International Journal of Scientific Research and Engineering Development-– Volume 5 Issue 4, July-August 2022

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Use of Isosurface Models for Delineating Source Kitchens

Selegha ABRAKASA

Geology Department, University of Port Harcourt, Port Harcourt.

Centre for Petroleum Geoscience, University of Port Harcourt, Port Harcourt.

World Bank Centre for Oil Field Chemical Research, University of Port Harcourt. Port Harcourt.

selegha.abrakasa@uniport.edu.ng

Abstract

Source kitchens exist in the subsurface and most cases need to be visualized as an efficientmethod for derisking exploration, hydrogen index which expresses the generated hydrocarbon in the kerogen is the parameter of interest. In this study, hypothetic hydrogen index (S_2) data was used for modeling, since the objective is to delineate source kitchens within the field of interest which is the Gabo Oil field in the Niger Delta Basin. The isosurface (subsurface) models indicated that the source kitchen for the suite of wells used in the study is located to the East close to GB Well 15 and 16.The study also unravel that progressive (increasing) maturation trends from the West to the East of the oil field and that the South and West of the field are less mature than the North and the East for the suite of wells used in this study. Contoured location map and 3D statistics map based on hydrogen index values were also generated.

Keywords: Source rock, Hydrogen Index, Source kitchen, Maturation model,

1.0. INTRODUCTION.

Source rocks are mostly shales that have abundant organic matter in the matrix and can generate hydrocarbon (petroleum), source rocks are identified by high TOC and good enough hydrogen index, however, the hydrogen index is the best parameter for identification of source kitchen, the hydrogen index represents the amount of hydrocarbon (petroleum) that can be generated per gram TOC or rock of the source rock or represents the hydrocarbon generating potential remaining in the sediment's kerogen(Dembicki, 2017).

However, within a volume or an area mass of a source rock there is a pod of active source rock, which is always within the geographic extent of a petroleum system, this is so, because the source rock is an essential element of the petroleum system, which expresses the link between the oil generated and its source rock and the reservoir, where the generated petroleum accumulates. The geographic extent of a petroleum system entails the pod of active source rock and all oil and gas seeps, shows and accumulations emanating and originating from the pod of active source rock. An example is figure 1, the geographic extent of the Dear–Boar petroleum system.

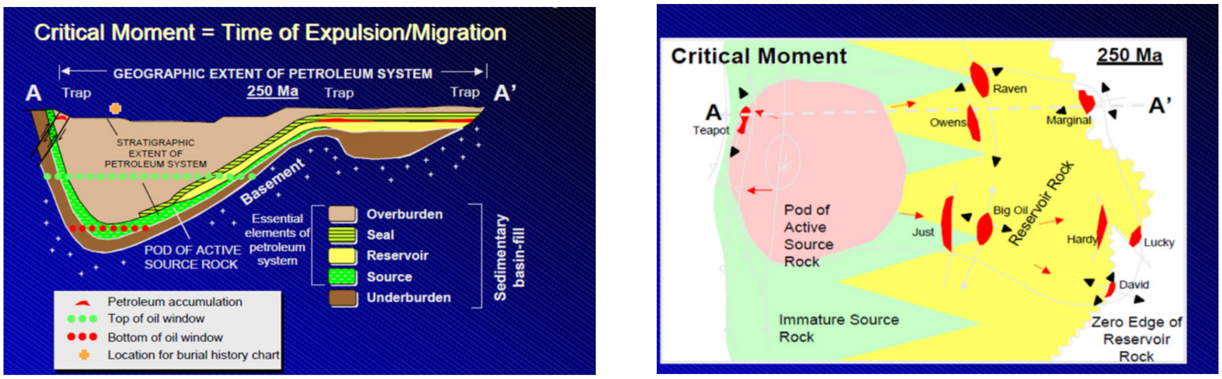

Figure 1. The geographic extent of the petroleum system showing the pod of active source rock and accumulations.

