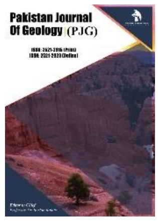
ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2521-2915 (Print)
ISSN: 2521-2923 (Online)
CODEN: PJGABN

Pakistan Journal of Geology (PJG)

DOI: http://doi.org/10.26480/pjg.02.2024.121.130



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RESEARCH ARTICLE

IDENTIFYING PROSPECTS IN THE "HONYX" FIELD IN NIGER DELTA REGION USING SEISMIC ATTRIBUTES

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ARTICLE DETAILS

Article History:

Received 23 August 2024
Revised 09 September 2024
Accepted 23 October 2024
Available online 29 October 2024

ABSTRACT

In the "HONYX" Field, Niger Delta, Gulf of Guinea, seismic attributes were employed to analyze the structural trend and identify regions that are favorable for hydrocarbon accumulation. Nestled in the Niger Delta basin, the 'HONYX' field spans approximately 75,000 km² and is situated between latitudes 4°N and 6°N and longitudes 3ºE and 9°E. One of the petroleum companies in Nigeria provided the data set, which included the Base map of the study region, well logs (LAS format), 3-D seismic data (SEG-Y), and Check shot survey used for this work. Faults picking, horizon mapping, and structural map production were the techniques employed to accomplish this goal. The DHIs (Sweetness and Instantaneous frequency), RMS Amplitude, and Variance were the seismic properties that were employed. In the research area, the Sweetness exhibits a strong amplitude in regions where there are isolated sand bodies surrounded by shale. On the Sweetness time slices, they appeared as brownish patches. From the seismic data, the instantaneous frequency parameter was also produced. On the sweetness time slice, however, the zone or zones with strong amplitude match the instantaneous frequency, which displays low frequency anomalies suggestive of cracked and hydrocarbon zones. The Variance Trends Analysis showed the two main faults in an east-west orientation. Following that, structural maps of depth and time were created for three defined horizons. Finally, this study demonstrated that the application of seismic attribute analysis has uncovered several hydrocarbon prospective zones that could be further revalidated and evaluated to a hydrocarbon prospect, away from the producing zone (which is common to all three reservoir tops). These prospect areas were identified on the three depth maps. The "HONYX" Field is effective for accumulating hydrocarbons, according to the observed data.

KEYWORDS

Field, Amplitude, Fault, Fold, Niger Delta.

1. INTRODUCTION

To map the subsurface, petroleum exploration extensively uses seismic and well log data. The two sources of information work in tandem: Although well logs provide a precise vertical resolution of the geology at the borehole, seismic profiles offer an essentially continuous lateral image of the subsurface. The morphology and stratigraphic changes resulting from the arrival times and amplitudes of the reflection events can be resolved very precisely using seismic profiles. Various methodologies have been developed to propagate log qualities (Formation evaluation) in order to minimize potential risks connected with hydrocarbon exploration and to find optimal production plans. Data must be properly applied in order to achieve high interpretation accuracy.

In light of these discoveries, the issue of where to find hydrocarbon and what kind of closure, as well as the reservoir unit and its hydrocarbon potential, becomes crucial. The primary obstacle now confronting the oil producing industries is the requirement for accurate and sufficient delineation of reservoir features and structural evaluation of the subsurface geology to ascertain the economic viability of hydrocarbon prospects and then fulfill the need for increased demand. A crucial step in the exploration and development stages of every discovery is the characterisation of its reservoir. According to a study, seismic characteristics analysis is the process used to derive corresponding subsurface geological information from seismic sections (Allistairetal, 1978). In order to forecast the features of subsurface reservoirs, seismic attributes are widely employed in the oil business (Chen et al., 1997). For a while now, the petroleum sector has found it advantageous to integrate 3D seismic models with petrophysical data (Adeoye and Enikauselu, 2009; Aigbedion and Iyayi, 2007; Emujakporue and Faluyi, 2015). Comprehensive knowledge of petrophysical features is highly needed in petroleum provinces where exploration and production techniques converge.

Seismic attributes are one of these techniques. Particularly since the introduction of 3D seismic data, seismic characteristics have been utilized for reservoir evaluation. According to several research, seismic characteristics can accurately and quantitatively predict reservoir geometries (Hossain, 2019). Additionally, for the goal of exploratory screening, a group researcher used seismic attribute analysis and depositional features to produce a regional reconnaissance interpretation of the source, reservoir, and seal rock distribution (Sahoo et al., 2019). By utilizing petrophysical analysis and deductions, some researchers evaluated the hydrocarbons in a field located offshore in the southwest of

Quick Response Code	Access this article online	
	Website: www.pakjgeology.com	**DOI:** 10.26480/pjg.02.2024.121.130

Cite The Article: Adegoke Hezekiah Blessing, Osisanya Olajuwon Wasiu, Saleh Alhaji Saleh, Eyankware Oghenenyoreme Moses, Gift Ojo Folashade (2024). Identifying Prospects in the "Honyx" Field in Niger Delta Region Using Seismic Attributes. *Pakistan Journal of Geology, 8(2): 121-130.*

the Niger Delta (Ologe et al., 2014). Their goal was to determine the lithological units inside the reservoir. Seismic attributes were also applied in the assessment of hydrocarbon potential in this region.

Opara and Osaki additionally employed seismic attributes to improve reservoir characterisation by addressing significant interpretive difficulties related to sub-seismic faults and minor stratigraphic features (Opara and Osaki, 2018). Furthermore, in order to uncover untapped hydrocarbon prospects, Okeke et al. (2018) reevaluated the hydrocarbon prospects in a Niger Delta field, while Hossain talked about the value of seismic attribute analysis in the seismic geomorphology research of the Moragot field, Gulf of Thailand (Hossain, 2019). In Edi field, Niger Delta, characteristics from seismic data were utilized to examine a high amplitude anomaly for the possible existence of hydrocarbons (Etuk et al., 2020). Even though the "HONYX" field has historically produced a respectable amount of hydrocarbons within the fault block's proven region, quality control and reprocessing of the seismic data have shown the possibility of hydrocarbon accumulations that were overlooked or missed within the field. This has prompted the use of a variety of seismic features to look into this observation and find new locations where hydrocarbons may be present in the field. The integration of various geological and geophysical data, particularly seismic attributes, plays a crucial role in modern hydrocarbon exploration. These techniques enable accurate delineation of reservoir features, structural evaluations, and predictions of hydrocarbon potential, thereby optimizing exploration efforts and production strategies in the oil and gas industry. This study aims to analyze seismic features in the "HonyxField" area to: i) utilize seismic data for structural analysis of horizons and delineate sand top boundaries from well logs, ii) identify and map subterranean geological features, iii) determine the structural trend of the region, iv) generate and evaluate structural maps of depth and time surfaces, and v) assess potential hydrocarbon-bearing areas.

2. Related Literature

According to a study, characteristics of fluid distribution, hydrocarbon estimation in situ, and permeability determination can be challenging due to reservoir heterogeneity and formation evaluation issues (Aizebeokhai and Olainka, 2011). They recommended that a combination of examination of the reservoir's geological framework, formation evaluation, estimation of the volume of hydrocarbon in place, and hydrocarbon-trapping elements (structural and stratigraphic) be utilized to characterize a reservoir. By interpreting seismic data, some researchers created horizon and structural maps of the underlying geology of portions of the Niger Delta (Obiadi, et al., 2016). On the basis of these maps, structural closures were found, which led to deeper horizons of producing fields. In 2009, Adetoye and Enikanselu utilized reflection properties extracted from subsurface maps to map the lateral bounds of reservoirs. A group researcher employed a suitable set of geophysical well logs for in-depth stratigraphic analysis of well log sequences in the Niger Delta (Omoboriowo, et al., 2012). Their findings demonstrate how variations in the deposition environments cause reservoirs to differ in their petrophysical features.

To get further information about the structures, stratigraphy, and hydrocarbon potential of the Akos oil field using the available seismic and a suite of well logs data, retrieved and evaluated four seismic properties of the Akos oil field (Godwin, et al., 2020). Rollover anticlines and growth faults are among the typical structural features of the Niger Delta, as demonstrated by Emujakporue's evaluation of the hydrocarbon potential of Amufield in the region (Emujakporue's, 2016). The study also included seismic and physical interpretations. Using the attribute technique, the Amu field's two primary reservoirs and seven normal faults were located. The process of obtaining related subsurface geological information from seismic sections is known as seismic attributes analysis (Allstair, 2011; Anstey, 1978; Avseth, et al., 2016; Burke, et al., 1971; Chen and Sidney, 1997). The oil industry makes considerable use of seismic features to forecast the qualities of subsurface reservoirs (Chen and Sidney, 1997; Pramanik, et al., 2003b; Srivastava, et al., 2003; Taner, et al., 1995).

