

A STUDY OF THE BATHYMETRY AND PALEOECOLOGY OF THE OLIGOCENE-LOWER MIOCENE DEPOSITS THROUGH FORAMINIFERA ASSEMBLAGES IN IONIAN ZONE (SW ALBANIA)

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ABSTRACT

The flysch-flyschoid deposits of Oligocene-Lower Miocene in Ionian zone, are successive and of great thicknesses. The planktonic and benthic foraminifera abundance and statistical method use in their study, make possible the plankton/ Total fauna ratio (P/P+B) calculation and knowing the foraminifera genera and species as well, which allow to be performed bathymetric and paleoecologic interpretations for all the flysch-flyschoid sequence. From this study resulted that the marine basin has been opened all the time, while its bathymetry has evolved.

During the earliest Lower Oligocene the basin depth is classified to have been of lower bathyal up to abyssal (1200-2000m), while the other part of Oligocene and upper most of Lower Miocene (up to the end of *Catapsydrax gr. dissimilis-Globigerinoides trilobus* zone) belonged to lower-middle bathyal (1200-600m).

During the upper part of Burdigalian age, the basin reached the greatest depth (lower bathyal) to abyssal (1200-2000m) which remained the same for a long time.

Based on the predominance of the foraminifera index groups for the paleoclimate (according to their possibility giving the modeling of depth stratification) we can say that the following climatic oscillations took place:

The bottom of Lower Oligocene-cold climate.

Lower Oligocene-temperate.

Middle Oligocene-Warm

Upper Oligocene-Lower part of Burdigalian-Warm up to subtropical.

Upper part of Burdigalian-Tropical.

KEY WORDS: Bathymetry, Paleoecology, Oligocene, Lower Miocene, turbidite deposits, Foraminifera, Ionian zone (SW Albania).

1. INTRODUCTION

During the planktonic and benthic foraminifera study (larger and small ones) of the flysch-flyschoid deposits dated Oligocene-Lower Miocene in Ionian zone (SW Albania) made for biostratigraphical intentions, the knowing of some microfaunistic index and parameters calculation was also realized permitting in this way the bathymetric and paleoecologic interpretations of the sedimentation basin.

This was made possible using the statistical methods in foraminifera study for some outcrop geological sections, situated in northern (Kruja) and southern (Luza), Gorisht, Vranisht-Bolene) part of Ionian zone, including all the deposits mentioned above (Fig. 1). The results drawn by this work are treated in the following chapters.

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2. BRIEFLY ON THE GEOLOGY AND LITHOBIOSTRATIGRAPHIC CHARACTERISTIC OF OLIGOCENE - LOWER MIOCENE DEPOSITS IN IONIAN ZONE

In SW Albania are distinguished the following tectonic zones:(from E to W): Krasta Cukali, Kruja, Ionian and Sazani. The Periadriatic Depression (UPA) lies transgressively on the Ionian zone. It consist of Tortonian-Pliocene deposits (Fig. 1). The largest part of Ionian zone is covered by pelagic limestones (Middle Jurassic-Late Eocene age). The Lower Oligocene flysch deposits lie successively on the carbonatic Upper Eocene ones through a transitory marly packet.

