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Spatial Variation of Reservoir Properties in Onshore Dove Field of the Niger Delta Region, Nigeria

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ABSTRACT: Spatial variation of reservoir properties in Dove Field, onshore Niger Delta was evaluated using standard seismic and well log information for six wells. Pattern maps, Sequential Gaussian Simulation (SGS), and geo-statistics Variogram, were used to determine the reservoir spatial variation property. The result revealed a Porosity range of 24% to 33% signifying possible hydrocarbon pore volume with an all-round interconnected pore space. Water saturation range 26% to 37%, with regions above 35% are seen as Aquifer. Shale volume range is 10% to 40%, indicating a good and efficient zone of shaly sand dispersal. Permeability range 600mD to 1600mD, with high permeability ranges of 800mD to 1200mD at the north-east section of the wells. High reservoir deliverability is anticipated within the producing zone of the Dove field considering its hydrocarbon pore volume as seen from the comparison of the Net-to-gross range of 55% to 85%, with the shale portion. The average values of porosity, permeability, shale volume, water saturation and net-to- gross in the Dove field are 28%, 800mD, 13%, 32% and 85%, which are typical of the Niger Delta and can serve as a basis for decision making in the Dove field.

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Successful appraisal of Petrophysical attributes: permeability, percentage of shale volume, water saturation, mineralogy, pore fluid type and porosity are critical for the mastery of the hydrocarbon capability of any field's framework productivity. (Barde *et al.,* 2002, 2000; Adejobi and Olayinka, 1997). Spatial reservoir studies is the blend of mineralogical and Petrophysical attributes. Furthermore, with the arrival of modern-day tools for logging and innovation with updated information acquisition, the requirement for Petrophysical analysis cannot be over stressed. The aim of this research is to develop a Petrophysical model of the "DOVE" field and the objectives are to differentiate and model; subsurface geometry, structural features and hydrocarbon reservoirs using petrography, core analysis and Petrophysical parameters of the "DOVE" field, Onshore Niger Delta. It is expected that this research will enhance studies in the estimating hydrocarbon potentials for the "DOVE" field Onshore Niger Delta. The Niger Delta is positioned in the Gulf of Guinea on the West-Coast of Africa (figure 1). Sub aerially, it covers about 72000km^2. During the Phanerozoic, the Niger delta happens to lie in the central part of Gondwana super continent. The partition of the Gondwana supercontinent into Africa and South America in the Mesozoic (late Jurassic to the cretaceous) was started by warm pluming that finished in the tensional burst along three straight cracks originating from at a triple point and situated roughly at 120^0. This triple junction denotes the position currently occupied by Niger delta. The delta has really prograded south-west, from Eocene to present, forming depobelts that express the most dynamic segment of the delta at each phase of its development (Doust and Omatsola, 1990). The geologic settings of Niger Delta are recorded in standard short articles of (Evamy *et al.,* 1978, Reijers *et al*., 1997; Akpabio *et al*., 2003). Geospartialy, the Niger Delta is marked by longitudes 5^0 and 8^{0}E and latitudes 3^0 and 6^{0}N respectively, occuping a total area of 7,500 km^2, with sediment thickness of 12,000 in the Gulf of Guinea (Bustin, 1988). The present Niger Delta sedimentary basin incorporates a lot bigger area than the level of the initial delta developed by the Niger Benue channel framework (Reijers *et al*., 1997). This incorporates the Cross River delta and expands eastwards into the continental margins of Cameroon and Equatorial Guinea. Its sedimentary wedge comprises of a submarine complex continental margin intruding into the Gulf of Guinea (Reijers, 1996). These depobelts are regressive and are one of the

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biggest in the world with sediment thickness and volume 10km and 500000km^3 respectively (Kaplan *et al* 1994).

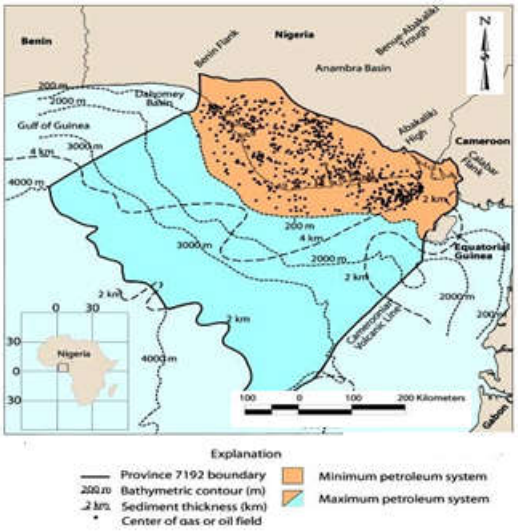

Fig 1: Showing Geology of Niger Delta (source: www.google.com)

