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DEPARTMENT OF EARTH SCIENCES (GEOLOGY)

Paleoenvironmental evolution in the late Neogene Lower Chelif basin based on benthic foraminifera (North-western Algeria)

Dissertation submitted to the Department of Earth sciences as a partial fulfilment of the requirements for thea ***Master's degree in Geology***

Presented by:

Ms.BoughabaMilouda Sara

Ms.MaabdiSouad

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ThanksGod , by whose grace good works are accomplished , to whom in life is life , to you the letter bends out of love and gratitude ; to you my mother.

Thank God the Almighty for giving us the health and the will to start and finish this thesis

This work would not be rich and would not have been able to have the day without the help and the supervision of Mr. Benzina.

We thank him for their quality of his exceptional supervision for his patience, rigor and availability during our preparation of this thesis.

Special thanks to Mr. Mazouzi A and Mr. Kechiched R for being the examinees of our work

BoughabaMilouda

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To my parents for their support and encouragement, to all my family for their support throughout my university career. May this work be the fulfillment of your so-called wishes, and flee from your unfailing support

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Maabdi Souad

Abstract.

The study of benthic foraminifera from the Messinian pre-evaporitic interval of Djebel Meni section (Northern west) allowed the reconstruction of surface and bottom-water conditions in the West Mediterranean during the interval that preceding the Messinian Salinity Crisis.

Our data point out to three-steps paleoenvironmental evolution. During the first stagepresents an assemblage with high diversity of benthic foraminifera. This features materialized by the dominance of the oxyphilic taxa, a well-ventilated bottom-water conditions beside a considerable bathymetric and well exchanges of ocean water with and into Chelif basin. During that period, this interval is consideredasan outer shelf to slope environment. The second stage corresponds to the middle part of the section. It refersto moderate decrease of oxygen content which seems to be the main factor that leads to this stage, since the diversity of benthic foraminifera species decreases. Where the third stage witnessed rapid decrease in number of taxa corresponding to the upper part of the section with a common presence of barrens intervals of benthic foraminifera. This interval is dominated by the stress-tolerant taxa *Bolivina*spp, *Bulimina*spp *and Rectuvigerina*sppgenus as dyoxic species with high salinity conditions. The interval refers to a oxygen depletion that probably caused by the restriction of Mediterranean water exchanges contributing to the stagnation of bottom water as shallowing environment referring to inner to middle shelf.

Key words

Benthic foraminifera, Messinian, pre-evaporitic, reconstruction, conditions, paleoenvironmental

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I.Introduction

The Lower Chelif basin is one among of the Neogene basins that stretch alongside the northern coast of Algeria. The genesis of these basins is due to the Alpine orogeny (Perrodon, 1957). The intra-mountainous geodynamic regime shaped the accommodation for the post-orogeny sedimentsdepositions. These later were generated through some successive and alternative geodynamic phases that are materialised in various continentalenvironments, lagoonal, and marine (Thomas, 1985). Thus, Lower Chelif basinis considered as the largest intra-mountainous basin in the north of the country (Perrodon, 1957). From this area many studies have been carried out about the anticlinal of Djebel Meni in general, and in its South-west side of the mountain in particular. This part is known under the name of «Abreuvoir section » that encompasses the limit between the middle and the upper Miocene (NeurdinTrescartes 1992; Rouchy et al.,2007; Belkebir et al., 2008).

The present research is for the end to study the different paleo-biocenoces of benthic foraminifera and to reconstruct the paleo-ecology of the different environments that restricted the late Neogene.

II. Geological setting

II.1.Area of study:

Djebel Meni section in particular includes the main formations in the basin. It isabout 15 km southward the Sour villages, next to Chelif Dam(Fig 3). This area has been subjected by some studies(Rouchy et al., 2007, Belkebir et al., 2008; Hebib, 2015and benzina et al., 2019).

II.2.Lithological section of Djebel Meni

Djebel Meni section in its lower part, starts with blue marls.This later is the continuity of a monotone formation (blue marls) which is attributed to the upper Tortonian and ascribing to the biozones of *Neogloboquadrina humerosa* and *dutertrei*(Belkebir et al., 1996). The diatomite (Tripoli formation) formation marks the upper part of the section that is attributed to the Messinian stage (Fig4), more particularly to *Globorotalia miotumida* biozones (Benzina et al., 2019). This part characterised by a cyclic alternation of blue marls with white diatomaceous beds. The pre-evaporitic formation consists of two distinguished members, while diatomaceous beds thin upward and the marls interbeds concomitantly thicken. Moreover, in comparison with lower member the upper one is marketed by an over slumping diatomaceous with more passages of ash layers (Fig4). The gypsum formation overlies conformably the previous one, it is a massive formation (stratum) devoid of marly passages (Benzina et al 2019).

II.3. Stratigraphy of study area

The Neogene lower Chelif basin contains mainly Miocene sediments, and Djebel Meni in particular encompasses the series Serravalo-Tortono-Messinian. In our study, we consider only the pre-evaporitic succession that comprises the Messinian stage.

The main biozones of the pre-evaporitic formation was established by Belkebir et al. (1996), whilethe bio events that mark this section are as follow in (Table. 2) according to Benzina et al., (2019).

Bioevent benzina (Djebel Meni section)	Age (Ma)
PF-Event 9: First Common Occurrence (FCO) of *G. miotumida*.	7.24
PF-Event 12: Influx of *G. nicolae.*	6.73
PF-event 13: The Last Common Occurrence (LCO) of *G. nicolae*	6.71
PF-Event14: Influx of *Globigerinellasiphonifera*	6.61
PF-Event15: Last Common Occurrence (LCO) of *G. miotumida*.	6.5
PF-Event16: Increasing abundance of stress- tolerant ben- thic foraminifera.	6.52
PF-Event 17: Last Occurrence (LO) of *G. miotumida*.	6.1

Table.1 : the main bio-events that are marked in the Messinian succession of Djebel Meni (benzina et al., 2019)

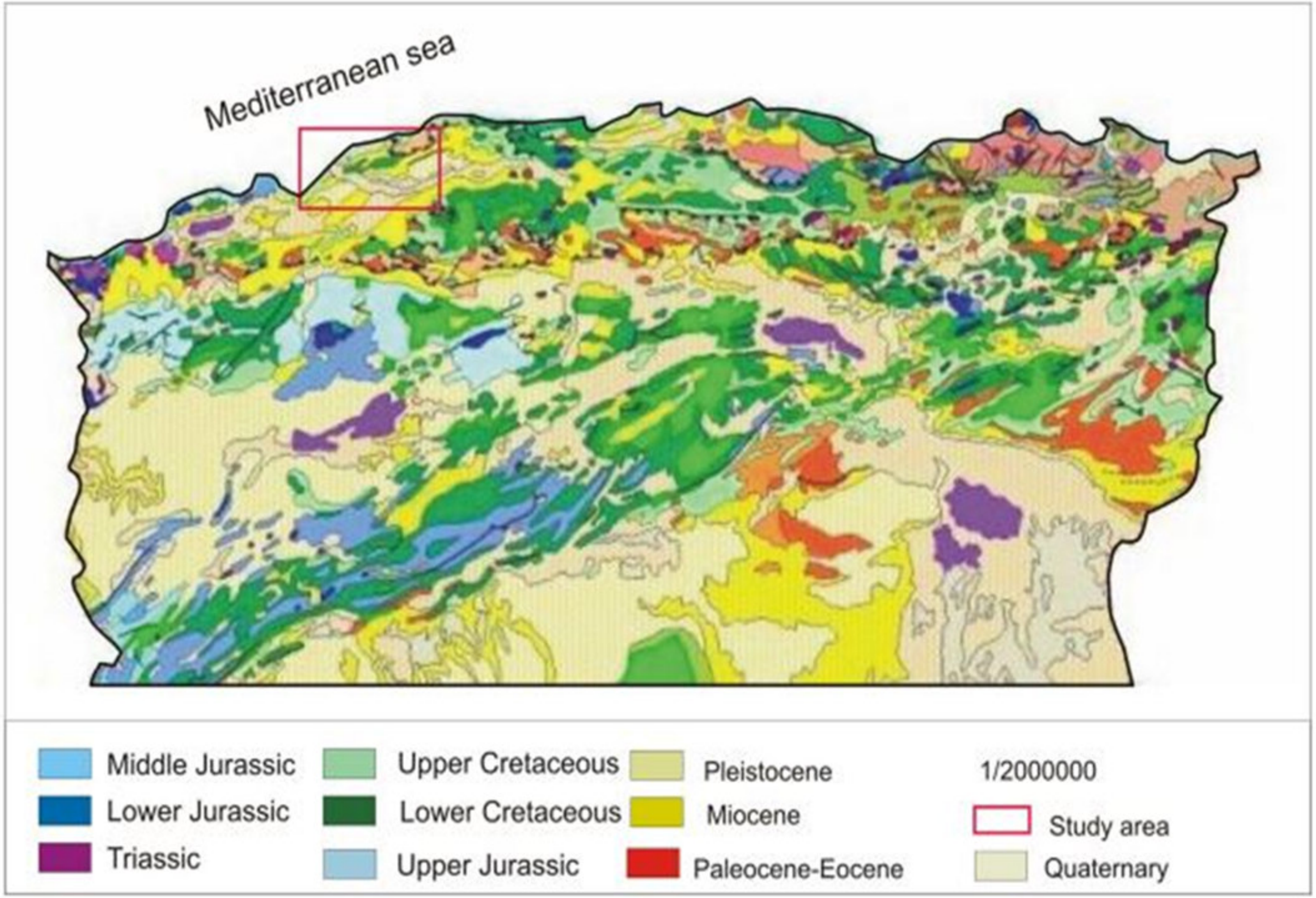

Fig.1.Geological map of the northern Algeria 1/2,000,000 (Ministry of Energy and Mining) (Benzina et al 2019)

