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**Improving the seismic imaging in Assam and Assam Arakan Basin :
A case study**

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Summary

The shooting geometry plays an important role in the success of a 3D survey. Proper azimuth and offset distribution are the key factors in the acquisition geometry. In addition to acquisition geometry, recording system also plays an equally important role in seismic data acquisition. There are number of tools/techniques in processing to focus and image the seismic reflections from the subsurface and work well for enhancement of seismic signal. But the first and foremost objective is to record the seismic signature from the subsurface.

This paper deals with imaging problem in complex geological setting of North of Khoraghat area in Dhansiri valley of Assam and Assam Arakan Basin which is situated in the North Eastern part of India. Seismic imaging in such complex areas has been a challenge for data acquisition & processing geophysicist. Different types of acquisition geometries had been tried & discarded in solving such type of problems. Due to advancement in technology, different types of acquisition geometries now can be simulated sitting in computer centre. Different types of acquisition geometries were simulated & their attributes were analyzed. This study suggested slant shooting geometry with eight shot & eight receiver lines swath & was finally adopted for data acquisition in the study area. This geometry has resulted in better data acquisition and delineation of small faults due to wide range of azimuths. Final processed data volume had significant improvement in continuity, standout & resolution of reflection events and thus enhancing the interpretability for structural & stratigraphic details.

Introduction

Data acquisition in the study area was done in two phases. In the first phase, part of the area was covered with eight shot / four receiver lines swath shooting geometry using two DFS-V seismic units each having 120 channels capacity (total channel 240) & sixty channel per receiver line making the spread of 2950 mt. In the second phase, rest of the assigned area was covered with eight shot / eight receiver lines swath, slant shooting geometry using state of the art technology UL-408 wire line telemetry seismic recording unit for high resolution survey with adequate foldage overlap. Seventy two channels per receiver line were laid which makes the spread of 3550 mts & total active channel 576. Seismic data acquisition system, 408UL, can handle a large number of channels with very good line control/monitoring support tools.

In the eastern part of the study area, data was acquired with pattern shot holes of three to four meters of depth due to drilling problem as thick boulder section did not allow to drill beyond three to four meters. Data recorded with pattern shot holes was contaminated with low frequency and shot generated ground rolls. Before stacking the data, it was necessary to enhance & balance the frequency spectrum of pattern shots comparable with single shot hole data(i.e. Common frequency band). Hence spectral balancing was done to bring pattern shot holes data at par with single shot hole data (i.e. common frequency band).

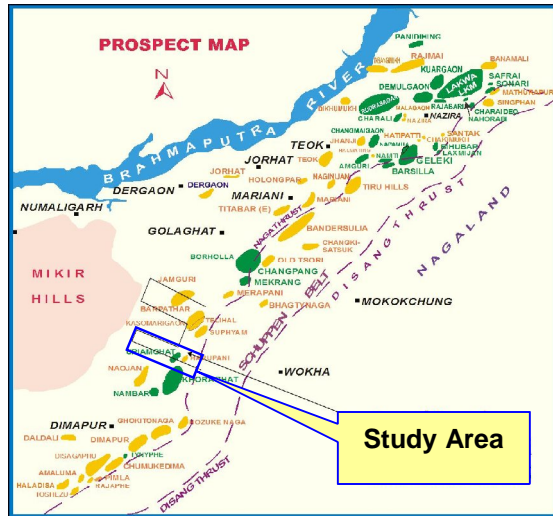
The study area is highly complex in nature with faults having throw of 300 milliseconds to 400 milliseconds. Enough shot record length was kept to faithfully record and preserve the



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diffracted energy generated from fault planes for proper migration and fault clarity.

Location Map of the area



Brief Geology of the area

The study area lies in Dhansiri Valley of Assam & Assam Arakan Basin and covers Uriamghat field. The stratigraphy consists of Metamorphic Archaean Basement overlain by Basal Sandstone (Tura formation) of Paleocene age. Sylhet Formation of early- middle Eocene age which is the producer in Khoraghat Field conformably overlies Tura Formation and is overlain unconformably by Kopili Formation.

Kopili Formation is predominantly argillaceous unit and is divisible into lower Charali member and upper Amguri member. Barail group is predominantly argillaceous and is differentiated into Demulgaon Formation (BMS) and Rudrasagar Formation (BCS) and is prolific producer of hydrocarbons in Khoraghat area.

