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Fixation of Processing Parameters for 2D OBC-TZ Survey - A Case Study

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Summary

Processing parameter fixation for OBC – Tz surveys has a direct bearing on the quality of data as the data to be dealt with belongs to three different zones or environments i.e. land, marine and transition zone. Parameter fixation has to be done with precision keeping in mind the environments and their effect on data. Considering the client requirement and acquisition environment, parameters fixed for data processing with accuracy and care is taken during processing at every QC step to obtain good quality processed data.

Introduction:

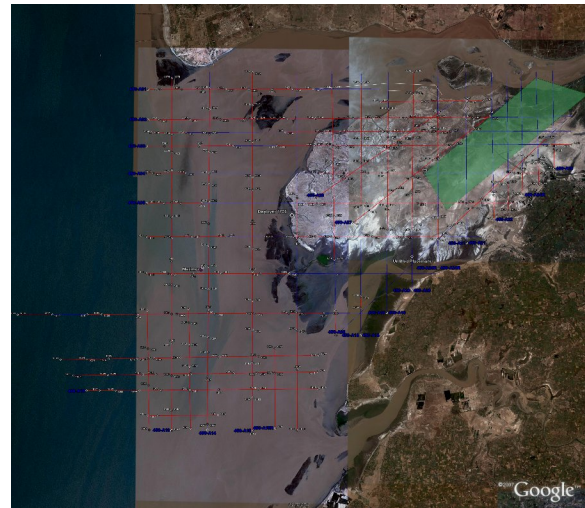
ONGC has awarded a contract to M/S YMG Over Seas Limited, Cyprus to acquire and process 2D OBC-TZ seismic data in CB-OSN-2003/1, NELP block. The survey zone is located in the Cambay Basin on the West Coast of India falling in the Shallow water in the depth range of 0 to 30 meters in Transition Zone and on Land.

2D OBC-TZ surveys were conducted in Aliabet (situated south of Dahej Port) area of Cambay basin with the following objectives:

To map pinch out limits of various sands within Dadhar Formation (1200ms-2000ms).

To map pinch out limits of various sands within Hazad Member (1300 ms-2300ms).

To map wedge out limits of various sands within Olpad Formation (2000 ms-3000 ms).



Area of operation in Aliabet, Gulf of Cambay
(Situated South of Dahej port)

Primary Exploration Environments for hydrocarbon exploration can be classified as Land (Down to coastal line), Transition Zone (Surf zone), Marine (Shallow & Deep Water).



In the transition zone, OBC surveys using with dual sensors will provide more flexibility of acquisition geometry with greater surface consistency. More flexibility in working is possible around obstructed zones. The method is efficient to remove ghosts and layer reverberations and noise reduction by eliminating cable vibration and strumming (Towing & surface weather condition). Better coverage can be achieved by eliminating by cable feather.

OBC survey is hybrid marine and land seismic data acquisition operation. It employs a stationary array of receiver stations on the ocean bottom and marine vessel towing only seismic energy source. As in land operations, the receiver array may be moved electronically with roll along switch to maintain desired source – to – receiver separation and shot points can be placed close to obstacles to get uniform coverage of congested area.

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Factors affecting OBC surveys are receiver locations (influenced by Water depth, Water currents and Dynamics of the cable falling through the water) and environment conditions (influenced by Debris on the sea floor, Tidal variations, Long cycle time, Excessive equipment deployment, and Complex operational coordination).

Dual sensor summation, de-convolution, de-multiple, velocity analysis stack and migration outputs are thoroughly examined to ensure quality processing. The outputs are subjected to quality checks with basin prior to acceptance.

All test panels prepared by M/s YMG processing experts based on industry practices were critically examined and thoroughly discussed. Additional test panels were generated wherever necessary. Parameters were compared and final parameters were fine tuned and jointly arrived at a conclusion.

Geology of the area:

The Cambay basin is an intra-cratonic basin, which came into existence at the close of the Mesozoic period by the development of tensional faults along its margins. The basin is divided into four tectonic blocks and the present area lies in Narmada and Broach blocks. The influence of major pre-Cambrian tectonic trends is on the Trap configuration and the nature of

the sedimentary cover overlying the Trap floor in Cambay Basin. In the area of study the ENE-WSW trending Satpura Orogenic belt is seen to continue in the basinal area between Narmada and Tapti rivers and its offshore continuation. In addition, the Pre-Cambrian floor of Cambay basin is also composed of Dharwar Orogenic belt.

Middle Eocene is the principal pay horizon in the basin; however, hydrocarbons are being produced from Paleocene, Lower Eocene, Oligocene and Lower Miocene levels also. Cambay, Kathana and Mahi fields are located in the northern part. Gandhar, Devla and Dahej in the east and Ankleshwar-Motwan-sisodra fields are in the southern part of the area. Towards the western boundary of the area, rocks of Miocene and upper cretaceous (Deccan Trap)/ Paleocene are exposed in Saurashtra area, where two structural wells near Gogha have been drilled up to Deccan Trap. In the Gulf of Cambay, two deep wells namely West Aliabet-1 (upto Trap) and North Tapti-1 have been drilled. Non –commercial oil in Dhadar Formation and dead oil in Miocene was met in West Aliabet-1 well and Miocene formation was found to be gas bearing in North Tapti-1 well.