The source rock consists of the pod which is or where the kitchen is located, implying where hydrocarbon is being generated. The active parameter which can identify the kitchen is the hydrogen index, and the source rock is normally present in the subsurface at about 1km to 2km deep below the surface, thus resolving the concern on how to view the distribution of the hydrogen index in the subsurface can easily provide the forum on which the pod of active source rock or the kitchen can be identified and located within the source rock area.

Previously, the study on identification and location of the source kitchen of producing source rock had been based on geochemical mapping on the surface with TOC or hydrogen index contours such as in figure 2, high TOCs corresponds to high hydrogen index areas.This study provides a much more detailed subsurface view of the variation.

Based on the aforementioned, the concept of Isosurface or subsurface modeling is being proposed, and this is the objective of this study.

In this study, the subsurface models of part of the Gabo field (GPS locations) are being generated using hypothetic hydrogen index data, which is a i-data (interval data) (RockWare, 2017), to identify and locate the hypothetic pod of active source rock and the direction of progressive maturation trend indicated by increasing trend of hydrogen index. The Gabo oil field is in the Western part of the Niger Delta basin.

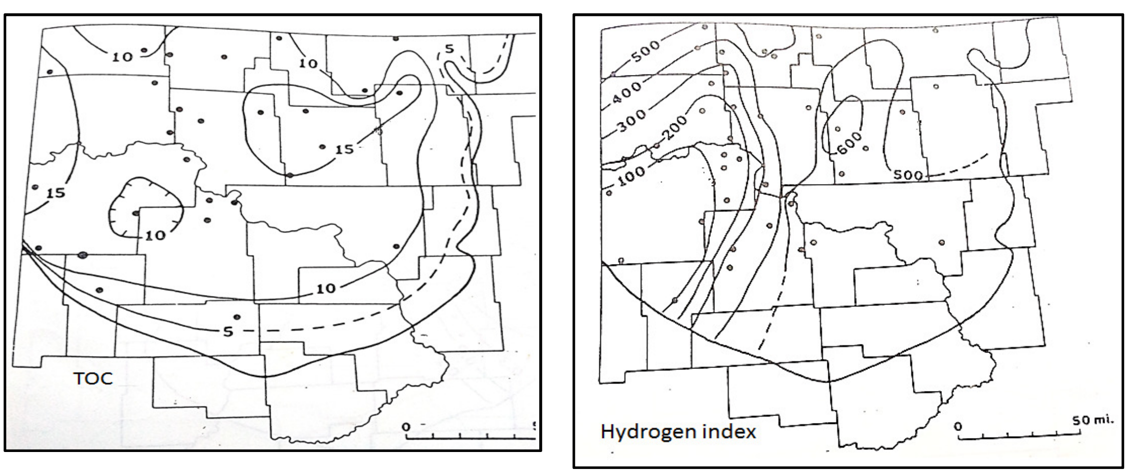

Figure 2. Geochemical map of TOC and Hydrogen index of Bakken Shale in Williston Basin (Aplin, 2004)

2.0. GEOLOGY OF THE NIGER DELTA BASIN.

The Niger Delta basin is located within latitude 3º North to 6º North and longitude 5º East to 8º East(Reijers , et al., 1997), it is a beehive of petroleum exploration and production. The Niger Delta basin exists and was deposited as mega sequences between intervals of 5Ma, these mega sequences were laterally linked into depobelts(Reijers, 2011). Stratigraphically, the Niger Delta basin has three stratigraphic units which are called Formations with different descriptive lithology. The most shallow stratigraphic layer is the Benin Formation, which is consist of mainly sand and standstones, this is underlain by the Agbada Formation with an intercalation of sandstones and shales while the deepest is the Akata Formation which is made up of mainly marine shales(Short & Stauble, 1967)
The Gabo oil field is in the Western part of the Niger Delta basin as shown in figure 3.

