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Forward Modeling Helps Delineating Reservoir from Seismic Data; a Case Study

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Summary

Delineating the pay sands for exploration/development in Cambay basin is generally interpretation of facies. Sands in Chatral unit I of Younger Cambay shale of Cambay basin are localized. Drilling exploratory/development locations on the basis of structural interpretation from surface seismic data have occasionally been successful in the study area. Utilizing leads from seismic forward modeling, the facies interpretation carried out through amplitudes studies validates at all the drilled well locations. Study seems to have resolved the issue of delineating the reservoir in Chatral I unit. Mapping through this method has brought out distribution of sands. Except two producing wells, all other wells around are placed outside the sand distribution map of the unit. No well is yet drilled in the area in the East of the producing wells, where mapping shows the presence of sand. The area is available for additional oil.

Keywords: *Seismic forward modeling, Reservoir Characterization, Acoustic Impedance, Amplitudes, Development, Exploratory wells.*

Introduction

Chatral Unit I, II and III of Younger Cambay shale are widely present in many of the fields of synrift Cambay basin, and are producers of hydrocarbon including Limbodra field. Field is situated on Eastern rising flank of the Nardipur low. It is bounded by basin margin fault in the East in synrift Cambay East in synrift Cambay basin (Fig1). Generalized stratigraphy of the block is shown in Fig2. The structural set up is bounded by older longitudinal faults trending NNW-SSE, most of which die out within Tarapur formation of younger age. Younger transverse faults trending in East-West direction divide the area into a number of cross faulted blocks. Nardipur low is envisaged as the kitchen for the oil accumulation in the field. Traps are structural and presence of reservoir ensures the hydrocarbon occurrence.

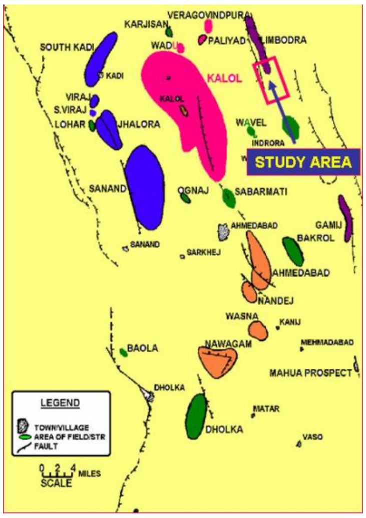

Figure1 Map showing location of the study area

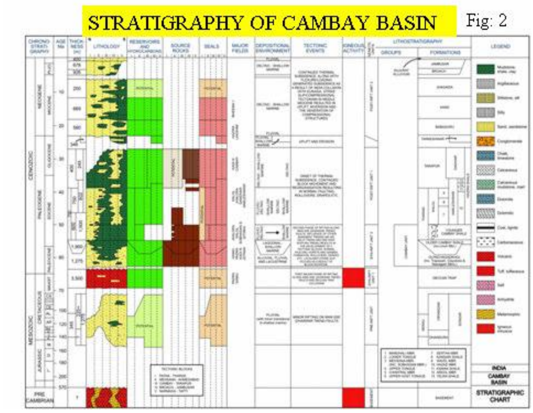

Figure2 Generalized stratigraphy of the study area

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3D seismic data under study has frequency band of 6-16- 30-56 Hz. in the zone of interest and Low to high impedance interface generates –ve number as polarity with ~50 degree phase.

The C and I are only wells producers from the Chatral I unit (Fig. 3) having net pay sand of 10m and 4m respectively. C has been producing over a long period with considerable production rate. Wells Viz. A, B, C, D and E, F and G and H have been drilled around wells C and I to explore and delineate the sand of Chatral I unit brought out using deposition model, but have not encountered the reservoir. The recently drilled well J, ~500m South of C within the Reserve Estimated (REC) limits of the pool, also did not encounter reservoir facies.

A study to understand the reservoir expression on log data and its interpretable manifestation on seismic data is undertaken with the help of seismic forward modeling. Exploratory well K has been under drilling further south of the well J at the time when the study was completed. Interpretation Seismic data in the light of inference drawn from the study showed the absence of Chatral unit I sand at the well location, which drilling results of well K confirmed.