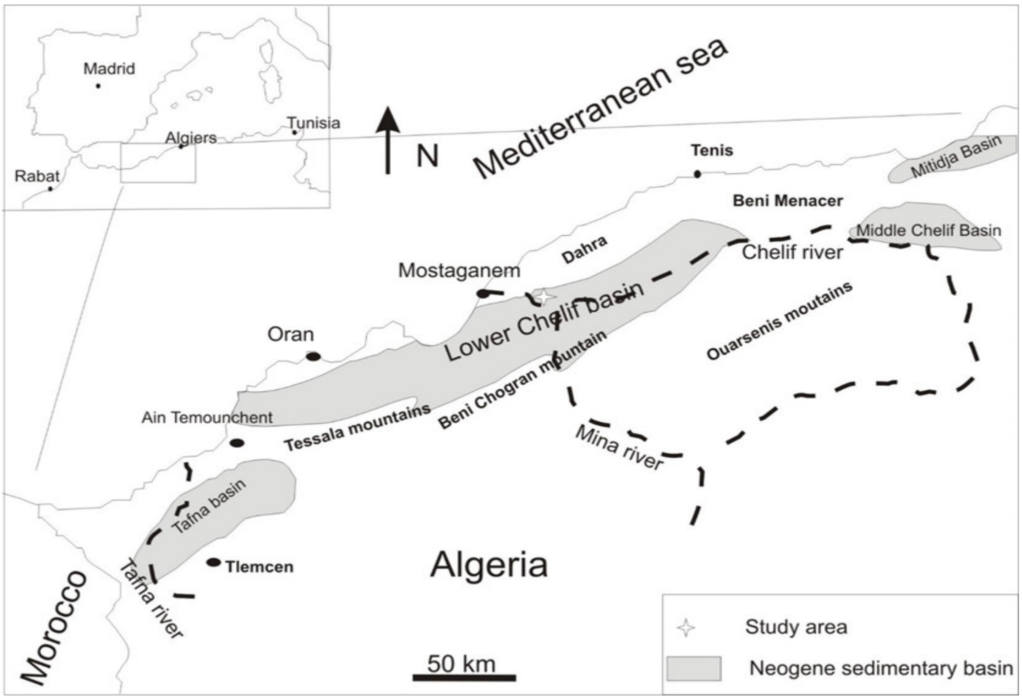

Fig.2.Geographic position of the studied area in Lower Chelif Basin (Benzina et al 2019)

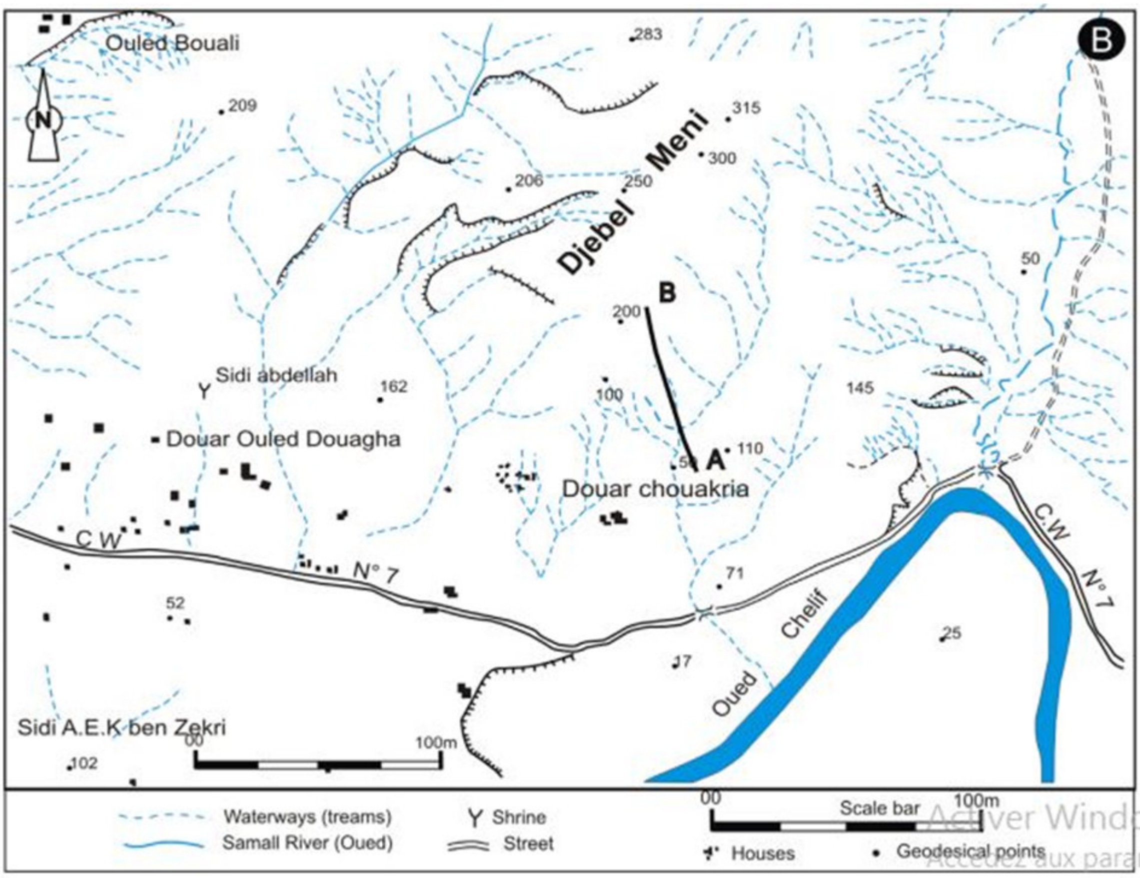

Fig.3.Sitution of Djbel Meni section in Lower Chelif Basin(Benzina et al 2019)

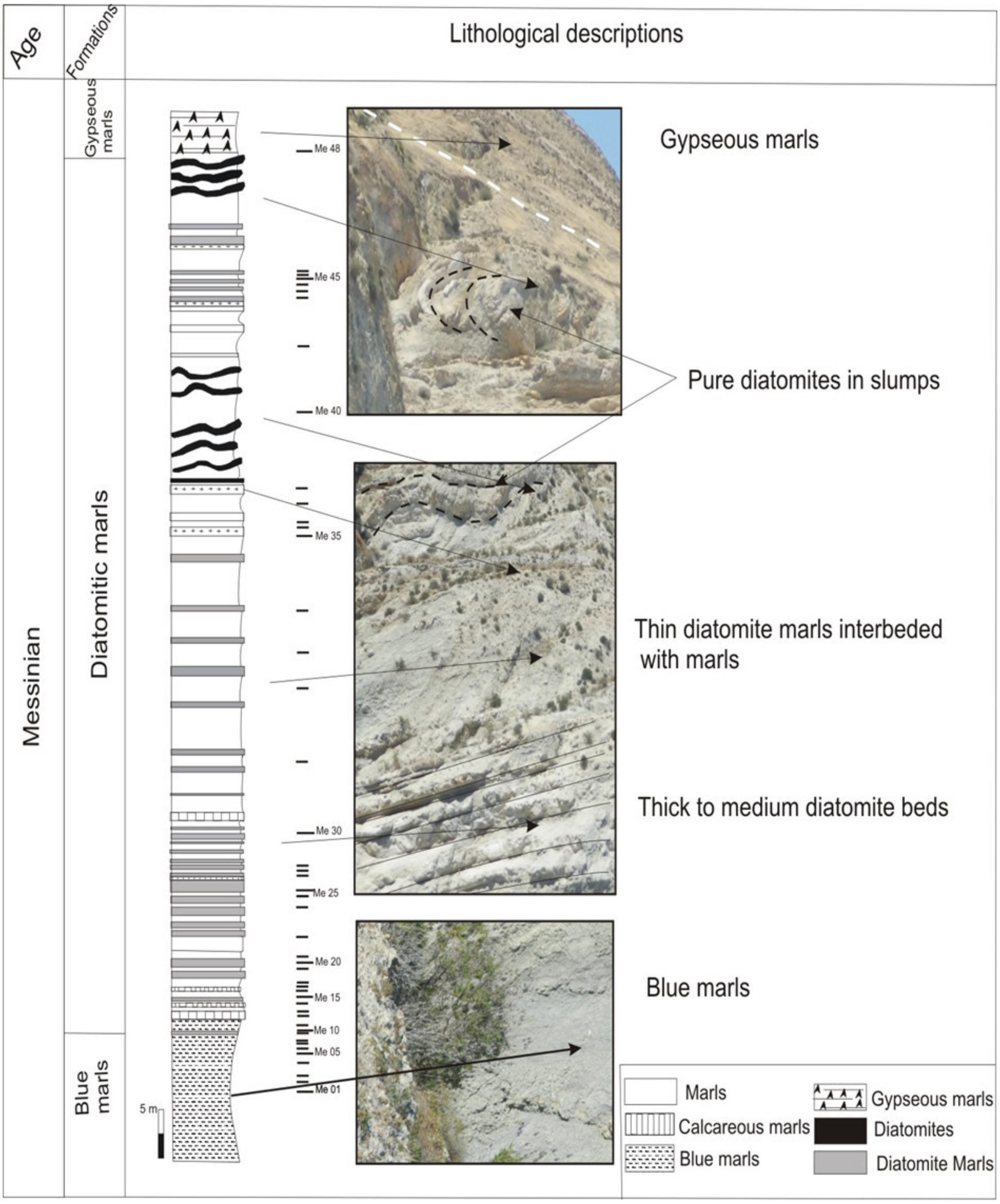

Fig.4.Stratigraphic succession of the late Neogene strata in Djbel Men*iin*(Benzina, 2008).

I. Problematic

Lower Chelif basin has been subjected by several biostratigraphic and paleoenvironmental studies. The research as a whole was based on following the faunistic associations evolution of foraminifera on one hand, on the other hand, tracing the biostratigraphic framework that requires the study of planktonic foraminifera and nanofossils alike. The paleoenvironmental features call on the study of the associations of benthic foraminifera. In this context, Benzina (2008) in Djebel Meni section has carried out a primary study. The author studied the assemblage of benthic foraminifera to trace the evolution of some ecological indices that serve to understand the environmental changes. The collected data by the aforementioned author will be the stone corner and the basic of the future biostatistical study in order to endorse the previous results.

III.1. Objectives

The current study aims at first to count know the different taxa, second to establish paleoecological changes that happened throughout the section and what are the main factor that influenced more this change. To sum up, the main purpose of this research is to understand the paleoenvironmental evolution during the pre-evaporitic period.

III.2. Material and methods

Samples that have been brought from the field, they were well prepared for a paleontological study in a previous engineering study by Benzina (2008). Bringing samples was accompanied by a detailed description of the different formations in Djebel Meni sections.

The final step concerns with statistical treatment of data in two methods (PCA and AHC). In fact, the treatment of such quantity of data will be much easier and feasible with such tools. The aim standing behind this is to highlight the different biofacies.

III.3.Statistical treatments

The data are represented in a table where the samples are in rows that refer to the observations, and the taxa (species) are in columns that refer to variations.

Before starting the data treatment statistically, some adjustments need to be done in terms of:

Gather all the species of the same genesis.

Excluding all taxa percentages that are less then 2% in order to get better representation.

The forms that do not bring any significant information are omitted also; example S*tillostomella.* The presence of such species may hide the information.

After each modification, the values recalculated in order to make the sum of variables percentage equal to 100 %.