Niger Delta sediment deposition has passed through three sequences, as seen in drilled well sections. Significant percentage of the Niger Delta oil are found on the continental shelf in water depth less than 200m or onshore and occur primarily in large, relatively simple structures (Ekweozor and Daukoru, 1994). The Niger Delta stratigraphic arrangement of is divided into three lithostratigraphic units namely, Benin, Agbada and the Akata Formation respectively (figure 2). Tectonic settings of the Niger Delta: The Niger Delta tectonic settings is influenced by the extensional rift system of the Gondwana supercontinent into Africa and South America in the Mesozoic with no basement influence.

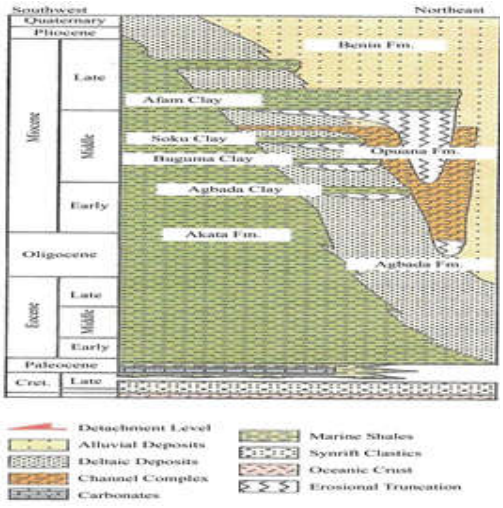

Fig 2: Showing the Lithostratigraphy of Niger Delta (source: www.google.com)

The shale diapirism of the deltaic deposits as a result of overpressure situated on the Niger Delta passive continental margin makes the Niger Delta Unique in the world. The Niger Delta, due to its unique tectonic setting, is divided into different zones such as Extensional zone lying on the continental shelf as a result of thickhead crust; transitional zone and contraction zone lying in the deeper basin ward part. The Niger Delta is believed to contain an estimated 260 trillion cubic feet of natural gas and 30 billion barrels of oil ranking it world number 7 in terms of production. The gross reservoir properties are functions of depth, sand/shale percentage ratio and the fault sealing potential. Hydrocarbon deposits are trapped in rollover anticlines associated with growth faults and related structural and stratigraphic traps, regional sand pinch-out, paleo-channel fills, and truncation. *It is believed that the Niger Delta source rocks are the shales* of *Akata* and Agbada *Formations, with* the hydrocarbon reserves occurring in the sandstone of Agbada Formation. *(*Ekweozor and Okoye, 1980; Ejedawe, 1981; Ejedawe and Okoh, 1981; Nwachukwu and Chukwura, 1986; Bustin, 1988). However, Evamy et al., (1978) noted that crude oil from Niger delta originates mostly from land plant materials. The shales contain high waxes and resins with structureless organic matter from marine sources as significant contribution. With this, Nigerian crude is ranked in the world as one of the best containing <0.4% sulpur (low sulpur crude), having two crude types namely; light paraffinic, waxy crude with pour points of about 20 to 90^{0}F; and naphthenic, non-waxy crude with specific gravity of less than 26^{0}API, with pour points below – 13^{0}F.

MATERIALS AND METHOD

Description of study area: The research area with a pseudo name DOVE is an Oil field with gas well Onshore Niger Delta Nigeria (figure 3).

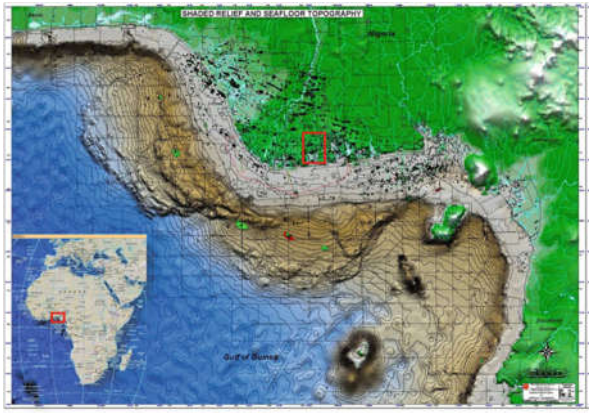

Fig 3: Location map of Niger Delta showing the study area (Source: www.google.com)

Materials: Seismic and well logs information were used in this research to build up the basic, stratigraphic and petrophysical properties of the DOVE field, using Petrel software following the method of Philip 2013. Table 1 demonstrates the suite of well log Data for the DOVE field.

