domain and Dip Move-out is carried out, which is followed by revision of velocities for DMO Stacks. The velocity profile is smoothed and is converted to interval velocities for successful completion of Pre-Stack Depth Migrated Stacks.

The Final Processing steps, accomplished in the third quarter are as follows:

1. CDP Sorting & Super gather formation
2. Velocity Analysis & Parameterization
3. Common Offset Selection
4. Common Offset Dip Move-Out
5. Pre-Stack Depth Migration.

1. CDP Sorting & 3D Supergather Formation:

The data at this stage has been processed in shot domain and has been filtered for the optimum frequency by carrying out spectral analysis. The shot period reverberations are filtered using predictive deconvolution. The data is now sorted into the CDP domain, which is included in the project database headers.

Since the data is extracted from Seg.Y volume, the3d supergathers formation is tailored according to the geometry of the given datasets. Supergather formation of CDP`s are essential for carrying out velocity analysis of a given dataset. After repetitive checks, final 3D supergathers are parameterized, which ensure assimilation of gathers to the geometry of both the datasets and to avoid sparseness in velocity analysis.

2. Velocity Analysis & Parameterization:

Once the supergathers are stored in the dataset, velocity panel is prepared using optimum velocity ranges and semblance values. This is carried out in Pre-compute Velocity Analysis. The pre-compute velocity analysis job is carried out to make Constant Velocity Stacks (CVS), which are used in picking velocity. These CVS stacks have partial Normal Move-out (NMO) applied, using range of velocity values. As there was no reference velocity, a range of velocity values were selected, by making brute stacks on different velocity ranges. Semblance is a helpful tool in identifying events of maximum stacking. It is representation of amplitudes in contours, and significantly assists in picking velocities. A semblance range of 1000 and 8000 is selected; with a semblance rate of 20 increment. Eleven Constant Velocity Stacks (CVS) are selected ensuring velocity picks for the entire depth of data. The maximum stretch percentage for NMO is 30. An optimum velocity selection entails repeated analysis by making stacks for every velocity pick. The velocity analysis was carried out along the supergathers which covered the entire dataset.

