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Physico-Chemical and Petrographic Characterization of Carbonated Rocks of Mintom (South-Cameroon) and Their Potential Uses

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Abstract

The characterization of carbonated rocks of Mintom allowed identifying three features (massive limestone, banded limestone and dolomite). Samples taken in these features were subjected to the physico-chemical analyses and to the mechanical tests. The results obtained show a convergence in the mineralogical composition in particular in the calcareous features (smectite, micas and calcite); the dolomite feature being mainly constituted by dolomite associated with the smectite. The chemical composition allows finding contents raised in CaO, in all the samples. However, in the dolomite and the banded limestone, the concentrations in MgO and in SiO_2 are also important. The mechanical properties showed a good compression resistance for the massive limestone and the dolomite, the mechanical behavior of the banded limestone being low. The exploitation of these results allows recommending carbonated rocks of Mintom in the production of the clinker, agricultural amendments and in the constructions of the civil engineering.

Keywords

Mintom, Carbonated Rocks, Characterization, Physico-Chemical, Petrographic

1. Introduction

The need for major infrastructure work in Cameroon imposes a cement addition use for various concrete formu-

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lations. This ambition faces a very low national production for this type of binder because of a limited number of cement manufactures. The characterization of carbonated rocks of Mintom appears as well as one of the avenues to explore in order to consider the production of clinker from these rocks that may serve as raw material for cement manufacture. It is also important to consider other uses for these materials. Under these conditions, a more holistic characterization appears necessary in order to optimize the exploitation of carbonated rocks of the study area. This publication has two main objectives, firstly, chemical and petrographic characterization of rocks and secondly the identification of potential uses of each material.

2. Presentation of the Study Area

The study area is located in the Dja and Lobo Division between the districts of Djoum and Mintom in the administrative region of South Cameroon. It is hosted in the great valley of the River Dja at 592 m altitude [1]. This area is subjected to the equatorial climate with four seasons and extends from 13˚10' - 13˚30' Long E and from 2˚44' - 2˚55' Lat N (**Figure 1**).

3. Previous Work on the Site

3.1. Geology

Carbonated rocks of Mintom constitute the upper series of Dja [2]-[4]. A part from the sedimentary formations, the area reveals the presence of metamorphic rocks (gneiss, schist, mica) and plutonic rocks (gabbro, granite). Structurally, the region is crossed by numerous of tectonic structures such as faults, folds and mylonite. The work of [5] show that this basin is limited at North by the Pan African belt and at south by the Congo Craton (**Figure 2**). The main geological formations (shales, dolomites and limestones) are covered with argillites and laterite. Two main soils run throughout the area including yellow lateritic soils in land and hydromorphic soils in the lowlands [1] [6] [7].

3.2. Lithostratigraphy

The study of [4] led to subdivide the upper Dja series in four lithological units from bottom to top, there are: The unity of Kol, made with diamictite on its base and pelit on the summit; Metou unit composed of massive dolomite; Mominbolé unit that has an alternation of limestone and clay: it is a pelitic limestone and the Atog Adjap unit composed of clear limestone and yellowish gray band. From the photogeological analysis [2] [4], it appears that, the different features which form the sedimentary basin of Mintom stick out in a powerful soil layer near the Dja River. The survey S1 of [2] in BI was used to estimate the relative thickness of limestone feature (**Figure 3**). Thus, the massive limestone has a thickness of 21 m, while the banded limestone features extends over a thickness of 24 m.

3.3. Methodology

The methodology of work is divided into two major activities including field campaigns and laboratory work.

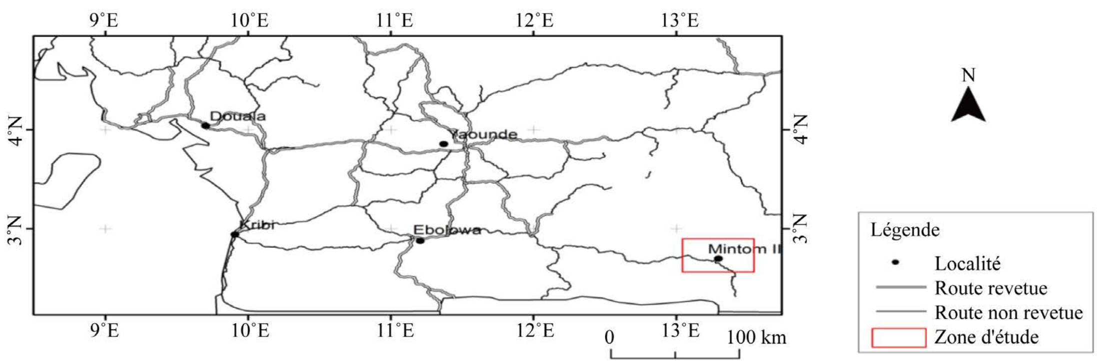


Figure 1. Location of the study area.