Table 1: well log data for DOVE field

Well Log Data for DOVE Field										
	GR	RES			NEU	DEN	SON	SP/Cal	Dev	Check-Shot
WELLS		LLD	MSFL	LLS						
DOVE01	Yes	Yes	N	N	N	Yes	Yes	N	N	Yes
DOVE02	Yes	N	N	N	N	Yes	Yes	N	N	N
DOVE03	Yes	N	Yes	N	Yes	Yes	Yes	N	Yes	N
DOVE04	Yes	Yes	N	N	Yes	Yes	Yes	N	N	N
DOVE05	Yes	Yes	Yes	N	Yes	Yes	Yes	N	N	N
DOVE06	Yes	N	N	N	Yes	Yes	Yes	N	Yes	N

Fig 4: Research Workflow after Philip 2013

RESULTS AND DISCUSSION

Display of Wells: Figure 5 shows the 3D window display of Well information for the six wells utilized in this research.

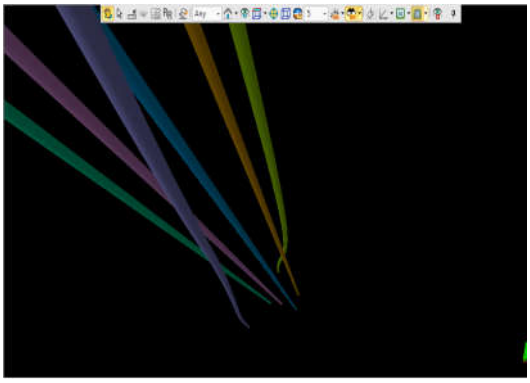

Fig 5: 3D Window Display of DOVE Field Six Wells

Outcome Model: The modeling process was intended to produce petrophysical models that depict reservoir properties from seismic and well data sets (figure 6 to figure 7). To develop property models, geological model needed at first to be built.

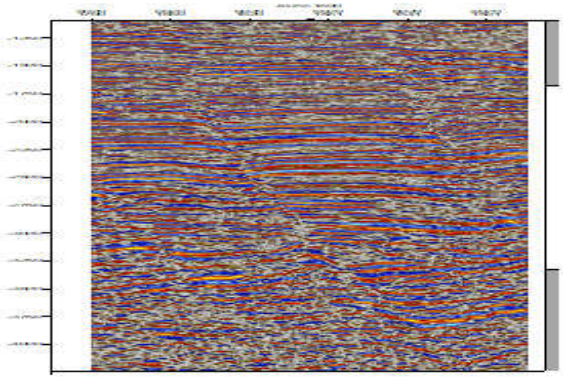

Fig 6: Showing the display of 3D seismic section

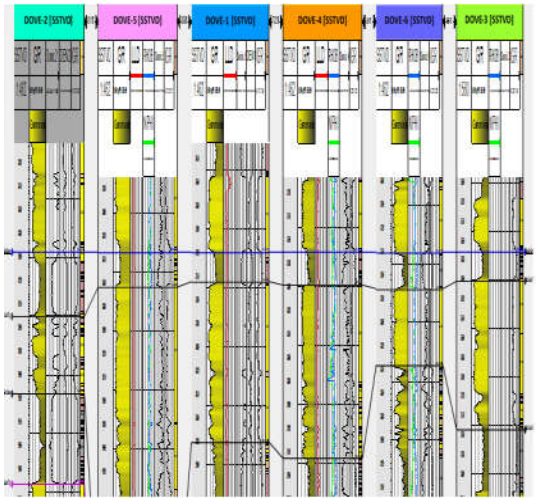

Fig 7: Display of well Section in well interpretation window

Geological Model: From seismic data, the seismic section with major faults label 1 to 2 in Figure 8 was produced. The geological model was produced by joining structural and stratigraphic details (figure 9 to figure 11).

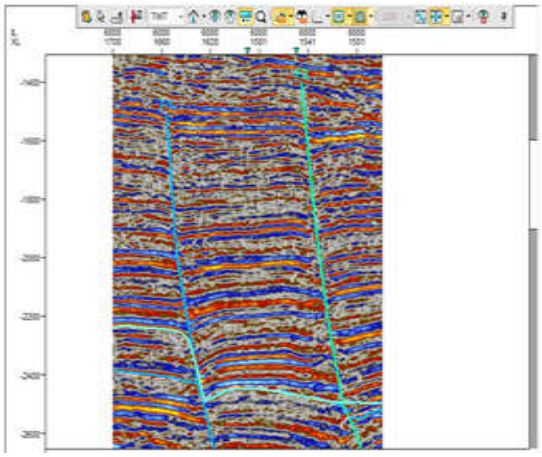

Fig 8: Seismic Section with two designated faults displayed in 3D Analysis Window

