Geological facies model on Benin offshore Basin.

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Abstract

This project was based on a new geological evaluation in Benin offshore basin. With the aim of better understand the geological model different tools for hydrocarbon prospection were applied along the study.

Through the integration of 3D seismic data and the available well data (three wells), it was possible to simulate the lithological facies in Benin Basin, between Romanche Fracture Zone and Chain Fracture Zone in Gulf of Guinea Province (West African Equatorial Margin).

The methodology includes the seismic interpretation of the main structural and stratigraphic levels (10 stratigraphic leves were interpreted).

As result of this model, it was observed that the Upper Cretaceous and Albian levels show good conditions for reservoir rocks because both contain a very good sandstones distribution southward. On the model, the seal distribution was also observed mainly for the Neogene levels. Finally, the presence of glauconite and limestone were identified below and in the Albian level showing a shallow marine deposition for this period of time.

Introduction

Benin Basin is located in the Gulf of Guinea Province of West Africa. The basin is limited by fracture zones, in this case the Keta-Togo-Benin Basin is located between Romanche Fracture Zone (west) and Chain Fracture Zone (east) as showed in the figure 1.

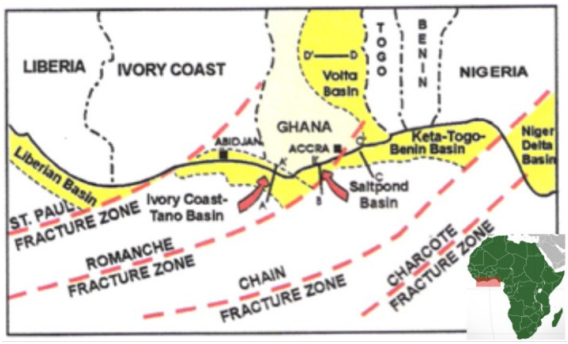

Fig. 1: *Gulf of Guinea Province with the basins limited by fracture zones (TGS, 2005).*

The tectonic history of Benin Basin is related to Gondwana breakup in the Early Cretaceous. The Gulf of Guinea evolution is a passive-margin basins controlled by transfer faults, this situation is different from the south of Niger Delta, where the tectonic features are mainly grabens and half-grabens. Another characteristic of the Gulf of Guinea Province is the absence of evaporites and halokinesis (Brownfield and Charpentier, 2006).

The study area involves a 3D seismic survey in Benin offshore about 3,419 km^2 (Figure 2).

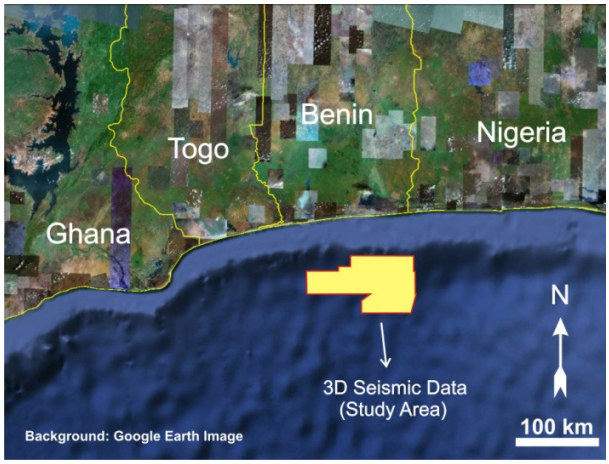

Fig. 2: *Study area location in Benin offshore (3D seismic data).*

The objective of the project is to perform a lithological characterization inside the study area. A lithological cube must be representative of the geological configuration; in order to achieve this goal; volumetric attributes and neural nets were applied.

The importance of the result is related to the possibility of better define the petroleum system, because it allows to perform a modeling with a high control of reservoirs and seals distribution; the technique also helps in the interpretation of depositional environments.

With the aim of improve the geological geometrical control, seismic interpretation and structural maps are necessary. For this task, it was important to integrate all the information including the three available (Fifa, Hihon and Sota) for a better litological calibration.

Methodology

In this project, it was essential to carry out the following stages:

- Lithofacies analysis of three wells data (Fifa, Hihon and Sota);

- Interpretation of 10 stratigraphic horizons on the 3D seismic data (Bottom Sea, Miocene, Oligocene, Paleocene, Top of Cretaceous, Campanian, Albian, two Pre-Albian horizons and Basement);

- Generation of structural maps for each stratigraphic horizons;

- Calculus of four attributes cubes based on the 3D seismic (amplitude), among these attributes, cubes of Chaos, Envelope, Variance and seismic inversion (acoustic impedance) were obtained;

- Geological facies obtained from neural networks process and use of attributes cubes calibrated by wells. (Figure 3);

- Extraction of facies maps for 8 horizons (Miocene, Oligocene, Paleocene, Top of Cretaceous, Campanian, Albian and two Pre-Albian).