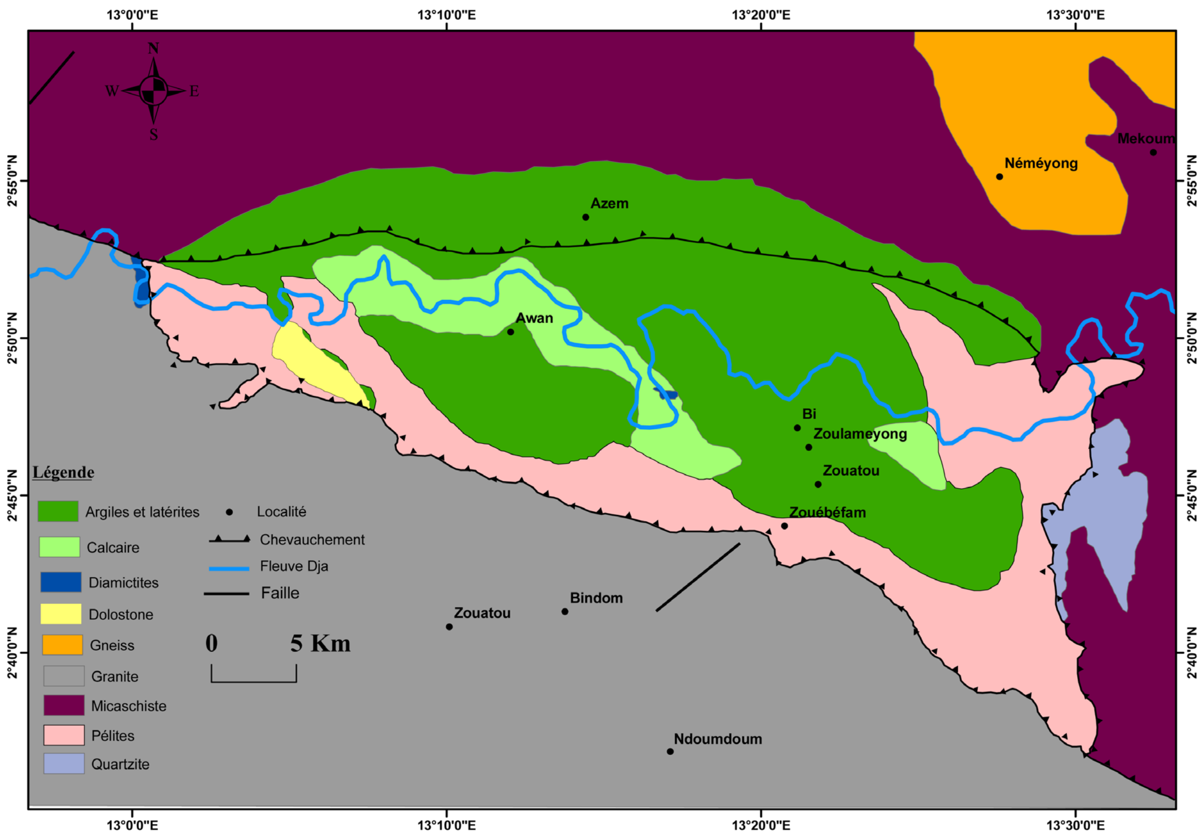


Figure 2. Geology of the area.

3.4. Field Campaigns

They took place in four stages. The first phase consisted of an exploration of the study area in order to locate outcrops; the second was used to determine the sampling points and the two last stages were devoted to sample in previously defined sampling points. The samples were collected by geological hammer at three points defined on various features. Then, they were packed in sampling plastic bags. Field campaigns have also helped to give the description of the different features encountered.

3.5. Laboratory Work

Laboratory work concern the analysis of different samples collected in the field. These analyzes were performed in different laboratories. The **Table 1** gives the synthesis of laboratory analysis.

