Scientific Research Publishing

Open Journal of Yangtze Gas and Oil, 2022, 7, 149-165
https://www.scirp.org/journal/ojogas
ISSN Online: 2473-1900
ISSN Print: 2473-1889

Contribution to the Characterization of Carbonate Rocks of the Nganzi Oil Exploration Block (Onshore of the DR Congo Coastal Basin)

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How to cite this paper: Osomba, D.W., Ediho, P.L., Diambu, S.M., Oyema, B.D., Kachunga, B.S., Nkoyi, J.O., Muamba, L.B. and Kilungu, J.K. (2022) Contribution to the Characterization of Carbonate Rocks of the Nganzi Oil Exploration Block (Onshore of the DR Congo Coastal Basin). *Open Journal of Yangtze Gas and Oil*, **7**, 149-165.
https://doi.org/10.4236/ojogas.2022.73009

Received: March 11, 2022
Accepted: May 17, 2022
Published: May 20, 2022

Abstract

The carbonate lithofacies of the Nganzi Exploratory Block located in the Lukula Territory in the Central Kongo Province were described in the field, sampled and subjected to microscopic, mineralogical, physico-chemical and petrophysical analyses. The aim is to increase the probability of discovery of deposits following the drilling of exploration wells in the most appropriate structures. These carbonates, limestones (white, greyish and greenish) and dolomites (massive and platelets) are presented in packstone, grainstone and wackestone textures. In addition to the essential minerals of these rocks, calcite and dolomite, we find quartz, plagioclase and kaolinite. With a porosity between 11% and 19% and a permeability of 138 to 155 mD, the Nganzi carbonates, which contain up to 23% oil, constitute good oil reservoirs. The characterization of the detrital facies and the acquisition of a seismic survey of the wells is essential to have a more detailed knowledge of the oil resources of the Nganzi Block.

Keywords

Nganzi Block, Limestone, Dolomite, Petrophysics, Texture, Surface Shows

1. Introduction

With an area of 800 Km^2, the Nganzi Block is one of the 6 Coastal Basin Blocks resulting from the Ex-Renderings of FINAREP and which have been opened to oil exploration. It is located in the Territory of Lukula in the Province of Kongo Central in the Democratic Republic of Congo. This Block was granted in 2008 by the Congolese State to the British company Oïl Society Compagny, in acronym Soco. The latter drilled 3 wells which gave only traces of degraded and non-marketable hydrocarbons. As a result of these results, deemed negative by Soco, this British oil operator withdrew from the Nganzi Block and the latter once again became open to oil exploration as required by the legislation currently in force [1]. In this state of affairs, the inventory and characterization of the lithofacies existing in this Block are necessary for the programming of additional seismic acquisitions aimed at increasing the probability of discovery of deposits following the drilling of other wells, exploration in the most appropriate structures. The main objective of this study is to: Determine the petrographic and structural characteristics; petrophysics of carbonate rocks of the Nganzi Block; in order to highlight the oil interest of this Onshore part of the DRC coastal basin. The knowledge of the elements of the Petroleum system will contribute to the new knowledge of the accumulations of hydrocarbons "hidden" in the intervals of the carbonated reservoir [2] [3]. It also has the advantage of contributing to the constitution of the geological file of this Block which is selected to be submitted to Calls for Tenders by the Ministry of Hydrocarbons.

2. Materials and Methods

The main materials used in this treatment work, without which we would not achieve our objectives, are:

- GPS for taking geographical coordinates in order to geo-reference the stations on the topographic background;
- Geologists' hammers to break the various outcrops on the ground in order to assess their color, facies, texture and to take rock samples;
- Geological compasses to take strike and dip measurements to orient planes and lineations;
- Cameras to take pictures of certain geologically interesting aspects;
- Binocular brand Leiça ZOOM 200;
- Sample bags, tape measure, field notebooks and topographic base;
- Hydrochloric acid (HCl) diluted to 10%;
- Markers for numbering samples, indicate polarity;
- The use of software made it possible to process the data.

We proceeded with the bibliographic study (in the state services of the country) of works relating to the geology of Kongo Central and more particularly of the Nganzi Block. The results of this article are acquired through the comparative methodology at two very complementary levels and reinforced by documented research in order to make appropriate interpretations.

2.1. In The Field

Two investigation and sampling campaigns took place on the Nganzi exploratory block (Figure 1).

- The first covered the northwestern part of the block;
- The second was carried out in the south-eastern part of the block.

2.2. In the Laboratory

The rock samples collected in the field were subjected to various laboratory analyses to highlight their petrographic, mineralogical, structural and petrophysical characteristics (Table 1).

01. Optical microscopy

Centre de Recherches Géologiques et Minières (CRGM) in Kinshasa Leitz Wetzaler microscope, 10x Describe the lithofacies.

02. X-ray fluorescence

Department of Geology of the Faculty of Sciences of the University of Liege in Belgium ARL 9400XP Determine the composition of major or trace chemical elements.