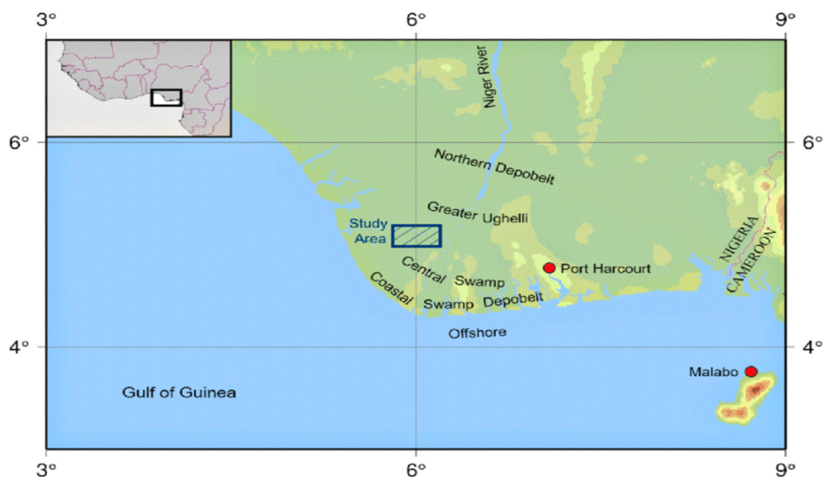

Figure 3. the Location of Gabo Oil field(Agbasi , et al., 2021)

3.0. MATERIALS AND METHOD

The materials entail drill cuttings obtained from different boreholes (wells) at regular intervals representing mature source rock region. These samples are subjected to Rock Eval analysis for TOC and hydrogen Index values, however the hydrogen index values used were hypothetic data. Software used is RockWares's Rockworks version 2017(RockWare, 2017).
The method entails the use of inverse distance weight method which basically involves the use of the eight closest control points to interpolate values for each voxel or building blocks. The model that will be generated depicts the subsurface variation of the hydrogen index values and represents the maturity variation and direction of increasing maturation which is represented by the direction of increasing hydrogen index (HI).

4.0. RESULTS AND DISCUSSION

Table 1 showing the GPS locations of selected wells and the HI for various depths (M) in Gabo Oil Field

Wells	Easting	Northing	Elevation	HI at 2100M	HI at 2400M	HI at 2600M
GB12	577816.87	237461.03	12	65	74	180
GB13	579016.69	235963.94	12	30	70	200
GB14	579869.14	238301.8	12	31	130	170
GB15	581648.49	240236.02	12	30	40	180
GB16	581644.19	240231.35	12	79	83	76
GB19	579381.09	243721.51	12	54	150	180
GB21	578129.27	238815.65	12	30	50	250
GB51	578284.15	238816.23	12	32	74	200
GB52	578327.55	238808.29	12	30	60	250
GB88	580204.98	238078.92	12	60	150	200

