

Application of Seismic Geomorphology for Frontier Hydrocarbon Exploration, South Anza Basin, East African Rift*

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Abstract

Application of advanced methods of reservoir characterization for frontier exploration (East African Rift, South Anza Basin, Kenya) is discussed. The current portfolio of the exploration program consists of vintage wells, a number of sparsely spaced 2D data and recently shot small-size 3D (100 km²) aiming at selecting future drilling location. Lack of geological and seismic data put some constrain on use of conventional geological and geophysical interpretation. However, application and integration of leading edge geological and geophysical methods of reservoir characterization makes it possible to substantially de-risk exploration efforts.

Introduction

For the frontier exploration areas such as East African Rift system, South Anza basin ([Figure 1](#)), integration of geological and geophysical methods within reservoir characterization framework is of great importance. Application of fault displacement analysis, seismic attribute generation, Chimney analysis, AVO and post-stack inversion in conjunction with advancement in sequence stratigraphy and seismic geomorphology (spectral decomposition and unsupervised neural network – UVQ analysis) leads to better understanding of regional petroleum system and to evaluate selected individual prospects.

Block 3A and 3B where Vanoil Energy has chosen to exercise its exploration effort covers the southern culmination and the deepest part of the Anza Graben within East African rift system. Anza basin itself is on trend with producing Melut and Muglad Basins of South Sudan and is of the same age of rifting. Location of recently acquired 3D, which is situated in the southwestern part of Block 3A, has been selected after working and applying leading edge analysis over different vintage 2D data sets available for this area ([Figure 2](#)). After thorough QC of 3D data received, several filters such as DSMF (dip-steered median filter) and DSDF (dip-steered diffusion filter) were applied to improve processing quality. 5D interpolation allowed suppression of acquisition artifacts.

Theory and/or Method

Reservoir characterization involves fully integrated approach toward seismic and geological data which proven useful especially for the frontier exploration areas. After careful examination of given set of 3D data we have decided to apply several methods aiming at revealing more hidden structures. Those methods include post-stack faults and fracture analysis, chimney analysis and seismic attribute generation, seismic geomorphology, as well as AVO interpretation and post-stack inversion. Seismic geomorphology, a term introduced by Henry Posamentier, involves a wide area of tools such as seismic facies analysis (UVQ), depositional slicing, and spectral decomposition. The purpose is to understand the depositional environment to better locate the reservoirs. Seismic geomorphology can only be applied on 3D, as it is equivalent to satellite images of the subsurface.

Examples

Results of Fault and Chimney analysis examples are shown on different time slices (2000 and 2400) ([Figure 3](#)). The migration indicators shown by the chimney analysis clearly mark the change from fluvio-deltaic lithology to floodplain fluvial deposition to the east. The results of Spectral decomposition and UVQ (Un-supervised Neural Network) are shown in [Figure 4](#). The rivers depositing clean sands originate from north-northwest and after following various stages of faulting open up into the main floodplain. UVQ map shows the transition from Yellow/Red facies to the Bluish facies with marked cuts showing possible erosional slope failure during deposition.

Conclusions

Results and fracture/fault and chimney analysis show that the whole area can be clearly divided into 2 sub-areas: less fractured and less “leaky” west and more fractured and much more “leaky” east which was confirmed by further seismic geomorphological results (spectral decomposition and UVQ). This made possible to narrow down exploration method and have priorities in selection of future drilling locations. The 3D analysis also allowed a complete re-thinking of the model derived from 2D. The future analysis continues over the several chosen drilling locations ([Figure 5](#)). The results of integrated analysis allow us to further de-risk exploration effort in this area, narrow down drilling locations and provide risk assessment for each location.

