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Rock Properties Analysis using Seismic inversion and Neural Network: a case study of Upper Assam Basin, India.

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Abstract

Quantitative estimation of petrophysical parameters from 3D seismic data has always been crucial and expensive for identification and assessment of reservoir rocks. In this case study, petrophysical evaluation from two wells JT and JK are carried out in combination with attributes derived from seismic inversion to estimate petrophysical parameters from a part of the upper Assam Basin. Quantitative evaluation of Petrophysical parameters provided the information on water saturation, availability of clay mineral, and pores in the rock volume. The 3D seismic data covers a 34 sq km block located within Latitude $26^0 14'$N to $26^0 22'$N and Longitude $93^0 56'$E to $94^0 2'$E in upper Assam Basin. The major reservoir rocks in the block are expected in the fractured granitic basement rock, Tura sandstones underlying Sylhet Limestone and, intra-formational argillaceous sandstones in Kopili formation. Sandstones within Cretaceous and Gondwana sequences and basal sandstone overlying the basement would also form prospective reservoir rocks. In the paper, rock physics modeling is estimated the reservoir rock found mainly sandstone with ~30% to ~60% clay matrix, and with the porosity ~10 % to ~20% where a wide range of water saturation found is ~12% to ~30%.

Keyword: Porosity, water Saturation, Shale volume, Neural Network.

Introduction

The Upper Assam Basin has been a tectonically active basin where hydrocarbon exploration is in production since last few decades and is considered a mature hydrocarbon province. The high quality wells are essential to generate wavelet, low frequency model, seismic velocity calibration, time to depth conversion, and for the calibration between attributes and well log properties with neural network approach. The subsurface is structurally complex characterized by numerous faults. The 3D post-stack seismic volume in the basin has been interpreted for better assessments of the underlying low acoustic impedance sand in the formations and validated with the wells-JT and JK. Imported well data such as sonic velocity and density are used with the geophysical information to build inverted seismic volume. The petrophysical parameters such as shale volume, water saturation are combined with attributes from inverted seismic sections to estimate these parameters within the whole seismic volume. Both the wells-JT and JK are drilled to the basement depth and placed within the seismic volume. The wells are also used to extract the wavelet from each of them. Both the wavelets are used in the seismic-tie correlation. To understand rock properties away from the well location, the lateral and vertical variation can be inferred via the quantitative interpretation of the seismic data. Here, we combine the seismic inversion analysis with well data to successfully resolve the problem of prospect evaluation. A workflow is established here to infer the potential zones of reservoir rock based on the quantitative interpretation of low impedance sand, porosity, water saturation and shale volume. The upper Assam basin is located in northeastern India and it is a self-slope basin shown in figure 1(a,b) (Bhandari et al. 1973; Kent and Dasgupta 2004). The basement rock is granite and, the sedimentation of ~7 km thick sedimentary rocks have been reported in the basin of tertiary period (Kent and Dasgupta 2004; Wandrey, 2004; Kumar et al. 2018).

