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PETROGRAPHIC CHARACTERISATION AND PALEOENVIRONMENTAL RECONSTRUCTION OF THE KIPALA SHALES (CENTRAL BASIN, DRC, KWILU PROVINCE).

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ABSTRACT

In order to fill the glaring gaps in geological data for the Kipala region, in the Kwilu province of the Democratic Republic of Congo, geological studies were carried out. The results identified four different lithofacies in the study area: dark greasy shale, feldspathic microgres, clayey sandstone and bituminous shale. The petrographic compositions and palaeoenvironmental conditions of the deposit are presented for the first time in this work. From a petrographic point of view, the rock samples analysed differ in the nature of their constituent minerals and/or matrix or cement. Similarly, there is a close relationship between local lake and river sediments. The size and degree of rounding of the clayey sandstones in the rocks studied suggest that they were transported over a long period under strong hydrodynamic conditions.

Keywords: shales, Petrography, Lithofacies, Paleoenvironmental, outcrops

1. INTRODUCTION

Given the current state of knowledge, it is very difficult to accurately estimate the geological resources present throughout the whole of the DRC, due to a lack of sufficient data, hence the real need for investment in geological exploration work [1]. The province of Kwilu (DRC) in general, and the Kipala region studied in particular, are no exception. The geology of this region remains unresolved.

From a geological point of view, the Kwilu province in general, and the Kipala region studied in particular,belong to the 'Kwango Group' of the litho-stratigraphy of the large central sedimentary basin of the DRC (Figure 1). This litho-stratigraphic column results from the compilation of outcrop and borehole data and the interpretation of seismic reflection profiles [2],[3],[4],[5],[6]. The level of knowledge of this Kwango group from a petrographic and palaeoenvironmental point of view varies from one part of Kwilu province to another, with only the Kikwit, Bulungu and Kipala regions having been investigated. The work of Passau in the first half of the 20th century (1920), followed by that of Henry (1986) obtained from data from two boreholes drilled by the DRC water administration in the Kikwit region in 1983, and in the Bulungu region in 1984, made it possible to establish that: (1) the Kwango Group is represented in these regions by a fairly monotonous succession of coarse-grained sandstones, sometimes conglomeratic, soft fine-grained sandstones with varying degrees of clay and occasional silicified levels, and at the base argillites, mainly red in colour, known as the 'Inzia layers'; (2) the 'Inzia layers' lie at a depth of around 250 to 300 m on a Precambrian bedrock which, unfortunately, does not outcrop in the region; and (3) all the geological

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formations in the region have an azimuthal direction varying from N170° to N180°, and a dip varying from 10 to 20° to the WNW. Still in the Kipala region, [7] and [24] focused their research on the discovery of a fossil fish site. The fossils are those of fish whose origin would later become the subject of controversy: continental origin for some authors e.g. [2], mixed for others. The latter authors see a mixture of fish of marine and continental origin, specific to the lagoon environment e.g. [24]. In the Kipala region studied, the tabular geological structure of these Cretaceous Kwango series and the existence of a thick Cenozoic sandy-loam cover mean that outcrops are very rare. As a result, the lithology of the Kwango Cretaceous series in the Kipala region is poorly known, to the extent that even on the 1:2,000,000 geological map of the DRC, the formations in this region are loosely grouped together under the term 'undifferentiated Cretaceous'[7].This review of the geological literature clearly shows a gap in our knowledge of the lithology of the Cretaceous Kwango series in the Kipala region. This gap motivated us to undertake this study, which will focus on determining the petrographic compositions of the various lithofacies that outcrop in the study area, together with the paleoenvironmental conditions of deposition, in order to place them in the regional geological context.

2. PRESENTATION OF THE STUDY AREA

2.1. Location, morphology and hydrography

The study area is located in the territory of Bulungu (Kwilu Province) in the central basin of the DRC, between longitude 16°.30 E, latitude 0°.30 S and longitude 25°.15 E, latitude 4°.30 S (Fig.2). It has long been the focus of the following scientific research: geology [8], [9]), geophysics [10],[11], stratigraphy [12],[5], palaeontology ([13],[14] and hydrocarbons [2],[15].

