

The Use of Seismic Attributes to Enhance Fault Interpretation – Case Study of Banskandi Field, Assam Arakan Fold Belt

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Keywords

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Summary

Seismic exploration in compressed anticlines of fold belt areas is a challenge worldwide. Banskandi anticline of Cachar Fold Belt was covered by Wide Azimuthal Seismic Survey. The data like conventional seismic data has low signal-to-noise ratio as we approach the anticline due to subsurface conditions as well as shadow zone created around the limb of anticlines. An integrated approach to the study of the fault patterns and seismic attributes was carried out on a part seismic data covering approximately 32 Km² of southern part of the Banskandi Field. This study aimed at improving the visualization of faults in the study area using three different filters: the dip-steered median filter to remove random noise and increase the lateral continuity of reflections, the dip-steered diffusion filter to sharpen the faults and the fault-enhancement filter used to enhance the discontinuities of the reflections.

The seismic volume was subjected to several stages of post-stack processing to remove random noise and enhance discontinuities. First, a raw-dip-steering volume was created. Several dip-steered filters were then applied to enhance faults and fractures visualization. Finally, similarity and curvature attributes were calculated on the dip-steered and fault enhanced volume. These final attributes helped detailing the geometry of the fault system and the numerous subtle lineaments in the study area with increased confidence in the seismic mapping of the faults. Similarity and curvature attributes of the seismic volume preserve subtle structural details and permit a more robust interpretation of the structures.

The workflow demonstrates the usefulness of volumetric seismic dip and curvature computation in rapid analysis of discontinuities prior to detail structural interpretation and would add to confidence with which wells can be placed in fold belt anticlines to avoid drilling hazards.

Introduction

Over the years, several Seismic attributes form an integral part of qualitative interpretative tool used by geoscientists to delineate geological features for oil and

gas exploration. The tools become of utmost importance in folded belts wherein challenges of interpreting folded anticline structures in seismic data is ability to distinguish seismically resolvable and sub-seismic scale (subtle) faults. The resolution limits of the seismic data acquired in logistically and tectonically difficult areas impact negatively on the resolvability of seismic events. Though the seismically resolvable faults may be interpreted using traditional diagnostic criteria, the subtle faults which are usually not visibly imaged by the conventional seismic sections and time slices displays, multiple seismic attributes for accurate detection and mapping of faults and fractures have been utilised. Development in seismic attribute computation is the concept of volume extraction of multi-trace seismic curvature steered by seismic dip data. The technique of dip steered seismic data along with filters and attributes like similarity, coherency along with structural dips have been used for detecting discontinuities in deciphering faults related to folded anticline of Banskandi field in Cachar Area of Assam-Arakan Fold Belt.

Geological Context of the Study Area

The Banskandi Field is part of the Tripura-Cachar Folded foredeep sedimentary prism of the Assam-Arakan orogenic belt. The area comprises a series of

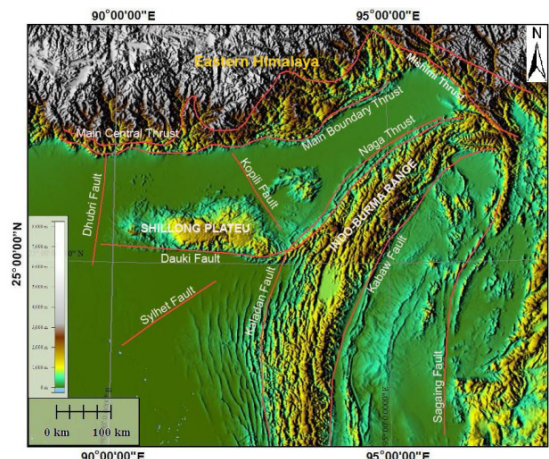
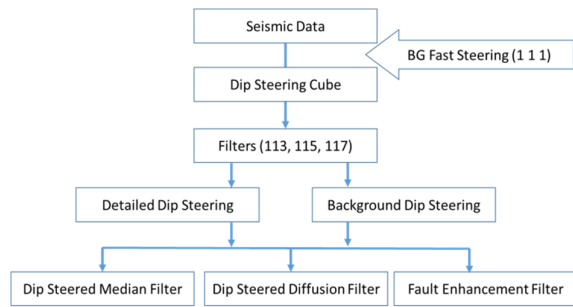


