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FORAMINIFERAL BIOFACIES ANALYSIS AND PALEOECOLOGICAL DATA ON UPPER CRETACEOUS SEDIMENTS OF THE GAGRA-JAVA ZONE (WESTERN GEORGIA)

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Abstract: The paper deals with actual questions concerning biofacies and paleoecology of the Gagra-Java zone. The Gagra-Java zone extends along the Southern slope of the Greater Caucasus, in its turn subdivided into three facies types: Abkhazia-Racha, Odishi-Okriba and Dzirula. The Cretaceous sediments have developed mainly in the junction area of the Georgian block - from the Western Georgia up to Upper Racha. The Upper Cretaceous sediments consist predominantly of terrigenous-volcanogenic (Cenomanian-Lower Turonian) and marly carbonate limestones with the layers of variegated flints (Upper Turonian-Maastrichtian). According to planktonic and benthic foraminifera in the Abkhazia-Racha sediments have been distinguished 14 foraminifera complexes. The detailed analyses have proved that: 1. The lower boundary of the Upper Turonian is connected to the massive occurrence of the genera *Marginotruncana pseudolinneiana-M. schneegansi-M. lapparenti*; 2. The Turonian/Coniacian boundary is based on the occurrence of *Marginotruncana coronata* Bolli; 3. The Coniacian/Santonian boundary - *Dicarinella concavata* (Brotzen); 4. The lower boundary of the Upper Santonian is based on the appearance of *Contusotruncana (Rosita) fornicata* (Plummer); 5. The Santonian/Campanian boundary is based on the presence of *Globotruncana arca* (Cushman); 6. The Campanian /Maastrichtian boundary - on the occurrence of *Globotruncanita stuarti* (Lapparent). In the Odishi-Okriba facies type has been distinguished the suite "Mtavari", investigated in detail by planktonic foraminifers. The analyses made possible to establish 5 foraminiferal zones in the studied sections. These complexes have been correlated with macrofauna and nannoplankton complexes to specify the age of the suite. At present, there exists a definite methodology for the reconstruction of some parameters of the paleobasin that is based on quantitative interrelations of foraminifer associations. This technique is based on actual data on contemporary water areas. The PF (Planktonic Foraminifer) data can be used for the interpretation of the fossil material data applicable in paleogeographic reconstructions. The relation of planktonic and benthic foraminifera and the content of planktonic complex enable to define depth of the basin. According to the percentage of the left- and right-coiling species of *Globotruncanidae* there have been estimated the temperature conditions of the Late Cetaceous basin. The question on the parity of left- and right-coiling foraminifera is a part of big problem of coiling directions in the nature.

Keywords: Georgia, Mtavari, Cretaceous, Foraminifer, Carbonate, Facies.

1. Introduction

In the Caucasian segment of the Alpine fold belt there are distinguished several geotectonic units are distinguished from each other by structural characters and their history of development (Fig. 1). The Cretaceous sediments are most developed in the Gagra-Java zone. The entire Gagra-Java zone is a part of a folded system of the Southern slope of the Greater Caucasus. It is presented by carbonate deposits that are grouped as follows: Abkhazian-Rachian and Odishi-Okriba facies types. In the western part of the studied territory the Upper Cretaceous sediments are mainly represented by carbonaceous rocks: marls, calcareous clays, chalk, calcareous marls and limestones with variegated flints. Terrigenous-volcanogenic formations are in subordinate position and are confined to the Cenomanian and Lower Turonian. The most complete sections of the Upper Cretaceous sediments are observed in the Chanistskali, Khobistskali, Tekhuri and Tskhenistskali river basins.

2. Materials and Methods

The Upper Cretaceous sediments of the Gagra-Java zone are represented mainly by firm carbon-

