



FACULTY OF HYDROCARBON, RENEWABLE ENERGIES AND EARTH SCIENCES

DEPARTMENT OF EARTH SCIENCES(GEOLOGY)

**PALEOENVIRONMENTAL STUDY BASED ON BENTHIC FORAMINIFERA IN  
GUETNA SECTION FROM TAFNA BASSIN, NW ALGERIA**

*Dissertation submitted to the department of Earth sciences as partial fulfillment of the requirement for Thea Master's degree in Geology*

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# *Acknowledgments*

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# *Dedication*

And their last prayer is: Praise be to Allah, the Lord of all the worlds.

Praise be to Allah at the beginning and at the end.

This journey was long. It had both failures and successes.

I am proud of the effort I made to reach my dream a moment I waited and dreamed of for a long time.

Today, a chapter of my story comes to an end. To the one who taught me how to give without asking for anything back To the one whose name I carry with pride, To the one whom Allah blessed with wisdom and dignity (my dear father). To the light of my eyes, the heart full of love, To the one whose prayers helped me succeed (my beloved mother). To my sisters (Khadija, Khawla, Siham, Nesrine, Sabrina), and to my brothers (Abderrazak, Mostafa, Abdelfattah), and to their children who give me strength in life May Allah always keep you close to me To every member of my family, young and old thank you. To my friends who stood by me during the hardest times at university (Rayane, Oumnia, Aouali, Soundous, Belkisse, Amira, Soumia, Manar, Amina ...) Thank you for walking with me on this journey. To my dear friend, my soul sister, the one who is like a sister even if not born from my mother, the one who supported me in my weakest moments (dear Rayane), words are not enough to describe you. Thank you from my heart for all your help and support. To my childhood friends, who left warm memories in my heart, to my dear girlfriends who were always there with love and kindness, and to my sweet cousin's daughters of my aunt (Romiassa and Somia), to my cousins (Ibtihal and Aridj) who shared with me joy and sadness, thank you for being a beautiful part of my life and this journey. To my professor who guided and supported me in this work (Mr. Ben Zina Mostafa) Thank you so much. I pray that Allah gives you success in your knowledge and career. I also thank my grandmother for her prayers. May Allah bless her with a long and healthy life.

Finally, I thank everyone who shared my happiness my (family, friends, loved ones, and teachers).

I ask Allah to give us all success and happiness in life.

*Chegoua Fatma Zahra*

# *Dedication*

Praise be to God, who guided us to this achievement that was once a dream for me and has now come true

I dedicate this accomplishment to my mother, the candle of my life, who sacrificed everything precious for me and taught me that love is action, not just words. To the soul of my father, may God have mercy on you and fill you with His satisfaction.

. To the one who was like a loving father to me, my elder brother Younes, who filled my life with care and love may you always be my support. This is for you.

To my dear siblings Halima, Hanin, Chifa, Taha, Fawzi, and Naïm who supported me throughout my life's journey. To those whose laughter melted away my exhaustion may you always be my unbreakable backbone.

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Finally, I will never forget God's grace and everyone who stood by me during my academic journey. I ask God to grant success to all.

*Difallah Riane*

# Abstract

Our paleontological study examined a section from the Geutna region located in the Tafna basin Northwestern Algeria, dating back to the Neogene period (late Miocene). Our study aims to reconstruct the paleoenvironmental conditions that prevailed during the Tortonian stage, whose stratigraphic age was determined based on the presence of a key planktonic foraminifera species (*Neogloboquadrina acostensis*). Our research primarily relied on the distribution and evolution of benthic foraminifera, through which we identified 14 species classified into 12 genera, most of which have calcareous test. This study distinguished two main environmental unit the first unit was dominated by the genus *Ammonia*; the second unit showed no dominant species (ecological equilibrium). We considered several factors, including foraminiferal assemblages, the number of benthic species, and the planktonic index, we were able to optian the following results, first stage a shallow marine environment with limited water exchange and minimal terrestrial sediment input. Second stage improved water circulation and increased terrestrial nutrient, enhancing the diversity of benthic and planktonic organisms. Third stage a return to marine esolution and reduced biodiversity. Fourth stage connection to the open sea without terrestrial sediment supply with rapid fluctuations possibly indicating influence, Considering the color variations in the layers (from gray to white to yellow), which reflect differences in depositional environments and rock/mineral composition over time, gray color: Indicates clay-rich rocks or organic limestone, formed in low-oxygen environments (e.g., deep oceans). White color: Suggests pure limestone, typically from clear marine environments or coral reef areas. Yellow color: Reflects iron oxides due to weathering or oxidation, signaling oxygen-rich environments (e.g., floodplains or continental regions). This color gradient represents a chronological sequence of the geological and climatic changes the region underwent during the formation of these layers.

## المخلص

دراستنا الحفرية تناولت مقطعاً من منطقة القيطنة الواقعة في حوض التافنة، شمال غرب الجزائر، تعود إلى الفترة النيوجينية (المايوسين الأعلى). تهدف دراستنا إلى إعادة بناء الظروف البيئية القديمة التي كانت سائدة خلال مرحلة التورتونيان، حيث تم تحديد العمر الطبقي اعتماداً على وجود نوع مهم من المنخربات العوالقية (*Neogloboquadrina acostensis*).

اعتمد بحثنا بشكل أساسي على توزيع وتطور المنخربات القاعية، حيث تمكنا من تحديد 14 نوعاً مصنفاً ضمن 12 جنساً، أغلبها ذات قشرة كلسية. وقد ميزت هذه الدراسة وحدتين بيئيتين رئيسيتين: الوحدة الأولى كانت تهيمن عليها أنواع من جنس الأمونيا، أما الوحدة الثانية فلم تُظهر نوعاً مهيمناً، ما يدل على توازن بيئي.

اعتمدنا على عدة عوامل، منها تجمعات المنخربات، وعدد الأنواع القاعية، ومؤشر العوالق، فتوصلنا إلى النتائج التالية:

المرحلة الأولى: بيئة بحرية ضحلة ذات تبادل مائي محدود ومدخل ضئيل للرواسب القارية.

المرحلة الثانية: تحسُّن في دوران المياه وزيادة في المغذيات القارية، ما أدى إلى تنوع أكبر في الكائنات القاعية والعوالقية.

المرحلة الثالثة: عودة إلى عزلة بحرية وتراجع في التنوع الحيوي.

المرحلة الرابعة: اتصال بالبحر المفتوح دون تغذية قارية، مع تقلبات سريعة قد تشير إلى تأثيرات خارجية.

وبالنظر إلى تدرجات الألوان في الطبقات (من الرمادي إلى الأبيض إلى الأصفر)، التي تعكس اختلافات في بيئة الترسيب وتركيب الصخور/المعادن مع مرور الزمن، نجد ما يلي:

اللون الرمادي: يشير إلى صخور غنية بالطين أو حجر جيرى عضوي، تشكّل في بيئات منخفضة الأوكسجين (مثل المحيطات العميقة).

اللون الأبيض: يدل على الحجر الجيري النقي، غالباً من بيئات بحرية صافية أو مناطق شعاب مرجانية.

اللون الأصفر: يعكس وجود أكاسيد الحديد نتيجة التجوية أو الأكسدة، ما يشير إلى بيئات غنية بالأوكسجين (مثل السهول الفيضية أو المناطق القارية).

يمثل هذا التدرج اللوني تسلسلاً زمنياً للتغيرات الجيولوجية والمناخية التي شهدتها المنطقة خلال تكوّن هذه الطبقات.

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# Chapter One

## 1. Introduction

The Tafna Basin is one of the most prominent sub littoral basins in northwestern Algeria (Thomas, 1986). It is named after the Tafna River in the Telemen region, where also it is considered as one of the most complex area in the southern Mediterranean margin, its origin dating back to the Neogene period (Guardia, 1975). The latter, reported that this basin contains a complete sedimentary cycle, which includes deposits from lakes, rivers, and seas. At the base of these deposits, there are continental sediments consisting of sandstones and clays. The Late Miocene has previously been attributed to these formations, based on direct correlations with marine deposits.

## 2. Geological setting

### 1.1 General Frame work

The Neogene Tafna Basin is located in the north-western Algeria, a complex region on the southern edge of the Mediterranean. Geographically, the basin is with the Traras massifs forming north-western, separating it from the Mediterranean Sea. The Telemcen Mountains mark its southern boundary, while the Sebâa Chioukh mountains extend eastward towards the Tessala mountains as its north-east boundary (Fig1)

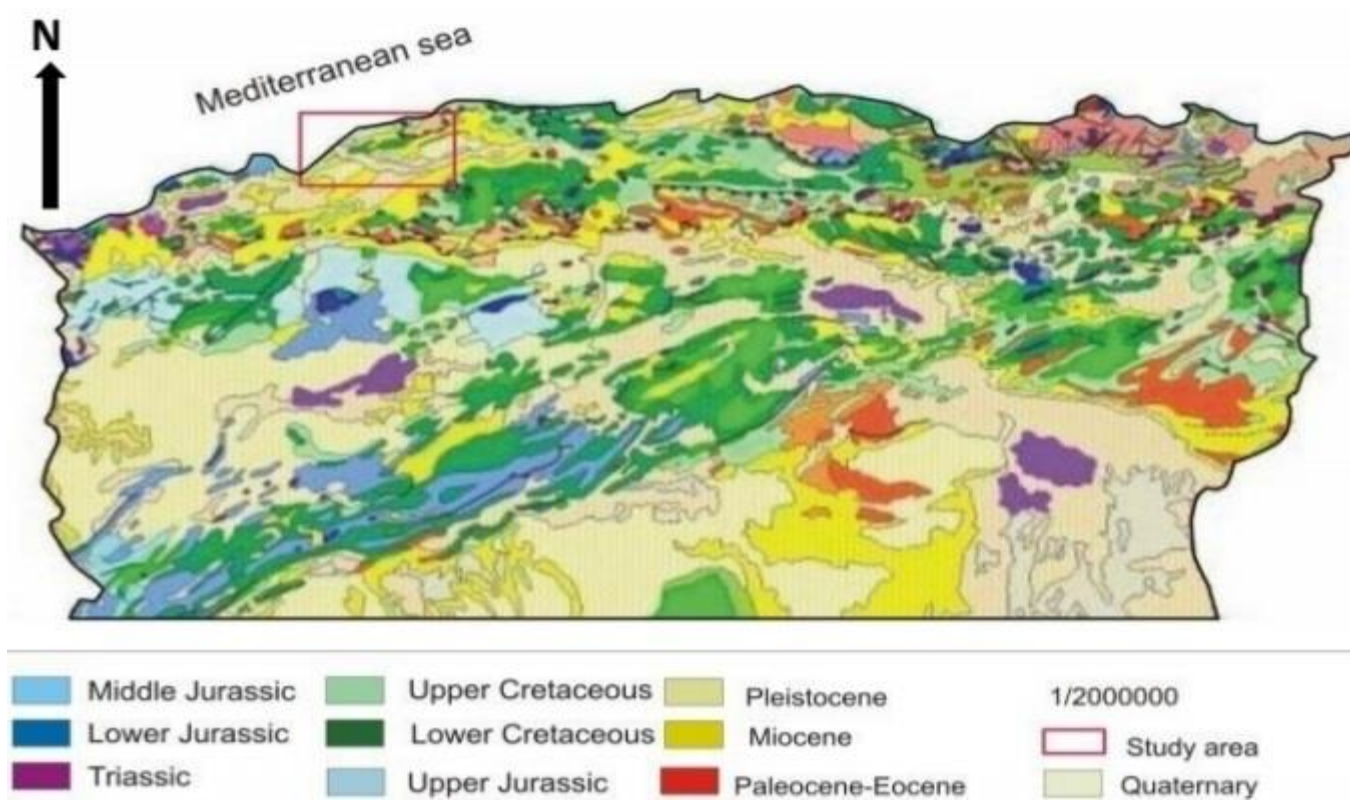


Figure.01. Geological map of the northern Algeria 1 /2,000,000 (Ministry of Energy and Mining) (in Benzina et al 2019)

1.2 Area of study

The Guetna area is located in the Tlemcen Province in the western part of Algeria. It is part of the geographical regions characterized by mountainous and rural landscapes. To the east, it is bordered by the municipality of Sidi Bakhit, and to the west by the municipality of Maghnia. To the north, it extends towards the Mediterranean coast. Qitna lies within the Tlemcen mountain range, which is known for its mountainous terrain and plateaus. The area is also close to the Algerian-Moroccan border, making it a region with significant strategic and geographical importance. The distance between the city of Tlemcen and the region of Khetina is approximately 15 to 20 kilometers. This area has not been well subjected by details research.