Fig 1. Tectonic Map of Tripura Cachar Fold Belt

sub-parallel, long, narrow doubly plunging anticlines arranged in an echelon fashion. Degree of deformation increases due east with progressively older rocks exposed in the core. The sedimentation in this basin probably started with a breakup of the Gondwana land in Jurassic and Cretaceous and had been almost continuous since then. It is filled mainly by orogenic sediment derived from the eastern Himalayas to the north and the Indo-Burman ranges to the east. These deposits record uplift and exhumation of mountain belts formed by the ongoing India-Eurasia collision. The bulk of the deltaic deposits are Miocene and younger. The folded anticlines are subjected to high pressure drilling hazards met in lower Bhuban, discerning of faults would greatly help in proper placement of wells which are not properly imaged in raw seismic.

Workflow

An integrated approach was undertaken by utilizing steering cube using OpendTect software (dGB Earth Sciences). A summary of the workflow is shown in Figure 2 below. The first step involves generation of a raw steering cube which involves extracting local dip and azimuth of the seismic events in inline and cross line direction at every sample point from the seismic amplitude volume utilizing BG Fast Steering algorithm. The second step followed comprised a two steps filter process proposed by Brouwer (2007) to create the steering cube: (1) first filtering (size 0x0x3, 0x0x5 & 0x0x7 – inline/crossline/number of samples) to create the detailed steering cube; and, (3) second filtering (size



3x3x0, 5x5x0 & 7x7x0 – inline/crossline/number of samples) to create the background steering.

Fig 2 Workflow adopted for Fault Enhancement

The steering cube forms the foundation for the structural oriented filtering of seismic volumes, enhancing multi-trace attributes and eventually curvature attribute generation. The third step involved using structurally-oriented filtering like dip-steered median, dip-steered diffusion and fault enhancement filter (Figure 3). The dip-steered median filter removes the random noises and enhances lateral continuity of the reflections in the seismic data, providing a smoothing of the edge effect, increasing the signal to noise ratio. The dip-steered diffusion filter enhances the discontinuity of the reflection hence enhancing the faults. the fault-enhancement filter works as the combination of dip-steered median filter, dip-steered diffusion filter, steering cube and seismic data.