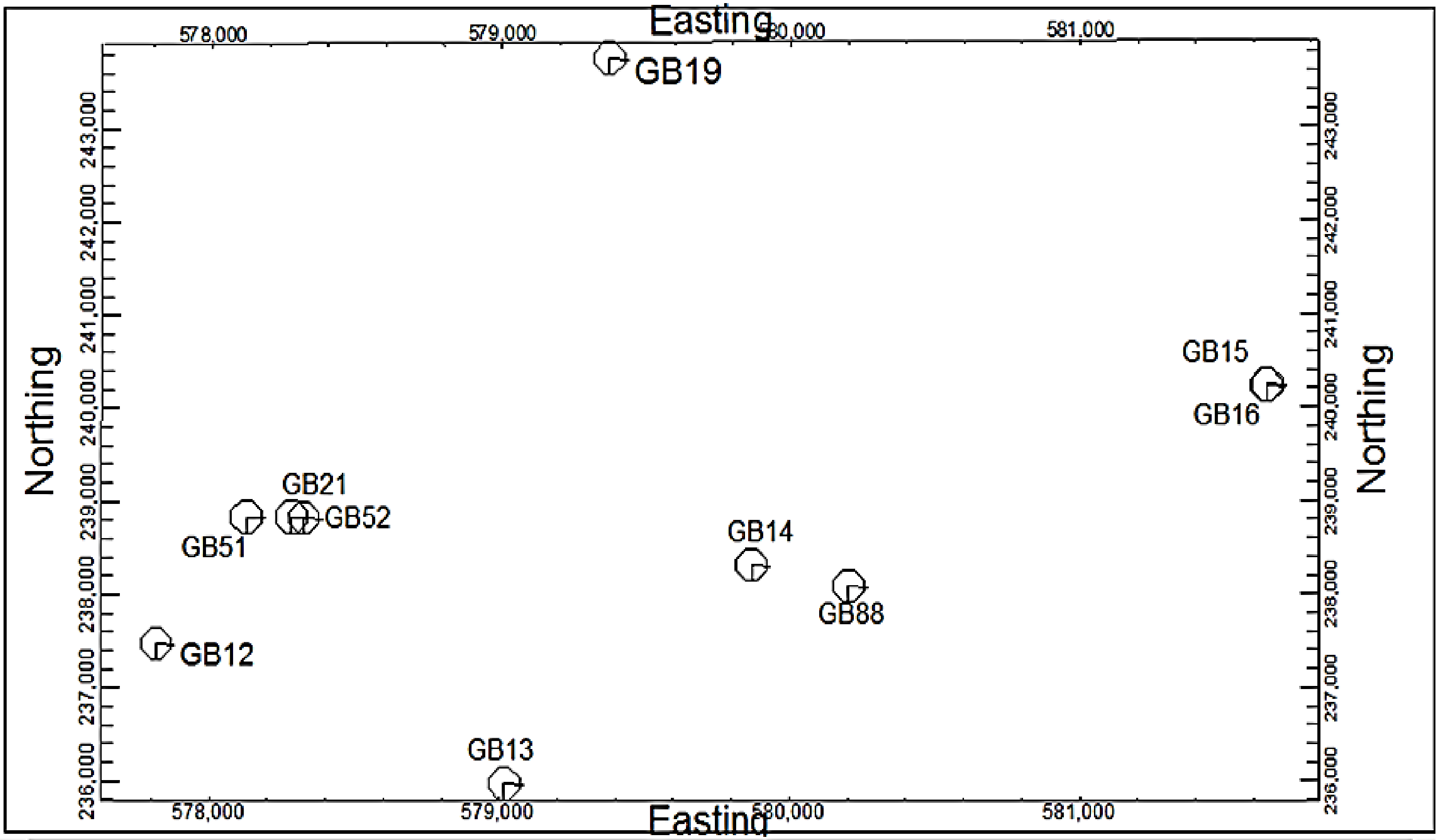

Figure 4. the Location Map of the Wells in Gabo Oil field based on GPS Data.

