Neural Network Application for Frontier Exploration: East / Central African Rift Example

Valentina Baranova, Azer Mustaqeem, Petro-Explorers Inc., Calgary, Canada, info@petroexplorers.com
and
Francis Karanja, Milestone Consultants Ltd., Nairobi, Kenya, fkaranja@milestonkenya.net,
Danson Mburu, Seismo Service Ltd., Nairobi, Kenya, seismoservice@gmail.com

GeoConvention 2012:Vision

Summary

Application of advanced methods of Reservoir Characterization for frontier exploration area (East African Rift basins specifically South Anza Basin, Kenya) is discussed. Lack of adequate geological and seismic data limits the use of conventional geological and seismic interpretation. However, application of neural network, especially chimney analysis on vintage dynamite seismic data of reasonable quality has led to mitigating risk of exploration and identifying new targets.

Introduction

The Neural Network plugin supports supervised and un-supervised neural network to combine multiple attributes into “Meta-attributes”. The main application of un-supervised networks is clustering of attributes and/or waveforms for seismic facies classification. The supervised approach is used for more advanced interpreter guided seismic analysis and to create object probability cubes such as TheChimneyCube® and TheFaultCube®. Neural Network supervised and un-supervised methods were applied for frontier exploration area in East African Rift, South Anza Basin in northeast Kenya.

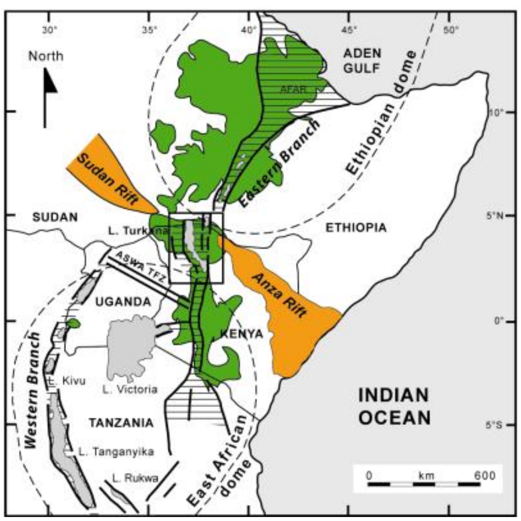

Figure 1: East Africa Rift system (South Anza Basin – Anza Rift)

In the area (Figure 1) many of the parameters related to active petroleum system and seals are least understood due to lack of well data and inconsistent seismic data coverage. Area under consideration is situated in the South Anza Basin and has only four wells drilled, and it has few 2D seismic lines shot and processed in different years. The project targets are to understand the regional petroleum system and to evaluate selected individual prospects and seals for feasibility of vertical hydrocarbon charge and risk of vertical hydrocarbon leakage through top seal or fault systems.

Method

The chimney processing methodology involves picking examples of highly probable gas chimneys and non-chimneys on seismic sections. Non-chimneys are often picked in chaotic seismic facies and faults not associated with hydrocarbon migration to distinguish the chimneys more clearly. In total, approximately several hundred chimney and non-chimney locations were interpreted on multiple 2D lines in the dataset. At these locations, a selection of seismic attributes were extracted and fed to the neural network engine, along with the user-interpreted chimney and non-chimney points. The neural network learns to correlate certain combinations of attributes with positive or negative identification of gas chimneys.

Chimney Analysis is a type of neural network which is an intelligent mix of a number of seismic attributes related to the effects of vertical hydrocarbon migration. Each attribute carries a partial correlation to the vertical migration. By integrating the attributes the software manages to create a stacking effect where these attribute reinforce each other. The examples of attributes used for the Chimney analysis in this project are: Similarity, Simple Chimney Attribute, Polar Dip, RMS (Root Means Square), Filter Residual, Average Frequency, Frequency Wash-Out Ratio, Average Frequency. The results obtained then are compared with the chimney interpretation model which shows the type of chimneys and the risk associated to each trap type.