03. X-Ray Diffraction

Department of Geology of the Faculty of Sciences of the University of Liege in

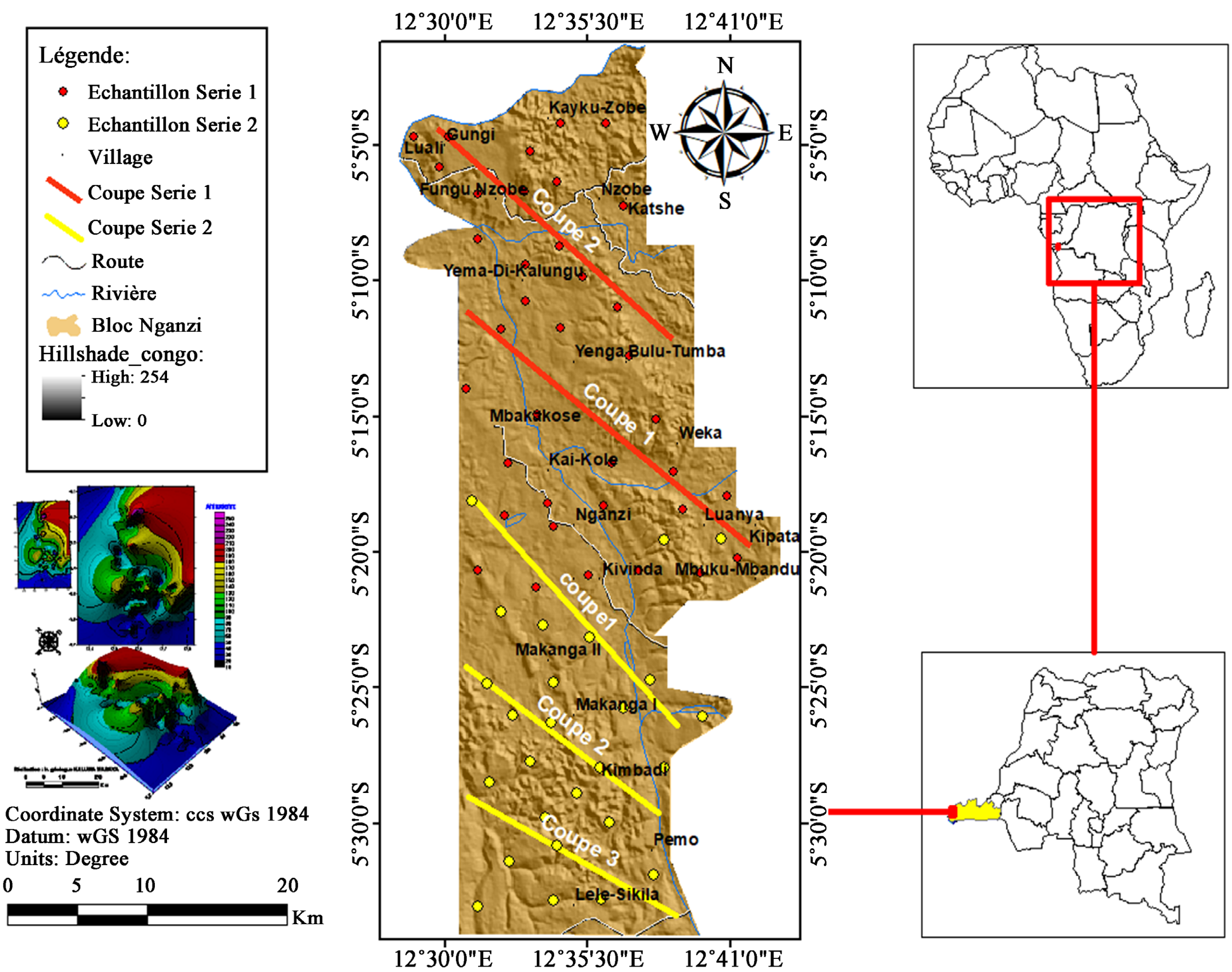

Figure 1. Presentation of the Nganzi Block and sampling sites.

Table 1. Analytical materials and protocols used for laboratory work.

N°	N° Type of Analysis	Laboratory Protocol	Materials	Objective of the Analysis
01	Optical Microscopy	Geological and Mining Research Center (CGRM) in Kinshasa	Microscope Leitz Wetzaler, 10x	Describe lithofacies
02	Fluorescence x	Department of Geology of the Faculty of Sciences of the University of Liège in Belgium.	ARL 9400XP	Determine the composition of major chemical elements or traces
03	X-Ray Diffraction X	Department of Geology of the Faculty of Sciences of the University of Liège in Belgium.	Bruker D8 Advance	Determine rock minerals
04	Infrared Spectroscopy (IR)	Faculty of Applied Sciences of the University of Liège in Belgium	Spectrometer Nicolet Nexus	Determine the minerals of rocks
05	Scan Electronic Microscopy (MEB)	Faculty of Applied Sciences of the University of Liège in Belgium	Zeiss Gemini	Determine the composition and map the chemical elements of the rocks
06	Extraction of the Hydrocarbon	Laboratory of the Road Office in Kinshasa	KUMAGAWA	extract the hydrocarbons contained in the rocks
07	Petrophysics	National Laboratory of Public Works of the Roads Office in Kinshasa	Test Tubes Ovens Test Tubes	Determine the porosity and permeability of rocks
08	Structural Measures Statistics	Software	Wintensor 5.8.6	Determine preferential directions and dipstops

Belgium Bruker D8 Advance to determine the minerals of rocks.

04. Infrared spectroscopy (IR)

Faculty of Applied Sciences of the University of Liège in Belgium Nicolet NEXUS spectrometer.

05. Scanning Electron Microscopy (SEM)

Faculty of Applied Sciences of the University of Liege in Belgium ZEISS Gemini determine the composition and map the chemical elements of rocks.

06. Extraction of hydrocarbon binder

National Laboratory of Public Works of the Office of Roads in Kinshasa KUMAGAWA Extract hydrocarbons contained in rocks.

07. Petrophysics

National Laboratory of Public Works of the Office of the Roads in Kinshasa Test tubes Ovens Test tubes determine the porosity and permeability of rocks.

08. Statistics of structural measurements

Software Wintensor 5.8.6 to determine the directions and the preferential dips of the strata.

3. Results and Interpretation

3.1. Lithofacies and Geological Sketch

From the analysis of petrographic field data coupled with the descriptions of the thin slides made, it appears that the lithofacies encountered in the study area are:

- Sandstone;
- White limestone;
- Massive dolomite;
- Dolomite in plate;
- Greenish limestone;
- Greyish limestone;
- Conglomerate sand;
- Pebbles impregnated with hydrocarbons.

a) Sample KDO1

The dark grey rock, with a massive appearance and fine grain size showing pores on the surface of the sample effervesces strongly with cold HCl.

Microscopically (**Figure 2**), dark brown hydrocarbon clusters and subrounded to subangular quartz grains, plagioclase with polysynthetic macles impregnated in sparitic cement are observed. According to the classification of Folk [4] this carbonate rock is an intrasparite of the packstone type.

b) Sample KD 17

Macroscopically, the rock of massive aspect has a fine granulometry, of dark gray color with micrograined texture of subplanar beds centimeters on the surface. It also reacts with cold hydrochloric acid diluted to 10% (**Figure 3**).

Microscopically (**Figure 4**), the rock shows ooids with concentric cortex around a micritic or microsparitic nucleus; these ooids can be alone or in aggregates composed of two or more elements.

According to the classification of Folk and Dunham [4] [5], this limestone is a grainstone oosparite.

c) Sample KK07

It is a limestone almost totally white in color with a brownish alteration color on the surface. It presents white peloids. We note the presence of millimetric to centimetric calcites.

Massive and rough to the touch, the rock effervesces in contact with HCl

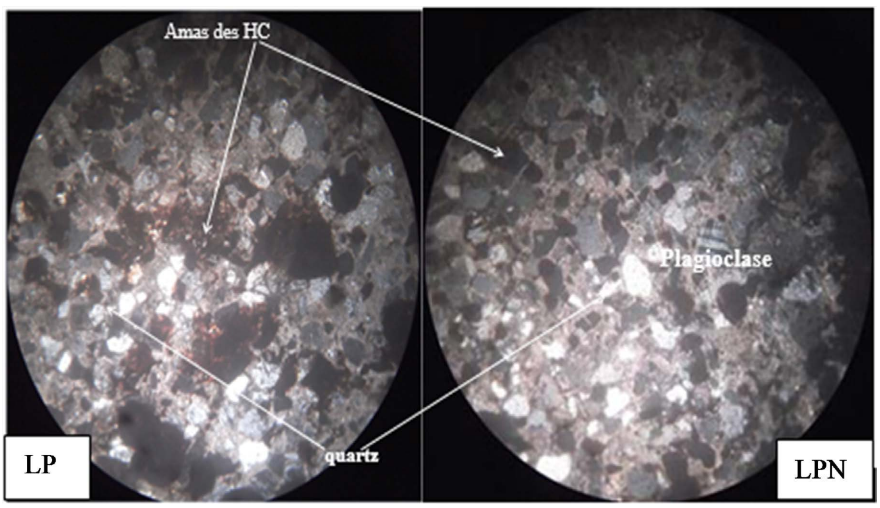

Figure 2. Photos of the thin section of sample KD01.

