7th International Conference & Exposition on Petroleum Geophysics

"HYDERABAD 2008"

P - 301

Modeling as an Aid in AVO Interpretation of Hydrocarbon in Virgin Area.

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Summary

Structural, stratigraphic or combination traps are the foremost requirement for drilling the hole for hydrocarbon. DHI on seismic data is appreciated to reduce the risk of drilling dry holes. AVO on seismic gather data is one such study. In areas having no wells, interpreting AVO for hydrocarbons is risky. However, modeling study based on certain assumptions and information can bring down the risk. The paper is about one such modeling study carried out in the area of proposed location. The results of well to be drilled will only confirm the interpretation.

Introduction

Study pertains to deep water in one of the basins of East coast of India. The well is proposed at a bright amplitudes as targets in Pliocene (Figure1) on a stratigraphic trap. AVO study carried out on such amplitudes anomaly shows no change in amplitudes or little increase or decrease with offsets (Figure2). Points plotted in intercept gradient space show up as anomalous with reference to background corresponding to the bright amplitudes (Castagna, J., Swan, H., and Foster, D., 1998). However, in the absence of calibration from well data, interpreting presence of hydrocarbons from the anomalous points is risky.

AVO modeling was carried out on certain information and assumptions to firm up the interpretation. The process involved generating the synthetic response for various perceived models to find out which one closely mimic the actual data. Two layered models consisting of shale and sand are considered. Data polarity and phase is ascertained from the reflection event generated from the seabed. The interval velocity used in the modeling has been derived from seismic velocity used for NMO correction in the target zone.

Three single interface models consisting of two layers each viz. shale and brine sand respectively constructed for the study. Models considered are simple in the sense they do not invite any complexity caused by thickness and other variations (Ross, C., 2000). The shale properties are kept fixed whereas sand parameters are changed by varying the porosity. The shear wave velocity for all the layers is calculated from compressional velocity using Greenberg Castagna transforms. Replacing brine by gas using Gassmann equations, the parameters for gas sands layer in all the three models are calculated. The synthetic responses generated for all the six models have been compared with actual responses to ascertain the interpretation.

Theory and/or Method

Model building:

The targeted bright amplitudes are interpreted to be given by the soft layers with the help of sea bed polarity and phase. Each of the three models constructed for the study are of single interface which is given by the sand overlain by shale. Velocity and density of shale in this interval for all the three models has been taken as 100us/ft (3054m/sec) and 2.35 gm/cc respectively i.e. close to the interval velocity derived from seismic.

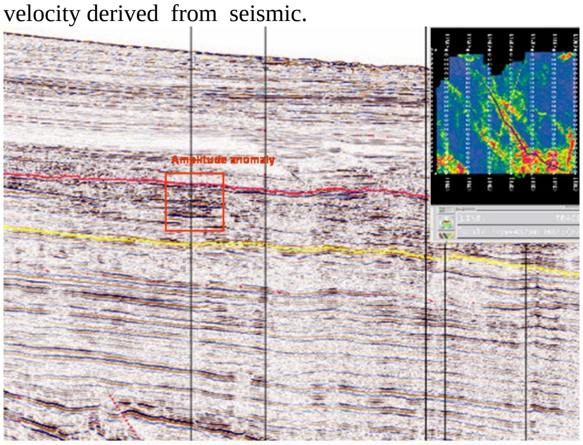

Fig.1 Amplitude anomaly identified on seismics and mapped. Zig zag line through anomaly.

Velocity and density for the sand layers for all the three models are calculated for porosity of 24%, 27% and 33% as 90us/ft and 2.25gm/cc; 100us/ft and 2.2gm/cc; 110us/ft and 2.15gm/cc; respectively. Shear wave velocity for layers in

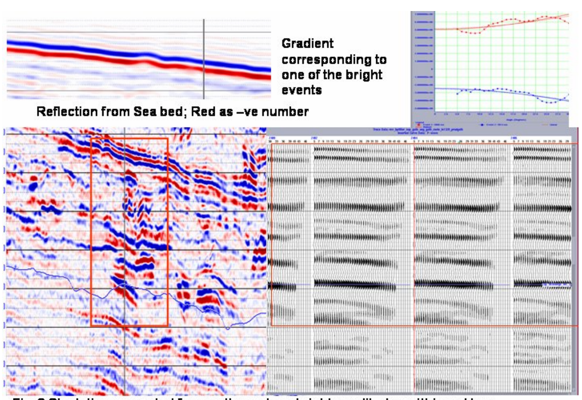

Fig. 2 Stack line generated from gathers show bright amplitudes within red box. Brightening of corresponding amplitude events with increase in angles at proposed location and around is observed in angle gathers.

