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Research Article

SEISMIC AND PETROPHYSICAL ATTRIBUTES OF RESERVOIRS IN "EBI" OIL FIELD, NIGER DELTA

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ABSTRACT

The evaluation of the petrophysical properties and seismic attributes of EBI Field, Niger Delta, Southern Nigeria using a suite of wireline logs from five (3) wells was carried out, Three-dimensional seismic data was used to identify the faults and map the horizons. Petrophysical parameters and time-depth structure maps were obtained. Seismic attributes was also employed in characterizing the reservoirs and hydrocarbon-bearing reservoirs with varying thickness were delineated. The identified prospective zones have good porosity, permeability, and hydrocarbon saturation. The environments of deposition were identified from log shapes which indicate a transitional-to-deltaic depositional environment. In this research work, new prospects have been recommended for drilling and further research work.

INTRODUCTION

Petroleum resources remain very vital to the economy of several nations of the world. The enormous cost of exploration for this all-important resource makes it necessary for the attainment of high level of perfection in the methods adopted for its detection and quantification. Since cost effectiveness is the driving factor in oil and gas industry, interest in reservoir evaluation is channel towards the need to quantify the reservoir with reduced level of uncertainty associated with geological models. Drilling of an oil well is very costly venture coupled with the fact that hydrocarbon reserve are depleting. The deposits yet undiscovered are in more complex geological environments and hence it is important to exploit new development with higher resolution seismic reflection methods. Analysis of seismic data is the key to reservoirs evaluation and subsurface pore fluid monitoring. While there have been great advances in 3D seismic data processing, the quantitative interpretation of the seismic data for rock properties still pose many challenges.

Quantitative seismic interpretation according to Avseth (2005) shows the application of rock physics in reservoir's parameters' prediction through integration of seismic data sedimentological information and stochastic methods.

STUDY AREA LOCATION:

The study area is located in the Cenozoic Niger Delta and is tagged EBI field which is situated at the intersection of the Benue Trough and the South Atlantic Ocean where a triple junction developed during the separation of the continents of South America and Africa in the late Jurassic

