

Improvement in Structural Imaging in Tripura Fold belt using Swath-Line Geometry

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Keywords

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Summary

In spite of advancement in seismic data acquisition and processing, imaging in structurally complex area such as fold belts has improved marginally. In such geologically complex areas conventional approach to imaging did not yield satisfactory results. Though in such areas 3-D survey is more preferable but due to several constraints, acquiring 3-D data is not possible. Rough topography & difficult accessibility makes 3-D land seismic data acquisition prohibitively expensive. Conventional 2-D land seismic data has its own limitations especially in fold belt areas, difficult to image anticlinal portion properly. An alternative to conventional 2-D in such areas is swath-line recording geometry. Swath-line recording provides much higher fold (720 fold in the present case) than typical 2-D land surveys, thus provides data with a much higher signal-to-noise ratio.

Introduction

Tripura area is located in the north eastern part of India and forms a part of Assam-Arakan frontal belt, characterized by a number of N-S trending long narrow elongated anticlines and broad flat intervening synclines, occurring in an en-echelon fashion. Located in this area, Baramura field is an asymmetric doubly plunging anticline trending roughly NNE-SSW. Tectonically Baramura falls in the frontal folded belt of Tripura, which is the western continuation of the Surma Valley folded belt. The eastern flank of Baramura structure has been affected by a thrust dipping westward and main hydrocarbon potentiality is in Bokabil and Upper Bhuban formations of Miocene age. The seismic exploration in this area is hindered

due to tough logistics, lack of accessibility and most importantly technological limitations. The conventional approach to seismic data acquisition and processing does not provide better imaging. There is a need to look into possibilities of unconventional geometries and processing algorithms.

Methodology

Swath-line data was acquired as a practical alternative to conventional 2-D land data acquisition to map anticline in an area of north eastern part of India with rough topography and difficult accessibility (Fig. 1).

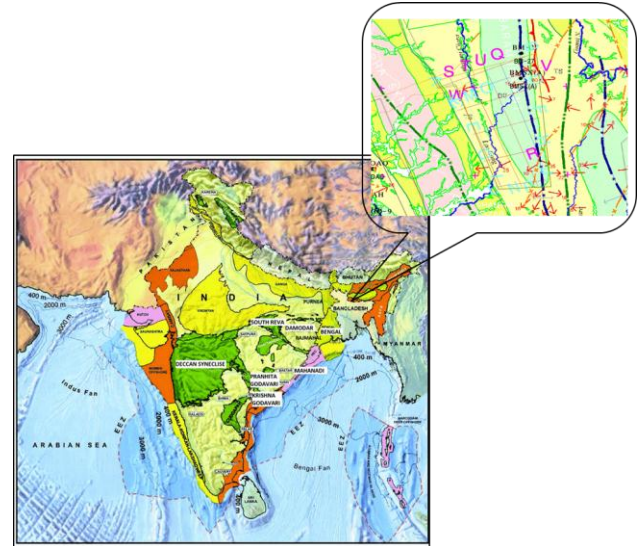
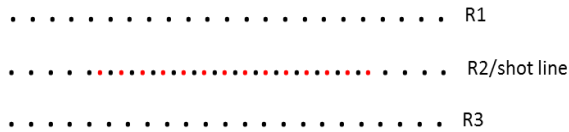


Fig. 1: Location of the study area in Tripura.

Total nine 2-D swath-lines data have been acquired along the South Baramura anticline, six lines along the dip direction & three lines along the strike direction to map anticline properly. The surface condition along the swath-line varies with large elevation differences from

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10 meter covered landscape to 150 meter hilly terrain along the line traverse (Fig. 3). The recording geometry consists of three receiver lines at 40 m separation and a single shot line along central receiver line (Fig. 2). The receiver's interval is 10 m. Symmetrical split spread geometry with 480 + 480 active channels in each receiver line & total 2880 channels in an active temple being used. Full-fold coverage along the CMP line is 720(360 in one strike line with 40 m shot interval), significantly higher than the fold that can be attained by conventional 2-D surveys.



Receiver line spacing	40 m
Receiver interval	10 m
Shot interval	20/40 m
Number of channels per receiver line	960
Number of receiver lines	3
Total number of channels	2880
Number of shot lines	1
Min/Max offset	5/4800 m
Fold along the CMP line	720/360

Fig.2: The swath-line recording geometry

The swath-line recording geometry is much like conventional marine recording geometry, and unlike the orthogonal recording geometry. The source-receiver azimuthal coverage in the case of the swath-line recording geometry is narrow and confined largely to the swath direction.

