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RESERVIOR CHARACTERIZATION AND STRUCTURAL INTERPRETATION OF SEISMIC PROFILE: OKPE FIELD NIGER DELTA, NIGERIA

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Abstract
3-D seismic data and well logs have been used to map the structure stratigraphy in Okpe field Niger delta.Wireline signatures were used to identify hydrocarbon bearing sands and evaluate petrophysical parameters for hydrocarbon pore volume determination. Three hydrocarbon reservoir were delineated (top 9,11 and 12) but only one horizon (top 9) was interpreted from the log signature. The depth structural map revealed northwest to southeast trending rollover anticlinal structures with major fault assisted closure to the reservoir. The result of the petro-physical analysis revealed that the average porosity and permeability are 0.186 and 340.402 darcys respectively. Net to gross values range from 0.94 to 0.98 which shows reservoir quality of clean sand and environment of deposition of channel environment. Estimation of the volume original oil place is 330,760,193.11438 barrels

Keyword: seismic, well log, hydrocarbon, horizon.

Introduction
Hydrocarbon in the Niger Delta is produced from unconsolidated sand and sandstone of Agbada Formation which is the source rock. However the introduction of the 3-D seismic revolution has allowed more valuable geological information that helps in exploration and exploitation of the hydrocarbon.
The information gotten from 3-D seismic data has led to the establishment of many oil wells around Niger Delta. 3-D seismic data set enables geoscientist to visualize and analyze the subsurface geomorphology. Seismic geomorphology interpretation is the preliminarymethod in picturing, mappingsubsurface geologic features, structural and stratigrahic interpretation possibly far from well control in petroleum exploration. Interpretation of structures and reservoir characterization using 3-D seismic cube and well data pose great challenges in mapping because of their complexities especially in structural deformations, and where identification of reservoir facies is a major challenge to plan delineation field appraisal and development drilling.Furum , 2014.
Therefore, the characterization of reservoirs requires the integration of different types of data to define reservoir model.
The objectives of this work are to make detailed use of available wire line log data to delineate the reservoir units in the wells in the field, determine the geometric properties, lateral variation in thickness, hydrocarbon accumulations and volumetric of the reservoir rocks.

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LOCATION AND GEOLOGY OF THE STUDY AREA

The Okpe field is located at the central swamp onshore Depo belt of western Niger Delta (fig 1). The Niger Delta is one of the prominent basins in West Africa and actually the largest Delta in Africa. The Niger Delta province contains only one identified petroleum system referred to as the tertiary Niger Delta of Akata – Agbada petroleum system (Reijers etal, 1997 & Tuttle etal, 1999). The geology of the tertiary section of the Niger Delta is divided into three Formations.

The Akata Formation is generally open marine and pro Delta dark grey shale with lenses of siltstone and sandstone and plant remains at the top. Plankton Foraminifera may account for over 50% of the rich micro-fauna and the benttonic assemblage indicates shallow marine sheff depositional environment.

The Agbada Formation consists of cyclic coarsing upward regressive sequence and poor sorting from the distribution migration and deposition which indicates floralorigin. It is the slat of most oil reservoirs and centers of over pressures.

The Benin Formation is a loose water bearing sand with occasional lignite and clay. It is made up of continental sand; the shallowest part of the sequence is composed almost entirely of non marine sand.

