KASDI MERBAH UNIVERSITY – OUARGLA

FACULTY OF HYDROCARBONS, RENEWABLE ENERGIES AND EARTH SCIENCES

Department of Earth Sciences

THE END OF STUDY MEMORY

Dissertation submitted to the Department of Earth sciences as a partial fulfilment of the

requirements for thea Master's degree in Geology

Option:

Sedimentary Basin Geology

THEME:

Mio-Pliocene Microfauna of Belidet Omor Clay from the Touggourt region

Presented by :

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The: 15/06/2023

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Academic year: 2022/2023

الاهداء

الحمد لله بارئ النسمة الخالق الذي لا اله إلا هو الناطق بالبيان و الحكمة

و الصلاة و السلام على الرسول محمد صلى الله عليه و سلم خاتم الانبياء و المرسلين

اهدي ثمرة جهدي الى :

التي حمتني و منحتني الحياة و احاطتني بحنانها و حرصت على تعليمي بصبرها و تضحيتها و كان دعاؤها سر نجاحي امي "حمادة قمره " حفظها الله

الذي دعمني في مشواري الدراسي و كان وراء كل خطوة اخطوها في طريق العلم الى من تعب و تشققت يداه في سبيل تعليمي ابي "خليف عباس " رعاه الله

الى من هما توأم روحي و سر سعادتي و كانتا بهجتي في حياتي ة اللتان كانتا معي في الحلوة و المرة أختاي "خليف نريمان" و "خليف نور الهدى"

الى من هم عوني و بلسم جروحي كما أنهم نور بصري أخوتي

" خليف عبد الرزاق "و " خليف عبد الباسط " و "خليف عبد الفتاح "

كما لا انسى ان اشكر كل عائلتي (خليف حمادة حميتي) فردا فردا كل باسمه كما لا انسى كل اصدقائي خاصة صديقتي "صفاء مرابط التي كانت دائما تدعمني برسائلها الايجابية و كذلك " وسام ورقلي " و " ريحانة كنونه "

شكرا لكم جميعا كل باسمه

سلاف خليف

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شكر و عرفان

الحمد لله والشكر لله الذي وفقنا وأعاننا على هذا العمل، راجيين من المولى عز وجل أن يجعل فيه نفعا للعباد .

نتقدم بأخلص عبارات الشكر وأسمى عبارات التقدير والعرفان والإمتنان إلى الأستاذ المشرف الأستاذ المحترم: **شريف أمين** على قبوله تحمل أعباء الإشراف على هذا العمل وعلى توجيهه ونصحه لنا . كما نشكره على المعاملة الطيبة التي حضينا بها من قبله، فجزاه الله عنا خير الجزاء .

كما نتوجه بالشكر إلى الأستاذ المساعد: بن خدة عبد الحكيم

و نتوجه بتحية إحترام وتقدير للأستاذة زويط خالدية على قبولها رئاسة اللجنة والأستاذ ريميتا عبد اللطيف على قبوله مناقشة هذا العمل.

ولا يفوتنا أن نشكر كل من ساندنا خلال مشوارنا التعليمي من أساتذة وطلبة . وبالأخص أساتذة وطلبة قسم ثانية ماستر جيولوجيا الأحواض الرسوبية دفعة 2023 .

نشكر جزيل الشكر من لا يمكن للكلمات أن توفي حقهم الوالدين الكريمين حفظهم الله ورعاهم.

الملخص

تم إنجاز هذا العمل بهدف إحياء و إعادة بناء البيئة القديمة لمنطقة بلدة عمر(ولاية وارقلة) خلال العصر الميوبليوسني وذلك من خلال الاعتماد على دراسة المتحيرات، حيث يشمل المتحيرات القاعية و العالقة التي تدل على العصر الميوبليوسني هذه المستحاثات القاعية تدل على وسط بحري قليل العمق، حيث يدل وجودها في الوسط القاري الى النقل بواسطة تيارات المياه.

الكلمات المفتاحية

البيئة القديمة، الميوبليوسني، بلدة عمر، المتحيرات، قاري .

Résumé

Ce travail a été réalisé pour mettre en évidence le Paleoenvironnement au cours du Mio-pliocène dans la région de Beldet Omar (Wilaya de Touggourt), en se basant sur l'étude des foraminifères. Ils comprennent des formes benthique et planctoniques, et ce sont reportés à un âge Mio-pliocène. Ces microfossiles sont entièrement d'un milieu marin peu profond. Leur existence dans dépôts continentaux indique un transport par des courant fluviatile.

Mots clés

Paleoenvironnement, Mio-pliocène, Beldet Omar, Foraminifères, continentaux.

Abestract

This work was carried out to highlight the paleoenvironment during the Mio-Pliocene in the Beldet Omar region (Wilaya of Touggourt), based on the study of foraminifera. They include both benthic and planktonic forms, and have been assigned to Mio-Pliocene age. These microfossils are entirely recorded in shallow marine environment, their presence in continental deposits indicates transport by fluvial currents.

Key words

Paleoenvironment, Mio-pliocene, Beldet Omar, Foraminifera, continental.

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General introduction

General introduction

The study is centered around the Mio-Pliocene period in the Touggourt region of northeastern Algerian Sahara. The sedimentary deposits in this region consist of clay, gypsum, and sand. The main objective of this study is to contribute to the understanding of the paleoenvironment in the Sahara by examining the sediments specifically in the Touggourt region. Site selection, morphological description, and sampling were conducted following a preliminary field study. In the laboratory, various methods including granulometric analysis, calcimetry, and mineralogical analysis were employed to characterize these soils.

The investigation of sedimentary deposits and the analysis of paleoenvironment in the Bildet Omor cut revealed the presence of a clay formation representing freshwater deposits from the Mio-Pliocene period.

