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CONTRIBUTION TO THE GEOLOGICAL AND PETROLEUM STUDY OF THE WEST-CONGOLIAN BASIN – CASE OF CARBONATES IN THE KITOBOLA REGION IN CENTRAL CONGO, D.R. CONGO

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ABSTRACT

Previous studies carried out in the West-Congolian basin have highlighted potential formations that could play a major role in a petroleum system. In order to complete and enrich the geological and petroleum dossier of the said basin, a field trip to the Kitobola locality in the province of Central Congo was necessary to sample, analyze and describe the carbonate formations that outcrop there, in order to detect their importance from a petroleum point of view by describing and analyzing their mineralogical characteristics, and geochemical characteristics of these rocks, as well as evaluating their basic petrophysical parameters, notably porosity and permeability, in order to determine the role they might play in a petroleum system. Samples were sent to CRGM laboratories for petrographic, petrophysical and geochemical analyses, which revealed the presence of limestones (mudstones, wackestones and pelmicrite) with low porosity ranging from 1.18 to 1.49% and near-zero permeability between 0.2 and 0.5 mD.

Geochemical analyses revealed a TOC ranging from 0.9 to 1.3 and high proportions of calcium oxide CaO associated with the limestones. As a result, these formations cannot be used as reservoirs, but rather as blankets, given their low porosity and near-zero permeability. On the other hand, they would make excellent source rocks in a petroleum system, given their very satisfactory TOC values. This article provides new information on the intrinsic characteristics (petrographic, petrophysical and geochemical) of the carbonate formations outcropping in the Kitobola region of the West Congolian Basin, while also highlighting potential source rocks or blankets.

Keywords: mudstones, wackestones, pelmicrite, TOC, Kitobola, West-Congolian Basin

INTRODUCTION

Within the framework of oil exploration in the Democratic Republic of Congo, and more specifically in the West-Congolian Basin, a survey of the Kitobola region and surrounding area has been initiated with a view to identifying and evaluating the petroleum interest of certain geological formations outcropping there. However, to date, the DRC has struggled to develop its sedimentary basins (divided into oil blocks) with sufficiently detailed geological, geophysical and geochemical files to attract more companies to the sector.

This study, carried out in the West-Congolian basin, in the Kitobola region to be precise, aims to contribute to this major exploratory challenge facing the country. It will focus primarily on the massive carbonate formations outcropping in the Kitobola region and its immediate surroundings, as these formations have particularly attracted our attention, firstly because of their intrinsic characteristics as determined by previous work, and secondly because of their accessibility, thickness, continuity and macroscopic characteristics (presence of innumerable cavities filled with white calcite and a fetid rotten-egg odour on the samples during sampling).

The West-Congolian Basin is part of the orogenic belt of the West-Congo Supergroup, underlain by Paleoproterozoic Noqui granites dating from 999±7 Ma [1]. It is located to the west of the African plate, where sediment accumulation and tectonic history have been known since the Neoproterozoic [2, 3, 4].

It should be noted that, according to some previous work, interesting oil seeps have been observed around Kimpese (located 29 km south of Kitobola) in a small well drilled in the clay-limestone formations and in another well drilled at Kisantu in the clay-sandstone formations [5]. This demonstrates the probable existence of source rocks that would have generated their hydrocarbons and the latter would have migrated along a network of faults. However, to date, no drilling or in-depth geophysical studies have been carried out in this basin, with a view to shedding more light on the probable existence of a hydrocarbon deposit or a functional petroleum system. The Pan-African orogeny, which exposes the potential geological formations in place [6], is thought to be one of the main reasons why companies have lost interest in this basin, given that the rocks potentially rich in organic matter are found at the surface and not at depth.

However, this basin could contain interesting structural traps, given its tectonic history [2, 7]. However, an important geological aspect to take into account is that certain surface formations are found deep underground in certain regions of the West-Congolian and also in the Cuvette Centrale, when analyzing the lithostratigraphic logs of these two basins. Consequently, the study of Kitobola's geological formations found in the West-Congolian basin would also shed more light on the understanding of this great basin of the Central Cuvette, which has not yet been properly explored.

In the absence of serious government involvement to support scientific research, the Kitobola region has never been the subject of an in-depth study aimed at characterizing in detail all the formations that outcrop there from a petroleum point of view, despite the interest that the geological history and tectonic context of this part of the West-Congolian Basin presents for geoscientists. However, the present study in the Kitobola region will enable this part of the basin, and even more so the scientific community, to acquire a geological dossier focusing on the petrographic, petrophysical and geochemical characterization of the carbonate formations that outcrop there. At the end of this exercise,

we will determine the importance of these carbonate formations from a petroleum point of view by describing and analyzing the mineralogical, chemical and geochemical characteristics of these rocks, as well as evaluating their basic petrophysical parameters, notably their porosity and permeability, in order to determine the role they would play in a petroleum system. It also aims to raise interest in this part of the basin within the scientific community and the government.

Our study area (Figure 1 and Figure 2), Kitobola and its immediate surroundings, are located in the territory of Mbanza-Ngungu, Cataractes district in the Province of Central Congo in the Democratic Republic of Congo, between 14° 29' and 14° 33' East longitude and between 05° 20' and 05° 23' South Latitude.

