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Application of 3D Static Modeling and Seismic Attribute analysis for Reservoir Characterization over Sobal-field Niger Delta

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Abstract : *Reservoir characterization using 3D static modeling and seismic attribute analysis were carried out for the evaluation of subsurface geologic features and hydrocarbon potential of an oil field in Niger Delta Basin. Well log and 3D seismic data with geophysical software were employed to identify, map, extract and characterize reservoir. The distribution, flow and detailed understanding of the hydrocarbon reservoir zone especially around the well locations in the Sobal- field Niger Delta and beyond were studied using networks of faults and horizons. Furthermore, structural and property modeling (net to gross, porosity, permeability, water saturation and facies) was performed using Sequential Gaussian Simulation and Sequential Indicator Simulation algorithms which were stochastically distributed using reservoir estimation within the constructed 3D grid. Sweetness, envelope and variance edge which are Seismic attributes were generated, and were subsequently analyzed to detect and improve the hydrocarbon presence along the faults in the subsurface. The result shows moderate to high sweetness zone (sweet spots) within the zone of interest, indicating low frequency and high amplitude of hydrocarbon bearing sand zone. The variance edge attribute enhance the faults and fractures signatures which enable discontinuity mapping within the zone of interest. Envelope attribute results show acoustic impedance contrasts highlighting discontinuities, lithology changes, faults and possibly presence of hydrocarbon (bright spots). The result from the petrophysical analysis indicates that the field average Net to Gross (NTG), Water Saturation (Sw), Permeability and Porosity respectively are: 25%, 33%, 550mD and 25%. This study has shows the effectiveness of 3D static modeling method and seismic attributes as a good geophysical process for optimizing, understanding, improving, identifying, extracting hidden information, delineating and predicting reservoir performance as well as production behavior of the reservoir.*

Keywords - *Envelope, Reservoir characterization, seismic attribute, Static modeling, Sweetness, Variance edge*

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I. INTRODUCTION

Reservoir characterization has long been identified as the ultimate process employed in detailed description of a reservoir in order to properly book the reserve and also to optimally place the wells and drain the reservoir [1]. Reservoir characterization is the process of describing various reservoir characteristics such as geologic, petrophysics, geochemical and engineering properties [2-3]. Reservoir characterization is the development of a detailed understanding of the reservoir, how it is put together and how it reacts to the production strategy [4].

According to [5], a broad, multidisciplinary and integrated approach is required for a thorough quantitative assessment of prospective area, therefore, for the hydrocarbon mapping, a comprehensive interpretation of the field well log, seismic data and with a suite of software that best images the complex seismic attributes within the subsurface are needed

Seismic attributes are specific measures geometric, kinematic, dynamic and statistical features derived from seismic surveys which provide a link between rock properties and seismic data [6]. Seismic attributes extract information from seismic data that is otherwise hidden in the data. This information can be used for characterizing, predicting and monitoring hydrocarbon reservoirs.

According to [7], the three dimensional (3D) static model of a reservoir is the last integrated product of the lithological, petrophysical, structural and stratigraphic modeling activities, where each of these four main stages are developed according to its specific workflow. It is also regarded as a conceptual 3D construction of a single reservoir or in some cases of a hydrocarbon reservoir field.

1.1 Location Of The Study Area

The field under study has been named 'SOBAL FIELD' and is located in the Niger Delta Basin of Nigeria (fig. 1). The study area is within the latitudes 4°, 7°N and longitudes 3°, 9°E, this forms a three-way arrangement within the Cretaceous duration of the continental disintegration [8-10]. Niger Delta is the largest delta in Africa with a sub-aerial exposure of about 75,000 km^2 and a clastic fill of about 9000–12,000 m (30,000–40,000ft) and terminates at different intervals by trangressive sequence [11].