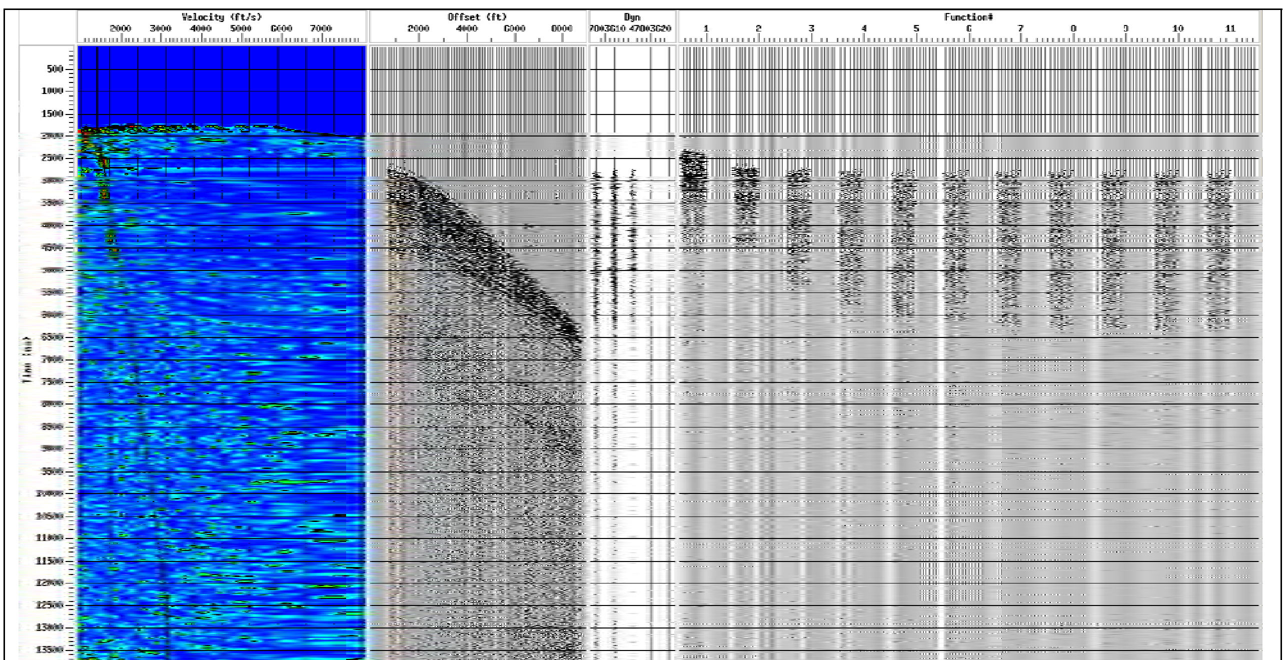

Fig.1 Velocity Panel of Inline 1498, depicting semblance plot and Constant velocity stack