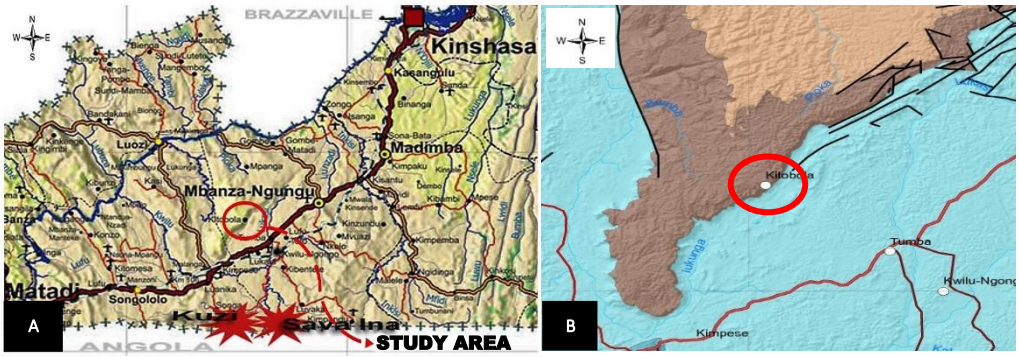

***Figure 1**. Location map of the West-Congolian (A) basin and study area (B)* [8]

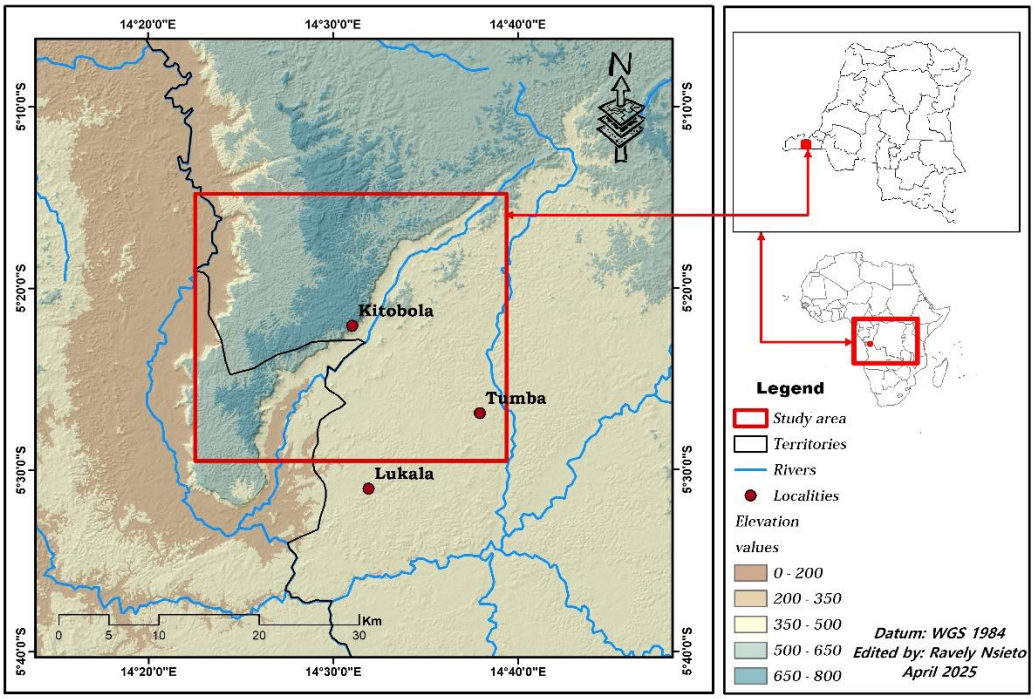

***Figure 2**. Study area location map* [9]

The lithostratigraphy of the West-Congolian ((Figure 3) evolved between 910 and 566Ma in the Neoproterozoïque and identified in the Cataract Group [1]. From bottom to top, this group comprises the following subgroups: Sansikwa; Lower Diamictite; Upper Shiloango; Upper Diamictite; Lukala Subgroup; Mpioka Subgroup. The study area is located in the Lukala subgroup, ± 1000m thick and composed of four clusters [10]. Outcropping rocks include pink to grey dolomites, schistose fasciated limestones, oolitic limestones, psammites, sandstones and shales. The soil in this area is tropical, clayey, chemically poor with a high *p*H [11, 12].

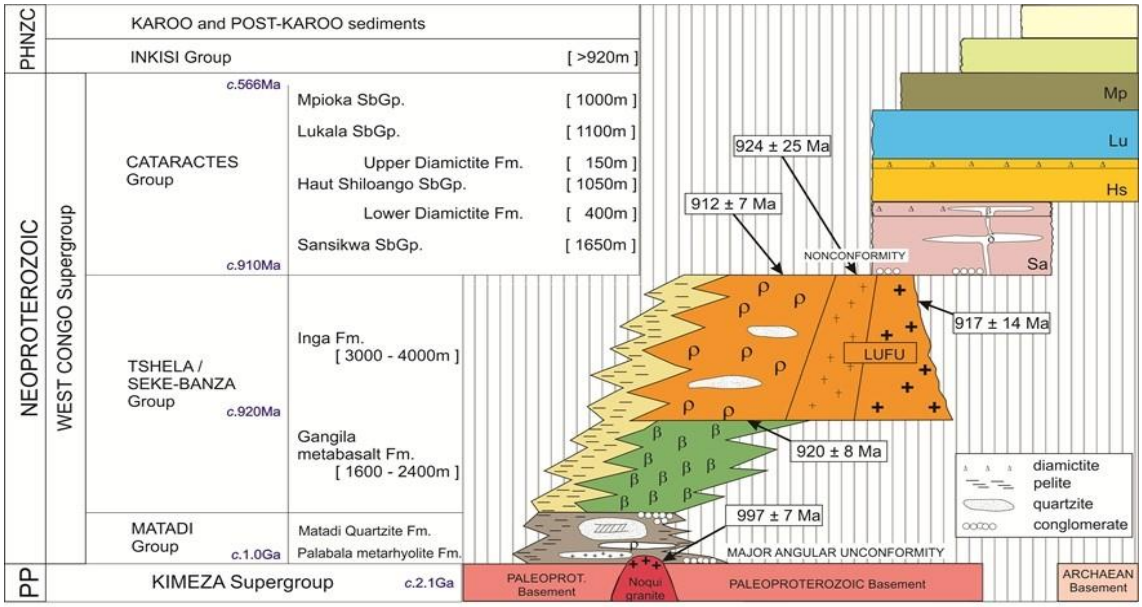

***Figure 3**. Lithostratigraphic log of the West-Congolian* [1]

Various research projects have been carried out in this sedimentary basin, but the one that caught our attention the most was the one carried out in Kitobola, where the author discussed the formation of the Bangu-Niari Conglomerate on the Bangu massif. After sampling and analysis as part of his research work, he was able to draw up a lithostratigraphic log of the region (Table 1), covering all the formations outcropping in and around Kitobola. We can also see our carbonate formations studied at the base of the lithostratigraphic log (Ngandu and Bangu formations belonging to the Lukala subgroup).

MATERIALS AND METHODS

Materials

The basic equipment (Figure 4) that enabled us to carry out a geological survey in the study area consisted of: geological compass (1), GPS (2), geological hammer (3), geological map of Central Congo (4), topographical map of the study area (5), 5 kg sledgehammer (6), digital camera (not shown in image), bottle of 10% dilute hydrochloric acid (8), syringe (9), black markers (10), plastic bags for packing samples (not shown in image), pen (14), notepad (13) and a machete (12) to clear a path through the bush.

Table 1. *Lithostratgraphic units outcropping at Kitobola* [13].

