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WELL CORRELATION AND SEISMIC STRATIGRAPHIC ANALYSIS OF "ENA FIELD", NIGER DELTA BASIN, NIGERIA

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Abstract

Hydrocarbon exploration is becoming increasingly more difficult and expensive, since most of the identified structural closures on the shelf and upper slope have been drilled, but there is enough possibility of finding more oil and gas in the deep-water plays, if more accurate exploration technique is employed in the right place. This work is an integrated sequence stratigraphic study of "Ena Field", in the coastal swamp depobelt I, Western Niger Delta, Nigeria. It is aimed at improving the present understanding of the structural development, sequence stratigraphic history, paleo-depositional environments and hydrocarbon reservoir potential of the field. A 3-D seismic volume, wireline logs from six wells were used to determine the different lithologies and to evaluate the reservoir properties, biofacies data and, check shot data were used to produced well-seismic ties on the 3-D seismic volume. Tie has a general good fitting. Seismic sequence interpretation revealed that the succession in the field consists of three sequence boundaries dated, 12.1Ma, 13.1Ma and 15.5Ma and three maximum flooding surfaces, dated 11.5Ma, 12.8Ma, and 15.0Ma respectively.

The correlation panel cross sections of the stratigraphic column revealed four wells to be dipping in NW – SE and three wells to be dipping NE – SW. The stratigraphic framework of the depositional sequence becomes thicker down the dip direction. Two correlation panel cross sections also showed the strike directions. The structure is bounded to the Northeast by a major growth fault. It is partially separated into two blocks by a synthetic growth fault with varying throws along its length. The depositional settings of the Middle Miocene strata were influenced by fluvial, tidal and marine systems. The up dip areas which seismically form a continuous high-amplitude reflection surface with closure signify possible hydrocarbon exploration targets. Good structures that favour hydrocarbon entrapment abound in the field. Oil and gas accumulation is high and widespread throughout the field.

Keywords: Seismic stratigraphy, Hydrocarbon potentials, sequence, exploration

1.0 INTRODUCTION

"Ena Field" lies at the co-ordinates 5° 39′ 32″ N and 5° 9′ 10″ E with elevation of 53 meters above sea level, is located in the coastal swamp I, Western Niger Delta Basin. (Figure 1) It is a gas and oil field, with, a total of over 40 wells drilled to date. The field consists of stacked reservoirs, located between 4,300 and 7,700 ft having maximum thickness of more than 3,400 ft. The prevailing structural styles in the field are that of basinward dipping of a major growth fault with varying throws along its length. The history of petroleum exploration has shown that there will always be enough possibility of finding more oil and gas, if more accurate exploration technique is employed in the right place. Seismic stratigraphy has turned out to be one of the best useful techniques in generating exploration prospects and predicting reservoir and seal quality in both stratigraphic and structural prospects. [1]

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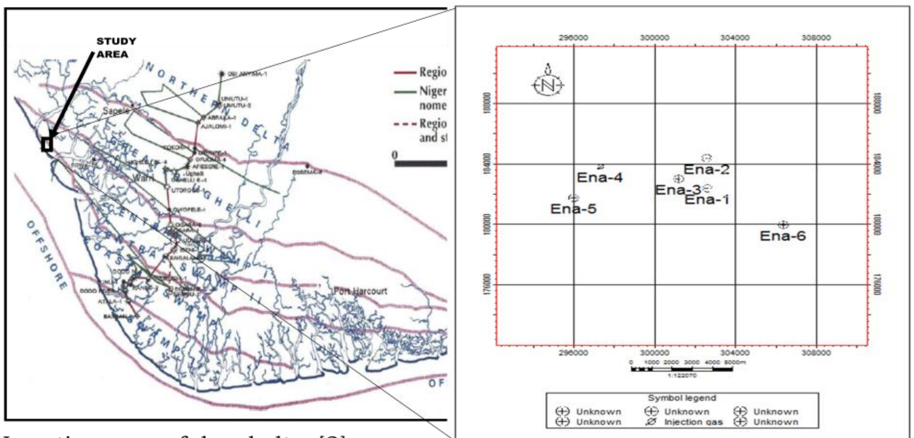
2.0 MATERIALS AND METHODS

A 3-D seismic volume of "Ena field" is covered by a grid of 3D seismic data set acquired in the early 90s covering approximately 310 Km^2 and has a bin size of 25m by 25 m in both inline and crossline directions, well log data suites, biofacies data, and check shot data provided for this work were prepared in Petrel. Check shot data was used for 2-way time interpretation that tied both well logs and seismic data together.