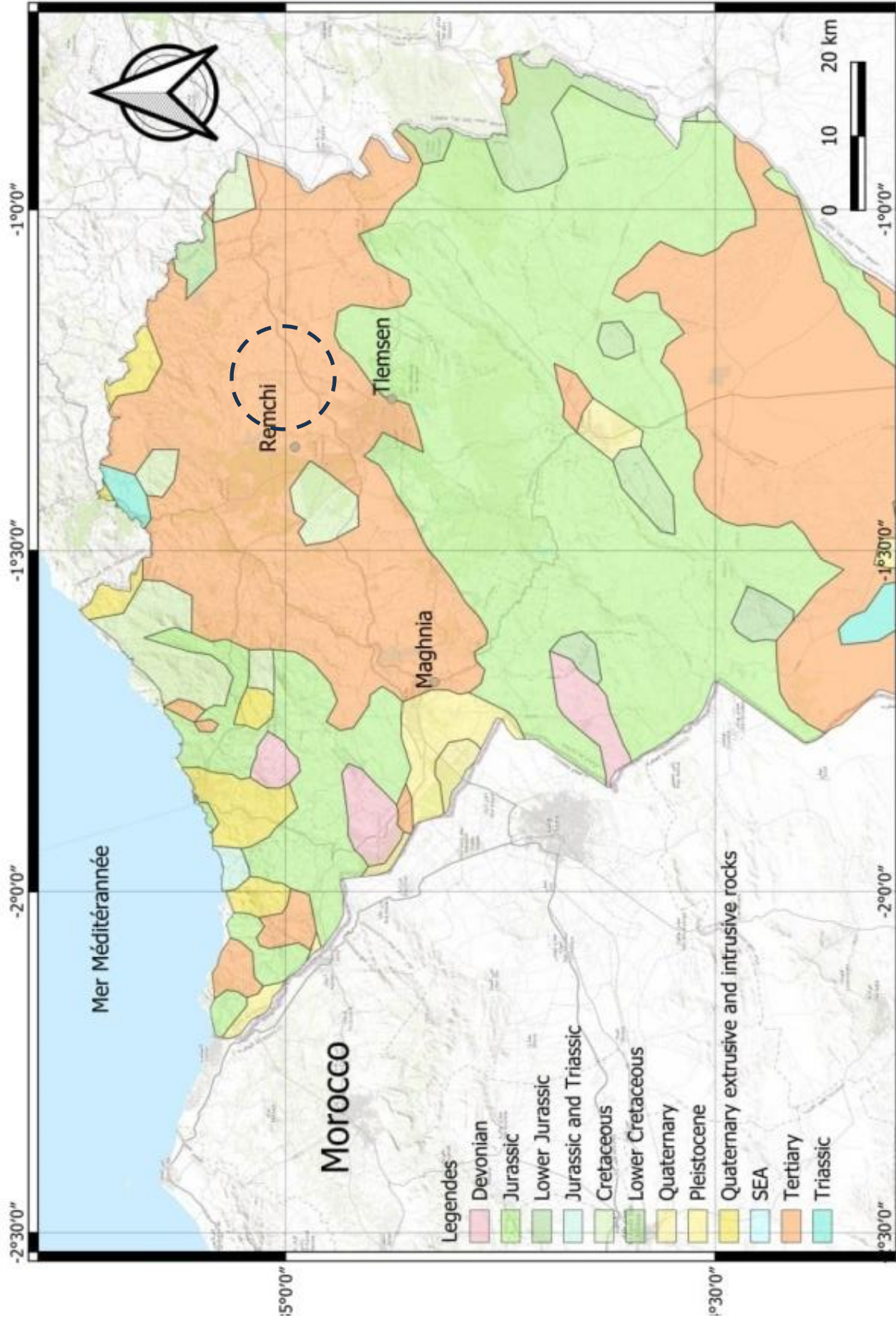
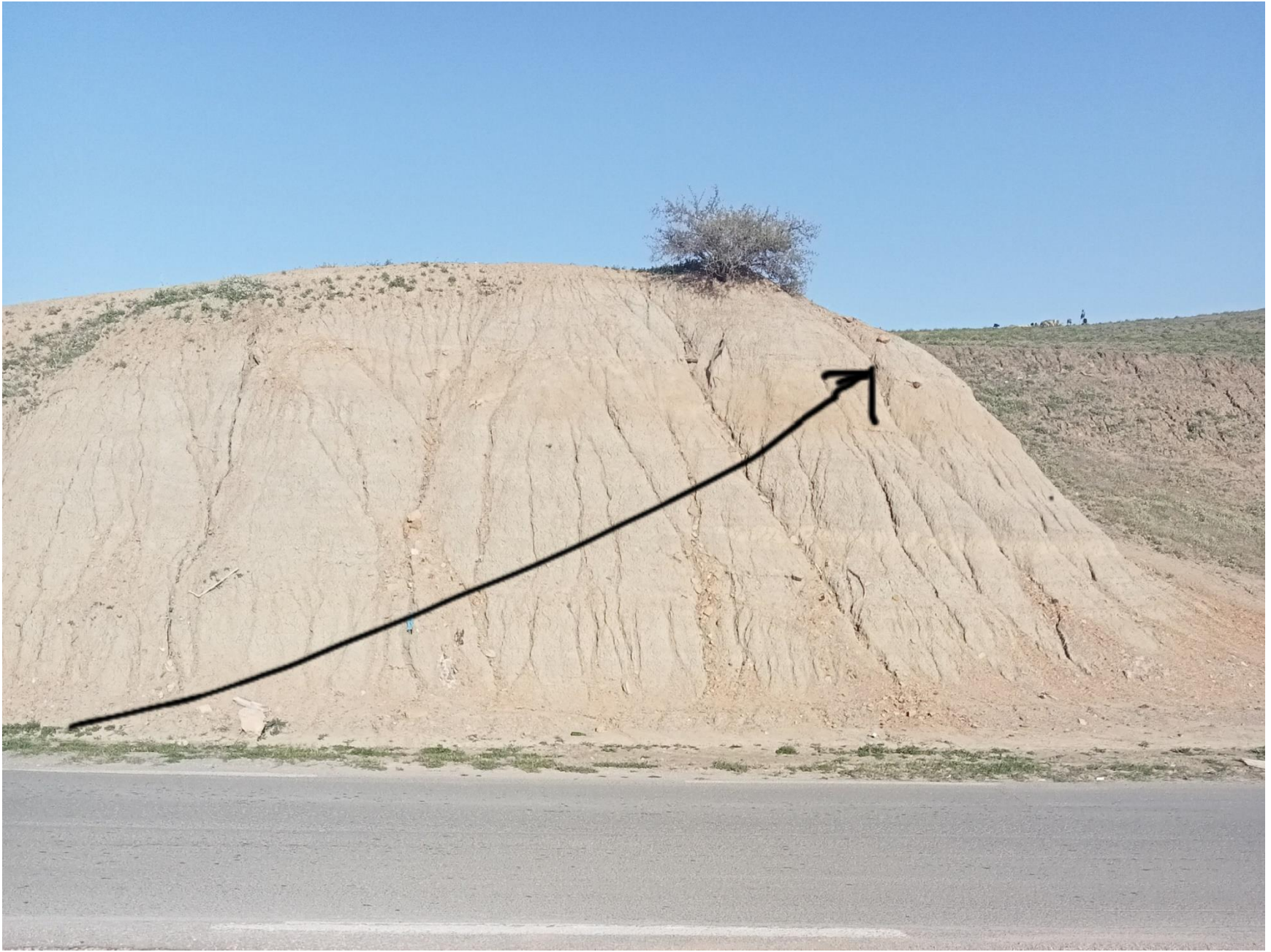


Figure.02. A map showing the study area (in dashed circle) from Tafna Neogene basin



**Figure03. The site of Geutna section**

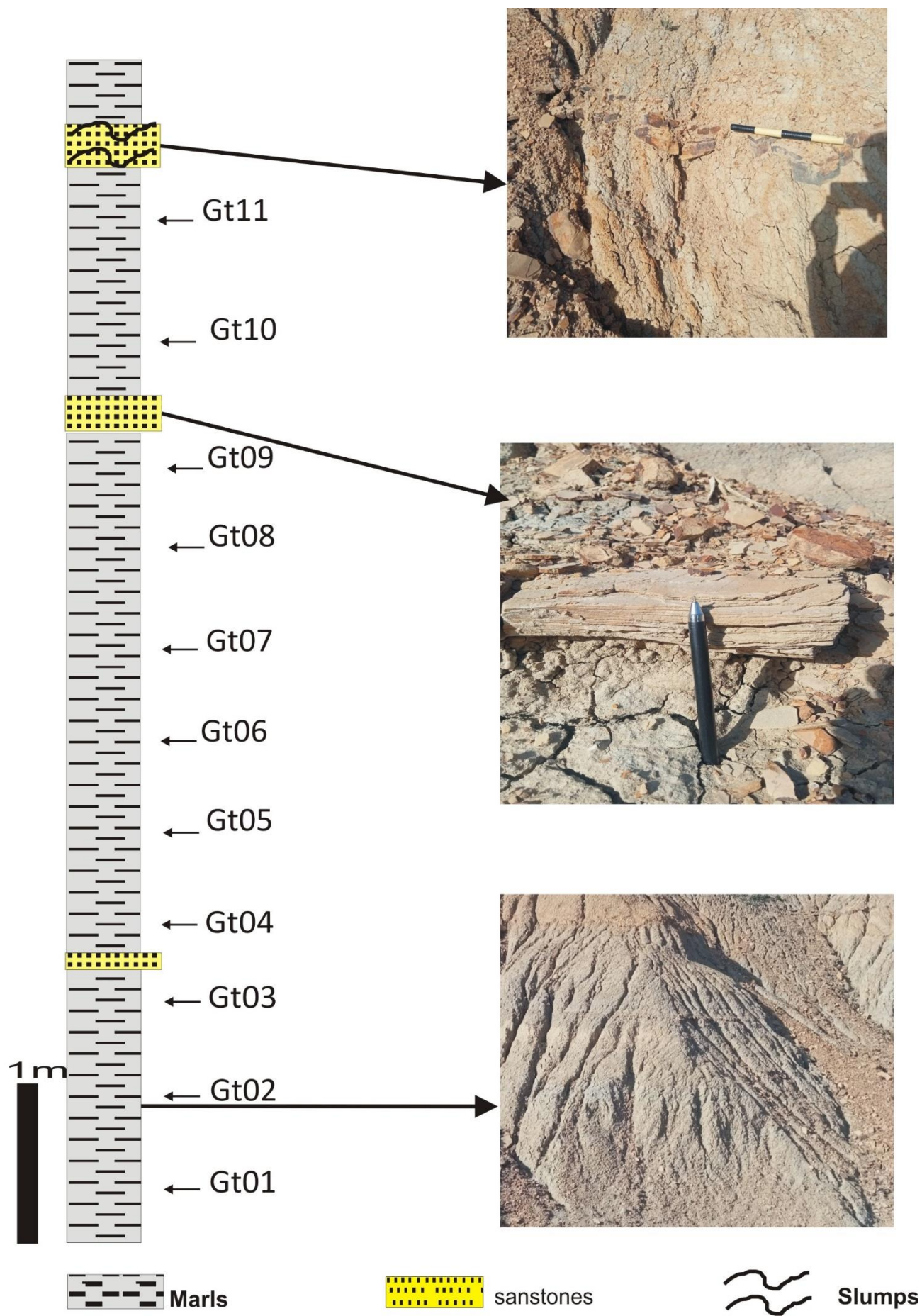


Figure.04. Lithostratigraphy of Geutna section

### 3. Lithostratigraphic of Geutna section

The Geutna section exposes two main facies that are marls interbedded by thin sandstones beds.

