

Implications for the Hydrocarbon Presence: An Example from Lower Indus Basin*

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Search and Discovery Article #10808 (2015)**

Posted December 14, 2015

*Adapted from oral presentation given at AAPG Eastern Section 44th Annual Meeting, Indianapolis, Indiana, September 20-22, 2015

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Abstract

The Lower Goru prospect is one of the promising zones for hydrocarbon exploration as proved in many oil and gas fields surrounding the study area. As a part of the Lower Indus Basin, the study area exhibits horst and graben type structures due to the effect of rifting of the Indian Plate. Wells were drilled after a conventional study which proved to be water wet. The present study utilizes seismic data and theoretical models of reflectivity to find the reason for the prospect failure. Rock physics parameters such as Poisson's ratio is helpful in identifying mature sediments and sometimes could serve as the hydrocarbon indicator in clastic sediments. Calculation of Poisson's ratio requires the assessment of shear wave velocity, which was estimated by using Castagna's relationships. Additionally, amplitude variation with different angles was analyzed by approximation of Zoepritz equations. The results show an anomaly zone in the north eastern part of the study area which is a horst structure, other than where wells were drilled. The current results are promising for further detailed modeling and evaluation study for the current prospect.

Selected Reference

Kazmi, A.H., and M.Q. Jan, 1997, Geology and Tectonics of Pakistan: Graphic Publishers, Karachi, Pakistan, 554 p.

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By

Syed Ali Asghar

Abstract

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- The study area exhibits horst and graben type structures due to the effect of rifting of the Indian Plate.
- Wells were drilled after a conventional study which proved to be water wet.
- The present study utilizes seismic data and theoretical models of reflectivity to find the reason for the prospect failure.
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- Additionally, amplitude variation with different angles was analyzed by approximation of Zoepritz equations.
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General Geological Settings

