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# ANALYSIS OF POROSITE-NEUTRON (NPHI) LOGGING DATA FROM THE KINKASI FIELD: THE CASE OF THE G UP, F AND E HORIZONS OF THE CENOMANIAN RESERVOIR (D.R. CONGO COASTAL BASIN)

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## ABSTRACT

Since the discovery of hydrocarbon deposits in the DR Congo Coastal Basin in general, and in the Kinkasi field in particular, several development wells have been drilled with a view to optimising the economic value of the reserves evaluated. Despite the large number of wells drilled in this onshore area of the Coastal Basin and a multitude of development studies, it should be noted that production is stagnating at around 10,000 barrels per day. This report is a considerable contribution to addressing these major concerns. Certainly, with the advancement of technology through the creation of supercomputers and software, these reprocessings can prove important in that they can bring to light certain information that previously went unnoticed. As well as highlighting the importance of modelling the petrophysical parameters of a reservoir in the development of an oil field, this subject provides assistance to the Production Engineer, insofar as it makes it possible to visualise, from the desktop with some software such as Microsoft Excel 2010 for the calculation of certain data with a view to representing them in the form of tables and graphs, the Geographic Information System (ArcGis 10.3) for representing the study area and drawing up maps of the spatial distribution of porosity-neutron horizons, areas of interest that could be the subject of in-depth studies ((location of new wells).

**Keywords:** Cenomanian reservoir, saturation, petrophysics, porosity, permeability

## INTRODUCTION

Bringing a hydrocarbon deposit into production requires a certain number of wells to be drilled, which requires 80% of the investment of the necessary funds. Decisions about the number of wells to be drilled and their location in relation to the various parts of the field are therefore very important. The aim is to drill wells capable of effectively draining all parts of the reservoir [1]. The studies leading to these decisions are based on a number of parameters, including the petrophysical properties of a reservoir, which do not appear as such at the bottom of the scale. Moreover, as these parameters vary in time and space, they are subject to evaluation or re-evaluation wherever possible. The Cenomanian reservoir of the Kinkasi Field abounds in good neutron porosity in the G, F and E horizons, which can contain a large volume of oil in place. To do this, we process the neutron porosity log data with the aim of restricting the zones abounding in good values of this porosity; make a qualitative interpretation of the logs from the wells under study; deduce the petrophysical characteristics (neutron porosity); locate the zones containing good values of neutron porosity [8].

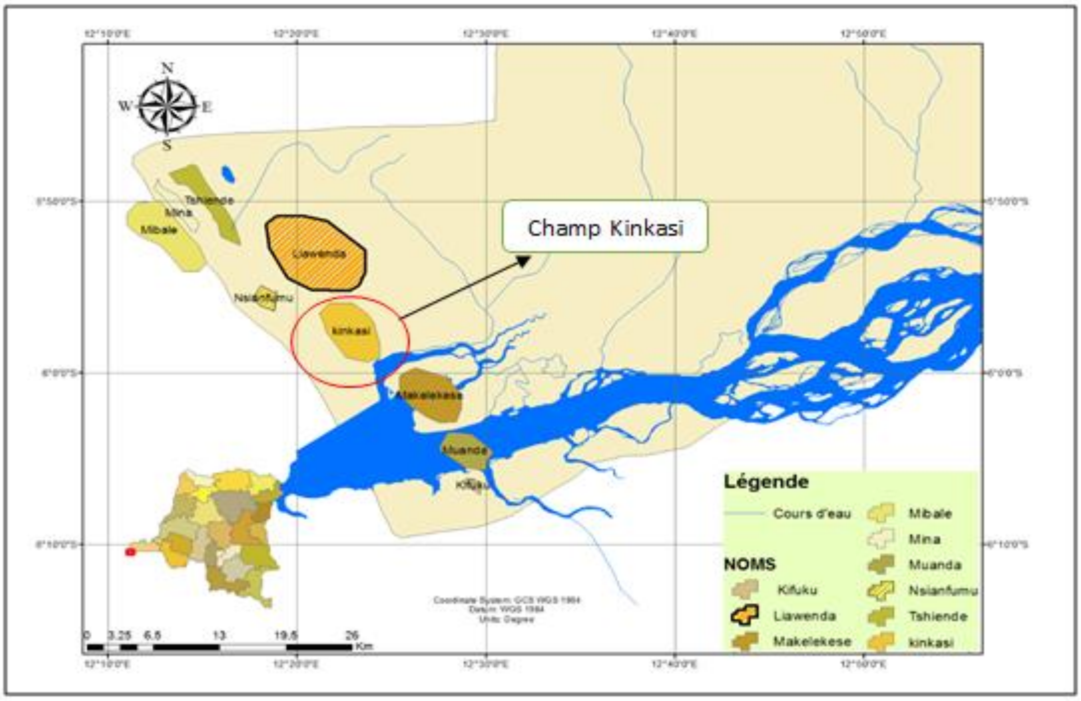


***Figure 1***. *Location of the Kinkasi field in the Coastal Basin of the DR Congo.*

Initially, field development focused on the upper layers of the Cenomanian (G to K). Only a few immersion wells produced oil in the lower layers C,D and E via wells KK-01, KK-04, KK-05, KK-07, KK-10, KK-11 and KK-17. In 2006, additional perforations in the E layer at wells KK-44 and KK-45 produced good results, and the potential for the lower layers (A, B, C and D) has been confirmed. Following these encouraging results, 9 additional wells targeting the lower layers were drilled in 2007. As of March 2009, 17.80 million barrels had been produced from the Cenomanian reservoir, mainly in the upper layers, with an estimated STOIIP (1P) of 245 million barrels, giving a current recovery factor of 7.2%. The 2P developed for the field is estimated at 5.9 million barrels and leads to a final recovery rate estimated at around 9.7% with existing wells only [2]. Structurally, the Cenomanian reservoir is a post-salt anticlinal structure-oriented NW-SE. It is a stratified reservoir with an average gross thickness of 150 m. Uncertainty about the structure is low, due to the large number of wells drilled. Faults are present in the southern part of the reservoir. They are visible on the seismic lines and propagate into the Vermelha [3]. It is important to note that production is restricted to around 10,000 barrels per day [4]. This drafting makes a significant contribution to these important concerns. Certainly, thanks to the evolution of technology through the creation of supercomputers and software, these reprocessings can be significant insofar as it is possible to bring to light certain information that was previously overlooked. In addition to the need to model the petrophysical parameters of a reservoir in the development of an oil field, this subject helps the Production Engineer, as it allows these parameters to be visualised from the office.