The first chapter of the study provides a detailed description of the geographical and geological features of the Touggourt region, with a specific focus on the Beldet Omor area.

The second chapter presents a systematic study of both benthic foraminifera and planktonic foraminifera.

The third chapter focuses on the paleoecology of the benthic foraminifera, and it presents the results of the analysis of calcium carbonate ($CaCO_3$) content in the samples collected from the region.

Chapter 01

The general framework

1. Introduction:

In this chapter, we aim to provide comprehensive information about the geographical and geological characteristics of the Touggourt region, specifically Beldet Omar, as well as its relation to the broader Sahara platform. We will describe the overall geographical framework of the region, including its general location and features. Additionally, we will examine the local geographical setting, focusing on the specific details and peculiarities of the area.

2. Geographical and Geological Location:

The Touggourt region, alternatively referred to as Beldet Omar, is situated within the Oued Righ valley in the northeastern region of the Sahara in Algeria. Specifically located in the Wilaya of Touggourt, it is positioned approximately 600 km southeast of the capital city, Algiers. The Oued Righ valley is geographically bounded by the Wilaya of El Oued to the north and east, the Oued Mya valley to the south, and the Mzab ridge to the west.

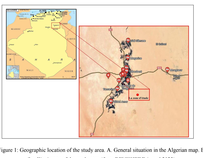

Figure 1: Geographic location of the study area. A. General situation in the Algerian map. B. Satellite image of the study area (from BENKHEDDA et al 2023).

The topography of the Oued Righ valley is characterized by relatively low-altitude terrain, particularly in the northern area where the chotts are located. These chotts are depressions situated below sea level. The term "Bas Sahara" or "Low Sahara" is used to describe this region due to its inclination towards the large chotts, which serve as outlets for excess water flowing from the northern Atlasic reliefs.

The average slope of the region is around 1%, and the longitudinal profile of the valley is highly irregular. Throughout the valley, a series of interconnected small chotts can be found.

3. Regional and Local Geological Setting:

3.1. The Algerian Saharan Platform:

The Algerian Saharan platform is geographically separated from the northern Alpine domain by the Southern Atlas fault. This fault extends from Agadir in Morocco to Gabes in Tunisia. The stratigraphic series in the Northern Sahara region exhibit the following characteristics:

1. Precambrian Shield: This shield consists of volcanic and metamorphic rocks that have undergone folding and flattening due to erosion processes.
2. Phanerozoic Era: This era is represented by a sequence of sedimentary deposits that span several thousand meters and originated from the Cambrian period onwards. These sedimentary rocks may exhibit various degrees of folding.
3. Quaternary Period: The Quaternary period is associated with the formation of a large, asymmetrical sedimentary basin. This basin is primarily characterized by the presence of sandy dunes.

3.2. The Algerian Lower Sahara Basin:

The Lower Sahara Basin is a wide basin that is geographically bounded by several features. It is limited to the west by the Mzab ridge, to the south by the Tadmait and Tinhert Hamada, and to the east by the plateaus of the Tunisian Dahra. The Lower Sahara Basin is characterized by relatively low elevation and a gentle inclination towards the

depression of Mya and Oued Righ. This inclination follows a south-southwest to north-northeast orientation.

The Saharan portion of the basin consists of a synclinal basin that encompasses sedimentary deposits ranging in age from the Cambrian to the Tertiary period. The majority of this area is covered by the vast eastern erg, which is a large expanse of sand dunes. Paleozoic strata can be observed in the southern part of the basin, situated between the plateaus of Tadmait and Timhert, as well as the Hoggar massif. The Mesozoic and Cenozoic rocks form the primary sedimentary series along the borders of the Lower Sahara Basin.

In the central part of the basin, late Tertiary and Quaternary continental deposits are prevalent. These deposits represent the more recent geological history of the region

4. Local Geology:

The geological map of Touggourt highlights the predominance of Quaternary formations in the region. Specifically, recent dunes are observed at Meggarine, Sidi Slimane, and Erg es-Sayah (Figure 2). Additionally, Quaternary continental deposits can be found at Merdjadja, Temacine, and Zaouia, characterized by alluvial sediments.

In the Ibéldet Aamar area, the sedimentary sequence is primarily composed of Quaternary sand deposits. These sands are found above the Mio-Pliocene clays and semi-permeable evaporates, which act as a separating layer from the Upper Pliocene strata. The thickness of the Quaternary sediments varies between 39m and 67m, as reported by LEMBAREK in 2008. These sediments serve as the primary underground water reservoir, which is replenished by the infiltration of precipitation from the seasonal rivers (oueds) originating from the surrounding elevated areas.

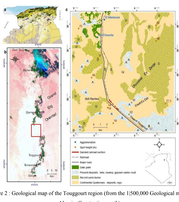

Figure 2 : Geological map of the Touggourt region (from the 1/500.000 Geological map of Algeria, Constantine south).

5.1.Lithostratigraphy:

In addition to the Quaternary and recent sandy dune deposits, the sedimentary series in the area have been investigated through drilling. The drilling studies have revealed that the oldest rocks encountered in the region are from the Albian age, which is a stage of the Cretaceous period. These Albian rocks represent the basement or underlying formations in the area.

Above the Albian rocks, the sedimentary cover consists of Mio-Plio-Quaternary strata. These strata encompass sediments deposited during the Miocene, Pliocene, and Quaternary periods. They are characterized by a variety of sediment types, including clays, sands, and evaporates, and have been the focus of geological studies in the region.