Lower Indus Basin

Extensional Regime

Horst & Graben Structure

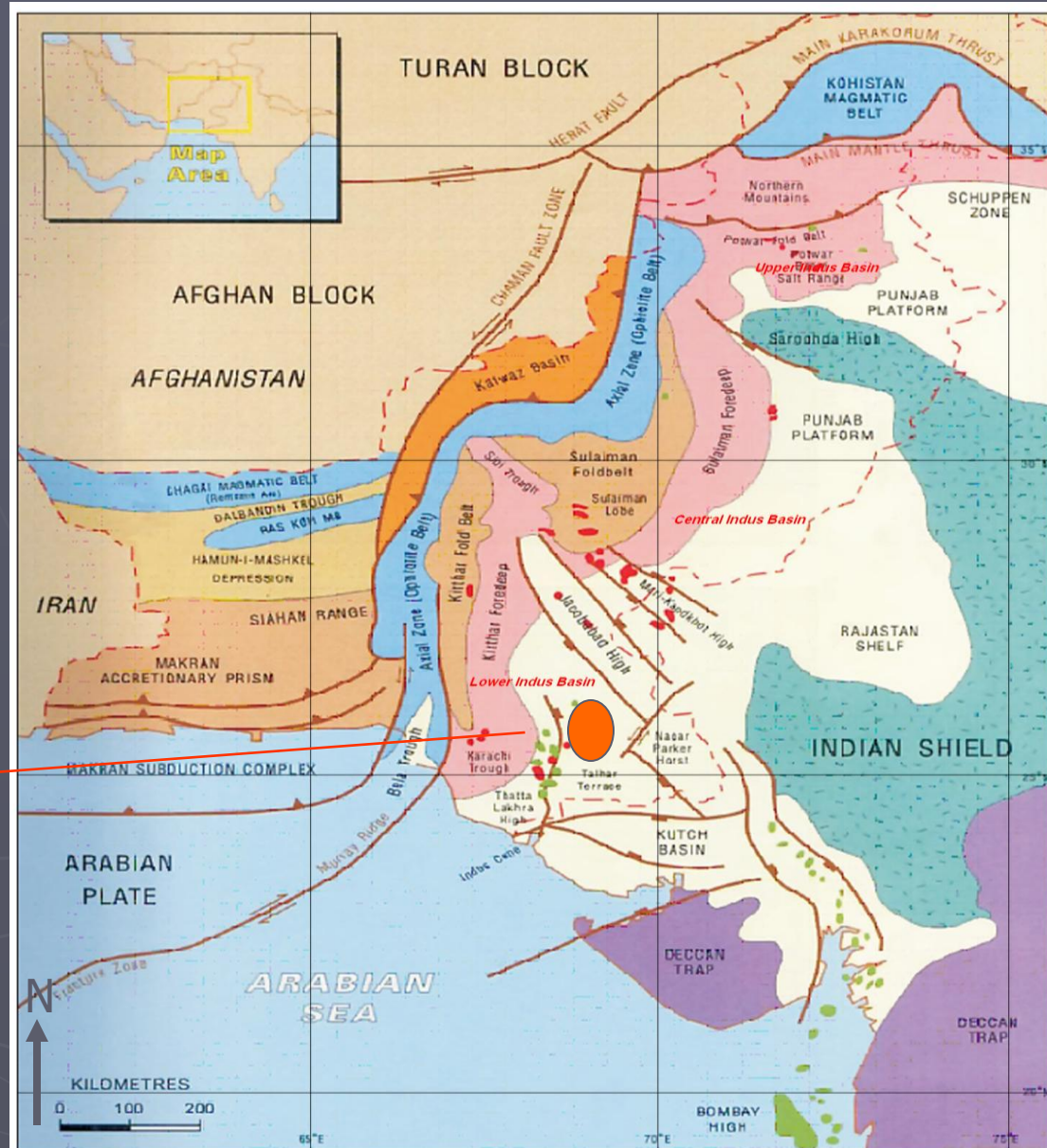
Target mainly Lower Goru
Basal Sand

The Coordinates that bound the area are

Lat: 26° 15' N - 26° 30' N

Long: 68° 41' 50" E - 69° 26' 13" E

Approx. 1,819.72 Sq. Km

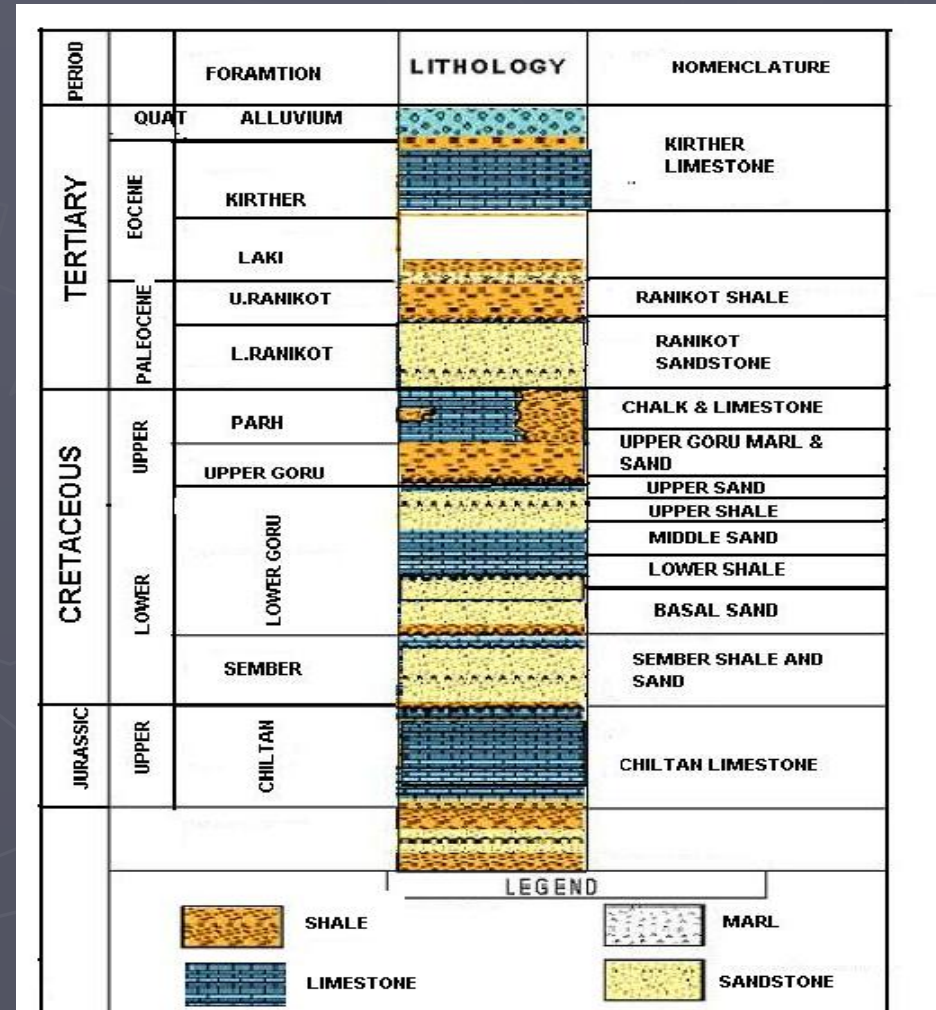


Introduction

- The Bitrisim Block & adjoining area (approximately 2256.48 Km²) is located in the Southern Indus Basin of Pakistan.
- The companies OGDCL and OMV together operate in Bitrisim since September, 1997.
- Recently, New Horizon Exploration and Production Limited (NHEPL) has received an exploration permit for some of the land.
