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INSIGHTS ON THE AGE AND PALEOENVIRONMENTS OF THE LATEST MAASTRICHTIAN - DANIAN STRATA AROUND OKIGWE - UMUASUA AXIS, ANAMBRA BASIN, SOUTHEASTERN NIGERIA

A set of twelve (12) outcrop samples of Late Cretaceous and Earliest Paleogene from Ihube, Okigwe-Arondizuogu, and Umuasua road sections in the Anambra Basin were palynologically examined to re-evaluate their age and reconstruct their paleoenvironments of deposition. Palynological analysis was carried out, using the standard conventional method of acid maceration for recovering the acid-insoluble organic-walled microfossils from sediments. Four (4) main lithological units were encountered which include, carbonaceous shale, sandstones, mudstones, and siltstones. Result from the palynological examination shows high dominance of terrigenous microflora (spores and pollen), especially the mangrove pollen over marine microplanktons in the samples from Ihube and Okigwe/Arondizuogu sections, whereas samples from the Umuasua section yielded more marine species, mostly the dinoflagellates with proximate cyst affinity, than the terrigenous forms. Age control was achieved based on the selected key stratigraphic index palynomorph assemblages recovered. A ***Latest Maastrichtian age*** *was assigned to the samples from Ihube and Okigwe-Arondizogu sections, with the following index species: Longapertites marginatus, Proxapertites operculatus, Proxapertites cursus, Retidiporites magdalenensis, Cingulatisporites ornatus, Proteacidites dehaani, Spinizonocolpites baculatus / echinatus, Mauritidites crassibaculatus, Distaverrusporites simplex, Foveotriletes margaritae, Constructipollenites ineffectus, and Longapertites microfoveolatus. This assemblage has been attributed to the palmae and belongs to the tropical – subtropical Senonian Palmae Province of South America and African region. Samples from the Umuasua section signal* ***Early Danian*** *based on Cordosphaeridium varians, Damassadinium californicum, Fibrocysta licia, Carpatella cornuta, Eisenackia circumtabulata, Carpatella septata, Senoniasphaera inornata, Tectatodinium rugulatum, Kenleyia leptocerata, and Palynodinium grallator. A mangrove swamp / or near shore brackish water environment of deposition was proposed based on the important environmentally significant miospore taxa such as those belonging to the palmae. Marine microplanktons such as the peridinioid (proximate cyst) dinocyst which occurred in high abundance over the gonyaulacacean (chorate cyst) species also demonstrated strong evidence of nearshore brackish water depositional condition, with reduced salinity fluctuation. The paleogeographic conditions suggested by the miospores association indicated a warm and humid climate in the region.*

***Keywords**: Anambra Basin, Dinoflagellates, Paleoenvironment, Sporomorph, Palmae.*

Chukwuemeka F. Odumodu

Department of Geology, Chukwuemeka Odumegwu Ojukwu University,
Anambra State
E-mail: raluchukwu@yahoo.com

Okechukwu N. Ikegwuonu

Department of Geology, Chukwuemeka Odumegwu Ojukwu University,
Anambra State
E-mail: okeynick2010@yahoo.com

Ayonma W. Mode

Department of Geology,
University of Nigeria, Nsukka
E-mail: wilfred.mode@unn.edu.ng

Introduction

The Nsukka Formation marks the topmost lithological unit of the Anambra Basin (Whiteman, 1982; Umeji and Nwajide, 2007). This formation was previously referred to as the Upper Coal Measures (Tattam, 1944; Du Preez, 1947; Simpson, 1955). Reyment (1965) however later formalized the name as Nsukka Formation. The type locality of the formation was designated north of Nsukka in an area along Nadu River by Reyment (1965) without any formal description of the type section.

Several studies have been carried out on the Nsukka Formation. However, most of these previous researches are mainly on the stratigraphy, sedimentology, ichnology and foraminiferal biostratigraphy Mbuk *et al.* (1985), Nwajide and Reijers (1996), Mode (2004), Mode and Odumodu (2014), Nwajide and Reijers (1996) reported that the depositional environment of Nsukka Formation was mainly a fluvial setting with marine incursions that mixed in shoreface sedimentation. Mode (2004) integrated lithofacies with microfaunal data and concluded that the formation was deposited from foreshore to shoreface and inner shelf environments. Mode and Odumodu (2014) using lithofacies and ichnological association distinguished and interpreted five lithofacies association for the Nsukka Formation ranging from lagoon/bay to foreshore, shoreface and proximal offshore.

Not much study has been undertaken in the aspect of palynology within the study region especially around the Umuasua area. The few palynological studies on the Nsukka Formation were concentrated mostly on the lower and middle parts of the formation exposed around Unadu, Ihube, Okigwe and Umulolo road cuts along the Enugu-Port Harcourt expressway (Reyment, 1965; Oboh-Ikhuenobe *et al.*, 2005; Umeji and Nwajide, 2007; Umeji and Edet, 2008; Chiaghanam *et al.*, 2012). However, little or no work has been done on the topmost unit of the formation exposed around the Umuasua town which has been considered and critically examined in this present study. Oboh-Ikhuenobe *et al.* (2005) and Umeji and Nwajide (2007) examined the lithofacies and palynofacies and suggested that the sediments were deposited in paralic and marine settings. Umeji and Edet (2008) examined the palynostratigraphy and paleoenvironments of the Nsukka Formation and concluded a paleoenvironments of deposition oscillating from north to south, between the lower and upper deltaic plains, varying from tidal flat, lagoon, tidal bar, raised bog and reed swamp in the north to nearshore open marine conditions in the south, while Chiaghanam *et al.* 2012 assigned a mangrove swamp/ or nearshore brackish water depositional setting to the formation. These previous researches are mainly preliminary but gave some insights into the age and paleoenvironments. More studies are therefore needed to concisely interpret them.

The present study aims at presenting a detailed reconstruction of the age and paleoenvironments of the Late Maastrichtian to Danian strata of the Nsukka Formation around Okigwe and Umuasua areas, using the organic-walled microfossils rich samples. Also, the issue of the presence of outcropping Danian deposit in the southeastern part of Nigeria and the demarcation/placement of the Cretaceous/Paleogene (K/Pg) boundary between the latest Maastrichtian bed and the earliest Danian deposits, and thus ending the old tradition of including the Danian in the Cretaceous, have been addressed using organic-walled microfossils.

Geological Setting and Stratigraphy

The study area lies within the southern part of the Anambra Basin towards the basin boundary with the overlying Niger Delta basin (Figure 1). The Anambra Basin represents a synclinal structure consisting of over 5,000 m thick sequence of Upper Cretaceous sediments. The basin evolved consequent to the Santonian folding and uplift of the Abakaliki region resulting to the dislocation of the downwarped Anambra Platform and Afikpo syncline (Murat, 1972;

Burke *et al.,* 1972; Kogbe, 1989). The stratigraphic sequence in the Anambra Basin starts with the Campanian to Maastrichtian Nkporo Group, which is successively overlain by the Lower Maastrichtian Mamu Formation and Middle Maastrichtian Ajali Formation. The Ajali Formation is also successively overlain by the Late Maastrichtian and Early Danian Nsukka Formation and the Imo Formation respectively (Figure 2, Table 1). Detailed stratigraphic descriptions of the Anambra Basin are available in many publications (Petters, 1978; Agagu *et al.*, 1985; Nwajide and Reijers, 1996). The Nsukka Formation consists of an alternating sequence of sandstones, dark shale and sandy shale with thin coal seams at several horizons (Simpson, 1954; Reyment, 1965).

Descriptions of Stratigraphic Sections

Three roadcut sections of the Late Maastrichtian to Danian Nsukka Formation outcropping at at Km 76 along Enugu-Port Harcourt highway (L1) and at 900 m from Okigwe junction along Okigwe – Nnewi road (L2) and at Umuasua roadcut, southeastwards of Okigwe, around Umuasua village (L3) were studied (Figure 2). The lithologs of the three sections are shown in Figures 3, 4 and 5 respectively. The section along Enugu – Port Harcourt road is about 33m thick and consists of shale, mudstone, siltstone and sandstone beds. The shales are mostly dark grey to black in colour and sometimes contain some ironstone concretionary horizons. The shale is rich in trace fossils such as *Planolites*, *Teichichnus* and *Thalassinoides*. In the basal parts, the shales are interbedded with siltstone, sandstone, and mudstone. The shales are fissile and richly fossiliferous. The sandstones are very fine to fine grained at the lower parts but become medium to coarse grained upwards. Prominent sedimentary structures in the sandstones include wave ripple lamination, ripple cross lamination, trough cross bedding, parallel lamination / bedding and bioturbation. Common biogenic structures in the sandstones include *Paleophycus*, *Thalassinoides*, *Skolithos* and *Ophiomorpha* burrows. An interbedding of rippled fossiliferous, limy calcareous sandstone with shale occurs in the upper part of the section. The section studied at Umulolo which is about 1.0 Km along Okigwe – Nnewi road is about 11.5 m thick. The lithology consists of fine to coarse grained sandstones, black shale, gray siltstone / shale heterolith and clayey sandstone above. Sedimentary structures present here include planar crossbedding, flaser bedding, parallel lamination and bioturbation.

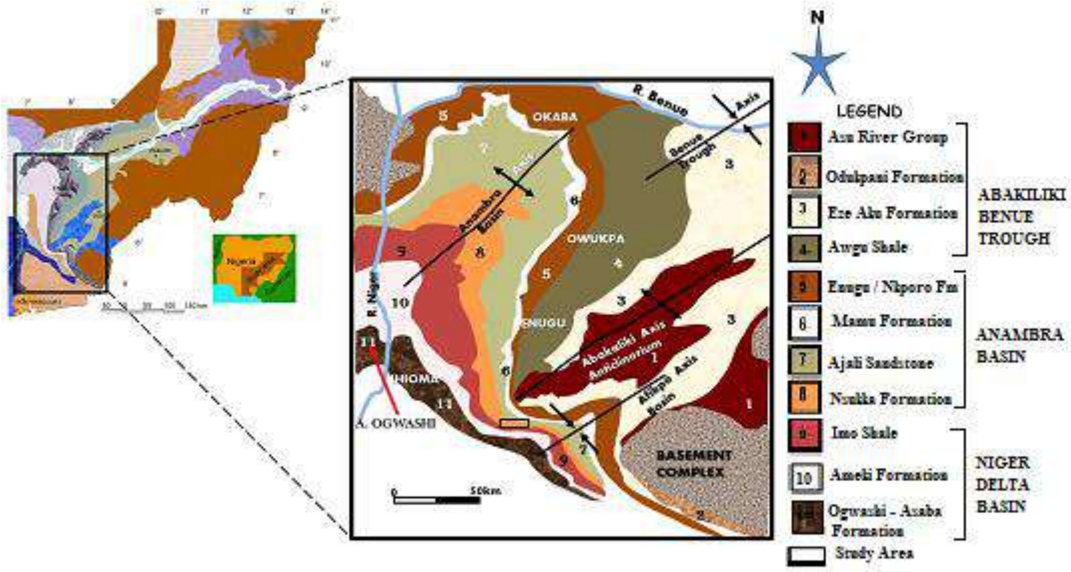
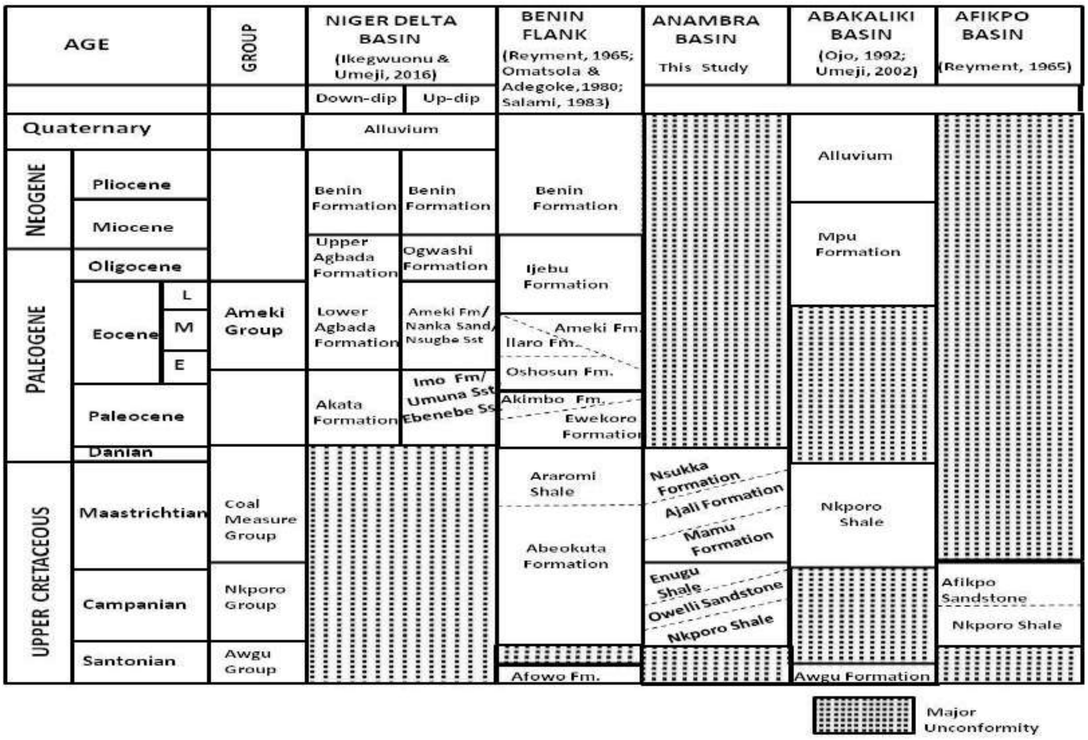


Figure 1. Geological map of southeastern Nigeria showing the study area (modified after Akande, 2007)

Table 1

Stratigraphic synopsis of southern Nigerian sedimentary basins according to various authors



AGE			GROUP	NIGER DELTA BASIN (Ikegwuonu & Umeji, 2016)		BENIN FLANK (Reyment, 1965; Omatsola & Adegoke,1980; Salami, 1983)	ANAMBRA BASIN This Study	ABAKALIKI BASIN (Ojo, 1992; Umeji, 2002)	AFIKPO BASIN (Reyment, 1965)
				Down-dip	Up-dip				
Quaternary				Alluvium		Benin Formation	▨	Alluvium	▨
NEOGENE	Pliocene			Benin Formation	Benin Formation		▨		▨
	Miocene						▨	Mpu Formation	▨
PALEOGENE	Oligocene			Upper Agbada Formation	Ogwashi Formation	Ijebu Formation	▨		▨
	Eocene	L	Ameki Group	Lower Agbada Formation	Ameki Fm/ Nanka Sand/ Nsugbe Sst		▨	▨	▨
		M				Ameki Fm. Ilaro Fm.	▨	▨	▨
		E				Oshosun Fm.	▨	▨	▨
	Paleocene			Akata Formation	Imo Fm/ Umuna Sst/ Ebenebe Ss	Akimbo Fm. Ewekoro Formation	▨	▨	▨
	Danian						▨	▨	▨
UPPER CRETACEOUS	Maastrichtian		Coal Measure Group	▨	▨	Araromi Shale Abeokuta Formation	Nsukka Formation Ajali Formation Mamu Formation	Nkporo Shale	▨
	Campanian		Nkporo Group	▨	▨		Enugu Shale Owelli Sandstone Nkporo Shale	▨	Afikpo Sandstone Nkporo Shale
	Santonian		Awgu Group	▨	▨	▨ Afowo Fm.	▨	▨ Awgu Formation	▨

▨ Major Unconformity

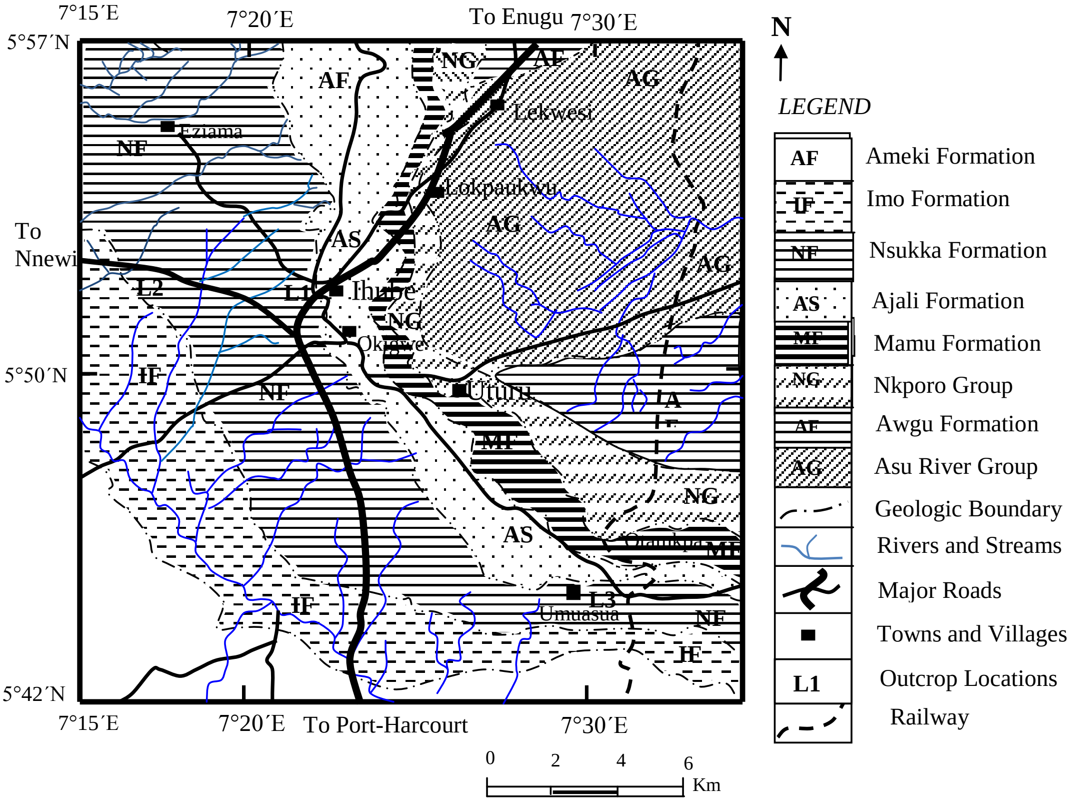


Figure 2. Geologic map of the study area and environs

The biogenic structures present in the shale include *Teichichnus* burrow. The beds dip at 9° in the Northwest direction. The section at Umuasua is about 32 m in thickness. It consists of conglomeritic sandstones, highly fissile shales and fine to coarse grained sandstones. The conglomeritic sandstone is highly fossiliferous, containing ammonites, bivalves and some gastropods. The shales also contain ironstone bands, nodules and concretions. Sedimentary structures observe in the section include wave ripple lamination and planar cross-beddings.

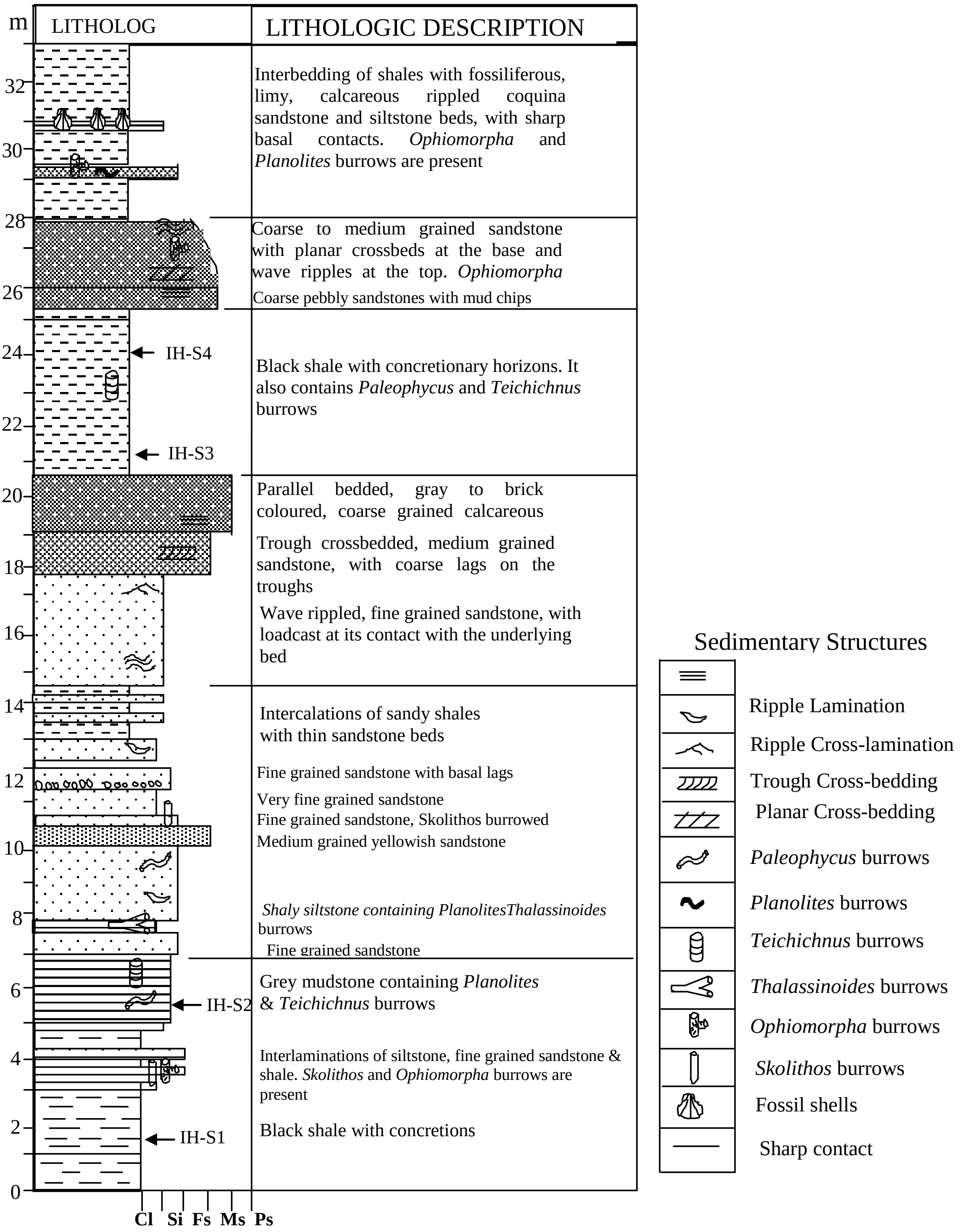


Figure 3. Lithologic Log of Nsukka Formation at Ihube along Enugu – Port-Harcourt Expressway

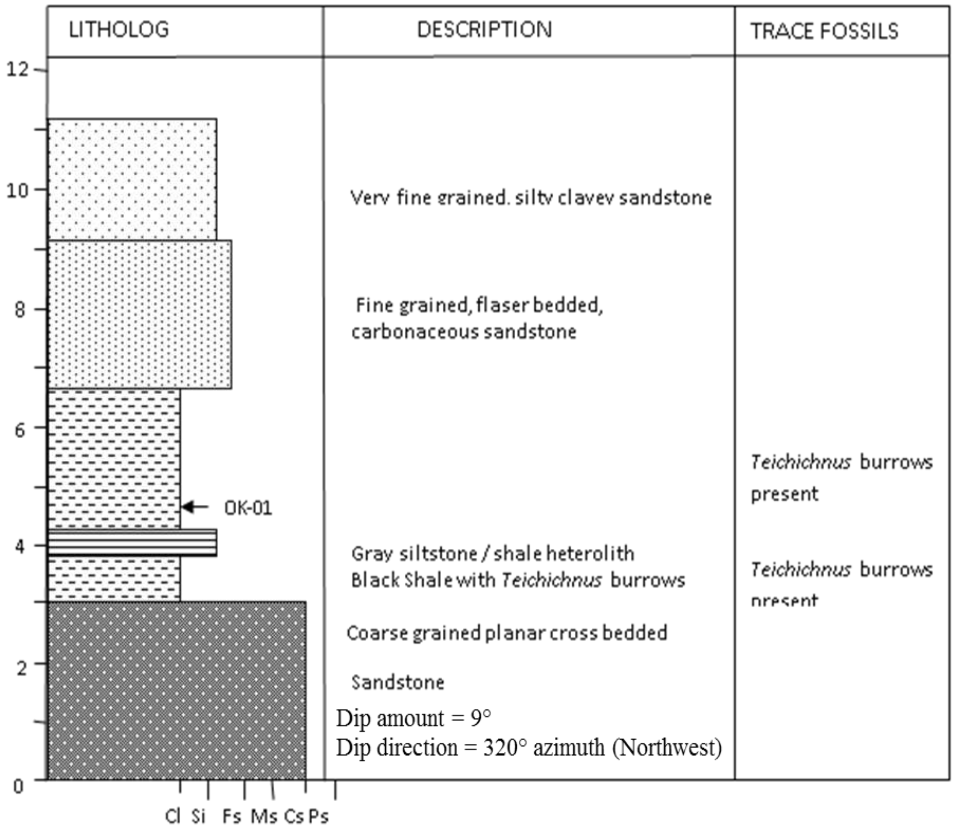


Figure 4. Litholog of Nsukka Formation at Umulolo along Okigwe – Arondizuogu Road

Method

The study area is located within the area bounded by Latitudes 5°42'N - 5°55'N and Longitudes 7°20'E - 7°30'E (Figure 2), lying within the southern part of the Anambra Basin towards the basin boundary with the Niger Delta basin of Nigeria (Figure 1). Twelve (12) samples were collected for this work (4 from Ihube section, 1 from Okigwe/Arondiziogu section, and 7 from the Umuasua section). Samples collected from these outcrop locations were processed and analysed for their palynomorphs content. Sample positions are shown in the simplified lithostratigraphy sections (Figures 3,4 & 5).