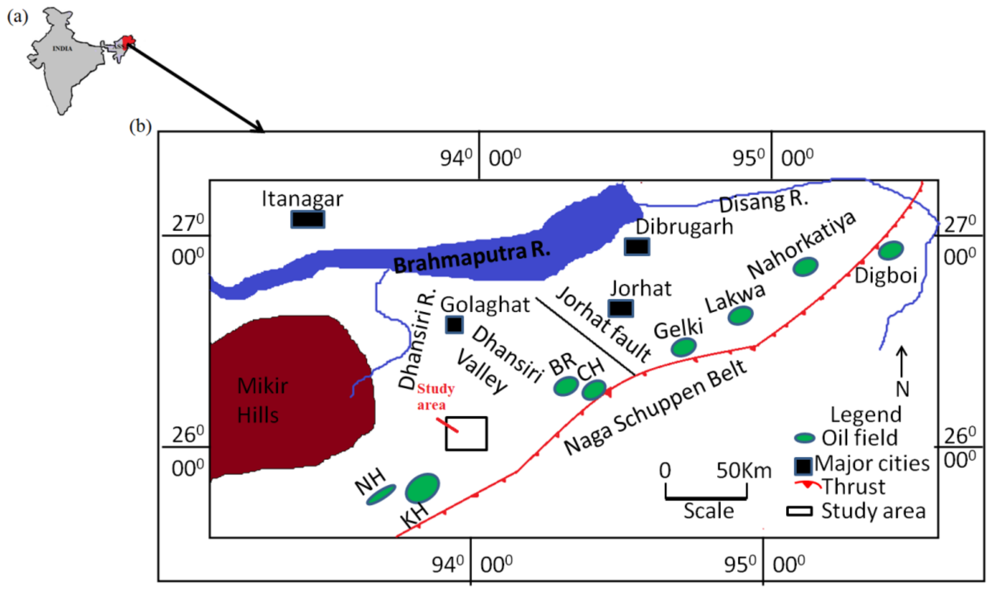

Figure 1: The location of basin in the (a) country map (b) part of upper Assam Basin where study block is located.

Methodology

The initial phase in the context of this work is to estimate the high resolution petrophysical parameters using wells JT and JK to identify the unexplored hydrocarbon-bearing province within reservoir rock interval (Bateman, 1985; Gogoi and Chatterjee, 2017a; Hussain et al. 2017a; Ishwar and Bhardwaj, 2013; Serra, 1984).