2.2 Geological setting

As mentioned above, the geological formations in the target area are part of the Kwango Group (or Kwango Formation) which, together with the Bokungu, Loia and Dekese Groups, forms the 'Cretaceous series' of the lithostratigraphic subdivision of the Central Cuvette Basin of the DRC [10] [11], [5], [2], and [15]. (It is important to remember that the main lithofacies making up the Kwango Group in Kwilu province in general are listed in the introductory section of this note; however, no data are available for the region under study. On the whole, the geological structure is almost tabular, with layers dipping 10° to 20° to the NW [15], and covered by a Cenozoic sandstone-clay cover that is sometimes very thick. This structural slope, which also affects the post-Cretaceous capping and levelling levels, is thought to be the result of the progressive uplift of the southern edge of the central DRC basin during the Quaternary [16], [6].

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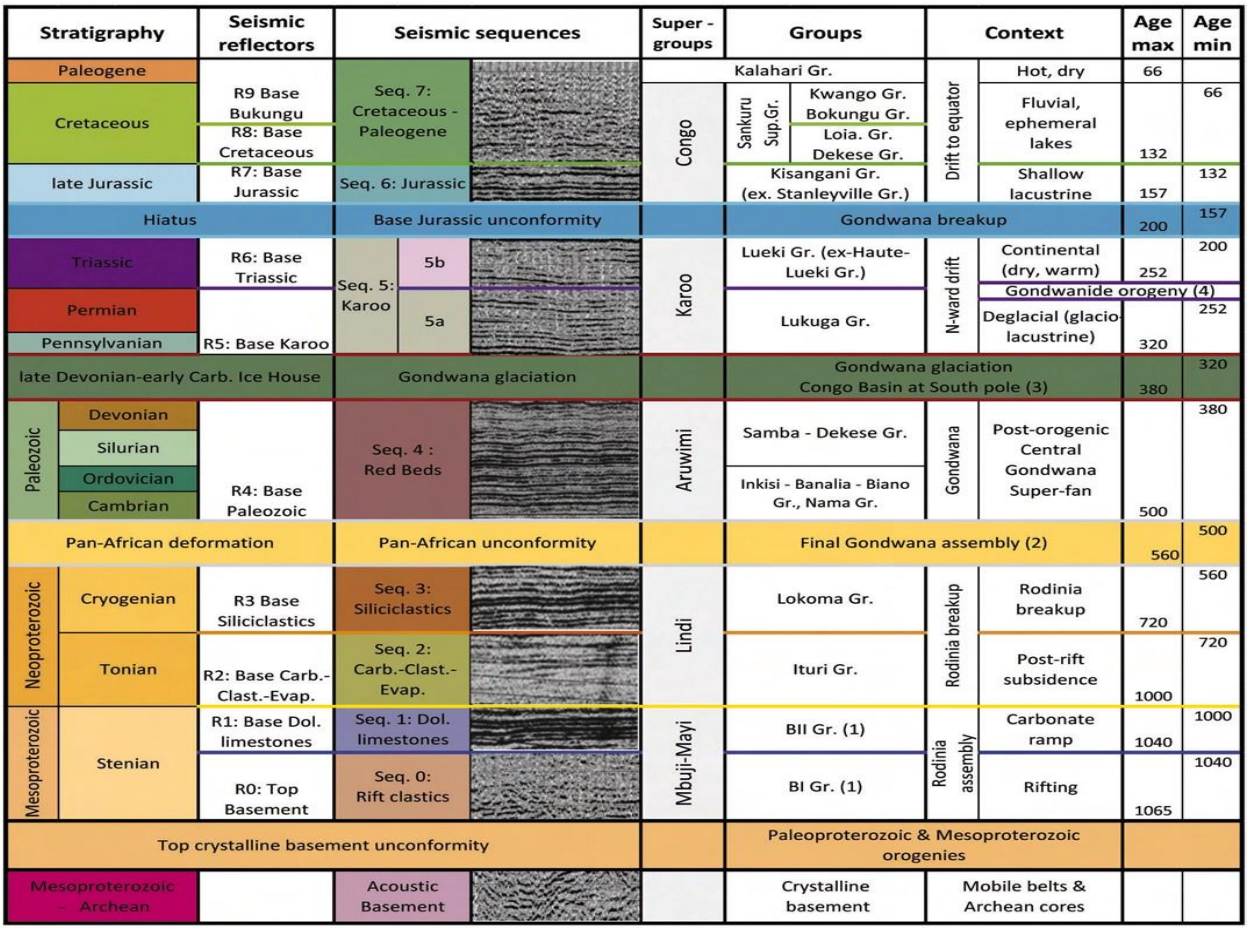

Figure 1: Composite seismo-stratigraphic model integrating well and outcrop data and seismic reflection profiles, age estimates for the central DRC sedimentary basin. The thick coloured lines refer to the limits of the sequences interpreted in the profiles [6].