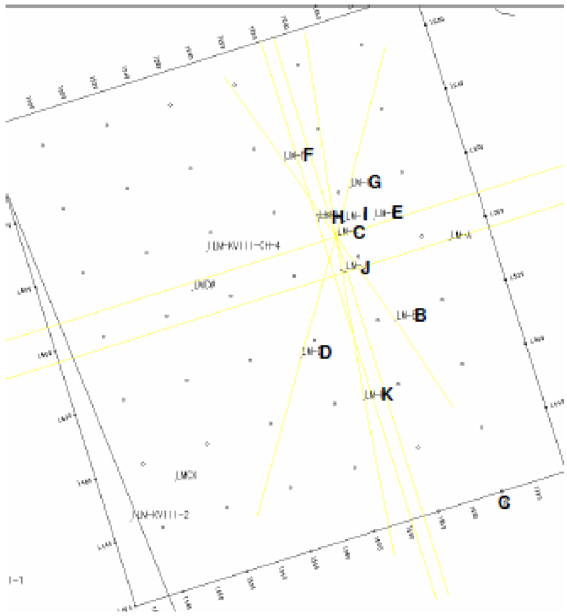

Figure3 Location map of study area.

Method

Study of log suite including derived acoustic impedance response over the interval covering Chatral I suggests that there is a distinct definition of the unit in term of impedance. Fig. 4 shows the type logs in the unit. Low Gamma ray counts on log data mark the beginning of the Chatral Unit I, which has thickness of ~45m. Unit overlies a thin streak of coal and is overlain by the interval consisting of bottom most coal of Kalol (Coal of Kalol-X). It begins with a high impedance hard layer which gradually looses its impedance with increasing depth to the characteristic shale impedance of the Chatral unit I. The sands in the Chatral unit I overlie the thin streak of coal sitting at the base of the unit and have higher impedance than characteristic shale (Fig 5). The K-X coal is divided into two layers by a streak of shale

One dimensional modeling (Meckel, L.D. Jr., and Nath, 1997, Anstey N. A., 1978) for both the cases of sand being absent and present is carried out by generating synthetic seismograms (Figs. 4 and 5).

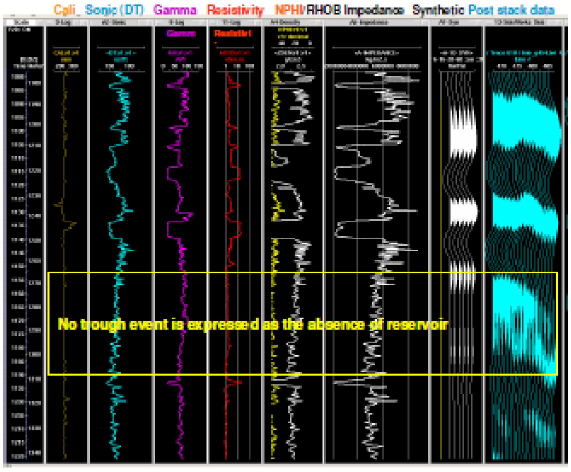

Figure4 Type logs of interval covering Chatral Unit I when reservoir is absent; Well K.

This base of hard streak of shale which looses gradually the impedance with increasing depth generates dominantly a low frequency peak (stretched over longer time). In the presence of higher impedance sand, the trough peak pair is generated within the interval of low frequency peak. The presence of the trough event within the low frequency peak interval is therefore interpreted as sand. Low frequency peak in the interval of Chatral I unit is interpreted as absence of reservoir. Log response for the case of sand in the unit gets translated into a unique seismic response interpretable as sand (Fig. 5). In the case of sand being absent in this unit, the corresponding seismic response is also unique and is interpreted as absence of sand (Figs. 4).

