# Stratigraphic Review of the Creataceous Tertiary Deposits of the Iullemmeden Basin in Niger and Nigeria

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**ABSTRACT----** ***The Cretaceous – Tertiary deposits of the Iullemmeden Basin in Niger and Nigeria have been reviewed. The sediments include the continental Tegama Series/Illo-Gundumi group made of fluvio-lacustrine deposits of conglomeratic base with massive, feldspathic clayey grits, pebbly sands and intercalation of nodular clays. They are overlain by the marine Majia/Rima group which consists of shale, marl, limestone and alternating sandstone. The Cretaceous sediments are unconformably overlain by the Tertiary marine Garadoua/Sokoto group which is made of slightly indurated bluish – grey shale, interbedded with limestone. The Continental Terminal Group made of ferruginized red and mottled massive clays with sandstone and lignite intercalations capped the stratigraphic succession. The Cretaceous sediments contain invertebrate fossils like Neolobites Vibrayeanus, Nigericeras, Coilopoceras inflatum and Libycoceras and vertebrate fossils particularly skulls, limb bones, teeth, etc. of crocodiles, dinausors and fishes. The Tertiary fauna is mainly made of bivalves, echinoids (Linthia soudanensis) gastropods, nautilus and foraminifera (Ranikauthalia). Economically, the Cretaceous –Tertiary deposits in both countries supply raw material (clays, limestones and gypsum) for the local cement factories with possibility of coal in near future in Niger Republic where the sediments are thicker.***

**Keywords----** Iullemmeden Basin, Stratigraphic Review, Nigeria, Niger,

## 1. INTRODUCTION

Niger and Nigeria are two West African countries linking the Sahara and the Atlantic Ocean. The two counties share an intracratonic inland basin that hosts key information on the geology of West Africa: the regional Iullemmeden. In Niger Republic, this basin runs in a north-south trend and is named the western basin. In Nigeria, it occupies the Northwestern part of the country locally known as the Sokoto basin. The name "Iullemmeden" was first given to the basin by [1] who effectively redefined the area previously described by [2] as the Bassin de L'Oued Azazouk.

The Basin is a large intracontinental depression overlying a buried rift system. It is bordered to the north by the igneous masses of Adrar des Iforas, the Hoggar and Air Mountains; to the south by the Benin Republic-Nigeria Basement; to the east by the Air-Damagaram axis and to the west by the River Niger Fault (Fig.1).

The basin is filled up with Paleozoic sediments in the North and Mesozoic – Cenozoic deposits in the south. It is associated with some mineralizations including uranium, coal, limestone, and water as the major ones.

A lot of thorough geological investigations have been undertaken from early 1900's to date. In Niger, we can cite the works of [1, 3, 3-18, 18-21] On the Nigerian side, [22, 23] carried out a detailed study on the Geology of Sokoto Basin. [24], also worked on the same basin.

The fact that this inland basin occupied parts of the two countries, the name of the lithostratigraphic units differ from one country to another, even though geological boundary is far different from political one. The present article focuses on an update of the state of knowledge of the stratigraphy of the Cretaceous – Tertiary sediments in the Iullemmeden basin in Niger and Nigeria. It aimed to review the different lithostratigraphic terminologies used in both countries and bring them together in order to facilitate their use to geoscientists in both countries who are sometimes limited by a language barrier as the two countries use French and English respectively as their official languages.