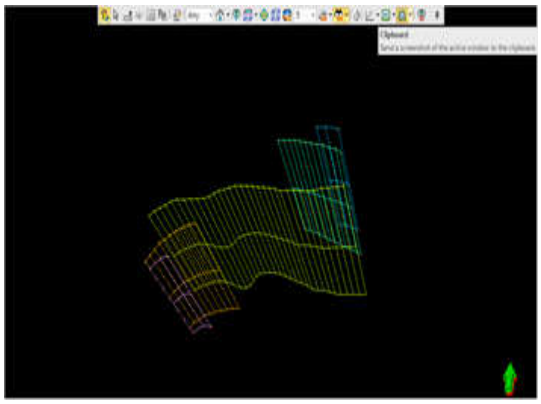

Fig 9: 3D Window display of Faults Model

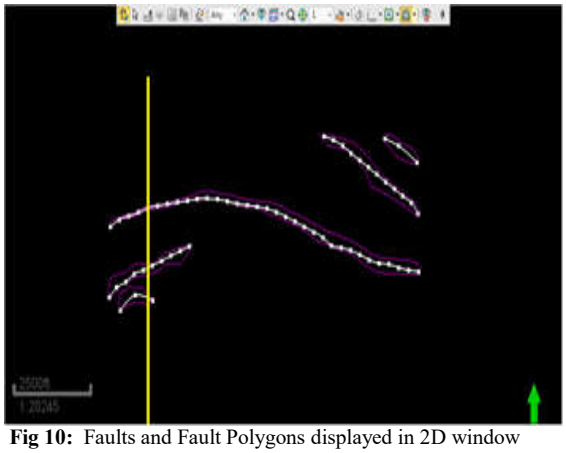

Fig 10: Faults and Fault Polygons displayed in 2D window

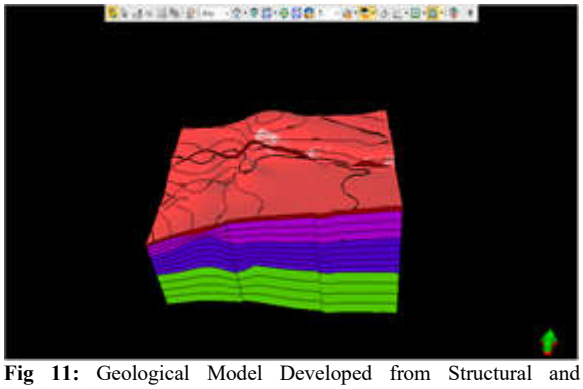

Fig 11: Geological Model Developed from Structural and Stratigraphic Frameworks

Property Models: Following the workflow portrayed in figure 4, permeability, porosity, water saturation, net-to-gross and shale volume models were produced.

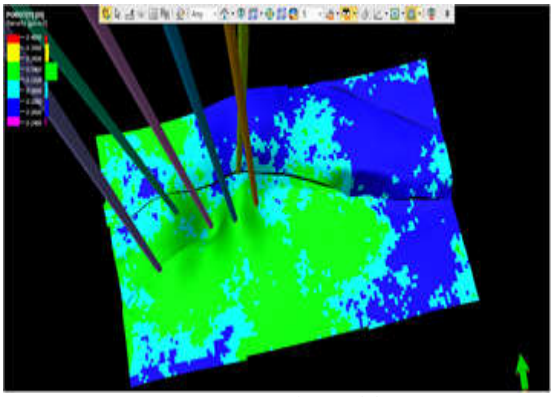

Fig 12: Porosity Model

Examination of the porosity model for the DOVE oil field revealed a Porosity range of 24% to 33% signifying possible hydrocarbon pore volume with an all-round interconnected pore spaces, which allow high reservoir deliverability (figure 12). This result agrees with works of other authors n the Niger Delta such as Asubiojo and Okunuwadje 2016, Saadu and

Nwankwo 2018, Kafisanwo *et al* 2018, Nwaezeapu *et al* 2019, and Orji *et al* 2019.

