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Petrography and Depositional Environments of the Palaeocene Malbaza Limestones in the Iullemmeden Basin (Tahoua Region, Central - Southern Niger)

Laouali Idi Karimou[1], Ibrahim Maharou Hassan[2], Illia Allo Daouda[3], Konate Moussa[4]

[1]Abdou Moumouni University, Ecole Normale Supérieure, SVT Department, Geology Laboratory: Basin and Georesources Team, Niamey, Niger
Corresponding Author Email: *karimidi85[at]gmail.com*

[2]Abdou Moumouni University, Faculty of Science and Technology, Geology Department, Geology Laboratory: Basin and Georesources Team, Niamey, Niger.
Email: *maharou86[at]gmail.com*

[3]AndréSalifou university, Faculty of Science and Technology, Department of Geology, Georesources and Environmental Geosciences Laboratory (LGGE), Zinder, Niger.
Email: *daoudaillia2412[at]gmail.com*

[4]Abdou Moumouni University, Faculty of Science and Technology, Geology Department, Geology Laboratory: Basin and Georesources Team, Niamey, Niger.2
Email: *konate.moussa[at]gmail.com*

Abstract: ***This study focuses on the reconstruction of the depositional environment of the Paleocene limestones of the Iullemmeden sedimentary basin in the Malbaza region. The methodology used is based on a petrographic and palaeoenvironmental study. The Palaeocene limestones of the Iullemmeden basin are zoogenic and show rapid facies variations. The petrographic description reveals three levels: slightly clayey chalky limestones, massive limestones and nodular limestones. The study reveals that the limestones at Malbaza have mudstone and wackstone textures. The depositional environment is a shallow, less agitated platform.***

Keywords: limestone, petrography, environments, Paleocene, Niger

1. Introduction

The sedimentary filling of the Iullemmeden basin took place in several sedimentary cycles: the Palaeozoic, the Mesozoic and the Cenozoic. In the south - eastern part of the basin (Malbaza region), three major lithostratigraphic units can be distinguished. These are, from base to summit: the Intercalary Continental, the post - Paleozoic marine and marginal - littoral series and the Terminal Continental sensu - stricto [15] [1].

The Malbaza region is particularly marked by the Upper Cretaceous - Paleocene transgression, during which the sediments making up the In Wagar and Garadaoua formations were deposited. These are overlain by continental deposits of the Terminal Continental (Ct). The outcrops at Malbaza consist mainly of clay - limestone sediments that make up the Garadaoua formation, divided into three members: the Kao, Tamaské and Barmou members.

The carbonate deposits of the Garadaoua Formation are essentially biogenic. Their formation mechanism is controlled not only by sediment input, but also by the physico - chemical conditions of the ocean (temperature, salinity, depth, turbidity, water agitation and nutrient input) and the marine organisms that produce biological sediments [14]. The nature and geometric arrangement of the carbonate facies make it possible to reconstruct the palaeogeography and palaeoenvironments of deposition. The contribution of biogenic carbonates in determining depositional environments is predominant. The recent studies carried out by [14], devoted to the Cretaceous - Paleogene in the Iullemmeden basin, were much more interested in the lithostratigraphic, palaeontological, palaeogeographic and structural studies of these formations. These have revealed the diversity of physical, chemical and biological characteristics of these clay - limestone formations, but the sedimentary dynamics behind the formation of these clay - limestone deposits have not yet been clearly elucidated. This sedimentation complex makes the Palaeocene - Ypresian deposits an interesting subject for study. Limited to the Malbaza sectors, the aim of this study is to understand the Palaeocene sedimentary dynamics in the Iullemmeden basin, particularly with regard to the limestone formations. It aims to reconstruct the environment in which these limestones were deposited. Specifically, it will determine the different facies indicative of the palaeo environments and the petrographic and palaeontological characteristics of the limestone deposits in the different environments.