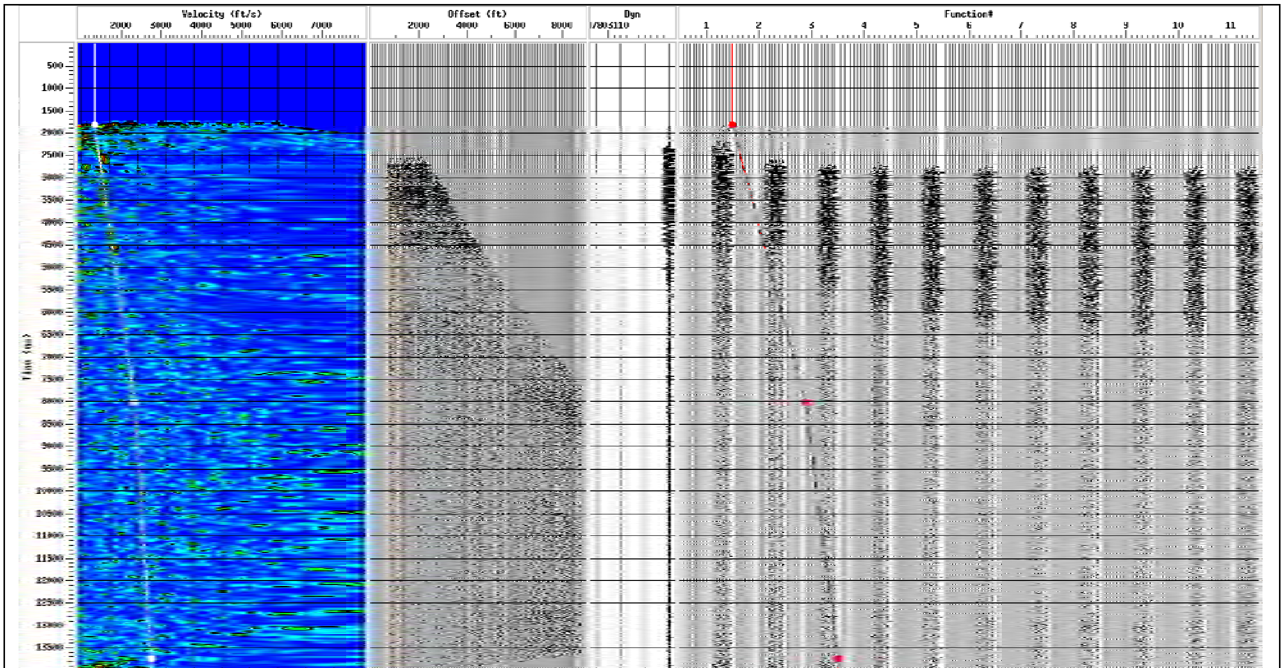

Fig.2 Normal Move-out applied to the above panel. Notice events are flattened

3. Common Offset Selection:

Upon selection of optimum velocity, the dataset is stored in Common Offset domain. Common offset datasets have traces which are sorted on basis of a common offset. This is essential for the ultimate Dip Move-out (Partial Migration), Pre & Post Stack Time and Depth Migrations. The dataset has Normal Move-out applied and traces are flattened prior to selection of common offsets. The dataset is tested using gamut of offsets and a common offset of 75 meters is selected. This common offset sorted data is stored and is later used for Dip Move-out and Pre-Stack Depth Migration.