all the models is derived by applying Castagna Greenberg transform to the compression velocities. Sand layer having 24% porosity is hard in comparison to shale when saturated with brine, whereas other two sand layers of porosity 27% and 33% are soft. The 80% of brine in sand has been substituted by gas using Gassmann relation leaving Sw 20%. All the sand layers when gas substituted become soft in comparision to shale. The Vp, Vs and density, impedance and poisson ratio curves for the models prior to fluid substitution are shown in blue color line and after substitution in red color (Figures 3, 4 and 5).

AVO modeling is carried out by ray tracing for all the six models using Zeopripritz/Aki Richard method. Zero phase Ricker wavelet is used to generate the synthetic gathers.

Observations:

The 24% porosity brine saturated sand layer generate low +ve intercept (0.032) and moderate –ve gradient (-0.088), whereas 27% porosity sand layer generate low –ve intercept (-0.033) and low +ve gradients (0.028), and 33% brine sand generate moderate –ve intercept (-0.070) and high +ve gradient (0.12).

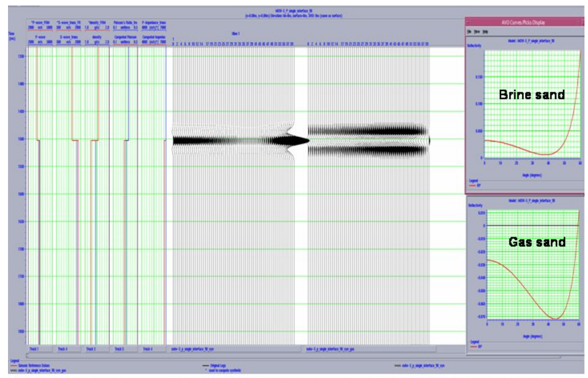

Fig. 3 Sand model with 24% porosity. Models with 100% Sw and 20% Sw (80% gas) are subjected to AVO modeling. The brine saturated sand layer generate low +intercept (.032) and moderate –ve gradient (-.088), whereas gas substituted sand layer generate low –ve intercept (-.026) and high –ve gradient (-.12)

The 24% porosity gas substituted sand layer generate low –ve intercept (-0.026) and high –ve gradient (-0.12), whereas 27% porosity gas substituted sand layer generates moderate -ve intercept (-0.117) and flat amplitudes (gradient=0.005). The 33% gas sand generate high –ve intercept (-0.17) and moderate +ve gradient (0.070) (Cambois, G., 2000).

The targeted bright amplitudes on stack data are interpreted as given by the soft layers, and corresponding gathers are observed to be close to flat with increase in offsets. Responses generated by six models are individually compared with actual stack and gather data.

Brine sand of 24% **does not mimic the observation as being hard** (Figure 3), and hence is disqualified as the interpretation of the observations.

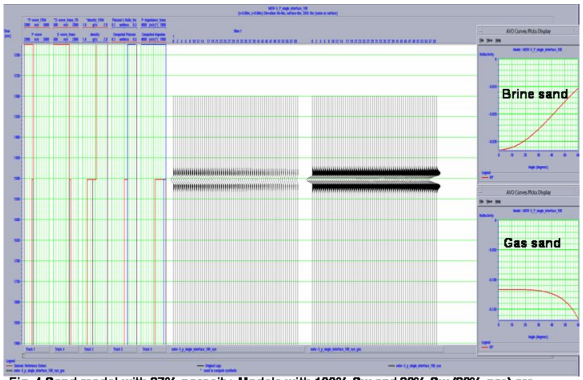

Fig. 4 Sand model with 27% porosity. Models with 100% Sw and 20% Sw (80% gas) are subjected to AVO modeling. The water sand layer generate low –ve intercept (-.033) and low gradients (.028), whereas gas substituted sand layer generate -intercept (-.117) and flat amplitudes (gradient.005)

Brine sand of 27% porosity despite being soft **generate little amplitude on seismic data and low +ve gradients and therefore can not generate bright amplitudes on stack data** (Figure 4), hence is disqualified as interpretation of the observations.