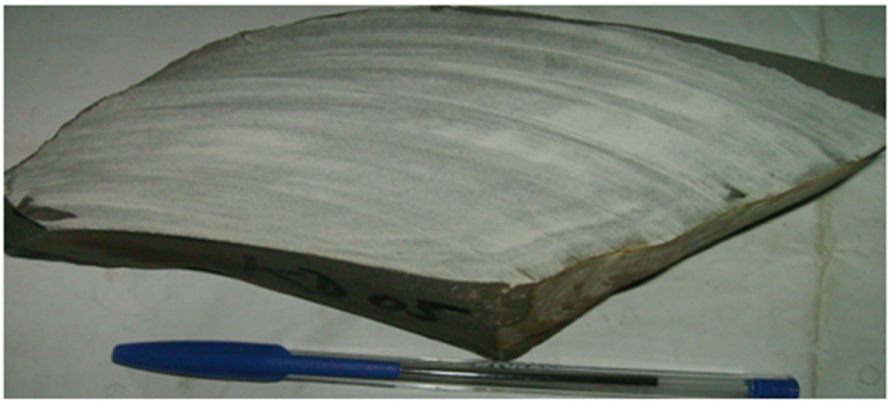

Figure 3. Photo of sample KD 17.

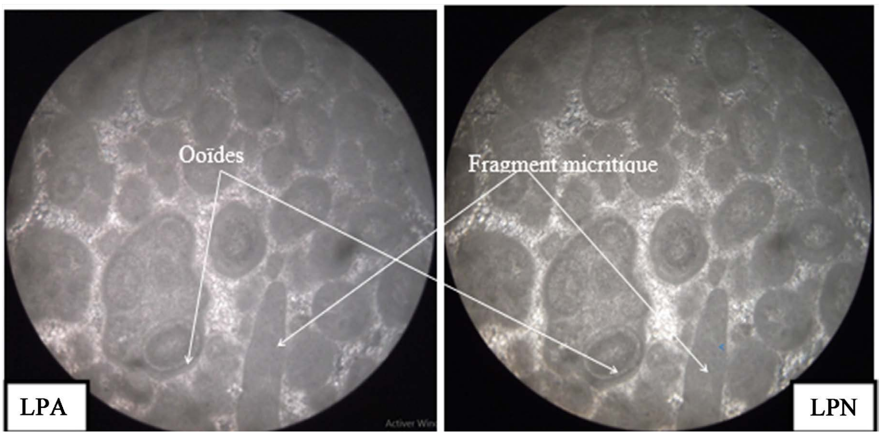

Figure 4. Photos of the thin slide of sample KD 17.

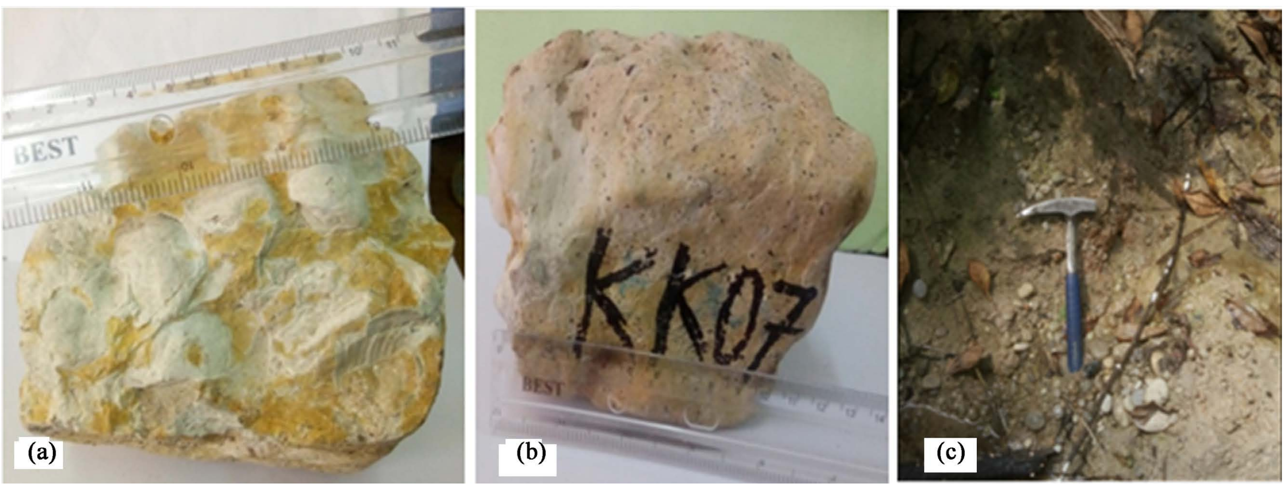

Figure 5. Photos of sample KK07 and view of field orientation.

diluted to 10%. We observe on the whole rock a dissemination of dark grey millimetric grains. On one of the walls of the sample, there is an impregnation of traces of fossiliferous organisms that look like a variety of brachiopods. This confers to this rock a biological nature (Figure 5).

Microscopically (Figure 6), this sample corresponds to packstone-type peloidal

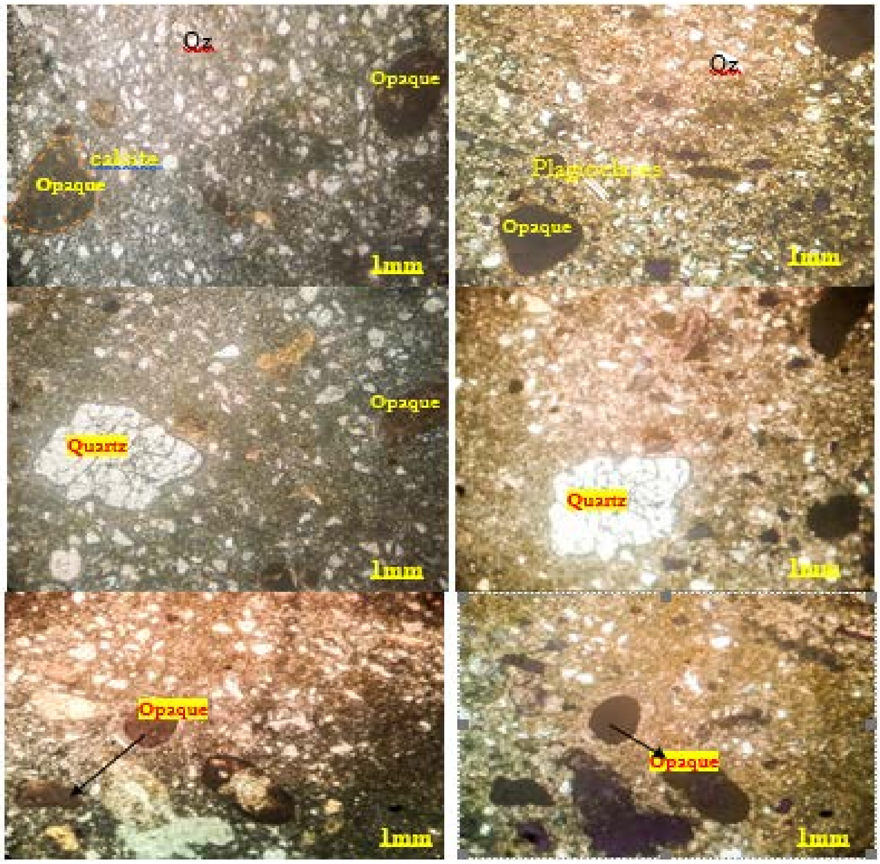

Figure 6. Thin slide photos of sample KK07.

limestone whose mineralogical compilation is made of detrital quartz grains, plagioclases, calcite crystals and fragments of brachiopods embedded in a sparitic cement. The latter have a diameter lower than 2 millimeters.

