P 146

Stochastic Approach to Delineate Facies - An Integrated Study Using Seismic Attributes and Facies Logs on a Clastic Oil & Gas Reservoir of Western onland Basin of India

Bisht. BS*, Singh. RBN, Bahuguna .MM, Das. PK, Shukla. Manish, Mondal Satyajit, Samir Walia**

Summary

The identification of reservoir distribution of fluvial channels depositional environments is a challenging task for field development planning. To accomplish this task an integrated approach is required, where seismic attributes along with the lithology logs and geological concept can be used to define facies away from the wells.

This study demonstrate how through a combination of seismic attribute tools and reservoir modelling, a robust static model can be developed for an oil & gas field in India. The integration of the geological knowledge, seismic and well data measurements provide a robust 3D static model which can be used to reduce the uncertainty and help in better understanding of reservoir facies distribution.

Key Words: *Facies Modelling, Seismic Attributes, Static Modelling, Stochastic facies distribution*

Introduction

The challenge in the case of an oil and gas field was to accurately locate the reservoir bodies. Distribution of Reservoir facies was mapped using a stochastic pixel based method along with seismic attribute as a trend.
Stochastic facies distribution is a widely used technique in reservoir modelling. For the present study, a facies indicator methodology has been used based on the Sequential Indicator Simulation principle. Facies Indicators is a stochastic pixel-based facies modelling technique that generates a discrete 3D facies parameter for the current realization. Each cell is assigned a facies code defining the facies that is present in that cell, based on probabilities calculated from well data and user-defined input.

In the present study, the spectral decomposition attribute seemed to be most suitable as an indication of a channel passing through the field which has a good correlation with the observation in drilled wells. Instead of using object based modelling, a pixel based facies modelling approach was therefore preferred due to good concentration of wells along the channel and few wells away from the channel.

Method of Building an Integrated 3D Static Model

The main objective was to build a robust 3D Static Model of an oil and gas field based on seismic and well measurements. After understanding the field geology and challenges, the following workflow (Figure-1) was designed in order to build a geocellular model (Figure-2).

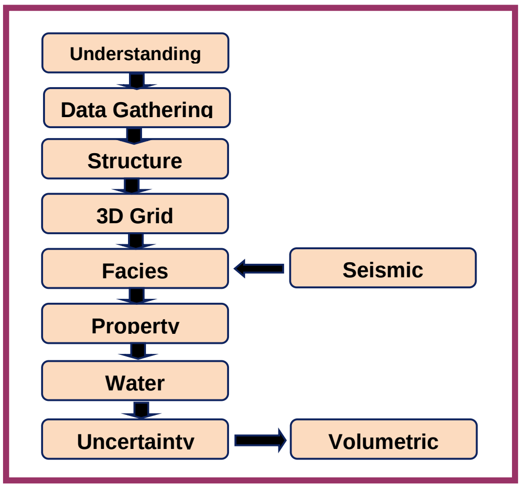

Figure-1: An Integrated Static Modelling Workflow

**ONGC Dehardun, India,*
***Roxar, Emerson Process Management, MEA*
Email: bisht_bs@ongc.co.in

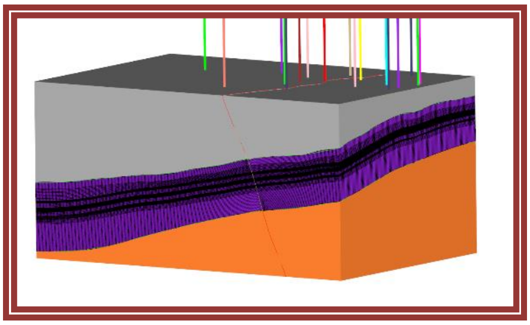

Figure-2: A 3D Grid with Wells and Overburden

Seismic Attribute Analysis

From the existing well data in the entire field, it's extremely important to make use of seismic data for facies delineation away from drilled wells.

The major challenge of using conventional seismic data is the resolution which may be 20m or more. However spectral decomposition may respond for 10 m with the available dominant frequency. Therefore spectral decomposition may be a useful technique for analyzing thin bed reservoirs and delineating depositional features, such as channels and reefs etc.