- The study area lies south of the Sukkur rift system and is surrounded by many structural units such as Mari-Khandkot high, Jacobabad-Khairpur high, Thatta-Hyderabad high and Panu-Aqil graben (Kazmi and Jan., 1997).

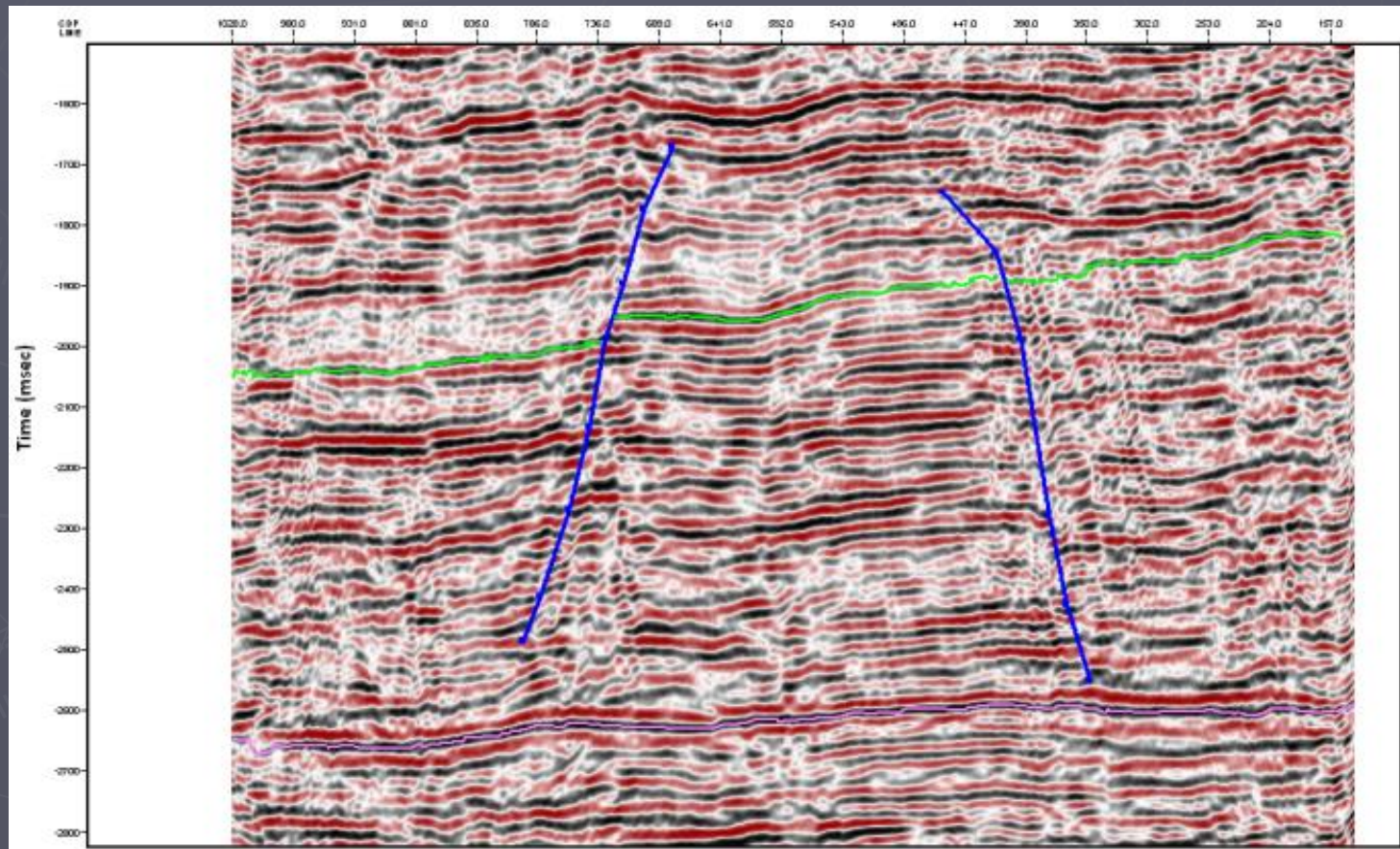
- As part of an active extensional tectonic regime, the area is dominated by horst and graben structures delineated by extensive seismic surveys.
- Major structures of the area are Chandesri, Ichri and Fateh which are horst blocks at Basal sand level and lie at the platform area of the Lower Indus basin.

