7th International Conference & Exposition
on Petroleum Geophysics

"HYDERABAD 2008"

P - 143

Application of Multi-Attribute Analysis in Mapping Favorable Facies Areas for Better Placement of Horizontal Wells in Mumbai High Field

A K Nauriyal , *MH Asset, ONGC, Mumbai, India, aknauriyal@rediffmail.com**

A K Sarkar , *MH Asset, ONGC, Mumbai, India, aksarkar01@rediffmail.com*

B V R R K Murthy, *MH Asset, ONGC, Mumbai, India, Krish492k@yahoo.co.in*

Summary

In this paper the authors have made an attempt to map the favourable facies through multi attributes analysis by extracting various attributes viz. absolute amplitude, relative acoustic impedance and acoustic impedance from amplitude preserved seismic data. Recently processed anisotropic pre-stack depth migrated (APSDM) seismic data scale back to time was used to extract various attributes as cited above. These attributes volume were subsequently converted into depth domain.

A systematic study of different attributes for predicting the areas of favourable reservoir facies confirms that the multi attribute analysis of these attributes are the best fit for predicting the relative petro-physical characters of the reservoir. The study could discriminate between good reservoir facies and tight reservoir facies and has been effectively used in precisely placing the horizontal wells. Different attribute maps were made for sub-layers within L-III layer of Mumbai High South field, which played an important role in guiding the horizontal wells passing through good reservoir facies.

Introduction

Ever since 3D seismic emerged as one of the powerful tools in exploration, the E & P industry has been greatly benefited from its application in the various facets of oil industry. The technology has increased the level of confidence in the minds of the geo-scientists as it proved its capability in accurately planning well locations besides making them economically viable. Seismic attributes are one of many tools used to help in selecting strategic placement of horizontal wells. The placement of landing point and then the modeling of the horizontal track(path) is crucial before the well is released for drilling. The image of the sub-surface can be predicted only by seismic and the meticulous planning can be done only with the help of seismic attributes. Seismic attributes are defined as a mathematical transform of the seismic trace to predict petro-physical properties of the rock. The flow chart shown in fig.1 is self-explanatory.

Normally geoscientists measure petro-physical properties using well logs or core data and then try to interpolate the data between the wells. Seismic data is incredibly rich with the information of the sub-surface in the form of amplitude, frequency, phase, geometry and texture. Each trace in seismic is a composite response of lithology, fluid content and other geological factors. Geo-scientists always look for the vital information regarding the rock and fluid content through the seismic traces.

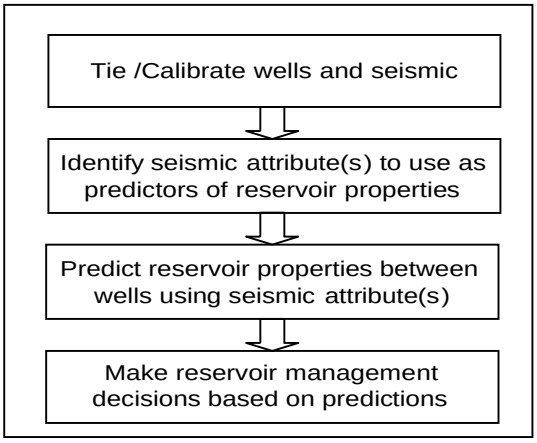

Fig: 1 Simple flow diagram showing use of seismic attributes to predict reservoir properties.

Methodology

Seismic multi-attribute analysis is a broad term that encompasses all geostatistical methods using more than one attribute to predict some physical property or the other of the earth. In many cases, we can show — using seismic modeling or rock physics — a physically justifiable relationship between a seismic attribute and the reservoir property of interest. When this is true, we are able to greatly reduce the uncertainty of inter-well predictions of reservoir properties. The simple flow diagram in Figure 1 illustrates the basic process.