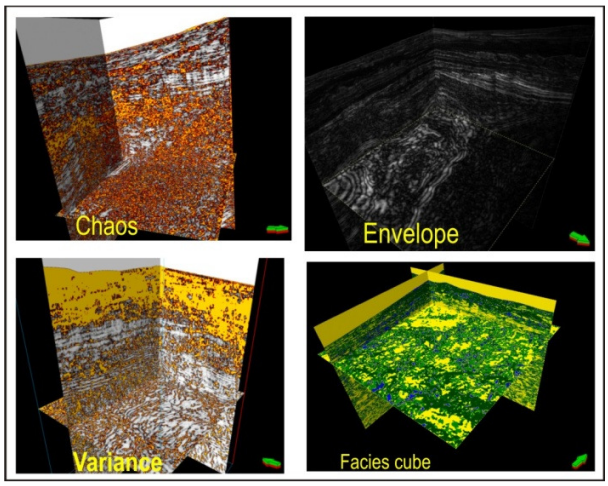

Fig. 3: Seismic attributes cubes oriented to Geological *Facies definition.*

Main Results

From the 3D seismic interpretation, it was possible to obtain the following results:

- The structural maps are defining the main basin geometry. For the basement (Figure 4) was verified structural highs and the principal depocenters of the Benin basin. For other levels, as show on the figure 5, it was identified structural closures that will configure structural traps for hydrocarbon.

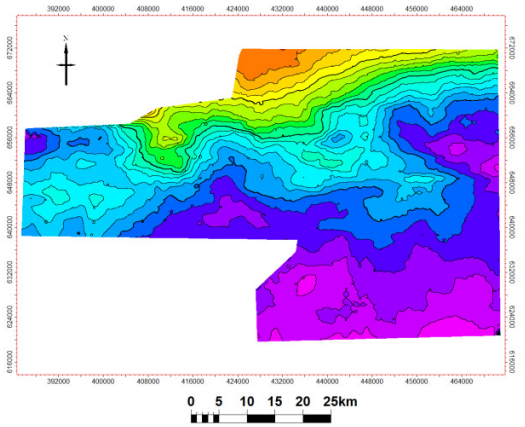

Fig. 4: *Basement structural map*

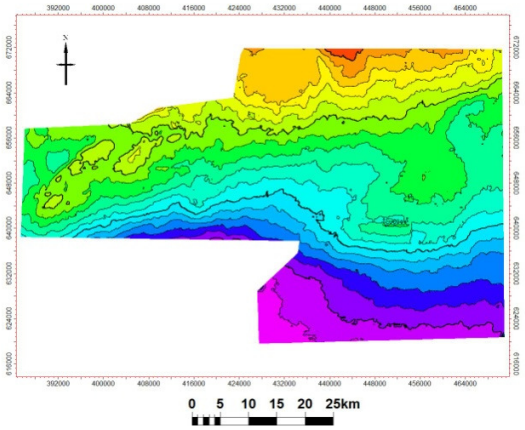

Fig. 5: *Cretaceous structural map.*

- The facies model (Figure 6) shows areas with high possibility of be good hydrocarbon reservoirs (mainly on the Campanian level, figure 7) and good seals level (mainly on the Neogene, figure 8). It was also observed zones that contain glauconite and limestone on the Albian level (conclusion based on Hihon well results) as showed in figures 9 and table 1.

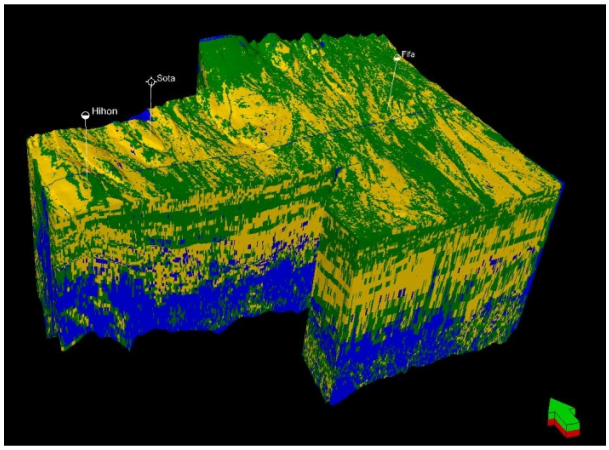

Fig. 6: *Facies model final result in 3D seismic data with the calibration of the three wells.*