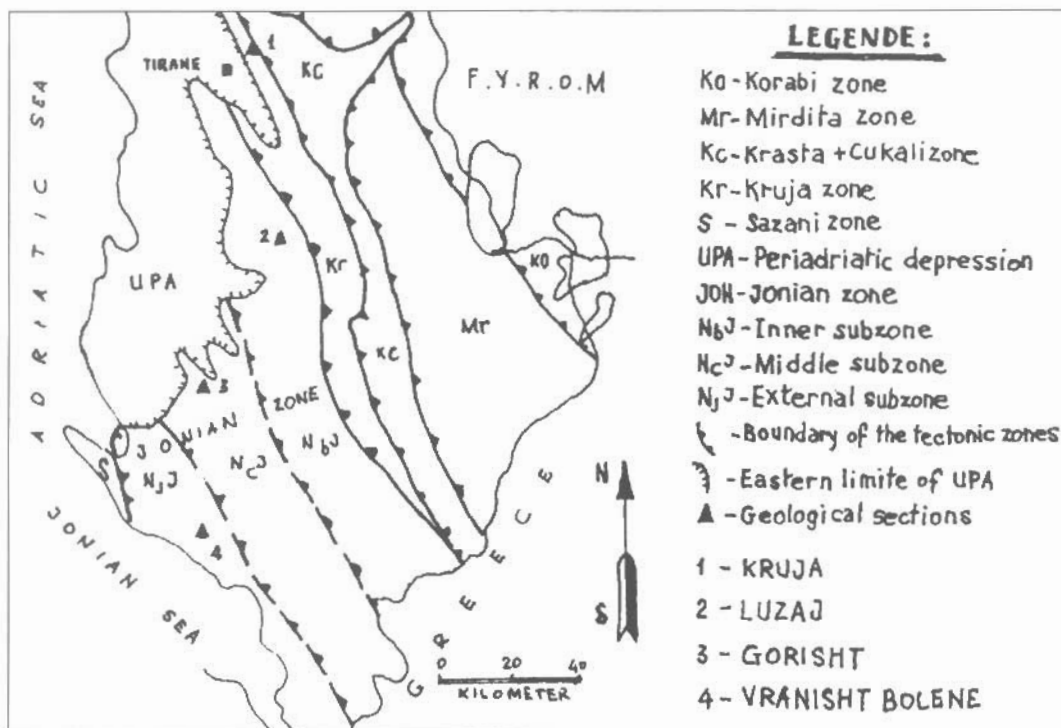


Fig.1: Tectonic zones and location of the geological sections studied in Ionian Zone (SW Albania)

Over this packet a variegated clay one is present. The section from Lower Oligocene to Early Miocene mainly consist flysch-flyschoid and premollasic sedimentary succesion. Lower part (Early Oligocene) is made up of marls and shaly silstones with intercalations of medium-to fine grained sandstones, fine-grained bioclastic limestones containing reworked, *g. Nummulites, Discocyclusina and Pellatispira*. Middle-Late Oligocene flysch is characterized by sandy to silty layers and intervals of massive coarser sandstones with conglomerates and olistostromes containg *Nummulites, Lepidocyclusina* (Middle Oligocene)(Fig.2).

Its the upper part(Late Oligocene to Aquitanian) is predominantly argillaceus. In parts (Western Albania) it contains fine to coarse-grained masively bedded sandstones with conglomeratic horizons and olistostromes. The limestone intercalations of late Oligocene often contain *Lepidocyclusina, Miogypsinoides, Austrorillina, Operculina* etc. and redeposited material from Kruja and Sazani zones.

Late Aquitanian-Lower part of Burdigalian comprises argillaceous to calcareous sediments (marls) and some intercalated silstones. The older interval consist of basal sandstones and conglomerates overlain by transgressive marine shales. Occassionally some bioclastic and Algal (Lithothamnium) limestones occur within this basal part. In synclinal areas the transgressive Burdigalian rests conformably on the Aquitanian flysch-flyschoid deposits, whereas on the anticlinal areas it overlies unconformably older strata. (Fig.3).

In the Middle-Upper part of Burdigalian, the paramolassic deposits of great thickness (massive marls) are encountered. All the deposits are successive and abundant in foraminifera planctonic and small benthic. The biostratigraphical events related to the foraminifera evolution from Oligocene to Lower Miocene in Ionian zone, are identical to those of Middle geographic latitudes given by other authors (Premoli Silva I., Boersma A., 1989; Boersma A., Premoli Silva I., 1991; Premoli Silva I., Spezzaferi S., 1990, 1991; Halloch P., Premoli Silva I., Boersma A., 1991; Parisi G., Coccioni P., 1988; Keller G., 1983; Adams C.G., 1981, AGIP S.p.A. 1988).