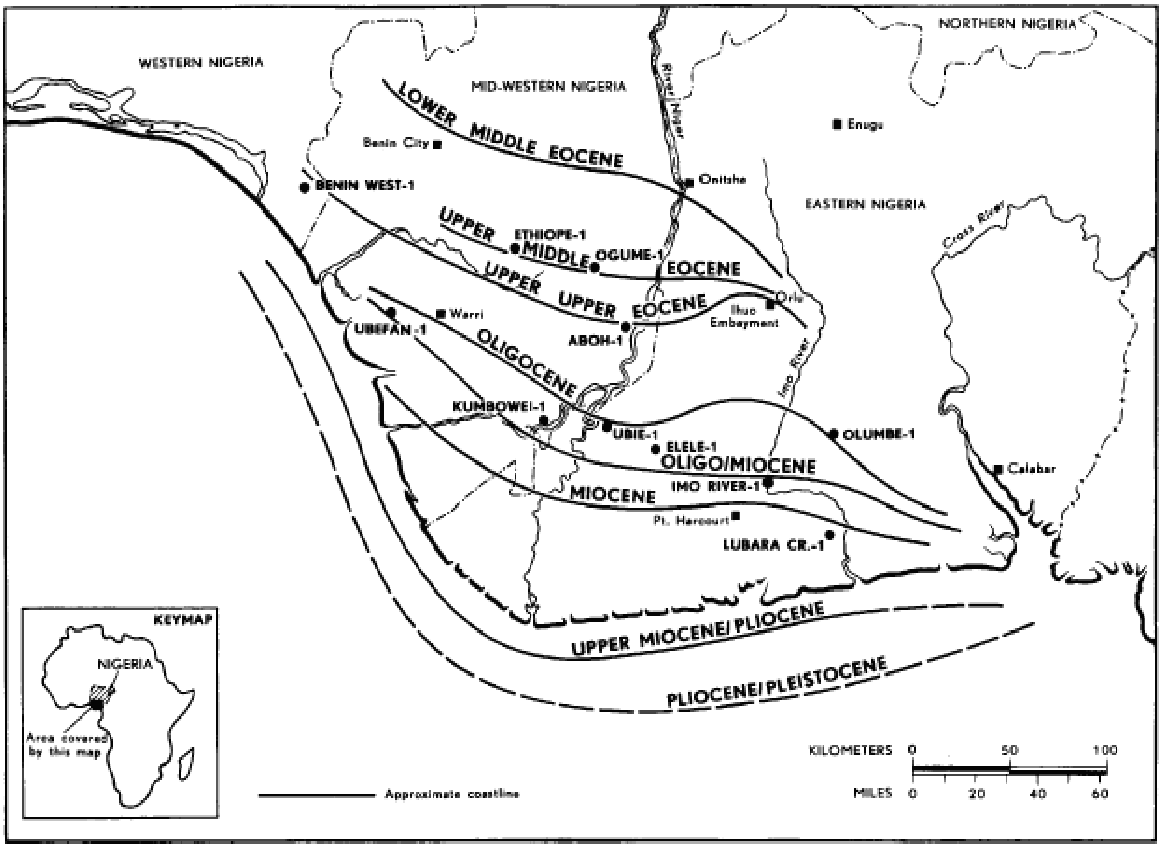

Figure 1: Palaeogeography of Tertiary Niger Delta showing stages of delta growth and progradation of coastline / shoreline from Early Eocene to Pleistocene with corresponding shift in depobelt southerly (*Adapted from Short and Stauble, 1967*).

METHODOLOGY

The materials used for this research work include the following: 3D stacked depth migrated seismic sections comprising of 400 inlines and 200 crosslines, base map of the study area, check shot survey curve, continuous velocity logs, gamma ray and resistivity logs. Integrated methods involving 3D seismic interpretation and petrophysical data analytical methods were employed to meet the objectives of this research. Interpretation of seismic sections was done interactively in Petrel software from where two (2) sand units were mapped and evaluated by generating various indicator maps such as structural, Isopach, Isochron and isodepth maps. Information is useful in determining appropriate locations for drilling exploratory, appraisal or development wells within a prospect.

The structure of the field of study was interpreted using 3D seismic data which was integrated with well logs. The inline and crossline numbers range from 5800 to 6200 and from 1480 to 1700, respectively. The reflection quality of the data is very good; faults and stratigraphic picks for horizons are easily recognizable. The wells (EBI 01, EBI 02, EBI , penetrated depths of −16,019.00 ft , −14996.00 ft , −12000.69 ft . Petrophysics were used to produce a comprehensive geophysical and geological evaluation of the study area. The acoustic velocities from the sonic logs were multiplied by density log to compute new acoustic impedance (AI) log. This impedance was converted to reflectivity, which was then converted from depth to time using an appropriate wavelet to produce a synthetic seismogram to tie the wells to seismic.

RESULTS AND DISCUSSIONS

This research defines the structural, petrophysical and volumetric characteristics of the interpreted horizons using 3D seismic and well log data. It therefore examines the hydrocarbon reservoir in terms of its geologic structures, reservoir properties and reserve estimates. The study integrated a suite of 800 seismic section (500inlines and 300 crosslines) and 3 composite well log data acquired over ‘ EBI Field, onshore Niger Delta Basin. The seismic section was mainly used for structural interpretation while the logs are essential for petrophysical evaluation of the delineated reservoir. The area obtained from the seismic section when combined with the thickness of the reservoir and other petrophysical parameters such as porosity (Ø), water saturation (Sw) is used in estimating for the volume of hydrocarbon in place of the reservoir. Two sands units (S1 and S2), which exists