- The Lower Goru Formation consists of different horizons of sand and shales.
- In the recent past, the main study dealt with the basal sand horizon of the Lower Goru Formation as a target reservoir in surrounding blocks.
- The basal sand is gas prone which is considered as a main reservoir in these regions. Sembar shales are the main source rock in the basin.

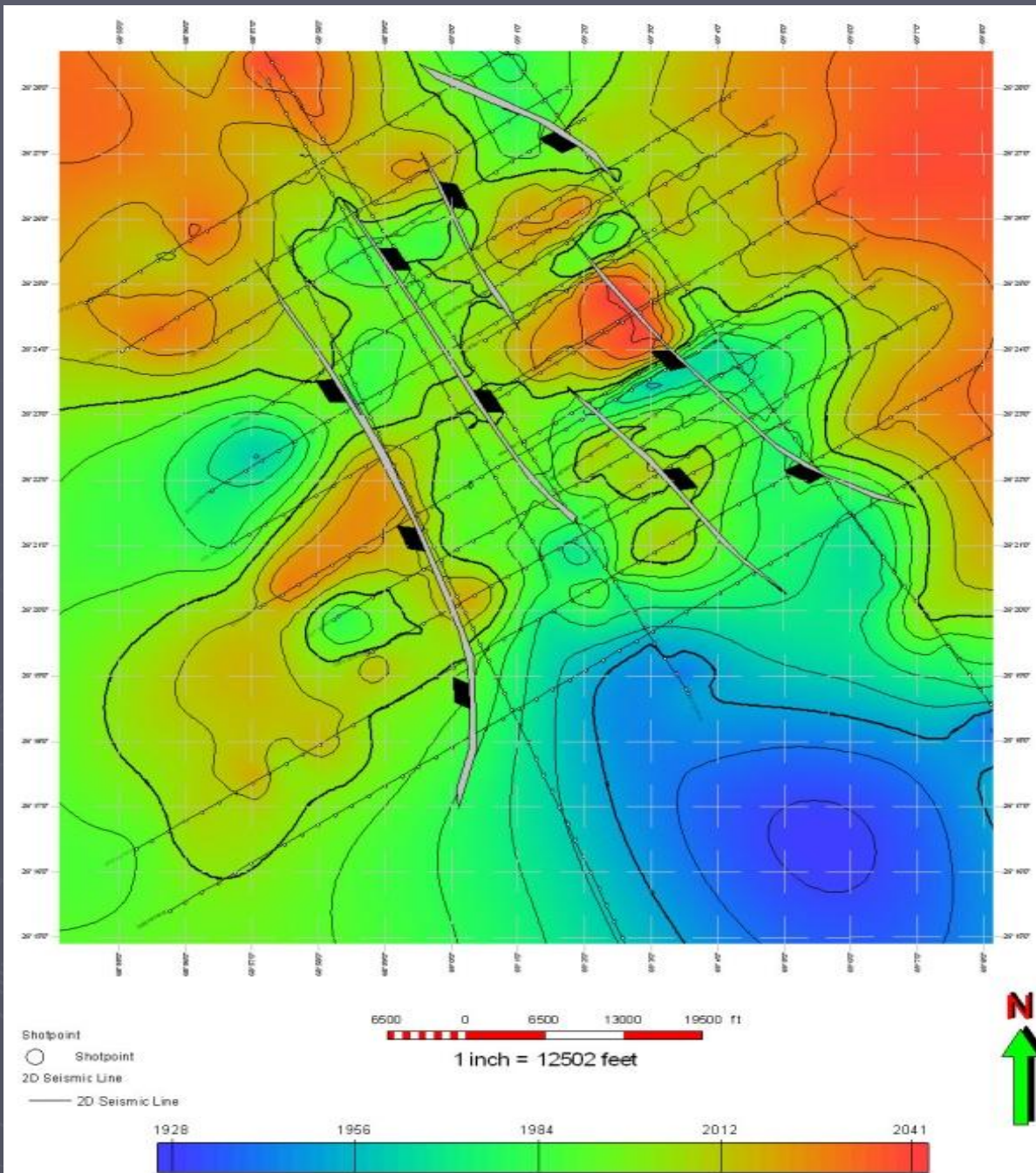


Theory and/ or Method

Lower Goru Basal sand horizon of Cretaceous age has been identified on the seismic section by using conventional seismic interpretation methods.



- The horizon shows medium to good reflection patterns on the seismic section marked in green color.
- The Lower Goru Formation is a sequence of sand and shale layers including many unconformities.