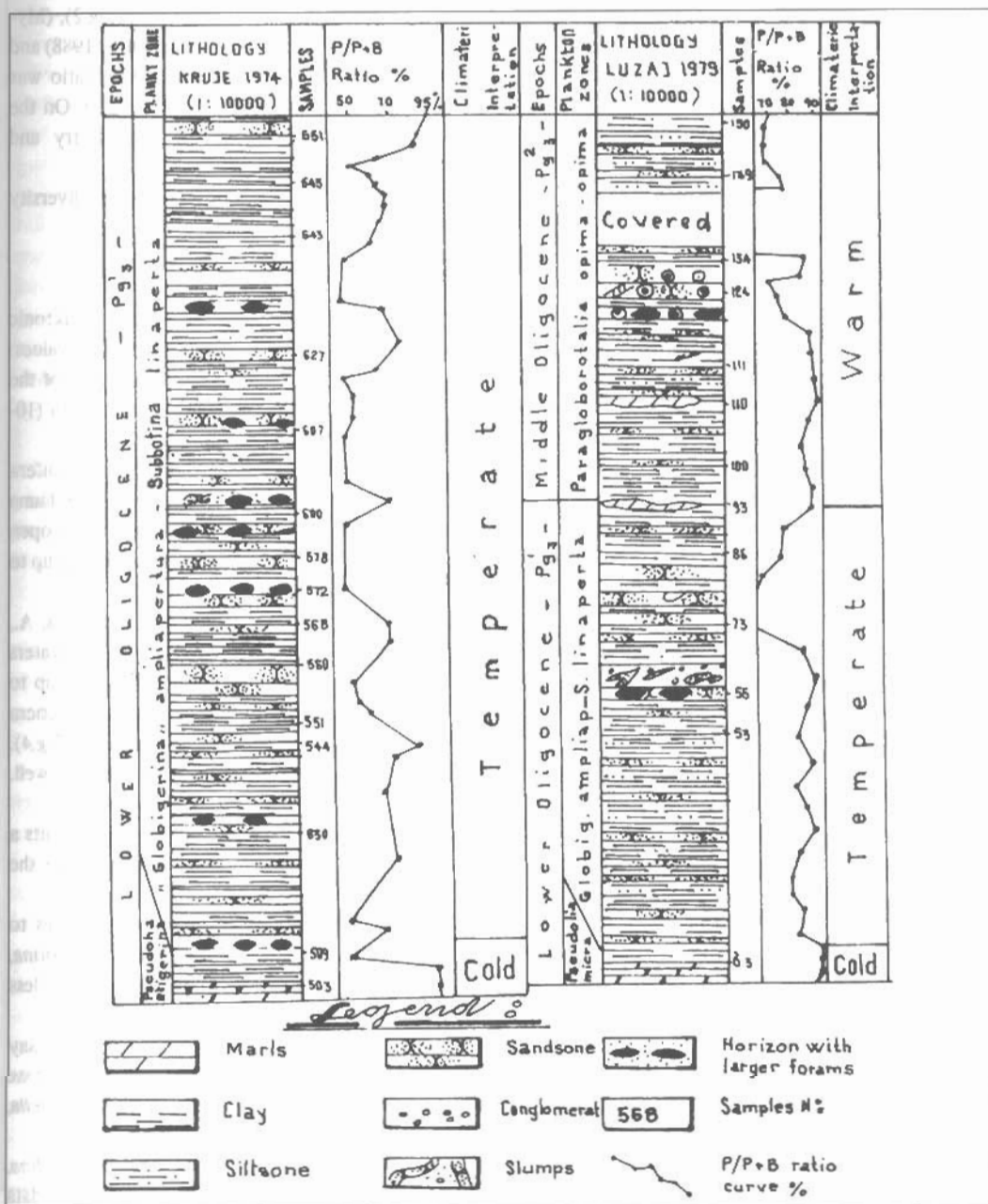


Fig.2: P/P+B Ratio, climatic interpretation and lithobiostratigraphy of the Kruja and Luzaj sections.
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By the numerous studies, it results that the Oligocene-Lower Miocene deposits are included between the planktonic foraminifera zones of *Pseudohastigerina micra* (at the bottom) and *Globigerinoides bisphaericus* (at the top) (Sadushi P., Myftari S., Dalipi V., Prillo S., 1988, Myftari S., Spiro Y., 1983, Myftari S., Shehu D., Jançe L., Roqi R., Vathi K., Budri E., 1989; Myftari S., Kurteshi F., 1994; Prillo S., 1984; Myftari S., Prillo S., Hasani L., Sadushi P., Shehu D., 1995).

3. THE RESULTS OF THE BATHYMETRIC AND PALEOECOLOGICAL STUDIES

From the foraminifera studies in Kruja section (Myftari, S. Spiro, Y. 1983) and Luzaj (Fig.2), (Myftari, S. Shehu, D. Jançe, L. Rroqi, R. Vathi, K. Budri, E., 1989), Gorrish (Myftari, S. Dalipi, V. 1988) and Vranisht-Bolene (Prillo, S. 1984), to biostratigraphical intentions, the plankton/Total fauna ratio was calculated (P/P+B). The obtained results were graphically represented for each section (Fig.2,3). On the other side, the dominant foraminifera groups study giving information on the bathymetry and paleoclimate was realized as well.

This work, also included the small and larger foraminifera study the knowing of their species diversity and evolution (Myftari, S., 1981).