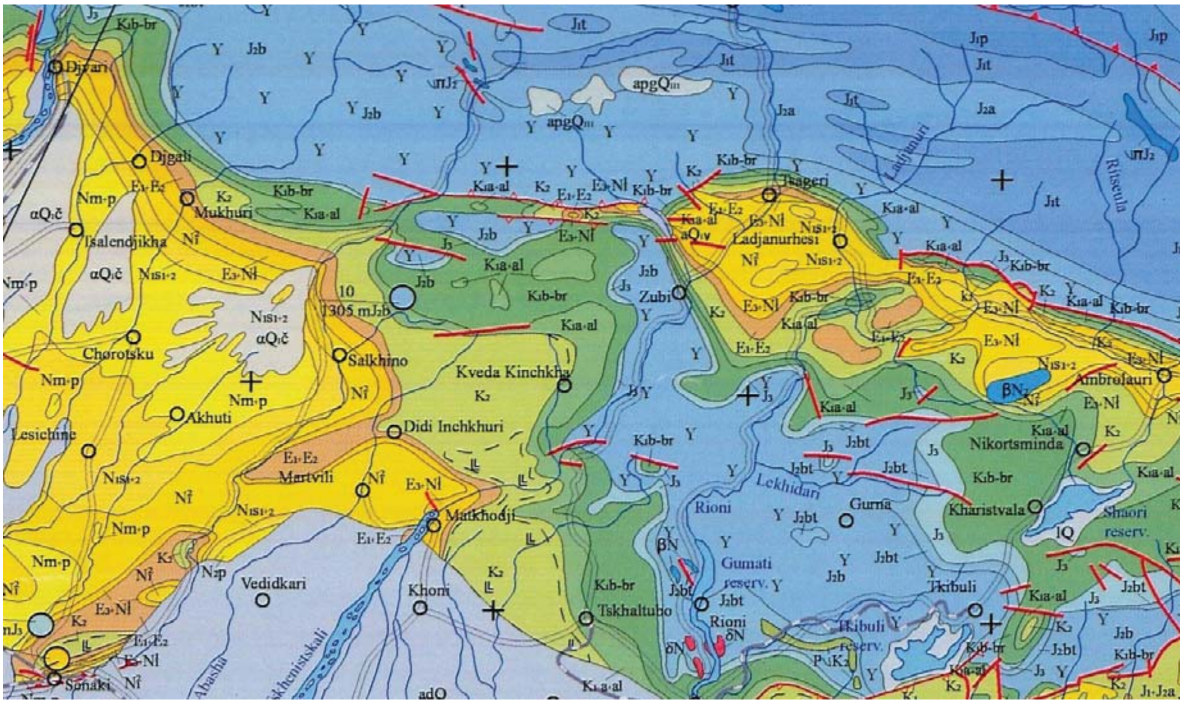


Fig. 1 Geological Map of the Studied Region

ate limestones with variegated flints. During the field- work 1800 samples were obtained. These samples were treated in the laboratory and washed with glacial acetic acid (CH_4COOH) and copper vitriol ($CuSO_4*H_2O$).

At present, there exists a definite methodology for the reconstruction of some parameters of the paleobasin that is based on quantitative interrelations of foraminifer associations. This technique is based on actualistic data fron contemporary water areas. The PF (Planktonic Foraminifer) data can be used for the interpretation of the fossil material data applicable in paleogeographic reconstructions specifying paleodepths.. According to the percentage of the left- and right-coiling species of *Globotruncanidae* there have been estimated the temperature conditions of the Late Cetaceous basins.

3. Biostratigraphy of the Gagra-Java Zone

The Study of distribution peculiarities of planktonic foraminifers in the Upper Cretaceous deposits of the investigated sections has allowed the determination of 14 foraminiferal assemblages:

I - the assemblage corresponding to the zone *Rotalipora appenninica*, is close by structure to the assemblage of *Hedbergella planispira* zone (Peryt, 1980) in Poland. Its systematic composition is close to the association of the zone *Rotalipora brotzeni* and *Rotalipora reichel*, of the Lower Cenomanian of Western Europe (Robaszynski,- and Caron, 1979; Robaszynski, Caron, et al. 1990).

II - the assemblage with the small *Hedbergella*, is characterized by presence of rather monotonous, but numerous small foraminifers. Stratigraphically it corresponds to the zone *Rotalipora cushmani*, known in the Middle- and Upper Cenomanian deposits of Western Europe and Poland (Robaszynski, Caron, 1979; Peryt, 1980).

III - the assemblage corresponding to the zone *Whiteinella archaeocretacea*, is characterized by the massive presence of the index-species and also a set of species *Whiteinella* and *Hedbergella*. This complex is close to those of the same zone found on the boundary of Cenomanian-Turonian sediments of Mediterranean and European areas (Robaszynski, Caron, 1979).

IV - the assemblage corresponding to the zone *Dicarinella hagni*, is characterized by a richer association of foraminifers. The leading part in this assemblage complex plays the index-species, and also *Whiteinella brittonensis* (Loeblich et Tappan, 1988) and *Praeglobotruncana oraviensis* Scheibnerova. Analogous zonal complex is characteristic of the Lower Turonian of Southern- and Western Europe, Tethyan region and North America (Pessagno, 1967; Sigal, 1977; Robaszynski, Caron, 1979; Robaszynski, Caron at al. 1984; Peryt, 1980).

V - the complex corresponds to the *Marginotruncana schneegansi* and *M. pseudolinneiana* zone and is characterized by abundance of the species: *Marginotruncana pseudolinneiana* Pessagno, *M. sigali* (Reichel), *M. angusticarinata* (Gand.). Stratigraphically it is the closest to the complex of the same named zone, established in the Upper Turonian-Lower Coniacian of Algeria, Western Europe and Tethyan region (Sigal, 1977; Robaszynski and Caron, 1979; Robaszynski, Caron, et al. 1990).

VI - the complex corresponds to the zone of *Marginotruncana coronata*; it is characterized by an abundance of the representatives of index-species, and *Marginotruncana renzi* (Gandolfi) and *M. marginata* (Reuss) as well. It is close to the assemblage of the zone "Grandes Rosalines " J.Sigal (1967) from the Turonian-Coniacian boundary of Boreal Europe and also is compositionally similar to the same name zone of Poland (Peryt, 1980).

VII - the complex corresponding to the zone *Marginotruncana renzi* and *Marginotruncana sigali*, is characterized by the intense presence of index-species. Here, the planktonic foraminifers are extremely abundant. Intrabenthic association is of certain interest for the abundance of genera *Stensioina*. Presence of considerable quantity of plano-convex planktonic representatives of *Marginotruncana* allows to define similarity of this association to the lowermost Coniacian *Marginotruncana coronata* zone of Poland (Peryt, 1980). It is probable, that stratigraphic interval of distribution of the VII complex together with those of the VI complex, corresponds to the zone of "Grandes Rozalines" J. Sigal. At the upper level both *Dicarinella primitiva* Dalbiez and *Marginotruncana tarfayaensis* (Lehmann) are observed.