#### **Sandstone's facies**

The sandstones appear in scatter way along the section as thin yellowish beds, they are fine-medium grained sandstone with horizontal and inclined laminations. The top of beds shows some ripples that are more likely got linguides forms, however the bottom part does show and specific sedimentological features except from a plane reactivation surface.

#### **Marls facies**

Throughout the section the change of marls color is quite evident. Where, the bottom part of the section exhibits a thick grayish interval of marls, which is intercepted by decametric whitish marls. The latter on its own, from the middle part, is overlain by thick grayish marls succeeded by a metric yellowish interval. While, the upper part exposes the reappearance of a metric grayish interval.

### 4. Previous works

Tafna Basin has been the subject of many geological works starting from the 19<sup>th</sup> century till the current time. Early ventures date as far back as the colonial era, the research being tentative in character but helping a lot towards opening the doors to subsequent works. The first works of the region were done by Bayle (1854) and Ville (1857), who investigated the Traras massif and eastern coast. Pouyanne, in 1876, published a work on iron ore deposits of the Ouelhaca area (lower Tafna), and he prepared a geological map on a scale of 1:100,000. Gentil's works (1896, 1898, 1903) are the first important volumes dedicated particularly to the Tafna Basin. In his works, Gentil presented a significant monograph addressing both the paleogeography and the lithostratigraphy of the area. He also attempted to describe the three Miocene sedimentary cycles: Lower Miocene (Cartenian), Middle Miocene (Helvetian+Tortonian), and Upper Miocene (Sahelian). Dalloni (1915a, b, c; 1917) later equated the Summitlim with the Pliocene of the Tafna Basin, contrary to Gentil's (1917a, b, c; 1918a, b), who attributed them to Sahelian (Upper Miocene). Later research started with Perrodon (1957), who placed the Tafna Basin limestone series in the second cycle of Miocene, and in part to Late Miocene, on the basis of micropaleontological studies. Guardia et al. (1974), Guardia (1975), and Saint Martin et al. (1983) explained these observations based on the facies of planktonic foraminifera, thus positioning fields of the blue marls and the limestone climax in the second post-nappes cycle of the Messinian. Geological map compiled by Guardia (1990) give a good inclusive picture of the geology of west Oran and appropriately marks the different outcrops. Additional information regarding the reef structures and volcanism during the Miocene were furnished by Sadran (1952, 1958) and Bellon et al. (1948). Chaix (1982) also made some contributions toward further working on this topic. Bessedik et al. (1997) Based on marine-continental correlations also founded upon the emergence of new planktonic foraminifera and micro-mammals in the Tafna lagoonal deposits and in the transitional marine deposits (Sig), attributed the Vallesien to these ones. Hamdane, (2004); as part of his doctoral thesis, performed the integration of the bryozoan's treatment from the various reef constructions of the Tafna Basin. Hence, Boucif (2006) conducted a geodynamic study of the Neogene, whereby he explicitly stated that Tafna Basin is subjected to the same geodynamic regime that had operated on the rest of the Neogene basins in the country's northern coast. There was a series of engineering interventions (Touati and Abdelli (2005); Belkhuane (2006); Benrezzak y Gourari (2010); Mahboubi (2012) Benzina (2012) y master's academic (yebdri y Neghraoui (2016); Habibes y Beddraoui (2016); Bezzaouia (2018); Guerfaf y Boulghit (2019)) KECHOUCHE y DEMAI (2020), current (interested) various aspects sedimentological, paleontological y biostratigraphy of the upper Miocene deposits.

### 5. Problematic

Tafna basin is considered as one of the Neogene basins from the northern west of Algeria, where many studies have been carried out in terms of geodynamic, sedimentology and paleontology. However, this latter knew some of them that involves the study of coral reef, trace fossils, micro-mammals and foraminifera. In this sense, our research looks for to endorse this aspect based on the study of benthic foraminifera in the region of Geutna (belongs somehow to the southern part of the basin) in order to get more insights about its paleoenvironmental conditions.

### 6. Materiel and Methods

Here are below the main material used in the laboratory for our procedure

- Sieve 125um
  - Binocular
  - Magnetic needle (for species selection)
  - boxes (for sample preservation)
  - Cells (for species preservation)
  - Absorbent paper
- **Methods**

A total of eleven (11) samples were collected from the study area and carefully prepared for paleoenvironmental analysis. Each sample was washed and sieved using a 125µm mesh. From every sample, we select randomly 300 specimens, to be identified at the species level. Then we move to the creation of graphical curves on the basis of the relative abundances of the identified taxa.

## Chapter One

The sample collection process was complemented by detailed documentation of the geological formations that encompasses the lithological and the sedimentological features along the Geutna section.

Data were organized in a table format, where each row represents a sample (observation), and each column corresponds to a different taxon (species rate), showing their variation throughout samples.

Before conducting statistical analysis, several adjustments were made to enhance the graphical representation and avoiding ambiguities in interpretations. Taxa with very low percentages were excluded to improve data representation. Additionally, species that do not have significant information were also omitted, as their presence could obscure important patterns.

### Foraminifera Identification

Species identification was performed by placing the dried specimens under an binocular and comparing them to previously documented fossil records found in scientific literature.



Figure. 05. The main materials used in the laboratory for our procedures.

### 7.Objectif

This research primarily aims to identify the various benthic and planktonic organisms present. Secondly, it seeks to analyze paleoenvironmental indicators to understand the main factors controlling their distribution. The main objective of this study to reconstruct the paleoenvironmental development that occurred during the specific time period in the Geutna region.

# Second Chapter

Systematic study

## Systematic study

### 1. Introduction

Foraminifera are single-celled organisms, members of a phylum or class of protists characterized by streaming granular ectoplasm for catching food and other uses; and commonly an external shell (called a "test") of diverse forms and materials. Foraminifera are found in all marine environments; they may be planktonic or benthic in mode of life. The generally accepted classification of the foraminifera is based on that of Loeblich and Tappan (1964).

#### 1.1 Definition of Systematic

In paleontology, systematic is the scientific analysis of the classification of fossil fauna and flora and their evolutionary interconnections in terms of their anatomical and morphological features. It is a process that tries to categorize organisms into natural categories (like species, genus, families.) reflecting their evolutionary history.

Paleontologists in this field use rigorous analytical techniques, like cladistics, to document phylogenetic relationships between fossil organisms. (Benton, 2015).

#### 1.2 Definition of Taxonomy

Taxonomy is defined as the science of classifying them in groups with shared characteristics. Taxonomists attempt to identify relationships between organisms, and place them into groups that are ranked, beginning with kingdom, then phylum, class, order, family, genus, and species. The taxonomy system allows for the study of living organisms and increases knowledge about how these organisms evolved and the variety of life there is.

Taxonomy is not exclusive to the biological sciences and is also used in areas such as informatics and education, to categorize groups of concepts and data (Campbell and Reece 2005).

## 2. SYSTEMATIC

### 2.1- Foraminifer Benthic

#### *Ammonia beccarii*

#### Systematic

**Kingdom:** *Protista*

**Phylum:** *foraminifera*

**Class:** *Globothalamea*

**Order:** *Rotalinda*

**Family:** *Ammonudae*

**Genus:** *Ammonia*

**Species:** *Ammonia beccarii*

#### Synonymy:

*Nautilus beccarii* var. *perverse* walker 1784

*Nautilus beccarii* Linnaeus, 1758

*Rotalia beccarii* (Linnaeus, 1758)

*Strobilus beccarii* (Linnaeus, 1758)

*Ammonia tepida* (Joseph, A. Cushman 1926)

*Ammonia beccarii* (Loeblich and Tappan 1958)

### 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 hut 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

### *Ammonia tepida*

### Systematic

**Suborder:** *Rotalioidae*

**Family:** *Rotalidae*

**Genus:** *Ammoninae*

**Species:** *Ammoniatepida* (Cushman, 1926)

### Synonymy

*Ammonia beccarii sub sp. Tepida* (Cushman 1926)

*Strobilus beccarii var-Tepida* (Cushman 1926)

*Rotalia beccarii var-Tepida* (Cushman 1926)

*Ammonia beccarii. Tepida* (Cushman 1926)

### Description

In the plane spiral test, the limestone has a granular structure with spiral body, the umbilical surface (ventral surface) protrudes, and the umbilical surface is concave, and the adult spiral surface (back surface) protrudes 2 or 3 circles. The size of the hut is steadily increasing. The opening is located at the bottom of the last chamber on the side of the umbilicus and extends to the umbilicus (Jean-Pierre DEBENAY 2009).



Figure. 06. *Ammonia tepida*.

### *Bulimina*

### Systematic

**Class:** *Globotlamea*

**Subclass:** *Rotaliana*

**Order:** *Rotaliida*

**Super family:** *Buliminoidea*

**Family:** *Buliminidae*

**Genus:** *Bulimina*

***Boliminafusiformis* Williamson 1858**

**Synonymy**

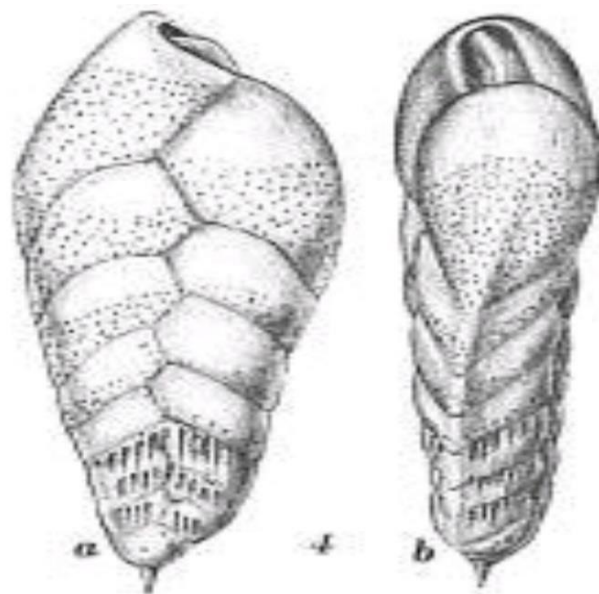
*Bulimina fusiformis* Williamson 1858

*Bulimina pupoides* var. *fusiformis* Williams 1858

*Fursenkoinafusiformis* Williamson 1858

**Description**

Plurilocular estrochospiral test, the test is moderately elongated, types of basal comma opening. Chambers added in a coil that forms a spire like a snail shell. The side on which all chambers are visible (evolute) is called the spiral side. On the other side only the final coil is visible (involute) and this is called the umbilical side.



**Figure.07. *Bulimina fusiformis* Williamson,1858.**

***Bolivina***

**Systematic**

**Kingdom:** *Protista* (Carl Linnaeus, 1758)

**Phylum:** *foraminifera* (Augustus Edward Hirst,1826)

**Class:** *Granuloreticulosa* (Frederik Nordenskiold,1888)

**Order:** *Rotaliida* (Ernst Haeckel,1865)

**Family:** *Bolivinidea* (Peter Hartman,1895)

**Genus:** *Bolivina* (John De La Petit,1844)

**Species:** *Bolivina sp*

**Synonymy**

*Bolivina dordigny*,1839: This is the original name of the genus.

*Bolivinites* Cushman,1911: proposed by Cushman as a subgenus or distinct genus, but was later considered a synonym of *Bolivina*.

Subbotina,1953: Used some species under the genus Bolivina in various contexts, but they were not officially accepted as synonyms.

Bolivinoides Cushman,1927: Sometimes considered a separate genus, but was later reclassified under Bolivina or considered a closely related genus.

### Description

Bolivina sp. is a genus of benthic foraminifera characterized by is elongated, biserial test, which is typically compressed and tapered toward the aperture. The chambers are arranged in two alternating rows, giving the test a slender appearance. The perforate, with a smooth or finely striated surface. The aperture is loop-shaped, located at the terminal end, and often has a small tooth plate.

Bolivina species are commonly found in marine environments, particularly in oxygen-depleted or dysoxic sediments, making them useful for paleoenvironmental studies (Sen Gupta, 2002).

## *Brizalina*

### Systematic

**Domain:** *Eukaryota*

**Kingdom:** *Protista*

**Phylum:** *Foraminifera*

**Class:** *Granuloreticulosa*

**Order:** *Miliolida*

**Family:** *Nodoscassidulinidea*

**Genus:** *Brizalina*

**species:** *Brizalina sp*

### Synonymy

The genus Brizalina was first described by Loeblich Tappan in 1987. They established it as a new genus based on specific morphological features distinguishing it from other related genera within the same family.