Lower Oligocene

From the transitory packet marls (*Pseudohastigerina micra*) a very abundant planktonic foraminifera assemblage was obtained. The plankton/Total fauna ratio (P/P+B) reaches very high values: 95-97%. There are high amounts (about 60%) of general quantity of the planktonic foraminifera of the genera of small sizes (*Pseudohastigerina*, *Tenuitella Chiloguembelina*), while the other part of them (10-37%) consists of species of medium and large sizes, a, g. *Subbotina*, *Globigerina*, *Catapsydrax*.

The benthic foraminifera are represented by genera of carbonate test and reaches 3-5% of foraminifera general quantity. A series of genera and species are encountered. The high values of plankton/Total fauna ratio (P/P+B), genera and species considered as indicators to the bathymetry, bears witness to an open marine basin with its eastern boundaries very enlarged, while the basin bathymetry has been of abyssal up to lower bathyal zone (2000-1200m) (Myftari, S., Kurteshi, F., 1994).

Basing on the domination of the planktonic species group given by different authors (Boersma, A., 1986, Hallock, P., Premoli Silva I., Boersma, A., 1991) we come to the conclusion that the surface waters temperature has been of cold one. This cold interval comes after a warm one that have existed up to Upper Eocene end, which is documented by the presence of larger and small foraminifera species and genera in the Ionian and Kruja zone. A part of them disappeared before the beginning of Lower Oligocene. (Fig.4). This cold interval is in accordance with the studies made in the Marche and Umbria basin (Italy) as well. (Parisi, G., Coccioni, R., 1988).

The other part of Lower Oligocene (*Globigerina ampliapertura-Subbotina linaperta* zone) presents a relative impoverishment in foraminifera complex in comparison with Lower Oligocene base. So the plankton/Total fauna ratio (P/P+B) diminished in values up to 60-75% (Fig.2).

The species of medium and large size are dominant, (about 80%) while the other part belongs to species of small sizes. The greatest part of the planktonic foraminifera assemblage consists of g. *Subbotina*, *Globigerina*, *Catapsydrax* exemplars, while *Globorotalia*, *Tenuitella* and *Chiloguembelina* are less encountered (about 10% of foraminifera general quantity).

Concerning the small benthic foraminifera (about 20% of the foraminifera general amount) we can say that both groups of agglutinate and carbonate test are encountered. From the foraminifera with agglutinate test can be mentioned g: *Ammodiscus*, *Rhabdamina*, *Reophax*, *Dorothia*, *Cylichnocyprina*, *Karrieriella*, *Cyclammina*, *Spiroplectamina*, *Vulvulina*, *Ammosphaeroidina*, etc.

The foraminifera of carbonate test are represented by g. *Heterolepa*, *Anomalinoidea*, *Anomalina*, *Gyroidina*, *Uvigerina*, *Rectuvigerina*, *Bulimina*, *Pleurostomella*, *Siphonodosaria*, etc. Basing on the data interpretation obtained from P/P+B ratio and benthic foraminifera species which are indicator to the bathymetry, we came to the conclusion, that the basin has been open, while the deposition depth of

Lower-Middle Oligocene flysch in Ionian zone has been of Lower bathyal up to Middle one (1200-600m). This is supported by the characteristic sedimentary structures encountered in all depositing sequence as well (Myftari, S., Kurteshi, F., 1994).

Similar small benthic foraminifera were also found in the Oligocene deposits of the Marche and Umbria regions (Parisi, G., Coccioni, R., 1988).