III.3.1. Principal components analyses (PCA)

Principal component analysis (PCA) is a statistical method that was invented in 1901 by Karl Pearson. It uses an orthogonal transformation to convert a set of observations (samples) of possibly correlated variables (species) into a set of values of linearly uncorrelated variables called principal components. This transformation is defined in such a way that the first principal component has the largest possible (genesis) variance (that is, accounts for as much of the variability in the data as possible), and each succeeding component in turn has the highest variance possible under the constraint that it is orthogonal to the preceding components. The resulting vectors (each being a linear combination of the variables and containing n observations) are an uncorrelated orthogonal basis set. PCA is sensitive to the relative scaling of the original variables.

Consequently, PCA allows the determination of variables that have the same environmental significance.

Only the axes which have significant information will be considered (in general the first two or sometimes the three axes that may have the average of percentages). For this operation, we use the Xlstat.

III.3.2.Ascendant Hierarchical Clustering (AHC)

Hierarchical clustering (also called hierarchical cluster analysis or HCA) is a method of cluster analysis , which seeks to build a hierarchy of clusters (groups). In general, the merges and splits of observations or variances are determined in a greedy manner. The results of hierarchical clusteringare usually presented in a dendrogram.

In fact, this method was elaborate first by JMBU in 1972. In the current study, the process looks for to merge samples according to their faunal similarity.

At this stage, we use also Xlstat.

Second Chapter: Systematic study

I. Introduction

I.1. Definition of Systematic

I.2. Definition of Taxonomy

I.3. The relationship between systematic and taxonomy

II. Systematics of some studied Taxa

Brizalinaspathulata (Williamson, 1858)

*Bolivinadilatata*Reusses 1850

*Buliminaaculeata*D’Orbigny, 1826

*Buliminaexilis*Brady, 1884

Buliminafusiformis Williamson, 1858

*Cassidulinalaevigata*D’Orbigny 1826

Cibicideslobatulus (Walker & Jacob, 1798)

Cibicidoidesungerianus (D’Orbigny, 1846)

Cibicidoidespseudoungerianus(Cushman, 1922)

Cibicidoidesitalicus Di Napoli Alliata, 1952

Hanseniscasoldanii (D’Orbigny, 1826

Cancrisauriculus (Fichtel et Moll, 1798)

*Planulinaariminensis*d'Orbigny, 1826

Siphoninareticulata (Czjzek, 1848)

*Uvegirinapregrina*Cushma 1923

I-Introduction

Foraminifera are a widely distributed and diverse order of protests in marine environments. They play an important role in ecological and paleo-ecological studies due to their high numerical density in marine sediments and the excellent preservation potential of their shells. Benthic foraminifera show a great diversity with more than 10,000 modern taxa (Sen Gupta, 2003). Lamarck established independent foraminiferal orders such as *Discorbis, Rotalia, Lenticulina*and*Nummulites*in 1801 and 1804 (*in*Nuglisch, 1985). D'Orbigny, who played an important role in foraminiferal research, categorized foraminifera as their own order inside the Cephalopoda in 1826, and Dujardin assigned them to the protozoa in 1841 (*in*Nuglisch, 1985).

I.1. Definition of Systematic

Systematic is consisting of a system, presented as a coherent body of ideas or principals. Systematic has concerned with classification.

I.2. Definition of Taxonomy

Is the methodology and principals of systematic botany and zoology and sets up arrangements of the kinds of plants and animals in hierarchies of superior and subordinates groups.

I.3. The relationship between systematic and taxonomy

Classification is the arrangement of organisms into groups (*taxa*, singular *taxon*) based on their relationships. It follows that identification can take place only after a classification has been established. It should be emphasized that not all authors adopt these definitions. Taxonomy is often used as a synonym of systematics.

I. Systematic

This part is devoted to the systematic study some species that are involved in our research.

Kingdom: chromista

Subkingdom: Harosa

Infrakingdom: Rhizaria

Phylum: Foraminifera

Class: Globothalamea

Subclass: Rotaliana

Order :Rotaliida

Brizalinaspathulata (Williamson, 1858)

Synonymy

1858 - *Textulariavariabilis* var. spathulata Williamson, Rec Foram. Gr. Brit., Roy. Soc., 4, p.
76, pl. 6, fig. 164-165.

1997 - *Brizalinaspathulata* (Williamson): DebenayetRedois, pl.1, fig.7.

2002 - *Brizalinaspathulata* (Williamson): Kaminski et al. , pl. II, fig. 9.

2008 - *Brizalinaspathulata* (Williamson): DizetFrancés, pl. 1, figs. 8, 9, 10.

2012 - *Brizalinaspathulata* (Williamson): Pérez et al., p.143, fig. 6 D.

Description

Thisspeciesiscompressedwithanacuteperipheryalmostkeeledandslightlydepressedcurvedlimbatesutureswhichformanangleofabout45°withthelongaxisofthetest.*B. spathulata*hasmorestronglytaperedlateralmargins.Thisspeciesmayalsohavebeenidentifiedas*B. dilatata*byvariousauthorsalthoughitlacksthesigmoidsuturesofthed'Orbignyspecies.Anothersimilarspeciesis*B. lanceolata*diNapolifromtheCalabrianofItalywhoseholotypehasstraightersutures(Wrightetal.,inedit).

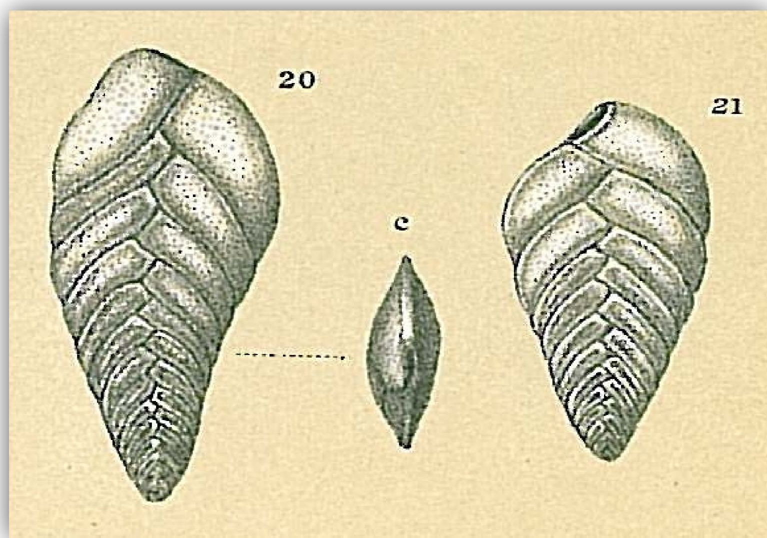

Figure5:*Bolivinaspathulata*Williamson,1858.

***Bolivinadilatata*Reusses 1850**

Synonymy:

1850 - *Bolivinadilatata* Reuses, Akad. Wiss.Math.Naturw., Wien, Bd. 1, p. 301.

1982 - *Bolivinadilatata*Reuss : Van der Zwaan, pl. 1, figs. 3, 4, 5.

1992 - *Bolivinadilatata*Reuss : Poignant et Moissette, pl. 1, fig.11.

2002 - *Brizalinadilatata*(Reuss) : Kaminski et al., pl. II, fig. 13.

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

Description:

Thisspeciesexhibitswelldevelopedsigmoidsutures.Thisisawell-knownNeogenespeciesfromthecircum-Mediterraneanarea.Specimensdescribedas*B.goesii*CushmanbyParker(1954)fromthenortheastGulfofMexicoareverysimilartothisspecies(Wrightetal,inedit)

4.*BuliminaaculeataD'Orbigny, 1826:*

Synonymy:

1826 - *Buliminaaculeata*D'Orbigny, Ann. Sci. Nat., sér. 1, 7, p. 269, n° 7.

1982 - *Buliminaaculeata*D'Orbigny: Van der Zwaan, pl. 2, figs. 1-2, text fig. 61.

2000 - *Buliminaaculeata*D'Orbigny: Baggley, pl. I, figs. 20-21.

2002 - *Buliminaaculeata*D'Orbigny: Kaminski et al., pl. III, Fig. 3.

2005 - *Buliminaaculeata*D'Orbigny: Van Hinsbergen et al., pl. III, fig. 11-12.

Description

Thisspeciesiseasilydistinguishedfrom*B.marginata*byitsflaringspines.Itmaybespecificwith*B.elongatasubulata*CushmanandParker,bothofwhichweredescribedfromtheMioceneoftheViennaBasin.*B.aculeata*hasmoreclearlydefinedspinesbutthevariationofthetwospeciesappearstooverlap.

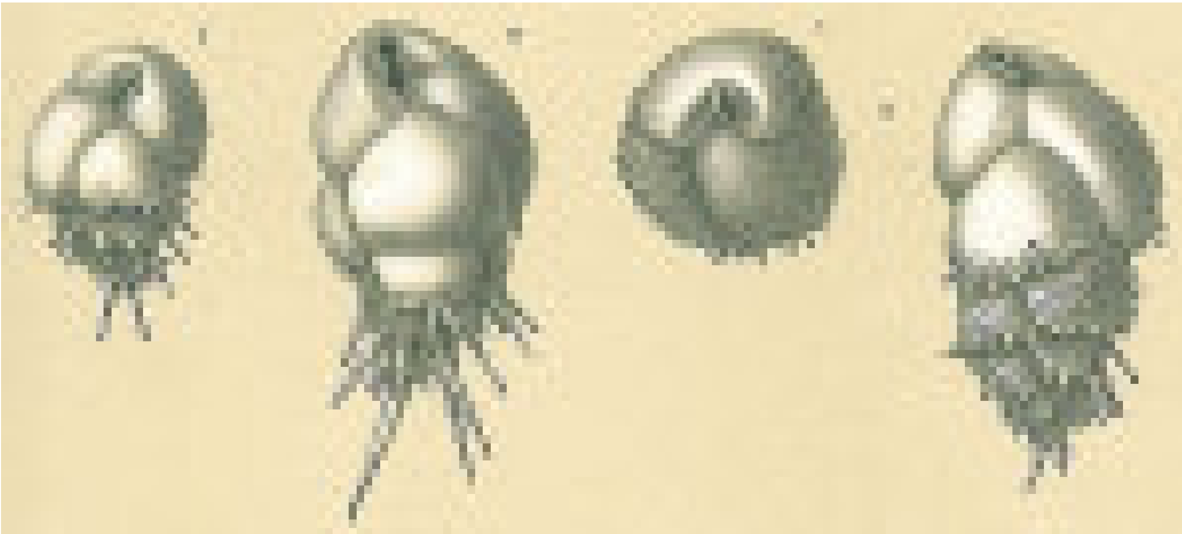

Figure06:*Bulimina aculeate*Orbigny,1826

*Buliminaelongata*D'Orbigny, 1826

Synonymy:

Synonymie:

1826 - *Buliminaelongata* D'Orbigny, Ann. Sci. Nat., sér. 1, vol. 7, p. 169.