### Description

Brizalina sp. Is a genus of benthic foraminifera belonging to the family Boliviniidea. These microorganisms are characterized by their elongated, biserial tests, which are often compressed and possess a distinct aperture at the terminal end. The test wall is typically calcareous and perforate, which a smooth or finely ornamented surface.

'Brizalina' species are commonly found in marine environments, particularly in shelf to deep-sea sediments, and are useful in paleoenvironmental reconstructions due to their sensitivity to changes in oxygen levels and organic matter availability (Murray,2006).

## *Elphidium*

### Systematic

**Domain:** *Eukaryota*

**Kingdom:** *Chromista*

**Phylum:** *foraminifera*

**Class:** *Globothalamea*

**Order:** *Rotaliida*

**Family:** *Elphidiidea*

**Genus:** *Elphidium*

**Species:** *Elphidium advenum*

### Synonymy

*Elphidium advenum* was first described by (Cushman in 1922).

This species has undergone several taxonomic revisions over the years. Synonymies or related forms include:

-*polystomella advena*: (earlier classification).

-*Elphidium crispum*: (partially synonymous in some studies).

-*Elphidium advenum*: (used to denote the typical form).

### Description

*Elphidium advenum* is a species of foraminifera, which are microscopic marine organisms with calcareous shells. This species is characterized by its flat shell divided into several chambers arranged in a spiral pattern. *Elphidium advenum* typically inhabits shallow marine environments, such as sandy and muddy a sediment, and is used as an environmental indicator to assess marine conditions like salinity and pollution.

## Laguna

### Systematic

**Kingdom:** *Protista*

**Phylum:** *Foraminifera*

**Class:** *Tubothalamea* (for benthic forms)

**Order:** *Rotaliida* or *Lagenida* (depending on the species)

**Family:** this can vary depending on the species of foraminifer involved (e. g. *Miliolida*, *Elphidiidae*, *Ammoniidae*)

**Genus** and **species:** specific species of benthic foraminifera in lagoon environments would be listed based on their taxonomic identification. For example, *Ammonia beccarii*, *Elhidium*spp., and *Lagenida* are commonly found in such environments.

### Synonymy

-**1799:** the first descriptions of foraminifera date back to the work of **Lamarck** and others.

### Description

is characterized by a unilocular shell with a bottle-shaped or elongated ovoid form, often featuring a smooth or finely pitted surface. The shell is composed of calcium carbonate and terminates in a tiny aperture at the narrow end, giving it a distinctive small bottle-like appearance (Loeblich and Tappan, 1998).



Figure. 08. *Laguna. Sp* (Lamarck,1799).

### *Nonionella*

#### Systematic

**Domain:** *Eukaryota*

**Kingdom:** *Chromista*

**Phylum:** *Foraminifera*

**Class:** *Globothalamea*

**Order:** *Rotaliida*

**Family:** *Nonionidae*

**Genus :** *Nonionella*

**Species :** *Nonionella Stella*

#### Synonymy

- "*Nonionella Stella*" was first described by "Cushman and **Moyer**" in 1930.

-This species is widely recognized in benthic foraminiferal studies and has not undergone significant taxonomic revisions.

- Synonyms or related forms include: "*Nonionella opima Stella*"

#### Description

*Nonionella Stella* is characterized by a small shell, approximately 0.45 mm in length and 0.35 mm in width, with a sub trochoid shape and rounded margins. The shell consists of 8-10 chambers in the final whorl, with clearly visible chambers separated by obliquely curved side is not completely closed, while the ventral side displays a distinctive rounded lobe in the final chamber.

One of the key features of this species is the presence of finger-like processes on the ventral side of the final chamber, which extend over the sutures of the preceding chambers. These processes give the shell a stellate (star-like) appearance, from which the species name *Stella* is derived. The external surface of the shell is smooth, with a long aperture that runs along the length of the final chamber (Cushman, j. A.; Moyer, D. A. (1930).



Figure. 09. *Nonionella Stella*.

*Stilostomella mappa*

**Systematic**

**Kingdom:** *Protista*

**Phylum:** *Rhizaria*

**Class:** *Foraminifera*

**Order:** *Lagenida*

**Family:** *Stilostomellidae*

**Genus:** *Stilostomella*

**Species:** *Stilostomella mappa*

**Synonymy**

-*Stilostomella stigmata* (Cushman,1927)

-*Stilostomella aciculate* (Cushman,1927)

-*Stilostomella Leptospira* (Cushman,1930)

-*Stilostomella robusta* (Schwager,1961)

**Description**

The genus *Stilostomella* is characterized by narrow and elongated shells.



Figure. 10. *Stilostomella mappa*.

***Nodosaria*****Systematic****Kingdom:** *Protozoa***Phylum:** *Foraminifera***Class:** *Tubothalmea***Order:** *Lituolida***Family:** *Nodosariidae***Genus:** *Nodosaria***Species:** *Nodosaria sp***Synonymy**

- "*Nodosaria radricula*" (Linnaeus,1758): One of earliest species, first described by Carl Linnaeus in the 18th century.

Characterized by its articulated calcareous shell and elongated shape.

- "*Nodosaria vertebralis*" (Batsch,1791): Distinguished its successive chambers arranged in a way that resembles vertebrae, hence its name "vertebralis".

- "*Nodosaria zippei* (Reuss,1845): First described in the mid-19<sup>th</sup> century and found in deep-sea sediments.

- "*Nodosaria solute*" (Reuss1863): Notable for its separated chambers compared other species.

**Description**

is a genus of marine foraminifera belonging to the order Lagenida. It is characterized by its calcareous, perforated test, composed of a linear series (uniserial) of chambers. Each chamber exhibits a distinct separation from the others through intermediate constrictions, giving it a bead-like appearance. These organisms possess a complex terminal aperture, often equipped with tooth-like structures (Loeblich and Tappan, 1998).

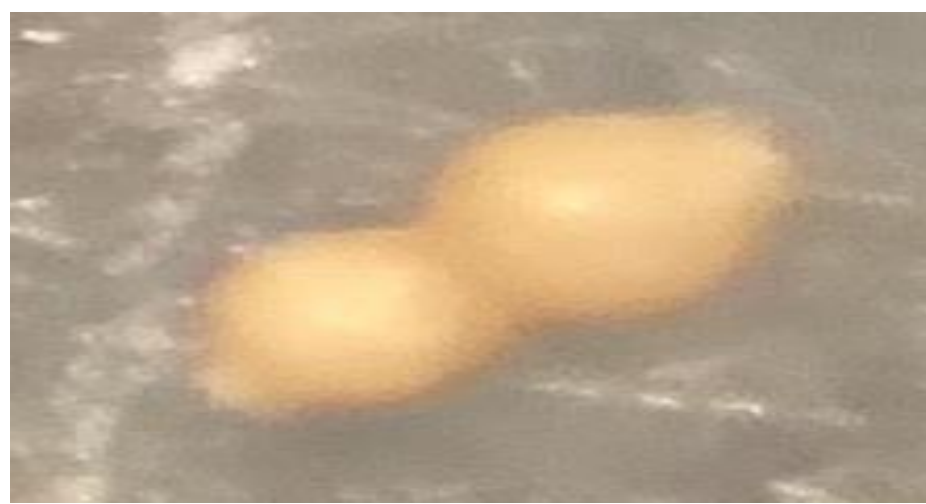


Figure. 11. *Nodosaria sp.*

***Quinqueloculina quadriloculina*****Systematic****Kingdom:** *Protista***Phylum:** *Foraminifera***Class:** *Tubothalamea***Order:** *Miliolida*

**Family :** *Miliolidae*

**Genus :** *Quinqueloculina*

**Species :** *Quinqueloculina quadrilateralis*

### Synonymy

The Species *Quinqueloculina quadrilateralis* was first described by the French paleontologist Alcide “d’Orbigny” in 1838 under the name *Triculina quadrilateralis*.

### Description

- “*Quinqueloculina quadrilateralis*” is a species of foraminifera characterized by a calcareous shell with a pentagonal to quadrilateral shape when viewed from the side, with chambers arranged in repetitive pattern.

-The shell surface is smooth to slightly grooved, with variations in aperture patterns.

-The color ranges from white to light gray.

-This species inhabits shallow tropical and subtropical marine environments, particularly in sandy and muddy sediments.



Figure. 12. *Quinqueloculina quadriloculina* (d’Orbigny,1839).

## *Quinqueloculina*

### Systematic

**Kingdom:** *animalia*.

**Phylum:** *arthropoda*.

**Sub order:** *Miliolacea* EHRENPERG1839.

**Family:** *Hauerininae* SCHWAGER1876.

**Sub family:** *Hauerininae* SCHWAGER1876.

**Genus :** *Quinqueloculina* D’ORBIGNY1826.

**Species :** *Quinqueloculina*.

### Synonymy

-*Quinqueloculina* d’Orbigny,1826-Original designation.

-*Triloculina* (Schwager,1876)-Some species were considered part of this genus but were later separated.

-*Biloculina*(d’Orbigny,1839)-Some species of *Quinqueloculina* were sometimes confused with *Biloculina* due to structural similarities.

-*Pyrgo* (Williamson,1858)-Some species were temporarily classified under this genus but were later corrected.

**Description**

This species 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 lide and 3 chambers on the other. 4 chambers visible laterally walls calcareous, porcelain, unperforated, pseudochitin in inner layer, open-ended, round, with single or double teeth (Loeblich and Tappan).1964.



Figure. 13. *Quinqueloculina sp* (Loeblich and Tappan, 1964).

***Textularia*****Systematic**

**Class:** *Globothalamea*

**Subclass:** *Textulariina*

**Order:** *Textulariida*

**Suborder:** *Textulariina*

**Super family:** *Textularioidea*

**Family:** *Textulariidae*

**Sub family:** *Textulariinae*

**Genus:** *Textularia*

*Textularia agglutinans* (d'Orbigny, 1839)

**Synonymy**

1839 *Textularia agglutinans* d'Orbigny.

1839 *Textularia agglutinans* d'Orbigny.

**Description**

*Textularia agglutinans* d'Orbigny is a large cosmopolitan agglutinated foraminifera species with an elongated biserial test and a low arch aperture.

*Uvigerina***Systematic**

**Kingdom:** *Protista*

**Phylum:** *Rotaria*

**Class:** *Foraminifera*

**Order:** *Rotaliida*

**Family:** *Uvigerinidae*

**Genus:** *Uvigerina*

**Species:** *Uvigerina peregrina* Cushman,1923

**Synonymy**

-Original scientific name: *Uvigerina peregrina* Cushman,1923.

-*Euuvigerina peregrina* (Cushman,1923), as referred to by Alves Martins and Ruivo Dragao Gomes in 2004.

-1923: Cushman first described the species.

-1981: Martin provided additional descriptions and images of this species.

-2012: Milker and Schmiendl reviewed its characteristics in their study.

**Description**

*Uvigerina peregrina* is characterized by the following features:

-Shape: Free-living, elongated shell, ranging from triserial to biserial arrangement in the final chambers.

-Chambers: Multiple, destiny, and swollen.

-Surface: perforated calcareous wall, adorned with discontinuous longitudinal ribs that intersect the sutures between chambers, with small granules present between the ribs.

-Aperture: Terminal, rounded, located on a tubular neck, surrounded by a thin, twisted lip.



**Figure. 14. *Uvigerina peregrina* (Cushman,1923).**

**Foraminifer planktonic**

Similar to the presence of planktonic foraminifera in the wad skak and wad ammia regions, we also found species of planktonic foraminifera in our samples. Although they are not dominant, we took them into consideration, and they are as follows:

-*Neogloboquadrina acostensis*.

-*Globigerinoides trilobus*.