3. METHODS, TECHNIQUES AND EQUIPMENT

Apart from the documentation phase, this work went through the following two stages:

3.1. Field research phase

An exhaustive geological survey was carried out in the region, particularly along the main watercourses (Kamazina, Kitamada, Bayelebwir, Mbaba.) and on the lower slopes (quarries). In order to get a general idea of the geological environment of the shales in the study area, we spent three weeks in the field carrying out an exhaustive geological survey and taking rock samples. The basic geological equipment used was as follows: a hammer, a compass with built-in clinometer (for structural measurements), a GPS (Grawin brand) (for geographical location), a marker, a notebook and pen, bags (for packing the samples) and a 1:125,000 topographical map of the study area (Figure 3).

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3.2. Laboratory research stage.

Laboratory research included (1) the selection of representative samples for the production of thin slides, at the Geosciences Laboratory of the University of Kinshasa. The thin sections were analysed under a polarising microscope. Mineral determination was based on the specific criteria established by [17], [18], using both Polarised Analysed Light (PAL) and Polarised Unanalysed Light (PUAL).

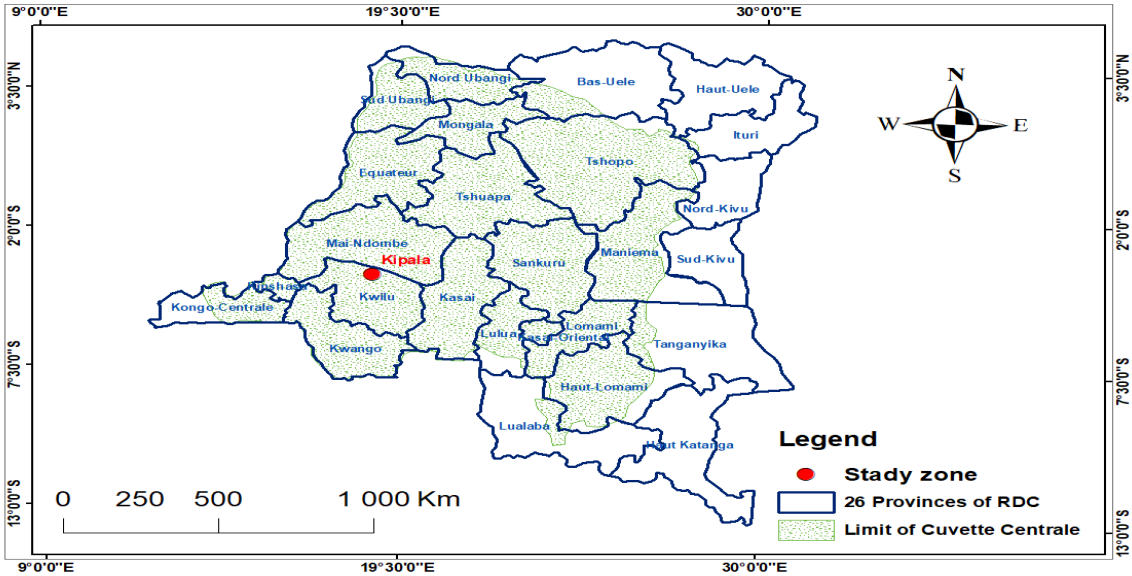

Figure 2. Map showing the location of the study area in the Central Cuvette region of the DRC

4. RESULTS AND DISCUSSION

The location of the observation and sampling stations (with the initials KPL) is shown in Figure 3.The geographical coordinates of the main observation and sampling stations are summarised in Table 1.

