PaperID **AU471**

Author **Avinash Pandey , ONGC , India**

Co-Authors **S K Mukharji**

Delineation of Fractured Basement Prospectivity by integrating Thinned Fault likelihood attribute and Image Log : A Case Study from Upper Assam Shelf, South.

Abstract

Upper Assam Shelf, South is a prolific producer of hydrocarbon from various pays (Paleogene to Neogene). The commercial discovery of oil from fractured Basement in this area was established during early seventies in Borholla Field. Recent finding of oil in the fractured Basement in Suphayam/ Dayalpur and Babejia area has propelled to revisit the prospectivity of fractured Basement in the reactive shelf area with existing G & G data. This paper describe the methodology of fracture intensity modeling using a new seismic attribute Thinned Fault Likelihood (TFL™) integrated with the geological and petrophysical data to evolve a integrated basement fracture model. Fracture intensity computed by Thinned fault Likelihood gave sharper resolution of faults and fractures compare to other attribute. Fracture modeling results has been calibrated with hydrocarbon accumulation pattern in basement wells tested in the area and has been of enormous help in defining prospect and drilling of wells for exploration as well as exploitation of basement reserves of the field.Usefulness of the derived seismic attributes is illustrated on a basement reservoir where a new well was recently drilled.

Introduction

The Assam-Arakan Basin is a poly-history basin controlled by the occurrence of more than one phase of sedimentation and tectonics which includes the northward collision of the Indian plate with the Tibetan plate and eastward movement of Indian plate towards the Burmese plate. Assam Shelf came into existence in the Late Cretaceous by a south easterly dipping block-faulting. The major deformational trend in the upper Assam shelf is in the form of NE-SW & ENE-WSW trending longitudinal faults which lie sub parallel to the Naga-Schuppen belt. Another relatively younger lineament exists in the form of cross faults trending in NW-SE direction which dissect the basement arch. The study area covers the Suphayam -Telihal to Babejia area in Upper Assam Shelf South (Figure.1) Basement reservoir is dominantly granite / granite gneiss is hydrocarbon bearing wherever major regional tectonic cross trends are observed. The matured Sylhet-Kopili-Barailshaly sediments buried in Dimapur low (Goswami et. al., 2005) are considered to be major kitchens for hydrocarbon in the adjoining structures of Suphayam-Telihal and babejia areas. Hydrocarbon have migrated into different structures either by short distance latero-vertical migration through deep rooted structure building faults, and long distance migration possibly through cross-faults/ regional unconformity.

Thinned Fault likelihood or TFL™ is a new attribute that brings out the disposition of fault and discontinuity in more accurate and sharper details. The thinned Fault likelihood attribute which is defined as a power of semblance, has a range of value between 0 and 1.This attribute is developed aiming to capture and delineate faults and fractures in area of interest, such that the algorithm scans the range of fault dips to identify maximum likelihood.

This thinned fault likelihood volume is the input for fracture intensity modeling combining with petrophysical and geological inputs. The fracture model thus generated successfully explains hydrocarbon accumulation patterns in basement wells drilled in this area.