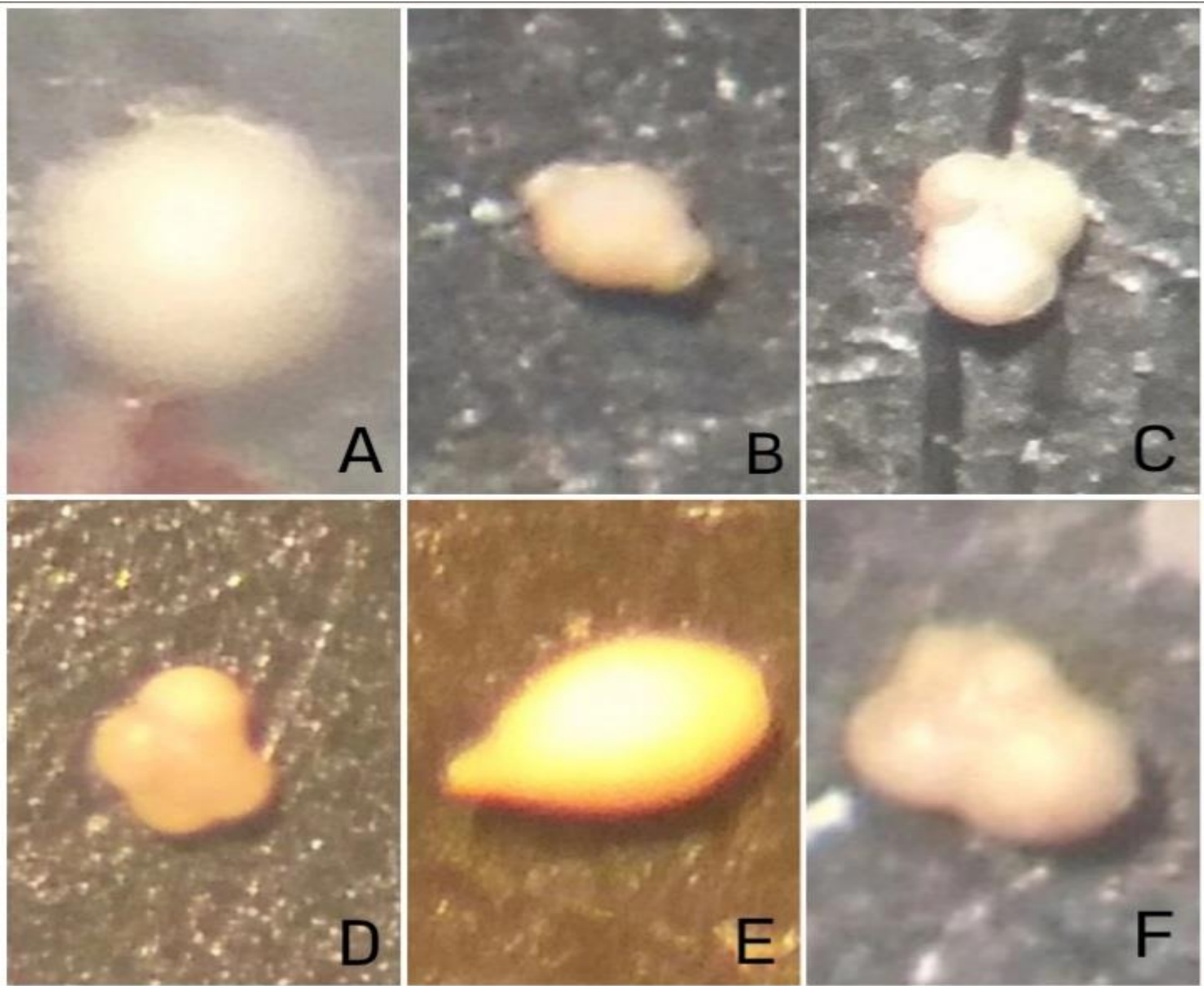
-*Globigerina bulloides*.

-*Globigerina anguliturbata* Bolli.

-*Globigerina anguliturbata* Bolli.

-*Globorotalia puncticulata*.

-*Orbulina universa*.



A. *Orbulina universa* B. *Laguna* sp C. *Globigerinoides trilobus* D. *Globorotalia puncticulata* E. *Laguna* sp F. *Globigerinoides trilobus*

Figure. 15. planktonic foraminifera

# Third Chapter

Paleontological study

## 1. Introduction

The objective of this chapter is to classify the types of benthic foraminifera in order to understand the evolution of the ancient environment based on Paleocological association.

## 2. Definition of benthic foraminifera Association

Benthic foraminifera association: is an arrangement of benthic foraminifera species that live together in a specific marine environment, which might be affected by water depth, salinity, oxygen amount, and substrate type. Such associations are frequently utilized as bioindicators to reconstruct paleoenvironmental conditions, such as sea-level fluctuations, nutrient availability, and ocean basins and circulation. Setting-specific differences in associations include shallow marine, deep-sea, or estuarine. Understanding the distribution and composition of these microorganisms provides insight into historical and contemporary ecological processes (Murray,2006).

The terminology used for the taxonomic quantification of associations is as follows:

**Dominant taxon:** when the taxon exceeds 50%.

**Abundant taxon:** when the taxon is between 25% and 50%.

**Frequent taxon:** when the taxon is between 10% and 25%.

**Present taxon:** when the is below 10%.

300 individuals from each sample are counted to determine the species they contain. These species are then classified in a table that includes the identified taxon, either at the species or genus level.

Based on the criterion of species dominance or non-dominance, it is possible to identify and group existing Paleocological units, each of which characterizes a specific paleoenvironment and reflects specific Paleocological conditions.

-Paleocological Unit 1: Dominated by *Ammonia*.

-Paleocological Unit 2: shows no (dominance c. a. d. equilibrium)

## 3. Paleocological unites analyses

The Paleocological unit 1(Tanatocenose one) is characterized by level (GT1 to GT5) at the base of the section It is dominated by opportunistic species from the genera *Ammonia*, which tolerate low oxygen condition and can thrive in oxygen depleted but nutrient rich environments (VAN DER ZWAAN, 1982 IN HEBIB 2002).

The Paleocological unit 2 (Tanatocenose two) in the samples ranging from (GT6 to GT11), no single foraminiferal species was dominant.

Table 01: The main species found in Geutna Section.

N°	GENUS	SPECIES	QUANTITATIVE CLASSIFICATION	Samples
01	<i>Ammonia</i>	<i>Ammonia tepida</i>	Dominant	01,02,03,04,05,09,10
			Abundant	07,08,11
	<i>Ammonia beccarii</i>	Dominant	03	
		Abundant	01,02,05	
		Frequent	04,10	
		Present	06,07,08,09,11	
02	<i>Bulimina</i>	<i>Bulimina sp</i>	Frequent	07
08			Present	03,05,07,08
09	<i>Bolivina</i>	<i>Bolivina sp</i>	Present	06,07,08
10	<i>Brizalina</i>	<i>Brizalina sp</i>	Present	07
11	<i>Elphidium</i>	<i>Elphidium Advenum</i>	Abundant	05
12			Present	06,07
13	<i>Laguna</i>	<i>Laguna sp</i>	Present	07,08
14	<i>Nonionella</i>	<i>Nonionella Stella</i>	Present	07,08
15	<i>Nodosaria</i>	<i>Nodosaria sp</i>	Present	05,07
16	<i>Stilostomella</i>	<i>Stilostomella Mappa</i>	Present	07
17	<i>Quinqueloculina</i>	<i>Quinqueloculina quadriloculina</i>	Present	04,05
		<i>Quinqueloculina sp</i>	Present	04,05,02,07
18	<i>Textularia</i>	<i>Textularia sp</i>	Present	07
19	<i>Uvigerina</i>	<i>Uvigerina</i>	Present	06,07

#### 4. Planktonic identified taxa

With our section we comprise set of planktonic foraminifera taxon that would help us to get more insights about that period of deposition.

Here are blow some of theme:

-*Neogloboquadrina acostensis*.

-*Globigerinoides trilobus*.

-*Globigerina bulloides*.

-*Globigerina anguliturai* Bolli.

-*Globigerina anguliturai cata* Bolli.

-*Globorotalia puncticulata*.

-*Orbulina universa*.

#### 5. Paleoecological indices

Pour étudier et analyser les caractéristiques et les événements environnementaux anciens liés au dépôt des couches dans la région de Geutna durant la phase transitionnelle du Néogène supérieur (plus précisément le Miocène supérieur), la recherche s'est appuyée sur deux principaux indicateurs environnementaux :

1. L'évolution du nombre d'espèces de foraminifères benthiques.
2. L'indice de pélagisme.

##### 5.1. Nombre d'espèces benthiques

Is the number of livings in the benthic zone the ecological region at the bottom of water bodies like ocean, seas, lakes, and rivers. It includes species that live on the surface of the sediments as well as those that are buried in the substrate. This index is one of the most important indicators to the computation of biodiversity, and the health of aquatic ecosystems.

## 5.2. Indice de pélagisme

L'indice de pélagisme (P/P+B) est un indicateur écologique quantitatif utilisé pour évaluer la dominance de la productivité pélagique (en pleine eau) dans les écosystèmes aquatiques. Il est calculé comme le rapport entre la productivité primaire dans la zone pélagique (P) et la somme des productivités pélagique et benthique (B), exprimé par la formule :

$$\text{Indice de pélagisme} = P / (P + B).$$

Cet indice reflète la dépendance relative de l'écosystème aux ressources pélagiques par rapport aux ressources benthiques : des valeurs élevées indiquent une dominance pélagique, alors que des valeurs faibles suggèrent une plus grande importance des communautés benthiques (Kufel et al., 2016). Il est largement utilisé dans les études sur les lacs et les réservoirs pour évaluer les impacts des changements environnementaux, tels que la charge en nutriments ou la disponibilité en lumière, sur la structure des réseaux trophiques aquatiques (Kufel et al., 2016).

**Tableau 02 : Taux de lithoclastes**

Echantillons	Quartz	Gypse	Oxydation
01	Fréquent	Présent	Dominant
02	Présent	Fréquent	Abundant
03	Présent	Présent	Dominant
04	Présent	Présent	Abundant
05	Présent	Présent	Fréquent
06	Présent	Présent	Abundant
07	Dominant	Fréquent	Fréquent
08	Abundant	Présent	Abundant
09	Présent	Présent	Présent
10	Nul	Nul	Dominant
11	Dominant	Présent	Abundant