2002 - *Buliminaelongata* D'Orbigny: Kaminski et al., pl. III, fig. 4.

2006 - *Buliminaelongata*D'Orbigny: Hebib, pl. I, fig. 5.

2008 - *Buliminaelongata*D'Orbigny: DizetFrancès, pl. I, Fig. 13.

2012 - *Buliminaelongata*D'Orbigny: Pérez et al, p. 143, fg. 6H.

Description:

It has an elongated shape that shows lodges wich are roughly in the same size, from the second half of the test. Van der Zwaan (1982) reports the species as forms of transition toward *B. aculeata*.

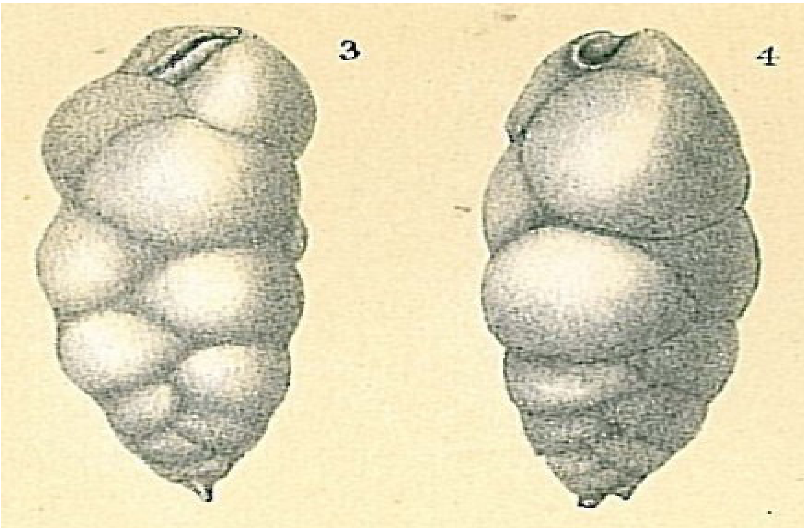

Figure7:*Bulimina elongate*D'Orbigny, 1826

Buliminaexilis Brady, 1884

Synonymy:

*Buliminaelegans*var.exilisBrady1884

*Buliminaexilis*Brady1884

*Eubuliminellaexilis*Brady1884

*Buliminaexilis*var. *tenuata*Cushman1927

Description:

Testmuchelongated,moreorlesscompressedontheirsides,arrangedintriserial spire (Brady1884).

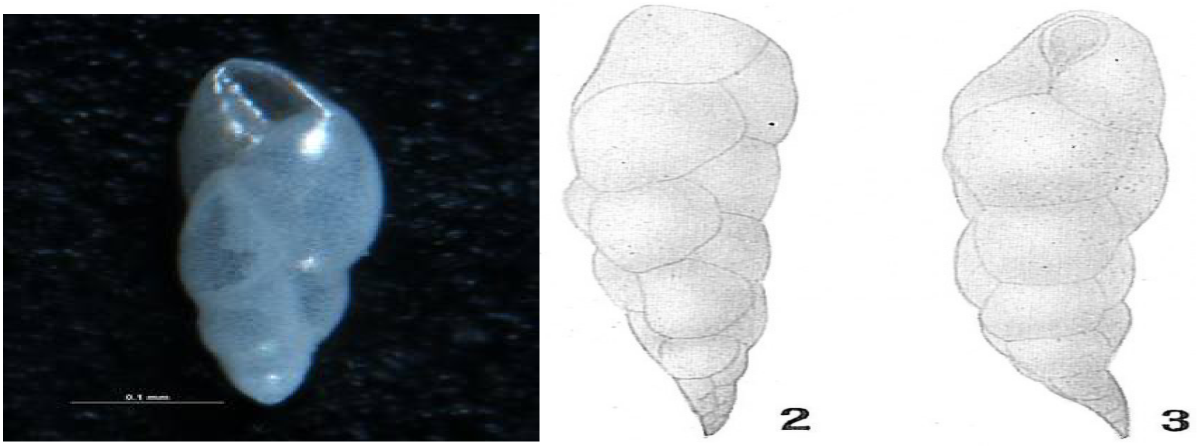

Fig. 8. *Bulimina exilis* Brady, 1884

***Buliminafusiformis*Williamson, 1858**

Synonym

*Buliminafusiformis*Williamson1858

*Buliminapupoides var. fusiformis Williamson*1858

*Fursenkoinafusiformis*Williamson1858

Description

Test elongated, tapering, somewhat *fusiformis,* chambers increasing is size and height as added, somewhat irregular, chambers comparatively few, distinct, irregularly spiral; suture distinct, depressed, wall smooth, finely punctate, aperture ovate, small.

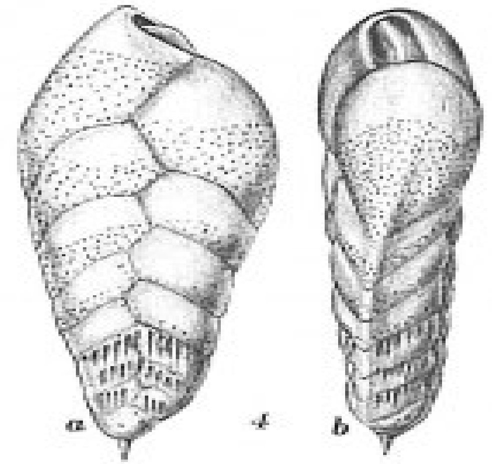

Fig. 9.*Buliminafusiformis*Williamson,1858.

Superfamily:Cassidulinoidea

Family:Cassidulinidae

Subfamily: Cassidulininae

Genus :Cassidulina

_Cassidulinalaevigata_D'Orbigny 1826

Synonymy:

1826 - *Cassidulinalaevigata* D'Orbigny: Ann. Sci. Nat., Paris, sér. 1, f. 7, p. 282, pl. 15, fig. 4-5, 5bis.

1974 - *Cassidulinalaevigata*D'Orbigny: Margerel, pl. 4, fig. 1.

2003 - *Cassidulinalaevigata*D'Orbigny: Murray, figs. 6.8-6.10.

2010 - *Cassidulinalaevigata*D'Orbigny: Margreth, p. 114, pl. 25, fig. 4.

2012 - *Cassidulinalaevigata* D'Orbigny: Pérez et al., p. 143, fig. 6N.

Description:

Cassidulinalaevigata: has a test lenticular to flattened with aperatura parallel to the peripheral margin partially closed by an aperture plate. The naturel of test is limestone, hyaline (Loeblich and Tappan 1988).

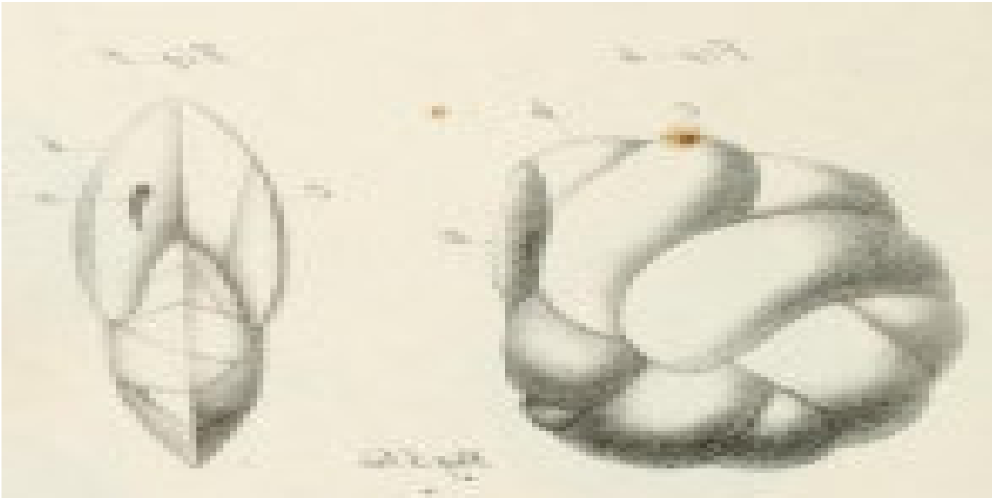
Fig. 10.*Cassidulinalevigata*Orbigny, 1826

Superfamily:**Planorbulinoidea**

Family:Cibicididae

Subfamily :Cibicidinae

Genus : Cibicides

***Cibicideslobatulus* (Walker & Jacob, 1798)**

Synonym

*Nautilus lobatulus*WalkerandJakob1798

*Lobatula vulgaris*Felming1828

*Trucatulinalobatula*Orbigny,Brady1884

*Cibicideslobatulus*WalkerandJacob,Cushman1931

Description

*Cibicideslobatulus*hastesttrochospiralandplanoconvex,containthreeandhalf whrolsendwithninetigesinthelastwhorl.Thenatureoftestislimestone(WalkerandJacob1798).

Fig. 11.*Cibicideslobatulus*(Walker & Jacob, 1798)

10.*Cibicidoidesungerianus* (D'Orbigny, 1846)

Synonymie:

1846 - *Rotalinaungeriana*D'Orbigny, Foram. Foss. Bass. Vienne, P. 157, pl. 8, figs. 16-18.

1982 - *Cibicidesungerianus* (D'Orbigny): Van der Zwaan, Utrecht, p. 147, pl. 6, figs. 2a-b.

1989 - *Cibicidesungerianus* (D'Orbigny): Verhallen, p.129, pl. 16, figs. 5-9.

2005 - *Cibicidesungerianus* (D'Orbigny): Van Hinsbergen et al. pl.I, fig.6.