In order to accurately map the underlying geological formations, accurately characterize the amplitudes of the seismic data, and gain information on reservoir features, seismic attributes are utilized in the majority of seismic exploration and reservoir studies (Pramanik, et al., 2002; Pramanik, et al., 2003a; Van Riel, 2000; Vig, et al., 2002). In addition, the study of seismic properties can provide information about reservoir characterization, drilling risk reduction, fluid content, stratigraphic and structural feature estimation, lithology typing, and improved definition and identification of sweet spots. Quantities of geometric, kinematic, dynamic, or statistical properties that can be extracted from seismic data are known as seismic attributes (Liner, 2004; Chopra and Marfurt 2005; Oyeyemi and Aizebeokhai, 2015). The geometrical seismic features are sensitive to the lateral fluctuation of azimuth, continuity, similarity, curvature, energy, and dip, and they can improve the visibility of the geometrical properties of seismic events (Adetokunbo et al., 2016). Seismic data is interpreted structurally and stratigraphically using the geometrical properties. Four seismic attributes—variance edge, sweetness, root mean square, and relative acoustic impedance—were utilized to the seismic data in this study in order to identify prospective hydrocarbon reserves in the Akos field.

2.1 Seismic Attribute Analysis

Channel and deltaic sands, lithology, and hydrocarbon/fluid accumulations can all be identified using surface seismic amplitude data. A thin bed tuning effect and/or fluctuation in net sand in a bed can cause amplitude anomalies (Muhammad et al., 2015; Ehinlaiye et al., 2022). Seismic exploration and interpretation's fundamental goal has always been to map out in detail the geological features that gave rise to hydrocarbon resources (Opara and Osaki, 2018; Osisanya, et al., 2023). The speed at which discoveries have been discovered using traditional approaches has slowed down significantly over time. Owing to the challenges associated with creating new fields, it has become necessary to revisit previously identified fields in order to increase the likelihood of finding hydrocarbons traveling through them. Therefore, in order to gain a deeper understanding of the dynamics and behavior of subsurface reservoirs, oil and gas explorers have to think of innovative methods for processing 3D seismic data.

2.2 Location and Accessibility of the research area

The study area is located within the Niger Delta as shown in Figure 1. The delta is one of the major regressive deltaic sequences in the world and is located in the Gulf of Guinea on the west coast of Central Africa, north of the equator between Latitudes 40N and 60N and Longitudes 30E and 90E in the southern part of Nigeria. It has a maximum thickness of 12,000 mandoccupies an area of 75,000 km^3. Additionally, it is characterized by very uniform temperatures and extremely heavy rainfall. It was most likely formed from a failed arm of a triple junction where the splitting of the African plate and the southern American plate, which probably began in the late Jurassic/early Cretaceous. The present core-shaped deltafront was formed during the Miocene.

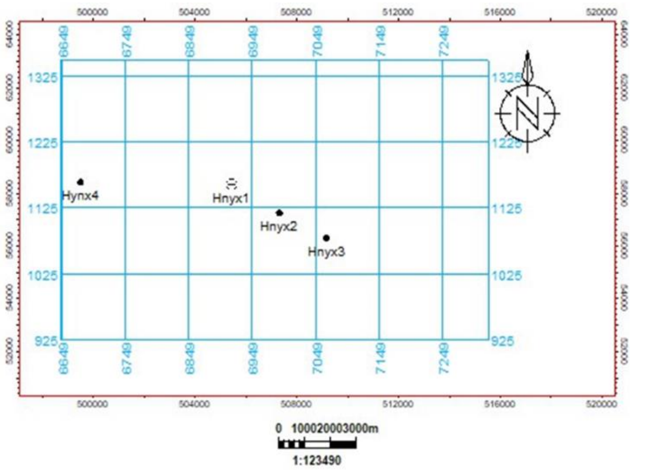


Figure 1: Base map of the Study area.

2.3 Geology of the Study Area

The Niger Delta is suitable for the Gulf of Guinea (Figure 1) and extends throughout the Niger Delta Province as defined (Klettetal, 1997). From the Neocene to the present, the delta has graded southwestward, forming depressions that represent the majority of the deltaateach stage of its development (Doustand Omatsola, 1990). These depressions form one of the largest tregressive deltas in the world with an area of 300,000 km2, a sediment volume of 500,000 km3 and a thickness of over 10 km in the basin depocenter (Hospers, 1965). The Niger Delta Province has only one identified petroleum system in this study, which is known as the eastern Niger Delta (Akata–Agbada) Petroleum System. The maximum extent of the petroleum system coincides with the boundaries of the province.

A prominent geological characteristic of the Niger Delta is its development fault pattern. Sedimentary faults and folds that trend East-West (E-W) are the defining features of the Niger Delta oil province. While growth faults, rollover anticlines, and muddipivism are detailed elsewhere (Figure 2.6), these features appear to be unconnected to the three main tectonic stages indicated above. It is more likely that these sediments themselves contain the energy responsible for their genesis than any external orogenic sources. Indeed, it is thought that these are gravity faults that occur simultaneously with rapid sedimentation and are caused by the underlying and mobile (horizontally and laterally) under-compacted Akka Shales being subjected to diverse loads. Because of the huge weight of sediments deposited in the delta front and the accompanying downdip subsidence, the strata have been tilted basin ward. This contemporaneous phenomenon of sedimentation and gravity faulting has resulted in the deposition of thicker sediments on the down-thrown block than on the up-thrown block. The majority of the oil accumulated in the Niger Delta is housed in the rollover-anticline structure. These structures' oil may be trapped in dip closures or an antithetic or synthetic fault.

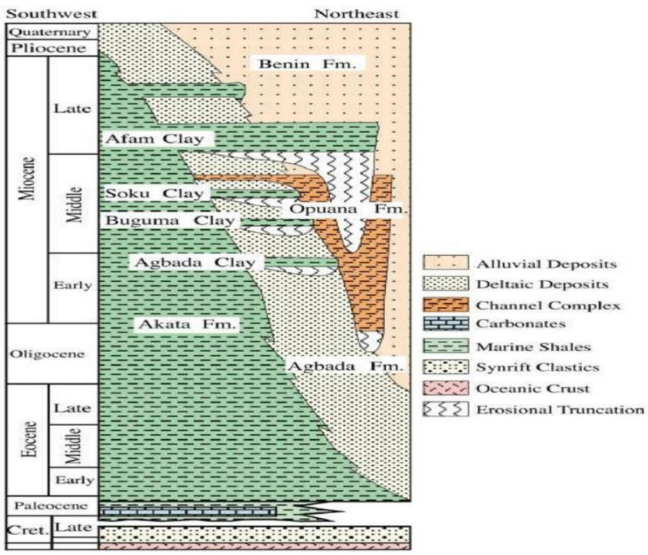


Figure 2: Stratigraphic column for the three formations of the Niger Delta. (Modified from Shannon and Naylor, 1989; Doust and Omatsola, 1989).

2.4 Local Geology

The geology of Southern Nigeria and Western Cameroun defines the onshore portion of the Niger Delta province (Figure 3). The Benin Flank, an east-to-north-trending hinge line situated south of the West African Basin Massif, forms the northern limit. The Apakaliki High's Cretaceous outcrops establish the North-East boundary, while the Calabar Front, a border that borders the nearby Precambrian, defines the East-South East boundary. The province's offshore boundaries are delineated to the east by the Cameroon volcanic line, to the west by the Eastern boundary of the Dahomey Basin (the easternmost West African transform fault passive margin), and, in areas where sediment thickness is greater than two kilometers, to the south and south-west by the 4000-meter bathymetric contour. The 300,000 km2 province contains the geologic portion of the Tertiary Niger Delta (Akata-Agbada) Petroleum.