In the paper the authors have extracted three different attributes viz. Acoustic impedance (AI), John Pendrel et.al,Jan_2001,Relative acoustic impedance (RAI) and Absolute amplitude. To extract the inversion volume the first critically important step is accurately tying the well and seismic both vertically and aerially,(Brian Russel et. al. 2006). The major thrust was laid on identifying most optimum wavelet. A statistical minimum-phase wavelet was identified for the seismic volume which had a decent amplitude and phase response. Fig; 2. The accurate tying of wells with the seismic was done by generating a synthetic trace at the well location and correlating it with the available seismic data. Fig: 3 A total of 15 wells which were have high degree of correlation were used for inversion. Once the tying of wells with seismic was done then model based inversion was carried and a highly resolved layered P-impedance volume in time was generated which was beautifully correlated with available well data, Fig: 4

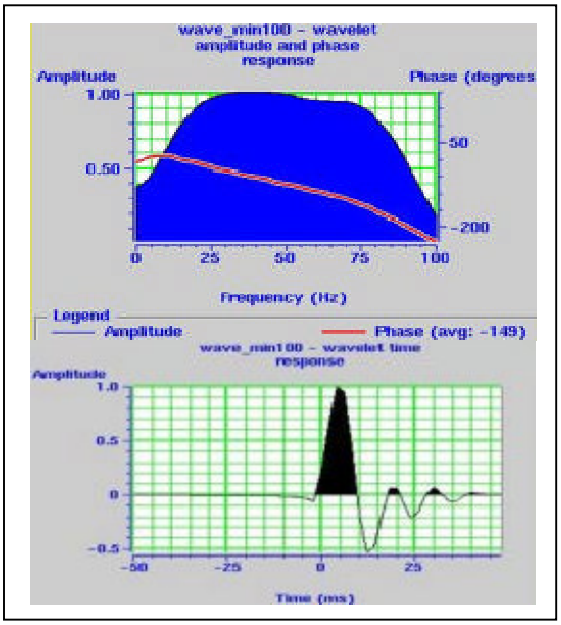

Fig: 2 Statistical Minimum-Phase Wavelet extracted from seismic volume and corresponding amplitude & phase response

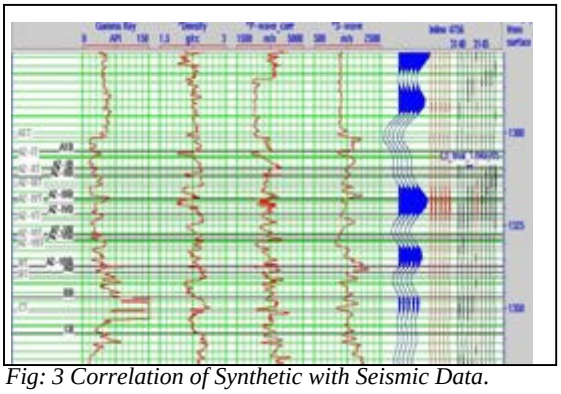

Fig: 3 Correlation of Synthetic with Seismic Data.

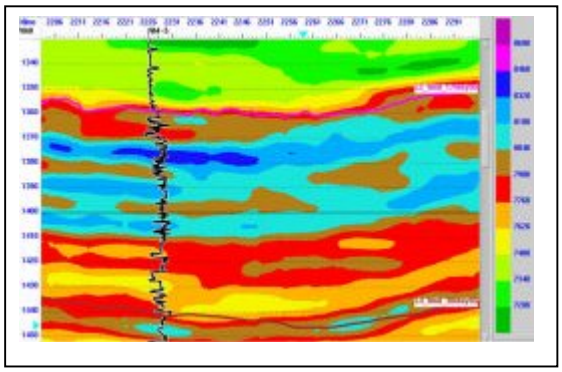

Fig: 4 Acoustic impedance volume showing the facies distribution

Crossplot analysis of well logs properties. Density, sonic and gamma-ray logs were collected from 15 wells in the Mumbai High area .The density and sonic logs are used to compute AI, and gamma-ray. Many cross-plots were generated to ascertain the data quality and Fig: 5 shows cross-correlation of 66.799% between predicted P-wave and actual recorded.