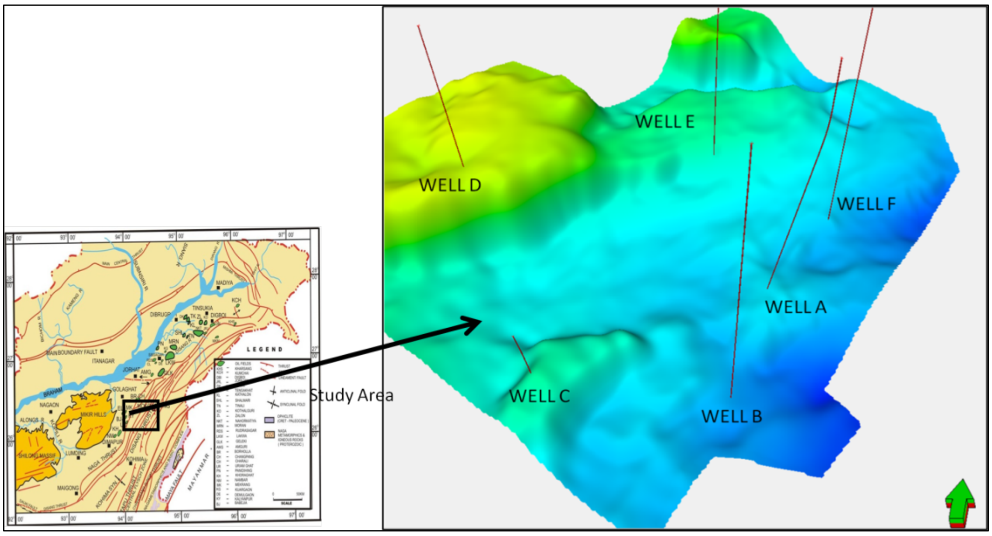

Figure 1: Geological map of Assam showing major tectonic elements and study area

Methodology

The study was carried out using the Prestack time migrated 3D seismic volume of the upper Assam Shelf South. Subsequent to initial loading the data was taken in the Open Dtect platform for the generation of steering cube. A dip azimuth volume which form the heart of TFL studies was created. Computation was carried out on steering cube to obtain the loacl dip of seismic reflector and associated discontinuities. In order to arrive at final cube that representative of faults and fracture, dip steered filter were applied in a sequential manner (Figure 2). This involves three main steps viz

- The smoothing of seismic reflectors through dip-steered median filtering.
- The enhancement of fault positions through dip-steered diffusion filtering.
- The merging of the first two steps through a logical statement to produce a fault enhanced seismic data.

Fault enhanced volume was used as a input for the thinned fault likelihood.Model builder was used to prepare the velocity model for converting time to depth volumes using time – depth data, RMS (stacking velocity) and calibrating with well picks. TFL volume was exported and further loaded to the Petrel platform for the fracture modelling.

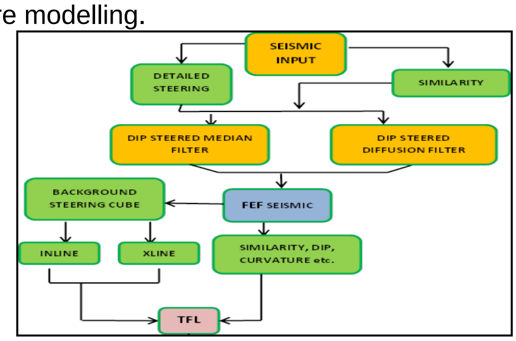

Figure2: Flowchart for the generation of the attribute thinned fault likelihood.

The next step included integrated analysis of fracture attributes from image logs of two wells, Well A and Well B.

Analysis of correlatability between seismic attribute thinned fault likelihood attribute and petrophysical properties using supervised ANN (Artificial neural Network) tool helped identify and organize the best fracture drivers.

A 3D structural model incorporating basement top to 300m below with cell size of50mx50mx10m was created .The upscale intensity logs and thinned fault likelihood attribute were used to statistically model the 3D fracture patterns. Four sets of fractures were identified and codified into fracture sets 1 to 4 (Figure 3).Using the well and seismic data fracture intensity was generated for each of the codified fracture sets, and intensity on arithmetic mean of four sets was derived .In total fracture intensity we can see the good match with the major fault trend in the study area. (Figure 5)