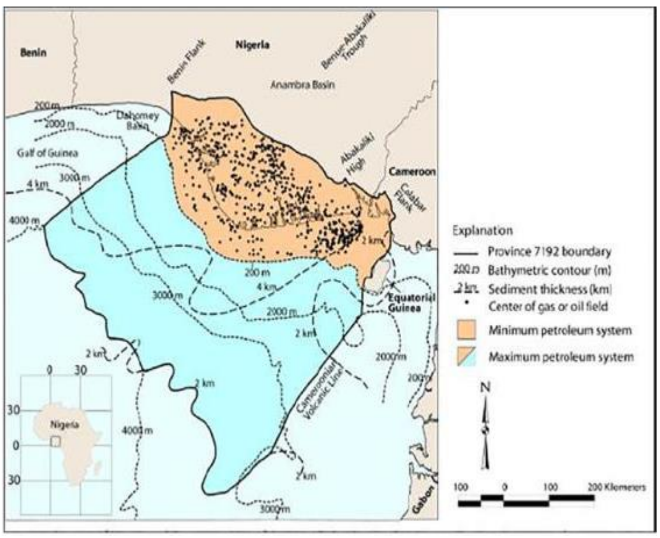


Figure 3: Geology Map of the Study area

2.5 Brief Information on Reservoir

There are some prerequisites and contributing elements that cause oil and gas to build up in the subsurface in commercial amounts. These have been reduced to five fundamental needs, which are colloquially known as the "magic five." A source is often shale or extremely fine-grained limestone containing at least 0.5% of the kind of organic materials that can eventually lead to petroleum. Heat: necessary in order to gelatinize petroleum from biological stuff and received from the soil by burying of the source rock. For oil to be formed, a temperature of about 1500 F is required; above about 3500 F, only gas is produced; beyond 4500 F, even that is destroyed. A reservoir is a layer or formation of porous and permeable rock, typically composed of carbonate and sandstone. Caprockorseal: A pervious layer above the reservoir that typically evaporates or holds onto petroleum.

Occasionally, the source rock itself may act as if it were directly above the reservoir. Trap: A subsurface habitat created by structural and stratigraphic management in which the sediment in a reservoir is prevented from migrating further and builds up as a result. In order to meet these requirements, a sedimentary basin with a minimum thickness of Between 2,000 and 2,500 meters. If only at the base of the series, this would guarantee that source rocks are nature to the oil generation threshold. Therefore, the fundamental strategy in exploration is to take into account each of the "magic five" individually and collectively and make sure they have been pleased with the field of study. If so, it makes sense to drill an exploration well at this expense.

2.6 Fundamental Principle of Seismic Reflection

The term "seismic" originates from the early 1900s, when equipment was created to identify seismic waves that were traveling through the earth. Through propagation outward from the earthquake's focal (source), these waves were picked up and recorded by earth-surface devices. The source/focus and size of the earthquake were determined by the examination and analysis of the recorded signals. More significantly, a more thorough examination of the shape of the recorded waves and their traveled ray trajectories revealed the nature of the earth's deep interior structure. These recordings demonstrated waves that had traveled deep into the earth and were reflected, refracted, or both back to the surface from subsurface seismic and/or acoustic interfaces between the material and the intermediate overlaying material. The product of a material's density and the speed at which an earthquake, strain, or disturbance propagates is known as its acoustic impedance. Typically shown in equation 1

$$A.I = \rho v \tag{1}$$

Where,

ρ = density, V =velocity

A.I =acoustic impedance

The reflective capacity is indicated by the reflection coefficient given by:

The parameter under measurement is the total time required for a generated wave to travel from its source to surface detectors, either directly or via reflection or refraction at subsurface interface layers.

2.7 Fundamental Principles of the Reflection Pathway

This approach is based on Snell's law, which says that I. At the point of incidence, reflected rays all lie on the same plane, and that ii. The angle of incidence and angle of refraction are equal. A subfield of seismology called reflection seismology creates images of the earth's subsurface by using reflected seismic waves. The fundamental idea of seismic survey is that sound is reflected at an interface between materials with sufficiently varied acoustic characteristics. The specified acoustic impedance as shown in Eqn. 2

$$RC = [\rho 2v2 - \rho 1v1] / [\rho 2v2 + \rho 1v1] \quad (2)$$

Where RC =Reflection coefficient

3. Materials and Methods

One of Nigeria's petroleum corporations provided the data set for this study, which included a basemap of the study region, composite geophysical well logs, 3-D seismic data (SEG-Y), and check shot surveys.

1) Basemap: This displays the positions of points, the two-dimensional grid of inlines and crossovers, and their orientations.

2) Well logs: These are utilized to give subsurface petroleum potential information. They also give exact control over how seismic data is interpreted, such as the depth to the tops of possible reservoirs (well tops).

3) The seismic section consists of many in lines that are 2D slices of a 3-D seismic data volume crosslines (dip direction) and strike direction.

4) Check shot: This includes two-way time and depth (displacement) measurements. are employed to correlate the velocities that result from integrating the sonic interval transit times; the corrected sonic may also be utilized to translate surface seismic time into depth and to compute the formation acoustic impedance required to produce a synthetic seismogram. Two-way time is the amount of time that passes between the source of a seismic wave, its reflection, and its return to a receiver at the surface of the earth following a loop tie. The horizon was mapped using the check shot value to create the Isopach Map, a depth structure map.

4. Methodology

4.1 Fault Picking

A fault is a fissure that runs parallel to the plane of movement and along which the opposing sides of the earth's substance have moved substantially. Dobrin reports a fault in the seismic section (Dobrin, 1981). i. Reflection discontinuities that follow a nearly linear pattern. ii. Divergence in dip that has nothing to do with stratigraphy. iii. The reflections below the alleged fault disappear.

4.2 Mapping of Horizons

According to a study, horizons are discrete reflections that correspond to mapable isochronous sedimentary units (Tearpock and Bischke, 1991). The horizons were selected using the well log data, which is a measure of the subsurface formation's receptivity. The first horizon was selected at a depth of 3166.00 meters (2618.91 meters for the second seismic section) from the well.At depths of 3544.82 meters (2838.50 meters below the seismic section) and 3826.11 meters (2991.48 meters below the seismic section), respectively, the second and third were also extracted from the well.

4.3 Seismic-to-Well-Tie

Determining the relationship between seismic reflections and stratigraphy is one of the first steps in analyzing this seismic information. A crucial stage in reservoir characterization is accurately linking wells and seismic data. A crucial task for this interpretation endeavor is well-to-seismictie. It is employed in the correlation of the 3D seismic volume with the well information (logs). This made it possible to compare the well-based and the 3D seismic data using crossplots. Bridging the gap between the temporal and depth domains, seismic-to-well tie is a crucial phase in the seismic interpretation workflow and is important at any stage of a field's development.

4.4 Generation of Structure Maps

By connecting points of equal time or depth with consistent contour intervals, time and depth structure maps were produced. Using time translated to depth by the check shot survey data, the time structure maps were used to create depth-structure maps.

4.5 Features Generation

4.5.1 3-D Curvature Amplitude of RMS

i. The variance attribute was created at intervals of 1372 ms, 1901 ms, and 2195 milliseconds, in that order. The time slices show how the field is structured.

ii. The Sweetness attribute was created at time intervals of 1372 ms, 1901 ms, and 2195 milliseconds, in that order. The link between sandbodies and host shale is shown in the time slices.

iii. At time intervals of 1372 ms, 1901 ms, and 2195 ms, respectively, instantaneous frequency was created. Frequency anomaly fluctuation is visible in the time slices.

4.6 Interpretation of Seismic Attributes

4.6.1 Seismic Attributes

Data produced seismically from prestack or post-stack time migration data is referred to as seismic attributes. Complex trace attributes, seismic event geometrical configurations, and their spatial and pre-stack changes are thus included in the attributes. These can include frequency, amplitude, velocity, and the rate at which any of these changes in relation to time or place. The main goals of the attributes are to give the interpreter precise and in-depth information on the lithological, structural, and stratigraphic features of these seismic prospects. the examination and interpretation of the subsurface's geometry and physical characteristics.

4.6.2 Variance Time Slices

The fault pattern over the whole region was visualized with the use of variance time slices at different Two-Way-Time (TWT) values. Because this method allows for a mathematical assessment of the 3-D seismic data volume without being prejudiced by previous interpretation, variance time slices were employed in the initial structural interpretation foundation. In variance computations, the waveform similarity of neighboring traces is compared. Neighboring traces and traces within a designated time range are cross-correlated. The center sample will be allocated the lowest estimated correlation coefficient.