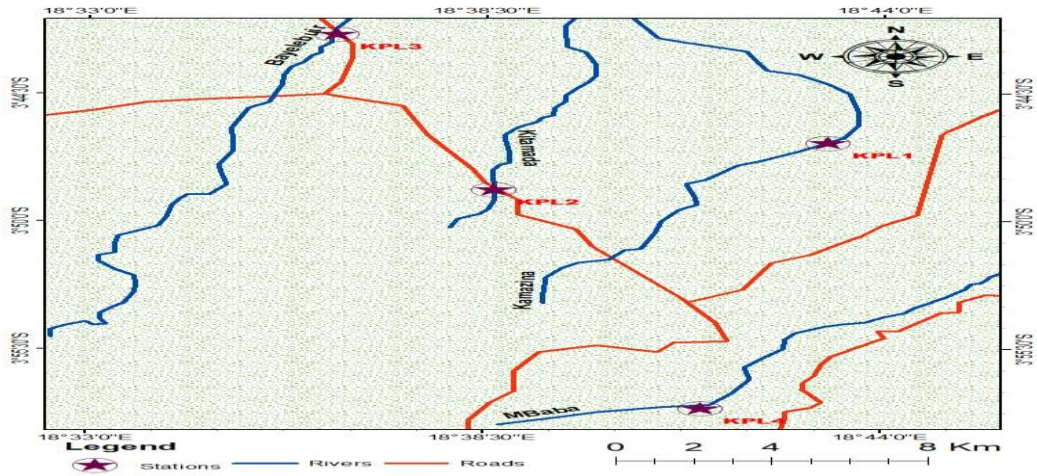

Figure 3.Location map of observation and sampling stations.

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Table1. Coordinates of the main observation and sampling stations in the Kipala region

Stations	Longitude	Latitude	Altitude (m)	Geographical Landmark
KPL1	E 18°37’14,9’’	S 3°56’36’’	415	River Kamazina
KPL2	E 18°36'609’’	S 3°54’48,6’’	436	River Kitamada
KPL3	E 18°35’57,69’’	S 3°55’32,514’’	426	River Bayelebwir
KPL4	E 18°35’47’’	S 3°55’6,44’’	453	River Mbaba

4.1. Petrographic analysis

From a petrographic point of view, four different lithofacies have been defined in the study area; their petrographic characteristics are presented below:

4.1.1. Dark greasy shales

Its most remarkable outcrops are located on the Kamazina river (station KPL1) (Figure 4.A and B),(Table 1).

Figure 4.Views of outcrops (A, B) and samples (C, D, E) of the Kipala dark and greasy shales.

Macrocopically, it is a dark, fine-grained rock that is oily to the touch. It has a millimetre to centimetre bedding and is cut into sheets. Its constituents are invisible to the naked eye, with the exception of pyrite, whose crystals reach centimetre size. Black laminae (organic matter?) sometimes run through the rock (Figure 4A and 4B).
Microscopic observations show that the rock has a pasty texture, with a fine to medium grain size, composed of quartz, accompanied by black micas, bound together by a clay cement; the grains are rounded to sub-rounded and poorly sorted. This lithofacies is classified as schist.

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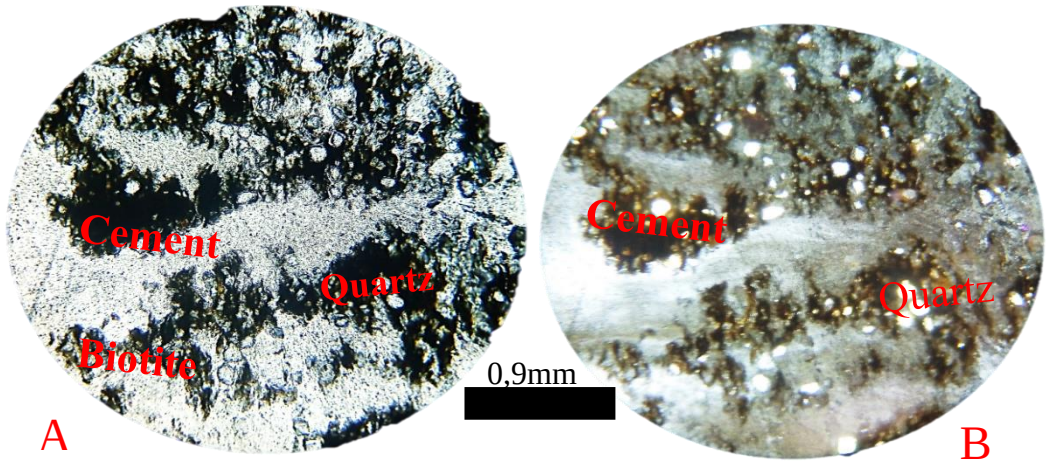

Figure5. Microscopic views of Black Schist (KPL1) (A: LPNA; B: LPA; magnification 10x).

4.1.2. Feldspathic microsandstone.

Typical outcrops of this lithofacies are located on the Kitamada river (KPL2 stations) (Figure 6) (table 1).