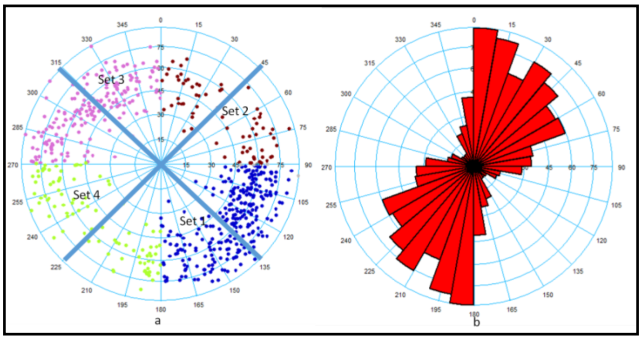

Figure 3: Combine dip plot of Image data with four identified fracture sets b) Combine Strike direction of the image data of well A and Well C

Result and case study:

The tadpole plot of dip poles of fractures in the wells Well A and Well C shows the presence of two dominant trends viz., NE-SW and NNW-SSE with wide dip scatter ranging from 30° to 90° (Figure.3). Though the regional SHmax direction in South Assam shelf varies from N-S to NE-SW, SHmax deduced at Well A is approx. E-W oriented indicating the strong influence of cross faults in the area.

E-W oriented fractures in the area are likely to be critically stressed and under dilation mode. Stress regime variations between grossly strike slip and thrust necessitates. Here thinned fault likelihood attribute brings out the cross trends in the area which are visible in the petrophysical data.

AntTrack volume generated on the discontinuity attribute only display the cross faults affecting basement. However TFL attributes was able to bring out their disposition in much better details.

Maximum amplitude from thinned fault likelihood volume along Basement surface indicates the presence of prominent lineaments and minor discontinuities / fractures in the study area Figure 3. Common observations suggest basement prospectively in fault damage zones and at junction of significant tectonic cross trends.

The model incorporated key basement wells in Suphyam and Babejia area and provided an effective explanation to anomalous hydrocarbon distribution pattern within basement.

The Wells A in Suphayam area which is located on the junction of two cross trend and has flowed hydrocarbons from basement,. TFL attribute and fracture intensity section shown the well has penetrated fracture cluster at depth where conductive fracture in image log has been identified. (Figure 6)

Well C in Babezia area is a recent well drilled on structural high and penetrated to basement 195m. It has been flowed gas . TFL attribute and fracture intensity section showing the fracture intensity which has been indetified in the image log data. (Figure7)

Well E and Well F drilled in 70-80 m within basement but did not yield hydrocarbons from basement. Fracture model seems to suggest absence of notable discrete fractures at the well.

(Figure 8&9)

Conclusions

Fracture intensity provides a quick way to visualize the trends of faults and fractures, which are not visible in seismic amplitude information and can be used to optimize well locationsThe major fault trends observed from thinned fault likelihood attribute in the area are NE-SW to ENE-WSW.These are also corroborated by petrophysical signatures representing the regional trends in the area. Since TFL attribute is guided by the inline and cross line dip of the seismic data it give sharp and accurate result which bring out the major cross trend in the area which are not visible in other attribute. Basement highs closer to the schuppen belt where evidences of intense cross faulting are evident are interesting from the basement exploration point of view in the area.

Acknowledgment

The paper is part of the project work carried out at COD–Basement Exploration ,ONGC, Mumbai. Authors express their sincere gratitude to ONGC for kind permission to prepare and publish the work. Views expressed in the paper are those of authors only and not of ONGC. Authors take this opportunity to express their sincere thanks to Shri S C Rao ,Smt. Kanchan Nitin Kadam, Ms. Payal Kataruka and Shri Dileep K. Singh for their active participation throughout the execution of the project.

References

OpenDetect Manual DGB earth sciences.
Sinha,P.K., Saha,P.K. and Vyas,S.K. ,2012: Evaluation of hydrocarbon potential of basement rocks in the area between Geleki and Mariani, A&AA Basin.ONGC unpublished report, KDMIPE, Dehradun.
Avinash Pandey , S. C Rao, S.K Mukharji and Chitnis S. N., 2017 Basement Prospectivity ofSouth Assam Shelf with special emphasis on Kalyanpur Suphayam and Uriamghat area unpublished report, CoDBex Mumbai
Basir, HadiMahdavi, Abdolrahim Javaherian, and Mehdi TavakoliYaraki. (2013) Multi-attribute ant-tracking and neural network for fault detection: a case study of an Iranian oilfield, Journal of Geophysics and Engineering 10.1: 015009.