Acknowledgements

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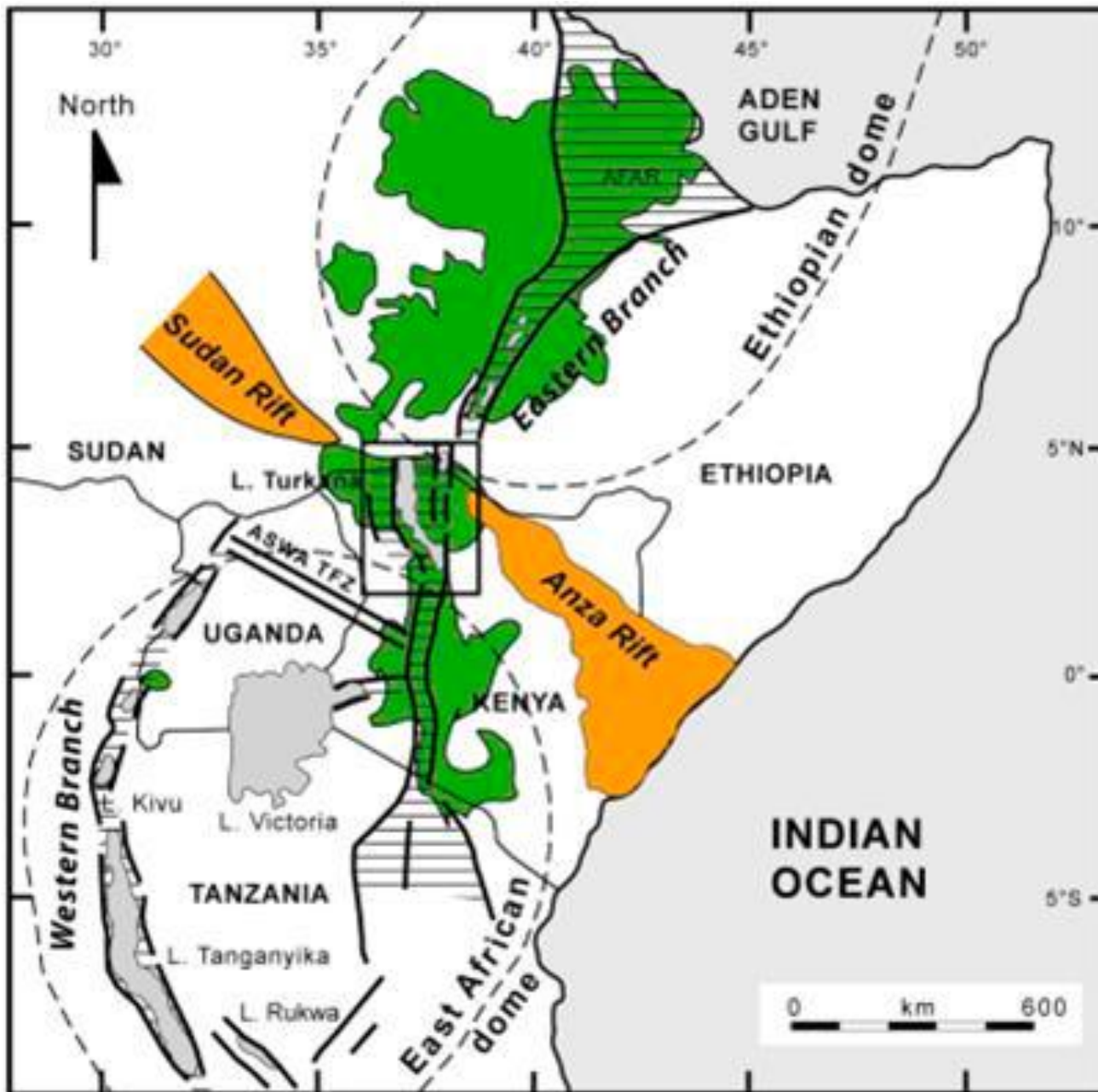


Figure 1. Frontier exploration areas, East African Rift system, South Anza basin.