Commercial accumulation of hydrocarbons has already been established in the adjacent area through the analysis of 2D / 3D seismic data.

The present 2D OBC and Transition Zone Seismic survey is aimed to acquire high resolution 2D data for precise mapping of the fault blocks and reservoir limits.

Method of approach:

PROCESSING PARAMETER STUDIES:

Parameter tests were conducted on lines 450-A02 and 450-A15. The test lines were shown in the location map placed above.

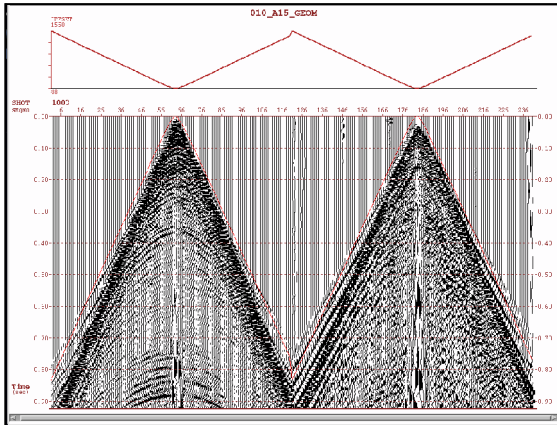
All processing parameter tests are conducted as per standard industry practice and are described below.

LP filter: LP filter 10-15 Hz is selected for subtraction of low velocity wave in noise zone from shot gather after identifying the noise zone.

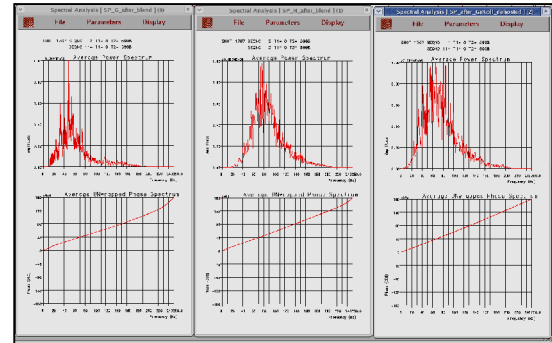
Dual sensor summation: Dual sensor summation has been made by selecting average amplitude and with 200ms time window for removing multiples that occur from surface-bottom reflection in receiver zone.



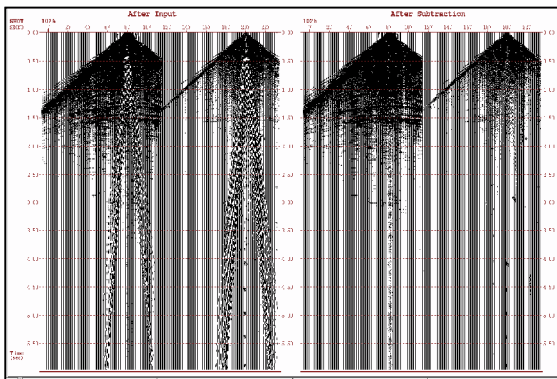
"HYDERABAD 2008"



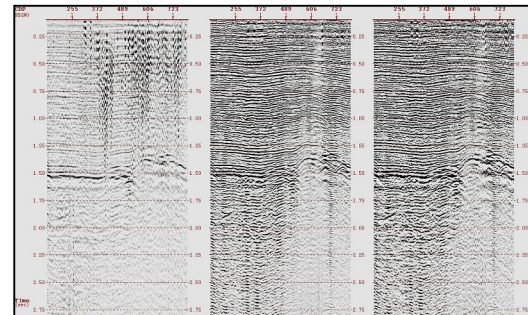
Common shot gather with offset graph overlay (red line on gather).



geophone hydrophone summed
Amplitude and phase spectrum diagrams.

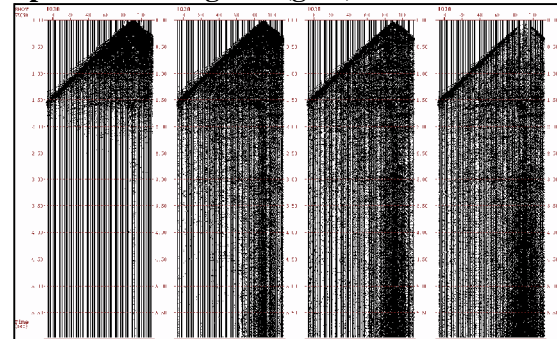


before after
Surface wave subtraction on geophone-hydrophone common shot gather



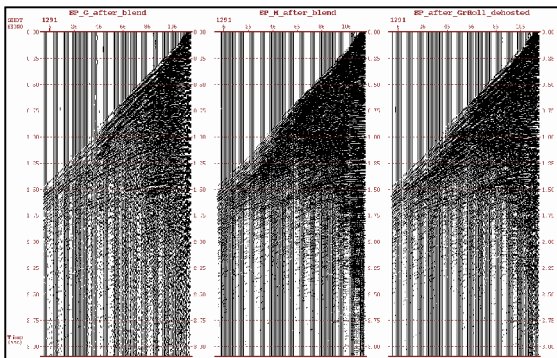
geophone hydrophone sum of g & h
CDP stack display