Biswas, S. K. (1987) Regional tectonic framework, structure and evolution of the western marginal basins of India, Tectonophysics, v.135, pp. 302-307.

Dasgupta, I. et al (2013) Geological modeling of Basement reservoirs of Padra field : published report by IRS,ONGC.
Chopra, Satinder, and Kurt J. Marfurt. (2007), Volumetric curvature attributes add value to 3D seismic data interpretation, The Leading Edge 26.7,pp 856-867.

Neves, Fernando A., Mohammad S. Zahrani, and Stephen W. Bremkamp (2004), Detection of potential fractures and small faults using seismic attributes, The Leading Edge 23.9: pp. 903-906.

Rao, R.P. and Talukdar,S.N.(1980), Petroleum geology of Bombay high field, India, in M.T. Halbouty (ed.) : Giant Oil and Gas Fields of the decade, AAPG Mem. 30, pp. 487-505.

Singhal, B. B. S., and Gupta,Ravi Prakash. Applied hydrogeology of fractured rocks. Springer,

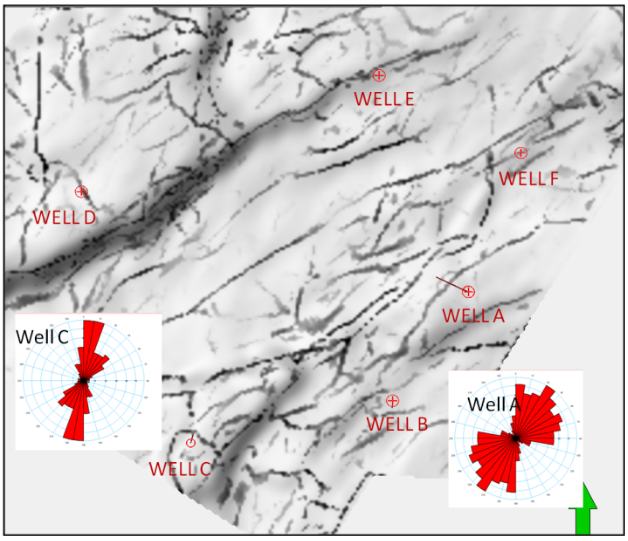

Figure 4:Maximum amplitude from Thinned fault likelihood volume for basement (in window 0-50m)