The sample preparation was carried out using the conventional method of acid maceration technique for recovering acid-insoluble organic-walled microfossils from sediments. Each sample was thoroughly cleaned to remove field contaminants. 10 g of each sample was weighted out in a standard weighing balance and gently crushed with agate mortal and piston. The crushed sample was digested for 30 minutes in 40 % conc. hydrochloric acid for removal of carbonate and 72 hours in 48 % conc. hydrofluoric acid to remove silicates. The digested sample was diluted with distil water and sieve-washed through 10 microns nylon mesh. The sieve-washed 10 g residues equivalent was partitioned into two parts, 5 g each, for oxidation and for kerogen assessment. The 5 g residue extracts were oxidized for 30 minutes in 70 % conc. HNO_3 and 5 minutes in Schulze solution to render the fossils translucent for transmitted light microscopy. The acid-free oxidized residues were rinsed in 2 % conc. KOH solution to neutralize the acid; swirled to remove the resistant coarse mineral particles and undigested organic matter. The swirled residues were collected on the sieve and stained with Safranin – O to increase the depth of contrast for microscopic examination and photography.

The stained residues (aliquots) were dispersed with polyvinyl alcohol, dried on cover-slips and mounted in petro-poxy resin. Five (5) slide was made from each sample and logged under the transmitted light microscopy. Light photomicrographs were taken with leica lll binocular microscope.

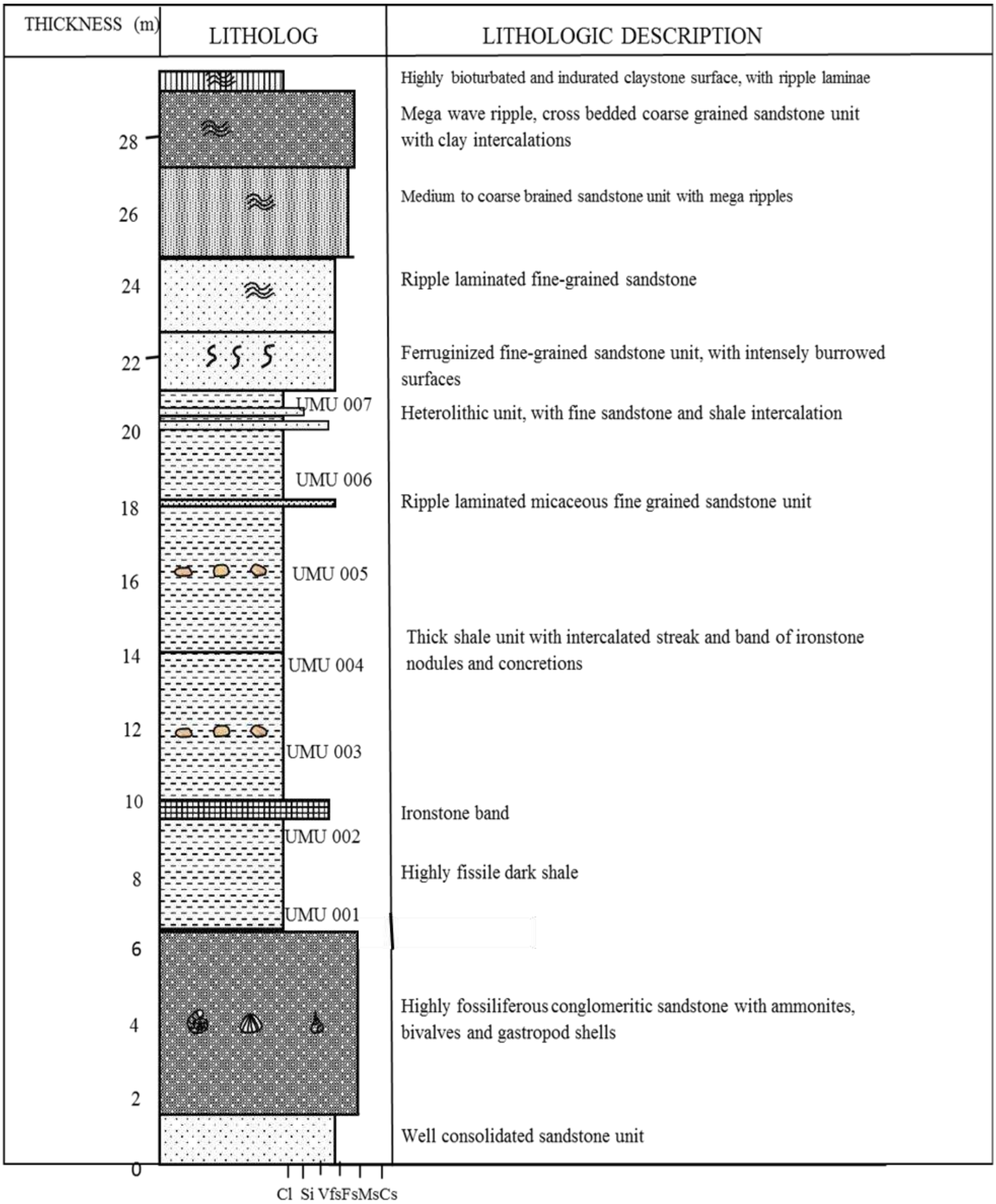


Figure 5. Lithologic section of Nsukka Formation along Umuasua Road cut in Isikwuato Village

Result

Figure 6 shows the occurrence and distributions of palymomorph species recovered from the examined samples from the Ihube, Okigwe/Arondizogu, and Umuasua sections.

Ihube Section (IH-S1 to IH-S7):

The Palynomorphs recovered in this sample include both terrestrial and marine species.

Terrestrial species: Among the sporomorph group were spores, pollen, and fungal spores. The spores encountered include *Polypodiaceiosporites reticulatus, Leiotriletes adriennis, Laevigatosporites ovatus, L. discordatus, Cyathidites minor, Azolla cretacea, Cycadopites ovatus, Schizophacus reticulatus Constructipollenites ineffectus,* and *Distaverrusporites simplex*. The pollen includes *Longapertites marginatus* (overwhelming abundance) and *Spinizonocolpites baculatus.* Other species present are *Mauritiidites crassibaculatus, Liliacidites nigeriensis, Echitriporites trianguliformis, Longapertites microfoveolatus, Proteacidites dehaani, Auriculidites reticulatus, Monoporites annulatus,* and *Proxapertites operculatus* (Figure 6 and Figure 7).

Marine species: The group of marine species includes dinoflagellate cysts, achritarchs, and foraminifera inner test lining. The dinoflagellate cysts species encountered included both gonyaulacacean and peridinecean species. They are *Dinogymnium acuminatum, Spiniferites sp., Cordosphaeridium inordes, Senegalinium sp., Operculodinium centrocarpum, Cyclonephelium deckoninckii, Lejeunecysta hyalina, Andalusiella manthei,* and *Ceratiopsis lepthoderma* (Figure 6 and Figure 7). Acritarch and forams test lining were not encountered.

Okigwe - Arondiziogu Section (OK-01)

This sample is rich in both terrigenous and marine species. The terrigenous species recorded include *Leiotriletes adriennis, laevigatosporites ovatus, Schizosphacus sp., Gleichiniidites senonicus, Matonisporis equiexinus, Cyathidites minor, Cycadopites ovatus, Distaverrusporites simplex,* and *Constructipollenites ineffectus*. Among the pollen species were *Monocolporopollenites sphaeroidalis, Longapertites marginatus* (high abundance), *Spinizonocolpites baculatus, Echitriporites trianguliformis, Proxapertites operculatus* (rare), *Psilatricolporites operculatus, Monoporites annulatus, Longapertites vaneedenburgi, Psilatriporites rotundus, Retidiporites magdalenensis, Proteacidites dehaani, Buttinia andreevi,* and *Psilatricolporites crassus.*

Marine species: The dinoflagellate cysts include *Spiniferites hyparacanthus, Achomosphaera sagena, Selenopemphix nephroides, Cordosphaeridium sp., Diphyes colligerum, Operculodinium centrocarpum, Dinogymnium acuminatum, Areoligera senoniensis, Ceratiopsis diebelii, Cleistosphaeridium diverspinosum,* and *Senegalinium sp.* (Figure 6 and Figure 7).

Umuasua Road Section:

The palynomorphs assemblage recorded in these samples includes both marine and terrestrial species. The dinoflagellate cysts especially those with chorate and proximate cysts affinity were recorded in high abundance over the terrigenous species.

UMU-001

This sample is overwhelmed by marine dinoflagellate cyst species, with minor occurrence of continental sporomorph (pollen and spores). Among the dinoflagellate cysts association recovered are *Damassadinium californicum, Fibrocysta spp., Fibrocysta licia, Carpatella cornuta, Eisenackia circumtabulata, Carpatella septata, Senoniasphaera inornata, Palynodinium grallator, Kenleyia leptocerata,* and *Tectatodinium rugulatum* (Figure 6)

The continentally derived sporomorphs were also recorded but in minor amount. They include *Laevigatosporites ovatus, Schizosporis sp., Cyathidites minor, Longapertites marginatus, Mauritiidites crassibaculatus, Liliacidites nigeriensis, Monoporites annulatus,* and *Retidiporites magdalenensis.*

UMU-002 to UMU-003

These samples have the lowest abundance and diversity of both terrigenous and marine species. The few terrestrial species represented in these samples include *Leiotriletes adriennis*, *Cyathidites minor*, *Spinizonocolpites baculatus*, *Liliacidites nigeriensis*, and *Monoporites annulatus*. The marine species include dinoflagellate cysts *Areoligera senoniensis*, *Cyclonephelium deckoninckii*, and *Eisenakia circutabulata*.

Umu-004 to Umu-007

This samples are mostly dominated by marine species with minor occurrence of terrigenous forms. The most abundant is *Cordosphaeridium varians* followed by *Glaphyrocysta ordinata* and *Areoligera senoniensis*. Other species present are *Cyclonephelium deckoninckii*, *Fibrocysta licia*, *Cordosphaeridium inordes*, *Systematophora areolata*, and *Deflandrea sp.*

The terrigenous species were sparsely represented. They include *Laevigatosporites ovatus*, *Cyathidites minor*, *Longapertites marginatus*, *Mauritiidites crassibaculatus*, *Monoporites annulatus*, and *Retidiporites magdalenensis.*

IH-SI	IH-S2	IH-S3	IH-S4	OK-01	UMU-001	UMU-002	UMU-003	UMU-004	UMU-005	UMU-006	UMU-007	SAMPLE NO PALYNOMORPHS
1	2	3	4	5	6	7	8	9	10	11	12	13
												SPORES
2	0	0	1	0	0	0	0	0	0	0	0	*Polypodiaceiosporites reticulatus*
8	3	4	2	15	0	2	3	0	0	0	2	*Leiotriletes adriennis*
19	11	9	5	30	2	0	1	3	4	2	0	*Laevigatosporites ovatus*
1	3	0	4	3	0	0	0	0	0	0	0	*Laevigatosporites discordatus*
2	3	0	2	10	0	0	0	0	0	0	0	*Schizosporis spp.*
0	1	0	0	2	0	0	0	0	0	0	0	*Gleichiniidites senonicus*
0	2	3	0	5	0	0	0	0	0	0	0	*Matonisporis equiexinus*
1	3	2	4	2	1	5	2	4	0	3	2	*Cyathidites minor*
0	1	0	0	2	1	0	0	0	0	0	0	*Constructipollenites ineffectus*
2	0	2	4	1	0	0	0	0	0	0	0	*Azolla cretacea*
1	2	0	1	0	0	0	0	0	0	0	0	*Schizophacus spp.*
4	2	1	3	1	0	0	0	0	0	0	0	*Distaverrusporites simplex*
3	1	3	3	2	0	0	0	0	0	0	0	*Cingulatisporites ornatus*
												POLLEN
10	16	9	12	31	3	1	0	2	0	1	0	*Longapertites marginatus*
2	1	2	4	8	3	0	1	0	2	2	0	*Mauritiidites crassibaculatus*
4	0	2	0	1	1	2	2	0	1	0	0	*Liliacidites nigeriensis*
4	6	2	3	5	0	0	0	0	0	0	0	*Echitriporites trianguliformis*
4	2	3	4	5	0	0	0	0	0	1	2	*Proxapertites operculatus*
0	1	0	2	7	0	0	0	0	0	0	0	*Tricolpites hians*
0	0	2	0	1	0	0	0	0	0	0	0	*Pachydermites diederixi*
0	3	1	2	4	0	0	0	0	0	0	0	*Psilatricolporites operculatus*
2	0	4	2	4	1	2	0	0	1	2	0	*Monoporites annulatus*
3	1	2	4	2	0	0	0	0	0	0	2	*Proxapertites cursus*
0	0	0	0	1	0	0	0	0	0	0	0	*Echiperiporites icacinoides*
0	0	0	0	2	0	0	0	0	0	0	0	*Inaperturopollenites hiatus*
0	2	2	1	2	0	0	0	0	0	0	0	*Longapertites vaneedenburgi*
0	1	0	0	1	0	0	0	0	0	0	0	*Psilatriporites rotundus*
1	0	2	1	2	0	0	0	0	0	0	0	*Buttinea andreevi*
0	3	1	4	2	0	0	0	0	0	0	0	*Psilatricolporites crassus*
0	4	3	1	1	0	0	0	0	0	0	0	*Spinizonocolpites echinatus*
2	3	0	2	1	0	0	0	0	0	0	0	*Proteacidites dehaani*
2	0	2	3	1	0	0	0	0	0	0	0	*Longapertites microfoveolatus*
6	2	2	4	1	0	0	0	0	0	0	0	*Auriculidites reticularis*
0	1	3	1	2	3	1	0	2	0	0	2	*Retidiporites magdalenensis*
0	3	3	1	2	0	0	0	0	0	0	0	*Monocolpites marginatus*
2	0	2	2	0	0	0	0	0	0	0	0	*Echiperiporites minor*
4	2	0	0	3	0	0	0	0	0	0	0	*Monocolporopollenites sphaeroidites*
2	4	2	3	4	0	0	0	0	0	0	0	*Constructipollenites ineffectus*
5	3	6	7	3	2	0	0	1	0	2	0	*Spinizonocolpites baculatus*

1	2	3	4	5	6	7	8	9	10	11	12	13
												MARINE SPECIES
0	0	1	0	3	0	0	0	0	0	0	0	*Spiniferites hyperacanthus*
0	2	0	2	2	0	0	0	0	0	0	0	*Chytroeisphaeridia sp.*
0	0	2	0	1	0	0	0	0	0	0	0	*Achomosphaera sagena*
0	1	3	2	2	0	0	0	0	0	0	0	*Selenopemphix nephroides*
3	2	0	5	16	0	0	0	0	0	0	0	*Spiniferites spp.*
0	0	2	0	1	0	0	0	0	0	0	0	*Cordosphaeridium fibrospinosum*
6	3	4	3	4	0	0	1	2	1	2	0	*Cordosphaeridium inordes*
0	0	0	0	0	5	2	1	0	3	2	0	*Cordosphaeridium varians*
0	1	0	0	1	0	0	0	0	0	0	0	*Cleistosphaeridium diversispinosum*
0	2	4	2	1	0	0	0	0	0	0	0	*Ceratiopsis diebelii*
0	2	0	1	1	4	2	0	2	0	1	3	*Areoligera senoniensis*
1	2	0	1	1	0	0	0	0	0	0	0	*Senegalinium sp.*
0	1	3	0	2	0	0	0	0	0	0	0	*Coronifera oceanica*
2	4	1	2	2	0	0	0	0	0	0	0	*Operculodinium centrocarpum*
6	4	2	3	1	0	0	0	0	0	0	0	*Dinogymnium accuminatum*
8	5	3	6	2	26	2	4	2	0	1	0	*Fibrocysta spp.*
2	0	1	2	0	4	1	2	0	2	4	1	*Cyclonephelium deckonincki*
0	2	0	3	0	3	0	0	2	0	0	0	*Glaphyrocysta ordinata*
2	1	2	0	0	0	0	0	0	0	0	0	*Lejeunecysta hyaline*
3	2	2	3	0	0	0	0	0	0	0	0	*Andalusiella manthei*
6	2	4	2	0	0	0	0	0	0	0	0	*Ceratiopsis lepthoderma*
0	0	0	0	0	5	2	0	1	0	1	0	*Systematophora areolata*
0	0	0	0	0	11	3	0	2	0	1	0	*Fibrocysta licia*
0	0	0	0	0	3	0	0	0	0	0	0	*Palynodinium grallator*
0	0	0	0	0	2	0	0	0	0	0	0	*Carpatella cornuta*
0	0	0	0	0	3	1	0	1	0	0	0	*Membranilarnacia tenella*
0	0	0	0	0	4	2	0	0	0	0	0	*Eisenackia circumtabulata*
0	0	0	0	0	3	1	0	0	0	0	0	*Carpatella septata*
0	0	0	0	0	6	0	0	3	0	3	0	*Danea abbreviata*
0	0	0	0	0	2	1	0	0	1	0	0	*Kenleyia leptocerata*
0	0	0	0	0	3	0	0	0	0	0	0	*Damassadinium californicum*
0	0	0	0	0	0	1	0	1	0	1	2	*Deflandrea sp.*
0	0	0	0	0	4	0	0	0	0	0	0	*Senoniasphaera inornata*

Figure 6. Shows the occurrence and distributions of palymomorph species recovered in the study area

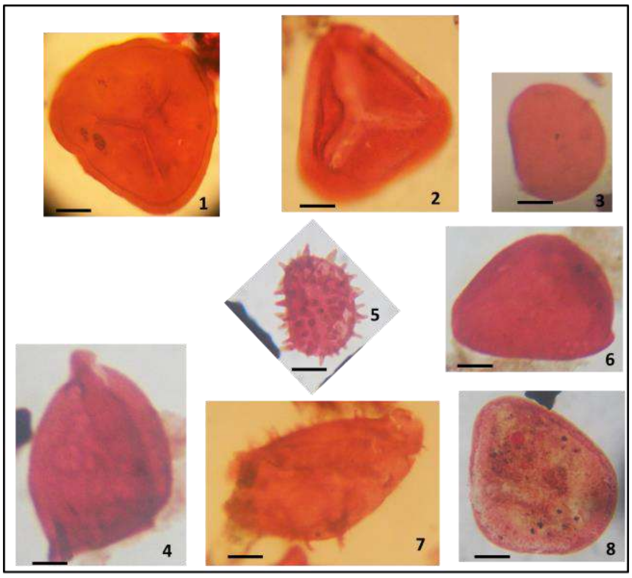


Figure 7. Micrographs of some latest Maastrichtian sporomorphs from Ihube and Okigwe sections. Scale of bar = 20 µm. Magnifications: 3, 4, 5, 6, 7, and 8 (x40), others (x100 oil immersion)

1. *Leiotriletes adriennis* POTONIE & GELLETICH 1933
2. *Polypodiaceoisporites reticulatus*
3. *Laevigatosporites ovatus* WILSON and WEBSTER 1946
4. *Auriculidites reticulatus* ELSIK 1964
5. *Spinizonocolpites baculatus* MULLER 1968
6. *Longapertites marginatus* VAN HOEKEN-KLINKENBERG 1964
7. *Mauritiidites crassibaculatus* VAN HOEKEN-KLINKENBERG 1964
8. *Longapertites vaneedenburgi* GERMERAAD, HOPPING & MULLER 1968

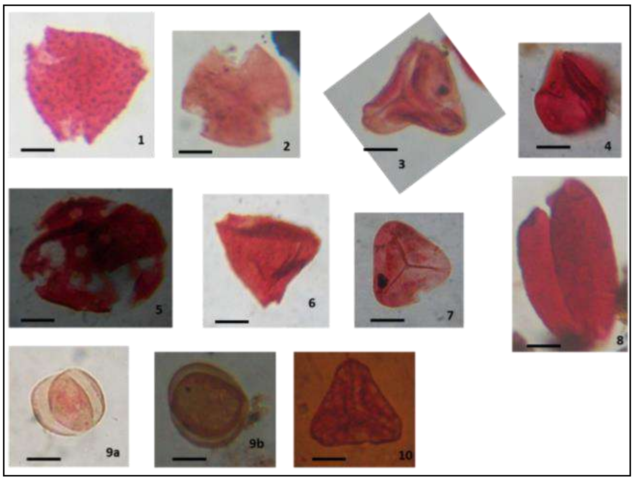


Figure 8. More pollen and spores from Ihube and Okigwe-Arondizogu sections. Scale of bar = 20 µm. Magnifications (x40)

1. *Echitriporites trianguliformis* VAN HOEKEN-KLINKENBERG 1964
2. *Tricolpites hians* STANLEY 1965
3. *Gleichenidites senonicus* ROSS 1949
4. *Monoporites annulatus* VAN DER HAMMEN 1954
5. *Buttinia andreevi* BOLTENHAGEN 1967
6. *Proteacidites dehaani* GERMERAAD, HOPPING AND MULLER 1968
7. *Cyathidites minor* COUPER 1953
8. *Schizosphacus reticulatus*
9. *9a&b.Proxapertites operculatus* GERMERAAD, HOPPING & MULLER 1981
10. *Cyathidites australis* COUPER 1953

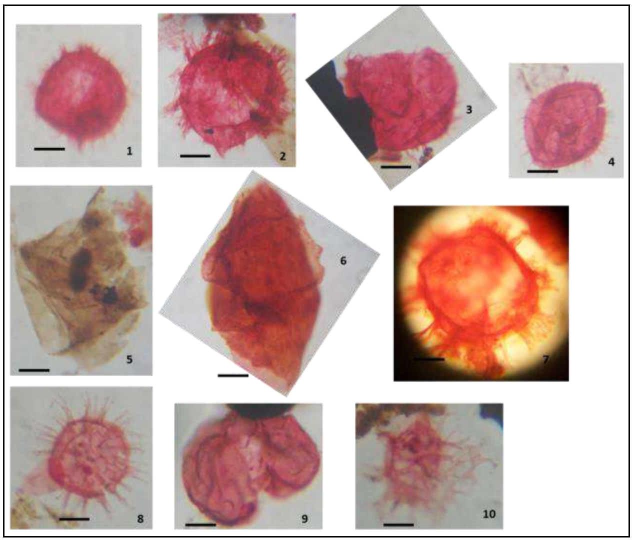


Figure 9. Micrographs of some dinoflagellate cysts from Ihube and Okigwe-Arondizogu sections. Scale of bar = 20 µm. Magnifications: No. 7 (x100 oil immersion), others (x40)

1. *Cordosphaeridium varians* MAY 1980
2. *Cordosphaeridium varians* MAY 1980
3. *Clyconephelium deckonickii* BOLTENHAGEN 1977
4. *Operculodinium centrocarpum* DEFLANDRE & COOKSON 1955
5. *Lejeunecysta hyaline* (GERLACH 1961) SARJEANT 1984b
6. *Dinogymniun acuminatum* EVITT 1961
7. *Cordosphaeridium fibrospinosum* DAVEY & WILLIAMS 1966 (x100)
8. *Diphycs colligerum* DEFLANDRE & COOKSON 1955
9. *Selenopemphix nephroides* BENEDEK & SARJEANT 1981
10. *Spiniferites hyperacanthus* JAN DU CHENE 1988

Discussion

Biostratigraphic Age Determination/Correlation

Biostratigraphic age assessment was based on selected key stratigraphic marker species of palynomorphs recovered from the examined samples. Figure 11 shows the stratigraphic range chart of the selected key age-diagnostic palynomorph species recorded in the study area.