VIII - the complex corresponding to the zone *Dicarinella concavata* is characterized by one specimens of the index-species, here as well *Marginotruncana paraconcavata* Pothault, *M. undulata* (Lehmann) and *Hedbergella flandrini* Porthault are met. Similar assemblages were established in the Paris Basin (Robaszynski, Caron, 1979) and in Algeria (Sigal, 1977). The restricted vertical and wide geographical distribution of this species defines its high stratigraphic value. The division of the Upper Coniacian-Santonian stratigraphic interval is connected with difficulties of morphological division of extremely similar species primitiva-concavata of the genus *Dicarinella*. The same problem appears in the case of nannoplankton zoning. Here, at the level of Coniacian-Santonian stages the layers have been identified with *Marthasterites furcatus* (Kilasonia, 1991; Lapachishvili, 1990).

IX - the complex corresponding to the zone *Contusotruncana (Rosita) fornicata*, contains the index-species, and also *Contusotruncana (Rosita) arcaformis* (Maslakova), *Dicarinella asymetrica* (Sigal), *Globotruncana bulloides* Vogler, *Archaeoglobigerina cretacea* (Orb.) et all. Concerning the systematic composition this association is the closer to a complex of the same-named zone *Globotruncana fornicata*, distinguished in the Upper Santonian sediments in Poland (Peryt, 1980) and North America (Pessagno, 1967). A similar zone complex is established in the Upper Santonian sediments of the Paris Basin (Robaszynski, Caron, et al. 1984) – as zone *Dicarinella asymetrica*.

X – this complex corresponds to the zone *Globotruncana arca*. Here important role is played by such double-keeled species, as *Globotruncana linneiana* (Orb.), *G. bulloides* Vogler, *G. ventricosiformis* Maslakova, *G. mariei* Banner et Blow, *G. rugosa* (Marie), *Globotruncanita elevata* (Brotz), and many others. This association is close to that homonymous zone traced in the lower part of the Campanian sediments in Poland (Peryt, 1980). The analogous complexes were found out in the Lower Campanian of the Paris Basin (Robaszynski, Caron, et al. 1984). The transition between the Santonian and Campanian coincides with the occurrence of the first representatives of *Globotrunca-nita*. The boundary between these stages coincides very often with the occurrence of the species *Globotruncanita elevata* (Robaszynski and Caron, 1979; Robaszynski, Caron, et al. 1984). At the same time, the species *Globotruncana arca* is another good marker for this boundary (Peryt, 1980). The lower boundary of this stage and the occurrence of index-species *Globotruncana arca* coincide with the occurrence of the zonal nannoplankton association *Tetralithus aculeus* (Lapachishvili, 1990).

XI - the complex corresponding to the zone *Globotruncana ventricosa* is characterized by a rich association of double-keeled forms, in which also *Globotruncana rosetta* (Carsey), *Globotruncanita atlantica* (Caron) and others have a leading part. By systematic composition this association is the closest to the assemblage of the homonymous zone of the Paris Basin (Robaszynski, Caron, et al. 1984).

XII - the complex corresponding to zone *Globotruncana morozovae*, besides the index- species, is characterized by the occurrence of forms, such as *Globotruncana majzoni* Sacal et Debour and *Rugoglobigerina rugosa* (Plumm). These two complexes (XI, XII) correspond to the nannoplankton zone *Tetralithus trifidus* (Kilasonia 1991; Lapachishvili, 1990).

XIII - the complex corresponds to the zone *Globotruncana stuarti*; it is characterized by the presence of the individual species *Contusotruncana (Rosita) contusa* (Cushman), and the continuing presence of forms with double-keel shells. A similar complex of the zone *Globotruncana falsostuarti* was established in the Lower Maastrichtian of Southern and Western Europe (Robaszynski, Caron, 1984). Concerning nannoplankton it corresponds to the layers with *Zigodiscus spirialis* (Kilasonia, 1991).

XIV complex corresponds to the zone *Abathomphalus mayaroensis*. Here, except the index-species, *Abathomphalus intermedius* (Bolli), *Globotruncana gagnebini* (Tilev) and *Globotruncana conica* (White) are represented. This zone is globally usually allocated in the upper part of the Maastrichtian sediments. Concerning nannoplankton, this level is distinguished as the zone Tetralithus murus (Kilasonia, 1991) (Table 1).

4. Biostratigraphy of the Odishi-Okriba facies type

Upper Cretaceous sediments of Odishi-Okriba facies type are spread as a discontinuous, southward bending of bow-shaped stripe and is known as the "southern calcareous stripe of Samegrelo" (Tsagareli, 1946). This facial type extends over the eastern part of the interfluves of the rivers Khobistskali and Tekhuri.