4. Presentation of the Results

4.1. Outcrops and Geological Structures

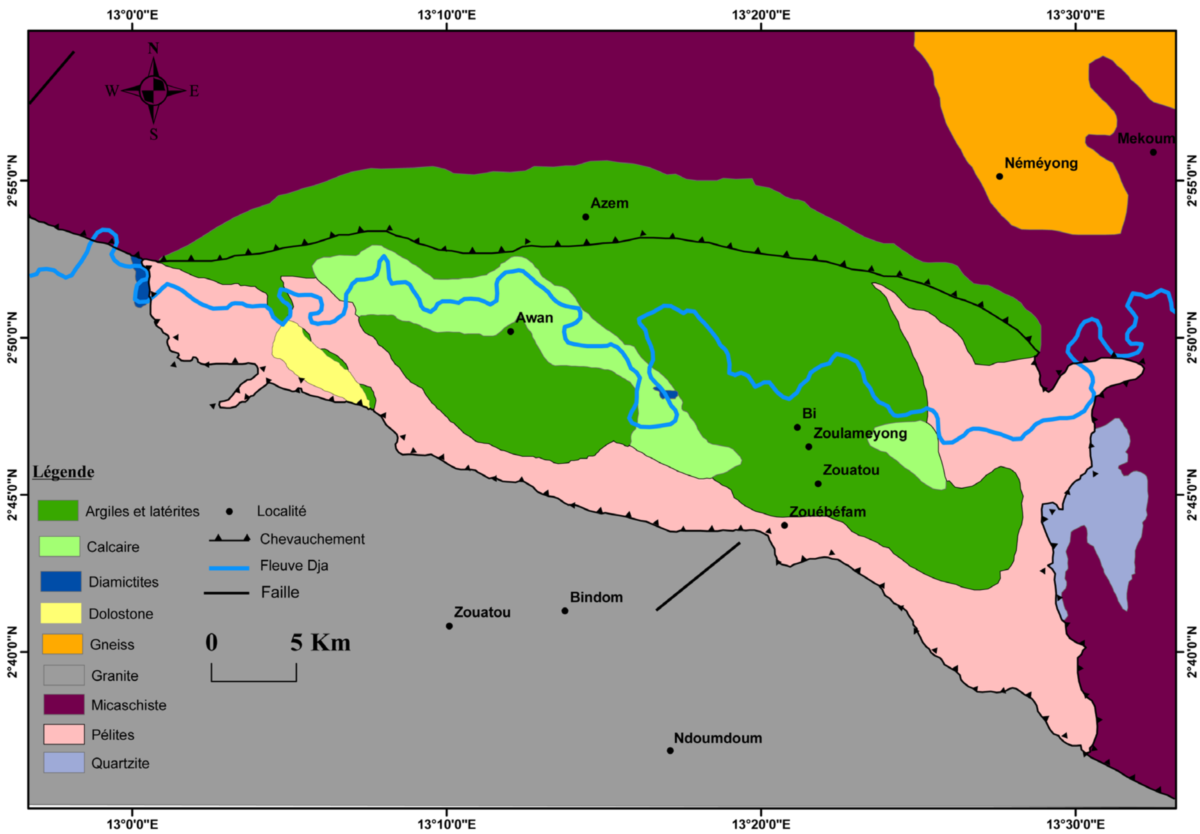
Several geological structures and outcrops were encountered (block, slab, escarpment, cleavage, bend, fault) (**Figure 4**).

4.2. Features

Three major features have been described from outcrops and geological structures (**Figure 5**). They are:

- **Massive limestone feature**

It is observed mainly in Atog-Adjap where it is very extensive. It is a hard gray rock and very effervescent in HCL. Its structure shows alternating benches separated by thin layer of dark argillite. In optical microscope, the rock is homogeneous and composed with very small crystals (<20 microns).



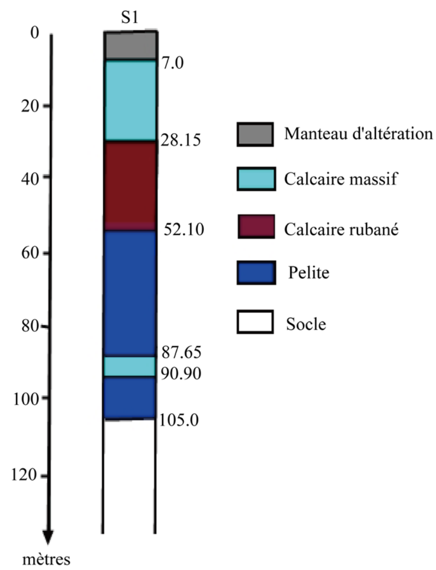


Figure 3. Stratigraphic log of survey S1.