Brine sand of 33% porosity despite being soft **generate moderate to bright amplitude on seismic data but at the same time generate very good +ve gradients on gathers** (Figure 5), and therefore disqualified as interpretation of the observations.

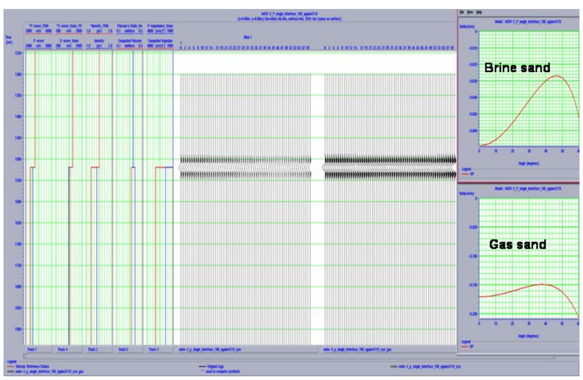

Fig. 5 Sand model with 33% porosity. Models with 100% Sw and 20% Sw (80% gas) are subjected to AVO modeling. The water sand generate moderate –ve intercept (-.070) and high + gradient (.12), Whereas gas sand high –ve intercept (.17) and moderate + gradient (0.070)

Gas sand of 24% porosity despite being soft layer generate **moderate amplitude on seismic data and good -ve gradients** (Figure 3), and therefore is disqualified as interpretation of the observations.

Gas sand of 27% porosity is soft layer generate **good amplitude on seismic data and very little gradients i.e. close to flat amplitudes with increase in offsets** (Figure 4), and therefore qualifies as interpretation of the observation.

Gas sand of 33% porosity despite being soft layer **generate bright amplitude on seismic data but good +ve gradients** (Figure 5), and hence is disqualified as interpretation of the observations.

Inferences:

Comparison of the responses generated from models with actual data shows that water sands generate low gradients when intercepts are very less, and moderate to bright amplitudes with high gradients. Therefore, does not mimic the observations made on stack and gather data and disqualifies as interpretation of observations.

Comparison of the responses generated from models with actual data shows the gas sand having porosity of 27% in this case closely mimics the actual observations. Corresponding to other two gas sands of porosities values 24 and 33 the gradients are -ve or +ve of substantial values. Therefore, gas sand of porosity close to 27% can be one of the possible solutions.

Conclusions

Technique is based on comparison of synthetic stack data and CMP gathers generated from models which is created with certain information and assumptions, with the field stacks and gathers data. It is observed the response generated from one of the gas sand models closely fits with the actual response. If assumptions come true, it will reduce risk of drilling dry hole. However, in the absence of well data the models representing the area is always an assumption and there may be other scenarios which may also can give the same type of expression in the gathers and stack data. However, it was felt that the modeling AVO responses can be the best option with various fluids and porosity parameters to mimic the observations. One of the gas sand models has generated the observed response. Results of well to be drilled will confirm the interpretation.

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Acknowledgements

Authors are thankful to ONGC for permitting to publish the work as paper. Views expressed in paper are those of authors only. The work is carried out at INTEG, GEOPIC, ONGC, Dehradun, India. Authors express their deep sense of gratitude and appreciation to Shri D.K. Pande Director (Exploration), ONGC, Shri S.K. Das, GGM-Head, GEOPIC and Shri S.V. Rao, ED- Chief E & D Dte., for providing the opportunity to bring out the work in present shape. Authors are thankful to Shyam Mohan, M. Murli, and PK Chaudhuri of ONGC for making themselves available for discussions and comments, which helped us to improve upon during the course of work. Authors appreciate the keen interest shown by the professionals Birbal Singh, AK Sood, C Mahapatra, AK Tondon, AK Srivastava, Hari Lal and their teams. Authors are thankful to BN Ghosh, BS Bora, and RCP Saxena, Subir Das, and RS Warraich, and other members of ONGC for extending support for such studies. Authors also appreciate the support by Shri MK Mathur CM(Prog.) - system group and his team to bring out the work in the present shape.

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