Spectral decomposition is a method for processing seismic data into frequency slices, as opposed to time or depth slices. When a spectral decomposition algorithm (such as a discrete Fourier transform) is applied to seismic reflection data, it breaks down the seismic signal into its frequency components. This enables the interpreter to visualize the data at specific frequencies and to identify stratigraphic and structural features that would otherwise be overlooked in full bandwidth displays.

Since the sand bodies are thin in nature in the area of study, it was considered worth trying to isolate the effect of frequency on stratigraphic features using spectral decomposition. S-transform technique was used to decompose seismic data between 10 Hz and 70 Hz.

Another useful workflow was strata grid functionality which extracts the seismic data between two seismic horizons, yielding a seismic data free from structural artifacts. This allows for the visualization of paleo-depositional surfaces and is very useful for geologic interpretation and modelling. For a better understanding of geological features, two strata grids were also generated and layers were define as base conformal at every 2ms. A single 40 Hz frequency volumes were also generated using spectral decomposition. Interestingly the cross-plot of GR vs. RMS amplitude attribute showed that high values of RMS amplitude (polygon in Figure-3) correlate well with GR<70 values indicative of sand.

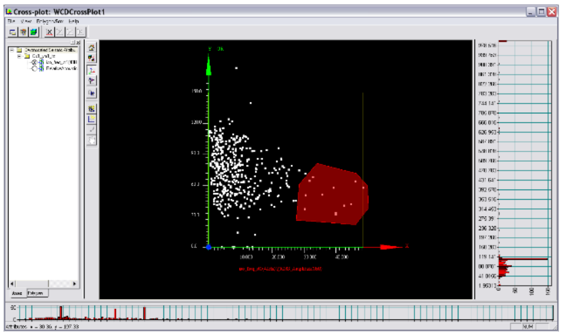

Figure-3: Cross-Plot (GR V/s RMS Amplitude)

Using the opacity functionality, which allows any attribute to be used as opacity, thereby bringing out subtle features which otherwise cannot be seen on the seismic data, a clear channel body was visible (Figure-4) passing through the field.

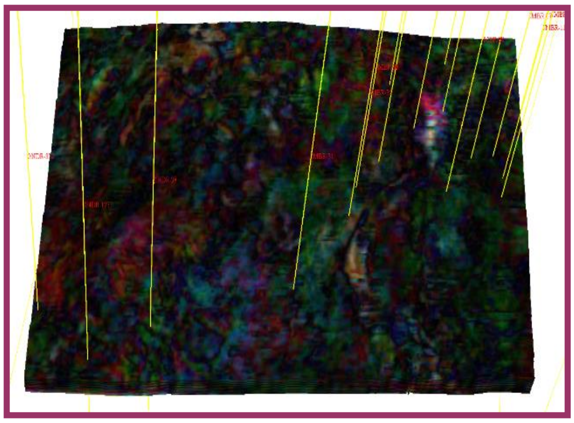

Figure-4: Seismic Attribute Shows a Channel Passing Through the Reservoir

Stochastic Facies Modelling

A detailed petrophysical analysis was also performed to detect the facies for each well. Typically three facies - Sand, Silt and Shale were detected at each well as illustrated under (Figure-5.)

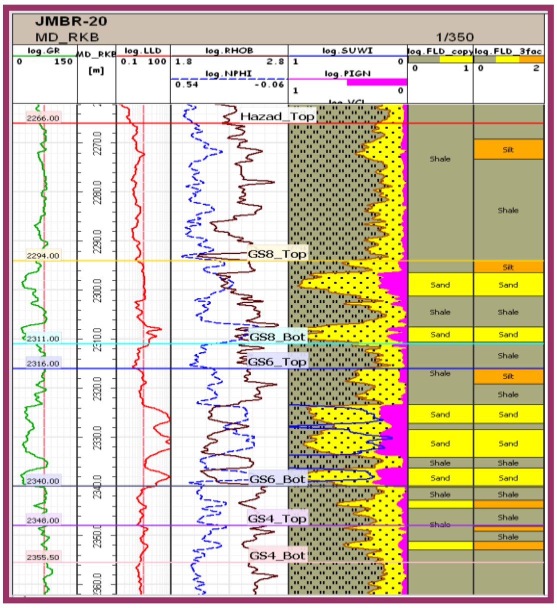

Figure-5: Lithology Log (Facies Log)

With growing popularity of stochastic approach, a number of facies modelling methods have emerged during the last ten to fifteen years.