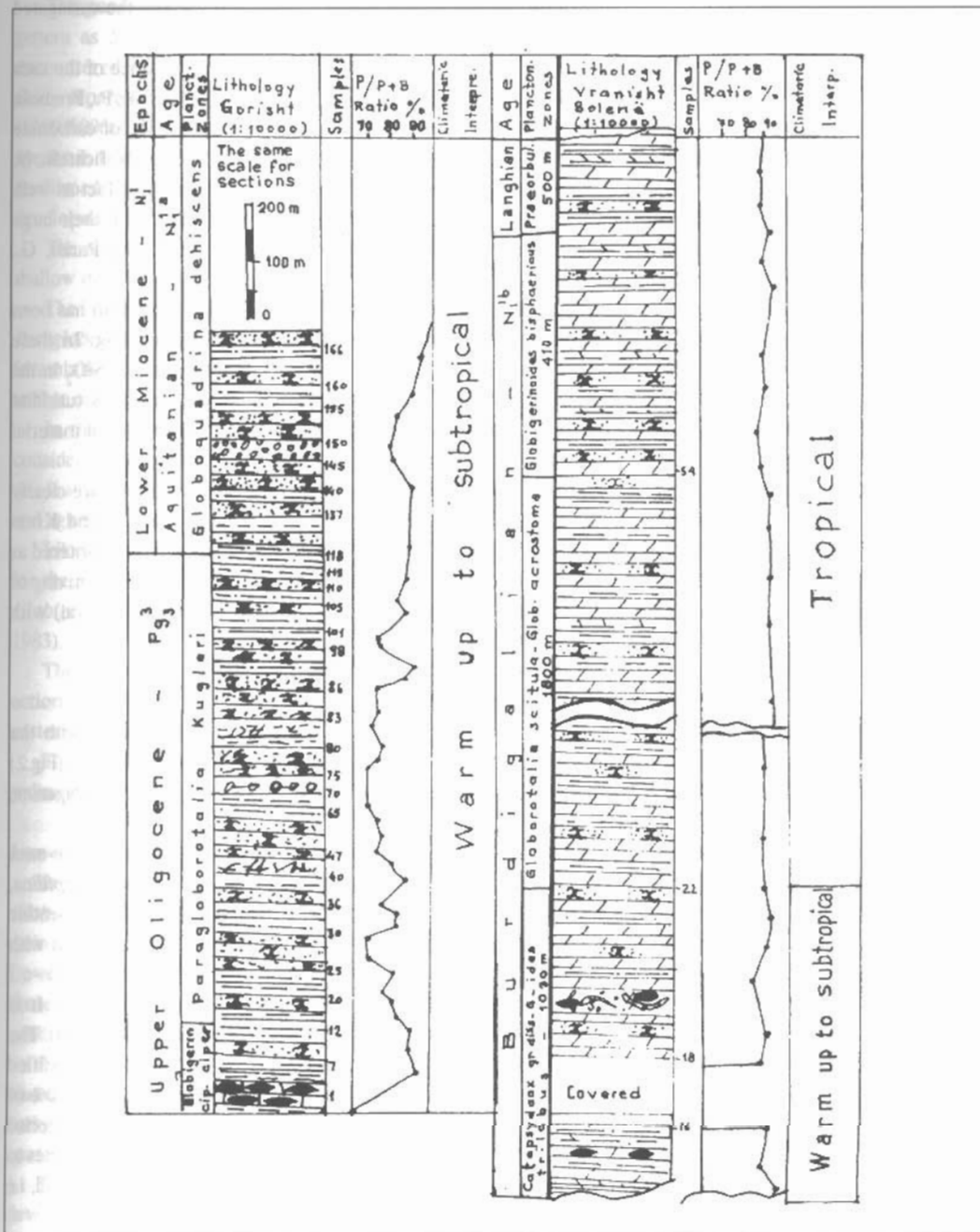


Fig.3: P/P+B ratio, climateric interpretation and lithobiostratigraphy of the Gorrish and Vranisht - Bolena sections (For legend see Fig.2)

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Generally, the small foraminifera assemblages encountered in Ionian zone are similar to those, of middle geographic latitudes regions. This similarity is also noticed in the complexes found in Mehestrihtian-Palogen flysch deposits of Labrador and North Sea (Grandstein, F., Berggren, W., 1981).

The presence in more than 50% of the planktonic foraminifera, general quantity of warm surface waters species group (Keller, G., 1983, Spezzaferri, S., Premoli, Silva, I., 1991) speaks to a temperate climate. This attests for a gradual warming of the surface waters which is also supported by the variegated clays presence abundant in ferrigenous oxides.

The waters of the basin into depth remain cold, that is verified by the permanent presence of the such exemplares as *g. Catapsydrax* and *Globigerina venezuelona* species (Keller, G., 1983, Hallock, P., Premoli, Silva, I. Boersma, A. 1991). In favor of this conclusion is the benthic foraminifera presence of carbonate test which are presented in species diversity. The presence of *g. Nummulites* with species *N. fichteli*, *N. vascus* species) and *Operculina*, wich lived in the basin margin (shallow zones) supports this fact as well, (Myftari, S., Kurteshi, F., 1994). The species diversity of the small benthic foraminifers and their large dimensions testifies for warm waters in middle geographic latitudes (Boersma, A., 1986, Parisi, G., Coccioni, R., 1988, Nocchi, M., Parisi, G., Monaco, P., etc 1986).