## MATERIALS AND METHODS

To achieve the objectives set for this work, we used Microsoft Excel 2010 software to calculate certain data and represent them in the form of tables and graphs, and the Geographic Information System (ArcGis 10.3) to represent the study area and draw up maps of the spatial distribution of porosity-neutron horizons.

To carry out this work, we used the method of collecting data from Perenco-Rep, reading publications, works and books relating to our study, and consulting the various reports on the development of the Kinkasi field. This analytical method enabled us to analyse critically the various items of information collected in works, articles and other documents relating to our subject, consulted in local libraries and on websites.

## RESULTS AND DISCUSSION

The Kinkasi formation is an excellent oil reservoir. It consists of vacuolated bioclastic limestones and banks of carbonate cement siltstones (Figure 2). This formation also contains banks of sandstone with calcareous cement, which are also reservoirs.

A gas/oil contact can be defined at around 1052 m (- 1010.5 m), while the oil/water contact has been placed at 1145 m (- 1003.5 m). The gas is located in the K sequence. Oil permeates the J, I, H and G sequences.

The thickness of the Kinkasi gas zone is 14 m with a useful power of 4.5 m. The oil permeates a height of 93 m, with an effective power of 46.5 m.

### *Presentation and location of the wells under study*

The wells subject of this study are located in the Kinkasi Field in the Coastal Basin of the Democratic Republic of Congo. These wells are therefore producers and have the geographical coordinates shown in Table 1. [2],[6],[17]

Figure 3 shows a map locating the wells under study in the Kinkasi Field in the DR Congo Coastal Basin. [16],[27],[28]

