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Seismic Inversion and EMERGE Studies for Porosity distribution analysis in DCS area, Bombay Offshore Basin

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Summary

Estimation of porosity in carbonate rocks continues to remain a challenge to the geoscientific community due to its inherently complex pore structure as well as wide variation of pore size and shape. In the present study, seismic inversion and EMERGE studies of 3D seismic data integrated with electrolog and well data, were carried out to identify the porosity pods and bring out porosity distribution within the Paleogene limestones of Bassein Lower, Bassein upper and Mukta Formations in the DCS area of Bombay Offshore Basin.

Introduction

The Bombay Offshore Basin is a pericratonic rift basin and is the largest among the west coast sedimentary basins of India. The basin is located on the western continental margin of India and is bounded by the Saurashtra arch in the north, Vengurla arch in the south, west coastline in the east and West Margin Basement Arch in the west. The basin covers an area of about 1, 48,000 sq km up to 200m isobath.

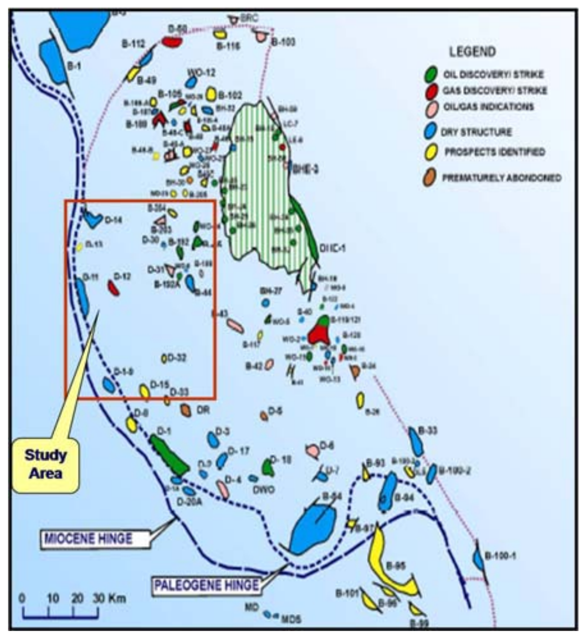

Fig 1: *Map showing area of study*

Hydrocarbon accumulations occur in carbonate reservoirs ranging in age from Middle Eocene to Middle Miocene. In general entrapment is structurally controlled with a few

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exceptions of stratigraphic / combination plays in Paleocene- Lower Eocene clastic reservoirs. While major pay zones occur in Bombay and Bassein formations, pay zones have also been identified in Bandra, Panvel, Daman, Mahuva, Heera, Mukta and Panna Formations. The major discoveries include Bombay High, Bassein, Neelam, Heera, South Heera, Panna and Mukta fields. The study area lies in the western part of Bombay High-DCS platform of Bombay Offshore basin (Fig.1). Hydrocarbon accumulations are established within the carbonates of Bassein- Lower (Middle Eocene), Mukta (Early Oligocene), Panvel- L-VI (Late Oligocene) and Miocene (L-II) in the study area. Hydrocarbon indications are observed within Bassein Upper in some wells.

Data and methodology

3D seismic volume of about 1200 sq KM area in DCS area was used for interpretation. The volume was processed at 32 bit and 2 MS sample interval with a grid of 12.5X 25m. The 3D Seismic data was tied up with electrologs with the help of synthetic seismograms. Nine seismic reflectors (H5, H4A, H4, H3B-Lr, H3B, H3A, L-VI, L-III and L-II) were correlated in the study area (Fig.2). Well data of twelve wells falling in the area covered by 3D seismic (Fig 3) were integrated in the study.

Seismic inversion of 3D volume was carried out and acoustic impedance volume was generated using Hampson-Russel software to bring out the porosity distribution and litho- facies variation in the area. Spatial and temporal distribution of litho-facies was analysed on different horizons by extracting seismic attribute viz. RMS Impedance within the windows close to top of Bassein lower, Bassein Upper and Mukta formations. Porosity volume was generated using EMERGE multi-attribute analysis and integrating the porosity values at six well points in the 3D area.

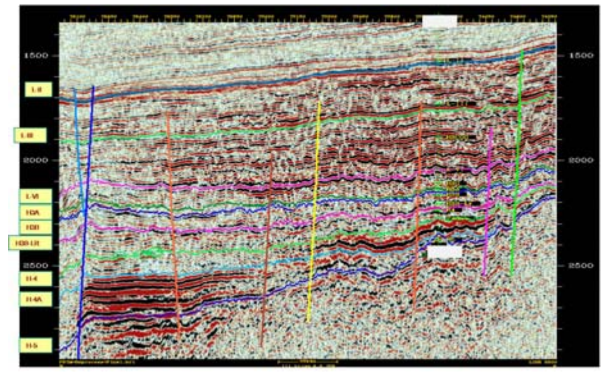

Fig 2: Inline showing mapped horizons

Inversion studies

Work Flow: Standard work flow acoustic impedance inversion was followed.