- The time structure map shows some structural closures and faults which are oriented in NW-SE directions representing horst and graben structures.
- Wells were drilled in the horst structures and the reservoir was found to be water wet.



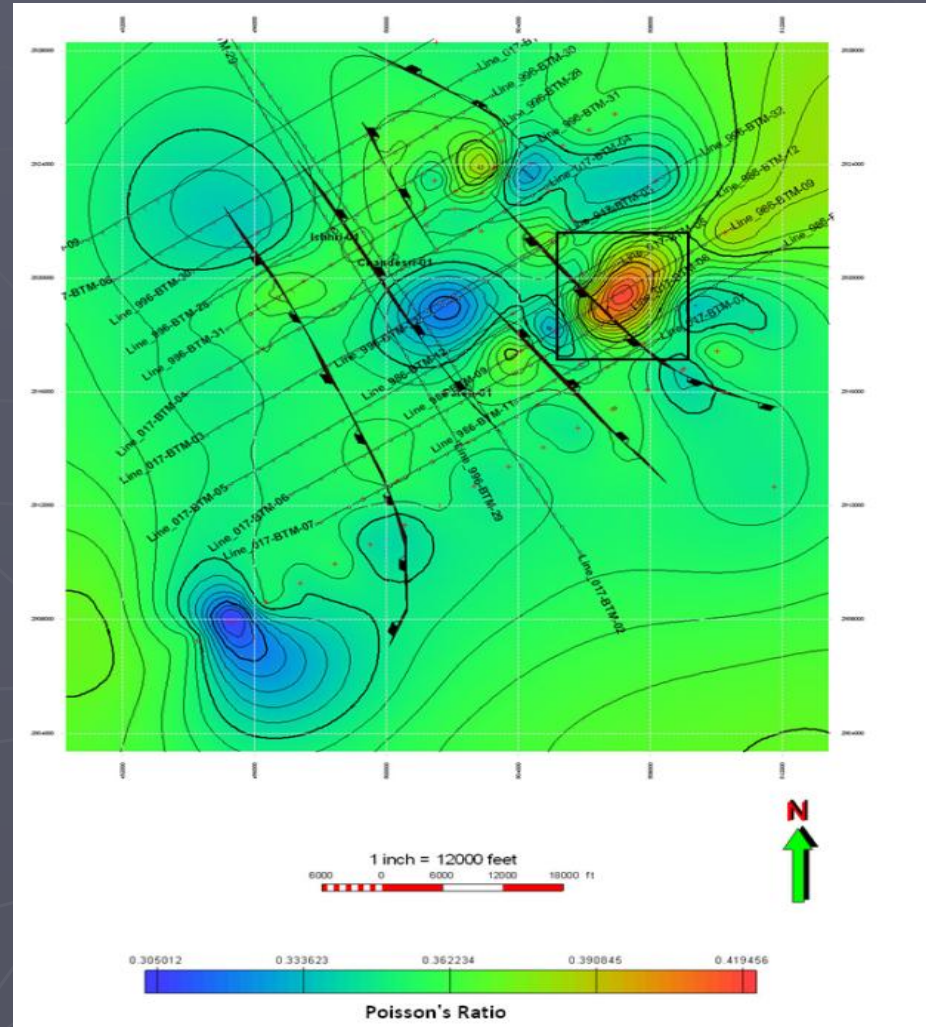
- Shear wave velocities (V_s) are required for most rock physical and AVO analyses.
- In conventional seismic and well logs acquisition shear wave velocities are not recorded.
- This task is usually filled by rock physical studies i.e. - to obtain V_s from P wave velocity (V_p).
- For calculation of Poisson's ratio shear wave velocity (V_s) is required, which was estimated by the following equation
- $V_p = 1.16V_s + 1.36$ (Km/s)