Lithostratigraphic units	Thickness	Lithofacies
Mpioka bass formation	50 m	Alternating benches of red or purple shale and gray or purple sandstone
Formation of the Bangu-Niari conglomerate	±15m	Alternating red and green shale benches with gravel and chippy brecciated benches.
		Benches of conglomerates with boulders, pebbles, gravels, chippings, rounded to subrounded, subangular to angular and rare lenses of sandstone and shale.
Ngandu formation	10 m	Calcareous-clay-sandstone rock, brownish to greenish in color.
Bangu formation		Alternating limestones in small, massive benches and others in flat platelets

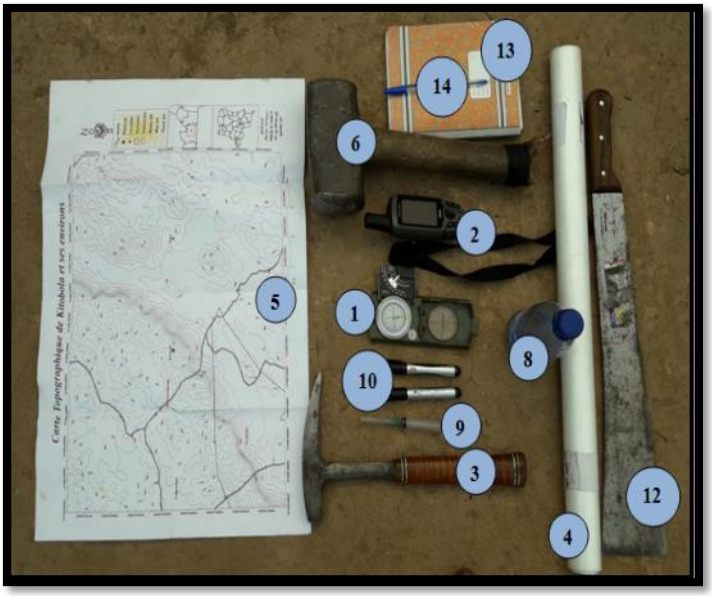

Figure 4*. Equipment used during the geological survey*

Methods

As required by scientific practice, we first reviewed the literature relating to our West-Congolian basin and our study area, then planned our field trip. Once in the field, we took and macroscopically described our rock samples (most of which were light grey in color and had a foul odour), described the relative outcrops and the geological context in which they were found (Figure 5).

On our return, we sent our samples to the laboratories of the Centre de Recherches Géologiques et Minières (CRGM) for petrographic (to determine, using a polarized or natural light petrographic microscope, the minerals present, the texture and structure relationships existing between the elements making up each sample, to determine its nature and to name it), petrophysical (to determine the porosity and permeability relative to each sample) and geochemical analysis (to determine the Total Organic Carbon and the proportions of the elements in each sample).

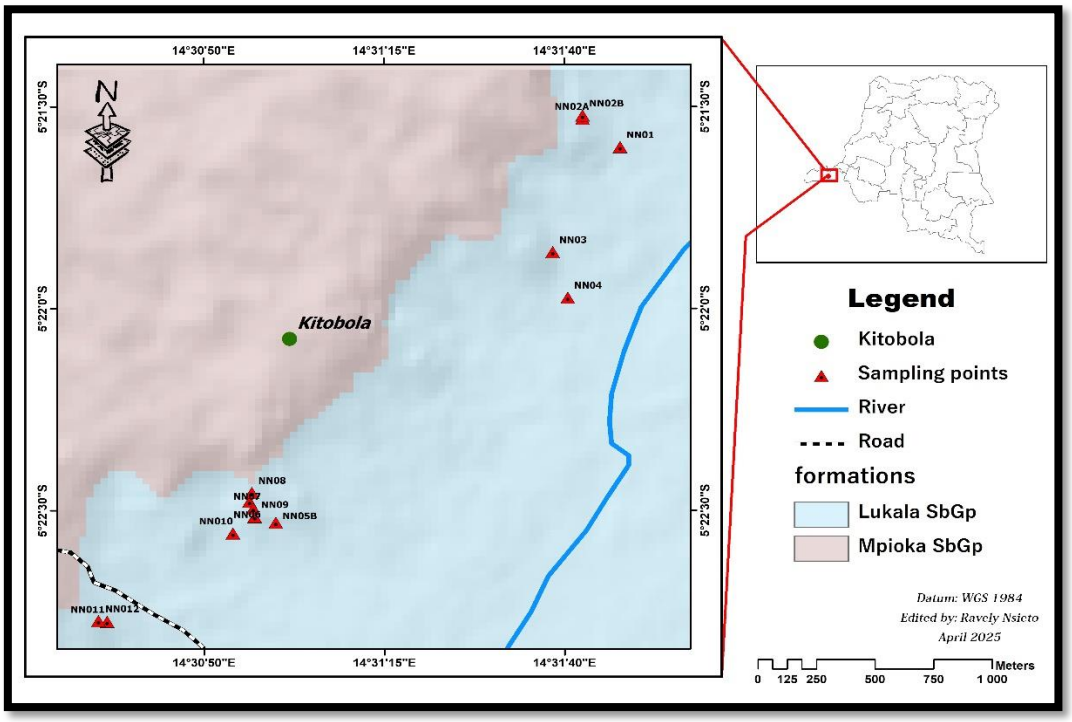

***Figure 5**. Sampling map* [14]

RESULTS AND DISCUSSIONS

The information and results obtained from the petrographic, petrophysical and geochemical analyses carried out in the laboratories of the geological and mining research center (CRGM) are as follows:

Petrographic analysis

We now turn to a petrographic description of the samples, starting with a macroscopic description in the field, followed by a microscopic description in the laboratory.

- Sample NN02A (Figure 6)

The rock is hard, massive and compact, with remarkable veins of white minerals (sample NN02A); it is gray in color, has a conchoidal fracture and is highly effervescent in contact with 10% hydrochloric acid. N 20ºNE and 13ºNW (direction and dip).

***Figure 6**. Limestone sample (A), limestone outcrop (B)*

The sample contains sparitic calcite veins and pellets, bathed in a carbonate mud (Figure 7). The overall crystal size ranges from less than 10µm to several micrometers, justified by the presence of micrite (1 to 4µm) and sparite (>50µm). The sample contains less than 10% figured elements (grains) in a high proportion of carbonate mud (microcrystalline calcite), with local cavities and quartz crystals. The rock is a ***Mudstone***.