2. Geographic and geomorphological setting of the study area

The study area is located between longitudes 5° and 7° East and between latitudes 14° and 16°, in the southern part of the Tahoua region (central - southern Niger) (**Fig.1).** It covers the Bouza and Keita departments over an estimated area of 9074 km2. The study area is bounded by the departments of Abalak to the north, Dakoro to the east, Madaoua to the south, Malbaza to the south - west, Illéla and Tahoua to the west (**Fig.1).**

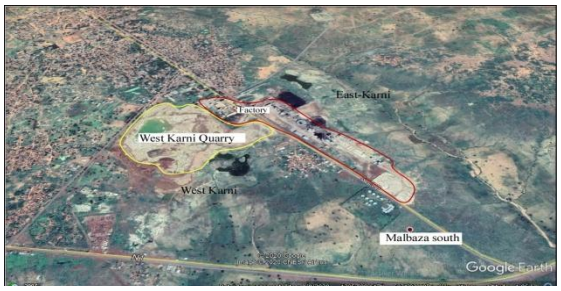

Figure 1: Location of the study area

3. Lithostratigraphy of the study area

The lithostratigraphic column of the Iullemmeden basin in the Malbaza region comprises two (2) formations [12] [20]:

- One (1) formation attributed to the Upper Cretaceous marks the base of the column. This is the In Wagar formation. This formation is essentially made up of silts and ferruginous clayey silts. Banks of ferruginous oolites appear as interbedded lenses at the base (**Fig.2).**
- The middle part of the column is represented by the Paleocene - Ypresian Garadaoua formation, consisting of more or less marly limestones, framed by papyracene shales.
- The top of the column corresponds to the Ader Doutchi formation of Middle to Upper Eocene age [15] [7], rich in ferruginous materials (sandstones, siltstones, ooids). This formation is referred to as the Terminal Continental (Ct1) [11].

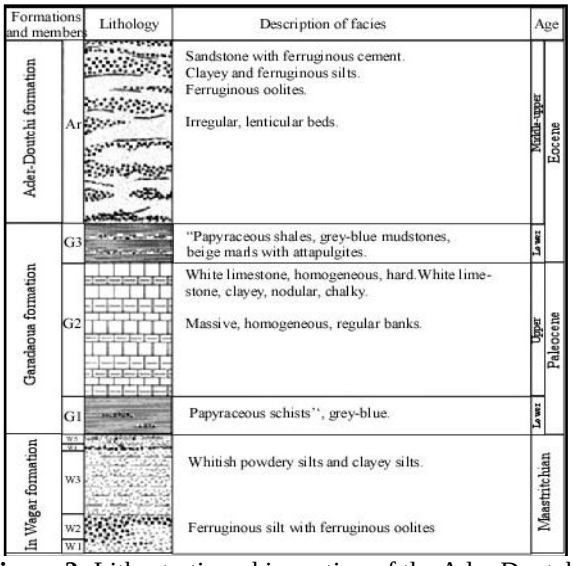

Figure 2: Lithostratigraphic section of the Ader Doutchi [12] [20].

4. Materials and Methods

4.1 Materials

The equipment used in this study includes field equipment (1: 200, 000 - scale geological map extracts, in particular the Konni - Madaoua sheets; a GARMIN GPS; a 12MP resolution digital camera; structural measurement and sampling equipment) and laboratory equipment (in particular a prowler for preparing thin sections; slides and slides; a polarising microscope with x40 magnification). The samples used were taken from the Malbaza quarry.

4.2 Methodology

The methodology used is organised into three successive phases:

- the literature review that prepared the fieldwork;
- the actual fieldwork (lithological description of outcrops, sampling and macroscopic petrographic analysis);
- laboratory work (preparation of thin sections and microscopic observation) and digital data processing (geological sections) using Canvas software (Deneba version 11 Build 1252), a CAD (Computer Aided Drafting) program. In total, twenty - one (21) of the twenty - eight (28) samples taken were used to make thin slides for the microscopic study.

5. Results

This study made it possible to define several facies and their depositional environment. It characterised the lithology by thin section and macroscopy, as well as the faunal content and biological structures of the Palaeocene limestones.