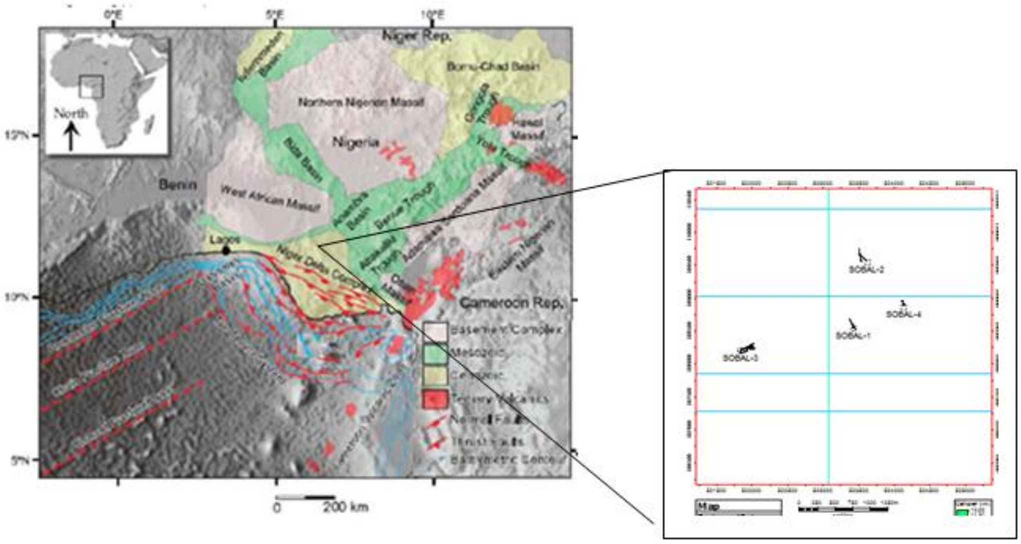


Figure 1: Location Map of Sobal Field Offshore Niger Delta, Nigeria (Modified from [12-13]).

II. MATERIALS AND METHODS

The materials required for this study comprised 3D Seismic data, Well deviation survey data, Suite of Well logs (Gamma ray log, density log, Caliper log, Resistivity log) and three Wells was used for this study. Petrel workflow was adopted for the integration of well log with seismic data, structural analysis, seismic attributes analysis and modeling to obtain the geological configuration of the study location.

Well correlation was done to properly delineate the reservoir and Petrophysical parameters were evaluated (fig. 2). Fault and Horizon interpretations were done in delivery of a 3D structural map of the reservoir (fig. 3). Fig. 4 shows the time and depth reservoirs structural map generated from the picked horizons. The field structure is bounded to the north and to the Southwest by major synthetic growth faults that defines the field. As it can be seen from the above figure, Reservoir is a Rollover anticline structure bounded to the North by the major (E-W trending) regional synthetic growth fault and to the Northwest by the west boundary fault with dip closures to the East and South. Structural, Stratigraphic, Lithological, and Petrophysical model were then integrated to produce the geological model (3D static model).