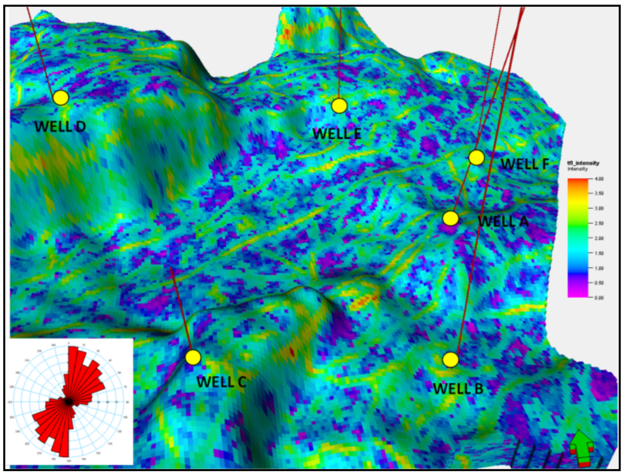

Figure 5:   Total Fracture intensity at basement top

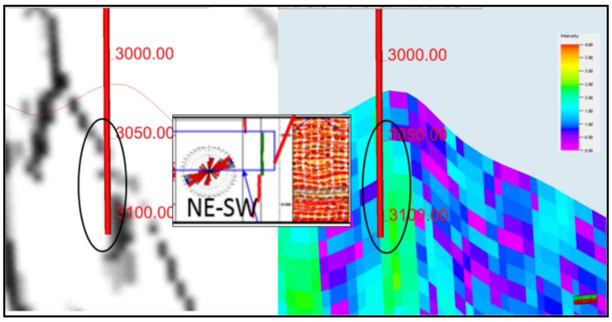

Figure 6:   Well A calibration with TFL ,Fracture intensity and Image data

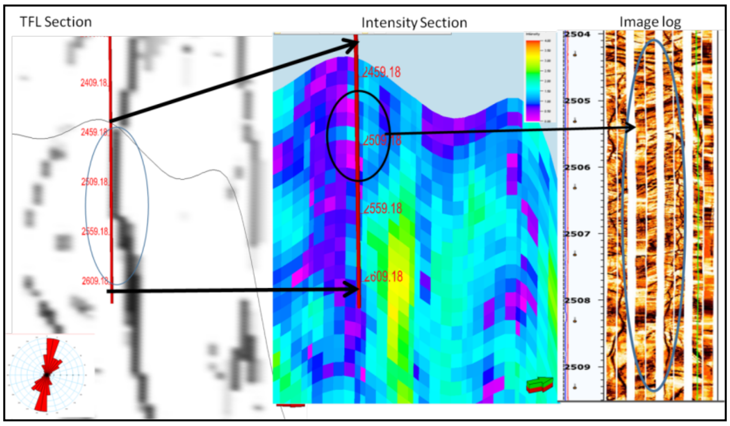

Figure 7: Well C calibration with TFL ,Fracture intensity and Image data

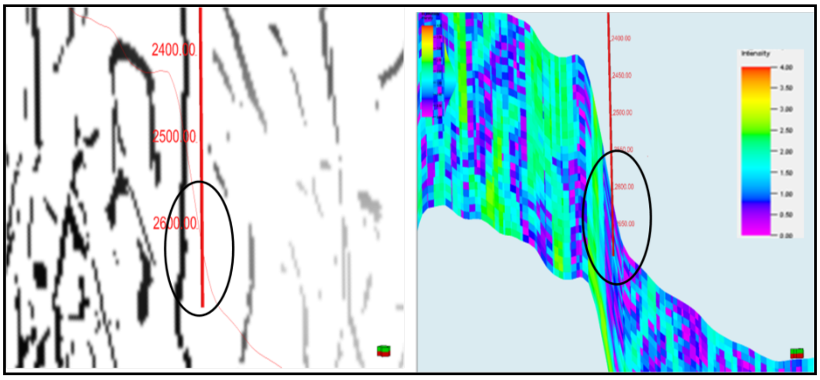

Figure 8: Well E calibration with TFL and Fracture intensity

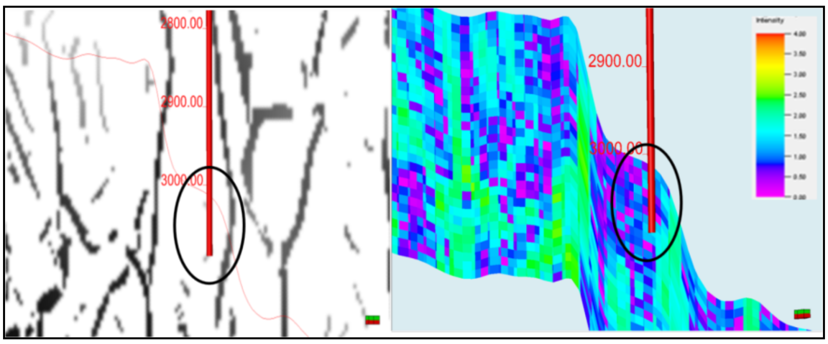

Figure 9: Well F calibration with TFL and fracture intensity