4. Common Offset Dip Move-Out:

Dip Move-out is partial migration and caters for the delayed time of seismic energy arrivals due to dip. It is pertinent to mention that this dataset has dip which is associated to the perceived salt dome. The dipping horizons spread out the seismic energy, which has to be collapsed to the true vertical depth. Common offset Dip Move-out requires common offset, which was saved in the dataset and used as an input. Dip Move-out is carried out using water velocity of 1500 m/sec, and can later be revised for varying velocities.

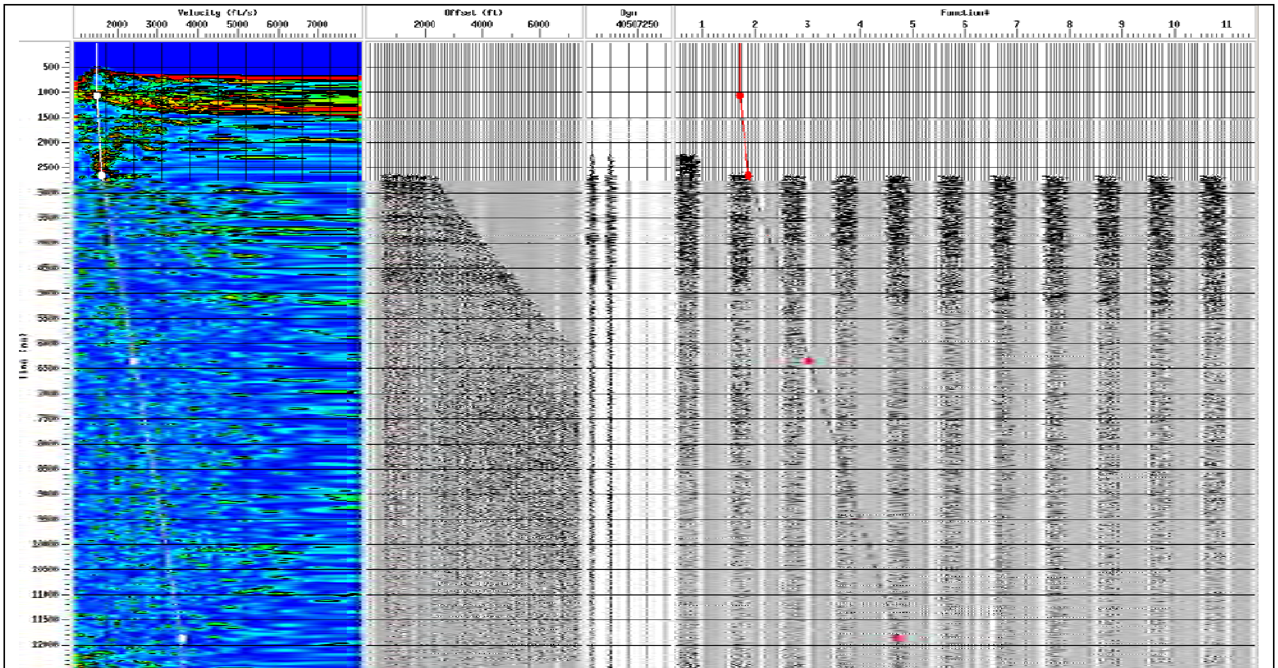

Fig.3 Velocity Revision /Correction of Dip-Move-out dataset along inline 24830. The amplitudes have more concentration of energy.