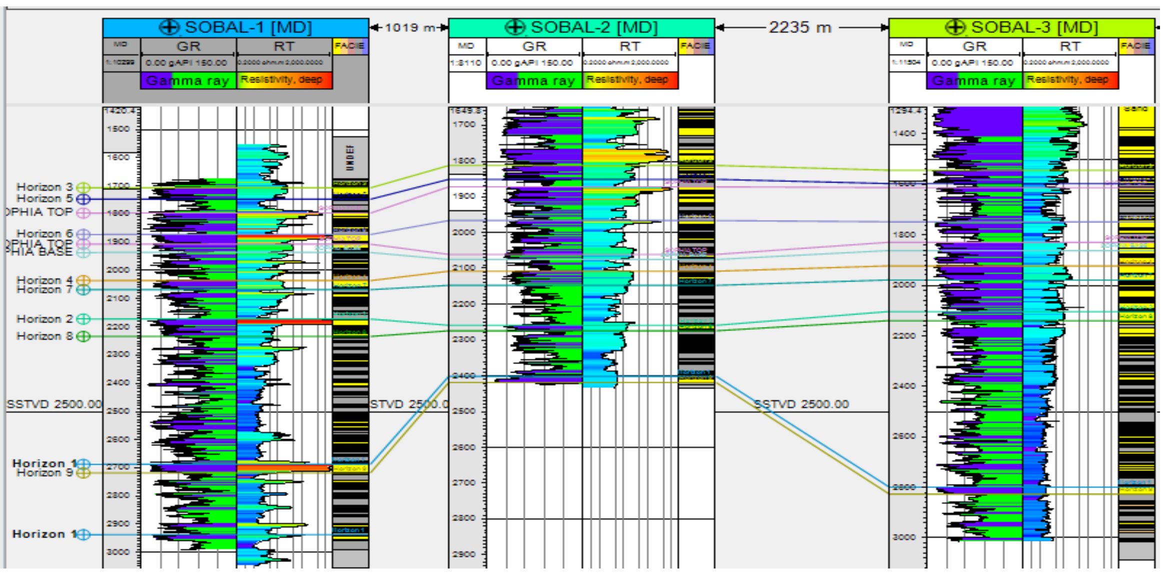


Figure 2: Three well logs showing structural correlation of SOBAL field.

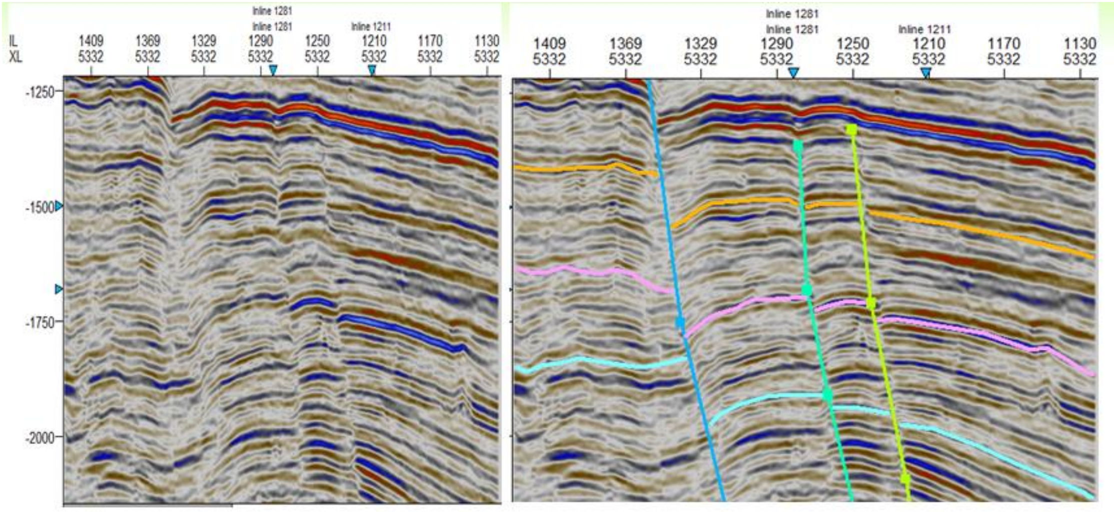
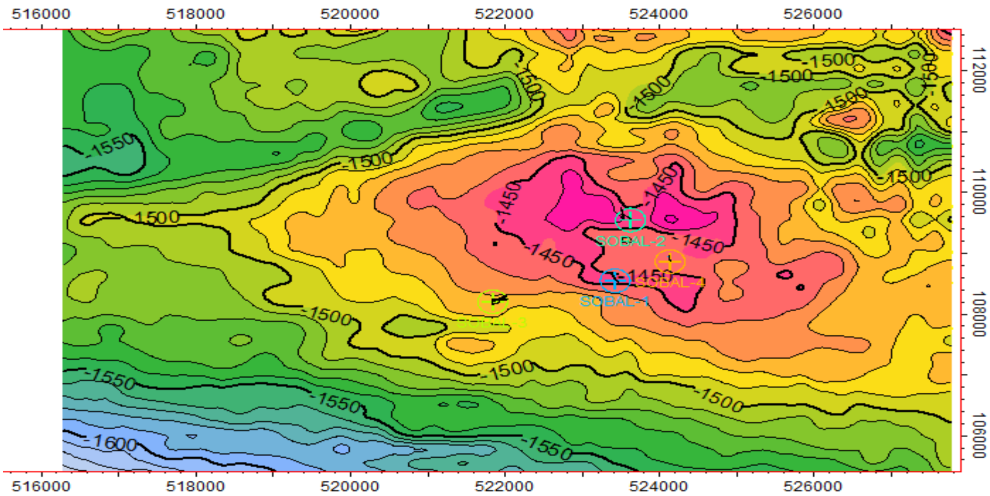