4.7 Sweetness

The reflection strength divided by the square root of the instantaneous frequency yields the sweetness. In siliciclastic environments, it typically serves as a sand-shale indication. It also draws attention to low frequency/high instantaneous amplitude events, like gas-saturated sands. The amplitude strength increases and the frequency content drops when hydrocarbons are present. Therefore, the combination of both traits, known as the sweetness attribute, results in a superior image. This characteristic frequently aids in locating not just fruitful exploratory wells but also provides insight into the size of the pool. (Hart, 2008).

4.8 Instantaneous Frequency

Since the instantaneous frequency attribute is a physical property that can be employed as an effective discriminator, it responds to both wave propagation effects and depositional properties.

Its applications consist of:

i. The low frequency anomaly hydrocarbon indicator. Because of the oil concentration in the pores, unconsolidated sands can occasionally intensify this effect.

ii. Fracture zone indication, as fractures can represent lower frequency zones.

The indication for bed thickness. In thinly laminated shales, for example, higher frequencies show abrupt interfaces; in more extensive bedding geometries, such as sand-prone lithologies, lower frequencies are indicated. (Washington, 2002).

5. Results and Discussion

5.1 Results

The results include time and depth structure maps to demonstrate geologic structures and changes in thickness that indicate the time and depth of the top of the reservoirs explored in the "Honyx" field. They also include well-log correlation, the formation of variance attribute, sweetness attribute, instantaneous attribute, and RMS amplitude. Additionally, wells were correlated to support the seismic interpretation.

5.2 Petrophysical Evaluation

Two primary limestones were extracted from the gamaray logs. These are shale and sandstones. The way the sand and gravel alternate is a sign that the lower portions of the wells are located in the Agbada Formation in the Niger Delta. Reversal of the Gamma Ray to the left, which is linked to high resistivity, indicates the reservoir intervals. It was considered that the gamma ray to the right's deflection and the low resistivity that accompanied it indicated the presence of a mudrock or shale reservoir. In the correlation study, the resistivity logs and gamama ray features were utilized. There was good agreement in the well logs correlation. The entire formation was taken into account, and it was found that there was good agreement regarding its continuity within the well's extent. The hydrocarbon resource was identified using the deep resistivity and gamma-ray logs and the well logs. In the correlation panel, the top of the detected reservoir is displayed. (Figure 7; Figure 4).

5.3 Seismic to Well Tie

The seismic interpretation required the detection and mapping of faults and horizons. The well logs identified the reservoir sands, which were then traced through the well-to-seismic tie (Figure 5). This action was taken to precisely define the location, length, and shape of the reservoirs in these seismic segments. Time-structural maps were then produced for the different time horizons.

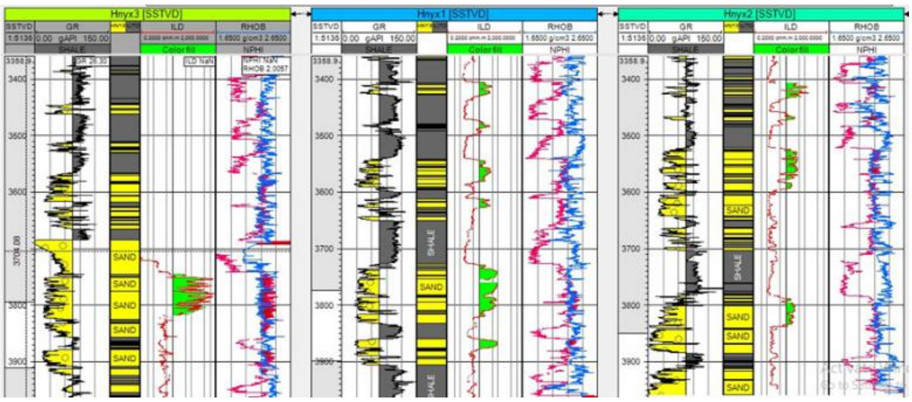


Figure 5: Well log Panel across the wells

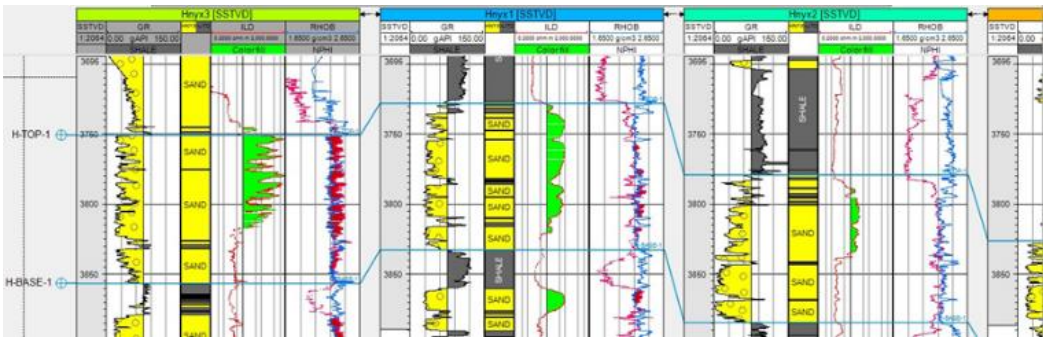


Figure 6: Correlation Panel across the wells

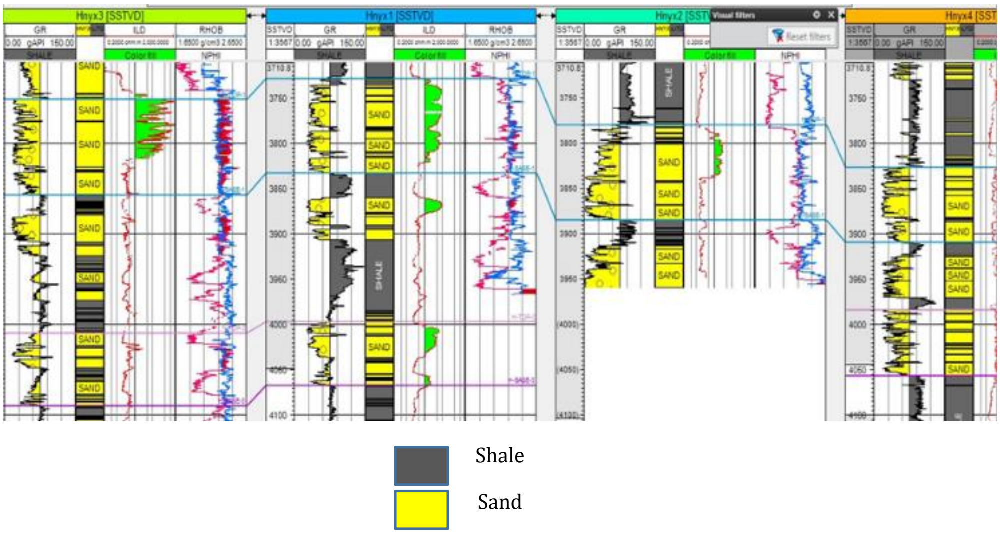


Figure 7: Correlation Panel across thewells

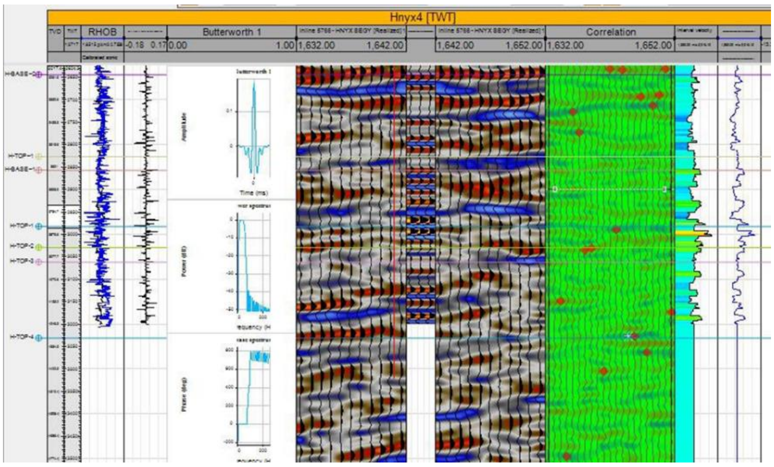


Figure 8: Synthetic generation and matching The synthetic seismogram and the seismic trace match well.