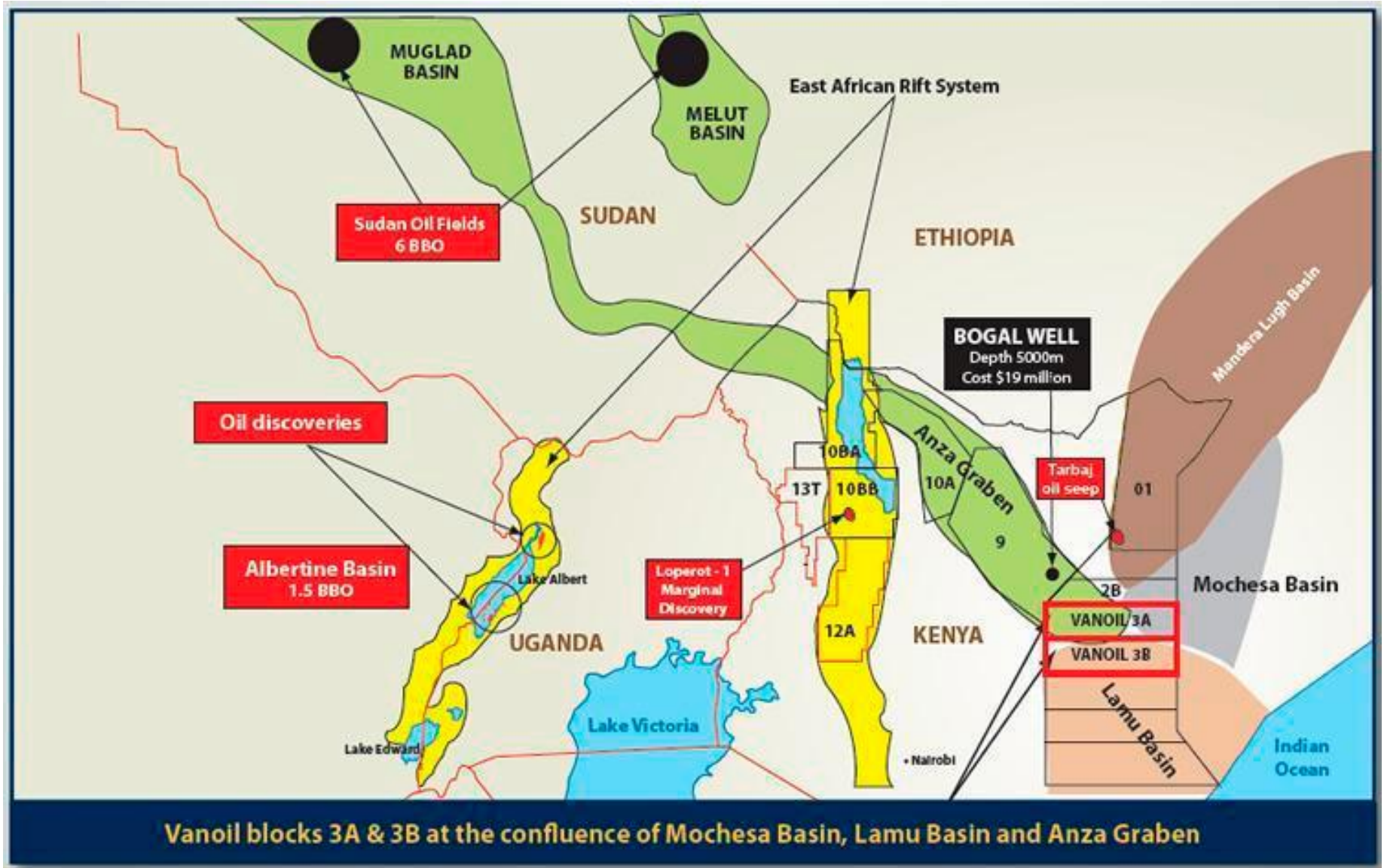


Figure 2. Location of recently acquired 3D data.