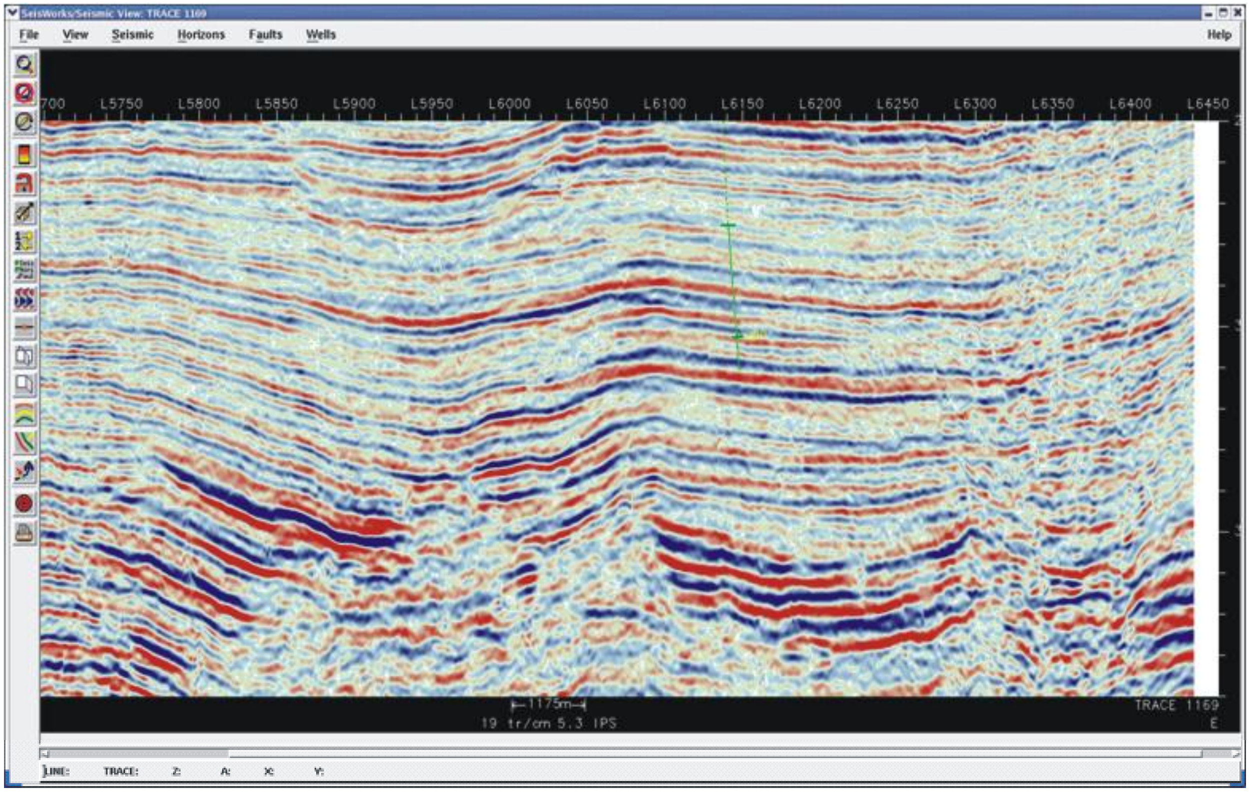

Figure 1: Trace 3D-Seismic of EBI Field

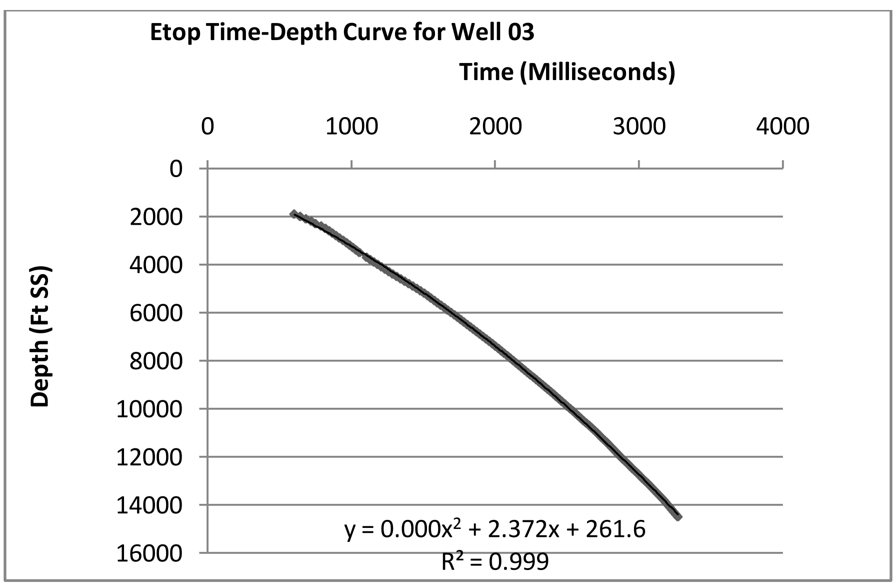

Figure 2: A plot of survey check shot travelling time against depth at EBI- 03. D: 14500.0ft. Sampled depth range: 1900.0 – 4500.0ft. Time is 2-Way.