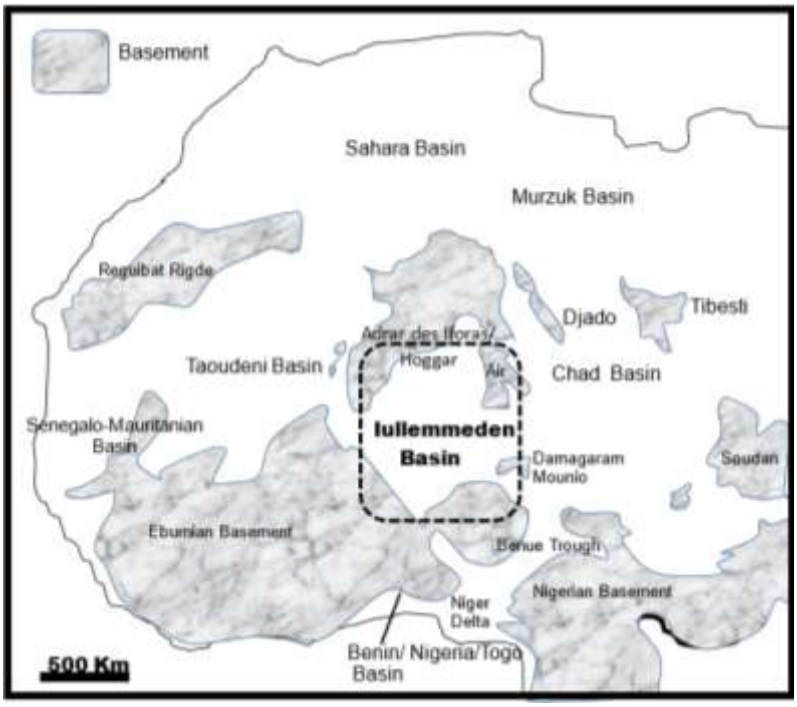


**Figure 1:** Location Map of the Iullemmeden Basin (Modified from [3]

## 2. GEOLOGICAL SETTING OF THE IULLEMMEDEN BASIN

The structural configuration of this basin seems to be controlled mainly by a NS to NNE-SSW faulting system that affected the Hoggar Massif. Geophysical data indicate a possible presence of deep grabens (rift system) in the SE of the basin. The Iullemmeden Basin has been described variously, as a cratonic basin [25] a graben developed along NW-SE basement lineaments [26] and as a half graben-synclinal structure, truncated to the southwest by NW-SE to N-S fault scarps by [27]. The origin of the Iullemmeden Basin may be linked with an elastic, or viscoelastic induced flexure of the lithosphere resultant of the sediment and water load that collected in the Benue Trough and Bilma graben structures; the resultant surface depression exceeding the width of the initial graben fivefold. It would appear however, that the main area of the Iullemmeden Basin began to subside during the Permo-Triassic with pre-Upper Cenomanian, non-marine sediments localized west of the Air Massif. The so-called "Bassin Continental Intercalaire" of [6] is the likely precursor to a broader, predominantly marine basin of the late Cretaceous-early Tertiary. If so, then the opening of the Benue Trough postdates the early phases of Mesozoic terrestrial deposition in the Iullemmeden Basin defined by [6]. The major marine transgression at the end of the Cenomanian however, is common to both. The gentle, prolonged down warping of the Iullemmeden Basin during the Upper Cretaceous-Lower Tertiary is characterized by the widespread continuity of deposits. Doming is also evident to the north of the Iullemmeden, with the northern domes associated with major fault systems. Three main fault trends are recorded within the basin. The most prominent trend NNE-SSW [22] and bound the Talach and Azaouak depressions and the In-Guezzam Horst. The other two fault directions are WSW-ENE and NW-SE.

## 3. THE CRETACEOUS – TERTIARY LITHOSTRATIGRAPHIC UNITS

The Iullemmeden basin is characterized by intercalation of continental and marine sedimentary sequences resting discordantly on one another. Paleozoic deposits are restricted to the northern part of the basin, where the Carboniferous Tereda and Tagora series are deposited. These are coarse-grained to clayey sandstones of continental, deltaic to marine sediments. Southward, the sediments become younger and the present review will look at the Cretaceous – Tertiary deposits in Niger and Nigeria.

## 3.1 The Early Cretaceous Tégama Series – Illo/Gundumi Formation

The Early Cretaceous lithostratigraphic sediments associated with the Iullemmeden basin are named the Tégama Series and Illo/Gundumi Formation respectively in Niger and Nigeria. These continental lithostratigraphic units are stratigraphically lateral equivalents and constitute a part of the regionally-known Continental Intercalaire. [4]first used the term "Continental Intercalaire" to design all continental sediments deposited between the Carboniferous and Upper Cenomanian marine transgressions. These transgressions affected progressively most of the basins in a southward direction. Where it overlies the basement rocks, the Continental Intercalaire evolved from the weathering of the same basement rocks.