The relative impoverishment in foraminifera (Fig.2) in some intervals of the Kruja section has been related to the local aggravation of the paleoconditions necessary for the foraminifera living. In these conditions, the presence of calcium carbonate (CaCO_3) in small amount and the increasing of SiO_2 in the basin has played a principal role. The entering of a considerable sandy material into the basin (by turbidite currents) in determined time spans brought to an impoverishment or lack of foraminiferic fossil material within the sediments which were being lithified.

In Fig.2, the slumping horizons which belong to Lower Oligocene deposits. (Kruja, Lazaj) are clearly noticed. The consist of bioclastic material derived from carbonate platforms of the Sazani and Kruja zones, within which large foraminifers of Paleocene-Lower Middle Eocene age fig.1-4, are encountered as well, which are redeposited within the Oligocene flysch. The turbidite currents made possible the mixing of these faunal assemblages, i.e. the mixing of the deep waters foraminifers (Lower-middle bathyal) with those of shallow ones during Oligocene time (Myftari, S., Kurteshi, F., 1994).

Middle Oligocene

The foraminifera assemblage of the *Paragloborotalia opima opima* zone in comparison with the precursory one, become more abundant. So, the P/P+B ratio reaches the values of 80-90% (Fig.2) testifying for an evident domination of the planktonic foraminiferes of *g. Paragloborotalia*, *Globigerina*, *Catapsydrax*, etc.

It's important to be stressed the great diversity of the small benthic foraminifers while the large ones have a good development in the shallow zones (basin margin). The genus *Lepidocyclina* (*Nephrolepidina*, *Eulepidina*) coexists with *g. Nummulites* (Fig.4) The high values of the P/P+B ratio, the small benthic foraminifera diversity attest for an open basin of lower up to middle bathyal depth (1200-6000m) with intensive action of the turbidite currents.

The paleotemperature of the surface water masses has been of the values higher than 15°C. It is documented by the presence of *g. Lepidocyclina* (Adams, C.G., Butlerlin, J., and Samanta, B.K., 1986). The relative warming of the surface water masses in comparison with those of Lower Oligocene is also testified by the small benthic foraminifera diversity. The presence in foraminifera assemblage of more than 50% of the total planktic species of warm aers as *Paragloborotalia opima opima*, *P. opima vana* *Globigerina ciperensis angulisutaralis* supports this fact. The presence (about 30%) of the cold waters index species as *g. Catapsydrax* and species *Glogerina venezuelana* indicates that into depth the waters have been cold, i.e the water column has been well diferentiated.

Upper Oligocene

The *Globigerina ciperensis ciperensis* zone assemblage continues to be remain abundant and the

P/P+B ratio has almost the same values that had in the precursory faunal zone. But it is important to notice that in this assemblage the planktonic species exemplars of the medium size (50-60% of the general amount of the planktic foraminifers) are dominant and a part of them is given in Fig.4.

There are also small benthic foraminifers which by their living nature are cosmopolite and in general, they are identical to those encountered in Middle Oligocene.

The genus *Lepidocyclina* continues to be also encountered in higher amounts accompanied by other genera as *Spiroclypeus*, *Austrotrillina*, *Miogypsinoides*, *Operculina*, *Pararotalia* etc. (Fig.4). They are encountered within the clastic-organogenous limestones and together with other benthic microfauna are easily separable from the rock. The marine basin has been open and of lower up to middle bathyal depth (1200-600m). The abundance of the planktonic foraminifers and the small benthic foraminifera diversity, speaks in favor of this fact. The basin margins has been very rich in calcium carbonate (CaCO_3) and it is confirmed both by the numerous clastic-organogenous limestone horizons presence and good development of larger foraminifera (Fig. 2,3).

The action of turbidite currents led to the mixing of the deep water fauna assemblage with that of shallow one.

The presence of the planktonic foraminifera species (*Globigerina ciperoensis angulisuturalis*, *Paragloborotalia opima nana*, *Paragloborotalia pseudokugleri*) and too much genera of the larger foraminifera, attests for a warm up to subtropical surface waters temperature. The climate has been similar to that of Upper Eocene in the middle geographic latitudes.

In the other part of Upper Oligocene (*Paragloborotalia kugleri* zone) the P/P+B ratio undergoes a considerable decreasing, reaching the values of 40-50%. The planktonic foraminifera species present in this faunal zone (Fig.3) are diverse. Concerning the small benthic foraminifera they are both of carbonate and agglutinate test.