Spherical divergence (gain) correction:



with out correction $A=t^{1.5}$ $A=t^{2.0}$ $A=t^{2.5}$

Spherical divergence (gain) correction on common shot gathers.



geophone hydrophone sum of g & h
Common shot gather

The data in Fig. have been corrected for geometric spreading on shot gathers using $t^{1.5}$, $t^{2.0}$ and $t^{2.5}$ scale functions separately. While primary reflection amplitudes are corrected for wave front divergence, energy associated with multiple reflections, coherent linear noise generated by water bottom point scatters and the random noise also is inevitably boosted by geometric spreading correction. The geometric



spreading using $t^{2.0}$ was turned out to be effective for adequate gain compensation.

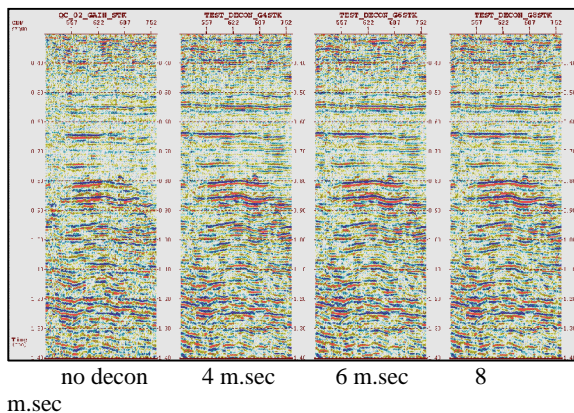
Statics:

Based on survey information for land data or navigation information for marine data, coordinates of shot and receiver locations for all traces are stored in trace headers. Change in shot and receiver locations are handled properly based on the information available in the observer's log. For land data, elevation statics are applied to reduce travel times to MSL (Mean Sea Level). The MSL is flat along the line. The reduction of travel times to MSL usually requires correction for the near surface weathering layer (LVL- low velocity layer), in addition to difference in elevation of source and receiver stations. Estimation and correction for the near surface effects are performed from the data base by computing auto statics with the velocity 1000m/s, 1500m/s for land and marine respectively.

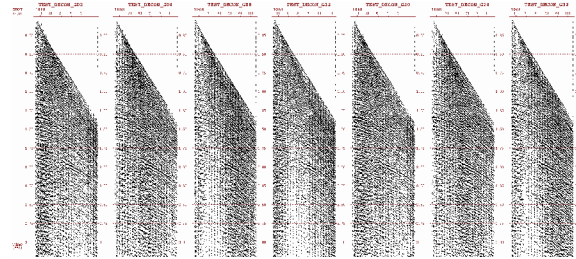
Surface consistent deconvolution:

In a transition zone, surface conditions at source and receiver locations vary significantly from dry to wet surface conditions. The seismic trace is decomposed into the convolution effects of S, R, X and earth impulse response, thus accounting for variations in wavelet shape affected by both near surface and near receiver conditions and S-R separation.

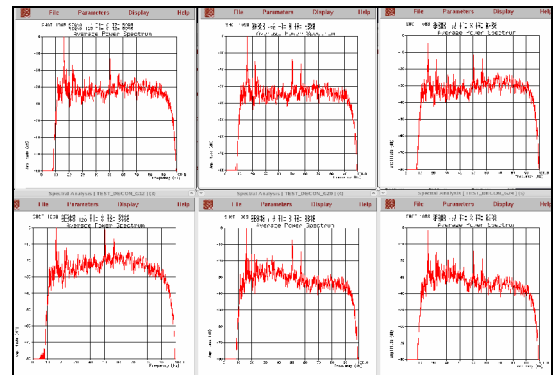
Test panels are generated using the prediction distance from 2ms, 4 ms, 6 ms, 8 ms, 10 ms, 12 ms, 20 ms, 24 ms and 32 ms. The 4ms prediction distance was found suitable as it was suppressing the high frequency end of the spectrum and preserving the overall spectral shape of the data. The parameter was confirmed by taking the test panels in stack mode and conducting spectral analysis for each panel.



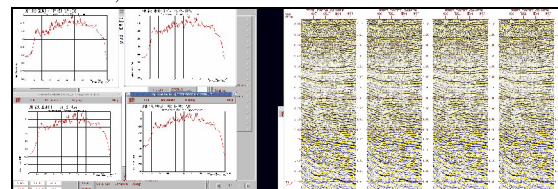
CDP stack after application of the deconvolution with the different gap size.