(a). Facies modeling utilises two main types of techniques: ***object modelling methods*** that include the Facies Composite, Facies Channels, and Facies Elementary methods proved to be very efficient if the shapes and size of the different facies are well known

(b). A ***pixel-based simulation technique***, that include the Facies Belts and the Facies Indicators methods. These methods do not reproduce a specific geometry (objects), but reproduce volume fractions, trends, and continuity defined by variograms.

Facies Indicators is a stochastic pixel-based facies modelling technique that generates a discrete 3D facies parameter for the current realization. Each cell in the parameter is assigned a facies code defining the facies that is present in that cell, based on probabilities calculated from well data and user-defined input. In this workflow, the pixel-based simulation technique was applied, due to the good coverage by wells along the channel. (Figure 6) illustrates the facies modelling workflow.

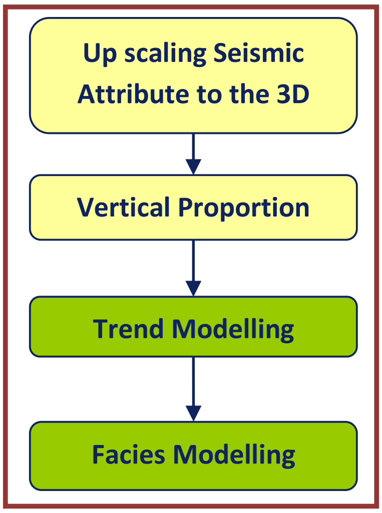

Figure-6: Facies Modelling Workflow

Upscaling Seismic Attributes to the 3D Grid

Since the seismic resolution is different from the 3D grid, to make use of seismic attributes generated under the Strata grid, it was rescaled to a 3D grid as illustrated in (Figure - 7).

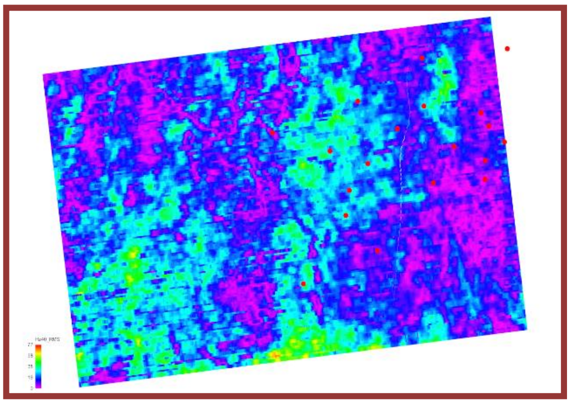

Figure-7: Shows a RMS Seismic Attribute Rescaled to 3D Grid at Layer No. 9.

Vertical Proportion Curve

Vertical proportion curves show vertical variations of the volume fractions for three facies sand, silt and shale facies as shown in Figure-8. This has been used as an input to guide the vertical distribution of the facies.

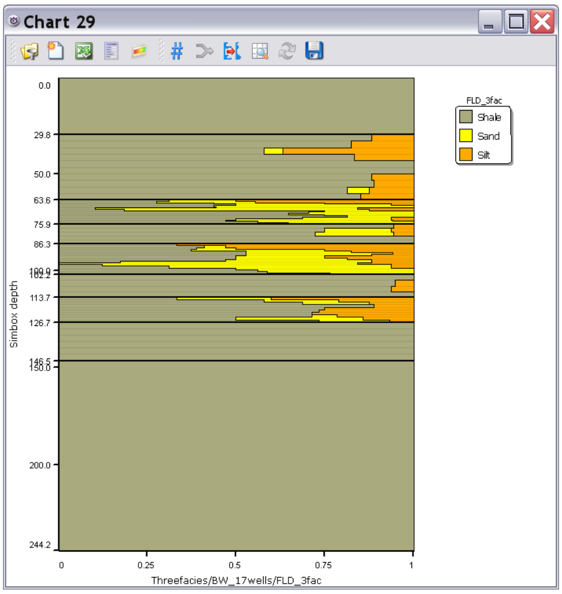

Figure-8: Vertical Proportion Curve

Trend Modelling

At the trend modelling stage, it uses an existing 3D parameter as a trend for example

(i) Using a modified seismic impedance cube as trend for porosity.
(ii) Using a simulated porosity cube as trend for permeability.