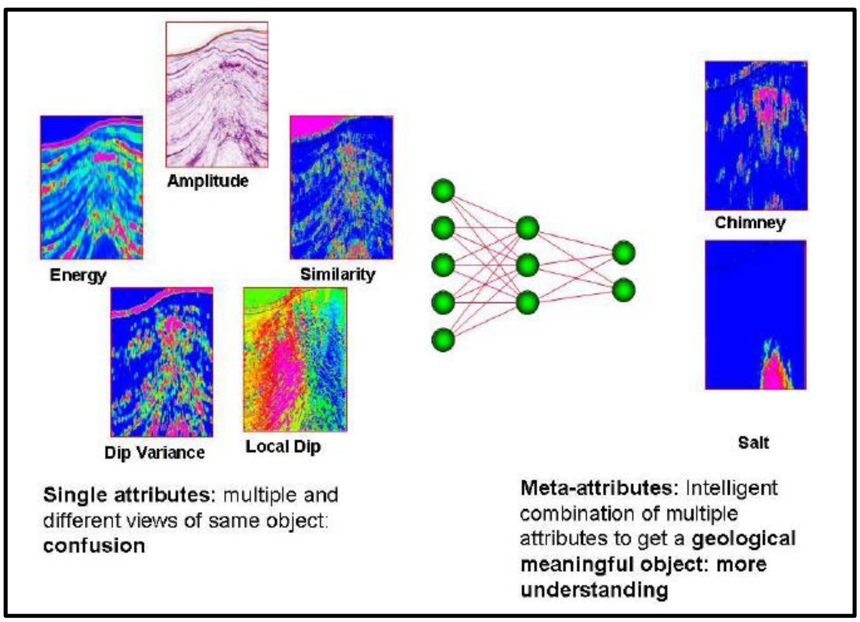

Figure 2: Application of Supervised Neural Networks, description of chimney processing.

Examples

Petroleum Exploration in Kenya has been sporadic and started in 1950s when BP and Shell started their program in the northern part of the Lamu Basin. Until now various companies put a lot of efforts in discovering hydrocarbon deposits. However, no proven reserves of hydrocarbons have yet been discovered. There are 36 blocks in four sedimentary basins. 2 blocks in the South Anza Basin have been selected for this project for further development. Initial exploration program has been set up. 2D seismic lines of different vintages along with the data of 4 wells drilled in different years are available for interpretation along with numerous geological and tectonic data and reports.

The question of feasibility applying chimney analysis to the project dataset has been under discussion since the start of the project. There are many indications on hydrocarbon vertical migration in this dataset. On the seismic lines chimneys often exhibit conical shapes of vertical effects and show as incoherent or hummocky signature on coherency/similarity sections. There are lots of chimney-look areas on almost every seismic line we had received which shows an active migration system in the uplifted and reactivated fault zones. On the basis of the discussion above and having in mind our many years of experience we could distinguish them in comparison to fault shadows and surface static effects.

Set of 2D seismic lines available has been divided into 3 groups in accordance with their vintage. Then, one test line out of every group has been chosen in order to train neural network which has been then applied for the whole group. As a result, we have chimney on all seismic lines. The integration of all the results into three dimensional maps and years of geological and geophysical experience allows better understanding of the hydrocarbon migration and trapping system ahead of any further well tests.

Conclusions

The results of chimney analysis are compared with the chimney interpretation model which shows the type of chimneys and the risk associated to each trap type. We have strong evidence of fault related chimneys for this basin.

Ranking of the leads have been divided into three categories: 1. Good leads, leads supported by good evidence of charge and seal; 2. Questionable leads, when some questions about structure, charge, or seal could be confirmed by 3D seismic data; and 3. High risk leads, where chimney results indicate high risk of seal or charge failure.

Based on chimney analysis for South Anza Basin we narrowed down the area of approximately 2,300 sq.km. for further 2d and 3d seismic acquisition, covering new focus area containing several highly prospective leads.

In conjunction with burial curves and geological insight the target areas with migration pathways and possible source rocks were remodeled in association with the chimney results.

Acknowledgements

Authors are grateful to dGB Earth Sciences for in-depth consultation and assistance in completing the project and Vanoil Energy (Kenya) for allowing presenting the results of this project.

References

AAPG Special Volumes. 1999. Geoscience of Rift Systems-Evolution of East Africa. AAPG Studies in Geology #44, Chapter 2: Geology and Geophysics of the Western Turkana Basins, Kenya.

Morley, C.K., 2002, Evolution of Large Normal Faults, Evidence from Seismic Reflection Data, AAPG Bulletin, v. 86, no. 6 (June 2002), p. 961–978

Morley, C. K., 1999a, Patterns of displacement along large normal faults: implications for basin evolution and fault propagation, based on examples from East Africa: AAPG Bulletin, v. 83, p. 613–634.

Morley, C. K., 1999b, Basin evolution trends in East Africa, in C. K. Morley, ed., Geoscience of rift systems—evolution of East Africa: AAPG Studies in Geology 44, p. 131–150.