- **Banded limestone feature**

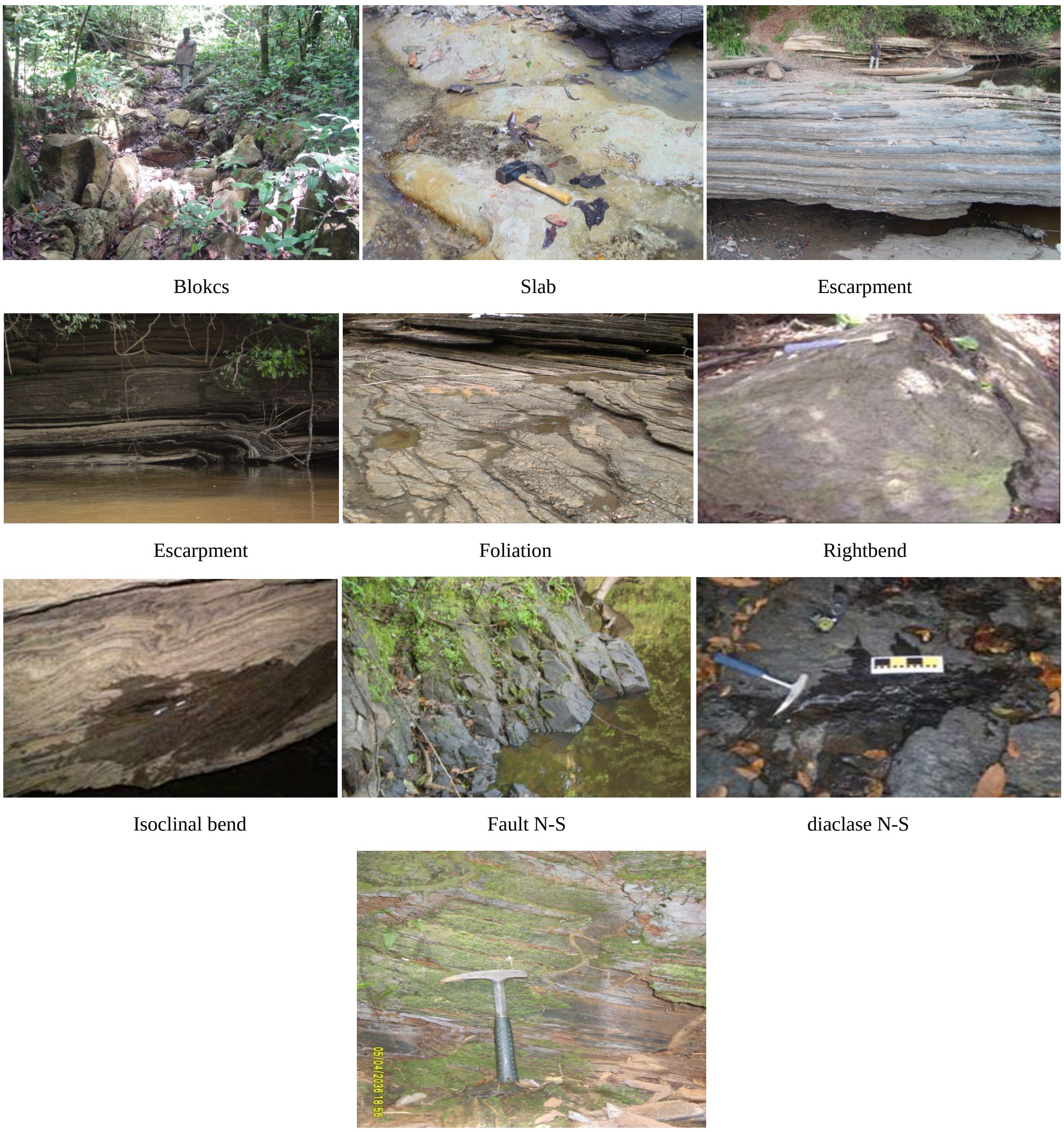
It is a dark gray rock characterized by alternating light and dark bands. The thickness of a band varies between 10 - 15 cm. In thin blade, the texture is cryptogranular with small calcite crystals (0.03 mm). We also note the presence of veins (e = 60 microns) filled with black politic material.