The sparite is equigranular, its constitution in natural light is visible in weak relief with the structure of peloids, without nucleus in the internal structure but with concentric laminae with strong color of absorption (yellow, ochre, brown). In the center of the slide is a large quartz crystal with low relief and clear appearance.

In polarized light, the mosaic sparitic cement, presents colors of birefringence in the pastel tones (green and pink washed) beyond the 3rd order. The minerals of detrital quartz with undulating extinction are visible in the clear shades of first order. Plagioclases are visible with polysynthetic macles with alternating extinction at 30˚ and low birefringence color (1st order gray). It is a brachiopod pelsparite of packstone type according to the classification of Folk [4] [5].

d) Sample KK12

It is a more or less homogeneous grey limestone with some rare occurrences of clayey beds mixed with the limestone and showing a multiplicity of visible fracture planes reminiscent of a damage zone.

Medium dense rock, quite compact and smooth to the touch, this limestone presents in the interbedded spaces, calcic recrystallizations strongly impregnated by organic activities (hydrocarbon impurities) hence the black coloration visible in these spaces. The rock effervesces in contact with 10% hydrochloric acid (Figure 7).

At the level of the thin slide, we observe crystals of heterogeneous size whose compilation of minerals is made of calcite, quartz and a non-negligible proportion of opaques, the whole coated in a microspartic binder (Figure 8) [4] [5]. The rock is an intramicrosparite of wackestone type.

In addition to these lithofacies, surface oil showings have been described, sampled and mapped in the study area, the Nganzi Block. The presence of these showings constitutes evidence of the functioning of the elements of the petroleum system and possibly a sign of the occurrence of hydrocarbons in this block because at the beginning of any history of petroleum exploration, the choice of areas to be explored is often imposed according to the existence of surface showings even if the presence of the latter does not necessarily guarantee the existence of exploitable deposits (Figure 9).

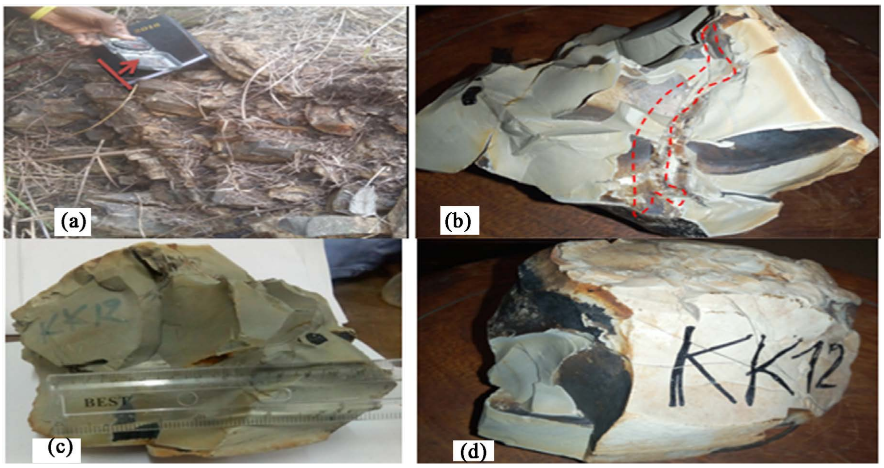

Figure 7. Photos of sample KK12 and view of orientation in the field.

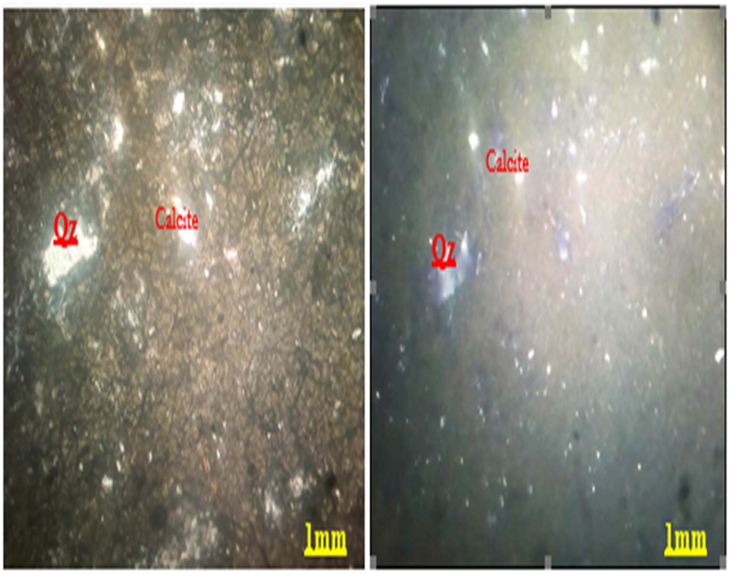

Figure 8. Thin-slide photos of sample KK12.