Application of deconvolution with different prediction distance (left to right) 2m.sec, 4m.sec, 6m.sec, 12m.sec, 20m.sec, 24m.sec, 32m.sec.

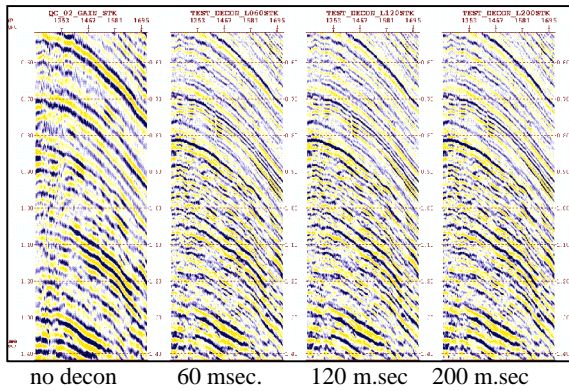


Power spectrum after application of deconvolution with prediction distance (top: left to right) 2m.sec, 4m.sec, 6m.sec, (below: left to right) 20m.sec, 24m.sec, 32m.sec.

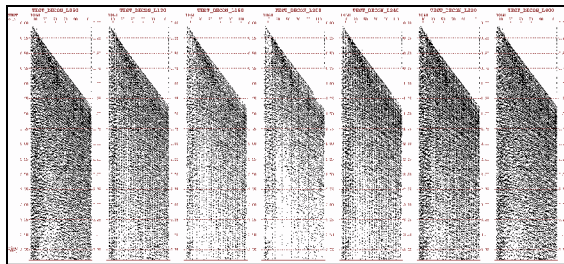


Power spectrum (left), CDP stack (right) after application of the deconvolution with the gap size 2m.sec, 4m.sec, 8m.sec.

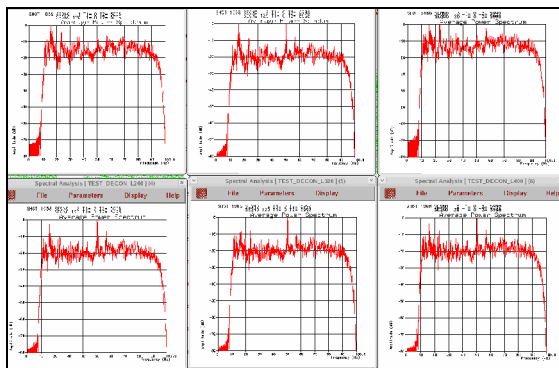
Fig. below shows the test panel for the operator length from 60ms, 120ms, 160ms, 200ms, 240ms and 320ms. The deconvolution using an operator length 200ms was found suitable with better spectral shape within the signal pass band.



CDP stack after application of the deconvolution with different operator length.

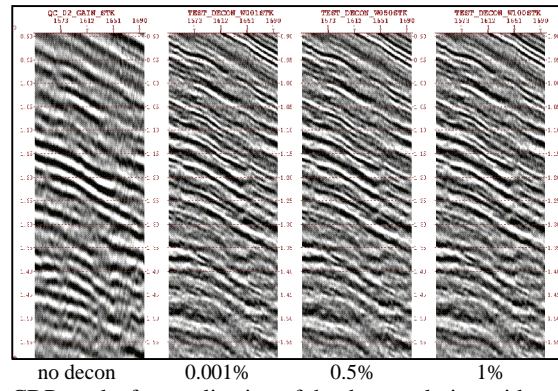


Shot gather after application of the deconvolution with different operator length (left to right) 60m.sec, 120m.sec, 200m.sec, 240m.sec, 320m.sec., 400m.sec



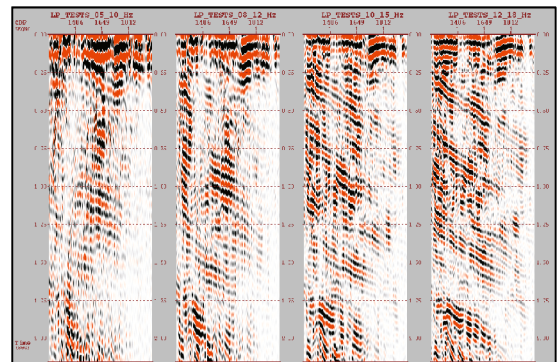
Power spectrum after application of deconvolution with operator length (top: left to right) 60m.sec, 120m.sec, (bottom: left to right) 200m.sec, 240m.sec, 320m.sec, 400m.sec

In figure shown below, the test panel for the white noise from 0.001%, 0.5%, 1%. The effect of varying pre-whitening is similar to the prediction distance, that is, the spectrum was becoming narrow in bandwidth as the percentage of pre-whitening is increased. Pre-whitening 0.5% preserves the spiky character of the output.