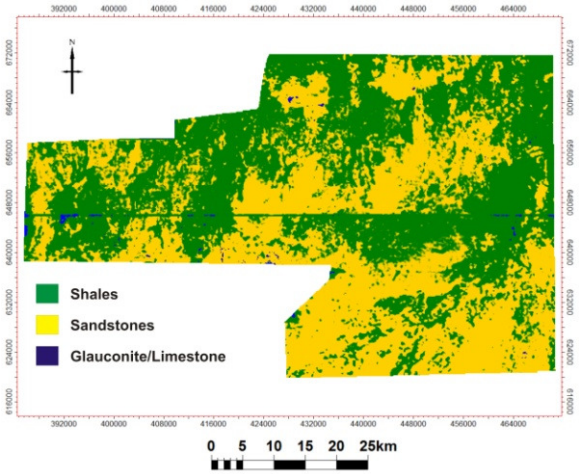

Fig. 7: *Campanian facies map.*

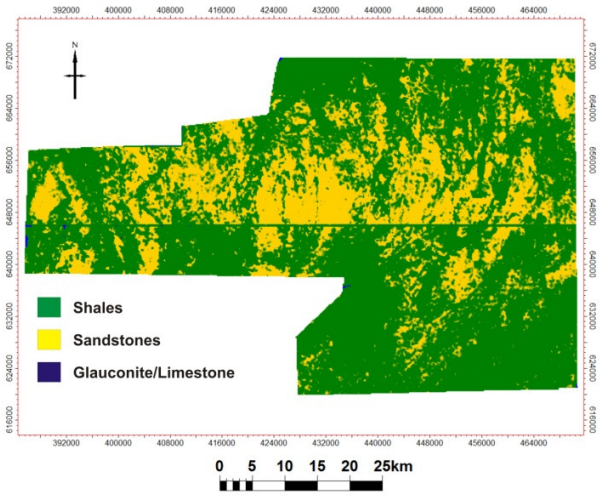

Fig. 8: *Oligocene facies map.*

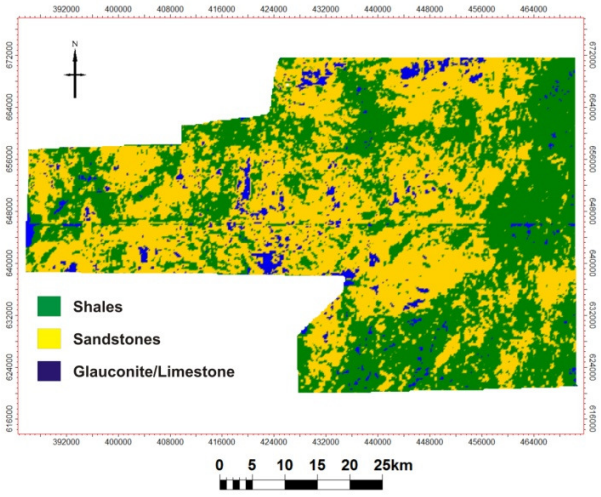

Fig. 9: *Albian facies map.*

DEPTH	CLAYS (%)					AUTHIGENIC (%)						TOTALS (%)			
meters	Shale Clasts	Matrix Clay	Kaolinite - Pore Filling	Grain Coating Clay	Glauconite	Calcite / Fe Calcite	Fe Dolomite / Ankerite	Grains Replaced by Calcite	Dolomite (non-ferroan)	Silica Cement / Quartz Overgrowths	Pyrite	Carbonates	Authigenic Minerals (non-carbonate)	Clays	Others
*3589.0	2	5	5	0	0	9	0	0	17	0	0	26	0	12	62
3602.0	Tr	Tr	0	0	0	25	0	0	12	0	0	38	0	0	61
3716.5	0	7	5	0	0	3	8	4	0	0	2	19	2	12	67
3730.0 (L)	8	2	2	0	Tr	4	1	0	0	0	1	8	1	12	80
3740.0 (L)	7	13	2	0	0	3	Tr	0	0	0	1	3	1	22	73
3746.5	Tr	6	3	0	Tr	4	0	0	0	Tr	1	11	1	9	78
3788.0	2	3	Tr	0	1	Tr	21	Tr	0	0	2	21	2	6	70
3842.5	1	6	3	0	0	1	0	0	0	Tr	1	2	1	10	86
3907.0	Tr	3	13	0	Tr	0	0	0	0	Tr	1	0	1	16	82
3931.0	Tr	4	9	0	0	12	10	5	0	Tr	1	27	1	13	58
3971.0	1	3	8	0	0	1	8	0	0	Tr	0	9	0	12	78
4007.0 (L)	7	3	5	0	0	2	14	1	0	0	1	17	1	15	68

Table 1: *Petrographic analysis of Hihon well highlighting the presence of glauconite in Albian (Core Laboratories, 2003).*

Conclusions

The geological facies model can provide important information about best areas to prospect hydrocarbon. It is important to mention that for this model the lithologies were simplified in three groups (sandstone, shales or limestone/glauconite), but the method is able to configure geological facies cubes using a number of lithologies as necessary; mixed lithologies are still able to be includes on the model.

The main confirmed reservoirs for this basin are the Campanian and the Albian, because both show a very good sandstone distribution, mainly domain by fluvial environments (several channels were interpreted on the seismic data).

Other important element is the presence of limestone in the Albian, this lithology confirm a shallow marine environment for this level.

The facies model proves to be a powerful tool for basins analysis, but it is high recommended to use other traditional exploratory tools (isopach, structural or attributes maps, etc) simultaneously with it.

Acknowledgments

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