Data Analysis

It is important to note that the swath-line data must be treated as 3-D data during most of the stages of processing, including near-surface modeling and subsurface imaging. The nonlinear travel time tomography (Zhang and Toksoz, 1998) was applied to the first-arrival times picked from the shot gathers and estimated a near-surface velocity model for statics corrections (Fig.4).

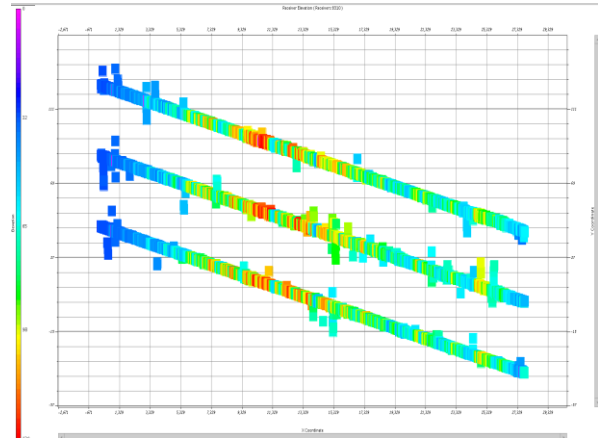


Fig. 3: Elevation profile of receivers along the swath line.

In conventional processing scenario, statics applied on the geometry merged gathers are actually supplied by field crew and derived on the basis of near surface model estimated using sparse up-hole data or shallow refraction survey.

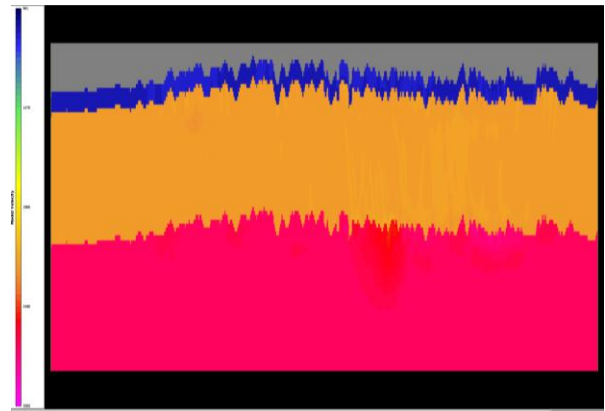


Fig. 4: Near surface model for computation of refraction statics.

But in this case field statics is no longer valid (statics comparisons have been shown in fig. 5) due to highly undulated acquisition surface and complex near surface geology. Extreme cautions regarding preservation of signal has been exercised during processing: geometric spreading correction followed by cascaded application of noise attenuation in the shot and CMP domains, aimed to reduce the strength of surface waves and guided waves.

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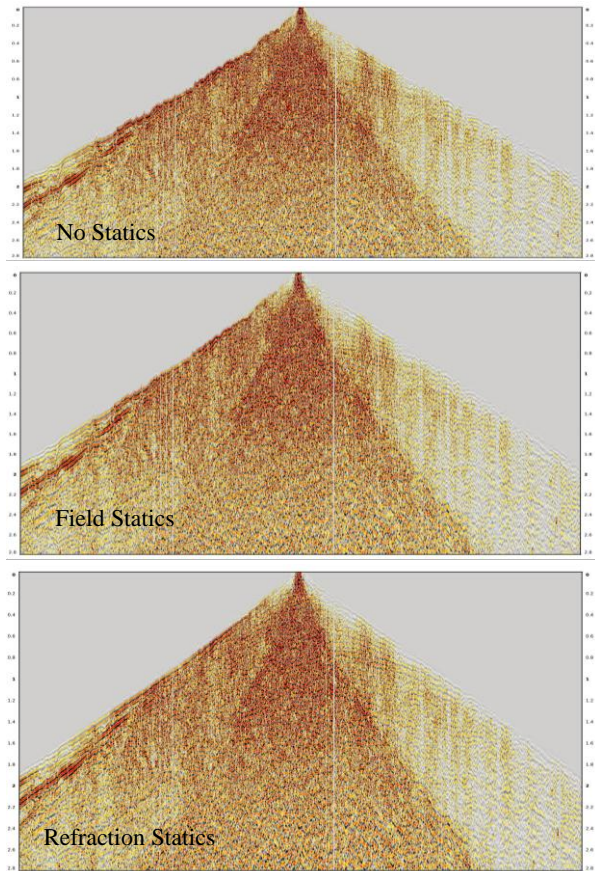


Fig.5: Improvement of events after refraction static application.