In Niger, the Tégama series constitute the lower part of the Tégama Group [5-7]. The upper part of the group is being called the Farak series. The Tégama series is further subdivided into the Tazolé at the base, Elrhaz in the middle and Echkar Formation on top. The Tazolé and Echkar formations are made of coarse feldspathic sandstones, with cross bedding while the Elrhaz is argillaceous and carbonaceous with dinosaurs and crocodiles bones which [7] presented as a vast and plane lens intercalated within the Tégama Group Sandstone. [28] subdivided the Tégama series in south of Air (Gadafaoua zone) into eight lithologic units.

The Gundumi-Illo Group in Sokoto Basin of Nigeria rests unconformably on the basement rocks. [23] carried out a detailed study of the geology of the Sokoto Basin. He described the Gundumi-Illo Group as fluvio-lacustrine deposits made of conglomeratic base with massive, feldspathic clayey grits and pebbly sands and intercalation of nodular and pisolitic clays on top of the Illo Formation.

## 3.2 The Late Cretaceous Lithostratigraphic Units

The Late Cretaceous period was characterized by sea invasion from the North in the basin with each of the transgressions overlapping the preceding one in a south-westerly direction (Fig.2). [6] defined six marine transgressions with three in the Cretaceous and the other three in the Uppermost Cretaceous and Lowermost Tertiary. [6] and [8] distinguished two marine transgressions of Late Cenomanian and Early Turonian respectively with the presence of *Neolobites Vibrayeanus* and *Nigericeras.* However, [18, 19] and even earlier work of Petropar geologists found in nearly the whole Iullemmeden Basin, the presence of the above two species in late Cenomanian. Hence, they concluded that it was the same marine transgression that occurred during the Late Cenomanian and Early Turonian.

### 3.2.1 The Mont Iguella Formation and the Overlying Unit

The first two marine transgressions of [6] which [18, 19] considered one transgression deposited the Mont Iguella, the "White limestone" Series and overlying unit in western Niger Basin (Iullemmeden). These three formations are restricted in Niger territory because the sea has not reached the Sokoto sector then. The Mont Iguella Series are composed of calcareous sandstone, fine grained sandstone, gypsiferous, glauconitic and very fossiliferous shale. The associated fossils include lamellibranches, gastropods, echinoids and ammonites. The second transgression of [18, 19] is dated Late Turonian-Coniacian which was marked by *Coilopoceras inflatum* and saw the deposition of shaly limestone, what [6] named as series of "Calcairesblancs (white limestone)". Overlying the "white limestone" is an upper series of marly limestone richer in fossils (dinosaur and crocodile bones, fish teeth, etc.) than the upper unit.

### 3.2.2 The Majia or Rima Group

The third and fourth marine transgressions happened during the Campanian-Lower Maastrichtian and Upper Maastrichtian respectively and were marked by *Libycoceras.* The Maastrichtian period was marked by the deposition of the Majia Group in western Niger and its lateral equivalent in Sokoto area is called the Rima Group. The Majia Group is made of the Alambanya, the Farin Doutchi and the Inwagar Formations. These are respectively named the Taloka, Dukamaje and Wurno Formations in the Sokoto sector. The Taloka and Alambanya are also called the Lower Sandstones and Mudstones, the Farin Doutchi and Dukamaje are called the Mosasauorus Shale and the Inwagar and Wurno, called the Upper Sandstones and Mudstones. Taloka or Alambanya Formation is made of essentially of white fine-grained friable sandstones and siltstones with thin intercalated mudstones and carbonaceous mudstones or shales. The Dukamaje/Farin Doutchi Formation contains predominantly gypsiferous shales, marls and mudstones. One striking feature of this formation is the very fossiliferous bone bed which contains skulls, crocodilian limb bones, and fish remains (teeth, vertebrae, bone fragments) (Fig. 3).