Latest Maastrichtian Age:

Samples from Ihube (IH-01 - IH-04) and Okigwe (OK-01) were assigned Late Maastrichtian age on the basis of the important stratigraphic age-diagnostic marker assembledge recovered. They include *Longapertites margnatus* and *Spinizonocolpites baculatus* (in overwhelming abundance). Other are *Mauritiidites crassibaculatus, Proteacidites miniporatus, Buttinia andreevi, Proxapertites operatatus, Distaverrusporites simplex, Cingulatisporites ornatus, Constructipollenites ineffectus, Retidiporites magdalenensis, Longapertites vaneedenburgi*, and *Gleicheniidites senonicus.* The age was strengthen by the common occurrence of a well-known Late Maastrichtian dinoflagellate cyst endemic species, *Dinogymnium spp.* (Figure 9). These selected taxa have comparable age ranges to those described by the previous workers from North and West Africa (Egypt, Senegal, Somalia, Nigeria, Gabon, Cote d' Ivoire); South America (Peru, British, Guiana, Brazil, Colombia, Surinam, Venezuela); Asia (India, Borneo), and Carribean. However, it is important to note that Okigwe sample (OK1-01) contains proxaperturate pollen, *Proxapertites operculatus,* which has been regarded as Paleocene marker (Van Hoe ken-klinkenberg, 1964). Although, this species occurred below the K/Pg boundary and gradually increased in the Paleocene (Van Hoe ken-klinkenberg, 1964). The presence of this species in OKI-01 sample signifies the incoming of the Cenozoic flora and the transitional position of the beds between the end of the Cretaceous and the beginning of the Paleogene (Umeji, 2005). Furthermore, the presence of a good number of *Dinogymnium spp.* and a pollen, *Buttinia andreevi*, in the samples from Ihube and Okigwe, have strongly confirmed age not younger than the Latest Maastrichtian.

The age range of the selected playnomorph taxa have been compiled from published works by Van der Hammen (1954), Van Hoe ken-klinkerberg (1964, 1966), Bottenhagen (1965), Jardine and Magloire (1965), Jan du Chêne and Salami, (1978), Herngreen (1975, 1981), Muller *et al.* (1987), Germeraad *et al.* (1968), Salami (1982, 1985, 1990), Schrank (1987), Edet and Nyong (1994), Herngreen *et al*. (1996), Oboh-Ikuenobe *et al*. (1998), Atta-Peters and Salami (2004), Umeji (2005, 2008) and Chiaghanam *et al*. (2012).

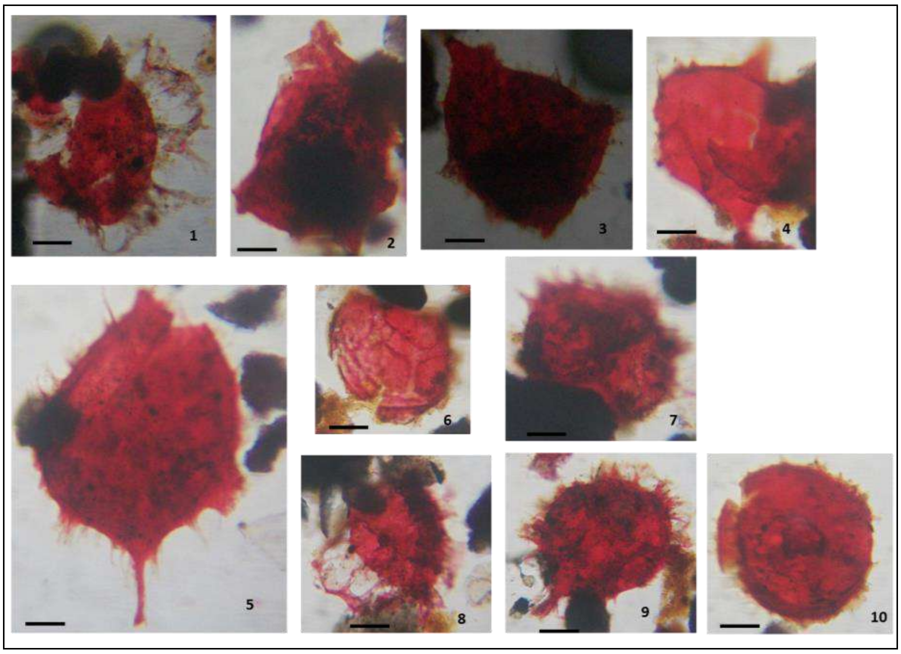


Figure 10. Micrographs of some key Danian dinoflagellate cysts from Umuasuwa section. Scale of bar = 20 µm. Magnifications (x40)

1. *Areoligera senoniensis* LEGEUNE-CARPENTIER 1938
2. *Carpatella septata* WILLUMSEN 2004
3. *Carpatella cornuta* WILLUMSEN 2004
4. *Fibrocysta licia* (JAIN ET AL. 1975) STOVER & EVITT 1978
5. *Fibrocysta licia* (JAIN ET AL. 1975) STOVER & EVITT 1978
6. *Eisenackia circumtabulata* DRUGG 1967
7. *Danea manicata* DAMASSA 1984
8. *Palynodinium grallator* GOCHT EX GOCHT 1973
9. *Cordosphaeridium varians* MAY 1980
10. *Tectatodinium rugulatum* (HANSEN 1977) MCMINN 1988

Cretaceous – Paleogene boundary and Early Danian

Samples from the Umuasua section were assigned Danian age on the basis of the following well known age-diagnostic dinoflagellate cysts assemblage, which have been recorded within the Danian deposits worldwide (Figure 11). They include *Cordosphaeridium varians Damassadinium californicum, Fibrocysta licia, Carpatella cornuta, Eisenackia circumtabulata, Carpatella septata, Senoniasphaera inornata, Tectatodinium rugulatum,, Kenleyia leptocerata, and Palynodinium grallator* (Figure 6) Jain *et al.* (1975), Oloto (1990), Umeji and Nwajide (2007), Slimani *et al.* (2010) (Figures 11 and 12)

Jain *et al.* (1975) recognized the Danian by the absence of the Maastrichtian dinoflagellate cysts, *Dinogymnium spp.* and the presence of species of the genera *Eisenackia, Deflandrea, Lejeunecysta, Cyclonephelium, Paleocystodinium, and Fibrocysta.* These species, however, show a closer affinity of the Danian to the Paleocene than to the Maastrichtian. Umeji and Nwajide (2007) noted that the occurrence of *Fibrocysta axiale*, in association with the above listed dinocysts assemblage, and the absence of *Dinogymnium spp.* corroborate a Danian age for the uppermost facies of the Nsukka Formation. Drugg (1967) found *Danea californica* (as *Palminickia californica*) restricted to the Danian. Oloto (1990) was able to recognize the two subzones in the Danian of Gbekebo-1 well, but not the zonules.

The work of Slimani *et al*. (2010) recorded that the dinoflagellate cysts *Carpatella cornuta* and *Damassadinium californicum* are global Danian index fossils, and *Eisenackia circumtabulata*, *Kenleyia spp.* and *Senoniasphaera inornata* may also be valuable for the identification of the K-Pg boundary in the Northern hemisphere middle latitudes, mainly the Mediterranean region. The same work also noted that the first occurrences (FOs) of these species are consecutive in ascending stratigraphic order within the lowermost Danian in biostratigraphically calibrated sections such as the Danish and Tunisian K-Pg stratotypes, and elsewhere in the Northern Hemisphere.

Williams *et al.* (2004), reported that *Eisenackia circumtabulata* appears for the first time at the K-Pg boundary (65 Ma) in the mid latitudes and equatorial realm from the northern Hemisphere, and earlier in the latest Maastrichtian (67 Ma) in the mid-latitudes of the southern Hemisphere. However, its FO marks exactly the basal Danian at EI Kef, where this species defines the lowermost dinoflagellate cyst subzone (Brinkhuis and Zachariasse, 1988). This species has also been reported in Danian strata from Ain Settara (Dupuis *et al.*, 2001), Caravaca (De Coninck and Smit, 1982), Alabama (Moshkovitz and Habib, 1993; Habib *et al.*, 1996), California (Drugg, 1967), and Mexico (Helenes, 1984).

The *Kenleyia spp.* have been recorded above the K-Pg boundary. These species have also been recorded above K-Pg boundary (within the lowermost Danian) and also in the latest Maastrichtian (Oloto, 1989) or just below the K-Pg boundary (Oboh-Ikuenobe *et al*., 1998; Dupuis *et al*., 2001).

Firth (1987) reported that the highest occurrence of *Palynodinium grallator* in sample 283.0 (top of interval B) is used to mark the top of the Maastrichtian in the Albany core (Hultberg, 1986; Hansen, 1977, 1979). He noted that the presence of *Carpatella cornuta* in interval C indicates a Danian age for this interval (Hansen, 1977, 1979).

In this study, the above species were encountered in the carbonaceous dark shale sample (UMU-001), immediately above the erosional surface of the latest Maastrichtian conglomeratic sandstone containing ammonites, gastropods, and pelecypods in the Umuasuwa section. These strongly agree with the earlier report by Reyment (1965) on boundary demarcation and proper placement of the K-Pg boundary on the outcrop scale in Nigeria. Thus, the K-Pg boundary is therefore placed between the topmost part of the latest Maastrichtian conglomeratic sandstone bed containing ammonites, (Figure 5 and Figure 11), and at the base of the overlying carbonaceous dark shale sample (UMU-001), with Danian dinoflagellate cysts assemblage. Meanwhile, the total disappearance of the latest Maastrichtian index species (e.g. *Dinogymnium spp.*, *Constructipollenites ineffectus, Distaverrusporites simplex*, *Cingulatisporites ornatus,* and *Buttinia andreevi*), in the carbonaceous dark shale sample (UMU-001) up the stratigraphic section in the Umuasuwa section gave credence to Danian age.

Paleoeocology and Paleoenvironments of Deposition

Based on the result from the given analysed samples, it is observed that Ihube and Okigwe samples have high dominance of terrigenous sporomorph (pollen and spores), over the marine species. Among the terrestrial species, monocolpate pollen especially the *Longapertites spp*. dominated the assemblage (Figure 7). The high abundance of these species with the co-occurrences of pteridophytic spores (monolete/trilete) and fresh water algal spores is suggestive of mangrove swamp and/or brackish water condition with low salinity fluctuation, and minor freshwater input. This is also support by high occurrence of peridinecean cysts over the gonyaulacacean species. The peridinecean dinocysts especially, *Dinogymnium spp.*, are well known as the inhabitants of near-shore brackish water environment with reduced salinity (Downie *et al*., 1971; Umeji, 2006, 2008). Schrank (1984) suggested that a palynomorph assemblage with higher content of land derived miospore indicates terrestrial conditions. In this study, the dominance of sporomorphs (e.g. *Longapertites, Spinizonocolpites,* and *Mauritiidites*), with some monolete and trilete spores over marine species is a strong indication of terrestrial conditions with minor marine influence, in a near-shore and/or brackish water environments of deposited.

Meanwhile, samples from Umuasua secton were heavily overwhelmed by marine dinoflagellate cysts. Most of them especially those with a proximate cyst affinity, are well known as inhabitants of shallow marine inner to outer neritic environments (Van Mourik *et al*., 2001). The *Cordosphaeridium spp.* especially *C. Varians,* with overwhelming abundance, has been interpreted as been restricted to the outer neritic environment. Large number of representatives of the *Cordosphaeridium* group have been widely reported from Mesozoic to Miocene neritic sediments (Schioiler *et al*., 1997). Brinkhuis (1994) suggested that *Areoligera* associations represent marginal marine to inner neritic water masses in low to middle latitude.

Conclusion

Palynological study and paleoenvironments of deposition of the Upper Cretaceous – Early Paleocene strata along the Ihube-Okigwe-Umuasua axis have been undertaken. Four (4) main lithological units were encountered which include, carbonaceous shale, sandstones, mudstone, and siltstone.

Result obtained from the palynological investigation indicated high dominance of terrigenous sporomorphs, especially the mangrove pollen over marine microplanktons in the samples from the base to the middle of the stratigraphic sequence at Uhube and Okigwe-Arondizuogu sections, whereas samples from the Umuasuwa section, at the top of the sequence, produced more marine species, mostly the dinoflagellates with proximate cyst affinity, than the terrigenous species.

Age determination was achieved on the basis of the selected key stratigraphic index palynomorph assemblages encountered. A **Latest Maastrichtian age** was assigned to the samples from Ihube and Okigwe-Arondizogu sections, while samples from the Umuasua section were dated **Early Danian.** These therefore have enabled the identification of the Danian strata, and resolution of basins boundary demarcation problem, with proper placement of the K-Pg boundary within the outcropping strata of the Nsukka Formation in the southeastern Nigeria.

Palynomorphs of environmental value indicated different depositional settings for the sediments, which ranged from mangrove swamp and/or brackish water, with low salinity fluctuation at the base of the stratigraphic sequence to shallow marine inner to outer neritic environments at the top.

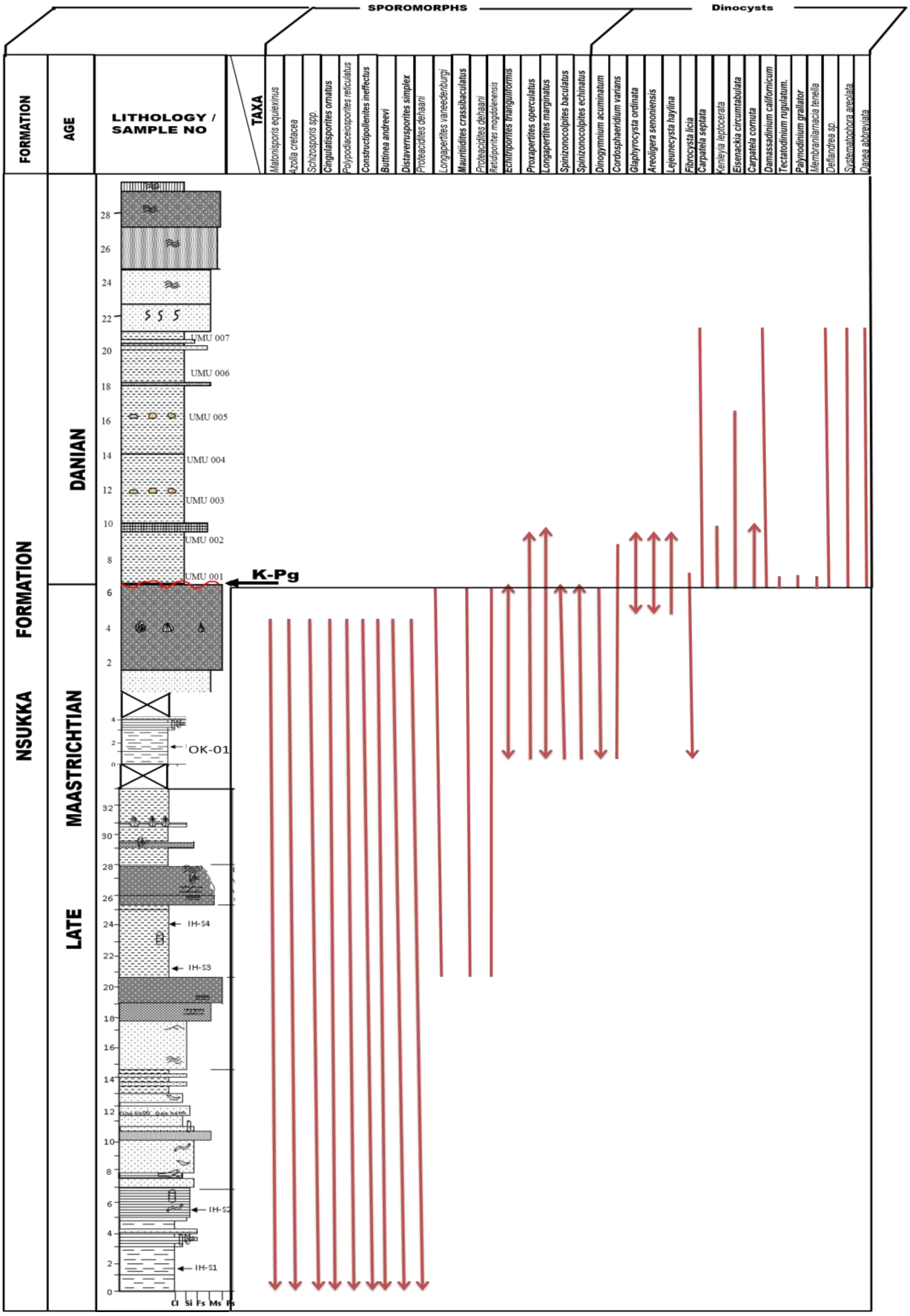


Figure 11. Shows the stratigraphic range chart of the selected key age-diagnostic palynomorph species recorded in the study area

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CƏNUB-ŞƏRQİ NİGERİYANIN OKİQVE-UMUASUVA OXU BOYUNCA GEC MAASTRİXT-DANİMARKA TƏBƏQƏLƏRİNİN YAŞI VƏ PALEOMÜHİTİ, ANAMBRA HÖVZƏSİ

Çukvuemeka F. Odumodu, Okeçukvu N. İkeqvuonu, Ayonma V. Mode

Anambra hövzəsinin İlhube, Okiqve-Arondizuogu və Umuasuva kəsilişlərinin Gec Təbaşir və Erkən Paleogen süxurlarının yaşını dəqiqləşdirmək və onların çökmə paleomühitini rekonstruksiya etmək məqsədilə həmin kəsilişlərin açılışlarından 12 nümunə götürülmüş və çöküntülərdən turşuda həll edilə bilən üzvi qabıqlı mikrofosillərin əldə olunmasına əsaslanan ənənəvi turş maserasiya metodunun tətbiqi ilə palinoloji təhlildən keçirilmişdir. Təhlillər nəticəsində kəsilişlərin tərkibində karbonlu şistlərdən, qumdaşılardan, gillərdən və alevritlərdən ibarət dörd əsas təbəqə müəyyən edilmişdir. Palinoloji təhlillərin nəticəsi onu göstərir ki, İlhube və Okiqve/Arondizuogu kəsilişlərindən yığılmış nümunələrdə üstünlük terrigen mikroflora (xüsusilə də spor və tozcuqlar), Umuasua kəsilişindən götürülmüş nümunələrdə isə terrigen formalardan fərqli spora qabığı quruluşuna sahib olan suda yaşayan növlər (əsasən dinoflagellatlar) təşkil edir. Nümunələrin yaşı seçilmiş stratiqrafik indekslər üzrə təyin olunan palinomorf komplekslər əsasında təyin edilmişdir. İlhube və Okiqve-Arondizoqu kəsilişlərindən götürülən nümunələrin yaşı **Gec Maastrixt dövrü** *olaraq təyin olunmuş, orada aşağıdakı növlər aşkar edilmişdir: Longapertites marginatus, Proxapertites operculatus, Proxapertites cursus, Retidiporites magdalenensis, Cingulatisporites ornatus, Proteacidites dehaani, Spinizonocolpites baculatus / echinatus, Mauritidites crassibaculatus, Distaverrusporites simplex, Foveotriletes margaritae, Constructipollenites ineffectus və Longapertites microfoveolatus. Sözü gedən kompleks Cənubi Amerika və Afrika bölgələrinin Senon dövrünün tropik-subtropik Palma əyalətinə aid edilmişdir. Umuasua kəsilişindən tapılmış növlərə görə (Cordosphaeridium varians, Damassadinium californicum, Fibrocysta licia, Carpatella cornuta, Eisenackia circumtabulata, Carpatella septata, Senoniasphaera inornata, Tectatodinium rugulatum, Kenleyia leptocerata və Palynodinium grallator) kəsilişin yaşı* **Erkən Danimarka** *olaraq təyin edilmişdir. Kəsilişlərdə palma taksonları kimi mühüm mühit formalaşdırıcı miospor taksonlarının müəyyən edilməsi, habelə nümunələrdə külli miqdarda mikroplankton növlərinin (məsələn peridinoid dinosistləri) tapılması çökmə prosesinin manqrov bataqlıqlarının və ya şorluluğun az tərəddüd etdiyi sahilyanı şoran su mühitində baş verdiyinə dəlalət edir. Miospor assosiasiyalarının xüsusiyyətlərinə əsaslanaraq belə nəticəyə gəlmək olar ki, çöküntü toplanma prosesi isti və rütubətli iqlim şəraitində baş vermişdir.*

ВОЗРАСТ И ПАЛЕОСРЕДА МААСТРИХТ-ДАТСКИХ ПЛАСТОВ, ОБНАРУЖЕННЫХ ВДОЛЬ ОСИ ОКИГВЕ-УМУАСУВА, ЮГО-ВОСТОЧНАЯ НИГЕРИЯ

Чуквуемека Ф. Одумоду, Окечукву Н. Икегвуону, Айонма В. Моде

Для того чтобы определить возраст и провести реконструкцию среды позднемелового и раннепалеогенового осадконакопления в разрезах Окигве-Арондизуогу и Умуасува, из соответствующих обнажений нами был произведен отбор 12 проб, которые были впоследствии подвергнуты палинологическому анализу. Анализ был проведен с использованием традиционного метода кислотной мацерации, заключающегося в получении микроокаменелостей с растворимой в кислоте органической оболочкой. В ходе исследований в разрезах было обнаружено 4 основных слоя, содержащих угленосные сланцеватые глины, песчаники, глины и алевролиты. В соответствии с результатами палинологических анализов среди проб, отобранных из разрезов Илхубе и Окигве/Арондизуогу, превалирует терригенная флора (споры и пыльца), особенно пыльца мангровых деревьев, которая преобладает над морским микропланктоном, в то время как пробы из разреза Умуасуа в основном содержат водные виды (преимущественно динфлягелляты). Возраст собранных проб был определен по опорным стратиграфическим комлпексом палиноморф. Возраст проб, отобранных из разреза Илхубе и Окигве-Арондизогу, был определен как ***поздний Маастрихт****. Сделано это было благодаря обнаружению следующих руководящих видов ископаемой флоры:* Longapertites marginatus, Proxapertites operculatus, Proxapertites cursus, Retidiporites magdalenensis, Cingulatisporites ornatus, Proteacidites dehaani, Spinizonocolpites baculatus / echinatus, Mauritidites crassibaculatus, Distaverrusporites simplex, Foveotriletes margaritae, Constructipollenites ineffectus *и* Longapertites microfoveolatus. *Описанный комплекс относится к пальмоцветным, распространенным в Сеноне пальмоцветной провинции Южной Америки и Африканского региона. Основываясь на обнаруженных в его составе остатках* Cordosphaeridium varians, Damassadinium californicum, Fibrocysta licia, Carpatella cornuta, Eisenackia circumtabulata, Carpatella septata, Senoniasphaera inornata, Tectatodinium rugulatum, Kenleyia leptocerata *və* Palynodinium grallator, *Умуасуанаский разрез был датирован как* ***ранний Даний.*** *Тот факт, что в составе разрезов были обнаружены такие важные таксоны миоспор, как таксоны пальмоцветов, а также то, что во всех пробах было обнаружено множество видов микропланктона (например перидиноидальные диноцисты), свидетельствует в пользу того, что осадконакопление происходило в условиях мангровых болот, либо прибрежных солоноватых вод с незначительной флуктуацией солености. Исходя из особенностей миоспоровых ассоциаций можно сделать вывод, что осадконакопление происходило в условиях теплого и влажного климата.*

PLANKTON STRATIGRAPHY OF THE LOWER PALEOGENE SEDIMENTS IN THE SOUTHEASTERN CAUCASUS

The article is dealing with the stratigraphy of the Lower Paleogene succession exposed in the Southeastern Caucasus deposits and characterizes plankton foraminifera complexes of the different stratigraphic age and correlate Lower Paleogene sediments in the North and Southeastern Caucasus.

