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Processing Challenges in Fold Belt areas: A case study of Rokhia structure, Tripura

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Summary

Imaging of structures associated with compressional tectonics has always been a challenge not only to the seismic data acquisition geophysicist but also to data processor and interpreter. This is primarily because of disturbances created not only in the subsurface but also on the surface and near surface due to folding, faulting, block rotation, wrenching etc associated with fold belt tectonics. Rokhia Anticline situated in Tripura fold belt area of Assam Arakan Basin is one such structure which was formed due to compressional tectonic activity. Attempts were made to image the structure using Gravity, Magnetic and 2D and 3D seismic data over a long time. However, due to near surface and surface complexities, the anticlinal part of structure could not be mapped clearly. Subsequent to acquisition of 3D data in different phases and merging and reprocessing of the same has brought out the structural aspects in greater detail.

The present paper deals with methodologies adopted to enhance signal-to-noise ratio, recalculate associated field statics and most important of all to determine a fairly consistent stacking velocity field which could be used to successfully image the structure with its details.

Introduction

Rokhia anticline is one of the important hydrocarbon bearing structures of Tripura, contributing 67% of the in place gas production. The structure has been divided into two culminations namely lower Konaban field in the northern part and Manikyanagar field to the south of Rokhia anticline (Fig 1). The western limit of the structure is marked by the Bangladesh Plains whereas the Agartala Syncline lies to the east of the structure. The present study is restricted to the Manikyanagar structure including northern part of Sonamura area. A Total of 27 wells have been drilled mostly on the crestal part of the anticline although imaging had not been satisfactory due to surface, sub-surface and near surface complexities.

Thirty-six fold 3-D seismic data was acquired over Manikyanagar structure covering an area of 200 sq km, to understand the aerial extent of various pay sands and lateral facies variations in the area spanning over three-field seasons (2004-05, 2005-06 and 2007-07). Extensive efforts have been made to image the crestal part of the anticline by pre-stack merging of various 3D data sets acquired over number of years using different acquisition geometries and recording instruments. This integrated volume of about 200 Sq. Kms 3D Seismic data was reprocessed using various processing flows to improve the imaging over the crestal part and devised a method to bring-out the details of the structure.

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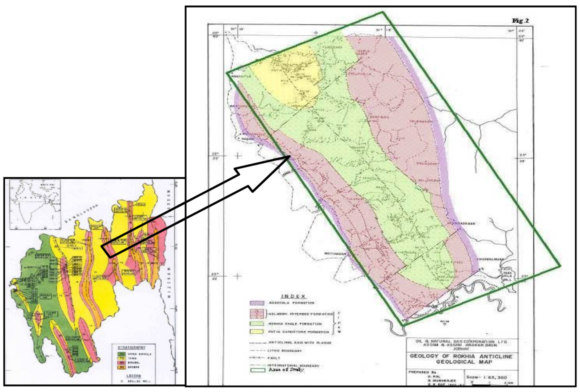

Fig.1 Location and formation map

Geology of the Area

Rokhia anticline is the outermost structure of the frontal fold belt of Tripura. It is tectonically least disturbed and is an elongated gently folded doubly plunging, flat topped, symmetrical anticline, trending

NNW-SSE. The structure contains two culminations, one occurring around Putia village and other, south of Jaangalia village separated by a broad saddle. Dip of the beds, in the western flank of northern culmination varies from 7^o to 9^o and that in eastern limb varies from 8^o to 12^o with generally lesser values in the axial zone. Dip of the beds in north –north westerly plunge is about 1^o to 2^o and in the south-south easterly plunge varies from 2^o to 3^o.

The oldest sediments exposed in the core of the anticline are Tipam Group of sediments, comprising alternating argillaceous and arenaceous beds. Four litho-units have been identified. The bottom three units are the parts of Tipam group, whereas the uppermost unit is the part of Dupitilla Formation (fig.2). The core of the northern culmination is occupied by older arenaceous sequence whereas the core of southern culmination is comparatively younger argillaceous sequence of Tipam Group.

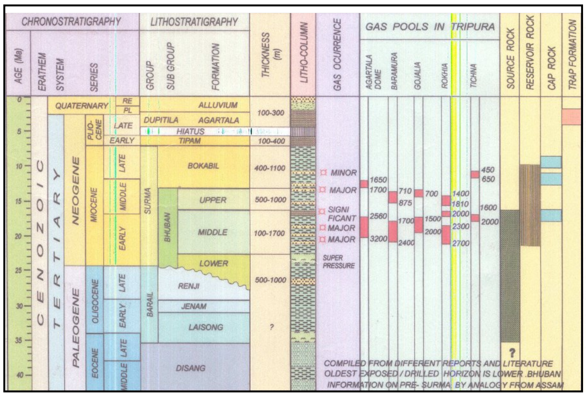

Fig.2 Stratigraphy of the area

Seismic surveys:

The seismic surveys started in 1979 with acquisition of 24 fold 2-D seismic data. During subsequent acquisition phases, the foldage of the 2-D seismic data increased to 48 and 60 in a bid to improve the data quality by enhancing signal to noise ratio. The 2-D seismic data was acquired over the Rokhia structure till 2003-04 in phases with the average grid of 2.5 * 5.0 km .The structure of Rokhia anticline was mapped with the help of 2-D seismic data.