- **Dolomite feature**

It is a massive ocher rock, very resistant to hammer and very low effervescence in HCl. In microscope, the bottom is dolomicritic with many microcracks showing dolomite and quartz recrystallization. It is noted the

Table 1. Summary of laboratory works.

Works and analysis performed	Laboratories involved
Cutting rocks, obtaining powders and preparation of thin sections	Minerals Processing Laboratory (MTL) of the Institute of Geological and Mining Research (IRGM) in Cameroon
DRX whole rock	Mission of Promotion of Local Materials (MIPROMALO), Cameroon
Preparation of thin sections Optical microscopy, major element (geochemistry)	Mineral Sciences Laboratory at the National Office of Geological Research, Algeria Office of Geological and Mining Research (BRGM), France
Physico-mechanical analyzes and mechanical tests	National Laboratory of Civil Engineering, Cameroon
Gravimetry, geochemistry of major elements	Laboratory of Chemical Analyzes, Figuil, Cameroon



Blokcs Slab Escarpment

Escarpment Foliation Rightbend

Isoclinal bend Fault N-S diaclase N-S

Pelit

Figure 4. Outcrops and structures of the study area.

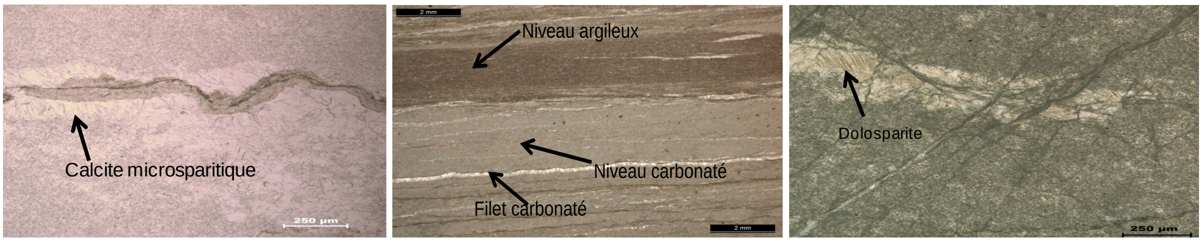


Figure 5. Features encountered. (1) Massive limestone feature; (2) Banded limestone feature; (3) Dolomite feature.

presence of micro-cracks and wall rock piles in pyrite grains.

4.3. Mineralogy

The X-ray diffraction analysis sample's powders obtained from different features gave the results that are illustrated by corresponding diffractograms. From these results (**Figure 6**), it appears that calcite, mica and smectite constitute the major elements of massive limestone. The banded limestone is composed of calcite; mica and smectite while the mineralogical composition of dolomite is made only by dolomite and smectite.

4.4. Geochemistry

Chemical analyzes of samples have identified the different chemical compositions of the different features expressed as percentages of oxides. **Table 2** presents the summary of the results. The analysis of these results shows that the massive limestone is rich in CaO and SiO_2, the massive limestone in CaO. For dolomite, the most important elements are the CaO and MgO. These contents can be the basis for various industrial uses.

4.5. Mechanical Properties

The exploitation of mechanical results (**Table 3**) shows that the massive limestone rock is a low-wear, resistant to both, fragmentation, and compression and relatively dense. The banded limestone meanwhile is a rock with high wear, weakly resistant to both fragmentation, and compressive strength and low density. Concerning dolomite, it is a rock with very low wear, very resistant to both, fragmentation and compression and relatively dense.

4.6. Areas of Use of Rocks

The main uses recognized for carbonated material and the main uses of specifications are presented below:

For massive limestone

It can serve as raw material for the production of clinker (CaO > 42% MgO < 2% Fe_2O_3 > 1% Al_2O_3 > 2% SiO_2 > 6%); Agriculture's amendments and production of quicklime. Mechanically, its low wear (MDE = 17%), high resistance to fragmentation (LA = 20%), its high compressive strength (MPa = 107) and its high density, predispose it in civil engineering work.