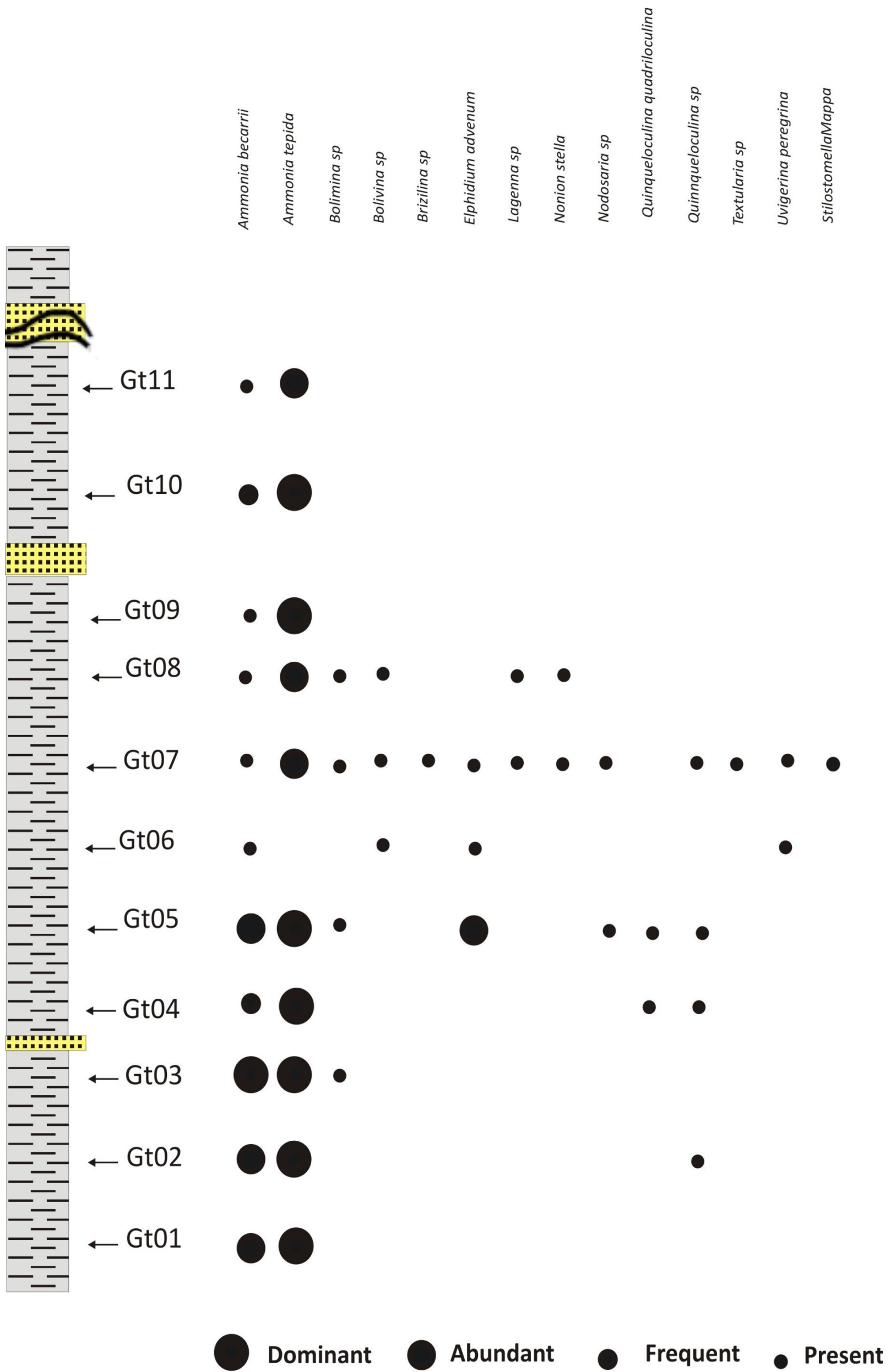


Figure 16. Évolution des foraminifères benthiques le long de la coupe de Geutna

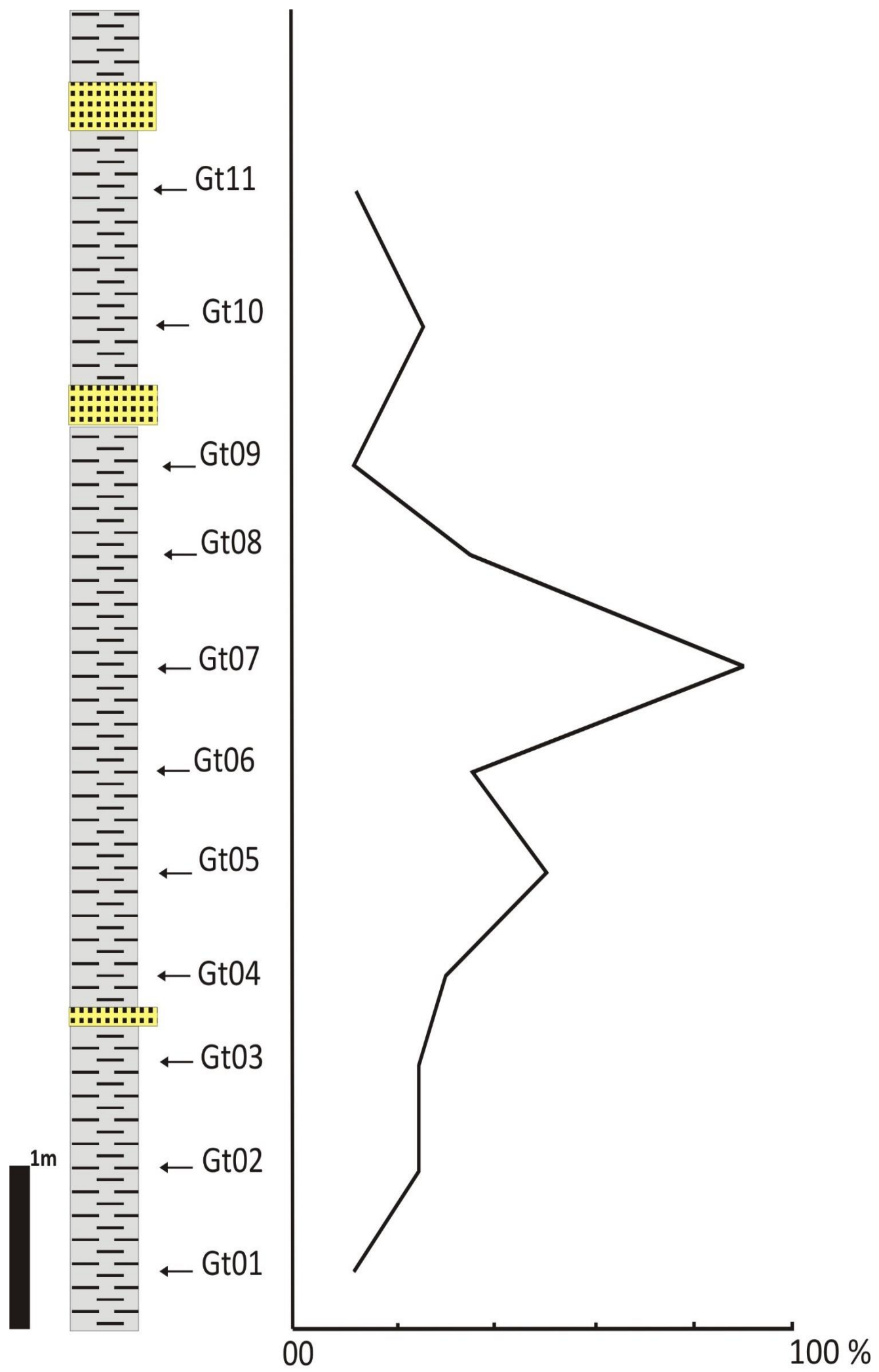


Figure 17. Évolution du nombre d'espèces benthiques

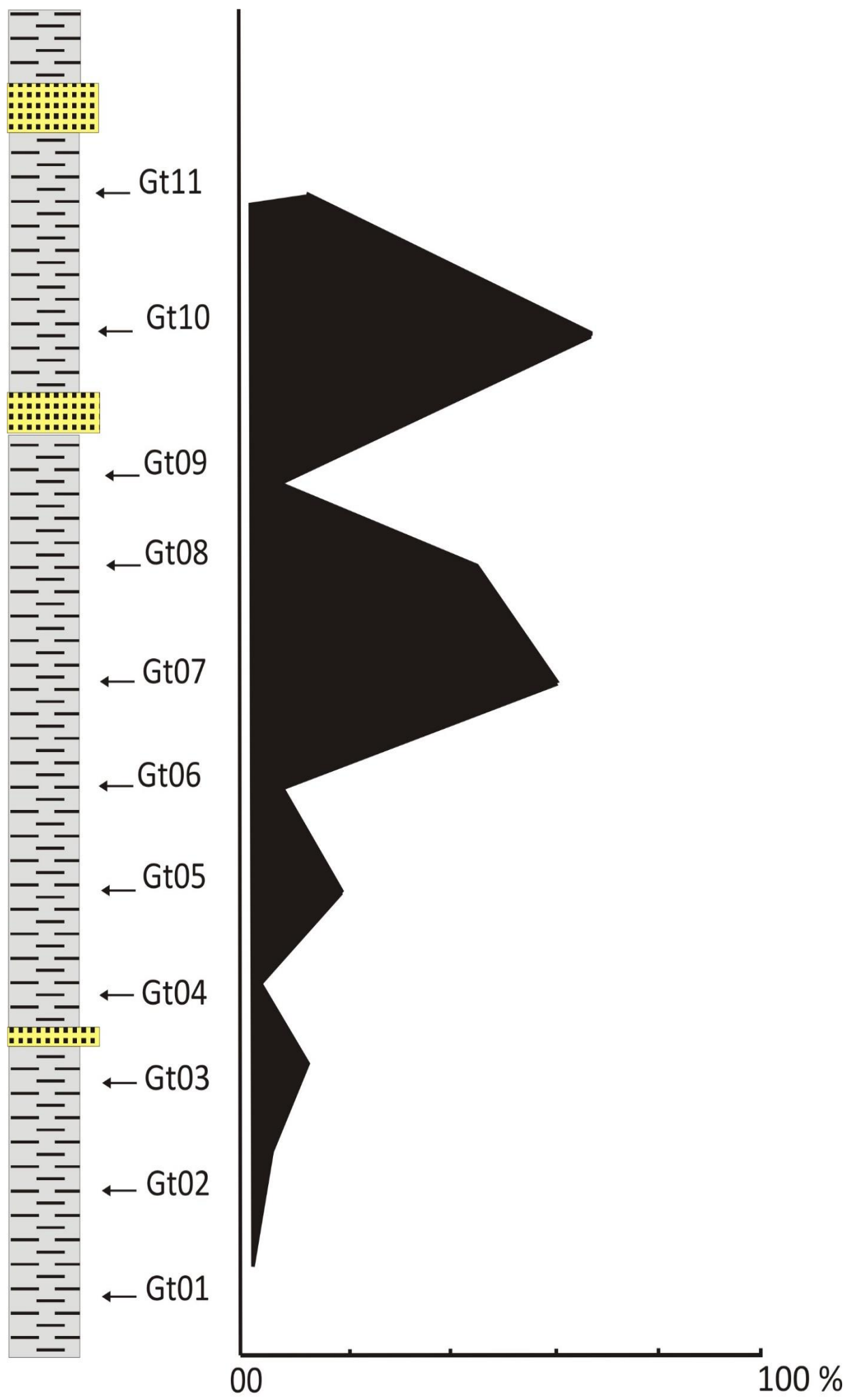


Figure 18. Évolution de l'indice de pélagisme

## 6. Importance écologique

Au total, 14 espèces ont été identifiées à partir de 11 échantillons. Nous avons constaté que les tests calcaires sont les plus abondants, sans aucune présence de formes agglutinées. La distribution des espèces benthiques significatives est présentée dans le tableau 01.

**Ammonia tepida** : Cette espèce est présente dans les milieux marins peu profonds et les eaux modérément salines, telles que les zones côtières. Elle préfère les sédiments argileux et gréseux, ce qui en fait un bioindicateur important pour l'étude des changements environnementaux (Murray, 2006).

**Ammonia beccarii** : Présente dans les estuaires, baies et zones marines peu profondes, elle est un indicateur clé des changements environnementaux passés et actuels grâce à sa large répartition et sa sensibilité aux variations de salinité et de température. Elle peut survivre dans des zones pauvres en oxygène et en nutriments (Murray, 2006).

**Bulimina sp** : Organismes unicellulaires vivant en eaux peu profondes à profondes, préférant les zones riches en matière organique. Les Bolivina sont des bioindicateurs de conditions anaérobies ou suboxiques.

**Quinqueloculina sp** : Espèce vivant dans des environnements marins peu profonds, notamment les zones côtières et les lacs salés. Elle est un bioindicateur important dans les études environnementales et paléontologiques (Sen Gupta, 2002).

**Elphidium advenum** : Cette espèce vit dans les environnements côtiers peu profonds, souvent dans des sédiments vaseux ou sableux. Elle se nourrit de matière organique et de bactéries, ce qui en fait un bioindicateur important

**Uvigerina sp** : Organismes unicellulaires vivant dans les zones profondes et très productives. Ils se nourrissent de matière organique et sont utilisés comme indicateurs des conditions environnementales (Murray, 2006).

**Laguna sp** : Vit dans les environnements marins benthiques, attachée au fond marin ou dans les sédiments. Elle est utilisée pour interpréter les changements climatiques et l'histoire des océans.

**Nonionella stella** : Cette espèce se distingue par sa coquille plate et sa structure à chambres multiples. Elle vit dans des zones marines benthiques riches en matière organique.

## 7. Évolution de l'indice paléoécologique

Nous avons étudié 11 échantillons. Les espèces identifiées ont été représentées selon le nombre d'espèces benthiques et l'indice de pélagisme. Cette évolution nous a permis de déduire le développement paléoenvironnemental..

### 7.1. Évolution du nombre d'espèces benthiques

Les variations du nombre de taxons benthiques montrent une valeur faible dans une partie de la section, tandis que l'échantillon (GT07) montre une augmentation notable. Par la suite, les valeurs diminuent généralement vers le sommet, avec quelques exceptions.

### 7.2. Évolution de l'indice de pélagisme

Le long de la coupe, le graphique montre quelques fluctuations. Les valeurs ne dépassent pas 70 %, sauf à certains niveaux comme (GT07) et (GT10) où elles atteignent respectivement 60 % et 68 %. Dans les autres échantillons, les valeurs sont inférieures à 50 %, notamment aux niveaux (GT07) et (GT10).