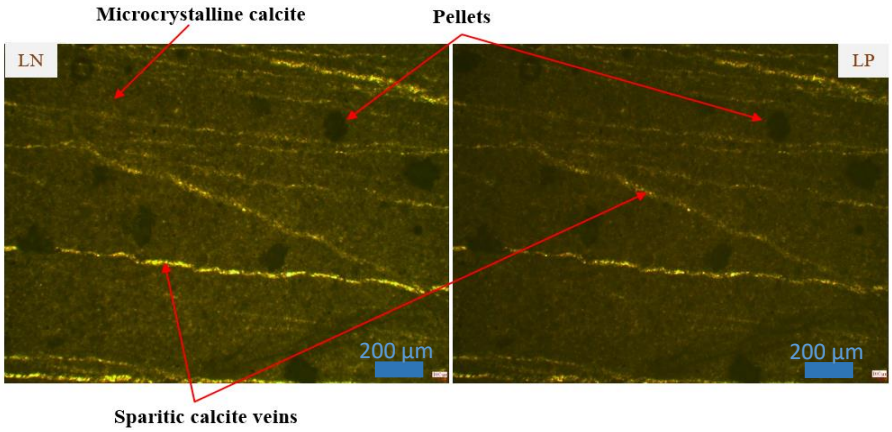

***Figure 7**. Microscopic observation of the NNO2A slide under natural (LN) and polarized (LP) light (100x)*

- Sample NN02B (Figure 8)

The rock is hard and coherent, with alternating strata (sample NN02B) and micro-holes. The presence of white mineral veins is also remarkable. It is dark gray in color, has a plate-like fracture and is highly effervescent in contact with 10% hydrochloric acid. N19ºNE and 16ºNW (direction and dip).

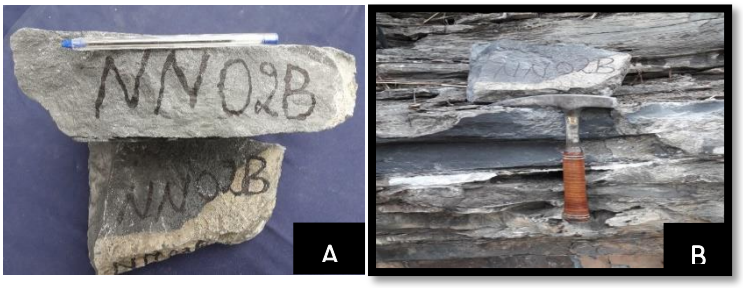

***Figure 8**. Limestone sample (A), limestone outcrop (B)*

The sample contains isolated large calcite crystals, crystalline calcite (sparite) and microcrystalline calcite. The overall size of the crystals is quite variable, ranging from less than 10µm to over 50µm. These large calcite crystals are subangular in shape. Micrite (during diagenesis) recrystallizes with an increase in crystal size, giving rise to a microsparite matrix. Native non-carbonate components: quartz, plagioclase. Epiclasts range in shape from subrounded to subangular (Figure 9: LN). The sample contains more than 10% of non-joining grains in a microsparite matrix. The rock is a ***Wackestone***.

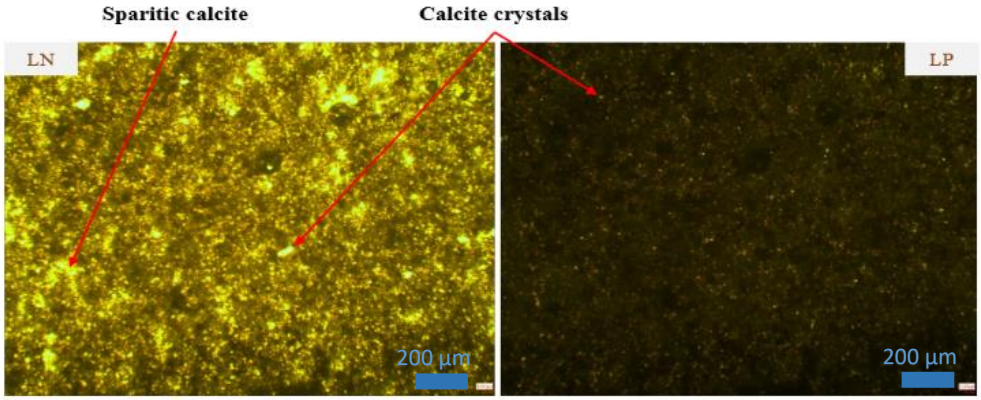

Figure 9. *Microscopic observation of the NNO2B slide under natural (LN) and polarized (LP) light (100x)*

- Sample NN04 (Figure 10)

The rock is hard, coherent and shows clearly visible and distinct strata with bedding (Sample NN04). It also contains quartz minerals that are shiny and visible to the naked eye; its color is whitish, its fracture is conchoidal and it effervesces on contact with 10% dilute hydrochloric acid. N20ºNE and 24ºNW (direction and dip).

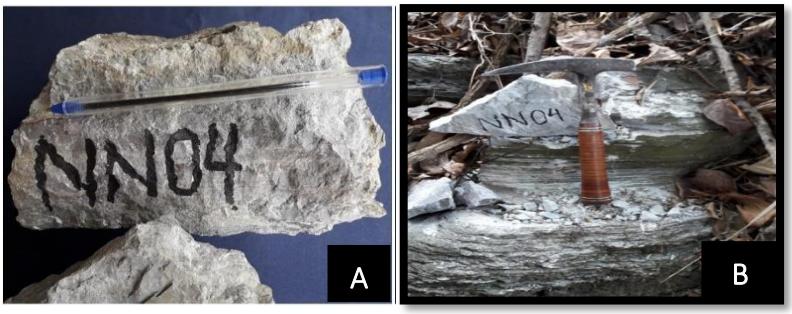

Figure 10. *Limestone sample (A), limestone outcrop (B)*

The sample (NN04) contains sparite (crystalline calcite) and more or less abundant pellets in a carbonate mud (Figure 11). Calcite crystals range in size from less than 10µm to several micrometers. The sample contains more than 10% allochemes in a carbonated mud (microcrystalline calcite), with a small proportion of sparitic calcite. The non-carbonate component is quartz. The rock is a ***Pelmicrite.***

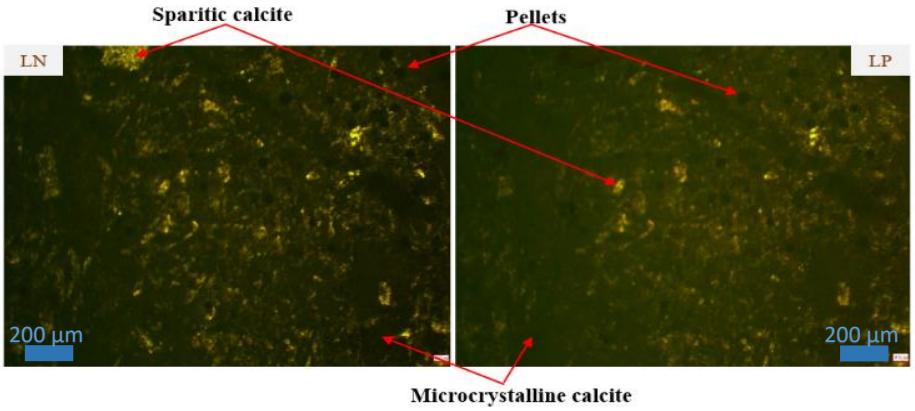

Figure 11. *Microscopic observation of the NNO4 slide under natural (LN) and polarized (LP) light (100x)*

- Sample NN05B (Figure 12)

The rock is hard, compact, with black minerals, veins of white minerals and breaks not followed by displacements (diaclases), as well as well-marked parallel stratification (Figure 12B). It is dark gray in color, has a plate-like fracture (Ech.NN05B) and is highly effervescent in contact with 10% hydrochloric acid. The rock smells like rotten eggs. N40ºNE and 16ºNW (direction and dip).