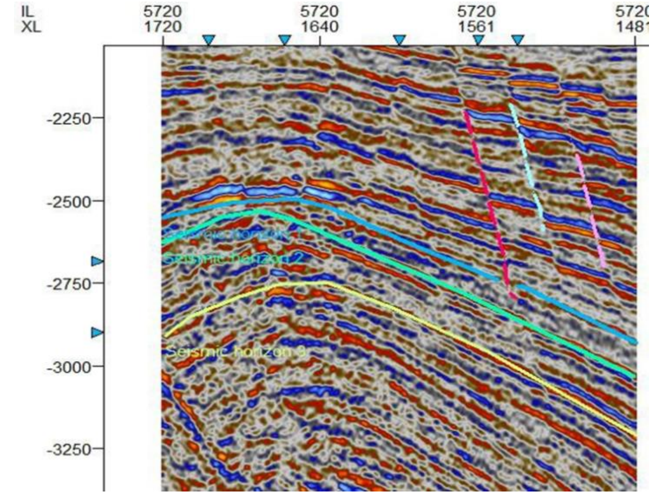


Figure 9: Seismic Section showing picked faults and mapped horizon.

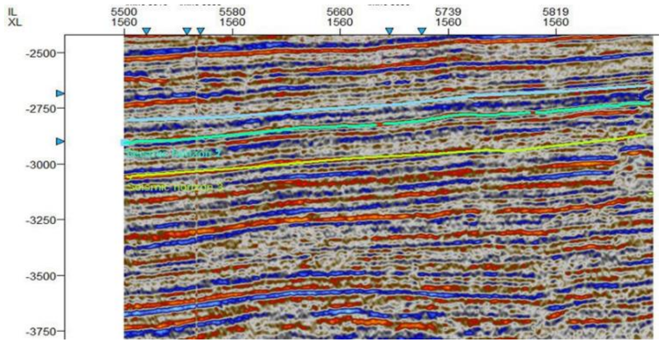


Figure 10: Seismic Section (cross line) showing mapped horizon

5.4 Interpretation of Horizons and Faults

5.4.1 Horizons

A mappable, isochronous geological time surface is called a horizon (Clausen and Korstgard, 1993; Tearpock and Bischke, 1991). As seen in Figure 10 above, three horizons were mapped by following three strong reflectors the whole survey length.

5.4.1.1 Horizon 1

A depth of 3166.00 meters (10385 feet) on the well logs corresponds to the mapping of 2618.91 meters on the survey. It is easy to notice the reflector nature on the seismic sections. The growing fault in the area controls its structural integrity.

5.4.1.2 Horizon 2

The survey mapped it at 2838.50 meters, which correlates to a depth of 3544.82 meters (11628 feet) according to the well logs. It is easy to notice the reflector nature on the seismic sections. The growing fault in the area controls its structural integrity.

5.4.1.3 Horizon Three

The depth recorded on the well logs is 3826.11 meters (12550 feet) based on the mapping of 2991.48 meters on the survey. It is easy to notice the reflector nature on the seismic sections. The growing fault in the area controls its structural integrity.

5.5 Interpretation of Faults

5.5.1 Faults

There are many first-orders growing faults in the region. As depth increases and becomes sole out in the lower Miocene, these first-order growth faults are characterized by increasingly thicker hanging-wall sequences. They have a very important role in the partitioning of hydrocarbons. At time slice, two significant growing faults were discovered and designated as Faults A (pink) and B (yellow). The variance is placed on the inline at 5670 ms (Figure 11). The faults are identified by progressively thicker hanging walls and sediment sequences that increase in depth. Both faults are oriented from west to east.

5.5.2 Variance Attributes

The degree to which fault segments are pronounced was displayed by the Variance time slices. The variance attribute's time slices were generated at a 25 ms period. Every time slice's fault segments were located and mapped (Figure 12 to 14). The faults are not always noticeable on the first surface, indicating that the surface is generated at a deeper depth. The faults are clearly visible and oriented west to east at a time of 2392 m on the second surface (Figure 13). Other faults begin to develop on the third surface at a deeper level of 2084 meters (6836 feet) (Figure 14).

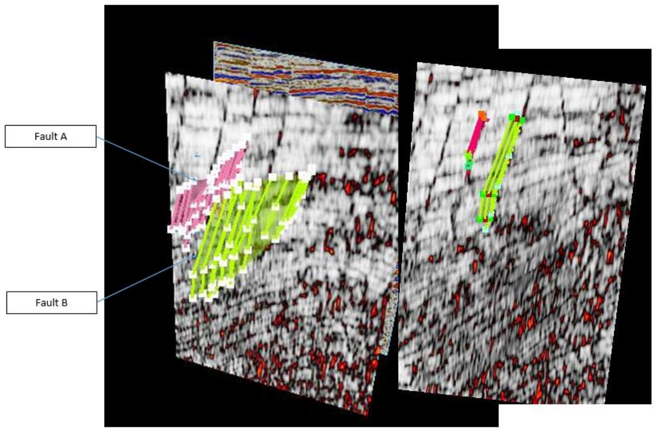


Figure 11: Interpreted variance (5670)of fault A and B

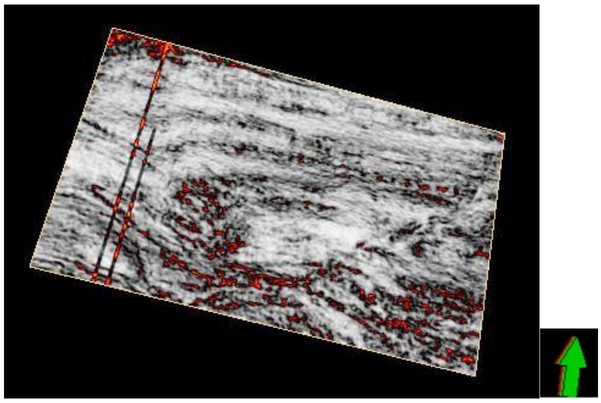


Figure 12: Variance on timeslice3336 ms where the fault is not pronounced.

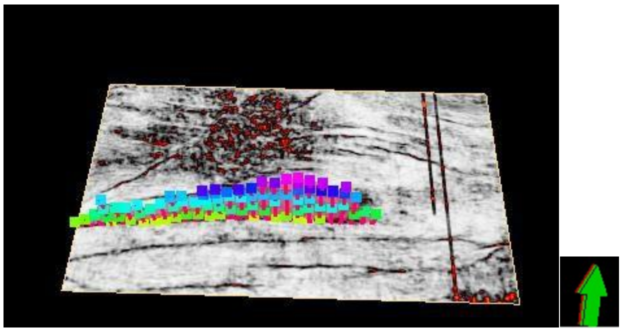


Figure 13: Variance on time slice 2392 ms showing the west-east orientation of the fault

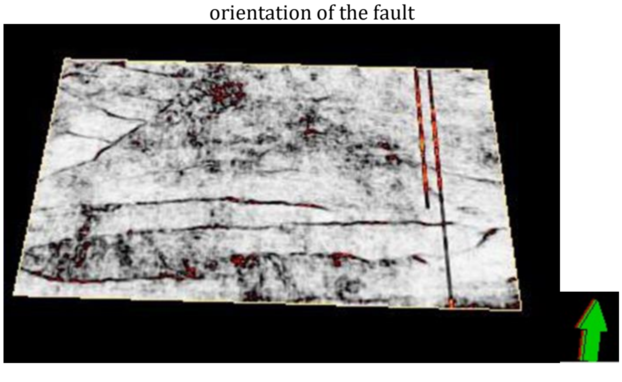


Figure 14: Variance at time2084 ms

5.6 Time Structural Map

5.6.1 The Horizon 1

Time structural map is displayed in Figure 15. The value of the contours varies from 2400 ms to 2900 ms. The northeastern region of this map has the lowest contour values, which range from 2400 to 2450 ms. Two significant errors were noted.

5.6.2 Time Structure Map of Horizon 2.

The Horizon 2 time structural map is displayed in Figure 16. The values of the contours range from 2550 ms to 3000 ms. The principal features defined are anticlines linked with growth faults, and the lowest contour values on this map are located in the northeastern region, with values ranging from 2550 to 2600 meters. There were two flaws found, both quite noticeable. The anticlinal structure's crest is a potentially promising hydrocarbon possibility with a high structural profile. The field's current wells were found to be around the mapped structural high, indicating compliance with the accepted interpretation.