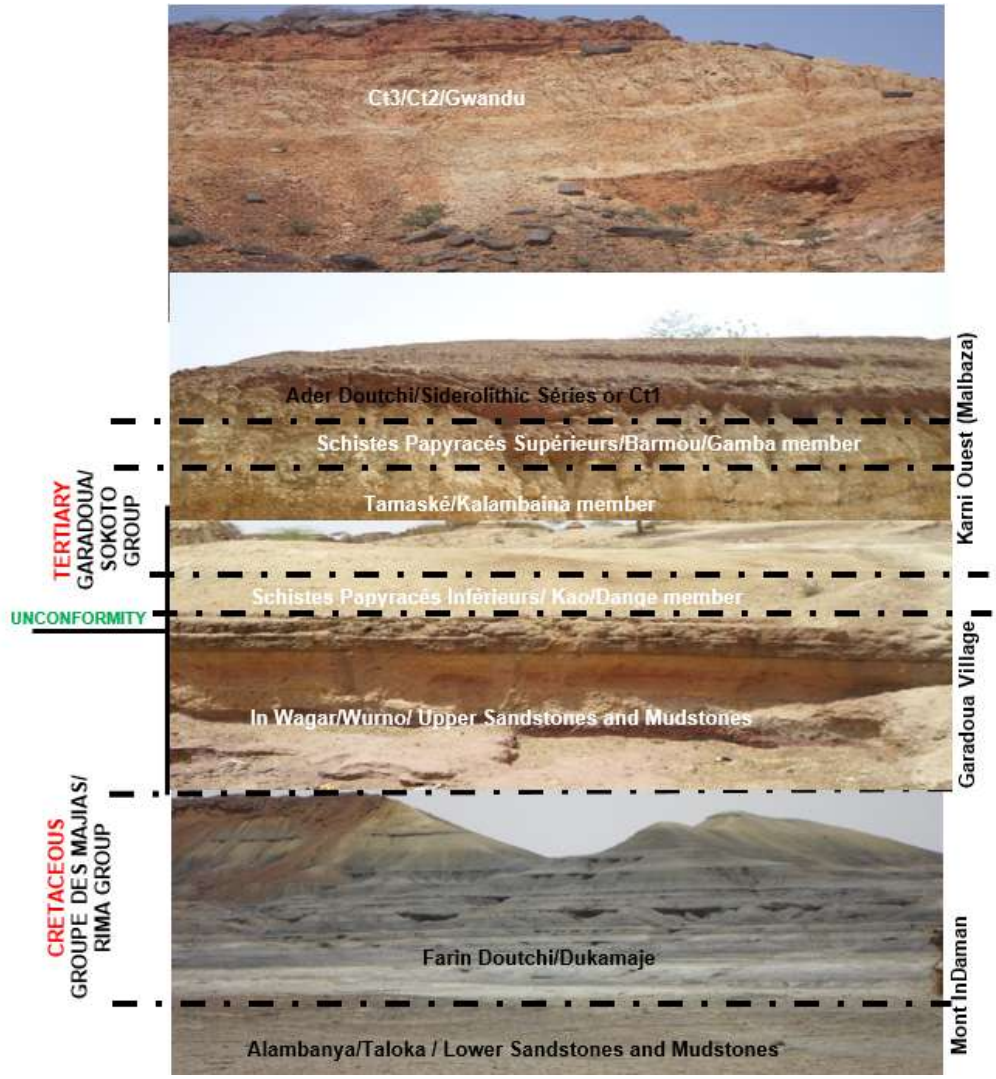


**Figure 2:** Stratigraphy of the Iullemmeden Basin in Tahoua area, Niger Republic

**Figure 3:** Skulls, limb bones and other parts of Vertebrates associated with Farin Doutchi Formation

In general, the Rima Group can be described as a set of shale, marl, limestone and alternating sandstone. The marine transgressions of the Late Cretaceous did not affect the south-eastern extremity of the Iullemmeden basin, around Maradi-Zinder in Niger Republic. Here, the sediments become more detritic, and coarser and fossil wood fragments are no longer abundant. These continental coarse-grained and crossed bedded sandstones engulfed within a kaolinite matrix is known as Continental Hamadien.

## 4. THE CRETACEOUS – TERTIARY BOUNDARY

The transition between the Cretaceous and the Tertiary deposits is clearly defined by a remarkable unconformity observed in Wurno in Sokoto area, Nigeria and in Garadoua in Tahoua area, Niger (Fig.4). This unconformity characterizes a regressive period during which the sea retreated from the area for some time and the top of the underlying formation (Wurno or Inwagar) was eroded and worn down, given a ferruginized lateritic cap. Below the unconformity, we can observe the Inwagar varicolored siltstones showing a very fine bedding, made conspicuous by the change in color from whitish – grey to yellowish – brown and red as [23] described the Wurno Formation.