A regional unconformity separates Barail Formation from Bokabil Formation. Bokabil Formation consists of lower shale unit having sporadic sand units within and the upper marine regressive Khoraghat sandstone.

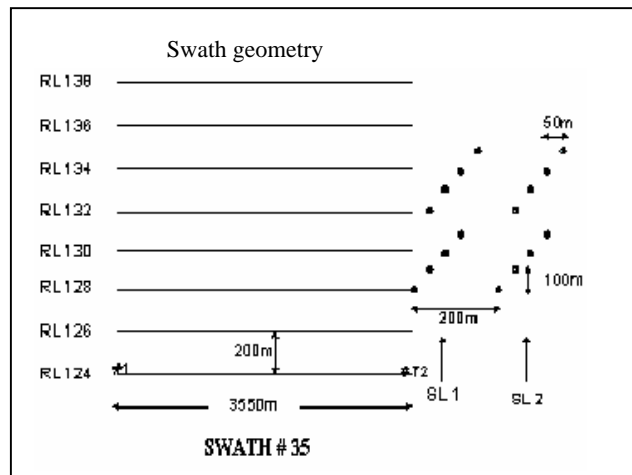
Tipam group of Mio-Pliocene age conformably overlies Bokabil Formation which is predominantly arenaceous. Moran group of Plio-Pliocene age unconformably overlies Tipam group. Tipam group is divided into lower Namasang Formation and upper Dekiajuli Formation. The alluvial of Brahmaputra and its tribulation unconformably overlies Moran group.

Data acquisition

Data acquisition in the study area was carried out adopting "Slant shooting geometry" in single phase only with following field & recording parameters.

Group interval	: 50 m
Shot interval	: 100 m
Receiver line interval	: 100 m
Source line interval	: 200 m
Bin size	: 25 m x 50 m
Total bin multiplicity	: 36(9x4) fold
No of receiver lines per swath	: 8
No of shot lines per swath	: 8
No of active channels	: 576
Type of geophone	: sm-24
Receiver array type	: array / bunched
Near offset	: 0 m to 200 m
Spread length	: 3550m
Far offset	: 3750 m
Swath roll-over	: SW to NE
Spread roll- on	: NW to SE
Shot hole depth	: 1 m – 24 m
Shot hole pattern	: single & pattern
Energy source	: dynamite
Charge size	: 1.0 - 4.0 kg
Record length	: 5 sec
Sampling interval	: 2 ms
Low cut filter	: out
High cut filter	: 200 hz
Recording unit	: UL-408
Data format	: SEG-D

Acquisition Geometry lay out



Data processing

The data was thoroughly examined for bad, reverse and leaky channels & corrective measures were taken to edit them. For optimum gain compensation, spherical divergence correction was applied using derived medium velocity. These velocities corrected the data for geometrical spreading in true sense. Data of single and pattern shots was brought in common frequency band and then surface consistent amplitude balancing was done to normalize the data. Merging issues in this study do not arise as the data was acquired in single phase only.



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As the conventional processing flow could not improve the data quality of phase-I, it was necessary to formulate a different processing approach/scheme to improve the data of phase-II. Processing parameters were optimized very precisely at the different stages of processing. This strategy worked well in bringing the expected improvement & achieving the set geological objective.

The following important processing steps were significant in improving the data :