5.6.3 Time Structure Map of Horizon 3

The Horizon 3 temporal structure map is displayed in Figure 17. The values of the contour lines go from 2700 to 3250 ms. The principal features shown are anticlines linked with growth faults, and the lowest contour values on this map are located in the northeastern region, with values ranging from 2,700 to 2,750 meters. Two prominent major faults were noted. The anticlinal structure's crest is structurally high and could be a viable hydrocarbon opportunity. The field's current wells were found to be around the mapped structural high, suggesting consistency with the current interpretation.

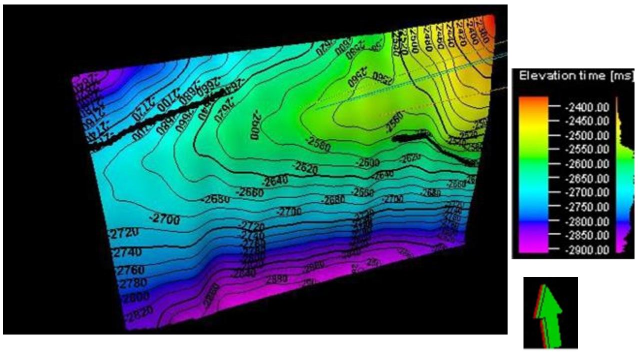


Figure 15: Time structure map with wells on Surface1

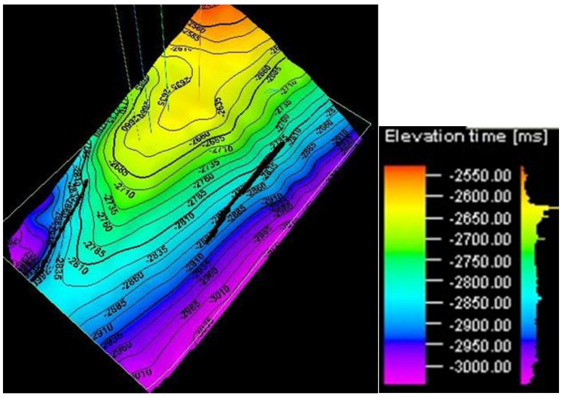


Figure 16: Time structure map with wells on surface 2

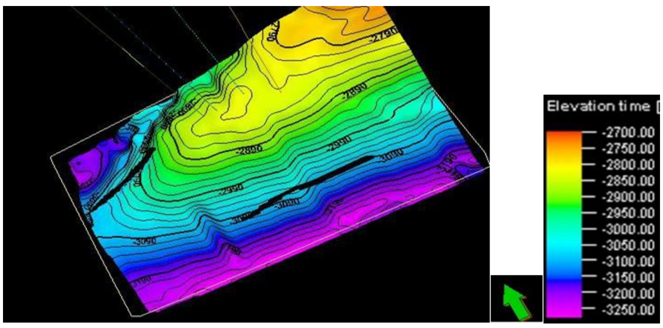


Figure 17: Time structure map with wells on Surface 3

5.7 Generation of Depth Map

The polynomial function created from the provided check-shot data was used to transform the time values of the horizons to depth. To transform the time structural map to a depth structural map, the available check-shot data were employed. Using check-shots from wells, Fig. 18, displays the polynomial plot (T-Z) illustrating the time-to-depth connection.

5.8 Depth Structural Map

The depth structural maps display the depth on top of the potential areas at different locations. Furthermore, they illustrate the connection between fault surface maps and structural geometries.

5.8.1 Depth Structural Map of Horizon 1

As observed in Figure 19, this horizontal lies within a depth range of 3100–3900 m with a contour interval of 50 m. Prospect A was found, with the closure taking place nearly in the middle. The closure provides a large space for prospects.

5.8.2 Depth Structural Map of Horizon 2

This horizon has a contour interval of 25 m and lies between 2025 and 2250 m in depth (Figure 20). With the closures, the prospect was found. With the fault-oriented west to east. The closure provides a vast region of potential.

5.8.3 Depth Structural Map of Horizon 3.

This horizon lies at a depth range of 2250–2600m(73818-8530ft) with a contour interval of 50m as seen in Figure 19 to 21. Prospect A was identified at a deeper depth of2425m (7956ft).

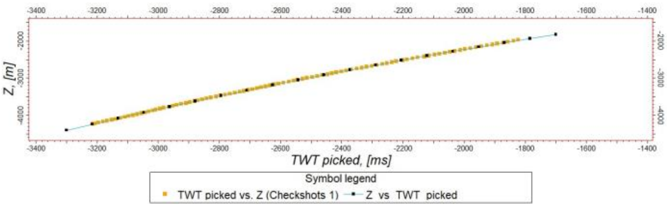
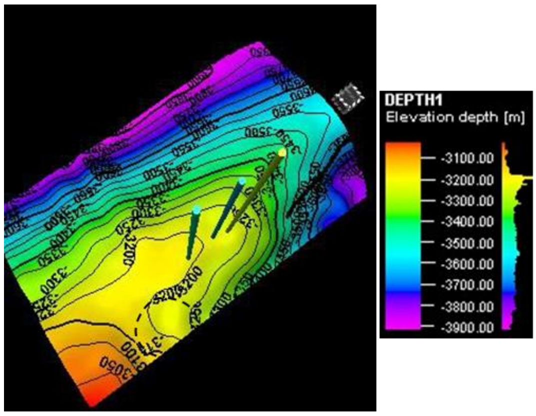


Figure 18: Polynomialplot (T-Z) showing the time to depth relationship, a curve generated using checkshots from wells



PROSPECTA

Figure 19: Depth Structural map on Horizon 1

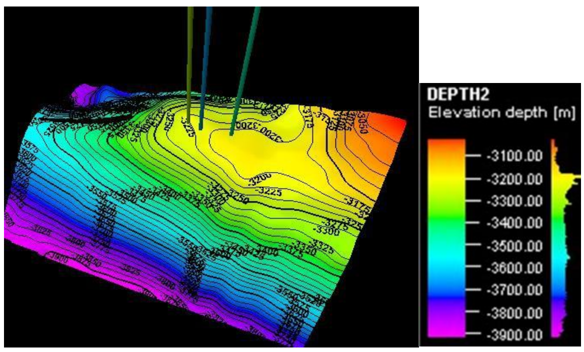


Figure 20: Depth Structural map on Horizon 2

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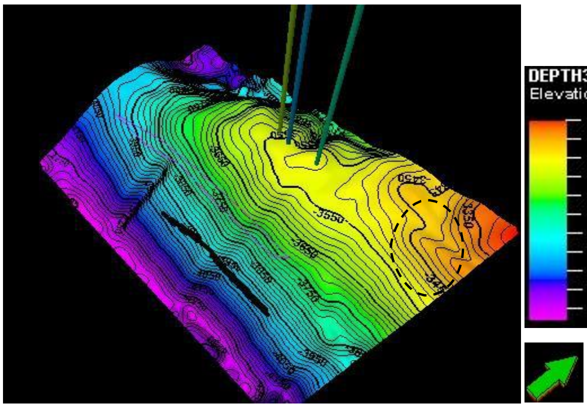

PROSPECTA

Figure 21: Depth Structural map on Horizon 3

5.9 Seismic Attributes

5.9.1 Sweetness

The promising locations were displayed by the Sweetness attributes generated. A 25 ms period was also used to construct the time slice softness property as shown in Figures 22 to 24. The brilliant patches on the first surface are not noticeable at a depth of 3674 meters (12150 feet), which is a modest depth. On the second surface, the brilliant spots began to show at a deeper depth of 2456 meters (8056 feet). Nonetheless, the bright spots between the faults are clearly visible at a depth of 2480 meters (8135 feet), which is indicative of potential locations. The regions exhibit stronger reflections in the surrounding shale because they have separate bodies and spots in shale successions.

5.9.2 Instantaneous Frequency

In contrast to others, the instantaneous frequency map displayed fluctuations in frequency anomalies. Time slices representing the three surfaces' instantaneous frequency attributes were created (Figures 25 to 26). The time slices revealed low-frequency anomalies between the two major faults that were found, which is a sign of fractured zones and hydrocarbons. However, this is consistent with the feature of sweetness where solitary sand bodies were noted.

5.9.3 RMS Amplitude

Findings show that structural control governs strong amplitude anomalies, which are shown to arise close to faults on structural topographies. Bright spot anomalies are a sign of the presence of hydrocarbons, according to assessments of seismic amplitude characteristics. Since the root-mean-square amplitude attribute is more sensitive to direct hydrocarbon indicators (DHIs) than other attributes and since its pattern of bright spots anomalously superposed on structural closures is distinct, it was utilized to identify potential zones see Figures 27 and 28.