Figure 6.Views of outcrops (A) and samples (B) from the Kitamada River Black Shale.

Macrocopically, there is an outcrop of centimetre-bedded clayey sandstone, which forms the bed of most of the rivers in the Kipala area. The rock found at this station is similar to that at station 1 (Figure 4). Microscopic observations show that the rock has a jointed texture and a medium to coarse grain size, rich in quartz, with cracks and angular to sub-angular grains bound together by clay cement (Figure 7).

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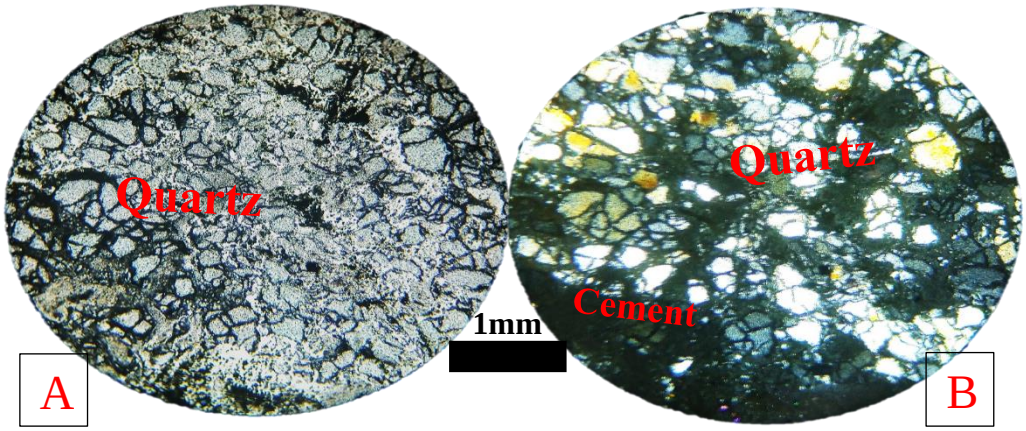

Figure 7: Microscopic views of the clay sandstone (KPL2) (A: LPNA; B: LPA; magnification 10x).

4.1.3. Clayey sandstone

The typical outcrops of this lithofacies are located on the Bayelebwir river (stations KPL3)(Figure 8A) (table 1).

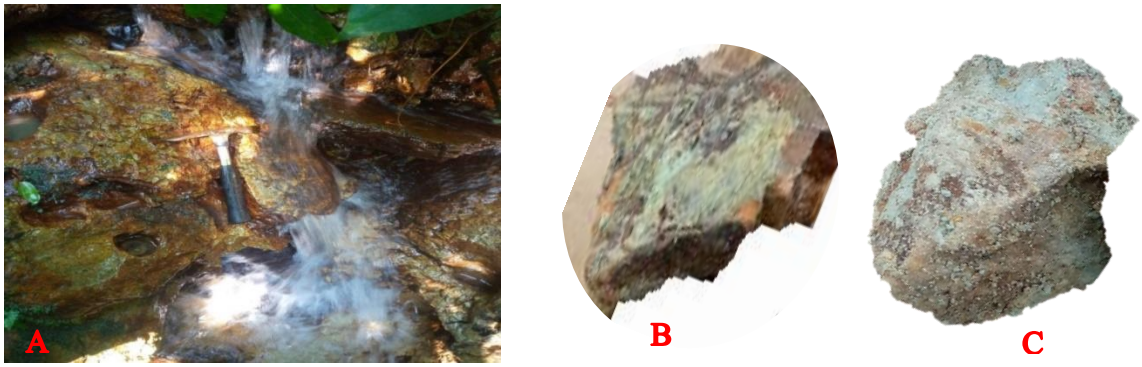

Figure .8 Views of outcrops (A) and samples (B,C) of Bayelebwir River claystone.

Macrocopically, there is an outcrop of centimetre-bedded clayey sandstone, next to which is an outcrop of a massive, greenish-grey mudstone, but it is very altered by the fact that it is in an aquatic environment (river) where it forms the river floor (Figure 8A).

Microscopically, it is jointed in texture, with a medium to coarse grain size, rich in quartz, which is rounded to sub-rounded in shape. Poorly sorted elements bound by a sandstone-clay cement. Opaque oxides (pyrite) are present in this rock (figure 9).