2007 - *Cibicidoidesungerianus* (D'Orbigny): Griveau, p. 75, pl. 1, figs. 3a-c.
Description:

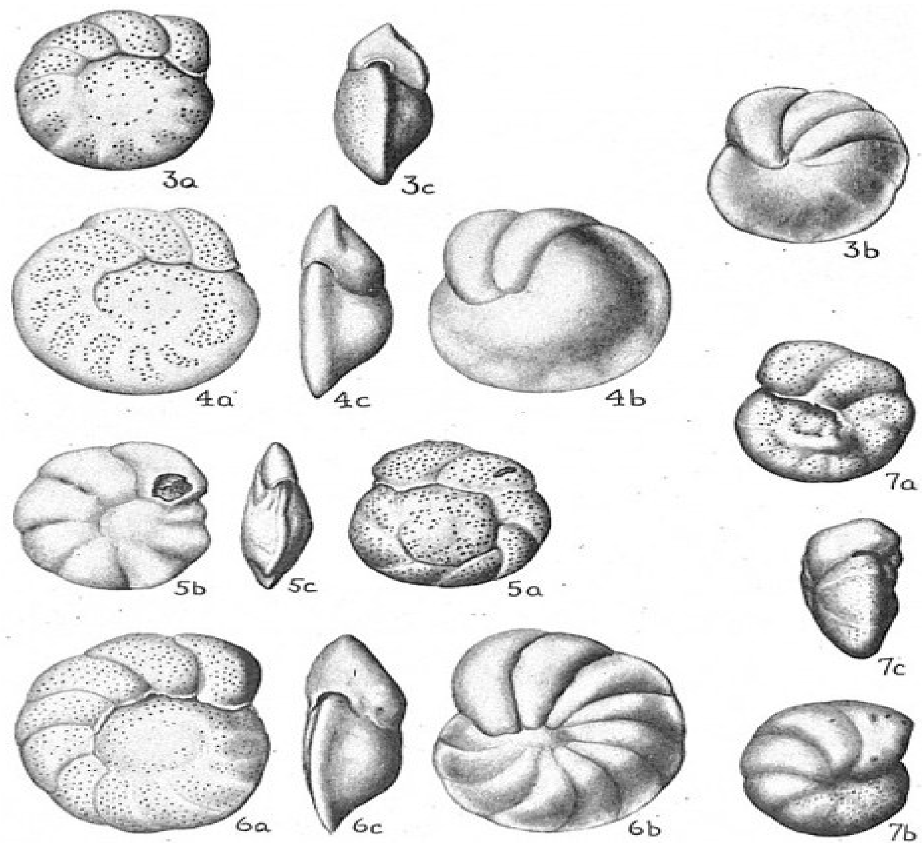

Figure12 :CibicidoidesungerianusOrbigny, 1846.

11.*Cibicidoidespseudoungerianus*(Cushman, 1922)

Synonym:

*Truncatulinapseudoungeriana*Cushman1922

*Cibicidespseudoungeriana*Cushman1922

*Cibicidespseudoungeriana*Cushman 1922

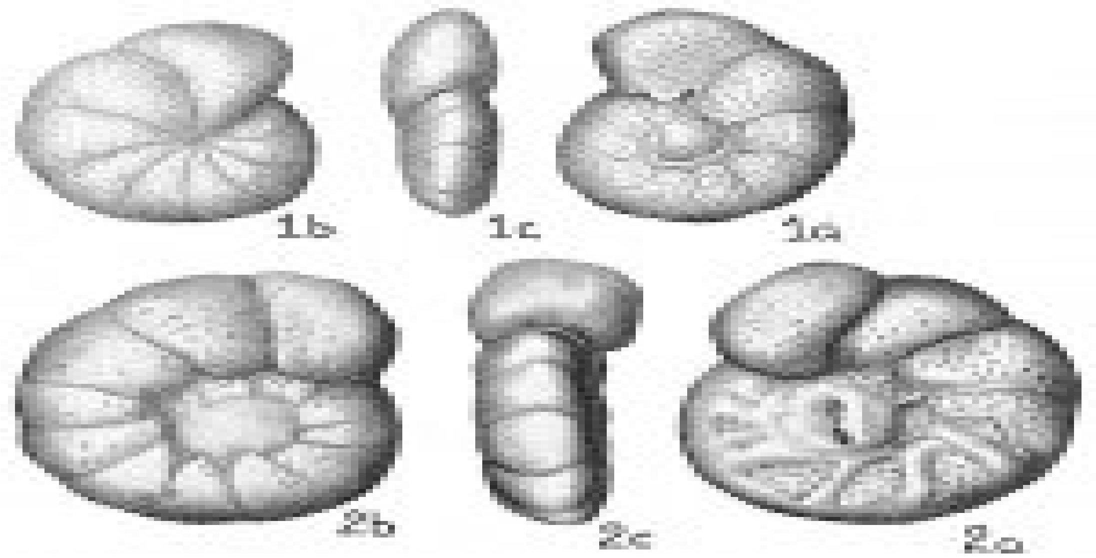

Figure13:*Cibicidoidespsedoungerianus*Cushman, 1922

***Cibicidoidesitalicus* Di NapoliAlliata, 1952**

Synonymy

1952 - *Cibicidesitalicus* Di NapoliAlliata, pp. 1-3. pl. 1, figs. 1-7.

1982 - *Cibicidesitalicus* Di Napoli: AGIP SPA, pl. LI, fig. 5.

2000 - *Cibicidesitalicus* Di NapoliAlliata: Kouwenhoven, pl. 3, figs. 2a-c.

2005 - *Cibicidesitalicus* Di NapoliAlliata: Van Hinsbergen et al.,pl.II, fig.8.

2006 - *Cibicidesitalicus* Di Napoli Alliata :Schweizer, pl. 3, figs. a-h.

Description

Cibicidoidesitalicus has a thick-walled hyaline test. The umbilical side flattens in the centre while the spiral side is strongly convex and hemispherical and shows a large number of chambers.

The periphery is rounded. The sutures are imperforate and superficial and the porosity is coarse on the spiral side.

Superfamily: Chilostomelloidea

Family: Gavelinellidae

Subfamily: Gavelinellinae

Genus:Gyroidina

***Hanseniscasoldanii* (D'Orbigny, 1826) Synonym:**

1826 - *Rotalia soldanii* D'Orbigny, Ann. Sci. Nat., 7, p. 278, n°5.

1985 - *Gyroidina soldanii* (D'Orbigny): Papp and Schmid, 60, Taf. 50, figs. 4–9.

2003 - *Gyroidinoides soldanii* (D'Orbigny): Rögl & Spezzaferri, pl. 8, fig. 4.

2005 - *Gyroidina soldanii* (D'Orbigny): Figueroa et al., p.349, fig. 34.

2007 - *Hansenisca soldanii* (D'Orbigny): Oblak, pl. 5, figs. 1a, b, c.

Description

*Gyroidina soldanii*hasatesttrochospirallywithsuturesradialapertureumbilicusandsecondaperaturecanbeseeonlywhenviwedobliquly.(LoeblichandTappan1988).

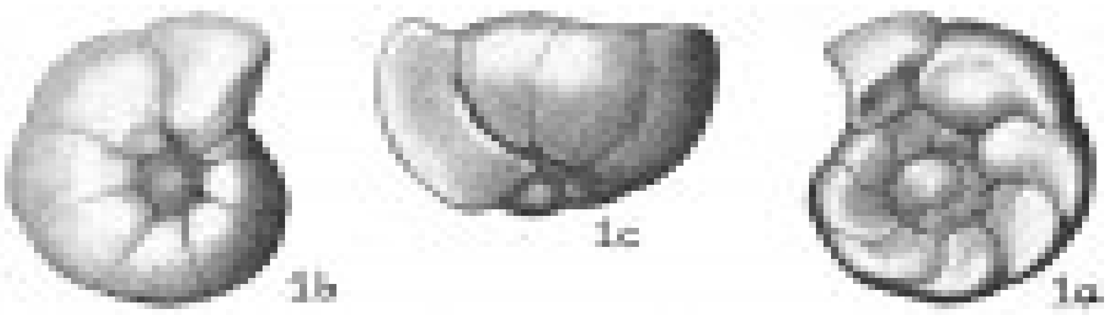

Figure14:Gyroidinasoldanii

Superfamily:Discorboidea

Family: Cancrisidae

Genus:Cancris

Cancrisauriculus (Fichtel et Moll, 1798)

Synonymy:

1798 - *Nautilus auricula*Fichtel and Moll, TestaceaMicroscopica, p. 108, pl. 20, figs. d-f.

1988 - *Cancrisauriculus* (Fichtel et Moll) :Loeblich et Tappan, pl. 591, figs. 1-3.

1989 - *Cancrisauriculus* (Fichtel et Moll) : Hulsbos et al., p. 270, pl. 3, fig. 15.

2005 - *Cancrisauricula* (Fichtel et Moll) : Van Hinsbergen et al., pl. II, fig. 1.

2007 - *Cancrisauriculus* (Fichtel et Moll) : Mojtahid, pl. 6.1, Fig. 10.

Description

This species presents a fairly broad test which differentiates it from *C. oblangus*, with a convex umbilical surface. It has a lobed outline. The suture lines are well marked and very limb.

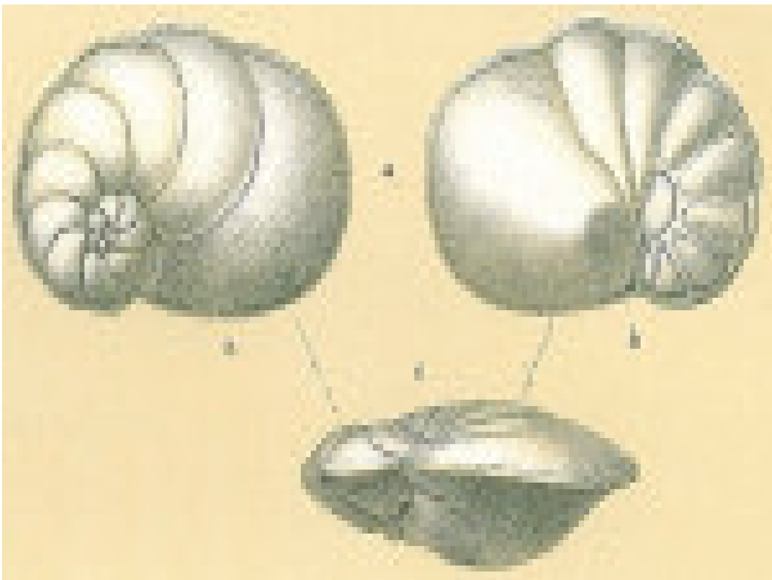

Figure15: *Cancrisauricula*Fichtel&Moll,1798.

Superfamily:Planorbulinoidea

Family: Planulinidae

Genus: Planulina

***Planulinaariminensis* d'Orbigny, 1826**

Synonymy

1826 - *Planulinaariminensis*D'Orbigny, Ann. Sci. Nat. P. 280, n°1, pl. 14, Fig. 1-3.

1988 - *Planulinaariminensis*D'Orbigny: Rezqi, pl. V, fig. 4.

2005 - *Planulinaariminensis*D'Orbigny: Van Hinsbergen et al., pl.1, fig. 15.

2007 - *Planulinaariminensis*D'Orbigny: Rouchy et al., pl. II, fig. 2.

2012 - *Planulinaariminensis* D'Orbigny: Pérez et al., p. 143, fig. 6K.

Description

*Planulinaariminensis*hasatesttrochospiralofabouttwowhorlswithnaturelimestone. Thisspeciesalthoughscatteredspecimensofthisspecieshadbeenfoundinseveral samples (LoeblichandTappan1988).