V_p is obtained from the seismic data and poisson's ratio is calculated by

$$\nu = 0.5(V_p^2 - 2V_s^2) / (V_p^2 - V_s^2)$$

Where ν is the poisson's ratio. The poisson's ratio of the Basal Sand horizon is estimated to lie between 0.251 and 0.419.

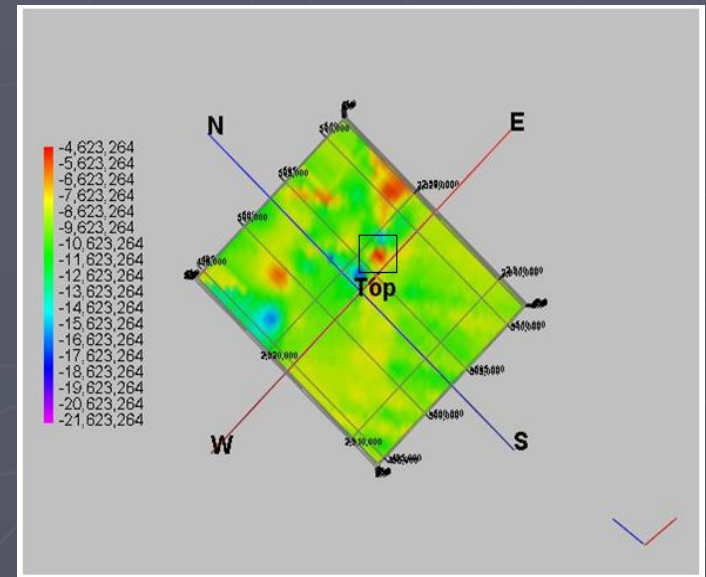
- A Poisson's ratio contour map shows an anomalous zone in the north east direction with a high Poisson's ratio.
- The drilled wells lie in the non-anomalous zone.



Theoretical analysis of reflectivity has been done by using the following equation

$$R_{PP} = \frac{1}{2 \cos^2 \theta} \frac{\Delta \alpha}{\alpha} - 4p^2 \beta^2 \frac{\Delta \beta}{\beta} + \frac{1}{2} (1 - 4p^2 \beta^2) \frac{\Delta \rho}{\rho}$$

- It also shows an anomaly at the same position as the Poisson's ratio map.
- The values of reflectivity were found increasing as the angle is increased in the analysis.



- This could be the result of possible changes in the nature of the fluids present in the rock or the changes in the rock itself compared to the site norms.
- Depending upon the geology of the reservoir, it could not be confirmed whether this increase in the reflectivity is due to the presence of hydrocarbons.
- Comments are made on the sediments consolidation by analyzing the values of Poisson's ratio which lie between 0.251 and 0.419 (Engelmark and Gatwick., 2000).
- This range of poisson's ratio for sediments lies between consolidated to unconsolidated sediments which results in an anomaly in the highlighted portion of the study area.

Conclusions and recommendations

- The overall interpretation is based upon conventional seismic data interpretation, rock physics, and theoretical modeling of reflectivities.
- The interpretation shows that there are localized structural closures present in the NE direction of the study area.
- The area is an extensional regime where normal faults are observed, making horst and graben geometries which are favorable for the accumulation of hydrocarbons.
- No substantial variation in the velocities is observed from the seismic and well data.

- Analysis of rock physics and theoretical reflectivities identify an anomalous zone in the north east of study area.
- This anomaly resulted from the physical state of the sediments which shows higher poisson's ratio when compared to site norms.
- The anomalous zone should be evaluated using 3D data sets involving AVO and rock physical studies.
- This may foster the proper understanding of the Basal Sand horizon in the study area which is producing in other oilfields present in the same structural basin.

Questions?