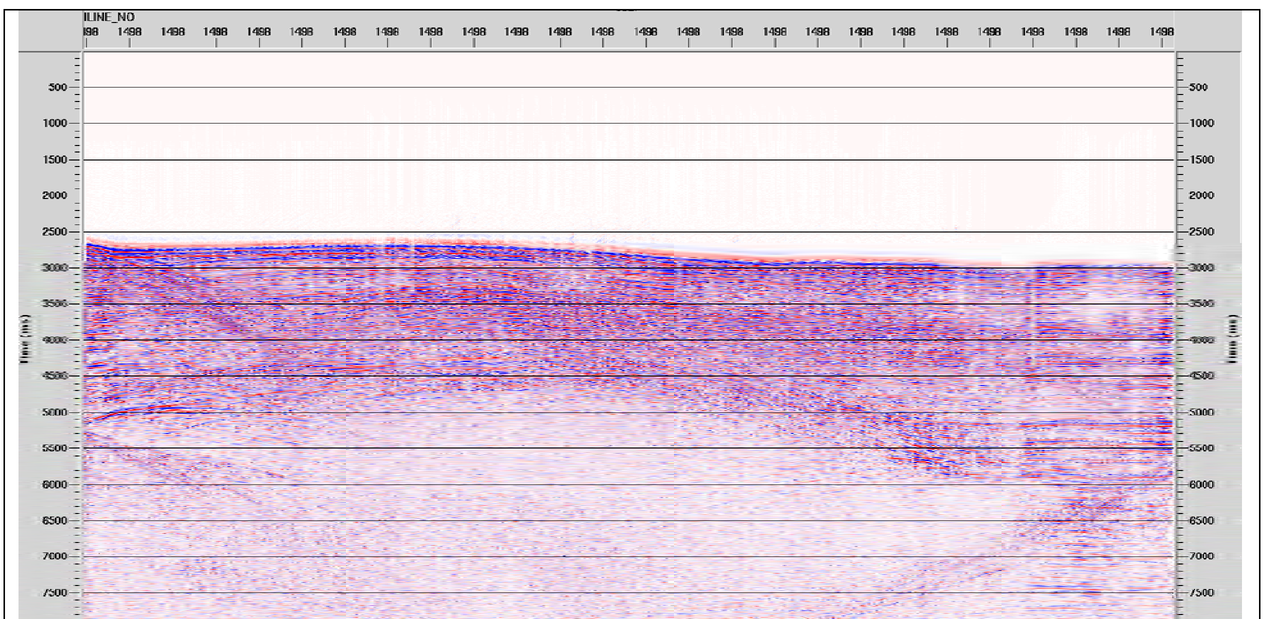

Fig.4 Common-Offset Dip Move-out Stack of Inline 1498

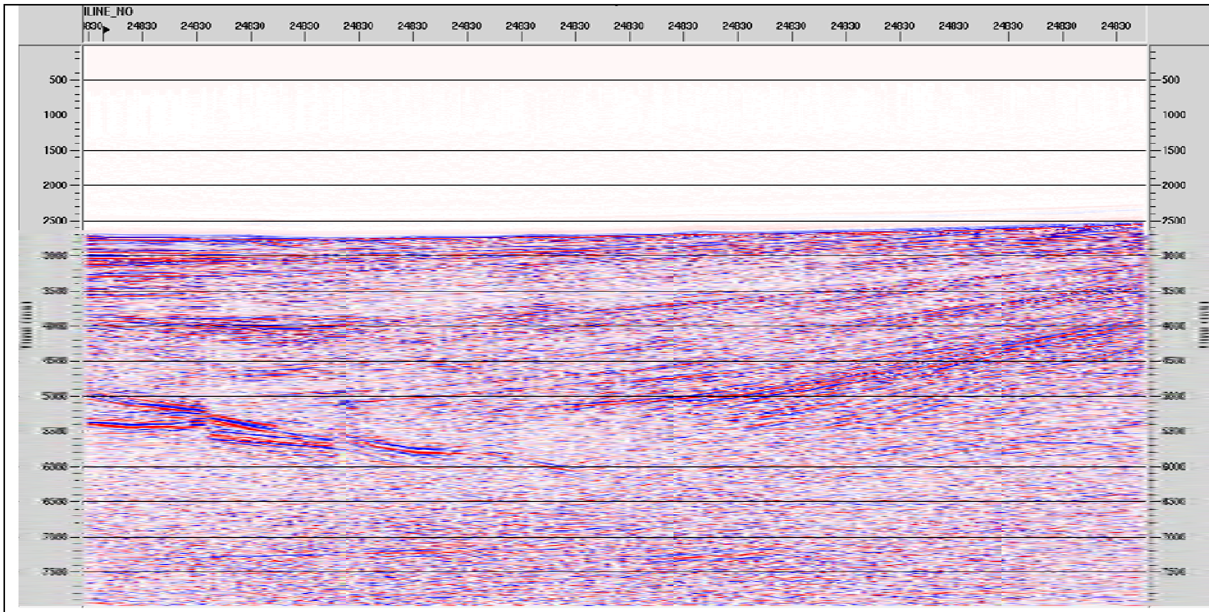

Fig.5 Common-Offset Dip Move-out Stack of Inline 24830

5. Pre Stack Depth Migration(PSDM):

Depth migration is state of the art algorithm which accounts for later velocity variation. The migration aperture is not a perfect hyperbola in regions of lateral velocity variation, which is to be accounted. Depth migration is a layer by layer operation and adjusts itself in terms of velocities for variation. This dataset poses challenge and does not render an optimum output using Time Migration. This is attributed to lateral velocity changes and salt diapers. Salt diaper causes non-hyperbolic diffracted energy and image rays behavior is not appropriate for Time Migration. Pre-Stack Kirchhoff Depth Migration is used which accounts for dips as steep as 90 degrees. This process requires significant processing time. The input velocity is interval velocity with respect to depth. The RMS velocity selected in Velocity Analysis step is converted into Interval velocity using Dix equation. PSDM is applied for Maximum frequency of 50 Hz for a maximum depth of 14000 meters. The migration aperture for the initial PSDM is 5000 m. An implicit Eikonal algorithm is used for carrying out PSDM, which predicts and estimates the wave propagation response in the subsurface.