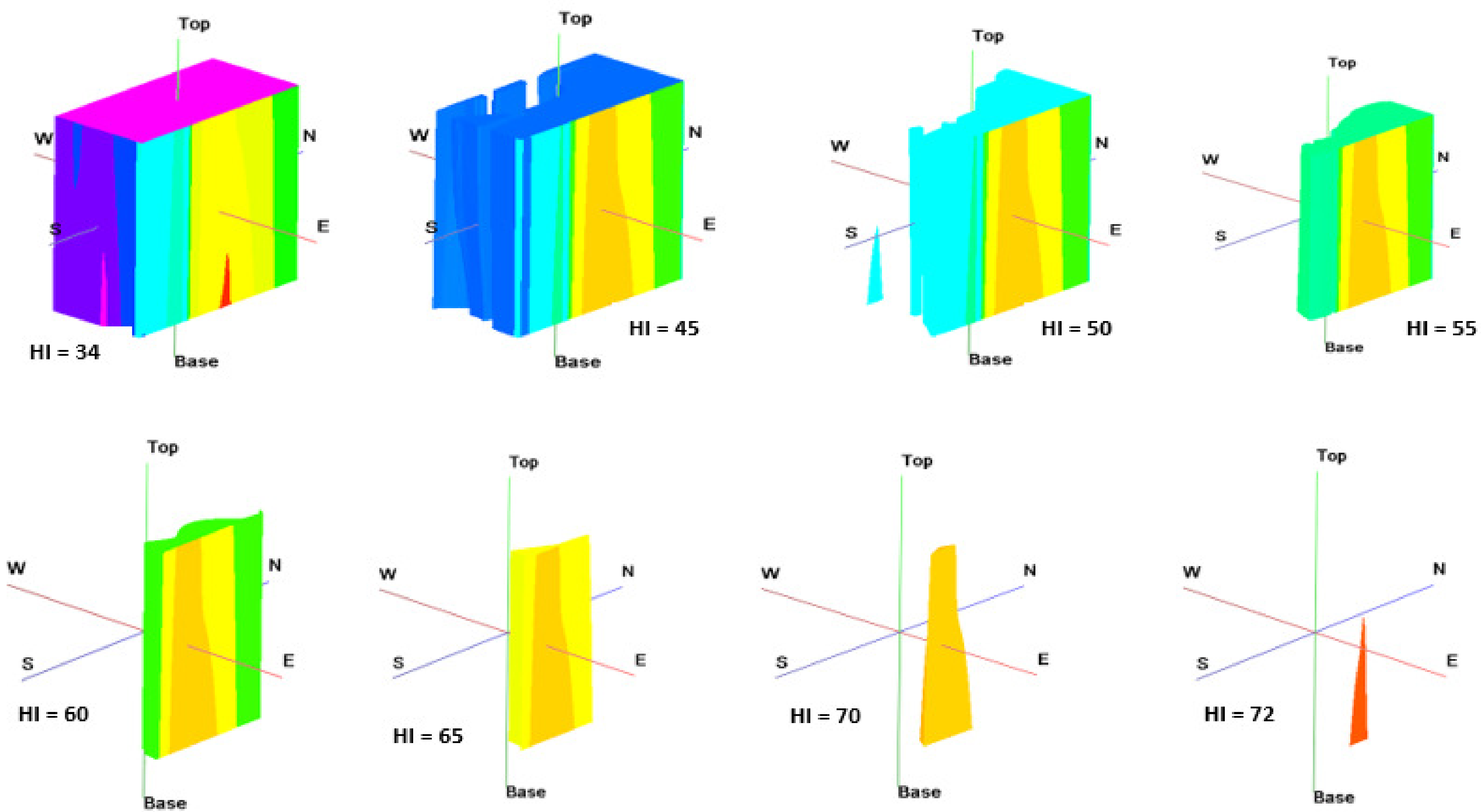

Figure 5. Models showing variation of HI in the Field, the Oil kitchen is in the East of the Field.