Likewise, in the precursory faunal zone, the index genera and species to the basin bathymetry, testify for the same living conditions, while the appearance of the new species as *Paragloborotalia kugleri* and *Globigerinoides primordius* speaks of a further increasing of the surface waters temperature (Keller G., 1983).

The relative impoverishment in planktonic foraminifera is related to the corrosion phenomenon action, because during this period massive sandstones were accumulated into the basin especially in the eastern part of the Ionian zone, which was very large).

This impoverishment is also related to the small quantity of CaCO_3 and SiO_2 increasing present in the sedimentation basin waters. (Gorriht section fig.3).

Lower Miocene

In the Lower Miocene deposits (Aquitanian up to the lower part of Burdigalian) included between *Globoquadrina dehhiscens* and *Catapsydrax gr.dissimilis-Globigerinoides trilobus* faunal zones, the P/P+B ratio undergoes an evident increase (Fig.3.), reaching values of 70-80% (in Aquitanian) and 80-95% in the Lower part of Burdigalian. Besides this, the planktic foraminifera are well developed and between them those of large and medium size are dominant. The last ones make up 70-80% of the planktic foraminifera general amount. The benthic foraminifera of carbonate test are well developed have a species variety.

Larger foraminifera as *Pararotalia*, *Lepidocyclina*, *Miogypsina*, *Operculina* genera, etc. are encountered. The high values of the P/P+B ratio and benthic species which are indicators to the bathymetry, testify that the basin continues to be increase of calcium carbonate (CaCO_3) amount contained in the basin waters, which influenced the impetuous development of the planktic foraminifera.

The surface waters temperature continues to increase (subtropical). This is based on the great development of g: *Globigerinoides*, *Globoquadrina*, *Globorotalia*, *Globigerina* species etc. The permanent presence of *Catapsydrax* genus exemplars speaks of cold waters into depth.

During Upper Burdigalian (*Globorotalia scitula* - *Globorotalia acrostoma* and *Globigerinoides bisphericus* zone) there is a great development of the planktic foraminifera in a such amount that they

become rockforming. The P/P+B ratio reaches the maximum values of 97-100% (Fig.3 Vranisht-Bolena section, Prillo S. 1984).