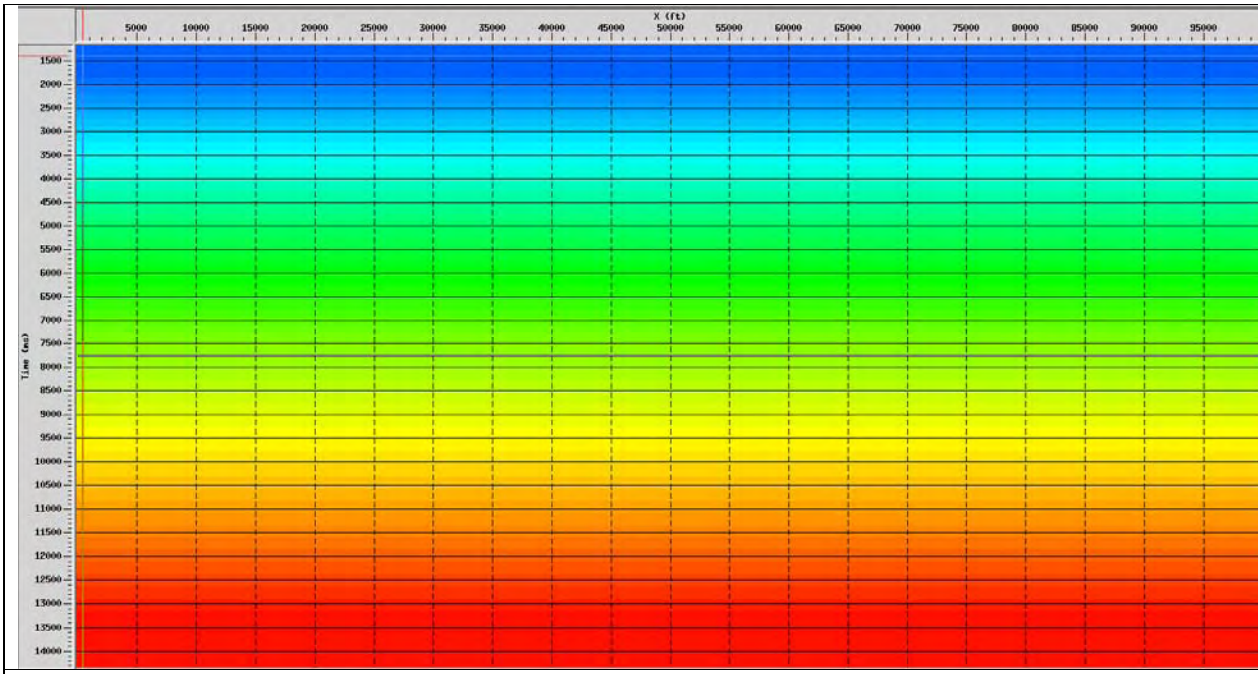

Fig.6. Velocity Smooth plot before Migration of Inline 1498

It is worthwhile to mention that aforementioned processing routines have been applied to both sets of data, which was provided by DOE. The stacks displayed in this report are of two in-lines 1498 and 24830, which represent both set of 3D datasets respectively.

This report concludes the advanced conventional processing application on the DOE datasets. Now the data is being examined to pick Bottom Simulating Reflectors (BSR) for the application of Travel Time Tomography. This will further estimate accurate RMS velocities and consequent interval velocities of the datasets, for creating more accurate Depth Migrated Stacks. The subsequent Depth Migrated Stacks obtained from Travel Time Tomography, will conclude the first phase of DOE project.