In order to develop a better understanding of the structural aspects and to map the extent of various pay sands, 36 fold 3D seismic data was acquired in different phases during three field seasons namely 2004-05, 2005-06 and 2006-07 covering an area of about 200 SSK over the Rokhia anticline starting from Sonamura in the south to Konaban in the north. The bin size used was 20 * 40 m with a group interval of 40m. Preliminary processing of each individual investigation was carried out during 2004-06 after acquisition of each campaign. At the end of total planned acquisition phase, pre-stack merging and reprocessing of all the five investigations was done at RCC, Jorhat after giving lot of emphasis on the recomputation of field statics, iterative model based velocity analysis followed by residual static calculations. This has improved the imaging in the crestal part of the area, which was very poorly imaged earlier. Pre stack time migration (PSTM) of the full volume data was also done. VSP data of wells # RO-15, 16, 22, 26, 27, 39, 40 and 41 has been used for seismic calibration at different places after generating synthetic seismograms and VSP corridor stacks.

Methodology:

The 3D data was acquired in five volumes over three years using same acquisition parameters, geometries and recording instruments covering about 200 Sq Kms of Rokhia structure. The volumes have been processed at RCC Joraht with special emphasis on improving the imaging in the crestal part which was imaged poorly. Analysis of field data revealed that the very undulatory surface and rapid lateral lithological variations in near surface has given rise to inadequate calculation of field statics, thus making the estimation of stacking velocities difficult. Also due to presence of thrusting in the area, faults on the crestal part of anticline made it difficult to image it properly.

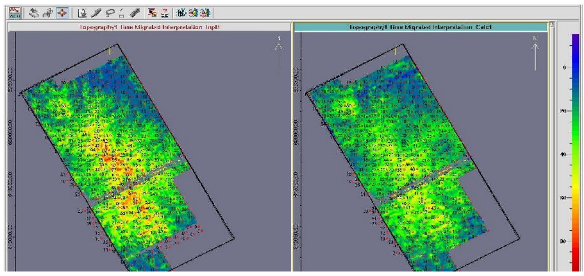

Fig.3a Elevation and receiver statics (*-1)

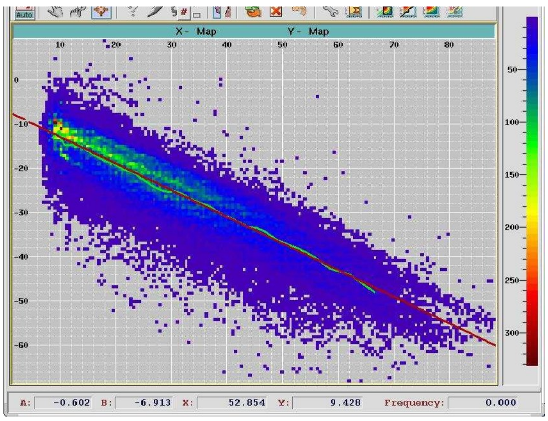

Fig.3b Cross plot of elevation and receiver statics

As seen in Fig.3a & 3b surface elevation changes are faithfully reflected in the field statics. Recomputation of field statics was done based on uphole modeling in the area. Summing up of two or three in-lines was adopted to increase the apparent fold of the data as the initial imaging is exceptionally poor (Fig.4a, 5a). It was observed that with 50 or more fold only, stack could show some image. Therefore apparent fold was increased to 70 (two adjacent lines were grouped together) in the beginning. For stacking velocity analysis up to 5 lines were combined and model based velocity analysis was carried out iteratively for stacking velocity estimation. This best velocity field, arrived at after number of iterations, was used for calculation of residual statics in normal fold data where no field statics was applied. Again after good number of iterations the residual statics values were perfected and final stacking velocity field was generated. This final stacking velocity field was used along with field statics. After final velocity estimation, it was observed that the crest was fairly well imaged. This velocity field was used for post stack migration of the data. Fig. (4a, b& c) shows a time slice indicating improvement in data quality at various stages of velocity building.

In addition to the improved imaging of the crest of Rokhia anticline using this methodology, it was found that deeper events which could not be mapped earlier due to poor data quality have also improved. However, due to limited frequency content available in the data and loss of event continuity, the mapping of pay sands of wells drilled on the crestal part of anticline was not possible. In view of discrete nature of various sand packs present in various formations continuity of sands throughout is not expected. Pre-stack Time Migration (PSTM) of the data using stacking velocity field as the initial velocity and carrying out horizon based velocity estimation has further improved the data particularly in the crestal part.