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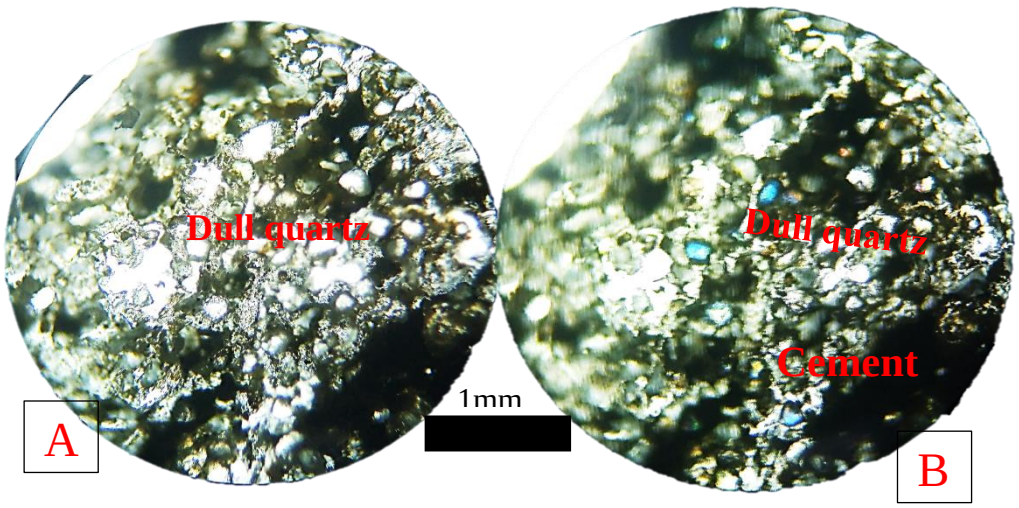

Figure 9. Microscopic views of the clay sandstone (KPL3). (A:LPNA; B : LPA; Magnification 10x.

4.1.4. Bituminous shale

The outcrops of this formation are located near the Mbaba river (station KPL4) (Figure 10.A and B)(table 1).

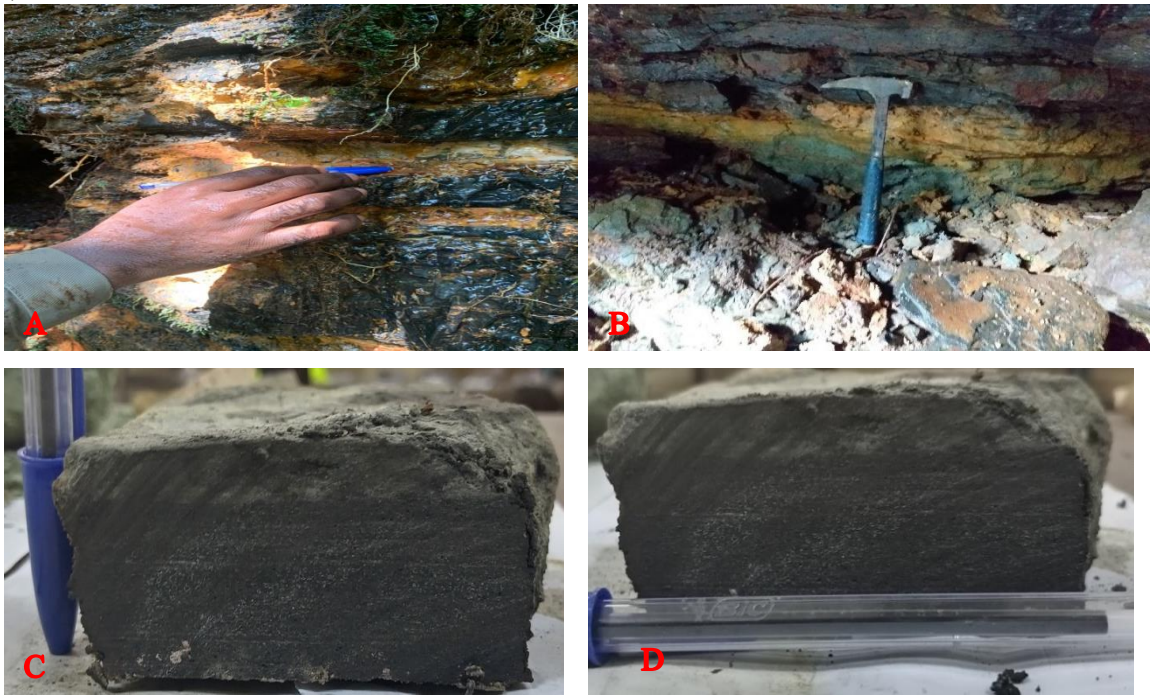

Photo 10. Views of outcrops (A, B) and samples (C, D) of the dark and greasy shales of the Mbaba river.