Reservoir Parameters:

The Petrophysical properties of " EBI " field reflect the ability of the formation to store and produce hydrocarbon. Hydrocarbon saturation parameter concentrates generally at the central and north-eastern parts. Faulting and folding play a prominent role in the definition of the structural setting. These structural features constitute the main structural traps detected in the study area.

The sands have good hydrocarbon potential that made them economically viable. The major anticlinal ridge in the mapped horizon is favorable to the accumulation of hydrocarbon. The work reveal that the central fault block of the field where there are existing wells have structural highs (anticlines) that are sandwiched between the growth faults, which are responsible for possible hydrocarbon accumulation. The isopach map revealed that the reservoir very thick and favourable for hydrocarbon accumulation. The isopach map shows thicker sediment in the central and southern parts of the field. The estimated hydrocarbon in place of the reservoir is satisfactory.

Since all the available wells were located consequent to a 3D seismic survey, high resolution 4D seismic survey should be carried out within the field in order to cater for the by passed hydrocarbon in the area. More rigorous stratigraphic framework should be built and integrate more data/information to develop the Prospect. The surrounding fields should also be developed because the reservoirs delineated extend outside the studied field.

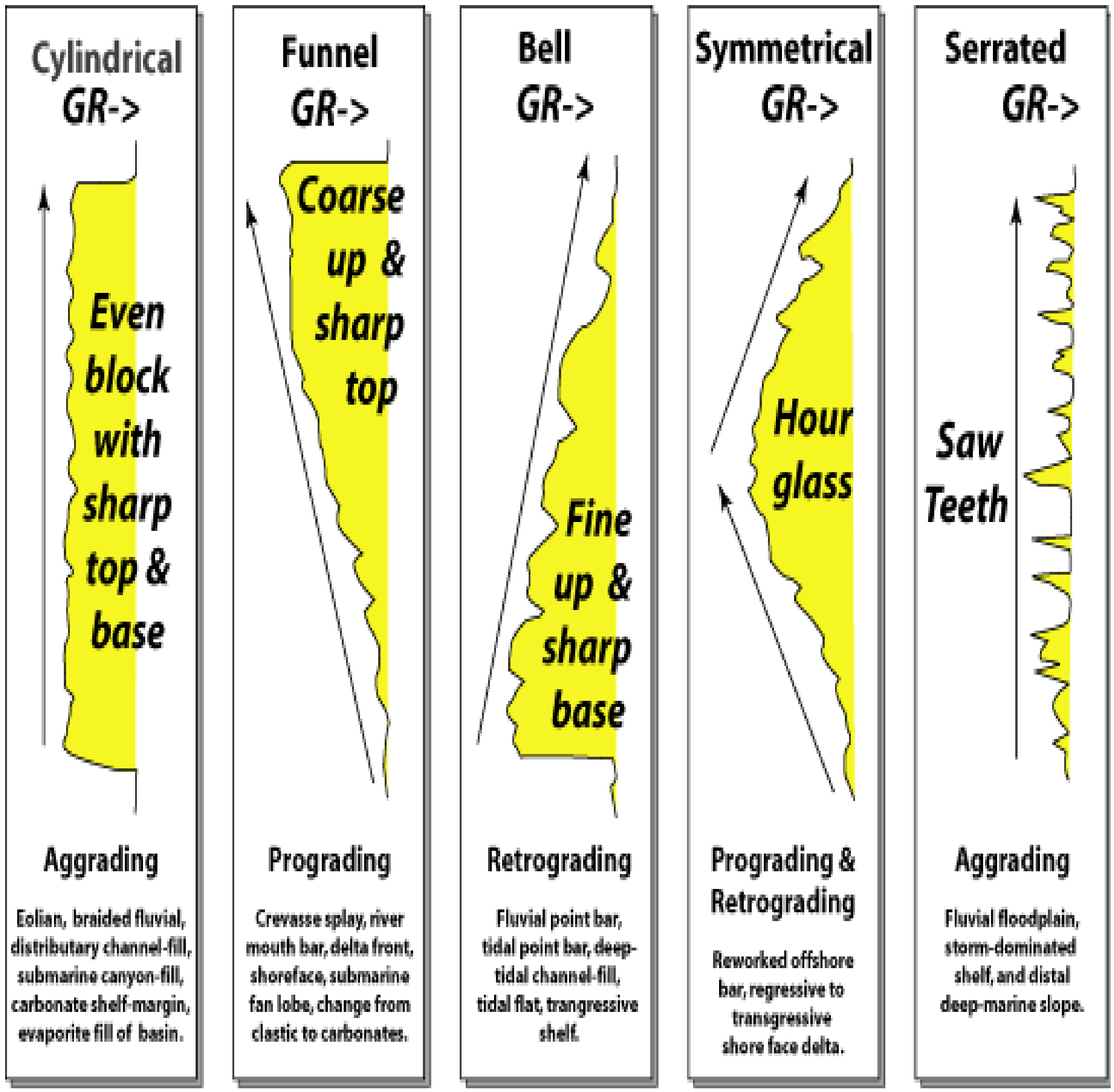

Figure 3: General gamma ray responses to grain size variations showing stacking pattern and depositional environment (*Adapted from Emery and Myers, 1996*).

Time structural contour maps were produced for three horizons defined on top of sand bodies, namely. The maps generated revealed two major faults (F1 and F2) which are growth faults and are very extensive. The major faults trend NE-SW and dip south terminating at the northwest flank of the field. The major faults show a subparallel relationship. The field is dissected by several crestal synthetic and antithetic faults. Most northerly minor faults are synthetic to the major fault M2; those at the central parts are antithetic. These intra field small-displacement faults are of varying lengths and most run almost parallel to the north bounding major structure building fault.