(iii) Using permeability, porosity, and an oil-water contact to create a 3D trend for water saturation.

In addition to that, a 3D trend has been created from the RMS amplitude at 40 Hz frequency and same is shown in Figure – 9.

Finally facies were populated stochastically using lateral trends derived from seismic attribute and vertical proportion curves derived from the lithology log along at the well location. Reservoir properties, such as porosity, water saturation, are populated guided by the facies as shown in (Fig 13 & 14) at layer - 9.

Facies Modelling Results

Figure 11 shows the lateral distribution of facies from reservoir top to the base (layer-1 top left to layer-18 bottom right) at different stratigraphic level and (Figure 12) shows the section along the wells.

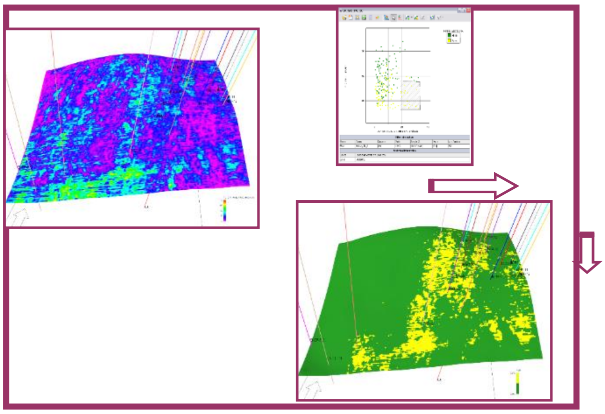

Figure-9: 3D Trend (Generated from Seismic Attribute) Workflow

Variogram analysis was also performed using the well data to estimate range. Figure 10 shows an example of the variogram modelling panel, where red dots are the data point and blue curves are the best fit curves in different directions.