5.1. The Albian

The Albian rocks in the area predominantly comprise sandstone and clay facies. These rocks are found above the Aptian formations and are overlaid by Cenomanian clays. It is recognized that a shift in the sedimentary regime and the deposition of detrital sediments took place between the lower Cretaceous period (Berriasian to Hauterivian) and the Albian stage (FABRE, 1976).

5.2. The Vraconian

The Vraconian interval is characterized by an irregular alternation of dolostone-claystones and sandstone-claystones. This stratigraphic unit is recognized as a transitional zone between the uppermost layer of the Continental Intercalaire, which consists of Albian sandstone, and the lowermost layer of the Terminal Complex, composed of Cenomanian clayey-carbonate. The average thickness of the Vraconian interval is approximately 150 meters.

5.3. The Cenomanian

The Cenomanian interval is predominantly composed of dolostones, limestones, clays, and anhydrite. The lower boundary of the Cenomanian is clearly defined by the transition from Albian sandstones to clays and evaporite deposits. On the other hand, the upper boundary is characterized by the presence of extensive limestone or dolostone beds of the Turonian formation.

5.4. The Turonian:

The Turonian interval is distinguished by the presence of limestone and dolostone formations, which create a distinct layer with a thickness ranging from 25 to 70 meters. This layer is characterized by a sharp discontinuity with the underlying Cenomanian evaporites and clays

5.5. The Senonian:

According to BUSH (1972), the Senonian period can be divided into two main facies. The lower Senonian is interpreted as sedimentation in a lagoon environment and comprises clays and sulfereous formations with anhydrite. The Upper Senonian is characterized by the presence of carbonate deposits.

5.6. The Eocene:

The Eocene period is predominantly characterized by the presence of dolostones and limestones in the carbonate deposits, which have a thickness ranging from 100 to 500 meters. Additionally, marly interlayers, clayey beds, and even salt deposits can be observed within the Eocene strata. Towards the uppermost part of the Eocene sequence, there is an alternation of limestone, anhydrite, and marl deposits, which can extend to several hundred meters below the chotts.

5.7. The Mio-Plio-Quaternary:

The Tertiary deposits in the Sahara region are estimated to have an average thickness of 150 meters and are primarily composed of continental sandy/sandstone and clayey units that contain gypsum crystals. Within the lower Sahara Basin, lacustrine sedimentation is prominent, particularly in the continental Terminal (Mio-Pliocene) deposits, which can reach thicknesses of several hundred meters, especially in the Algerian-Tunisian Chotts. In the Oued Righ region, the Plio-Quaternary deposits consist of clayey-sandy layers interspersed with gypsum, indicating a lacustrine environment during the drying phases of lagoons and chotts. These deposits are subsequently overlain by Quaternary sandy dunes.

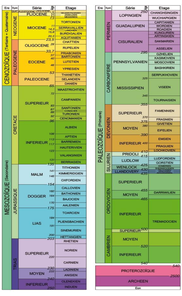

Figure 03 : Synthetic stratigraphic log of Tsoggoart region (KHADIRAOUI&BOUNGIB, 2014) .

Tectonics of the Oued Righ region:

The marine rocks in the Sahara region have undergone both vertical and horizontal tectonic movements during the Hercynian orogeny, as well as subsequent post-Triassic tectonic phases. The Atlas orogeny, in particular, has played a significant role in causing extensive deformations and transforming the Mesozoic rocks. As a result, the Ntab dorsals have been uplifted into ridges, the Tadmait area has formed a basin, and the Amguid-el-Biod axis has undergone collapse, leading to the formation of a meridional synclinal axis that extends towards the Aurès region.

Additionally, during the Plio-Quaternary phase, which is recognized as a major paroxysmal Alpine phase, pronounced variations in elevation occurred in an east-west direction. This led to the uplift of the Aures massif and the subsidence of the southern part known as the "Sillon sud aurésien." These tectonic fractures have influenced the flow of groundwater, causing it to move towards chotts (salt lakes) such as Chotts Melghir and Chotts Merouane.

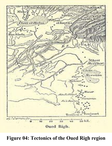

Figure 04: Tectonics of the Oued Righ region

7. Objective:

The primary aim of this study is to present a detailed taxonomic description of the diverse assemblages of benthic and planktonic foraminifera discovered in the northeastern Sahara region of Algeria. These microorganisms play a crucial role as bioindicators, offering valuable insights into the paleoenvironmental conditions prevalent during the specified time period.

8. Materials and Methods:

A total of 19 samples, with weights ranging from 200g to 300g each, were systematically collected from the Baledit Omar quarry for the purpose of conducting a comprehensive paleontological study. To ensure accuracy, these samples underwent a meticulous preparation process, which included thorough washing and subsequent sieving using mesh sizes of 250µm, 125µm, and 80µm.

The foraminifera obtained from the samples were then subjected to detailed examination and description. Each specimen was carefully analyzed, and its morphological characteristics were documented in order to accurately identify and classify the different taxa present.

9. Determination of Foraminifera:

The identification of foraminiferal species was carried out by examining the dried specimens under a binocular microscope. This process involved carefully observing the morphological features of the fossil individuals and comparing them with documented descriptions available in scientific literature and bibliographic sources. The aim was to match the observed characteristics of the specimens with known species and establish their taxonomic classification.

By utilizing established references and comprehensive descriptions from the scientific community, the identification process aimed to ensure accurate classification of the foraminiferal species encountered in the study samples.

Chapter 02 systematic study

1. . Introduction:

The studied section, located approximately 6km west of Beldit Amar, has a total thickness of about 30 m. It is mainly composed of red clays with intermittent occurrences of yellow sand lenses (Figure 05). This section represents a continuation of the Beldit Amar Clays Formation, which is a continental sedimentary unit assigned to the Mio-Pliocene epoch.