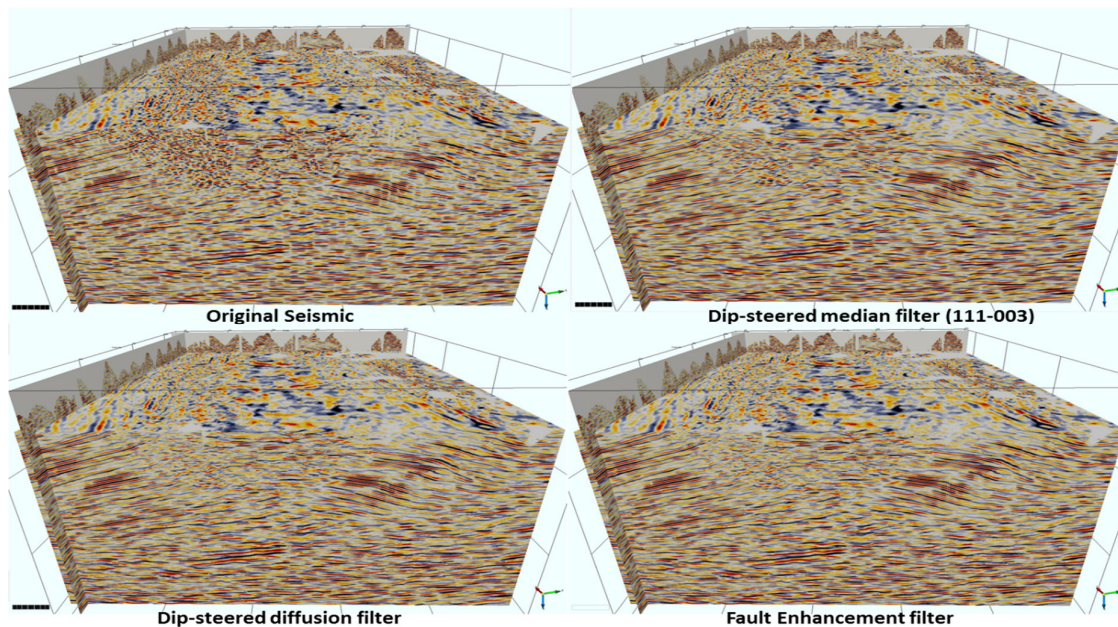


Fig 3 Fault Enhancement Filters

Results and Discussion

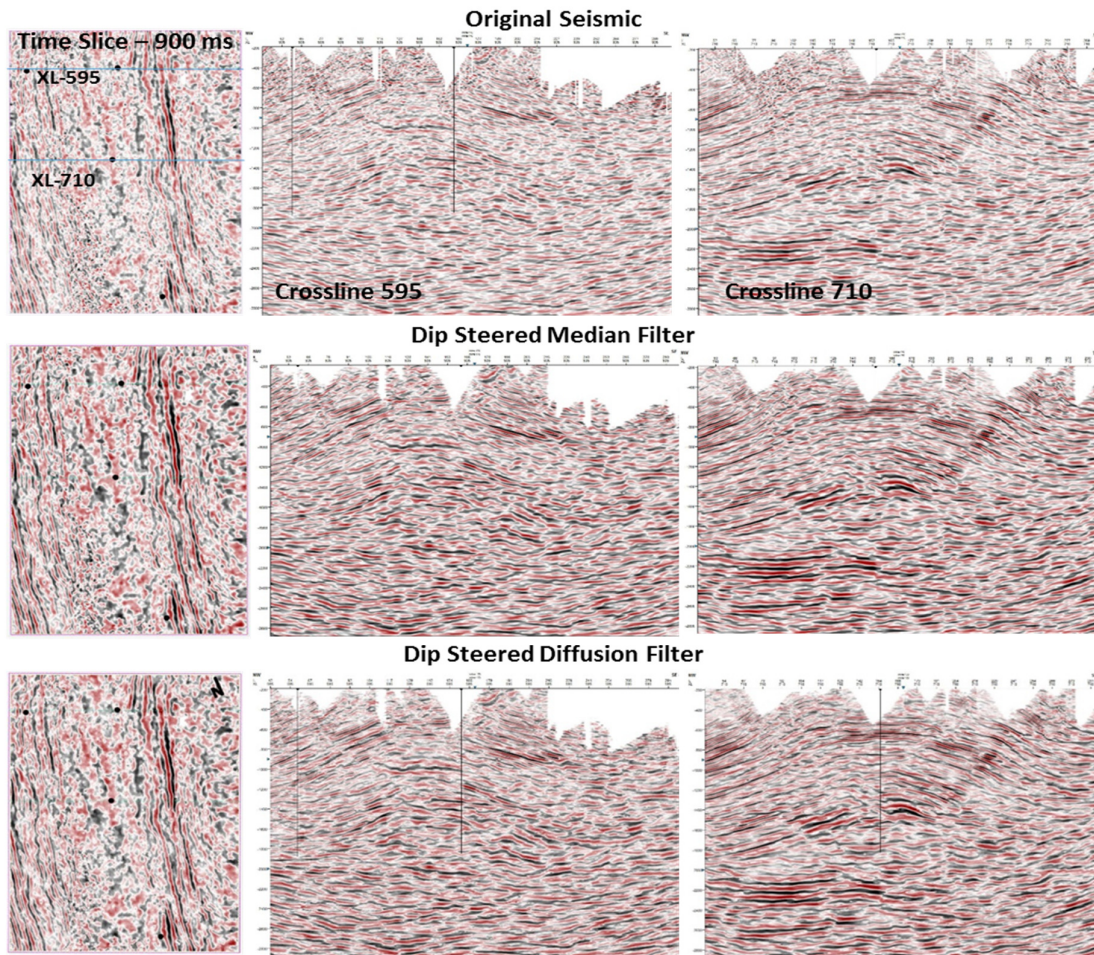
Fault Interpretation: The structural framework was constructed by picking fault segments on crossline 595 and 710 sections of seismic volume since they are passing through drilled wells. These faults are represented on the seismic sections as discontinuous reflection along a preferred orientation of reflectors or as distortion of amplitude around the fault zones. A total of five faults coded as: F1, F2, F3, F4 and F5 were identified on the crossline (Figure 4) using all the filtered structural oriented seismic data; The Faults F1 and F2 are the main thrust fault responsible for folding while F3 and F4 are antithetic faults. The F5 is cross fault cutting across the anticline is accentuated by fault enhanced filtered data on the time slices.