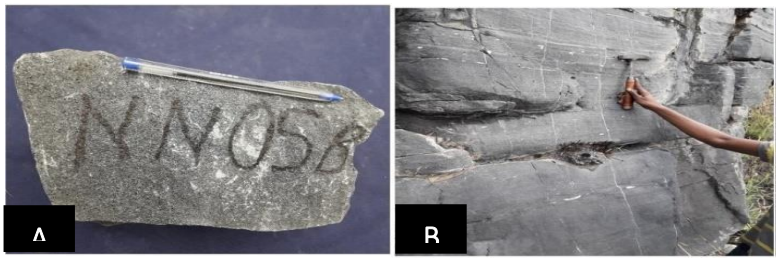

Figure 12. *Limestone sample (A), limestone outcrop (B))*

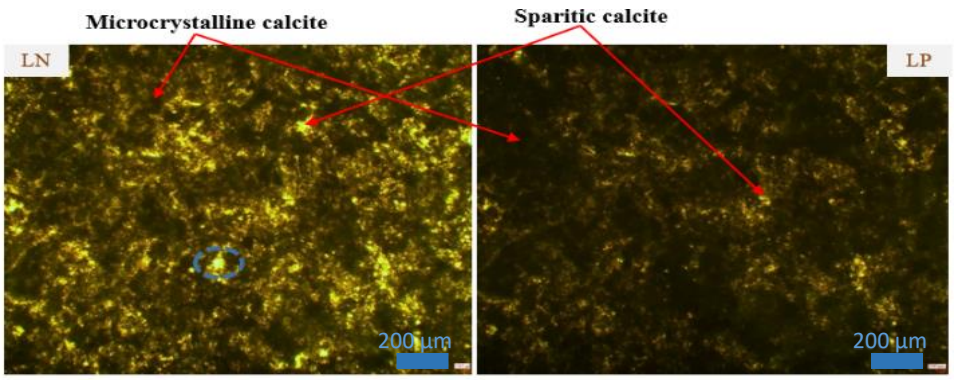

Figure 13. *Microscopic observation of the NNO5B slide under natural (LN) and polarized (LP) light (100x)*

The sample contains crystalline and microcrystalline calcite, as well as quartz crystals. The overall size of the crystals varies from less than 10µm to over 50µm. Recrystallization of micrite is observed, giving rise to larger crystals (Figure 13). The sample contains around 10% of non-joining grains in microcrystalline calcite, with a high proportion of sparitic calcite giving a microsparitic matrix. The rock is a ***Wackestone***.

- Sample NN06 (Figure 14)

The rock is hard, coherent and displays quartz minerals visible to the naked eye, as well as fine to coarse grains. It has a variegated color, a conchoidal fracture (Sample NN06) and exhibits strong effervescence on contact with 10% dilute hydrochloric acid. N40ºE and 12ºNW (direction and dip).

Figure 14. *Limestone sample (A), limestone outcrop (B)*

The sample contains both crystalline and microcrystalline calcite (Figure 15). Overall crystal size varies from less than 10µm to several micrometers. The sample presents a carbonate slurry with a dissemination of very small sub-rounded to rounded quartz grains. The proportion of figured elements (grains) is generally less than 10%, and they are non-joined in a micritic matrix with local sparitic calcite. The rock is a ***Mudstone***.

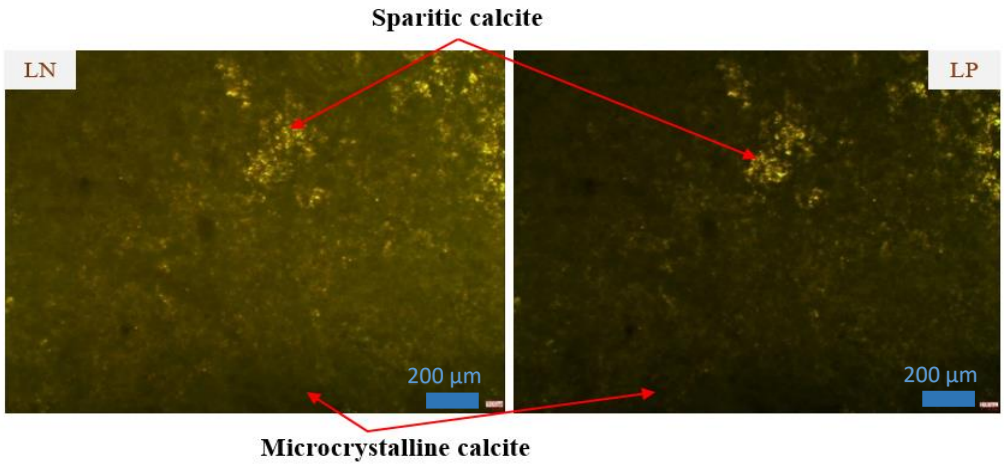

Figure 15. *Microscopic observation of the NN06 slide under natural light (LN) and polarized light (LP) (100x)*

- Sample NN012 (Figure 16)

The rock is hard and compact, with veins of white minerals visible to the naked eye, large quartz crystals and very pronounced bedding. It is light gray in color, has a plate-like fracture and is highly effervescent in contact with 10% hydrochloric acid. It should be noted that the rock shows the after-effects of more or less advanced tectonics (sample NN012) due to the shape of the beds. N10ºNE and 20ºNW (direction and dip).

***Figure 16**. Limestone sample (A), limestone outcrop (B)*

The rock contains sparitic calcite and isolated calcite and quartz grains, as well as microcrystalline calcite (primary sediment). Overall crystal size ranges from less than 10µm to over 50µm. Recrystallization of microcrystalline calcite is also observed, resulting in larger crystals (Figure 17). The sample contains more than 10% non-joining grains in a microsparite matrix, with locally large crystals of sparitic calcite; the rock is a ***Wackestone***.