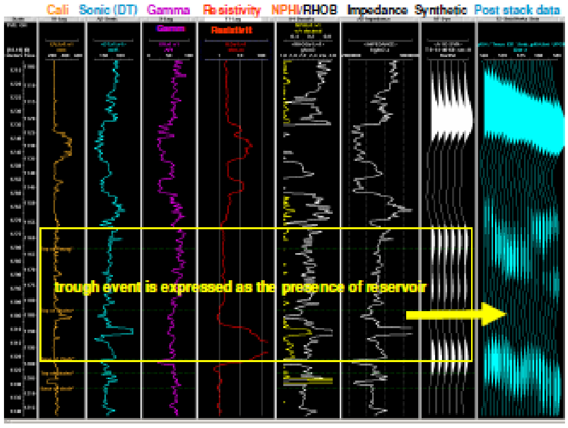

Figure5 Type logs of interval covering Chatral Unit I; Well-C.

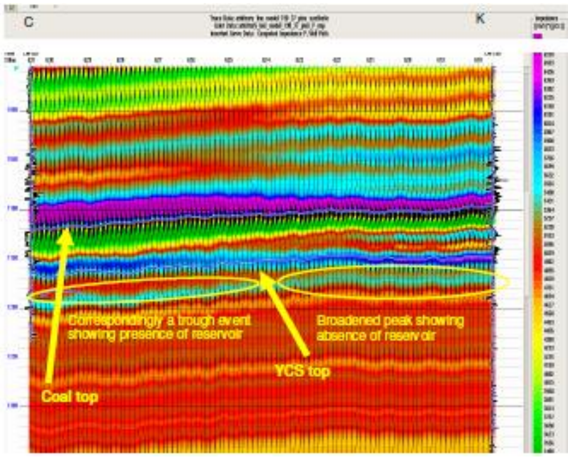

Figure6 2D impedance model (in Color) in time domain generated by linearly interpolating the impedance logs of K and C. It is overlain by corresponding seismic response.

A 2D impedance model in time domain is generated by linearly interpolating impedance logs of well C having sand and well K not having sand. Depth to time conversion has been done by velocities derived from sonic logs and well seismic ties. Seismic response generated from the model shows the trough event getting calibrated at sands, and correspondingly a broader peak is calibrated as absence sand. Therefore, the presence and absence of sands is interpretable on seismic data.

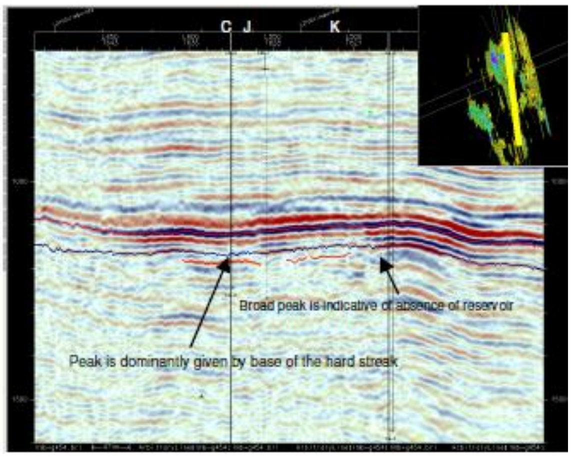

Figure7 Arbitrary seismic line passing through well C having sand and wells J and K showing absence of sand.

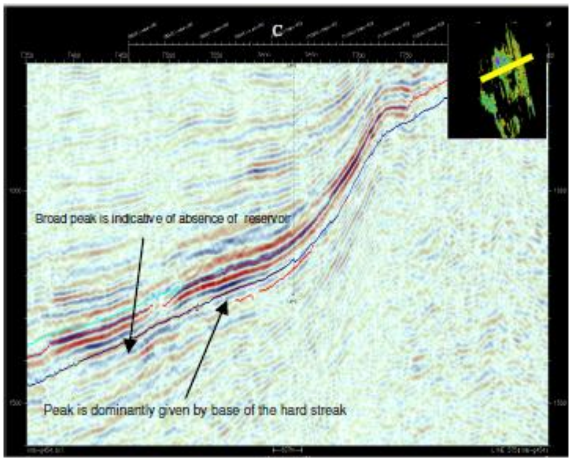

Figure8 seismic inline through well C having sand.

