Imaging Sub-Thrust Over Langai Anticline-
A Model Based Approach

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Summary

Seismic exploration in complex tectonic regime is a major challenge for both acquisition and processing . Imaging the Langai anticline in the Cachhar area of Assam-Arakan fold belt is a classic example. Recently 2D seismic data was acquired along a few profiles with the aim to image sub-thrust over Langai anticline. Acquisition parameters were optimized with model based ray tracing , carried out with different geometrical parameters. Subsequently the data was processed with a judicious combination of an iterative method of field statics computation , multi stage velocity analysis at very close interval , far-offset limitation etc. The efforts brought out the complex sub-surface features with enhanced resolution to meet the exploration objectives.

Introduction

Geologically, Cachar area forms a part of Assam-Arakan frontal thrust fold belt. It typically exhibits sub-latitudinal, parallel to sub-parallel, elongate and en echelon folds, which display westerly convexity between 24° N due to wrenching. The area exposes a colossal thickness exceeding 10 km of clastic sediments comprising alternating succession of shale, mudstone, siltstone, and sandstone ranging in age from Eocene to Recent. Six mega litho-stratigraphic units viz. Disang, Barail, Surma, Tipam, Dupitilla, and Dihing were deposited under varying depositional environment from marine to brackish, marginal marine to fluvial. The stratigraphic succession over Longai anticline [2], covering an area of about 400 sq. km and bounded by Latitude 24°09’ 00" N & 24°33’ 00" N : Longitude 92°12’ 00" E & 92° 20’ 00" E is shown below:

Group	Formation	Thickness (m)	Lithology
Post Tipam	Dupitilla	900+	Mainly sandstone with clays
Tipam	Tipam sandstone	1500	Dominantly sandstones with interbeds of siltstone, clays and strings of lignitic coal
Surma	Bokabil /	1230/	Dominantly shale with minor clays
	Upper Bhuban	650+	Alternations of sandstones

Langai anticline is a doubly plunging, narrow elongated, tightly folded anticline having N-S to NNE-SSW trend with steep limbs. Its eastern limb is dislocated by prominent longitudinal reverse fault, which diminishes at both the plunging ends. Northern plunge is sharper than the southern with plunge dip of 10° towards north. Besides being delimited by north-south trending longitudinal faults, this structure is also dissected by six prominent cross faults resulting the structure into five sub-blocks. The core of anticline exposes upper Bhuban formation. Sand stones of younger formations Tipam & Dupitilla are exposed on the flanks. The Langai anticline is an exploration target due to its proximity to the gas producing Adamtilla field where Bokabil and Tipam formations are hydrocarbon bearing. Another interesting geological observation is the thickness of Bokabil formation in the exposed axial part along Hatikhira-Churaibari road traverse is 550 m over Langai anticline [1] .

Adjoining figures 1 and 2 depict the satellite image of the area and the location map for data acquisition with superimposed outcrops.

Following a brief introduction to regional geology and tectonics of the area , acquisition and processing methodologies are briefly described in section II. Section II also provides the processing sequences , pitfalls and the resulting post-stack migrated seismic sections of selected lines . Finally it has been concluded that a model based acquisition and judicious parameterization of processing variables are essential for imaging beneath the complex tectonic regimes.