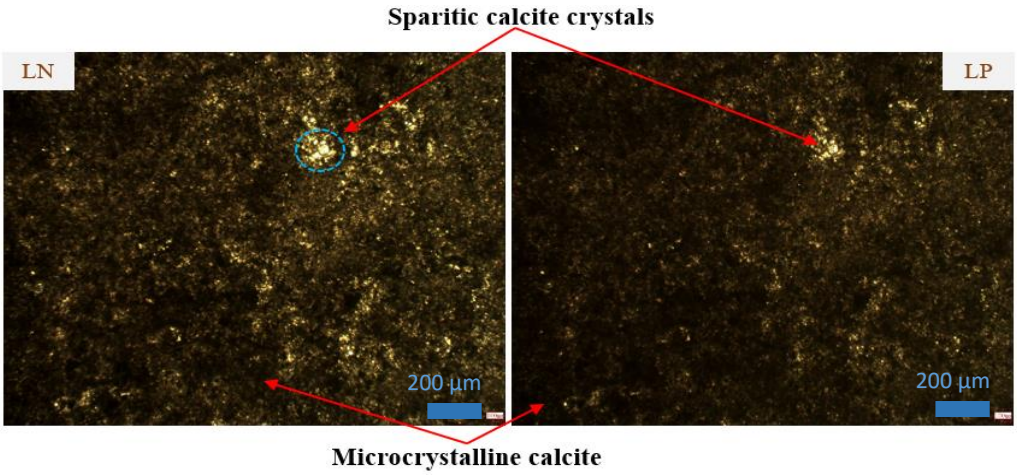

***Figure 17**. Microscopic observation of the NN012 slide under natural light (LN) and polarized light (LP) (100x)*

Combining macroscopic observations recorded in the field, such as the sample's reaction to hydrochloric acid, and microscopy results, we deduce that samples NN02A, NN02B, NN04, NN05B, NN06 and NN12 are indeed limestone rocks. They are indeed Mudstones, Wackstones and Pelmicrite (according to the classifications of Dunham (1962) [15] supplemented by Embry & Klovan (1972) [16] and Folk (1962) [17]), insofar as the grains (corpuscles) are found in a certain proportion (< 10% or > 10%) and not contiguous in the carbonate mud (micritic matrix) with sparitic calcite in variable proportion depending on the case.

Carbonate petrofacies can be composed of several different lithofacies (calcitic, dolomitic and others) depending on the case [15, 17, 18]. For our case, our petrofacies types are those of carbonate rocks formed mainly of calcite (calcitic lithofacies). Our formations were therefore formed in an environment where conditions are conducive to calcite precipitation. It is imperative to stress that detailed information on petrographic types, composition and microtexture [18] is of paramount importance in petroleum geology, as this information can be used in rock characterization or reservoir modeling.

Petrophysical analysis

In this section, analysis has provided us with the petrophysical properties essential for characterizing sedimentary rocks, namely porosity and permeability.

1. **Porosity measurement**

To measure the porosity of the samples in the CRGM laboratory, we have based ourselves on Archimedes' principle, which states that anybody immersed in a fluid undergoes a buoyant force equal to the weight of the displaced fluid. Here is how it's done [19]:

For the materials to be used, we need rock samples; a precision balance to weigh the samples; a transparent container containing a fluid (generally water) in which the sample will be immersed; a support to keep the sample immersed without touching the bottom of the container.

- The precision balance is used to weigh the sample dry. Record this value as the weight of the sample in air (P_1)
- The sample is placed in the transparent container containing water and care is taken to ensure that the sample is completely immersed in the fluid but does not touch the bottom or walls of the container.
- Once the sample is immersed and saturated, it is weighted again. Note this value as the weight of the rock in the fluid (P_2).
- We calculate the sample volume: $V_t : \frac{P1-P2}{d(fluids)}$ (1)
- The total porosity is then calculated: a graduated test tube is filled with a known quantity of water (Vi = 500 ml, for example) and enough is slowly poured into a closed container holding the rock sample to saturate it. Vr is taken to be the volume remaining in the test tube. The pore volume is then deduced as follows:

$$V_p = V_i - V_r \text{ with } \Phi = \frac{Vp}{Vt} \quad (2)$$

2. **Permeability measurement**

The intrinsic permeability of a rock is its ability to allow a saturated fluid to flow through its pores. It can be calculated using Darcy's law (1856) [20]. Consider a sample of length L, saturated with a fluid of dynamic viscosity μ, through which a flow Q (measured under the conditions of slice L) passes horizontally; under steady-state conditions, the upstream pressure is P, the downstream pressure is P - dP. If there is no reaction of the fluid with the rock, which is the most general case, we have:

$$Q = A * \frac{K}{\mu} * \frac{dp}{dl} \quad (3)$$

where:

Q - flow in cm^3/sec;

μ - fluid viscosity in centipoise;

A - surface crossed in cm^2;

K - coefficient of permeability in Darcy (value dependent on fluid properties according [21]);

P - pressure, in atm;

L - length, in cm;

There are several methods for determining the permeability of a rock sample. In the present work, we used the airflow method (using a constant or variable-load air permeameter). The results of the laboratory petrophysical analyses made in CRGM laboratory are shown in the table 2:

***Table 2**. Petrophysical properties of various samples (CRGM)*

Sample	***Porosity* (%)**	***Permeability (mD)***
NN02A	1.18	0.30
NN02B	1.39	0.40
NN04	1.29	0.50
NN05B	1.22	0.20
NN06	1.49	0.50
NN012	1.33	0.40

In relation to all the porosity and permeability values reported in Table 2, we have deduced, based on certain technical files that classify rocks according to porosity or permeability that our formations are in a low porosity and very low permeability interval. Classification of porosity (ø) and permeability (k) values are presented in the table 3.

***Table 3**. Classification of porosity* (ø) *and permeability (k) values*

Classification of porosity values (ø) [23, 24]:	**Classification of permeability values (k) [24]**
• Low if ø < 5%	• Poor if k < 1 mD
• Medium if 5% < ø < 10%	• Average if 1 mD < k < 10 mD
• Average if 10% < ø < 20%	• Moderate if 10 mD < k < 50 mD
• Good if 20% < ø < 30%	• Good if 50 mD < k < 250 mD
• Excellent if ø > 30%	• Very good if k > 250 mD

Based on this description, we have concluded that we are dealing on the one hand with rocks of low porosity ranging from 1.18 to 1.49% and on the other with rocks of very low permeability ranging from 0.2 to 0.5 mD, values well below 1 mD. In view of this, we say that these formations cannot serve as good reservoirs, since fluids can neither move nor be stored in sufficient quantities in the rock. Instead, these formations could be used as source or cover rocks.