Terrigenous and volcanic rocks in the general context of carbonate sedimentation are characteristic of the Odishi-Okriba facies type. In the Tekhuri and Tskhenistskali river basins strata enriched by tuffaceous material are developed among the white and red limestones. Volcanic rocks are more widely spread in the southern strip of Samegrelo and in Okriba which are already distinguished by Meffert B.F. (1931) as the "Mtavari Suite". This suite contains reddish, brownish, yellowish-gray basaltic and porphyritic effusives and their pyroclastolites with layers of limestones and sandstones (Nadareishvili, 1980). The age of the whole mentioned series of deposits is determined as Late Turonian. The upper limit of the sequence is differently dated in different areas. E.g. in some places the top of the sequence rises up to the Campanian, and in other places it is limited by the Turonian and probably partially by Coniacian (Lekvinidze, 1960). The thickness of the sequence varies from several tens to several hundred of meters. The "Mtavari" suite is best observable in the interfluves of the Rioni and Tskhaltsitela, where volcanogenic rocks dominate. Within the limits of this facies type, in the vicinity of the village Gordi (basin of the river Tskhaltsitela), a stratigraphic section. Here are distinguished the following subdivisions: the "Mtavari" suite that corresponds to the Late Turonian-Late Santonian, the Upper Okumi suite – to the Campanian and the Mokvi suite corresponding to the Maastrichtian time.

The general thickness of the "Mtavari" sequence is 80 m (Table 2). The lower part is represented by brownish-pink tuff-gravel stone of different granulation. They comprise interlayers of pinkish limestones (thickness of streak 0,5-20 cm) with *Inoceramus lamarcki* Park (determination by Gambashidze R.A.). Herein, planktonic foraminiferal complexes were found: *Marginotruncana pseudolinneiana* Pessagno, *M. schneegansi* (Sigal), *M. marginata* (Reuss), *Dicarinella hagni* (Scheibnerova), *D. imbricata* (Mornod), *Hedbergella delrionensis* (Carsey), *Whiteinella archaeocretacea* Pessagno, *Heterohelix reussi* (Cushman), *H. globulosa* (Ehrenberg), *Globigerinelloides bentonensis* (Morrow), at the top of the limestone layer *Marginotruncana coronata* (Bolli), *Stensioina granulata kelleri* (Koch.), *Loeblichella spp.* occur. Alongside with the listed above, here is found *Tetralithus pyramidus* Gardet.

Brownish tuff-stones with streaks of red and grey limestones continue the section. In this part of the section the following were found: macrofauna - *Inoceramus cf. sturmi* And. (identification of Tsagareli A.L. and Gambashidze R.A.). Foraminifera - *Marginotruncana sigali* (Reichel), *M. renzi* (Sigal) were identified in the section for the first time, while *Marginotruncana pseudolinneiana* Pessagno, *M. marginata* (Reuss), *Dicarinella imbricata* (Mornod), *Globigerinelloides bentonensis* (Morrow), *Whiteinella archaeocretacea* Pessagno, *Hedbergella delrionensis* (Caesey), *Heterohelix reussi* (Cushman) continue to exist and among

Table 1. Microbiostratigraphic Zonation of the Upper Cretaceous Planktic Foraminifer