5.1 Petrographic and palaeontological description

The Malbaza sedimentological section is about 15 m thick. It comprises the Garadaoua Formation and the Ader Doutchi Formation (**Fig.3 and 4).** The Garadaoua Formation is subdivided into five levels (**Fig.3 and 4)** grouped into three members: Kao (G1), Tamaské (G2) and Barmou (G3). The Kao member has a single level, made up of laminated clay and marl. The Tamaské Member comprises three levels. The base level is made up of slightly clayey chalky limestones, containing a variety of fossils and microfossils. These include sea urchins (Linthiasudanensis, Plesiolampas), lamellibranch casts, gastropods (Strombus), foraminifera (Rotalia, Elphidium, Discorbis, Ranikothalia) and ostracods (Phalcocythere, Bythocypris, Nucleolina. . . etc) [1].

The intermediate level of the Tamaské Member is represented by a bed of massive, white limestone containing nautiluses (Eutriphocerasmentesisnov. sp., Deltoidonautilussudanensis), sea urchins (Plesiolampassaharae, Linthiasudanensis), internal casts of lamellibrachids, gastrepods, foraminifera and ostracods. The top of the Tamaské Member is represented by a bed of nodular, indurated limestone with shell debris, in places containing pockets of decalcification. These are filled with clays from the overlying environment [1]. The Barmou Member, which forms the top of the Garadaoua Formation,

is represented by a bed of papyractite shales. The top of the section is represented by the Ader Doutchiformation, consisting of ferruginous oolitic sandstones with varying degrees of clay.

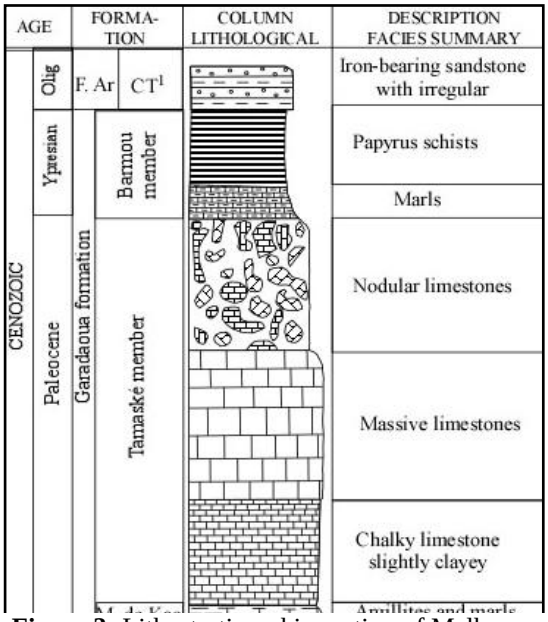

Figure 3: Lithostratigraphic section of Malbaza.

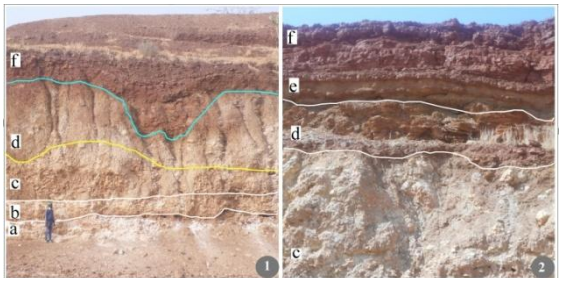

Figure 4: Main lithofacies observed in the Malbaza area. a) chalky limestones with varying degrees of clay content b) massive limestones c) nodular limestones d) calcareous marls e) papyraceous shales f) ferruginous sandstones of Terminal Continental 1 (Ct1).

5.2 Palaeontological study

This concerns only the Tamaské Member, which consists solely of the limestone deposits that are the subject of this study. The palaeontological contents yielded macrofossils and microfossils of Palaeocene age.

5.2.1. Macroscopic description

The Tamaské Member, made up of three limestone levels, is very rich in nautiluses, bivalves (lamellibranchs, brachiopods), gastropods and sea urchins. The nautiluses are represented by three species: Deltoidonautilus (D. sudanensis, D. chedeaui and D. molli), Cimomia (Cimomianigerensisn. sp. and cimomialata n. sp) and Eutrephoceras (Eutrephocerasaff. carolinensis). This faunal association is found in all levels of the Tamaské Member. Of these nautilus species, D. molli is the most common in the limestone formations of the Malbaza region [10] **(Fig.5).** Previously, D. molli was attributed to the Lower Eocene in Niger [10]. In Mali, it was attributed to the Montian (Palaeocene) [22] and to the terminal Palaeocene (Thanetian) and Ypresian by [19]. The levels containing D. molli are thought to represent the Paleocene and/or Lower Eocene. Several studies carried out in Niger [16] [11] [6] [12], Mali [2 - 3] [4] [5] and Senegal [8] have made it possible to specify the Palaeocene age of the D. molli levels in these three countries.