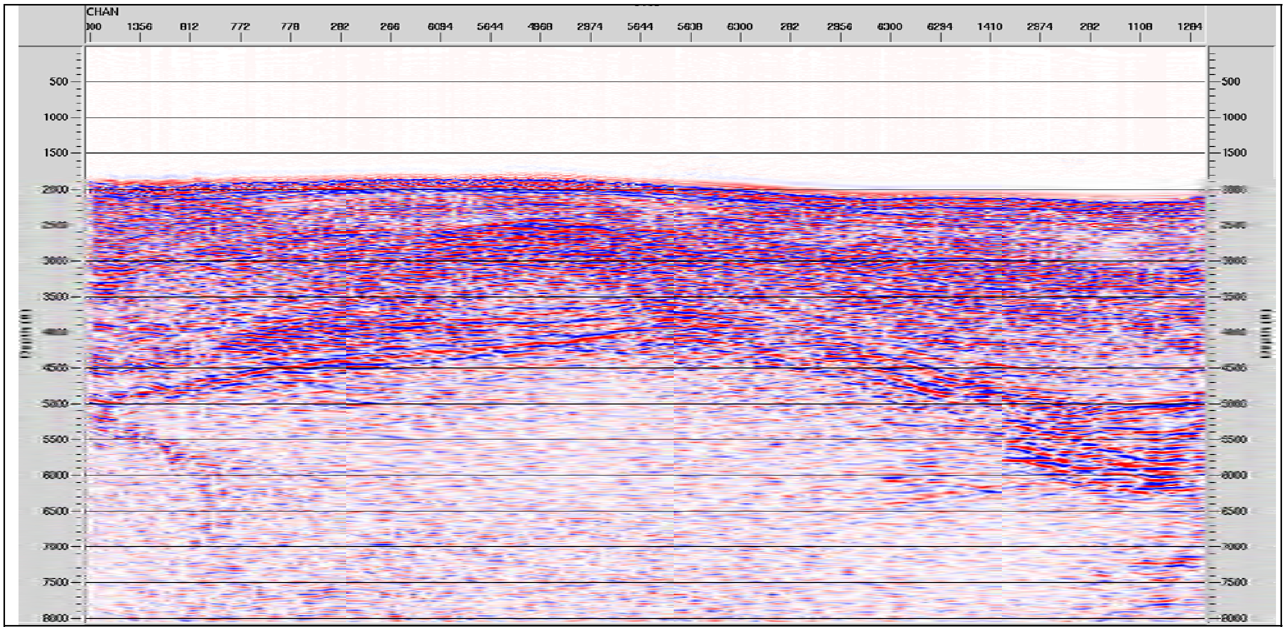

Fig.7 Pre-Stack Depth Migrated Section of Inline-1498

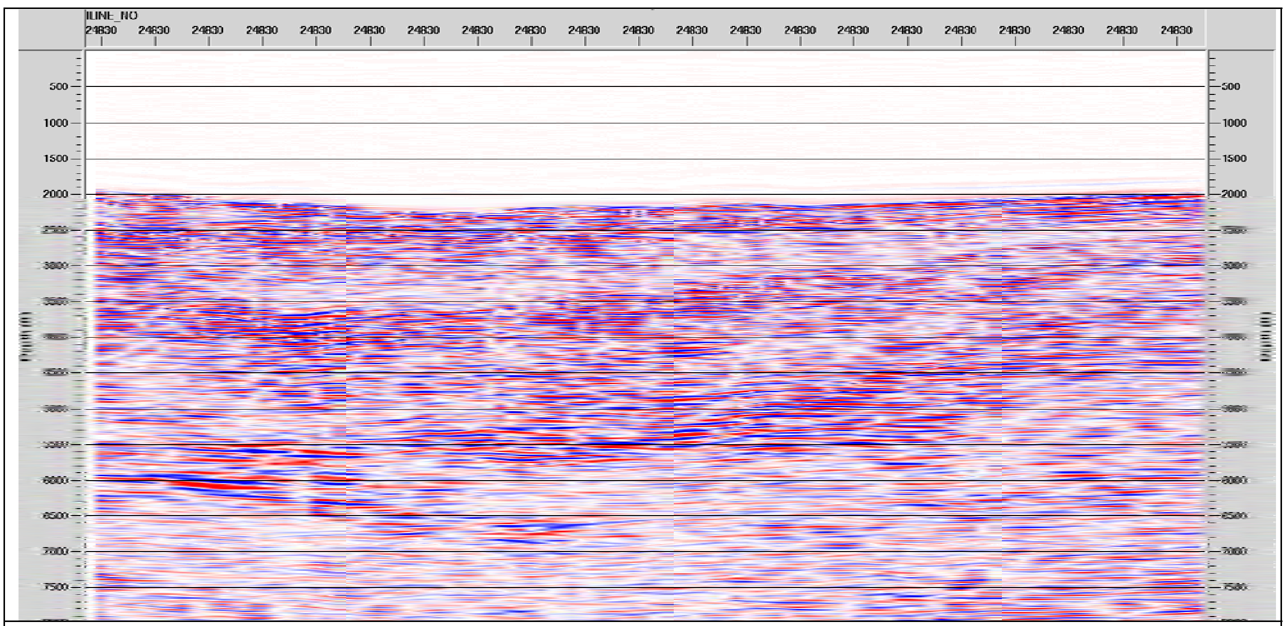

Fig.8 Pre-Stack Depth Migrated Section of Inline-24830

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