STAGE	SUBSTAGE	Lithology	Robaszynski, Caron 1979-1984 Western Europe	Foraniniferal zones and characteristic species Western Georgia
MAASTRICHTIAN	Upper	Grey limestones with concretion flint	Abathomphalus mayaroensis	**Abathomphalus mayaroensis**: Chiloguembelina praecursor Kazimiez, Guembelitria cretacea (Cushman), Abathomphalus intermedius (Bolli), Globotruncana conica (White).
			Gansserina ganseri	**Globotruncanita stuarti**: Rosita (Contusotruncana) contuse (Cushman), Gansserina gansseri (Bolli), Abathomphalus intermedius (Bolli),Globotruncana majzoni Sacal et Debuerle, Gl. marie Banner et Blow, Gl. ventricosiformis Masl., Globotruncanita stuartiformis (Dalbiez), Rugoglobigerina rugosa (Plummer),
	Lower		Globotruncana falsostuarti	
CAMPANIAN	Upper	White limestones	Globotruncanita calcarata	**Globotruncana morozovae**: Rugoglobigerina rugosa (Plummer), Globotruncana majzoni Sacal et Debuerle, Globotruncana linneiana (Orb.), Gl. aegyptica Nakkadi, Gl.rosetta (Carsey), Gl.rugosa (Marie), Rosita (Contusotruncana) plummerae (Ggandolfi), Archaeoglobigerina blowi Pessagno, Ar. cretacea (Orb.).
	Lower		Globotruncana ventricosa	**Globotruncana ventricosa**: Globotruncana atlantica (Caron), Gl. aegyptica Nakkadi, Gl. rosetta (Ccarsey), Gl. rugosa (Marie), Rosita (Contusotruncana) plummerae (Ggandolfi), Archaeoglobigerina blowi Pessagno, Ar. cretacea (Orb.).
			Globotruncanita elevata	**Globotruncana arca**: Globotruncanita stuartiformis (Dalbiez), Gl. elevate (Brotzen), Globotruncana linneiana (Orb.), Gl. bulloides Vogler, Gl. ventricosiformis Masl., Gl. marie Banner et Blow, Heterohelix reussi (Cushman), Heterohelix globulosa (Ehrenberg), H.moremani (Cushman), H. ventrilabrelliformis (Van der Sluis).
SANTONIAN	Upper	Limestone with layers of marls and sandstones	*Dicarinella asymetrica*	**Rosita (Contuzotruncana) fornicata**:Contusotruncana (Rosita) arcaformis, Dicarinella asymetrica (Sigal), Globotruncana bulloides Vogler, Archaeoglobigerina cretacea (Orb.).
	Lower		Dicarinella concavata	**Dicarinella concavata**: Marginotruncana coronata (Bolli), M. paraconcavata Porthault, M. tarfauaensis (Lehmann), M. sinuosa Porth., M.pseudolinneiana Pessagno, M. sigali (Reichel), M.schneegansi (Sigal), M. marginata (Reuss), Dicarinella primitive (Dalbiez), Heterohelix reussi (Cushman), Heterohelix globulosa (Ehrenberg),
CONIACIAN	Upper	Limestones with variegated flint		**Marginotruncana renzi/M.sigali**: Marginotruncana sigali (Reichel), M. tarfauaensis (Lehmann), M. sinuosa Porth., Whiteinella archaeocretacea Pessagno, Wh. brittonensis (Loeblich et Ttappan), Wh. baltica Douglas et Rrancin, , Stensioina praeexculpta (Keller), St. emscherica Baryschnicova, St. granulate Keller, Gyroidinoides depresus (Alt.), Gy. costulata (Marie).
	Lower		Marginotruncana schneegansi	**Marginotruncana coronata**: Marginotruncana renzi (Gandolfi), M. sigali (Reichel), M. tarfauaensis (Lehmann), M. sinuosa Porth., Whiteinella archaeocretacea Pessagno, Wh. brittonensis (Loeblich et Ttappan), Wh. baltica Douglas et Rrancin, Stensioina praeexculpta (Keller), St. emscherica Baryschnicova, St. granulate Keller, Gyroidinoides depresus (Alt.), Gy. costulata (Marie).
TURONIAN	Upper			**Marginotruncana pseudolinneiana/M.schneegansi**:M. sigali (Reichel), M. marginata (Reuss), M. marianosi (Douglas), Whiteinella archaeocretacea Pessagno, Heterohelix reussi (Cushman), Heterohelix globulosa (Ehrenberg).
	Middle		Praeglobotruncana helvetica	**Dicarinella hagni**: Hedbergella delrionensis (Carsey), Whiteinella archaeocretacea Pessagno, Dicarinella imbricate (Mornod), Heterohelix reussi (Cushman), Heterohelix globulosa (Ehrenberg), Stensioina granulate (Koch.).
	Lower		Whiteinella archaeocretacea	**Whiteinella archaeocretacea**: Praeglobotruncana praehelvetica (Bolli), Pr. gibba Klaus, Dicarinella imbricate (Mornod).
CENOMANIAN	Upper	Silicified limestone	Rotalipora cushmani	
	Lower	Limestone with schistous marl		**Fine Hedbergella**: Hedbergella delrionensis (Carsey), H. planispira (Tappan), Globigerinelloides bolli Pessagno.
			Rotalipora reichel	**Rotalipora appenninica**:Hedbergella delrionensis (Carsey), H. planispira (Tappan), Globigerinelloides bolli Pessagno, Gl. carsey (Bolli, Loeblich et Tappan), Heterohelix globulosa (Ehrenberg).

Table 2. Correlation of the Biostratigraphic Zonality for the Upper Cretaceous

STAGE	SUBSTAGE	Macrofauna zones	Calcareous nannofossil zones	Planktic Foraminifera zones: Facies type Abkhazia-Racha	Planktic Foraminifera zones: Facies type Odishi-Okriba
		Western Georgia			
MAASTRICHTIAN	Upper	Pachidiscus gollevillensis	Tetralithus murus	Abathomphalus mayaroensis	
	Lower	Belemnitella lanceolata	Lithraphidites quadratus	Globotruncanita stuarti	
CAMPANIAN	Upper	Belemnitella langei Belemnitella mucronata	Tetralithus trifidus	Globotruncana morozovae Globotruncana ventricosa	Globotruncana ventricosa
	Lower	Micraster schroederi	Tetralithus aculeus	Globotruncana arca	Globotruncana arca
SANTONIAN	Upper	Belemnitella praecursor		*Rosita (Contuzotruncana) fornicata*	Rosita (Contuzotruncana) fornicata
	Lower	Inoceramus cordiformis Inoceramus undulatoplicatus		Dicarinella concavata	
CONIACIAN	Upper	Inoceramus involutus	Marthasterites furcatus	Marginotruncana renzi/M.sigali	Marginotruncana renzi/M.sigali
	Lower	Inoceramus wandereri		Marginotruncana coronata	Marginotruncana coronata
TURONIAN	Upper	Inoceramus lamarcki	Tetralithus pyramidus	Marginotruncana pseudolinneiana/ M.schneegansi	Marginotruncana pseudolinneiana/ M.schneegansi
	Middle			Dicarinella hagni	
	Lower	Inoceramus labiatus	Microrhabdulus decoratus	Whiteinella archaeocretacea	
CENOMANIAN	Upper	Praeactinocamax sp. Acantoceras rothomagense			
	Lower	Mantelliceras mantelli Aucellina krasnopolskii		Fine Hedbergella Rotalipora appenninica	

benthonic forms - Stensioina exculpta (Reuss), St. granulata granulata (Olbertz), Lenticilina sp.

The Upper Okumi suite, with a thickness of 75 m, is built up of pelitomorphic, light pink, almost white, thick-layered chalky limestone. At the lower part of the sub-suite there is *Micraster schroederi* Stoll., (identifications of Tsagareli A.L., Gambashidze R.A.); in the suite the first representatives of *Globotruncana arca* (Cush)., *G. linneiana* (Orb)., *Contusotruncana (Rosita) fornicata* (Plum.) are observed, and also *Marginotruncana marginata* (Reuss), *Heterohelix reussi* (Cushman), *H. globulosa* (Ehrenberg) are present.