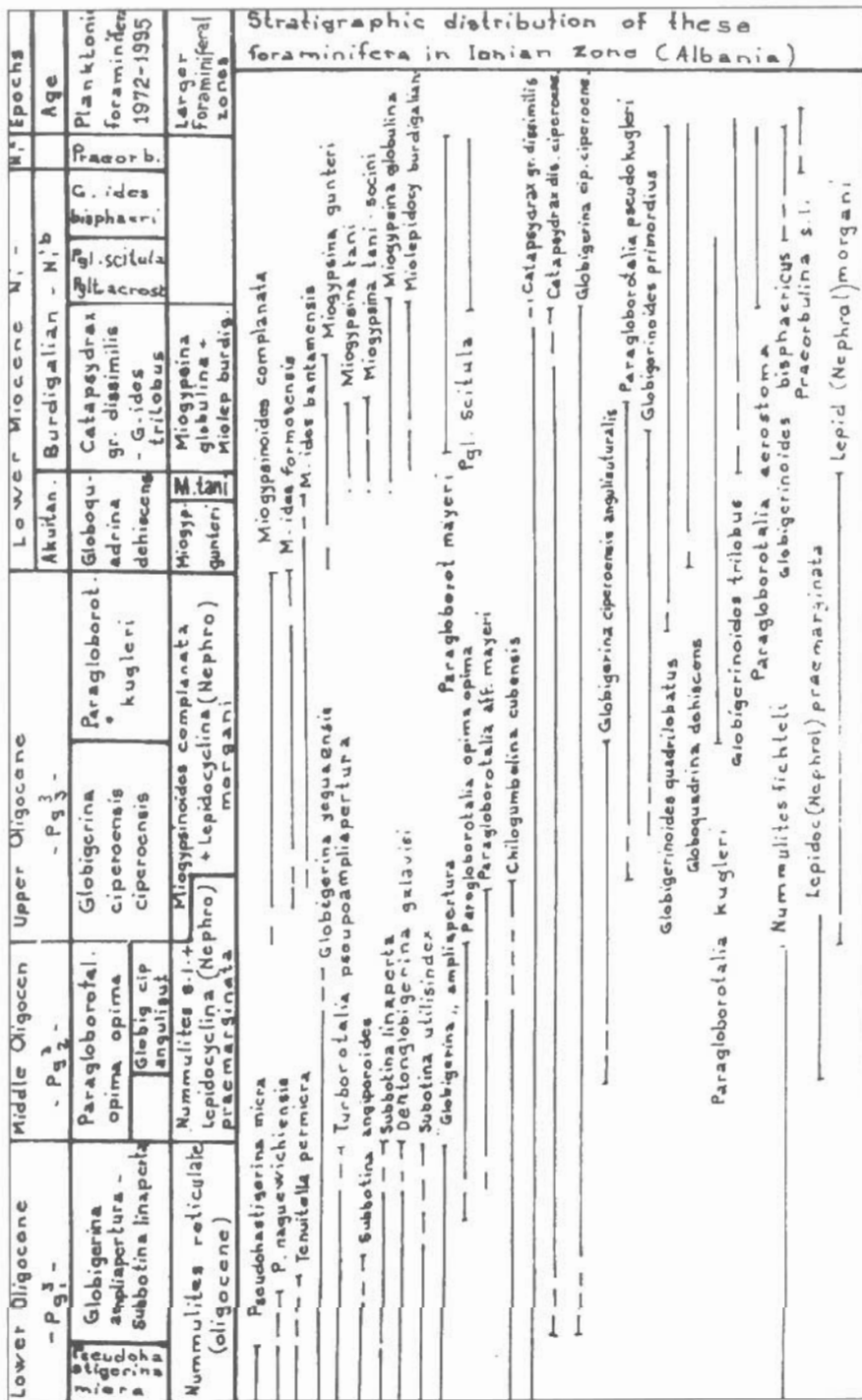


Fig.4: Correlation between planktonic and larger foraminiferal zones of the Oligocene-Lower Miocene, and stratigraphic distribution in the Ionian Zone (Albania).

The planktonic foraminifera exemplares are very developed and well preserved. Many genera and planktonic and benthic foraminifera species which were frequent in Oligocene and lower part of Lower Miocene, disappear. The small benthic foraminifera are unimportant in quantity and are represented by genera and species of deep waters (Prillo, S., 1984).

The high values of the P/P+B ratio, the planktonic foraminifera extraordinary development, great thicknesses of the massive marls and the bathymetry indexes obtained from the benthic foraminifera, attest for an open basin with eastern boundaries very advanced (to the east of the Ionian zone) and depth classified from abyssal to lower bathyal (2000-1200m). The presence of Radiolaria and siliceous interbeds (especially in the western part of the Ionian zone) within the massive marls speaks in favour of this argument as well.

The paleoclimatic indexes show for a tropical climate during this time and high calcium carbonate (CaCO₃) percentage contained in the basin waters.

Within the less shallow zones of the basin the turbidite currents action has been limited or of non considerable importance. However, the *Lithothamnium* limestones presence within the massive marls speaks both of the action of these currents and their forming conditions in a tropical climate.

Approximative conditions continue to be remained for the basin even for the posterior deposits of Langhian and Serravallian age, which are not object of this study.

4. CONCLUSIONS

1. The flysch-flyschoid deposits of Oligocene-Lower Miocene are successive and of great thickness. The statistical study of planktonic and benthic foraminifera (large and small ones), made possible a bathymetric and paleoecologic interpretations.

2. The marine basin by has always been opened. Its depth has evolved in time :

- At the Lower Oligocene bottom it has been of abyssal-lower bathyal depth 2000-1200m).
- During other part of Lower Oligocene, Middle-Upper Oligocene and Lower Miocene (up to the lower part of Burdigalian) the basin depth has been lower-middle bathyal (1200-600m).
- During the deposits sedimentation of the other part of Burdigalian the basin depth have been identical to that of the lower Oligocene bottom.

3. Basing on the P/P+B ratio calculated values, index foraminifera genera and species dominance, we can say that the following climatic oscillations took place

- Lower Oligocene bottom : cold climate.
- Lower Oligocene : temperate.
- Middle Oligocene - lower part of Burdigalian : warm up to subtropical.
- Upper part of Burdigalian : Tropical.

4. The turbidite currents action has been intensive and made possible their mixing of the deep waters species with those of shallow ones.

This is evident especially in the occurrence of the small benthic foraminifera assemblages with those of the larger foraminifera ones of the same age within the flysch-flyschoid sequence of Oligocene-Lower Miocene.

5. The redeposition phenomenon of the foraminifera derived from Paleocene-Eocene deposits within the flysch-flyschoid sequence is a common one. It is very evident mainly in the slumping horizons and clastic-organogenous within above mentioned sequence.

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