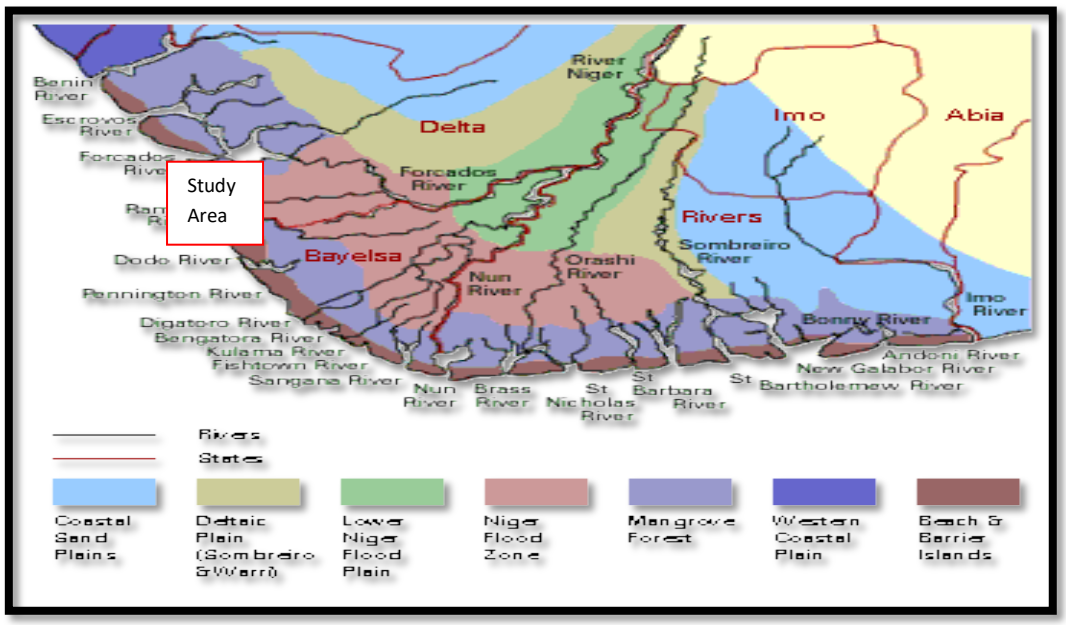

Fig 1; Map of Niger Delta indicating the study area (Aniefiok *et al*., 2013)

MATERIALS AND METHODS

The data used in this work include: digital suites of geological well logs, check shot data and 3-D seismic data. The composite geophysical logs used are the gamma-rays, electrical resistivity, Neutron and density logs (fig 2). Petrel softwarewas used to interpret the seismic data, generate maps and well log sections. The gamma-ray and resistivity logs were used to delineate lithofacies. The target horizon (top 9) was identified on both the well logs and seismic sections. The horizon (top 9, 11 and 12)were determined using the reflection characteristic of the 3-D seismic volume, stratigraphic indicators and the nature of the gamma-ray curves. After correlation, time and depth structural maps were produced using the software. The synthetic seismogram was built using the petrel, well to seismic tie module and the hydrocarbon reservoirs was obtained from the check shot data and displayed on seismic lineswhere they intersected (figure 3).The Archie Juhasz and Indonesian model were used for water saturation evaluation.

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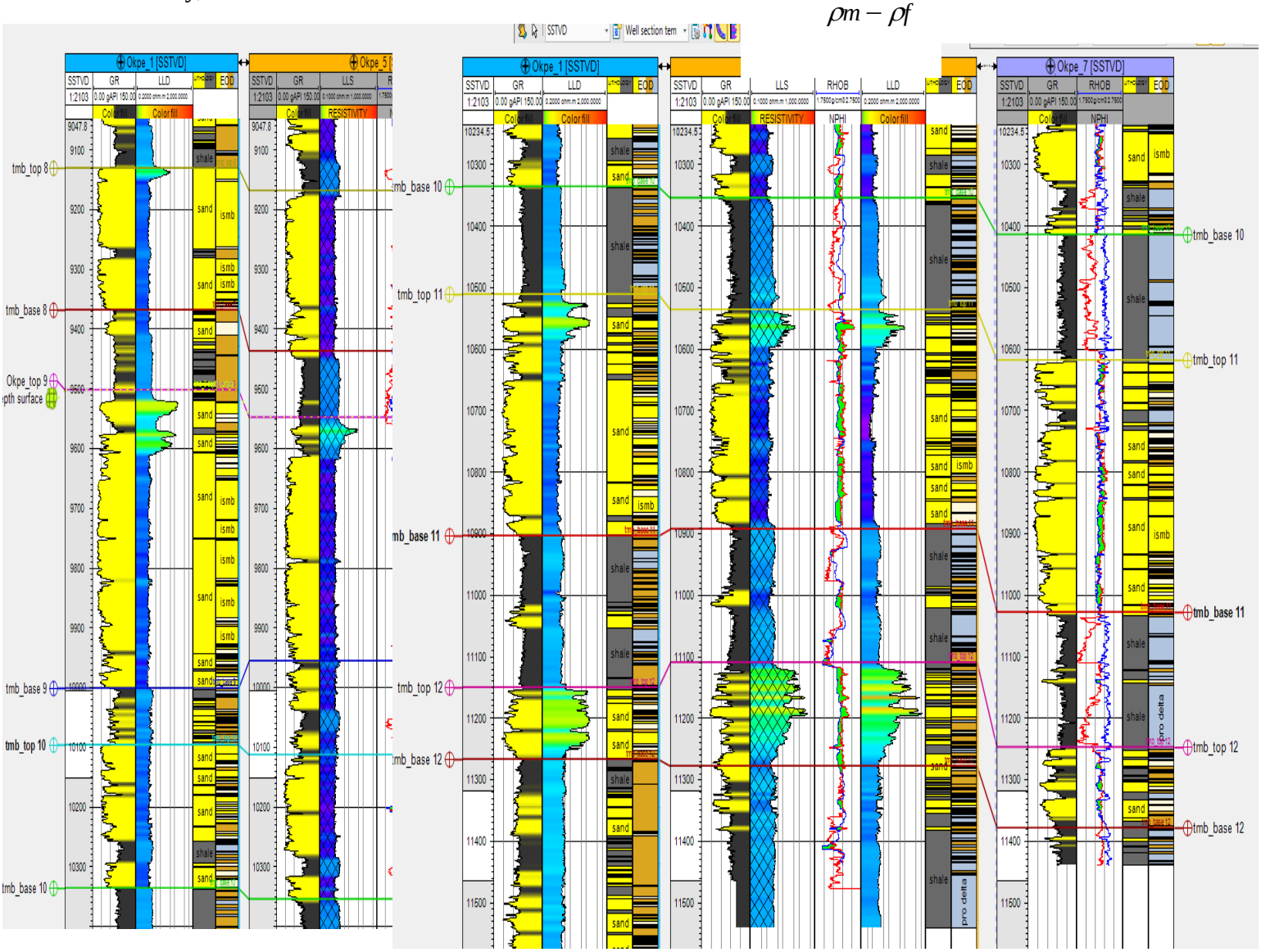
$$S_{w(Archie)} = \left[\frac{a \times R_w}{R_t \times \phi_t^m} \right]^{1/n}$$