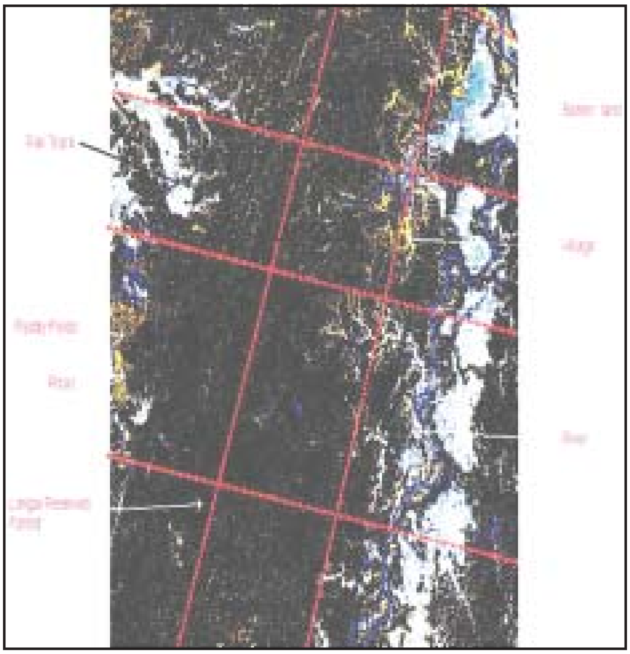

Fig.1. Landsat Image of the Area

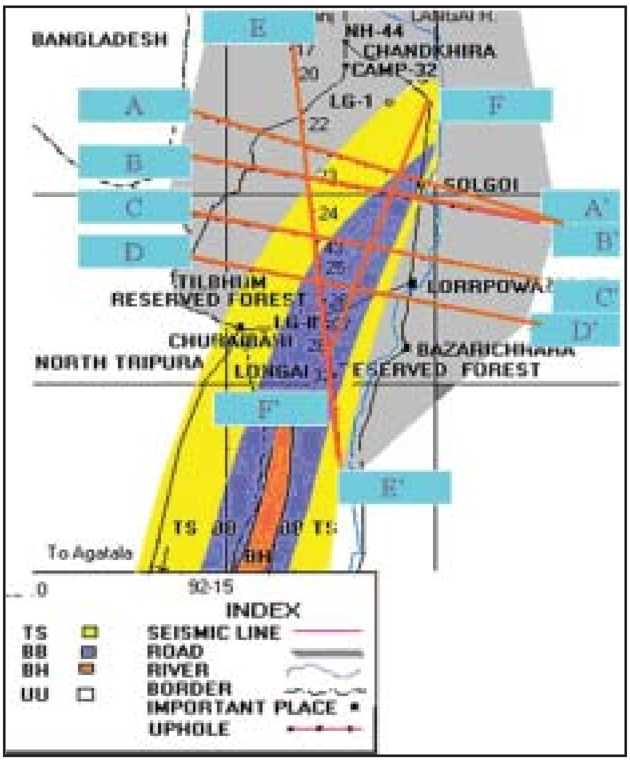

Fig. 2. Location Map with Outcrop

Methodology & Results

During data acquisition phase , a model based approach viz. ray tracing algorithm with different geometrical parameters , was used to generate synthetic traces. The model and the synthetic section with optimum acquisition parameters are shown in figures 3 and figure 4. Also during acquisition , near surface models were prepared with the help of Up-hole survey/shallow refraction survey at close grid for the optimization of shot hole depth .

The final parameters for acquisition of the 2D data is shown in Table I. Validation of the model was carried out by generating a synthetic section [Figure 4] with the model based velocity.

Table I. Optimized acquisition parameters.

Spread geometry	End On/ 160 channels
Record Length	5 Seconds
Sampling Interval	2 ms
Offset Range	25m /4000 m
Group Interval/ Shot Interval	25 m/ 50 m

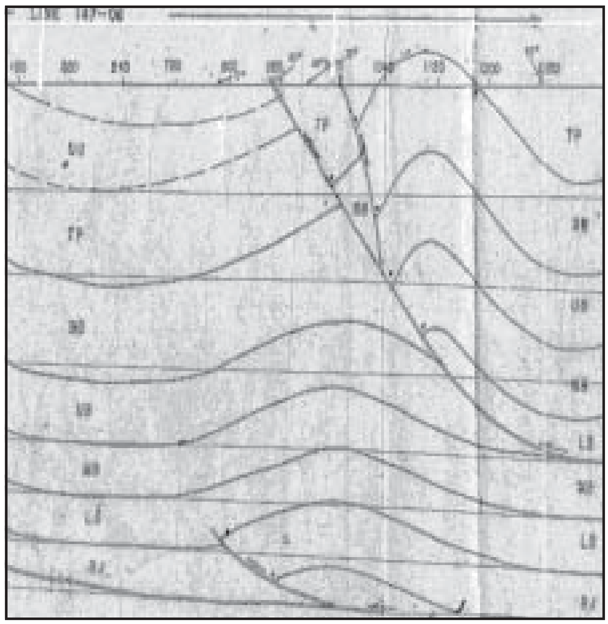

Fig. 3 . 2D Geological Model of Line CC'

After application of different field statics, brute stacks were taken , compared qualitatively and best field statics were used in subsequent processing . field statics were re-calculated using the up-hole values against each shot depth recorded at the time of seismic data acquisition. Proper smoothening of the erratic uphole values, considering the elevation and shot hole depth of the shot point was done. Shot and Receiver points were brought to the base of weathering layer (LVL) using smoothened up-hole values.