Keywords: Paleogene, zonal stratigraphy, foraminifera, plankton, Paleocene, Eocene.

H.A. Allahverdiyeva

Azerbaijan National Academy of Sciences,
Institute of Geology and Geophysics,
H.Cavid pr. 119, Baku, AZ 1143
E-mail: hallahverdiyeva63@gmail.com

Introduction

Paleogene deposits are widely occurring across the Southeastern Caucasus region. These sediments had been studied by a number of researchers, including I.M.Gubkin (1914), D.V.Golubyatnikov (1915), V.V.Bogachov (1926), V.V.Weber (1930), N.B.Vassoyevich (1932), J.M.Khalilov (1962,1967), H.A.Ahmadov (1957), J.M.Khalilov and L.J.Mammadova (1984), A.A.Alizadeh, (1989), etc.

Stratigraphy of the Lower Paleogene sediments of Azerbaijan had been implemented in 1969 and 1980 by M.A.Baghmanov.

Paleogene succession of the Southeastern margin of the Greater Caucasus system (Figure 1) are divided into four local stratigraphic units listed from the bottom to the top: 1) Ilkhidagh Suite (Danian Stage); 2) Sumgayit Suite (Paleocene); 3) Koun Suite (Eocene); 4) Maykopian Series (Oligocene-Lower Miocene).

The Paleogene sedimentary facies of Azerbaijan segment of the Southeastern Caucasus differ from the contemporaneous facies of the neighboring areas that makes correlation of these sediments within the Greater Caucasus an actual and important.

Lower Paleogene

The Lower Paleogene deposits in the Southeastern Caucasus are widely occurring across the territory of Azerbaijan, where they are recorded in the main structural complex, and display sharp horizontal and vertical facies changes over the studied area.

Within their occurrence areas the Paleocene and Eocene successions are easily recognized for their color and facies. In some cases, especially in regions with active volcanism, environmental and thickness changes are observed within quite short distances.

Stratigraphy of these sediments differs within various regions: six suites are recognized in the Mountain Talysh, four suites in the central part of the Lesser Caucasus, four suites in Araz zone and three suites in the Southeastern Caucasus. Stratigraphic units of the different regions have completely different colorization, lithology, and had been accumulated in different setting, the faunal assemblages are also differ in various regions. Depending on their media such complexes consist of the organisms belonging to different groups and genera. There are no fossils in the Paleogene deposits of Mountain Talysh, except for rich mollusk fauna recovered from the Neslin Suite (Late-Middle Eocene). This fauna is mainly represented by helmet snails.

In the center of the Lesser Caucasus region there is almost no fauna found in the Paleocene-Eocene succession, except for nummulites recorded in Zod horizon.

In Nakhchivan Autonomous Republic, there is a typical Mediterranean marine fauna, which is not reported anywhere else on the territory of Azerbaijan. Stratigraphic schemes developed for various faunal groups are well correlated with each other.

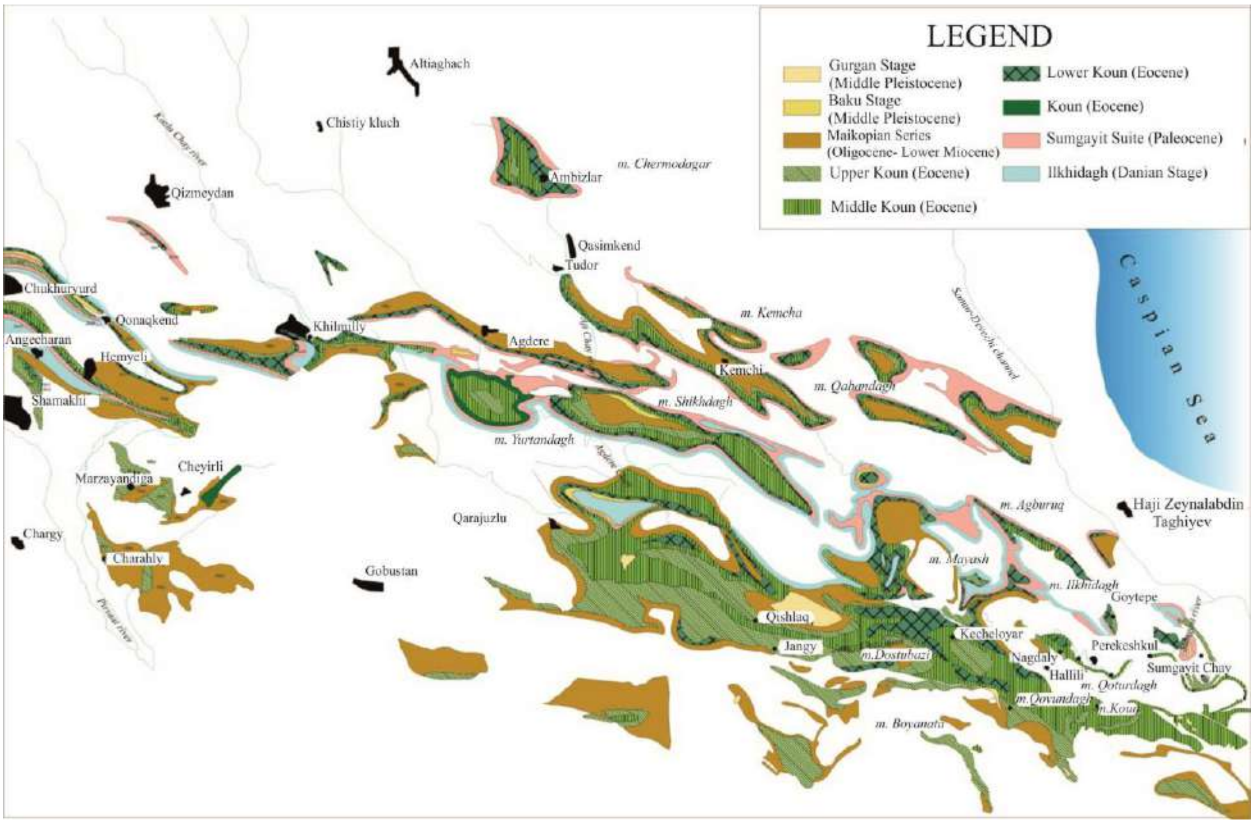

Figure 1. Geological map of the Lower Paleogene deposits in the Southeastern Caucasus

Fossil assemblages from all regions of Azerbaijan are characterized by wide development of plankton foraminiferas.

In the Southeastern Caucasus the biostratigraphy and lithofacies of widely occurring Ilkhidagh, Sumgayit and Koun Suites had been studied by V.V.Weber (1935), D.V.Golubyatnikov (1914), I.M.Gubkin (1914, 1916), N.S.Shatsky (1927) and others.

The zonal stratigraphy had been implemented by M.A.Baghmanov (1980, 2005). It had been revealed that described sediments are characterized by very wide development of plankton foraminiferas and absence of any other groups of fauna.

Plankton foraminiferas are also widely occurring in Paleocene and Eocene deposits in other parts of Azerbaijan.

It has to be mentioned that stratigraphy of the Paleocene and Eocene successions of the Southeastern Caucasus had been always studied based on rich plankton foraminifera records in the same-age North Caucasus deposits. As generally agreed by Russian microfaunists Southeastern Caucasus Paleocene and Eocene deposits are more rich with plankton foraminiferas. In this context Yunusdagh sections has been chosen as etalon section for Crimea-Caucasus oil region of Georgia and Ukraine.

In Southeastern Caucasus neither Ilkhidagh and Sumgayit Suites, nor Koun Suite have macrofaunal remains. However, these units demonstrate very rich plankton fauna records. For this reason we present in this paper the stratigraphy and correlation of Paleogene sediments based on their plankton foraminifera associations.

Paleocene succession is composed of Danian, Selandian and Thanetian Stages.

Lower Paleocene, Danian Stage. Ilkhidagh Suites corresponds to the Danian Stage. The Suite had been distinguished in Absheron peninsula by I.M.Gubkin (1916) who reported it on the northeastern slope of Ilkhidagh mountain between the sections of Agburun and Sumgayit Suites. Lithologically these sediments having thickness varying from 0-

35 m to 500 m are composed of alternating grey, dark-grey marls and carbonate mudstones with light-grey and yellowish-grey sandstones.

The Danian succession is divided into two zones from the top to the bottom (*Globoconusa daubyergensis* and *Acarinina inconstans*) and characterized by the following microfauna fossils: *Globoconusa daubjerensis* (Bronn), *Globigerina triloculinoides* (Plumm.), *G.varianta* (Subb.), *G.inflata (*Orb.*), G.moskvini* (Schuts.), *G.pseudobulloides* (Plumm.), *G. fringa* (Subb.), *Globorotalia pseudobulloides* (Plumm), *Lagena simplex* (Reuss), *L. marginata* (Wolker et Boys), *Eponides trumpyi* (Nuttall), *Heterohelix crinita* (Glaessn.), *H. mica* (Subb.), *H. pumilla* (Subb), *Cibicides perlucidus (*Nutall), *Textularia excolata* (Cushman), *Anomalina danica, etc*. (Brotzen), *Nutalloides trümpyi* (Nutall.), *N. praemegastomus* (Myatl.), *Gyroidina globosa* (Hagen), *Trochammionoides irregularis* (White) və s. təyin edilmişdir.

In some places Danian deposits unconformably overlie with 65^0-70^0 angle Maastrichtian grey to dark-grey marls and mudstones with the interlayers of fine-grained, dense, hieroglyphic calcareous sandstones.

Such stratigraphic scheme doesn’t correlate with the Crimea scheme, which had been developed in 1962. Paleocene is represented by Inkermanian and Kachaian Stages, Lower Eocene by Bakhchisaray, Middle Eocene by Simferopol, and Upper Eocene – by Bodrakian (Kuberlin and Kerestin) Stages.

Later, this stratigraphic scheme had been slightly chenged as a result of more recent studies. Thus, Simferopol Stage was dated back to Lower Eocene, and a depositional break was identified in the upper part of Lower and lower part of Middle Eocene times. Bodrakian Stage was completely referred to Middle Eocene, leaving only Alma Stage to date back to the Upper Eocene.

In the North Caucasus region foraminifera bearing stratas had been first discovered back in 1907. Then, the strata had been identified as a Suite and a Stage. These layers are divided into 6 Suites, from the bottom to the top: Abazin, Kutaisi, Kaluji, Khaijen and Kum Suites, and Beloglinka horizon.

Danian Stage of the North Caucasus region is represented by Kubanian and Elburgan Suites as well as by a small part of Goryachiy Kluch Suite.

Kuban Suite (sometimes called a horizon) contains remains of sea urchins (*Echinocorys pyrenaicus* Seun., *E. oblignus* (Nills) (Moskvin, 1951) and small foraminiferas (*Bolivinopsisex* gr. *Carinataeformis (Moroz).*, *Verneuilina kelleri* (Moroz.), *Plectina convergens* (Kell.), *Arenobulimina preslii* (Reuss), *Gyroidinn caucasica (*Subb.), *Globigerina rnoskvini (*Schutzk.), *Anomalina velascoensis (*Cush). (Keller, 1950).

Elburgan Suite corresponds to the zones of *Globigerina taurica, Globigerina triloculinoides* zonaları, and to the lower part of *Acarinina incontans* zone.

There are the following foraminiferas recorded in the horizon’s marly deposits: *Ammodiscus incertus* (d’Orb.), *Glomospira charoides* (Park, et Jon.), *Lituotuba caucasina* (Moroz.), *Trochamminoides irregularis* (White), *Haplophragmoides deformis* (Andr.), *Textularia plummerae* (Lalick.), *Bolivinopsis* ex gr. *carinataeformis (*Moroz.), *Textulariella varians* (Glaess.), *Heterostomella gigantica* Subb., *Marssonella indentata* (Cush, et Jarv.), *Arenobulimina preslii* (Reuss), *Flabellina rugosa* (d ’Orb) var. *reticulosa* (Moroz), (msc.), *Bolirinoides decorata* (Yon.) var. *delicatula* (Cush.), *Valvulineria allomorphinoides* (Reuss), *Gyroidina globosa* (Hag.), *G. soldani* (d ’Orb.), *G. caucasica* (Subb.), *Eponides trümpyi* (Nutt.), *Siphonina prima* (Plumm.), *Pulvinulinella alata* (Marss.), *Pullenia quinqueloba* (Reuss), *Globigerina pseudobulloides (*Plumm.), *G. triloculinoides* (Plumm.), *Acarinina angulata* (White), *Anomalina pertusa* (Marss.,), *A. praeacuta* (Vass.), *A. groserugosa* (Cümb.), *A. velascoensis* (Cusli.), *Cibicides proprius* (Brotzen), *C. hemicompressus* (Moroz.) və b. (Schutskaya, 1960).

Based on the large data set collected on the territory of Azerbaijan we suggest the following corrections in the stratigraphy of Paleogene succession, i.e. *Globorotalia angulata* and *Acarinina subsphaerica* zones date back to New Selandian and Kachaian Stages of Paleocene.

Selandian Stage (Globorotalia angulata zone) is represented by the lower portion of Sumgayit Suite, which also includes Thanetian Stage. H.P.Sjögren (1891) had distinguished Sumgayit Series in the river valley of Sumgayit chay. Lithology of these up to 100 m thick sediments is represented by grey sandy limestones, marls, dark-green and dark-red mudstones.

Selandian deposits contain rich complex of *Globorotalia angulata* zone, including remains of *Globorotalia angulata* (White), *G. compressa (*Plumm), *G. pseudomenardi, G. pileata (*Khalil), *G. moskvini* (Schuts.*)*, *Globigerina varianta* (Subb.), *G. triloculinoides* (Plumm.), *Trochamminoides irregularis* (White*)*, *Glomospira charoides* (Park. et Jon.), *Hormosina ovulum* (Grzyb.), *Rabdammina cylindrica* (Glaessn.), *Nutalloides trümpyi* (Nutall.).

Small lower part of **Goryachiy kluyuch** Suite refers to the Danian Stage, while the other parts belong to Selandian Stage.

The Suite corresponds to *Acarinina djanensis* zone and to the upper part of *Acarinina acarinata* zone. It is generally built by grey calcareous sandstones, but its' top portion is dominated by muddy- silty sediments. 107 thick mudstone horizon contains *Rhabdammina cylindrica* (Glaes.), *Ammodiscus incertus* (Orb.), *Glomospira charoides* (Parker et Jones), *Trochamminoides proteus* (Karrer), *Textularia agglutinans* (Orb.), *Spiroplectammina clotho* (Grzyb.), *S.rosula* (Ehrenberg), *Haplophragmoides subsphaeroides* (Subb.), *Heterostomella rara* (Subb.), *Acarinina conicotruncata* (Subb.) (Subbotina,1950).

Upper Paleocene, Thanetian Stage. Upper Sumgayit series of the Southeastern Caucasus region refer to the Upper Paleocene and conformably overlie Lower Sumgayit deposits. Upper Paleocene Series is composed of alternating dark red, brown, dark green, greenish - grey mudstones. Upper Sumgayit sediments transgressively overlie the Upper Cretaceous deposits with angular and azimuthal unconformity. Often in the bottom of Upper Sumgayit Suite there is a layer of gravelites or coarse-grained sandstones. The Suite is of 10-200 m thick.

Thanetian Stage is divided into *Acarinina subsphaerica* and *Acarinina acarinata* zones. It contains large amounts of *Acarinina subsphaerica* (Subb.), *Ac. intermedia* (Subb.*)*, *Ac. acarinata* (Subb.), *Globorotalia compressa* (Plumm), *Globigerina varianta (*Subb.), *G. triloculinoides* (Plumm.), *G. eocaenica* (Gümb.), *G. quadritriloculinoides* (Chalilov), *G. nana* (Chalilov), *G. velascoensis* (Cushman), *Ammodiscus incertus (*d. Orb), *Rhabdammina cylindrica* (Glaessn.), *Glomospira charoides* (Park. et Jon.), *Hormasina ovulum* (Grayb.*)*, *Trochamminoides irregularis* (White).

Eocene. In Southeastern Caucasus, Eocene succession consists of Koun Suite distinguished in 1914 by I.M.Gubkin between Sumgayit and Maikopian Suites. The Suite is divided into lower, middle and upper horizons. Sediments of Koun Suite have very different colorization.

Lower Koun SubSuite corresponds to Ypresian, Middle – to Lutetian and Bartonian, and Upper – to Priabonian Stages.

Lower Eocene, Ypresian Stage. Lower Koun (also known as white) SubSuite consists of alternating greenish-grey and light green dense marly mudstones with similarly colored dense marls and rare 20-40 m thick layers of sandstones. Occasionally, there are bentonite layers described in the SubSuite. The thickness of the Suite varies within 70-200 m diapason.

Ypresian Stage is divided into the following three microfaunal zones: *Globorotalia subbotinae, Globorotalia marginodentata* and *Globorotalia aragonensis*. It must be mentioned that Ypresian deposits are quite widely occurring throughout the Southeastern Caucasus territory. Deposits of this zone conformably overly

Upper Paleocene Series and get exposed in the form of reddish-brown, originally dark-green mudstones. These deposits contain fossils of radiolarians as well as *Globorotalia subbotinae* (Moroz), *Acarinina subsphaerica* (Subb.), *Globigerina varianta* (Subb.), *G. triloculinoides* (Plumm), *Nuttalloides trümpyi* (Nutt.), *Bulimina pseudopuschi* (Subb.), *Textularia agglutinans* (Orbigny), *Anomalina affinis* (Hantken) and *Eponides subumbonatus* (Myatl.).

Globorotalia marginodentata zone is also commonly occurring in the Southeastern Caucasus region. The zone had been first identified in the North Caucasus by N.N. Subbotina (1953) and refers to the middle portion of Lower Eocene. The succession is composed of alternating grey, greenish-grey, coffee-brown mudstones. Deposits contain plenty of *Globorotalia marginodentata* (Subb.) *Globigerina varianta* (Subb.), *G.frontosa* (Subb.), *G. triloculinoides* (Plumm.), *Acarinina acarinata* (Subb.), *Anomalina affinis* (Hantken), *Nuttalloides trumpyi* (Nutall.), *Glomospira charoides etc*. (Park et. Jon.). The zone is also rich with fossil radiolarians, e.g. *Cenosphaera ispharensis* (Lipm.), *C. turkmenica (*Lipm.), (Khalilov, Mammadov, 1984).

Globorotalia aragonensis zone is represented by bentonite mudstones and marly mudstones with rare interlayers of sandstones. These widely occurring deposits contain fossils of *Globorotalia aragonensis* (Nutt.), *G. caucasica* (Glaessn), *Globigerina posttriloculinoides* (Chalil.), *G. triloculinoides* (Plummer), *G. eocaenica* (Terq.), *G.inaequispira* (Subb.), *G. lensiformis* (Subb.), *G. varianta* (Subb.), *Hastigerina micra* (Cole), *Nuttalloides trumpyi* (Nutall.), *Glomospira charoides, etc.* (Park et. Jon), *Ammodiscus incertus* (d, Orb), *Acarinina pentacamerata* (Subb.) as well as radiolarians and other microfauna.

Abazin Suite has a stratotype in Kuban section. Composed of mudstones and marls the zone has its' lower segment that is rich with fossils. This portion corresponds to the upper part of *Acarinina acarinata* zone. At the same time in the upper part of *Globorotalia subbotinae* zone there are recorded the following fossils: *Rhabdammina cylindrica* (Glaessner), *Glomospira charoides* (Parker et Jones), *Ammodiscus incertus* (Orb.), *Spiroplectammina rosula* (Ehrenberg), *S. clotho* (Grzyb.), *Textularia agglutinans* (Orb.), *Proteonina complanata* (Franke), *Glomospira charoides* (Parker et Jones), *Trochamminoides irregularis* (White) var.. *planulata (*Schutzk.), *T. coronatus* (Brady), *Haplophragmoides deformis* (Andr.), *H. subglobosus* (Sars.), *H. caucasicus* (Schutzk.), *Bolivinopsis spectabilis* (Grzyb.), *Bigenerina plana* (Subb.), *Heterostomella rara* (Subb.), *Bolivinoides aragonensis* (Nutta11), *Gaudryina kabardinensis* (Schutzk.), *G. zolkaensis* (Schutzk.), *Gyroidina soldanii* (Orb.), *Globigerina triloculinoides (*P1umm.), *Globigerinella voluta* (White), *Globorotalia densa* (Cushm.), *G. angulata* (White) var. *praepentacamerata (*Schutzk.) var. *kubanensis* (Schutzk.), *Cibicides pygmaeus* (Hantk.). Also there is a lot of radiolarians, e.g. *Carposphaera sexaxialia* (Борисенко), *Cenosphaera selentschukensis* (Борисенко), *C. micra* (Борисенко), *C. reticulatus* (Борисенко) (def. N.N.Borisenko and E.K.Schutskaya (50 m).