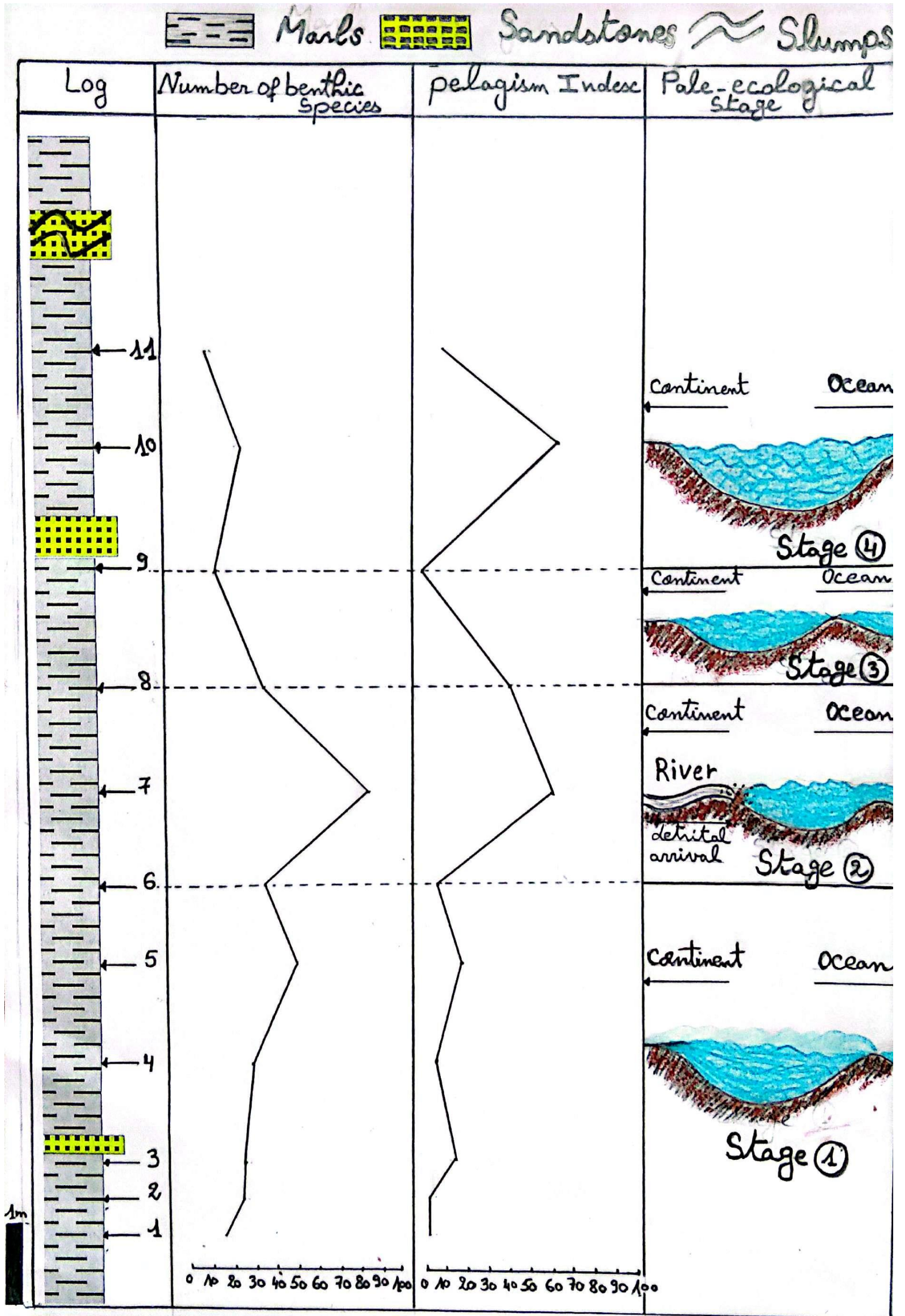


Figure 19. Les quatre étapes paléoenvironnementales

### 8. Synthèse paléoécologique

Dans notre étude, nous avons pris en compte plusieurs facteurs : l'association des foraminifères benthiques, l'indice de pélagisme et le nombre d'espèces benthiques. Sur la base de ces données, nous avons pu dégager les résultats suivants :

**Première étape (GT01 à GT06):** Faible indice de pélagisme indiquant des échanges limités avec la mer. L'arrivée réduite de matériel détritique continental influence la faible diversité des foraminifères benthiques, caractéristique d'un environnement restreint de type marin peu profond.

**Deuxième étape (GT07 à GT08):** Indice de pélagisme élevé indiquant des échanges marins plus importants. La forte présence de quartz reflète un apport continental significatif. Cela se traduit par une richesse en foraminifères benthiques et planctoniques, probablement due à une bonne aération et un apport nutritif continental.

**Troisième étape (GT09):** Faible indice de pélagisme indiquant une connexion marine limitée. Cette condition se reflète par la baisse du nombre de foraminifères benthiques dans un environnement restreint.

**Quatrième étape (GT10 à GT11) :** Bien que l'indice de pélagisme soit élevé, l'absence de quartz suggère une connexion unilatérale avec la mer. Le faible nombre de foraminifères benthiques pourrait résulter d'un apport nutritif retravaillé accompagné de détritiques continentaux.

Nous faisons également référence aux changements brusques entre les échantillons (GT07), (GT09) et (GT10), comme une possible indication d'une influence tectonique.

Nous soulignons également le changement de couleur des couches dans cette section : du gris au blanc puis au jaune, ce qui reflète les changements dans l'environnement de dépôt et la composition des roches. Le gris indique souvent des roches riches en argile ou en matière organique (milieu marin profond pauvre en oxygène). Le blanc reflète la présence de calcaire pur, suggérant un environnement marin propre ou récifal. Le jaune est associé aux oxydes de fer résultant de l'altération, indiquant un milieu riche en oxygène, comme les plaines inondables. Cette variation chromatique représente donc une séquence chronologique de changements environnementaux pendant la sédimentation (Boggs, 2012).

## 9. Conclusion

Notre étude paléontologique a porté sur une coupe de la région de Geutna, située au sud du bassin de Tafna, au nord-ouest de l'Algérie, datant du Miocène supérieur.

L'objectif était de déterminer les conditions paléoenvironnementales durant l'âge Tortonien, avec un repérage biostratigraphique basé sur la présence d'une espèce planctonique clé : *Neoglobobulina acostensis*.

L'étude repose principalement sur la distribution et l'évolution des foraminifères benthiques, avec 14 espèces identifiées, appartenant à 12 genres, majoritairement à test calcaire.

Deux unités environnementales principales ont été distinguées :

Une première unité dominée par le genre *Ammonia*.

Une seconde unité sans espèce dominante particulière (équilibre).

Nous avons pris en compte plusieurs facteurs, tels que l'association de foraminifères, le nombre d'espèces benthiques et l'indice pélagique. Sur cette base, nous avons pu obtenir les résultats suivants :

Dans notre étude expérimentale, nous avons considéré de nombreux paramètres : l'association de foraminifères benthiques, l'indice de pélagisme et l'indice du nombre d'espèces de foraminifères benthiques. Selon ces données, nous sommes parvenus au résultat suivant :

Première étape (GT01 à GT06) : Faible indice de pélagisme indiquant des échanges limités avec la mer. L'arrivée réduite de matériel détritique continental influence la faible diversité des foraminifères benthiques, caractéristique d'un environnement restreint de type marin peu profond.

Deuxième étape (GT07 à GT08) : Indice de pélagisme élevé indiquant des échanges marins plus importants. La forte présence de quartz reflète un apport continental significatif. Cela se traduit par une richesse en foraminifères benthiques et planctoniques, probablement due à une bonne aération et un apport nutritif continental.

Troisième étape (GT09) : Faible indice de pélagisme indiquant une connexion marine limitée. Cette condition se reflète par la baisse du nombre de foraminifères benthiques dans un environnement restreint.

Quatrième étape (GT10 à GT11) : Bien que l'indice de pélagisme soit élevé, l'absence de quartz suggère une connexion unilatérale avec la mer. Le faible nombre de foraminifères benthiques pourrait résulter d'un apport nutritif retravaillé accompagné de détritiques continentaux.

Nous faisons également référence aux changements brusques entre les échantillons (GT07), (GT09) et (GT10), comme une possible indication d'une influence tectonique.

Nous soulignons également le changement de couleur des couches dans cette section : du gris au blanc puis au jaune, ce qui reflète les changements dans l'environnement de dépôt et la composition des roches.

Le gris indique souvent des roches riches en argile ou en matière organique (milieu marin profond pauvre en oxygène).

Le blanc reflète la présence de calcaire pur, suggérant un environnement marin propre ou récifal.

Le jaune est associé aux oxydes de fer résultant de l'altération, indiquant un milieu riche en oxygène, comme les plaines inondables.

Cette variation chromatique représente donc une séquence chronologique de changements environnementaux pendant la sédimentation (Boggs, 2012).