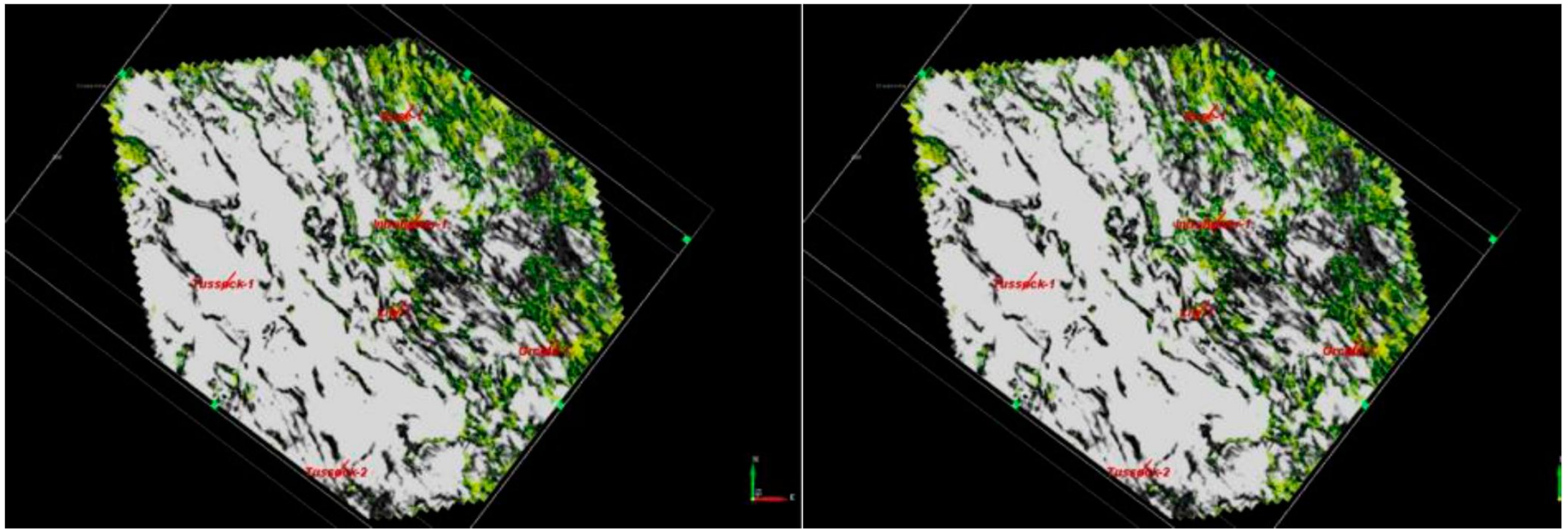


Figure 3. Results of Fault and Chimney analysis examples are shown on different time slices (2000 and 2400).