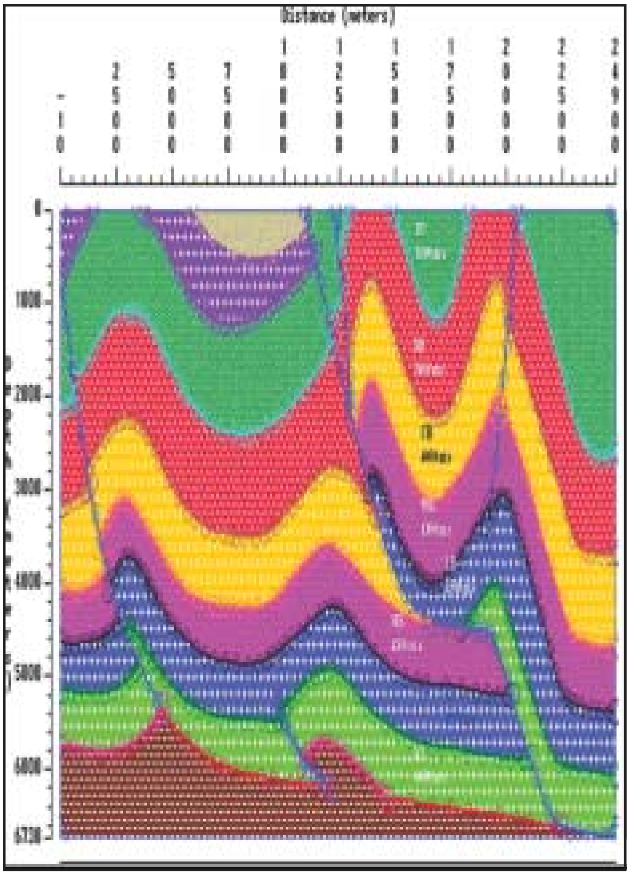

Fig. 4. Synthetic section

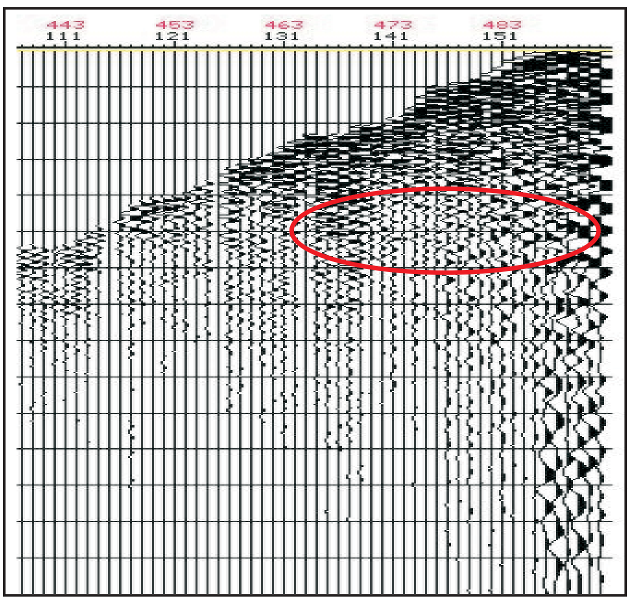

Fig.5. Sample Gather

To bring out the shot point and receiver point to MSL, stacks were generated with different values of sub-