CDP stack after application of the deconvolution with the white noise level.

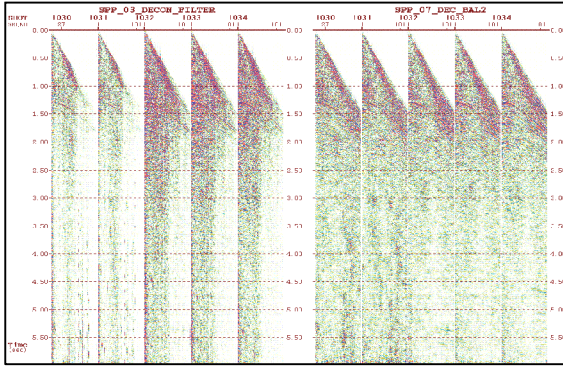
In Fig. shown below, results of low pass filtering with different boundaries 5-10Hz, 8-12Hz, 10-15Hz and high pass filtering with different boundaries i.e., 80-90Hz, 90-100Hz, 100-110Hz, were attached. The broad band filter 8-12-90-100 Hz is found suitable for the data. Improvement in reflection continuity observed after application of surface consistent deconvolution.



Different low pass filtered partial stack panel. From left to right: filter boundary 5-10 Hz, filter boundary 8-12 Hz, filter boundary 10-15 Hz, filter boundary 12-18 Hz

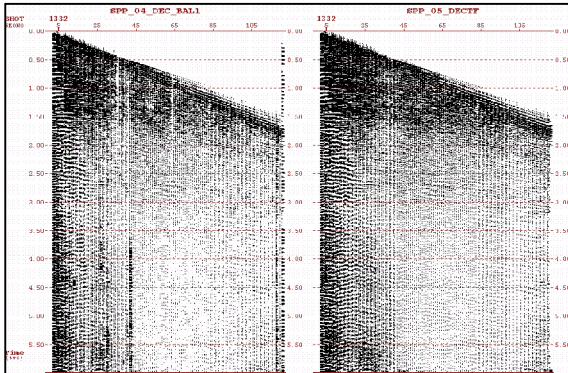
The land data contains less high frequency and more low frequency compare to marine data. The spectral equalization has been made between land and marine data by using the *matching filter* for land data 0-20Hz (0.4), 20-30Hz(1.0), 30-42Hz(0.9), 42-60Hz(1.5), 60-90Hz (1.1)and for marine data 0-20Hz (1.0), 20-30Hz(1.3), 30-60Hz(1.0), 60-90Hz (1.1).

Surface consistent amplitude trace balancing was done for equalizing amplitude level of traces on multi shot gather based on two key model i.e., shot and receiver. The parameters selected are 100- 2000ms for zero offset and are 1700-3500ms for 3000m offset. These values are to be varied depending up on the requirement of data.

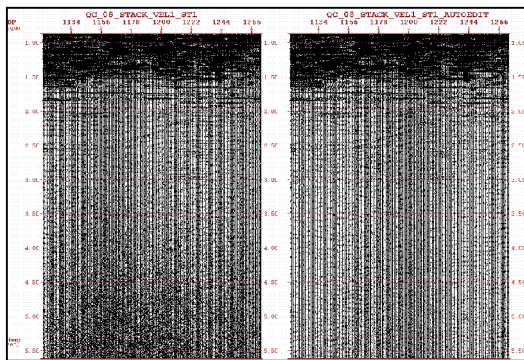


Multi shot gathers display before (left side) and after (right side) balancing.

Gain correction is applied to the traces with abnormal decay followed by auto/ manual editing of traces with abnormal amplitudes on shot gather.



Common shot gather displays before (left side) and after (right side) absolute amplitude auto editing.

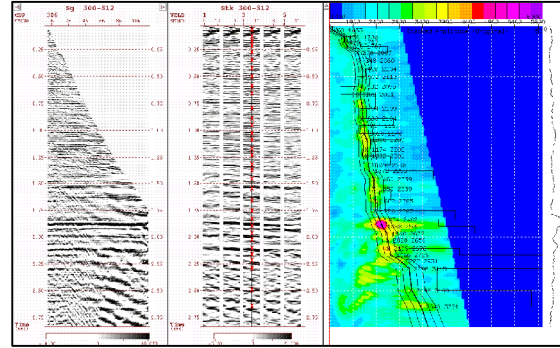


Stack displays before (left side) and after (right side) gain correction

Velocity Analysis

The velocity analysis is performed at every 2km on 11-13 CDP super gathers. Velocity-time pairs are picked from these spectra based on maximum coherency peaks to form velocity functions at analysis

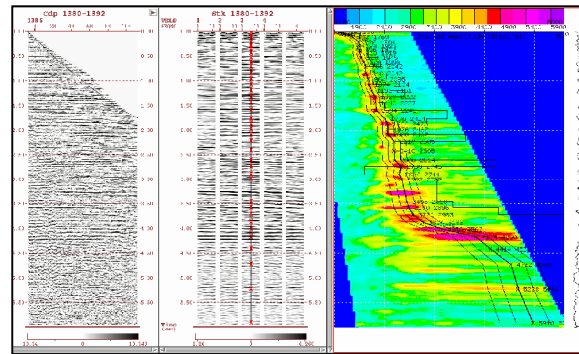
locations. The velocity functions picked at analysis locations are spatially interpolated between the analysis locations to create a velocity field. Red in shallow portion and blue in deep portion of the section correspond to low and high velocities, respectively. This velocity field is used to supply a velocity function for each CMP gather along the profile.