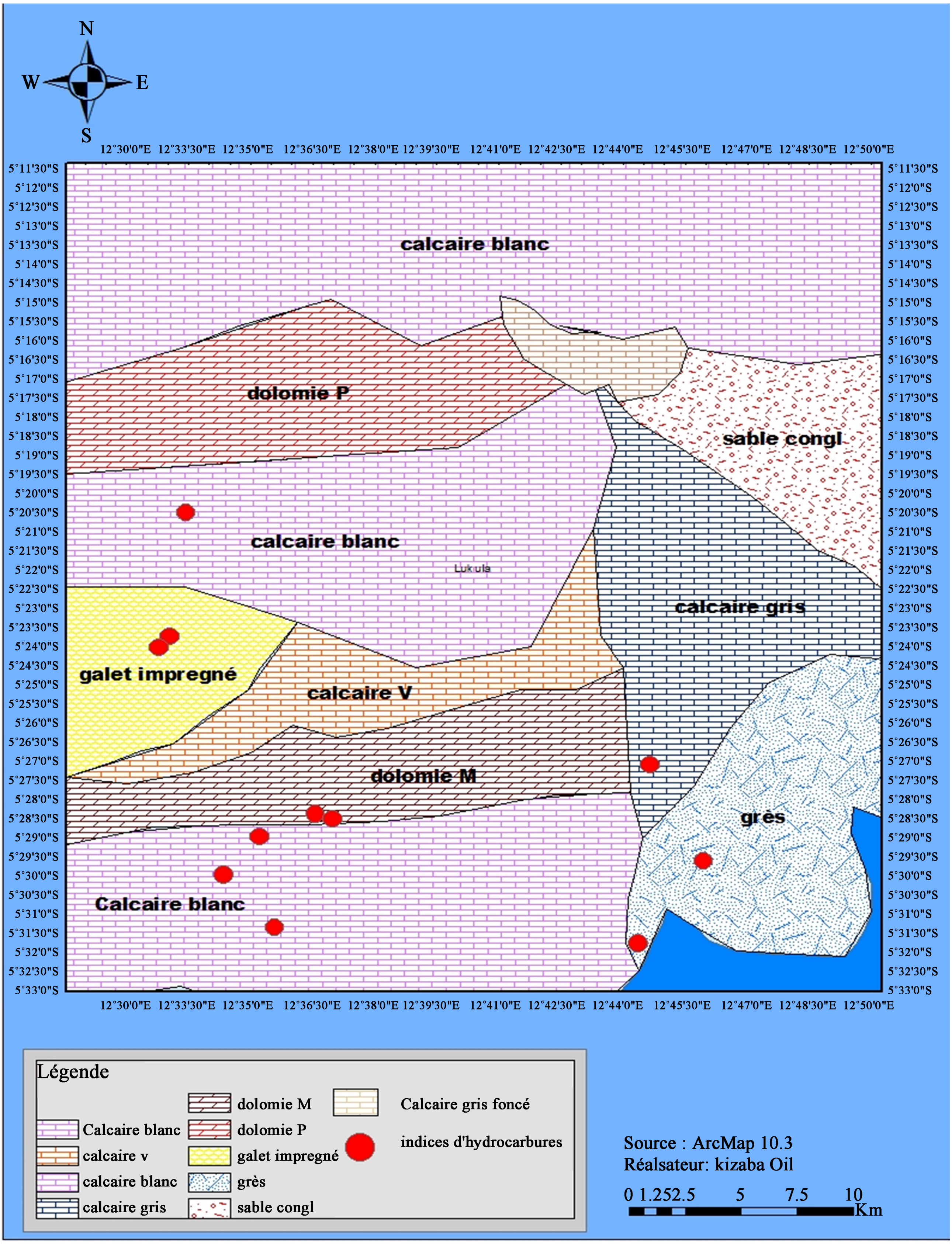

Figure 9. Geological sketch of the study area showing the oil showing stations.

3.2. Statistical Representation of the Stratification Planes

Statistical analysis of 40 planar structural measurements (layering planes) taken in the field and their projection on the stereographic grid was done to determine the preferential directions and dips of the strata (Figure 10).

Two major facts emerge:

- The highest frequencies are between 10˚ and 20˚, 30˚ and 40˚ and 90˚ and 140˚ for the stratification planes; between 10˚ and 20˚ for the dips;
- A multimodality indicated by the presence of two peaks, which translates into the coexistence of two large families of stratification planes.

3.3. Chemical Composition

Table 2 and Figure 11 present the results of chemical analysis by volumetry and

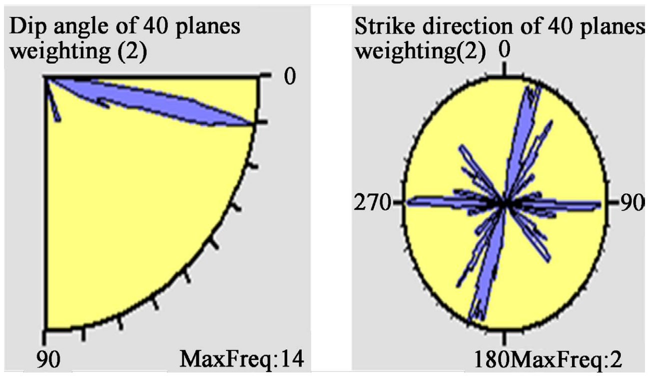

Figure 10. Dip and direction of 40 stratification planes on frequency rosettes.

Table 2. Results of chemical analysis of rocks from Nganzi

Paramètres dosés	Volumétrie/Colorimétrie (CRGM)			Fluorescence X (ULiège)	
	% (Ech.KKS52)	% (Ech.KKS12)	% (Ech.KD21)	% (Ech.KD21)	% (Ech.KD01)
SiO_2	26.22	17.34	19.06	16.62	16.35
TiO_2	0.08	-	-	0.41	0.56
Al_2O_3	6.18	3.36	3.30	7.86	11.29
Fe_2O_3	6.1	1.04	1.00	2.56	4.60
MnO	-	-	-	0.08	0.08
MgO	0.79	1.15	1.20	3.01	12.18
CaO	10.4	40.68	41.05	47.60	19.43
Na_2O	0.41	1.32	1.11	0.00	0.00
K_2O	3.66	1.72	1.67	3.32	0.99
P_2O_5	ND	0.04	0.03	0.05	0.03
SO_3	-	0.08	0.08	-	-
Hydrocarbure	22.98	-	-	-	-
Humidité (à110˚C)	-	-	1.00	-	-
LOI (Perte au feu)	22.98	31.7	30.15	18.47	34.48
Total	99.8	998.43	99.65	99.98	99.90

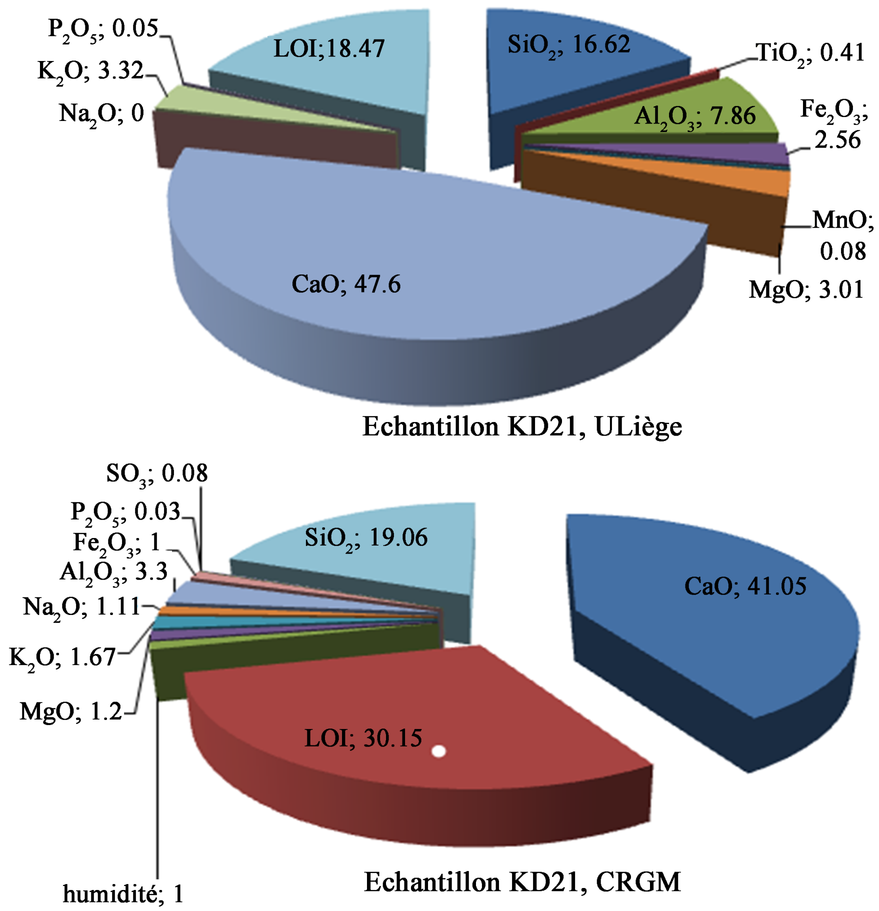

Figure 11. Circle diagram of the distribution of elements in the carbonate rock of Nganzi.