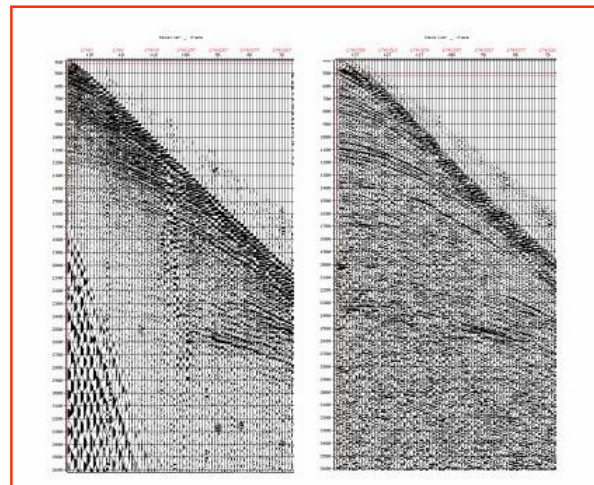
1. The application of spiking deconvolution and spectral balancing has significantly improved the overall section by suppressing ground roll, enhancing the signal bandwidth and removing ringing energy. Spectral balancing was the most useful and effective tool in improving the data in this study & specially in the pattern shots region. This process effectively eliminated frequencies below ten Hz and above seventy Hz and substantially reduced the spectral peak attributed by the guided waves.
2. Stacking velocities in 3D fashion were determined from composite velocity analysis in a grid of 250X250 mts to produce best stack and bring out the events that were often missed by coarse velocity analysis & because of the rapid lateral velocity changes. This procedure yielded the best improvement in stand out, continuity and resolution of reflection events. Spectral balancing proved very effective in bringing out quite good resolution of stacking velocities and their easy interpretability.
3. Application of two pass surface-consistent residual static corrections improved the continuity of reflections by resolving the statics caused by rapid variations in near surface.
4. Dip move out (DMO) invariably helped to resolve structures in areas having conflicting dips and improved the imaging. It also made the interpretations of the velocity analysis easier and suppressed the over all noise level.
5. Migration process increased the spatial resolution by collapsing the diffractions and moving the events to their true reflecting positions.

Processing Steps :

Data conversion
Geometry
Editing
Spherical divergence correction
Pre-filtering
Spiking deconvolution
Spectral balancing
Velocity analysis-I
Residual statics-I
Velocity analysis-II
Residual statics-II
DMO Velocity analysis
DMO stack
Random noise attenuation
Deconvolution after stack
Migration

Results & Discussions

Raw shot gathers were thoroughly analyzed for different type of source generated noise masking the signal. Fig.1 & fig. 2 show raw shot gathers & their frequency spectra for single & pattern shots.





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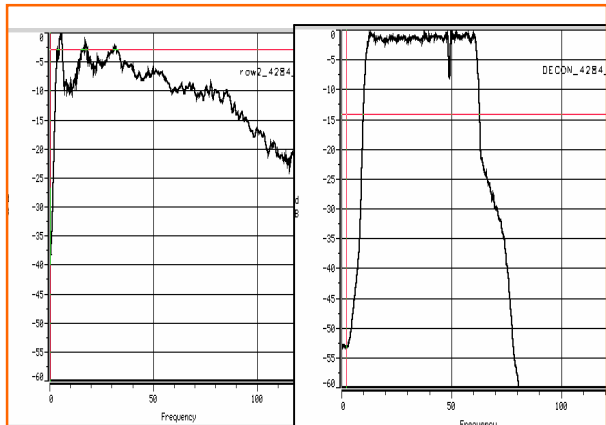


Figure 1(b) : Single shot frequency spectrum before & after spiking deconvolution - spectral balancing

The frequency analysis tests on the raw shot gathers suggested that the best way to attenuate these surface noises & balance the frequency spectrum was to apply spiking deconvolution & spectral balancing on a trace-by-trace basis. A representative comparison of the raw field record of single shot before & after spectral balancing is shown in figure 1(a), its frequency spectrum in figure 1(b) which shows the significant degree of amplitude balancing that has helped to suppress the ground roll & enhanced the signal bandwidth. This was achieved without sacrificing lateral continuity & resolution.

A representative comparison of the raw field record of pattern shot before & after spectral balancing, fig. 2(a), its frequency spectrum, fig. 2(b), shows the significant degree of amplitude balancing that has helped to suppress the ground roll & enhanced the signal bandwidth. After spiking deconvolution & spectral balancing the frequency spectrum of pattern shot, fig. 2(b), is almost matching with frequency spectrum of single shot, fig. 1(b). By above process all the data was brought in common frequency band & then further processing was done.