Fault Enhancement Filter: Figure 4 shows a series of amplitude time slice extracted from the seismic volume at 900 ms and adjoining crossline XL595 and

710 vertically stacked in order demonstrating raw seismic data, fault enhanced filter (dip median, diffusion and fault enhancement filter). We can clearly see how the filter has enhanced the edges and focus of the faults.

Attribute Analysis: Different attributes (i.e. dip steered similarity, 3D edge enhancement, Variance, ant track) were also run along with the fault enhancement filtered cube and comparisons were attempted on time slice to study the efficacy of enhanced fault filters. Slices were taken at 980 millisecond. Different attributes (Figure 6) extracted were used to study different subtle and sub-seismic faults missed by conventional seismic interpretation.

It was observed that the enhanced fault filters along with few attributes were effective in delineating faults in folded anticline zones.



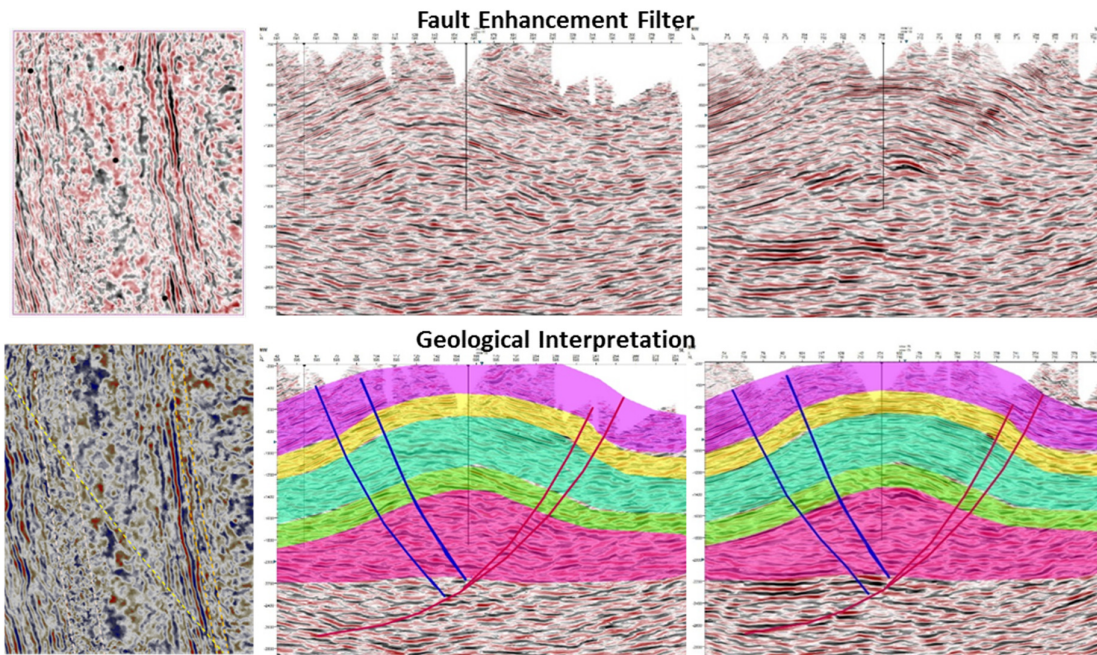


Fig 4 Various Fault Enhancement and interpretation thereof

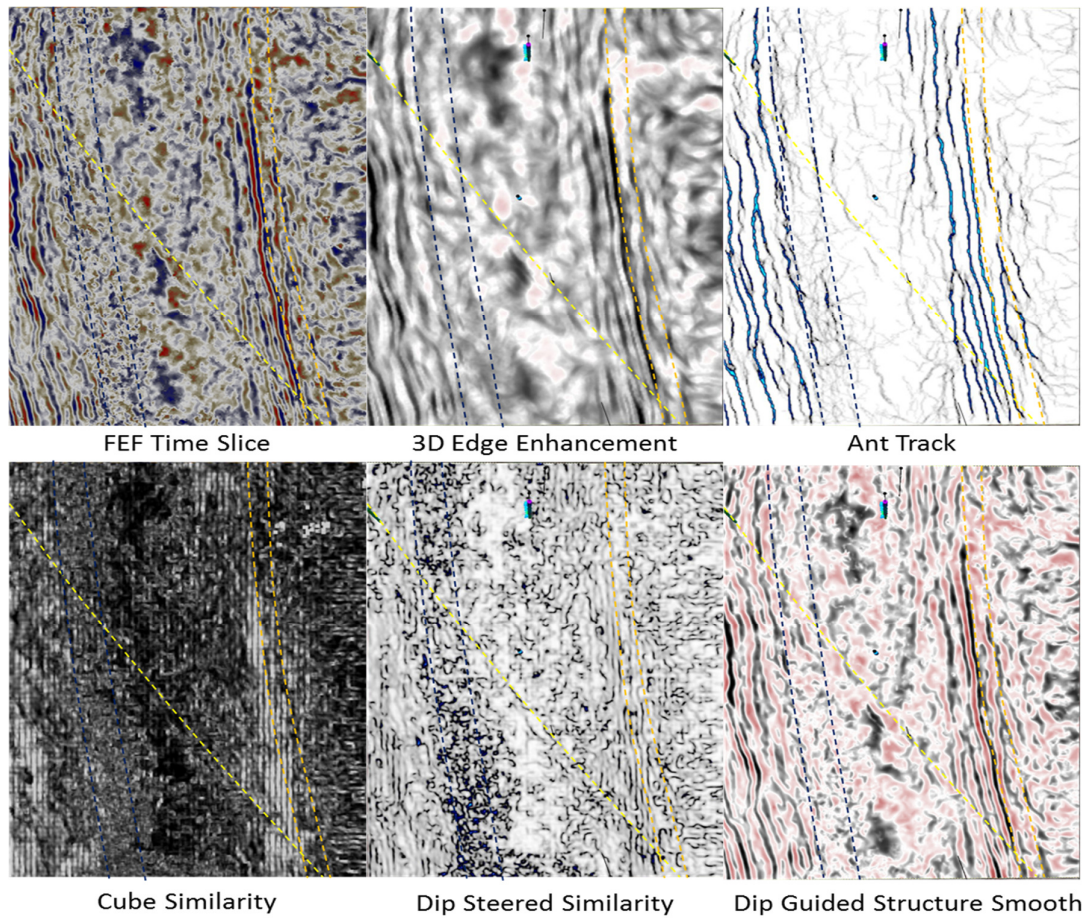


Fig 5 Fault interpretation based on various seismic attributes on time slice

Conclusion

Interpretation of the 3D seismic data for locating both seismic scales' and sub-seismic scales' structural elements has been demonstrated to be more efficient by the use of seismic attribute mapping and analysis. Various fault enhancement filters can be utilised in tandem for mapping fault in thrust fold belt areas where seismic imaging of fault forming the anticline is a challenge accentuated by the difficult logistic terrain. Identification of faults in fold belt to certain degree of confidence helps in placement of well as the deeper Lower Bhuvan occur in high pressure regime where in drilling hazard associated with faults can be planned with proper well engineering.

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