X-ray fluorescence of five rock samples extracted at Nganzi.

In addition, Scanning Electron Microscopy (SEM) analysis identified and mapped the seven main chemical constituent elements of the minerals in the KD01 rock sample.

These are oxygen, calcium, silicon, potassium, magnesium, aluminum and iron (Figure 12 and Figure 13; Table 3).

The rock analyzed by scanning electron microscope is therefore an impure carbonate: dolomitic limestone.

The content of potassium and aluminium of about 10% can be attributed to the existence of a kaolinitic type clay and plagioclase identified in the same sample by thin section examination and X-ray diffraction.

3.4. Mineralogical Composition

The analysis of diffractograms of rock samples KD01 and KD21 shows that they are mainly composed of calcite, dolomite, kaolinite, gibbsite, tridymite and quartz [6] [7] [8].

The infrared spectrum (Figure 14) also confirms the existence of calcite with its usual wave number of about 1400 cm^{-1} in the rock sample KD01 [8] [9].

Microscopic and mineralogical analysis shows that the carbonate lithofacies of

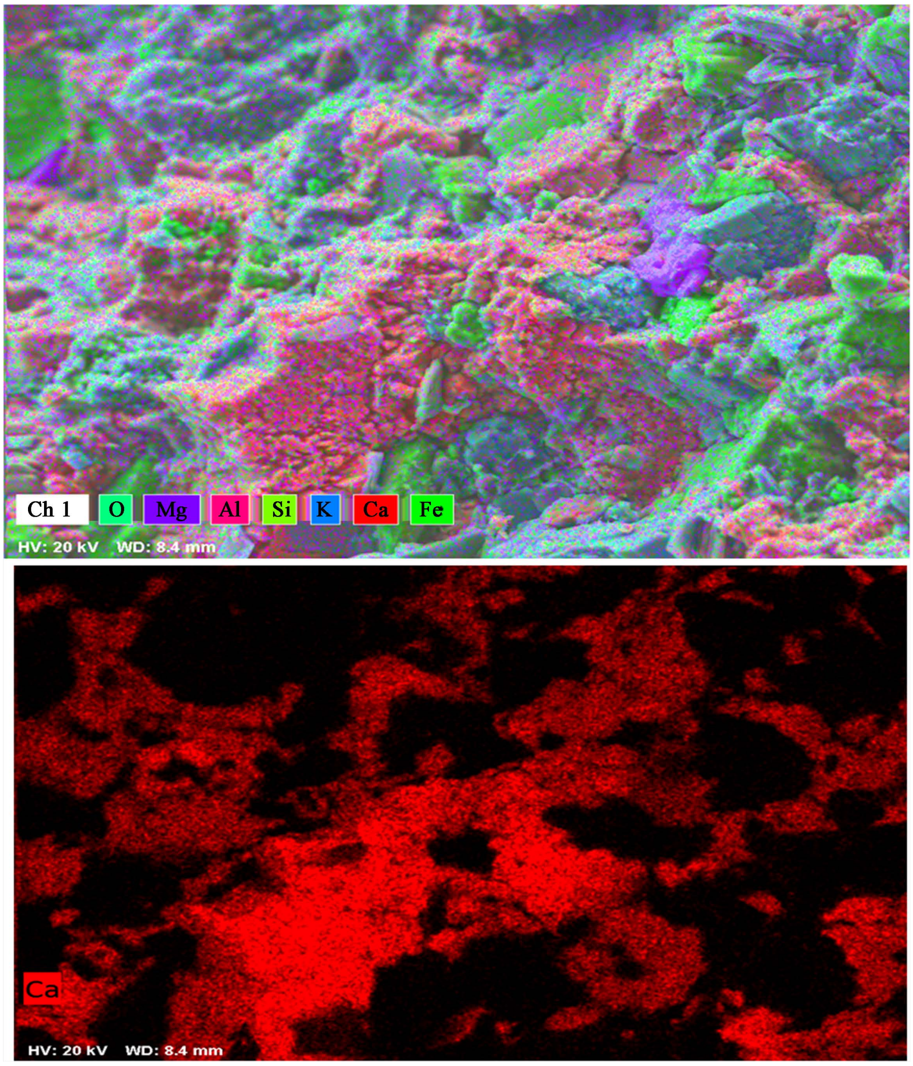

Figure 12. Cartographie des éléments chimiques de l'échantillon rocheux KD01.

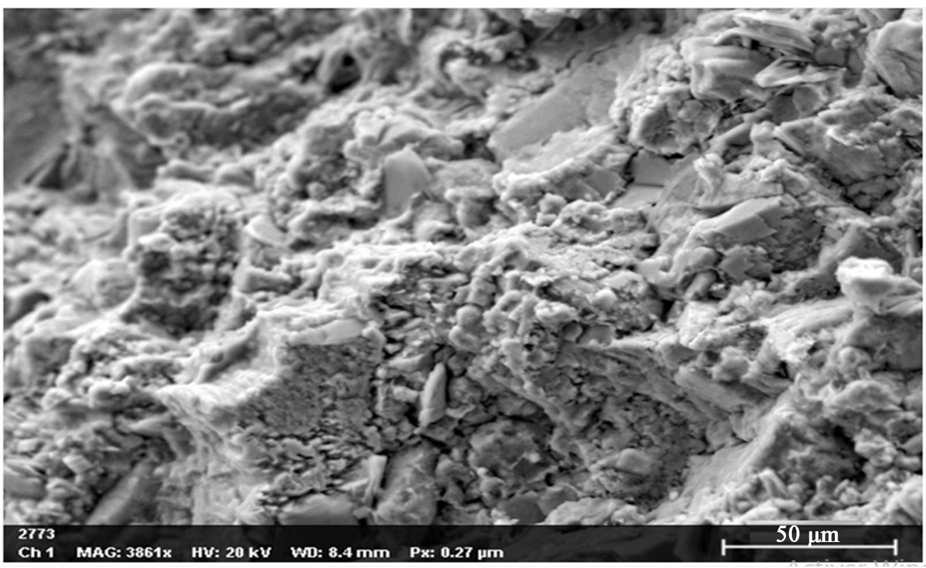

Figure 13. SEM image of sample KD01.

Table 3. SEM normalized mass concentration (%) of the main chemical elements of the rock sample KD01.