In fold belt seismic data especially in this case; over exposed anticlines signal-to-noise ratio (S/N) is very poor & reflection hyperbolic pattern is hardly observed. In structurally complex areas out of plane reflections are very common. Hence it is important to get rid of masked noise in data cautiously. As most of the noise removal algorithms presume that signal strength is sufficient than noise whereas in this area the S/N is small which forces to carry out frequency dependent noise attenuation in narrow bands and thereby enabling searching of anomalous amplitudes & subsequent attenuation. Later on noise attenuation carried out in post stack level.

Velocity analysis plays a very crucial role in this data. Consistent reflection hyperbola are nearly absent at gather level; it becomes difficult to carry out velocity analysis based on flattening of hyperbola. Semblance based approach with super gather mode also does not give much reliable estimate of the velocity. Under this circumstances constant velocity stack method (CVS) of velocity analysis is helpful to give an initial estimate of velocity. Repeated refinement of CVS velocity is carried out to get the best stack result. In order to pick CVS based velocity a prior knowledge of geological structure is must.

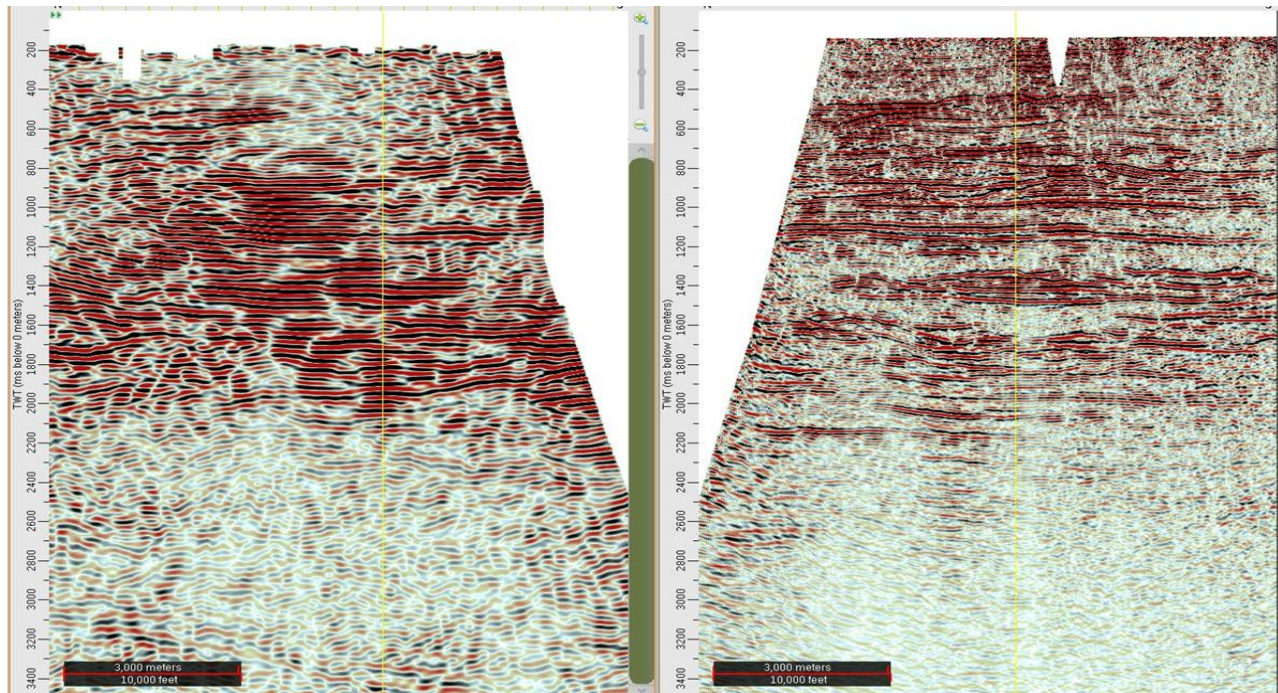


Fig.6: Stack of vintage 2D RI: 40m, SP: 80m, Symmetric-Split Spread 240channels with 60-fold data (left) and swath-line 2D RI: 10m, SP: 40m, Symmetric-Split Spread 2880 channels with 360-fold (right) only in overlapping area.