Macroscopically, the rock is black and strewn with black laminae, very rich in organic matter.
Microscopically, the rock exhibits a fine-grained texture criss-crossed by numerous bands of matter that remain black in both LPNA and LPA, with little quartz (Figure 11).

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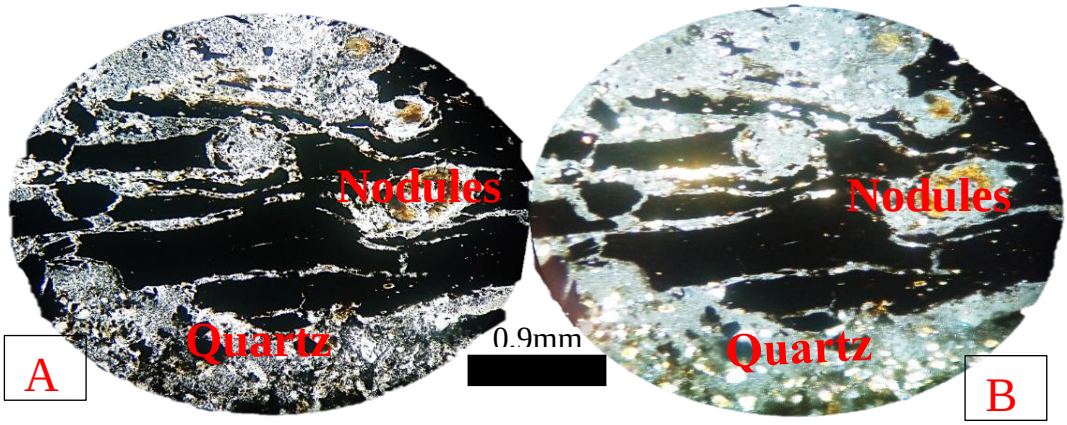

Figure 11: Microscopic views of the bituminous shale (KPL4) (A: LPNA; B: LPA; magnification 10x).

4.2. Paleoenvironmental conditions of deposition of the rocks studied.

Given the size and shape of the rock, which is essentially made up of coarse, sometimes conglomeratic sandstones interspersed with levels of fine soft sandstones, shales and clayey sandstones that are abundant in most of the rocks studied, there is reason to believe that the hydrodynamic regime that transported these shales and clayey sandstones varied somewhat between continental and mixed origins (continental + marine), i.e. a lagoon environment. Some of the rocks studied have a clay matrix with discrete fine grains of silica. As we know, clay minerals are the product of the alteration of sedimentary, metamorphic and igneous rocks. However, these rocks do not contain pre-existing clay minerals, but one of their constituents, feldspar, is easily degraded into clays [20]. Burial-related dissolution therefore mainly affects the most vulnerable grains, namely feldspars (particularly potassic feldspars), whose elements contribute to the formation of clays [20], [19]. As for the siliceous cement present in the other rocks studied, in agreement with certain authors [21], [22], it mainly comes from interstitial silica released by the destruction of potassium feldspars and the transformation of smectite into illite (illitisation), and more rarely from the effects of quartz dissolution under high pressure. The siliceous cement is then organised around the periphery of the original quartz grains in successive layers [23], when these rocks were deposited in an oxidising environment.

5. CONCLUSION

A geological study carried out in the Kipala region, Kwilu province (DRC) revealed four different lithofacies (dark greasy shale, feldspathic microgres, clayey sandstone, bituminous shale) in Cretaceous formations that were previously undifferentiated in the study area, although they had been attributed to the Kwango group.
From a petrographic point of view, some of the rocks studied have a clay matrix and others a siliceous cement, with quartz grains that are sometimes blunt and sometimes rounded to sub-rounded, testifying to long and short transport respectively from the feeder zone to the sedimentation basin.
This hypothesis can be compared with that of [24], which suggests that the sedimentation environment for the lithofacies in the Kipala region was a lagoon, linked to the sea by a narrow channel, which closed at certain times. According to this author, this would explain the alternation of marine and freshwater fish fossils, and the absence of large species at the Kipala site [2].

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