Throughout the formation, there are intercalations of sand layers that vary in thickness from a few centimeters to several meters. These sand layers exhibit distinctive channel-like characteristics, including graded bedding and oblique or cross stratification. Additionally, paleosol layers, indicating ancient soil formation, are present within the section.

The studied succession corresponds to the Mio-Pliocene Touggourt Clays Formation. It is underlain by phreatic groundwater at its lower boundary and overlain by Quaternary deposits and recent sandy dunes at its upper boundary

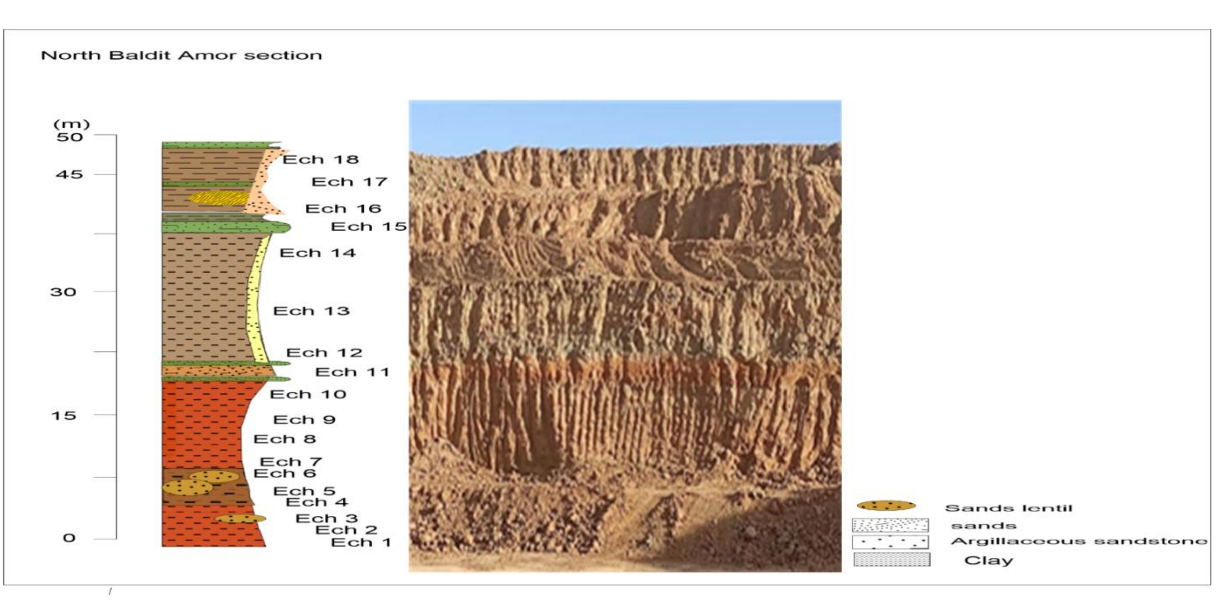

Fig 05Lithostratigraphic succession of Beldit Amor Section

2. Systematic study

Foraminifera play a crucial role in biostratigraphy, which involves dating and correlating sedimentary layers. They are valuable as indicators of past environmental conditions, providing essential ecological data. Moreover, the mineralized shells of foraminifera serve as a geochemical record, offering insights into paleotemperatures and paleogeographic characteristics.

These microorganisms inhabit various environments, including marine and some continental settings, and they can exist as either planktonic or benthic forms. The classification system widely used for foraminifera is the one developed by LOEBLICH & TAPPAN (1964). In our current study, we have identified approximately 22 taxa, with a focus on 17 genera and 10 species. It is important to note that 12 of these taxa are currently designated under open nomenclature

1.1. Planktonic foraminifera

In this present work, the assemblage of microfauna provides 06 species of planktonic foraminifera, which help well to at least propose an age for the studied sediments.

Kingdom: *chromist*
Subkingdom: *Harosa*
Infrakingdom: *Rhizaria*
Phylum: *Foraminfera*
Class: *Globothalamea*
Order : *Rotaliida*
Family: *Globigerinidae* Carpenter, PARKER & JONES, 1862
Genus: *Globigerinoides* CUSHMAN, 1927.

Type species: ***Globigerinoides bulloides* CRESCENTI, 1966**

Synonymy

1966- *Globigerinoides bulloideo* Crescenti : Sulla biostratigrafia del Miocenealloriante et confine marchigiano-abruzzese. Geologica ROMANA 5. p. 43, fig. 8, n°3, 3a, fig. 9.

1972- *Globigerinoidesbulloidea*: TJALSMAR WONDER, pl. 1, fig. 3-5.

1980- *Globigerinoidesbulloidea*: WEBNLI, pl. 4, fig. 2.

1985- *Globigerinoidesbulloidea*Crescenti: BELKEBIR, *Thèse 3 ème cycle*, pl. II, fig. 3.

2006- *Globigerinoides bulloidea*s Crescenti : BOUKLI-HACENE, *Thèse Doct. Etat. Univ. Etat. Univ.Pres.* pl. IV, fig. 3.

Description

The general morphology of the specimen closely resembles that of *Globigerinoides bulloides*; however, it differs in having a secondary opening on the spiral side, positioned at the base of the last chamber. The final chamber exhibits four globular chambers, resulting in a distinctly lobed test. The umbilicus is wide and open.

Distribution-wise, *Globigerinoides bulloides* has been documented from the lower Miocene period, specifically from the Burdigalian stage to the present day (LIRER and al., 2019).