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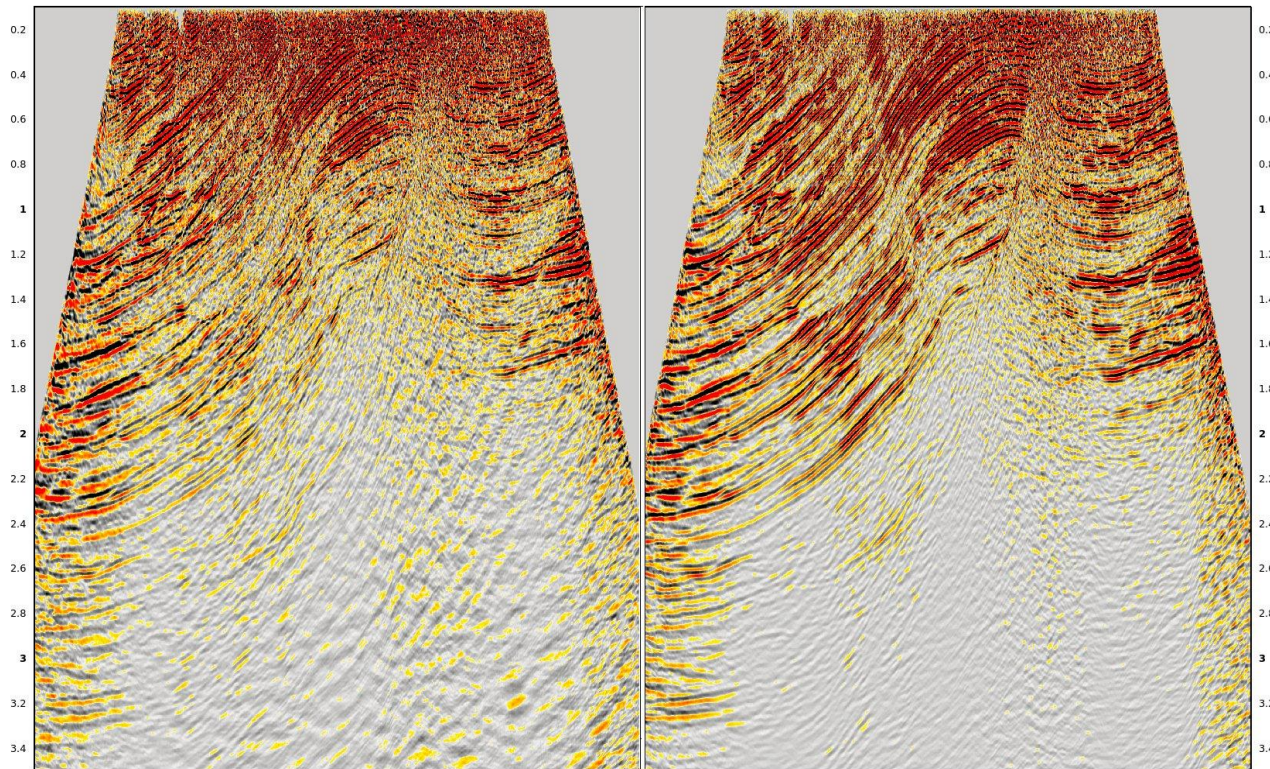


Fig. 7A: Stacks of swath-line with single receiver line (left) and with three receiver lines (right) along dip direction.