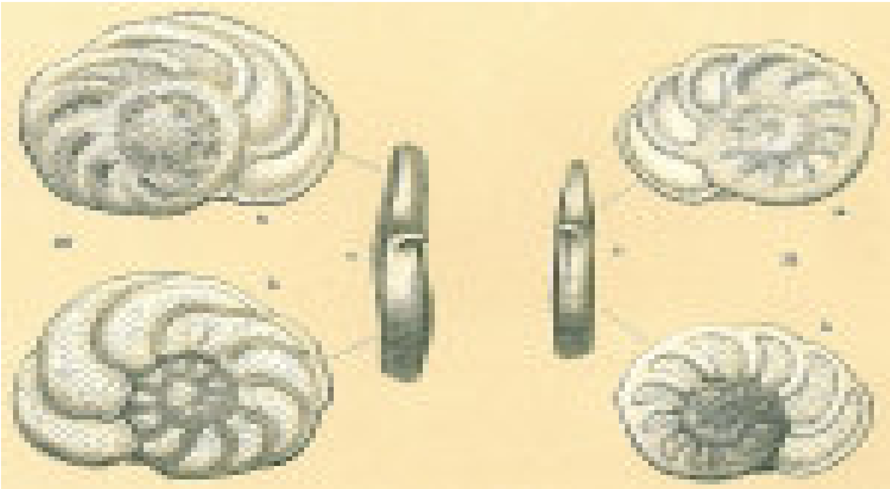

Figure16: *Planulinaariminensis*Orbigny,1826

Superfamily:Siphoninoidea

Family: Siphoninidae

Subfamily:Siphonininae

Genus:Siphonina

***Siphoninareticulata* (Czjzek, 1848)**

Synonym:

*Discrobisreticulata*Cžjžek1848

*Epistominareticulata*Cžjžek1848

*Rotalinareticulata*Cžjžek1848

*Truncatulinareticulata*Cžjžek1848

*Siphoninafimbriata*Reuss1848

Description

It is slightly asymmetrical biconvex form. The hyaline limestone test is grossly perforated,But this porosity is rather sparse. The opening, circular and bordered by a curved lip, is carried by a small collar.

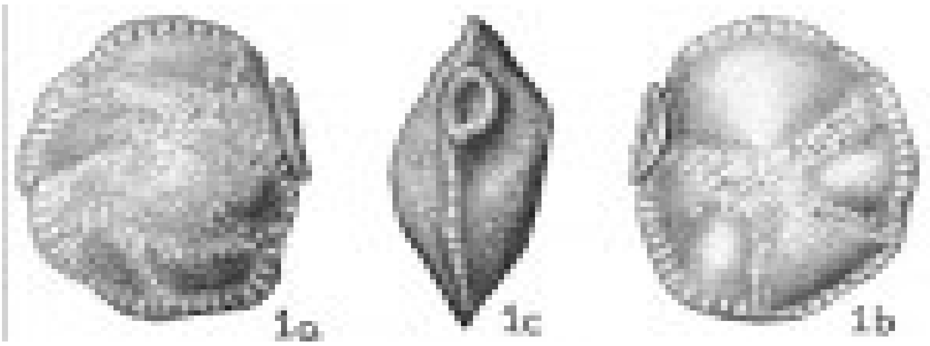

Figure17: *Siphoninareticulate*Cžjžek,1848

Superfamily:Cassidulinoidea

Family: Uvigerinidae

Subfamily:Uvigerininae

Genus:Uvigerina

*Uvegirinapregrina*Cushman1923

Description:

Testelongatetriserialwithdistinctandsurfacelongitudinal.Thenatureoftestislimestone.*Uvegirinaperegrina*hasanapertureterminal (LoeblichandTappan1988).

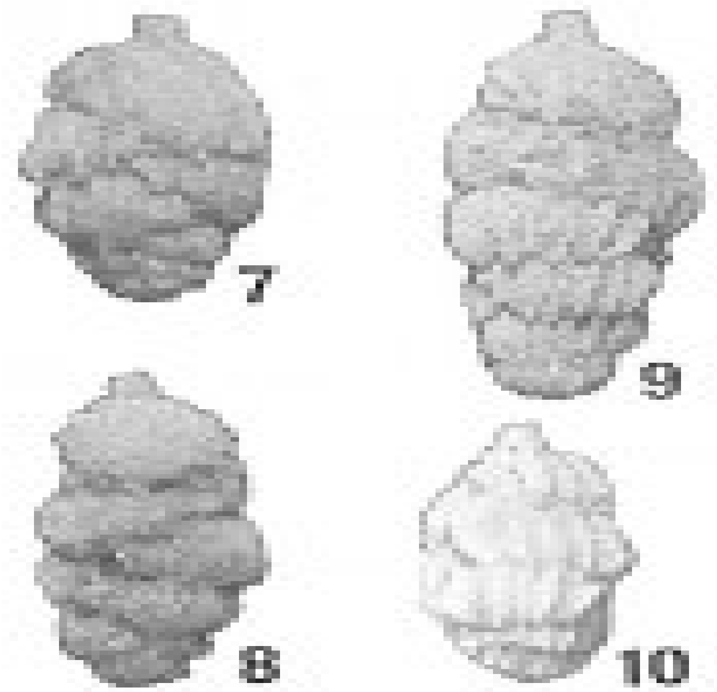

Fig. 17.*Uvegirinaperegrina*Cushman,1923

Third chapter: Statistical analysis

I-Introduction

The paleoenvironment changes is likely reflected on the relative abundance of different taxa (table 2), with regard the changes in the abundance of organic flux, changes in the stratification depths or character of the different deep-water mass (e.g. jorisson, 1999; Hebib., 2006).

A strong relationship exists between the level of oxygen content in water, the abundance and diversity of benthic taxa (Kaiho, 1994, jorisson et al., 1995). The downward organic flux, that controls the complex relationship between food and oxygen availability in the benthic environment, appears to be the main factor determining the distribution of benthic foraminifera. The area with highest downward organic flux are typified by a number of very opportunistic taxa, that can be epifaunal as well as potentially mobile infaunal. These taxa are most able to profit from the combination of high food availability and fair oxygen levels (case of Paleecological unites I and II). The area with low organic fluxes are characterized by a most stable fauna (Paleecological unites III) consisting of less-tolerant taxa in combination with (Jorissen et al., 1992).

Kouyoumontzakis(1987) mentioned that foraminifera associations are qualitatively and quantitatively dependent on the amount of silt in suspension contained in water or settled on the bottom. The existence of a silted bottom is rarely favourable for the benthic foraminifera (Kouyoumontzakis, 1979).

Table 1: Taxa (adopted in the current study)source of data (Benzina, 2008).

Anomalionidescicatricosus	*Cancris auricular*
Bolivinadilatata	*Dentalinalegumeniformis*
Bulivinaspathulata	*Planulinaariminsis*
Bolivinamiocenica	*Siphonina reticulate*
Bulimina aculeate	*Uvigerina peregrine*
Buliminaelongate	*Lenticulinarotulata*
Buliminafusiformis	*Lenticumlinaechinata*

Buliminaexilis

Cassidulinalevigata

Globocassidulinasubglobosa

Cibicideslobatolus

Cibicidoidesungerianus

Cibicidoidespsedoungerianus

Lenticulinaariminsis

Martinottiellacommunis

Rectuvigerinacylindricagaudryinoides

Rectuvigerinacylindricacylindrica

Cibicidesitalicus

Gyroidynasoldani

Table 2: percentages of taxa in samples of Djebel Meni section (Benzina, 2008).

	Anomlinoidesp	*Bignerinaspp*	*Bolivina p*	*Buliminasp*	*Cancrssp*	*Cassiduinaa*	*Cibicidscf*	*Cibicdoidescf*	*Clavulna*	*Criboroblin*	*Cylindroclavil*	*Dentalna*	*Gyrodinsoldani*	*Heterolepadutemplei*	*Lentcculina*	*Bignerinaspp*	*Planulinaarminensis*	*Rectuvigrina*	*spirosigmolinitatenuis*	*Siphoninareticulata*	*Uvigerinap*
M 1	8	0	0	0	4	5	3,67	7,67	3	2	1	5	3	3	13	3	12	6	0	5	10
M 2	8,33	1,33	7	1,33	1	3,33	12	10	0	0	0	7,33	4	0	9	0	11	3	0	2	5
M 3	7,67	1,67	2,33	0	2	3,67	9	11	0	0,33	0	4,33	3,67	0	15	0	1	6	0	5	9
M 4	3,67	2,67	1,67	2,33	1,33	2,33	9	7,33	2,67	0,33	0	3	1,33	4	13,7	0	20	2	0	3,33	4
M 5	10	3,67	1,67	0	2,33	0	11	14,7	5,67	0	1,33	2	2,67	2,33	7,33	0,67	10,3	0,33	0	7	2,67
M 6	4,33	0,67	0,67	0	1,67	0	5	17	1	0	0	2	3	0	8	1	28,3	5	0	2	10
M 7	8	0	9	2	1	0,33	13	20	0,33	0	0,33	1,33	1,33	1,33	6	2	14	2	3	7	6
M 8	6,33	2,33	2,67	0,33	2	8	11	10	0	0,33	0	4,67	2,67	0,67	9,67	4	17	1	0,67	10	1
M 9	3	4,67	5	1,33	2	1	8	7	3,33	0,33	1,33	4	3,33	1	4	1,33	17	2	3,67	9	6
M 10	3,33	2,67	5	0	2	2,33	7,67	6,67	2,67	0	1,33	5	3	1,67	7,33	1	23,3	2	0,33	1,33	7
M 11	0,67	0,67	0	2,33	4,67	4	7	2	7	1	2	2,33	1,67	1,67	11,3	1,33	31	1	4,33	0	3,67
M 12	11	0,33	13,7	0,33	0,67	9	15	10	5	4,67	0,67	3,33	1	0,33	8,33	4	7	1	0,67	0,33	4
M 13	17	0	5	2,33	0,67	0,67	17	11	4	0,67	0,67	0	4	0,67	5,67	2	4	5	3	0,33	10
M 14	13,3	0	2,33	1,67	2,33	6	3,67	3,33	12,3	3	1,67	2,67	1	0,33	16	0	5	3	7	0	9
M 15	6,67	0	4,33	8,33	2,67	2,33	7	3	8	3	0	3	5	0	9	0,67	6,67	2	8	0	8
M 16	4,67	0	26	6	0,67	11	12,3	3,67	0	2	0	2,67	3	0	4	0,67	4,33	1	0	0	0
M 17	11	0,33	8	0,67	0	7,33	15	11	7,33	0,33	1,33	3,67	0	0	15	0	6,33	0	0	0	0
M 18	17	0,67	2	1,67	3,67	0,33	19	15	10	1,33	2,33	1,33	0	7	14,7	2	0,33	0	1	0	1,33
M 19	9,67	0	0,33	0,67	1,33	1	6,67	4,33	25,3	1,67	6,67	1	0	0,33	5	3,33	0,33	0	9	0	13,7
M 20	0,67	0,33	0,33	1,33	6	10,7	14	8	0	5,67	0	3	1,67	0	9,67	13	0,67	0	0	3	1