- SEG-Y data of 3D volume, Well data, TD curves, Log data, formation tops and horizon data were imported into HR platform.
- Analysed, edited and despiked the log data wherever necessary.
- Generated cross plots at well locations to determine the best log parameter for estimating porosity. It was found that AI exhibited the most linear relationship with porosity.

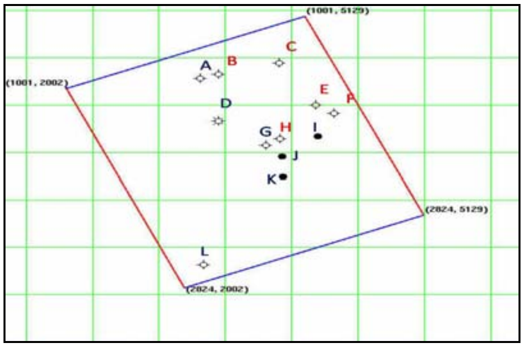

Fig. 3: Map showing distribution of wells in 3D area

- Selected the best wells in terms of areal distribution, availability of curves and quality of curves.
- Synthetic tie at selected well locations and fine tuned TD tables so as to achieve the best correlation possible between well and seismic in the zone of interest (between H3A top to H4 top covering Mukta, Bassein Upper and Bassein lower formations).
- Generated the initial model and checked for any deviation at the well locations.
- Generated arbitrary lines across key wells to do QC at well locations.
- Generated the model based AI volume using the statistically derived wavelet.
- Generated horizon based AI slices to study distribution of AI across the 3D area.

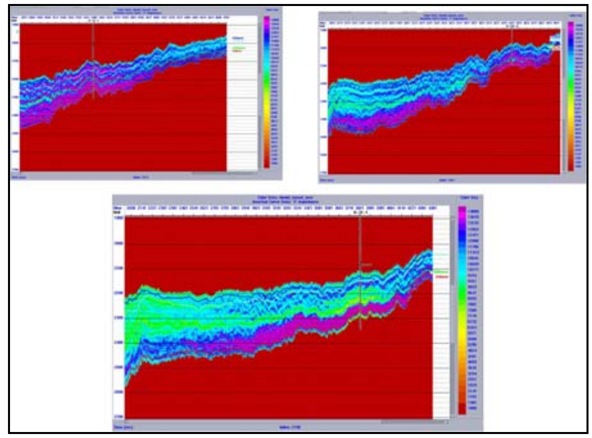

Fig 4: AI distribution along selected lines

Interpretation:

RMS average impedance near top of H3B Lr. within a window of 10 ms below H3B Lr (Fig 5a) indicates relatively lower impedance values in the south central part and very low values in area to the south and south-western part, suggesting good reservoir facies development. This is also corroborated from the higher porosity values obtained in electrologs in well L in the south-west. In the area around well D, relatively higher impedance values are observed indicating poor porosity development. The area to the north-east of well D, indicates relatively lower impedance values suggesting probable development of good reservoir facies.

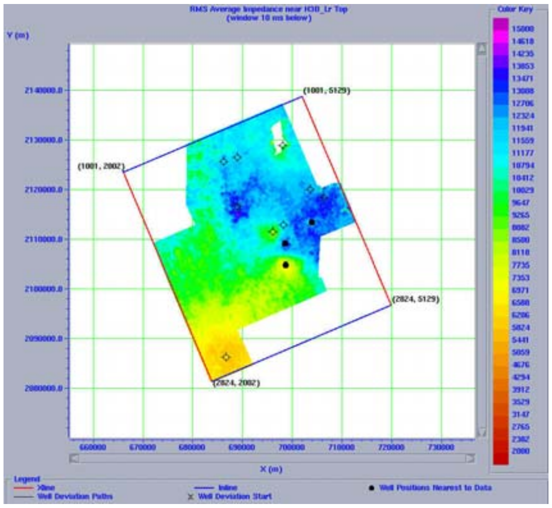

Fig. 5a: AI slice near top of H3B_Lr

RMS average impedance near top of H3B (Fig 5b) within a window of 10 ms below H3B indicates relative lower impedance values in the south central area and very low values in the south western part, suggesting good reservoir facies development. Similar to H3B Lr, the impedance values reduce gradually to the south and south-west suggesting improvement of reservoir facies development. The north-western part shows higher impedance values. The area around well C shows relatively lower values indicating possible development of reservoir facies within Bassein upper.