The other nautilus species, namely Cimomialata, Cimomianigerens and Cimomiaaffcarolinense, which are respectively close to Cimomiawelleyi, Cimomiaseptemcastrensis and Eutrephoceras [9] reported in the Eocene series of Somalia [17], are now attributed to the Palaeocene by analogy with the Ranikot series of India [14].

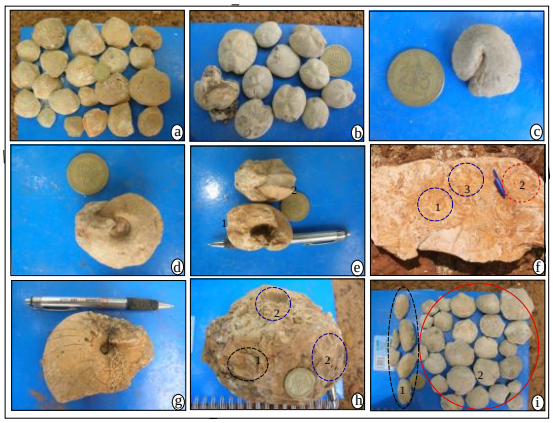

Figure 5: Faunal content of the Tamaské member at Malbaza. a) Bivalve molluscs: Brachiopods b) Sea urchin: Linthiasudanensis c) Cimomia: Cimomianigerensisnov. sp d) Eutrephoras: Eutrephorasnov. sp e) Deltoidonautilus and Cimomia: 1e - D. sudanensusnov. sp 2e - C. latanov. sp f) Gastropod molluscs: 1f - Eovasum cf. frequens 2f - Heligmotenia molli 3fEovasum sudanensis g) Deltoidonautilusmolli h) Gastropods and traces of Bivalves: h1 - gastropod h2 - Spondilusquadricostatusi) Bivalve molluscs: 1i - Brachiopods (Panopeasaharienis) 2i - lamellibranchs of the genus Tellina.

5.2.2. Microscopic description

The faunistic and floristic content of the Garadaoua **(Fig.6)** Formation is essentially dominated by benthic foraminifera (Ranikothalia and Lockartia). In most West African Tertiary basins, these foraminifera are associated with other foraminifera (Rotalia, Pararotalia, Nonion, Valvulina), algae, ostracods and a macrofauna of echinoderms and lamellibranchs (Alzouma, 1994) [1].

Observation of thin sections of the Tamaské Member (**Fig.6)** revealed the presence of microfossils characteristic of the Palaeocene. These are mainly Ranikothaliabermudezi in the limestone levels. This Ranikothaliabermudezi fossil has made it possible to assign an upper Paleocene age to the Malbaza limestone deposits.

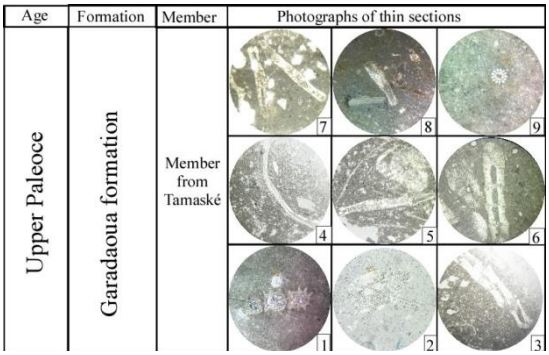

Figure 6: Microfauna of the Tamaské member. 1) Dinoflagellates (Cordosphaeridiumsp), 2) Ostracods, 3) Ranikothaliabermudezi, 4) Syncolpae (Terscissussp), 5) Foraminifera, 9, 10 and 11) Corded Nummilites (Ranikothaliabermudezi) associated with a few ostracods, 12) Irregular sea urchin silk.