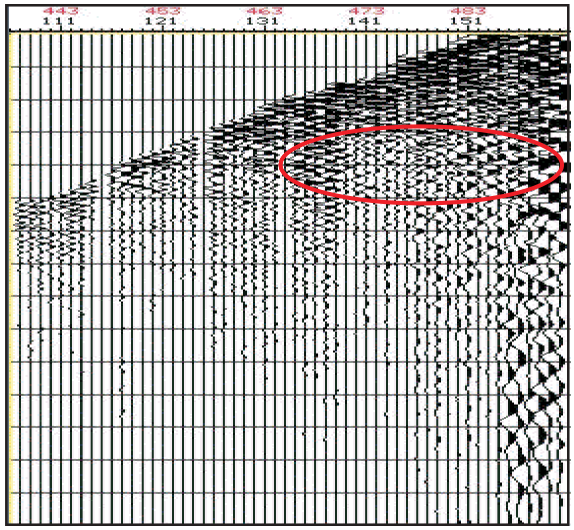

Fig. 6. Gathers after application of Field Statics

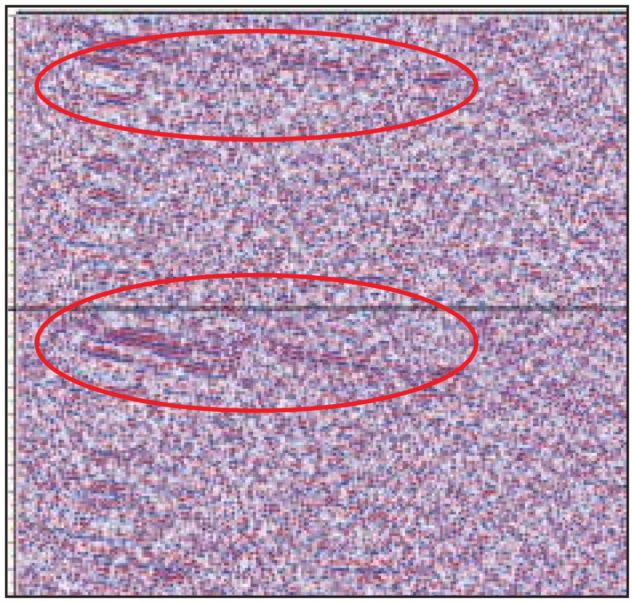

Fig.7. Brute Stack of line AA2 with model based and recomputed Filed Statics

weathering velocities and the optimum sub-weathering velocity field was finally chosen.

The raw data have ground roll at 6-12 Hz also S/N ratio of seismic reflectors at shallow and deeper levels were poor . The preprocessing includes editing phase , Selection of decon parameters to bring out the primaries, spectral analysis on the decon gathers specially on the crest of the anticline to eliminate the dominant noise frequencies , application of various filters. Coherency based velocity picking at very close interval on the super gathers of 11 CMP gathers was used for a generating the first velocity