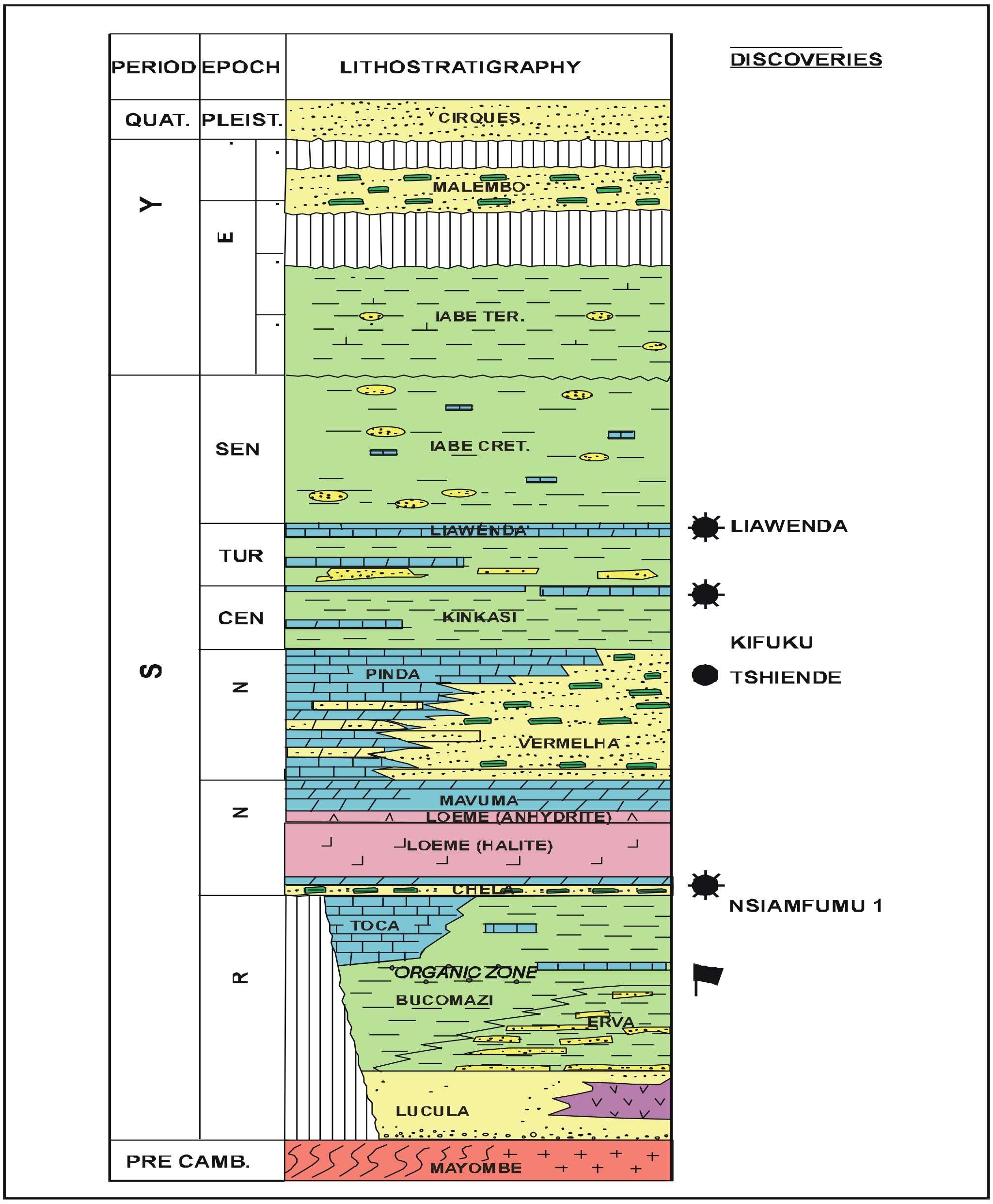


***Figure 2*** *Stratigraphic log of the Coastal Basin of DR Congo*

***Table 1.*** *Geographical coordinates of the various wells*

| Wells | Longitude (m) | Latitude (m) |
|---|---|---|
| KK02 | 205319,5 | 9351792 |
| KK03 | 206656,2 | 9348965,6 |
| KK04 | 204604,8 | 9351184,8 |
| KK05 | 206542,7 | 9349741,9 |
| KK18 | 204103,9 | 9350793,9 |
| KK30 | 203794,9 | 9352074,1 |
| KK17 | 202471,8 | 9352075,8 |

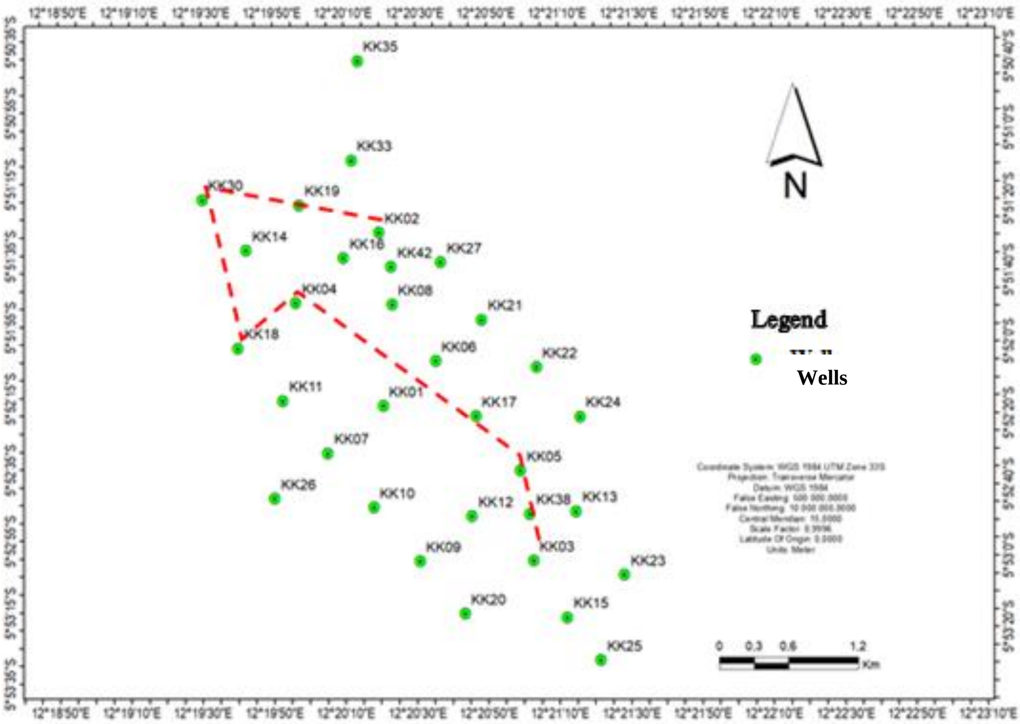


***Figure 3****.Map showing the location of our wells under study in the Kinkasi field (red line connects the wells under study)*

## *Presentation of log diagraphs*

In analysing the porosity-neutron log data, we studied only the porosity-neutron log, as it allows us to deduce one of the important petrophysical properties of the reservoir, namely: porosity. Figure 4 shows the log for the wells under study [4],[5],[7],[8],[9]

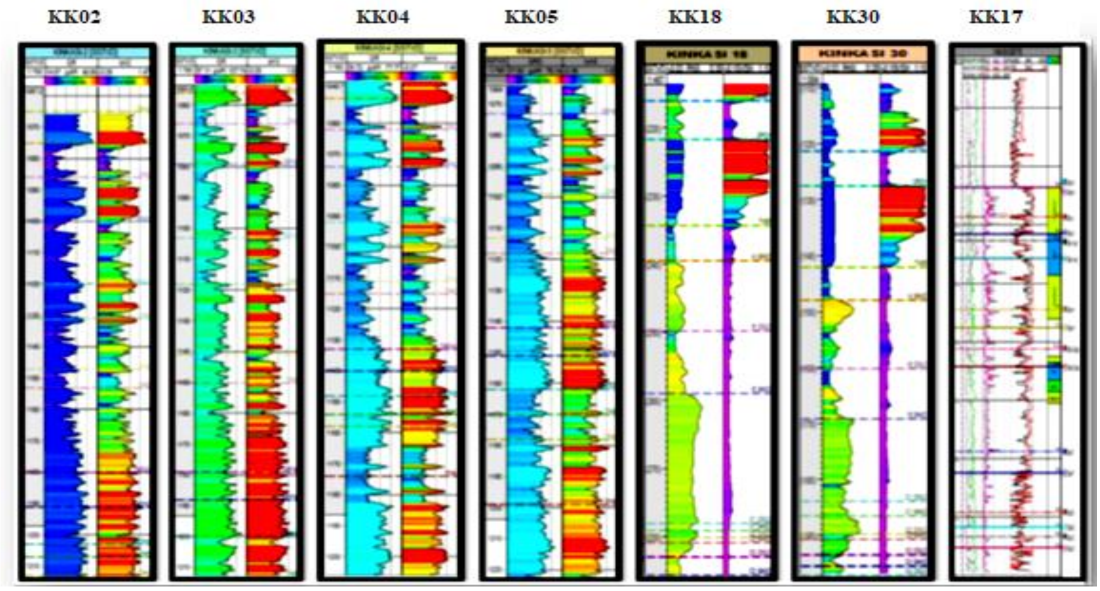


***Figure.3*** *Presentation of log data from the various wells*

### *Vertical and lateral evolution of average porosity*

- ***Horizon Top G***

The porosity data, derived from the interpretation of the Neutron porosity digraph in our 7 wells in the Kinkasi Field, indicate the following values by following its vertical-spatial evolution:

✓ Well KK-02 has a high Neutron porosity value of 27%;

✓ Low porosity is found in well KK04, with a value of 17.33%;

Based on the porosity scale, only two wells have porosities above 20% (very good porosity). These are wells KK-02 and KK-05. The remaining 5 wells have porosities in the good range of the porosity scale. This allows us to estimate that the porosity in the 7 wells producing from the Gup horizon varies from good to very good. Figure 4 shows an image locating all the average porosity values in each well of the Gup horizon [10], [11], [23].

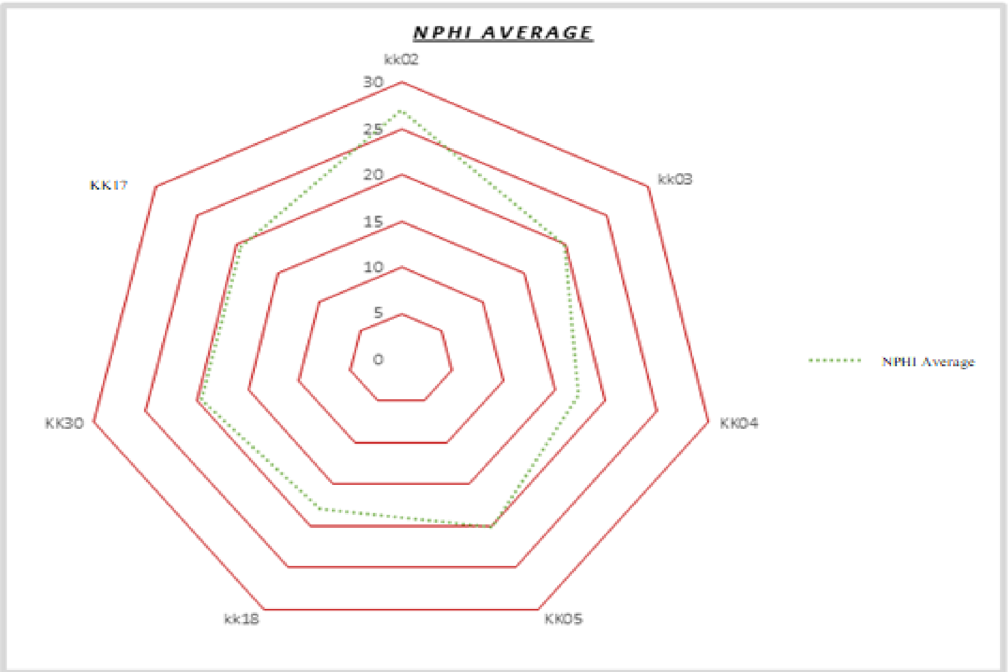


***Figure 4.*** *Average porosity trends in 7 wells producing from the Gup horizon of the Cenomanian reservoir of the Kinkasi Field.*

- ***Horizon Top F***

A vertical-spatial characterisation of the porosity data for the Top F horizon reveals the following results: 5 wells are in the very good porosity range, with porosities greater than 20%. These are wells KK-02, KK-03, KK-04, KK-18 and KK-30; one well (KK-05) is in the good porosity range.

Figure 5 below shows the change in average porosity for the 7 wells considered.

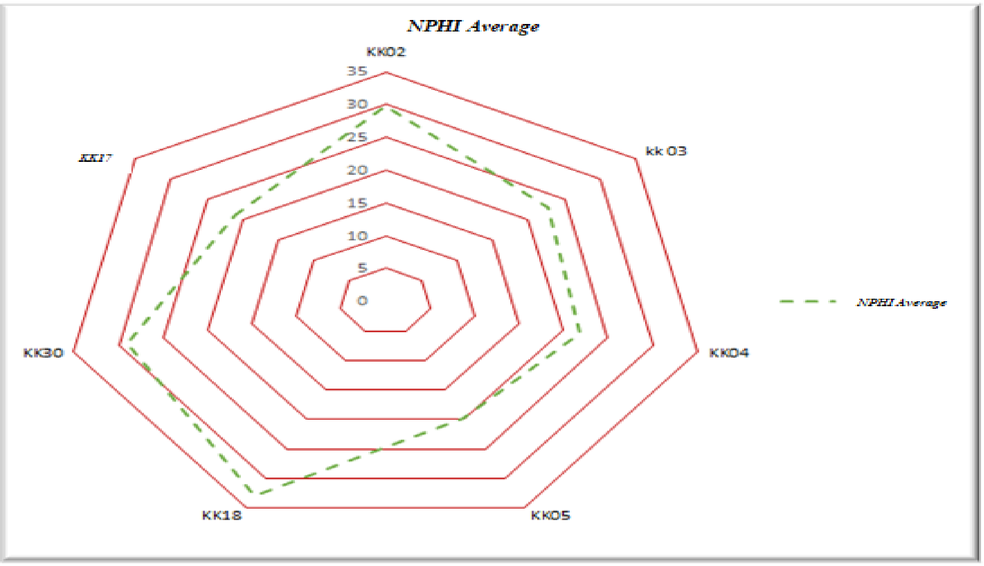


***Figure 5.*** *Evolution of average porosity in 7 wells producing from the Top F horizon of the Cenomanian reservoir of the Kinkasi Field.*

### ➢ *Horizon Top E*

If we look at Figure 6, which shows the change in average porosity from the delayed neutron porosity log in the Top E horizon, we can see that 4 wells have very good porosities, including KK-03, KK-18, KK-30 and KK-17, and 3 wells with porosities of less than 20% (KK-02, KK-04 and KK-05) are in the good porosity range (Figure 6).