5.3 Paleoenvironment of deposits

The Malbaza section has two formations: the Ader Doutchi formation of Oligocene age [18], consisting of the latest continental deposits (Ct1), and the Garadaoua formation of Palaeocene - Ypresian age [13], comprising clay - limestone deposits. This latter formation is subdivided into three members: Kao, Tamaské and Barmou.

The Malbaza section (Fig.8) begins with the Kao member, which is a marly clay with foraminifera (Haplophragmoides) (**Fig.7).** The presence of rare agglutinated foraminifera (Haplophragmoides) indicates an internal neritic domain that is not very open. These results show that the deposits occurred in a shallow or marginal marine environment. This interpretation is corroborated by the presence of fragments of gastropods and lamellibranchs. The black colour of the clays indicates deposition in calm, reducing or anoxic conditions. This is a confined marine environment (infralittoral zone). The biomicritic limestones with abundant and diverse fauna of the Tamaské Member were deposited in an open marine environment [21]. This is a carbonate platform - type environment (shallow, warm waters), with infralittoral shelving, as evidenced by the presence of ostracods and foraminifera. The presence of photophytic organisms (algae, Ranikothalia) indicates that the waters were clear. Traces of bioturbation observed in the limestone facies and the presence of endofauna (Linthia, Ranikothalia and bivalves) imply the existence of a loose palaeofloor at the time of sedimentation. The Tamaské Member ends in an essentially calcitic carbonate sedimentation. Dolomite is very rare, indicating that the environment was not very magnesian [9]. These limestones generally have a dominant wackstone texture in a micritic matrix. The organisms present are clearly marine. All these criteria indicate a shallow, calm platform environment, in which sediment deposition takes place close to the wave action zone. The abundance of micritic mud indicates an environment sheltered from waves. Above the Tamaské limb, the Barmou limb and the Keita limb, made up of papyrus shale and dolomitic marl respectively, were deposited. These deposits correspond to a shallower, confined coastal carbonate platform environment.

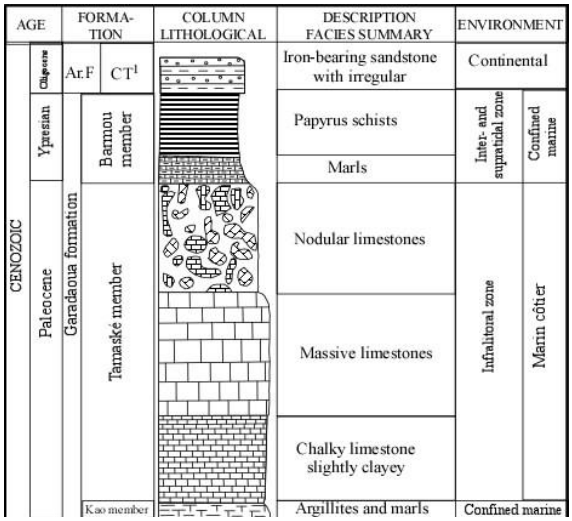

Figure 7: Sedimentological section of Malbaza showing depositional environments.

6. Conclusion

The main results obtained in this study provide new information on the petrographic and palaeoenvironmental characteristics of the limestones of the Iullemmeden sedimentary basin in the Malbaza sector. This study shows that the Palaeocene limestones of Malbaza are zoogenic and present three limestone levels of different rheology. These three limestone layers make up the Tamaské Member. Microscopic observation of thin sections reveals that these limestones are predominantly mudstone and wackstone, rarely packstone. They were deposited in a coastal marine environment (infralittoral zone).

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Author Profile

Dr LAOUALI IDIKarimou: Lecturer and researcher at the Ecole Normale Supérieure, Abdou Moumouni University, Niamey/Niger. Geology laboratory: Basin and geo resources team.

Dr IBRAHIM MAHAROU Hassan: Lecturer and researcher at the Faculty of Science and Technology, Abdou MoumouniUniversity, Niamey/Niger. Geology laboratory: Basin and georesources team.

M. ILLIA ALLO Daouda: Doctoral student at the André Salifou University in Zinder/Niger. Georesources and Environmental Geosciences Laboratory (LGGE).

Pr KONATE Moussa: Lecturer and researcher at the Faculty of Science and Technology, Abdou MoumouniUniversity, Niamey/Niger. Geology laboratory: Basin and georesources team.