**Figure 4:**Cretaceous –Tertiary Boundary Observed in Garadoua Village, Tahoua, Niger

### 4.1 The Tertiary Deposits

The Tertiary period witnessed the fifth marine transgression of [6] which deposited in Upper Paleocene the Garadoua Formation corresponding to the Sokoto Group Nigeria respectively. The Sokoto Group is made of the Dange at the base, the Kambaina in the middle and the Gamba on top.

In Niger, they are respectively called the Kao, the Tamaské and the Barmou members from base to top. The base of Garadoua Formation is observed in Garadoua village and is made of slightly indurated bluish – grey shale, interbedded with thin layers of yellowish – brown limestone as the Dange Unit in Sokoto area. [6] called the base and the top of the Garadoua Formation, "Schistepapyracé" because of the fissile nature of the two horizons. This formation has been mined both in Niger and Nigeria for decades for the quality of limestone it contains. The fauna is very diverse and include bivalves, echinoids (*Linthia soudanensis*) gastropods, nautilus and foraminifera *(Ranikauthalia)*. In Garadoua village, the type locality, we can observe the dissolution and the crystallization of the limestone due to the exposure to acid rain fall (Fig.5).

**Figure 5:**Dissolution, and crystallization effects on limestone in Garadoua Village, Niger

## 5. THE CONTINENTAL TERMINAL

Overlying disconformably the marine Garadoua Formation is the Continental Terminal (Ct) Group. This is subdivided into three members: the Ct1 at the bottom, Ct2 in the middle and Ct3 on top. The Ct1 is being called the Ader Doutchi member or Siderolithic series by [6]. This consists mainly of red and mottled massive clays with sandstone intercalations.

The Ct2 or sandy clays with lignite corresponds to sandy and clayey deposits of light to varicolored materials in an oxidized environment. In reducing conditions, the sediments become dark with lignite and pyrite.

In Sokoto Sector, the Ct1 and Ct2 do not really extend, rather the Sokoto Group is being overlain by the Gwandu member which can be correlated to the Ct3. this is a clayey sandstone made of coarse grained to conglomeratic sand at the base and a medium to fine sand on top. The Continental Terminal Group forms extensive outcrops in Nigeria, where represented by the Gwandu Formation [23], as the ‘’Grés du Niger” by [29] or “Grés du Moyen Niger” by [30] in Niger and in Benin Republics. The figure 5 below shows the Cretaceous – Tertiary lithostratigraphic units of the Iullemmeden Basin outcropping in Tahoua area of Niger Republic.

### 5.1 Economic Potential Associated with the Cretaceous -Tertiary Deposits

The major economic potential associated with these sediments include industrial minerals (limestone, clays and gypsum), iron ore (Oolites, laterite and ferruginized sandstones) and lignite or coal.

The limestone deposits are found within the Mont Iguella, Farin Doutchi or Dukamaje and mainly within the Sokoto Group/Garadoua Formation specifically the Tamaské or Kalambaina member. The clays are associated virtually in all the formations; from kaolinitic clay in the Illo and Gwandu Formations, to smectite in the Garadoua and Farin Doutchi Formations. The Gypsum occurs within the Farin Doutchi/Dukamaje and Kao/Dange member. These industrial minerals are actively mined by the Sokoto and Malbaza Cement factories in Nigeria and Niger Respectively. The Giant Dangote Group has also acquired an exploitation permit to install a cement in Garadoua village in Niger Village.

The iron ore is found within the Ader Doutchi/Gwandu Formation known as the Siderolithic series by [6]. [23]and[31] recognized two varieties namely the indurated with iron content of 80-85% and the non-indurated with iron content of less than 60%. However, the problem associated with mining of these iron ore varieties is the grade of cementation. The laterite and ferruginized sandstones contain less than 45% Fe, so they are only used for subgrade materials for road construction.

Some thin horizons of lignite occur within the Taloka Formation [32]. In Tahoua area of Niger Republic the relative stability of the basin coupled with the absence of important detrital sediments during the burial of organic matter lead to the formation of coal deposits of high quality in the Tertiary Continental Terminal.

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