The interpreted Neutron logging data from the 7 wells studied and the resulting findings are summarised in Table 2 below, and summarised in Figure 7. [12],[24],[25]

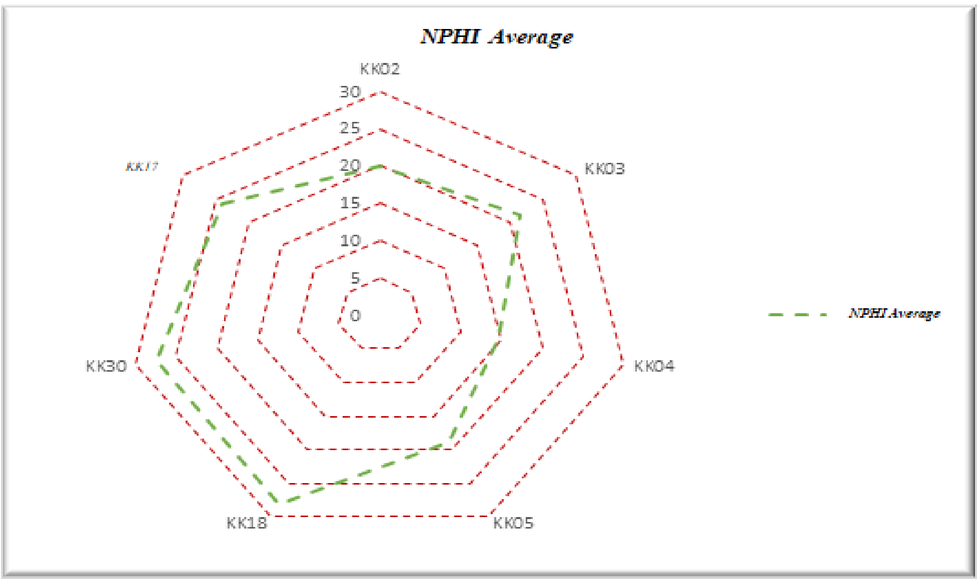


***Figure 6.*** *Average porosity trends in 7 wells producing from the Top E horizon of the Cenomanian reservoir of the Kinkasi Field*

***Table2.*** *Logging data for the 7 wells producing from the Top G, Top F and Top E horizons of the Cenomanian reservoir in the Kinkasi field.* [13],[14]

| ***Wells*** | ***Horizons of the Cenomanian reservoir*** | ***NPHI Average (%)*** | ***Findings on porosity*** |
|---|---|---|---|
| *KK02* | *TOP G* | *27* | *Very good* |
| | *TOP F* | *29,73* | *Very good* |
| | *TOP E* | *19,91* | *Good* |
| *KK03* | *TOP G* | *20* | *Good* |
| | *TOP F* | *22,79* | *Very good* |
| | *TOP E* | *21,48* | *Very good* |
| *KK04* | *TOP G* | *17,33* | *Good* |
| | *TOP F* | *21,77* | *Very good* |
| | *TOP E* | *14,47* | *Good* |
| *KK05* | *TOP G* | *20,172* | *Very good* |
| | *TOP F* | *19,74* | *Good* |
| | *TOP E* | *18,87* | *Good* |
| *KK18* | *TOP G* | *18* | *Good* |
| | *TOP F* | *33* | *Very good* |
| | *TOP E* | *28* | *Very good* |
| *KK30* | *TOP G* | *19,5* | *Good* |
| | *TOP F* | *29* | *Very good* |
| | *TOP E* | *27,5* | *Very good* |
| *KK17* | *TOP G* | *19,55* | *Good* |
| | *TOP F* | *21* | *Very good* |
| | *TOP E* | *24* | *Very good* |

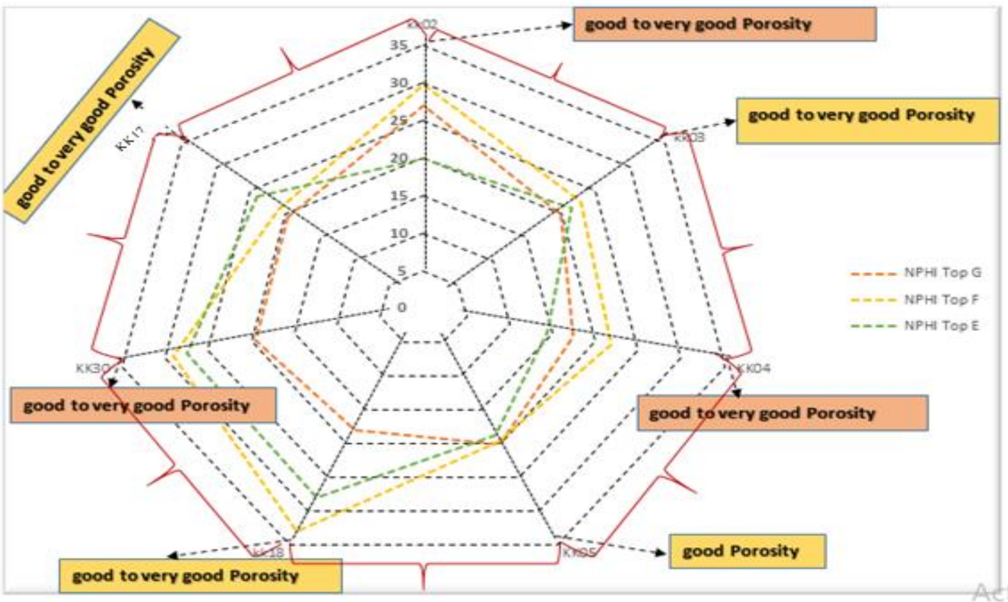


***Figure7.*** *Evolution of average porosity in 7 wells producing from the Top G, Top F and Top E horizons of the Cenomanian reservoir of the Kinkasi Field* [15],[16],[18],[19],[30]