Remarks

Based on the characteristic criteria observed in the morphology and test of the studied specimen, it is assigned to *Globigerinoidesbulloidea CRESCENTI 1966*, as described by BENKHEDDA (2022) from the Upper Miocene of the Tebessa region. Similar specimens resembling G. bulloides have been identified in Mio-Pliocene non-marine strata of the Blidet Omar region in Touggourt.

Type species:*Globigerinoides trilobus* REUSS, 1850

Synonymy

1950- *Globigerinoidestrilobus*Reuss: DENKSCH *K. AKAD. WISS. WIEM. 1*, p.374, p. 147, fig. 11a-c.

1966- *Globigerinoïdestrilobus* (Reuss): VERVLOET, SCHOTANUS& JENS UTRECHT NV, pl. X, fig. 1a-2c.

1975- *GLobigerinoïdesquadrilobatustriloba*: STAINFORTH *et al.,* fig. 138, n°4, 5.

1983- *Globigerinoïdestriloba* (Reuss) : KENNETT & SRINIVASAN, Hutch. Ross Publ. Comp., p. 62, pl. 13, fig. 7-9.

Description

The test of the specimen exhibits a low trochospiral shape, composed of three cells in the last turn. It is subrectangular in form with a slightly lobed outline. The three chambers are subspherical in shape and show a rapid increase in size. The last elongated chamber typically comprises approximately half of the test.**Repartition**: *Globigerinoides trilobus* has been documented from the lower Miocene (Burdigalian to recent LIRER andal 2019)

Remarks

Based on the characteristic criteria observed in the test and the morphology of the last turn, we assign the studied specimen to *Globigerinoides trilobus*. This assignment is in accordance with the diagnosis described by Benkhedda in 2022 from the Upper Miocene of the Tebessa region. Similar specimens resembling *G. trilobus* have also been identified in Mio-Pliocene non-marine strata of the Blidet Omar region in Touggourt.**Type species: *Globigerinoides* sp.**

Its distinctive feature is the presence of multiple secondary apertures on the spiral face.**Type species: *Globigerina* sp.**

Description

The genus ***Globigerina*** is characterized by a trochospiral test with spherical or ovoid chambers and an umbilical main opening. *Glutinous backbones*, belonging to the rubrics *Gfobigerina*, *Globigerinoides* and *Hastigerina* is. An thesis about the role of performance of this sphaerical chamber, in the vital cycle of this planktonic foraminifera, is stablished. The final conclusion is that *Orbulina* isn't a rubric but a temporary form in colorful foraminifera of planktonic life.

Sous Famille : Orbulininae SCHULTZE, 1854

Genre : Orbulina d'ORBIGNY, 1839.

Type Species: ***Orbulina universa, D'ORBIGNY, AND BRÖNNIMANN, 1951***

Synonymy

Concinnophaera ciliata STUARI, 1866 –

Globigerina bilobata d'ORBIGNY, 1846 –

Orbulina bilobata (d'ORBIGNY, 1846)

Orbulina parva RHUMBLE*r*, 1949

Description

Test spherical composed of single spherical chamber, final chamber entirely parte of the test, which is usually reduced. In the adult, an inter Globigerina stge may be enveloped by the final spherical chamber. Surface densely perforate with numerous small openings of two distinct sizes.

Repartition: *Globigerinoides trilobus* has been documented from the lower Miocene (Burdigalian to recent LIRER et al 2019)

Remarks

On the basis of the characteristic criteria, represented by the test, final chamber, we assign the studied specimen to *Orbulina universa*, accordingly to the diagnosis of described by BENKHEDDA 2022 from the Upper Miocene of Tebessa region. Very similar specimens have been attributed to. from Mio-pliocene non-marine strata of bloden omar region(Touggourt

Orbulina sp.

Description

Structure based on spherical or ovoid test riddled with small more or less apparent pores. The surface of the test may therefore have a smooth, pitted or reticulated appearance.

Family: Globorotaliidae CUSHMAN, 1927.
Genus :Globorotalia CUSHMAN, 1927.
Type Species: *Globorotalia scitula* Brady, 1882

1882 *Pulvinulinascitula*Brady. Brady. p.716 pl. 103, fig. 7a-c
1957 *Globorotaliascitula*Brady. Bolli: pl. 29, figs. 11a-12c
1979 *Globorotaliascitula* Brady. Serrano. P. 151, Pl. 7, fig.4-7.
1993 *Globorotaliascitula* BRADY.CHAISSON&LECKIE: 173, 174 pl. 4, fig. 6; pl. 6, fig. 15-16

DescriptionLow trochospiral test, with a external smooth surface, the umbilicus is moderately deep, extending from the umbilical opening towards the periphery, bordered by a small lip

Remarks

On the basis of the characteristic criteria, represented by the surface, the test, we assign the studied specem to *Globorotalia scitula*, accordingly to the diagnosis of described by cole 1942 from the Miocene of california region. Very similar specimens have been attributed to *G. scitula* from Mio-pliocene non-marine strata of beldt Omo regionTouggourt

genus: *Globigerinella* BOLL 1957
Type Species :*Globigerinella obesa* BOLL 1957

Synonymy

1957 *Globorotaliaobesa* Bolli : U. S. Nat. Mus. Bull., 215, p. 119, pl. 29, figs. 2a-c.

1972 *Globorotaliaobesa*Bolli : Bizon&Bizon,*Edit. Technip,* Paris, *p. 100, figs. 1-3.*

*1983 Globorotaliaobesa*Bolli : Kennet et Srinivasan, *Hutch. Roos. Pub.*Comp., p. 134, pl. 59, fig. 3-5.

Description

Low trochospiretest , with four chambers in the last spiral and which fasten together. The chambers are spherical and the last chamber occupies more than 1/3 of the whole size of the body. The opening is interomarginal to extraumbilical relatively rounded and slightly elongated. On the helical side, the sutures are radial to slightly twisted and depressed, the chambers feel to fit together.