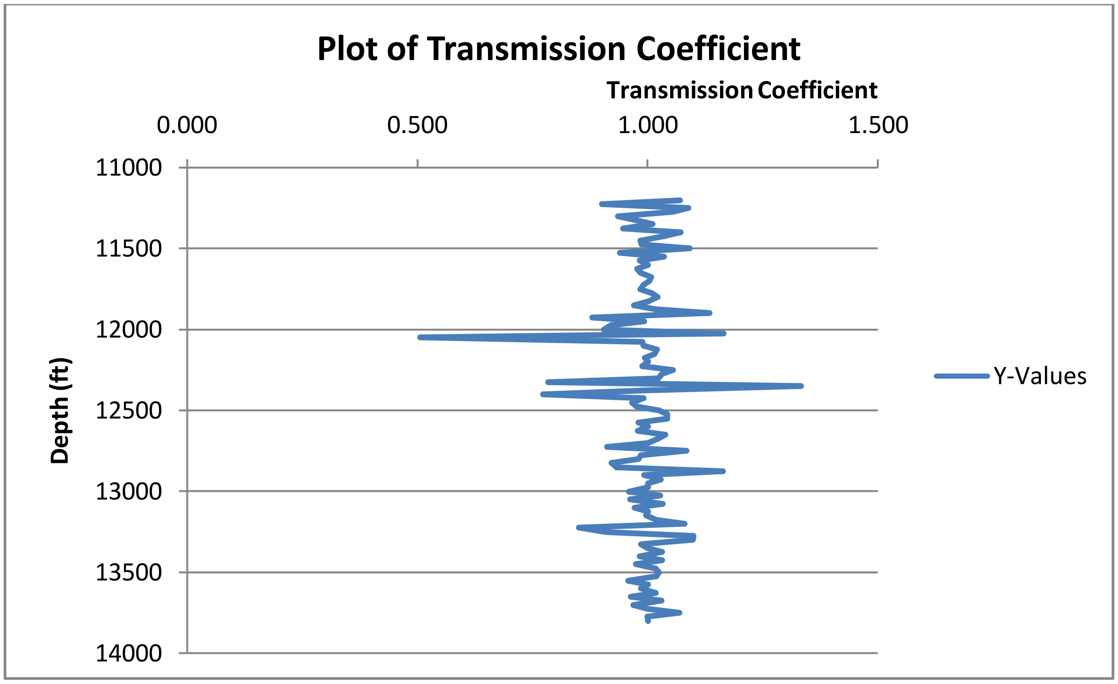

Figure 4: Transmission coefficient profile at EBI- Well 03

Litho Units	Well 01		Well 02		Well 03	
	Fluid type	**Fluid contact**	**Fluid type**	**Fluid contact**	**Fluid type**	**Fluid contact**
Sand A	Gas, Oil and Water	GUT: 11325 GOC: 11375 OWC: 11600	Gas, Oil and Water	GUT: 11325 GOC: 11350 OWC: 11800	Gas, Oil and Water	GUT: 11375 GOC: 11475 OWC: 11625
Sand B	Gas, Oil and Water	GUT: 11950 OUT: 12000 OWC: 12300	Gas, Oil and Water	GUT: 11950 GOC: 11985 OWC: 12150	Oil and water	OUT: 12050 OWC: 12300
Sand C	Oil	OUT: 12550 OWC: 12725 WDT: 12810	Gas, Oil and Water	GUT: 12525 GOC: 12950 OWC: 12625	Gas, Oil and Water	GUT: 12600 GOC: 12635 OWC: 12800
Sand D	Gas, Oil and Water	GUT: 12875 GOC: 13000 ODT: 13225 WUT: 13200	Gas, Oil and Water	GUT: 12815 GOC: 12950 OWC:1 3025	Gas, Oil and Water	GUT: 12900 GOC: 12975 ODT: 13200 WUT: 13050

Table 1: Reservoir fluid type and column

Time structure map for reservoir Sand development in EBI field is somewhat uniform west-east across the field but better developed towards the main structure building fault. Growth faults and anticlines ar apparent on this field which serves as traps acting either as fault assisted as in minor fault F1 or anticline closures as in faults F2. The anticlines and fault-assisted closures are good hydrocarbon prospects in the Niger Delta. The wells in this field are located on the downthrown block of the major fault , in the rollover anticlines formed against the fault

The capability of the faults to act as seals depends on the amounts of throw and the volume of shale smeared along the fault planes .A. Closure   which is a prospect area conspicuously has higher amplitude than the present area (closure 1) where all the present wells are drilled. This trend is also noticed on all other amplitude attribute maps generated. On the Rms amplitude attribute map, closure has moderate amplitude ranging from 30 to 65. This fact is further buttressed on the maximum amplitude and average energy attribute map with closure having values range between 60–80 and 1560–6020, respectively, while the last closure has values as high as 150 and 8790..