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### *Spatial evolution of porosity data*

- ***In the Gup horizon***

Looking at the map showing the horizontal distribution of porosity in the 7 wells producing from the Gup horizon of the Kinkasi Field, we can see that the north-eastern part has very good porosity [20],[21],[22]. The blue colour on the map indicates the presence of a zone with low porosity values (less than 20%). Figure 8 shows the maps of porosity distributions in the 2D and 3D models of 5 wells producing from the Gup horizon of the Kinkasi Field.

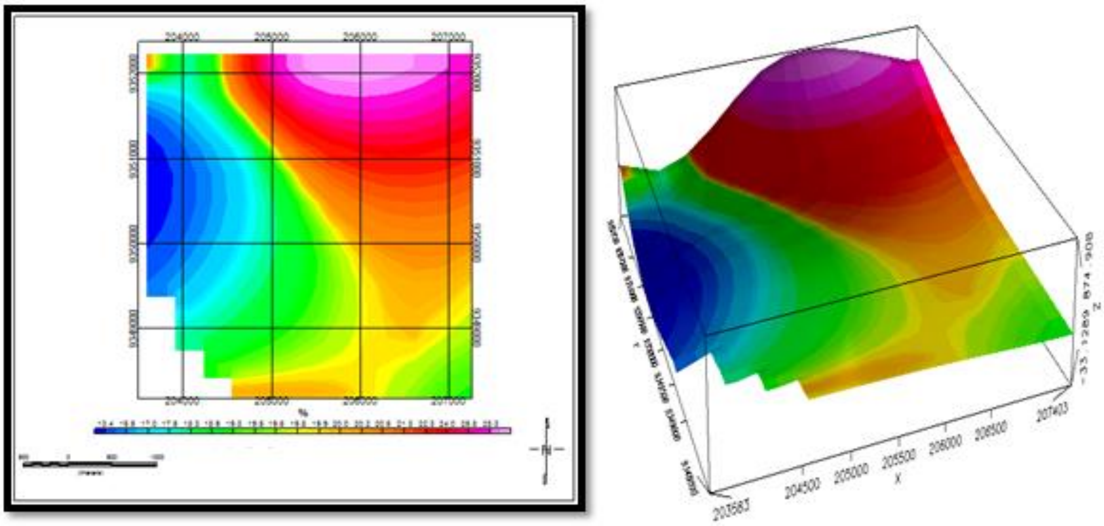


***Figure 8.*** *Spatial evolution of porosity in the 5 wells producing from the Gup horizon of the Kinkasi field*

The maps shown in Figure 9 below isolate the zones of very good and good porosity in the Gup horizon of the Cenomanian reservoir of the Kinkasi Field [26],[27].

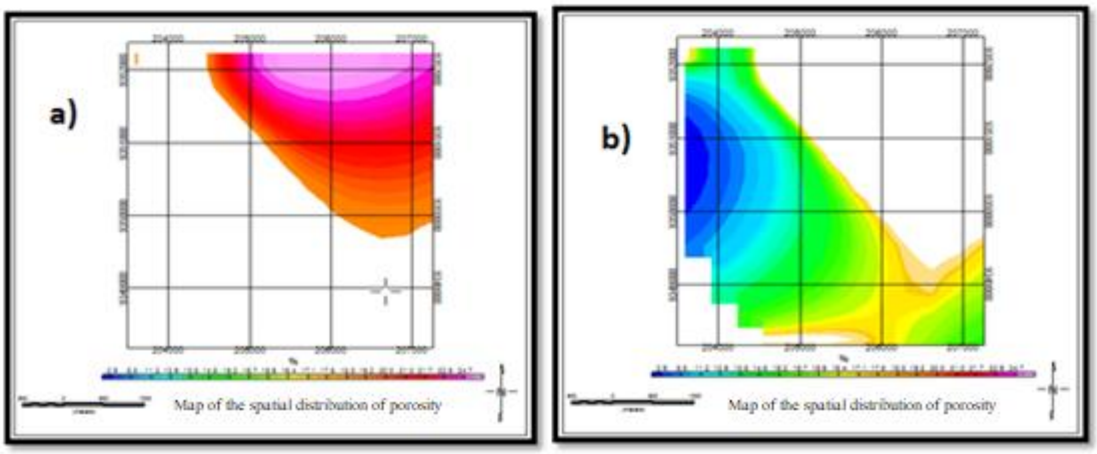


***Figure 9.*** *Location of areas of very good and good porosity in the Gup horizon*
*(a: Area of very good porosity, b: Area of good porosity)*

- ***In the F horizon***

The distribution of porosity data in the F horizon of the Kinkasi Field gives the same results as in the Gup horizon. This distribution shows very good porosity in the north, Followed by good porosity in the western part towards the centre (Figure 10).