The upper part of the subsuite consists of light grayish and white, medium- and thick-layered pelitomorphic limestones with the interlayers of greenish-grey marls and concretions of grey flint. They contain *Belemnitella mucronata* Schloth., *Belemnella langei langei* Jet. (identifications of Nazarishvili T.J). In the limestones *Globotruncana ventricosa* White., *Globotruncanita stuartiformis* (Dalb.), *Archaeoglobigerina cretacea* (Orb.), *Heterohelix striata* (Ehrenberg) were found. *Globotruncana arca* (Cushman), *G. linneiana* (Orb.), *Rosita fornicata* (Plum.), *Heterohelix reussi* (Cushman) continue to exist.

Mokvi suite is build by grey and light grey pelitomorphic, thick-layered limestones with admixture of black flint. This suite is characterized by the presence of *Pachydiscus cf. colligatus* (Binkh.) and in the upper part of the section remains of *Gryphaea vesicularis similes* Push are rarely found. Numerous fragments of double-keel planktonic foraminifera are also present in this suite. Observable thickness of the suite is 20 m.

Thus, 5 foraminiferal complexes have been established in the studied section:
I. Complex *Marginotruncana pseudolinneiana* and *Marginotruncana schneegansi* are found together with mollusks of the *Inoceramus lamarcki* zone and corresponds to the nannoplankton zone of *Tetralithus pyramidus*. The complex is dated as early Turonian.
II. Complex *Marginotruncana coronata* corresponds to a mollusks zone of *Inoceramus sturmi* and nannoplankton zone of *Marthasterites furcatus*. The age is determined as early Coniacian.
III. Complex *Marginotruncana sigali* and *Marginotruncana renzi* (Mtavari Suite). Stratigraphically the given complex corresponds to the *Inoceramus involutus* zone. It is dated as Upper Coniacian.
IV. Complex *Globotrunca arca* is characterized by the abundance of index-species and it corresponds to the layer with *Micraster schroederi* and the nannoplanlankton zone of *Tetralithus aculeus*. It is dated as early Campanian.
V. Complex *Globotruncana ventricosa* corresponds to the layers with *Belemnitella mucronata* and corresponds to a zone of *Tetralithus aculeus* and a part of *Tetralithus trifidus* by nannoplankton. The age is determined as Middle Campanian.

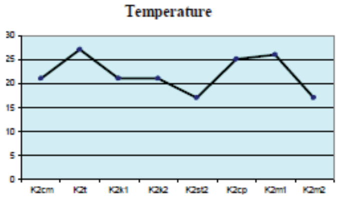
5. Some data on the Late Cretaceous paleogeography

It is noteworthy that the Cretaceous epoch in the Gagra-Java zone was the period of flourishing of planktonic foraminifers, where Globotruncanides dominated. This geological time was characterized by high rates of evolution, maximal taxonomic diversity and wide geographic rage. At that time different morphological types of shells have been developed, became adapted to live not only to areas remote from the coast but also at different depths in marine basins. At present a definite methodology for the reconstruction of some basin parameters, based on quantitative interrelations within the foraminifera associations. This method is based on actualistic data from contemporary water areas. Data on recent PF (Planktonic Foraminifera) can be applied for interpretation of the obtained information concerning the fossil material for the paleogeographic reconstructions, in order to specifying paleodepths. The appropriate quantitative calculations allow the building up of diagrams with curves establishing the changes of the P/B (Planktonic/Benthic) relation, and also the definition of the "shallow", "transitive" and “deep-water" paleoenvironments (Caron., Homewood, 1983). The produced curves allow the reconstruction of transgressive-regressive cycles to be solved in the process of paleobasin development. The main factors that have influence on foraminifer distributions in water column are depth, temperature and salinity of the marine basin. Reconstruction of living conditions of Late Cretaceous planktonic foraminifera is based, first of all on the knowledge of the ecology of foraminifera in recent marine basins. On the basis of qualitative and quantitative analyses of the planktonic and benthic foraminiferal sequences the paleogeographic reconstructions were done.

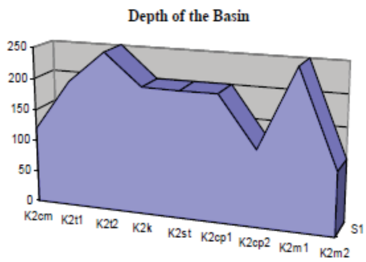
The observations on distribution of planktonic (PF) and benthic foraminifer (BF) shells in modern oceanic silts has shown the following regularity: in areas remote from the coastal line, the PF shells make 99 % of the samples and only 1 % falls on BF. Close to the coastal line this parity gradually decreases and already in sublittoral zone, at a depth below the 50m, BF reaches 99 %, and PF 1 % (Krasheninikov, 1960). This pattern of distribution of BF and PF (B/P relation) enables to define depths of sediment-formation. The open-sea relations of ecological types of foraminifera shows obvious prevalence of PF (70-99 %). The unstable percentage in PF and BF species quantity is characteristic of open-sea shallow sediments of the mid shelf. Here calcareous-secreted benthos (P/B – 7/86 %, rarely 15/82 %) usually prevail. The lagoon-sea coastal sediments of the shelf characterized with the predominance (up to 100 %) of BF, are here missing, or sporadically distributed (PF less than 10 %) (in table 3 is given some data on the Late Cretaceous paleogeography of the Gagra-Java zone).