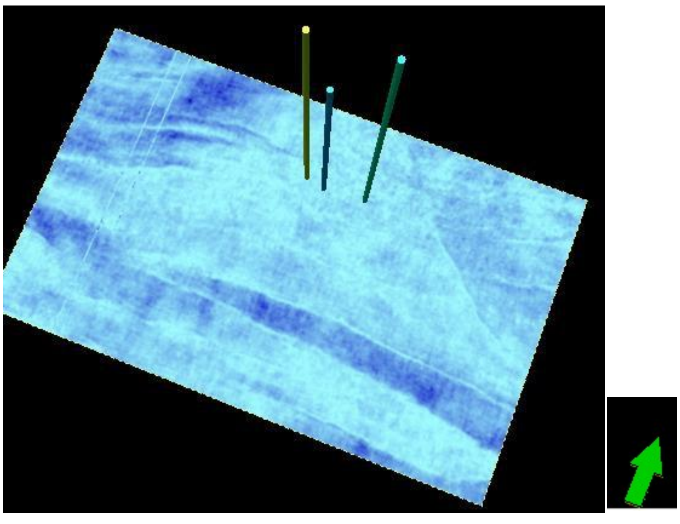

Figure 22: Sweetness on Surface1(3704)

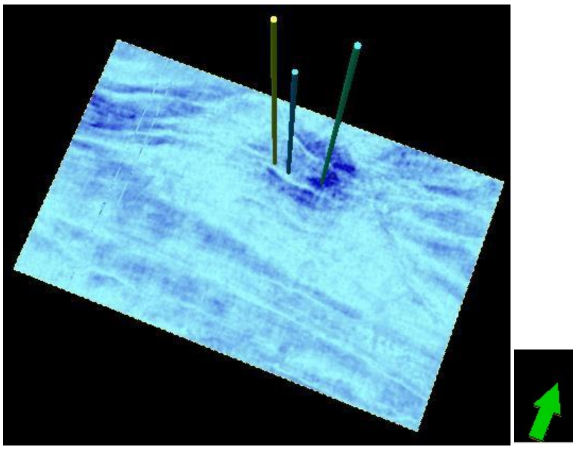

Figure 23: Sweetness on Surface2 (2456)

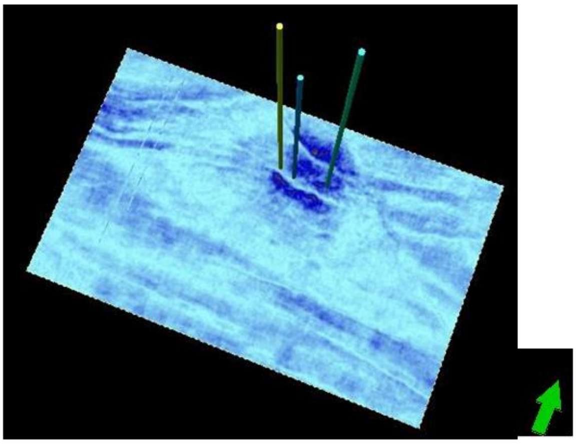

Figure 24: Sweetness on Surface3(2480ms)

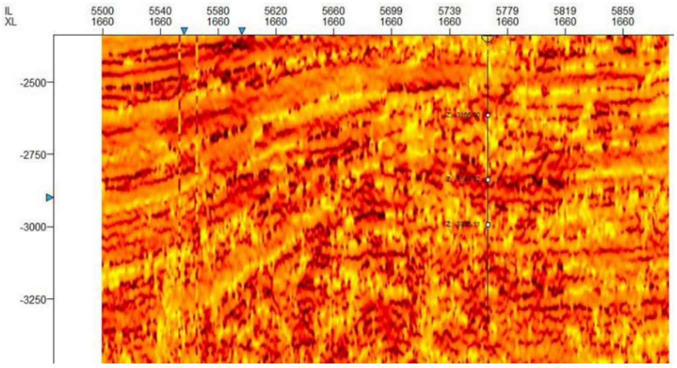

Figure 25: Instantaneous Frequency

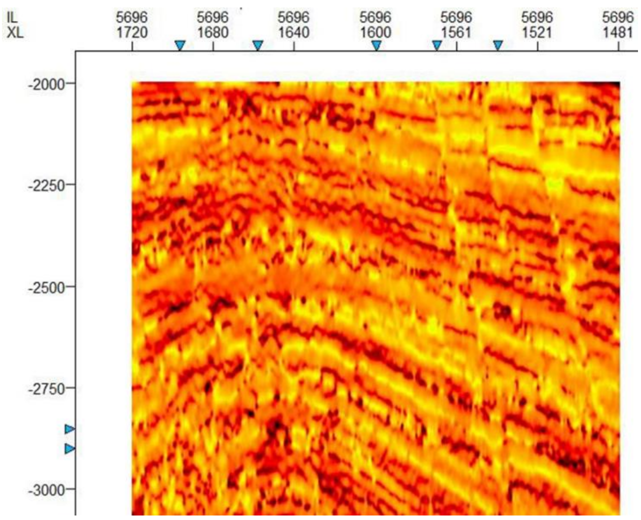

Figure 26: Instantaneous Frequency

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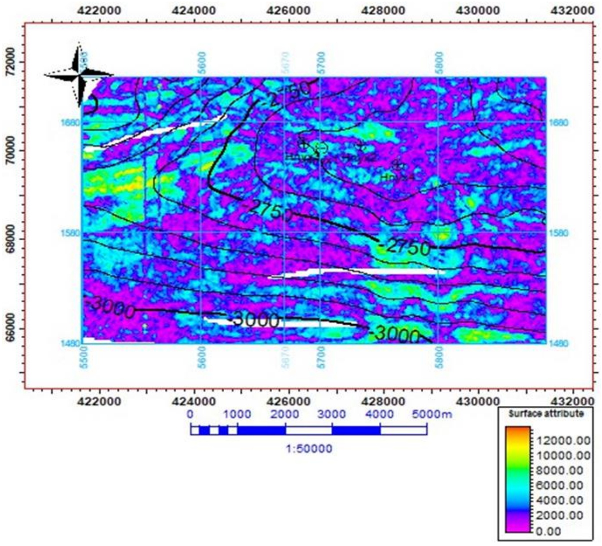

Figure 27: RMS Amplitude for Surface 1

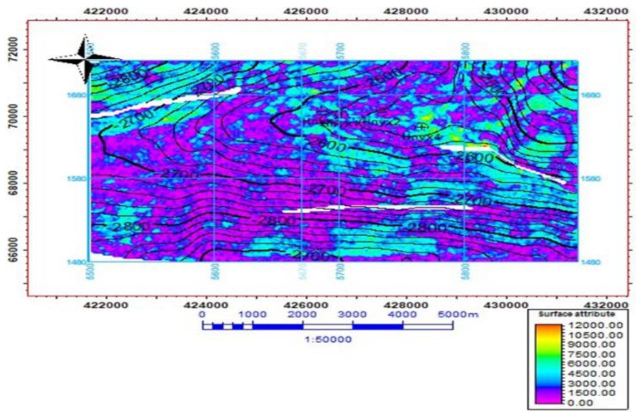

Figure 28: RMS Amplitude for Surface 2

6. Conclusion

The findings of the three-dimensional seismic structural study conducted in the "Honynx" field showed a structurally controlled field made up of growth, synthetic, and antithetic faults. Two significant growing faults in the area have been identified and correspondingly mapped. The structural style of the area was studied using seismic properties (Variance, Sweetness, Instantaneous frequency at different time intervals, RMS Amplitude), Time, and Depth structure maps developed for each of the horizon. The field's failed segments are depicted by the variance time slices. A huge fault started to show depth. The faults are oriented from west to east, and at a deeper depth, further faults begin to develop. Stronger reflections of solitary bodies in the field are shown by the Sweetness Time slices. The brilliant patches have depth and are clearly defined. The instantaneous frequency time slices exhibit low frequency anomalies that point to cracked zones and hydrocarbons. This work has demonstrated that the use of seismic attribute analysis has revealed further hydrocarbon-prospective zones that might be further revalidated and appraised to a hydrocarbon prospect, distant from the producing zone, which is common to all three reservoir tops. These prospect areas were detected on the three depth maps. According to the obtained results, the field is effective at accumulating hydrocarbons.