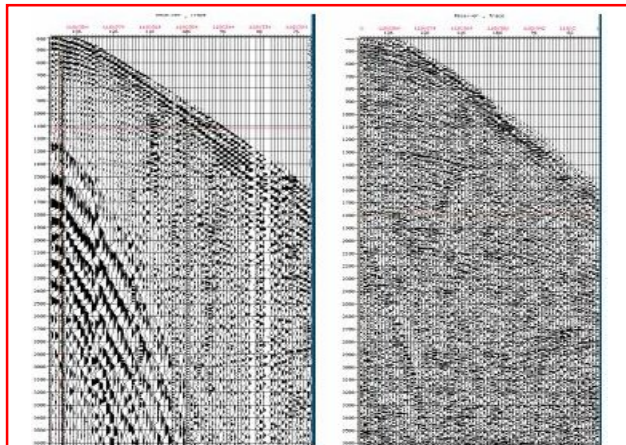


Figure 2(a) : Pattern shot before & after spiking deconvolution - spectral balancing

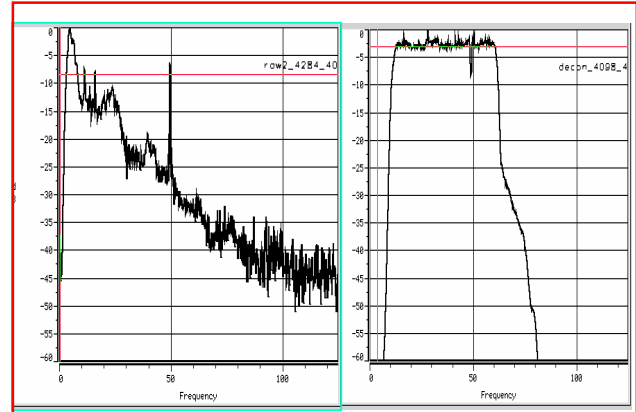


Figure 2(b) : Pattern shot frequency spectrum before & after spiking deconvolution - spectral balancing

Spectral balancing not only helped in improving the signal bandwidth but it also helped a lot in determining the stacking velocities more accurately & confidently which in turn produced best stack. Composite velocity analysis, fig.3, demonstrate the very good resolution of velocities & their easy interpretability.

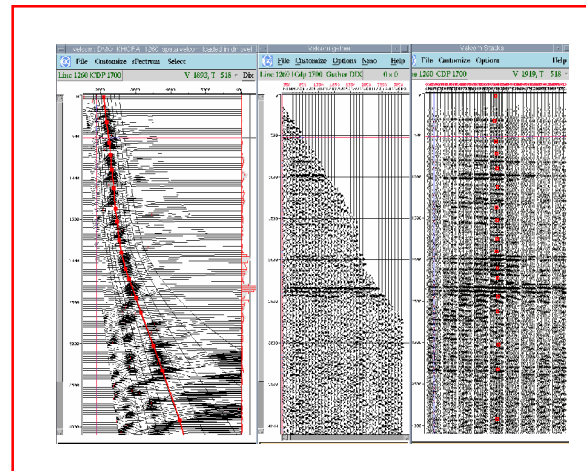


Figure 3 : Composite velocity analysis after spiking deconvolution & spectral balancing

Furthermore, velocity analysis confidence was increased on DMO corrected gathers. The final section, figure 5, shows significant overall improvement in continuity & resolution of reflection events brought out by spiking deconvolution & spectral balancing specially in pattern shots region. The detailed velocity analysis in a grid of 250X250 mts paid rich dividend in enhancing the subsurface image in complex geological setting.



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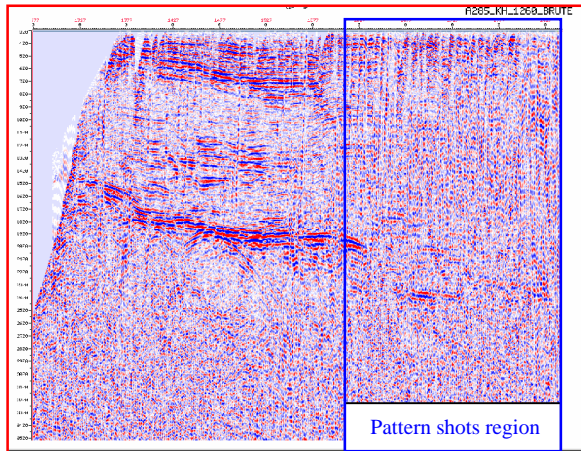


Figure 4 : Brute stack

Brute stack, figure 4, shows poor image of the subsurface in the eastern part of the line as indicated in the box where data was acquired with pattern shots as drilling was not possible in this part due to thick boulder section. Though, the imaging quality is satisfactory in the western part where data was acquired with single shot.