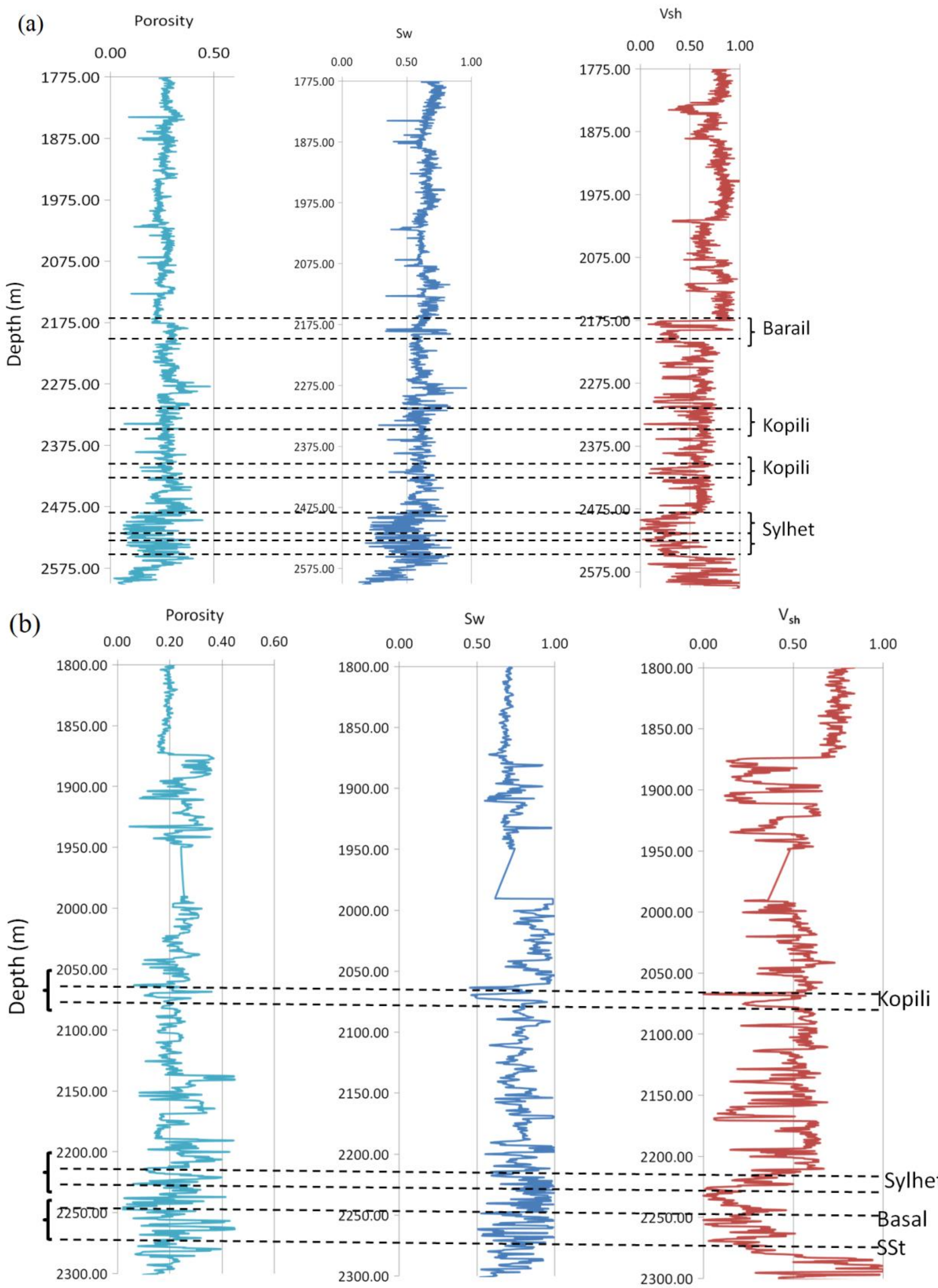

Figure 2: The well log response is showing the petrophysical parameters with depth in (a) well- JT (b) well-JK, and the estimated reservoir depth is marked with dashed line.

3D subsurface modeling of petrophysical parameters

In this context, the 3D seismic data is used to study acoustic impedance, porosity, water saturation and shale volume, and their variations in both vertical and horizontal direction. Shale volume and water saturation is derived by a non-linear neural network approach which used several best fit multi-attributes with the density and impedance model (Poupon and Leveaux, 1971). In this paper, four attributes, namely, Amplitude envelope (density), integrated absolute amplitude (inverted impedance), amplitude weighted cosine phase, Filter 5/10-15/20 (density) are used in the neural network process to estimate shale volume for the whole seismic volume, whereas three attributes integrated absolute amplitude (inverted impedance), density**2, inverted impedance are used to estimate saturation model from neural network approach for the whole seismic volume.

Figure. 3a shows the 3D mapping of impedances within a time interval ~1612 ms to ~2397ms, which is used in the study to estimate porosity (Fig. 3b), water saturation (Fig. 3c), and Shale volume (Fig. 3d). For better assessment, the time slices for porosity (Fig. 4a), water saturation (Fig. 4b), and Shale volume (Fig 4c) of time ~1794 ms is shown in figure.4. From these slices, we identify hydrocarbon found in sandstone with ~30% to ~60% clay matrix, of porosity from ~10 % to ~20% with a wide range of water saturation from ~12% to ~30%.

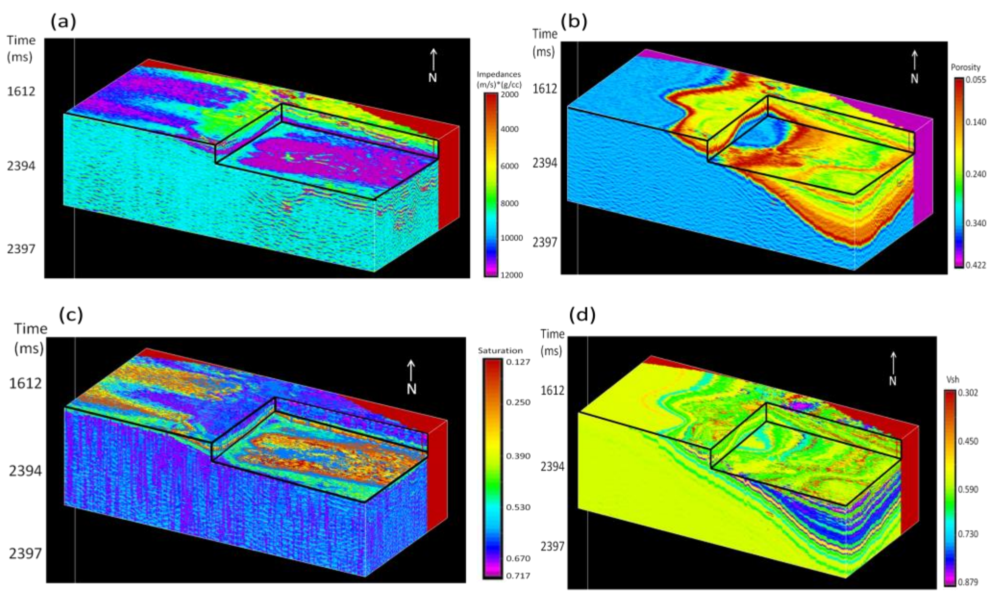

Figure 3: The 3D mapping of (a) acoustic impedance (b) porosity (c) saturation (d) shale volume within time ranges ~1612ms to ~2397ms in the study area.