Net to gross calculation for the reservoirs was carried out by applying appreciate cut-offs to the computers volumes of shale (VSH)

$$Vshgr = \frac{GR - GR_{matrix}}{GR_{shale} - GR_{matrix}}$$

The density log was used for the estimation in the shale, water and hydrocarbon bearing sands using the following formular.

Finally, the volumetric calculation of the reservoir sand wa $\Phi t = \frac{\rho m - \rho \log}{\rho m - \rho f}$ formular



OOIP = GRV x NTG x POROSITY x 7758 (1-SW).

Fig. 2 Showing well-to-well correlation panel of the study area

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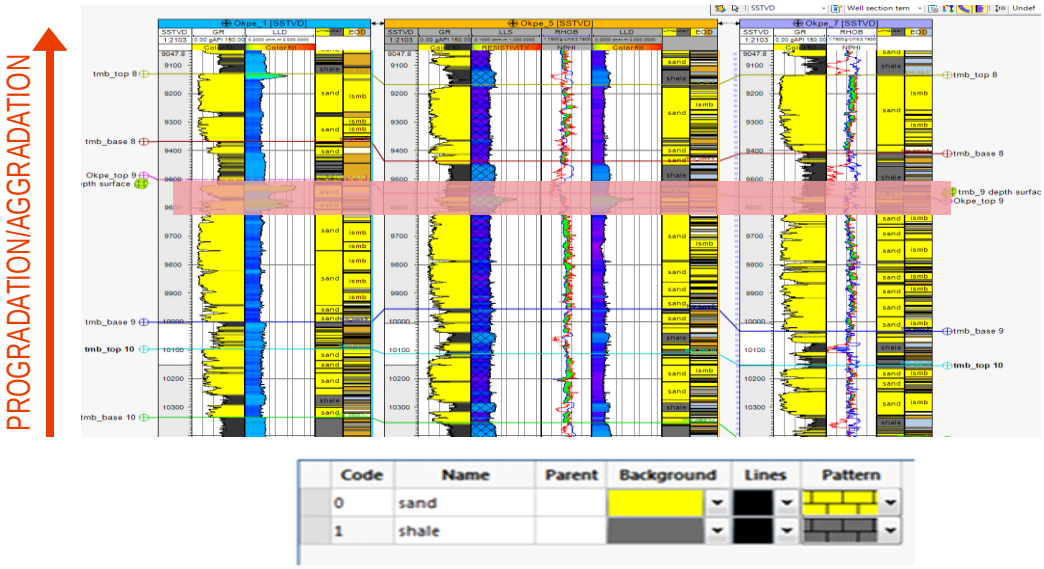

Fig. 3 Type-log of Okpe field

RESULTS AND DISCUSSION

Three horizons (TOP 9, 11 and 12) were interpreted and mapped using their seismic continuity and adequate seismic to well correlation (figure 2) the results obtained from interpretation of only one horizon (top 9) are presented in this paper. The stratigraphic trends showed a general lateral continuity of the lithologic units across the field (figure 3) the thick purple line shows the horizon of interest and red arrow shows that the sands packaging are coarsing upward, that is progredation/aggradations. The logs show fluvial (blocky signatures) with inlets of coarsing upward signature which is a typical of shoreface environment. This shows that the environment of deposition is most probably parallic.