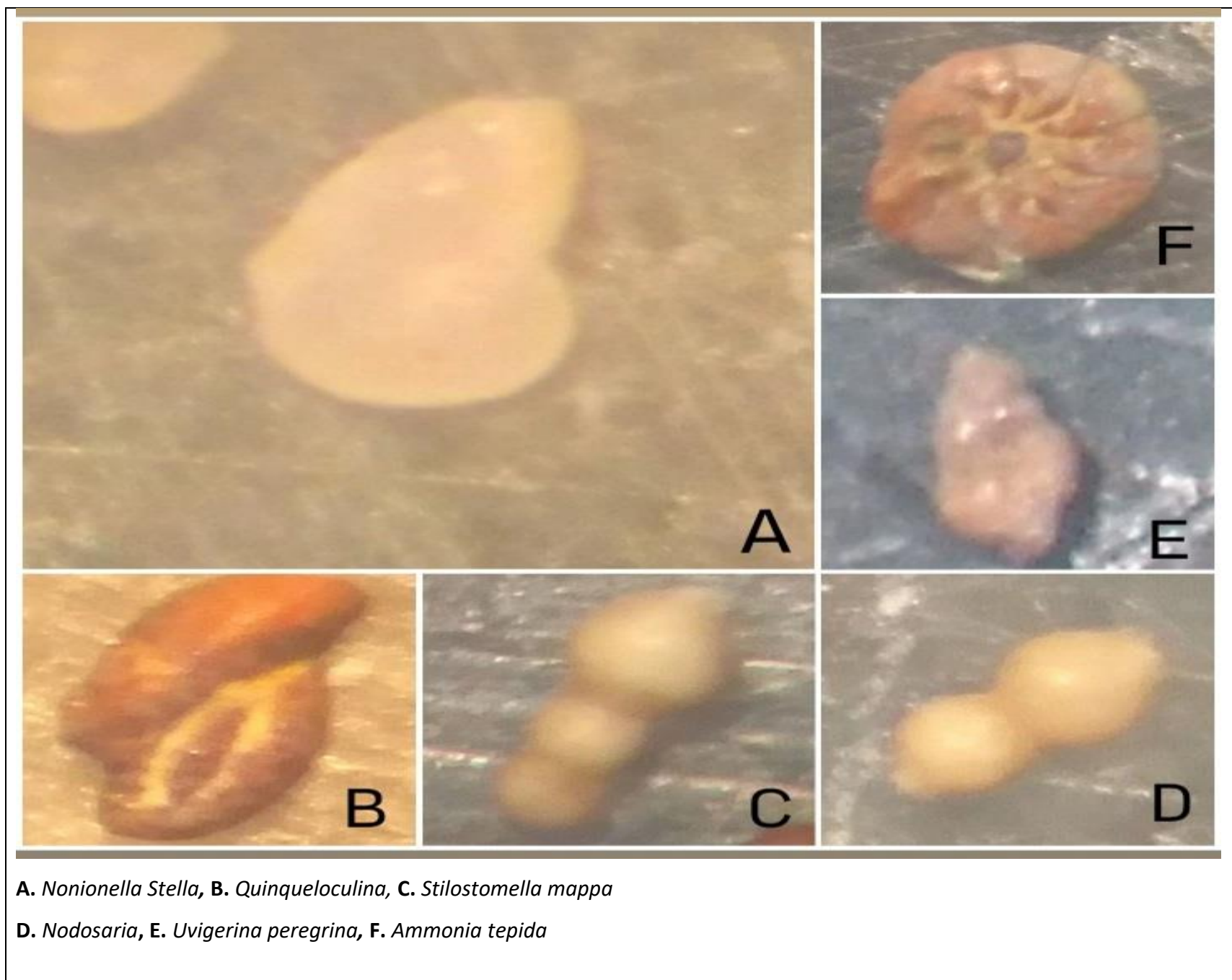


Figure.20. Benthic foraminifera

Figure.A

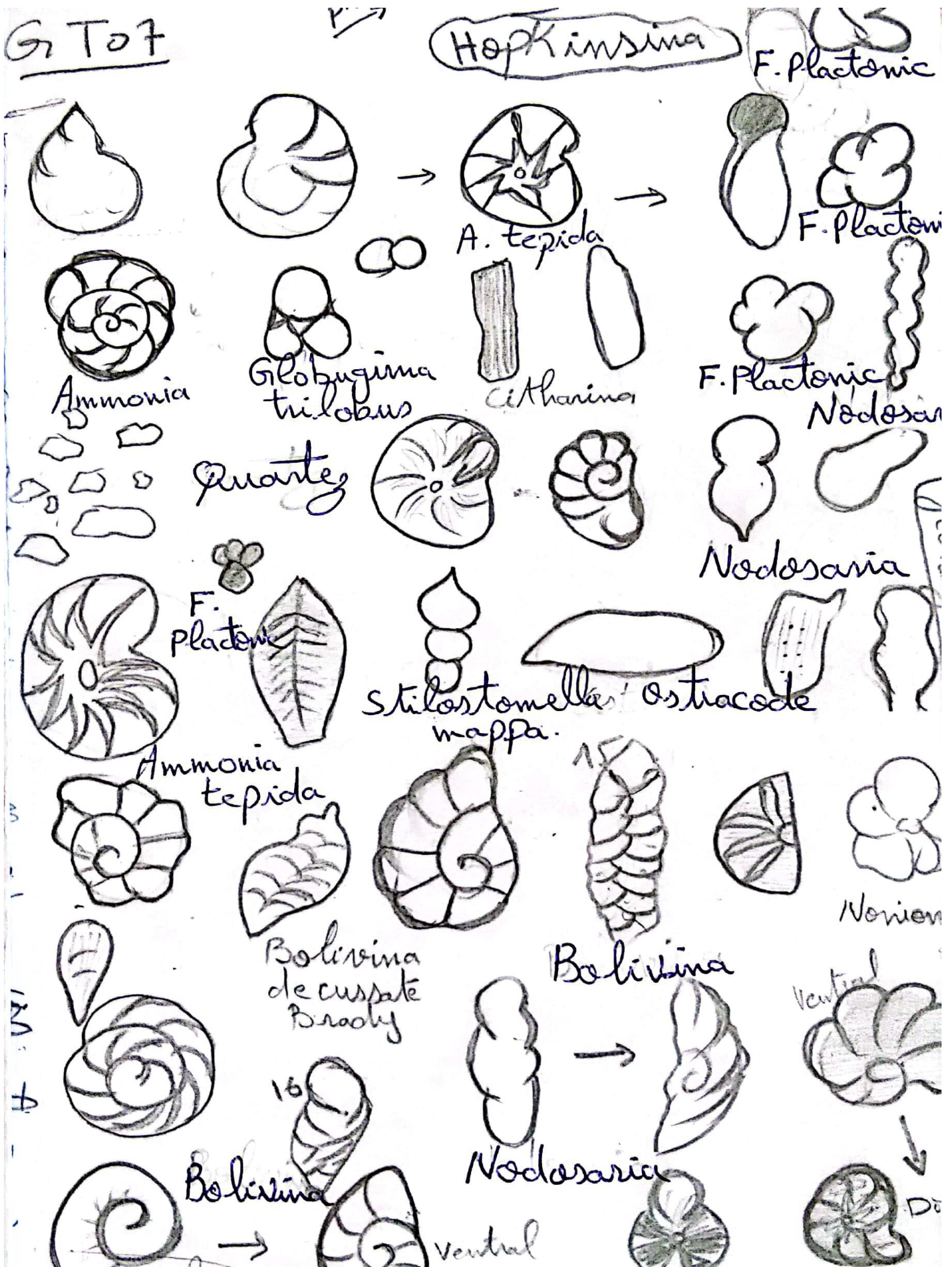


Figure. B

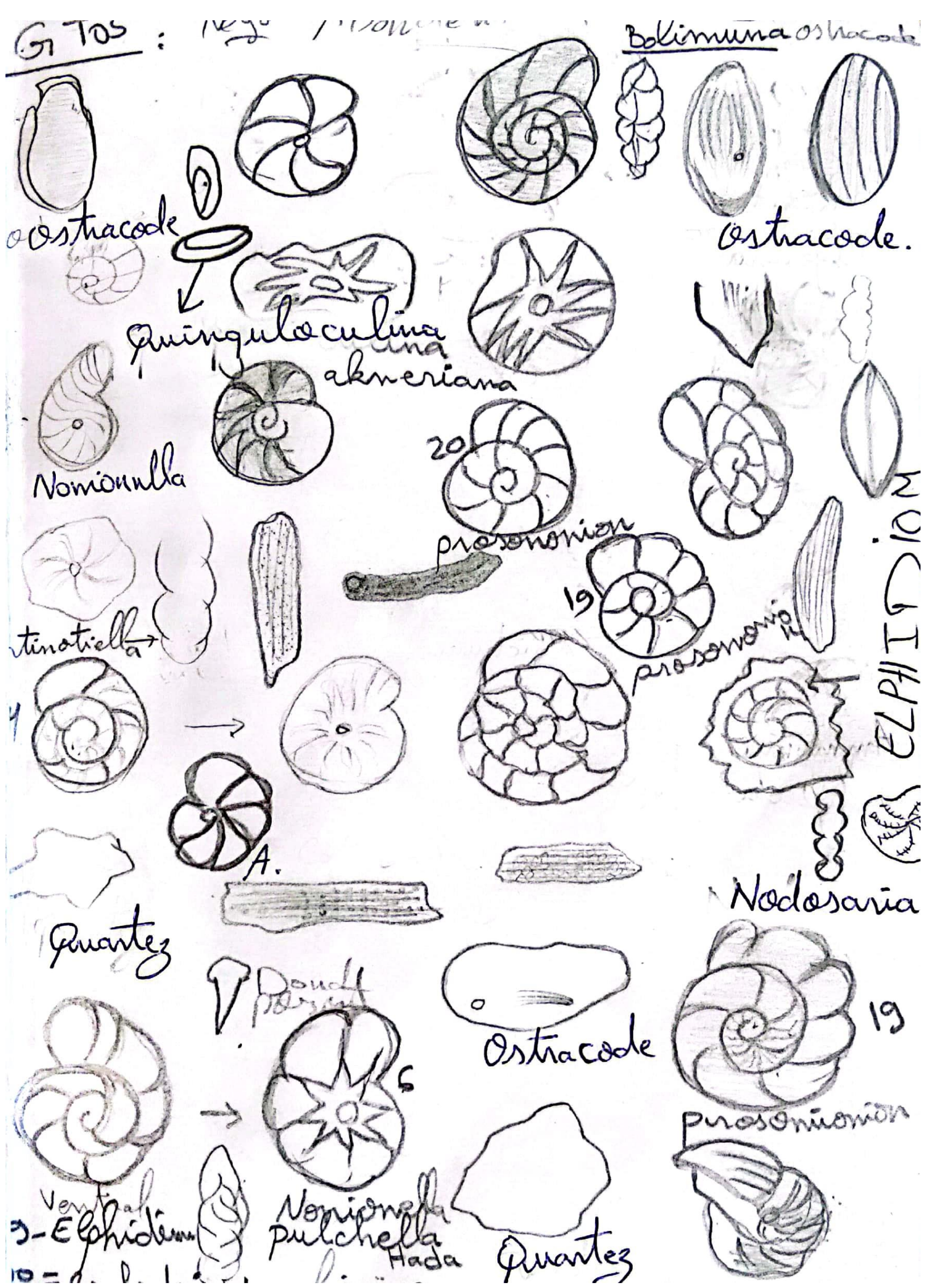


Figure. C

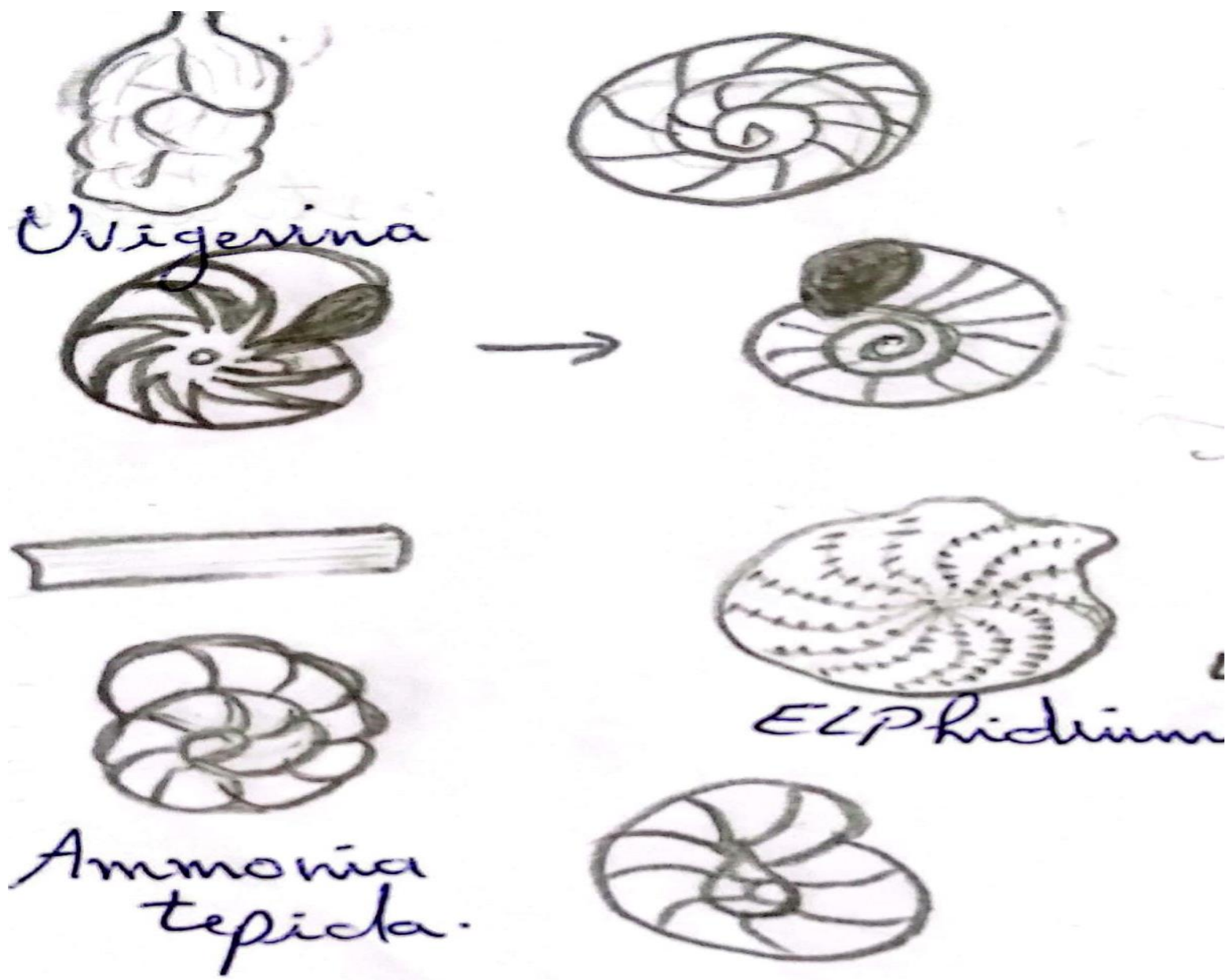


Figure. 21. A. B. C. Benthic and Planktonic foraminifera

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