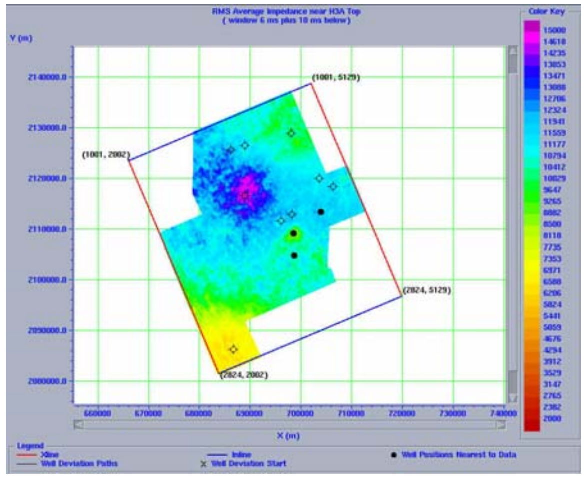

Fig. 5b: AI slice near top of H3B

RMS average impedance near top of H3A (Fig 5c) within a window of 10 ms below excluding 6 ms from top of H3A indicates similar impedance distribution in the area with respect to Bassein upper, excepting relatively higher values around well D and surrounding area in the north-western part.

EMERGE Study:

After analyzing the cross plots (Fig.6) a linear inverse relationship was observed in the wells between P-impedance and porosity. Geostatistical analysis like Multiattribute and Probabilistic Neural Network (PNN) study was carried out for estimating the porosity distribution within the major pay zones in the study area. For porosity estimation the following work flow was adopted.

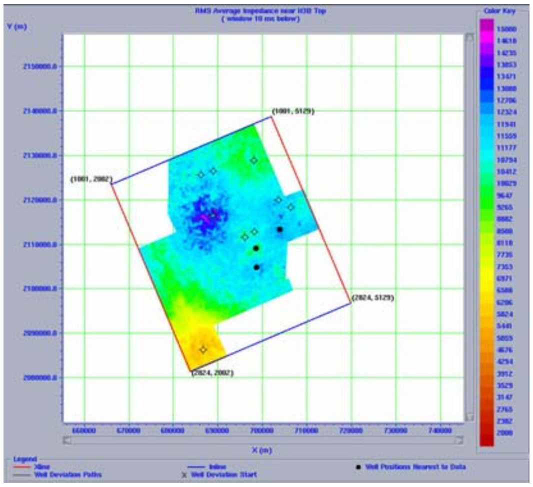

Fig. 5c: AI slice near top of H3A

- Impedance volume was imported into the EMERGE domain followed by seismic volume/ well data/Horizons.

- The porosity data was integrated with P- impedance values at six well locations scattered over the 3D area.

- Multiattribute analysis analysis was carried out for H3A, H3B and H3B_Lr separately.

- Results of Multiattribute transform were taken as input for PNN transform and Porosity volume was generated in the zones of interest throughout the 3D volume.

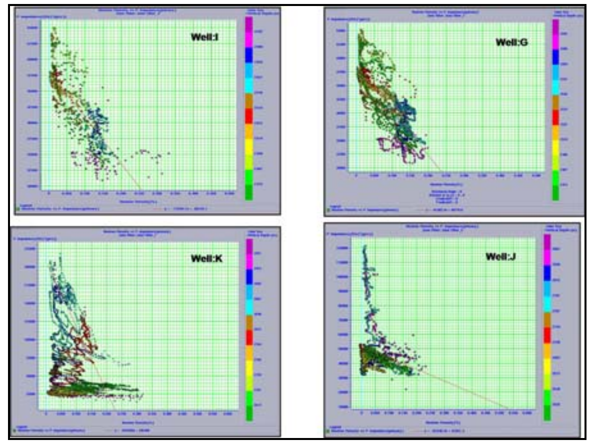

Fig 6: Cross plots between AI and porosity at wells

- Horizon guided slices were generated to see areal distribution of computed porosity.