	Anomlinoidesp	*Bignerinaspp*	*Bolivina p*	*Buliminasp*	*Cancrssp*	*Cassiduinaa*	*Cibicidscf*	*Cibicdoidescf*	*Clavulna*	*Criboroblin*	*Cylindroclavil*	*Dentalna*	*Gyrodinsoldani*	*Heterolepadutemplei*	*Lentcculina*	*Bignerinaspp*	*Planulinaarminensis*	*Rectuvigrina*	*spirosigmolinitatenuis*	*Siphoninareticulata*	*Uvigerinap*
M 21	0	0	0,33	1,67	3,33	2	4,67	3,33	19	1,33	7	9	0,33	1	14,7	0,67	3,33	0	3,33	0	10
M 22	3	0	11	8	1,67	0	10	4	0	4	0	12	0,67	0	11	0,33	17	0	0	0	10
M 23	2	0	3,33	0	0	16	12	5	0	3	0	9	2,33	2,33	8	8,67	0,33	0	2,67	0	15
M 24	12	0	0	0	0	7,67	24	15	0	0	0	0	0	0	0,33	14	0	3	1	0	23
M 27	20,3	0	0,67	0	0	1	41,3	15,3	0	0,33	0	0	0	0	0	12,3	0,33	0	0	0	2
M 28	0	0	3,33	0,67	3	0	4	7	0	4	0	7,67	5,67	0	30,3	4,33	6,67	0	1	0	0
M 29	1	0	4,67	2,67	1	5,33	19	22	0	0,33	0	1	5,33	0	9	3,33	22,7	0	0	0	1
M 30	3	0	11,7	9,33	1,67	2,33	18,7	10,3	0	0	0	0	4,67	0,67	3,67	1,67	10,3	6,67	0	0	11,7
M 31	3	0	3	5,33	3	5	12,3	14	0	0	0	0	3	0	0	2,67	35,7	0	0	0	7
M 32	2	0	16	9	1	4,67	4,67	22	0	0	0	0	5	2	2	2	4	11	0	0	12
M 33	3	1	2,33	8,33	5	8	10	7	6	0	3	2	2	0	0	2	2	8	3	0	12
M 34	0,33	0	3	42	0	1,33	6	3	0	2	0	2,33	8,67	0	6,33	0	15	0	0	0	1
M 40	0	0	37	19	0	0,33	3	0	0	0	0	0	0	0	0	0,33	4	32	0	0	3,67
M 44	1	0	35	13	0	0,33	3	1	0	0	0	0	2,67	0	0	1	6	23,7	0	0	13
M 45	0	0	32	14	0	1	6	4	0	2	0	2	5	1	4	2	4	0	1	3	17
M46	0	0	30	66	0	0	0	0,33	0	0	0	0	0	0	0	0	0,67	2,67	0	0	0
M 48	0	0	20	48	0	0	0	0	0	0	0	0	0	0	0	0	1	31	0	0	0

II- Results and interpretations

1- Principal components analysis

Three axes have been considered the account for 48.6 % of the total variance. Their proper values are given in table 3.

	F1	F2	F3
Eigenvalue	4,289	3,121	2,790
Variability (%)	2,424	14,862	13,284
Cumulative %	2,424	35,286	48,60

Table 3: percentages of three considered axes

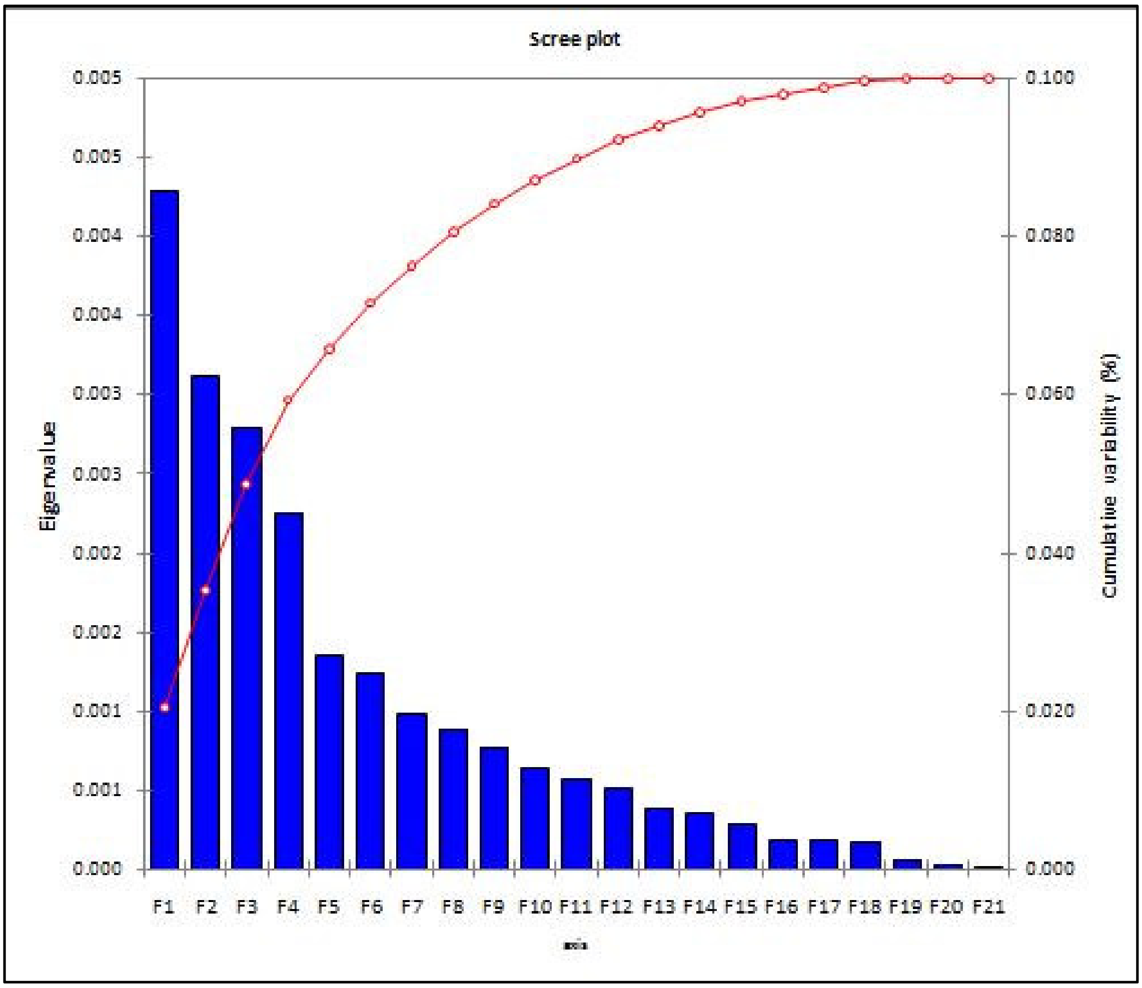

Fig.18. Diagram of PCA principal component analysis

Principal component analysis has been applied on data filled up in table 1 where their factorial analysis are reported as follow in table 4.

Variables	PCA-1 loadings	PCA-2 loadings	PCA-3 loadings
Anomalinoides	**-0,384**	0,223	**-0,484**
Bigenerina	**0,560**	0,269	**0,560**
Bolivina	-0,093	-0,250	-0,093
Bulimina	0,005	-0,261	0,005
Cancris	0,286	-0,303	0,286
Cassiduina	-0,194	0,297	-0,194
Cibicides	**-0,478**	**0,591**	**-0,478**
Cibicidoides	-0,044	**0,627**	-0,044
Clavulina	-0,292	**-0,476**	-0,292
Cribrorobina	-0,028	-0,269	-0,028
Cylindroclaviluna	-0,233	**-0,544**	-0,233
Dentalina	0,388	-0,253	0,388
Gyroidina	**0,483**	0,178	**0,483**
Heterolepa	0,151	0,043	0,151
Lenticulina	**0,411**	-0,212	**0,411**
Melonis	**-0,514**	**0,571**	**-0,514**
Planulina	**0,614**	0,195	**0,614**
Rectuvigrina	-0,112	-0,269	-0,112
Sigmolinita	-0,283	**-0,490**	-0,283
Siphoninareticulata	**0,538**	0,286	**0,538**
Uvigerina	**-0,380**	-0,072	**-0,380**
	Variances 20,42 %	Variances 14,86%	Variances 13,28%

Table 4. Benthic foraminifera categories loading on the first (PCA-1), second (PCA-2) and third (PCA-3). The values of leadings taxa for each group are in bold. Source of data (Benzina, 2008)

To understand the paleoenvironmental conditions that controlled the main evolution of the bottom water setting, Principal Components Analysis (PCA) has been applied on correlation matrix to assemblage of benthic foraminifera. In this sense, three factors were considered the account for 48.6 % of the total variance (Table1). The less significant values of the other factors were omitted in order to get an appropriate associations of species.

Factor 1 (PCA-1) designates 20 % of the variance. Taxa with large positive loadings are *Bolivinaspp*, *Buliminaspp* and *Rectuvigerinaspp* (Table 1).. PCA-1 distinguishes between a low-diversity assemblage (positively correlated with PCA-1) contains principally of (deep) infaunal taxa. taxa of this assemblage indicate a specific restricted environment with stress conditions regarding oxygen reduction, high food supply and high salinity (Di Stefano et al., 2010),

Whereas, from Me 25 onward PCA-1 shows a positive scores, that indicate an unstable environmental characterised by the settlement of permanent stress conditions. the upper part of the section show the domination of *Bolivininaspp* **and** *Buliminináspp* that reach up to 30% and 66% respectively. these taxa have the ability to modifying their microhabitat from infaunal to epifaunal looking for opportunistic life strategy of adaptation (Kaiho, 1994). shallow-dwelling and deep-dwelling infauna increase upon the oxygen content and food availability (Di Stefano et al., 2010).

Factor 2 (PCA-2) describes 14.9 % of the variance. It is positively loaded by *Cibicides* group, *Cibicidoides* gr, *Anomalinoides* gr, *Melonis* and *Siphoninareticulata.* Whereas*,* species with negatively loaded are *clavulina* and *Sigmolinita*. PCA-2 describes taxa that are positively loaded as an assemblage of species preferring shallow oxyphilic environment. In deed, PCA-2 involves both epifaunal and shallow infaunal species, referring to stable ecosystem that is to say a stable environment which is suitable for many more benthic species on contrary to species positively loaded in PCA-1.

Factor 3 (PCA-3)describes 13 % , where the associations loading Factor 3 do not bring any interesting information likely to explain the factor. This phenomenon can be interpreted in two different ways: either these species agree to live under very varied environmental conditions (eurytype species) or they require a whole set of very strict but intermediate factors (stenotype species living in an environment of average depth, oxygenation, productivity and salinity). Therefore, the interpretation of this factor needs additional investigation with more quantitative analysis involved (Drinian et al., 2007).