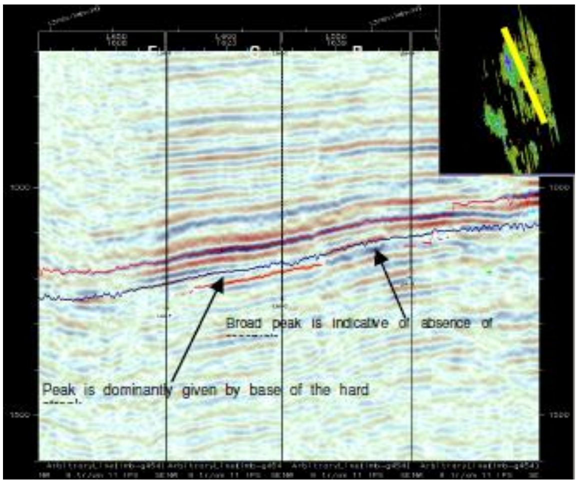

Figure9 Arbitrary seismic line passing through well C having sand and wells F and B showing absence of sand.

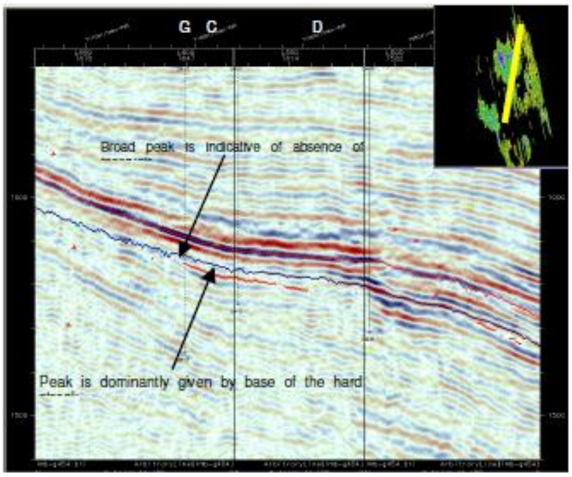

Figure10 Arbitrary seismic line passing through well C having sand and wells G and D showing absence of sand.

The inferences derived from modeling study are utilized in mapping the reservoir from the 3D PSTM seismic data covering the study area. Seismic sections from 3D volume show calibration of sand as trough event and its correlation (Figs.7 to 10). Correlation is made in auto mode by picking the maximum –ve amplitude of the trough event. Average amplitude attribute over 8ms window with reference to correlated marker in the center is derived. Attribute shows the extension of the reservoir on the map. Higher values of average amplitude attribute are interpreted to be caused by thicker reservoir (Fig. 11).

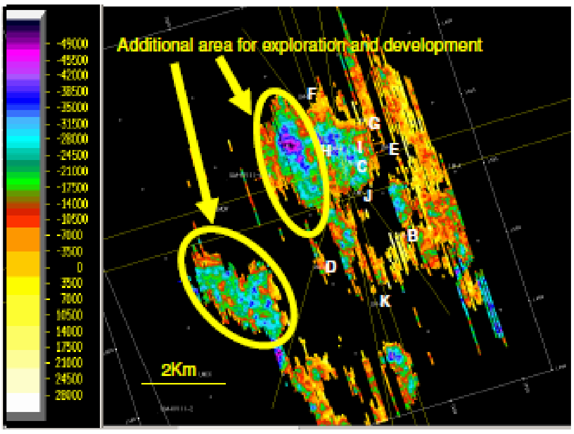

Figure11 Distribution of sand of Chatral Unit I brought out from average impedance attribute.

Conclusions

Facies interpretation and mapping carried out using inferences from forward modeling validates at all the drilled wells and have resolved the issue of delineating the reservoir in the area.

Except producing wells C and I, all other wells around these two wells are placed outside the Chatral I sand. No well is yet drilled in the East of the producing wells, where sand has been mapped through this study. This area is available for additional oil.

The applicability of the method is being explored for Chatral I sand in nearby area and sands of other units of Chatral.

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