To improve the imaging quality of data with pattern shots, processing tests suggested for enhancing signal strength & balancing the frequency spectrum which was best achieved by application of spiking deconvolution & spectral balancing on a trace-by-trace basis. This process helped quite a lot in improving the over all imaging quality & signal bandwidth of data & brought out remarkable improvement in the part of the area with pattern shots as it is demonstrated in the fig.5.

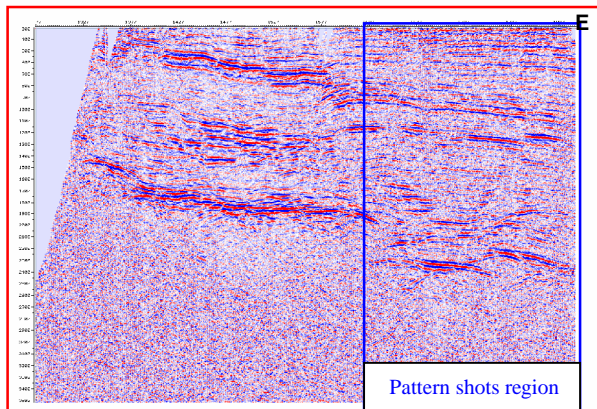


Figure 5 : Stack after application of spiking deconvolution & spectral balancing

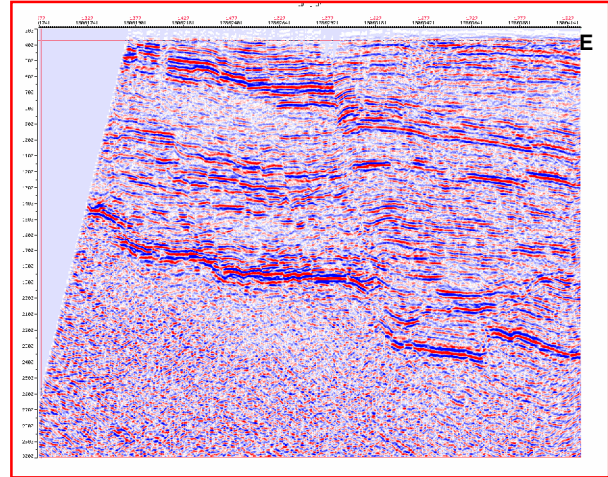


Figure 6 : Final migrated section

Final migrated section, figure 6, shows significant improvement in continuity, resolution & better stand out of reflection events with better fault pattern definition & clarity. High resolution data helped in easy interpretation of structural & stratigraphic details with fullest confidence. This all was attributed by best acquisition geometry which helped in recording all the details of the subsurface very precisely & faithfully and the processing scheme & efforts made in improving the smallest recorded seismic signature of the earth.

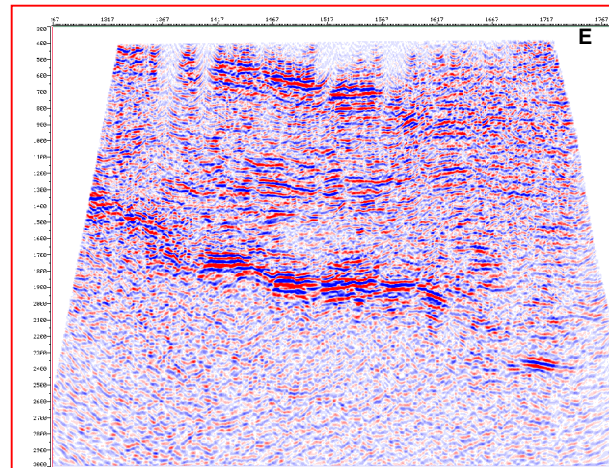


Figure 7 : Final migrated section (Old)

Figure 7 is a final migrated section of the same location (i.e. same CDP line) as of figure 6 falling in the overlap zone from the first phase of data volume. The improvement brought out by acquisition geometry & processing scheme is well demonstrated in figure 6 as compare to figure 7.



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Conclusions

1. Slant shooting acquisition geometry helped quite a lot in mapping the subsurface features more precisely & faithfully.
2. Spiking deconvolution followed by spectral balancing proved to be an effective tool for enhancing the reflected energy at the expense of surface waves.
3. Spectral balancing played significant role in balancing the amplitude & frequency of pattern/multi-shot hole data.

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