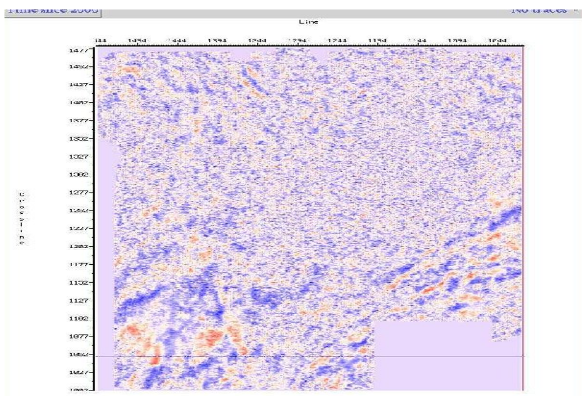

Fig.4a Time Slice at 2sec with field statics only

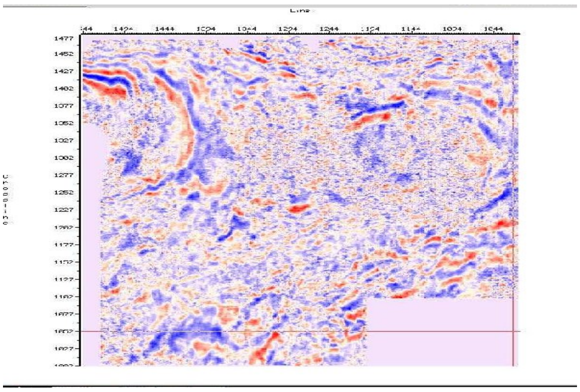

Fig.4b Time Slice at 2sec with residual (general approach)

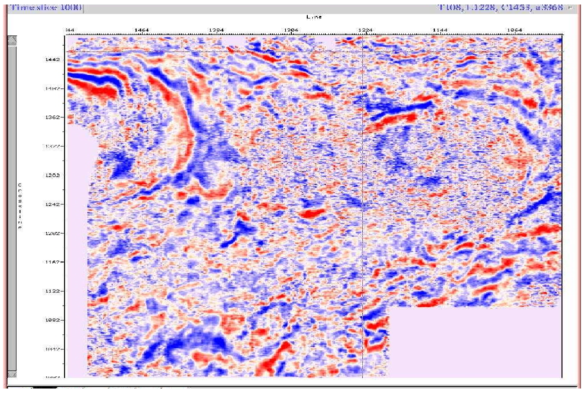

Fig.4c Time Slice at 2sec. structure based model velocity (after 8 iterations)

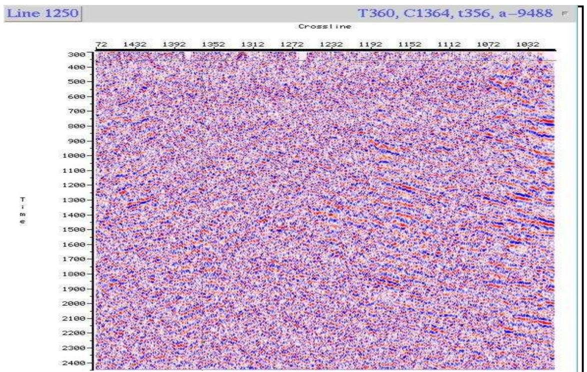

Fig.5a IL1250 with field statics only

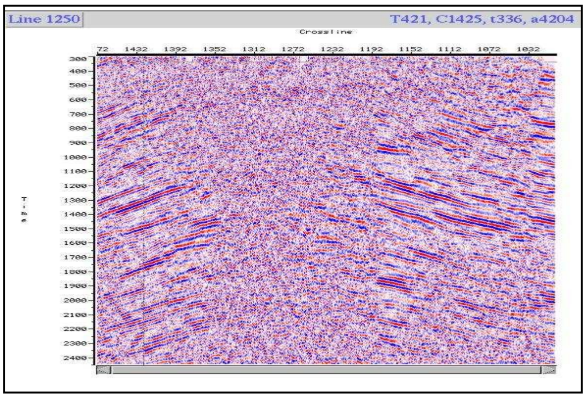

Fig.5a IL1250 with residual (general approach)

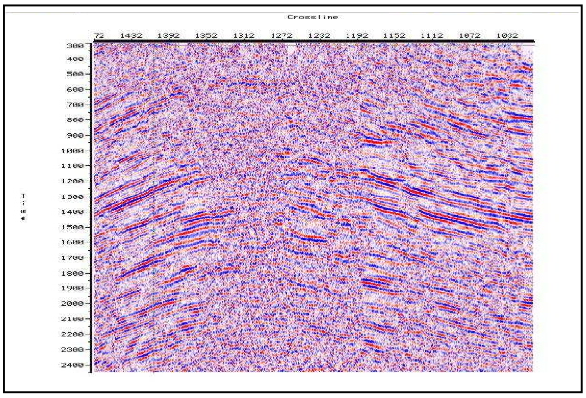

Fig.5a IL1250 structure based model velocity (after 8 iterations)

Conclusions

The study has brought out the fact emphatically that in the undulating terrain affected by severe near surface lithological variations, the adopted methodology of model based field statics computation, increase of virtual fold for estimation of velocity field and finally iterative residual statics computations only can bring improvement in imaging of the crest of the structure.

It may thus be concluded that meaningful imaging of crestal parts of the anticlines in the fold belt areas can be achieved by (a) closer sampling during data acquisition (b) increase of signal-to-noise ratio by increasing fold and (c) model based residual computation and velocity estimation.

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