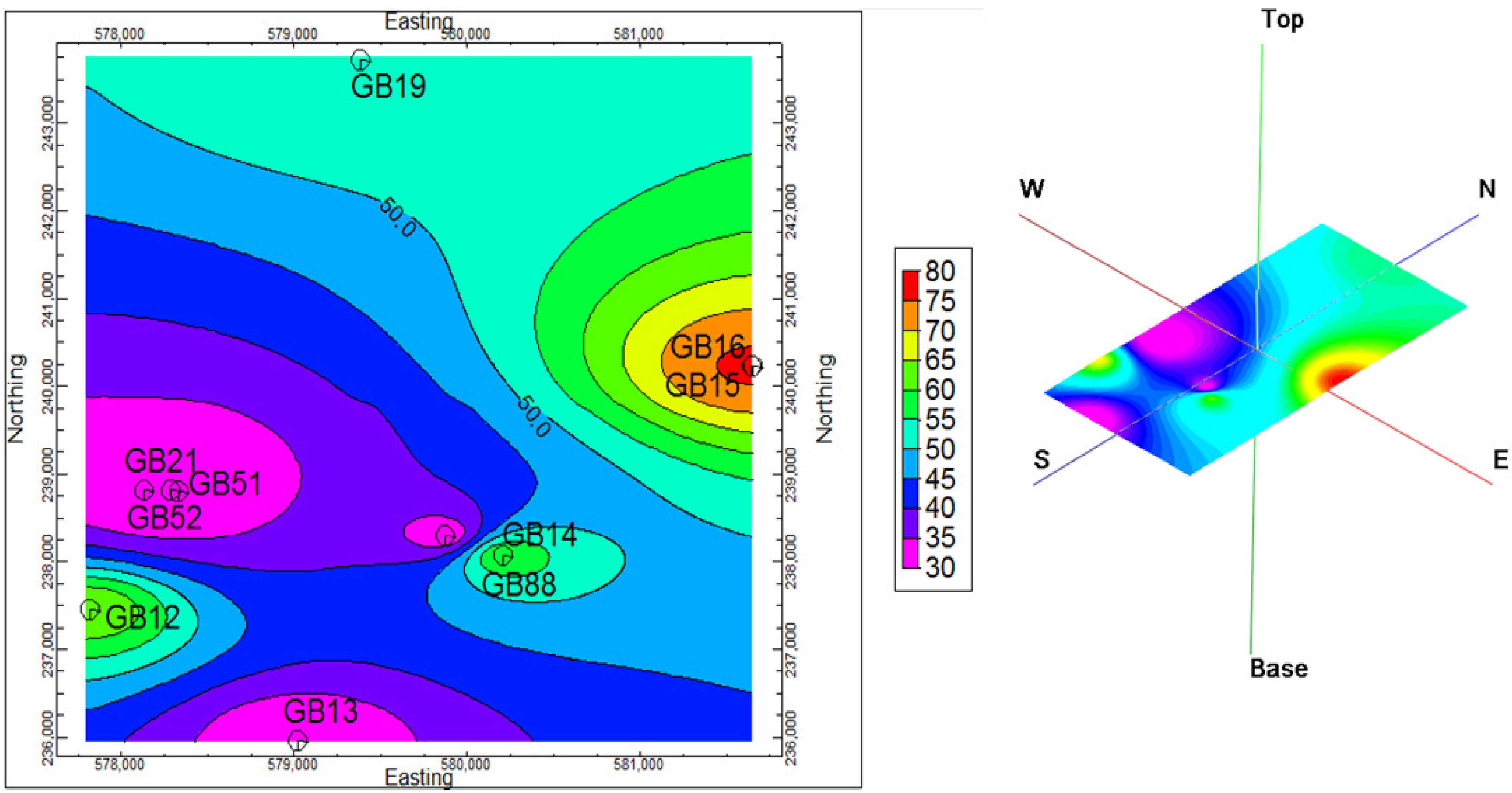

Figure 6. Contoured Location map and 3D statistics map based on lower range of hydrogen index values

Table 1 shows the GPS (Global Positional System) coordinates and the hydrogen index value of the samples for the corresponding wells and depths. These data are the i–data (interval data) which are based on depth intervals(RockWare, 2017).

4.1 LOCATION MAP

Figure 4 is the location map; it portrays the location of the various wells relative to each other with reference to the GPS data. The location maps(figures 4 and 6) can also be used to identify the wells nearest to the source kitchen and direction of progressive increase in hydrogen index (HI), which indicates the maturation trend.(Galushkin, 2016)

4.2 SUBSURFACE MODELS

Figure 5 consists of the various models generated using various threshold valuesof hydrogen index values, each of the model bears an HI value (threshold value), the value implies that the model represents area/volume that have higher HI values relative to the value it bears. The models show that the HI decreases from the East to the West, implying that maturity trend decrease to the west of the field. This also implies that the oil kitchen (most mature area of the field) is in the East of the field. It is also observed that the more mature portion of the source rock occurs at a deeper depth in the East of the field.(Galushkin, 2016)

The knowledge of the maturity trend and position of the oil kitchen (pod of active source rock) will suggest the direction of progressive maturation;thus, some area will be source rock while others will be potential source rock.It should be recalled that source rocks are volume of rock that has generated or is generating and expelling hydrocarbons in sufficient quantities to form commercial oil and gas accumulations. The contained sedimentary organic matter must meet minimum criteria of organic richness, kerogen-type and organic maturity(Brooks & Fleet, 1987). While potential source rock is that volume of rock that has the capacity to generate hydrocarbons in sufficient quantities to form commercial oil and gas accumulations but has not yet reached the state of minimum hydrocarbon generation because of insufficient organic maturation(Brooks & Fleet, 1987),(Hantschel & Kauerauf, 2009).