Remarks

On the basis of the characteristic criteria, represented by the last chamber, the sutures, we assign the studied specimen to *Globigerinellaobesa*, accordingly to the diagnosis of described by BRAZIER & STRONG 1989 from the middle Miocene of new zealand region. Very similar specimens have been attributed to *G. obesa* from Mio-pliocene non-marine strata of beldri Omor regionTouggourt

I.2. Benthic foraminifera

The benthic foraminifera are more the abundant among the assemblage, with 13genus and 14species

Sous-ordre : ROTALIINA Delage&Hérouard, 1896

Family :Rotaliidae EHRENBERG, 1839

Genus :*Ammonia* LINNE, 1758

Type Species: *Ammonia beccari (Cushman, 1926)*

Synonymy

Nautilus beccarii var. Perverse Walker, 1784

Nautilus beccarii Linnaeus, 1758

Rotaliabeccarii (Linnaeus, 1758)

Strebluschreccarii (Linneaeus, 1758)

Description

Flat helical test, limestone with granular structure, with hook threads, bulge on navel surface (ventral), indented toward umbilicus, helical surface (dorsal) bulges 2 or 3 threads, in adults, septal The chamber is spaced relative to the species with ammonia. The size of the bat is steadily increasing. The opening is located at the bottom of the last compartment on the side of the navel and extends towards the navel.

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Family: BOLIVINIDAE Cushman, 1927

Genus: *Bolivina* D'Orbigny, 1839

Type Species: *Bolivina dilatate Reusses 1850*

Synonymy

1850 – *Bolivina dilatata* Reusses, Akad. Wiss.Math Naturw., Wien, Bd. 1, p. 301.

1982 – *Bolivina dilatata* Reuss : Van der Zwaan, pl. 1, figs. 3, 4, 5.

1992 – *Bolivina dilatata* Reuss : Poignant et Moissette, pl. 1, fig.11.

2002 – *Brizalina dilatata* (Reuss) : Kaminski et al., pl. II, fig. 13.

2008 – *Brizalinadilatata*(Reuss) : Dce et francès, pl. I, figs. 11-12.

Description:

This species exhibits well developed sigmoid sutures. This is a well-known Neogene species from the circum-Mediterranean area. Specimens described as B.goesii Cushmanby PARKER (1954) from tHe northeast Gulf of Mexico are very similar to this species (Wrightetal,inedit).

***Genus: Brizalina* COSTA, 1856**

Type Species: *Brizalina sp*

Description

Test elongate, lanceolate, compressed, periphery acute to carinate, bisurial throughout, chambers broad and low, sutures oblique, wall calcareous, hyaline, optically radial, fine hyperforate, may be basally apiculate, surface smooth or may have low and narrow imperforate longitudinal costae, most prominently
on the early half of the test; aperture a basalloop that extends up the apertural face, with bordering lip and internal tooth plate, triangular attached part of the tooth plate extending within to the previous foramen and denticulate ,narrow and elongate free part projecting through the apertural opening. U. Cretaceous (Campanian) to Holocene; cosmopolitan.

Family: BULIMINIDAE Jones, 1875

Genus:*Bulimina*d'Orbigny, 1826

Type Species:*Bulimina fusiformis Williamson, 1858*

Synonymis

*Buliminafusiformis*Williamson1858

*Bulimina*pupoides var. *fusiformis* Williamson1858

*Fursenkoinafusiformis*Williamson1858

Description

The specimen is elongated, tapered, slightly fusiform, the chambers increase with size and height, some irregularities, less chambers, obvious, irregular spiral; sutures are obvious, concave, smooth walls, with fine spines, Mouth ovate and small.

Family: GAVELINELLIDAE Hofker, 1956

Genus:*Gyroidina* d'Orbigny, 1826

Type Species: *Gyroidina* sp

Description

Test shows a rounded periphery with a trochospiral arrangement of the chambers. the spirale face is flat contrasting with the much more convex umbilical face. suture lines are radial to curved. the wall is calcareous, hyaline and perforated. the interio-marginal opening draws a slit connecting the periphery to the umbilicus.

Family :CIBICIDIDAE Cushman, 1927

Genus :*Cibicidoides*Thalmann, 1939

Type Species:*Cibicidoides sp*

Description

Trochospiral test, plano-convex in cross section, and a convex umbilical side , flattened or slightly convex , spiral side evolves . seven to nine moderately inflated chambers gradually increase in size. the primary aperture is a narrow equatorial slite bordered by thin lip , extending from the hairspring side

Family: Siphoninidae Cushman 1927

***Genus: Siphonina* Reuss, 1850**

Type Species: *Siphoninasp*

Description

It is a slightly asymmetrical bioconvex shape. the hyaline calcareous test is coarsely perforated. but this porosity is rather sparse. the circular opening, bordered by a curved lip, is supported by a small collar.