For banded limestone

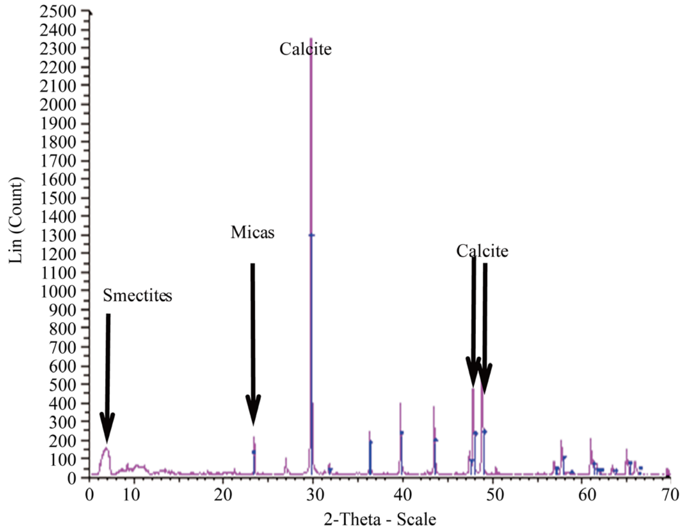
Their high wear MDE = 48%), low resistance to fragmentation (LA = 27.5%), their low density and compressive strength MPa = 49) showed that the main uses of this material are recruited in the areas of ornamental stones.

For dolomite

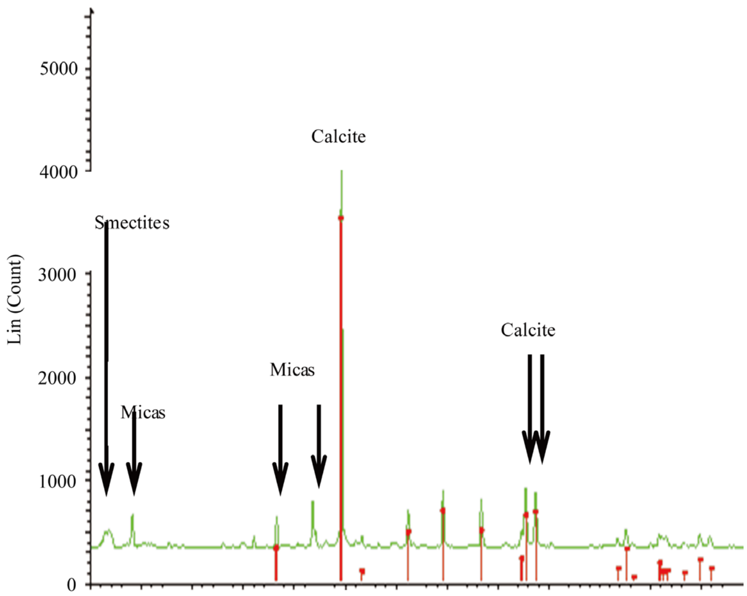
Geochemical properties of dolomite show that it can be used in the steel industry or agriculture as amendments. Its mechanical properties notably its low wear (MDE = 11%) its high resistance to fragmentation (LA = 19%), its high compressive strength (MPa = 118) and high density, describe it as good material in civil engineering.

5. Discussion of Results

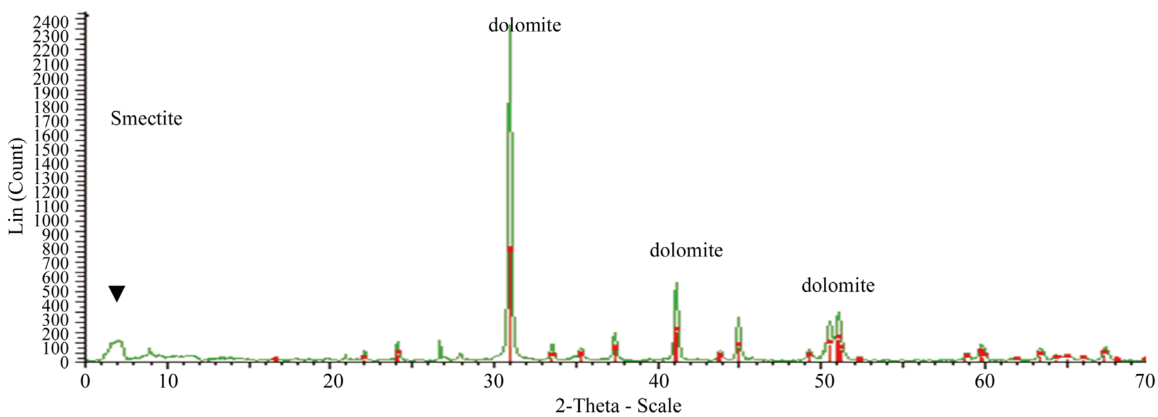
The Mintom carbonate rocks were already the subject of previous work [4] [8] and [9]. The [2] and [3] have focused on the establishment of a cement factory in Mintom and the determination of its location. The study of the



(a)



(b)



(c)

Figure 6. Mineralogy of features. (a) Massive limestone; (b) Banded limestone; (c) Dolomite.