Table 3. Some data on the Late Cretaceous Paleogeography of the Gagra-Java Zone.

K_2m_2	17
K_2m_1	26
K_2cp	25
K_2st	17
K_2k_2	21
K_2k_1	21
K_2t	27
K_2cm	21



K_2m_2	100
K_2m_1	250
K_2cp	120
K_2cp_1	200
K_2st	200
K_2k_2	200
K_2k_1	250
K_2t	200
K_2cm	120



There are three associations of recent PF depending on depth of their habitation during the life cycle:

1) The "shallow-water" forms living in the euphotic zone at a depth down to 50м fine spiny species with thin-walled shells belong to them.
2) "Transitive" forms living at depths from 50m down to 100 m. They are represented by coarser species with spiny and smooth shell walls, sometimes with outlined keel belts.
3) The "deep-water" forms - for them optimum depths exceeds 100м. They are represented by genera with thick, intensely sculptured shells having ribs, keels and spines.

Thereby, with the increase of the basin depth the replacement of one morphotype by others in the following order takes place: spherical morphotype, flattened, keel-like, planoconvex. The "shallow-water" morphotypes are represented by the following genera: *Heterohelix, Hedbergella, Globigerinelloides, Whiteinella*, to the "transitive" – fine ones, and to the "deep-water" forms – all with sculptured shells (Rotalipora, Marginotruncana, Contusotruncana, Dicarinella, Globotruncana, etc*)*.

It is supposed, that the existing climatic fluctuations have been expressed in the changes of coiling mode of some PF species, and right-coiling shells of *Globotruncanida* are spread under comparatively high-temperature conditions. This assumption is based on data from the recent environment, as the study of the species *Globorotalia truncatuloides, Globigerina pachyderma, Globotruncana bulloides* in the Atlantic Ocean - revealed, that high percentage of the left-coiling forms is connected with more water masses of low temperature (Meuter F. and Laga P., 1970). High percentage of right-coiling shells (90-95 %) *Globorotalia* specifies a tropical climate, and correspondingly, the high percent of left-coiling ones (75-97 %) are typical for subtropical climate (Boltovskoy and Boltovskoy,1970; Boltovskoy, 1973; Kopaevich, 1978). The PF assemblages are divided into three climatic groups: warm-temperate, subtropical and tropical.

At the beginning of the Cenomanian PF complexes are represented by the following genera: *Rotalipora (40%), Hedbergella (40%), Globigerinelloides (10%), heterohelix (5%)*. The total PF makes 95 %. The amount of left-coiling shells reaches 20-30 %. The number of deep-water taxons does not exceed 40 %. The obtained data specifies that during this period the depth of the basin reaches 100-120m. Near-surface water temperature of the Cenomanian basin was estimated to be from 17^0C up to 21^0C (Gambashidze. and Iasamanov, 1980; Gambashidze, 1981).

At the end of Cenomanian the foraminifer complexes were uniform and were represented mainly by planktonic genera (96%): *Hedbergella, Globigerinelloides*. Benthonic orictocenosis assemblages make only 4 % of the total amount of foraminifera. The Quantity of left-coiling shells in this period has not changed (20-30 %). In the middle of the Cenomanian a shoaling of the basin took place evidenced by the impoverishment of foraminiferal complexes. Water temperature did not exceed 21^0C, and in some places it declined to $15\text{-}17^0$C (Gambashidze and Iasamanov, 1980; Gambashidze, 1981).

At the beginning of Early Turonian the following genera participated in the planktonic assemblages orictocenosis (PF-95%): *Whiteinella (40%), Hedbergella (30%), Dicarinella (10%), Praeglobotruncana (5%), Globigerinelloides (5%), Heterohelix (5%)*. P/B ratio – 95/5%. Percentage of left-coiling forms does not exceed 10%. Number of deep-water taxons was not less than 35-40 %.

The upper part of Early Turonian is represented by the benthos-planktonic ratio (P/B-55/45%). The planktonnic complex comprises: *Dicarinella (20%), Whiteinella (15%), Praeglobotruncana (5%), Hedbergella (10%), Globigerinelloides (3%), Heterohelix (2%).* The amount of left-coiling forms does not exceed 5-10%. Thus, in the Turonian depth of the basin exceeded 200m, and the percentage (5-10%) of left-coiling forms specifies gradual increase of basin temperatures (20-22^{0}C) (Gambashidze and Iasamanov, 1980; Gambashidze, 1981).

The Late Turonian is represented by planktonic orictocenosis (P/B-80/20%). The planktonic complex contains: *Marginotruncana (40%), Dicarinella (20%), Whiteinella (10%), Hedbergella (5%), Heterohelix (5-15%)*. The left-coiling species does not exceed 10 %. All data attest to the widening (200-250м.) and deepening of the basin down to 80 m. The intensive process of volcanic activity begins from this period. The reduction of left-coiling shells in the Late Turonian (up to 5 %) specifies high temperature (from 22^{0}C up to 25-27^{0}C), that is connected with the ingress of warm waters from the Mediterranean, and activation of submarine volcanism.