CDP supergather after NMO (left), Partial stacks (middle), Coherency plot (right)

Residual Auto Static correction:

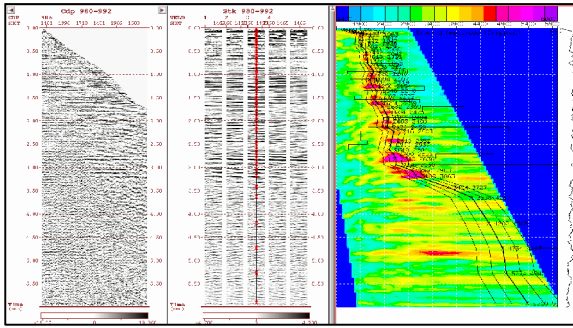
Surface consistent residual auto static correction is applied from the created data base. The correlation window selected is 10- 1500ms. As the dips are varying, 11 cdp points instead of 21 cdp points was suggested for statics calculation/ application. The velocity analysis after residual static correction was performed at 1.0 km interval and generated NMO corrected super gathers and five partial diverse percentage stacks.



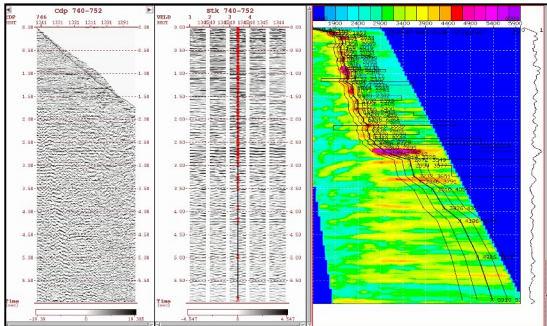
Velocity analysis _DMO_Land



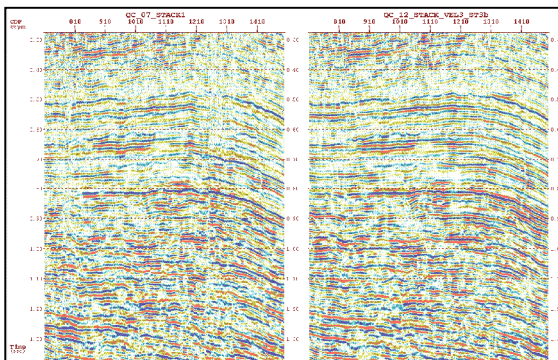
"HYDERABAD 2008"



Velocity analysis _DMO_TZ



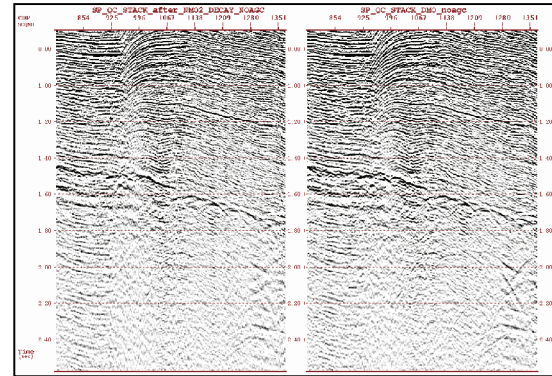
Velocity analysis _DMO_MARINE



Residual static correction on CDP stack

DMO Correction

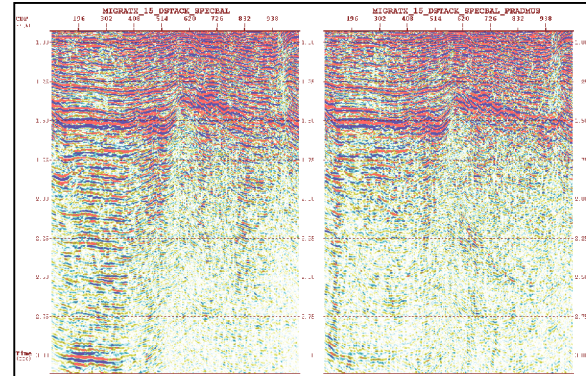
CMP DMO has performed by using Kirchoff algorithm to make dip move out correction for obtaining good imaging of conflicted dips. The Maximum offset 3000m, time 1750m and velocity 2200 m/s, are fixed for CMP DMO.