Analysis of Results

The computed porosity map near top of H3B Lr (Fig 7a) brings out the porosity distribution close to top of Bassein Lower in the area. It indicates poor

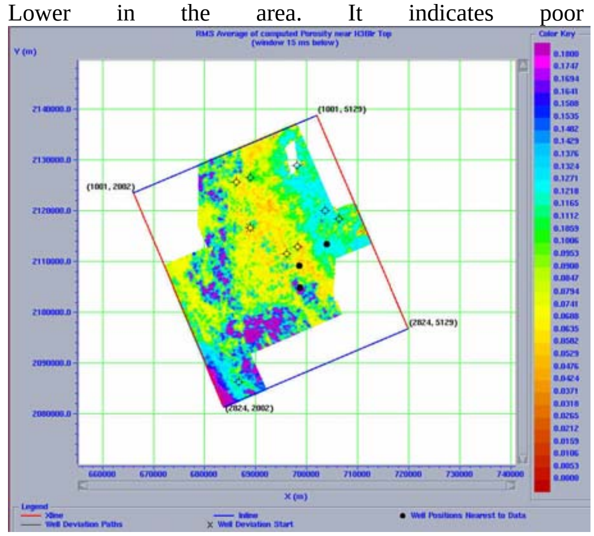

Fig7a: Computed porosity slice near top of H3B_Lr

porosity distribution towards the eastern and north-eastern part. Fair to moderate porosities are indicated in the central and south-central part. Good development of porosity is observed to the south, west and south-western part.

The computed porosity map near top of H3B (Fig 7b) also brings out a similar porosity distribution picture at top of Bassein Upper excepting overall poor porosity development and little tighter facies to the north-east.

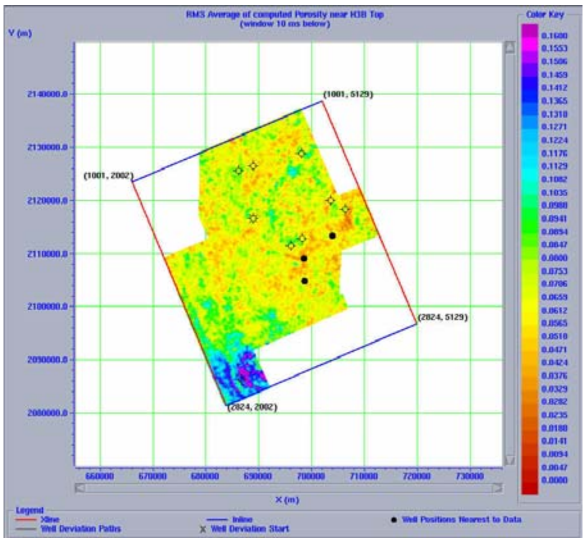

Fig 7b: Computed porosity slice near top of H3B

The computed porosity map near top of H3A (Fig.7c) brings out an overall fair porosity distribution picture close to top of Mukta Formation. Moderate porosity development is indicated in the area to the north-west and east. Fair to good porosity development is observed in the north-eastern part. Moderate porosity development is indicated in the south and south-western part of the study area.

Conclusions

Inversion studies and geo-statistical analysis carried out using Hampson-Russel software has helped to give an insight about the distribution of porosity within the 3D area.

RMS average impedance maps in general indicate good reservoir facies development in the south and south-western part. The impedance values are observed to reduce gradually to the south and south-west suggesting improvement of reservoir facies development.

The computed porosity distribution derived from EMERGE study indicates poor porosity towards the eastern part. Fair to moderate porosities are indicated in the south central part. Good development of porosity is observed to the south and south-western part.

The results of the inversion studies greatly depend upon the quality of seismic data and log data. Well to seismic tie is possibly the most crucial step in any inversion study.

Presence of multiples in the zone of interest poses difficulty in the correlation of well logs with seismic. Similarly, spiky logs also need to be edited before generating impedance curve.

Use of cross plotting helps to select the right known earth property which best represents the unknown quantity (porosity).

The distribution of wells in the area of study is crucial as accuracy of statistical analysis tends to decrease as one move away from the tie points.

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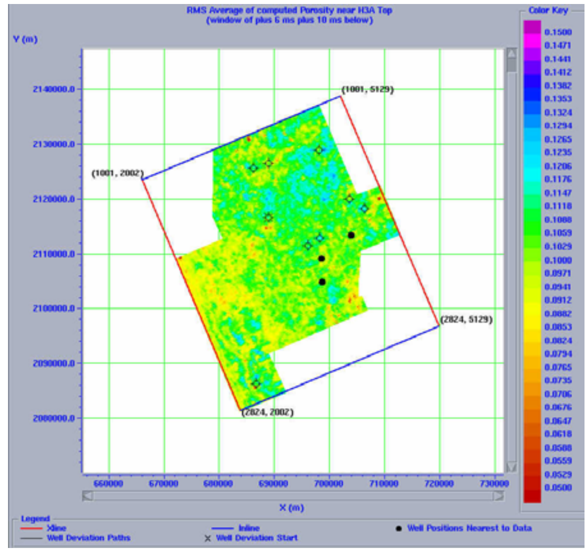

Fig 7c: *Computed porosity slice near top of H3A*