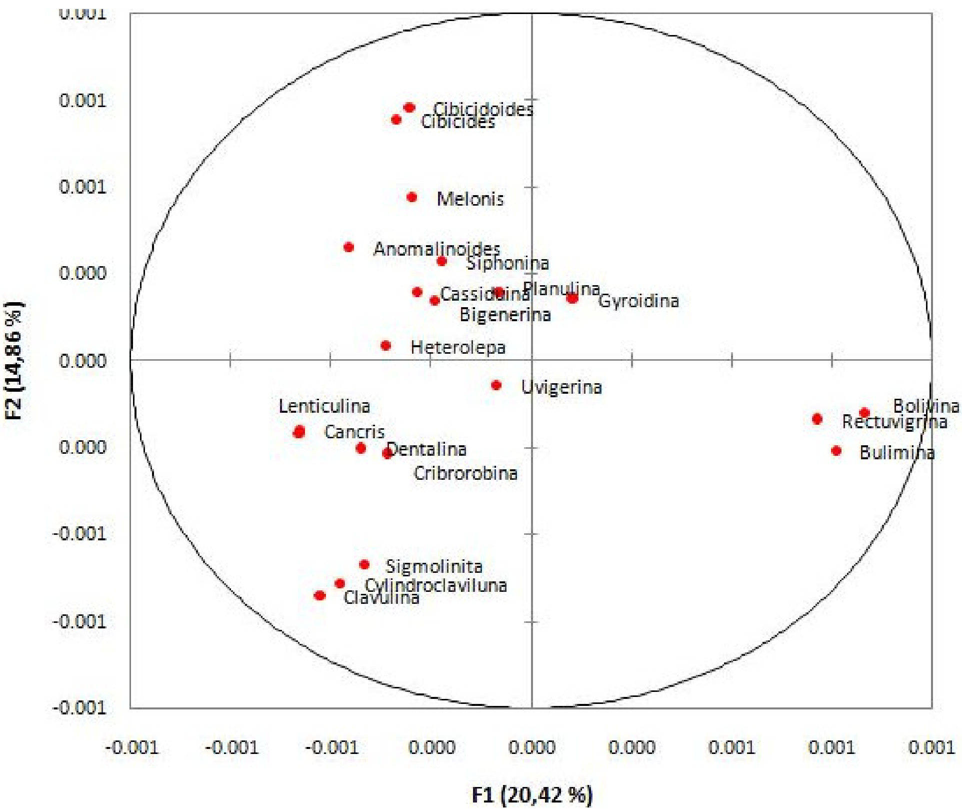

Fig. 19 . Diagram of Principal components analysis applied on F1and F2 (~ 35%)

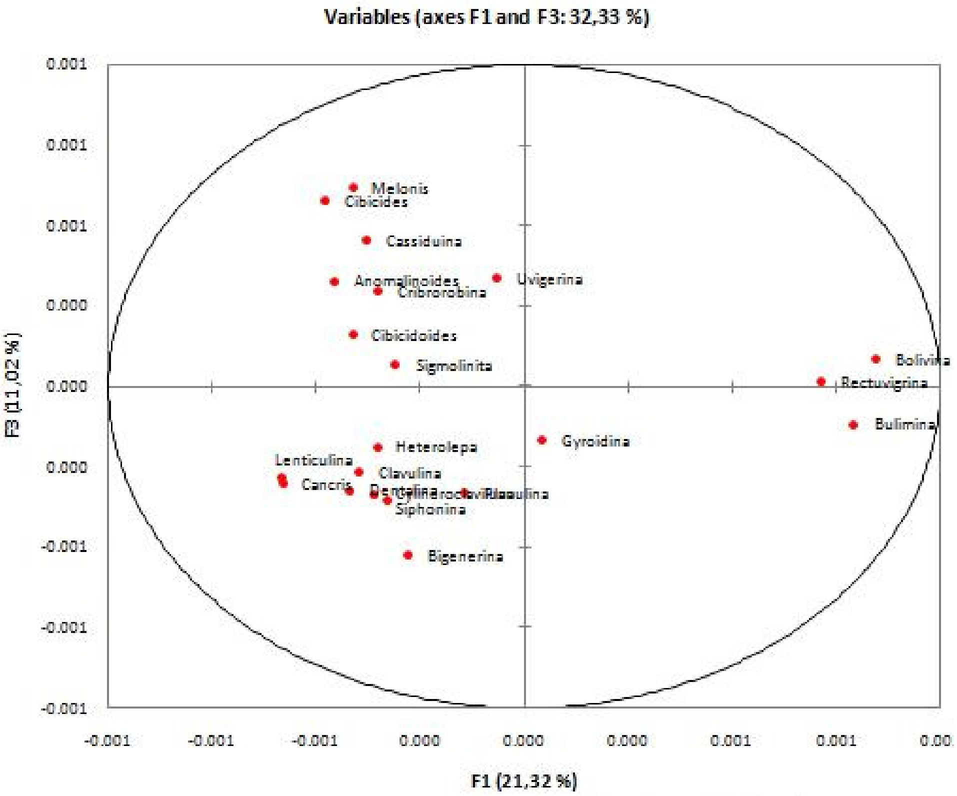

Fig. 20 . Diagram of Principal components analysis applied on F1and F3 (~32%).

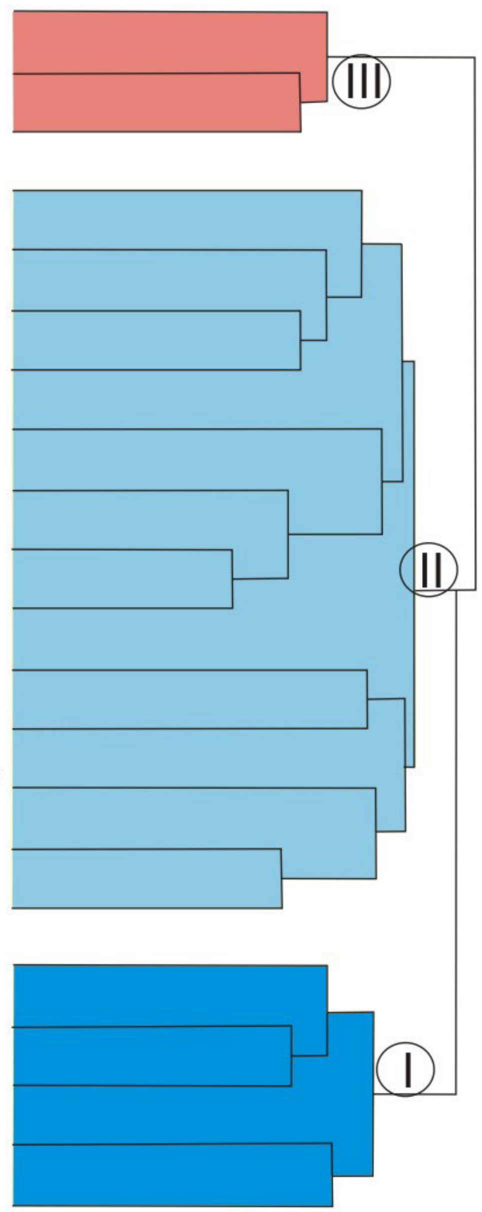

Fig.21.Dendrogram resulting from cluster analysis of benthic foraminiferal assemblage using XLSTAT Data source (Benzina, 2008)..

III- Synthesis of paleoenvironnemental evolution

Group I: Consists of taxa that refer to the first stage of evolution of benthic foraminiferal assemblagesThe assemblage is characterised by highly oxygenated bottom-water that indicate well-ventilated environment. Thus a normal salinity in open-ocean, eutrophic conditions (Benzina. 2008) . See (Fig. 19, 21).

Group II: Regarded as second stage of evolution,.Where **b**enthic of this assemblages are mostly found in the middle part of the section. The record Seems likely received a smoothdecline of seafloor conditions that can be interpreted as a significant decrease of the oxygen content (Benzina, 2008). Di Stefano et al. (2010) and Hebib (2015) points to the stagnation of deep-water, long with high supply of organic matte (Fig. 19, 21).

Group II: It is characterized by a huge and decrease in number of species, consequently the dominance of some specific species. This dominance typified the upper part of the section where we notice that interval barren of benthic foraminifera come to be more frequent (Benzina, 2008). However the dominance of stress-tolerant benthic species and the presence of barren intervals testify seafloor conditions characterized by dysoxia, high salinity and high fertility associated to oxygen depletion and salinity increase (Van der Zwaan 1982; Di Stefano et al., 2010). These conditions contribute to the disappearance of huge number of foraminifera. Unstable and stressed conditions allow only to a few taxa as oligotrophic species to prevail in such circumstances (Benzina. 2008) See (Fig. 20, 21).

VI- Conclusion

Our findings are likely Corresponds to the second transgressive–regressive of the Tortono- Messinian that adjusted to “megasequences” and “cycle” among the three cycles that characterized the late Miocene.The current study regarding the paleoenvironmentalchanges during the late the study area in Neogene basin reveals distinct stages of evolution.

The lowermost part (up to M 25) presents an assemblage with high diversity of benthic foraminifera. According to Benzina. 2008, this features materialized by the dominance of the oxyphilic taxa (*Cibicides, Planulina, Spiroloculinadepressa, Siphonina,Uvigerinaproboscidea, Cibicidoidesungerianu)* .This character looks like to be the most important factor that governs the vertical distribution of species, however the assemblage indicates a well-ventilated bottom-water conditions beside a deepdepth denoting a the degree of exchanges of water with and into the Neogene basin during that period.(Fig. 19,20, 21).

The moderate decrease of the main factors content thatcontrol the previous group seem to be the main elememts that leads to this stage, since the diversity of benthic foraminifera species drops down on one hand, on the other hand and more particularly the taxa such(*Cibicides,Cibicidesrefulgens, Planulinaariminensis,Cibicidoides, planoconvexa,)* were gradually substituted by other ones (*Lenticulina, Dentalina*sp, *Gyroidinasoldanii*), this evolution is considered as the another stage of changes that corresponds to the central part of the section.

The steady decrease in number of taxa characterises the upper part of the section witnessed a common presence of barrens intervals of benthic foraminifera. The stress-tolerant taxa are so dominant *Bolivina*sp, *Bulimina*sp *and Rectuvigerina*spgenus as dyoxic species with high salinity conditions. The interval refers to a oxygen depletion that probably caused by the restriction of Mediterranean water exchanges contributing to the immobility of bottom water(Benzina. 2008). The aforementioned settings along with species of this assemblage suggests ashallowmarinenvironment.

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