CDP stack is displayed before (left side) and after (right side) CMP DMO

Radon Demultiple:

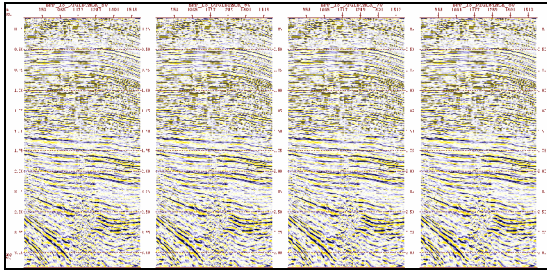
Parabolic Random Transform performed in high resolution mode to attenuate multiples. The parameters like lower end -500, low cut -490, high cut 50 and high end 70, are selected.



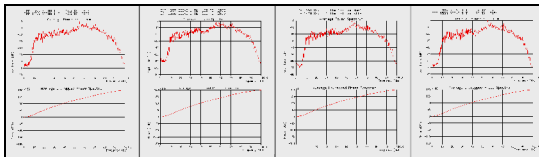
CDP stack display before (left side) & after (right side) multiple waves suppression

Final Stack:

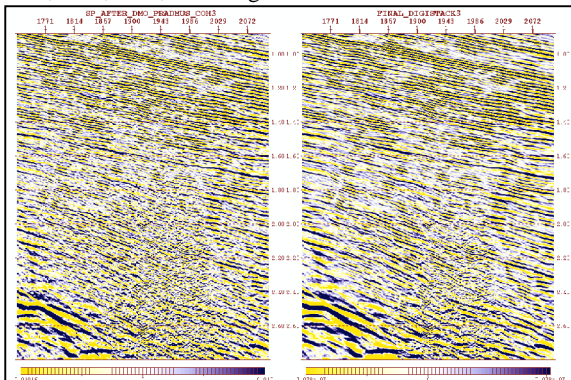
Final CDP stacking was done by normalizing amplitudes by number of live samples. Coherent filtering with signal extraction was done with 20%, 30%, 40% and 50% original trace add back. 40% (0.40) original trace adds back is found to be the best suitable one for the data.



CDP stack after application of coherent filtering with signal extraction (right to left) 20%, 30%, 40%, 50% original trace add back.



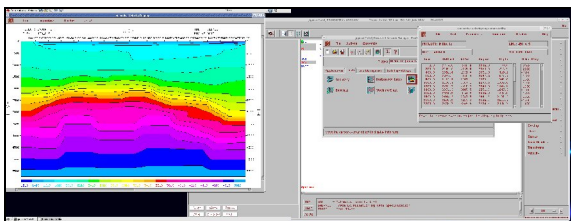
Power spectrum for CDP stack after application of coherent filtering with signal extraction (right to left) 20%, 30%, 40%, 50% original trace add back.



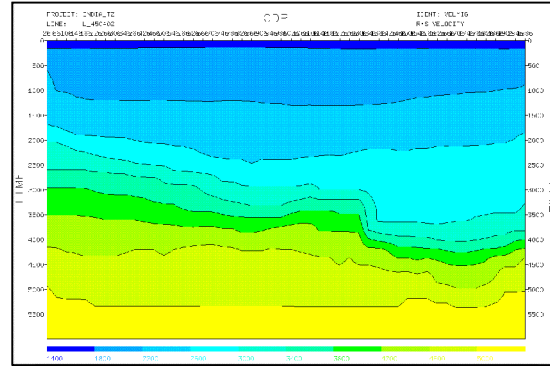
CDP stack is displayed before (left side) and after (right side) coherent filter application

Migration Velocity field:

2D migration velocity construction has been performed by Computing velocity model for migration smoothing (5points) and interpolate (10CDP, 50ms) stacking velocity field.



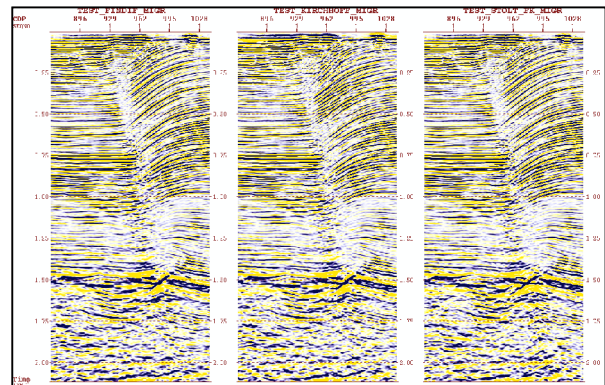
Stack muting was done for maximum time amplitude tapering with Ramp length 200ms.mute time was fixed at 5780 ms.