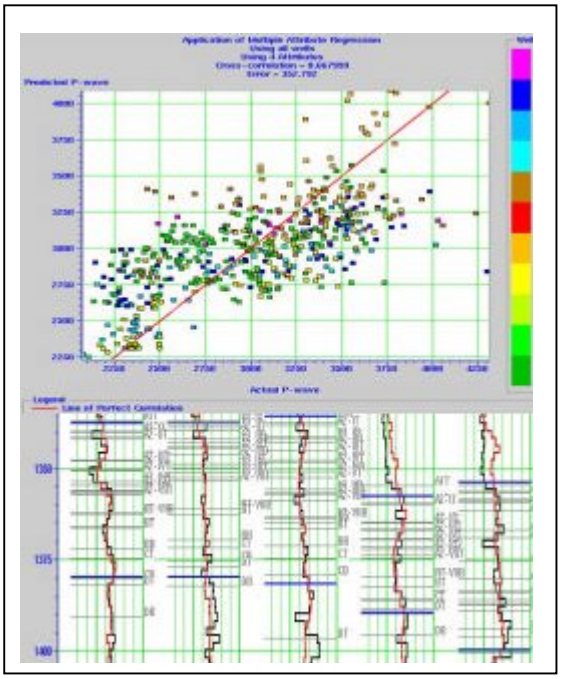

Fig :5 Cross-correlation (66%) Between predicted and Actual P-wave

This high degree of correlation clearly shows that the predicted P-wave volume is in close resemblance to the actual geology of the reservoir and thus the AI volume generated can be with great certainty be used to determine the facies with near accuracy.

Jose calderon et al (2007) have described seismic attributes such as acoustic impedance are often used to map lateral variation of reservoir rock properties (e.g.,porosity ,lithology,fluids etc).What we need is to understand the relation ship between these properties and seismic acoustic properties (i.e. velocity, acoustic impedance).

We have not only attempted to correlate the physical links between the seismic elastic properties and facies distribution, but have also tried to improve the predictive ability of such properties derived from well logs through multi attribute analysis using the acoustic impedance with other seismic attributes.

Discussions

One horizontal well was under drilling in A1(L-III) layer and it encountered bad facies. When examined, it was found that the track was falling in low amplitude zone in the absolute amplitude attribute map. Subsequently the well was plugged back and side tracked in the zones showing moderately good amplitude and the same was later proved to be having good reservoir facies. This incidence enhanced the confidence in the utility of the attribute and its veracity in deciding the location of the well along with the positioning of the sidetrack while drilling a horizontal well (fig 6 to 9). There is another incident to prove the best utility of the said attribute. Based on the above experience and using the same attribute map another horizontal well, located around 800 meters away from the previous well, was drilled through A2-III layer and was sidetracked in the zone where better absolute amplitude was present. The well started producing around 1000 bopd after final completion. This success gave high confidence level in the utility of the absolute amplitude map for the purpose of horizontal drilling and thus opened up opportunities to venture in other areas.