Spectres	O	Mg	Al	Si	K	Ca
1	46.31		10.59	28.68	14.42	
5	60.22			1.02		38.76
6	62.40	12.17				25.43
Moyenne	56.31	12.17	10.59	14.85	14.42	32.10

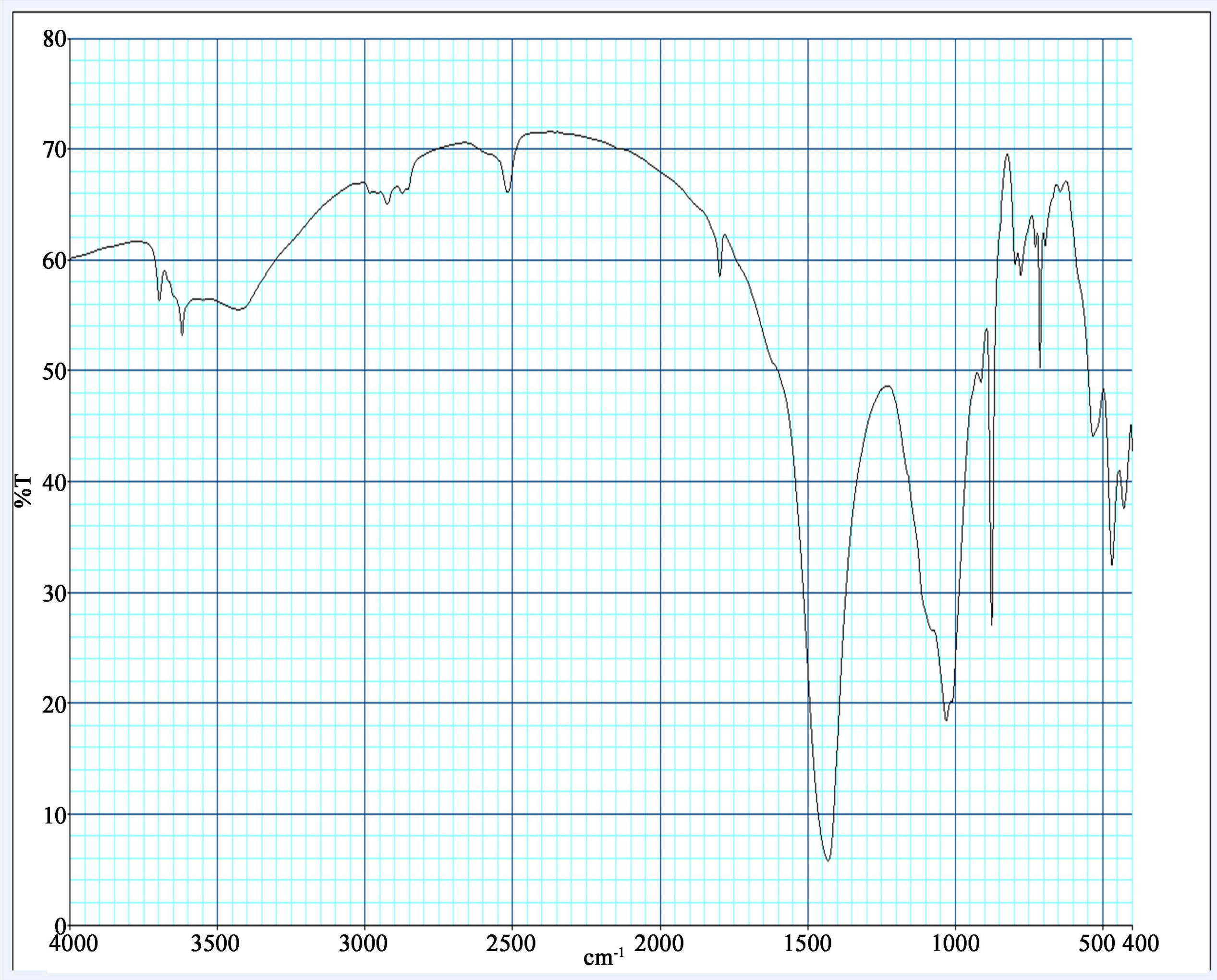

Figure 14. Infrared spectrum of sample KD01.

the Nganzi Block is composed of the following minerals: calcite, dolomite, quartz, plagioclase, kaolinite and opaques.

Angular to sub-angular sparite crystals and calcite veinlets observed in some samples suggest a neomorphism explaining the replacement of sparite at cavities left by supratidal domain evaporites [10].

The observed automorphic, subautomorphic and xenomorphic quartz grains are fine to coarse; some with cracks and show uniform extinction which shows that they originate either from volcanic rocks or recycled sedimentary rocks). The different quartz shapes described indicate that the hydrodynamic regime that transported these grains into the carbonate platform varied somewhat. Taking into account the size of the grains, their shape as well as their degree of rounding, we can say that these particles underwent a long transport by water. The existence of plagioclases recognizable by their polysynthetic macles suggests the presence of reliefs responsible for a rapid transit of sediments towards the basin. As a result, this carbonate platform was considerably supplied with detrital and terrigenous elements [11].

3.5. Porosity and Permeability

The geological investigations carried out on the surface of the Nganzi Block and the results of the laboratory analyses allow us to affirm that this Block is very interesting for petroleum. The geophysical characteristics that sufficiently prove the petroleum interest of the Nganzi Block are listed in **Table 4**.

Table 4. Petrophysical characteristics of the lithofacies of the Nganzi Block.

Echantillon	Lithofaciès	Perméabilité (K) en Md	Porosité (Φ) en %	% Huiles	Observation
KK07	Calcaire blanc	138	16.35	-	
KK12	Calcaire grisâtre	155	13	-	Réservoirs potentiels
KK16	Calcaire verdâtre	145	18.48	-	
KD01	Calcaire gris foncé	152	12.65	20.15	Réservoir imprégné d'huile
KK52	Grès calcareux	162	17.65	22.98	Réservoirs gréseux imprégnés d'hydrocarbures

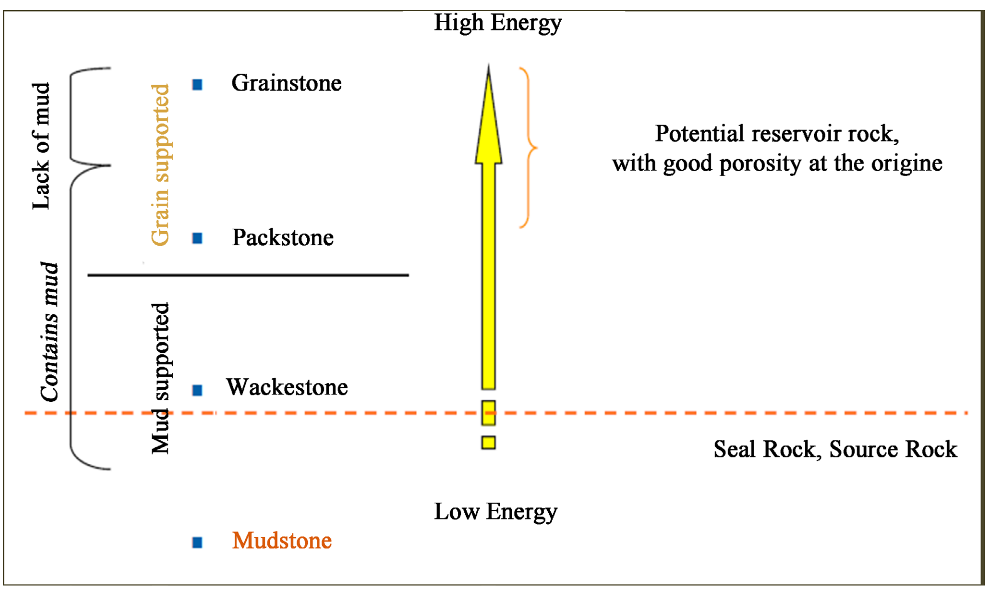

Figure 15. Textures of carbonate rocks according to the energy of deposition and their petroleum interest (Huc A.Y., 2006) [14].