Figure 3: Seismic section showing the interpreted faults and horizon of interest.



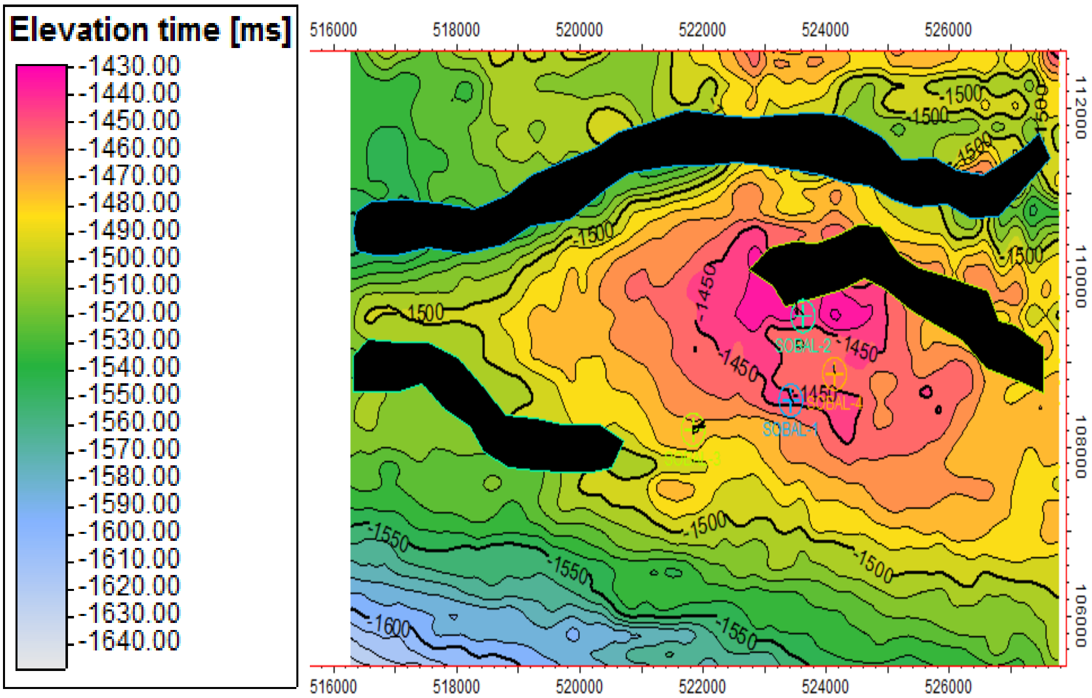


Figure 4: Reservoir Structure displaying faults

III. RESULTS AND DISCUSSION

The variance edge (Fig. 5a) seismic attribute enhance the faults signatures within the seismic data volume with an edge enhancement option which enables the mapping across discontinuities within the data. Envelope attribute (Fig. 5b) displays acoustically strong/bright events on both negative and positive events attribute, the bright spots from this attribute are important as they can indicate presence of hydrocarbon. The essence of generating a sweetness attributes (Fig. 5c) on the seismic volume is to identify “sweet spots” places that are oil and gas on the seismic section. The arrow in Figure 4 shows regions with seismic anomalies in the seismic data which shows hydrocarbon bearing sand units.