Georgiyev Suite is exposed in the river valley of Kuban, where it is represented by green limy siltstones, which conformably overly the Abazin Suite's sediments. Deposits of the Suite correspond to the zones of *Globorotalia marginodentata* and *Globorotalia aragonensis*.

Middle Eocene. Within the region's boundaries, Middle Eocene is represented by both Lutetian and Bartonian Stages.

Lutetian Stage is characterized by brown sediments and unstable thickness. V.V.Weber (1930) divided this Stage into three major facies - coffee-brown massive, monotonous mudstones in the south, dark greenish-grey schistose shales (often with dark-brown pyrobitumen interlayers) in the center, and alternation of schistose shales with pyrobitumen interbeds in the north.

Thickness of Middle Koun equals 300-400 m in southern, 200-250 m in central and 250-400 m in northern facies zones.

Lutetian Stage of the Southeastern Caucasus region corresponds to the zones of *Acarinina bullbrooki* and *Acarinina rotundimarginata*.

Acarinina bullbrooki deposits are composed of grey, greenish-grey and reddish-brown mudstones and marls which conformably overly the Ypresian Series. In some parts of these series, there are thin (12 m) interlayers of bentonite mudstones, and more rarely sandstones. The deposits of this zone contain foraminiferas, e.g. *Acarinina bullbrooki* (Bolli), *Ac. triplex* (Subb), *Ac. pentacamerata* (Subb.), *Globigerina eocaenica* (Terq.), *G. triloculinoides* (Plummer), *G. varianta* (Subb), *Globorotalia caucasica* (Glaess.), *Nutalloides trumpyi (*Nutt.). There are also large amounts of radiolarians.

Cherkess Suite is represented by greenish-grey mudstone – sandy siltstones and greenish marls recorded in the structure of Kuban section. For being rich with plankton foraminiferas, the Suite corresponds to *Acarinina bullbrooki* and *Acarinina rotundimarginata* zones.

Acarinina bullbrooki zone is composed of an alternation of grey, brownish-grey and dark brown fat mudstones with coffee-brown sandstones.

Acarinina rotundimarginata zone is represented by an alternating coffee-brown sandstones with yellowish-grey, grey mudstones and dark-brown fat mudstones. These deposits contain fossils of *Acarinina rotundimarginata* (Subb.), *Globigerina eocaenica* (Terq.), *G.posttriloculinoides* (Chalil.) *G. frontosa* (Subb.), *Hastigerina micra* (Cole), *Nuttalloides trumpyi* (Nutt.), *Glomospira charoides* (Park. et Jon.).

Bartonian Stage. *Hantkenina alabamensis* and *Globigerina turkmenica* zones. Within the boundaries of Southeastern Caucasus region, deposits of these zones conformably overly Lutetian series. The zones consist of greenish-grey and reddish marly mudstones, sandy mudstones and dark-grey mudstones with the interlayers of fine and medium-bedded sandstones (10-30 cm). Having the total thickness of 124 m, deposits contain *Globigerina turkmenica* (Chalil.), *G. praebulloides* (Blow), *G. posttriloculinoides* (Chalil.), *G. frontosa* (Blow), *G. pseudoeocaena* (Subb.), *G.ouachitaensis* (Howe et Wall.), *Bolivina budensis* (Hantken), *Hastigerina micra* (Cole), *Cibicides ungerianus* (Orbigny) *Anomalina granosa* (Hantken), *A. simplex* (Brotzen), *Eponides trümpyi* (Maslakova), *Globigerinoides subconglobatus* (Chalil).

Hantkenina alabamensis zone corresponds to strata of grey mudstones with no fauna remains therein the Southeastern Caucasus stratigraphic scheme, this zone is conventionally corresponded in the upper successions of Lutetian Stage.

Kerestin Suite is built by limestones and marls corresponding to *Hantkenina alabamensis* zone. The Suite is represented by 5-7 m thick alternating greenish-white dense and soft marls, which directly underlie the Kum horizon. Marls contain fossils of *Globigerina eocaena* (Gümb.), *Globigerinoides subconglobatus* (Chalil.), (Subbotina, 1953).

Kum horizon corresponds to *Hantkenina alabamensis* (upper successions) and *Globigerina turkmenica* zones. Deposits of the horizon are built by brownish-grey thin-laminated marls with plenty of fossil scales and vertebrae of *Linolepis caucasica Rom*., and minor foraminiferas, e.g. *Globigerina turkmenica* (Chalil.), *Globigerina* ex gr. *bulloides* (Orb.), *Giümbelina* ex gr. *globifera* (Reuss), *Nonion micrus* (Cole), *Hantkenina alabamensis* (Cushm), *Acarinina rugosoaculeata* (Subb.), etc. Kum horizon is 40 m thick.

Upper Eocene, Priabonian Stage. Upper (green) Koun Suite is containing homogenous dark and yellowish-green mudstones with the interlayers of reddish-brown mudstones, siltstones and sandstones. Thickness of the Stage varies between 300 and 575 m in Gobustan.

Priabonian deposits are widely developed in the territory of Southeastern Caucasus where they are distinguished in *Globigerina corpulenta* and *Globigerina officinalis* zones.

Deposits of *Globigerina corpulenta* zone overlies *Globigerina turkmenica* series, and is represented by whitish-grey, greenish-grey and marly mudstones with the interlayers of grey, greenish-grey, reddish-brown sandstones.

The zone contains fossils of *Globigerina corpulenta* (Subb.), *G. eocaenica* (Terq.), *G. praebulloides* (Blow), *G. ouachitaensis* (Howe et Wall.), *G. inflata* (Orb.), *Globigerapsis index* (Finl.), *Bolivina caucasensis* (Chalil.), *B. binaensis* (Chalil), *Nonion agderensis* (Chalil), *Bulimina woodwardi* (Tutkowski), *Cibicides dutemplei* (Orbigny), *C. lobatus* (Walk. et Yac.) *etc*., *C. perlucidus* (Nutt.), *Globigerinella micra* (Cole), *Baggina iphigenia* (Samoil.), *Anomalina hantkeni* (Grzybowski), *A.granosa* (Hantken), *Globigerinoides rubriformis* (Subb.), *Nonion pseudomartkobi* (Chalil.).

Globigerina officinalis zone conformably overlies *Globigerina corpulenta* zone series. It is composed of grey, green, reddish-brown mudstones and marls with colorful mudstone and sandstone interlayers. Deposits of the zone contain fossils of *Globigerina officinalis* (Subb.), *G. pseudoeocaena* (Subb.), *G. inflata* (Orb.), *G. eocaena (Terq.)*, *G. postcretacea (Mjatliuk)*, *G. praebulloides* (Blow.), *G. ouachitaensis* (How.et Wall.), *Bolivina antegressa* etc (Subb.), *B. tuberna gradata* (Chalilov), *Nonion curviseptum* (Subb), *Pullenia bulloides* (d, Orb), *Hormosina ovulum* (Grzybowski), *Baggina iphigenia* (Samoilova), *Hastigerina micra* (Cole), *Ammodiscus incertus* (d, Orb.), *Glomospira charoides* (Park et Jon), *Cibisides lobatulus* (Walk. et Jac.), *Nutalloides trumpyi* (Nutt.).

Beloglin horizon preserves its' typical facies and micropaleontological features both in the North Caucasus and Crimea regions. In the North Caucasus the horizon covers **Belaya Glina Suite** composed of white limestones. The Suite is distinguished within *Globigerapsis tropicalis* zone and *Bolivina* containing stratas.

Greyish, greenish and bluish white marls of the horizon are rich with small foraminiferas, e.g. *Heterostomella siphonella* (Reuss), *Vulvulina spinosa* (Cush.), *Marginulina fragaria* (Gümb.), *M. bohmi* (Reuss), *Bulimina truncana* (Cümb)., *Bolivina antegressa* (Subb.), *B. nobilis* (Hant.), *B. floridana* (Cush.), *Uvigerina hispida* (Schw.), *Bifarina millepunctata* (Tutk.), *Valvulineria iphigenia* (Sami)., *Cassidulina globosa* (Hantk.), *Nonion curviseptus* (Subb.), *Globigerina bulloides* (d 'Orb.) var. *bulloides* (d 'Orb.), *G. corpulenta* (Subb)., *G. inflata* (d 'Orb.), *G. eocaenica* (Terq), *Globigerinoides conglobatus* (Brady), *Anomalina acuta* var. *taurica* Sami., *Planulina costata* (Hantk.), *Cibicides pigmeus* (Hantk)., *Globigerinoides conglobatus* (Brady), *Globigerina inflata* (Orb.), *Bolivina coelata* (Cushm)., upward the section *Globigerina corpulenta* (Subb.), *Uvigerina* ex gr *jacksonensis* (Cushm.), and more upward *Gyroidina soldanii* (Orb)., *Eponides umbonatus* (Reuss), *Cibicides ungerianus* (Orb.), *C. dutemplei* (Orb.), C. *refulgens* (Montl.), *Bolivina nobilis* (Hantk.), *B. beyrichi* (Reuss), *B. antegressa* (Subb.), *Bulimina truncana* (Gümb.), *Uvigerina pygmea* (Orb.), *Nonion curviseptus* (Subb.), *Angulogerina angulosa*. (Will.), etc. The horizon's thickness is 80-100 m. (Subbotina, 1950).

Comparison of Lower Paleogene deposits of the Southeastern and North Caucasus regions is provided in Table.

Conclusion

Conducted studies resulted in the detail stratigraphic descriptions of the Lower Paleogene deposits in the Southeastern Caucasus and the development of their microfaunistic and lithological characteristics.

For the first time Paleogene Suites of Azerbaijan have been correlated to their stratigraphic analogues in the North Caucasus.

Table

Comparison of Southeastern and North Caucasus Lower Paleogene deposits

System	Series	SubSeries	Stage	Suite	Southeastern Caucasus	North Caucasus	
Paleogene	Eocene	Upper	Priabonian	Koun	*Globigerina officinalis*	Beloglin	*Globigerapsis tropicalis* *Bolivina*-lar
					Globigerina corpulenta		
		Middle	Bartonian		*Globigerina turkmenica*	Kum	*Globigerina turkmenica*
					Hantkenina alabamensis	Kerestin	*Hantkenina alabamensis*
			Lütet		*Acarinina rotundimarginata*	Cherkess	*Acarinina rotundimarginata* *Acarinina bullbrooki*
					Acarinina bullbrooki		
		Lower	Ypresian		*Globorotolia aragonensis*	Georgiyev	*Globorotolia aragonensis* *Globorotolia marginodenta*
					G. marginodentata		
					G. subbotinae	Abazin	*Globorotolia subbotinae*
	Paleocene	Upper	Thanetian	Sumgayit	*Acarinina subsphaerica*		
					Acarinina acarinata	Qoryachiy klyuch	*Acarinina acarinata* *Acarinina djanensis*
		Lower	Selandian		*Globorotalia angulata*		
			Danian	Ilkhidagh	*Acarinina incontans*	Elburgan	*Acarinina incontans* *Globorotalia triloculinoides* *Globigerina taurica*
					Globoconusa daubjergensis	Kuban	

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CƏNUB-ŞƏRQİ QAFQAZIN ALT PALEOGEN ÇÖKÜNTÜLƏRİNİN PLANKTON FORAMİNİFERLƏRƏ GÖRƏ STRATİQRAFİYASI

H.Ə. Allahverdiyeva

Cənub-Şərqi Qafqazın Alt Paleogen çöküntülərinin stratiqrafiyası və ona uyğun lay dəstələrinin mikrofauna və litologiyasına görə xarakteristikası verilmişdir. Plankton foraminiferləri komplekslərinin müfəssəl təhlili nəticəsində tədqiqat rayonunun və Şimali Qafqaz Alt Paleogen çöküntülərinin korrelyasiyası aparılmışdır.

СТРАТИГРАФИЯ НИЖНЕПАЛЕОГЕНОВЫХ ОТЛОЖЕНИЙ ЮГО-ВОСТОЧНОГО КАВКАЗА ПО ПЛАНКТОННЫМ ФОРАМИНИФЕРАМ

Х.А. Аллахвердиева

Дана стратиграфическая характеристика нижнепалеогеновых отложений Юго-Восточного Кавказа на основании микрофаунистического и литологического состава соответствующих отложений. В результате детального анализа комплексов планктонных фораминифер произведена корреляция нижнепалеогеновых отложений района исследований и Северного Кавказа.

SEDIMENTATION CONDITIONS OF LOWER PLIOCENE DEPOSITS IN LOWER KURA DEPRESSION (BASED ON GEOCHEMICAL CRITERIA)

The paper presents complex analysis of the Productive Series sediments (PS) (lithofacies, chemical composition and reservoir properties), and discussion on regional regularities of their change within the Kurovdagh-Neftchala anticline zone of the Lower Kura depression. It has been revealed that lithology of the studied sediments is dominated by a silt fraction. The southeastward trend (from Kyurovdagh field towards Neftchala field) of increase of proportion of fine fraction is observed. It determined the similarly directed V_{shale} lowering trend as well as decrease of MgO, P_2O_5 and Fe_2O_3, and increase of CaO contents.

It was concluded based on geochemical criteria that the Lower Pliocene basin was characterized by shallow water sedimentation with frequently occurring transgressions and regressions and salinity changes. We can state that the level of water mineralization was low.

These regional lithological changes of the PS sediments are well correlated with their oil-gas content. The northwest--southeast trending reduction of hydrocarbon reserves, initial well rates and the methane homologs in extracted gases is observed. This trend is, apparently, related to increase of clay fraction in PS reservoir rocks.

Keywords: Productive Series, sedimentation conditions, geochemical and lithofacies composition, reservoir properties, oil-gas content, Lower Kura depression, Azerbaijan.

A.A. Feyzullayev

Azerbaijan National Academy of Sciences,
Institute of Geology and Geophysics,
H.Cavid pr. 119, Baku, AZ 1143
E-mail: fakper@gmail.com

V.N. Lunina

Azerbaijan National Academy of Sciences,
Institute of Geology and Geophysics,
H.Cavid pr. 119, Baku, AZ 1143
E-mail: luna-az@rambler.ru

G.G. Ismayilova

Azerbaijan National Academy of Sciences,
Institute of Geology and Geophysics,
H.Cavid pr. 119, Baku, AZ 1143
E-mail: gulkhar@rambler.ru

I.M. Mammadova

SOCAR Research and Design
Institute of Oil and Gas,
E-mail: mamedaslan@rambler.ru

G.T. Ahmadova

Oil nd Gas Production
Department of G.Z.Tagiyev,
E-mail: gunayheydarova@mail.ru

Introduction

The first priority task of today’s oil-gas exploration is assessment of production units’ heterogeneity (Huseynova, Khuduyeva, 2016; Pulkina, Zimina, 2012; Sidorov, Nizayev, 2006; Feyzullayev, 1992; Feyzullayev et al., 2018).

In the South Caspian basin the Pliocene Productive Series is a main reservoir unit containing large hydrocarbon reserves. The current paper is dealing with the regularities of sedimentation conditions and reservoir properties changes of the Productive Series sediments within the Kurovdagh-Neftchala anticline zone of the Lower Kura depression (Figure 1).

Material

During the long-term development of oil-gas fields in the South Caspian basin a large data set was accumulated that allows detailed investigation of reservoir properties changes in the regional context.

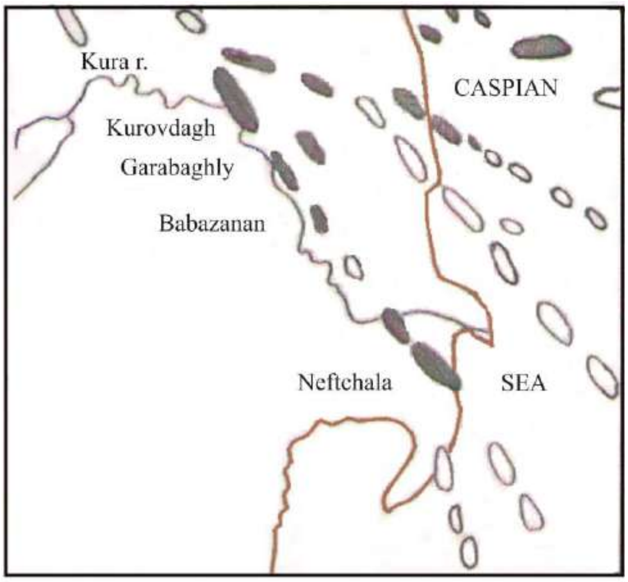

Figure 1. Lower Kura Petroleum Province and adjacent offshore area of the Caspian Sea. Location scheme of studied oil-gas fields

The questions that arose during fields' development have been investigated based on studies of the composition, petrophysical, chemical and other characteristics of PS deposits.

Study of geochemical and lithofacies composition as well as reservoir properties of the PS sediments was based on the analysis of 277 core samples collected from 64 boreholes, including 167 samples (61 boreholes) from Kurovdagh field, 35 samples (13 boreholes) from Garabagly structure, 48 samples (7 boreholes) from Babazanan structure and 27 samples (13 boreholes) from Neftchala field.

In order to eliminate an influence of a stratigraphic factor the same age rocks have been analyzed and compared within one data set. These studies include V horizon of the PS, which is analogous to Surakhany Suite lowers in Absheron stratigraphic scheme of the Productive Series.

Discussion of study results

Sedimentation conditions of the Productive Series sediments according to geochemical criteria

There are shown in the Table 1 and Figure 2 ratios of different oxides in the Productive Series sediments that are used as chemical indicators of PS sedimentary environment.

The data received display the following patterns.

The values of *TiO_2/Al_2O_3 ratio* significantly declines in the direction from Garabaghly towards Neftchala field (Figure 2), which testifies to increased depth of the sedimentation basin (Yudovich, Ketris, 2011) and change from humid to more arid conditions.

Table 1

Chemical indicators of PS sedimentation conditions

Area	CaO/MgO	Na_2O/K_2O	SiO_2/Al_2O_3	TiO_2/Al_2O_3	Fe_2O_3/MnO	K_2O/Al_2O_3
Kurovdagh	3,11	1,38	4,25	0,12	58,8	0,180
Garabaghly	2,54	1,22	4,72	0,09	72,9	0,217
Babazanan	6,31	1,11	3,78	0,08	34,2	0,217
Neftchala	6,27	1,41	4,61	0,07	23,8	0,211

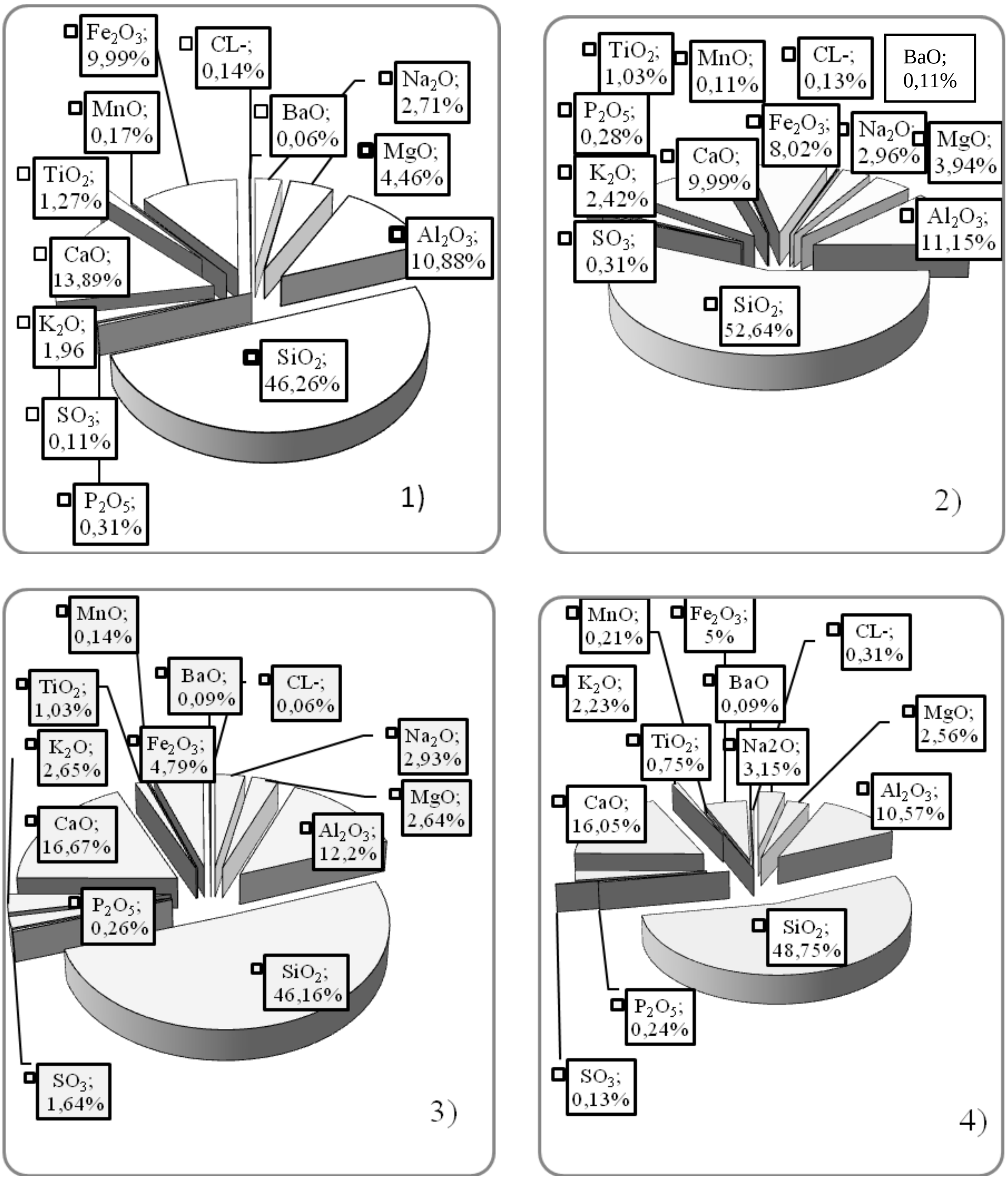

Figure 2. Chemical composition of core samples from different South Caspian fields, Lower Kura depression: **1** – Kurovdagh (well #425, interval 2496-2500 m); **2** – Garabagly (well #76, interval 2690-2700 m); **3** – Babazanan (well #49, interval 4311-4320 m); **4** – Neftchala (well #731, interval 2840-2845 m)

According to *Na_2O/K_2O ratio* values *(>1)* chemical weathering of the provenance area was weak (Bektobayeva et al., 2013).

Fe_2O_3/MnO ratio reflects the geochemical conditions in the depositional basin (Yudovich, Ketris, 2011) and indicates the elevated reducing conditions from Garabagly towards Neftchala field.

K_2O/Al_2O_3 ratio (potassium module) lets us to assess the occurrence of K containing rock-forming minerals in rocks such as micas and potassium fieldspars (Cox et al., 1995). Usually

K_2O/Al_2O_3 value doesn't exceed 0.3 in redeposited fine-grained terrigenous sediments, and these values are typical for the studied fields.