Sub-order: *Miliolacea* EHRENBERG, 1839

Family *Hauerinidae* SCHWAGER, 1876

Genus *Quinqueloculina* D'ORBIGNY, 1826

Type Species:*Quinqueloculinasp*

Description

The sample is wound with half-coil-length chambers and alternates periodically in 5 spaced winding planes, but with continuous chambers in spaced planes so that 3 chambers are visible on one side of the lid and 3 chambers on the other. 4 chambers visible laterally; walls calcareous, porcelain, unperforated, pseudochitin in inner layer, few agglomerates on outer surface; open-ended, round, with single or double teeth (Loeblich and Tappan). 1964)

Sous ordre TEXTULARIINA Delage&Hérouard, 1886

Family: TEXTULARIIDAE Ehrenberg, 1838

Genus ;*Textularia* Defrance, 1824

Type Species: *Textularia agglutinans (d'orbigny 1839)*

Synonymy:

1839 Textulariaagglutinansd'Orbigny PI. 13, fig. 1

1839 Textulariaagglutinansd'Orbigny: 144, pl. 1, figs 17-18.

Description:

Textulariaagglutinansd'Orbigny is a large cosmopolitan agglutinated foraminifera species with an elongated biserial test and a low arch aperture

Sous-ordre : LAGENINA Delage &Hérouard, 1896

Family : NODOSARIIDAE Ehrenberg, 1838

***Genus: Dentalina* Risso, 1826**

Type Species:* **Dentalinasp**

Description

Test is elongated and arched, the chambers rather swollen, have a uniseriate arrangement. the sutures are oblique. the aperture is terminal radiate, often in a submarginal position.

***Genus: Nodosaria* Risso, 1826**

Type Species: ***Nodosaria* sp**

Description

Test elongate, multilocular, ovate proloculus followed by uniserial and rectilinear globular to ovate chambers; wall calcareous, hyaline, perforate, surface smooth and uncommented; aperture terminal, radiate or rounded and bordered by radiating grooves, produced on a neck

Family*: *Robivinitidae

Genus: Fursenkoina

Type Species: *Fursenkoina* sp

Description

The test is small, elongated, and has an oval profile. The cells are elongated but swollen, and the sutures are clearly visible. The opening found at the end of the last box is the slit located on the penultimate box. It lines the lips and has plaque inside. Test smooth, glossy, and transparent. The twist of the test may resemble a coil and cause an elegant confusion with Bulimimella, but the opening slit is quite unique and helps avoid confusion

Family : VAGINULINIDAE Reuss, 1860

Genus : Lenticulina Lamarck, 1804

Type Species: *Lenticulina sp*

Description

Planar helical, compressed and lenticular. Initially rolled up, later often unfolded. Later chamber widths vary, most diagnostic features are retraction sutures, early bulges, and large size

***Genus: Amphicoryna* Schlumberger, 1881**

Type Species: *Amphicoryna scalaris Batsch, 1791*

1791 - Nautilus scalaris, Batsch.

1982 - AmphicorynaScalaris (Batsch) : AGIP SPA, pl. XIX, Fig 7.

1973 - AmphicorynaScalaris (Batsch) : Rev. Espa. De Micropal. Vol. 2, PL. VI, Fig 20

Description:

The test wall is calcareous and the surface covered with ridges running along most of the length of the chambers. The test is elongate and uniserial, circular in cross-section, with several inflated globular chambers, separated by deeply incised sutures. A maximum of approximately twenty ridges run along the terminal chamber. The ridges increase in number towards the terminal chamber and do not extend the full length of the chambers. The aperture is terminal at the end of a neck.

3. Conclusion

In this chapter, we provide a description of 14 species of benthic foraminifera and 8 species of planktonic foraminifera. These species were discovered for the first time in the Tougguurt area, providing valuable insights into the paleoenvironment of this region

Chapter 03

The result

1. Introduction

In this section, we aim to visualize the paleoecology of benthic foraminifera and determine the paleoenvironment during the Pliocene age. Additionally, we conducted carbon detection using Bernal's calcimetry system.

2. Paleoecology and microhabitats

of benthic foraminifera A comprehensive summary of the paleoecological preferences of the most representative benthic foraminifera, grouped according to similar paleoecological affinities, has been compiled for the studied section. This compilation includes information on paleobathymetry, microhabitat, oxygen preferences, and other relevant ecological data (refer to Table 01).

The microhabitats of benthic foraminifera have been identified based on the classification proposed by CORLISS (1985, 1991) and CORLISS & CHEN (1988), which categorize them as epifaunal, shallow-infaunal, or infaunal. The relative abundance of different microhabitats can provide insights into organic carbon flux to the seafloor and the oxygenation levels of the bottom water (CORLISS & CHEN, 1988; JORISSEN ET AL., 1995; JORISSEN, 2002).

Table 01. Paleoecological inferences and microhabitat preferences of benthic foraminifera found in the section studied.

Species/Genera	Paleobathymetry	Microhabitat	Oxygen
*Bolivina dilatata*Reuss 1850.	Inner shelf-bathyal	Infaunal	Low-oxygen dysoxia
Bulimina costata d'Orbigny 1826 *Bulimina fusiformis Williamson 1858.*	Inner shelf-bathyal	Infaunal	Dysoxia
Cibicidoides spp.	Shelf-bathyal	Epifaunal	Oxic
Amiculina spp.	Shelf-bathyal	Epifauna	Suboxic to Oxic
bretalina spp.	Rarely shallower	Epifaunal	Low-oxygen
siphonina spp.	Rarely shallower	Epifaunal-shallow infaunal	oxyphilic
Fursenkoinasp	Outer shelf-bathyal	Infaunal	Anoxic

Ammoniabeccarii Cushman 1926	Shallower	Shallow infaunal	Suboxic
Textulariaaggliutinans d orbigny 1839	Shelf-shallower	Epifaunal-shallow infaunal	Suboxic to Oxic
Gyroidinasp	Shallower	Epifaunal-shallow infaunal	Oxic to anoxic
Quinaueloculinasp	Inner shelf	Epifaunal-shallow infaunal	Oxic to Suboxic
Dentalinasp	Shallower	Shallow infaunal	Suboxic
Nodosariasp	Shelf-shallower	Shallow infaunal	Oxyphilic
Amphicorinspscalarisbatsch 1791	Neritic-bathyal	Deep infaunal	Intermediate organic

Based on the data presented above, the rocks at the base of the sequence were likely deposited in a fluvio-lacustrine setting characterized by episodes of higher energy, as indicated by the presence of the genus Chicoidoides. The presence of Chicoidoides also suggests well-oxygenated bottom waters and intervals with enhanced primary productivity. The presence of planktonic foraminiferal species further supports the existence of episodes of high primary productivity, possibly due to high nutrient flux from the land.