Source rock maturation is driven majorlyby temperature and pressure and type of organic matter, generally deeper series are subjected to higher pressures and temperature, studies have also shown that the maturation of organic matter which are embedded into the matrix of source rock could bepreferentially influenced by dykes, this partly explains why oil kitchen occurs the way they do. The part of source rock with organic matter which is preferentially influenced into maturation then becomes the source kitchen. This could happen due to the presence of dikes, faults, and fractures which could serve as conduits for transfer of heat to provide the necessary activation energy to trigger and foster the process of maturation and generation of petroleum (hydrocarbon)(Pepper & Corvit, 1995).

The source rock may commence generation of oil earlier due to the required lesser activation energy such as by Type IIS organic matter, which is richer in sulphur and have both carbon–carbon linkages/bonds

and sulphur–carbon linkages/bonds, the sulphur–carbon linkages/bonds are weaker than the carbon–carbon linkages/bonds, thus will commence generation of petroleum earlier(Pepper & Corvit, 1995).
These phenomena explain the existence of the oil kitchen. The direction of progressive maturation of the source rock can be delineated following the direction of increasing hydrogen index which is collectively indicated by the models.

In this study, the models indicated that the source kitchen is to the East close to Wells GB15 and 16, as infigure 6 and the progressive decrease in hydrogen index is to the West of the Oil Field as indicated by the suite of Wells used in this study, this invariably indicates, that increasing maturation is progressively occurring from the West to the East of the Gabo Oil Field as indicated by the suite of Wells used in this study. Though, these data may not necessarily influence/determine the occurrence of oil accumulations, but it provides a knowledge of the dynamics of source rock maturation and hydrocarbon generation. The accumulation of hydrocarbon very much depends on availability of migratory conduits and porous media for storage space.

5.0 CONCLUSION

In this study subsurface (isosurface) models were generated to portray the subsurface distribution of oil kitchen, based on hydrogen index values.
This method is hereby presented as a best practice method for viewing the subsurface dynamics of maturation process and location of source kitchen in relation to the maturation direction.
The use of GPS data gives appropriate locations of model objectives and interest.

6.0 REFERENCES

Brooks, J. & Fleet, A. J., 1987. *Marine Petroleum Source Rocks,The Geological Society.*. Oxford, London.: Blackwell Scientific Publications.

Agbasi , O. E., Sen , S., Inyang, N. J. & Etuk, S. E., 2021. Assessment of pore pressure, wellbore failure and reservoir stability in the Gabo field, Niger Delta, Nigeria - Implications for drilling and reservoir management. *Journal of African Earth Sciences,* p. 1–4.

Aplin, A. C., 2004. *Reservoir and Migration Geochemistry Lecture Notes,* Newcastle: Newcastle University.

Dembicki, H., 2017. *Practical Petroleum Geochemistry for Exploration and Production.* 1st ed. Amsterdam : Elsevier Inc.

Galushkin, Y., 2016. *Non-standard Problems in Basin Modelling.* 1st ed. Switzerland: Springer International Publishing.

Hantschel , T. & Kauerauf, A. I., 2009. *Fundamentals of Basin and Petroleum Systems Modeling.* 1st ed. Berlin, Heidelberg : Springer-Verlag .

Pepper, A. S. & Corvit, P. J., 1995. Simple kinetic models of petroleum formation, Part I: oil and gas generation from kerogen. *Marine and Petroleum Geology,* 12, No. 3, pp. 291-319.

Reijers , T. J., Petters , S. W. & Nwajide, C. S., 1997. The Niger Delta Basin. In: *African basins. Sedimentary Basins of the World.* Amsterdam: Elsevier, p. 145–168..

Reijers, T. J., 2011. Stratigraphy and sedimentology of the Niger Delta. *Geologos,* p. 133–162.

RockWare, I., 2017. *RockWorks Training Manual,* Golden, Colorado.: Rockware Earth Science and GIS Software.

Short , K. C. & Stauble, A. J., 1967. Outline of Geology of Niger Delta. *AAPG,* pp. 761-779.