Recommendation

The "Honyx" Field provides potential anticlinal structures and closures that obstruct the structures, so transforming them into effective hydrocarbon accumulation trapping systems. According to the study's findings, a thorough petrophysical analysis of the Field should be conducted.

References

Adetokunbo, P., Al-Shuhail, A.A., Al-Dossary, S., 2016. 3D seismic edge detection using magic squares and cubes. Interpretation, 4 (3), Pp. T271–T280.

Adetoye, T.O., and Enikanoselu, P., 2009. Reservoir mapping and volumetric analysis using Seismic and Well Data: Ozean Journal of Applied Sciences, 2 (4), Pp. 66-67.

Aizebeokhai, A., Olayinka, I., 2011. Structural and Stratigraphic mapping of EMI field, offshore Niger Delta. J. Geol. Mining. Res., 3, Pp. 5-38.

Allstair, R.B., 2011. Interpretation of 3D seismic data, 7th edn. The American Association of Petroleum Geologists and Society of Exploration Geophysics, Tusla

Anstey, N.A., 1978. Seismic exploration for sandstone reservoir. Inter Human Res. Dev. Corp.

Avbovbo, 1978. Eocenede positof alluvial plains and in the Gulf of Mexicov., 32, Pp. 15-29.

Avseth, P., Mukerji, T., Mavko, G., 2005. Quantitative seismic interpretation. Cambridge University Press, Cambridge, Pp. 168–170.

Burke, K., Dessauvagie, T.F., Whiteman, A.J., 1971. The opening of the Gulf of Guinea and the geological history of the Benue Trough and the Niger Delta. Nature, 233, Pp. 51–55.

Chen, Q., Sidney, S., 1997. Seismic attribute technology for reservoir forecasting and monitoring. Lead Edge, Pp. 445–456.

Chopra, S., Marfurt, K.J., 2005. Seismic attributes—a historical perspective. Geophysics 70 (5), Pp. 3SO–28SO.

Clausen and Korstgard, 1993. Channel detection in 3D seismic sweetness. AAPG Bulletin, v. 92, Pp. 733-742.

Doust and Omatsola, 1990. Deep water Petroleum Systems in Nigeriav, 47, Pp. 12-15.

Ehinlaiye, M.D., Osisanya, O.W., Ighrakpata, F.C., Saleh, A.S., Ibitoye, T.A., 2022. Seismic Interpretation and Petrophysical Analysis for Evaluation of Ataga Field, Onshore Niger Delta, Nigeria. Journal of Applied Science and Environmental Management, 26 (5), Pp. 921-927.

Ejedawe, 1995. Occurrence of Mioceneoil in South Louisiana. Gulf coast association of geological societies transactions. Pp. 94-98.

Ekweozor and Daukoru, 1994. Edge detection of Stratigraphic analysis using 3D seismic data,6 Annual international meeting Society of Exploration Geophysicists Expanded Abstracts, Pp. 324 327.

Emujakporue, G.O., 2016. Evaluation of Hydrocarbon Prospect of Amu Field, Niger-Delta, Nigeria. Int. Res. J. Geol. Min., 6 (1), Pp. 001-008.

Etuk, N.O., Aka, M., Agbasi, O.E., Ibuot, J., 2020. Evaluation of seismic attributes for reservoir characterization over Edi field, Niger Delta, Nigeria using 3d seismic data. International J. of Advan. Geosci., 8 (2), Pp. 168–172.

Harperand, B.L., and DeRuiter, 1997. Cenozoic, in A.Salvador, ed, the Gulf of Mexico Basin, The Geology of North America, boulder, Geological Society of America. Vj. Pp. 245-324.

Hart, B., 2008. Channel detection in 3-D seismic data using wetness AAPG Bulletin, 92, Pp. 733-742.

Hospers, 1965. Igneous in Salvador, A. editor, The Gulf of Mexico Basin, boulder, Colorado, geological society of America, The Geology of North America, v.j., Pp. 91-108.

Hossain, S., 2019. Application of seismic attribute analysis in fluvial seismic geomorphology. Journal of Petroleum Exploration and Production Technology. https://doi.org/10.1007/s13202-019-00809-z

Lambert-Aikhionbare, I., 1984. Geology of the Atlantic and Gulf Coastal Province of North America. New York.

Liner, C.L., 2004. Elements of 3D seismology, 2nd edn. PennWell Books, Tulsa, OK.

Micheal, 1999. Structure Framework in Salvador, A., editor, the Gulf of Mexico Basin Boulder, Colorado, Geological Society of America, the Geology of North America, j. Pp. 31-52.

Muhammad, N., Muhammad, K.J., Sayed, S.RM., Nassir, S.A., Shazia, A., Farhan, K., Nisar, A., 2015. Seismic and well-log driven structural and petrophysical analysis of the Lower Goru Formation in the Lower Indus Basin, Pakistan. Geosci. J., DOI 10.1007/s12303-015-0028-z\

Obiadi., 2019. Petrophysical properties and 3D geologic modelling of the reservoirs ands of JIOfield, Niger Delta, Nigeria. J. Basic Phys. Res., Pp. 1-1.

Okeke, H.C., Okoro, A., Ezediegwu, P.C., Chinwuko, A.I., Onuigbo, E.N., Omeokachie, A., 2018. Evaluation of Hydrocarbon Prospect of Tomboy C-field Offshore Niger Delta, Nigeria. J. of Basic Phys. Res., 8 (2), Pp. 65–78.

Ologe, O., Bakole, S., Oke, S., 2014. Hydrocarbon Prospecting Over 'Ok' field, Niger Delta Using Petrophysical and Seismic Attributes Analysis. Nig. J. of Technology, 33 (3), Pp. 40–408.

Opara, A.I., Osaki, L.J., 2018. 3–D Seismic attribute analysis for enhanced prospect definition of "Opu Field'', C oastal Swamp Depobelt Niger Delta. Nigeria. J. of Appl. Sci. 18 (2), Pp. 86-102.

Osisanya, O.W., Ogugu, A.A., Saleh, A.S., Eyankware, O.M., Oyanameh, E.O., 2023. Petrophysical Evaluation and Seismic Interpretation of Geowil Hydrocarbon Bearing Reservoir in the Niger Delta Region of Nigeria. J. Appl. Sci. Environ. Manage., 27 (9) Pp. 2031-2040.

Oyeyemi, K.D., Aizebeokhai, A.P., 2015. Seismic attributes analysis for reservoir characterization; ofshore Niger Delta. Pet Coal., 57 (6), Pp. 619–628.

Pramanik, A.G., Singh, V., Srivastava, A.K., 2003b. Seismic attributes and their role in reservoir characterization. In: Proceedings of PETRO TECH-2003 held in January 2003, New Delhi

Pramanik, A.G., Singh, V., Srivastava, A.K., Rakesh, K., 2002. Stratigraphic Inversion for enhancing vertical resolution. Geo- horizons, 7 (2), Pp. 8–18.

Pramanik, A.G., Srivastava, A.K., Singh, V., Katiyar, R., 2003a. Strati- graphic interpretation using post-stack inversion: case histories from Indian Basins. In: Expanded abstract, 65th EAGE conference held on June 2–6, Stavanger, Pp. 52.

Sahoo, T.R., Hill, M., Browne, G.H., 2014. Seismic attribute analysis and depositional elements in the Canterbury Basin. Geotechnical Petroleum Forum, Wellington, New Zealand.

Srivastava, A.K., Singh, V., Samanta, B.G., Sen, G., 2003. Utilization of seismic attributes for reservoir mapping: a case study from Cambay Basin, India. CSEG Recorder, 28 (8), Pp. 46–50.

Taner, M.T., Schuelke, J.S., Doherty, R.O., Baysal, E., 1995. Seismic attributes revisited. In: Expanded abstract, society of Van Riel P (2000) The past, present, and future of quantitative reservoir characterization. Lead Edge, 19 (8), Pp. 878–881.

Van Riel, P., 2000. The past, present, and future of quantitative reservoir characterization. Lead Edge, 19 (8), Pp. 878–881.

Vig, R., Singh, V., Kharoo, H.L., Tiwari, D.N., Verma, R.P., Chandra, M., Sen, G., 2002. Post stack seismic inversion for delineating thin reservoirs: a case study. In: Proceedings of 4th conference and exposition in petroleum geophysics (Mumbai-2002) held during Jan 7–9, p 287–291