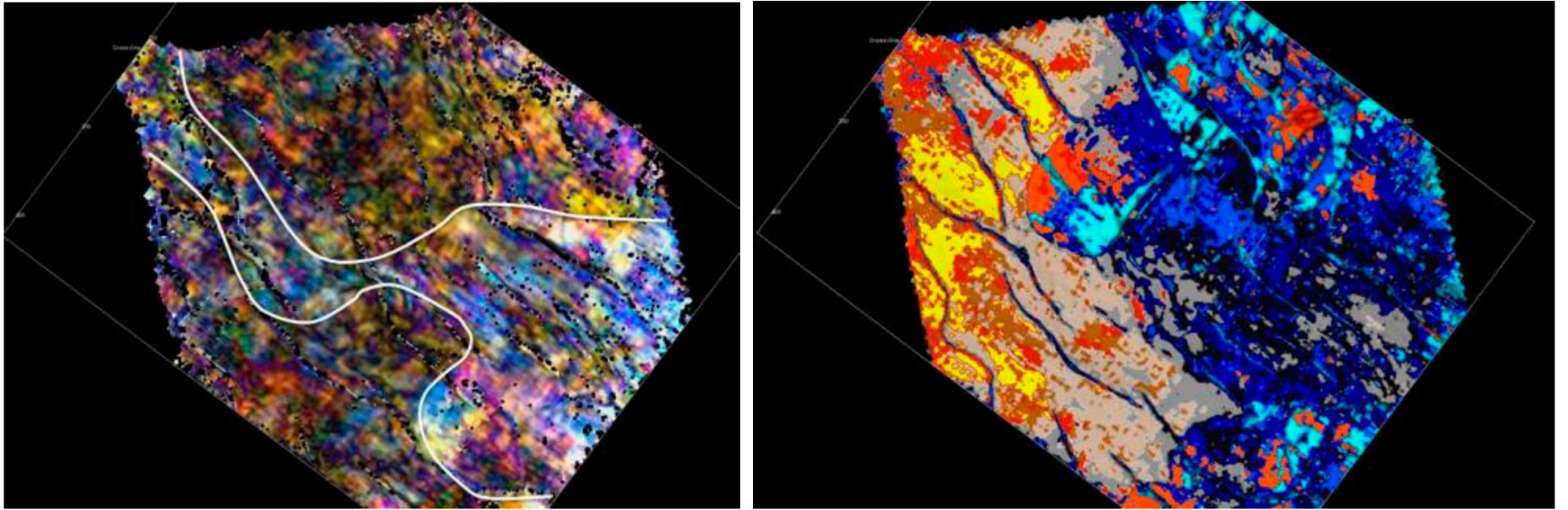


Figure 4. The results of Spectral decomposition (left) and UVQ (Un-supervised Neural Network) (right).

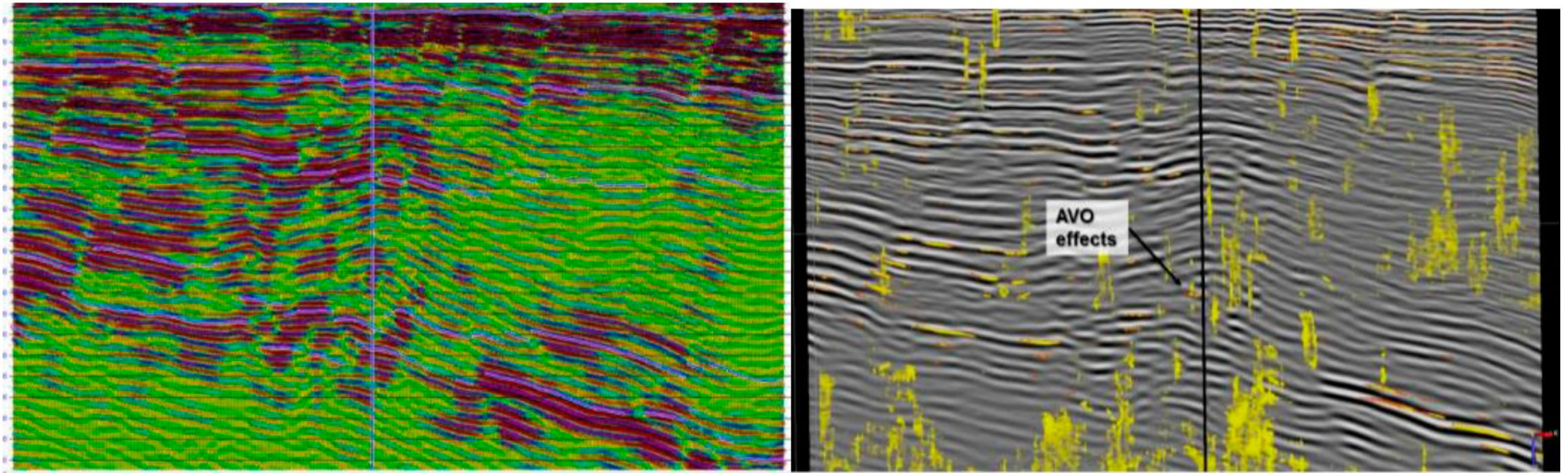


Figure 5. Results from analysis of several drilling locations (left – colored inversion and right - AVO response).