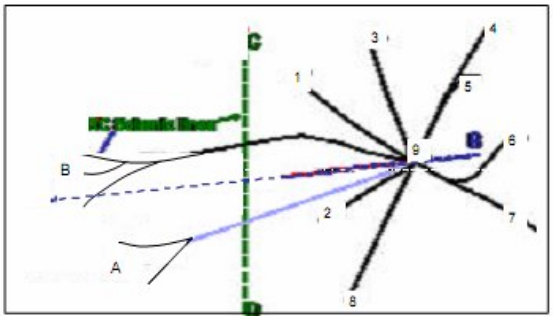

Fig: 6 Location Map showing the arbitrary traverse CD

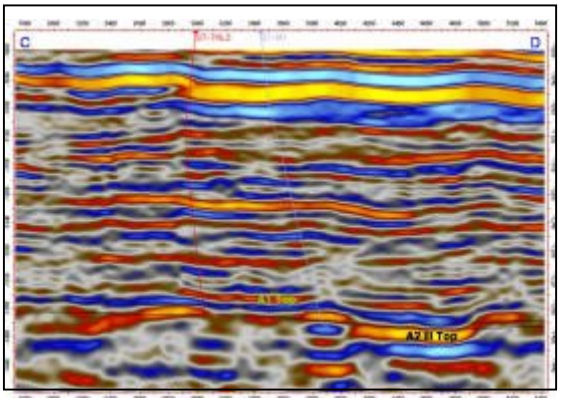

Fig: 7 Arbitrary Seismic Section along line CD

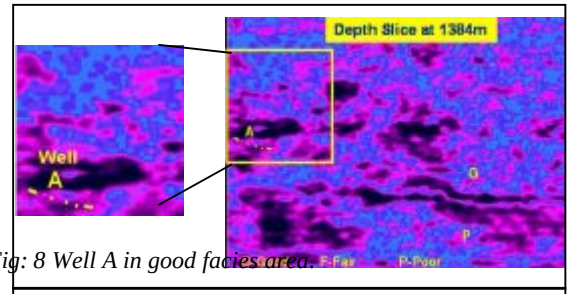

Fig: 8 Well A in good facies area.

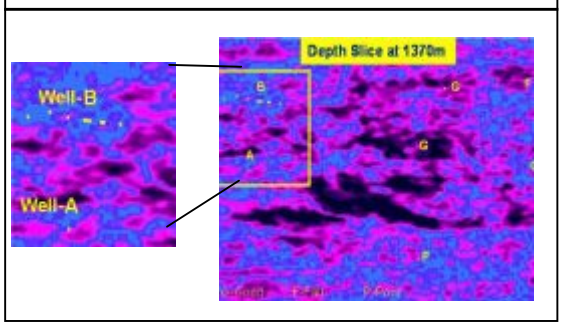

Fig: 9 Well B in bad facies area.

Multi attribute analysis comprises of its own a method in which external attributes have been calculated and matched such that they all point towards favorable facies with greater certainty. Relative AI, Absolute amplitude and AI have been used to predict good facies areas in a complex carbonate regime Fig: 10

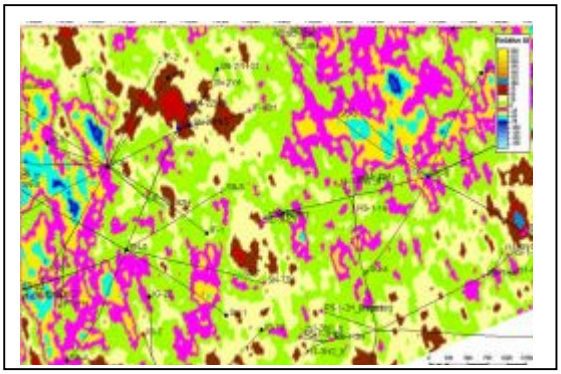

Fig: 10 Relative Acoustic Impedance attribute for B layer depicting the facies variation.

Theory behind Relative Acoustic Impedance is that it is the product of density & seismic velocity, which is a function of rock property, fluid content etc. Relative AI is calculated by integrating the trace, then passing the result through a low-pass Butterworth filter. It reflects physical property contrast; it relates to porosity and indicates discontinuities.

The authors has also used the ant-track attribute which is proprietary of a company but the theory involved is that it joins the discontinuities encountered in the variance volume. It clearly brings out the fracture network and their orientation .This attribute has been used to identify the possible fracture trends so that laterals can be placed effectively avoiding fractures .Fig:11 & 12.

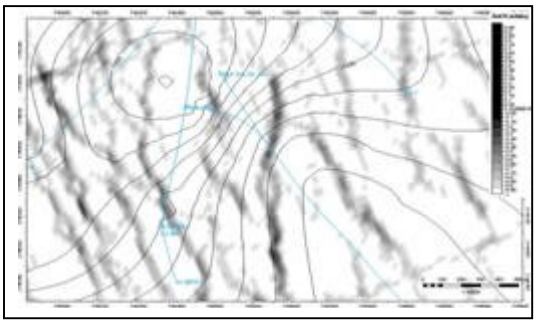

Fig: 11 Ant-Track attributes to identify the possible fracture network.