In the Early Coniacian P/B ratio corresponds to 85/15%. The planktonic complex is represented by the following genera: *Marginotruncana (50%), Dicarinella (20%), Whiteinella (5%), Hedbergella (5%), Heterohelix (5%).* Number of left-coiling shells does not exceed 20 %. In the second half of the Coniacian the P/B ratio decreases from 75/25% down to 70/30%. And the number of left-coiling shells does not exceed 5 %. All data establish that the depth of the basin is invariable, and water temperature declines to 21^{0}C .

At the beginning of the Santonian the PF complex practically has not changed, but at the end of this period new genera have appeared: *Contusotrunacana (10%), Globotruncana (2%), Marginotruncana (45%), Dicarinella (13%), Heterohelix (5%), Globigerinelloides (5%), Globotruncana (2%).* Benthonic foraminifera make about 60 %, and the left-coiling forms reach 30-40 %. The received data specify that at this time there was an expansion of the basin indicated by the presence of the Middle European forms, and temperature of water has declined to 15-17^{0}C. In some places it reached 20^{0}C, and the depth of the basin constituted between 150-200м.

The Early Campanian planktonic assemblages (P/B - 80/20 %) is represented by *Globotruncana (45%), Contusotruncana (15%), Globotruncanita (10%), Heterohelix (1%), Globigerinelloides (6%).* The Middle Campanian planktonic-benthic orictocenosis (P/B-50/50 of %) consists of *Globotruncana (25%), Contusotruncana (10%), Globotruncanita (5%), Archaeoglobigerina (2%), Globigerinelloides (3%), Hedbergella (5%).* Amount of left-coiling forms decreased to 5 %. The Late Campanian benthos orictocenosis (P/B-40/60 %) is represented by *Globotruncana (15%), Globotruncanita (5%), Contusotruncana (10%), Archaeoglobigerina (5%), Globigerinelloides (5%), Heterohelix (5%).*Foraminifera assemblages make it possible to assume that in the Campanian there was a shallow sea with a depth of 150-200m. At the end of the Campanian depth of the basin did not exceed 100-120 m. The increase of left-coiling forms at the end of the Campanian up to 10 %, is indicative of the higher temperature conditions (20-20,5^{0}C) than it was in the beginning of the Late Campanian.

At the beginning of the Maastrichtian the Benthonic-Planktonic orictocenosis (P/B-75/25%) is represented by *Globotruncana (60%), Globotruncanita (10%), Heterohelix (5%)).*The role of keelless taxsons has increased: *Rugoglobigerina (10%), Abathomphalus (10%), Archaeoglobigerina (5%).* The Left-coiling forms make 10 %. All data attest to the existence of extensive epicontinental basin in the beginning of the period. The Late Maastrichtian planktonic-benthic (P/B-50/50%) orictocenosis is represented by *Globotruncana (35%), Abathomphalus (5%), Globotruncanita (10%), Rugoglobigerina (15%), Archaeoglobigerina (5%), Heterohelix (5%).* At the very end of the Maastrichtian a benthonic orictocenosis (B/P-70/30%) had developed; here these forms are represented by the following benthic genera- *Stensioina, Eponides, Gyroidinoides, Anomalina, Parella, Bolivinoides,* and the planktonic foraminifers are presented by *Globotruncana (15%), Globotruncanita (5%), Contusotruncana (10%), Archaeoglobigerina (5%), Globigerinelloides (5%), Heterohelix (5%).* The left-coiling forms reach 5 %. The bathymetric parameters in the beginning of the Maastrichtian Age had higher values, than at the end of the Campanian (P/B-70/30 %), and the increasing role of deep-water taxsons points to the deepening of the basin, than it was at the end of the

Early Maastrichtian. However from the second half of the Early Maastrichtian the gradual shoaling of the basin has been outlined, evidenced by the prevalence of benthonic orictocenosis (P/B-30/70 %) throughout the whole territory. At this point water temperature varied from 17,5^{0}C to 26^{0}C.

Thus, with the help of the carried out analyses it is possible to evaluate a warm tropical climate, during the Upper Cretaceous period in the Gagra-Java zone, where temperature of water varied from 15^{0}C to 27^{0}C, and depth of the basin - from 80m to 250м (in table 3 is given some data on the Late Cretaceous paleogeography of the Gagra-Java zone).

6. Conclusions

Detailed study of the two facies zones in the Gagra-Java zone by foraminifers and their correlation with macro- and nannoplankton zones gave possibility of allocating the zonal foraminifera complexes and also to specify their age.

- The lower boundary of the Upper Turonian is connected with the massive occurrence of the genera *Marginotruncana,* among them deserves attention *pseudolinneiana-schneegansi-lapparenti*;
- The boundary between the Turonian and Coniacian is defined by the occurrence of *Marginotruncana coronata* Bolli;
- The boundary between the Coniacian and Santonian passes at the occurrence of *Dicarinella concavata* (Brotzen);
- The lower boundary of the Upper Santonian is drawn at the occurrence of *Contusotruncana (Rosita) fornicate* (Plummer);
- The boundary between the Santonian and the Campanian is connected with the first occurrence of *Globotruncana arca* (Cushman);
- The boundary between the Campanian and Maastrichtian is defined by the occurrence of *Globotruncanita stuarti* (Lapparent).

Studying the assemblage composition and species abundances and range enabled the paleogeographic reconstruction of the parameters of the paleogeographic environments of the study region. All the obtained data are innovative for the Gagra-Java zone.

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