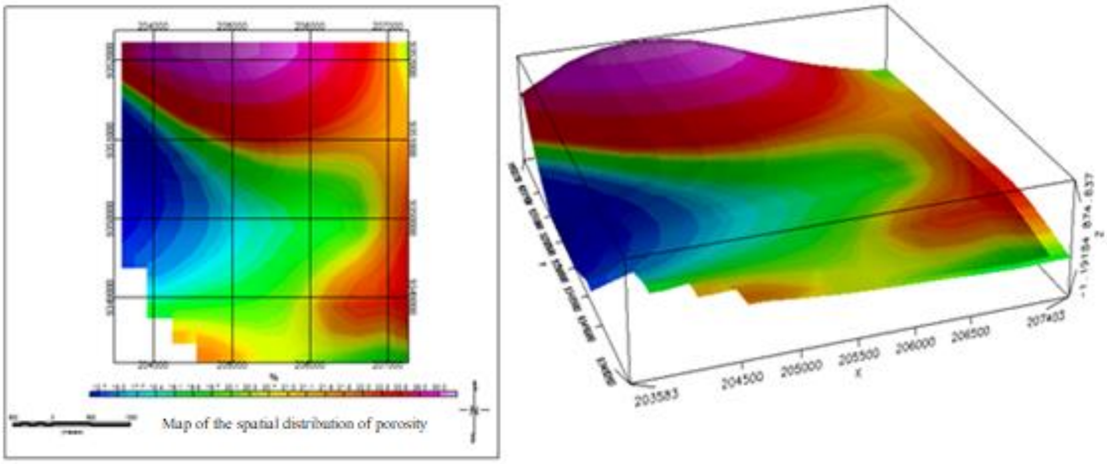


***Figure 10.*** *Spatial evolution of porosity in the 5 wells producing from the F horizon of the Kinkasi Field.*

Referring to the porosity distribution map in the F horizon of the Kinkasi Field, we also identify two main zones: zones with very good porosity, i.e. greater than 20%, and zones with porosity of less than 20% (Figure 11).

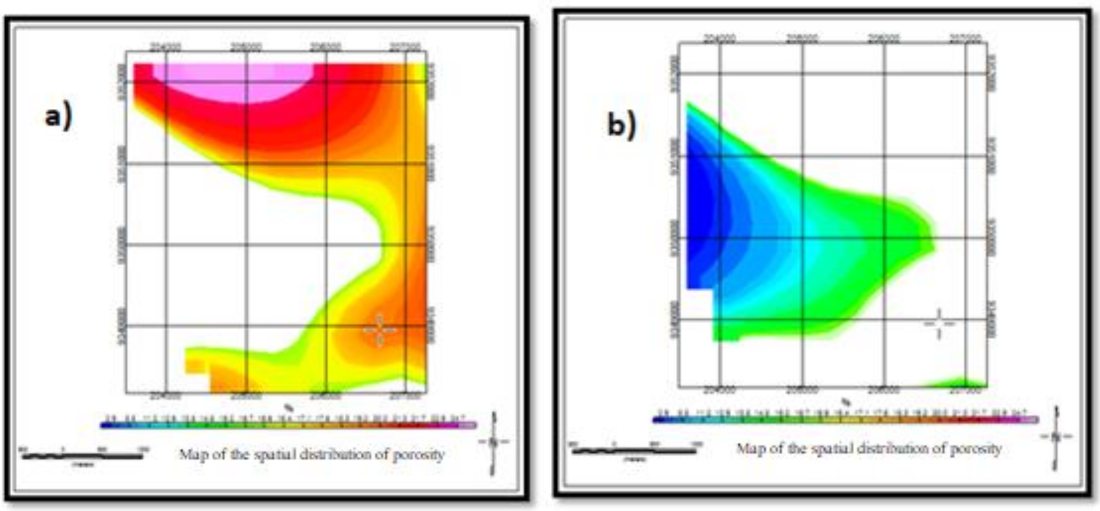


***Figure 11.****Location of areas of very good and good porosity in the F horizon (a: Area of very good porosity, b: Area of good porosity)*

- ***In the E horizon***

The horizontal porosity distribution map shows two large areas with very good porosity. One is located to the NNW and the other to the SE. Figure 12 below shows a 2D and 3D neutron porosity distribution map of the Kinkasi Field [28].

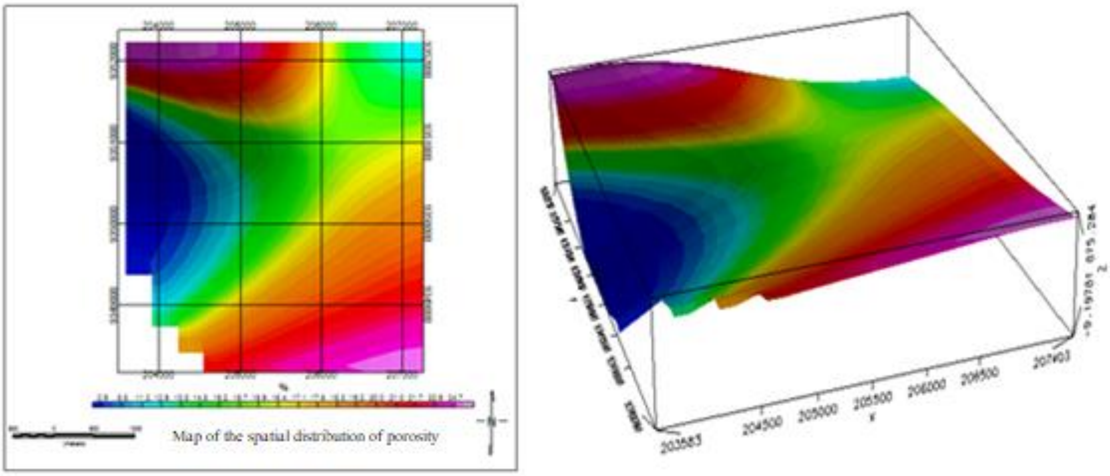


***Figure 12.*** *Porosity map of the three horizons (Gup, F and E )of the Cenomanian reservoir.*

By isolating the horizontal porosity distribution map in the E horizon, the results obtained are presented in figure 13.