Table 2. Summary of the results of chemical analysis.

Sample/Feature	SiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	SO_3	PF	Total
Massive limestone	6.70	1.70	0.74	0.02	1.10	48.30	<Ld	0.63	0.11	<Ld	0.32	39.00	98.30
Banded limestone	23.48	5.43	3.50	0.10	2.53	25.71	0.13	2.35	0.36	0.11	<Ld	29.46	93.16
Dolomite	5.72	1.79	0.93	0.06	18.42	29.29	0.01	0.54	0.11	0.05	0.32	42.80	99.72
L.d	0.2	0.2	0.05	0.02	0.2	0.1	0.2	0.05	0.05	0.05	0.05	0.1	

Table 3. Mechanical properties of the samples collected in different features.

	Nbreof test	MDE in % (wear)	LA in % (fragmentation)	Compressive strength (MPa)	Volumetric weight in (g/cm^3)
Massive limestone	1	16	**22**	**126**	**2.55**
	2	18	**18**	**91**	**2.52**
	3	/	/	**104**	**2.04**
	4	/	/	/	**2.18**
	average	17	**20**	**107**	**2.32**
Banded limestone	**1**	**49**	**26**	**45**	**1.93**
	2	**47**	**29**	**45.6**	**1.91**
	3	/	/	**56.2**	**2.18**
	4	/	/	/	**2.00**
	average	**48**	**27.5**	**49**	**2.00**
Dolomite	**1**	**10**	**20**	**135**	**2.07**
	2	**12**	**18**	**100**	**2.20**
	3	/	/	**120**	**2.48**
	4	/	/	/	**2.31**
	average	**11**	**19**	**118**	**2.30**

environment deposits of carbonate rocks and their implications on the theory of the earth Snowball in Neprozoic is tackled by [4]. All these studies agree on the fact that the carbonate rocks of Mintom fall into several features organized in different lithostatic units. However, on contrary, the work of [4], which identify three different features in the basin notably massive limestone, banded limestone and dolomite, [2] had reported only made of limestone feature. Also, there is a clear difference between the origins of the samples analyzed; the samples analyzed in this study were collected in the feature of rock outcrops while other authors have analyzed samples with a drill core S1. The comparison results show that the samples of the core, especially the upper part with a depth of between 7 m and 28 m have great interest in the production of clinker thank to their very high content CaO. This result is in agreement with the work of the Ministry of Scientific Research and Innovation, which situates the limestone under a layer of laterite and conglomerate at the same depth. All authors also agree on the various highlighted carbonated rocks for direct use in the context of civil engineering constructions or indirect use when chemical composition is favorable to the production of clinker [2] [4] [8]-[11]. However, several security arrangements must be made to face several diseases in the locality of the clinker's manufactory [12]-[15].

6. Conclusion

This work, done in the Mintom sedimentary basin in equatorial South East Cameroon, was to examine all uses of an industrial nature of carbonate rocks of the basin. To do this, petrographic, mineralogical and geochemical characterization prior, associated with physical-mechanical testing was necessary. The main results show that the studied basin contains three features including the massive limestone, banded limestone and dolomite. The massive limestone is hard rock, light gray, to micritic texture composed of calcite, combined with small amounts of mica and smectite. The chemical composition is dominated by the CaO while banded limestone is a dark gray rock with cryptogranular texture composed of calcite and mica. The dolomite is a massive ocher rock with dolomicritic texture and composed essentially of dolomite. Its chemical composition is dominated by CaO and MgO. In mechanical terms, the massive limestone and dolomite rocks are dense, which exhibit good resistance to wear, fragmentation and compression. Conversely, banded limestone is softer and more fragile. The petrological, physical and mechanical properties of materials studied show that they can serve as raw material suitable for the production of clinker, lime and agricultural amendments and civil engineering's work.

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