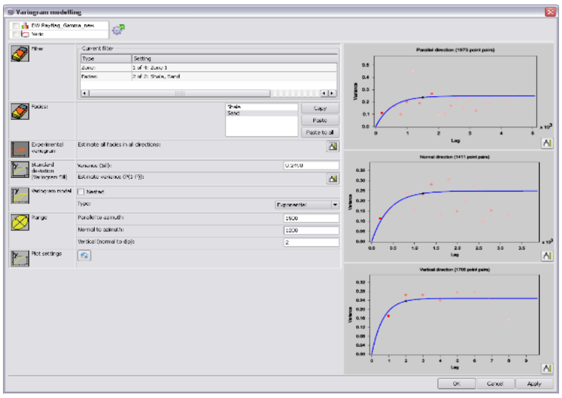

Figure-10: Variogram Analysis

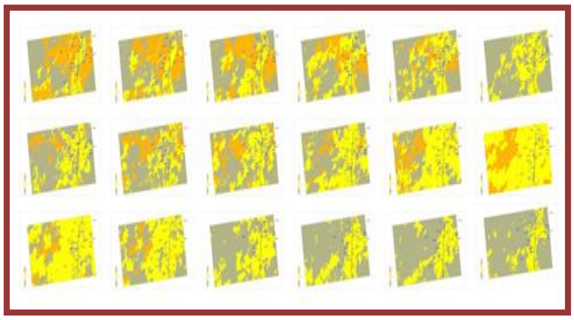

Figure-11: Facies Lateral Distribution

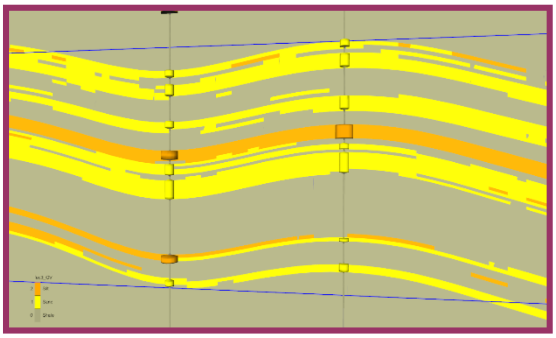

Figure-12: Vertical Facies Distribution

Porosity Modelling

Porosity is a key parameter for describing the quality of the reservoir. The effective porosity obtained from processing of well log data has to be upscale at grid level in such a way, so that it will preserve the real porosity information. The up scaled porosity was populated in the area using facies distribution as a guide. Figure-13 shows the distribution of the porosity in the layer No.9 which is well correlated with the facies model. This porosity model has confirmed the porosity value in the well which was not considered in the model during porosity modeling process.

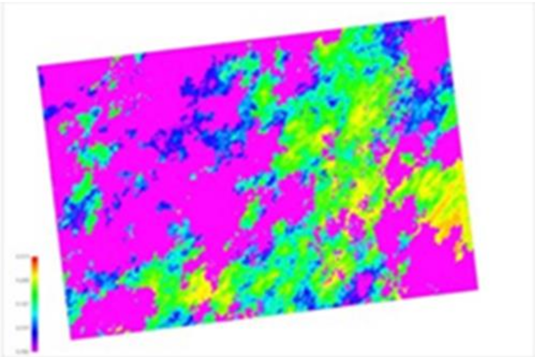

Figure-13: Porosity Distributio**n**

Saturation Modelling

Saturation modeling has been carried out by taking the water saturation Sw obtained from the processed log data. The OWC has been taken from the known value of the area.

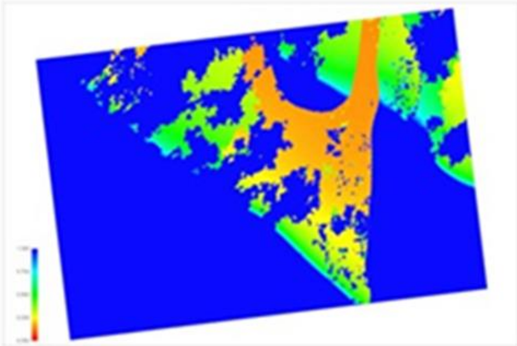

Figure-14: Porosity Distribution

Conclusion

With an integrated approach involving multiple disciplines, such as petrophysics, geophysics and geology, an effective and robust 3D reservoir model based on facies distribution has been generated.

Stochastic facies modelling gave an edge to integrate lateral trend from seismic attribute and vertical trend from lithology log to define reservoir facies in the area.

Knowing the facies distribution precisely porosity and saturation has also been populated in the area.

The results are validated in the new drilled well data after this modeling process.

Acknowledgement

The authors are indebted to Shri Anil Sood, GGM-HOI-GEOPIC, Dehradun, India for providing the technical input and guidance for writing this paper and Shri S.K.Das, ED-BM-WON Vadodara for technical guidance and encouragement.

Thanks are due to Shri AK Tandon Head-INTEG, GEOPIC, Dehradun, India for providing all kind of support for this work.

We wish to express our thanks to Roxar, Emerson Process Management, MEA for providing technical help in static model building during the project work.

The authors are grateful to the concern geoscientist of this domain for providing necessary input during the project work and writing this paper.

We thank ONGC management for allowing us to submit this paper in SPG international conference -2013

The views expressed in this paper are solely of the authors and do not necessarily reflect the view of ONGC.

References

Deutsch, C.V. 2003. Geostatistical Reservoir Modelling, 1-376. New York: Oxford University Press

Kelkar, M and Perez, G. 2002. Applied Geostatistics for Reservoir Characterization. 1-264. Society of Petroleum Engineers.

Jarvis, K., Folkers, A., Mesdag, P. [2004] Reservoir characterization of the Flag Sandstone, Barrow Sub-Basin, using an integrated, multiparameter seismic AVO inversion technique. The Leading Edge, 23(8), 798-800.

Mallet, J.-L., Geomodeling, Applied Geostatistics Series. Oxford University Press. ISBN 978-0-19-514460-4