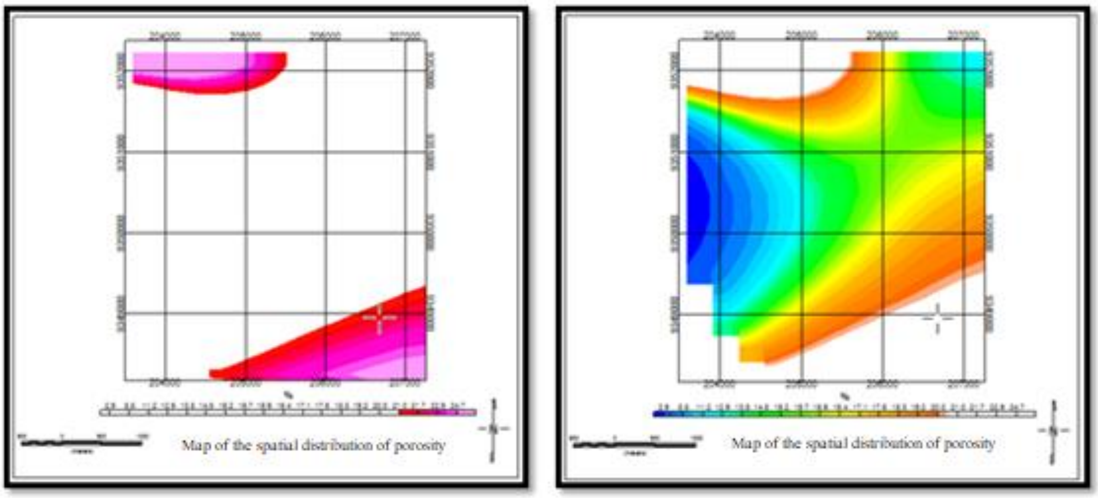


***Figure 13.*** *Location of areas of very good and good porosity*

The map shown in figure 14 superimposes the 3D porosity maps of three horizons (Gup, F and E) of the Cenomanian reservoir of the Kinkasi Field. [29]

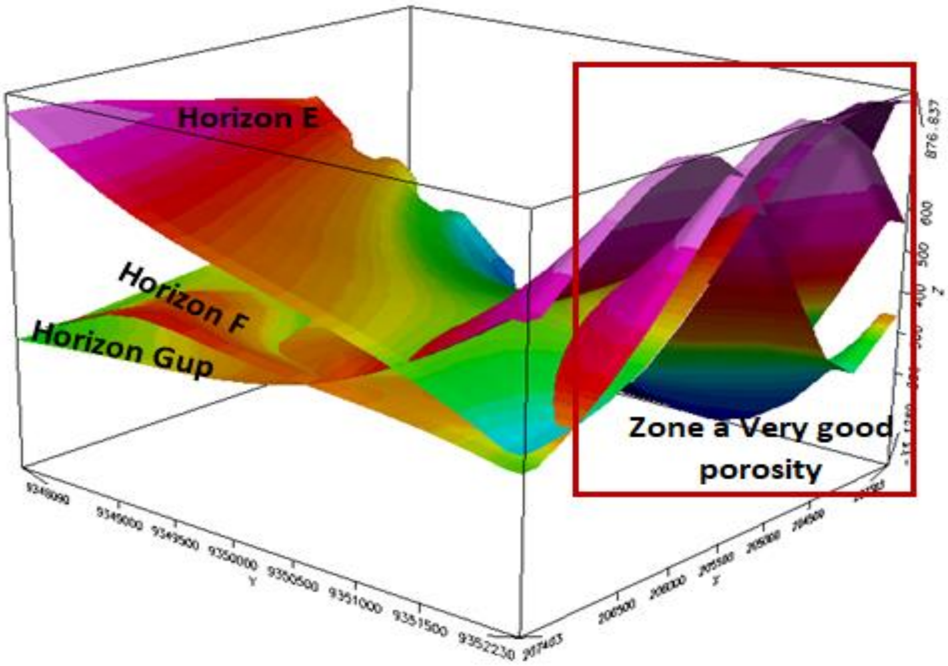


***Figure 14.*** *Superimposes of 3D porosity models of three horizons (Gup, F and E) of the Cenomanian reservoir of the Kinkasi Field.*

## CONCLUSIONS

This study was based on the analysis of porosity-neutron log data from 7 wells producing from the Gup, F and E horizons belonging to the Cenomanian reservoir of the Kinkasi field in the D.R. Congo Coastal Basin).

The main objective of this study was to locate zones with good porosity values, as porosity is one of the important petrophysical properties that must be studied during the development of an oil field, by increasing the number of production wells. To do this, we first interpreted the porosity logs for these 7 wells in order to determine their vertical and spatial evolution; then we drew up horizontal porosity distribution maps to identify the areas with good porosity values.

After these interpretations, the results of our studies on vertical and spatial evolution (Gup Horizon) showed that two wells had porosities greater than 20% (very good porosity): wells KK-02 and KK-05. For the remaining 5 wells, porosity is in the good range of the porosity scale. This allows us to estimate that the porosity in the 7 wells producing from the Gup horizon varies from good to very good. Top F: 5 wells are in the very good porosity range, with porosities greater than 20%: wells KK-02, KK-03, KK-04, KK-18 and KK-30. Only one well (KK-05) is in the good porosity range Horizon Top E: 4 wells have very good porosities, namely: KK-03, KK-18, KK-30 and KK-55, and 3 wells with porosities below 20% (KK-02, KK-04 and KK-05) are thus in the good porosity range.

With regard to the horizontal distribution of porosity (Gup Horizon), it was found that in the north-eastern part of the field, porosity is very good. However, there is a zone with low porosity values (less than 20%). This allows us to characterise it as a zone with good porosity. Horizon F: The very good porosities are located in the North, followed by the good porosities located towards the Western part. Horizon E: The map of the porosities distributed in a horizontal way shows us two large Zones having very good porosities. One is located to the north, heading north-west, and the other to the south-east.

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