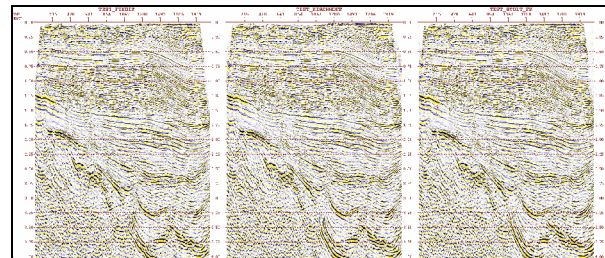
Migration velocities field

Migration:

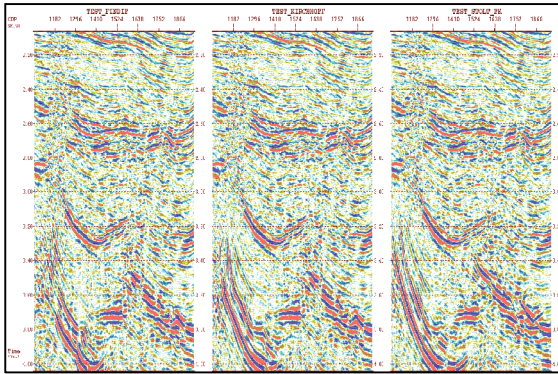
2D migration was done by using Finite-Difference migration, Kirchoff migration and Stolt migration. The Finite-Difference algorithm has been selected to obtain true imaging with max dip - 7ms/trace, layer - 24ms (3900) and 80ms (6000).



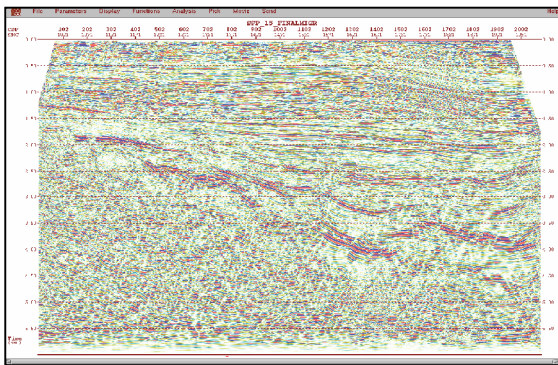
Finite difference Kirchoff Stolt
Stacks after migration with different algorithms



Finite difference Kirchoff Stolt
Stacks after migration with different algorithms



Finite difference Kirchhoff Stolt
Stacks after migration with different algorithms



Final migration stack 450-A02

Spectral balancing:

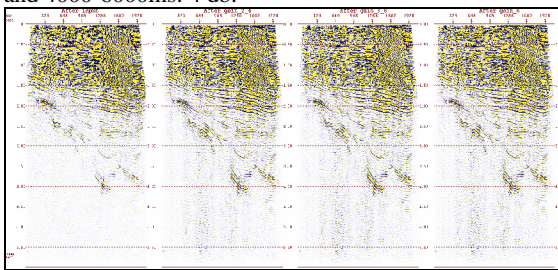
Spectral balancing (whitening) was performed by frequency scalars to flattening of amplitude spectrum to maximize time and dynamic resolution.

Parameters were as follows:

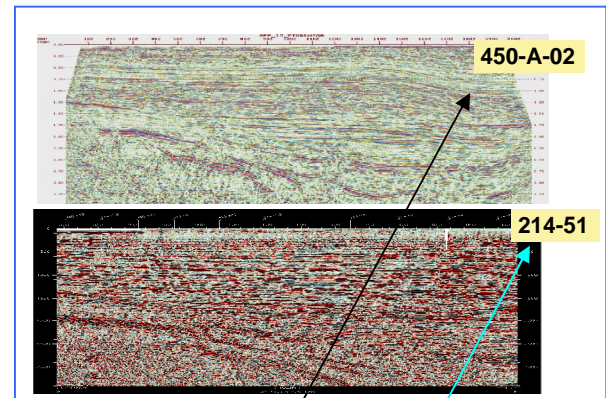
6-30 Hz (5), 30-110 Hz (10) and (0.001) till end.

TVF and scaling:

Time variant band pass filters 8-12-90-100 (0-1800ms), 8-12-70-80 (2500-4000ms), 6-12-50-60 (4000-6000ms) are used. Mild Scaling was selected as follows: 0-2000ms: No Scaling, 2000-4000ms: 2 db and 4000-6000ms: 4 db.



In all, processing parameters for marine and land parts are no different except for spectral balancing. Perfect spectral balancing parameters are very much necessary as those are the ones which make section look alike in all the three zones including the places where the transition from one zone to the other occurs. Line no.450-A-02 is one such line which is passing through the entire three zones. Spectral balancing on that line has eliminated all the differences and hence the same parameters were selected.



Comparison between OBC and old 2Dline

Conclusions:

The efforts taken to acquire good quality data have become fruitful as the end product is of good quality. Data acquisition and navigation QC tests have built up confidence. Processing parameter fixed onboard on seeing different test panels. Velocity analysis is done based on old data and understanding from brute stacks, with precision. Post stack migrated data processed is delivered to the basin and the client feedback on the earliest and timely output is good and able to help the client in preliminary understanding of the block before going to final interpretation with PSTM output at a later stage.

Acknowledgements:

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