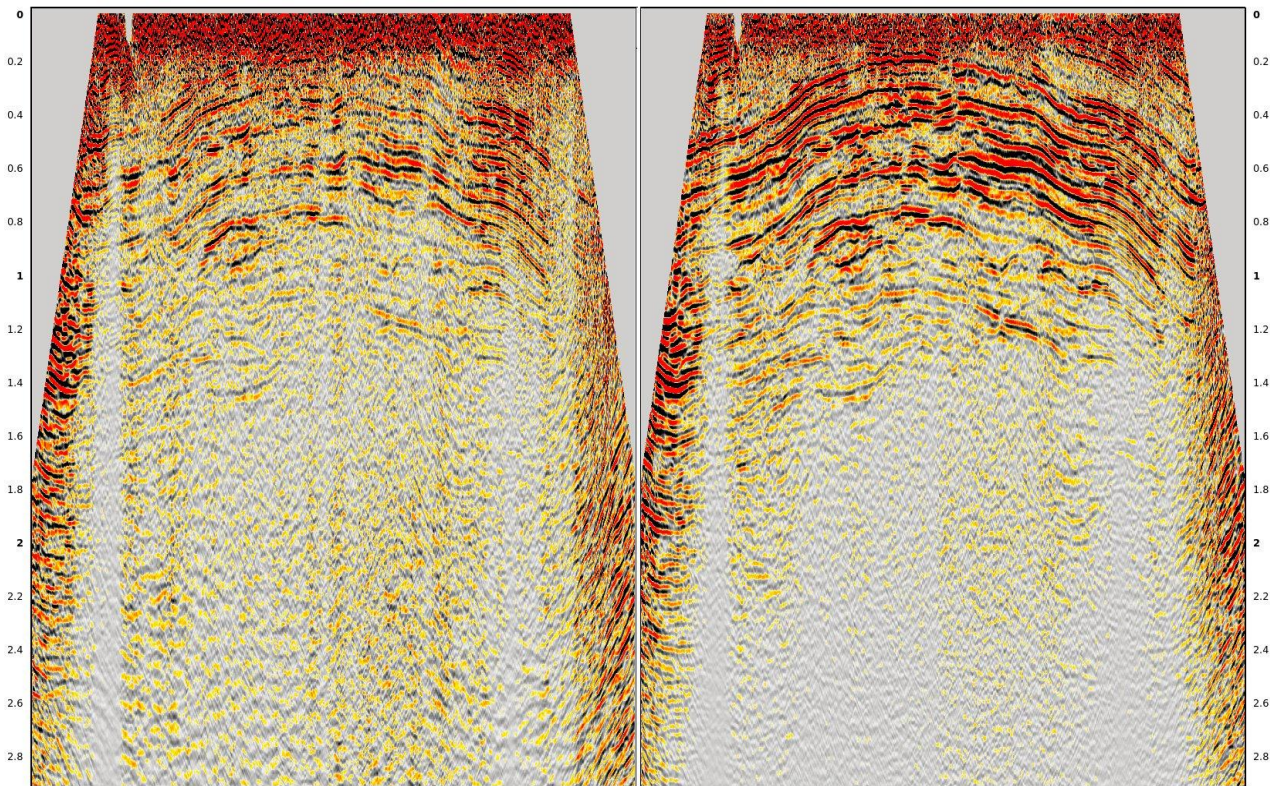


Fig. 7B: Stacks of swath-line with single receiver line (left) and with three receiver lines (right) along strike direction.



Final stack compare with vintage 2D in small overlapping area shown in fig. 6, the improvement in the signal-to-noise ratio by swath-line recording markedly evident.

For comparative study same data have been processed by selecting seismic data along central receiver line only, which is similar to the conventional 2-D geometry. The same processing parameters were used in processing both the dataset: single receiver line dataset and full swath line dataset. The results were compared in both along dip and strike direction as shown in fig. 7A and 7B.

Result

Image quality is better in swath line processing as compared to that of single line (conventional 2-D). Resolution, both vertical & horizontal got enhanced; fault demarcation and structural delineation were observed to be better in the case of swath line geometry.

Conclusion

In the current study it is shown that in onshore fold belt areas having severe topography and difficult accessibility, where conventional 2-D seismic data acquisition fails to provide adequate image, while 3-D acquisition is too expensive and logistically very onerous, *high-fold Swath-line data acquisition* is a better over-all option. Swath-line data, however, must be treated as 3-D data during all significant stages of processing. Swath-line recording and processing provides much higher foldage along with significant improvement in S/N ratio, and thus provides a superior subsurface image in such areas.

References

Singh, P. K., Das Gupta, R., Singh, N.P., "Thrust Belt Imaging: Challenges and their possible solutions with special reference to Upper Assam Basin". 10th Biennial International Conference & Exposition on Petroleum Geophysics, Hyderabad-India, P-205.

Zhang, J. and Toksoz, M. N., 1998, Nonlinear refraction travel time tomography: Geophysics, 63, 1726-1737.

Yilmaz O., 1987, Seismic Data Processing, Tulsa: Society of Exploration Geophysicists.

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