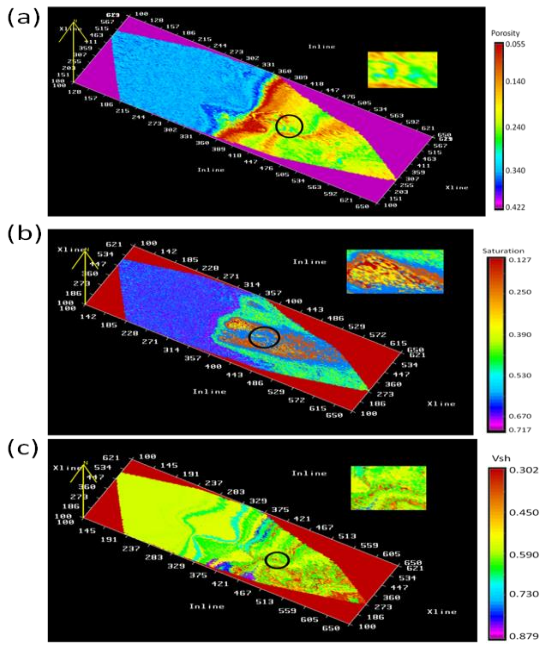

Figure 4: The time slices of time ~ 1794ms to demonstrate (a) porosity (b) Water saturation (c) shale volume.

Conclusions

In this case study, we report on some new results of petrophysical parameters in the upper Assam Basin with the use of attributes using neural network algorithm from inverted seismic volume. We predict porosity within the 3D seismic volume which shows a linear trend with the density model whereas water saturation and volume of shale are non-linear with attributes, and therefore neural network is used to derive these parameters in this structurally complex area. Our final results include prospect zones of hydrocarbons in sandstone with ~30% to ~60% clay matrix, of porosity from ~10 % to ~20% with a wide range of water saturation from ~12% to ~30%..

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References

Bateman, R.M., 1985, Openhole Log Analysis and Formation Evaluation, *Pretice Hall PTR, New Jersey*, *647.*

Bhandari, L.L., Fuloriya, R.C., Sastri, V.V. 1973, Stratigraphy of Assam valley, India1, *AAPG Bulletin, 57(4)*, 642-654. https://doi.org/10.1306/819A4310-16C5-11D7-8645000102C1865D.

Gogoi, T., Chatterjee, R., 2017a, Mapping of shale volume using neural network modeling in part of Upper Assam basin, India. *In: 12th Biennial International Conference and Exposition, Society of Petroleum Geophysicists. Extended Abstracts, 174.*

Hussain, M., Chun, W.Y., Khalid, P., Ahmed, N., and Mahmood, A., 2017a, Improving petrophysical analysis and rock physics parameters estimation through statistical analysis of Basal sands, Lower Indus

Basin, Pakistan, *Arabian Journal for Science and Engineering, 42*, 3699-3715. https://doi.org/10.1007/s13369-017-3029-6.

Ishwar, N.B., Bhardwaj, A., 2013, Petrophysical well log analysis for hydrocarbon exploration in parts of Assam arakan basin, India. *In: 10th Biennial International Conference and Exposition, Society of Petroleum Geophysicists, Kochi,* 153-158.

Kent, N.W., and Dasgupta, U. 2004, Structural evolution in response to fold and thrust belt tectonics in northern Assam. A key to hydrocarbon exploration in the Jaipur anticline area, *Marine and petroleum Geology, 21(7),* 785-803. https://doi.org/10.1016/j.marpetgeo.2003.12.006.

Kumar, M., Dasgupta, R., Singha, D.K, Singh, N.P. 2018, Petrophysical evaluation of well log data and rock physics modeling for characterization of Eocene reservoir in Chandamari oil field of Assam-Arakan basin, India, *Journal of Petroleum Exploration and Production Technology, 8*, 323-340. https://doi.org/10.1007/s13202-017-0373-8.

Poupon, A., Leveaux, J., 1971, Evaluation of water saturation in shaly formations. *In: SPWLA 12th Annual Logging Symposium*, society of petrophysicists and well-log analysts, 1-2.

Serra, O., 1984, Fundamentals of well-log interpretation, 1. The acquisition of logging data. *Developments in petroleum science, 15A.*

Wandrey, C.J. 2004, Sylhet-Kopili / Barail-Tipam composite total petroleum system, Assam geologic province, India. In: Wandrey, C.J. (Ed.), Petroleum Systems and Related Geologic Studies in Region 8, South Asia, *US Geological Survey Bulletin, 2208-D*, 1-19.