CaO/MgO ratio values (>1) point at low mineralization of the Lower Pliocene sedimentation basin (Bekbotayeva et al., 2013). These values reduce in the direction from Garabagly towards Neftchala field.

SiO_2/Al_2O_3 ratio is sensitive to sediment recycling and weathering processes. The longer the terrigenous material is transported from its' provenance area, the more sediments tend to be enriched by the quartz than the fieldspar (Kazansky, 1983; Roser, Korsch, 1986). Values of this ratio do not significantly change within the studied fields and remain within 3.78-4.72 limits. These data testifies to more or less equal distance from provenance areas for both studied fields, and equal enrichment of sediments with quartz rather feldspars.

Sr/Ba ratio is a criteria used to distinguish between marine and freshwater sediments. The ratio's value is usually less than 1 for freshwater, and more than 1 for marine deposits (Katchenkov, 1959; Bektobayeva et al., 2013). Application of Sr/Ba ratio for paleoenvironmental reconstructions is based on accumulation of Ba in shallow water sediments in contrast to Sr, which precipitate only from the sea water, and its content in sediments increases with the salinity growth. Thus, high Sr/Ba ratio indicates an increased salinity of the basin. .

In Figure 3 the distribution of Sr/Ba ratio's values in the Productive Series sediments exposed in Kirmaki and Yasamal Valleys are shown (Huseynov, 2003). The Sr/Ba curve displays rapid Sr/Ba ratio variations along PS section testifying to rapid salinity changes in the Pliocene basin.

Lithological changes in the Productive Series sediments

The data demonstrate the lateral lithology changes from Kurovdagh field towards Neftchala field expressed in reduced number of sand beds. In Neftchala field sandy sediments containing more than 50% of sand fraction were not revealed. As seen from the Figure 4 the southeastward trend of decrease of proportion of sand fraction in sediments of horizon V from 2,7 value in Kurovdagh field to 0,37 value in Neftchala field is observed. Thus, sandiness nearly reduces by 7 times.

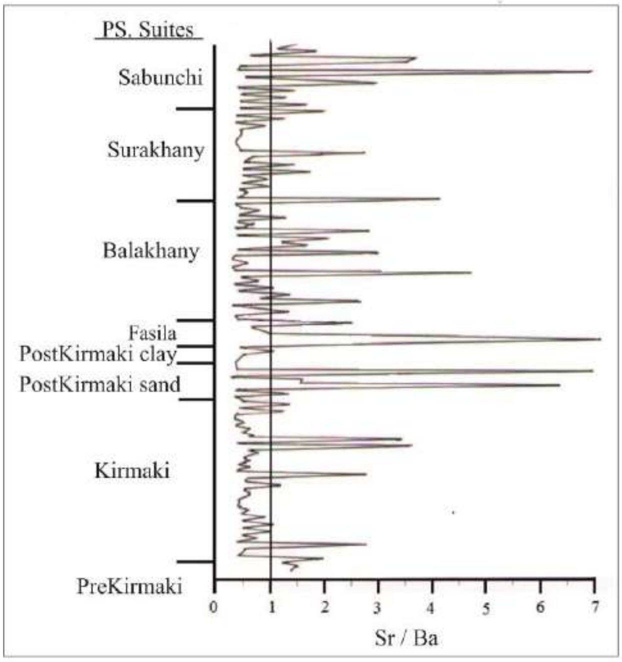

Figure 3. The curve of Sr/Ba ratio values in Productive Series sediments in Kirmaki and Yasamal Valleys (Huseynov, 2003)

Reservoir properties of the Productive Series rocks within the structures belonging to Kurovdagh-Neftchala anticline zone are mainly determined by a prevalence of silt fraction. Reservoir properties of different lithology rocks are largely variable. For instance, the porosity of sandstones varies from 16% to 47% and permeability from $7*10^{-15}m^2$ to $676*10^{-15}m^2$. The common southeast directed trend of the worsening of reservoir properties of PS rocks is recorded (Figure 5).

We have recorded a link between lithological variations and hydrocarbon gases composition (Figure 6). In the southeast direction a less share of homologs of methane in PS sediments is observed, which is apparently related to an increased content of the clay fraction having high adsorption properties and detaining heavy hydrocarbon gases. As seen from Table 2, hydrocarbon reserves reduce in the same way too (Feyzullayev, 1992).

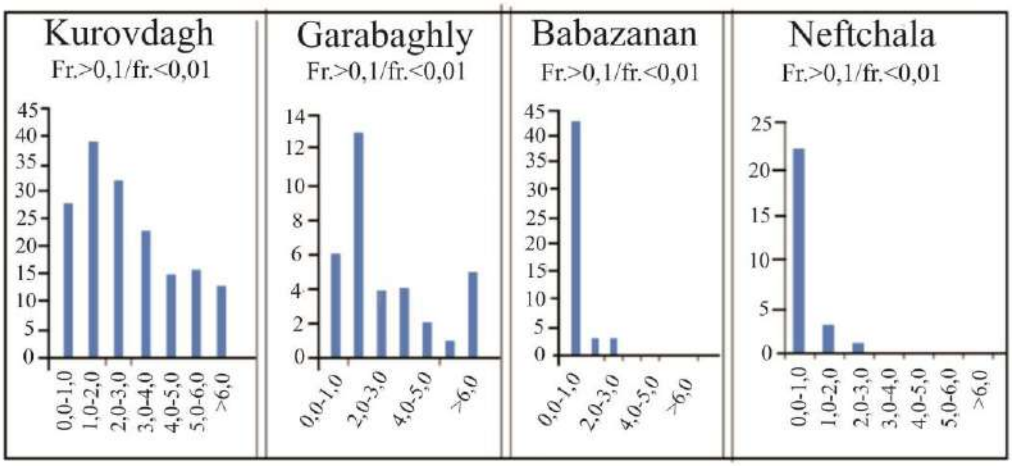

Figure 4. The plot reflecting the proportion of sand fraction's change in rocks of horizon V (analogues to Surakhany Suite) in Kurovdagh, Garabaghly, Babazanan and Neftchala areas

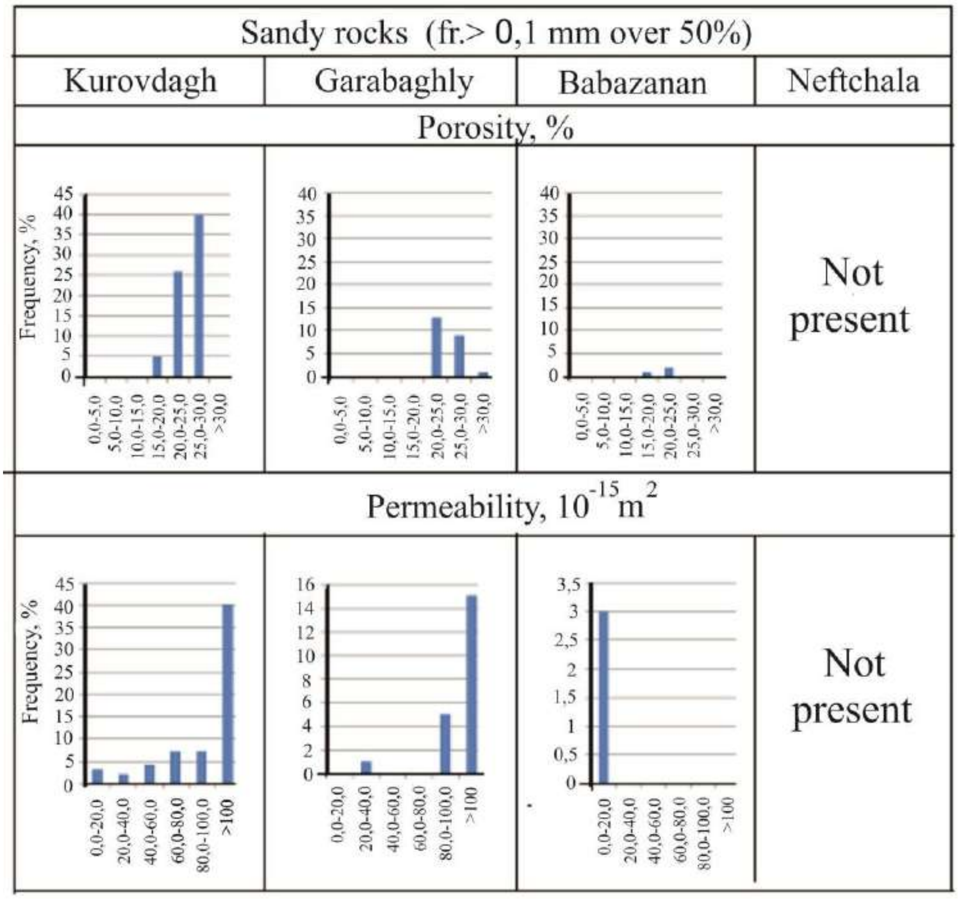

Figure 5. The plot reflecting reservoir properties changes within the Kudovdagh - Neftchala anticline zone

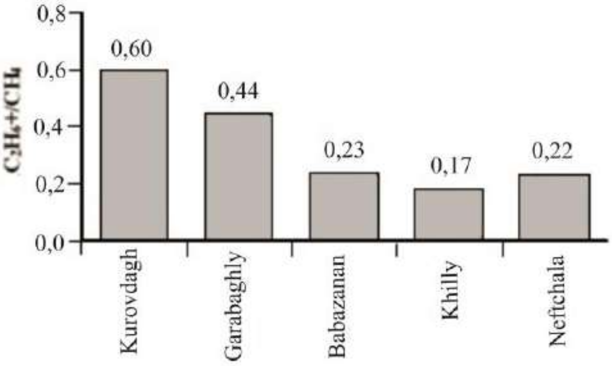

Figure 6. Histograms showing an average C_2H_6+/CH_4 ratio's values in the gases from PS sections of the Kurovdagh - Neftchala anticline zone

Table 2

A+B+C categories of oil-gas reserves of the upper horizons of the Productive Series as of 01.01.1968

Deposit	Oil (standard unit)	Gas (standard unit)		
		dissolved	free	total
Kurovdagh	115,4	29,8	23,4	34,0
Garabaghly	110,8	18,4	1,0	18,6
Neftchala	1,0	1,0	-	1,0

Table 3 demonstrates some production characteristics of the horizon V in the Kurovdagh, Garabaghly and Neftchala fields. Following changes are recorded from Kurovdagh field in the northwest towards Neftchala field in the southeast: 1) oil-gas contour 4.6 times reduces; 2) 38% reduction of N/G ratio and 64% decline of oil recovery factor; 3) initial oil flow of the wells 4.5 times fall; water flow / oil flow ratio 3 times increases that testifies to significant water saturation of the reservoir rocks and reduction of hydrocarbon reserves.

Conclusions

The analyses of chemical, lithological compositions and reservoir properties of the Productive Series sediments show the following results:

1. MgO, P_2O_5 и Fe_2O_3 contents reduce from Kurovdagh filed in the northwest towards Neftchala field in the southeast. PS sediments in Babazanan and Neftchala fields are characterized by relatively high CaO contents.

2. From Garabaghly towards the Neftchala fields an increase of the depositional basin's depth and reduction of the geochemical conditions are observed.

Table 3

Production characteristics of Kurovdagh, Garabaghly and Neftchala fields

Field	Start of operation	Number of production horizons	Oil contour $10^4 m^2$	N/G, m	Initial oil flow rate, standard units	Water flow / oil flow	Oil recovery coefficient
Kurovdagh	1955	25	1280	16	178,2	7	0,238
Garabaghly	1960	11	469	17	84,4	2	0,124
Neftchala	1931	15	279	10	39,2	23	0,085

3. In general, the Lower Pliocene basin within the studied area was characterized by shallow depth, high-frequency transgression-regression cyclicity and rapidly changing mineralization of the water, which was at low level.

4. Remoteness of studied sediments from the provenance areas was more or less equal that caused the equal quartz/ feldspar ratio in the sediments.

5. The share of fine fraction increases from Kurovdagh field in the northwest towards Neftchala field in the southeast that caused decrease in the sand/clay fractions ratio and worsening of reservoir properties of the Productive Series rocks.

6. A recorded lithology change trend is well correlated with the oil-gas content variations in the Productive Series succession. It has been revealed southeast directed decrease of hydrocarbon reserves, initial oil flow and content of methane homologs in the recovered gas that is linked with the increasing Vshale values in the PS section.

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AŞAĞI KÜR ÇÖKƏKLİYİNDƏ ALT PLİOSEN ÇÖKÜNTÜLƏRİNİN ƏMƏLƏGƏLMƏ ŞƏRAİTİ (GEOKİMYƏVİ KRİTERİLƏR ƏSASINDA)

Ə.Ə. Feyzullayev, V.N. Lunina, G.H. İsmayılova,
İ.M. Məmmədov, G.T. Əhmədova

Məqalədə Məhsuldar qatın (MQ) kompleks analizi (litofasial, kimyəvi tərkibi və süxurların həcm-süzmə xüsusiyyətləri) yerinə yetirilmiş və Aşağı Kür çökəkliyində Kürovdağ-Neftçala antiklinal zonası sərhədində bu parametrlərin dəyişməsinin regional qanunauyğunluğuna baxılmışdır. Tədqiq olunan süxurların litoloji tərkibində alevrit fraksiyasının üstünlük təşkil etdiyi müəyyən edilmişdir. Bununla əlaqədar ŞmQ-dən (Kürovdağ sahəsi) CŞ-ə (Neftçala sahəsi) qumlu fraksiyanın gilliyə nisbətinin göstəricilərinin azalması müşahidə edilir ki, bu da həmin istiqamətdə süxurların süzülmə-tutum xassələrinin pisləşməsində görünür. Həmin istiqamətdə MgO, P_2O_5 *və* Fe_2O_3 *oksidlərinin miqdarının azalması eləcə də CaO-nin miqdarının artması qeyd edilir. Geokimyəvi kriterilər əsasında Alt Pliosen hövzəsi bütünlükdə sahil-dəniz sedimentasiyası şəraiti ilə xarakterizə olunur. Bununla əlaqadar transqressiyanın reqressiya ilə tez-tez əvəz olunması və müvafiq olaraq suyun duzluluğunun ehtizazları baş verir. Eyni zamanda suyun minerallaşması yüksək deyildir.*

Süxurların litofasial xüsusiyyətlərinin dəyişilməsinin regional xarakteri MQ neft-qazlılığı ilə yaxşı korrelyasiya edir. Rezervuar süxurlarının gilliliyinin artması ilə əlaqədar ŞmQ-dən CŞ-ə doğru karbohidrogen ehtiyatlarının, quyuların ilkin debitlərinin və alınan qazda metanın homoloqlarının azalması müəyyən edilmişdir.

УСЛОВИЯ НАКОПЛЕНИЯ НИЖНЕПЛИОЦЕНОВЫХ ОСАДКОВ В НИЖНЕКУРИНСКОЙ ВПАДИНЕ (ПО ГЕОХИМИЧЕСКИМ КРИТЕРИЯМ)

А.А. Фейзуллаев, В.Н. Лунина, Г.Г. Исмайлова,
И.М. Мамедова, Г.Т. Ахмедова

В работе выполнен комплексный анализ (литофациальный, химический состав и фильтрационно-емкостные свойства пород) Продуктивной толщи (ПТ) и рассмотрены региональные закономерности их изменения в пределах Кюровдаг-Нефтечалинской антиклинальной зоны Нижнекуринской впадины. Установлено, что в литологическом составе изученных пород преобладает алевритовая фракция. При этом с СЗ (площадь Кюровдаг) на ЮВ (площадь Нефтчала) наблюдается уменьшение значений отношения песчаной фракции к глинистой, что проявляется ухудшением в этом направлении фильтрационно-емкостных свойств пород. Отмечено закономерное уменьшение в указанном направлении содержания оксидов MgO, P_2O_5 и Fe_2O_3 и увеличение содержания CaO. По геохимическим критериям сделан вывод, что, в целом, нижнеплиоценовый бассейн характеризовался прибрежно–морской обстановкой осадконакопления, с частой сменой трансгрессий и регрессий и, соответственно, колебаниями солености воды. При этом минерализация воды была невысокой.

Региональный характер изменения литофациальных свойств пород хорошо коррелируется с нефтегазоносностью ПТ. Выявлено уменьшение запасов углеводородов, начальных дебитов скважин и содержания гомологов метана в извлекаемом газе в направлении с СЗ на ЮВ, связанное, вероятнее всего, с увеличением глинистости пород резервуара.

DEVELOPMENT OF LARGE BARRIER-LAGOON SYSTEMS ON THE EASTERN AND SOUTH-EASTERN BALTIC SEA COASTS

The paper is dealing with the geological structure and evolution of large barrier-lagoon systems in the eastern and southeastern coasts of the Baltic Sea. The data available on some coastal - deltaic plains in the Leningrad Region, Latvia and Lithuania are discussed in the article. The data obtained display a similar mechanism of these systems' evolution. A significant rise of the sea level during the Littorina Sea transgression initiated formation of large transgressive bars at the margins of deltaic plains and lagoons on the surface of these plains.

Keywords: sea-level change, coast, barrier-lagoon system, paleogeography

E.N. Badyukova

Lomonosov Moscow State University,
Faculty of Geography,
E-mail: badyukova@yandex.ru

L.A. Zhindarev

Lomonosov Moscow State University,
Faculty of Geography,
E-mail: lutas2005@yandex.ru

S.A. Lukyanova

Lomonosov Moscow State University,
Faculty of Geography,
E-mail: Geomorpho2006@yandex.ru

G.D. Solovieva

Lomonosov Moscow State University,
Faculty of Geography,
E-mail: g.d.solovieva@yandex.ru

Introduction

The geological and geomorphological background of large barrier-lagoon systems have been recently studied in details in the SE Baltic region including the Curonian and Vistula Spits and the adjacent coasts of the central and eastern Poland during several field campaigns (Badyukova et al., 2008). The results strongly suggest that sea level fluctuations are the key factor influencing the barrier systems' formation and evolution. This factor was also crucial in the evolution of large constructional landforms on the eastern coasts of the Baltic Sea, including the Gulf of Finland, Latvian and Lithuania coasts.

Neva Lowland

The lowland is located between the Gulf of Finland and the Ladozhskoye Lake. The area is characterized by a flat relief with rare small elevations. Two terrace levels are distinguishable; the upper of them is linked to the Baltic Ice Lake (dated to 12600-10300 BP), which is a freshwater lake formed at the southern margin of the Scandinavian ice sheet. The younger – Littorina Sea (brackish water stage of the Baltic Sea dated to 7500-4000 BP) terrace – forms a gently sloping plain that occurs as a narrow fringe surrounding the Gulf coasts. Its boundaries are marked by ancient beach ridges and scarps modeled by marine erosion (Znamenskaya, 1956).

The Neva Lowland includes Sestroretsk and Lakhti depressions, together with the land adjoining the lowermost part of the Neva River. In spite of extensive geological data set displaying the evolution of the eastern part of the Gulf of Finland in the Holocene, there are several "white spots" still to be investigated.

Sestroretsk basin and Sestroretsk Razliv Lake.

The Sestroretsk Razliv Lake did not exist until the early XIX century. Its present area was occupied by two rivers - Sestra and Chernaya; a stream formed as a result of their joining was known under the name of the Gagarka River. The dam constructed latter in 1723 resulted in flooding of the lowermost parts of the Sestra and Chernaya Rivers' valleys and a part of the coastal plain. The inundated areas formed the Lake Razliv, which is about 5 km long and 4 km wide; the present lake is drained by artificial channel (Sestra Zavodskaya) connecting two dune ridges.

The Sestroretsk depression containing the lake is separated from the Gulf of Finland by a 1–3 km wide and 10 km long sandy barrier. The sand beds are thickest in the western part of the barrier; there they form several dune ridges up to 10–12 m in height (Znamenskaya, 1956) creating an echelon along the sea coast. The wind direction determines the dunes migration from west to east. The previously buried trees are exposed in deflation basins (Sokolov, 1884). Similar processes are typical in the Curonian and Vistula spits (Badyukova et al., 2008). There are vast marshes developed at the back side of each large sand ridge, such as Kanavnoye and Sestroretsk marshes. The latter one is the largest marsh in the region.

The dune formation on the Gulf of Finland coasts started about 3000–3500 years ago. By that time the region had been already inhabited according to archeological findings recovered from the dunes near the town of Sestroretsk. 11 archeological sites were excavated from the dunes on the western coast of the Lake Razliv; they contain some Stone Age tools and numerous ceramic fragments attributed to the III – II centuries BC. The Neolithic sites Sosnovaya Gora and Sosnovaya Gora 1 were found on the eastern coast of the Sestroretsk Razliv Lake, within a rather narrow sand ridge. In the Sosnovaya Gora 1 site stratigraphical, lithological, and geochemical studies have been conducted. The results obtained allow reconstructing the principal stages of the environmental evolution and colonization by primitive people. The ceramic fragments recovered from that site are dated to ~ IV millennium BC – 4890±35 yr. BP (3715–3636 cal).

The ridges are 10–13 m a.s.l. and have pines in the NE of Sestroretsk marsh. Judging from the map and description done in XIX century these ridges can be interpreted as dunes related to one of the Littorina Sea coastline development stage. This coastline had a barrier-lagoon complex (Figure 1).

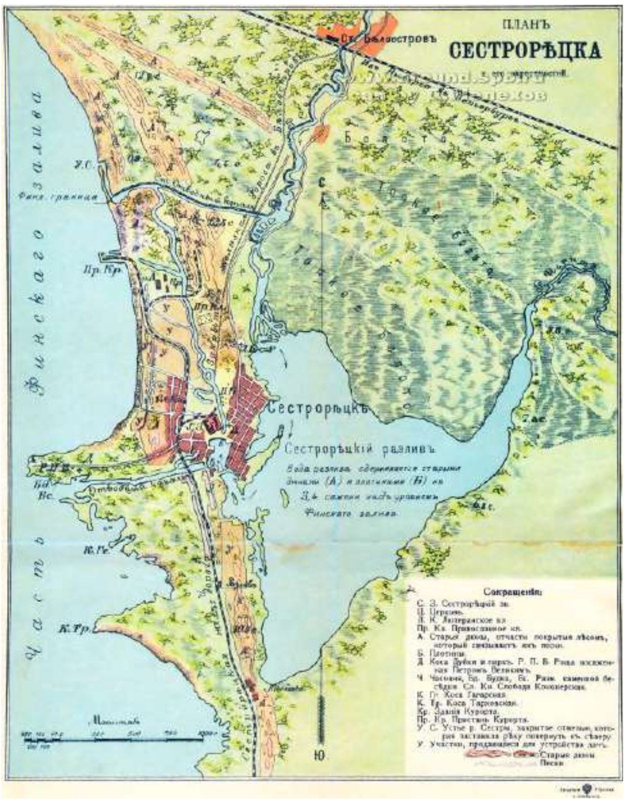


Figure 1. The Sestroretsk Razliv Lake mapped at end of XIX century

All the boreholes drilled on the Sestroretsk marsh penetrated a 1.5 m to 3 m thick peat layer and reached at a depth of 4–5 m a diatom gyttja attributable to the Littorina Sea. The gyttja is 3–4 m thick, sometimes up to 10 m (Belikov, 1999). Similar deposits are found on the right bank of the Sestra Zavodskaya channel, 200 m downstream from the railroad bridge; the diatom gyttja of the Littorina age occurs there at a depth of ~3 m under aeolian sands. Such succession is traced over a large area (Yakovlev, 1925).