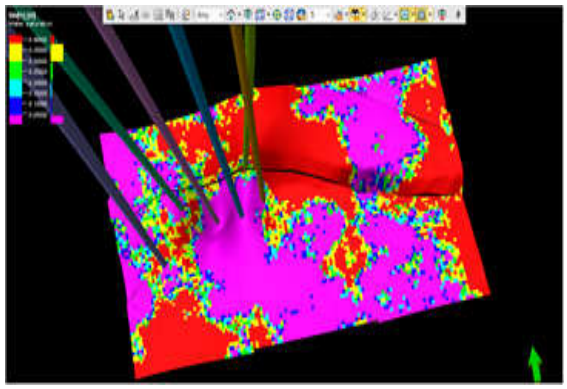

Fig 13: Water Saturation Model

Water saturation for the DOVE field was evaluated to run between 26% to 37% (figure 13). Regions with water saturation above 35% were viewed as Aquifer. See the legend for the water saturation distribution within the reservoir. As observed, at locations north-west, south-west and south-east, water saturations approaching 100 percent are experienced in this way making it infeasible for the hydrocarbon production. Works of other authors in the Niger Delta such as Asubiojo and Okunuwadje 2016, Saadu and Nwankwo 2018, Horsfall *et al* 2018 and Nwaezeapu *et al* 2019, agrees with findings of this study.

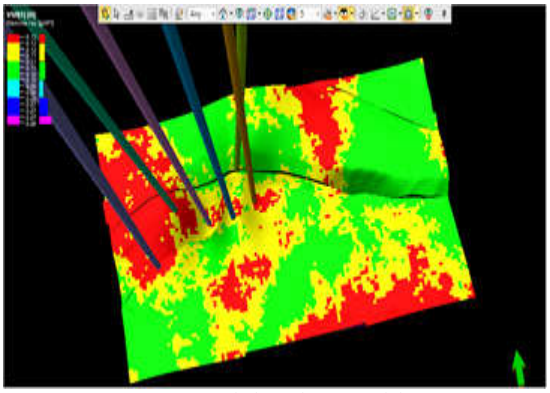

Fig 14: Shale Volume Model

Shale volume for the DOVE field ranged from 10% to 40%, indicating a fairly good productive zone with shaly sand distribution. This result is in agreement with results of Oluwatoyin 2016 and Horsfall *et al* 2018 who carried out similar studies in the Niger Delta area.

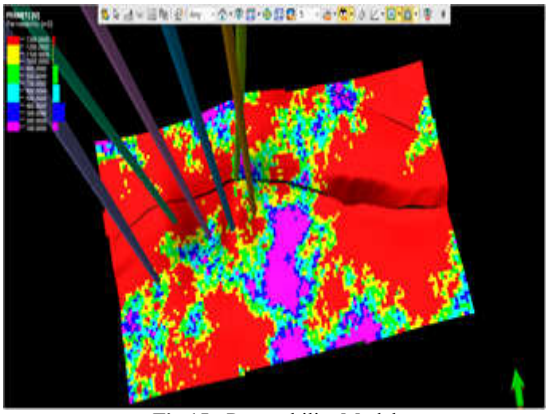

Fig 15: Permeability Model

Examination of the permeability model ranged from 600mD to 1600mD, with high permeability ranges of 800mD to 1200mD at the north-east section of the wells. This result agrees with the findings of other authors in the Niger Delta such as Oluwatoyin 2016, Saadu and Nwankwo 2018, and Orji *et al* 2019.

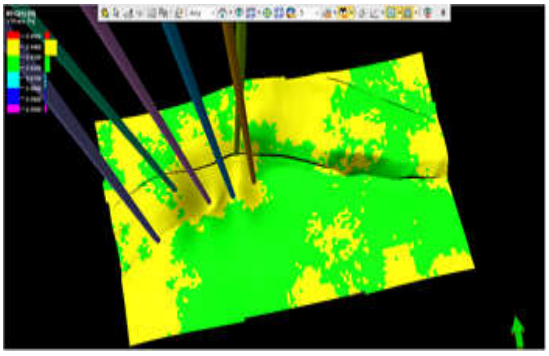

Fig 16: Net-to-Gross Model

High reservoir deliverability is anticipated within the producing zone of the Dove field considering its hydrocarbon pore volume as seen from the comparison of the Net-to-gross range of 55% to 85%, with the shale portion. This result agrees with works of other author's n the Niger Delta such as Asubiojo and Okunuwadje 2016, Falebita and Olusanya 2017, Horsfall *et al* 2018, Kafisanwo *et al* 2018 and Nwaezeapu *et al* 2019.

Table 2: Summary of Petrophysical Properties of the DOVE Field

S/N	Property	Values
1	Permeability	600mD -1600mD
2	Porosity	24 % - 33 %
3	Water saturation	26 % - 37 %
4	Net-to-Gross	55 % - 85 %
5	Shale Volume	10 % - 40 %

Conclusion: Petrophysical examination result demonstrated that the DOVE field has normal porosity, porousness, shale volume, water immersion and net-to-net separately are: 28%, 800mD, 13%, 32% and 85%, which are typical of the Niger Delta and can serve as a basis for decision making in the Dove field.

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