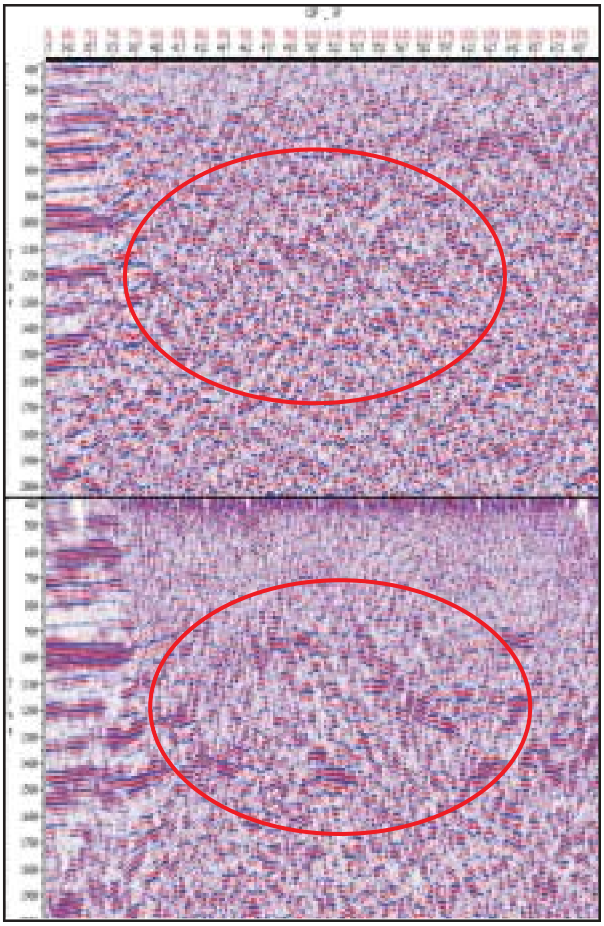

Fig.8. Final Stacks of EE2 without/with Offset limitation

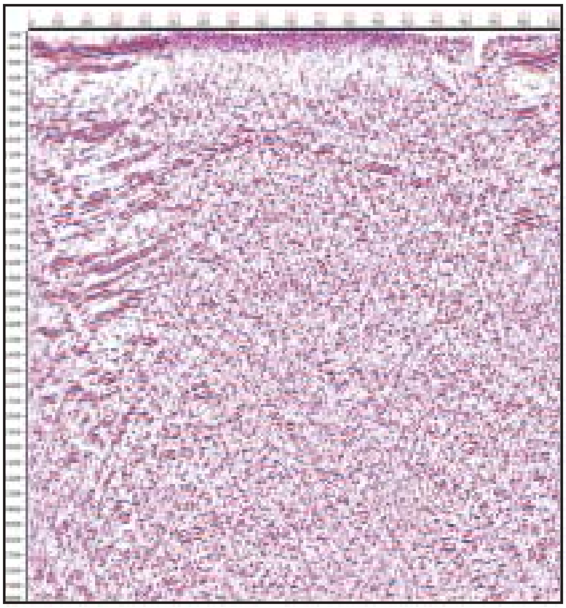

Fig. 9. Final Stack of Line DD2

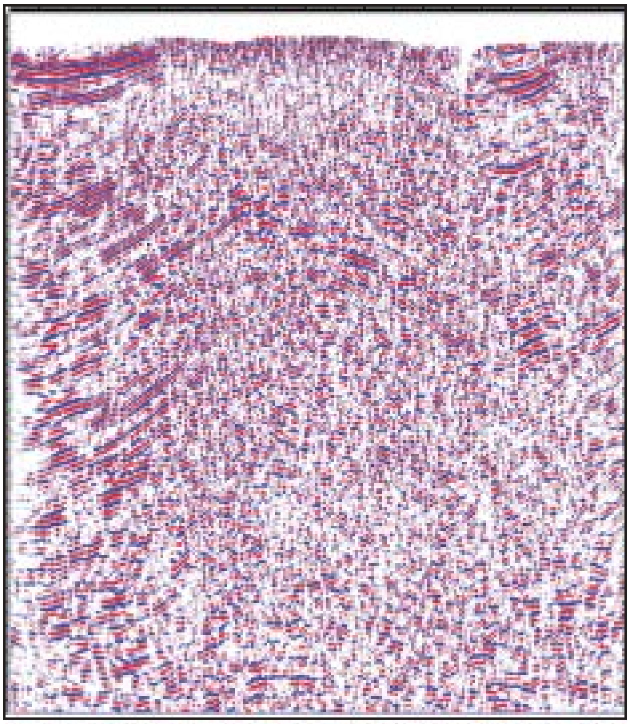

Fig.10. Migrated Seismic Section for Line DD2

field . Two passes of residual statics further improved the semblance of the reflectors and improved the velocity field . Dip move out velocity picking at 125 m interval was finally done for enhancing spatial continuity and stack response.

Random noise attenuation was carried out to enhance S/N ratio. Wave equation migration was finally performed for the correct disposition of seismic reflectors [Figure 10]. All the dip lines were processed with the above mentioned sequence and resulted in a well imaged sub-surface.

But the crestal part on the strike line (EE') could not be brought out clearly with the same methodology. In addition to above mentioned processing efforts , line EE' therefore , was processed with limiting the offset range . Along with testing the offset ranges, NMO mute and DMO velocity were also reviewed. The processed output thus resulted in the meaningful imaging of the crestal part for the dip line (Fig8).

The final processing sequence at a glance is : Demux data ,SI 2ms, RL 5secs , True amplitude recovery (REFOR 1.8),Geometry and trace header updating, Interactive trace editing. Field statics application, CDP sorting at 12.5 m, Pre filter L.C. 8Hz/24 dB; H.C. 70 Hz/72 dB , DBS (Predictive Deconvolution): OL 240 ms, PD 12 ms, WN 0.5%, window 300-2000 ms , Spectral whitening . Single window equalization , Velocity analysis I on DCN gathers at 250 mts , Residual statics surface consistent , Velocity analysis II on two pass residual gathers at 250 mts , DMO gather generation (Kirchhoff method) , Velocity analysis III on DMO gathers at 125 mts , Application of Space variant mute , DMO stack with Velocity III , Random noise attenuation , Application of time variant post stack filter time variant.(0-3000: 10-50 Hz;3000-5000: 8-40 Hz) , Finite Difference Wave Equation Post Stack Migration with 90% of DMO velocity.

A comparison with a vintage line parallel to AA2 provides corroborative evidence that the processing efforts led to the enhancement in imaging

Conclusion

An integrated approach consisting of ray trace modeling for optimizing acquisition parameters, a systematic approach for estimation of field statics , velocity analysis at close interval and judicious offset limitation could result in a meaningful imaging in a complex tectonic regime , where reflection seismic data often suffers from moderate to poor S/N ratio and severe statics problems.

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Views expressed in this paper are that of the author (s) only and may not necessarily be of ONGC.

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