The second lithological zone extends from the depth of −8974.44 ft to about −13088.50 ft showing the net pay of the reservoirs in EBI 01, 02, 03,In EBI-01, only reservoir sand here is hydrocarbon bearing which is evident with the high resistivity in the sand . The reservoir interval is between 21622.3 and 24111.3 ft. The pay interval is relatively dirty which is noticeable on the neutron density crossplot with the data points clustering around the sandstone. At interval 10830.50 ft, there was a glaring change in the petrophysical parameters, the porosity increased from 15.42% to 31.55% with a decrease in the water saturation and volume of shale from 68 to 32% and 61 to 39%, respectively. Average petrophysical parameters for EBI-01 05. Buckles and neutron-density crossplot for reservoirs in EBI- 02, 03, and 05ST and 06ST respectively. Reservoir sand here displays progradational to retrogradational stacking patterns but is generally coarsening upward. The sands are massive with thin shalyinterbeds. The depositional environments inferred are point bars and delta distributary channel fills. The sand F   is generally aggradational.

The field structure is an elongate anticline, wedged between the field’s west-southeast trending major structure building faults to the north which is the principal displacement zone) and a northeast-southwest trending fault splay to the south. It can be deduced from this study that the wells drilled on the study area were located to target the rollover anticline formed on the downthrown side of the fault F1 and assisted by minor fault F2.An amalgamation of the results from petrophysics, seismic structural mapping, and various seismic attributes (acoustic amplitude, rms amplitude, average energy, and maximum amplitude) has revealed closure as a new prospect where new exploration efforts can be directed to because it is more hydrocarbon charged than closure in the reservoirs.

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