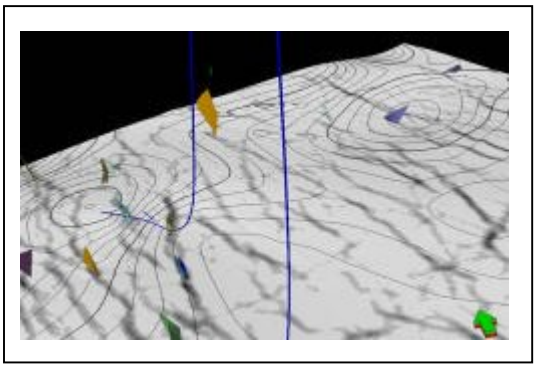

Fig: 12Well being intersected by faults detected with the help of Ant-track attribute.

Conclusions

We must be judicious in choosing the seismic attributes which we believe are related to the reservoir property. Using that attribute or set of attributes, the help of the dense seismic data is taken to guide the prediction of reservoir properties between sparse well data. Linear or nonlinear regression, geostatistical, or neural networks can be adopted in predicting the reservoir properties from the attributes. The purpose is to facilitate the reservoir management decisions — such as placement of location number of wells to be drilled, depletion strategy and gas , water injection policies. Only those seismic attributes that have a physically justifiable relationship with the reservoir property should be considered as candidates for predictors.

The development of a field depends upon how successfully wells are placed in the right position and how best laterals are tracked through good reservoir facies. The modeling of a track prior to drilling is of paramount important and seismic attribute will help in avoiding the placement of a well in an unfavourable reservoir facies. The uncertainty in the well placement in proper reservoir facies can be reduced by choosing a proper seismic attribute

References

Brian Russell, Dan Hampson, and Bradley Bankhead,An Inversion Primer, Veritas/Hampson-Russell, Calgary, Canada and Houston, Texas, USA. CSEG recorder 2006 special edition

J. E. Calderon, ecopetrol s.a., Bogotá,Colombia, J. CASTAGNA, University of Houston, USA .Porosity and lithologic estimation using rock physics and Multi-attribute transforms in Balcon Field, Colombia.the leading edge february 2007.

Seismic inversion – the best tool for reservoir characterization, John pendrel, jason geosystems Canada, CSEG recorder.Jan_2001

Further Reading

Cynthia t. Kalkomey, Mobil E&P Technical Center, Dallas, Texas Potential risks when using seismic attributes as predictors of reservoir properties. March 1997 the leading edge.

Helland-Hansen, D., Magnus, I., Edvardsen, A., Hansen, E., 1997, Seismic Inversion for Reservoir Characterization and Well Planning in the Snorre Field, The Leading Edge, **16** #3, p.269

J. P. Castagna, M. L. Batzle, and R. L. Eastwood,1985, Relationships between compressional-wave and shear-wave velocities in elastic silicate rocks geophysics vol. 50, no. 4 (April 1985); p. 571-581.

Latimer, R.B., Davison, R., Van Riel, P., 2000, An Interpreter's Guide to Understanding and Working with Seismic-Derived Acoustic Impedance Data, The Leading Edge, **19** #3, p.242

Patrick Connolly, BP Amoco, Houston, Texas, U.S. Elastic impedance, The leading edge April 1999

Acknowledgements

The authors sincerely acknowledge the ONGC authority for permitting to publis h the data and the findings of the study. The authors are thankful to Shri Apurba Saha, ED - Asset Manager, MH Asset, Mumbai for providing an opportunity, encouragement, infrastructure and technical support. Thanks are due to M r. S.K.Verma, SSM, MH Asset, Mumbai , Shri S.Chandrasekaran, GM(R),MHS, MH Asset, Mumbai Shri G.C.Katiyar,GM(Geophy), MH Asset, Mumbai and Shri V.V.Kamat, DGM (Geology), SST, MHS, MH Asset, Mumbai for their keen interest and valuable guidance. The authors also intend to place it on record the immense support and co-operation extended by Shri.O.P.Srivastava Dy.S.G(S), GPS,Western offshore ,Mumbai , in attributes selection.