The facies encountered in the study area are predominantly carbonate; they belong to the Vermelha and Mavuma formations which constitute the main reservoir rocks in the Onshore part of the Coastal Basin in production. These carbonate lithofacies described present potential reservoir qualities for conventional hydrocarbons because [12] [13] [14].

- Porosity and permeability values of these rocks are average as they are respectively between 13 to 19% and 138 to 155 mD;
- Wackestone, packstone and grainstone type textures are generated in a high hydrodynamic energy environment marked by pseudomorphism and bioturbation phenomena (**Figure 15**).

The active surface showings mapped in the study area are unmistakable evidence of hydrocarbon genesis in the coastal basin. These surface hydrocarbon occurrences are therefore strong evidence of a well-functioning petroleum system in the area. The hydrocarbons would be dysmigrated through faults in the carbonate rocks as attested by the microfractures in the made-up slides and would also be due to a sealing defect above the formations encountered. Two hypotheses would explain the origin of these hydrocarbons:

Firstly, they would come from the Bucomazi bedrock rich in type I organic matter, which is about 10% TOC. These hydrocarbons migrated by per-ascensum along the normal faults generated by the distension movements during the rifting process in the birth of the Atlantic Ocean. They moved laterally through porous and permeable drains in the monoclinal Chela Formation [15] [16] [17].

Secondly, they would come from the post-salt formations of MAVUMA and VERMELHA and would be dysmigrated as a result of biodegradation of hydrocarbons or as a result of a sealing defect above these formations, which are considered to be productive reservoirs in certain oil fields of the Perenco-Rep. concessions.

4. General Conclusions

In order to restart the exploration works in the Nganzi Block located onshore of the DR Congo Coastal Basin, the carbonate lithofacies were described on the field, sampled and submitted to laboratory analyses in Europe (Belgium) and locally, at the National Laboratory of Public Works of the Office de Route and at the Centre des Recherches Géologiques et Minières in Kinshasa.

On the petrographic and mineralogical level, eight (08) lithofacies, of which three (03) are detrital and five (05) carbonate, have been recognized in the Nganzi Block. These are: sands, sandstones, hydrocarbon impregnated pebbles, white limestones, grey limestones, green limestones, massive dolomites and dolomites in platelets. The carbonate lithofacies are characterized by wackestone, packstone and grainstone textures with a predominance of the usual minerals, calcite and dolomite. These rocks have been contaminated by terrigenous inputs highlighted in their mineralogical composition by quartz, plagioclase and kaolinite.

With an oil content of about 23%, the Nganzi carbonates have a porosity of between 11 and 19% and a permeability varying from 138 to 155 mD. They are therefore potential oil reservoir rocks.

These results are sufficient proof that the Nganzi Exploration Block is interesting from a petroleum point of view.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] DR Congo (2015) Law No. 15/012 of August 1, 2015 on the General Hydrocarbons Regime. Official Journal of the DR Congo, 56th Year, 1st Part, Special Issue, Kinshasa, 48 p.

[2] Sanda, O., Mabrouk, D., Tabod, T., Marcel, J., Essi, J. and Ngos III, S. (2020) The Integrated Approach of Seismic Attributes for the Lithological Characterization of Reservoirs: Case of Block F3, North Sea-Netherlands Sector. *Open Journal of Earthquake Research*, **9**, 273-288. https://doi.org/10.4236/ojer.2020.93016

[3] Arbab, B., Jahani, D. and Movahed, B. (2017) Characterization of Carbonate Reservoirs in Low Resistivity Peasant Areas in the Buwaib Formation, Persian Gulf. *Open Journal of Geology*, **7**, 1441-1451. https://doi.org/10.4236/ojg.2017.79096

[4] Dunham, J. (1970) Reef Stratigraphy versus Reef Ecology. *American Association of Petroleum Geologists Bulletin*, **54**, 1931-1932.

[5] Folkl (1980) Petrology of Sedimentary Rocks. Hemphills, Austin, 182.

[6] Wetshondo Osomba, D. (2012) Characterization and valuation of clay materials in the Province of Kinshasa (DR Congo). Doctoral Thesis, Applied Sciences, University of Liège/Wallonia-Europe University Academy, Liège, 340.

[7] Thorez, J. (1976) Practical Identification of Clay Minerals. Ed. G. Lelotte, Dison, 90 p.

[8] Brown, G. and Brindley, G.W. (1980) X-Ray Diffraction Procedures for Clay Mineral Identification. In: Brindley, G.W. and Brown, G. Eds., *Crystal Structures of Clay Minerals and Their X-Ray Identification*, Mineralogical Society of Great Britain and Ireland, London, 305-359. https://doi.org/10.1180/mono-5.5

[9] Cook, H.E., Johnson, P.D., Matti, J.C. and Zemmels, I. (1975) Methods of Sample Prepration and X-Ray Diffraction Analysis in X-Ray Mineralogy Laboratory, Deep Sea Drilling Project, University of California, Riverside. In: Kaneps, A.G., *et al.* (Eds.), *Initial Reports of the Deep Sea Drilling Project XXVIII*, Printing Office, Washington DC, 999-1007.
https://www.semanticscholar.org/paper/Methods-of-Sample-Preparation-and-X-Ray-Diffraction-Cook-Johnson/0e78699f3c5f17b50ea71c79dfd058f84a76b448

[10] Boulvain, F. (2017) Elements of Sedimentology and Sedimentary Petrology. Lab. Sedimentary Petrology, University of Liège, Liège, 29 p

[11] Lucia, J. (2007) Carbonate Reservoir Characterization. The University of Texas at Austin, Bureau of Economic Geology, Geological Circular, Austin, 342 p.

[12] Perrodon, A. (1985) Petroleum Geodynamics: Genesis and Distribution of Hydrocarbon Deposits. Second Edition (Revised and Supplemented), Masson-Elf Aquitaine, Paris, 385 p.

[13] Cossé, R. (1988) The Deposit. Technip and French Institute of Petroleum, Paris, 352 p.

[14] Huc, A.Y. (2006) Petroleum Geochemistry. Course Notes, French Petroleum Institute (IFP), Paris, 115 p.

[15] Espitalie, J., Laporte, J.l., Madec, M., Marquis, F., Leplat, P., Paulet, J. and Boutefeu, A. (1977) Rapid Method for Source Rocks Characterization and for Determination of Petroleum Potential and Degree of Evolution. *Revue de l'Institut Francais du Petrole*, **32**, 23-42. https://doi.org/10.2516/ogst:1977002 https://ogst.ifpenergiesnouvelles.fr/articles/ogst/abs/1977/01/vol32n1p23/vol32n1p23.html

[16] Reyre, D. (1984) Petroleum Characteristics and Geological Evolution of a Passive Margin. The Case of the Bas-Congo-Gabon Basin. *Bulletin des Centres de Recherches. Exploration—Production Elf Aquitaine*, **8**, 303-332. https://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&idt=8939675

[17] Hamm, P.H. and Hochstrasser, L.M. (1998) Structure of the Amide I Band of Peptides Measured by Femtosecond Nonlinear-Infrared Spectroscopy. *The Journal of Physical Chemistry B*, **102**, 6123-6138. https://doi.org/10.1021/jp9813286