The origin of the fine sand laminae observed in the sequence may be attributed to storm activity, longshore drifts, or fluvial and deltaic influences, as supported by the presence of coally material. A fluvial influence would indicate a high nutrient flux to the lake environment, leading to seasonal high primary productivity, periodic higher current energy, and subsequent oxygenation of the bottom water. This influence might have diminished during the deposition of sediments in the middle of the sequence.

The presence of the gastropod species Perinella conica supports the interpretation of a lower mid-eulittoral and intracontinental lake environment, characterized by calm conditions and non-tidal areas. This species has been reported from the coast of North Africa, occupying a position below 20 cm of water in saline environments. It is also found abundantly in muddy sand overlying coral rock in the upper eulittoral of central African areas, hypersaline lagoons, enclosed bays, and shallow hypersaline pools on rocky shores in southern Europe.

Considering the ecology and paleoecology of Pirenella conica from neighboring regions, the most likely environment for this species in our investigated region is the muddy upper eulittoral zone of a hypersaline lake.

3. Method of Berner Calcimetry

To determine the percentage of carbonates in the studied samples, we employed a chemical analysis method called Berner Calcimetry.

3. 1. Protocol:

To measure the lime content in the clay, a sample weighing 0.5g was taken from each layer and placed in a device capable of measuring the volume of carbon dioxide (CO2) released during the reaction of the sample with hydrochloric acid (HCl). From these measurements, the following results were obtained using the appropriate calculation method.

100g(CaCo3) =22400ml(Co2) m(CaCo3)=V(Co2)*100/22400 T(CaCo3)= m(CaCo3)*100/0

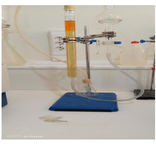

Fig 06: **Berner calcemitry dvise and protocole**

The chemical analysis (Table 1, Fig. 06) of several samples from the Mio-Pliocene clays of Beldet Omar indicates a low carbonate content in almost all the samples:

Table. 02. Analyses chimiques des argiles de beldet Omar (teneur en $CaCo_3$, volume C Cc2)

Samples	CaCm (g)	Limestone (%) [CaCm/%]
BA1	0.006696	1.339286
BA2	0.033482	6.696429
BA3	0.035714	7.142857
BA4	0.035714	7.142857
BA5	0.104911	20.98214
BA6	0.022321	4.464286
BA7	0.017857	3.571429
BA8	0.098214	19.64286
BA9	0.006696	1.339286
BA10	0.004464	0.892857
BA11	0.049107	9.821429
BA12	0.042411	8.482143
BA13	0.051339	10.26786
BA14a	0.024554	4.910714
BA14b	0.051339	10.26786
BA15	0.066964	13.39286
BA16	0.060268	12.05357
BA17	0.078125	0.078125
BA18	0.069196	0.069196

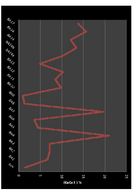

Figure 07 A curve showing the amount of lime in terms of the percentage of carbon (19 sample).

3.2. Interpretation

The results of our analysis (refer to the graphical curve in Figure 07and the accompanying table) indicate variations in the lime content throughout the studied succession from Bekkri Amar (Al-Aar). Generally, the percentage of carbonates is low and exhibits an uneven distribution without evident organization. This scarcity can be attributed to the very low abundance of microfauna in a continental environment, particularly in fluvi-lacustrine settings such as inundation plains. These conditions are unfavorable for the development of biota, especially foraminifera, which are the main carbonate producers. The analysis reveals a range of values, with the lowest percentage (0.89% for BA10) observed in the middle part of the studied section. Conversely, the highest percentage (20.98% for BA5) is recorded in the lowermost part of the succession. The limited presence of carbonates and microfauna is clearly associated with the high energy of the fluvial currents, which hinder the survival of microfauna.

4.Depositional model

The studied succession predominantly consists of clay facies with intermittent lenses of sands. The sand layers exhibit cross- and oblique bedding, occasionally containing gravel and coarse sand, and are organized in a fining-upward sequence. These characteristics are indicative of a fluviatile environment, specifically an alluvial plain (inundation plain), representing the lower part of a fluvial system characterized by low to calm energy conditions.

During periods of weak hydrodynamics, claystone deposits, composed of very fine particles, are formed. As the hydrodynamic energy increases, sandy sediment layers are deposited as discontinuous beds or lenses. These represent episodes of high hydrodynamics within the inundation plain, likely associated with sandy channels.

General Conclusion

General conclusion

The studied outcrops in the Bled Omar area, located in the Wilaya of Touggourt, are characterized by clay-dominated deposits with intermittent sandy lenses. Previous studies have arbitrarily assigned these deposits to the Mio-Pliocene age.

Through a new collection and investigation of 14 clay samples systematically selected across the Bled Omar quarry, the laboratory study yielded significant results. The presence of Miocene foraminifera was identified, including 14 species of benthic and 8 species of planktonic foraminifera. The paleoecology of these foraminifera suggests shallow marine conditions. However, the sedimentological data obtained from the study indicate a fluvio-lacustrine environment, characterized by the presence of sandy channels exhibiting graded bedding, cross bedding, and coal remnants.

Given that the identified microfauna are typically associated with marine environments, their presence in the studied area suggests that they were transported by fluvial currents from a marine setting

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