The net to gross values distribution was carried out stochastically using Sequential Gaussian Simulation (SGS). The porosity and permeability were distributed in the model using “Sequential Gaussian Simulation” (SGS) that was conditioned to the facies model and to the wells. A total porosity and permeability cut-offs of 0.15% and 120mD respectively were applied to the model and multiple realizations were run on the porosity and permeability models which were conditioned to the respective facies though the permeability was conditioned to the respective porosity as a secondary variable. Water saturation value of 46% was used, derived from petrophysical interpretation which is used in the model (Fig. 6 - 10).

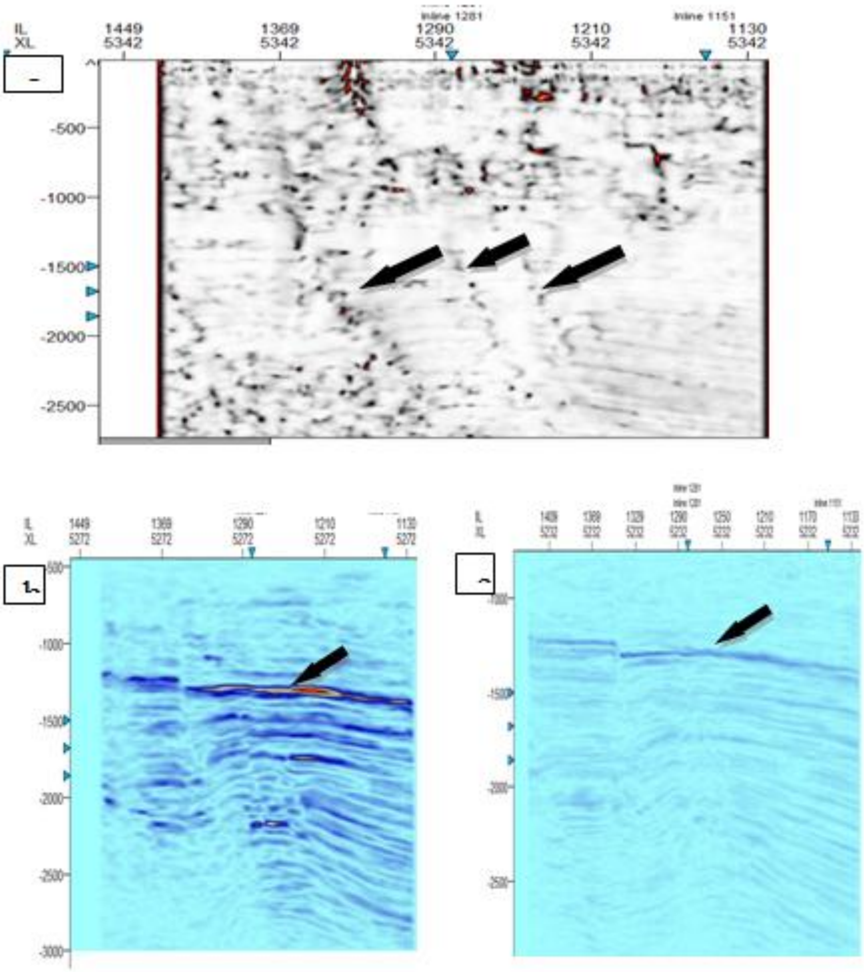


Figure 5: (a) Variance attribute (b) envelope attribute (c) sweetness attribute. These arrows shows seismic anomalies