Location map of depobelts, [2]

Figure 1: Map of Niger Delta depobelts showing the location of study area [2] and spatial distribution of wells in the base map.

3.0 DISCUSSION

Well Correlation

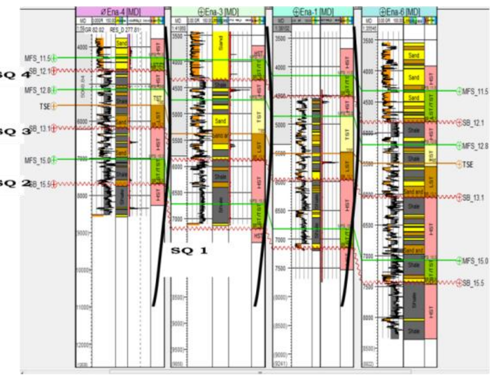
The occurrence of the identified chronostratigraphic surfaces at different depths along dip and strike lines in the studied wells shows evidence of faulting and the sand packaging increases along the dip direction in the well field. Correlation was achieved using the recognized and identified constrained chronostratigraphic surfaces typified by Maximum Flooding Surfaces (MFSs) and Sequence Boundaries (SBs). Correlation helped to compartmentalize the stratigraphic section and showed how the surfaces correlated along dip and strike at certain depths within the depositional basin, thus depicting basin geometry and depositional sequences across the field.

The displayed correlation panel cross section A (Figure 2a) indicates that the stratigraphic column appears to be dipping in NW –SE and deposition tends to be thicker in wells Ena-4, Ena-3 to Ena-1 and Ena- 6, which were located down dip. Another displayed correlation panel cross section B (Figure 2b) indicates that the stratigraphic column appears to be dipping in NE – SW and deposition trend is confirmed to be thicker in wells Ena-2, Ena-3 and Ena5. The third displayed correlation panel cross section C (Figure 3a) indicates that the stratigraphic column appears to be in strike direction E – W in wells Ena-2 and well Ena-4. Lastly, the displayed correlation panel cross section D (Figures 3b) shows also the stratigraphic column appears to be in strike direction E – W in wells Ena-1 and Ena-5. The structural setting of the field as shown by the correlation panels discussed above indicates hanging wall with fault line depositional model and also the displacement of sediments across the fault planes by the rollover fault systems, which are characteristic of the Niger Delta.

Seismic to well calibration

Seismic sequence analysis is based on the identification of stratigraphic units composed of a relatively conformable succession of genetically related strata termed depositional sequence. [3] The relationship of the wells with the structural patterns is super-imposed on the seismic data to identify the possible MFS's and SBs on the seismic section. [4] (Figure 4)

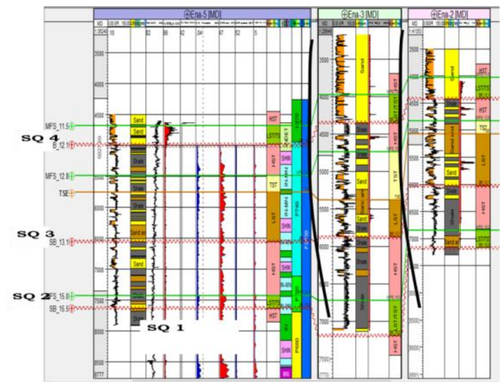
Dipping NW-SE direction



A

Figure 2a: Cross section of Ena-4, Ena-3, Ena-1 and Ena-6 dipping direction.

Dipping NE-SW direction



B

Figure 2b: Cross section of Ena-5, Ena-3 and Ena-2 dipping direction.

Strike E - W direction

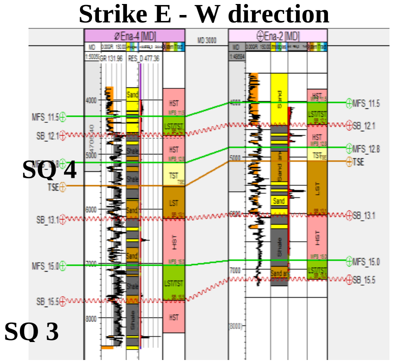


Figure 3a: Cross section of Ena-4 amd Ena-2 on strike direction.