All above mentioned allow us suggesting that the infilling of the ancient Sestra River valley with up to 50 m thick sediments started at the time of Littorina transgression and was accompanied by inundation of the coastal plain. The coastal plain was separated from the sea by a barrier; the old lagoon formed behind this barrier turned into swamp at recent time. All subsequent fluctuations of the sea level and the post-glacial isostatic uplifts of the land surface resulted in the gradual shoreline movement seaward and development of a series of barrier-lagoon systems. The Sestroretsk dunes represent the youngest such large barrier.

Lakhti depression and Lakhtinsky Razliv Lake.

The Lakhtinsky Razliv Lake is attached to the Lakhti depression at a level of around 3 m a.s.l. The lake is fed by two rivers – Kamenka and Chernaya, and is connected with the Nevskaya Guba bay by a channel. A large up to 4 m in height barrier separates the lake basin from the sea. The barrier has southeast orientation and contains alternating ridges and linear depressions trending from W to E (Polynov et al., 1924).

A very deep buried valley attached to a deep-seated regional tectonic sublatitudinal fault is identified in the Primorsk region. The Lakhti depression partially coincides with this buried valley (the side tributaries of the buried valley are found in the vicinities of Ol'gino village), and partially with an active submeridional fault (Karpova, 2014). The Lakhti depression occupies the most part of the wetland. It has been studied since the early XX century. Particular interest have works by K.K.Markov (1931) who in details described sedimentary sections penetrated by boreholes (Figure 2 A, B). He mentioned two peat horizons separated by a layer of sandy loam. Judging from diatom and pollen assemblages this layer can be dated as Littorina age. Later multidisciplinary studies of the Lakhtinsky Razliv deposits make is possible to subdivide these sediments into Yoldia Sea (weakly saline sea dated to 11700-10700 BP), the Ancylus Lake (freshwater lake dated to 10700-9800 BP) and the Littorina Sea successions (Figure 2 C, D) (Morozov, 2012). A layer of gyttja from a depth of 2.6 to 2.9 m was dated by ^{14}C to 9160±150 yr. BP (10 746–9891 cal. BP).

In the borehole C the upper portion of the section is composed of bluish-gray silty clay with rare black hydrotroilite interlayers, and light brown fine sands and clays of the Littorina age. Upward the section they are gradually replaced with dark brown peat. The radiocarbon data obtained for the sample collected from the peat's base show that the Littorina Sea regression and peat accumulation began at 2890±100 yr. BP (3268–2790 cal.) (Morozov, 2012).

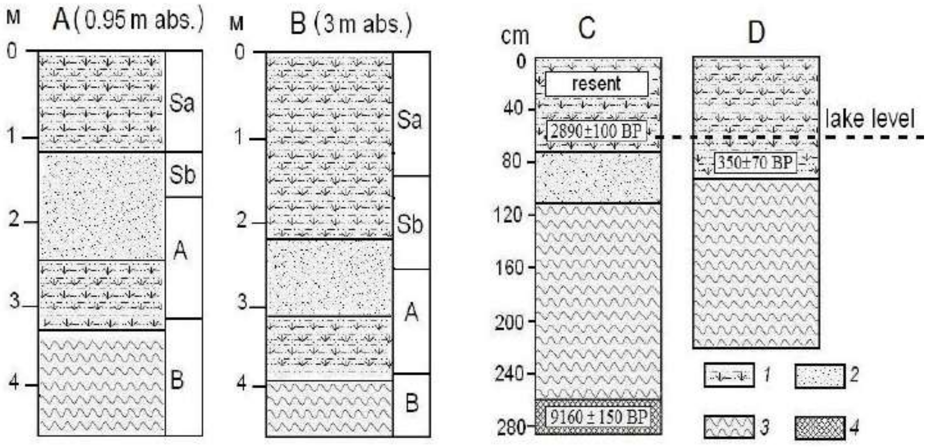


Figure 2. Boreholes in the Lakhti wetland. **A, B** – according to Markov, 1931; **C, D** – according to Morozov, 2012). **1** – peat, **2** – sand, **3** – clay, **4** – gyttja

Boreholes drilled near the Ol'gino settlement penetrated marine sands and reached buried peat layer of the Littorina age at a depth of 4–6 m (Yakovlev, 1925). As follows from the drilling results the barrier has been gradually migrating landward. Under conditions of the rising sea level the coastal plain was partially inundated, and a lagoon formed behind the bar. Such a mechanism of the barrier-lagoon system development is universal and has been observed in many coastal regions (Badyukova et al., 1996).

Several boreholes drilled within the Lakhtinsky Razliv Lake at different depths reached a weakly decomposed peat horizon. The age of this horizon by ^{14}C data was estimated as 314 ± 100 yr BP. Thus, these data display the lower position of the Baltic Sea level at that time comparing with the present one. Geological and geomorphological analysis of the Curonian and Vistula Spits also provide evidences of the Baltic Sea level fluctuations during the historical time. Two of its high stand (0.5–1.0 m above the present Baltic Sea level) are dated to ~1700 BP, and to the Viking epoch (IX–X centuries) (Badyukova et al., 2010).

The Neva Lowland within the limits of Saint-Petersburg city

Paleoenvironmental reconstructions in the eastern part of the Gulf of Finland are particularly complicated by the man-induced changes in landscapes. That makes studies of archeological objects particularly significant. The first archeological site of the Neolithic – Early Metal age discovered in the Neva River basin – Okhta 1 – is located near the Saint-Petersburg city center, on the Okhtinsky Point (Gusentsova et al., 2010; Kulkova et al., 2010).

By detailed studies, using recent scientific approach and methods the Littorina Sea coastline within the city limits has been identified. The coastline is distinctly seen in the topography as a series of erosion scarps and beach ridges (Sorokin et al., 2015) traced on the Neva Lowland for a distance up to 13 km from the today's coastline. One of the largest constructional landforms on the Neva Lowland within the city boundaries is the sandy Ligovka Spit extending from the southern coast of Neva Guba towards NE as far as the Neva channel (Figure 3).

The Ligovka Spit surface is at 7–8 m a.s.l., while the surface of Littorina age around the spit is 3 to 4 m lower. The spit is about 10 km long and from 600 m to 2 km wide. It is composed of cross-bedded (diagonal-bedded) sands of Littorina age replaced upwards with coarse sands containing gravels and pebbles. The total thickness of sands varies from 5 to 7 m. The entire spit body does not lie on marine sediments as it is most typical of such constructional landforms; it occurs directly on the continental deposits. The sands overlie peat beds over the entire length of the spit. The deposits of peat (changing sometimes into gyttja) exceeds in thickness all the known buried peatlands of the Littorina age (Yakovlev, 1926). Within the city boundaries maximum to 13.6 m thick the Littorina deposits are mostly composed of bluish and gray sands, sandy silts and loams, rarely they include vivianite particles and peat interlayers traced along their strike. The gyttja, clays including those known as therapeutic muds in the Sestroretsk Razliv Lake (Geological atlas, 2009) are also assigned to the Littorina Sea deposits.

Judging from the morphological and lithological characteristics of the Ligovka Spit, it can be conluded that this formation landform is not connected to marine regressional, though that is an idea of a number of researchers (Yakovlev, 1926; Markov, 1931; Gusentsova et al., 2010; Sorokin et al., 2015). We have considered the Ligovka Spit as a large barrier developed at the margin of the coastal plain against the background of rising sea level; in the process a lagoon was formed at the back of the barrier, while the bar itself grew in thickness and moved towards the lagoon. We have proposed a similar scenario of the barrier-lagoon systems evolution on the Curonian and Vistula Spits. Such a mechanism of the barrier formation is actually universal and may be observed on all the marine coasts (Badyukova et al., 1999).

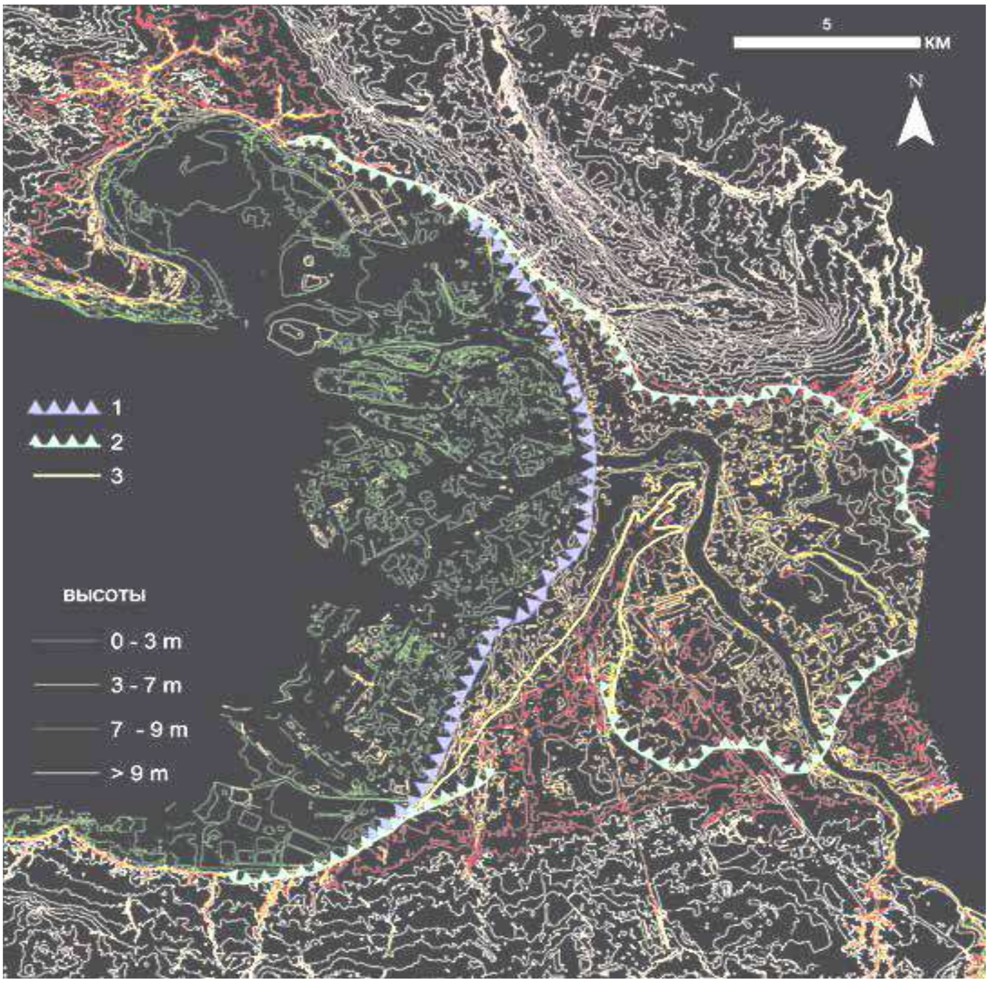


Figure 3. Areas of the Littorina Sea coastal landforms. **1** – boundary of the "Vasileostrov" terrace 0–3 m a.s.l. dated to Old Baltic transgression; **2** – "Okhtinskaya" terrace boundary dated to the maximum stage of the Littorina transgression; **3** – Ligovka Spit (outlined by 6 m isohypse), according to Sorokin et al., 2015

It can be concluded that the lagoon was developed at the initial stages of the Littorina transgression over a significant part of the present day city area; it was separated from the Gulf of Finland by a large barrier. Lagoonal sediment composed of fine laminated sands and silts are exposed at the confluence of the Neva and Okhta rivers. The environments on the lagoonal coasts were beneficial for human habitation. The earliest archeological sites on the Okhtinsky Point are dated to the first half of the V millennium BC (Gusentsova et al., 2010). The lagoon was undoubtedly drained at that time (as it received rivers) and was permanently connected with the sea. During the large-scale Littorina transgression and the subsequent regression of the sea, some oscillations of the Baltic Sea level occurred (recorded, in particular, in the Okhta I archeological site). The sea level decline and rise resulted in development of a wide arc of the 'Vasileostrov' terrace modeled by marine erosion (Sorokin et al., 2015).

The Narva–Luga Lowland

The lowland is situated at the mouth of the Narva and Luga rivers and is distinguished because of complicated topography. Lakes and swamps occupy a considerable portion of its surface, with constructional coastal landforms of various ages between them. The lowland includes three isolated plateau fragments known as Kurovitsky, Krikovsky and Kurgalsky, the latter forms a peninsula of the same name separating the Narva Bay from the Luga Bay.

The western slope of the peninsula drops towards the Narva Bay as a scarp with a high dune ridge stretching along its edge (Figure 4A). The source of the aeolian sands was fluvioglacial sediments exposed in a paleocliff at the plateau margin (Figure 4B).

There are several generations of spits on the lowland varying widely in their size, age, and orientation. The largest of them – Riygiküla, Kudruküla, and Meriküla ones – were firstly described in details by K.K.Markov (1931). The Riygiküla Spit is the farthest from the sea. It forms an arc encircling the southern periphery of the lowland, and is composed mostly of coarse littoral deposits. Radiocarbon data obtained on the archeological site 5305–5040 yr BC (Gerasimov et al., 2015), allow assignment of this ancient coastline to an early stage of the Littorina transgression.

A younger constructional landform – that is Kudruküla Spit – extends as an arc of 25 km in length and 0.2 to 1.5 km in width along the Narva Bay coast. A chain of dunes up to 15 m in height marks its axis, although no evidences of sands have been found on the surface, which is composed mostly of coarse-grained sand and pebbles. In the central part of the arcuate spit there are an archeological sites dated to 2215–2020 yr BC. Further there are dunes having maximum 20 m in height and forming a facing east scarp towards the swamped surface of the ancient lagoon.

To the north there is another archeological site dated to 1910 yr BC. The Kudruküla spit is located on the southern slope of the Kurgalsky plateau’s remnant (~20 m in height) composed of fluvioglacial deposits (Figure 4 B). There are archeological sites existing along its edge, their age is estimated as 3970–3940 yr BC (Gerasimov et al, 2015).

The Kudruküla spit sites are localized on sandy ridges of a moderate height alternating with swamped depressions. Quite possible the ridges represent former foredunes developed at the back share during slowly lowering sea level (Badyukova et al., 2015). Similar eolian landforms are found in other parts of the Narva-Luga Lowland. Both relative elevation and the altitude a.s.l. increase southwards and reach 4–6 m at the distance of 2 km from the sea.

At present the lowland is separated from the sea with a long barrier beach of Meriküla. The sand occuring in large quantities within the littoral zone served as a material for formation of a series of massive dune ridges up to 20 m high and up to 2 km across on the whole.

Figure 4A. An overgrown downwind slope of the dune

Figure 4B. Fluvioglacial deposits

As follows from the drilling data given in the monograph by K.K.Markov (1931) (Figure 5), a series of lagoons developed successively on the coastal waterlogged plain during the Littorina. That is confirmed by the peat occurrence at the base of diatomaceous gyttja of the Littorina age. An abundance of sand in the coastal zone favored development of large bars and deposition of diatom gyttja in lagoons.

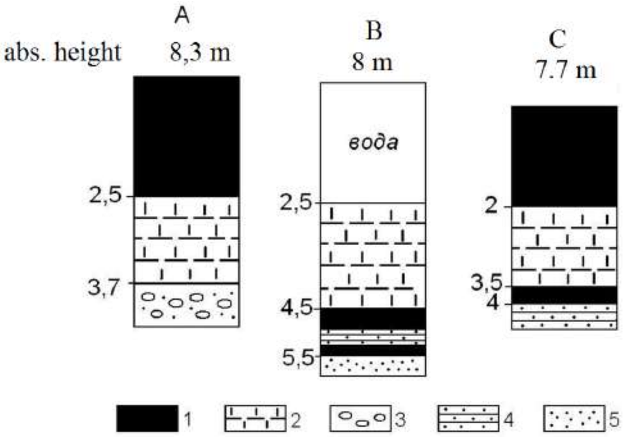


Figure 5. Boreholes on the Narva-Luga Lowland (according to Markov, 1931).
1 – peat, **2** – gyttja, **3** – sand with gravel and pebbles, **4** – sandy loam, **5** – sand

It should be noted in conclusion that data revealed by drilling, along with dated archeological artifacts and the results of geomorphological analysis of the Narva-Luga Lowland allow conclusion that the barrier-lagoon systems evolved there throughout the Littorina time that resulted in formation of several generations of lagoons formed on the coastal plain. The lagoons separated from the sea by sand barriers (Riygiküla, Kudruküla, and Meriküla Spits) developed in a successive order on the low deltaic plain slowly prograding seawards. The latter may be ascribed both to isostatic uplift of the Earth's crust and to sediments accumulation in the nearshore zone. Another evidence supporting idea on proradation of the coastal line comes from the archeological data, i.e. the yongest archeological object is found on the most seaward position of the coastal line.

The Coasts of Latvia

The barrier-lagoon systems are widely developed over the Latvian and Lithuanian coasts. The largest and most thoroughly studied is Ventspils Lagoon which is 30 km long and up to 15 km wide and dessicated by the Venta River. The lagoon is separated from the sea by a large barrier bar with several dune massifs on its surface. Both the barrier and the lagoon include a few islands composed of glacial till and fluvioglacial sediments. There are known several sections with lagoonal or beach deposits attributed to the Littorina sea basin, occurring above the gyttja or peat beds subaerially formed on the coastal plain. Few an example, is a section near Varve settl. 10 km south of Ventspils where a sapropel bed dated at 7110±170 yr BP occurs under the barrier and lagoon deposits of the Littorina Sea (Figure 6B) (Devirts et al, 1968). In the northern part the lagoon there are lagoonal and fluvial sands

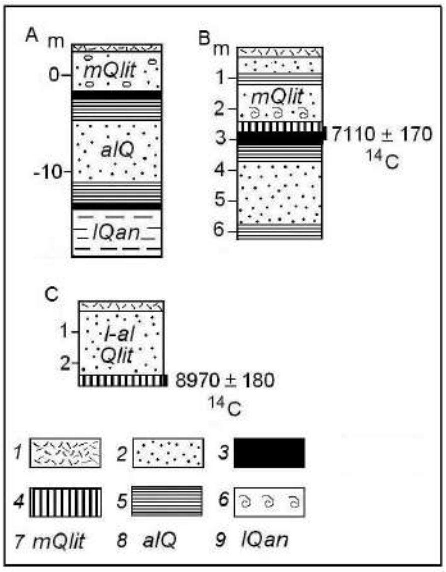


Figure 6. Boreholes in the Ventspils Lagoon (according to Devirts et al., 1968; Djinoridze et al., 1967). **1** – soil, **2** – sand, **3** – peat, **4** – gyttja, **5** – clay, **6** – mollusk shells

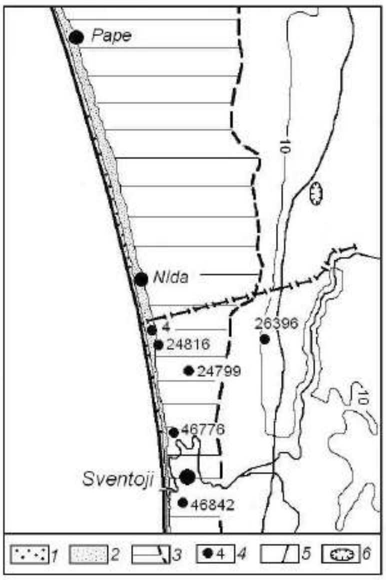
2.5 m thick overlying sapropel dated at 8970±180 yr BP (Figure 6 C). There is another section on the left bank of the Venta River near Ventspils at 4 m a.s.l. where gyttja is unconformably overlain by marine sands (Figure 6 A) (Djinoridze et al., 1967).

The Coasts of Lithuania

An extensive barrier-lagoon system extends for more than 60 km southward from Liepaja to the Lithuania boundary and further south to Šventoji settlement. It abounds in lakes Liepājas and Tosmares. Formerly the lakes were connected with each other forming a large Curonian Gulf behind the Curonian barrier. At present the lowland surface lies above the sea level and is strongly waterlogged. The peat drilled in one of the largest wetlands is up to 10 m in thickness.

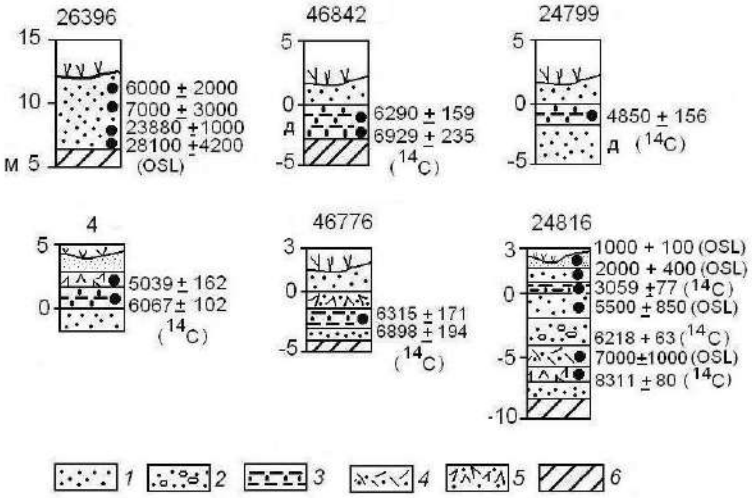
The coastal lowland is separated from the sea with a sandy barrier that includes occasional morainic hills forming minor cusps of the shoreline. The sandy barrier is up to 2 km in width and bears a series of dune ridges 20–30 m (and more) in height. Locally the barrier is partly eroded and reduced in width and height. A significant part of the coast is noted for a presence of a linear uplift in the offshore zone traceable almost from the water edge to a depth of 40 m (Figure 6). It is known as Liepaja Swell and marked with boulder fields (eroded till) and outcrops of Pre-Quaternary rocks (Veynberg et al., 1986).

The coastal zone experiences starvation in sedimentary material which accounts for the barrier erosion, its displacement landwards, and stratigraphic position above the coastal wetland sediments. During strong storms (such as in 1967) the lower segments of the barrier are overwashed by waves, the sediments being moved into the lagoon (Bulgakova, 1982). The most detailed studies of the coastal lowland were performed in the vicinities of the Šventoji town, several boreholes have been drilled there (Figure 7 A, B).



A

Figure 7A. Boreholes near Šventoji (according to Damušytė, 2011). **1** – beach, **2**– dunes, **3** – paleo-lagoon, **4** – boreholes, **5** –road, **6** – quarry



B

Figure 7B. Sedimentary sections drilled in the Šventoji vicinities (according to Damušytė, 2011). **1** – sand, **2** – sand with graves and pebbles, **3** – gyttja, **4** – sandy peat, **5** – peat, **6** – till

The material obtained was further thoroughly studied using palynological analysis and dating by radiocarbon and OSL methods (Damušytė, 2011). As can be seen in given sections, the Littorina transgression deposits are dominated by lagoon facies (Figure 7).

They occur immediately above the deposits formed earlier on the coastal lowlands, i.e. fluvial sands, gyttja or peat. Beach facies of the Lttorina age penetrated by borehole 24816 were dated by ^{14}C as 6218±63 yr, which is indicative of the shoreline advance. At this time similar prograding coastlines have been observed on the Curonian and Vistula Spits (Badyukova et al., 2010), as well as on all the above listed segments of the lowland.