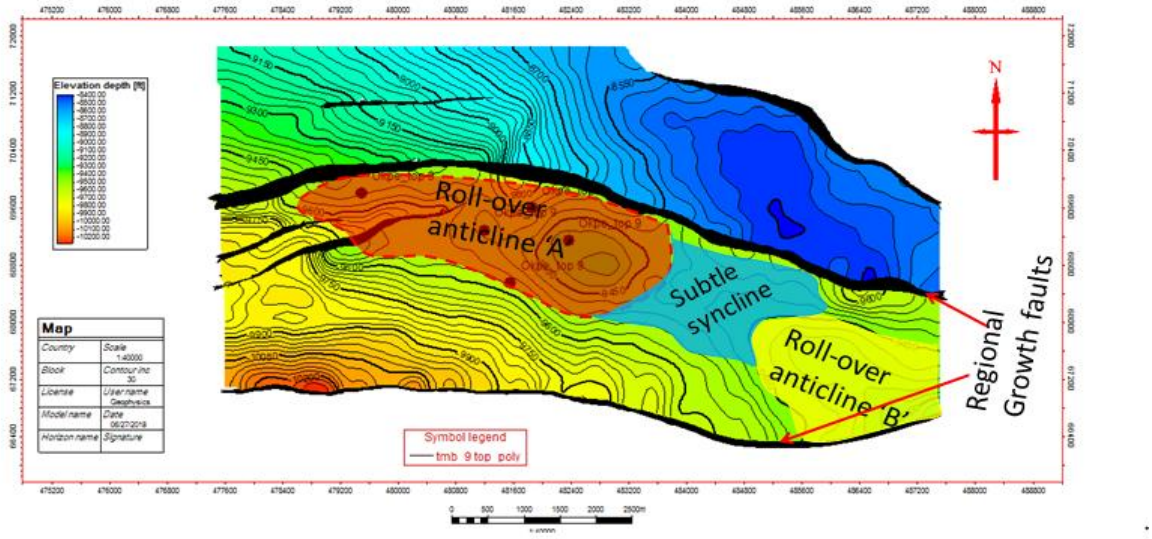

Fig.4: Interpreted structural maps of Tmb-9 Top.

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The field consists of two regional, synthetic and growth fault with few minor faults which was interpreted as minor reservoir faults. (Figure 4) The regional faults cut across two major growth anticlines labeled A and B. The anticline A and B are located North-West and South-West respectively. These two anticline rolled into the major faults as a roll over anticline and interpretation shows that wells have been drilled through the A anticline.

The results of petro-physical analysis in (table 1 and 2) are centered on anticline (A) for wells 1,2,4,5, and 7 the porosity is fair to good, which ranges from (0.15-0.21) except the porosity of well 1 which is 0.2. The average porosity is about 0.186 which is fair to good sandstone reservoir rocks that can accumulate hydrocarbon.

The net-to-gross values ranges from 0.94 to 0.98, which shows reservoir quality of clean sand and environment of deposition of inner stream bar/channel environment. Well 2 and 5 have good hydrocarbon saturation of 0.58 and 0.76 respectively, which means that they are more prolific that other wells that have values range from 0.31 to 0.47.

The reservoir characterization is underpinned by volumetric calculation of the reservoir sand, which shows that original oil in place is 330, 760, 193.11438 barrels.

Table. 1 Petrophysical data for well 1,2,4,5 and 7

Well	Zone	Top (Ft)	Base (Ft)	Gross (Ft)	Net (Ft)	NTG	HC SATURATION	POROSITY	PERMEABILITY (m/darcys)	WATER SATURATION
OKPE-1	tmb-9	9489.46	9990.39	500.93	490.9114	0.98	0.47	0.2	400.08	0.53
OKPE-2	tmb-9	9546.87	10040.48	493.61	478.8017	0.97	0.58	0.18	360.6	0.42
OKPE-4	tmb-9	9403.8	9762.93	359.13	337.5822	0.94	0.31	0.21	410.5	0.69
OKPE-5	tmb-9	9539.71	9947.46	407.75	387.3625	0.95	0.76	0.15	160.23	0.24
OKPE-7	tmb-9	9554.32	10047.61	493.29	478.4913	0.97	0.42	0.19	370.6	0.58

Table. 2 **Okpe Reservoir Averages**

RESERVOIR	FLUID TYPE	NTG	HC SATURATION	POROSITY	PERMEABILITY (M/DARCYS)	WATER SATURATION
tmb-9	OIL	0.962	0.508	0.186	340.402	0.492

Conclusion

3-D seismicand well log data have been used to illustrate structural characteristics of identified sand bodies within the subsurface of Okpe field. From the well log interpretation, three hydrocarbon producing reservoir (top 9, 11 and 12) were identified. The time and depth structural maps show subsurface structural geometry and possible hydrocarbon trapping potential. Two major growth faults and few minor faults were observed. The subsurface reservoir trapping mechanism of the area was revealed to be fault-assisted rollover anticlinal structures. Estimation of original oil in place of anticline A is 330,760,193.11438 barrels.
Finally, the petro-physical values of porosity, net to gross, water saturation, hydrocarbon saturation and permeability that were computed from the petrel were ideal for the Niger Delta sands.

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