Micritic matrices with very low porosity and permeability data are dense micritic matrices, composed of anhedral or subhedral crystals with fused contacts. These micrites are only observed in internal platform levels, generally in association with a high clay content [25].

Geochemical analysis

Elemental geochemical analysis can be used to determine the elemental composition of a rock (mass concentration of the various elements, generally expressed as oxides for the major elements) [26], but in this study we have gone a step further by determining the Total Organic Carbon (TOC) content, a parameter that provides information on the concentration of organic matter in the rock.

For geochemical analysis, we used the chemical reaction method (assays), element by element, to determine the elemental composition of these rock samples (i.e. the mass concentration of the various elements), generally expressed as oxides for the major elements. In addition, we also carried out TOC determinations, though we won't go into detail on the different operating procedures to avoid overloading this work, nevertheless, the method used to calculate TOC is elemental combustion, which relies on the complete combustion of the sample at a high temperature in a furnace, thereby converting organic carbon into carbon dioxide (CO_2). This CO_2 is then quantified by a suitable detector (a thermal conductivity detector or an infrared absorption spectrometer) enabling the concentration of organic carbon in the sample to be determined [32].

The results of geochemical analyses made in CRGM laboratory are shown in the table 4:

***Table 4**. Geochemical composition of samples (CRGM)*

Major elements	***Centesimal composition in % (NN05B)***	***Centesimal composition in % (NN06)***	***Centesimal composition in % (NN012)***
SiO_2	6.0	4.0	7.8
Al_2O_3	9.5	8.5	7.2
Fe_2O_3	2.5	3.2	3.2
CaO	68.5	66.9	70.2
MgO	3.5	5.1	2.1
K_2O	3.9	5.2	4.8
Na_2O	3.7	5.1	2.9
P_2O_5	0.5	0.7	0.4
TiO2	0.01	0.1	0.03
TOC	**1.1**	**0.9**	**1.3**

The different concentrations of the elements in the samples provide some precision as to the lithology of our samples. The high concentration of calcium oxide (CaO) in our samples justifies the fact that our formations are indeed carbonate formations, specifically limestone, as proven by petrographic results [27, 28]. Calcium oxide content is a determining element in the classification of carbonate formations, and high CaO content is a key indicator of limestone.

The proportions of total organic carbon in our samples showed that the organic matter content was high enough to make these rocks potential source rocks. TOC in limestones and shales is assessed as follows in the Table 5 [29, 30].

Table 5. *TOC assessment in limestone and shale*

Potential source rock		
Ranking	***Shale***	***Limestone***
	TOC (%)	TOC (%)
Poor	0 - 0.5	0 - 0.12
Fair	0.5 - 1.0	0.12 - 0.25
Good	1.0 - 2.0	0.25 - 0.50
Very good	2.0 - 4.0	0.50 - 1.0
Excellent	> 4.0	> 1.0

Based on this classification, we can say that our samples analyzed in the geochemistry laboratory have the best total organic carbon (TOC) content, ranging from 0.9 to 1.3, which places them in the category of very good and excellent source rock. So they are indeed potential source rocks.

CONCLUSIONS

The formations found and sampled are essentially limestones of the clay-limestone subgroup according [2] or the Lukula subgroup according to [8]. These formations were formed in a very calm environment, this is justified by the presence of a micritic matrix which is indicative of a calm environment devoid of the slightest current.

Interpretation of the analytical results clearly demonstrates that the samples sent to the various laboratories (NN02A, NN02B, NN04, NN05B, NN06 and NN012) for petrographic, petrophysical and geochemical analyses are indeed limestones (mudstones, wackstones and pelmicrite) [15,16,17,18] insofar as the grains (corpuscles) are found in variable proportions (from less than 10% to more than 10%) and non-joined in a micritic matrix with sparitic calcite in variable proportions depending on the case. The petrofacies determined in this study are those of carbonate rocks composed mainly of calcite.

With very low porosity ranging from 1.18 to 1.49% and near-zero permeability ranging from 0.2 to 0.5 mD, we can safely conclude that our formations cannot serve as good reservoirs [22, 23], but rather as cover rocks in view of their petrophysical parameters or

as source rocks. These low petrophysical parameter values, coupled with the lithological nature of these formations, tell us that they were emplaced in an environment devoid of any turbidity, ensuring the deposition of very fine sediments (carbonate mud).

The proportion of calcium oxide (CaO) in our samples (NN05B: 68.5%, NN06: 66.9%, NN012: 70.2%) reaffirms the petrographic results, insofar as the proportion of calcium oxide is a determining parameter in the classification of carbonate formations, and high proportions of calcium oxide (CaO) are indicative of limestone, which is the case here. TOC contents are very satisfactory (ranging from 0.90 to 1.30) and, according to the classification of potential source rocks used, our formations fall within the ranges of very good and excellent source rocks [29, 30, 31]. This means that our Neoproterozoic (Ediacaran) formations would have already produced hydrocarbons where they are found under the right conditions (burial, pressure, temperature). We would point out here that in this basin, numerous oil showings have been found in localities just a few kilometers from our study area.

As mentioned above, this study shed light on the intrinsic characteristics of the carbonate formations outcropping in the Kitobola region by determining the lithology, mineralogical, chemical and geochemical characteristics of these formations, as well as basic petrophysical parameters. This study revealed that the limestones found in the study area have interesting and varied characteristics, enabling them to be qualified as source rocks on the one hand, in view of their lithology and TOC values, and cover rocks on the other, in view of their very low petrophysical parameters. However, based on previous work and the lithostratigraphic log of the region, we classify these formations as potential source rocks in the West Congolian Basin.

REFERENCES

[1] Tack, L., Wingate, M.T.D., Liegeois, J.P., Fernandez-Alonso, M., Deblond, A., Magmatisme du Néoprotérozoïque précoce (1000-910 Ma) des groupes Zadinien et Mayumbien (Bas-Congo): début du rifting de Rodinia à la limite occidentale du craton du Congo. Precambrian Research, pp. 277–278, 2001.