Conclusion

Large constructional landforms of a barrier type have unified mechanism of their development. They initially were formed as marine bars in Holocene. The ice sheet retreat and decay produced a great volume of fluvioglacial sands and gravels that served as a construction material for the barrier formation all over the studied coastal region. Both the formation and further evolution of the barriers were greatly influenced by the sea level transgressive-regressive cycles. Many of the constructional barriers are essentially syngenetic landforms and include some earlier landforms such as fragments of deltaic plains, and remnants of tills or glacio-lacustrine sediments.

Acknowledgments

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BALTİK DƏNİZİNİN ŞƏRQ VƏ CƏNUB-ŞƏRQ SAHİLLƏRİNDƏ SƏDD-LAQUN SİSTEMLƏRİNİN TƏKAMÜLÜ

E.N. Badyukova, L.A. Jindaryev, S.A. Lukyanova, Q.D. Solovyeva

Məqalədə Baltik dənizinin şərq və cənub-şərq sahillərində iri sədd-laqun sistemlərinin geoloji quruluşu və təkamülü məsələləri açıqlanmış, Leninqrad vilayətinin, eləcə də Latviya və Litvanın sahilyanı delta düzənliklərindən toplanmış materiallar ətraflı müzakirə olunmuşdur. Araşdırmalar nəticəsində əldə edilmiş məlumatlar müəlliflərə sədd-laqun sistemlərinin inkişafının əsasında universal mexanizmlərin durması qənaətinə gəlməyə imkan yaratmışdır. Litorin transqressiyası dövründə baş vermiş dəniz səviyyəsinin artması delta düzənliklərinin qurtaracağında iri transqressiv barların əmələ gəlməsini mümkün etmiş, bunun ardınca isə düzənlik səthlərində laqunların yaranmasına səbəb olmuşdur.

РАЗВИТИЕ БАРЬЕРНО-ЛАГУННЫХ СИСТЕМ НА ВОСТОЧНОМ И ЮГО-ВОСТОЧНОМ ПОБЕРЕЖЬЕ БАЛТИЙСКОГО МОРЯ

Е.Н. Бадюкова, Л.А. Жиндарев, С.А. Лукянова, Г.Д. Соловьева

В статье рассматривается геологическое строение и эволюция больших барьерно-лагунных систем на восточном и юго-восточном побережье Балтийского моря. Детально обсуждаются материалы, полученные на прибрежных дельтовых равнинах в Ленинградской области, Латвии и Литве. Данные исследований позволили авторам придти к заключению об универсальном механизме развития барьерно-лагунных систем. Подъем уровня моря во время Литориновой трансгрессии способствовал формированию крупных трансгрессивных баров, сформировавшихся на краю дельтовых равнин, и образованию лагун за ними на поверхности этих равнин.

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Books:

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MÜƏLLİFLƏR ÜÇÜN QAYDALAR

“Neftli-qazlı hövzələrin stratiqrafiyası və sedimentologiyası” elmi beynəlxalq jurnalı dünyanın müxtəlif yerlərində neftli-qazlı hövzələrin stratiqrafiyası və sementologiyasının müxtəlif aspektlərini işıqlandıran məqalələri nəşr edir. Jurnal ildə iki dəfə nəşr olunur və burada məqalələr, icmallar, müzakirələr və qısa məlumatlar çap edilir. Məqalələr azərbaycan, rus və ingilis dillərində təqdim oluna bilər. Jurnalın maraqlarına aşağıdakılar aiddir: çöküntütoplanmasının, xüsusən, ana süxurların və kollektorların müasir və qədim şəraitləri, çökmə prosesinin modelləşməsi, torpaqəmələgəlmə və diogenez, paleoiglim, dənizlərin səviyyəsinin dəyişməsi və süxurların çökməsi, müasir və qazıntı fauna və flora kompleksləri və fasial analizdə onların istifadəsi, stabil izotopların geokimyası və biogeokimyası, süxurların çökmə şəraitindən asılı olaraq kollektorların xarakterlərinin dəyişməsi, neftli-qazlı çöküntü qatlarına tətbiq olunan bio-, lito-, xemo-, eko-, xromo-, seysmo-, sekvensstratiqrafiya və bu kimi başqa stratiqrafiya üsullarının inteqrasiyası.

Məqalələrin təqdim olunma forması

Müəlliflər öz məqalələrinin mətnlərini aşağıdakı elektron ünvana göndərməlidirlər: info@isjss.com

Kompüter faylının adında birinci müəllifin inisialları olmalıdır. Rəsmlər ayrıca fayllarda göndərilməlidir, lakin rəsmlərin yeri məqalənin mətnində rəsmin nömrəsini göstərməklə qeyd edilməlidir. Rəsm olan faylların adlarında birinci müəllifin inisialları və rəsmin nömrəsi olmalıdır.

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Redaksiya heyəti həmçinin məqalələrin çap variantını aşağıdakı ünvana göndərməyinizi xahiş edir: “Neftli-qazlı hövzələrin stratiqrafiyası və sedimentologiyası” jurnalının redaksiyası, Hüseyn Cavid prospekti 29A, Azərbaycan Elmlər Akademiyasının Geologiya İnstitutu, Bakı, AZ 1143. Kompüter faylı (məqalənin mətni) məqalənin çap olunmuş variantına uyğun olmalıdır.

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Məqalənin mətninə aşağıdakılar daxil edilməlidir:

Universal Onluq Təsnifatı (UOT) – sol küncdə, Times New Roman – 12 pt şrifti ilə, iki interval ötürməklə məqalənin adı yazılmalıdır.

Məqalənin adı – Times New Roman – 14 pt şrifti ilə, qalın baş hərflərlə, mətnin eni boyunca və səhifənin ortasına nisbətən simmetrik olaraq yazılır, daha sonra isə iki interval ötürməklə müəllifin soyadı və inisialı yazılmalıdır. Xahiş edirik əlaqə saxlanılacaq müəllifi göstərin.

Müəllifin inisialı və soyadı – Times New Roman – 12 pt şrifti ilə, qalın hərflərlə, səhifənin ortasına nisbətən simmetrik olaraq yazılır, daha sonra isə iki interval ötürməklə təşkilatın adı və onun elektron ünvanı yazılmalıdır.

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Annotasiya – qısa xülasə (1 səhifəyədək), daha sonra başlıca sözlər (8 sözə qədər). Times New Roman – 12 pt. şrifti. Başlıca sözlər qalın şriftlə yazılmalıdır. Daha sonra 2 intervalla məqalənin əsas mətni yazılmalıdır.

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Cədvəllər məqalənin mətni çərçivəsində yerləşdirilir və Word formatında təqdim edilir. Cədvəllər yuxarı sağ küncündən ardıcıl olaraq nömrələnməlidir. Hər bir cədvəlin adı olmalıdır və bu ad nömrədən sonra yazılmalıdır. Cədvəllərin ad və nömrələri qalın Times New Roman – 12 şrifti ilə yazılmalıdır. Cədvəllərdəki sütunların yarımsərlövhələri qısa olmalı, ölçü vahidlərinin adları dəyirmi mötərizələrdə verilməlidir. Cədvəllər mətnin kənarlarından qırağa çıxmamalıdır. Cədvəlin bir səhifədən digər səhifəyə keçməsi yolverilməzdir. Mətnə aid cədvəllərin maksimum sayı 5 ola bilər.

İxtisarlar, ümumi qəbul edilmiş bir neçə ixtisarlar (və s., məs.,) istisna olmaqla, istinadlarda açılmalıdır.

Qazıntı halında tapılan qalıqlar “Beynəlxalq zooloji nomenklatura məcəlləsinə” əsasən təsvir olunmalıdırlar. Mətndə flora və faunanın növlərinin latın adları taksonun müəllifinin soyadı ilə müşayiət olunmalıdır. Latın sözləri kursivlə verilməlidir.

Formulları yazarkən Beynəlxalq Sİ sistemində qəbul olunmuş fiziki vahidlərdən və işarələrdən istifadə etmək lazımdır. Formullar aralıq hesablamalarsız, orada istifadə olunan simvolların mütləq açılması şərti ilə formuldan dərhal sonra verilməlidir. Mətndə, adı çəkilərsə, formulların nömrələri böyük mötərizələrdə, mətnin sağ həddinə yaxın, formul ilə eyni xətdə yazılır. Formulların yazılması üçün Microsoft Equation 3 redaktorundan istifadə tövsiyə olunur. Sonra isə iki interval ötürməklə ədəbiyyatın siyahısı verilməlidir.

Ədəbiyyat – mətndə ədəbiyyata istinad xronoloji qaydada, dəyirmi mötərizələrdə verilir (müəllif/lər, il). Üçdən artıq müəllifin işinə istinad edildikdə isə, birinci müəllifin soyadı göstərilir (məs. Quliyev və digərləri, 2005). Məqalədə hər hansı müəllifsiz yazıya istinad etmədikdə, onda həmin yazının adının ilk iki sözü yazılır (məs. Stratiqrafiya məcəlləsi..., 2005). Ədəbiyyatın siyahısı məqalənin sonunda əlifba sırası ilə verilir. Burada bütün müəlliflərin soyadları və inisialları, nəşr olunan il, məqalə və ya kitabın adı, jurnalda çap olunubsa jurnalın adı və nömrəsi və məqalənin ilk və sonuncu səhifələri göstərilməlidir. Kitaba istinad edildikdə isə kitabdakı səhifələrinin sayı da göstərilməlidir.

Siyahıda eyni müəllifin eyni ildə nəşr olunmuş yazılarına istinad etdikdə, onda onları ilini qeyd etdikdən sonra indeksləşdirmək lazımdır: a, b, c və s. Tezislərə verilən istinadlar da eyni qaydada yerinə yetirilməlidir. Müəllifin(lərin) soyad və inisialları kursivlə yazılır.

Aşağıda müxtəlif biblioqrafik istinadların nümunələri verilir:

Kitablar:

Бабаев, Д.Х., Гаджиев, А.Н., 2006. Глубинное строение и перспективы нефтегазоносности бассейна Каспийского моря, Б., «Nafta-Press», 305 с.

Kőthe, A., 1990. Paleogene Dinoflagellates from Northwest Germany – Biostratigraphy and Paleoenvironment, Hanover, 111 p.

Dövri nəşrlərdə/jurnallardakı məqalələr:

Бабаев, Ш.А., 2005.Влияние условий окружающей среды на морфологию раковин нуммулитов //

Известия АН. Серия наук о Земле, № 2, с. 62–66.

Hallam, A., 2001. A review of the broad pattern of Jurassic sea-level changes and their possible causes in the light of current knowledge. Palaeogeogr., Palaeoclimatol., Palaeoecol, v. 167, pp. 23–37.

Məcmuələrdəki (o cümlədən dövri məcmuələrdəki) məqalələr:

Кузнецова, З.В., 1959. Нижнемиоценовые отложения Азербайджана, их расчленение и сопоставление с синхроничными отложениями Грузии // Вопросы геологии и геохимии. – Б.: Азернешр, 207–216.

Delamette, M., Caron, M., Brehert, J., 1986. Essai d'interpretation genetique des facies euxiniques de l'Eo-Albien du bassin vocontien (SE France) sur la base des donnees macro- et microfauniques. C.R. Acad. Sc. Paris. ser. II, v. 302, pp. 1085–1090.

Rezüme. Özündə məqalə haqqında əsas məlumatı, araşdırmanın məqsəd və vəzifələri, istifadə olunan metodikanı, əldə edilən nəticələri özündə əks etdirən geniş rezüme ingilis dilində təqdim edilməlidir. Rezümenin məqsədi ingilisdilli auditoriyanın rus və ya azərbaycan dillərində çap olunmuş məqalələrlə tanış olmasıdır.

İllüstrasiyalar. Hər bir rəsm (xəritə, diaqram, sxem və s.) ayrıca fayl şəklinə təqdim olunur. Yuxarıda qeyd edildiyi kimi faylın adında rəsmin nömrəsi və müəllifin inisialları olmalıdır.

Rəsmlər TIFF, 300 dpi , PDF və ya CDR formatında qəbul edilir. İllüstrasiyalar mətndə onlara edilən istinada uyğun nömrələnməlidir. Hər bir rəsm 160 mm x 230 mm ölçüsündən böyük olmamalıdır. Xəritələrdə miqyas göstərilməlidir.

Məqalənin çap olunmuş variantında rəsmlərin arxasında karandaşla onların nömrələri, məqalənin birinci müəllifinin soyadı və məqalənin adı göstərilir.

Hər rəsmin başlığı olmalıdır. Rəsmlərə aid olan izahatların siyahısı ayrıca vərəqdə, elektron və ya çap olunmuş variantda təqdim olunmalıdır. Mətnə aid olan rəsmlərin sayı 10-dan artıq olmamalıdır.

Jurnalın redaksiya heyəti rəngli şəkillərin ödənişsiz çapını təmin edir.

Redaksiya məqaləni resenziya üçün təqdim etmə hüququnu özündə saxlayır. Məqalənin çap olunmuş variantı yoxlama və çap və redaktə zamanı yol verilən səhvlərin düzəldilməsi üçün geri müəllifə göndərilir. Müəllif məqalənin çap olunmuş variantında çapa hazır edilmiş mətn və digər materiallara düzəliş etməməlidir.

Gecikmələrin qarşısını almaq məqsədilə, müəlliflərə son variantın redaksiyaya geri qaytarılmasının elektron poçt ilə həyata keçirmələri və çapa hazır variantın alındığı gündən iki həftə müddətində düzəlişlər barədə məlumat vermələri tövsiyə olunur.

Məqaləyə müəllifin arayışı və ekspertiza aktı əlavə olunmalıdır.

Məqalənin jurnala verilməsi onun əsli olduğu, heç vaxt çap edilmədiyi və digər nəşrlərə göndərilmədiyi anlamındadır. Məqalə müəlliflərin hər biri tərəfindən imzalanmalı və onun redaksiyaya təqdim olunma tarixi göstərilməlidir.

ПРАВИЛА ДЛЯ АВТОРОВ

Международный научный журнал «*Стратиграфия и седиментология нефтегазоносных бассейнов*» публикует статьи, освещающие различные аспекты стратиграфии и седиментологии нефтегазоносных бассейнов в различных частях мира. Сферой интересов журнала являются современные и древние условия осадконакопления, в особенности, нефтематеринских пород и коллекторов, моделирование процесса седиментации, почвообразование и диагенезис, палеоклимат, изменения уровня моря и седиментация, современные и ископаемые комплексы фауны и флоры и их использование в фациальном анализе, геохимия стабильных изотопов и биогеохимия, изменения коллекторских свойств в зависимости от условий отложения осадков, интеграция различных стратиграфических методов, таких, как био-, лито-, хемо-, эко-, хроно-, сейсмо-, секвенсстратиграфия применительно к осадочным толщам нефтегазоносных областей.

Журнал выходит два раза в год и публикует статьи, обзорную информацию, дискуссии и краткие сообщения. Статьи могут быть представлены на азербайджанском, английском и русском языках.

Форма представления статьи

Авторы должны высылать тексты своих статей на следующий электронный адрес: info@isjss.com

Название компьютерного файла должно содержать инициалы первого автора. Рисунки должны быть высланы в отдельных файлах, однако, местоположение рисунков должно быть показано в тексте статьи путем указания номера рисунка. Названия файлов, содержащих рисунки, должны включать инициалы первого автора и номер рисунка.

Текст статьи должен быть представлен в Word формате (Word 6,0 – 8,0). Размер статьи не должен превышать 20 страниц формата А4, отступ со всех сторон – 2 см, рекомендуемый шрифт – Times New Roman, размер шрифта – 12, межстрочный интервал – 1,5, каждый абзац начинается с отступом 0,8 см от левого края колонки. Текст статьи должен быть отформатирован в соответствии с этими требованиями, все строки должны быть выровнены слева направо, не выходя за поля текста. Статья должна включать также соответствующий графический материал (не менее одного рисунка), список используемой литературы, таблицы, если необходимо, и расширенное резюме. Редакция журнала не принимает не содержащие рисунки статьи.

Редакция журнала также просит высылать распечатанные варианты статей по адресу: Редакция журнала «Седиментология и стратиграфия нефтегазоносных бассейнов», Институт геологии НАН Азербайджана, пр. Г. Джавида 29А, Баку, AZ 1143, Азербайджан. Компьютерный файл (текст статьи) должен соответствовать распечатанному варианту статьи.

Страницы не должны быть пронумерованы в электронном варианте статьи. В распечатанном варианте статьи номера страниц проставляются в верхнем правом углу.

Статья должна быть подписана всеми авторами на последней странице распечатанного варианта с указанием даты представления статьи в редакцию.

Текст статьи должен включать:

УДК – в левом углу, шрифт Times New Roman – 12 pt, через два интервала печатать название статьи

Название статьи – шрифт Times New Roman – 14 pt, буквы заглавные, утолщенные (bold), расположенные симметрично относительно середины страницы по всей ширине текстового поля, далее через два интервала печатать инициалы и фамилии авторов. Пожалуйста, укажите автора, с которым необходимо поддерживать связь.

Инициалы и фамилии авторов – шрифт Times New Roman – 12 pt, буквы строчные (bold), расположить симметрично относительно середины страницы, далее через два интервала печатать название организации и ее e-mail.

Название организации, в которой работают авторы и ее e-mail: шрифт Times New Roman – 12 pt, буквы строчные (bold), расположить симметрично относительно середины страницы. Пожалуйста, дайте полный адрес организации, где работа была выполнена, а также адрес авторов в настоящий момент, если он изменился. Если авторов несколько и они имеют различное место работы, то перед названиями этих организаций следует проставить цифры в порядке возрастания. Ту же цифру указать и в надстрочном индексе после фамилии авторов, работающего в этой организации, например, И.С.Гулиев [1], А.А. Фейзуллаев[2] и т.д. Далее через два интервала печатать аннотацию.

Аннотация - краткая аннотация (до 1 страницы), далее ключевые слова (до 8 слов). Шрифт Times New Roman – 12 pt., ключевые слова печатать жирным шрифтом. Далее через два интервала печатать основной текст статьи.

Текст статьи – основной текст, который рекомендуется строить по общепринятой в международных журналах схеме, используя следующие подзаголовки: «Введение», «Материал», «Методика», «Результаты и обсуждение», «Заключение (выводы)», «Список литературы». Подзаголовки печатать жирным шрифтом Times New Roman – 12 pt и расположить симметрично относительно середины страницы, каждый подраздел отделять от предыдущего одним интервалом.

Таблицы размещаются в пределах текста статьи и должны быть представлены в формате Word. Они должны быть пронумерованы последовательно в верхнем правом углу над самой таблицей. Каждая таблица должна иметь название, которое следует за номером таблицы. Печатаются номера таблиц и их названия шрифтом Times New Roman – 12 pt жирными буквами. Подзаголовки в колонках таблицы должны быть краткими, наименования единиц измерения должны даваться в круглых скобках.

Таблицы не должны выходить за пределы текстового поля, перенос таблицы с одной страницы на другую не допускается. Максимальное допустимое количество таблиц в статье 5.

Сокращения за исключением немногих общепринятых (т.е., др., т.д.) должны быть расшифрованы в ссылках.

Ископаемые остатки следует описывать согласно «Международному кодексу зоологической номенклатуры». Приводимые в тексте латинские названия видов флоры и фауны должны сопровождаться фамилией автора таксона. Латынь следует набирать курсивом.

При написании **формул** следует использовать физические единицы и обозначения, принятые в Международной системе СИ. Формулы даются без промежуточных выкладок с обязательной расшифровкой используемых в них символов, которые даются сразу после формулы. Номера формул, если они упоминаются в тексте, проставляются в круглых скобках около правой границы текста на одной линии с формулой. Для набора формул рекомендуется использовать редактор Microsoft Equation 3, далее через два интервала печатать список литературы.

Литература. В тексте статьи ссылка на литературу дается в круглых скобках (Автор/ы, год) в хронологическом порядке. Если ссылка дается на работу где более трех авторов, то указывается фамилия первого автора (например, Гулиев и др., 2005). Если ссылаемая работа приводится без авторов, то пишутся два первых слова ее названия (например, Стратиграфический кодекс…., 1998). Список литературы приводится в алфавитном порядке в конце статьи и должен включать фамилии и инициалы всех авторов, год издания, название статьи/книги, в случае публикации в журнале – его название и номер выпуска, номера первой и последней страниц статьи. Если ссылка сделана на книгу, то необходимо указать количество страниц в книге.

Если список содержит ссылки на работы одного и того же автора, опубликованные в один и тот же год, то необходимо придать им индексы а, б, в и т.д. после указания года издания. Ссылки на тезисы докладов даются аналогичным образом. Фамилии и инициалы авторов приводятся курсивом.

В списке литературы вначале приводятся публикации, изданные на кириллице, а затем латинским шрифтом.

Ниже приводятся примеры различных библиографических ссылок.

Книги:

Бабаев, Д.Х., Гаджиев, А.Н., 2006. Глубинное строение и перспективы нефтегазоносности бассейна Каспийского моря, Б. – «Nafta-Press», 305 с.

Kőthe, A., 1990. Paleogene Dinoflagellates from Northwest Germany – Biostratigraphy and Paleoenvironment, Hanover, 111 p.

Статьи в периодических журналах:

Бабаев, Ш.А., 2005. Влияние условий окружающей среды на морфологию раковин нуммулитов // Известия НАНА. Серия наук о Земле, № 2, с.62–66.

Hallam, A., 2001. A review of the broad pattern of Jurassic sea-level changes and their possible causes in the light of current knowledge // Palaeogeogr., Palaeoclimatol., Palaeoecol., v.1 67, pp. 23–37.

Статьи в сборниках (в том числе перодических):

Delamette, M., Caron, M., Brehert, J., 1986. Essai d'interpretation genetique des facies euxiniques de l'Eo-Albien du bassin vocontien (SE France) sur la base des donnees macro- et microfauniques // C.R. Acad. Sc. Paris. ser. II., v.302, pp. 1085–1090.

Резюме. Расширенное резюме на английском языке, содержащее основную информацию о статье, в том числе цель и задачи исследования, использованная методика, полученные результаты и выводы, должно быть также представлено. Цель резюме – ознакомление англоязычной аудитории со статьями, опубликованными на русском и азербайджанском языках.

Иллюстрации. Каждый рисунок (карта, диаграмма, схема и т.д.) представляется в виде отдельного файла. Как выше уже было указано, название файла должно содержать инициалы первого автора и номер рисунка.

Рисунки принимаются в форматах TIFF (300 dpi), PDF or CDR files Иллюстрации обязательно нумеруются в порядке их указания в тексте. Каждый рисунок не должен превышать размера 160 мм x 230 мм. На картах обязательно указывать масштаб.

В распечатанном варианте статьи номера рисунков указываются на их обороте простым карандашом с указанием фамилии первого автора и названия статьи.

Каждый рисунок должен иметь заглавие. Список подрисуночных подписей должен быть представлен в электронном и распечатанном виде на отдельном листе. Количество рисунков в статье не должно превышать 10.

Редакция журнала обеспечивает **бесплатное** печатание цветных рисунков.

Редакция оставляет за собой право передать статью на рецензию. Верстка статьи направляется автору для проверки и исправления ошибок, допущенных при наборе и редактировании.

Для исключения задержек с возвращением верстки в редакцию авторам рекомендуется пользоваться электронной почтой и сообщать об исправлениях в течение двух недель после получения верстки.

К статье должны прилагаться авторская справка и акт экспертизы.

Подача статьи в журнал означает, что она оригинальна, нигде не публиковалась и не была направлена в другие издательства.

CONTENTS

MÜNDƏRİCAT

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