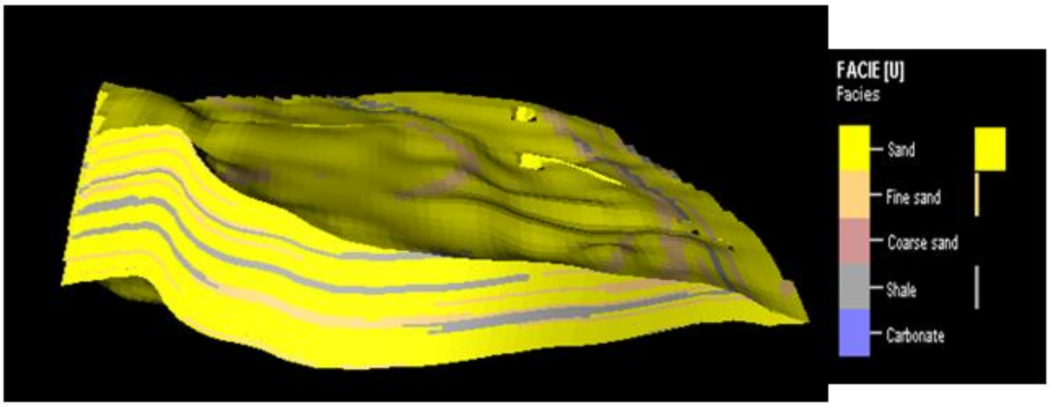


Figure 6: The facies model

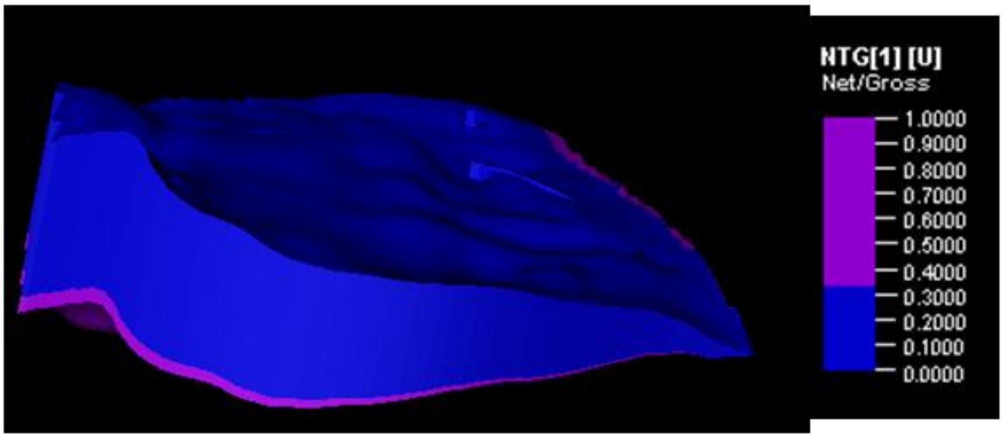


Figure 7: The NTG (Net to Gross) model

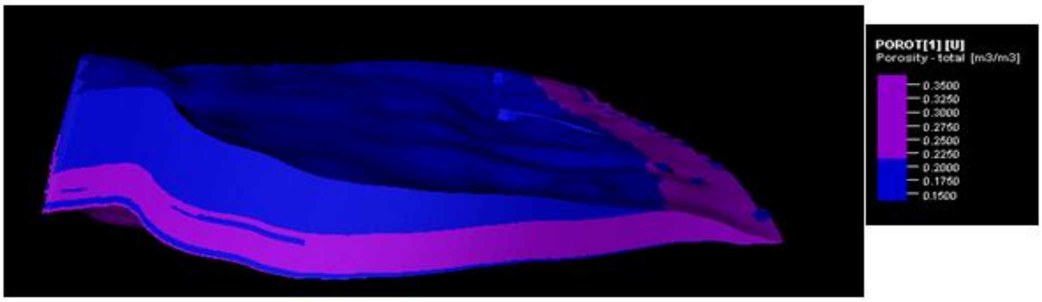


Figure 8: The porosity model

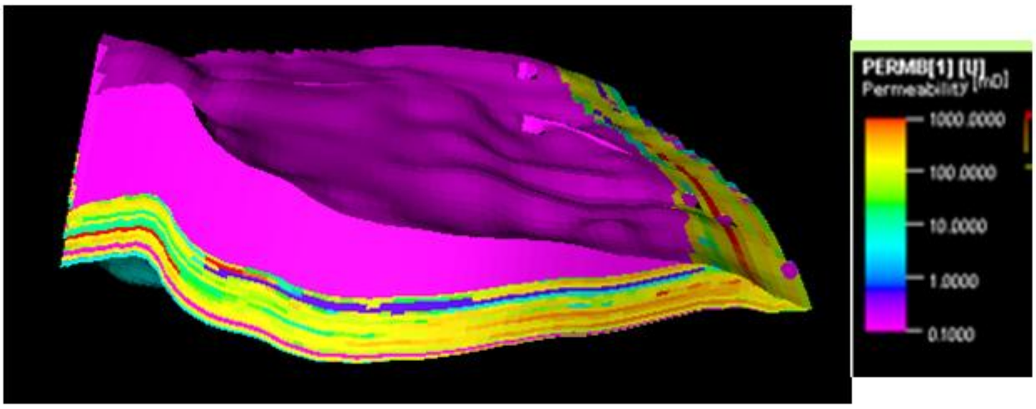


Figure 9: The permeability model

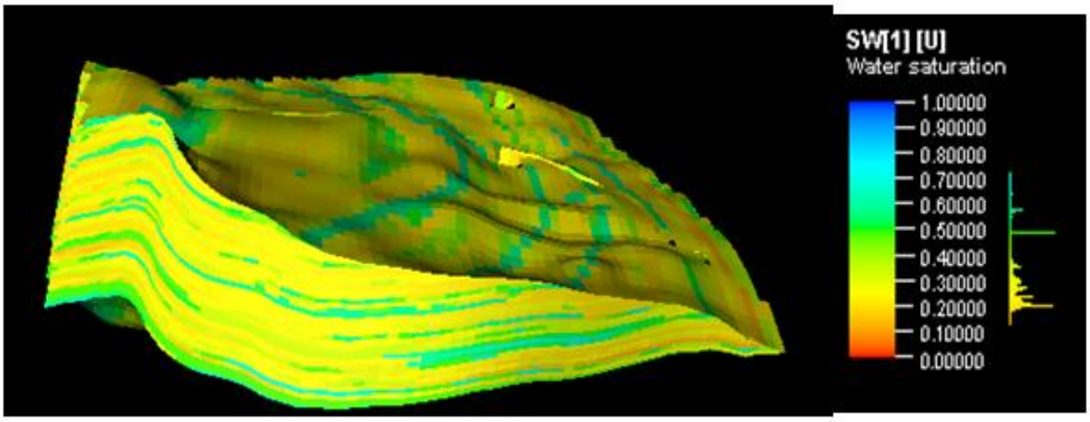


Figure 10: The water saturation (Sw) Model

IV. CONCLUSION

3D reservoir modeling was constructed using all the available data that is fit for this study. Structure shape and boundaries were defined by the formation top and base surfaces that interpreted from 3D seismic. Generating a 3D geological grid, the most essential goal is to preserve the small features from well logs and seismic data as much as possible. Therefore, a 50m grid-size was used in X and Y directions and the formation were divided into four major zones. Seismic attributes has been able to indicate seismic anomalies showing presence of hydrocarbon and enhanced Stratigraphic Faults.

Reservoir property modeling was made using well-log by constructing variogram model for each of the property.The reservoirs of interest, was penetrated at depths 1905.81–1935.84 ft, 2060.91-2075.48 ft and 1829.23-1861.85 ft, across the wells. The model reveals that NTG is between 0-50%, Sw is between 18-48%, Permeability is between 100-1000Md and Porosity 0-50%. The result from the petrophysical analysis indicates that the field average NTG, Sw, Permeability and Porosity respectively are: 25%, 33%, 550mD and 25%.

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