[2] Kadima E., Structure and geological history of the Congo Basin: an integrated interpretation of gravity, magnetic and reflection seismic data, Basin Research, University of Lubumbashi, Royal Museum for Central Africa, Belgium, pp. 504, 2011

[3] Cibambula C.M.E., Makutu M.J.A., Kanika M.T., Mvuemba N.F., Nzau M.C., Mabedi T.H., Mayombo B.E., Mutamba N.R., Dépôt du conglomérat de Bangu-Niari et analyse morphogéométrique des fractures dans l'avant pays de la chaîne panafricaine West Congo: cas du secteur de Kimpese, Rev. Cong. Sci. Nucl., Vol. N°27, pp. 90-110, 2013

[4] Pedrosa-Soares, A.C., Alkimim, F.F., Tack, L., Noce, C.M., Bambinski, L.C.S., Martins-Neto, M.A., Similaries and difference between the Brazilian and African counterparts of the Neoproterozoic Araçuai-West Congo orogen. Pre-Cenozoic correlations across the South Atlantic region, Geol. Soc., London, Special Publ. 294, pp. 153-172, 2008

[5] Diemu Tshiband B., Notes de cours de Géologie Pétrolière de la R.D.C, Grade I Exploration-production, Université de Kinshasa, D.R. Congo, pp. 10-25, 2015.

[6] Cahen, L., La stratigraphie et la tectonique du super-groupe Ouest-Congolien dans les zones médianes et externes de l'orogenèse Ouest-Congolienne (Panafricaine) du Bas-Congo et dans les régions voisines, Ann. Mys. Royal de l'Afrique centrale, Belgium, pp.90-146, 1978

[7] Lepersonne J., Structure géologique du bassin intérieur du Zaïre, Acd. Roy. Sci, Belgique, pp 4-20, 1978.

[8] CRGM-MRAC, Carte géologique de l'Ouest-Congolien, 2013

[9] Nsieto, R., Study area location map, ArcGis, Datum: WGS 84, 2025.

[10] Delhaye, F., Sluys, M., Présentation d'une carte géologique originale du Congo Occidental à l'échelle de I : 200 000, publiée sous le titre: Esquisse géologique du Congo Occidental. Étude du système schisto-calcaire (Ann. Soc. Géologique de Belgique, Publ. relatives au Congo belge et régions voisines, année 1923-1924, annexe au t. XLVII, Liège, pp. 45-49, 1929

[11] Baeyens, J., Les sols de l'Afrique centrale, spécialement du Congo Belge. Institute National pour l'Etude Agronomique du Congo Belge, pp. 95-100, 1938.

[12] Denisoff, L, Prade, J., Drachousoff, V., Corrélation des travaux INÉAC-GER dans la zone agricole de Thysville (BasCongo). Compte rendu de la deuxième Conférence interafricaine des Sols, Léopoldville, (Dir. Agric, Forêts et Élev. du Min. des Afï. Africaines, Bruxelles), 1954

[13] Cibambula, M., La formation du Conglomérat de Bangu-Niari sur le massif de Bangu (Degré carré de Ngungu): Une Diamictite non glaciaire, Témoin de la fragmentation de Rodenia dans le fossé de la Basse-Sangha, Mémoire de DEA, Faculté des Sciences, Université de Kinshasa, RDC, p.34-36, 2012.

[14] Nsieto, R., Sampling map, ArcGis, Datum: WGS 84/ UTM 33S, 2025.

[15] Dunham, R.J., Classification of Carbonate Rocks According to Depositional Texture. In: Ham, W.E., Ed., Classification of Carbonate Rocks, AAPG, Tulsa, pp. 108-121, 1962.

[16] Embry A.F., Klovan J.E., Absolute water depth limits of late Devonian paleoecological zones. Geologische Rundschau, Germany, vol. 61, pp. 672-686, 1972.

[17] Folk, R.L., Spectral subdivision of limestone types, in W.E. Ham, ed., Classification of carbonate Rocks-A Symposium: AAPG Memoir 1, pp. 62-84, 1962.

[18] Cehlarov A., Frunzescu D., Branoiu G., 2010, Mineralogical-petrographical details on the clastes of rudites from olistolithes conglomerates within Badenian Salt Breccia from Bădila (Buzău Valley), Buletinul Universităţii Petrol-Gaze din Ploieşti, vol. 62, Seria Tehnica, Nr. 3B, pp. 230-242, 2010.

[19] Pinot, P., Détermination de la porosité des roches calcaires : méthodes et incertitude de mesure, laboratoire commun de métrologie, LNE-LCM/Cnam, France, pp. 39-47, 2015.

[20] Darcy, H., In: Dalmont, V., Ed., Les Fontaines Publiques de la Ville de Dijon: Exposition et Application des Principes à Suivre et des Formules à Employer dans les Questions de Distribution d'Eau. Paris, pp. 647, 1856.

[21] Freeze R.A., Cherry J.A., Groundwater: Englewood Cliffs, NJ, Prentice-Hall, pp. 130, 1979.

[22] Levorsen, A., Geology of petroleum, the University of Chicago, pp. 122-133, 1956.

[23] René Cossé, Techniques d'exploitation pétrolière, Livre, Edité par Technip, France, pp. 31-31, 1988.

[24] Djebbar T., et al., Pétrophysics: theory and practice of measuring reservoir rock and fluid transport properties, Gulf professional publishing, pp. 989, 2004.

[25] Deville M., Origine sédimento-diagenetique de réservoirs carbonatés microporeux : Exemple de la formation Mishrif (Cénomanien) du Moyen-Orient, thèse, Fac.Sci, Université de Bourgogne, 2011.

[26] Ruben K., Notes de cours de Géochimie de la matière organique, IIème Grade Expo, Université de Kinshasa, pp. 27-28, 2017.

[27] Wang H., Alfredsson V., Tropsch J., Ettl R., Nylander T., Formation of $CaCO_3$ deposits on Hard Surfaces; effect of Bulk Solution Conditions and Surface Properties. American Chemical Society Appl. Mater. Interfaces 5, pp. 4035-4045, 2013

[28] Legros J.P., Le calcaire: de la Pierre à la civilisation, Académie des Sciences et Lettres de Montpellier, V54, France, pp 10-11, 2023.

[29] Espitalie, J., Deroo, G., Marquis, F., La Pyrolysis Rock-Eval Etses Applications. Oil and Gas Science and Technology (OGST), Revue d'IFP, Part I, 40, pp. 563-578, Part II, 40, pp. 755-784, 1985.

[30] Peters, K.E., Guidelines for Evaluating Petroleum Source Rock Using Programmed Analysis. The American Association of Petroleum Geologists Bulletin, vol. 70, pp. 318-329, 1986.

[31] Espitalié, J., Laporte, J.L., Madec, M., Marquis, F., Leplat, P., Paulet, J., Boutefeu, A., Méthode rapide de caractérisation des roches-mères, de leur potentiel pétrolier et de leur degré d'évolution, Revue de l'Institut Français de Pétrole, France, vol. 32, pp. 23-42, 1977.

[32] Giovanni, C., Proix N., Ciesielski H., Dosage du carbone organique par combustion sèche, Institute National de la Recherche Agronomique, Laboratoire d'analyses des sols, France, p.1-8, 2007.

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