Strike E - W direction

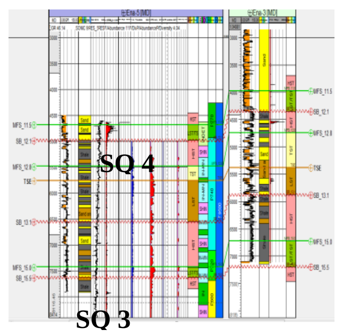


Figure 3b: Cross section of Ena-5 and Ena-3 on the strike direction

SQ 2 **SQ 2**

The quality of the data varies from very good to shallow levels, poor quality at deeper depth. [5] Discontinuous low amplitude somewhat chaotic reflection character punctuated by discontinuous high amplitude events was mapped between 500ms – 1000ms which is cha **SQ 1** of the continental-transitional environments of Benin Formation. High-medium amplitude parallel continuous high frequency reflections between 1000ms to 2250ms characterize Agbada Formation, interpreted as thick sand body with inter-bedding shales deposited in a low – medium energy deltaic front; inner - middle neritic shelf margin. The seismic reflection package below 2500ms has low amplitude and variable weak reflection strength suggesting Akata Formation. Lateral thickness changes of sequences lower within the Agbada Formation (sequences 1–4) show greater structural influence, with layers clearly thickening directly adjacent to faults along basinward tilted fault blocks and thinning over the crests of rollover anticlines (Figure 6). Contour closures against the major structure building faults represent a faulted anticlinal structure juxtaposed against the fault. These structures form the majority of structural traps in the Niger Delta. [6] (Figure 7)

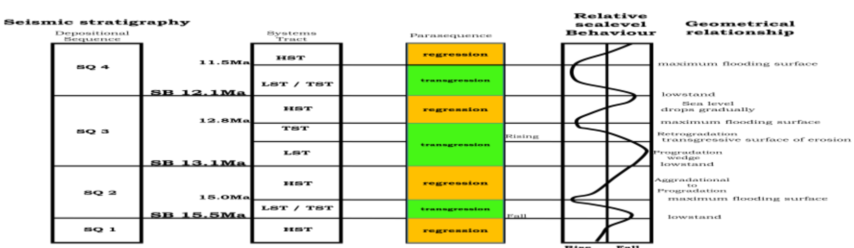


Figure 4: Schematic Seismic parameters within the third-order sequences and their systems tracts. [7]

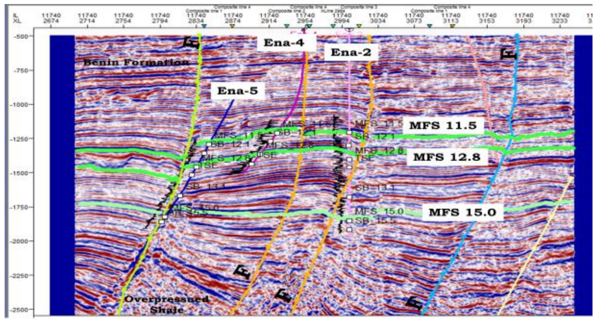


Figure 5: Seismic interpretation of a vertical well and two diverted wells, inline 111740 showing the SB's, MFS's and the faults. [7]

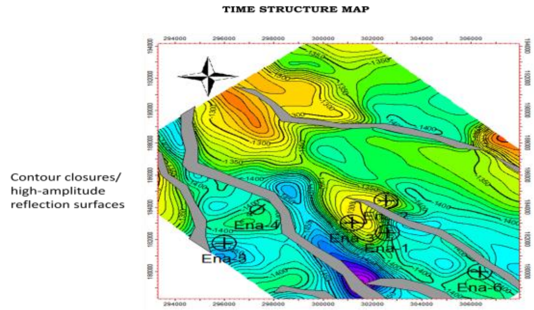


Figure 6: MFS 12.8Ma surface with up dip areas is an implication of hydrocarbons.

4.0 CONCLUSION

Results of well correlation and seismic sections showed that delineated constrained surfaces were not laterally continuous. These truncations were inferred to be caused by syndepositional faults and the sand thickness increases along the dipping direction in the field. Heavy faulting and open fracturing promoted permeability and the migration of fluid in the potential reservoir within the down throw channel sands with thinly bedded shale. [8] Three sequence boundaries (SB) dated 12.1Ma, 13.1Ma and 15.5Ma were identified basically on the inflection from overall progradation to overall retrogradation of parasequences in the shallowing sand units. Three candidate maximum flooding surface (MFS) dated 11.5Ma, 12.8Ma, and 15.0Ma were recognized based on the maximum shale peak, the separation of high neutron and low density values with constituent high gamma readings.

In "Ena Field" the primary seal rock are the inter-bedded shale, the juxtaposition of reservoir sands against shale beds due to faulting creates good seal reliability. [9] Traps can be partly stratigraphic or enhanced with postdepositional structuring that motivating migration from the source rocks to the reservoirs. [10] In terms of hydrocarbon exploration, the up dip areas which seismically form a continuous high-amplitude reflection surface with closure signify possible implication of hydrocarbon.

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